RELION® 630 SERIES

Power Management PML630/Compact Load-Shedding Solution

Technical Manual

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Warranty

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

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This product complies with 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 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2014/35/EU). This conformity is the result of tests conducted by ABB 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.

Table of contents

Section 1 Introduction

1.1 This manual

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

1.2 Intended audience

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

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

1.3 Product documentation

1.3.1 Product documentation set

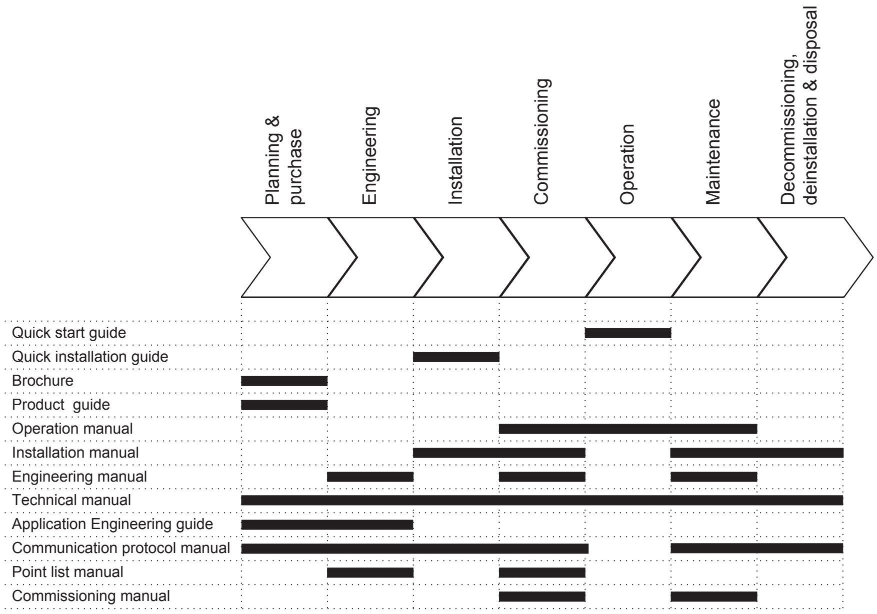

Figure 1: The intended use of documents during the product life cycle

See the 630 series documentation for installation and commissioning manuals. The PML630 documentation set includes only application engineering guide, engineering manual, IEC 61850 communication protocol manual, IEC 61850 point list manual, operation manual and technical manual.

1.3.2 Document revision history

Document revision/date	Product version	History
A/2011-05-04	1.1	First release
B/2011-11-03	1.1.1	Content updated to correspond to the product series version
C/2012-03-29	1.1.2	Content updated to correspond to the product series version
D/2013-10-14	1.2	Content updated to correspond to the product series version
E/2016-08-29	1.2.1	Content updated to correspond to the product series version
F/2019-08-27	1.2.1	Content updated

1.3.3 Related documentation

Name of the document	Document ID
Application Engineering Guide	1MRS757394
Engineering Manual	1MRS757184
IEC 61850 Communication Protocol Manual	1MRS757260
IEC 61850 Point List Manual	1MRS757261
Operation Manual	1MRS757183

Download the latest documents from the ABB Web site http://www.abb.com/relion.

1.4 Symbols and conventions

1.4.1 Symbols

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

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

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

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

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

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

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons.
  To navigate between the options, use and .
- Menu paths are presented in bold.
  Select **Main menu/Settings**.
- WHMI menu names are presented in bold.
  Click **Information** in the WHMI menu structure.
- LHMI messages are shown in Courier font.
  To save the changes in nonvolatile memory, select `Yes` and press .
- Parameter names are shown in italics.
  The function can be enabled and disabled with the *Operation* setting.
- The ^ character in front of an input or output signal name in the function block symbol given for a function, indicates that the user can set an own signal name in PCM600.
- The * character after an input or output signal name in the function block symbol given for a function, indicates that the signal must be connected to another function block in the application configuration to achieve a valid application configuration.

1.4.3 Functions, codes and symbols

Table 1: Functions included in the device

Functionality	IEC 61850
Generic process I/O	
Single point control (8 signals)	SPC8GGIO[1)]
Double point indication	DPGGIO[1)]
Single point indication	SPGGIO[1)]
Generic measured value	MVGGIO[1)]
Event counter	CNTGGIO[1)]
Monitoring	
Measured value limit supervision	MVEXP[1)]
Station battery supervision	SPVNZBAT[1)]
Power management (load-shedding)	
Critical circuit breaker	NCBDCSWI
Table continues on next page	

Functionality	IEC 61850
Contingency based load-shedding core function	LSCACLS
Busbar-wise sheddable loads data	LDMMXU
Busbar-wise load feeders load-shedding command	LSPTRC
Power source	PSCSWI
Subnetwork supervision	SNWRCLS
Network power source	NPMMXU
Information exchange between peer PML630s	PPLSGGIO[2)]
Disturbance recorder functions	
Analog channels 1-10 (samples)	A1RADR
Analog channel 11-20 (samples)	A2RADR
Analog channel 21-30 (samples)	A3RADR[1)]
Analog channel 31-40 (calc. val.)	A4RADR[1)]
Binary channel 1-16	B1RBDR
Binary channel 17-32	B2RBDR
Binary channel 33-48	B3RBDR
Binary channel 49-64	B4RBDR[1)]
Disturbance recorder	DRRDRE
Multipurpose functions	
Position evaluate	POS_EVAL[1)]
Double point indication	DPGGIO[1)]
Multipurpose analog protection	MAPGAPC[1)]
Station communication (GOOSE)	
Binary receive	GOOSEBINRCV
Double point receive	GOOSEDPRCV
Integer receive	GOOSEINTRCV
Measured value receive	GOOSEMVRCV
Single point receive	GOOSESPRCV

1) The function is not used by default. However, it is kept enabled in the Application Configuration tool for instantiation in any additional logic other than features offered by the PML630 connectivity package.
2) The PPLSGGIO function block is instantiated only when the cPMS - LS Configuration B is selected in the configuration wizard of PML630.

Section 2 PML630 overview

2.1 Overview

PML630 is a Power Management device that provides comprehensive load-shedding solution for the power network in an industrial plant. It protects the plant against blackouts and power source outages due to system disturbances. This device is a member of ABB's Relion® product family and a part of its 630 product series characterized by functional scalability and flexible configurability. PML630 is identical to the Relion 630 series protection relays and does not have any specific hardware modules. It is only the application functions pre-loaded in the device that differentiate it from the 630 series protection relays.

The device supports various modes of load-shedding.

- Fast load-shedding based on network contingencies
- Slow load-shedding based on transformer overloading or the maximum demand violation on the grid tie feeder
- Manual load-shedding based on operator-defined priorities or amount of loads to be shed in kW

PML630 complies to the IEC 61850 standard and offers seamless connectivity with other Relion 615/620/630 series protection relays, RIO600 IO units and COM600 to realize the load-shedding functionality. The device uses GOOSE and MMS communication profiles for I/O data exchange with Relion product family protection relays and COM600.

The PML630 load-shedding controller essentially handles load-shedding functionality for plant electrical network. This comprises of various components.

- 6 generators
- 2 external network connectivity (tie line or grid transformers) and 6 busbars
- 15 network breakers
- 60 load-shedding groups (10 loads/load groups per busbar)

This is referred as cPMS - LS configuration A (for load-shedding power management function).

All the six generators could also be configured as utility grid transformers.

When the power network configuration exceeds the limits defined for a PML630 in Configuration A, an additional PML630 device can be configured in a peer-to-peer method thereby dividing the network into sectors called power network areas. Each PML630 is responsible for the load-shedding action in its respective area, based on the power source capabilities and inter-power network area connectivity status. The coordination of load-shedding actions between the PML630 IEDs is handled by suitable parameterization. This arrangement of multiple PML630 IEDs in a peer-to-peer method is called cPMS - LS configuration B.

The PML630 IEDs communicate with each other also using IEC 61850 GOOSE. Likewise, cPMS - LS configuration B is also a feature in PML630. The Configuration B is always built up over and above the Configuration A and hence the latter is a prerequisite.

The maximum recommended number of PML630 IEDs in a peer-to-peer mode in Configuration B is three.

The power network areas would be connected to each other through their grid 1 or grid 2 power source connection points.

2.2 Product version history

Product version	Product history
1.1	First release
1.1.1	Maintenance release
1.1.2	Maintenance release
1.2	• Support for Relion® 620 series, RIO600 in the solution cluster • Fast load-shedding: external trigger enabling, extending network capability with Configuration B • Slow load-shedding: coverage of all 6 generators for current-based overload load-shedding, 2 grid transformers' currents can be directly monitored for overcurrent using 8 CT TRM card; provision for direct reduction of overload (in addition to power-balance calculations) • Manual load-shedding: defining load-shedding by power value from LHMI/COM600, external trigger for all 4 subnetworks • Underfrequency load-shedding using 630 series' Multipurpose analog protection MAPGAPC for underfrequency detection and activation through fast and slow load-shedding functions • Manual load-shedding mode not affected when fast and slow load-shedding modes are blocked • Provision for external inhibition of load feeders • Adaptation for double-busbar configuration
1.2.1	Maintenance release

2.3 PCM600 and IED connectivity package version

- Protection and Control IED Manager PCM600 Ver.2.5 or later
- ABB IED Connectivity Package PML630 Ver.1.2.1

Download connectivity packages from the ABB Web site
http://www.abb.com/substationautomation

2.4 Local HMI

The LHMI is used for setting, monitoring and controlling the device. The LHMI comprises the display, buttons, LED indicators and communication port.

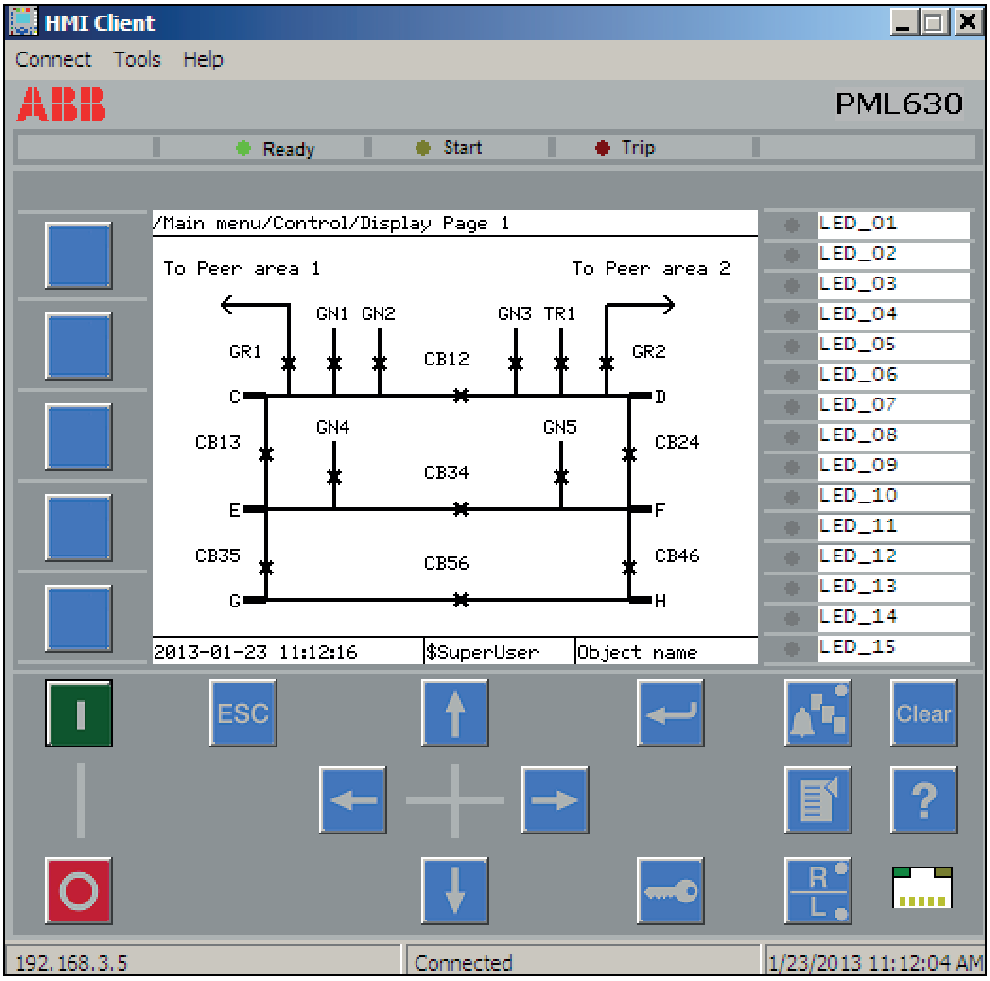

Figure 2: LHMI

2.4.1 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.

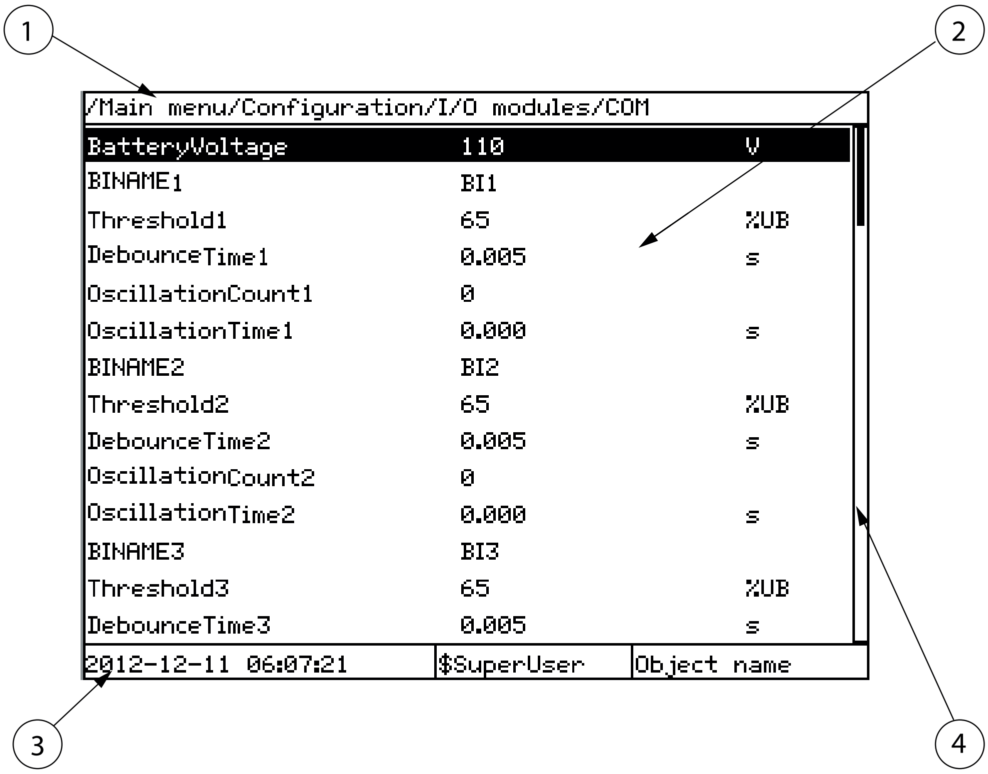

Figure 3: Display layout

1 Path

2 Content

3 Status

4 Scroll bar (appears when needed)

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

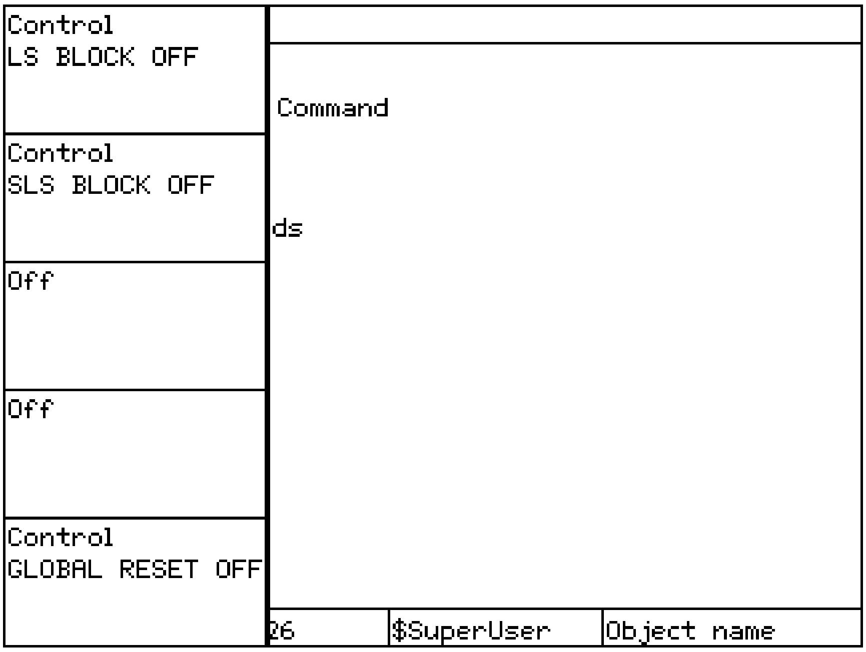

Figure 4: Function button panel

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

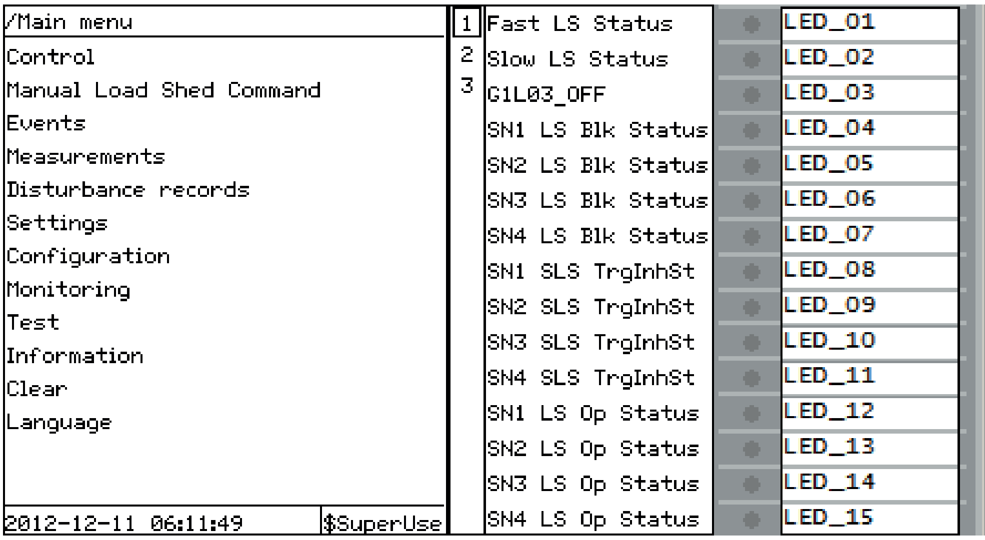

Figure 5: Alarm LED panel

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

2.4.2 LEDs

The LHMI includes three indicators above the display: Ready, Start, and Trip. The load shed start (initiation of power balance calculation) and operate (initiation of load-shed commands) are mapped to LHMI Start and Trip LEDs respectively.

There are also 15 matrix programmable alarm LEDs in front of the LHMI. Each LED indicates three states with the colors: green, yellow and red.

2.4.3 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, provide help, make new settings and confirmations.

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

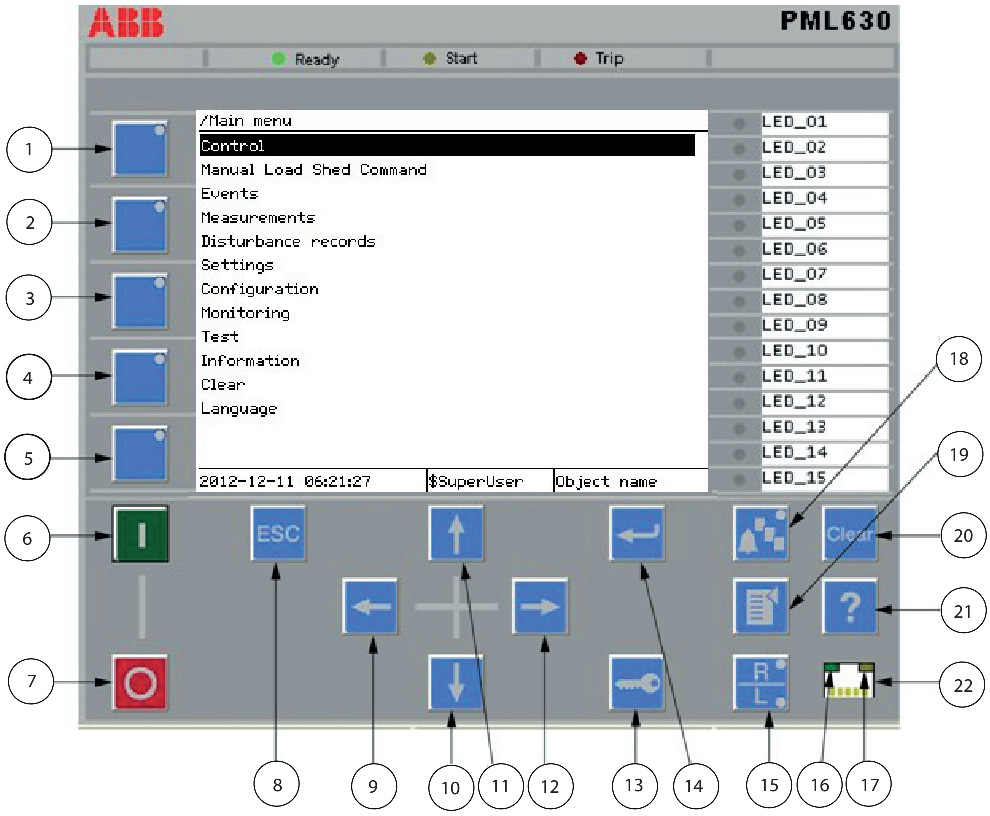

Figure 6: LHMI keypad with object control, navigation and command push buttons and RJ-45 communication port

1...5	Function button	14	Enter
6	Disabled in PML630	15	Disabled in PML630
7	Disabled in PML630	16	Uplink LED
8	Escape	17	Not in use
9	Left	18	Multipage
10	Down	19	Menu
11	Up	20	Clear
12	Right	21	Help
13	Key	22	Communication port

2.5 Web HMI

The WHMI enables the user to access the device via a web browser. The supported Web browser version is Internet Explorer 7.0 or later.

WHMI is disabled by default. To enable the WHMI, select **Main menu/Configuration/HMI/Web HMI/Operation** via the LHMI.

WHMI offers several functions.

- Alarm indications and event lists
- System supervision
- Parameter settings
- Measurement display
- Disturbance records

The menu tree structure on the WHMI is almost identical to the one on the LHMI.

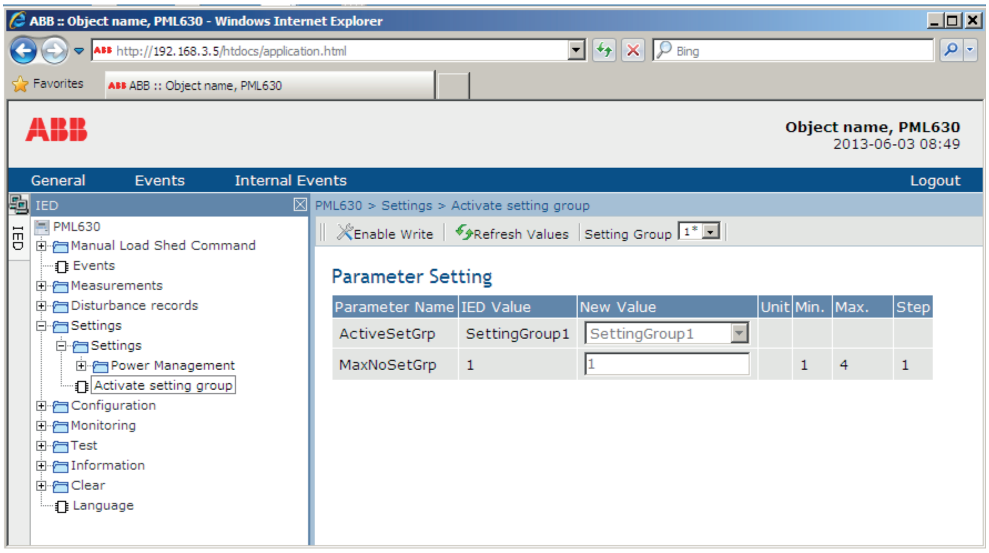

Figure 7: Example view of the WHMI

The WHMI can be accessed locally and remotely.

- Locally by connecting the user's computer to the device via the front communication port.
- Remotely over LAN/WAN.

Thus, the WHMI can be used remotely to set the device parameters and also other Relion series protection relays from a central operation workplace in the substation or the plant network.

2.5.1 Command buttons

Command buttons can be used to edit parameters and control information via the WHMI.

Table 2: Command buttons

Name	Description
Enable Write	Enabling parameter editing.
Disable Write	Disabling parameter editing.
Write to IED	Writing parameters to the device.
Refresh Values	Refreshing parameter values.
Commit	Committing changes to device's non-volatile flash memory.
Reject	Rejecting changes.
Manual trigger	Triggering the disturbance recorder manually.
Save	Saving the disturbance recording.
Freeze	Freezing the values so that updates are not displayed.
Continue	Receiving continuous updates to the monitoring view.
Delete	Deleting the disturbance record.

2.6 Authorization

The user categories are predefined for the LHMI and WHMI, each with different rights.

The IED users can be created, deleted and edited only with PCM600. One user can belong to one or several user categories.

At delivery, the IED user has full access as SuperUser until users are created with PCM600. Logging on is not required for the LHMI.

Table 3: Predefined user categories

Username	User rights
SystemOperator	Control from LHMI, no bypass
ProtectionEngineer	All settings
DesignEngineer	Application configuration
UserAdministrator	User and password administration

All changes in user management settings will cause an IED reboot.

2.7 Communication

The IED supports IEC 61850-8-1 standard for communication. This includes MMS communication profile for vertical communication and GOOSE communication profile for horizontal communication.

All operational information and controls are available through these profiles. The IED operator functionality is achieved through the MMS communication profile or through the WHMI client surface.

The IED exchanges load-shedding operational signals using the IEC 61850 GOOSE profile from feeder IEDs (REF/REM/RET615, REF/REM/RET620, REF/REG/REM/RET630 and Remote I/O Unit RIO600 1.2). The IED receives binary and analog signals from feeder IEDs for load-shedding input data processing.

- The data transfer from a generator or transformer IEDs (RET615, RET620, REG/RET630 and Remote I/O Unit RIO600 1.2) to the IED includes circuit breaker status, trip or critical alarms, power and current (for transformer feeder IEDs).
- The data transfer from the load feeder IEDs (REF/REM/RET615, REF/REM/RET620, REF/REM/RET630 and Remote I/O Unit RIO600 1.2) to the IED includes circuit breaker status and power.

The load-shedding information (binary signals) is sent to the load feeder IEDs using IEC 61850 GOOSE communication profile. The IED can also interoperate with other IEC 61850 compliant IEDs including Relion® 630 and 615 series of IED's and reports events to five different IEC 61850 clients (HMI/Gateways and so on) simultaneously using the MMS communication profile.

All communication connectors, except for the front port connector are placed on integrated communication modules.

The IED supports SNTP and IRIG-B time synchronization methods with a time-stamping resolution of 1 ms.

Ethernet based:

- SNTP (Simple Network Time Protocol)

With special time synchronization wiring:

- IRIG-B

PML630 Ver.1.2.1 supports ANSI/CN protection relays of the 615 and 620 series, REG615 and RIO600 Ver.1.2 or later in addition to the IEC protection relays mentioned in this section.

Section 3 Basic functions

3.1 User authentication

3.1.1 Authority check ATHCHCK

3.1.1.1 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 PCM600 is implemented at both access points to the IED.

- Local, through the LHMI
- Remote, through the communication ports

3.1.1.2 Operation principle

Different levels (or types) of users can access or operate different areas of the IED and tools' functionality.

Table 4: Predefined user types

User type	Access rights
SystemOperator	Control from LHMI, no bypass, protection function activation and deactivation
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 LHMI on the IED. There are no users, groups or functions that can be defined on LHMI.

Use only characters A - Z, a - z and 0 - 9 in user names and passwords.

Include at least one user in the UserAdministrator group to be able to write users created in PCM600 to the IED.

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, the user can perform a Log on using the password assigned in the tool. The default user is Guest.

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

If one user leaves the IED without logging off, the IED returns to Guest state, in which only reading is possible, after the timeout (set in **Main menu/Configuration/HMI/LHMI/Display Timeout**) elapses. 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, the Log on window opens if a user attempts a Log on by pressing the Key push-button or if the user attempts to perform an operation that is password protected.

See the operation manual for more information on the logon procedure.

After a successful Log on, the LHMI returns to the actual setting folder if, for example, a password protected setting needs to be changed. If the Log on has failed, an "Error Access Denied" message opens. If the user enters an incorrect password three times, the user is blocked for ten minutes before a new attempt to log in can be performed. The user is blocked from logging in from the LHMI, WHMI and PCM600. However, other users are allowed to log in during this period.

3.1.1.3 Settings

The function does not have any parameters available in LHMI or PCM600.

3.1.2 Authority status ATHSTAT

3.1.2.1 Function block

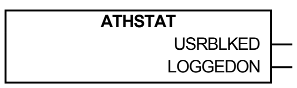

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Figure 8: Function block

3.1.2.2 Functionality

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

3.1.2.3 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.

3.1.2.4 Signals

Table 5: 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

3.1.2.5 Settings

The function does not have any parameters available in LHMI or PCM600.

3.2 Local human-machine interface LHMI

3.2.1 Local HMI screen behaviour

3.2.1.1 Settings

Table 6: 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	Main menu Control Events Measurements Disturbance records Monitoring	-	-	Main menu	Default screen
EvListSrtOrder	Latest on top Oldest on top	-	-	Latest on top	Sort order of event list
AutoIndicationDRP	Off On	-	-	Off	Automatic indication of disturbance report
SubstIndSLD	No Yes	-	-	No	Substitute indication on single line diagram
InterlockIndSLD	No Yes	-	-	No	Interlock indication on single line diagram
BypassCommands	No Yes	-	-	No	Enable bypass of commands

3.2.2 Local HMI signals

3.2.2.1 Function block

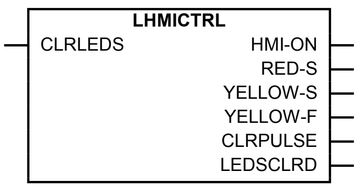

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Figure 9: LHMICTRL function block

3.2.2.2 Signals

Table 7: LHMICTRL Input signals

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

Table 8: LHMICTRL Output signals

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

3.2.3 Basic part for the LED indication module

3.2.3.1 Function block

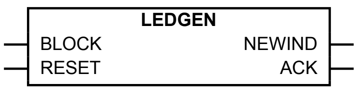

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Figure 10: LEDGEN function block

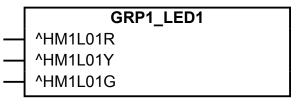

Figure 11: GRP1_LED1 function block

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

3.2.3.2 Functionality

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

Each indication LED on LHMI can be set individually to operate in six different sequences; two as follow type and four as latch type. Two of the latching sequence types are intended to be used as a protection indication system, either in collecting or restarting mode, with reset functionality. The other two are intended to be used as signalling system in collecting mode with acknowledgment functionality.

3.2.3.3 Operation principle

Status LEDs

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

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

Indication LEDs

Operating modes

Collecting mode

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

Re-starting mode

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

Acknowledgment/reset

- From LHMI
    - The active indications can be acknowledged/reset manually. Manual acknowledgment and manual reset have the same meaning and is a common signal for all the operating sequences and LEDs. The function is positive-edge triggered, not level triggered. Acknowledge/reset via the Clear button and menus on the LHMI.
- From function input
    - The active indications can also be acknowledged/reset from an input, ACK_RST, to the function. This input can, for example, be configured to a binary input operated from an external push button. The function is

positive-edge triggered, not level triggered. This means that even if the button is continuously pressed, the acknowledgment/reset only affects indications active at the moment when the button is first pressed.

- Automatic reset
  - Only indications defined for re-starting mode with the latched sequence type 6 (LatchedReset-S)The can be automatically reset. When the LEDs have automatically been reset, still persisting indications are indicated with a steady light.

Operating sequence

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

The figures below show the function of available sequences selectable for each LED separately. For sequence 1 and 2 (Follow type), the acknowledgment/reset function is not applicable. Sequence 3 and 4 (Latched type with acknowledgement) are only 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 restarting mode. The letters S and F in the sequence names have the meaning S = Steady and F = Flash.

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

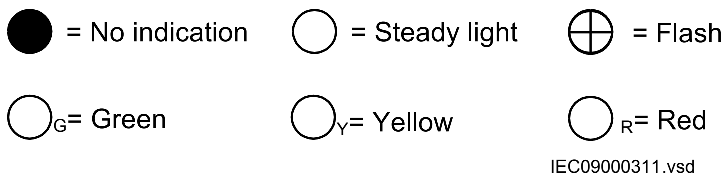

Figure 12: Symbols used in the sequence diagrams

Sequence 1 (Follow-S)

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

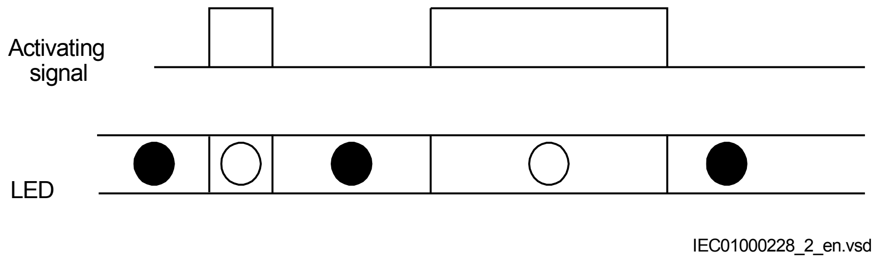

Figure 13: Operating sequence 1 (Follow-S)

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

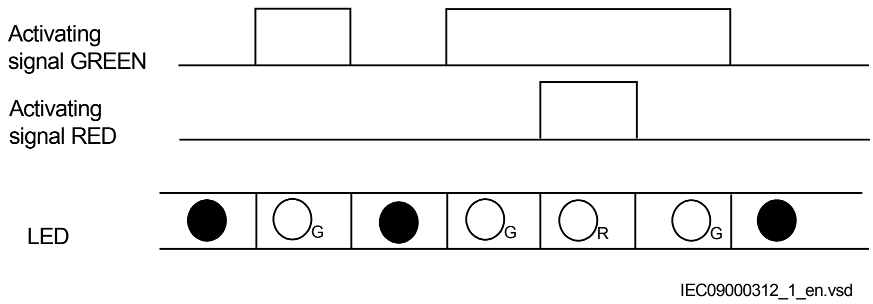

Figure 14: Operating sequence 1, two colors

Sequence 2 (Follow-F)

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

Sequence 3 (LatchedAck-F-S)

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

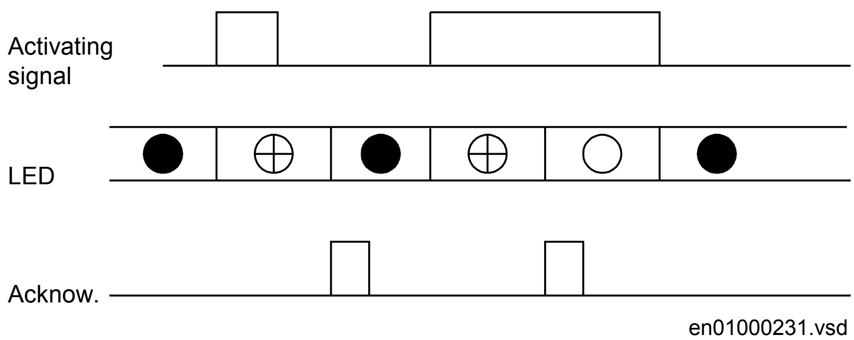

Figure 15: Operating sequence 3 (LatchedAck-F-S)

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

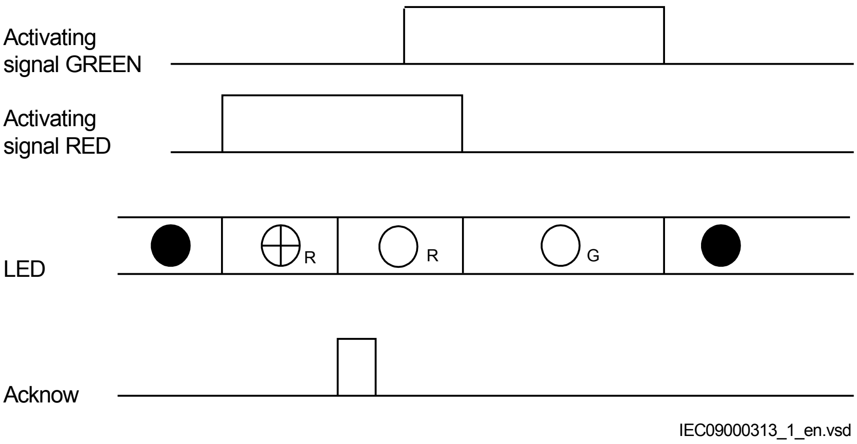

Figure 16: Operating sequence 3, 2 colors involved

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

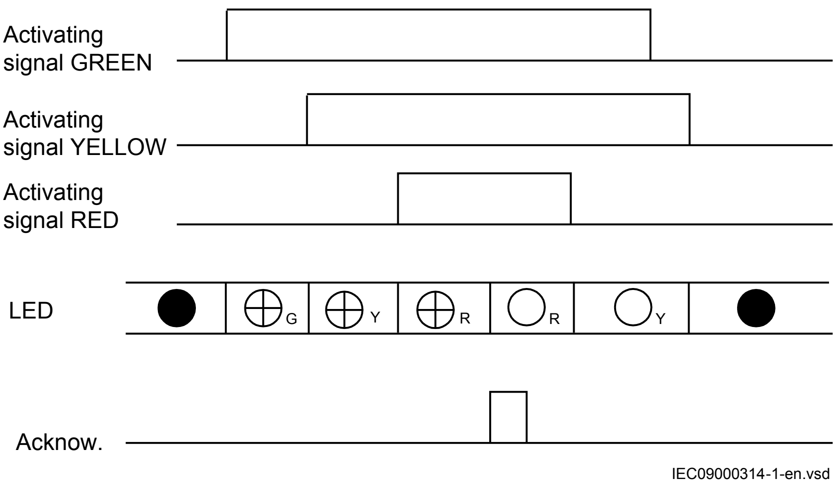

Figure 17: Operating sequence 3, three colors involved, alternative 1

If an indication with higher priority appears after acknowledgment of a lower priority indication the high priority indication is shown as not acknowledged according to Figure 18.

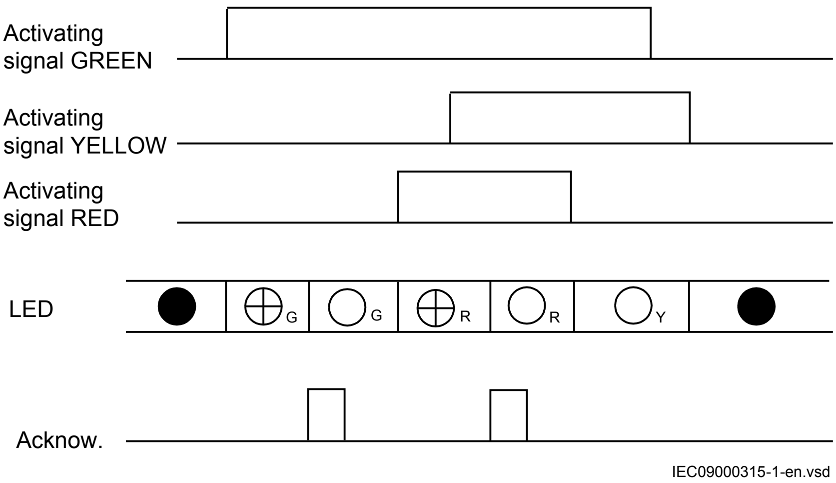

Figure 18: Operating sequence 3, three colors involved, alternative 2

Sequence 4 (LatchedAck-S-F)

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

Sequence 5 (LatchedColl-S)

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

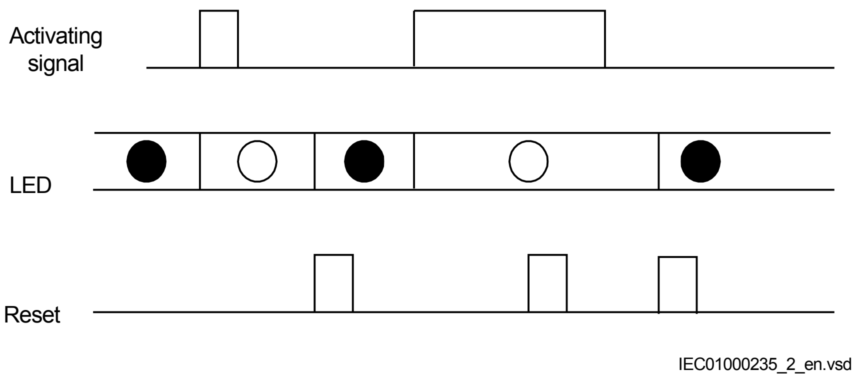

Figure 19: Operating sequence 5 (LatchedColl-S)

That means if an indication with higher priority has reset while an indication with lower priority still is active at the time of reset, the LED changes color according to Figure 20.

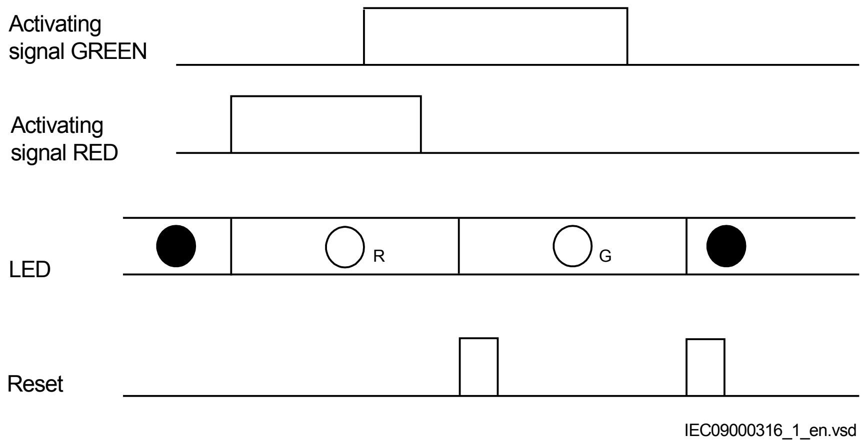

Figure 20: Operating sequence 5, two colors

Sequence 6 (LatchedReset-S)

In this mode all activated LEDs, which are set to sequence 6 (LatchedReset-S), are automatically reset at a new disturbance when activating any input signal for other LEDs set to sequence 6 (LatchedReset-S). Also, in this case indications that are still activated are not 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.

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

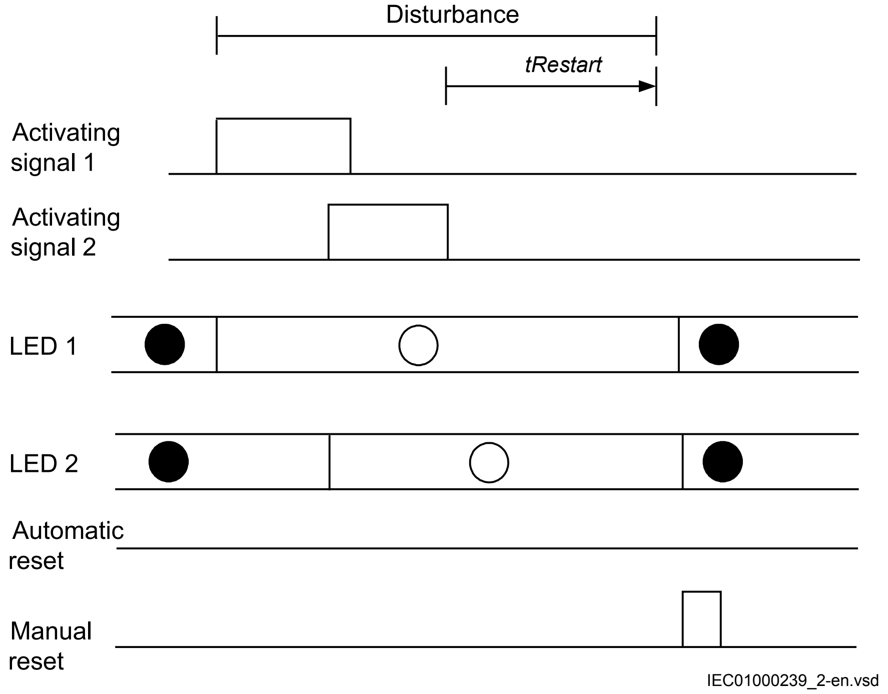

Figure 21: Operating sequence 6 (LatchedReset-S), two indications within same disturbance

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

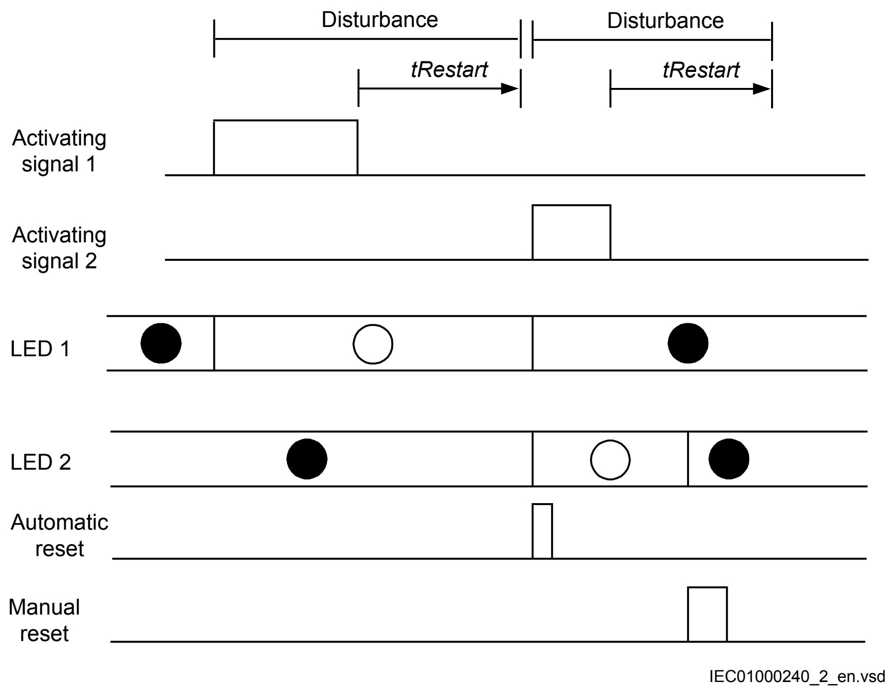

Figure 22: Operating sequence 6 (LatchedReset-S), two different disturbances

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

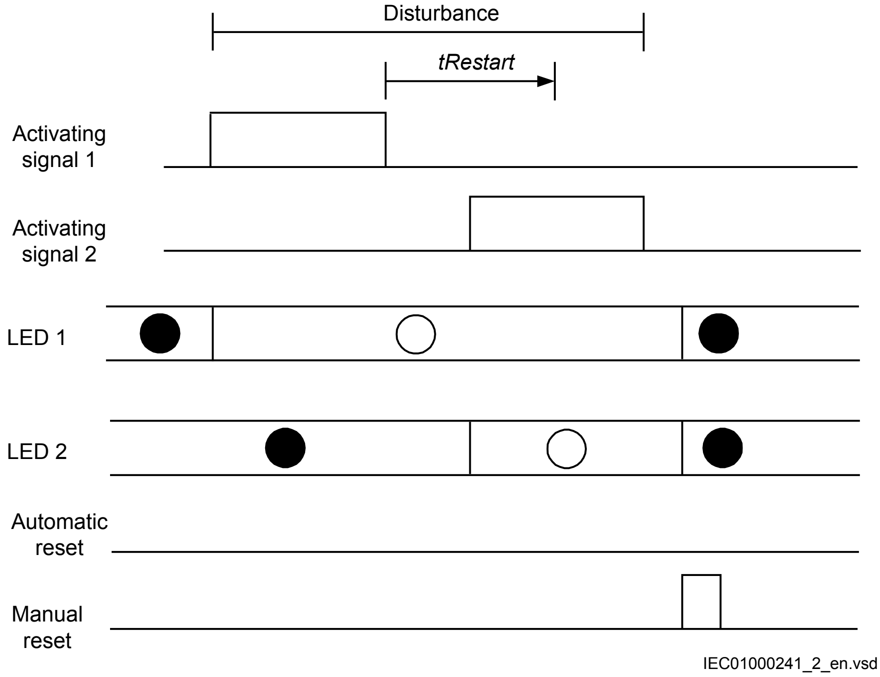

Figure 23: Operating sequence 6 (LatchedReset-S), two indications within same disturbance but with reset of activating signal between

Figure 24 shows the timing diagram for manual reset.

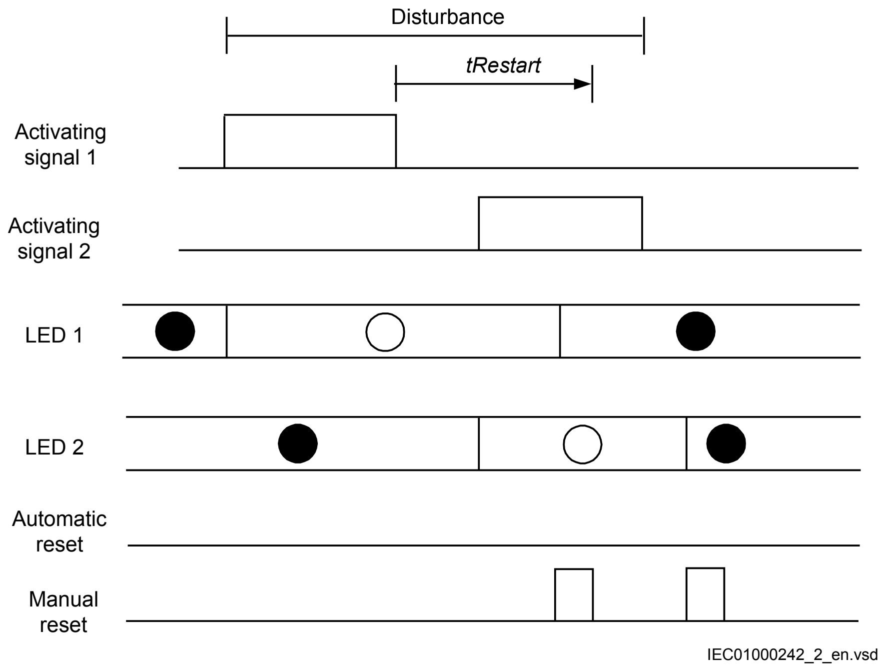

Figure 24: Operating sequence 6 (LatchedReset-S), manual reset

3.2.3.4 Signals

Table 9: 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 10: 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 11: LEDGEN Output signals

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

3.2.3.5 Settings

Table 12: 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 13: GRP1_LED1 Non group settings (basic)

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

3.2.4 Display part for HMI function keys control module

3.2.4.1 Function block

Figure 25: Function block

3.2.4.2 Functionality

LHMI has five function buttons, directly to the left of the display, that can be configured either as menu shortcut or control buttons. Each button has an indication LED that can be configured in the application configuration.

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

3.2.4.3 Operation principle

Each output on the FNKEYMD1 - FNKEYMD5 function blocks can be controlled from the LHMI function keys. By pressing a function button on the LHMI, the output status of the actual function block changes. 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 control the behavior of the function block. These settings and parameters are normally set using the Parameter Setting tool.

Operating sequence

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

Mode 0 (OFF)

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

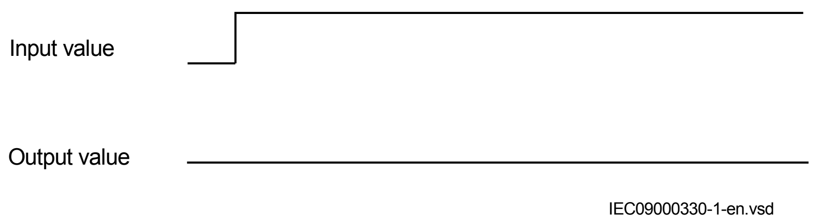

Figure 26: Sequence diagram for Mode 0

Mode 1 (TOGGLE)

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

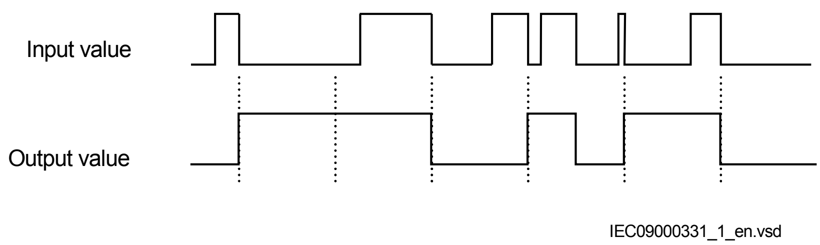

Figure 27: Sequence diagram for Mode 1

Mode 2 (PULSED)

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

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

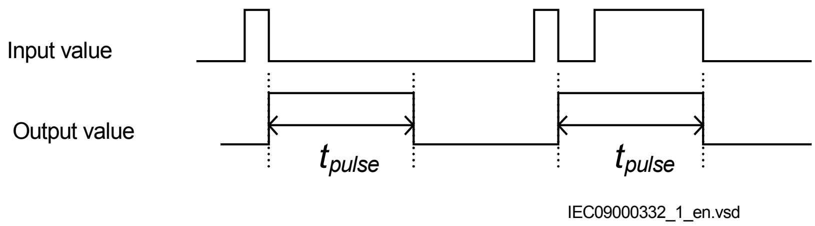

Figure 28: Sequence diagram for Mode 2

Input function

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

3.2.4.4 Signals

Table 14: FNKEYMD1 Input signals

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

Table 15: FNKEYMD1 Output signals

Name	Type	Description
FKEYOUT1	BOOLEAN	Output controlled by function key

3.2.4.5 Settings

Table 16: 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 17: FNKEYTY1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Type	Off Menu shortcut Control	-	-	Off	Function key type
MenuShortcut	Main menu Control Events Measurements Disturbance records Monitoring	-	-	Main menu	

3.3 IED identifiers TERMINALID

3.3.1 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.

3.3.2 Application

3.3.2.1 Customer-specific settings

The customer-specific settings are used to give the IED a unique name and address. The settings are used by a central control system to communicate with the IED. The customer-specific identifiers are found in the LHMI or WHMI in **Configuration/ System**.

The settings can also be made from PCM600.

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

3.3.3 Settings

Table 18: TERMINALID Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
StationName	0 - 18	-	1	Station name	Station name
StationNumber	0 - 99999	-	1	0	Station number
ObjectName	0 - 18	-	1	Object name	Object name
ObjectNumber	0 - 99999	-	1	0	Object number
UnitName	0 - 18	-	1	Unit name	Unit name
UnitNumber	0 - 99999	-	1	0	Unit number
TechnicalKey	0 - 18	-	1	AA0J0Q0A0	Technical key

3.4 Product information

3.4.1 Functionality

The Product identifiers function identifies the IED. The function has seven presets, settings that are unchangeable but important.

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

The settings are visible on the LHMI or WHMI, under **Information/Product identifiers**.

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

3.4.2 Settings

The function does not have any parameters available in LHMI or PCM600.

3.5 Primary system values PRIMVAL

3.5.1 Functionality

The rated system frequency and phasor rotation are set in **Main menu/ Configuration/System** in the LHMI and PCM600.

3.5.2 Application

The rated system frequency is set in **Main menu/Configuration/System** in the LHMI and PCM600.

3.5.3 Settings

Table 19: 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

3.6 Global phase base values BASEPH

3.6.1 Functionality

Almost all the current, voltage and power setting values are given in per unit (p.u.) values. The p.u. values are relational values to certain base values (given in A, kV, kVA). The base values are separate setting parameters for an IED. The base values are set independently of the used measurement device primary ratings. This allows for the settings to be given in relation to the nominal current and voltage values of the protected object, for example, if the measurement devices are oversized and their primary ratings are higher than the nominal values of the protected object.

The phase-to-earth or phase-to-phase base values are defined in BASEPH. The global settings related to BASEPH are located in **Configuration/Analog inputs/Base values/Phase Grp 1…3** in LHMI and **Configuration/Analog inputs/Base values/BASEPH :1…3** in PST.

The BASEPH (Phase Grp) is called phase-to-earth or phase-to-phase base value group.

There are three groups (instances) of BASEPH (Phase Grp). As a default, all the applicable functions in the IED are set to use the same group of the base values. However, in each applicable function there is a selection (Base value Sel phase advanced settings) where one of the three possible groups can be selected individually for the function in question.

For example, all PHxPTOC functions use the first group Base value Sel phase = "Phase Grp 1" as a default but two other groups "Phase Grp 2" are "Phase Grp 3" are possible to select.

3.6.2 Settings

Table 20: BASEPH Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Voltage base Val PP	0.01 - 440.00	kV	0.01	20.00	Voltage base value, phase-to-phase
Current base Val Ph	1 - 9999	A	1	400	Current base value, phase
S base value 3Ph	0.05 - 1800000.00	kVA	0.05	13856.00	Three-phase power base value

3.6.3 The principles for voltage settings given in pu

The voltage base value in BASEPH is the phase-to-phase voltage. This means that in voltage settings related to phase-to-phase voltage, 1.0 p.u. corresponds to 20.00 kV (assuming the default value for the Voltage base Val PP setting). An example of this kind of setting is DSTPDIS PP V Ph Sel GFC (the default value 0.8 pu corresponds to 0.8 x 20 kV = 16 kV).

For the voltage settings that are related to the phase-to-earth voltage, the functions contain internal scaling factor (0.5774). Therefore for the voltage settings related to the phase-to-earth voltage, 1.0 results in a nominal phase-to-earth voltage of 11.55 kV, assuming the default value 20.00 kV for the Voltage base Val PP setting. An example of this kind of setting is PSPTOV Start value (the default value 1.1 pu corresponds to 1.1 x 0.5774 x 20 kV ≈12.7 kV).

There are few functions for which the internal scaling is not done. In these functions it can be selected whether phase-to-phase voltages or phase-to-earth voltages are used, for example, the Voltage selection setting in PHPTOV. This also means that the voltage settings in these functions can be either related to the phase-to-phase voltage or to the phase-to-earth voltage depending on the selection. In functions, for example, PHPTOV, PHPTUV and SYNCRSYN, 1.0 p.u. corresponds to 20.00 kV, assuming the default value for the Voltage base Val PP setting regardless of the voltages used in the functions. If the Voltage selection setting in PHPTOV is set to “phase-to-earth” ("1"), a value of 0.64 p.u. for Start value results in 12.8 kV (≈1.1 x 11.55 kV)

3.7 Parameter setting group handling

3.7.1 Functionality

The different groups of settings are used to optimize the IED operation for different system conditions. By creating and switching between fine-tuned setting sets, either from the LHMI or configurable binary inputs, results in a highly adaptable IED that can cope with a variety of system scenarios.

3.7.2 Setting group handling SETGRPS

3.7.2.1 Settings

Table 21: 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

3.7.3 Parameter setting groups ACTVGRP

3.7.3.1 Function block

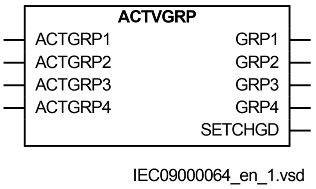

Figure 29: Function block

3.7.3.2 Signals

Table 22: 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 23: 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

3.7.3.3 Settings

The function does not have any parameters available in LHMI or PCM600.

3.7.4 Operation principle

Parameter setting groups (ACTVGRP) function has four functional inputs, each corresponding to one of the setting groups stored in the IED. Activation of any of these inputs changes the active setting group. Five functional output signals are available for configuration purposes.

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

Each input of the function block can be configured with PCM600 to connect to any of the binary inputs in the IED.

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

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

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

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

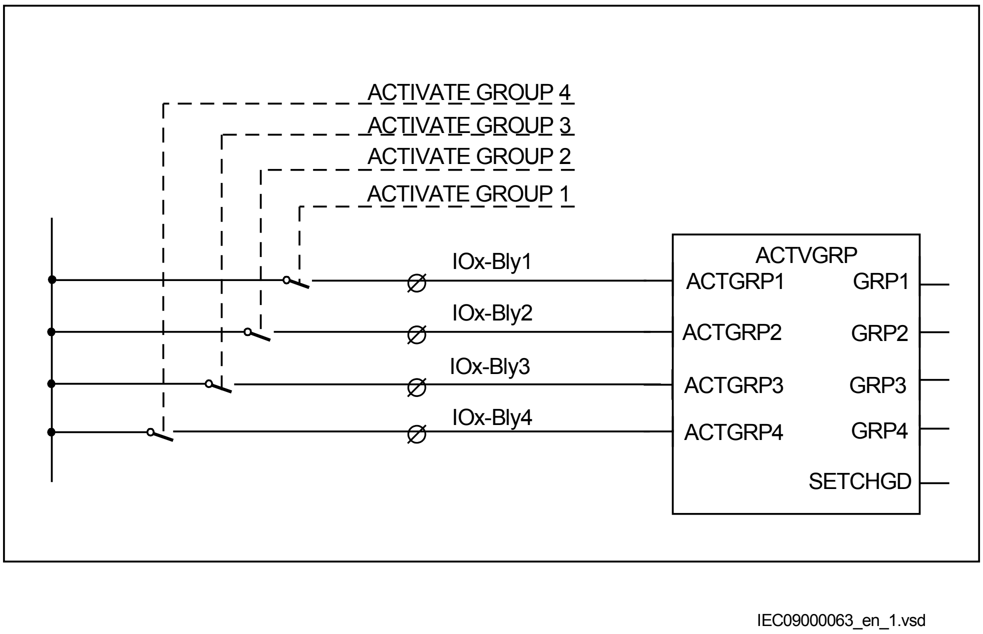

Figure 30: Connection of the function to external circuits

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

3.7.5 Application

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

Different conditions in networks with different voltage levels require highly adaptable protection and control units to best provide for dependability, security and selectivity requirements. Protection units operate with a higher degree of availability, especially, if the setting values of their parameters are continuously optimized according to the conditions in the power system.

Operational departments can plan for different operating conditions in the primary equipment. The protection engineer can prepare the necessary optimized and pre-tested settings in advance for different protection functions. Four different groups of setting parameters are available in the IED. Any of them can be activated through the different programmable binary inputs by external or internal control signals.

3.8 Signal matrix for analog inputs SMAI

3.8.1 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 used by the respective functions in Application Configuration, for example, protection, measurement or monitoring.

The SMAI function is used within PCM600 in direct relation with the Signal Matrix or the Application Configuration tools.

3.8.2 Signal matrix for analog inputs SMAI_20_1

3.8.2.1 Function block

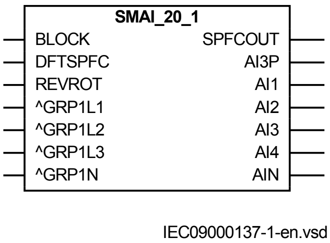

Figure 31: SMAI_20_1 function block

3.8.2.2 Signals

Table 24: SMAI_20_1 Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block group 1
DFTSPFC	REAL	20.0	Number of samples per fundamental cycle used for DFT calculation
REVROT	BOOLEAN	0	Reverse rotation group 1
GRP1L1	STRING	-	First analog input used for phase L1 or L1-L2 quantity
GRP1L2	STRING	-	Second analog input used for phase L2 or L2-L3 quantity
GRP1L3	STRING	-	Third analog input used for phase L3 or L3-L1 quantity
GRP1N	STRING	-	Fourth analog input used for residual or neutral quantity

Table 25: SMAI_20_1 Output signals

Name	Type	Description
SPFCOUT	REAL	Number of samples per fundamental cycle from internal DFT reference function
AI3P	GROUP SIGNAL	Grouped three phase signal containing data from inputs 1-4
AI1	GROUP SIGNAL	Quantity connected to the first analog input
AI2	GROUP SIGNAL	Quantity connected to the second analog input
AI3	GROUP SIGNAL	Quantity connected to the third analog input
AI4	GROUP SIGNAL	Quantity connected to the fourth analog input
AIN	GROUP SIGNAL	Calculated residual quantity if inputs 1-3 are connected

3.8.2.3 Settings

Only values 1-3 of the parameter *GlobalBaseSel* should normally be used. The values 1-3 refer to the global base value groups Phase Grp 1, Phase Grp 2 and Phase Grp 3 correspondingly (BASEPH1, BASEPH2 and BASEPH3 in PCM600). The selection affects the actual limit for frequency calculation set by *MinValFreqMeas* which by default is 10% of the *Voltage base Val PP* in the selected group. The values 4-6 refer to Residual Grp 1, Residual Grp 2 and Residual Grp 3 (BASERES1, BASERES2 and BASERES3 in PCM600) correspondingly and they are typically not to be used in this connection.

Table 26: SMAI_20_1 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups
DFTRefExtOut	InternalDFTRef DFTRefGrp1 DFTRefGrp2 DFTRefGrp3 DFTRefGrp4 DFTRefGrp5 DFTRefGrp6 DFTRefGrp7 DFTRefGrp8 DFTRefGrp9 DFTRefGrp10 DFTRefGrp11 DFTRefGrp12 External DFT ref	-	-	InternalDFTRef	DFT reference for external output
DFTReference	InternalDFTRef DFTRefGrp1 DFTRefGrp2 DFTRefGrp3 DFTRefGrp4 DFTRefGrp5 DFTRefGrp6 DFTRefGrp7 DFTRefGrp8 DFTRefGrp9 DFTRefGrp10 DFTRefGrp11 DFTRefGrp12 External DFT ref	-	-	InternalDFTRef	DFT reference
ConnectionType	Ph-N Ph-Ph	-	-	Ph-N	Input connection type
AnalogInputType	Voltage Current	-	-	Voltage	Analog input signal type

Table 27: SMAI_20_1 Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Negation	Off NegateN Negate3Ph Negate3Ph+N	-	-	Off	Negation
MinValFreqMeas	5 - 200	%	1	10	

Even if the *AnalogInputType* setting of a SMAI block is set to *Current*, the *MinValFreqMeas* setting is still visible. This means that the minimum level for current amplitude is based on *Voltage base Val PP*. For example, if *Voltage base Val PP* is 20000, the minimum amplitude for current is 20000 * 10% = 2000. This has practical affect only if the current measuring SMAI is used as a frequency reference for the adaptive DFT. This is not recommended, see the Setting guidelines.

3.8.3 Signal matrix for analog inputs SMAI_20_2

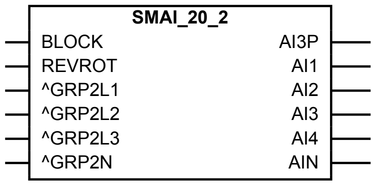

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Figure 32: SMAI_20_2 to SMAI_20_12 function block

Note that input and output signals on SMAI_20_2 to SMAI_20_12 are the same except for input signals GRPxL1 to GRPxN where x is equal to instance number (2 to 12).

3.8.3.1 Signals

Table 28: SMAI_20_2 Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block group 2
REVROT	BOOLEAN	0	Reverse rotation group 2
GRP2L1	STRING	-	First analog input used for phase L1 or L1-L2 quantity
GRP2L2	STRING	-	Second analog input used for phase L2 or L2-L3 quantity
GRP2L3	STRING	-	Third analog input used for phase L3 or L3-L1 quantity
GRP2N	STRING	-	Fourth analog input used for residual or neutral quantity

Table 29: SMAI_20_2 Output signals

Name	Type	Description
AI3P	GROUP SIGNAL	Grouped three phase signal containing data from inputs 1-4
AI1	GROUP SIGNAL	Quantity connected to the first analog input
AI2	GROUP SIGNAL	Quantity connected to the second analog input
AI3	GROUP SIGNAL	Quantity connected to the third analog input
AI4	GROUP SIGNAL	Quantity connected to the fourth analog input
AIN	GROUP SIGNAL	Calculated residual quantity if inputs 1-3 are connected

3.8.3.2 Settings

Only values 1-3 of the parameter *GlobalBaseSel* should normally be used. The values 1-3 refer to the global base value groups Phase Grp 1, Phase Grp 2 and Phase Grp 3 correspondingly (BASEPH1, BASEPH2 and BASEPH3 in PCM600). The selection affects the actual limit for frequency calculation set by *MinValFreqMeas* which by default is 10% of the *Voltage base Val PP* in the selected group. The values 4-6 refer to Residual Grp 1, Residual Grp 2 and Residual Grp 3 (BASERES1, BASERES2 and BASERES3 in PCM600) correspondingly and they are typically not to be used in this connection.

Table 30: SMAI_20_2 Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GlobalBaseSel	1 - 6	-	1	1	Selection of one of the Global Base Value groups
DFTReference	InternalDFTRef DFTRefGrp1 DFTRefGrp2 DFTRefGrp3 DFTRefGrp4 DFTRefGrp5 DFTRefGrp6 DFTRefGrp7 DFTRefGrp8 DFTRefGrp9 DFTRefGrp10 DFTRefGrp11 DFTRefGrp12 External DFT ref	-	-	InternalDFTRef	DFT reference
ConnectionType	Ph-N Ph-Ph	-	-	Ph-N	Input connection type
AnalogInputType	Voltage Current	-	-	Voltage	Analog input signal type

Table 31: SMAI_20_2 Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Negation	Off NegateN Negate3Ph Negate3Ph+N	-	-	Off	Negation
MinValFreqMeas	5 - 200	%	1	10	

Even if the *AnalogInputType* setting of a SMAI block is set to *Current*, the *MinValFreqMeas* setting is still visible. This means that the minimum level for current amplitude is based on *Voltage base Val PP*. For example, if *Voltage base Val PP* is 20000, the minimum amplitude for current is 20000 * 10% = 2000. This has practical affect only if the current measuring SMAI is used as a frequency reference for the adaptive DFT. This is not recommended, see the Setting guidelines.

3.8.4 Application

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 used by the respective functions in Application Configuration, for example, protection, measurement or monitoring.

The SMAI function is used within PCM600 in direct relation with the Signal Matrix or the Application Configuration tools.

3.8.5 Operation principle

Every Signal matrix for analog inputs function (SMAI) can receive four analog signals (three phases and one neutral value), either voltage or current, see Figure 31 and Figure 32. SMAI outputs give information about every aspect of the 3ph analog signals acquired (phase angle, RMS value, frequency and frequency derivates etc. – 244 values in total). The BLOCK input will reset all outputs to 0.

The output signals AI1 to AI4 in SMAI_20_x function block are direct outputs of the, in SMT or ACT, connected input group signals to GRPxL1, GRPxL2, GRPxL3 and GRPxN, x=1-12. GRPxN is always the neutral current. If GRPxN is not connected, the AI4 output is all zero. The AIN output is the calculated residual sum of inputs GRPxL1, GRPxL2 and GRPxL3 and is equal to output AI4 if all inputs, including GRPxN, are connected. Note that function block will always calculate the residual sum of current/voltage if the input is not connected in SMT or ACT. Applications with a few exceptions shall always be connected to AI3P.

Value group 1 to 3 for setting *GlobalBaseSel* refers to phase and phase-to-phase global base value function instances. Value group 4 to 6 refer to residual global base value function instances and are not intended for most applications.

More detailed explanation of some of the settings and example of using frequency adaptive DFT.

DFTRefExtOut: Parameter valid for function block SMAI_20_1:1, SMAI_20_1:2 and SMAI_80_1 only. Reference block for external output (SPFCOUT function output).

DFTReference: Reference DFT for the block.

These DFT reference block settings decide DFT reference for DFT calculations (*InternalDFTRef* will use fixed DFT reference based on set system frequency. *DFTRefGrpn* will use DFT reference from the selected group block, when own group selected adaptive DFT reference will be used based on calculated signal frequency from own group.*ExternalDFTRef* will use reference based on input DFTSPFC.

MinValFreqMeas: The minimum value of the voltage for which the frequency is calculated, expressed as percent of "Voltage base Val PP" (of the selected BASEPH group).

Settings *DFTRefExtOut* and *DFTReference* shall be set to default value "InternalDFTRef" if no VT inputs are available. If, however, it is necessary to use frequency adaptive DFT (*DFTReference* set to other than default, refering current measuring SMAI) when no voltages are available, one must note that the MinValFreqMeas setting is still set in reference to "Voltage base Val PP" (of the selected BASEPH group). This means that the minimum level for current amplitude is based on Voltage base Val PP. For example, if Voltage base Val PP is 20000, the resulting minimum amplitude for current is 20000 * 10% = 2000.

Example of adaptive frequency tracking

Task time group 1	
SMAI instance	**3 phase group**
SMAI_20_1:1	1
SMAI_20_2:1	2
SMAI_20_3:1	3
SMAI_20_4:1	4
SMAI_20_5:1	5
SMAI_20_6:1	6
SMAI_20_7:1	7
SMAI_20_8:1	8
SMAI_20_9:1	9
SMAI_20_10:1	10
SMAI_20_11:1	11
SMAI_20_12:1	12

DFTRefGrp7

Task time group 2	
SMAI instance	**3 phase group**
SMAI_20_1:2	1
SMAI_20_2:2	2
SMAI_20_3:2	3
SMAI_20_4:2	4
SMAI_20_5:2	5
SMAI_20_6:2	6
SMAI_20_7:2	7
SMAI_20_8:2	8
SMAI_20_9:2	9
SMAI_20_10:2	10
SMAI_20_11:2	11
SMAI_20_12:2	12

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Figure 33: SMAI instances as organized in different task time groups and the corresponding parameter numbers

The example shows a situation with adaptive frequency tracking with one reference selected for all instances. In practice each instance can be adapted to the needs of the actual application.

Example 1

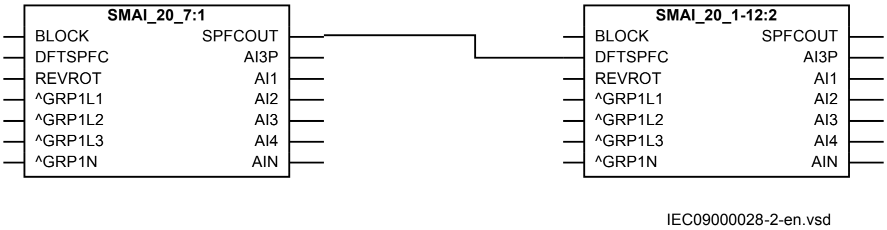

Figure 34: Configuration for using an instance in task time group 1 as DFT reference

Assume instance SMAI_20_7:1 in task time group 1 has been selected in the configuration to control the frequency tracking (For the SMAI_20_x task time groups). Observe that the selected reference instance must be a voltage type.

For task time group 1 this gives the following settings:

SMAI_20_7:1: *DFTRefExtOut* = *DFTRefGrp7* to route SMAI_20_7:1 reference to the SPFCOUT output, *DFTReference* = *DFTRefGrp7* for SMAI_20_7:1 to use SMAI_20_7:1 as reference.

SMAI_20_2:1 - SMAI_20_12:1 *DFTReference* = *DFTRefGrp7* for SMAI_20_2:1 - SMAI_20_12:1 to use SMAI_20_7:1 as reference.

For task time group 2 this gives the following settings:

SMAI_20_1:2 - SMAI_20_12:2 *DFTReference* = *ExternalDFTRef* to use DFTSPFC input as reference (SMAI_20_7:1)

3.9 Measured value expander block MVEXP

3.9.1 Function block

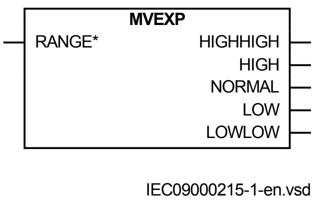

Figure 35: Function block

3.9.2 Functionality

The current and voltage measurements functions (CMMXU, RESCMMXU, RESVMMXU, VPHMMXU, VPPMMXU and PWRMMXU), current and voltage sequence measurement functions (CSMSQI and VSMSQI) and IEC 61850 generic communication I/O functions (MVGGIO) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block has been introduced to enable translating the integer output signal from the measuring functions to five binary signals: below low-low limit, below low limit, normal, above high-high limit or above high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

3.9.3 Operation principle

The input signal must be connected to a range output of a measuring function block (CMMXU, RESCMMXU, RESVMMXU, VPHMMXU, VPPMMXU, PWRMMXU, CSMSQI, VSMSQI or MVGGIO). The function block converts the input integer value to five binary output signals.

Table 32: Input integer value converted to binary output signals

Output	Measured supervised value				
	below low-low limit	between low-low and low limit	between low and high limit	between high-high and high limit	above high-high limit
LOWLOW	High				
LOW		High			
NORMAL			High		
HIGH				High	
HIGHHIGH					High

3.9.4 Application

The current and voltage measurement functions (CMMXU, RESCMMXU, RESVMMXU, VPHMMXU, VPPMMXU and PWRMMXU), current and voltage sequence measurement functions (CSMSQI and VSMSQI) and IEC 61850 generic communication I/O functions (MVGGIO) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block (MVEXP) has been introduced to enable translating the integer output signal from the measuring functions to five binary signals: below low-low limit, below low limit, normal, above high-high limit or above high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

3.9.5 Signals

Table 33: MVEXP Input signals

Name	Type	Default	Description
RANGE	INTEGER	0	Measured value range

Table 34: 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

3.9.6 Settings

The function does not have any parameters available in LHMI or PCM600.

3.10 Pulse counter PCGGIO

3.10.1 Function block

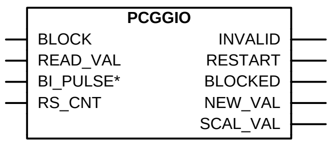

Figure 36: Function block

3.10.2 Functionality

Pulse counter (PCGGIO) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the BIO (binary input/output) module and read by the PCGGIO function. A scaled service value is available over the station bus.

3.10.3 Operation principle

The registration of pulses is done according to setting of *CountCriteria* parameter on one of the 9 binary input channels located on the BIO module. Pulse counter values are sent to the station HMI with predefined cyclicity without reset.

The reporting time period can be set in the range from 1 second to 60 minutes and is synchronized with absolute system time. Interrogation of additional pulse counter values can be done with a command (intermediate reading) for a single counter. All active counters can also be read by IEC 61850.

Pulse counter (PCGGIO) function in the IED supports unidirectional incremental counters. That means only positive values are possible. The counter uses a 32 bit format, that is, the reported value is a 32-bit, signed integer with a range 0...+2147483647. The counter value is stored in semiretain memory.

The reported value to station HMI over the station bus contains Identity, Scaled Value (pulse count x scale), Time, and Pulse Counter Quality. The Pulse Counter Quality has four options.

- Invalid (board hardware error or configuration error)
- Wrapped around
- Blocked
- Adjusted

The transmission of the counter value can be done as a service value, that is, the value frozen in the last integration cycle is read by the station HMI from the database. PCGGIO updates the value in the database when an integration cycle is finished and activates the NEW_VAL signal in the function block. This signal can be time tagged, and transmitted to the station HMI. This time corresponds to the time when the value was frozen by the function.

The BLOCK and READ_VAL inputs can be connected to blocks, which are intended to be controlled either from the station HMI or/and the LHMI. As long as the BLOCK signal is set, the pulse counter is blocked. The signal connected to READ_VAL performs readings according to the setting of parameter *CountCriteria*. The signal must be a pulse with a length >1 second.

The BI_PULSE input is connected to the used input of the function block for the binary input output module (BIO).

The RS_CNT input is used for resetting the counter.

Each PCGGIO function block has four binary output signals that can be used for event recording: INVALID, RESTART, BLOCKED and NEW_VAL. These signals and the SCAL_VAL signal are accessable over IEC 61850.

The INVALID signal is a steady signal and is set if the binary input module, where the pulse counter input is located, fails or has wrong configuration.

The RESTART signal is a steady signal and is set when the reported value does not comprise a complete integration cycle. That is, in the first message after IED start-up, in the first message after deblocking, and after the counter has wrapped around during last integration cycle.

The BLOCKED signal is a steady signal and is set when the counter is blocked. There are two reasons why the counter is blocked.

- The BLOCK input is set
- The binary input module, where the counter input is situated, is inoperative

The NEW_VAL signal is a pulse signal. The signal is set if the counter value was updated since last report.

The SCAL_VAL signal consists of scaled value (according to parameter *Scale*), time and status information.

3.10.4 Application

Pulse counter (PCGGIO) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the binary input module (BIO), and read by the PCGGIO function. The number of pulses in the counter is reported via the station bus to the substation automation system or read via the station monitoring system as a service value. When using IEC 61850-8-1, a scaled service value is available over the station bus.

The normal use for this function is the counting of energy pulses from external energy meters. An optional number of inputs from the binary input module in IED can be used for this purpose with a frequency of up to 35 Hz. PCGGIO can also be used as a general purpose counter.

3.10.5 Signals

Table 35: PCGGIO Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function
READ_VAL	BOOLEAN	0	Initiates an additional pulse counter reading
BI_PULSE	BOOLEAN	0	Connect binary input channel for metering
RS_CNT	BOOLEAN	0	Resets pulse counter value

Table 36: PCGGIO Output signals

Name	Type	Description
INVALID	BOOLEAN	The pulse counter value is invalid
RESTART	BOOLEAN	The reported value does not comprise a complete integration cycle
BLOCKED	BOOLEAN	The pulse counter function is blocked
NEW_VAL	BOOLEAN	A new pulse counter value is generated
SCAL_VAL	REAL	Scaled value with time and status information

3.10.6 Settings

Table 37: PCGGIO Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
EventMask	NoEvents ReportEvents	-	-	NoEvents	Report mask for analog events from pulse counter
CountCriteria	Off RisingEdge Falling edge OnChange	-	-	RisingEdge	Pulse counter criteria
Scale	1.000 - 90000.000	-	0.001	1.000	Scaling value for SCAL_VAL output to unit per counted value
Quantity	Count ActivePower ApparentPower ReactivePower ActiveEnergy ApparentEnergy ReactiveEnergy	-	-	Count	Measured quantity for SCAL_VAL output
tReporting	1 - 3600	s	1	60	Cycle time for reporting of counter value

3.10.7 Measured values

Table 38: PCGGIO Measured values

Name	Type	Default	Description
ResetCounter	BOOLEAN	0	Resets pulse counter value from LHMI

3.10.8 Monitored data

Table 39: PCGGIO Monitored data

Name	Type	Values (Range)	Unit	Description
CNT_VAL	INTEGER	-	-	Actual pulse counter value
SCAL_VAL	REAL	-	-	Scaled value with time and status information

3.10.9 Technical data

Table 40: Pulse counter PCGGIO technical data

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

3.11 Fixed signals FXDSIGN

3.11.1 Function block

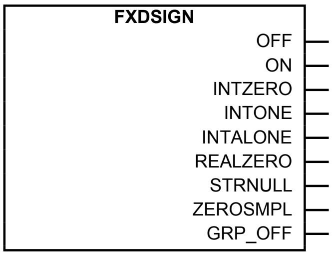

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Figure 37: Function block

3.11.2 Functionality

The Fixed signals function (FXDSIGN) generates a number of pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/value, or for creating certain logic.

3.11.3 Operation principle

The FXDSIGN function block has nine outputs.

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

3.11.4 Application

The Fixed signals function (FXDSIGN) generates a number of pre-set (fixed) signals that can be used in the configuration of an IED, either for forcing the unused inputs in other function blocks to a certain level/value, or for creating certain logic.

3.11.5 Signals

Table 41: 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

3.11.6 Settings

The function does not have any parameters available in LHMI or PCM600.

3.12 Event counter CNTGGIO

3.12.1 Function block

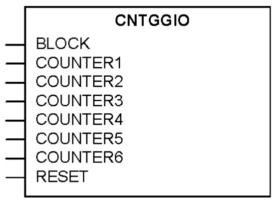

Figure 38: Function block

3.12.2 Functionality

The event counter function CNTGGIO consists of six counters which are used for storing the number of times each counter has been activated. It is also provided with a common blocking function for all six counters to be used, for example, at testing. Each counter can be set to "On" or "Off" separately with a parameter setting.

3.12.3 Operation principle

The event counter function has six inputs for increasing the counter values for each of the six counters respectively. The content of the counters is increased by one step for each positive edge of the input respectively. The maximum count-up speed is 10 pulses per second. The maximum counter value is 10000. The counter stops at 10000 and no restart takes places, even if the count exceeds 10000.

A mechanism for limiting the number of writings per time period is included in the product to avoid the risk of the flash memory becoming worn out due to too many writings. As a result, it can take a long time, up to one hour, before a new value is stored in the flash memory. If a new CNTGGIO value is not stored before auxiliary power interruption, it is lost. The CNTGGIO-stored values in the flash memory are, however, not lost at an auxiliary power interruption.

The function block also has an input `BLOCK`. The activation of the `BLOCK` input blocks all six counters. The inputs can be used for blocking the counters at testing, for example.

All inputs are configured via PCM600.

3.12.3.1 Reporting

The content of the counters can be read in the LHMI.

Reset of counters can be performed in the LHMI and with a binary input.

Reading of the content and resetting of the counters can also be performed remotely with PCM600 or, for example, MicroSCADA.

3.12.4 Technical data

Table 42: CNTGGIO Technical data

Function	Range or value	Accuracy
Counter value	0-10000	-
Maximum count up speed	10 pulses/second	-

3.13 Test mode functionality TESTMODE

3.13.1 Function block

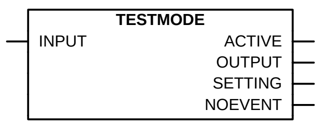

Figure 39: Function block

3.13.2 Functionality

When the Test mode functionality TESTMODE is activated, all the protection functions in the IED are automatically blocked. It is then possible to unblock every function(s) individually from the LHMI to perform the 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 remains in TESTMODE with the same protection functions blocked or unblocked as before the power was removed. All testing is done with the actually set and configured values within the IED. No settings are changed to avoid mistakes.

3.13.3 Operation principle

IED functions can be tested in test mode. The IED can be set to test mode either by activating the input `SIGNAL` on the function block TESTMODE, or setting *TestMode* to "On" in the LHMI.

When the IED is in test mode, the `ACTIVE` of the function block TESTMODE is activated. The outputs of the function block TESTMODE show the cause of the *Test mode* is set to "On" state, that is, input from configuration (`OUTPUT` output is activated) or setting from LHMI (`SETTING` output is activated).

When the IED is in test mode, the yellow STARTLED flashes 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 IED functions can be individually blocked by local HMI settings. To enable blockings, the IED must be in test mode (output `ACTIVE` is activated). When leaving the test mode and entering the normal mode, the blockings are disabled and everything is set to normal operation. In the test mode, all testing can be done with the actually set and configured values within the IED. If any setting values are changed during the testing, they should be changed back to original values before entering the normal mode.

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

The blocking of a function concerns all the output signals from the actual function, so no outputs are 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 re-enters test mode and all functions are blocked, also the functions that were unblocked before the change. During the re-entering to test mode, all functions are temporarily unblocked for a short time, which may lead to unwanted operations. This is only valid if the IED is put in TEST mode by a binary input, not by LHMI.

The TESTMODE function block can 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 maintenance test.

3.13.4 Application

The protection and control IEDs may have a complex configuration with many included functions. To make the testing procedure easier, the IEDs include the feature that allows individual blocking of a single-, several-, or all functions.

This means that it is possible to see when a function is activated or trips. It also enables the user to follow the operation of several related functions to check correct functionality and to check parts of the configuration, and so on.

3.13.5 Signals

Table 43: TESTMODE Input signals

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

Table 44: 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

3.13.6 Settings

Table 45: 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

3.14 Disturbance record DRRDRE

3.14.1 Disturbance report DRRDRE

3.14.1.1 Function block

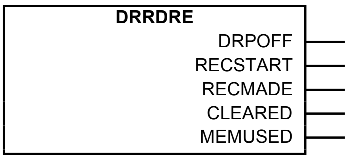

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Figure 40: Function block

3.14.1.2 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 DRRDRE, 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 64 binary signals.

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

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

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

A disturbance is defined as an activation of an input to the AxRADR or BxRBDR function blocks, which are set to trigger the disturbance recorder. All signals from start of pre-fault time to the end of post-fault time are included in the recording.

Every disturbance report recording is saved in the IED in the standard Comtrade format. The same applies to all events, which are continuously saved in a ring-buffer. The LHMI 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.

3.14.1.3 Operation principle

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

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

Figure 41 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 DRRDRE acquires information from both AxRADR and BxRBDR.

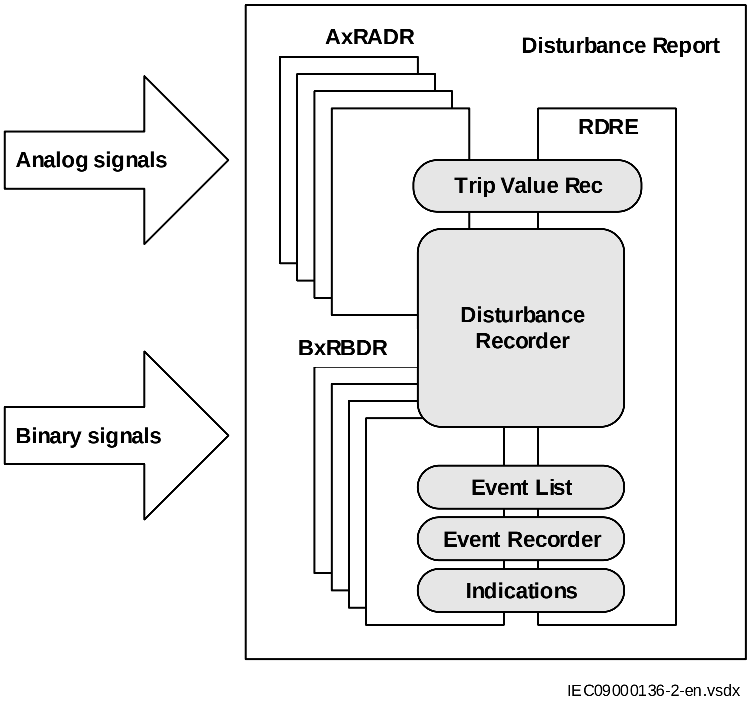

Figure 41: Disturbance report functions and related function blocks

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 gets an identification number in the interval from 0-999.

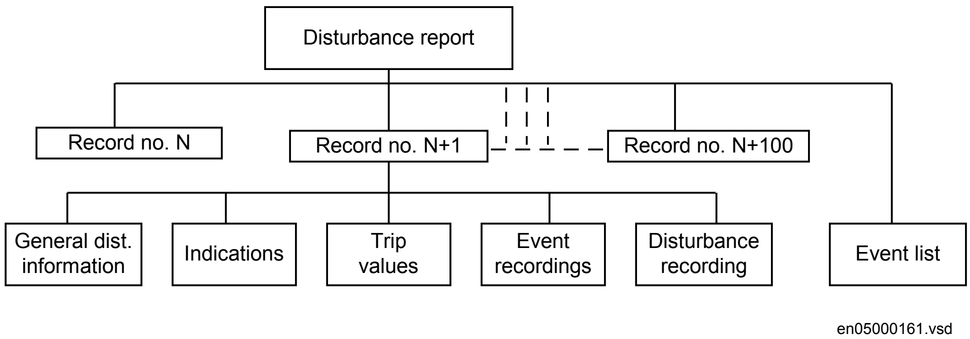

Figure 42: Disturbance report structure

Up to 100 disturbance reports can be stored. If a new disturbance is to be recorded when the memory is full, the oldest disturbance report is overwritten by the new one. The total recording capacity for the disturbance recorder is depending of sampling frequency, number of analog and binary channels and recording time. In a 50 Hz system it is possible to record 100 where the maximum recording time is 3.4 seconds. The memory limit does not affect the rest of the disturbance report (Event list, Event recorder, Indications and Trip value recorder).

The maximum number of recordings depend on each recordings total recording time. Long recording time reduces the number of recordings to less than 100.

Disturbance information

Date and time of the disturbance, the indications, events, fault location and the trip values are available on the LHMI.

To acquire a complete disturbance report, use a PC and either the PCM600 Disturbance Handling tool or MMS (over 61850) client. The PC can be connected to IED front port, or remotely via a station bus.

Indications

Indications is a list of signals that are activated during the total recording time of the disturbance (not time-tagged). See the section about indications for detailed information.

Event recorder

The event recorder can contain a list of up to 150 time-tagged events which have occurred during a disturbance. The information is available via the LHMI or PCM600. See the event recorder section for detailed information.

Event list

The event list may contain a list of totally 1000 time-tagged events. The list information is continuously updated when the selected binary signals change state. The oldest data is overwritten. The logged signals can be presented via LHMI, WHMI or PCM600. See the event list section for detailed information.

Trip value recorder

The recorded trip values include the phasors of the selected analog signals before the fault and during the fault. See the trip value recorder section for detailed information.

Disturbance recorder

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

Time tagging

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

Recording times

Disturbance report DRRDRE records information about a disturbance during a settable time frame. The recording times are valid for the whole disturbance report.

Disturbance recorder, event recorder and indication function register disturbance data and events during tRecording, the total recording time.

The total recording time, tRecording, of a recorded disturbance is:

tRecording = *Pre-trigger time* + tFault + *Post-trigger time* or *Pre-trigger time* + *Recording time limit*, depending on which criterion stops the current disturbance recording

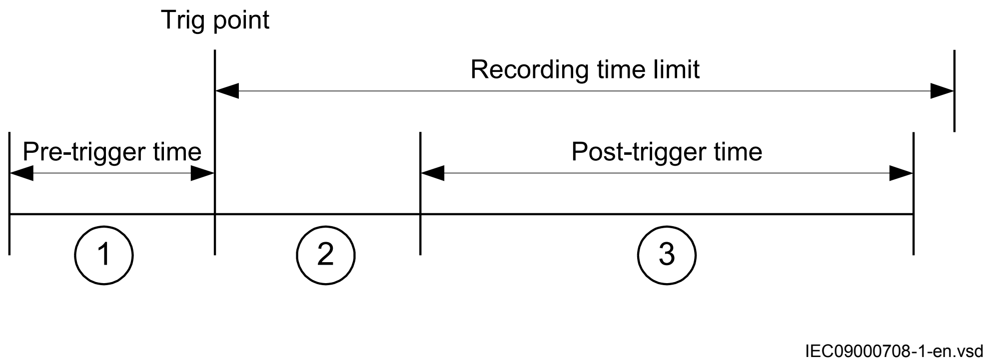

Figure 43: Recording times definition

Pre-trigger time, 1	Pre-trigger recording time. The time before the fault including the operate time of the trigger. Use the setting *Pre-trigger time* 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 *Recording time limit* the limit time).
Post-trigger time, 3	Post fault recording time. The time the disturbance recording continues after all activated triggers are reset. Use the setting *Post-trigger time* to set this time.
Recording time limit	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 *Recording time limit* to set this time.

Analog signals

Up to 40 analog signals can be selected for recording by the disturbance recorder and triggering of the disturbance report function. Of those signals, 20 are reserved for external analog signals from analog input modules via preprocessing function blocks (SMAI). The last 20 channels can be connected to internally calculated analog signals available as function block output signals (phase differential currents, bias currents and so on).

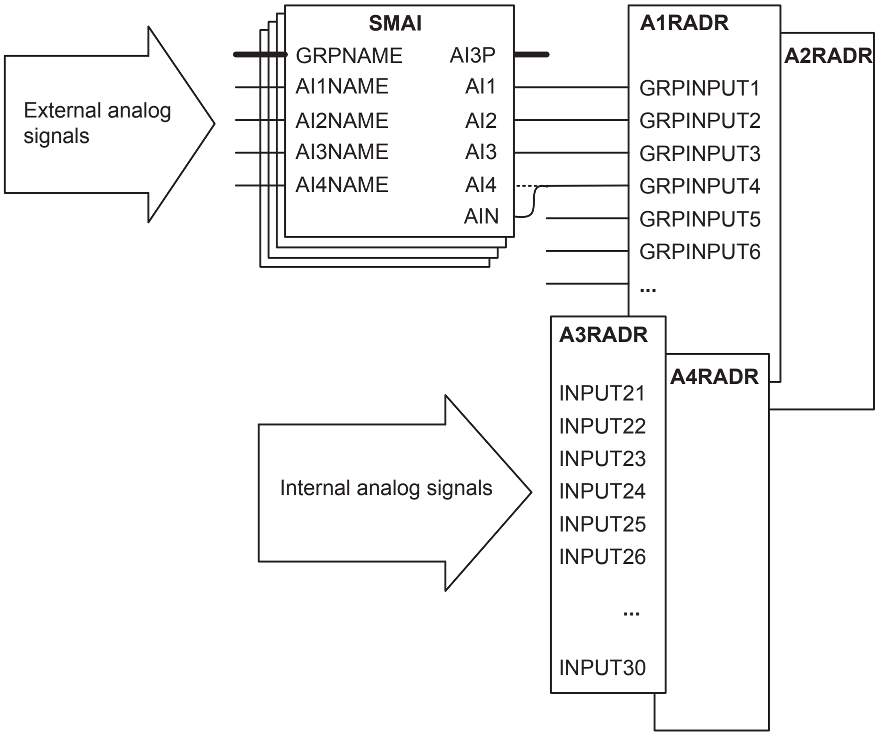

Figure 44: Analog input function blocks

The external input signals are acquired, filtered and skewed, and after configuration available as an input signal on the AxRADR function block via the SMAI function block. The information is saved at the disturbance report base sampling rate (1000 or 1200 Hz). Internally calculated signals are updated according to the cycle time of the specific function. If a function is running at lower speed than the base sampling rate, th disturbance recorder uses the latest updated sample until a new updated sample is available.

Application Configuration tool is used for analog configuration of the disturbance report.

The SMAI function block 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 Ch* = "On" means that it is recorded by the disturbance recorder. The trigger is independent of the setting of *Operation Ch*, 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 Ch* = "Off", no waveform (samples) are recorded and reported in graph. However, the trip value, pre-fault and fault value are recorded and reported. The input channel can still be used to trig the disturbance recorder.

If *Operation Ch* = "On", waveform (samples) is recorded and reported in graph.

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

Binary signals

Up to 64 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 in two occasions.

- Corresponding function block is included in the configuration
- Signal is connected to the input of the function block

Each of the 64 signals can be selected as a trigger of the disturbance report (*Operation Ch* = "Off"). A binary signal can be selected to activate the yellow (START) and red (TRIP) LED on the LHMI: *Set LED* = "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 64 signals with LHMI: *Show indication*="Show/Hide".

Trigger signals

The trigger conditions affect the entire disturbance report, except the event list, which runs continuously. As soon as at least one trigger condition is fulfilled, a complete disturbance report is recorded. On the other hand, if no trigger condition is fulfilled, there is no disturbance report, no indications, and so on. It is important to choose the right signals as trigger conditions.

There are three different trigger types.

- Manual trigger
- Binary-signal trigger
- Analog-signal trigger (over/under function)

Manual trigger

A disturbance report can be manually triggered from the LHMI, WHMI, 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, that is, logic one or a logic zero, can be selected to generate a trigger (*Trigger level* = "Trig on 0/Trig on 1"). When a binary signal is selected to generate a trigger from a logic zero, the selected signal is not listed in the indications list of the disturbance report.

Analog signal trigger

All analog signals are available for trigger purposes, whether they are recorded in the disturbance recorder or not. The settings are *Over trigger Ch*, *Under trigger Ch*, *Over Trg Lev Ch* and *Under Trg Lev Ch*.

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 LHMI and PCM600.

Post retrigger

Disturbance report function does not automatically respond to any new trig condition during a recording, after all the 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 (*Post-retrig* = "On") during the post-fault time. In this case a new, complete recording starts and, during a period, run in parallel with the initial recording.

When the retrig parameter is disabled (*Post-retrig* = "Off"), a new recording does not start until the post-fault (*Post-trigger time* or *Recording time limit*) period is terminated. If a new trig occurs during the post-fault period and lasts longer than the proceeding recording, a new complete recording is started.

Disturbance report function can handle at maximum 3 simultaneous disturbance recordings.

3.14.1.4 Application

To get fast, complete and reliable information about disturbances in the primary and/ or in the secondary system, it is important to gather information on fault currents, voltages and events. It is also important to have a continuous event-logging to enable monitoring in an overview perspective. These tasks are accomplished by the disturbance report function DRRDRE. The function provides a better understanding of the power system behavior and related primary and secondary equipment during and after a disturbance.

The analysis of the recorded data provides valuable information that can be used to explain a disturbance, in changing IED setting plan, to improve existing equipment, and so on. This information can also be used when planning for and designing new installations, that is, a disturbance recording can be a part of functional analysis.

Disturbance report DRRDRE is always included in the IED. It acquires sampled data of all the selected analog and binary signals connected to the function blocks.

- Maximum 20 external analog signals
- 20 internal derived analog signals
- 64 binary signals

Disturbance report function is a common name for several functions, such as indications, event recorder, event list, trip value recorder and disturbance recorder.

Disturbance report function is characterized by great flexibility as far as configuration, starting conditions, recording times, and large storage capacity are concerned. Thus, disturbance report is not dependent on the operation of protective functions, and it can record disturbances that are not discovered by protective functions. Disturbance report can be used as an advanced stand-alone disturbance recorder.

Every disturbance report recording is saved in the IED. The same applies to all events which are continuously saved in a ring-buffer. LHMI can be used to get information about the recordings, and the disturbance report files can be uploaded in the PCM600 using the disturbance handling tool, for report reading or further analysis (using WaveWin, that can be found on the PCM600 installation CD). The user can also upload disturbance report files using MMS (over IEC 61850-8-1) clients.

If the IED is connected to a station bus (IEC 61850-8-1), the disturbance recorder (record made and fault number) and the fault locator information are available as GOOSE or report control data.

The analog output data from the load shedding function block for example, sheddable load, load mismatch and so on, is connected to the A4ARDR function block for recording the changes in the output data during a specified time period. This recording is initaiated by a binary trigger connected to one of the BxRBDR components. A pre-trigger time (max value = 3 s) and a post-trigger time (max value = 10 s) can be configured and the changes during the configured period of time is recorded. These changes can be viewed using the Disturbance Recording Viewing tool. Apart from generating the disturbance records , BxRBDR can be used for creating process events and for configuring the start and trip LED on the LHMI overlay. Binary output from the load shedding function block can be connected to the BxRBDR block to generate the process events.

Presently the disturbance recorder does not support calculated analog values or sample values from an application thread that has a SMAI function configured for 80 samples/cycle.

3.14.1.5 Signals

Table 46: DRRDRE 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

3.14.1.6 Settings

Table 47: DRRDRE Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Off/On
Pre-trigger time	0.05 - 3.00	s	0.01	0.10	Pre-fault recording time
Post-trigger time	0.1 - 10.0	s	0.1	0.5	Post-fault recording time
Recording time limit	0.5 - 8.0	s	0.1	1.0	Fault recording time limit
Post-retrig	Off On	-	-	Off	Post-fault retrig enabled (On) or not (Off)
Max Num records	10 - 100	-	1	100	Maximum number of stored disturbances
Reference channel	1 - 30	Ch	1	1	Trip value recorder, phasor reference channel
Operation mode test	Off On	-	-	Off	Operation mode during test mode

3.14.1.7 Monitored data

Table 48: DRRDRE Monitored data

Name	Type	Values (Range)	Unit	Description
DRPOFF	BOOLEAN	0=FALSE 1=TRUE	-	Disturbance report function turned off
RECSTART	BOOLEAN	0=FALSE 1=TRUE	-	Disturbance recording started
RECMADE	BOOLEAN	0=FALSE 1=TRUE	-	Disturbance recording made
CLEARED	BOOLEAN	0=FALSE 1=TRUE	-	All disturbances in the disturbance report cleared
MEMUSED	BOOLEAN	0=FALSE 1=TRUE	-	More than 80% of memory used
Memory used	INTEGER	-	%	Memory usage (0-100%)
Fault number	INTEGER	-	-	Disturbance fault number

Table 49: DRRDRE Monitored data channels

Name	Type	Values (Range)	Unit	Description
Under Lev Trg Ch 1	BOOLEAN	0=FALSE 1=TRUE	-	Under level trig for analog channel 1 activated
Over Lev Trg Ch 1	BOOLEAN	0=FALSE 1=TRUE	-	Over level trig for analog channel 1 activated

Monitored data values are the same for each channel. The channel numbers are shown after the parameter name in LHMI and PCM600.

3.14.2 Analog input signals A1RADR and A2RADR

3.14.2.1 Function block

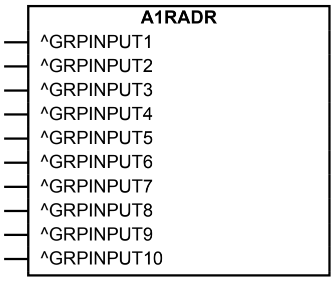

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Figure 45: Function block

3.14.2.2 Signals

The input signal tables for A1RADR and A2RADR are similar except for the GRPINPUT number.

- A1RADR, GRPINPUT1 - GRPINPUT10
- A2RADR, GRPINPUT11 - GRPINPUT20

Table 50: A1RADR input signals

Name	Type	Default	Description
GRPINPUT1	GROUP SIGNAL	-	Group signal for input 1

Values are the same for each input signal. The channel numbers are shown after the parameter name in LHMI and PCM600.

3.14.2.3 Settings

Setting tables for A1RADR and A2RADR are similar except for channel numbers.

- A1RADR, channel01 - channel10
- A2RADR, channel11 - channel20

Table 51: A1RADR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation Ch 1	Off On	-	-	Off	Operation On/Off

Table 52: A1RADR Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Nominal value Ch 1	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 1
Under trigger Ch 1	Off On	-	-	Off	Use under level trigger for analog channel 1 (on) or not (off)
Under Trg Lev Ch 1	0 - 200	%	1	50	Under trigger level for analog channel 1 in % of signal
Over trigger Ch 1	Off On	-	-	Off	Use over level trigger for analog channel 1 (on) or not (off)
Over Trg Lev Ch 1	0 - 5000	%	1	200	Over trigger level for analog channel 1 in % of signal
IEC60870-5-103					
Function type Ch 1	0 - 255	-	1	0	Function type for analog channel 1 (IEC60870-5-103)
Information Num Ch 1	0 - 255	-	1	0	Information number for analog channel 1 (IEC60870-5-103)

Settings are the same for each channel. The channel numbers are shown after the parameter name in LHMI and PCM600.

3.14.3 Analog input signals A3RADR and A4RADR

3.14.3.1 Function block

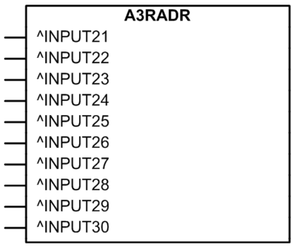

Figure 46: Function block

3.14.3.2 Signals

Input signal tables for A3RADR and A4RADR are similar except for the GRPINPUT number.

- A3RADR, INPUT21 - INPUT30
- A4RADR, INPUT31 - INPUT40

Table 53: A3RADR input signals

Name	Type	Default	Description
INPUT21	REAL	0	Analog channel 21

3.14.3.3 Settings

Setting tables for A3RADR and A4RADR are similar except for the channel numbers.

- A3RADR, channel 21 - channel 30
- A4RADR, channel 31 - channel 40

Table 54: A3RADR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation Ch 21	Off On	-	-	Off	Operation On/Off

Table 55: A3RADR Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Nominal value Ch 21	0.0 - 999999.9	-	0.1	0.0	Nominal value for analog channel 21
Under trigger Ch 21	Off On	-	-	Off	Use under level trigger for analog channel 21 (on) or not (off)
Under Trg Lev Ch 21	0 - 200	%	1	50	Under trigger level for analog channel 21 in % of signal
Over trigger Ch 21	Off On	-	-	Off	Use over level trigger for analog channel 21 (on) or not (off)
Over Trg Lev Ch 21	0 - 5000	%	1	200	Over trigger level for analog channel 21 in % of signal
IEC60870-5-103					
Function type Ch 21	0 - 255	-	1	0	Function type for analog channel 21 (IEC60870-5-103)
Information Num Ch 21	0 - 255	-	1	0	Information number for analog channel 21 (IEC60870-5-103)

3.14.4 Binary input signals BxRBDR

3.14.4.1 Function block

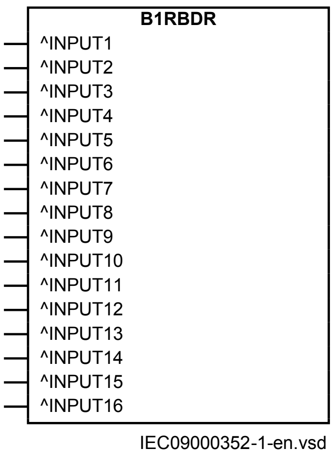

Figure 47: Function block

3.14.4.2 Signals

Input signal tables for B1RBDR - B4RBDR are all similar except for the INPUT number.

- B1RBDR, INPUT1 - INPUT16
- B2RBDR, INPUT17 - INPUT32
- B3RBDR, INPUT33 - INPUT48
- B4RBDR, INPUT49 - INPUT64

Table 56: B1RBDR input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Binary channel 1

Input settings are the same for each channel. The channel numbers are shown after the parameter name in LHMI and PCM600.

3.14.4.3 Settings

Setting tables for B1RBDR - B4RBDR are all similar except for the binary channel numbers.

- B1RBDR, channel1 - channel16
- B2RBDR, channel17 - channel32
- B3RBDR, channel33 - channel48
- B4RBDR, channel49 - channel64

Table 57: B1RBDR Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Trigger operation 1	Off On	-	-	Off	Trigger operation On/Off
Set LED 1	Off Start Trip Start and Trip	-	-	Off	Set LED on HMI for binary channel 1

Table 58: B1RBDR Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Trigger level 1	Trig on 0 Trig on 1	-	-	Trig on 1	Trigger on positive (1) or negative (0) slope for binary input 1
Show indication 1	Hide Show	-	-	Hide	Indication mask for binary channel 1
IEC60870-5-103					
Function type Ch 1	0 - 255	-	1	0	Function type for binary channel 1 (IEC60870-5-103)
Information Num Ch 1	0 - 255	-	1	0	Information number for binary channel 1 (IEC60870-5-103)

Settings are the same for each channel. The channel numbers are shown after the parameter name in LHMI and PCM600.

3.14.5 Technical data

Table 59: DRRDRE technical data

Function	Range or value	Accuracy
Pre-fault time	(0.05–3.00) s	-
Post-fault time	(0.1–10.0) s	-
Limit time	(0.5–8.0) s	-
Maximum number of recordings	100, first in - first out	-
Time tagging resolution	1 ms	See time synchronization technical data
Maximum number of analog inputs	20 + 20 (external + internally derived)	-
Maximum number of binary inputs	64	-
Maximum number of phasors in the Trip Value recorder per recording	30	-
Maximum number of indications in a disturbance report	64	-
Maximum number of events in the Event recording per recording	150	-
Maximum number of events in the Event list	1000, first in - first out	-
Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)	340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz	-
Sampling rate	1 kHz at 50 Hz 1.2 kHz at 60 Hz	-
Recording bandwidth	(5-300) Hz	-

3.15 Self supervision with internal event list

3.15.1 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.

3.15.2 Internal error signals INTERRSIG

3.15.2.1 Function block

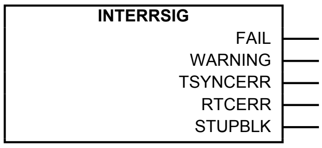

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Figure 48: Function block

3.15.2.2 Signals

Table 60: INTERRSIG Output signals

Name	Type	Description
FAIL	BOOLEAN	Internal fail
WARNING	BOOLEAN	Internal warning
TSYNCERR	BOOLEAN	Time synchronization error
RTCERR	BOOLEAN	Real time clock error
STUPBLK	BOOLEAN	Application startup block

3.15.2.3 Settings

The function does not have any parameters available in LHMI or PCM600.

3.15.3 Internal event list SELFSUPEVLST

3.15.3.1 Settings

The function does not have any parameters available in LHMI or PCM600.

3.15.4 Operation principle

The self-supervision operates continuously.

- 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 LHMI, from the Event Viewer in PCM600 or from a SMS/SCS system.

Under the Diagnostics menu in the LHMI the present information from the self-supervision function can be reviewed. The information can be found under **Monitoring/Internal Events** or **Monitoring/IED Status**. The information from the self-supervision function is also available in the Event Viewer in PCM600.

A self-supervision summary can be obtained by means of the potential free alarm contact (INTERNAL FAIL) located on the power supply module. This output relay is activated (no fault) and deactivated (fault) by the Internal Fail signal, see Figure 49. Also the software watchdog timeout and the undervoltage detection of the PSM deactivates the relay.

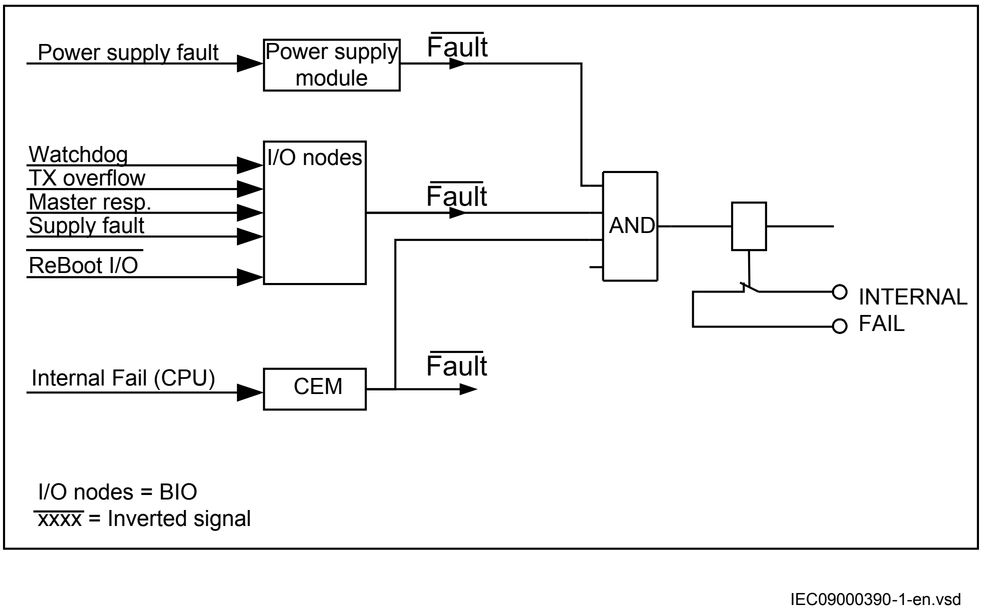


Figure 49: Hardware self-supervision, potential-free contact

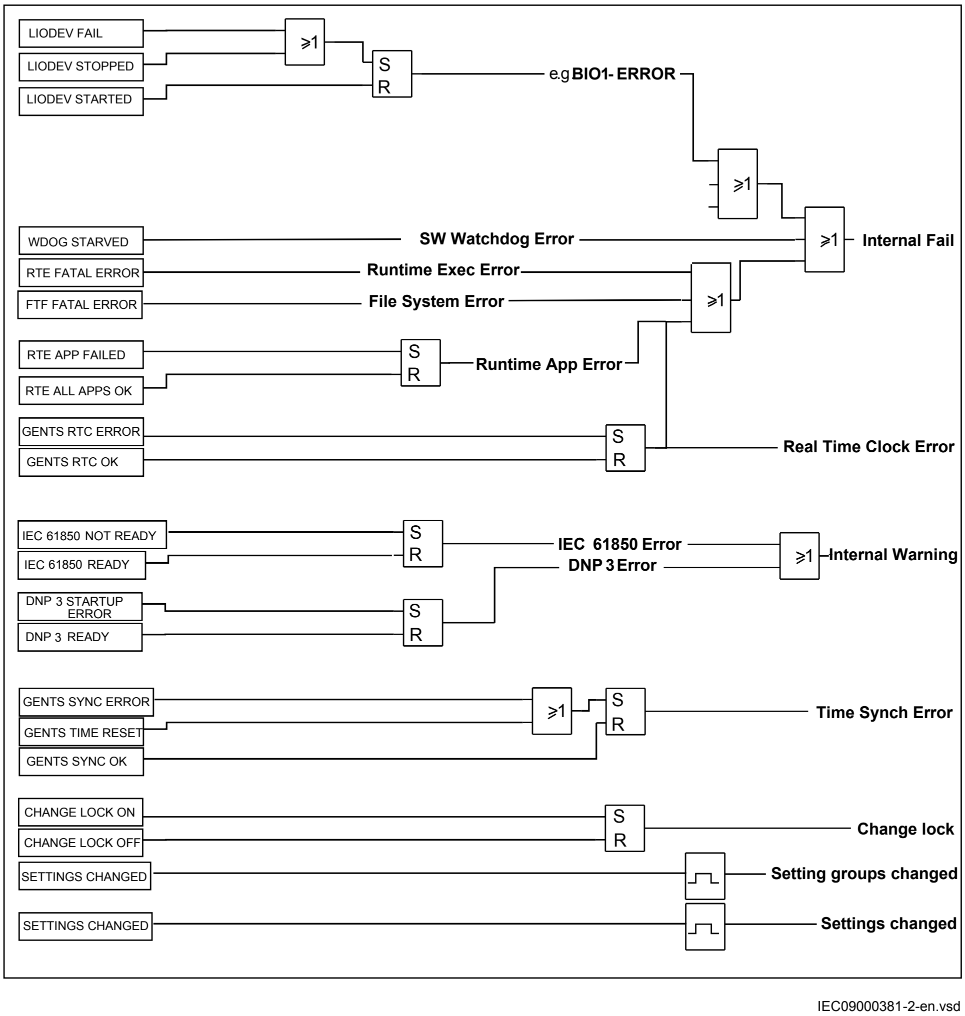


Figure 50: Self supervision, function block internal signals

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 Signal Matrix. Error signals from time synchronization can be obtained from the time synchronization block INTERSIG.

3.15.4.1 Internal signals

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

- Standard signals are always presented in the IED, see Table 61.
- Hardware dependent internal signals are collected depending on the hardware configuration, see Table 62.

Explanations of internal signals are listed in Table 63.

Table 61: SELFSUPEVLST standard internal signals

Name of signal	Description
Internal Fail	Internal fail status
Internal Warning	Internal warning status
Real Time Clock Error	Real time clock status
Time Synch Error	Time synchronization status
Runtime App Error	Runtime application error status
Runtime Exec Error	Runtime execution error status
IEC61850 Error	IEC 61850 error status
SW Watchdog Error	SW watchdog error status
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 62: Self-supervision's hardware dependent internal signals

Card	Name of signal	Description
PSM	PSM-Error	Power supply module error status
TRM	TRM-Error	Transformator module error status
COM	COM-Error	Communication module error status
BIO	BIO-Error	Binary input/output module error status
AIM	AIM-Error	Analog input module error status
RTD	RTD-Error	Resistance temperature detector / mA-output module error status

Table 63: Explanations of internal signals

Name of signal	Reasons for activation
Internal Fail	This signal is 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 is active if one or more of the following internal signals are active; IEC 61850 Error, DNP3 Error
Real Time Clock Error	This signal is active if there is a hardware error with the real time clock.
Time Synch Error	This signal is 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 is 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 is 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 is 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 is 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 generates an internal event to the internal event list if any setting(s) is changed.
Setting Group(s) Changed	This signal generates an internal event to the Internal Event List if any setting group(s) is changed.
Change Lock	This signal generates an internal Event to the Internal Event List if the Change Lock status is changed
File System Error	This signal is active if both the working file and the backup file are corrupted and cannot be recovered.

3.15.4.2 Run-time model

The analog signals to the A/D converter is internally distributed into two different converters, one with low amplification and one with high amplification, see Figure 51.

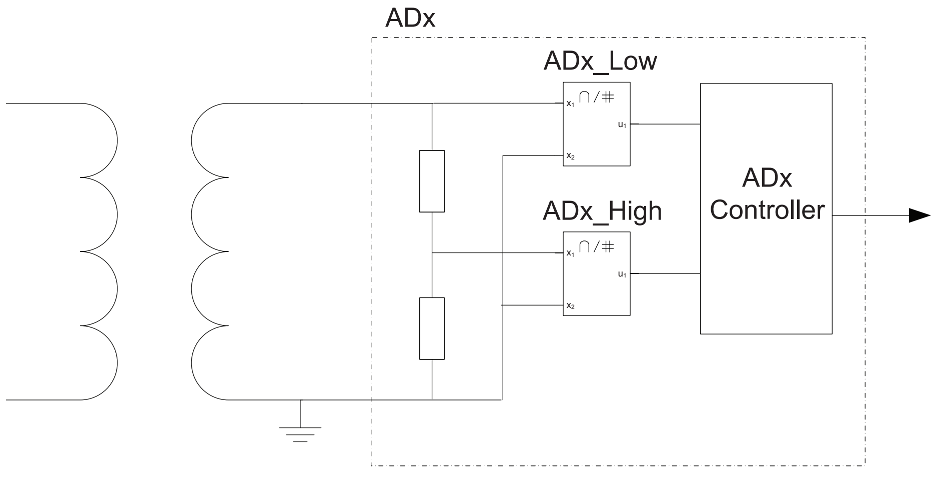


Figure 51: Simplified drawing of A/D converter for the IED.

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. 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 is 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 is informed and an alarm is given for A/D converter failure.

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

3.15.5 Application

The protection and control IEDs have many functions included. Self supervision with internal event list (SELFSUPEVLST) and internal error signals (INTERRSIG) function provides supervision of the IED. The fault signals make it easier to analyze and locate a fault.

Both hardware and software supervision is included and possible faults can be indicated through a hardware contact on the power supply module and/or through the software communication.

Internal events are generated by the built-in supervisory functions. The supervisory functions supervise the status of the various modules in the IED and, in case of failure, a corresponding event is generated. Similarly, when the failure is corrected, a corresponding event is generated.

Apart from the built-in supervision of the various modules, events are also generated when the status changes for the built-in real time clock (in operation/out of order) or external time synchronization (in operation/out of order). Events are also generated whenever any setting in the IED is changed.

The internal events are time tagged with a resolution of 1 ms and stored in a list. The list can store up to 40 events. The list is based on the FIFO principle, that is, when it is full, the oldest event is overwritten. The list can be cleared via the LHMI.

The list of internal events provides valuable information, which can be used during commissioning and fault tracing.

The list of internal events can be found in the LHMI, WHMI or PCM600.

The list can be cleared via the LHMI or WHMI menu **Clear/Clear internal event list**.

3.15.6 Technical data

Table 64: Self supervision with internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	

3.16 Time synchronization

3.16.1 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 protection system. This makes it possible to compare event and disturbance data between all IEDs in a station automation system.

Do not use the MicroSCADA OPC server as a time synchronization source.

3.16.2 Time synchronization TIMESYNCHGEN

3.16.2.1 Settings

Table 65: 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 IED as synchronization master

3.16.3 Time synchronization via SNTP

3.16.3.1 Settings

Table 66: 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

3.16.4 Time system, summer time begin DSTBEGIN

3.16.4.1 Settings

Table 67: 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

3.16.5 Time system, summer time ends DSTEND

3.16.5.1 Settings

Table 68: 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

3.16.6 Time zone from UTC TIMEZONE

3.16.6.1 Settings

Table 69: TIMEZONE Non group settings (basic)

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

3.16.7 Time synchronization via IRIG-B

3.16.7.1 Settings

Table 70: 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

3.16.8 Operation principle

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.

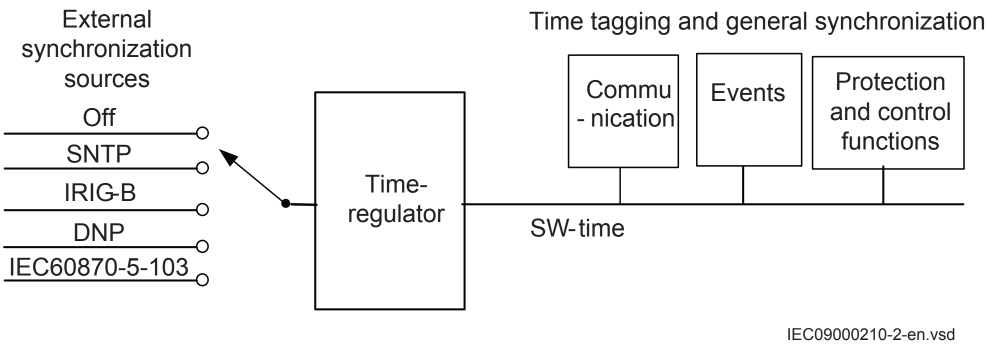


Figure 52: Design of time system (clock synchronization)

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

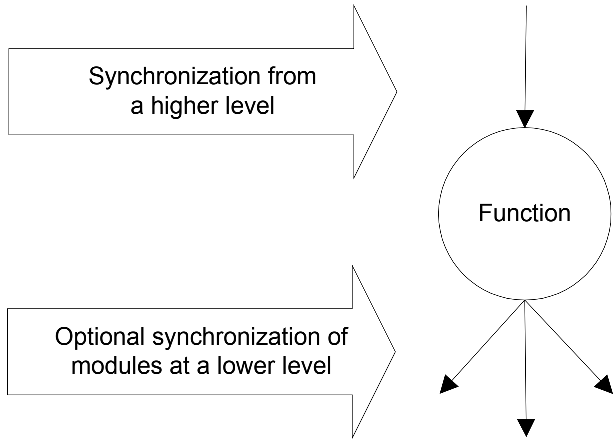


Figure 53: Synchronization principle

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 in three ways.

- 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

3.16.8.1 Real-time clock 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 provides 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 is lost completely.

Time synchronization startup procedure

The first message that contains the full time (as for instance SNTP and IRIG-B) gives an accurate time to the IED. The IED is brought into a safe state and the time is set to the correct value. After the initial setting of the clock, one of three things happens with each of the coming synchronization messages, configured as “fine”.

- If the synchronization message, which is similar to the other messages, from its origin has an offset compared to the internal time in the IED, the message is used

directly for synchronization, that is, for adjusting the internal clock to obtain zero offset at the next coming time message.
- If the synchronization message has an offset that is large compared to the other messages, a spike-filter in the IED removes this time-message.
- If the synchronization message has an offset that is large, and the following message also has a large offset, the spike filter does not act and the offset in the synchronization message is compared to a threshold that defaults to 500 milliseconds. If the offset is more than the threshold, the IED is brought into a safe state and the clock is set to the correct time. If the offset is lower than the threshold, the clock is adjusted with 10 000 ppm until the offset is removed. With an adjustment of 10 000 ppm, it takes 50 seconds to remove an offset of 500 milliseconds.

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

Rate accuracy

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

Time-out on synchronization sources

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

3.16.8.2 Synchronization alternatives

Two main alternatives of external time synchronization are available. The synchronization message is applied either via any of the communication ports of the IED as a telegram message including date and time or via IRIG-B.

Synchronization via SNTP

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

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

Synchronization via IRIG-B

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 LHMI.

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 DNP

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

See the communication protocol manual for a detailed description of the DNP3 protocol.

3.16.9 Application

Time synchronization is used to achieve a common time base for the IEDs in a protection and control system. This makes comparison of events and disturbance data between all IEDs in the system possible.

Time-tagging of internal events and disturbances are an excellent help when evaluating faults. Without time synchronization, only the events within the IED can be compared to one another. With time synchronization, events and disturbances within the entire station, and even between line ends, can be compared at evaluation.

In the IED, the internal time can be synchronized from a number of sources.

- SNTP
- IRIG-B

Do not use the MicroSCADA OPC server as a time synchronization source.

3.16.10 Technical data

Table 71: Time synchronization, time tagging

Function	Value
Time tagging resolution, events and sampled measurement values	1 ms

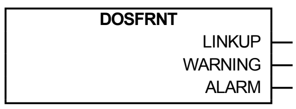
3.17 Denial of service

3.17.1 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 is 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.

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

3.17.2.1 Function block



IEC09000133-1-en.vsd

Figure 54: Function block

3.17.2.2 Signals

Table 72: 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

3.17.2.3 Settings

The function does not have any parameters available in LHMI or PCM600.

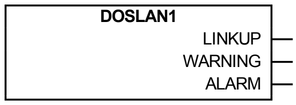
3.17.2.4 Monitored data

Table 73: 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

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

3.17.3.1 Function block



IEC09000134-1-en.vsd

Figure 55: Function block

3.17.3.2 Signals

Table 74: 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

3.17.3.3 Settings

The function does not have any parameters available in LHMI or PCM600.

3.17.3.4 Monitored data

Table 75: DOSLAN1 Monitored data

Name	Type	Values (Range)	Unit	Description
State	INTEGER	0=Off 1=Normal 2=Throttle 3=DiscardLow 4=DiscardAll 5=StopPoll	-	Frame rate control state
Quota	INTEGER	-	%	Quota level in percent 0-100
IPPackRecNorm	INTEGER	-	-	Number of IP packets received in normal mode
IPPackRecPoll	INTEGER	-	-	Number of IP packets received in polled mode
IPPackDisc	INTEGER	-	-	Number of IP packets discarded
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
NonIPPackRecNorm	INTEGER	-	-	Number of non IP packets received in normal mode
NonIPPackRecPoll	INTEGER	-	-	Number of non IP packets received in polled mode
NonIPPackDisc	INTEGER	-	-	Number of non IP packets discarded

3.17.4 Operation principle

The denial of service functions (DOSLAN1 and DOSFRNT) measures the IED communication load and, if necessary, limit it to avoid compromising the IEDs control and protection functionality due to high CPU load. The function has three outputs.

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

3.18 IEC 61850-8-1 communication protocol

3.18.1 Functionality

IEC 61850-8-1 protocol allows IEDs from different vendors to exchange information and simplifies system engineering. Peer-to-peer communication according to GOOSE is part of the standard. Disturbance files uploading is provided.

The event system has a rate limiter to reduce CPU load. Each channel has a quota of 10 events/second. If the quota is exceeded the event channel is blocked until the event changes is below the quota.

3.18.2 Communication interfaces and protocols

Table 76: Supported station communication interfaces and protocols

Protocol	Ethernet		Serial
	100BASE-TX RJ-45	100BASE-FX LC	Glass fibre (ST connector)
IEC 61850–8–1	●	●	-
● = Supported			

3.18.3 Application

The IEC 61850-8-1 communication protocol allows vertical communication to HSI clients. It allows horizontal communication between two or more IEDs from one or several vendors to exchange information, and to use it in the performance of their functions and for correct co-operation.

GOOSE, which is part of the IEC 61850–8–1 standard, allows the IEDs to communicate state and control information amongst themselves, using a publish-subscribe mechanism. When detecting an event, the IED(s) use a multi-cast transmission to notify the devices that have registered to receive the data. An IED can report its status by publishing a GOOSE message. It can also request a control action to be directed at any device in the network.

The analog output data from the load shedding function block, such as sheddable load and load mismatch, is connected to the A4ARDR function block for recording the changes in the output data over a specified period of time. This recording is initaiated by a binary trigger connected to one of the BXRBDR components. A pre-trigger time (max. value = 3 s) and a post-trigger time (max value = 10 s) can be configured, and the changes during the configured time period is recorded. These changes can be viewed using the Disturbance Recording Viewing tool. Apart from generating the disturbance records, BXRBDR can be used for creating process events and for configuring the start and trip LED on the LHMI overlay. Binary output from the load shedding function block can be connected to the BxRBDR block to generate the process events.

IEC 61850–8–1 specifies only the interface to the substation LAN. The LAN itself is left to the system integrator.

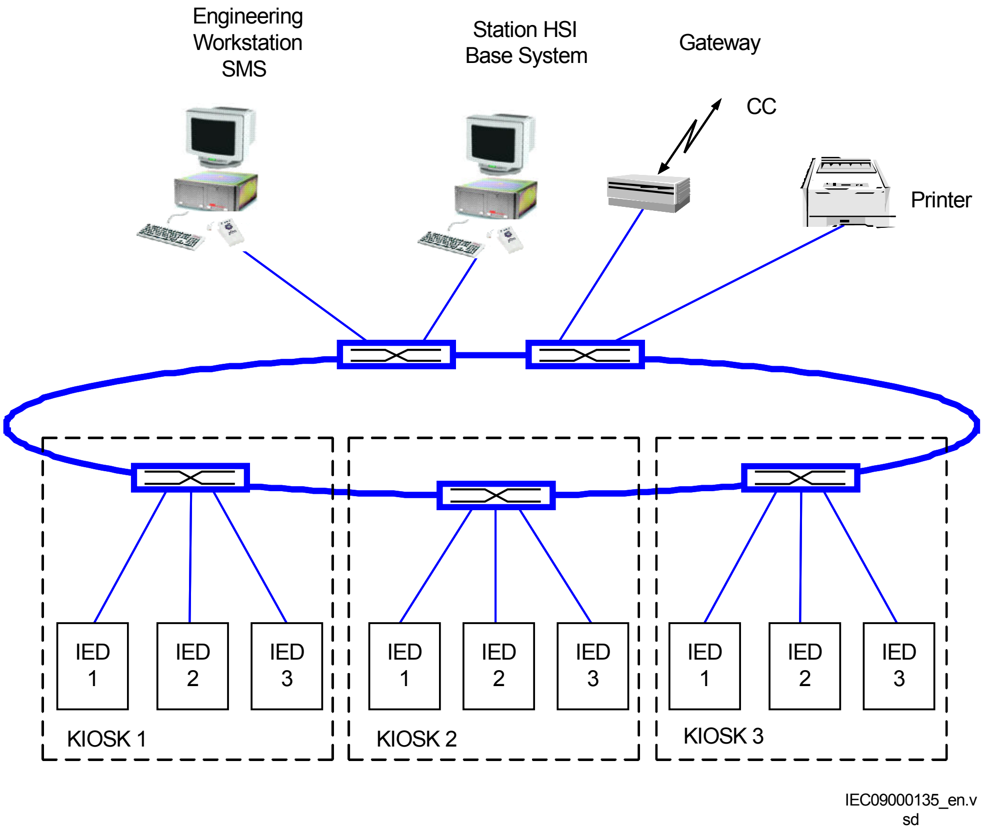


Figure 56: Example of a communication system with IEC 61850–8–1

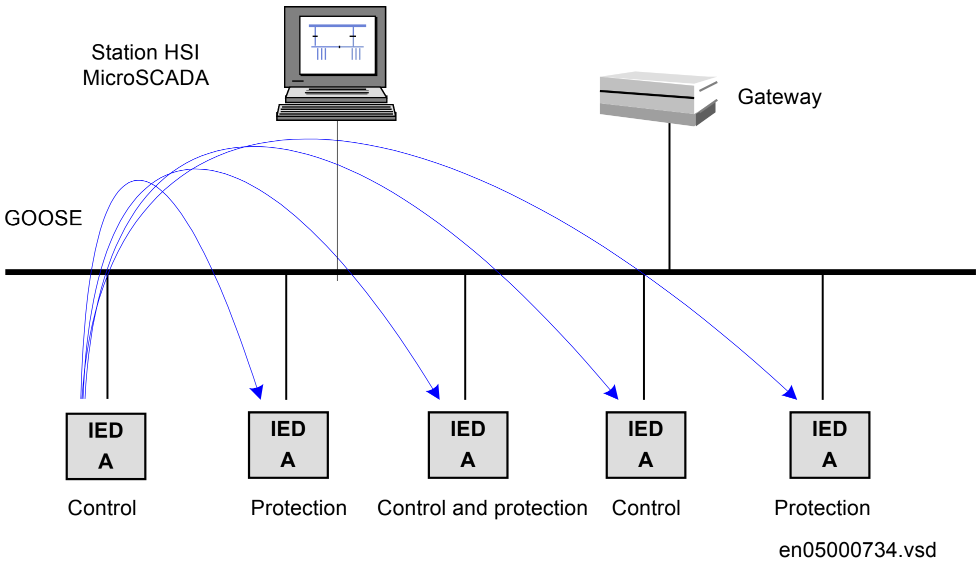


Figure 57: Example of a broadcasted GOOSE message, peer-to-peer communication

3.18.3.1 Horizontal communication via GOOSE

GOOSE messages are sent in horizontal communication between the IEDs. The information, which is exchanged, is used for station wide interlocking, breaker failure protection, busbar voltage selection and so on.

The simplified principle is shown in Figure 58. When IED1 has decided to transmit the data set it forces a transmission via the station bus. All other IEDs receive the data set, but only those who have this data set in their address list takes it and keeps it in an input container. It is defined, that the receiving IED takes the content of the received data set and makes it available for the application configuration.

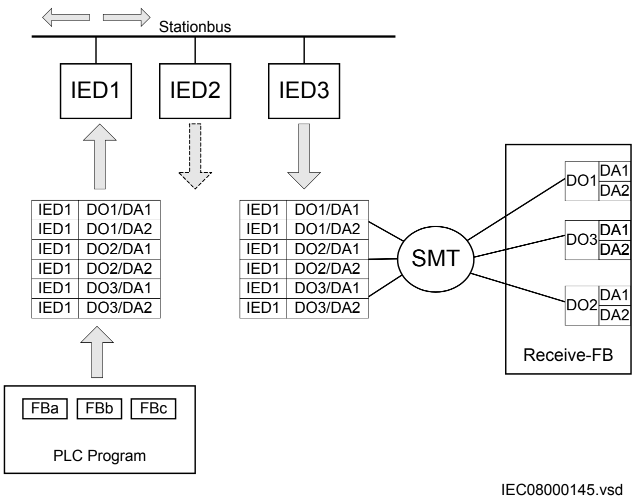
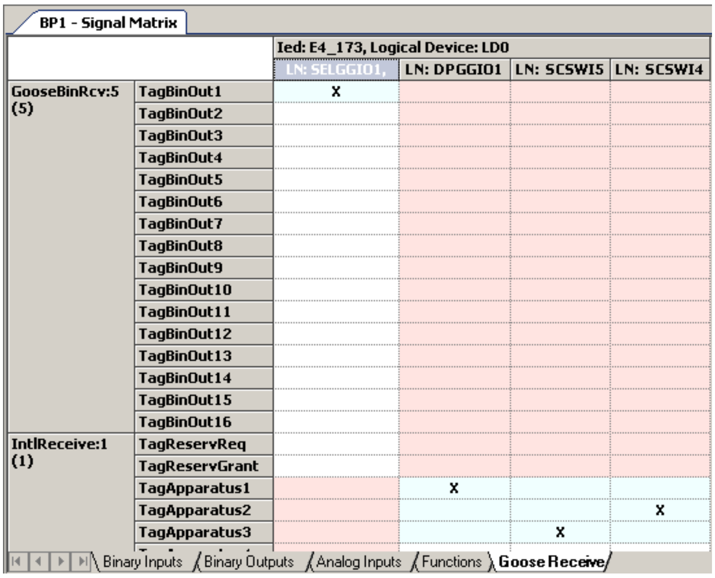


Figure 58: SMT: GOOSE principle and signal routing with Signal Matrix

Special function blocks take the data set and present it via the function block as output signals for application functions in the application configuration. Different GOOSE receive function blocks are available for the specific tasks.

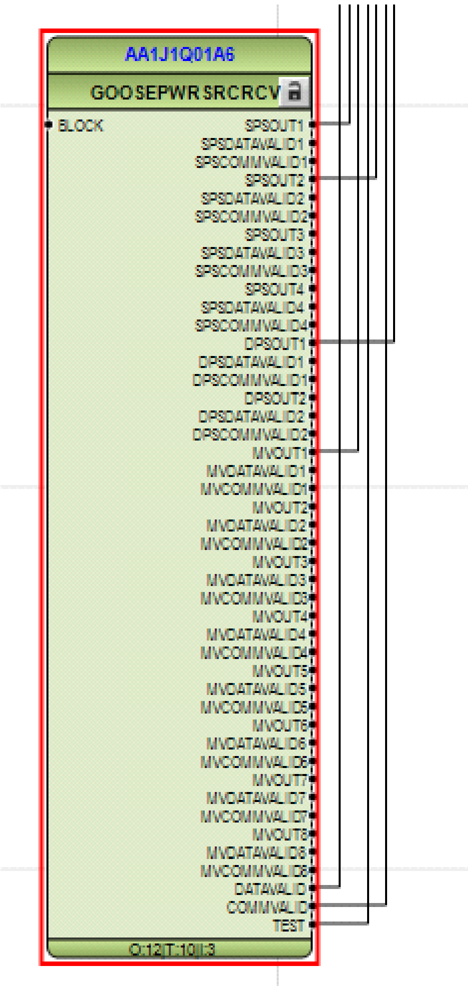
Signal Matrix links the different data object attributes (for example stVal or magnitude) to the output signal to make it available for functions in the application configuration. When a matrix cell array is marked red the IEC 61850-8-1 data attribute type does not fit together, even if the GOOSE receive function block is the partner. Signal Matrix checks this on the content of the received data set.



IEC08000174.vsd

Figure 59: SMT: GOOSE marshalling with Signal Matrix

GOOSE receive function blocks extract process information, received by the data set, into single attribute information that can be used within the application configuration. Crosses in the SMT matrix connect received values to the respective function block signal in Signal Matrix.


AA1J1Q01A6
GOOSEPWRSRCRCV
BLOCK
SPSOUT1
SPSDATAVALID1
SPSCOMMVALID1
SPSOUT2
SPSDATAVALID2
SPSCOMMVALID2
SPSOUT3
SPSDATAVALID3
SPSCOMMVALID3
SPSOUT4
SPSDATAVALID4
SPSCOMMVALID4
DPSOUT1
DPSDATAVALID1
DPSCOMMVALID1
DPSOUT2
DPSDATAVALID2
DPSCOMMVALID2
MVOUT1
MVDATAVALID1
MVCOMMVALID1
MVOUT2
MVDATAVALID2
MVCOMMVALID2
MVOUT3
MVDATAVALID3
MVCOMMVALID3
MVOUT4
MVDATAVALID4
MVCOMMVALID4
MVOUT5
MVDATAVALID5
MVCOMMVALID5
MVOUT6
MVDATAVALID6
MVCOMMVALID6
MVOUT7
MVDATAVALID7
MVCOMMVALID7
MVOUT8
MVDATAVALID8
MVCOMMVALID8
DATAVALID
COMMVALID
TEST
O:12|T:10|I:3

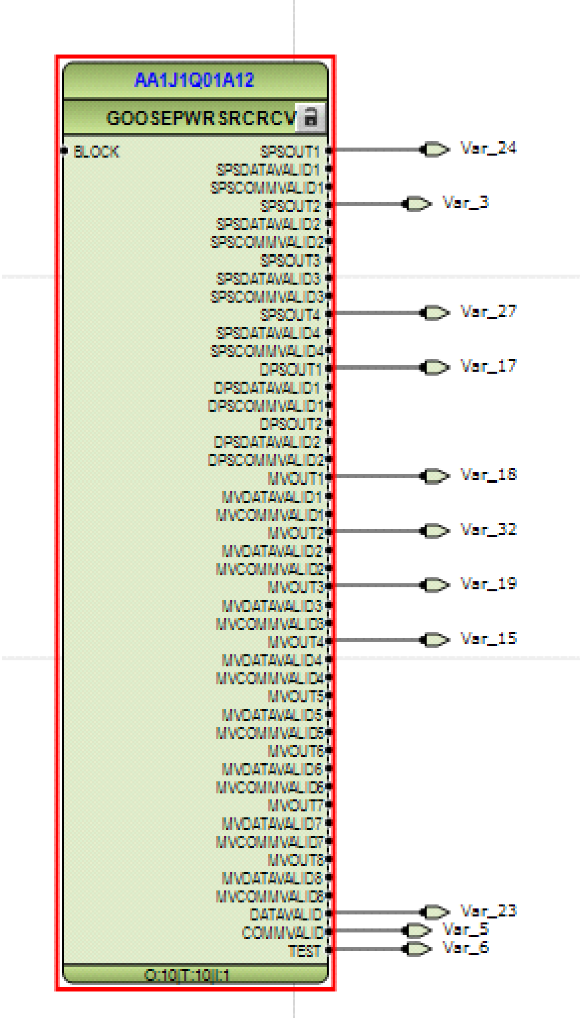


Figure 60: SMT: GOOSE receive function block with converted signals

3.18.4 Settings

Table 77: IEC61850-8-1 Non group settings (basic)

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

3.18.5 Technical data

Table 78: IEC 61850-8-1 communication protocol

Function	Value
Protocol	IEC 61850-8-1
Communication speed for the IEDs	100BASE-FX
Protocol	IEC 608–5–103
Communication speed for the IEDs	9600 or 19200 Bd
Protocol	DNP3.0
Communication speed for the IEDs	300–19200 Bd
Protocol	TCP/IP, Ethernet
Communication speed for the IEDs	100 Mbit/s

3.19 GOOSE receive GOOSEPWRFDRRCV

3.19.1 Function block

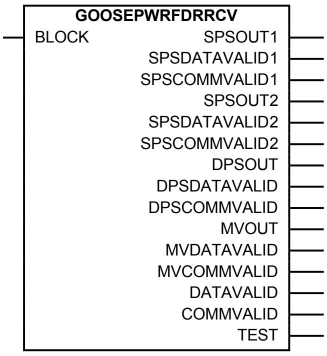


Figure 61: Function block

3.19.2 Functionality

GOOSEPWRFDRRCV is a GOOSE receive function block used for receiving a set of data from IEDs associated with load shed and network circuit breakers, required to handle the load shedding functionality.

3.19.3 Signals

Table 79: GOOSEPWRFDRRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 80: GOOSEPWRFDRRCV Output signals

Name	Type	Description
SPSOUT1	BOOLEAN	SPS output 1
SPSDATAVALID1	BOOLEAN	Valid data on SPS output 1
SPSCOMMVALID1	BOOLEAN	Communication valid for SPS output 1
SPSOUT2	BOOLEAN	SPS output 2
SPSDATAVALID2	BOOLEAN	Valid data on SPS output 2
SPSCOMMVALID2	BOOLEAN	Communication valid for SPS output 2
SPSOUT3	BOOLEAN	SPS output 3
SPSDATAVALID3	BOOLEAN	Valid data on SPS output 3
SPSCOMMVALID3	BOOLEAN	Communication Valid for SPS Output 3
SPSOUT4	BOOLEAN	SPS output 4
SPSDATAVALID4	BOOLEAN	Valid data on SPS output 4
SPSCOMMVALID4	BOOLEAN	Communication Valid for SPS Output 4
SPSOUT5	BOOLEAN	SPS output 5
SPSDATAVALID5	BOOLEAN	Valid data on SPS output 5
SPSCOMMVALID5	BOOLEAN	Communication Valid for SPS Output 5
DPSOUT	INTEGER	DPS output
DPSDATAVALID	BOOLEAN	Valid data on DPS output
DPSCOMMVALID	BOOLEAN	Communication valid for DPS output
MVOUT	REAL	MV output
MVDATAVALID	BOOLEAN	Valid data on MV output
MVCOMMVALID	BOOLEAN	Communication valid for MV output
DATAVALID	BOOLEAN	Data valid
COMMVALID	BOOLEAN	Communication valid
TEST	BOOLEAN	Test output

3.19.4 Settings

Table 81: GOOSEPWRFDRRCV Non group settings (basic)

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

3.20 GOOSE receive GOOSEPWRSRCRCV

3.20.1 Function block

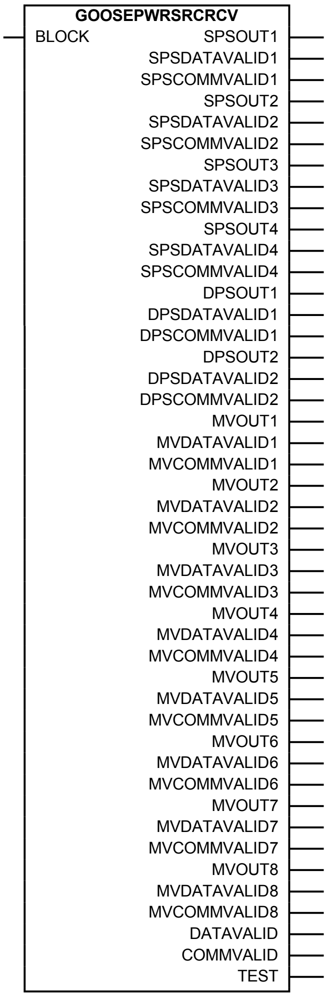


Figure 62: Function block

3.20.2 Functionality

GOOSEPWRSRCRCV is a GOOSE receive function block used for receiving a set of data required for load shedding functionality from IEDs associated with power sources like generators and grid transformers.

3.20.3 Signals

Table 82: GOOSEPWRSRCRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 83: GOOSEPWRSRCRCV Output signals

Name	Type	Description
SPSOUT1	BOOLEAN	SPS output 1
SPSDATAVALID1	BOOLEAN	Valid data on SPS output 1
SPSCOMMVALID1	BOOLEAN	Communication valid for SPS output 1
SPSOUT2	BOOLEAN	SPS output 2
SPSDATAVALID2	BOOLEAN	Valid data on SPS output 2
SPSCOMMVALID2	BOOLEAN	Communication valid for SPS output 2
SPSOUT3	BOOLEAN	SPS output 3
SPSDATAVALID3	BOOLEAN	Valid data on SPS output 3
SPSCOMMVALID3	BOOLEAN	Communication valid for SPS output 3
SPSOUT4	BOOLEAN	SPS output 4
SPSDATAVALID4	BOOLEAN	Valid data on SPS output 4
SPSCOMMVALID4	BOOLEAN	Communication valid for SPS output 4
DPSOUT1	INTEGER	DPS output 1
DPSDATAVALID1	BOOLEAN	Valid data on DPS output 1
DPSCOMMVALID1	BOOLEAN	Communication valid for DPS output 1
DPSOUT2	INTEGER	DPS output 2
DPSDATAVALID2	BOOLEAN	Valid data on DPS output 2
DPSCOMMVALID2	BOOLEAN	Communication valid for DPS output 2
MVOUT1	REAL	MV output 1
MVDATAVALID1	BOOLEAN	Valid data on MV output 1
MVCOMMVALID1	BOOLEAN	Communication valid for MV output 1
MVOUT2	REAL	MV output 2
MVDATAVALID2	BOOLEAN	Valid data on MV output 2
MVCOMMVALID2	BOOLEAN	Communication valid for MV output 2
MVOUT3	REAL	MV output 3
MVDATAVALID3	BOOLEAN	Valid data on MV output 3
MVCOMMVALID3	BOOLEAN	Communication valid for MV output 3
MVOUT4	REAL	MV output 4
MVDATAVALID4	BOOLEAN	Valid data on MV output 4
MVCOMMVALID4	BOOLEAN	Communication valid for MV output 4
MVOUT5	REAL	MV output 5
MVDATAVALID5	BOOLEAN	Valid data on MV output 5

Table continues on next page

Name	Type	Description
MVCOMMVALID5	BOOLEAN	Communication valid for MV output 5
MVOUT6	REAL	MV output 6
MVDATAVALID6	BOOLEAN	Valid data on MV output 6
MVCOMMVALID6	BOOLEAN	Communication valid for MV output 6
MVOUT7	REAL	MV output 7
MVDATAVALID7	BOOLEAN	Valid data on MV output 7
MVCOMMVALID7	BOOLEAN	Communication valid for MV output 7
DATAVALID	BOOLEAN	Data valid
COMMVALID	BOOLEAN	Communication valid
TEST	BOOLEAN	Test output

3.20.4 Settings

Table 84: GOOSEPWRSRCRCV Non group settings (basic)

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

3.21 Horizontal communication via GOOSE for interlocking GOOSEINTLKRCV

3.21.1 Function block

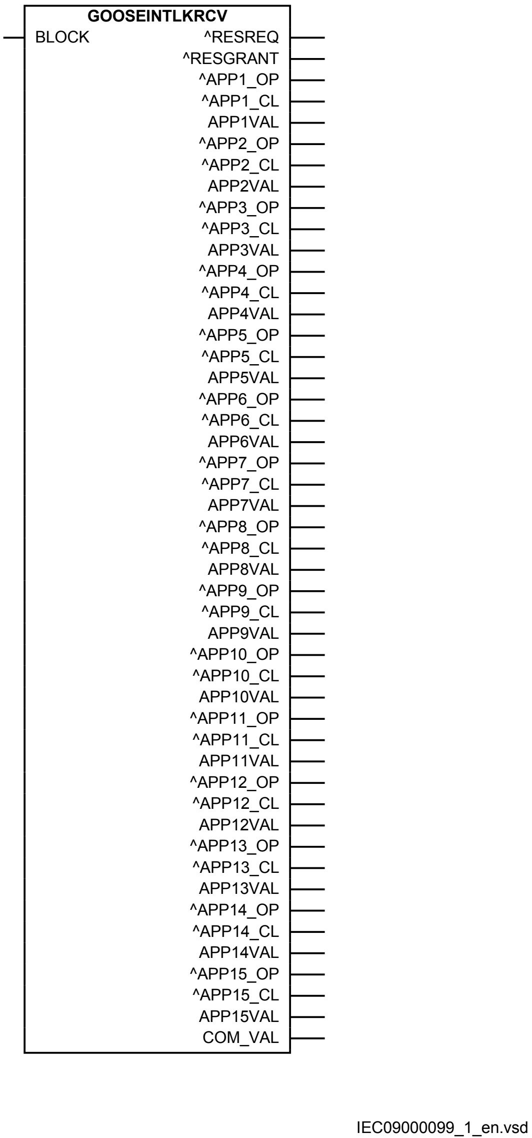


Figure 63: Function block

3.21.2 Signals

Table 85: GOOSEINTLKRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 86: GOOSEINTLKRCV Output signals

Name	Type	Description
RESREQ	BOOLEAN	Reservation request
RESGRANT	BOOLEAN	Reservation granted
APP1_OP	BOOLEAN	Apparatus 1 position is open
APP1_CL	BOOLEAN	Apparatus 1 position is closed
APP1VAL	BOOLEAN	Apparatus 1 position is valid
APP2_OP	BOOLEAN	Apparatus 2 position is open
APP2_CL	BOOLEAN	Apparatus 2 position is closed
APP2VAL	BOOLEAN	Apparatus 2 position is valid
APP3_OP	BOOLEAN	Apparatus 3 position is open
APP3_CL	BOOLEAN	Apparatus 3 position is closed
APP3VAL	BOOLEAN	Apparatus 3 position is valid
APP4_OP	BOOLEAN	Apparatus 4 position is open
APP4_CL	BOOLEAN	Apparatus 4 position is closed
APP4VAL	BOOLEAN	Apparatus 4 position is valid
APP5_OP	BOOLEAN	Apparatus 5 position is open
APP5_CL	BOOLEAN	Apparatus 5 position is closed
APP5VAL	BOOLEAN	Apparatus 5 position is valid
APP6_OP	BOOLEAN	Apparatus 6 position is open
APP6_CL	BOOLEAN	Apparatus 6 position is closed
APP6VAL	BOOLEAN	Apparatus 6 position is valid
APP7_OP	BOOLEAN	Apparatus 7 position is open
APP7_CL	BOOLEAN	Apparatus 7 position is closed
APP7VAL	BOOLEAN	Apparatus 7 position is valid
APP8_OP	BOOLEAN	Apparatus 8 position is open
APP8_CL	BOOLEAN	Apparatus 8 position is closed
APP8VAL	BOOLEAN	Apparatus 8 position is valid
APP9_OP	BOOLEAN	Apparatus 9 position is open
APP9_CL	BOOLEAN	Apparatus 9 position is closed
APP9VAL	BOOLEAN	Apparatus 9 position is valid
APP10_OP	BOOLEAN	Apparatus 10 position is open
APP10_CL	BOOLEAN	Apparatus 10 position is closed
APP10VAL	BOOLEAN	Apparatus 10 position is valid
APP11_OP	BOOLEAN	Apparatus 11 position is open
APP11_CL	BOOLEAN	Apparatus 11 position is closed
APP11VAL	BOOLEAN	Apparatus 11 position is valid
APP12_OP	BOOLEAN	Apparatus 12 position is open
APP12_CL	BOOLEAN	Apparatus 12 position is closed
APP12VAL	BOOLEAN	Apparatus 12 position is valid

Table continues on next page

Name	Type	Description
APP13_OP	BOOLEAN	Apparatus 13 position is open
APP13_CL	BOOLEAN	Apparatus 13 position is closed
APP13VAL	BOOLEAN	Apparatus 13 position is valid
APP14_OP	BOOLEAN	Apparatus 14 position is open
APP14_CL	BOOLEAN	Apparatus 14 position is closed
APP14VAL	BOOLEAN	Apparatus 14 position is valid
APP15_OP	BOOLEAN	Apparatus 15 position is open
APP15_CL	BOOLEAN	Apparatus 15 position is closed
APP15VAL	BOOLEAN	Apparatus 15 position is valid
COM_VAL	BOOLEAN	Receive communication status is valid

3.21.3 Settings

Table 87: GOOSEINTLKRCV Non group settings (basic)

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

3.22 Goose binary receive GOOSEBINRCV

3.22.1 Function block

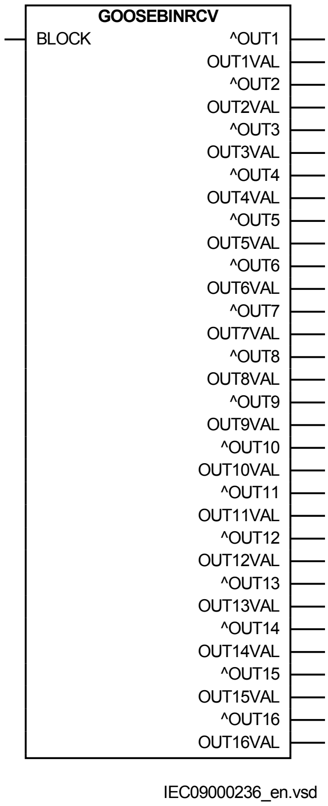


Figure 64: Function block

3.22.2 Signals

Table 88: GOOSEBINRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 89: 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
Table continues on next page		

Name	Type	Description
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
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

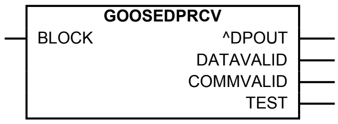
3.22.3 Settings

Table 90: GOOSEBINRCV Non group settings (basic)

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

3.23 GOOSE function block to receive a double point GOOSEDPRCV

3.23.1 Function block



IEC10000249-1-en.vsd

Figure 65: Function block

3.23.2 Functionality

GOOSEDPRCV is used to receive a double point value using IEC61850 protocol via GOOSE.

3.23.3 Operation principle

The DATAVALID output is HIGH if the incoming message is with valid data.

The COMMVALID output becomes LOW when the sending IED is under total failure condition and the GOOSE transmission from the sending IED does not happen.

The TEST output will go HIGH if the sending IED is in test mode.

The input of this GOOSE block must be linked in Signal Matrix by means of a cross 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, the DATAVALID output is HIGH. If quality data validity is INVALID, QUESTIONABLE, OVERFLOW, FAILURE or OLD DATA, the DATAVALID output is LOW.

3.23.4 Signals

Table 91: GOOSEDPRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 92: 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

3.23.5 Settings

Table 93: GOOSEDPRCV Non group settings (basic)

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

3.24 GOOSE function block to receive an integer value GOOSEINTRCV

3.24.1 Function block

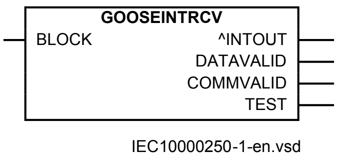


Figure 66: Function block

3.24.2 Functionality

GOOSEINTRCV is used to receive an integer value using IEC61850 protocol via GOOSE.

3.24.3 Operation principle

The DATAVALID output is HIGH if the incoming message is with valid data.

The COMMVALID output becomes LOW when the sending IED is under total failure condition and the GOOSE transmission from the sending IED does not happen.

The TEST output will go HIGH if the sending IED is in test mode.

The input of this GOOSE block must be linked in Signal Matrix by means of a cross 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, the DATAVALID output is HIGH. If quality data validity is INVALID, QUESTIONABLE, OVERFLOW, FAILURE or OLD DATA, the DATAVALID output is LOW.

3.24.4 Signals

Table 94: GOOSEINTRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 95: 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

3.24.5 Settings

Table 96: GOOSEINTRCV Non group settings (basic)

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

3.25 GOOSE function block to receive a measurand value GOOSEMVRCV

3.25.1 Function block

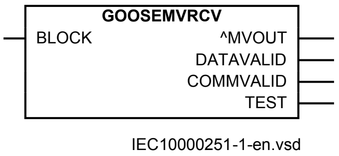


Figure 67: Function block

3.25.2 Functionality

GOOSEMVRCV is used to receive measured value using IEC61850 protocol via GOOSE.

3.25.3 Operation principle

The DATAVALID output is HIGH if the incoming message is with valid data.

The COMMVALID output becomes LOW when the sending IED is under total failure condition and the GOOSE transmission from the sending IED does not happen.

The TEST output will go HIGH if the sending IED is in test mode.

The input of this GOOSE block must be linked in Signal Matrix by means of a cross to receive the float values.

The implementation for IEC 61850 quality data handling is restricted to a simple level. If quality data validity is GOOD, the DATAVALID output is HIGH. If quality data validity is INVALID, QUESTIONABLE, OVERFLOW, FAILURE or OLD DATA, the DATAVALID output is LOW.

3.25.4 Signals

Table 97: GOOSEMVRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 98: GOOSEMVRCV 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

3.25.5 Settings

Table 99: GOOSEMVRCV Non group settings (basic)

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

3.26 GOOSE function block to receive data sets required for load shedding GOOSEINTMVRCV

3.26.1 Function block

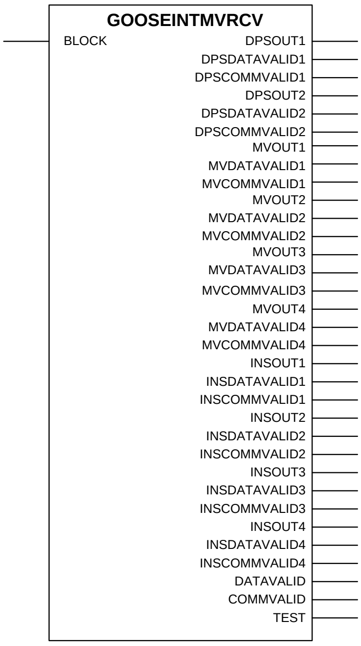


Figure 68: Function block

3.26.2 Functionality

The GOOSE receive function block GOOSEINTMVRCV is used for receiving a set of data required for load-shedding and manual load-shedding functionality from an external system/IEDs with the power sources like generators and grid transformers.

3.26.3 Signals

Table 100: GOOSEINTMVRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of output signals

Table 101: GOOSEINTMVRCV Output signals

Name	Type	Description
DPSOUT1	INTEGER	DPS output 1
DPSDATAVALID1	BOOLEAN	Valid data on DPS output 1
DPSCOMMVALID1	BOOLEAN	Communication Valid for DPS Output 1
DPSOUT2	INTEGER	DPS output 2
DPSDATAVALID2	BOOLEAN	Valid data on DPS output 2
DPSCOMMVALID2	BOOLEAN	Communication Valid for DPS Output 2
MVOUT1	REAL	MV output 1
MVDATAVALID1	BOOLEAN	Valid data on MV output 1
MVCOMMVALID1	BOOLEAN	Communication Valid for MV Output 1
MVOUT2	REAL	MV output 2
MVDATAVALID2	BOOLEAN	Valid data on MV output 2
MVCOMMVALID2	BOOLEAN	Communication Valid for MV Output 2
MVOUT3	REAL	MV output 3
MVDATAVALID3	BOOLEAN	Valid data on MV output 3
MVCOMMVALID3	BOOLEAN	Communication Valid for MV Output 3
MVOUT4	REAL	MV output 4
MVDATAVALID4	BOOLEAN	Valid data on MV output 4
MVCOMMVALID4	BOOLEAN	Communication Valid for MV Output 4
INSOUT1	INTEGER	INS output 1
INSDATAVALID1	BOOLEAN	Valid data on INS output 1
INSCOMMVALID1	BOOLEAN	Communication Valid for INS Output 1
INSOUT2	INTEGER	INS output 2
INSDATAVALID2	BOOLEAN	Valid data on INS output 2
INSCOMMVALID2	BOOLEAN	Communication Valid for INS Output 2
INSOUT3	INTEGER	INS output 3
INSDATAVALID3	BOOLEAN	Valid data on INS output 3
Table continues on next page		

Name	Type	Description
INSCOMMVALID3	BOOLEAN	Communication Valid for INS Output 3
INSOUT4	INTEGER	INS output 4
INSDATAVALID4	BOOLEAN	Valid data on INS output 4
INSCOMMVALID4	BOOLEAN	Communication Valid for INS Output 4
DATAVALID	BOOLEAN	Data valid
COMMVALID	BOOLEAN	Communication valid
TEST	BOOLEAN	Test Output

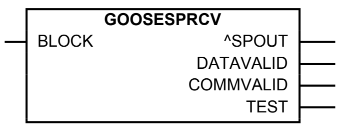
3.26.4 Settings

Table 102: GOOSEINTMVRCV Non group settings (basic)

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

3.27 GOOSE function block to receive a single point value GOOSESPRCV

3.27.1 Function block



IEC10000248-1-en.vsd

Figure 69: Function block

3.27.2 Functionality

GOOSESPRCV is used to receive a single point value using IEC61850 protocol via GOOSE.

3.27.3 Operation principle

The DATAVALID output is HIGH if the incoming message is with valid data.

The COMMVALID output becomes LOW when the sending IED is under total failure condition and the GOOSE transmission from the sending IED does not happen.

The TEST output will go HIGH if the sending IED is in test mode.

The input of this GOOSE block must be linked in Signal Matrix by means of a cross 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, the DATAVALID output is HIGH. If quality data validity is INVALID, QUESTIONABLE, OVERFLOW, FAILURE or OLD DATA, the DATAVALID output is LOW.

3.27.4 Signals

Table 103: GOOSESPRCV Input signals

Name	Type	Default	Description
BLOCK	BOOLEAN	0	Block of function

Table 104: 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

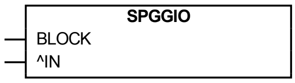
3.27.5 Settings

Table 105: GOOSESPRCV Non group settings (basic)

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

3.28 IEC 61850 generic communication I/O function SPGGIO

3.28.1 Function block



IEC09000237_en_1.vsd

Figure 70: Function block

3.28.2 Functionality

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

3.28.3 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.

3.28.4 Application

IEC 61850-8-1 generic communication I/O functions (SPGGIO) function is used to send one single logical output to other systems or equipment in the substation. It has one visible input, that should be connected in ACT.

3.28.5 Signals

Table 106: SPGGIO Input signals

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

3.28.6 Settings

The function does not have any parameters available in LHMI or PCM600.

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

3.29.1 Function block

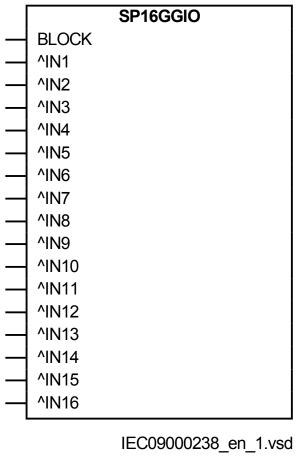


Figure 71: Function block

3.29.2 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.

3.29.3 Operation principle

Upon receiving signals at its inputs, the IEC 61850 generic communication I/O functions 16 inputs (SP16GGIO) function sends the signals over IEC 61850-8-1 to the equipment or system that requests these signals. To be able to get the signal, one must use other tools, described in the engineering manual and define which function block in which equipment or system should receive this information.

There are also 16 output signals that show the input status for each input as well as an OR type output combined for all 16 input signals. These output signals are handled in the Parameter Setting tool.

3.29.4 Signals

Table 107: 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

3.29.5 Settings

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

3.29.6 Monitored data

Table 108: 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
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
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

3.30 IEC 61850 generic communication I/O function MVGGIO

3.30.1 Function block

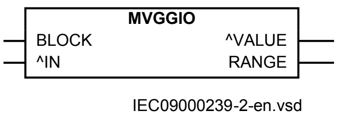


Figure 72: Function block

3.30.2 Functionality

IEC 61850 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.

3.30.3 Operation principle

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

3.30.4 Application

IEC 61850 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.

3.30.5 Signals

Table 109: MVGGIO Input signals

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

Table 110: MVGGIO Output signals

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

3.30.6 Settings

Table 111: 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)

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
MV lLim	-5000.00 - 5000.00	xBase	0.01	-800.00	Low limit multiplied with the base prefix (multiplication factor)
MV llLim	-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)

3.30.7 Monitored data

Table 112: 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

3.31 IEC 61850 generic communication I/O functions DPGGIO

3.31.1 Function block

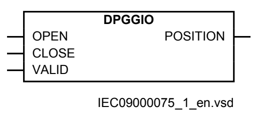


Figure 73: Function block

3.31.2 Functionality

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

3.31.3 Operation principle

Upon receiving the input signals, the IEC 61850 generic communication I/O functions (DPGGIO) function block sends the signals over IEC 61850-8-1 to the equipment or system that requests these signals. To be able to get the signals, PCM600 must be used to define which function block in which equipment or system should receive this information.

3.31.4 Signals

Table 113: DPGGIO Input signals

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

Table 114: DPGGIO Output signals

Name	Type	Description
POSITION	INTEGER	Double point indication

3.31.5 Settings

The function does not have any parameters available in LHMI or PCM600.

3.32 Configurable logic blocks

3.32.1 Standard configurable logic blocks

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

- **OR**
- **INVERTER** inverts the input signal
- **PULSETIMER** can be used, for example, for pulse extensions or limiting of operation of outputs
- **GATE** is used for controlling if a signal should be able to pass from the input to the output or not, depending on a setting

- **XOR**
- **LOOPDELAY** used to delay the output signal one execution cycle
- **TIMERSET** has pick-up and drop-out delayed outputs related to the input signal; the timer has a settable time delay
- **AND**
- **SRMEMORY** is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. Set input has priority.
- **RSMEMORY** is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block after a power interruption should return to the state before the interruption, or be reset. Reset input has priority.

3.32.1.1 OR function block

Function block

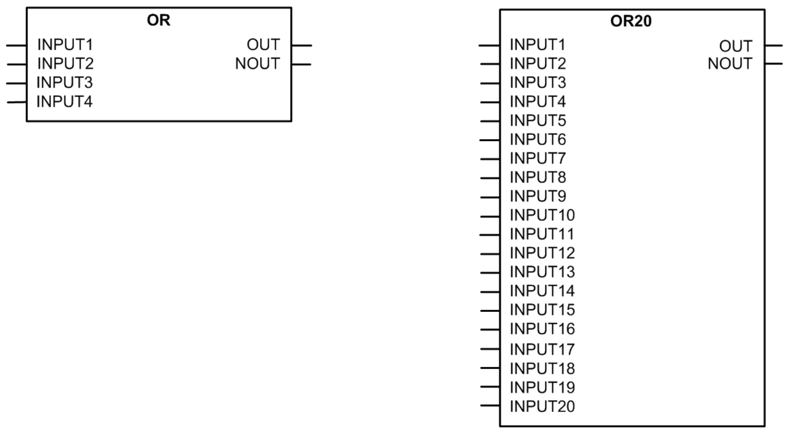


Figure 74: Function block

Functionality

OR and OR20 are used to form general combinatorial expressions with Boolean variables.

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

OR has six inputs and OR20 has 20 inputs. The output OUT has a default value FALSE initially, which suppresses one cycle pulse if the function has been put in the wrong execution order.

Connect at least one output to another function block or to a variable for the function to execute correctly.

Signals

Table 115: 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 116: OR20 Input signals

Name	Type	Default	Description
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
INPUT17	BOOLEAN	0	Input 17
INPUT18	BOOLEAN	0	Input 18
INPUT19	BOOLEAN	0	Input 19
INPUT20	BOOLEAN	0	Input 20

Table 117: OR Output signals

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

Table 118: OR20 Output signals

Name	Type	Description
OUT	BOOLEAN	Output
NOUT	BOOLEAN	Inverted output

Settings

The function does not have any parameters available in LHMI or PCM600.

3.32.1.2 Inverter function block INVERTER

Function block

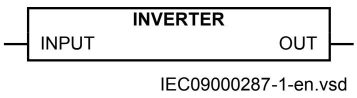


Figure 75: Function block

Signals

Table 119: INVERTER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 120: INVERTER Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

The function does not have any parameters available in LHMI or PCM600.

3.32.1.3 PULSETIMER function block

Function block

IEC09000291-1-en.vsd

Figure 76: Function block

Functionality

The pulse function can be used, for example for pulse extensions or limiting of operation of outputs. The PULSETIMER has a settable length.

Signals

Table 121: PULSETIMER Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 122: PULSETIMER Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 123: 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

3.32.1.4 Controllable gate function block GATE

Function block

IEC09000295-1-en.vsd

Figure 77: Function block

Functionality

The GATE function block is used for controlling if a signal should pass from the input to the output or not, depending on setting.

Signals

Table 124: GATE Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 125: GATE Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

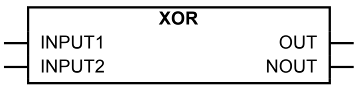
Settings

Table 126: GATE Group settings (basic)

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

3.32.1.5 Exclusive OR function block XOR

Function block



IEC09000292-1-en.vsd

Figure 78: Function block

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.

Signals

Table 127: XOR Input signals

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

Table 128: 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 LHMI or PCM600.

3.32.1.6 Loop delay function block LOOPDELAY

Function block

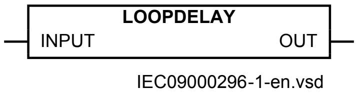


Figure 79: Function block

Functionality

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

Signals

Table 129: LOOPDELAY Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 130: 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 LHMI or PCM600.

3.32.1.7 Timer function block TIMERSET

Function block

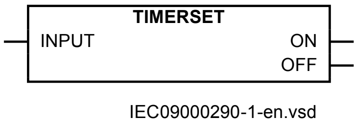


Figure 80: Function block

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*.

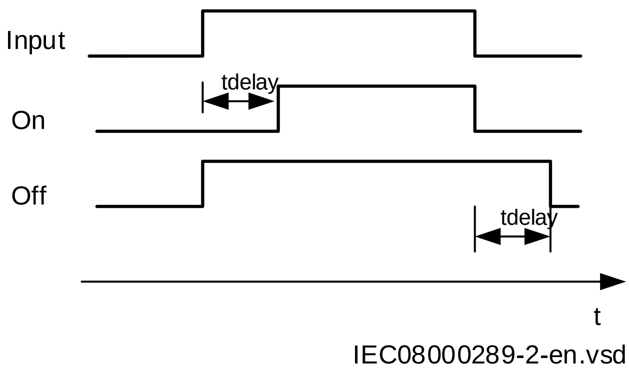


Figure 81: TIMERSET Status diagram

Signals

Table 131: TIMERSET Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 132: TIMERSET Output signals

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

Settings

Table 133: 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

3.32.1.8 AND function block

Function block

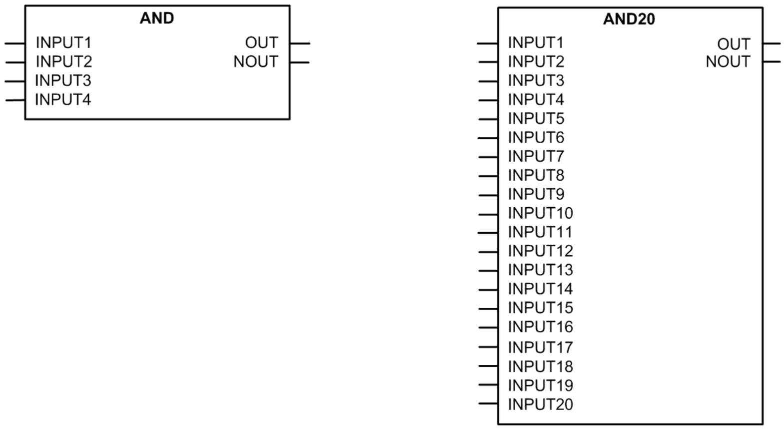


Figure 82: Function block

Functionality

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

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

AND has four inputs and AND20 has 20 inputs. The output `OUT` has a default value FALSE initially, which suppresses one cycle pulse if the function has been put in the wrong execution order.

Connect at least one output to another function block or to a variable for the function to execute correctly.

Signals

Table 134: 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 135: AND20 Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	1	Input 1
INPUT2	BOOLEAN	1	Input 2
INPUT3	BOOLEAN	1	Input 3
INPUT4	BOOLEAN	1	Input 4
INPUT5	BOOLEAN	1	Input 5
INPUT6	BOOLEAN	1	Input 6
INPUT7	BOOLEAN	1	Input 7
INPUT8	BOOLEAN	1	Input 8
INPUT9	BOOLEAN	1	Input 9
INPUT10	BOOLEAN	1	Input 10
INPUT11	BOOLEAN	1	Input 11
INPUT12	BOOLEAN	1	Input 12
INPUT13	BOOLEAN	1	Input 13
INPUT14	BOOLEAN	1	Input 14
INPUT15	BOOLEAN	1	Input 15
INPUT16	BOOLEAN	1	Input 16
INPUT17	BOOLEAN	1	Input 17
INPUT18	BOOLEAN	1	Input 18
INPUT19	BOOLEAN	1	Input 19
INPUT20	BOOLEAN	1	Input 20

Table 136: AND Output signals

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

Table 137: AND20 Output signals

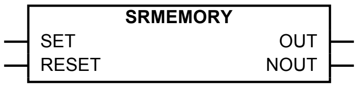
Name	Type	Description
OUT	BOOLEAN	Output
NOUT	BOOLEAN	Inverted output

Settings

The function does not have any parameters available in LHMI or PCM600.

3.32.1.9 Set-reset memory function block SRMEMORY

Function block



IEC09000293-1-en.vsd

Figure 83: Function block

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 returns the state it had before or if it is reset. For a Set-Reset flip-flop, `SET` input has higher priority over `RESET` input.

Table 138: Truth table for the Set-Reset (SRMEMORY) function block

SET	RESET	OUT	NOUT
1	0	1	0
0	1	0	1
1	1	1	0
0	0	0	1

Signals

Table 139: SRMEMORY Input signals

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

Table 140: SRMEMORY Output signals

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

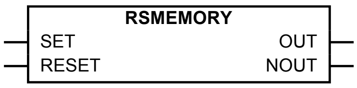
Settings

Table 141: SRMEMORY Group settings (basic)

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

3.32.1.10 Reset-set with memory function block RSMEMORY

Function block



IEC09000294-1-en.vsd

Figure 84: Function block

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 returns the state it had before or if it is reset. For a Reset-Set flip-flop, `RESET` input has higher priority over `SET` input.

Table 142: Truth table for RSMEMORY 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

Signals

Table 143: RSMEMORY Input signals

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

Table 144: RSMEMORY Output signals

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

Settings

Table 145: RSMEMORY Group settings (basic)

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

3.32.1.11 Equality check for real signals EQR

Function block

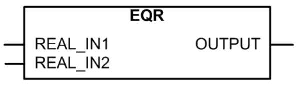


Figure 85: Function block

Functionality

The EQR function block compares the real inputs `REAL_IN1` and `REAL_IN2` and activates the binary output `OUTPUT`, if `REAL_IN1` is equal to `REAL_IN2`.

If `REAL_IN1` == `REAL_IN2`, `OUTPUT` = 1, else `OUTPUT` = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 146: EQR Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 147: EQR Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.12 Equality check for integer signals EQI

Function block

Figure 86: Function block

Functionality

The EQI function compares the integer inputs `INT_IN1` and `INT_IN2` and activates the binary output `OUTPUT`, if `INT_IN1` is equal to `INT_IN2`.

If `INT_IN1` = `INT_IN2`, `OUTPUT` = 1, else `OUTPUT` = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 148: EQI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 149: EQI Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.13 Greater than check for real signals GTR

Function block

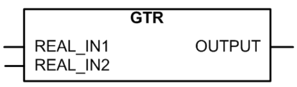


Figure 87: Function block

Functionality

The function compares the real inputs `REAL_IN1` and `REAL_IN2` and activates the binary output `OUTPUT`, if `REAL_IN1` is greater than `REAL_IN2`.

If REAL_IN1 > REAL_IN2, OUTPUT = 1, else OUTPUT = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 150: GTR Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 151: GTR Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.14 Greater than check for integer signals GTI

Function block

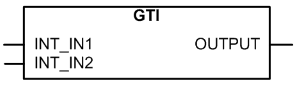


Figure 88: Function block

Functionality

The function compares the integer inputs INT_IN1 and INT_IN2 and activates the binary output OUTPUT, if INT_IN1 is greater than INT_IN2.

If INT_IN1 > INT_IN2, OUTPUT = 1, else OUTPUT = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 152: GTI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 153: GTI Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.15 Greater than or equal check for real signals GER

Function block

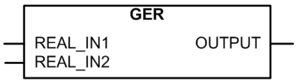


Figure 89: Function block

Functionality

The function compares the real inputs `REAL_IN1` and `REAL_IN2` and activates the binary output `OUTPUT`, if `REAL_IN1` is greater than or equal to `REAL_IN2`.

If `REAL_IN1` ≥ `REAL_IN2`, `OUTPUT` = 1, else `OUTPUT` = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 154: GER Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 155: GER Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.16 Greater than or equal check for integer signals GEI

Function block

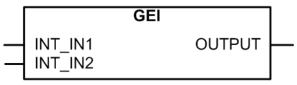


Figure 90: Function block

Functionality

The function compares the integer inputs INT_IN1 and INT_IN2 and activates the binary output OUTPUT, if INT_IN1 is greater than or equal to INT_IN2.

If INT_IN1 ≥ INT_IN2, OUTPUT = 1, else OUTPUT = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 156: GEI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 157: GEI Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.17 Less than check for real signals LTR

Function block

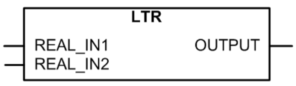


Figure 91: Function block

Functionality

The function compares the real inputs REAL_IN1 and REAL_IN2 and activates the binary output OUTPUT, if REAL_IN1 is less than REAL_IN2.

If REAL_IN1 < REAL_IN2, OUTPUT = 1, else OUTPUT = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 158: LTR Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 159: LTR Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.18 Less than check for integer signals LTI

Function block

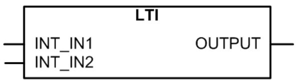


Figure 92: Function block

Functionality

The function compares the integer inputs `INT_IN1` and `INT_IN2` and activates the binary output `OUTPUT`, if `INT_IN1` is less than `INT_IN2`.

If `INT_IN1` < `INT_IN2`, `OUTPUT` = 1, else `OUTPUT` = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 160: LTI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 161: LTI Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.19 Less than or equal check for real signals LER

Function block

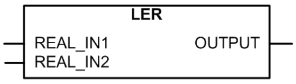


Figure 93: Function block

Functionality

The function compares the real inputs REAL_IN1 and REAL_IN2 and activates the binary output OUTPUT, if REAL_IN1 is less than or equal to REAL_IN2.

If REAL_IN1 ≤ REAL_IN2, OUTPUT = 1, else OUTPUT = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 162: LER Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 163: LER Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.20 Less than or equal check for integer signals LEI

Function block

Figure 94: Function block

Functionality

The function compares the integer inputs INT_IN1 and INT_IN2 and activates the binary output OUTPUT, if INT_IN1 is less than or equal to INT_IN2.

If $\texttt{INT\_IN1} \leq \texttt{INT\_IN2}$, $\texttt{OUTPUT} = 1$, else $\texttt{OUTPUT} = 0$.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 164: LEI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 165: LEI Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.21 Not equal check for real signals NER

Function block

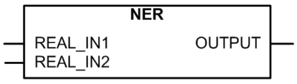


Figure 95: Function block

Functionality

The function compares the real inputs REAL_IN1 and REAL_IN2 and activates the binary output OUTPUT, if REAL_IN1 not equal to REAL_IN2.

If $\texttt{REAL\_IN1} \neq \texttt{REAL\_IN2}$, $\texttt{OUTPUT} = 1$, else $\texttt{OUTPUT} = 0$.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 166: NER Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 167: NER Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.1.22 Not equal check for integer signals NEI

Function block

Figure 96: Function block

Functionality

The function compares the integer inputs `INT_IN1` and `INT_IN2` and activates the binary output `OUTPUT`, if `INT_IN1` is not equal to `INT_IN2`.

If `INT_IN1` ≠ `INT_IN2`, `OUTPUT` = 1, else `OUTPUT` = 0.

Logic function blocks do not have the hysteresis feature. Oscillating outputs should be avoided when comparing analog signals that have very closely varying values.

Signals

Table 168: NEI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 169: NEI Output signals

Name	Type	Description
OUTPUT	BOOLEAN	Binary output

3.32.2 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.

3.32.2.1 ORQT function block

Function block

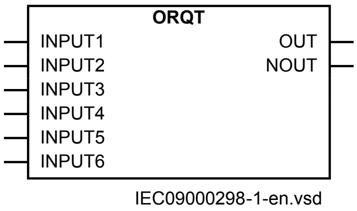


Figure 97: Function block

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.

Signals

Table 170: 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 171: 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 LHMI or PCM600.

3.32.2.2 INVERTERQT function block

Function block

IEC09000299-1-en.vsd

Figure 98: Function block

Signals

Table 172: INVERTERQT Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 173: INVERTERQT Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

The function does not have any parameters available in LHMI or PCM600.

3.32.2.3 Pulse timer function block PULSTIMERQT

Function block

IEC09000304-1-en.vsd

Figure 99: Function block

Functionality

Pulse timer function block (PULSETIMERQT) can be used, for example, for pulse extensions or limiting of operation of outputs. The pulse timer has a settable length and also propagates quality and time.

When the input goes to 1 the output is 1 for the time set by the time delay parameter *t*. Then return to 0.

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

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

Signals

Table 174: PULSETIMERQT Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 175: PULSETIMERQT Output signals

Name	Type	Description
OUT	BOOLEAN	Output signal

Settings

Table 176: 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

3.32.2.4 XORQT function block

Function block

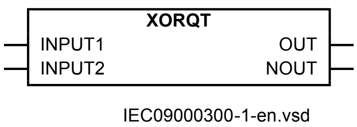


Figure 100: Function block

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.

Signals

Table 177: XORQT Input signals

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

Table 178: 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 LHMI or PCM600.

3.32.2.5 Settable timer function block TIMERSETQT

Function block

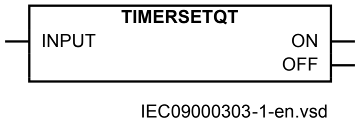


Figure 101: Function block

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 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 does not lead to an updated timestamp on the output.

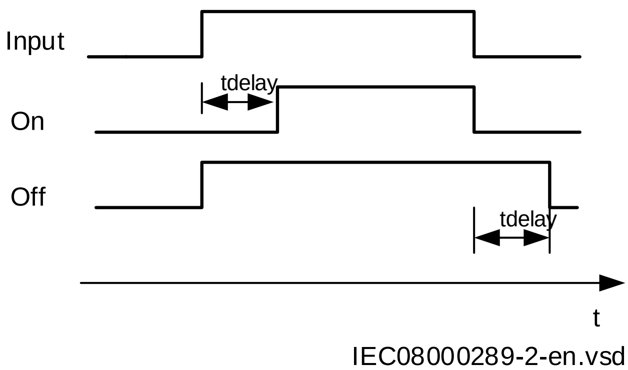


Figure 102: TIMERSETQT function

Signals

Table 179: TIMERSETQT Input signals

Name	Type	Default	Description
INPUT	BOOLEAN	0	Input signal

Table 180: TIMERSETQT Output signals

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

Settings

Table 181: 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

3.32.2.6 ANDQT function block

Function block

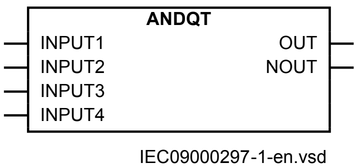


Figure 103: Function block

Functionality

ANDQT function is used to form general combinatory expressions with Boolean variables. ANDQT function block has four inputs and two outputs.

Default value on all four inputs is logical 1 which makes it possible to use only the required number of inputs and leave the rest un-connected. The output `OUT` has an initial default value 0, which suppresses one cycle pulse if the function has been put in the wrong execution order.

Signals

Table 182: 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 183: ANDQT Output signals

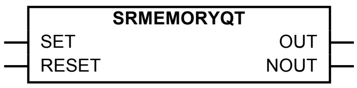
Name	Type	Description
OUT	BOOLEAN	Output signal
NOUT	BOOLEAN	Inverted output signal

Settings

The function does not have any parameters available in LHMI or PCM600.

3.32.2.7 Set-reset function block SRMEMORYQT

Function block



IEC09000301-1-en.vsd

Figure 104: Function block

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 returns to its previous state or if it is reset. SRMEMORYQT propagates quality and time as well as value.

Table 184: SRMEMORYQT functionality

SET	RESET	OUT	NOUT
1	0	1	0
0	1	0	1
1	1	1	0
0	0	0	1

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

Signals

Table 185: SRMEMORYQT Input signals

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

Table 186: SRMEMORYQT Output signals

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

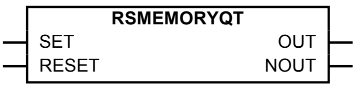
Settings

Table 187: SRMEMORYQT Group settings (basic)

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

3.32.2.8 Reset-set function block RSMEMORYQT

Function block



IEC09000302-1-en.vsd

Figure 105: Function block

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 returns to its previous state or if it is reset.

Table 188: RSMEMORYQT functionality

SET	RESET	OUT	NOUT
1	0	1	0
0	1	0	1
1	1	0	1
0	0	0	1

Signals

Table 189: RSMEMORYQT Input signals

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

Table 190: RSMEMORYQT Output signals

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

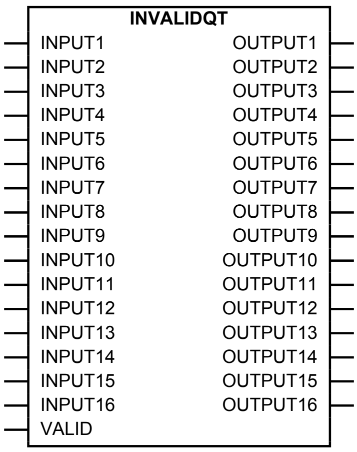
Settings

Table 191: RSMEMORYQT Group settings (basic)

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

3.32.2.9 INVALIDQT function block

Function block



IEC09000305-1-en.vsd

Figure 106: Function block

Functionality

INVALIDQT is a 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 is set. The timestamp of an output is set to the latest timestamp of INPUT and VALID input.

Signals

Table 192: INVALIDQT Input signals

Name	Type	Default	Description
INPUT1	BOOLEAN	0	Indication input 1
INPUT2	BOOLEAN	0	Indication input 2
INPUT3	BOOLEAN	0	Indication input 3
INPUT4	BOOLEAN	0	Indication input 4
INPUT5	BOOLEAN	0	Indication input 5
INPUT6	BOOLEAN	0	Indication input 6
INPUT7	BOOLEAN	0	Indication input 7
INPUT8	BOOLEAN	0	Indication input 8
INPUT9	BOOLEAN	0	Indication input 9
INPUT10	BOOLEAN	0	Indication input 10
INPUT11	BOOLEAN	0	Indication input 11
INPUT12	BOOLEAN	0	Indication input 12
INPUT13	BOOLEAN	0	Indication input 13
INPUT14	BOOLEAN	0	Indication input 14
INPUT15	BOOLEAN	0	Indication input 15
INPUT16	BOOLEAN	0	Indication input 16
VALID	BOOLEAN	1	Inputs are valid or not

Table 193: 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

Table continues on next page

Name	Type	Description
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 LHMI or PCM600.

3.32.3 Application

A set of standard logic blocks, like AND or OR, and timers are available for adapting the IED configuration to the specific application needs. Additional logic blocks that have the capability to propagate timestamp and quality beside the normal logical function are also available. Those blocks have a designation including the letters QT, for example, ANDQT or ORQT.

3.32.4 Technical data

Table 194: Configurable logic blocks

Logic block	Quantity with cycle time			Range or value	Accuracy
	fast	medium	normal		
AND	60	60	160	-	-
B16I	5	5	-	-	-
GATE	10	10	20	-	-
IB16A	5	5	-	-	-
INVERTER	30	30	80	-	-
ITOR	10	10	10	-	-
LOOPDELAY	10	10	20	-	-
MINMAXR	5	10	5	-	-
OR	60	60	160	-	-
PULSETIMER	10	10	20	(0.000–90000.000) s	± 0.5% ± 25 ms
RSMEMORY	10	10	20	-	-
RTOI	10	10	10		
SRMEMORY	10	10	20	-	-
SWITCHI	10	10	10	-	-
SWITCHR	10	10	10	-	-
TIMERSET	10	10	20	(0.000–90000.000) s	± 0.5% ± 25 ms
XOR	10	10	20	-	-

Table 195: Configurable logic Q/T

Logic block	Quantity with cycle time		Range or value	Accuracy
	medium	normal		
ANDQT	20	100	-	-
INVALIDQT	6	6	-	-
INVERTERQT	20	100	-	-
ORQT	20	100	-	-
PULSETIMERQT	10	30	(0.000-90000.000) s	± 0.5% ± 25 ms
RSMEMORYQT	10	30	-	-
SRMEMORYQT	10	30	-	-
TIMERSETQT	10	30	(0.000-90000.000) s	± 0.5% ± 25 ms
XORQT	10	30	-	-

3.33 Boolean 16 to integer conversion B16I

3.33.1 Function block

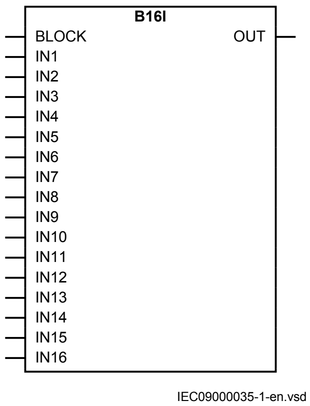


Figure 107: Function block

3.33.2 Functionality

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

3.33.3 Operation principle

Boolean 16 to integer conversion function (B16I) is used to transform a set of 16 binary (logical) signals into an integer. The BLOCK input freezes the output at the last value.

3.33.4 Signals

Table 196: B16I Input signals

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

Table 197: B16I Output signals

Name	Type	Description
OUT	INTEGER	Output value

3.33.5 Settings

The function does not have any parameters available in LHMI or PCM600.

3.33.6 Monitored data

Table 198: B16I Monitored data

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

3.34 Integer to boolean 16 conversion IB16A

3.34.1 Function block

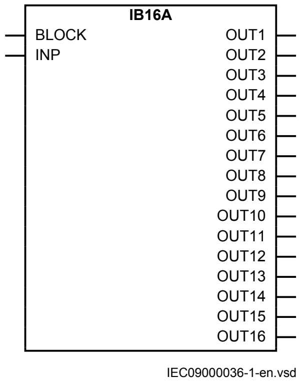


Figure 108: Function block

3.34.2 Functionality

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

3.34.3 Operation principle

Integer to boolean 16 conversion function (IB16A) is used to transform an integer into a set of 16 binary (logical) signals. IB16A function is designed for receiving the integer input locally. The BLOCK input freezes the logical outputs at the last value.

3.34.4 Signals

Table 199: IB16A Input signals

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

Table 200: IB16A Output signals

Name	Type	Description
OUT1	BOOLEAN	Output 1
OUT2	BOOLEAN	Output 2
OUT3	BOOLEAN	Output 3
OUT4	BOOLEAN	Output 4
Table continues on next page		

Name	Type	Description
OUT5	BOOLEAN	Output 5
OUT6	BOOLEAN	Output 6
OUT7	BOOLEAN	Output 7
OUT8	BOOLEAN	Output 8
OUT9	BOOLEAN	Output 9
OUT10	BOOLEAN	Output 10
OUT11	BOOLEAN	Output 11
OUT12	BOOLEAN	Output 12
OUT13	BOOLEAN	Output 13
OUT14	BOOLEAN	Output 14
OUT15	BOOLEAN	Output 15
OUT16	BOOLEAN	Output 16

3.34.5 Settings

The function does not have any parameters available in LHMI or PCM600.

3.35 Additional arithmetic and logic functions

3.35.1 Additional arithmetic and logic functions

The additional arithmetic or logic functions are used in the ACT level as a connection between function blocks.

The available arithmetic functions are integer addition, integer division, integer multiplication, integer subtraction, real addition, real division, real multiplication, real subtraction, integer to real conversion, real to integer conversion and ten input real minimum or maximum functionalities.

The available logic functions are two-input integer switch and two-input real switch functionalities.

3.35.2 ADDI function block

3.35.2.1 Function block

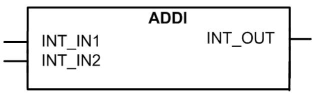


Figure 109: Function block

3.35.2.2 Functionality

ADDI integer adding block adds the integer inputs `INT_IN1` and `INT_IN2` together. ADDI executes the equation:

$$INT\_OUT = INT\_IN1 + INT\_IN2$$

(Equation 1)

3.35.2.3 Signals

Table 201: ADDI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 202: ADDI Output signals

Name	Type	Description
INT_OUT	INTEGER	Integer output

3.35.3 ADDR function block

3.35.3.1 Function block

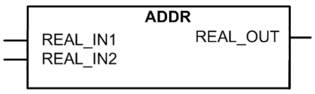


Figure 110: Function block

3.35.3.2 Functionality

ADDR real adding block adds the real inputs `REAL_IN1` and `REAL_IN2` together. ADDR executes the equation:

$$REAL\_OUT = REAL\_IN1 + REAL\_IN2$$

(Equation 2)

3.35.3.3 Signals

Table 203: ADDR Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 204: ADDR Output signals

Name	Type	Description
REAL_OUT	REAL	Real output

3.35.4 DIVI function block

3.35.4.1 Function block

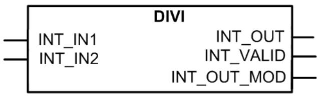


Figure 111: Function block

3.35.4.2 Functionality

DIVI integer division block divides the `INT_IN1` input by `INT_IN2`. The output of the division, the module of division `INT_OUT_MOD` and the validity of integer division in case of division by zero `INT_VALID`.

DIVI executes two equations

$$INT\_OUT = \frac{INT\_IN1}{INT\_IN2}$$

(Equation 3)

$$INT\_OUT\_MOD = MOD\left(\frac{INT\_IN1}{INT\_IN2}\right)$$

(Equation 4)

Table 205: INT_VALID behavior

Input INT_IN2	Output INT_VALID
Zero	FALSE
Lower or higher than zero	TRUE

3.35.4.3 Signals

Table 206: DIVI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 207: DIVI Output signals

Name	Type	Description
INT_OUT	INTEGER	Integer output
INT_VALID	BOOLEAN	Integer output validity
INT_OUT_MOD	INTEGER	Integer output division modulo

3.35.5 DIVR function block

3.35.5.1 Function block

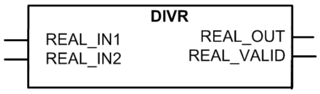


Figure 112: Function block

3.35.5.2 Functionality

DIVR real division block divides the REAL_IN1 input by REAL_IN2. The outputs are the division and the division validity in case of division by zero REAL_VALID.

DIVR executes an equation

$$REAL\_OUT = \frac{REAL\_IN1}{REAL\_IN2}$$

(Equation 5)

Table 208: REAL_VALID behavior

Input REAL_IN2	Output REAL_VALID
Zero	FALSE
Lower or higher than zero	TRUE

3.35.5.3 Signals

Table 209: DIVR Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 210: DIVR Output signals

Name	Type	Description
REAL_OUT	REAL	Real output
REAL_VALID	BOOLEAN	Real output validity

3.35.6 MULI function block

3.35.6.1 Function block

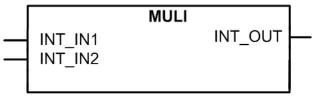


Figure 113: Function block

3.35.6.2 Functionality

MULI integer multiplication block multiplies the integer input `INT_IN1` with the `INT_IN2` integer input.

MULI executes the equation

$$INT\_OUT = INT\_IN1 \cdot INT\_IN2$$

(Equation 6)

3.35.6.3 Signals

Table 211: MULI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 212: MULI Output signals

Name	Type	Description
INT_OUT	INTEGER	Integer output

3.35.7 MULR function block

3.35.7.1 Function block

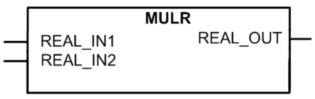


Figure 114: Function block

3.35.7.2 Functionality

MULR real multiplication block multiplies the real input REAL_IN1 with the real input REAL_IN2.

MULR executes the equation:

$$REAL\_OUT = REAL\_IN1 \cdot REAL\_IN2$$

(Equation 7)

3.35.7.3 Signals

Table 213: MULR Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 214: MULR Output signals

Name	Type	Description
REAL_OUT	REAL	Real output

3.35.8 SUBI function block

3.35.8.1 Function block

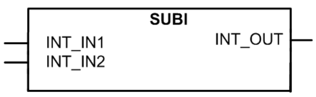


Figure 115: Function block

3.35.8.2 Functionality

SUBI integer subtracting block subtracts the integer input INT_IN2 from the INT_IN1 integer input.

SUBI executes the equation:

$$INT\_OUT = INT\_IN1 - INT\_IN2$$

(Equation 8)

3.35.8.3 Signals

Table 215: SUBI Input signals

Name	Type	Default	Description
INT_IN1	INTEGER	0	Integer input 1
INT_IN2	INTEGER	0	Integer input 2

Table 216: SUBI Output signals

Name	Type	Description
INT_OUT	INTEGER	Integer output

3.35.9 SUBR function block

3.35.9.1 Function block

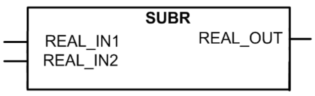


Figure 116: Function block

3.35.9.2 Functionality

SUBR real subtracting block subtracts the real input `REAL_IN2` from the real input `REAL_IN1`.

SUBR executes the equation:

$$REAL\_OUT = REAL\_IN1 - REAL\_IN2$$

(Equation 9)

3.35.9.3 Signals

Table 217: SUBR Input signals

Name	Type	Default	Description
REAL_IN1	REAL	0.0	Real input 1
REAL_IN2	REAL	0.0	Real input 2

Table 218: SUBR Output signals

Name	Type	Description
REAL_OUT	REAL	Real output

3.35.10 ITOR function block

3.35.10.1 Function block

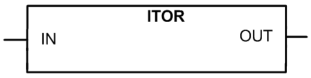


Figure 117: Function block

3.35.10.2 Functionality

ITOR integer to real conversion block converts the integer input `IN` to the real value output `OUT`.

3.35.10.3 Signals

Table 219: ITOR Input signals

Name	Type	Default	Description
IN	INTEGER	0	Integer input

Table 220: ITOR Output signals

Name	Type	Description
OUT	REAL	Real outpout

3.35.11 RTOI function block

3.35.11.1 Function block

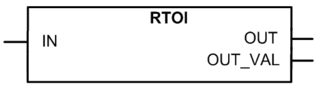


Figure 118: Function block

3.35.11.2 Functionality

RTOI real to integer conversion block converts the real input `IN` to the integer value output `OUT` with the validity information `OUT_VAL` as the real value can exceed the integer size.

Table 221: RTOI OUT_VAL logic

Value of OUT_VAL	Description
TRUE	Integer conversion valid
FALSE	Absolute real input size exceeds the maximum integer size

3.35.11.3 Signals

Table 222: RTOI Input signals

Name	Type	Default	Description
INT	REAL	0.0	Real input

Table 223: RTOI Output signals

Name	Type	Description
OUT	INTEGER	Integer output
OUT_VAL	BOOLEAN	Output conversion validity

3.35.12 MINMAXR function block

3.35.12.1 Function block

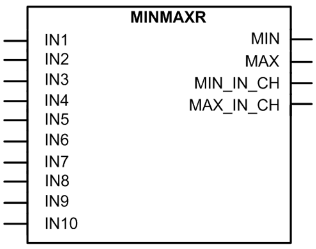


Figure 119: Function block

3.35.12.2 Functionality

MINMAXR minimum and maximum value selector from the real input signals finds the minimum and maximum value from the ten inputs and gives the quantities of these to the outputs `MIN` and `MAX` as well as the channel number that has the absolute minimum and maximum values `MIN_IN_CH` and `MAX_IN_CH`. When using less than ten inputs, the last connected input should be connected to all the rest open inputs for correct operation.

3.35.12.3 Signals

Table 224: MINMAXR Input signals

Name	Type	Default	Description
IN1	REAL	0.0	input channel1
IN2	REAL	0.0	input channel2
IN3	REAL	0.0	input channel3
IN4	REAL	0.0	input channel4
IN5	REAL	0.0	input channel5
IN6	REAL	0.0	input channel6
IN7	REAL	0.0	input channel7
IN8	REAL	0.0	input channel8
IN9	REAL	0.0	input channel9
IN10	REAL	0.0	input channel10

Table 225: MINMAXR Output signals

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

3.35.13 SWITCHI function block

3.35.13.1 Function block

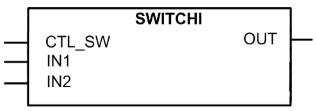


Figure 120: Function block

3.35.13.2 Functionality

SWITCHI integer switching block, operated by the `CTL_SW` input, selects the output `OUT` between the inputs `IN1` and `IN2`.

Table 226: SWITCHI output logic

CTL_SW	OUT
FALSE	IN2
TRUE	IN1

3.35.13.3 Signals

Table 227: SWITCHI Input signals

Name	Type	Default	Description
CTL_SW	BOOLEAN	1	Control Switch
IN1	INTEGER	0	Integer input 1
IN2	INTEGER	0	Integer input 2

Table 228: SWITCHI Output signals

Name	Type	Description
OUT	INTEGER	Integer switch output

3.35.14 SWITCHR function block

3.35.14.1 Function block

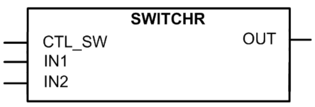


Figure 121: Function block

3.35.14.2 Functionality

SWITCHR real switching block, operated by the `CTL_SW` input, selects the output value `OUT` between the `IN1` and `IN2` inputs.

CTL_SW	OUT
FALSE	IN2
TRUE	IN1

3.35.14.3 Signals

Table 229: SWITCHR Input signals

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

Table 230: SWITCHR Output signals

Name	Type	Description
OUT	REAL	Real switch output

3.36 Factory settings restoration

In case of configuration data loss or error that prevents the IED from working properly, the configuration can be restored to the original factory state. All default settings and configuration files stored in the factory are restored.

For further information on restoring factory settings, contact customer support.

3.37 GATEWAY function block

Table 231: GATEWAY Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
GWAddress	0 - 18	IP Address	1	0.0.0.0	Gateway address

3.38 SYSTEMTIME function block

Table 232: SYSTEMTIME Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
SystemTime	System time				

3.39 WEBSERVER function block

Table 233: WEBSERVER Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation On/Off
Write mode	Writing disabled Writing enabled	-	-	Writing disabled	Writing of settings enabled
Session timeout	2 - 60	Min	1	3	Session timeout

Section 4 Protection functions

4.1 Multipurpose analog protection MAPGAPC

4.1.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE C37.2 device number
Multipurpose analog protection	MAPGAPC	MAP	MAP

4.1.2 Function block

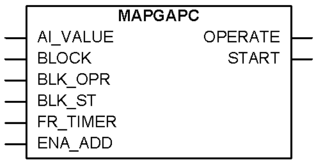


Figure 122: Function block

4.1.3 Functionality

The multipurpose analog protection function MAPGAPC is used as a general protection with many possible application areas as it has flexible measuring and setting facilities. The function can be used as an underprotection or overprotection with a settable absolute hysteresis limit. The function operates with the definite time (DT) characteristics.

The function contains a blocking functionality. It is possible to block function outputs, the definite timer or the function itself, if desired.

4.1.4 Operation principle

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

The operation of the multipurpose analog protection function can be described using a module diagram. All the modules in the diagram are explained in the next sections.

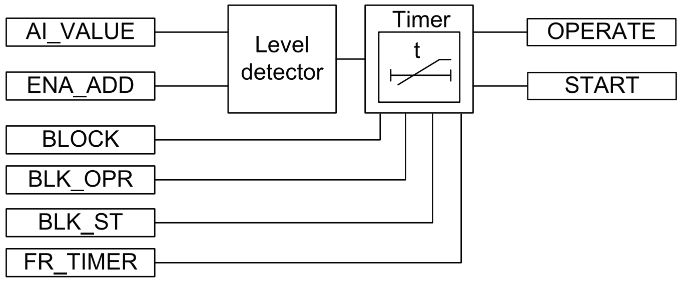


Figure 123: Functional module diagram

Level detector

The level detector compares `AI_VALUE` to the *Start value* setting. The *Operation mode* setting defines the direction of the level detector.

Table 234: Operation mode types

Operation Mode	Description
"Under"	If the input signal `AI_VALUE` is lower than the set value of the "Start value" setting, the level detector enables the timer module.
"Over"	If the input signal `AI_VALUE` exceeds the set value of the *Start value* setting, the level detector enables the timer module.

The *Absolute hysteresis* setting can be used for preventing unnecessary oscillations if the input signal is slightly above or below the *Start value* setting. After leaving the hysteresis area, the start condition has to be fulfilled again and it is not sufficient for the signal to only return to the hysteresis area. If the `ENA_ADD` input is activated, the threshold value of the internal comparator is the sum of the *Start value Add* and *Start value* settings. The resulting threshold value for the comparator can be increased or decreased depending on the sign and value of the *Start value Add* setting.

Timer

Once activated, the timer activates the `START` output. The time characteristic is according to DT. When the operation timer has reached the value set by *Operate delay time*, the `OPERATE` output is activated. If the starting condition disappears before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operation timer resets and the `START` output is deactivated.

MAPGAPC can be blocked from the binary input `BLOCK`. The activation of the `BLOCK` input deactivates all outputs and resets internal timers. The start signals from the function can be blocked from the binary input `BLK_ST`. The operate signals from the function can be blocked from the binary input `BLK_OPR`. The operation timer counting can be frozen to the prevailing value by activating the `FR_TIMER` input signal.

4.1.5 Application

The function block can be used for any general analog signal protection, either underprotection or overprotection. The setting range is wide, allowing various protection schemes for the function. Thus, the absolute hysteresis can be set to a value that suits the application.

The temperature protection using the RTD sensors can be done using the function block. The measured temperature can be fed from the RTD sensor to the function input that detects too high temperatures in the motor bearings or windings, for example. When the `ENA_ADD` input is enabled, the threshold value of the internal comparator is the sum of the *Start value Add* and *Start value* settings. This allows a temporal increase or decrease of the level detector depending on the sign and value of the *Start value Add* setting, for example, when the emergency start is activated. If, for example, *Start value* is 100, *Start value Add* is 20 and the `ENA_ADD` input is active, the input signal needs to rise above 120 before MAPGAPC operates.

4.1.6 Signals

Table 235: MAPGAPC Input signals

Name	Type	Default	Description
AI_VALUE	REAL	0.0	Analog input value
BLOCK	BOOLEAN	0	Block overall function
BLK_OPR	BOOLEAN	0	Block operate output
BLK_ST	BOOLEAN	0	Block start output
FR_TIMER	BOOLEAN	0	Freeze internal operate timer
ENA_ADD	BOOLEAN	0	Enable start using added start value

Table 236: MAPGAPC Output signals

Name	Type	Description
OPERATE	BOOLEAN	Operated
START	BOOLEAN	Started signal

4.1.7 Settings

Table 237: MAPGAPC Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Start value	-10000.0 - 10000.0	-	0.1	0.0	Start value
Start value Add	-100.0 - 100.0	-	0.1	0.0	Added value to start value
Operate delay time	0.03 - 200.00	s	0.01	0.03	Operate delay time

Table 238: MAPGAPC Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Operation mode	Over Under	-	-	Over	Operation mode (1=Over;2=Under)

Table 239: MAPGAPC Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Absolute hysteresis	0.01 - 100.00	-	0.01	0.10	Absolute hysteresis for operation
Reset delay time	0.00 - 60.00	s	0.01	0.00	Reset delay time

4.1.8 Measured values

Table 240: MAPGAPC Measured values

Name	Type	Default	Description
AI_VALUE	REAL	0.0	Analog input value
BLOCK	BOOLEAN	0	Block overall function
BLK_OPR	BOOLEAN	0	Block operate output
BLK_ST	BOOLEAN	0	Block start output
FR_TIMER	BOOLEAN	0	Freeze internal operate timer
ENA_ADD	BOOLEAN	0	Enable start using added start value

4.1.9 Monitored data

Table 241: MAPGAPC Monitored data

Name	Type	Values (Range)	Unit	Description
OPERATE	BOOLEAN	0=FALSE 1=TRUE	-	Operated
START	BOOLEAN	0=FALSE 1=TRUE	-	Started signal
START_DUR	REAL	-	%	Start duration in percentage of the total operating time

4.1.10 Technical data

Table 242: MAPGAPC Technical data

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

Section 5 Supervision functions

5.1 Station battery supervision SPVNZBAT

5.1.1 Identification

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

5.1.2 Function block

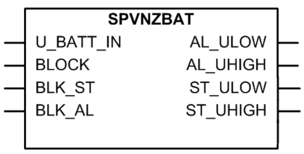


Figure 124: Function block

5.1.3 Functionality

The station battery supervision function SPVNZBAT is used for monitoring battery terminal voltage.

SPVNZBAT activates the start and alarm outputs when the battery terminal voltage exceeds the set upper limit or drops below the set lower limit. A time delay for the overvoltage and undervoltage alarms can be set according to definite time characteristics.

In the definite time (DT) mode, SPVNZBAT operates after a predefined operate time and resets when the battery undervoltage or overvoltage condition disappears.

The function contains a blocking functionality. It is possible to block function outputs, timers or the function itself, if desired.

5.1.4 Operation principle

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

The function execution requires that at least one of the function outputs is connected in configuration.

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

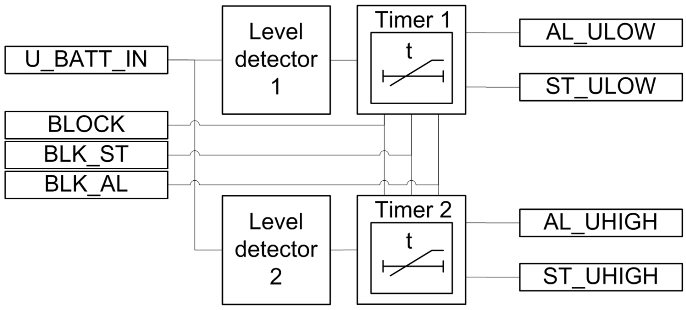


Figure 125: Functional module diagram

The battery rated voltage is set with the *Battery voltage Rtg* setting. The value of the *Low battery value* and *High battery value* settings are given in relative per unit to the *Battery voltage Rtg* setting.

Level detector 1

The level detector compares the battery voltage `U_BATT_IN` to the set value of the *Low battery value* setting. If the value of `U_BATT_IN` input drops below the value of the *Low battery value* setting, the level detector sends an enabling signal to the timer 1 module.

The measured voltage between the battery terminals U_BATT is available in monitored data view.

Level detector 2

The level detector compares the battery voltage `U_BATT_IN` to the set value of the *High battery value* setting. If the value of `U_BATT_IN` exceeds the set value of the *High battery value* setting, the level detector sends an enabling signal to the timer 2 module.

Timer 1

Once activated, the timer activates the `ST_ULOW` output for undervoltage condition. When the operate timer has reached the value set by the *Alarm delay time* setting, the `AL_ULOW` output is activated. If the voltage returns to normal value before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the `ST_ULOW` output is deactivated.

The activation of the `BLOCK` input resets the timer and deactivates the `ST_ULOW` and `AL_ULOW` outputs. The activation of `BLK_ST` and `BLK_AL` blocks the individual start and alarm outputs respectively.

Timer 2

Once activated, the timer activates ST_UHIGH for overvoltage condition. When the operate timer has reached the value set by the *Alarm delay time* setting, the AL_UHIGH output is activated. If the voltage returns to normal value before the module operates, the reset timer is activated. If the reset timer reaches the value set by *Reset delay time*, the operate timer resets and the ST_UHIGH output is deactivated.

The activation of the BLOCK input signal resets the timer and deactivates the ST_UHIGH and AL_UHIGH outputs. The activation of BLK_ST and BLK_AL blocks the individual alarm and operate outputs respectively.

5.1.5 Application

Usually, the load on the DC system is a constant resistance load, for example, lamps, LEDs, electronic instruments and electromagnetic contactors in a steady state condition. A transient RL load exists when breakers are tripped or closed.

The battery voltage has to be continuously monitored as the batteries can withstand moderate overvoltage and undervoltage only for a short period of time.

- If the battery is subjected to a prolonged or frequent overvoltage, it leads to the ageing of the battery, which may lead to the earlier failure of the battery. The other occurrences may be the thermal runaway, generation of heat or increased amount of hydrogen gas and the depletion of fluid in case of valve regulated batteries.

- If the value of the charging voltage drops below the minimum recommended float voltage of the battery, the battery does not receive sufficient charging current to offset internal losses, resulting in a gradual loss of capacity.
    - If a lead acid battery is subjected to a continuous undervoltage, heavy sulfation occurs on the plates, which leads to the loss of the battery capacity.

5.1.6 Signals

Table 243: SPVNZBAT Input signals

Name	Type	Default	Description
U_BATT_IN	REAL	0.00	Battery terminal voltage
BLOCK	BOOLEAN	0	Block of function
BLK_AL	BOOLEAN	0	Blocks the alarm signals
BLK_ST	BOOLEAN	0	Blocks the start signals

Table 244: SPVNZBAT Output signals

Name	Type	Description
AL_ULOW	BOOLEAN	Alarm when voltage has been below lower limit for a set time
AL_UHIGH	BOOLEAN	Alarm when voltage has exceeded higher limit for a set time
ST_ULOW	BOOLEAN	Start signal when battery voltage drops below lower limit
ST_UHIGH	BOOLEAN	Start signal when battery voltage exceeds upper limit

5.1.7 Settings

Table 245: SPVNZBAT Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation Off/On
Battery voltage Rtg	20.00 - 250.00	V	1.00	110.00	Battery rated voltage
Low battery value	0.60 - 1.40	pu	0.01	0.70	Lower limit for the battery terminal voltage
High battery value	0.60 - 1.40	pu	0.01	1.20	Upper limit for the battery terminal voltage
Alarm delay time	0.100 - 60.000	s	0.001	0.200	Delay time for alarm

Table 246: SPVNZBAT Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Reset delay time	0.000 - 60.000	s	0.001	0.000	Reset time provided to reset the timers

5.1.8 Measured values

Table 247: SPVNZBAT Measured values

Name	Type	Default	Description
U_BATT_IN	REAL	0.00	Battery terminal voltage
BLOCK	BOOLEAN	0	Block of function
BLK_AL	BOOLEAN	0	Blocks the alarm signals
BLK_ST	BOOLEAN	0	Blocks the start signals

5.1.9 Monitored Data

Table 248: SPVNZBAT Monitored data

Name	Type	Values (Range)	Unit	Description
U_BATT	REAL	-	kV	Service value of the battery terminal voltage
AL_ULOW	BOOLEAN	0=FALSE 1=TRUE	-	Alarm when voltage has been below lower limit for a set time
AL_UHIGH	BOOLEAN	0=FALSE 1=TRUE	-	Alarm when voltage has exceeded higher limit for a set time
ST_ULOW	BOOLEAN	0=FALSE 1=TRUE	-	Start signal when battery voltage drops below lower limit
ST_UHIGH	BOOLEAN	0=FALSE 1=TRUE	-	Start signal when battery voltage exceeds upper limit

5.1.10 Technical data

Table 249: SPVNZBAT Technical data

Characteristic	Value
Operation accuracy	±1.0% of the set value
Operate time accuracy	±1.0% of the set value or ±40 ms

Section 6 Measurement functions

6.1 Three-phase current CMMXU

6.1.1 Identification

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

6.1.2 Function block

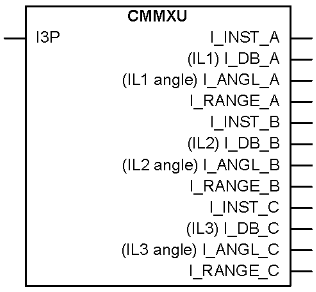


Figure 126: Function block

6.1.3 Signals

Table 250: CMMXU Input signals

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

Table 251: CMMXU Output signals

Name	Type	Description
I_INST_A	REAL	Phase A amplitude, magnitude of instantaneous value
I_DB_A	REAL	Phase A amplitude, magnitude of reported value
I_ANGL_A	REAL	Phase A angle, instantaneous value
I_RANGE_A	INTEGER	Phase A amplitude range
Table continues on next page		

Name	Type	Description
I_INST_B	REAL	Phase B amplitude, magnitude of instantaneous value
I_DB_B	REAL	Phase B amplitude, magnitude of reported value
I_ANGL_B	REAL	Phase B angle, instantaneous value
I_RANGE_B	INTEGER	Phase B amplitude range
I_INST_C	REAL	Phase C amplitude, magnitude of instantaneous value
I_DB_C	REAL	Phase C amplitude, magnitude of reported value
I_ANGL_C	REAL	Phase C angle, instantaneous value
I_RANGE_C	INTEGER	Phase C amplitude range

6.1.4 Settings

Table 252: CMMXU Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	On	Operation On / Off
A deadband PhA	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
A Hi high Lim PhA	0.0 - 100000.0	A	0.1	500.0	High High limit (physical value)
A high limit PhA	0.0 - 100000.0	A	0.1	400.0	High limit (physical value)
A low limit PhA	0.0 - 100000.0	A	0.1	0.0	Low limit (physical value)
A low low Lim PhA	0.0 - 100000.0	A	0.1	0.0	Low Low limit (physical value)
A minimum PhA	0.0 - 100000.0	A	0.1	0.0	Minimum value
A maximum PhA	0.0 - 100000.0	A	0.1	500.0	Maximum value
A Db type PhA	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
A deadband PhB	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
A Hi high Lim PhB	0.0 - 100000.0	A	0.1	500.0	High High limit (physical value)
A high limit PhB	0.0 - 100000.0	A	0.1	400.0	High limit (physical value)
A low limit PhB	0.0 - 100000.0	A	0.1	0.0	Low limit (physical value)
A low low Lim PhB	0.0 - 100000.0	A	0.1	0.0	Low Low limit (physical value)
A minimum PhB	0.0 - 100000.0	A	0.1	0.0	Minimum value
A maximum PhB	0.0 - 100000.0	A	0.1	500.0	Maximum value
A Db type PhB	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type
A deadband PhC	1 - 300	Type	1	10	Cycl: Report interval (s), Db: In % of range, Int Db: In %s
A Hi high Lim PhC	0.0 - 100000.0	A	0.1	500.0	High High limit (physical value)
A high limit PhC	0.0 - 100000.0	A	0.1	400.0	High limit (physical value)
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
A low limit PhC	0.0 - 100000.0	A	0.1	0.0	Low limit (physical value)
A low low Lim PhC	0.0 - 100000.0	A	0.1	0.0	Low Low limit (physical value)
A minimum PhC	0.0 - 100000.0	A	0.1	0.0	Minimum value
A maximum PhC	0.0 - 100000.0	A	0.1	500.0	Maximum value
A Db type PhC	Cyclic Dead band Int deadband	-	-	Cyclic	Reporting type

Table 253: CMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
A Zer deadband PhA	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
A limit Hys PhA	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
A Zer deadband PhB	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
A limit Hys PhB	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits
A Zer deadband PhC	0 - 100000	m%	1	500	Zero point clamping in 0,001% of range
A limit Hys PhC	0.000 - 100.000	%	0.001	5.000	Hysteresis value in % of range and is common for all limits

6.1.5 Monitored data

Table 254: CMMXU Monitored data

Name	Type	Values (Range)	Unit	Description
I_INST_A	REAL	-	A	Phase A amplitude, magnitude of instantaneous value
I_DB_A	REAL	-	A	Phase A amplitude, magnitude of reported value
I_ANGL_A	REAL	-	deg	Phase A angle, instantaneous value
I_RANGE_A	INTEGER	0=Normal 1=High 2=Low 3=High-High 4=Low-Low	-	Phase A amplitude range
I_INST_B	REAL	-	A	Phase B amplitude, magnitude of instantaneous value
I_DB_B	REAL	-	A	Phase B amplitude, magnitude of reported value
I_ANGL_B	REAL	-	deg	Phase B angle, instantaneous value
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
I_RANGE_B	INTEGER	0=Normal 1=High 2=Low 3=High-High 4=Low-Low	-	Phase B amplitude range
I_INST_C	REAL	-	A	Phase C amplitude, magnitude of instantaneous value
I_DB_C	REAL	-	A	Phase C amplitude, magnitude of reported value
I_ANGL_C	REAL	-	deg	Phase C angle, instantaneous value
I_RANGE_C	INTEGER	0=Normal 1=High 2=Low 3=High-High 4=Low-Low	-	Phase C amplitude range

6.1.6 Technical data

Table 255: CMMXU Technical data

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

Section 7 Power management functions

7.1 Load-shedding

Load-shedding functionality ensures the power availability to critical process loads in an industrial network by dropping the less critical loads. Contingency based load-shedding is used as the primary load-shedding function in industrial systems as it is fast and selective in operation.

PML630 provides system level disturbance management for small and medium-sized industrial power systems. The IED supports three types of load-shedding functions.

- Fast load-shedding based on network contingencies.
- Slow load-shedding based on overloading the grid transformer or violating the maximum demand at the grid connection.
- Manual load-shedding based on operator-initiated actions like priority definition or load-shedding in terms of power to be shed.

The fast or slow load-shedding functions depend on the type of the load-shedding trigger generation. While the fast load-shedding mode is triggered based on contingencies like the opening of power source circuit breaker(s), opening of bus coupler(s), opening of tie circuit breaker(s) or due to the protection operation of any of the above equipment, the slow load-shedding mode is activated due to the overloading of power sources. In both cases, the same power shortfall is used for fast and slow load-shedding actions. The slow load-shedding action is also possible with the absolute value of overloading for power source(s). Hence, the slow load-shedding mode considers the maximum of power shortfall and the absolute value of overloading amount for power source(s).

Table 256: Power network configuration limits for PML630 in cPMS - LS Configuration A

Network element	Number
Sources	6
External connections to adjacent electrical network areas (with PML630-based load-shedding)	2
Busbars/bus sections	6
Busbars/bus sections with connected power sources	4
Busbars/bus sections with sheddable loads connected	6
Bus couplers/tie circuit breaker	15
Sheddable loads per bus bar	10
Shedding priority number assigned to sheddable loads	1..19

If there are no external connections to adjacent electrical network areas, the external connections can be configured as grid transformers.

When the electrical network size exceeds the network definition/configuration mentioned earlier, additional PML630 is needed to handle load-shedding for an extended network. In such a scenario, the electrical network is divided into smaller network areas and each network area is allocated its own PML630 (and associated supporting feeder IEDs) that is responsible for the load-shedding functionality in that designated area. In a network segment, a PML630 exchanges information related to its own area with the adjacent area's PML630. This is to consider the overall power system data while doing load-shedding in its own area. Such a configuration is referred to as cPMS load-shedding configuration B.

In cPMS load-shedding configuration B, PML630s share the spinning reserve (that is, power balance) power over GOOSE communication with each other. Load-shedding can also be initiated in one of the network areas on the opening of remote end circuit breaker or extending load-shedding action.

In certain conditions, PML630 automatically reverts to the cPMS load-shedding configuration A mode.

- When PML630 loses communication with the PML630s of adjacent electrical areas.
- When the load-shedding is blocked in adjacent network areas.
- When the PML630s of adjacent electrical areas go into test mode.
- When circuit breaker is opened for external connections at either end.

For these causes, PML630 does not consider the load-shedding data received from an adjacent PML630.

7.2 Load-shedding principles and terminology

Figure 127 is a typical single-line diagram of an industrial system showing different network elements and their nomenclature in an electrical network.

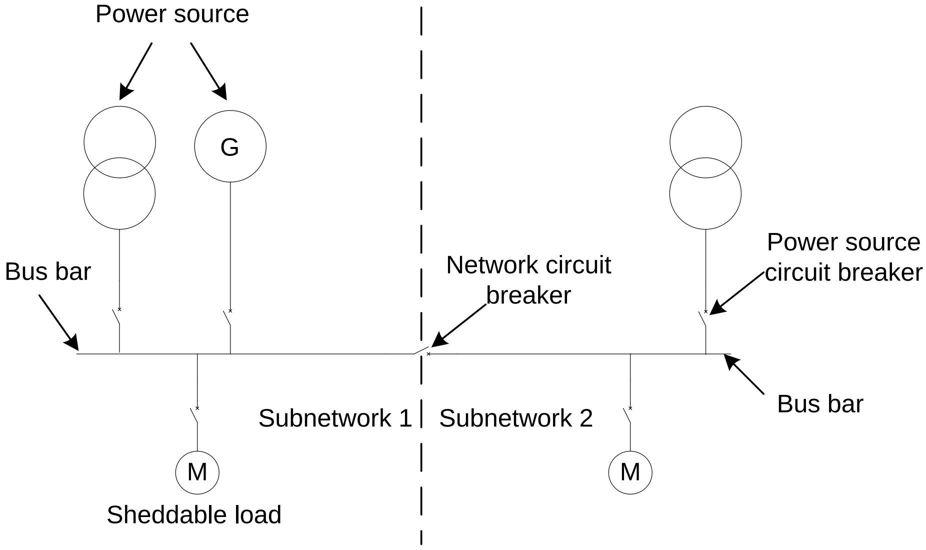


Figure 127: Typical single-line diagram of an electrical network area

Figure 128 shows the signal flow diagrams between load-shedding functions.

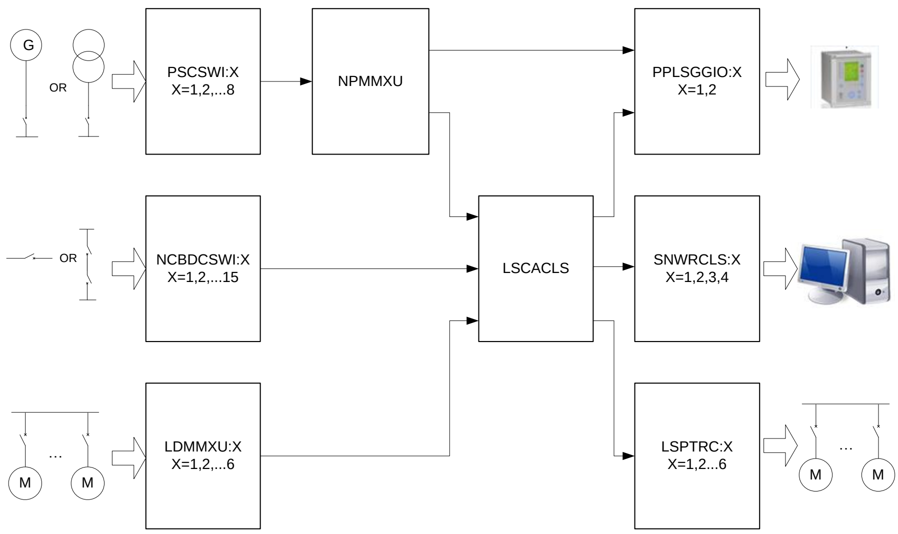


Figure 128: Signal flow diagram

Here X = number of instance of respective functions.

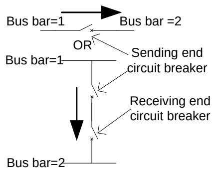
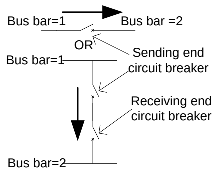
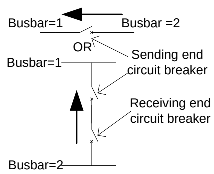
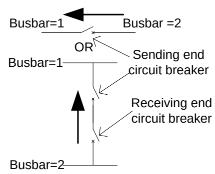
PPLSGGIO is instantiated based on external connection configuration.

7.2.1 Power flow sign conventions

The power flow sign convention of network circuit breaker in PML630 is considered positive if the power flow direction is from the lower busbar number to the higher busbar number (for example, 1...2 or 2...4 or 1...3), else considered negative. The power flow sign convention in PML630 can be corrected by the settings *Send Pow convention* or *Rcv Pow convention* for sending-end circuit breaker IED or receiving-end circuit breaker IED respectively in NCBDCSWI, if required.

Table 257 shows the correction for power flow sign convention in PML630 for bus coupler/tie circuit breaker connected between busbar = 1 and busbar = 2. Similar logic applies to other instance of network circuit breaker.

Table 257: Power flow sign convention in PML630 IED for network circuit breaker

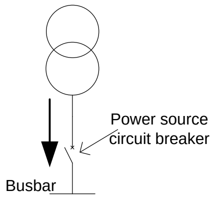
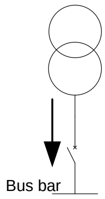
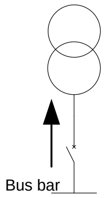
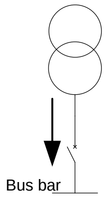
Power flow sign convention in sending-/receiving-end CB IED	Power flow sign convention in PML630 IED	Send Pow convention or Rcv Pow convention setting
		Positive XX
		Negative XX

PML630 processes the power values in kW. Hence, sending-end circuit breaker IED power or receiving-end circuit breaker IED power units in PML630 can be converted to kW based on the *Send Pow convention* or *Rcv Pow convention* setting respectively. In Table 257, “Positive XX” means “Positive W”, “Positive kW” or “Positive MW”. See NCBDCSWI for details regarding the power unit conversion.

The power flow sign convention of the source in PML630 is positive if the power flow direction is towards the busbar, otherwise it is negative. The power flow sign convention in PML630 can be corrected with the *Power convention* setting for the power source in PSCSWI.

Table 258 shows the correction for power flow sign convention in PML630 for the power source.

Table 258: Power flow sign convention for power source

Power flow sign convention in power source CB IED	Power flow sign convention in PML630 IED	Power convention setting
		Positive XX
		Negative XX

The power source circuit breaker IED power unit in PML630 can be converted to kW based on the *Power convention* setting. In Table 258, "Positive XX" means "Positive W", "Positive kW" or "Positive MW". See PSCSWI for details regarding the power unit conversion.

7.2.2 Compensated circuit breaker status

The compensated circuit breaker status is calculated for the power source, network circuit breaker and sheddable load for the load-shedding functionality. The compensated circuit breaker status is calculated by considering the respective circuit breaker position, IED data quality, circuit breaker in service/test and lockout protection operation as shown in Table 259.

Table 259: Conditions for compensated circuit breaker status calculation

Compensated CB status for power source	Compensated CB status for bus coupler/tie circuit breaker	Compensated CB status for load feeder
• Circuit breaker position • Circuit breaker in service/test • IED data quality • Lockout operation status	• Circuit breaker position • Circuit breaker in service/test • IED data quality • Lockout operation status	• Circuit breaker position • IED data quality

Depending on the network circuit breaker configuration as bus coupler/tie circuit breaker, the compensated circuit breaker status is calculated for the network circuit breaker. See PSCSWI, NCBDCSWI and LDMMXU for details regarding compensated circuit breaker status calculation.

The compensated circuit breaker status has only two states, closed or open, as confirmed.

7.2.3 Load-shedding trigger

PML630 performs load-shedding action in an electrical network area due to fast load-shedding trigger, slow load-shedding trigger, external load-shedding trigger input or manual load-shedding trigger. PML630 also performs load-shedding action in the electrical network area if load-shedding is extended from an adjacent electrical network area.

7.2.3.1 Fast load-shedding trigger

Fast load-shedding trigger due to power source, bus coupler or tie circuit breaker is initiated in the conditions as shown in Table 260.

Table 260: Conditions for fast load-shedding trigger calculation

Fast load-shedding trigger due to power source	Fast load-shedding trigger due to bus coupler/tie circuit breaker
• Circuit breaker position from closed to open • Circuit breaker position from intermediate to open • Lockout operation status	• Circuit breaker position from close to open • Circuit breaker position from intermediate to open • Lockout operation status

Depending on the network circuit breaker configuration as bus coupler/tie circuit breaker, the compensated circuit breaker status is calculated for the network circuit breaker.
See PSCSWI and NCBDCSWI for details regarding fast load-shedding trigger calculation.

Fast load-shedding trigger can also be initiated by the external trigger input, if configured, in the LSCACLS. In the cPMS load-shedding configuration B, the remote -end circuit breaker disconnection also initiates fast load-shedding trigger.

The fast load-shedding trigger is inhibited (that is, blocked) in an individual source or network circuit breaker by an external inhibition signal in PSCSWI and NCBDCSWI respectively.

7.2.3.2 Slow load-shedding trigger

Slow load-shedding trigger due to power source is initiated in certain conditions.

- Phase overcurrent detection module has operated.
- Calculated average demand is violated.
- External input is configured and the input gets activated, for example transformer or feeder overcurrent IED (RET/REF630) start signals.

If the power flow of the power source is away (that is, power flow direction is negative) from the busbar, slow load-shedding trigger from the respective power source is not initiated.
The slow load-shedding trigger due to external input is active if the phase overcurrent detection module is enabled.
See PSCSWI and NPMMXU for details regarding slow load-shedding trigger calculation.

When phase overcurrent is detected, it is expected that the actual current of power source comes down when the load feeders are tripped. If the current does not fall below the threshold value, PML630 retriggers the slow load-shedding action until the current is reduced. This retriggering of the slow load-shedding trigger due to phase overcurrent can be handled by a set interval time. The delay in updating the currents in the phase overcurrent detection module of the power source after the load feeder has tripped can also be handled by retriggering after the set interval time.

The slow load-shedding trigger for the individual power source is disabled by external inputs in respective PSCSWI.

The slow load-shedding trigger is inhibited (that is, blocked) for all the power sources by an external input in NPMMXU.

7.2.3.3 Manual load-shedding trigger

The manual load-shedding trigger is initiated in each subnetwork by the system operator irrespective of a power shortfall.

Manual load-shedding can be executed either based on priority or power (that is, amount of load to be shed). If configured, it is also possible to execute the manual load-shedding action initiated by an external input. If an external system (such as COM600) sends information for load-shedding (priority or by power) along with an external trigger, load-shedding can be activated for the subnetwork.

See LSCACLS for load-shedding action due to manual load-shedding trigger.

7.2.3.4 Extended load-shedding trigger

In cPMS load-shedding configuration B, extended load-shedding trigger is initiated from adjacent PML630s during contingency in the extended electrical network area.

PML630 performs load-shedding action in its own area, provided that an adjacent PML630 has executed the load-shedding action and the actual shed load is less than required. PML630 receives the load-shedding information from an adjacent PML630 to shed identified loads in its own area.

The load-shedding trigger is extended by an adjacent PML630, provided that a load-shedding action is initiated in the respective adjacent PML630 due to fast load-shedding trigger, external trigger input or load-shedding trigger received from another adjacent PML630.
See NPMMXU, LSCACLS and PPLSGGIO for details regarding extended load-shedding action.

7.2.4 Load-shedding blocking

Load-shedding is blocked due to various conditions of power source, bus coupler or tie circuit breaker.

Load-shedding blocking is calculated as shown in Table 261.

Table 261: Conditions for load-shedding blocking calculation

Load-shedding blocking due to power source	Load-shedding blocking due to bus coupler/tie circuit breaker
• Circuit breaker position is in intermediate for more than set value of circuit breaker intermediate setting. • Circuit breaker position is invalid. • IED data quality is bad.	• Circuit breaker position is in intermediate for more than set value of circuit breaker intermediate setting. • Circuit breaker position is invalid. • IED data quality is bad.

Depending on the network circuit breaker configuration as bus coupler/tie circuit breaker, the load-shedding blocking is calculated for the network circuit breaker.

Load-shedding is also blocked if the power source for an external connection is not configured correctly.

If the load-shedding blocking is activated due to the power source, load-shedding is blocked in the respective subnetwork where the power source is connected.

If the load-shedding blocking is activated due to the network circuit breaker, load-shedding is blocked in the associated subnetworks of a network circuit breaker.

If two subnetworks are formed due to the open status of the compensated circuit breaker status of the network circuit breaker and load-shedding blocking is activated from the respective network circuit breaker, the load-shedding is blocked in both associated subnetworks.

Load-shedding can also be blocked in all the subnetworks by an external input if configured in LSCACLS.

The manual load-shedding action can be performed even though load-shedding is blocked in subnetworks.

Load-shedding blocking calculated due to various conditions for power source or network circuit breaker can be overridden with the *Block override* setting in PSCSWI and NCBDCSWI respectively.

See PSCSWI, NCBDCSWI and LSCACLS for details regarding load-shedding blocking calculation.

7.2.5 Power data holding and delay

PML630 holds the power data at every measurement cycle. This data is used in load-shedding calculation after the delay of one to two measurement cycles. Here, for example, T, 2T and 3T represent the measurement cycle. This deliberate delay is to ensure that the load-shedding core function LSCACLS always works on the power system data that is not influenced by a transient or a disturbance situation.

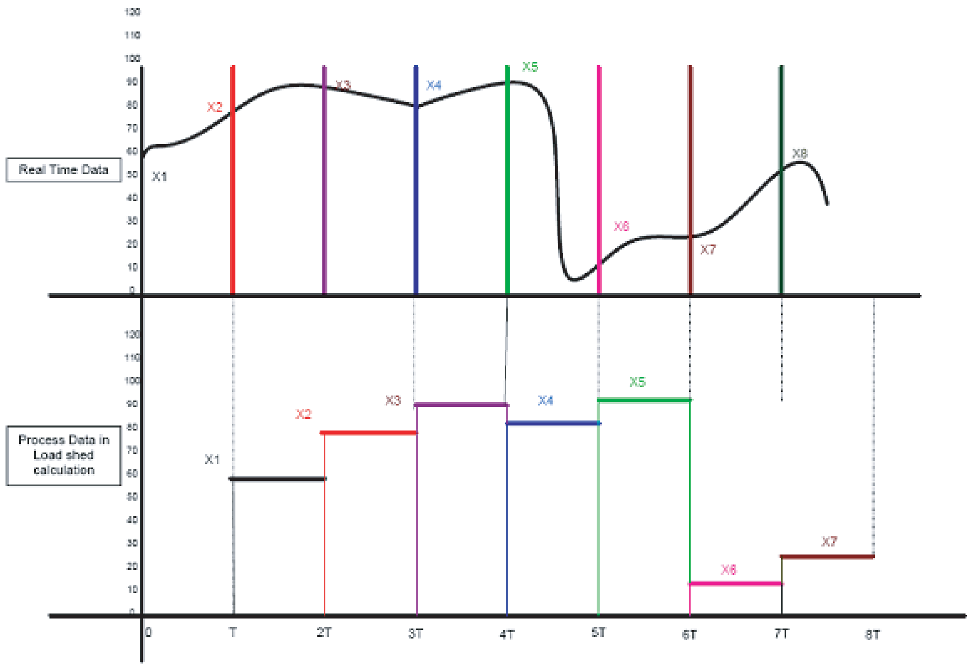


Figure 129: Hold and delay of power data

7.3 Load-shedding functions

7.3.1 Power source circuit breaker function PSCSWI

- PSCSWI can be configured for generator/external source.
- PSCSWI receives the circuit breaker position, island and parallel information of external source, governor mode of generator source and power values of power source.
- PSCSWI calculates the available power, amount of overload, compensated circuit breaker status, fast load-shedding trigger, demand- or overcurrent-based slow load-shedding trigger, island or parallel mode for generator source, load-shedding blocking and load-shedding block override signals.
- The governor mode of the generator and the available power of the power source can be the setting or the communicated inputs received from the external IED via IEC 61850 GOOSE.

7.3.2 Load busbar monitoring function LDMMXU

- LDMMXU receives the circuit breaker position and the power values of the sheddable loads connected on same busbar.
- LDMMXU calculates the shedding priority, operator inhibitions or system inhibition for each sheddable loads.

7.3.3 Network circuit breaker function NCBDCSWI

- NCBDCSWI can be configured for tie circuit breaker or bus coupler.
- NCBDCSWI receives the circuit breaker position and the power values of network circuit breaker.
- NCBDCSWI calculates the compensated circuit breaker status, fast load-shedding trigger and load-shedding blocking.

7.3.4 Network power monitoring function NPMMXU

- NPMMXU receives data for an individual source from PSCSWI. NPMMXU also receives the load-shedding data from the adjacent PML630s via IEC61850 GOOSE.
- NPMMXU controls the extended load-shedding functionality with the configuration of the external connection connectivity setting.
- NPMMXU does not consider the load-shedding data received from an adjacent PML630 if the circuit breaker is opened of the remote end or the power source for the external connection or the adjacent PML630 load-shedding is blocked in its electrical network area, the external connection in the adjacent PML630 is not configured correctly, the adjacent PML630 is in the test mode or its data quality is bad.

- NPMMXU controls the modes by which the load-shedding data (that is, spin reserve or extended load-shedding power) can be shared to two adjacent PML630s.
- NPMMXU configures the phase overcurrent-based slow load-shedding trigger from continuous to periodic based on the setting.
- NPMMXU calculates slow load trigger, load-shedding blocking and overload amount for slow load-shedding and island/parallel status for each busbar. NPMMXU also calculates the fast load-shedding trigger common for all subnetworks due to fast load-shedding trigger generation from any power source or the opening of the circuit breaker of external connections at either end.

7.3.5 Contingency based load-shedding function LSCACLS

- LSCACLS receives the load-shedding data from NPMMXU, NCBDCSWI and LDMMXU.
- LSCACLS identifies the network configuration of the system through the compensated circuit breaker status of the network circuit breakers. At any instance of time, a maximum of four active subnetworks can be formed.
- LSCACLS calculates the available power of generator based on its governor mode and island/parallel status of the busbar to which it is connected.
- LSCACLS also calculates the total available power, total active power, total overload amount in each subnetwork based on available powers, active powers of each source and spin reserve received from adjacent PML630s in corresponding subnetworks. The total active power represents the total loads connected in the subnetwork.
- The power shortfall calculation module is common for fast load-shedding trigger, slow load-shedding trigger and external trigger.
- LSCACLS calculates the load-shedding blocking status, fast load-shedding trigger and slow load-shedding trigger in each subnetwork.
- LSCACLS calculates the cumulative shedding power corresponding to each priority (from 1...19), total sheddable power, total shedding power inhibited by system and the total shedding power inhibited by operator.
- The cumulative shedding power at each priority determines that all the loads having priority setting less than or equal to the load-shedding priority are dropped, provided that the load-shedding triggers are active.
- LSCACLS calculates the load-shedding priority based on various conditions, for example, power shortfall, overloading amount, load-shedding power of adjacent electrical networks or manual load-shedding action and associated load-shedding trigger(s). Table 262 shows the load-shedding priority (p1, p2…) calculation with respect to load-shedding initiation.

Table 262: Load-shedding priority calculation

Load-shedding initiation	Shed power calculation	Load-shedding priority calculation
Fast load-shedding trigger, slow load-shedding trigger or external trigger	Cumulative shedding power ^{p1} ≥ Power shortfall	p1
Slow load-shedding trigger	Cumulative shedding power ^{p2} ≥ Total overload amount	p2
Extended load-shedding trigger	Cumulative shedding power ^{p3} ≥ load-shedding power of adjacent PML630	p3
Manual load-shedding trigger (power-based)	Cumulative shedding power ^{p4} ≥ Manual load-shedding power	p4
Manual load-shedding trigger (priority-based)	Manual load-shedding priority setting = p5	p5

The load-shedding priority due to slow load-shedding trigger is calculated as the maximum of p1 and p2.

If the load-shedding action is initiated due to multiple load-shedding triggers simultaneously, the priority order in which the cause of load-shedding is calculated follows a certain sequence.

- Extended load-shedding (in combination with any other load-shedding triggers)
- Fast load-shedding (in combination with slow load-shedding or manual load-shedding triggers)
- Slow load-shedding (in combination with manual load-shedding trigger)
- Manual load-shedding

Irrespective of multiple load-shedding trigger conditions, if the load-shedding priority is calculated corresponding to the overload amount and slow load-shedding trigger, then the cause of load-shedding is slow load-shedding.
Similarly, if the load-shedding priority is calculated corresponding to the manual load-shedding priority and the manual load-shedding trigger, the cause of load-shedding is manual load-shedding.

In load-shedding blocking condition, the load-shedding in the subnetwork can be executed via the manual load-shedding trigger.

- LSCACLS calculates the trip information for each load feeder connected to the busbars in the respective subnetwork based on load-shedding priority. The trip command is active for a load feeder, provided that the calculated load-shedding priority is less than or equal to the priority setting for the respective load feeder.

- When load-shedding priority is calculated with LSCACLS, various subnetwork information required for subnetwork display is latched.
- The latched output signals can be reset through the respective reset inputs of each subnetwork. If a load-shedding action occurs before a reset of the subnetwork, the old latched outputs are replaced with the new, that is, latest, set of values. LSCACLS can record up to three load-shedding priorities. All the subnetworks can be reset from the common reset input. On activation of the reset signal, the latched outputs in the subnetworks are reset.
- LSCACLS calculates the spinning reserve and the extended load-shedding power of the subnetworks connected to the adjacent electrical network areas..
- The spinning reserve in the subnetwork is equal to the difference of sum of the available power of all the sources and the total active power in the respective subnetwork. The extended load-shedding power in the subnetwork is equal to the difference of power shortfall and the actual shedding power, provided that the load-shedding priority is 19 and the cause of load-shedding is fast load-shedding or extended load-shedding.

If PML630 is configured (cPMS configuration B) to have extended electrical networks present on both sides and both electrical networks areas are connected to the same subnetwork, the spin reserve and the extended load-shedding power to be shared with both the adjacent PML630s depends on the spin reserve sharing mode or extended load-shedding sharing mode calculated by NPMMXU.

- LSCACLS also calculates the status to inform if either the spin reserve or the extended load-shedding power is active. If both the statuses are active, the extended load-shedding power status takes precedence over the spin reserve status.

7.3.6 Load-shedding trip command function LSPTRC

- Each instance of LSPTRC receives load-shedding operation information for its load-shed feeders from the LSCACLS.
- The individual instance of LSPTRC sends operating signals to the corresponding load-shedding feeders on that busbar.

7.3.7 Subnetwork output function SNWRCLS

- Each instance of SNWRCLS receives load-shedding information for the corresponding subnetwork from LSCACLS.
- The individual instance of SNWRCLS provides various outputs for the respective subnetwork for monitoring or supervision purposes.

7.3.8 Peer-to-peer load-shedding function PPLSGGIO

- Each instance of PPLSGGIO receives the data from LSCACLS and NPMMXU.
- The individual instances of PPLSGGIO processes the data for an extended load-shedding action.
- The individual instance of PPLSGGIO provides outputs for the corresponding load-shedding data of the adjacent network area. These outputs are used for monitoring purposes.

Table 263: Input signal enum descriptions and corresponding values

Enum description	Value
Bad	0
Good	1
Intermediate	0
Open	1
Close	2
Invalid	3
Island	0
Parallel	1
Droop	1
MW	2
ISO	3
P-Control	4
Optimize	5
Base load	6
Peak load	7

7.4 Power-source circuit breaker PSCSWI

7.4.1 Identification

Table 264: Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/ IEEEidentification
Power source circuit breaker	PSCSWI	-	PSCSWI

7.4.2 Function block

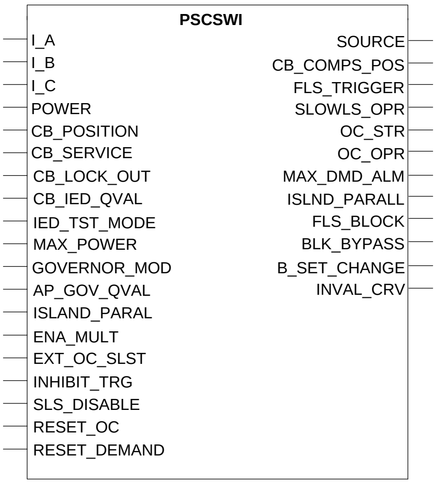


Figure 130: Function block

7.4.3 Functionality

The input interface function PSCSWI processes the circuit breaker status and power values of the power source. PSCSWI identifies the load bus bar number to which the power source is connected and provides the available power, active power and the governor mode of the power source for the power balance calculation.

PSCSWI calculates the compensated circuit breaker position depending on the power source IED quality status, circuit breaker position, circuit breaker service position and protection lockout status.

PSCSWI generates the fast load-shedding trigger due to circuit breaker position change or protection lockout operating and slow load-shedding trigger due to the phase overcurrent detection or maximum demand violation.

PSCSWI also generates the load-shedding blocking signal due to the bad data quality or power source IED in the test mode or power source circuit breaker position in intermediate or invalid, that blocks the load-shedding.

When external inhibition input is active or blocking signal is active, the fast load-shedding trigger and slow load-shedding trigger are inhibited.

Selecting the appropriate setting changes the power configuration, sign convention and unit of the active power. PSCSWI also has the provision to select the available power either as communication value or setting. Similarly, the governor mode for the generator can be selected from the communication value or setting.

7.4.4 Operation principle

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

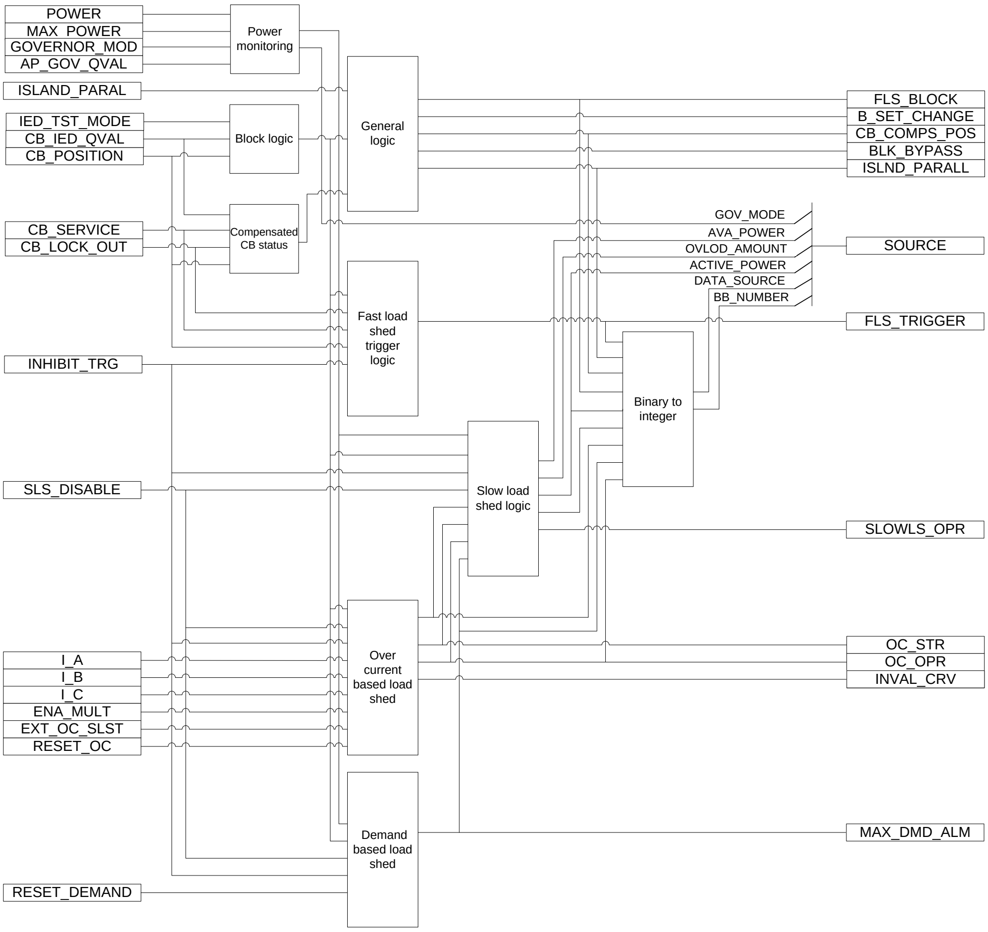


Figure 131: Functional module diagram

7.4.4.1 Power monitoring

This module calculates the available power and active power of the power source. It also calculates the governor mode of the generator.

The units of the `POWER` and `MAX_POWER` inputs can be W, kW or MW. This module converts the units of the `POWER` and `MAX_POWER` inputs in kW as the *Power convention* setting.

The `POWER` and `MAX_POWER` inputs must have the same unit.

Table 265: The unit conversion for active power

Power convention setting	Input	Calculated active power
Positive W	POWER	POWER × [0.001]
Negative W	POWER	POWER × [-0.001]
Positive kW	POWER	POWER × [1]
Negative kW	POWER	POWER × [-1]
Positive MW	POWER	POWER × [1000]
Negative MW	POWER	POWER × [-1000]

Table 266: The unit conversion for available power

Power convention setting	Input	Calculated active power
Positive W	MAX_POWER	MAX_POWER × [0.001]
Negative W	MAX_POWER	MAX_POWER × [-0.001]
Positive kW	MAX_POWER	MAX_POWER × [1]
Negative kW	MAX_POWER	MAX_POWER × [-1]
Positive MW	MAX_POWER	MAX_POWER × [1000]
Negative MW	MAX_POWER	MAX_POWER × [-1000]

This module calculates the available power of power source as per the *Ava power mode*, *Ava power relative* and *Maximum Ava power* settings as shown in Table 267.

Table 267: The available power calculation

Ava power mode setting	Calculated available power
Set Max Ava power	Available power = Maximum Ava power setting
Set Ava Pow relative	Available power = POWER input × Ava power relative setting If POWER input × Ava power relative setting ≥ Maximum Ava power setting or POWER input <0.0, Available power = Maximum Ava power setting
Comm Max Ava power	Available power = MAX_POWER input, provided input AP_GOV_QVAL is Good. If AP_GOV_QVAL input is Bad, Available power = Maximum Ava power setting
Comm spin reserve	Available power = POWER input + MAX_POWER input, provided input AP_GOV_QVAL is Good. If AP_GOV_QVAL input is Bad or POWER <0.0, Available power = Maximum Ava power setting

During the power-exporting condition, the available power and active power of the power source can be configured using the *Power Cfg export Mod* setting.

If the *Power Cfg export Mod* setting is “Pow & Ava Pow Zero” and active power value is negative, the calculated available power and active power values are zero.

If the *Power Cfg export Mod* setting is “Pow & Ava Pow No Chg” and active power value is negative, the calculated available power and active power values remain same as the calculated values.

The calculated available power is reported to the Slow load shed logic module. The calculated active power is reported to the Slow load shed logic, Demand based load shed and Binary to integer modules.

PSCSWI can handle the generator source or external source by setting the values of *Source configure* to “Generator” for the generator and “External source” for an external source.

The governor mode of the generator is provided by `GOV_MODE` output. The `GOV_MODE` output is “Not applicable” for an external source.

If the *Enable Comm Gov mode* setting is “Enable” and the `AP_GOV_QVAL` input is ”Good”, the `GOV_MODE` output is same as the `GOVERNOR_MOD` input.

If the *Enable Comm Gov mode* setting is “Disable” or the `AP_GOV_QVAL` input is ”Bad” or the `GOVERNOR_MOD` input is invalid, the `GOV_MODE` output is same as the *Governor mode* setting.

7.4.4.2 Block logic

This module calculates the load-shedding blocking status based on the circuit breaker data quality, circuit breaker position or IED test mode of the power source.

If the input `CB_IED_QVAL` (power source IED data quality) is "Bad” at the measurement cycle, the load-shedding blocking status is TRUE for the duration of the `CB_IED_QVAL` input being "Bad" and for additional t+T time as shown in Figure 132.

If the input `CB_IED_QVAL` is "Bad” within a measurement cycle, the load-shedding blocking status is TRUE for the duration of the `CB_IED_QVAL` input being "Bad" as shown in Figure 133. Once the `CB_IED_QVAL` input changes from "Bad" to "Good", the load-shedding blocking status changes from TRUE to FALSE.

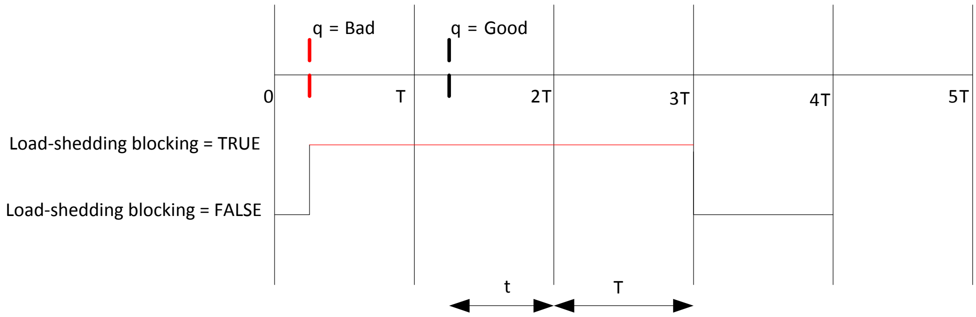


Figure 132: Logic for load-shedding blocking status at the time of measurement cycle

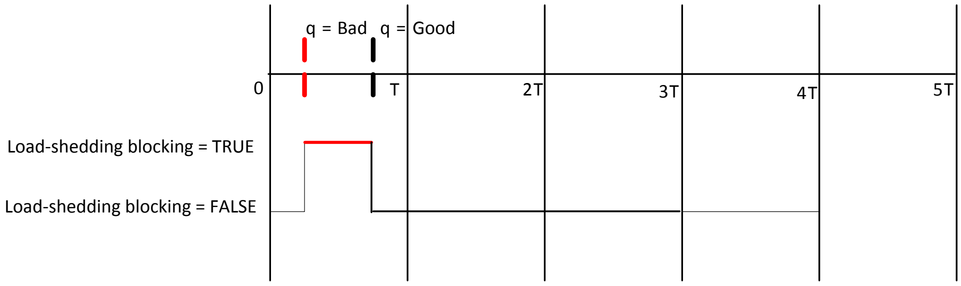


Figure 133: Logic for load-shedding blocking status within the measurement cycle

Where

q	CB_IED_QVAL
T, 2T, 3T	Measurement cycle
t	Time between the change of CB_IED_QVAL input from “Bad” to “Good” and the next measurement cycle.

If the `IED_TST_MODE` input is TRUE or the `CB_POSITION` input is "Invalid”, or the `CB_POSITION` input remains in the “Intermediate” position for more than the *CB Interm time* setting, the load-shedding blocking status is TRUE.

The load-shedding blocking status is reported to the General logic module, Fast load-shedding trigger logic module, Slow load-shedding logic module, Over current based load-shedding module and Demand based load-shedding module.

7.4.4.3 Compensated CB status

This module calculates the compensated circuit breaker status by considering the circuit breaker position, circuit breaker in service/test status and IED data quality of the power source.

The conditions to set the compensated circuit breaker status as TRUE.

- The input CB_POSITION (power source circuit breaker position) is "Close".
- The input CB_SERVICE (power source circuit breaker in service) is TRUE.
- The input CB_LOCK_OUT (Protection lockout operation status of power source) is FALSE.
- The input CB_IED_QVAL is "Good".

If one or more of the above conditions are not met, compensated circuit breaker status is FALSE.

If the load-shedding blocking status is activated due to bad IED data quality and the *Block override* setting is “Quality bad CB open”, then compensated CB status is FALSE.

If the load-shedding blocking status is activated due to bad IED data quality and the *Block override* setting is “Quality bad CB close”, the output compensated CB status is TRUE.

If the calculated compensated CB status is TRUE, the output CB_COMPS_POS is “Close”, else the output CB_COMPS_POS is “Open”.

The calculated compensated circuit breaker status is reported to the Binary to integer module.

7.4.4.4 General logic

This module calculates FLS_BLOCK output, BLK_BYPASS output and island parallel status based on various conditions.

The FLS_BLOCK output provides the load-shedding blocking signal after considering the override action using the *Block override* setting. The BLK_BYPASS output indicates the successful overridden action of the load-shedding blocking signal.

Table 268: Calculation of the FLS_BLOCK and BLK_BYPASS outputs

Load-shedding blocking conditions	Block override setting	BLK_BYPASS output	FLS_BLOCK output
IED_TST_MODE = TRUE	IED test mode All yes	TRUE	FALSE
	No Quality bad CB close Quality bad CB open CB Interm or invalid	FALSE	TRUE
CB_IED_QVAL = Bad	Quality bad CB close Quality bad CB Open All yes	TRUE	FALSE
	No IED test mode CB Interm or invalid	FALSE	TRUE
CB_POSITION = Intermediate or Invalid	CB Interm or invalid All yes	TRUE	FALSE
	No IED test mode Quality bad CB close Quality bad CB open	FALSE	TRUE
If mutiple load-shedding blocking signals are active simultaneously (IED_TST_MODE = TRUE, CB_IED_QVAL = Bad, CB_POSITION = Intermediate or Invalid)	All yes	TRUE	FALSE
	CB Interm or invalid IED test mode Quality bad CB close Quality bad CB open	TRUE	TRUE
	No	FALSE	TRUE

The *Block override* setting is preferred to be kept as “No”.

If the input `ISLAND_PARAL` is “Parallel” and the compensated circuit breaker status is TRUE, the output `ISLND_PARALL` is “Parallel”, else the output `ISLND_PARALL` is “Island”.

For generator, the output `ISLND_PARALL` remains “Island”.

The output `B_SET_CHANGE` remains active for 500 ms if one or more basic settings are changed (See Table 273 and Table 275). After 500 ms, the output `B_SET_CHANGE` is FALSE.

The General logic module provides the `FLS_BLOCK` (load-shedding blocking), `ISLND_PARALL` (island or parallel mode) and `CB_COMPS_POS` (compensated circuit breaker status) signals to the Binary to integer module.

7.4.4.5 Fast load shed trigger logic

This module calculates the fast load shed trigger to initiate the load-shedding action.

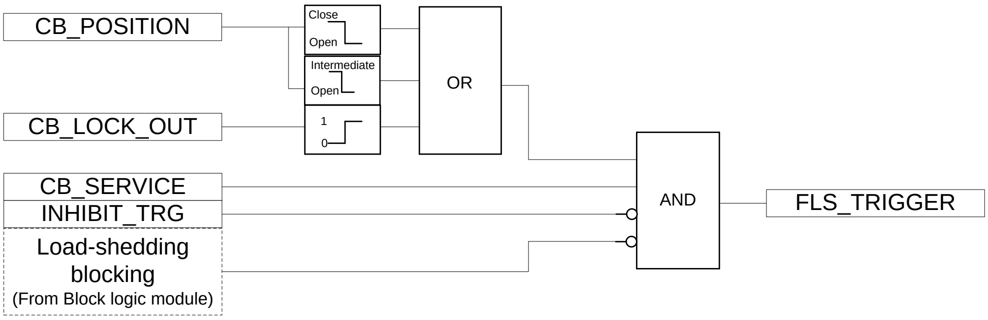


Figure 134: Fast load shed trigger logic

If the BLK_BYPASS output is active, FLS_TRIGGER remains FALSE.

The output FLS_TRIGGER (fast load-shedding trigger) is provided to the Binary to integer module.

7.4.4.6 Over current based load shed

This module calculates the slow load-shedding start and slow load-shedding trigger based on the phase overcurrent detection of the power source or external trigger input activation.

The *Slow load shed mode* setting enables or disables the Over current based load shed module. If the *Slow load shed mode* setting is "OC & Ext Trg " or "OC, Max Dmd, Ext Trg", the Over current based load shed module is enabled, else it is disabled.

This module compares the effective start value to the maximum of the I_A, I_B, I_C inputs.

If the input ENA_MULT (enable start value multiplier) is TRUE, the effective start value is the product of the *Start value* and *Start value Mult* settings, else the effective start value is same as the *Start value* setting.

If the maximum of the I_A, I_B, or I_C inputs is greater than the effective start value, the output OC_STR (overcurrent start) is TRUE, else the output OC_STR is FALSE. The maximum of the I_A, I_B, or I_C input is provided as the MAX_CURRENT output. The effective start value is provided by the PICKUP output.

If the phase overcurrent is detected, the output OC_TIME (overcurrent operating time) is calculated as per the *Operating curve type* setting. After the operate time, the OC_OPR output is TRUE.

The calculated `OC_TIME` output reflects the timings when the IED receives the input currents. Hence, the actual time of the trigger matches the `OC_TIME` output only if the current inputs remain the same throughout the duration of the overload. If the input current changes subsequently, the `OC_TIME` output time also changes correspondingly.

The output `ELAPSE_TIME` is time elapse after `OC_STR` is TRUE.

The outputs `OC_TIME` and `ELAPSE_TIME` are reported for the monitoring view. Once the output `OC_STR` is FALSE, the outputs `OC_TIME` and `ELAPSE_TIME` are reset.

The module can be reset by the input `RESET_OC`. If the input `RESET_OC` is TRUE, the outputs `OC_OPR`, `OC_TIME` and `ELAPSE_TIME` are reset.

The different ANSI/IEC curve type operating time characteristic depends on the *Curve parameter A*, *Curve parameter B*, *Curve parameter C*, *Curve parameter D*, *Curve parameter E*, *Time multiplier*, *Operating curve type*, *Operate delay time* and *Minimum operate time* settings. Similarly, the reset curve functionality depends on the *Type of reset curve* and *Reset delay time* settings.

In this function block, some of the settings are set in per unit (pu). These per unit values are relational to the certain base values. The PML630 IED supports alternative base value groups in the *Base value Sel phase* setting, for example “Phase Grp 1”, “Phase Grp 2” and “Phase Grp 3”.

The output `INVAL_CRV` is TRUE if the *Operating curve type* setting is selected "Programmable" and the curve parameter values are invalid, else the output `INVAL_CRV` is FALSE.

For more information on overcurrent start and operate based on different *Timer characteristics* and relevant inputs, see the PHLPTOC function of the three-phase non-directional overcurrent protection PHxPTOC in the 630 series technical manual.

For a detailed description of the definite time characteristics and current based inverse definite minimum time (IDMT) characteristics, see the general function block features section in this manual.

The overcurrent settings in PML630 must be coordinated carefully with the IED of the power source.

The external slow load-shedding trigger is also initiated if the input `EXT_OC_SLST` changes from FALSE to TRUE.

This module inhibits the OC_STR and OC_OPR outputs and slow load-shedding trigger due to external input in any of the following conditions.

- The input INHIBIT_TRG is TRUE.
- The input SLS_DISABLE is TRUE.
- The load-shedding blocking status (from the Block logic module) is TRUE.

If the Over current based load shed module is disabled, the outputs OC_OPR and OC_STR are FALSE, the Slow load shed trigger module due to external input EXT_OC_SLST is inactive and the outputs OC_TIME and ELAPSE_TIME are zero.

The Over current based load shed module provides the OC_STR (overcurrent start) signal to the Slow load shed logic module. It also provides the OC_OPR (overcurrent operate), external slow load-shedding trigger signal to the Slow load shed logic module and the Binary to integer module.

7.4.4.7 Demand based load shed

This module calculates the linear average demand based on an active power (from the Power monitoring module) of the power source over a set interval time. Based on the comparison of the linear average demand and set maximum demand value of source, demand-based slow load-shedding action is initiated.

The *Slow load shed mode* setting enables or disables the Demand based load shed module. If the *Slow load shed mode* setting is "Max Dmd Trg" or "OC, Max Dmd, Ext Trg", the Demand based load shed is enabled, else it is disabled

Based on the measured powers (power received from source IED), the Demand based load shed module internally calculates the linear average of the demand over the *Demand interval* setting. The *Demand interval* setting can be set to "1 Minute", "5 Minute", "10 Minute", "15 Minute", "30 Minute", "60 Minute" or "180 Minute". A new demand value is obtained every one minute, indicating the actual demand over the time interval preceding the update time. Based on the sliding average and final output value, the demand values are updated at the end of the time interval. For monitoring, the demand value output is AVG_DEMAND in kilowatt and the energy demand output is PERIODIC_KWH in kilowatt hour.

For example, the demand value based on the setting interval "180 Minute" is displayed in the output for the first time after 180 minutes and the value is calculated from the interval t0 – t180. The next value is displayed at the t180+1 and it is based on the average between t0+1 – t180+1.

If the linear average of the demand on the power source exceeds the *Maximum demand* setting limit, the MAX_DMD_ALM output (maximum demand operate) is TRUE. The RESET_DEMAND input resets the Demand based load-shedding module. If the RESET_DEMAND input is TRUE, the MAX_DMD_ALM output is TRUE and both the AVG_DEMAND and PERIODIC_KWH outputs are reset to zero.

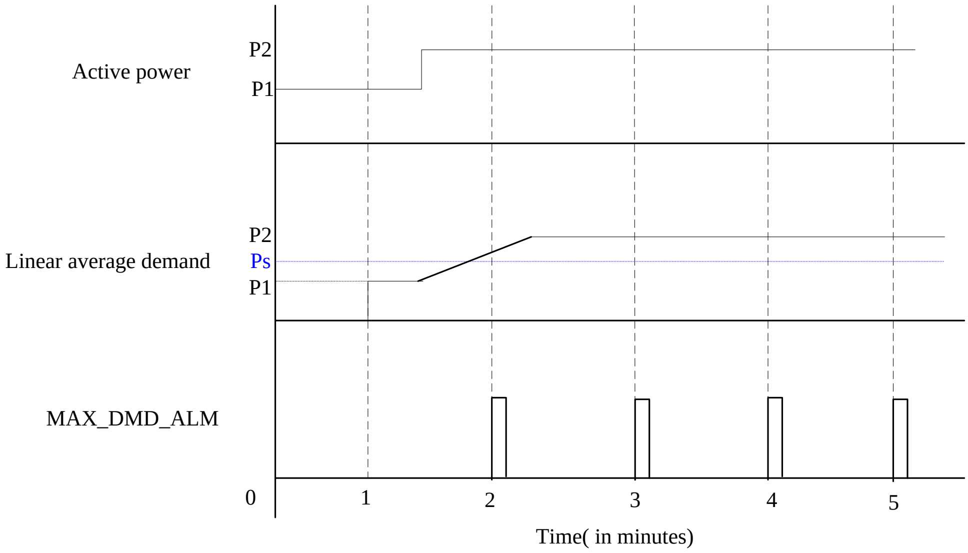


Figure 135: Maximum demand scenario-1

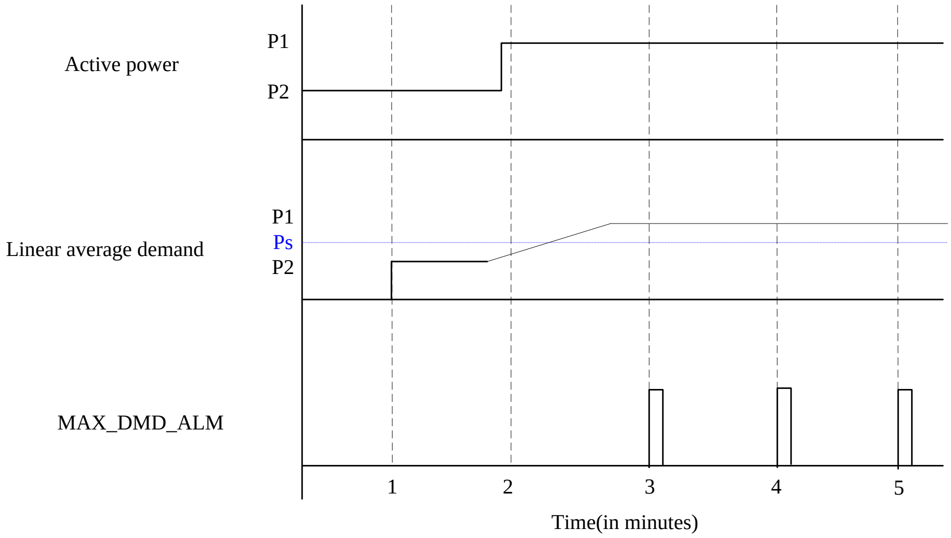


Figure 136: Maximum demand scenario-2

Where

P1	First active power value
Ps	*Maximum demand* setting
P2	Second active power value

Depending on the instant of change of the input power P1 to P2 as shown in Figure 135 and Figure 136, the maximum demand trigger can be activated either at minute 2 of the maximum demand scenario 1 or at minute 3 of the maximum demand scenario 2.

This module inhibits MAX_DMD_ALM output in any of the following conditions.

- The input INHIBIT_TRG is TRUE.
- The input SLS_DISABLE is TRUE.
- The load-shedding blocking status (from the Block logic module) is TRUE.

If the Demand based load shed module is disabled, MAX_DMD_ALM is FALSE, and the AVG_DEMAND and PERIODIC_KWH outputs are zero.

This module provides the MAX_DMD_ALM to Slow load shed logic module and Binary to integer module.

7.4.4.8 Slow load shed logic

This module calculates the available power, active power, slow load-shedding start, slow load-shedding trigger and slow load trigger inhibition signals. The Slow load shed logic module also calculates the overload amount during the overloading of the power source.

If the load-shedding blocking status is TRUE due to bad IED quality in the circuit breaker open position and the *Bypass block* setting is “Quality bad CB open”, the outputs AVA_POWER and ACTIVE_POWER are zero, else the outputs are the same as the available power and active power calculated in the Power monitoring module.

The slow load shed start and slow load-shedding trigger signals are activated based on various conditions, provided active power of the power source is positive. If the active power value is negative, the slow load-shed start and slow load-shedding trigger signals remain inactive.

The slow load-shedding start is activated if any of the following conditions satisfy.

- The OC_STR output is TRUE.
- The MAX_DMD_ALM output is TRUE.
- The external slow load-shedding trigger changes from FALSE to TRUE.

The slow load-shedding trigger is activated if any of the following conditions satisfy.

- The OC_OPR output is TRUE.
- The MAX_DMD_ALM output is TRUE.
- The external slow load-shedding trigger changes from FALSE to TRUE.

The slow load-shedding trigger is provided by the SLOWLS_OPR output.

If the SLOWLS_OPR output is TRUE, the AVA_POWER output is the same as the *Ava power SLS Trg* setting, else the AVA_POWER output remains the same as calculated above.

The slow load-shedding trigger is inhibited due to any of the following conditions.

- The INHIBIT_TRG input is TRUE.
- The SLS_DISABLE input is TRUE.
- The load-shedding blocking status is TRUE.
- The *Slow load shed mode* setting is “Disable”.

The Slow load shed logic module calculates the overload amount of the power source as the difference of the active power (from the Power monitoring module) and the *Ava power SLS Trg* setting. For monitoring view, the OVLOD_AMOUNT output provides the calculated overload amount. The OVLOD_AMOUNT output is zero when the active power value is less than the *Ava power SLS Trg* setting or the active power value is negative.

The Slow load shed logic module can handle the slow load-shedding based on the overloading of the power source by the *En Ov load Amnt shed* setting set to ”Yes”. The slow load-shedding based on the overloading of the power source can be disabled by the *En Ov load Amnt shed* setting set to ”No” and the OVLOD_AMOUNT output set to zero.

For monitoring view, the SLOWLS_MODE output provides the enabled or the disabled status of the Slow load shed logic module.

The slow load shed mode indicates if the slow load-shedding is disabled or enabled due to overcurrent based load shed or demand based load shed. The slow load shed mode is provided by the SLOWLS_MODE output.

The SLOWLS_MODE output is "Disable" if any of the following condition satisfy.

- The INHIBIT_TRG input is TRUE.
- The SLS_DISABLE input is TRUE.
- The Load-shedding blocking status is TRUE.
- The *Slow load shed mode* setting is “Disable”.

The SLOWLS_MODE output is “OC & Ext Trg” if the *Slow load shed mode* setting is “OC & Ext Trg”. Similarly, the SLOWLS_MODE output is “Max Dmd Trg” if the *Slow load shed mode* setting is “Max Dmd Trg”. The SLOWLS_MODE output is “OC, Max Dmd, Ext Trg” if the *Slow load shed mode* setting is “OC, Max Dmd, Ext Trg”.

If the SLOWLS_MODE is “Disable”, the output SLOWLS_OPR, slow load-shedding start and slow load trigger inhibition signals are FALSE and the output OVLOD_AMOUNT is zero.

The outputs AVA_POWER and ACTIVE_POWER are reported for the monitoring view.

The ACTIVE_POWER (active power), slow load-shedding start and slow load trigger inhibition signals are reported to the Binary to Integer module.

7.4.4.9 Binary to integer module

The DATA_SOURCE output provides the load-shedding data for the power source. The data is also available in the monitoring view.

The DATA_SOURCE output consists of various binary information as shown in Table 269.

Based on the *Source configure* setting, the Binary to integer module calculates the power source configuration status.

If the *Source configure* setting is set to “Generator”, the power source configuration status is FALSE. If the *Source configure* setting is set to “External source”, the power source configuration status is TRUE.

If the ACTIVE_POWER output is positive, the overcurrent operation status, maximum demand operation status and external slow load-shedding trigger remain same as received from the respective modules.

If the ACTIVE_POWER output is negative, the overcurrent operation status, maximum demand operation status and external slow load-shedding trigger are FALSE.

If the CB_COMPS_POS output is “Close”, the compensated circuit breaker close status is TRUE, else compensated circuit breaker close status is FALSE. If the CB_COMPS_POS output is “Open” and FLS_TRIGGER is TRUE, the compensated circuit breaker open status is FALSE.

Irrespective of the CB_COMPS_POS output, the compensated circuit breaker open status is TRUE if the FLS_TRIGGER is FALSE.

Table 269: DATA_SOURCE bits information

Bits	Bit Description	Short name of signal
1	Source configuration	SOURCE_CONFIG
2	Compensated CB closed status	COMP_CB_CLS
3	Fast load-shedding trigger	FLS_TRIGGER
4	Fast load-shed block	FLS_BLOCK
5	Island parallel status	ISLAND_PARALL
6	Overcurrent operating status	OC_OPR
7	Slow load-shed start	SLOWLS_STR
8	Maximum demand operating status	MAX_DMD_ALM
Table continues on next page		

Bits	Bit Description	Short name of signal
9	Slow load trigger inhibit status	SLS_TRG_BLK
10	External slow load-shedding trigger	EXT_SLOW_TRG
11	Compensated CB open status	COMP_CB_OPN

The *Busbar number* setting sets the power source load busbar number (`BB_NUMBER`). The group output `SOURCE` consists of signals for respective power source which are provided to the NPMMXU function.

Table 270: The group signals for SOURCE

Signal description	Group signal SOURCE	Signal short name for power source instance < n>
Configuration status for power source	Bit 1 of DATA_SOURCE	CONFIG_SRC <n>
Compensated CB close status for power source	Bit 2 of DATA_SOURCE	CCB_CLS_SRC <n>
Fast load shed trigger for power source	Bit 3 of DATA_SOURCE	FLS_TRG_SRC <n>
Fast load shed blocking for power source	Bit 4 of DATA_SOURCE	FLS_BLK_SRC <n>
Island parallel status for power source	Bit 5 of DATA_SOURCE	ISD_PAR_SRC <n>
Over current operate status for power source	Bit 6 of DATA_SOURCE	OC_OPR_SRC <n>
Slow load shed start for power source	Bit 7 of DATA_SOURCE	SLS_STR_SRC <n>
Maximum demand operate status for power source	Bit 8 of DATA_SOURCE	MAX_DMD_SRC <n>
Slow load trigger inhibit status for power source	Bit 9 of DATA_SOURCE	SLS_INH_SRC <n>
External slow load shed trigger for power source	Bit 10 of DATA_SOURCE	EXT_SLT_SRC <n>
Compensated CB open status for power source	Bit 11 of DATA_SOURCE	CCB_OPN_SRC <n>
Available power of power source	AVA_POWER	AVA_POWER_SRC <n>
Active power of power source	ACTIVE_POWER	ACT_POWER_SRC <n>
Governor mode of generator	GOV_MODE	GOV_MODE_SRC <n>
Overload amount of power source	OVLOD_AMOUNT	OVLOD_SRC <n>
Busbar number of power source	BB_NUMBER	BB_NUM_SRC <n>

7.4.5 Signals

Table 271: PSCSWI Input signals

Name	Type	Default	Description
I_A	REAL	0.0	Phase A RMS current of power source
I_B	REAL	0.0	Phase B RMS current of power source
I_C	REAL	0.0	Phase C RMS current of power source
POWER	REAL	0.0	Active power from power source
CB_POSITION	INTEGER	1	Circuit breaker position of source
CB_SERVICE	BOOLEAN	0	Circuit breaker service position of power source
CB_LOCK_OUT	BOOLEAN	0	Circuit breaker lockout status of power source
CB_IED_QVAL	BOOLEAN	1	Circuit breaker IED quality status of power source
IED_TST_MODE	BOOLEAN	0	IED test mode behaviour of power source
MAX_POWER	REAL	0.0	Available power of power source on communication
GOVERNOR_MOD	INTEGER	3	Governor mode of generator on communication
AP_GOV_QVAL	BOOLEAN	1	Quality status of available power and governor mode on comm
ISLAND_PARAL	BOOLEAN	1	Island or parallel mode for external power source
ENA_MULT	BOOLEAN	0	Enable signal for current multiplier
EXT_OC_SLST	BOOLEAN	0	External slow load shed trigger for power source
INHIBIT_TRG	BOOLEAN	0	Inhibit the trigger from power source
SLS_DISABLE	BOOLEAN	0	Slow load shed disable of power source
RESET_OC	BOOLEAN	0	Reset for over current
RESET_DEMAND	BOOLEAN	0	Reset for maximum demand

Table 272: PSCSWI Output signals

Name	Type	Description
SOURCE	GROUP SIGNAL	Group signal of power source
CB_COMPS_POS	INTEGER	Circuit breaker position of power source
ACTIVE_POWER	REAL	Active power of power source
AVA_POWER	REAL	Available power of power source
FLS_TRIGGER	BOOLEAN	Fast load shed trigger from power source
SLOWLS_OPR	BOOLEAN	Slow load shed trigger from power source
OC_STR	BOOLEAN	Over current start of power source
OC_OPR	BOOLEAN	Over current operate status of power source
MAX_DMD_ALM	BOOLEAN	Max demand operate alarm for power source
ISLND_PARALL	BOOLEAN	Island or parallel mode status of external source
FLS_BLOCK	BOOLEAN	Fast load shed block from power source
BLK_BYPASS	BOOLEAN	Block is bypassed
B_SET_CHANGE	BOOLEAN	One or many basic setting change
INVAL_CRV	BOOLEAN	Invalid curve parameters

7.4.6 Settings

Table 273: PSCSWI Group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Start value	0.05 - 5.00	pu	0.01	0.05	Start value
Start value Mult	0.8 - 10.0	-	0.1	1.0	Multiplier for scaling the start value
Time multiplier	0.05 - 15.00	-	0.05	1.00	Time multiplier in IEC/ANSI curves
Operating curve type	ANSI Ext. inv. ANSI Very inv. ANSI Norm. inv. ANSI Mod. inv. ANSI Def. Time L.T.E. inv. L.T.V. inv. L.T. inv. IEC Norm. inv. IEC Very inv. IEC inv. IEC Ext. inv. IEC S.T. inv. IEC L.T. inv. IEC Def. Time Programmable RI type RD type	-	-	IEC Def. Time	Selection of time delay curve type
Operate delay time	0.04 - 200.00	s	0.01	0.04	Operate delay time

Table 274: PSCSWI Group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Type of reset curve	Immediate Def time reset Inverse reset	-	-	Immediate	Selection of reset curve type

Table 275: PSCSWI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Block override	No IED test mode Quality bad CB close Quality bad CB open CB Interm or invalid All yes	-	-	No	Bypass block due to IED test or data quality or CB position
Maximum Ava power	0.0 - 999999.9	kW	0.1	0.0	Maximum available power of power source
Governor mode	Droop MW ISO P-Control Optimize Base load Peak load	-	-	ISO	Governor mode of generator

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Slow load shed mode	Disable OC & Ext Trg Max Dmd Trg OC, Max Dmd, Ext Trg	-	-	Disable	Enable slow load shed trigger of power source
Maximum power SLS	0.0 - 999999.9	kW	0.1	0.0	Maximum power of source during slow load trigger
Maximum demand	0.0 - 999999.9	kW	0.1	0.0	Maximum power demand of power source

Table 276: PSCSWI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Source configure	External source Generator	-	-	External source	Source type configure as generator or external source
Busbar number	Source Not Configure Load Bus Bar 1 Load Bus Bar 2 Load Bus Bar 3 Load Bus Bar 4	-	-	Source Not Configure	Load bus bar number of power source
CB Interm time	0 - 500	ms	10	200	Circuit breaker intermediate time
Power convention	Positive W Negative W Positive kW Negative kW Positive MW Negative MW	-	-	Positive W	IED power unit and sign convention of source
Ava power mode	Set Max Ava power Set Ava Pow relative Comm Max Ava power Comm spin reserve	-	-	Set Max Ava power	Available power mode selection
Ava power relative	100.00 - 400.00	%	1.00	100.00	Available power as percentage of active power
Enable Comm Gov mode	Disable Enable	-	-	Disable	Enable governor mode of generator on communication
Demand interval	1 Min 5 Mins 10 Mins 15 Mins 30 Mins 60 Mins 180 Mins	-	-	15 Min	Time interval for energy calculation
En Ov load Amnt shed	No Yes	-	-	No	Enable overload amount based slow load trigger
Power Cfg export Mod	Pow & Ava Pow No Chg Pow & Ava Pow Zero	-	-	Pow & Ava Pow No Chg	Power configuration during power flow direction negative
Base value Sel phase	Phase Grp 1 Phase Grp 2 Phase Grp 3	-	-	Phase Grp 1	Selection of one of the Global Base Value groups

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Curve parameter A	0.0086 - 120.0000	-	0.0001	28.2000	Parameter A for customer programmable curve
Curve parameter B	0.0000 - 0.7120	-	0.0001	0.1217	Parameter B for customer programmable curve
Curve parameter C	0.02 - 2.00	-	0.01	2.00	Parameter C for customer programmable curve
Curve parameter D	0.46 - 30.00	-	0.01	29.10	Parameter D for customer programmable curve
Curve parameter E	0.0 - 1.0	-	0.1	1.0	Parameter E for customer programmable curve
Reset delay time	0.000 - 60.000	s	0.001	0.020	Reset delay time
Minimum operate time	0.040 - 60.000	s	0.001	0.040	Minimum operate time for IEC/ANSI curves

7.4.7 Measured values

Table 277: PSCSWI Measured values

Name	Type	Default	Description
I_A	REAL	0.0	Phase A RMS current of power source
I_B	REAL	0.0	Phase B RMS current of power source
I_C	REAL	0.0	Phase C RMS current of power source
POWER	REAL	0.0	Active power from power source
CB_POSITION	INTEGER	1	Circuit breaker position of source
CB_SERVICE	BOOLEAN	0	Circuit breaker service position of power source
CB_LOCK_OUT	BOOLEAN	0	Circuit breaker lockout status of power source
CB_IED_QVAL	BOOLEAN	1	Circuit breaker IED quality status of power source
IED_TST_MODE	BOOLEAN	0	IED test mode behaviour of power source
MAX_POWER	REAL	0.0	Available power of power source on communication
GOVERNOR_MOD	INTEGER	3	Governor mode of generator on communication
AP_GOV_QVAL	BOOLEAN	1	Quality status of available power and governor mode on comm
ISLAND_PARAL	BOOLEAN	1	Island or parallel mode for external power source
ENA_MULT	BOOLEAN	0	Enable signal for current multiplier
EXT_OC_SLST	BOOLEAN	0	External slow load shed trigger for power source
INHIBIT_TRG	BOOLEAN	0	Inhibit the trigger from power source
SLS_DISABLE	BOOLEAN	0	Slow load shed disable of power source
RESET_OC	BOOLEAN	0	Reset for over current
RESET_DEMAND	BOOLEAN	0	Reset for maximum demand

7.4.8 Monitored data

Table 278: PSCSWI Monitored data

Name	Type	Values (Range)	Unit	Description
DATA_SOURCE	INTEGER	-	-	Load shed data for power source
CB_COMPS_POS	INTEGER	1=Open 2=Close	-	Circuit breaker position of power source
ACTIVE_POWER	REAL	-	kW	Active power of power source
AVA_POWER	REAL	-	kW	Available power of power source
GOV_MODE	INTEGER	1=Droop 2=MW 3=ISO 4=P-Control 5=Optimize 6=Base load 7=Peak load 0=Not applicable	-	Governor mode of generator
AVG_DEMAND	REAL	-	kW	Average demand over set interval of power source
PERIODIC_KWH	REAL	-	kWh	Periodic energy at demand interval of power source
MAX_CURRENT	REAL	-	A	Maximum of three phase current of power source
OVLOD_AMOUNT	REAL	-	kW	Overload amount during slow load trigger
PICKUP	REAL	-	-	Pick up value for over current start of power source
ELAPSE_TIME	REAL	-	s	Elapse time after overcurrent start
OC_TIME	REAL	-	s	Time require for over current operate
SLOWLS_MODE	INTEGER	1=Disable 2=OC & Ext Trg 3=Max Dmd Trg 4=OC, Max Dmd, Ext Trg	-	Enable or disable signal for curr and demand based load shed
FLS_TRIGGER	BOOLEAN	0=FALSE 1=TRUE	-	Fast load shed trigger from power source
SLOWLS_OPR	BOOLEAN	0=FALSE 1=TRUE	-	Slow load shed trigger from power source
OC_STR	BOOLEAN	0=FALSE 1=TRUE	-	Over current start of power source
OC_OPR	BOOLEAN	0=FALSE 1=TRUE	-	Over current operate status of power source
MAX_DMD_ALM	BOOLEAN	0=FALSE 1=TRUE	-	Max demand operate alarm for power source

Table continues on next page

Name	Type	Values (Range)	Unit	Description
ISLND_PARALL	BOOLEAN	1=Parallel 0=Island	-	Island or parallel mode status of external source
FLS_BLOCK	BOOLEAN	0=FALSE 1=TRUE	-	Fast load shed block from power source
BLK_BYPASS	BOOLEAN	0=FALSE 1=TRUE	-	Block is bypassed
B_SET_CHANGE	BOOLEAN	0=FALSE 1=TRUE	-	One or many basic setting change
INVAL_CRV	BOOLEAN	0=FALSE 1=TRUE	-	Invalid curve parameters

7.4.9 Technical data

Table 279: PSCSWI technical data

Characteristic	Details	Value
Operation accuracy		At the frequency $f = f_n$ ±1.5% of the set value or $\pm 0.002 \times I_n$
Start time[1)2)]	$I_{Fault} = 2 \times$ set Start value	Typical: 23 ms (±15 ms)
Reset time		<45 ms
Reset ratio		Typical 0.96
Retardation time		<30 ms
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3)]

1) Current before fault = $0.0 \times I_n$, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum Start value = $2.5 \times I_n$, Start value multiples in range of 1.5...20

7.5 Load busbar monitoring LDMMXU

7.5.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE identification
Load busbar monitoring	LDMMXU	-	LDMMXU

7.5.2 Function block

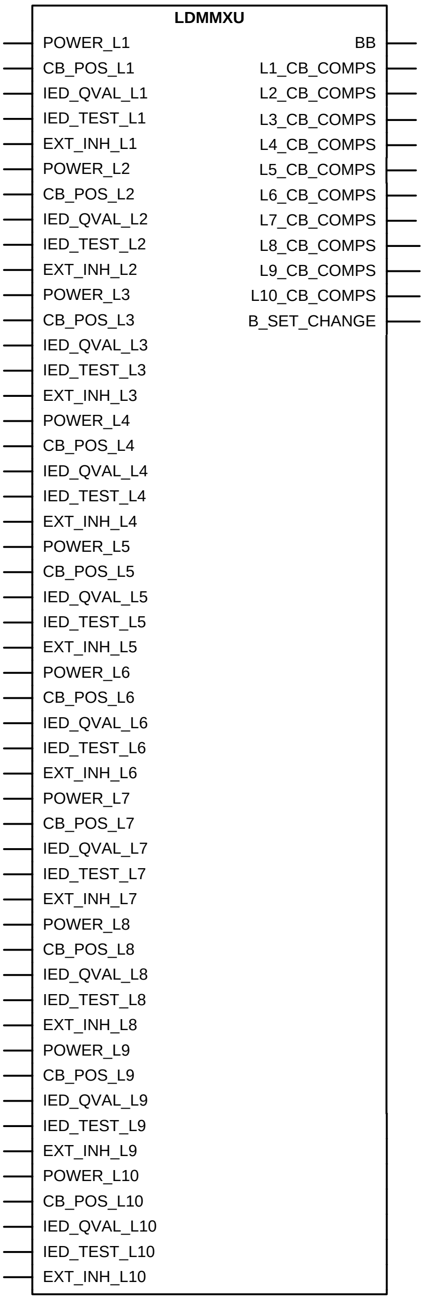


Figure 137: Function block

7.5.3 Functionality

Load busbar monitoring LDMMXU function calculates the compensated CB status and load-shedding inhibit status for individual sheddable loads. The load-shedding priority or inhibit status and power value of each sheddable load is reported to LSCACLS for load-shedding action.

7.5.4 Operation principle

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

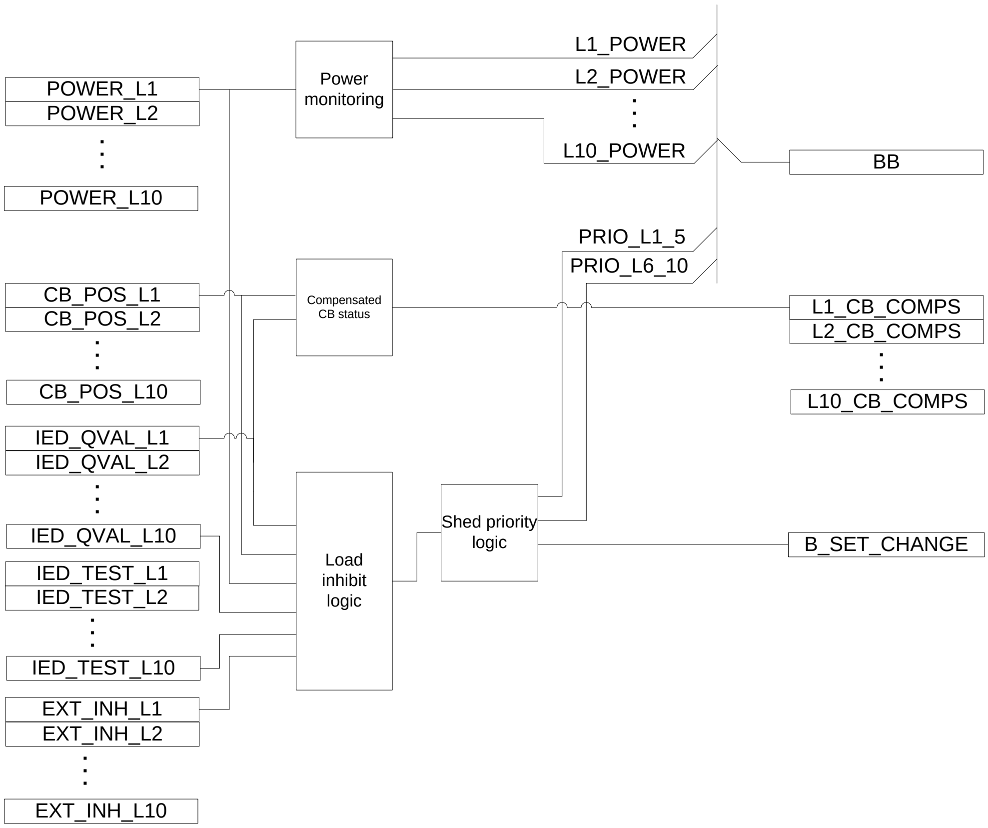


Figure 138: Functional module diagram

The Power monitoring, Compensated CB status and Load inhibit logic modules are identical for sheddable load1 to sheddable load10. Hence, the logic explained in these modules for sheddable load1 also applies to sheddable load2, sheddable load3 and so on.

7.5.4.1 Power monitoring

This module converts the units of the `POWER_L1` input (sheddable load1 active power) in kW as the *Power convention L1* setting. The `L1_POWER` output is provided for monitoring view.

Table 280: Unit conversion of power for the sheddable load1

Power convention L1 setting	Input	L1_POWER output
W	POWER_L1	POWER_L1 × [0.001]
kW	POWER_L1	POWER_L1 × [1]
MW	POWER_L1	POWER_L1 × [1000]

7.5.4.2 Compensated CB status

This module calculates the compensated CB status for sheddable load1. The `L1_CB_COMPS` output provides the compensated CB status for sheddable load1.

The conditions to set the `L1_CB_COMPS` output as "Close".

- The input `CB_POS_L1` (sheddable load1 circuit breaker position) is "Close".
- The input `IED_QVAL_L1` (sheddable load1 IED data quality) is “Good”.

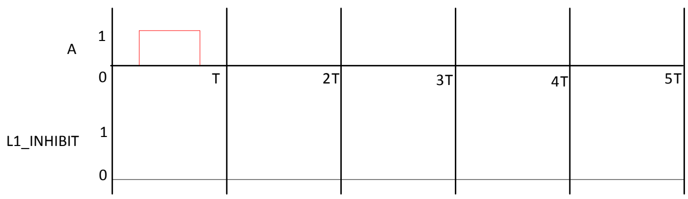
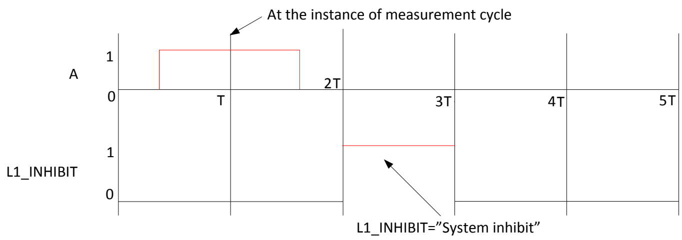
When either of the above conditions are not met, `L1_CB_COMPS` output is "Open".

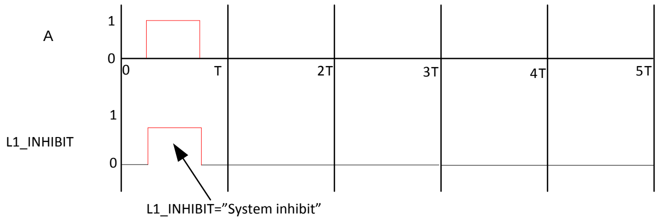
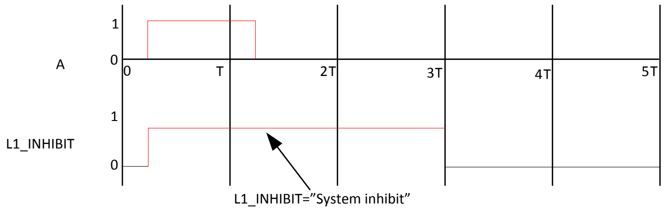
7.5.4.3 Load inhibit logic

The sheddable load1 can be inhibited by an operator based on the *Inhibit L1* setting. The sheddable load1 can be inhibited by a system based on various conditions as shown in the Table 281.

If the sheddable load1 is not inhibited by the system or operator, the `L1_INHIBIT` output is "Not Inhibit".

Table 281: Calculation of the L1_INHIBIT output

Cause of inhibition of sheddable load	L1_INHIBIT output
A = setting Inhibit L1 is Active	L1_INHIBIT = Operator Inhibit
A= input CB_POS_L1 is Open and input POWER_L1 ≠ 0 (within measurement cycle)	 L1_INHIBIT = Not Inhibit
A = input CB_POS_L1 is Open and input POWER_L1 ≠ 0 (at measurement cycle)	
Table continues on next page	

Cause of inhibition of sheddable load	L1_INHIBIT output
A = input IED_QVAL_L1 is Bad (within measurement cycle)	
A = input IED_QVAL_L1 is Bad (at measurement cycle)	
A = input IED_TEST_L1 is TRUE or input EXT_INH_L1 is TRUE or input CB_POS_L1 is Intermediate or Invalid	L1_INHIBIT = System Inhibit
T, 2T, 3T are the measurement cycles.	

If the sheddable load1 is inhibited by the system and operator at the same time, the output L1_INHIBIT is "Operator Inhibit".

The calculated L1_INHIBIT output is available for the monitoring view and reported to the Shed priority logic module.

7.5.4.4 Shed priority logic

This module calculates the shed priority of a sheddable load based on the system or operator inhibition. The *Priority L1* setting sets the priority of the sheddable load1. The *Priority L1* value ranges from 1 to 19, where 1 is the lowest important sheddable load and 19 is the highest important sheddable load. The priority setting is also available as the L1_SHED_PRIO output for the monitoring view.

The priority setting is effective only if the sheddable load is not inhibited by the system or operator.

The priorities of the sheddable load1...5 can be monitored as output PRIO_L1_5 and sheddable load6...10 can be monitored as output PRIO_L6_10 coded integer (32 bit) form.

Each sheddable load priority is represented by 5-bit information as shown in Table 282.

Table 282: PRIO_L1_5 bits information

Bits	Bits description
1...5	Sheddable load1 priority
6...10	Sheddable load2 priority
11...15	Sheddable load3 priority
16...20	Sheddable load4 priority
21...25	Sheddable load5 priority

Similarly, the priority for each sheddable load that is sheddable load6...10 is represented by consecutive five bits of `PRIO_L6_L10`.

The output `B_SET_CHANGE` remains active for 500 ms if one or more basic settings are changed. After 500 ms, the output `B_SET_CHANGE` is FALSE.

The group output `BB` consists of signals for ten sheddable loads which are provided to the LSCACLS function.

Table 283: Group signals for BB

Signal description	Group signal BB
Active power of sheddable load1 to sheddable load10	L1_POWER to L10_POWER
Shed priority data of sheddable loads 1...5	PRIO_L1_5
Shed priority data of sheddable loads 6...10	PRIO_L6_10

7.5.5 Signals

Table 284: LDMMXU Input signals

Name	Type	Default	Description
POWER_L1	REAL	0.0	Active power of sheddable load1
CB_POS_L1	INTEGER	1	Circuit breaker position of the sheddable load1
IED_QVAL_L1	BOOLEAN	1	Circuit breaker IED quality status of sheddable load1
IED_TEST_L1	BOOLEAN	0	IED test mode behaviour of sheddable load1
EXT_INH_L1	BOOLEAN	0	External inhibit of sheddable load1
POWER_L2	REAL	0.0	Active power of sheddable load2
CB_POS_L2	INTEGER	1	Circuit breaker position of sheddable load2
IED_QVAL_L2	BOOLEAN	1	Circuit breaker IED quality status of sheddable load2
IED_TEST_L2	BOOLEAN	0	IED test mode behaviour of sheddable load2
EXT_INH_L2	BOOLEAN	0	External inhibit of sheddable load2
POWER_L3	REAL	0.0	Active power of sheddable load3
CB_POS_L3	INTEGER	1	Circuit breaker position of sheddable load3

Table continues on next page

Name	Type	Default	Description
IED_QVAL_L3	BOOLEAN	1	Circuit breaker IED quality status of sheddable load3
IED_TEST_L3	BOOLEAN	0	IED test mode behaviour of sheddable load3
EXT_INH_L3	BOOLEAN	0	External inhibit of sheddable load3
POWER_L4	REAL	0.0	Active power of sheddable load4
CB_POS_L4	INTEGER	1	Circuit breaker position of sheddable load4
IED_QVAL_L4	BOOLEAN	1	Circuit breaker IED quality status of sheddable load4
IED_TEST_L4	BOOLEAN	0	IED test mode behaviour of sheddable load4
EXT_INH_L4	BOOLEAN	0	External inhibit of sheddable load4
POWER_L5	REAL	0.0	Active power of sheddable load5
CB_POS_L5	INTEGER	1	Circuit breaker position of sheddable load5
IED_QVAL_L5	BOOLEAN	1	Circuit breaker IED quality status of sheddable load5
IED_TEST_L5	BOOLEAN	0	IED test mode behaviour of sheddable load5
EXT_INH_L5	BOOLEAN	0	External inhibit of sheddable load5
POWER_L6	REAL	0.0	Active power of sheddable load6
CB_POS_L6	INTEGER	1	Circuit breaker position of the sheddable load6
IED_QVAL_L6	BOOLEAN	1	Circuit breaker IED quality status of sheddable load6
IED_TEST_L6	BOOLEAN	0	IED test mode behaviour of sheddable load6
EXT_INH_L6	BOOLEAN	0	External inhibit of sheddable load6
POWER_L7	REAL	0.0	Active power of sheddable load7
CB_POS_L7	INTEGER	1	Circuit breaker position of the sheddable load7
IED_QVAL_L7	BOOLEAN	1	Circuit breaker IED quality status of sheddable load7
IED_TEST_L7	BOOLEAN	0	IED test mode behaviour of sheddable load7
EXT_INH_L7	BOOLEAN	0	External inhibit of sheddable load7
POWER_L8	REAL	0.0	Active power of sheddable load8
CB_POS_L8	INTEGER	1	Circuit breaker position of the sheddable load8
IED_QVAL_L8	BOOLEAN	1	Circuit breaker IED quality status of sheddable load8
IED_TEST_L8	BOOLEAN	0	IED test mode behaviour of sheddable load8
EXT_INH_L8	BOOLEAN	0	External inhibit of sheddable load8
POWER_L9	REAL	0.0	Active power of sheddable load9
CB_POS_L9	INTEGER	1	Circuit breaker position of the sheddable load9
IED_QVAL_L9	BOOLEAN	1	Circuit breaker IED quality status of sheddable load9
IED_TEST_L9	BOOLEAN	0	IED test mode behaviour of sheddable load9
EXT_INH_L9	BOOLEAN	0	External inhibit of sheddable load9
POWER_L10	REAL	0.0	Active power of sheddable load10
CB_POS_L10	INTEGER	1	Circuit breaker position of the sheddable load10

Table continues on next page

Name	Type	Default	Description
IED_QVAL_L10	BOOLEAN	1	Circuit breaker IED quality status of sheddable load10
IED_TEST_L10	BOOLEAN	0	IED test mode behaviour of sheddable load10
EXT_INH_L10	BOOLEAN	0	External inhibit of sheddable load10

Table 285: LDMMXU Output signals

Name	Type	Description
BB	GROUP SIGNAL	Group signal of sheddable loads
L1_POWER	REAL	Active power of the sheddable load1
L1_CB_COMPS	INTEGER	Circuit breaker position of sheddable load1
L2_POWER	REAL	Active power of the sheddable load2
L2_CB_COMPS	INTEGER	Circuit breaker position of sheddable load2
L3_POWER	REAL	Active power of the sheddable load3
L3_CB_COMPS	INTEGER	Circuit breaker position of sheddable load3
L4_POWER	REAL	Active power of sheddable load4
L4_CB_COMPS	INTEGER	Circuit breaker position of sheddable load4
L5_POWER	REAL	Active power of the sheddable load5
L5_CB_COMPS	INTEGER	Circuit breaker position of sheddable load5
L6_POWER	REAL	Active power of the sheddable load6
L6_CB_COMPS	INTEGER	Circuit breaker position of sheddable load6
L7_POWER	REAL	Active power of the sheddable load7
L7_CB_COMPS	INTEGER	Circuit breaker position of sheddable load7
L8_POWER	REAL	Active power of the sheddable load8
L8_CB_COMPS	INTEGER	Circuit breaker position of sheddable load8
L9_POWER	REAL	Active power of the sheddable load9
L9_CB_COMPS	INTEGER	Circuit breaker position of sheddable load9
L10_POWER	REAL	Active power of the sheddable load10
L10_CB_COMPS	INTEGER	Circuit breaker position of sheddable load10
B_SET_CHANGE	BOOLEAN	One or many basic settings change

7.5.6 Settings

Table 286: LDMMXU Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Priority L1	1 - 19	-	1	19	Load shed priority of sheddable load1
Priority L2	1 - 19	-	1	19	Load shed priority of sheddable load2
Priority L3	1 - 19	-	1	19	Load shed priority of sheddable load3
Priority L4	1 - 19	-	1	19	Load shed priority of sheddable load4
Priority L5	1 - 19	-	1	19	Load shed priority of sheddable load5
Table continues on next page					

Name	Values (Range)	Unit	Step	Default	Description
Priority L6	1 - 19	-	1	19	Load shed priority of sheddable load6
Priority L7	1 - 19	-	1	19	Load shed priority of sheddable load7
Priority L8	1 - 19	-	1	19	Load shed priority of sheddable load8
Priority L9	1 - 19	-	1	19	Load shed priority of sheddable load9
Priority L10	1 - 19	-	1	19	Load shed priority of sheddable load10
Inhibit L1	Inactive Active	-	-	Active	Load shed inhibit for sheddable load1
Inhibit L2	Inactive Active	-	-	Active	Load shed inhibit for sheddable load2
Inhibit L3	Inactive Active	-	-	Active	Load shed inhibit for sheddable load3
Inhibit L4	Inactive Active	-	-	Active	Load shed inhibit for sheddable load4
Inhibit L5	Inactive Active	-	-	Active	Load shed inhibit for sheddable load5
Inhibit L6	Inactive Active	-	-	Active	Load shed inhibit for sheddable load6
Inhibit L7	Inactive Active	-	-	Active	Load shed inhibit for sheddable load7
Inhibit L8	Inactive Active	-	-	Active	Load shed inhibit for sheddable load8
Inhibit L9	Inactive Active	-	-	Active	Load shed inhibit for sheddable load9
Inhibit L10	Inactive Active	-	-	Active	Load shed inhibit for sheddable load10

Table 287: LDMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Power unit L1	MW kW W	-	-	W	Power unit for sheddable load1
Power unit L2	MW kW W	-	-	W	Power unit for sheddable load2
Power unit L3	MW kW W	-	-	W	Power unit for sheddable load3
Power unit L4	MW kW W	-	-	W	Power unit for sheddable load4
Power unit L5	MW kW W	-	-	W	Power unit for sheddable load5
Power unit L6	MW kW W	-	-	W	Power unit for sheddable load6

Table continues on next page

Name	Values (Range)	Unit	Step	Default	Description
Power unit L7	MW kW W	-	-	W	Power unit for sheddable load7
Power unit L8	MW kW W	-	-	W	Power unit for sheddable load8
Power unit L9	MW kW W	-	-	W	Power unit for sheddable load9
Power unit L10	MW kW W	-	-	W	Power unit for sheddable load10

7.5.7 Measured values

Table 288: LDMMXU Measured values

Name	Type	Default	Description
POWER_L1	REAL	0.0	Active power of sheddable load1
CB_POS_L1	INTEGER	1	Circuit breaker position of the sheddable load1
IED_QVAL_L1	BOOLEAN	1	Circuit breaker IED quality status of sheddable load1
IED_TEST_L1	BOOLEAN	0	IED test mode behaviour of sheddable load1
EXT_INH_L1	BOOLEAN	0	External inhibit of sheddable load1
POWER_L2	REAL	0.0	Active power of sheddable load2
CB_POS_L2	INTEGER	1	Circuit breaker position of sheddable load2
IED_QVAL_L2	BOOLEAN	1	Circuit breaker IED quality status of sheddable load2
IED_TEST_L2	BOOLEAN	0	IED test mode behaviour of sheddable load2
EXT_INH_L2	BOOLEAN	0	External inhibit of sheddable load2
POWER_L3	REAL	0.0	Active power of sheddable load3
CB_POS_L3	INTEGER	1	Circuit breaker position of sheddable load3
IED_QVAL_L3	BOOLEAN	1	Circuit breaker IED quality status of sheddable load3
IED_TEST_L3	BOOLEAN	0	IED test mode behaviour of sheddable load3
EXT_INH_L3	BOOLEAN	0	External inhibit of sheddable load3
POWER_L4	REAL	0.0	Active power of sheddable load4
CB_POS_L4	INTEGER	1	Circuit breaker position of sheddable load4
IED_QVAL_L4	BOOLEAN	1	Circuit breaker IED quality status of sheddable load4
IED_TEST_L4	BOOLEAN	0	IED test mode behaviour of sheddable load4
EXT_INH_L4	BOOLEAN	0	External inhibit of sheddable load4
POWER_L5	REAL	0.0	Active power of sheddable load5
CB_POS_L5	INTEGER	1	Circuit breaker position of sheddable load5

Table continues on next page

Name	Type	Default	Description
IED_QVAL_L5	BOOLEAN	1	Circuit breaker IED quality status of sheddable load5
IED_TEST_L5	BOOLEAN	0	IED test mode behaviour of sheddable load5
EXT_INH_L5	BOOLEAN	0	External inhibit of sheddable load5
POWER_L6	REAL	0.0	Active power of sheddable load6
CB_POS_L6	INTEGER	1	Circuit breaker position of the sheddable load6
IED_QVAL_L6	BOOLEAN	1	Circuit breaker IED quality status of sheddable load6
IED_TEST_L6	BOOLEAN	0	IED test mode behaviour of sheddable load6
EXT_INH_L6	BOOLEAN	0	External inhibit of sheddable load6
POWER_L7	REAL	0.0	Active power of sheddable load7
CB_POS_L7	INTEGER	1	Circuit breaker position of the sheddable load7
IED_QVAL_L7	BOOLEAN	1	Circuit breaker IED quality status of sheddable load7
IED_TEST_L7	BOOLEAN	0	IED test mode behaviour of sheddable load7
EXT_INH_L7	BOOLEAN	0	External inhibit of sheddable load7
POWER_L8	REAL	0.0	Active power of sheddable load8
CB_POS_L8	INTEGER	1	Circuit breaker position of the sheddable load8
IED_QVAL_L8	BOOLEAN	1	Circuit breaker IED quality status of sheddable load8
IED_TEST_L8	BOOLEAN	0	IED test mode behaviour of sheddable load8
EXT_INH_L8	BOOLEAN	0	External inhibit of sheddable load8
POWER_L9	REAL	0.0	Active power of sheddable load9
CB_POS_L9	INTEGER	1	Circuit breaker position of the sheddable load9
IED_QVAL_L9	BOOLEAN	1	Circuit breaker IED quality status of sheddable load9
IED_TEST_L9	BOOLEAN	0	IED test mode behaviour of sheddable load9
EXT_INH_L9	BOOLEAN	0	External inhibit of sheddable load9
POWER_L10	REAL	0.0	Active power of sheddable load10
CB_POS_L10	INTEGER	1	Circuit breaker position of the sheddable load10
IED_QVAL_L10	BOOLEAN	1	Circuit breaker IED quality status of sheddable load10
IED_TEST_L10	BOOLEAN	0	IED test mode behaviour of sheddable load10
EXT_INH_L10	BOOLEAN	0	External inhibit of sheddable load10

7.5.8 Monitored Data

Table 289: LDMMXU Monitored data

Name	Type	Values (Range)	Unit	Description
L1_POWER	REAL	-	kW	Active power of the sheddable load1
L1_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load1
L1_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load1
L1_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load1
L2_POWER	REAL	-	kW	Active power of the sheddable load2
L2_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load2
L2_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load2
L2_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load2
L3_POWER	REAL	-	kW	Active power of the sheddable load3
L3_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load3
L3_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load3
L3_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load3
L4_POWER	REAL	-	kW	Active power of sheddable load4
L4_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load4
L4_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load4
L4_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load4
L5_POWER	REAL	-	kW	Active power of the sheddable load5
L5_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load5
L5_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load5

Table continues on next page

Name	Type	Values (Range)	Unit	Description
L5_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load5
L6_POWER	REAL	-	kW	Active power of the sheddable load6
L6_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load6
L6_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load6
L6_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load6
L7_POWER	REAL	-	kW	Active power of the sheddable load7
L7_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load7
L7_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load7
L7_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load7
L8_POWER	REAL	-	kW	Active power of the sheddable load8
L8_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load8
L8_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load8
L8_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load8
L9_POWER	REAL	-	kW	Active power of the sheddable load9
L9_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load9
L9_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load9
L9_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load9
L10_POWER	REAL	-	kW	Active power of the sheddable load10
L10_CB_COMPS	INTEGER	1=Open 2=Close	-	Circuit breaker position of sheddable load10
L10_SHED_PRIO	INTEGER	-	-	Shed priority of sheddable load10

Table continues on next page

Name	Type	Values (Range)	Unit	Description
L10_INHIBIT	INTEGER	2=System Inhibit 0=Not Inhibit 1=Operator Inhibit	-	Load shedding inhibit status of sheddable load10
B_SET_CHANGE	BOOLEAN	0=FALSE 1=TRUE	-	One or many basic settings change
PRIO_L1_5	INTEGER	-	-	Shed priority data of sheddable loads 1 to 5
PRIO_L6_10	INTEGER	-	-	Shed priority data of sheddable loads 6 to 10

7.6 Network circuit breaker NCBDCSWI

7.6.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE identification
Network circuit breaker	NCBDCSWI	-	NCBDCSWI

7.6.2 Function block

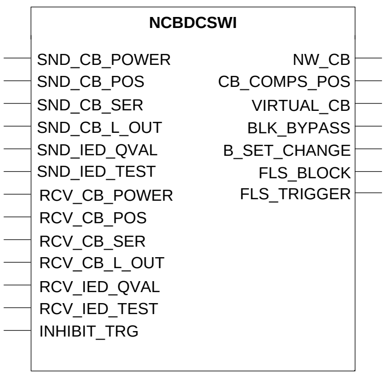


Figure 139: Function block

7.6.3 Functionality

The network circuit breaker function NCBDCSWI is the input interface for bus coupler or tie feeder circuit breaker. It can be configured for either bus coupler or tie circuit breakers connecting two busbars. This function can also be configured as virtual circuit breaker when two busbars are permanently connected to each other. Based on the various inputs and type of network circuit breaker configuration, it calculates the active power, fast load-shedding trigger, fast load-shedding block and compensated CB status. It has the provision to bypass the fast load-shedding block caused by various conditions. It reports the load-shedding data and active power of network circuit breaker to LSCACLS for load-shedding action.

7.6.4 Operation principle

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

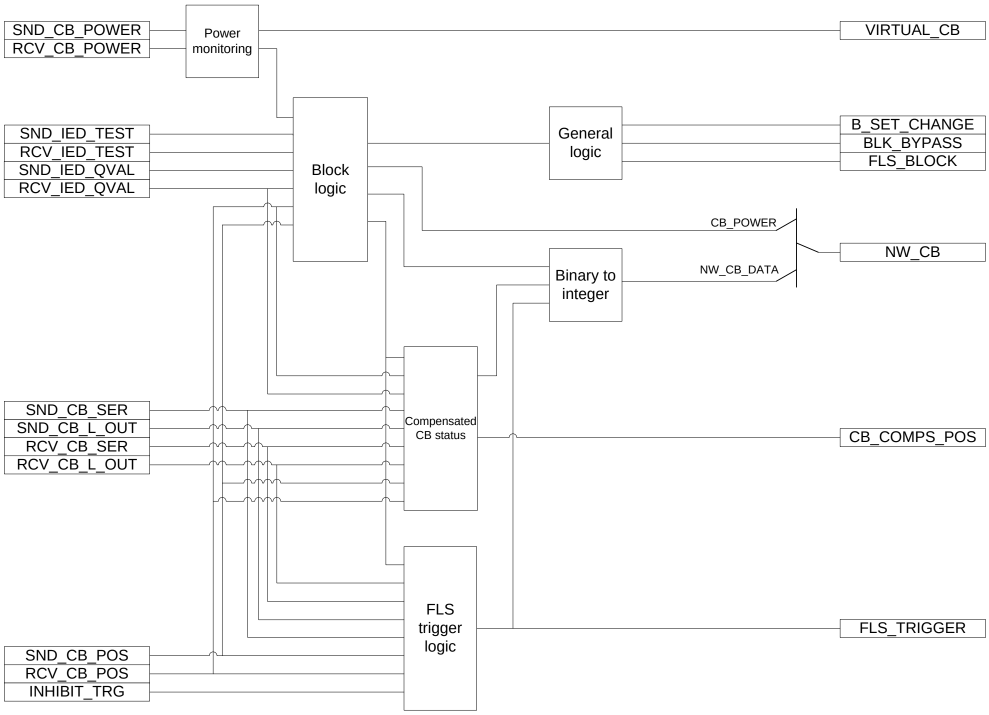


Figure 140: Functional module diagram

7.6.4.1 Power monitoring

Based on the network circuit breaker configuration, NCBDCSWI can be configured for a bus coupler or tie circuit breaker.

If one network circuit breaker is connected in a busbar configuration as shown in Figure 141, the *CB configuration* setting is set to “Bus coupler”.

If two network circuit breakers are connected in a busbar configuration as shown in Figure 142, the *CB configuration* setting is set to “Tie breaker”.

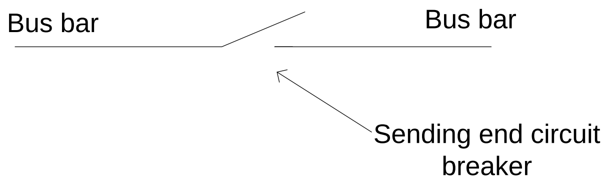


Figure 141: Bus coupler configuration

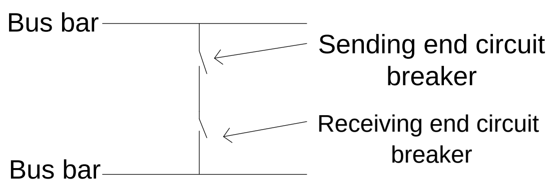


Figure 142: Tie circuit breaker configuration

This module converts the units of `SND_CB_POWER` (sending-end circuit breaker power) and `RCV_CB_POWER` (receiving-end circuit breaker power) inputs in kW based on the *Send Pow convention* and *Rcv Pow convention* settings as shown in Table 290.

Table 290: Calculation of sending/receiving-end circuit breaker output

Setting	Values	Calculated sending-end CB power/receiving-end CB power
Send Pow convention	Positive W	SND_CB_POWER × [0.001]
	Negative W	SND_CB_POWER × [-0.001]
	Positive kW	SND_CB_POWER × [1]
	Negative kW	SND_CB_POWER × [-1]
	Positive MW	SND_CB_POWER × [1000]
	Negative MW	SND_CB_POWER × [-1000]
Rcv Pow convention	Positive W	RCV_CB_POWER × [0.001]
	Negative W	RCV_CB_POWER × [-0.001]
	Positive kW	RCV_CB_POWER × [1]
	Negative kW	RCV_CB_POWER × [-1]
	Positive MW	RCV_CB_POWER × [1000]
	Negative MW	RCV_CB_POWER × [-1000]

If the *CB configuration* setting is “Bus coupler”, the network circuit breaker power is same as the calculated sending-end circuit breaker power.

If the *CB configuration* setting is “Tie breaker” and the *CB pow consider* setting is “Sending end IED”, the network circuit breaker power is same as the calculated sending-end circuit breaker power.

If the *CB Configuration* setting is “Tie breaker” and the *CB pow consider* setting is “Receiving end IED”, the network circuit breaker power is same as the calculated receiving-end CB power.

If two busbars are connected with each other permanently, then the network circuit breaker between the two busbars can be configured with the *CB configuration* setting set to “Virtual breaker”. If the *CB configuration* setting is set to “Virtual breaker”, no connection should be made at the input side of NCBDCSWI, so that it assumes all the default values of respective inputs.

In Power monitoring, the network circuit breaker power is zero and the `VIRTUAL_CB` output is “Enable”.

The calculated network circuit breaker power is reported to the Block logic module.

7.6.4.2 Block logic

Depending on various conditions and *CB Pow consider* setting, the load-shed blocking signal is calculated for bus coupler and tie breaker configuration as shown in Table 291 and Table 292 respectively.

Table 291: The calculation of Load shed blocking signal for Bus Coupler configuration

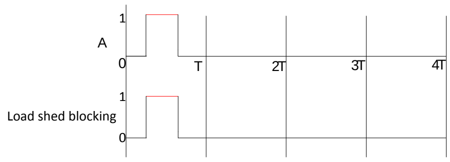
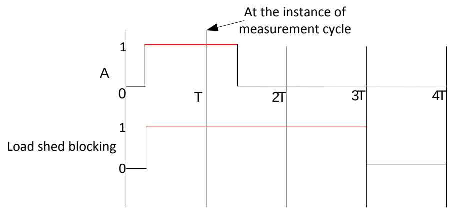
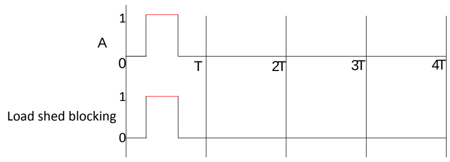
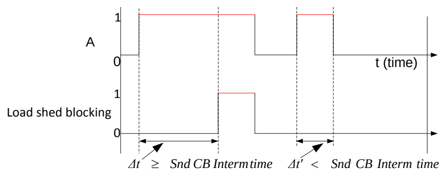
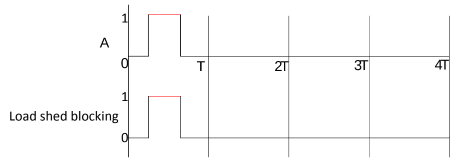
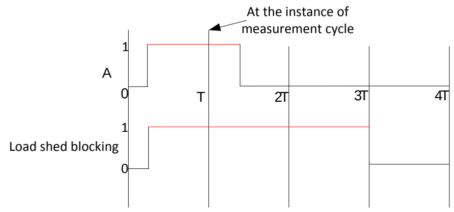
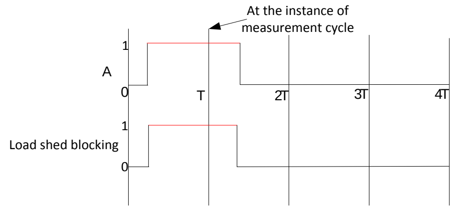
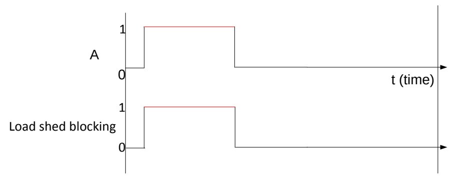
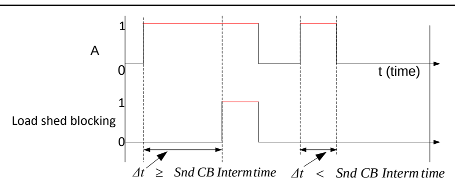
CB configuration setting	Conditions	Load shed blocking signal
Bus Coupler	A = input SND_IED_QVAL is Bad (Within measurement cycle)	
Bus Coupler	A = input SND_IED_QVAL is Bad (At measurement cycle)	
Bus Coupler	A = input SND_IED_TEST is TRUE or SND_CB_POS is Invalid	
Bus Coupler	A = input SND_CB_POS is Intermediate	
T, 2T and 3T are the measurement cycles.		

Table 292: The calculation of load shed blocking signal for tie breaker configuration

<table>
<tr><th>CB configuration setting</th><th>CB Pow consider setting</th><th>Conditions</th><th>Load shed blocking signal</th></tr>
<tr><td>Tie breaker</td><td>Sending end IED
Receiving end IED</td><td>A = input SND_IED_QVAL is Bad or RCV_IED_QVAL is Bad (Within measurement cycle)</td><td>
</td></tr>
<tr><td>Tie breaker</td><td>Sending end IED</td><td>A = input SND_IED_QVAL is Bad (At measurement cycle)</td><td>

Identical logic if the CB Pow consider setting is selected as "Receiving end IED" and input <code>RCV_IED_QVAL</code> is “Bad” at measurement cycle.</td></tr>
<tr><td>Tie breaker</td><td>Sending end IED</td><td>A = input RCV_IED_QVAL is Bad (At measurement cycle)</td><td>

Identical logic if the CB Pow consider setting is selected as "Receiving end IED" and input <code>SND_IED_QVAL</code> is “Bad” at measurement cycle.</td></tr>
<tr><td>Tie breaker</td><td>Sending end IED
Receiving end IED</td><td>A = input SND_IED_TEST is TRUE or SND_CB_POS is Invalid or RCV_IED_TEST is TRUE or RCV_CB_POS is Invalid</td><td>
</td></tr>
<tr><td>Tie breaker</td><td>Sending end IED
Receiving end IED</td><td>A = input SND_CB_POS is Intermediate</td><td>

Identical logic if input <code>RCV_CB_POS</code> is “Intermediate” and the Δt value exceeds or is less than the Rcv CB Interm time setting as shown above.</td></tr>
</table>

This module processes the network circuit breaker power received from the Power monitoring module based on the load-shedding blocking signals, as shown in Table 293 and the *Block override* setting. This processed network circuit breaker power is provided by the `CB_POWER` output for the monitoring view.

Table 293: Calculation of the CB_POWER output

Load-shedding blocking signals	Block override setting	CB_POWER output
Active due to IED data quality	Quality bad CB close Quality bad CB open	0
Active due to IED data quality or IED test mode or circuit breaker position	All yes	0

For all other conditions of the load-shedding blocking and the *Block override* setting, the `CB_POWER` output remains same as the calculated value from the Power monitoring module.

The module reports the load-shedding blocking signals to the Compensated circuit breaker status module, FLS trigger logic module, General logic module and Binary to integer module.

7.6.4.3 Compensated circuit breaker status

This module calculates the compensated circuit breaker status for the various *CB configuration* settings.

The inputs to calculate the compensated circuit breaker status when the *CB configuration* setting is “Bus coupler”.

- Sending-end circuit breaker position.
- Sending-end IED data quality.
- Sending-end lockout operating status.
- Sending-end circuit breaker service status.

The inputs to calculate the compensated circuit breaker status when the *CB configuration* setting is “Tie breaker”.

- Sending-end and receiving-end circuit breaker positions.
- Sending-end and receiving-end IED data qualities.
- Sending-end and receiving-end lockout operating status.
- Sending-end and receiving-end circuit breaker service status.

Figure 143 shows the logic for the calculation of compensated circuit breaker status for network circuit breaker.

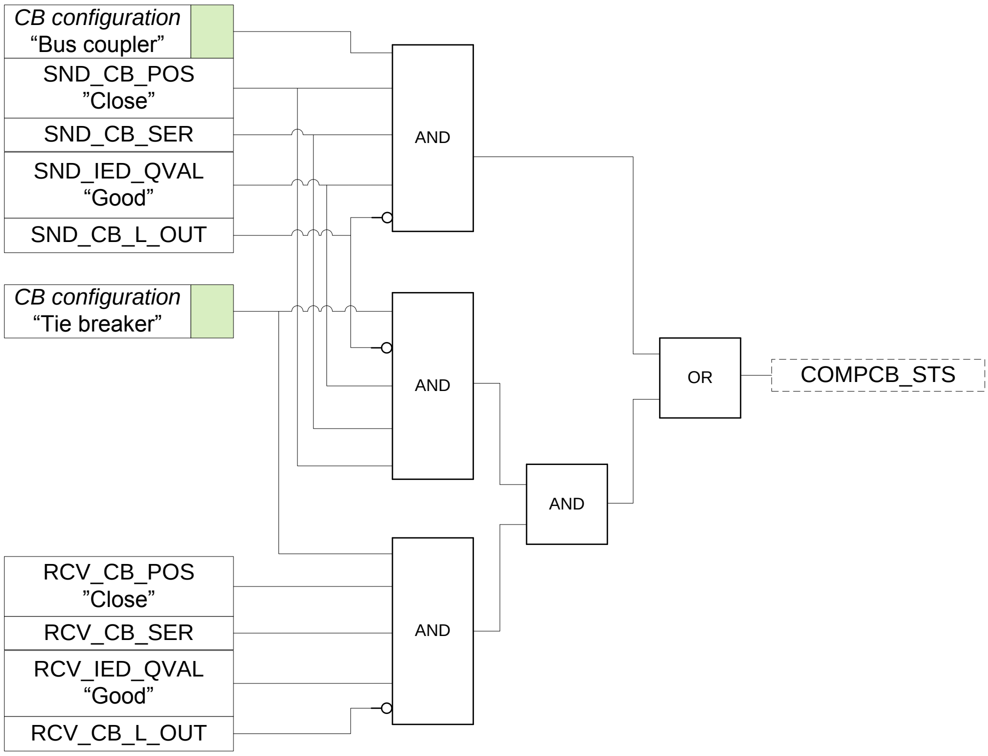


Figure 143: Compensated circuit breaker status logic

If the load-shedding blocking signal is active due to IED data quality bad and the *Block override* setting is set to “Quality bad CB close”, `COMPCB_STS` is active.

If the load-shedding blocking signal is active due to IED data quality bad and the Block override setting is set to “Quality bad CB open”, the `COMPCB_STS` signal is inactive.

If the load-shedding blocking is active due to various other conditions, that is, IED data quality bad or IED in test mode or circuit breaker in intermediate/invalid position and the *Block override* setting is set to “All yes”, the `COMPCB_STS` signal is inactive.

If the *CB configuration* setting is set to “Virtual breaker”, the `COMPCB_STS` signal is active.

If `COMPCB_STS` is active, the `CB_COMPS_POS` output is “Close”, else the `CB_COMPS_POS` output is “Open”.

The `COMPCB_STS` signal is reported to the Binary to integer module.

7.6.4.4 FLS trigger logic

This module calculates the fast load-shedding trigger.

The inputs to calculate the fast load-shedding trigger if the *CB configuration* setting is set to “Bus coupler”.

- Sending-end circuit breaker position.
- Sending-end lockout operating status.
- Sending-end circuit breaker service status.

The inputs to calculate the fast load-shedding trigger if the *CB configuration* setting is set to “Tie breaker”.

- Sending-end and receiving-end circuit breaker positions.
- Sending-end and receiving-end lockout operating status.
- Sending-end and receiving-end circuit breaker service status.

The calculation of the `FLS_TRIGGER` output logic is shown in Figure 144.

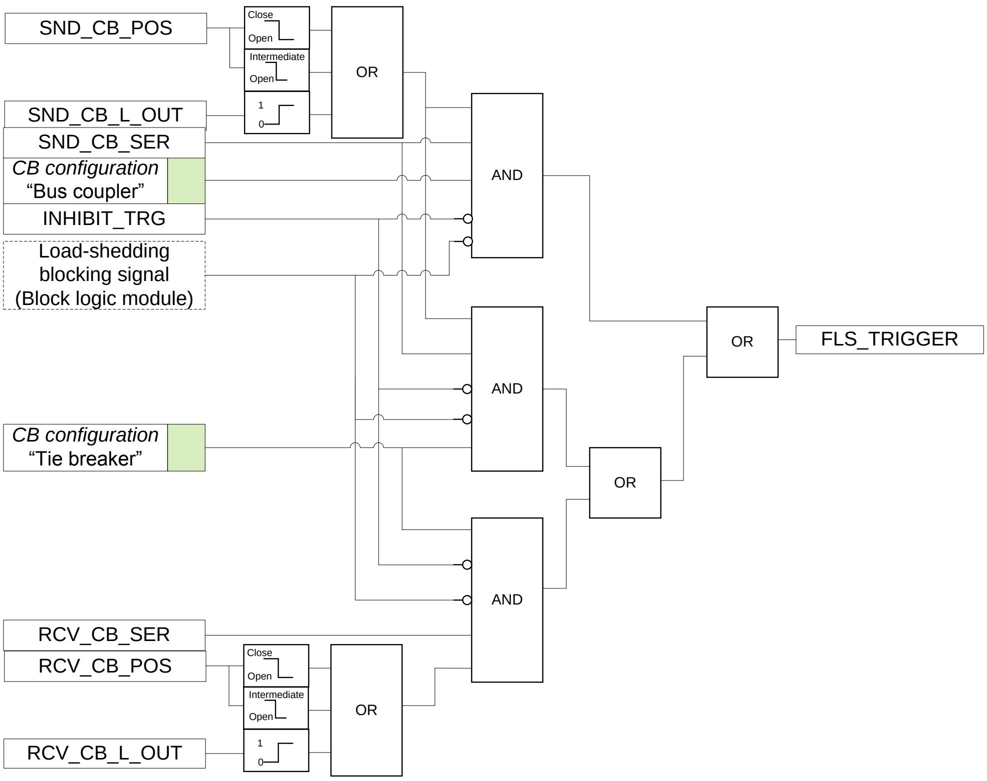


Figure 144: Fast load-shedding trigger initiation logic

The `FLS_TRIGGER` output is reported to the Binary to integer module.

7.6.4.5 General Logic

This module calculates `FLS_BLOCK` and `BLK_BYPASS` outputs based on various conditions

The `FLS_BLOCK` output provides the load-shedding blocking signal after considering the override action using the *Block override* setting. The `BLK_BYPASS` output indicates the successful overridden action of the load-shedding blocking signal.

Table 294: Calculation of FLS_BLOCK and BLK_BYPASS outputs for bus coupler configuration

CB Configuration setting	Load-shedding blocking conditions	Block override setting	BLK_BYPASS output	FLS_BLOCK output
Bus coupler	SND_IED_TEST = TRUE	IED test mode All yes	TRUE	FALSE
		No Quality bad CB close Quality bad CB open CB Interm or invalid	FALSE	TRUE
Bus coupler	SND_IED_QVAL = Bad	Quality bad CB close Quality bad CB Open All yes	TRUE	FALSE
		No IED test mode CB Interm or invalid	FALSE	TRUE
Bus coupler	SND_CB_POS = Intermediate or Invalid	CB Interm or invalid All yes	TRUE	FALSE
		No IED test mode Quality bad CB close Quality bad CB open	FALSE	TRUE
Bus coupler	If multiple load-shedding blocking signals (SND_IED_TEST = TRUE , SND_IED_QVAL = Bad, SND_CB_POS = Intermediate or Invalid) are active simultaneously	All yes	TRUE	FALSE
		CB Interm or invalid IED test mode Quality bad CB close Quality bad CB open	TRUE	TRUE
		No	FALSE	TRUE

Table 295: Calculation of FLS_BLOCK and BLK_BYPASS outputs for tie breaker configuration

CB Configuration setting	Load-shedding blocking conditions	Block override setting	BLK_BYPASS output	FLS_BLOCK output
Tie breaker	SND_IED_TEST = TRUE RCV_IED_TEST = TRUE	IED test mode All yes"	TRUE	FALSE
		No Quality bad CB close Quality bad CB open CB Interm or invalid"	FALSE	TRUE
Tie breaker	SND_IED_QVAL = Bad RCV_IED_QVAL = Bad	Quality bad CB close Quality bad CB Open All yes	TRUE	FALSE
		No IED test mode CB Interm or invalid	FALSE	TRUE

Table continues on next page

CB Configuration setting	Load-shedding blocking conditions	Block override setting	BLK_BYPASS output	FLS_BLOCK output
Tie breaker	SND_CB_POS = Intermediate or Invalid RCV_CB_POS = Intermediate or Invalid	CB Interm or invalid All yes	TRUE	FALSE
		No IED test mode Quality bad CB close Quality bad CB open	FALSE	TRUE
Tie breaker	If multiple load-shedding blocking signals are active simultaneously (SND_IED_TEST = TRUE, RCV_IED_TEST = TRUE, SND_IED_QVAL = Bad, RCV_IED_QVAL = Bad, SND_CB_POS = Intermediate OR Invalid, RCV_CB_POS = Intermediate or Invalid)	All yes	TRUE	FALSE
		CB Interm or invalid IED test mode Quality bad CB close Quality bad CB open	TRUE	TRUE
		No	FALSE	TRUE

The *Block override* setting is preferred to be kept as “No”.

If the `BLK_BYPASS` output is active, the `FLS_TRIGGER` output remains FALSE.

If the *CB configuration* setting is set to “Virtual breaker”, the `FLS_BLOCK` and `BLK_BYPASS` outputs are FALSE.

The output `B_SET_CHANGE` is TRUE if one or more basic settings are changed, and the output remains active for 500 ms, see Table 300.

7.6.4.6 Binary to integer

This module calculates the integer data based on various load shed information of the network circuit breaker as shown in the Table 296.

Table 296 shows the individual bits information of the `NW_CB_DATA` output.

Table 296: NW_CB_DATA bits information

Bit	Bit description	Signal name
1	Compensated CB status	COMPCB_STS
2	Fast load-shedding trigger	FLS_TRIGGER
5	Load-shedding blocking due to IED data quality and CB position	BLK_QUA_POS
6	Load-shedding blocking due to IED test mode	BLOCK_TEST

The group output NW_CB consists of signals for network circuit breaker which are provided to LSCACLS function.

Table 297: Group signals for NW_CB for corresponding instance of <ij>

Signal description	Group signal description for NW_CB	Signal short name for network circuit breaker instance
Compensated CB status	Bit 1 of NW_CB_DATA	$COMP\_STS\_CB_{ij}$
Fast load-shedding trigger	Bit 2 of NW_CB_DATA	$FLS\_TRG\_CB_{ij}$
Load-shedding blocking due to IED data quality and CB position	Bit 5 of NW_CB_DATA	$FLS\_BLK\_CB_{ij}$
Load-shedding blocking due to IED test mode	Bit 6 of NW_CB_DATA	$TST\_BLK\_CB_{ij}$
Network circuit breaker power	CB_POWER	$POWER\_CB_{ij}$

7.6.5 Signals

Table 298: NCBDCSWI Input signals

Name	Type	Default	Description
SND_CB_POWER	REAL	0.0	Sending end network CB active power
SND_CB_POS	INTEGER	1	Sending end network CB position
SND_CB_SER	BOOLEAN	1	Sending end network CB service position
SND_CB_L_OUT	BOOLEAN	0	Sending end network CB lockout status
SND_IED_QVAL	BOOLEAN	1	Sending end CB IED data quality status
SND_IED_TEST	BOOLEAN	0	Sending end network CB IED test mode behaviour
RCV_CB_POWER	REAL	0.0	Receiving end network CB active power
RCV_CB_POS	INTEGER	1	Receiving end network CB position
RCV_CB_SER	BOOLEAN	1	Receiving end network CB service position
RCV_CB_L_OUT	BOOLEAN	0	Receiving end network CB lockout status
RCV_IED_QVAL	BOOLEAN	1	Receiving end CB IED data quality status
RCV_IED_TEST	BOOLEAN	0	Receiving end network CB IED test mode behaviour
INHIBIT_TRG	BOOLEAN	0	Inhibit the trigger from network CB

Table 299: NCBDCSWI Output signals

Name	Type	Description
NW_CB	GROUP SIGNAL	Group signal of network CB
CB_POWER	REAL	Active power of network CB
CB_COMPS_POS	INTEGER	Circuit breaker position of network CB
VIRTUAL_CB	BOOLEAN	Virtual CB configuration is selected
BLK_BYPASS	BOOLEAN	Block is bypassed
Table continues on next page		

Name	Type	Description
B_SET_CHANGE	BOOLEAN	One or many basic settings change
FLS_BLOCK	BOOLEAN	Fast load shed block from network CB
FLS_TRIGGER	BOOLEAN	Fast load shed trigger from network CB

7.6.6 Settings

Table 300: NCBDCSWI Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Block override	No IED test mode Quality bad CB close Quality bad CB open CB Interm or invalid All yes	-	-	No	Bypass block due to IED test or data quality or CB position

Table 301: NCBDCSWI Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
CB configuration	Bus coupler Tie breaker Virtual Breaker	-	-	Bus coupler	Network CB configuration
CB Pow consider	Sending end IED Receving end IED	-	-	Sending end IED	CB power to be considered for sending or receiving end
Snd CB Interm time	0 - 500	ms	10	200	Sending end CB intermediate time
Send Pow convention	Positive W Negative W Positive kW Negative kW Positive MW Negative MW	-	-	Positive W	Sending end IED power convention
Rcv CB Interm time	0 - 500	ms	10	200	Receiving end CB intermediate time
Rcv Pow convention	Positive W Negative W Positive kW Negative kW Positive MW Negative MW	-	-	Positive W	Receiving end IED power convention

7.6.7 Measured values

Table 302: NCBDCSWI Measured values

Name	Type	Default	Description
SND_CB_POWER	REAL	0.0	Sending end network CB active power
SND_CB_POS	INTEGER	1	Sending end network CB position
SND_CB_SER	BOOLEAN	1	Sending end network CB service position
Table continues on next page			

Name	Type	Default	Description
SND_CB_L_OUT	BOOLEAN	0	Sending end network CB lockout status
SND_IED_QVAL	BOOLEAN	1	Sending end CB IED data quality status
SND_IED_TEST	BOOLEAN	0	Sending end network CB IED test mode behaviour
RCV_CB_POWER	REAL	0.0	Receiving end network CB active power
RCV_CB_POS	INTEGER	1	Receiving end network CB position
RCV_CB_SER	BOOLEAN	1	Receiving end network CB service position
RCV_CB_L_OUT	BOOLEAN	0	Receiving end network CB lockout status
RCV_IED_QVAL	BOOLEAN	1	Receiving end CB IED data quality status
RCV_IED_TEST	BOOLEAN	0	Receiving end network CB IED test mode behaviour
INHIBIT_TRG	BOOLEAN	0	Inhibit the trigger from network CB

7.6.8 Monitored data

Table 303: NCBDCSWI Monitored data

Name	Type	Values (Range)	Unit	Description
CB_POWER	REAL	-	kW	Active power of network CB
NW_CB_DATA	INTEGER	-	-	Load shed data of network CB
CB_COMPS_POS	INTEGER	1=Open 2=Close	-	Circuit breaker position of network CB
VIRTUAL_CB	BOOLEAN	1=Yes 0=No	-	Virtual CB configuration is selected
BLK_BYPASS	BOOLEAN	0=FALSE 1=TRUE	-	Block is bypassed
B_SET_CHANGE	BOOLEAN	0=FALSE 1=TRUE	-	One or many basic settings change
FLS_BLOCK	BOOLEAN	0=FALSE 1=TRUE	-	Fast load shed block from network CB
FLS_TRIGGER	BOOLEAN	0=FALSE 1=TRUE	-	Fast load shed trigger from network CB

7.7 Network power monitoring NPMMXU

7.7.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE identification
Network power monitoring	NPMMXU	-	NPMMXU

7.7.2 Function block

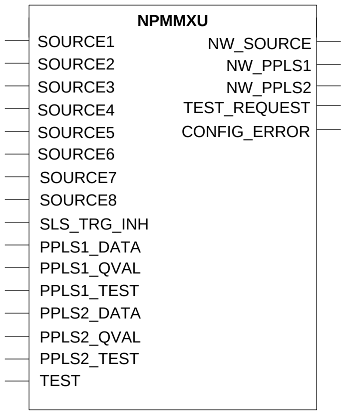


Figure 145: Function block

7.7.3 Functionality

The network power monitoring function NPMMXU controls the load-shedding action by processing the load-shed data of various power sources received from the corresponding instances of PSCSWI functions. This function also controls the load-shedding action for configuration B by processing the load-shedding data received from the adjacent electrical areas, calculating the spinning reserve sharing mode and must-shedding sharing mode. This function calculates the island-parallel status, fast load-shedding block, slow load-shed trigger, slow load-shedding inhibition and overload amount for busbar 1... busbar 4.

This function configures the available power and active power for power sources connected to the adjacent electrical areas. The load-shedding data of power sources and adjacent electrical areas are reported to LSCACLS for load-shedding action.

7.7.4 Operation principle

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

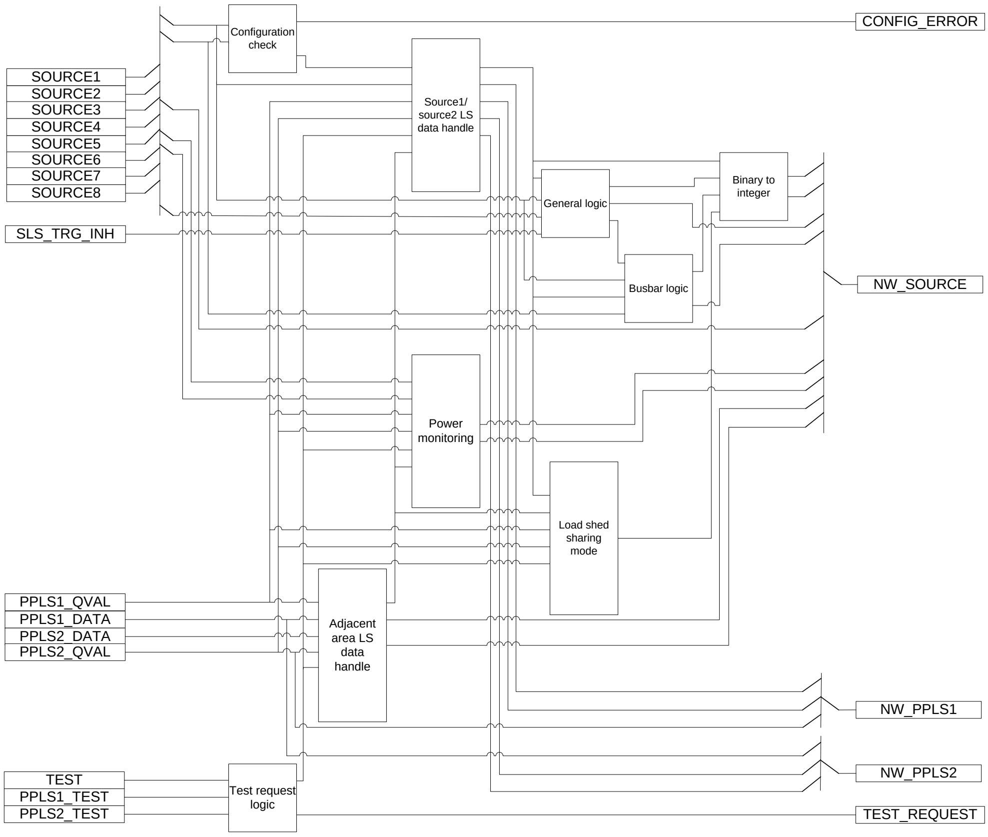


Figure 146: Functional module diagram

NPMMXU receives the inputs from power sources through the SOURCE1... SOURCE8 group inputs. The SOURCE1 group input consists of load-shedding information corresponding to the power source 1. Similarly, SOURCE2...SOURCE8 contain load-shedding information for the corresponding power sources.

This function receives the load-shedding data of adjacent electrical network area 1 and adjacent electrical network area 2 through the PPLS1_DATA and PPLS2_DATA inputs respectively. Table 304 shows the information contained in the PPLS1_DATA input. The PPLS2_DATA input contains the identical information for adjacent electrical network area 2.

Table 304: PPLS1_DATA bits information

Bits	Bit Description
1	CB status of adjacent electrical network area 1
2	Power balance status of adjacent electrical network area 1
3	Must-shedding status of adjacent electrical network area 1
4	Error status of adjacent electrical network area 1
5...29	Spinning reserve or must shed of adjacent electrical network area 1
30	CB blocking status of adjacent electrical network area 1
31	Load-shedding blocking status of adjacent electrical network area 1

7.7.4.1 Configuration check

Based on the configuration of power source 1 and power source 2, the module calculates the configuration check.

The configuration check is activated if any of the condition is true.

- The power source 1 is configured as generator.
- The power source 1 is configured for busbar number other than 1.
- The power source 2 is configured as generator.
- The power source 2 is configured for busbar number other than 1 or 2.

If the configuration check is activated, the `CONFIG_ERROR` output is TRUE, else the `CONFIG_ERROR` output is FALSE.

The configuration check signals for the power source 1 and power source 2 are provided to the Source 1/source 2 LS data handle module.

7.7.4.2 Test request logic

Based on the test modes of PML630s installed in the adjacent electrical network areas, PML630 can be configured to the test mode if the `TEST_REQUEST` output is activated.

Table 305 shows the calculation of the `TEST_REQUEST` output with respect to the *Disable test request* setting and various inputs.

Table 305: TEST_REQUEST output calculation

Setting	Input(s)		Output
Disable test request	TEST	PPLS1_TEST or PPLS2_TEST	TEST_REQUEST
No	FALSE/TRUE	FALSE	FALSE
	FALSE/TRUE	TRUE	TRUE
Yes	FALSE/TRUE	FALSE	FALSE
	FALSE/TRUE	TRUE	FALSE

This module calculates the load-shedding enable signals `ENA_PPLS1` and `ENA_PPLS2` for adjacent electrical areas. These status signals determine whether the load-shedding data of the corresponding adjacent electrical network areas are considered or not.

Table 306 shows the calculation of the `ENA_PPLS1` status signal for electrical network area 1. Similarly, the `ENA_PPLS2` is calculated for electrical network area 2.

Table 306: Calculation for ENA_PPLS1

Inputs		Signal
TEST	PPLS1_TEST	ENA _PPLS1
FALSE	FALSE	TRUE
FALSE	TRUE	FALSE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

The ENA_PPLS1 and ENA_PPLS2 signals are provided to the Power monitoring module, Adjacent area LS data handle module, Source1/source2 LS data handle module and Load shed sharing mode module.

7.7.4.3 Adjacent area LS data handle

Based on the different conditions, this module processes the adjacent electrical network areas load-shedding data.

The module considers the PPLS1_DATA input in following conditions.

- The *Grid1 connectivity* setting is set to “Peer substation”.
- The PPLS1_QVAL input is Good.
- The compensated CB status of power source1, that is, CCB_CLS_SRC1, is TRUE.
- The enabling load-shedding status, that is, ENA_PPLS1, is TRUE.

If any one or more of the above conditions are not true, the module considers the PPLS1_DATA input as zero.

The must-shedding status (that is, bit 3 of PPLS1_DATA) remains unchanged, if all of the following conditions are satisfied.

- The bit 1 of PPLS1_DATA, is TRUE.
- The bit 4 of PPLS1_DATA, is FALSE.
- The bit 30 of PPLS1_DATA, is FALSE.
- The bit 31 of PPLS1_DATA, is FALSE.

If any of the above conditions is not satisfied, the must-shedding status is FALSE.

The power balance status (that is, bit 2 of PPLS1_DATA) remains unchanged, if the following conditions are satisfied.

- All conditions for processing the must-shedding status hold good.
- The overcurrent operate status for power source 1, that is, OC_OPR_SRC1 is FALSE.
- The maximum demand operate status for power source 1, that is, MAX_DMD_SRC1 is FALSE.
- The external slow load-shed trigger for power source 1, that is, EXT_SLT_SRC1 is FALSE.

If any of the above conditions is not satisfied, the power balance status is FALSE.

The logic is identical for processing the PPLS2_DATA input and its power balance status and must-shedding status.

The processed inputs PPLS1_DATA and PPLS2_DATA are provided as PEER1_DATA and PEER2_DATA respectively. Table 307 shows the bits and corresponding signal name for PEER1_DATA and PEER2_DATA.

Table 307: The bits description for PEER1_DATA AND PEER2_DATA

Bit No	Signal name for PEER1_DATA	Signal name for PEER2_DATA
1	RCV_CB_STS1	RCV_CB_STS2
2	RCV_SR_STS1	RCV_SR_STS2
3	RCV_MS_STS1	RCV_MS_STS2
5 .. 29	RCV_LS_POW1	RCV_LS_POW2
30	RCV_CB_BLK1	RCV_CB_BLK2
31	LS_BLK_STS1	LS_BLK_STS2

The module provides the PEER1_DATA and PEER2_DATA to Source1/source2 LS data handle module, Power monitoring module and Load shedding sharing mode logic module.

7.7.4.4 Source1/source2 LS data handle

Based on the different conditions, the module calculates the compensated circuit breaker status, island parallel status, fast load-shedding blocking status, circuit breaker blocking status and fast load-shedding trigger for power source 1 and power source 2.

Table 308: Calculation of compensated CB status for power source 1

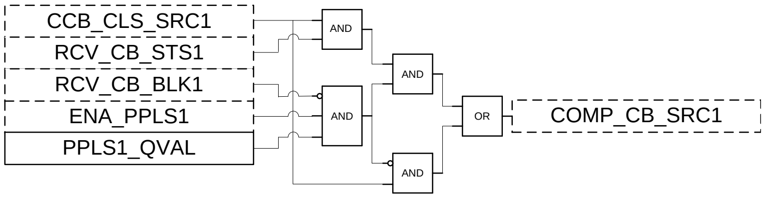
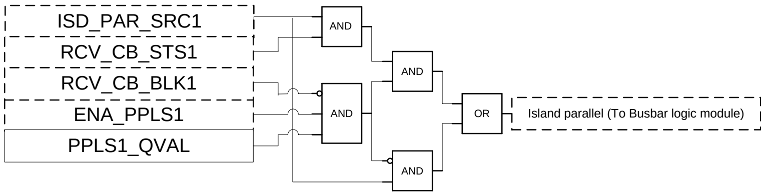
Setting Grid1 connectivity	The calculated Compensated CB status for Power source 1
External source	CCB_CLS_SRC1
Peer substation	

Table 309: Calculation of island or parallel status for power source 1

Setting Grid1 connectivity	The calculated island parallel status for Power source 1
“External source”	ISD_PAR_SRC1
“Peer substation”	

This module calculates `CB_BLK_SRC1`, that is, circuit breaker blocking status for adjacent electrical area connected by power source 1 if any of the following conditions is satisfied.

- The *Grid1 connectivity* setting is set to “External source”.
- The configuration error for power source 1 is activated.
- `FLS_BLK_SRC1` is activated.

The fast load-shedding blocking status for power source 1 is activated if `FLS_BLK_SRC1` is activated or power source 1 configuration error is activated.

The fast load-shedding trigger for power source 1 is activated if the following conditions are satisfied.

- If `FLS_TRG_SRC1` is activated.
- If `RCV_CB_STS1` changes from TRUE to FALSE, provided *Grid1 connectivity* setting is set to “Peer substation” and `RCV_CB_BLK1` is inactive and input `PPLS1_QVAL` is "Good" and fast load-shedding blocking status (as calculated above) is inactive.

The logic is also identical for calculating the compensated circuit breaker status, island parallel status, fast load-shedding blocking status, circuit breaker blocking status and fast load-shedding trigger by considering the corresponding data for power source 2, *Grid2* *connectivity* setting, `PEER2_DATA`, `PPLS2_QVAL` and `ENA_PPLS2`.

The module reports the calculated compensated circuit breaker statuses for power source 1 and power source 2 to the Binary to integer module and Load shed sharing mode module.

The module reports the calculated fast load-shedding triggers for power source 1 and power source 2 to the General logic module.

The module reports the calculated island parallel status, fast load-shedding blocking status for power source 1 and power source 2 to the Busbar logic.

7.7.4.5 Power monitoring

The module calculates the available powers and active powers for power source 1 and power source 2.

Based on the *Grid1 connectivity* setting and various other conditions, available power and active power for power source 1 are calculated as shown in Table 310.

Table 310: The calculation of available power and active power for power source 1

Setting Grid1 connectivity	Output AVA_POWER_SRC1	Output ACT_POW_SRC1
External source	AVA_POW_SRC1 = AVA_POWER_SRC1	ACT_POW_SRC1 = ACT_POWER_SRC1
Peer substation	1. AVA_POW_SRC1 = ACT_POWER_SRC1, if ACT_POWER_SRC1 ≥ 0 2. AVA_POW_SRC1 = 0.0, if PACT_POWER_SRC1 < 0 3. AVA_POW_SRC1 = AVA_POWER_SRC1, provided any of the following is satisfied. • LS_BLK_STS1 is activated • ENA_PPLS1 is deactivated • Input PPLS1_QVAL is Bad • OC_OPR_SRC1 is activated • MAX_DMD_SCR1 is activated • EXT_SLT_SRC1 is activated	1. ACT_POW_SRC1 = ACT_POWER_SRC1, if ACT_POWER_SRC1 ≥ 0 2. ACT_POW_SRC1 = 0.0, if ACT_POWER_SRC1 < 0 3. ACT_POW_SRC1 = ACT_POWER_SRC1, provided any of the following is satisfied. • LS_BLK_STS1 is activated • ENA_PPLS1 is deactivated • Input PPLS1_QVAL is Bad

The logic is identical for calculating the `ACT_POW_SRC2` and `AVA_POW_SRC2` outputs for power source 2.

The `ACT_POW_SRC1`, `ACT_POW_SRC2`, `AVA_POW_SRC1` and `AVA_POW_SRC2` outputs are reported for the monitoring view.

7.7.4.6 General logic

The module calculates the slow load-shedding trigger, slow load-shedding enable status for each power source based on various conditions.

Based on the *Ov Curr Trg interval* setting, overcurrent operating statuses of the power sources can be configured to re-trigger the slow load trigger.

If the *Ov Curr Trg interval* setting is zero, slow load-shedding trigger remains active until the overcurrent operating status is activated.

If the overcurrent status is activated, slow load-shedding trigger is calculated at an interval of *Ov Curr Trg interval* setting. Figure 147 shows the calculation of slow load-shedding trigger if `OC_ORP_SRC1` gets activated for power source 1.

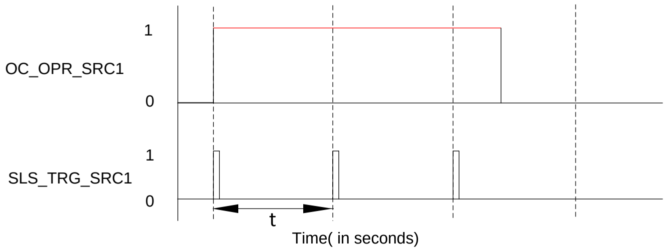


Figure 147: Profile of slow load trigger w.r.t Ov Curr Trg interval setting

Here, t = Set value of *Ov Curr Trg interval* setting

Figure shows the calculation of slow load-shedding trigger and slow load-shedding enable signals for power source 1.

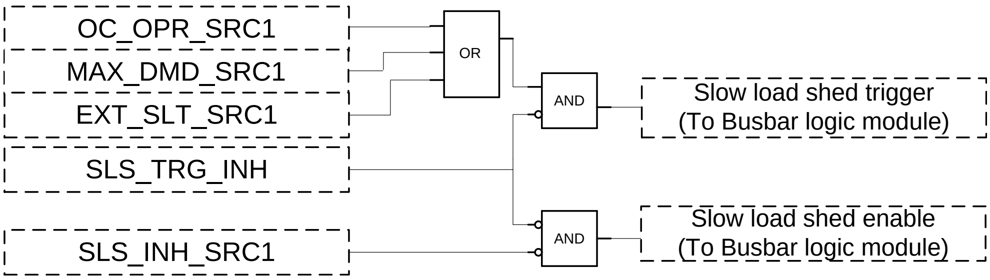


Figure 148: Logic for calculation of slow load-shedding trigger and slow load-shedding enable signals for power source 1

The logic is identical for all the power sources.

The module also calculates the slow load-shedding start, fast load-shedding trigger and busbar number signals for all the power sources.

If the slow load-shedding start signal is activated for any power source (power source 1...power source 8), slow load-shed start `SLS_START` is activated, provided the `SLS_TRG_INH` input is FALSE.

If the fast load-shedding trigger is activated for any power source (power source 1...power source 8), fast load-shedding trigger SRC_FLS_TRG is activated.

The busbar number of power sources are represented by BB_NUMBER signal. For example, the BB_NUMBER = 4332121 represents busbar number of power source 1 = 1, busbar number of power source 2 = 2, busbar number of power source 3 = 1, busbar number of power source 4 = 2, busbar number of power source 5 = 3, busbar number of power source 6 = 3, busbar number of power source 7 = 4 and busbar number of power source 8 = 4.

The module reports the slow load-shedding start and fast load-shedding trigger signal to the Binary to integer module.

The module reports the slow load-shedding trigger and slow load-shedding enabling status signals for each power source to the Busbar logic module.

7.7.4.7 Load-shed sharing mode

The module calculates the spinning reserve sharing mode and must-shedding sharing mode. These modes determine how to share the spinning reserve and must shed with the PML630s installed in the adjacent electrical network areas.

Based on the condition1 and condition2, the module calculates the must-shedding sharing mode MUST_SHD_MOD and spinning reserve sharing mode SP_RESV_MOD as shown in Table 311 and Table 312.

Table 311 and Table 312 also show the values corresponding to the must-shedding sharing mode and spinning reserve sharing mode, for example, must-shedding sharing mode = 2 (Zero-full) means the must-shedding shared with adjacent electrical network area1 is zero and the must-shedding shared with adjacent electrical network area 2 is full.

Table 311: Calculation of must-shedding sharing mode

Sl No	Condition1	Condition2	MUST_SHD_MOD
1	If all the following conditions are satisfied: • Grid1 connectivity setting is Peer substation. • Input PPLS1_QVAL is Good. • COMP_CB_SRC1 is TRUE. • ENA_PPLS1 signal is TRUE. • RCV_MS_STS1 is FALSE. • LS_BLK_STS1 is FALSE.	If all the following conditions are satisfied: • Grid2 connectivity setting is Peer substation. • Input PPLS2_QVAL is Good. • COMP_CB_SRC2 is TRUE. • ENA_PPLS2 signal is TRUE. • RCV_MS_STS2 is FALSE. • LS_BLK_STS2 is FALSE.	Extended LS sharing setting
2	$X_{condition1}$	$Y_{condition2}$	2 (Zero-full)
3	$Y_{condition1}$	$X_{condition2}$	3 (Full-zero)
4	$X_{condition1}$	$X_{condition2}$	Extended LS sharing setting

Table 312: Calculation of spinning reserve sharing mode

Sl No	Condition1	Condition2	SP_RESV_MOD
1	If all the following conditions are satisfied: • Grid1 connectivity setting is Peer substation. • Input PPLS1_QVAL is Good. • COMP_CB_STS1 is TRUE. • ENA_PPLS1 signal is TRUE.	If all the following conditions are satisfied: • Grid2 connectivity setting is Peer substation. • Input PPLS2_QVAL is Good. • COMP_CB_STS2 is TRUE. • ENA_PPLS2 signal is TRUE.	2 (Full-full)
2	$X^{condition1}$	$Y^{condition2}$	3 (Zero-full)
3	$Y^{condition1}$	$X^{condition2}$	4 (Full-zero)
4	$X^{condition1}$	$X^{condition2}$	2 (Full-full)

Here the notation $X^{condition1}$ means at least one of the conditions in condition1 in Sl No 1 is not satisfied. The notation $Y^{condition1}$ means all the conditions in condition1 in Sl No 1 are satisfied.

The module reports the calculated spinning reserve sharing mode and must-shedding sharing mode to the Binary to integer module.

7.7.4.8 Busbar logic

The module calculates the fast load-shedding blocking, island parallel status, slow load-shedding trigger, slow load-shedding enable status and the amount of overload for busbar 1, busbar 2, busbar 3 and busbar 4.

If fast load-shed blocking signal is activated for any power source <n> configured on busbar <x>, fast load-shed blocking signal `FLS_BLK_BB <x>` is activated for the corresponding busbar (Here x = 1 to 4).

Similar logic is used for calculation of the island parallel status `ISD_PAR_BB <x>`, slow load-shedding trigger `SLS_TRG_BB <x>` and slow load-shedding enable signal `SLS_ENA_BB <x>` for busbar 1, busbar 2, busbar 3 and busbar 4.

If slow load-shed trigger is activated for any power source <n> configured on busbar <x>, overload amount for busbar <x>, `OV_LOAD_BB <x>` is same as the overload amount `OVLOD_SRC <n>` for the corresponding power source. If slow load trigger is activated for all power sources at the same instance, `OV_LOAD_BB <x>` is the sum of overload amount for the corresponding power sources connected to the same busbar.

The overload amount for any busbar remains zero if the slow load-shedding trigger is inactive for respective power sources on the same busbar.

The module reports the fast load-shedding blocking, island parallel status, slow load-shedding trigger and slow load-shedding enabling status for busbar 1, busbar 2, busbar 3 and busbar 4 to the Binary to integer module.

7.7.4.9 Binary to integer

This module provides the `DATA_SOURCE` and `DATA_LODSHED` outputs for the monitoring view.

Table 313: DATA_SOURCE bits information

Bits	Bit Description	Short name of signal
1	Fast load-shedding blocking for busbar 1	FLS_BLK_BB1
2	Fast load-shedding blocking for busbar 2	FLS_BLK_BB2
3	Fast load-shedding blocking for busbar 3	FLS_BLK_BB3
4	Fast load-shedding blocking for busbar 4	FLS_BLK_BB4
5	Fast load-shedding trigger from power sources	SRC_FLS_TRG
6	Compensated CB status for power source 1	COMP_CB_SRC1
7	Compensated CB status for power source 2	COMP_CB_SRC2
8	Compensated CB status for power source 3	CCB_CLS_SRC3
9	Compensated CB status for power source 4	CCB_CLS_SRC4
10	Compensated CB status for power source 5	CCB_CLS_SRC5
11	Compensated CB status for power source 6	CCB_CLS_SRC6
12	Compensated CB status for power source 7	CCB_CLS_SRC7
13	Compensated CB status for power source 8	CCB_CLS_SRC8

Table 314: DATA_LODSHED bits information

Bits	Bit Description	Short name of signal
1	Slow load-shedding trigger for busbar 1	SLS_TRG_BB1
2	Slow load-shedding trigger for busbar 2	SLS_TRG_BB2
3	Slow load-shedding trigger for busbar 3	SLS_TRG_BB3
4	Slow load-shedding trigger for busbar 4	SLS_TRG_BB4
5	Island parallel status for busbar 1	ISD_PAR_BB1
6	Island parallel status for busbar 2	ISD_PAR_BB2
7	Island parallel status for busbar 3	ISD_PAR_BB3
8	Island parallel status for busbar 4	ISD_PAR_BB4
9...11	Calculated spin reserve sharing mode	SP_RESV_MOD
12...14	Calculated must shed sharing mode	MUST_SHD_MOD
15	Slow load-shedding enabling status for busbar 1	SLS_ENA_BB1
16	Slow load-shedding enabling status for busbar 2	SLS_ENA_BB2
17	Slow load-shedding enabling status for busbar 3	SLS_ENA_BB3
18	Slow load-shedding enabling status for busbar 4	SLS_ENA_BB4
20	Slow load-shedding start for power sources	SLS_START

The group output NW_SOURCE contains signals which are reported to LSCACLS function. Table 315 shows the group signals for NW_SOURCE.

Table 315: Group signals for NW_SOURCE

Signal description	Group signal NW_SOURCE
Fast load-shed blocking for busbar <x>	Bit 1..Bit 4 of DATA_SOURCE
Fast load-shed trigger from power sources <n>	Bit 5 of DATA_SOURCE
Compensated CB status for power source	Bit 6..Bit 13 of DATA_SOURCE
Available power of power source <n>	AVA_POW_SRC <n>
Active power of power source <n>	ACT_POW_SRC <n>
Slow load-shed trigger for busbar <x>	Bit 1..Bit 4 of DATA_LODSHED
Island parallel status for busbar <x>	Bit 5..Bit 8 of DATA_LODSHED
Spinning reserve sharing mode	Bit 9..Bit 11 of DATA_LODSHED
Must-shed sharing mode	Bit 12..Bit 14 of DATA_LODSHED
Slow load-shedding enabling status for busbar <x>	Bit 15..Bit 18 of DATA_LODSHED
Slow load-shedding start for power sources	Bit 20 of DATA_LODSHED
Governor mode of generators	GOV_MODE_SRC <n>
Busbar number of power source <n>	BB_NUMBER
Load-shed power of adjacent area connected with power source 1	RCV_LS_POW1
Spinning reserve status of adjacent area connected with power source 1	RCV_SR_STS1
Must-shed status of adjacent area connected with power source 1	RCV_MS_STS1
Load-shed power of adjacent area connected with power source 2	RCV_LS_POW2
Spinning reserve status of adjacent area connected with power source 2	RCV_SR_STS2
Must-shed status of adjacent area connected with power source 2	RCV_MS_STS2
Overload amount for busbar <x>	OV_LOAD_BB <x>

The group outputs NW_PPLS1 and NW_PPLS2 contain signals which are reported to corresponding instances of the PPLSGGIO function. Table 316 and Table 317 show the group signals for NW_PPLS1 and NW_PPLS2 respectively.

Table 316: The group signals for NW_PPLS1

Signal description	Group signal NW_PPLS1
Load-shed data of adjacent area connected with power source 1	PPLS1_DATA
Fast load-shed blocking status for power source 1	CB_BLK_SRC1
Compensated CB open status for power source 1 (External connection)	CCB_OPN_SRC1

Table 317: The group signals for NW_PPLS2

Signal description	Group signal NW_PPLS2
Load-shed data of adjacent area connected with power source 2	PPLS2_DATA
Fast load-shed CB blocking status for power source 2	CB_BLK_SRC2
Compensated CB open status for power source 2	CCB_OPN_SRC2

7.7.5 Signals

Table 318: NPMMXU Input signals

Name	Type	Default	Description
SOURCE1	GROUP SIGNAL	-	Group signal from power source 1
SOURCE2	GROUP SIGNAL	-	Group signal from power source 2
SOURCE3	GROUP SIGNAL	-	Group signal from power source 3
SOURCE4	GROUP SIGNAL	-	Group signal from power source 4
SOURCE5	GROUP SIGNAL	-	Group signal from power source 5
SOURCE6	GROUP SIGNAL	-	Group signal from power source 6
SOURCE7	GROUP SIGNAL	-	Group signal from power source 7
SOURCE8	GROUP SIGNAL	-	Group signal from power source 8
SLS_TRG_INH	BOOLEAN	0	Slow load shed trigger inhibit
PPLS1_DATA	INTEGER	0	LS data of electrical area connected with power source 1
PPLS1_QVAL	BOOLEAN	0	Data quality of electrical area connected with power source 1
PPLS1_TEST	BOOLEAN	0	Electrical area PML test mode connected with power source 1
PPLS2_DATA	INTEGER	0	LS data of electrical area connected with power source 2
PPLS2_QVAL	BOOLEAN	0	Data quality of electrical area connected with power source 2
PPLS2_TEST	BOOLEAN	0	Electrical area PML test mode connected with power source 2
TEST	BOOLEAN	0	Test mode behaviour of PML IED

Table 319: NPMMXU Output signals

Name	Type	Description
NW_SOURCE	GROUP SIGNAL	Group signal of network power sources
NW_PPLS1	GROUP SIGNAL	GrGroup signal of electrical area connected with power source1
NW_PPLS2	GROUP SIGNAL	Group signal of electrical area connected with power source2
AVA_POW_SRC1	REAL	Available power of power source1
ACT_POW_SRC1	REAL	Active power of source1
AVA_POW_SRC2	REAL	Available power of power source2
ACT_POW_SRC2	REAL	Active power of power source2
TEST_REQUEST	BOOLEAN	Test request for the IED due to peer PML IED in test mode
CONFIG_ERROR	BOOLEAN	Incorrect configuration of power source1 or power source2

7.7.6 Settings

Table 320: NPMMXU Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Grid1 connectivity	External source Peer substation	-	-	External source	Source1 connectivity configuration with Grid1
Grid2 connectivity	External source Peer substation	-	-	External source	Source1 connectivity configuration with Grid2
Ov Curr Trg interval	0.00 - 3.00	s	0.01	0.00	Time interval for over current based slow load trigger
Extended LS sharing	Half Half Zero full Full zero	-	-	Half Half	Extended load shed sharing for peer substations
Disable test request	No Yes	-	-	No	Disable test request for PML test mode

7.7.7 Measured values

Table 321: NPMMXU Measured values

Name	Type	Default	Description
SLS_TRG_INH	BOOLEAN	0	Slow load shed trigger inhibit
PPLS1_DATA	INTEGER	0	LS data of electrical area connected with power source1
PPLS1_QVAL	BOOLEAN	0	Data quality of electrical area connected with power source1
PPLS1_TEST	BOOLEAN	0	Electrical area PML test mode connected with power source1
PPLS2_DATA	INTEGER	0	LS data of electrical area connected with power source2
Table continues on next page			

Name	Type	Default	Description
PPLS2_QVAL	BOOLEAN	0	Data quality of electrical area connected with power source2
PPLS2_TEST	BOOLEAN	0	Electrical area PML test mode connected with power source2
TEST	BOOLEAN	0	Test mode behaviour of PML IED

7.7.8 Monitored data

Table 322: NPMMXU Monitored data

Name	Type	Values (Range)	Unit	Description
AVA_POW_SRC1	REAL	-	kW	Available power of power source1
ACT_POW_SRC1	REAL	-	kW	Active power of source1
AVA_POW_SRC2	REAL	-	kW	Available power of power source2
ACT_POW_SRC2	REAL	-	kW	Active power of power source2
DATA_SOURCE	INTEGER	-	-	LS Trigger,LS block & CB position data of power sources
DATA_LODSHED	INTEGER	-	-	Load shed data of power sources & load shed sharing modes
TEST_REQUEST	BOOLEAN	0=FALSE 1=TRUE	-	Test request for the IED due to peer PML IED in test mode
CONFIG_ERROR	BOOLEAN	0=FALSE 1=TRUE	-	Incorrect configuration of power source1 or power source2

7.8 Contingency based load-shedding LSCACLS

7.8.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE identification
Contingency based load-shedding	LSCACLS	-	LSCACLS

7.8.2 Function block

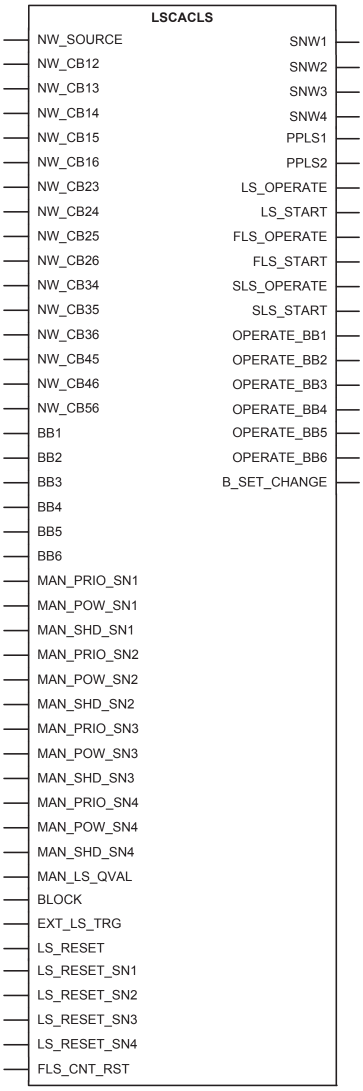


Figure 149: Function block

7.8.3 Functionality

The contingency based load-shedding function LSCACLS receives the load-shedding data of power sources, network circuit breakers and sheddable loads from NPMMXU, NCBDCSWI and LDMMXU. This function also receives the load-shedding data of the adjacent electrical areas from NPMMXU. This function determines the number of groups (subnetwork) of connected busbars and identifies power sources, network circuit breakers, and sheddable loads in respective groups. During contingency, this function calculates the load shed priority in the subnetworks provided there is shortfall in power in the corresponding subnetworks.

This function also allows the manual load-shedding action that can be executed by the operator based on power or priority.

This function generates the trip information for sheddable loads in the corresponding subnetworks based on the calculated load shed priority. This function reports the load shed trip information of individual sheddable loads to the corresponding load shed trip command function LSPTRC

This function blocks the load-shedding action in the subnetworks if the load shed blocking signals are activated by power sources, network circuit breakers or activation of external input.

This function calculates the spinning reserve and must shed information of the subneworks to share with connected adjacent electrical areas. This information is provided to the corresponding peer-to-peer load-shedding function PPLSGGIO.

This function reports the various load-shedding information of the subneworks to the corresponding subnetwork output function SNWRCLS for display.

7.8.4 Operation principle

The *Operation* setting is used to enable or disable the function. The corresponding parameter values are "On" and "Off". The operation of LSCACLS can be described by using a module diagram. All the modules in the diagram are explained in the next section.

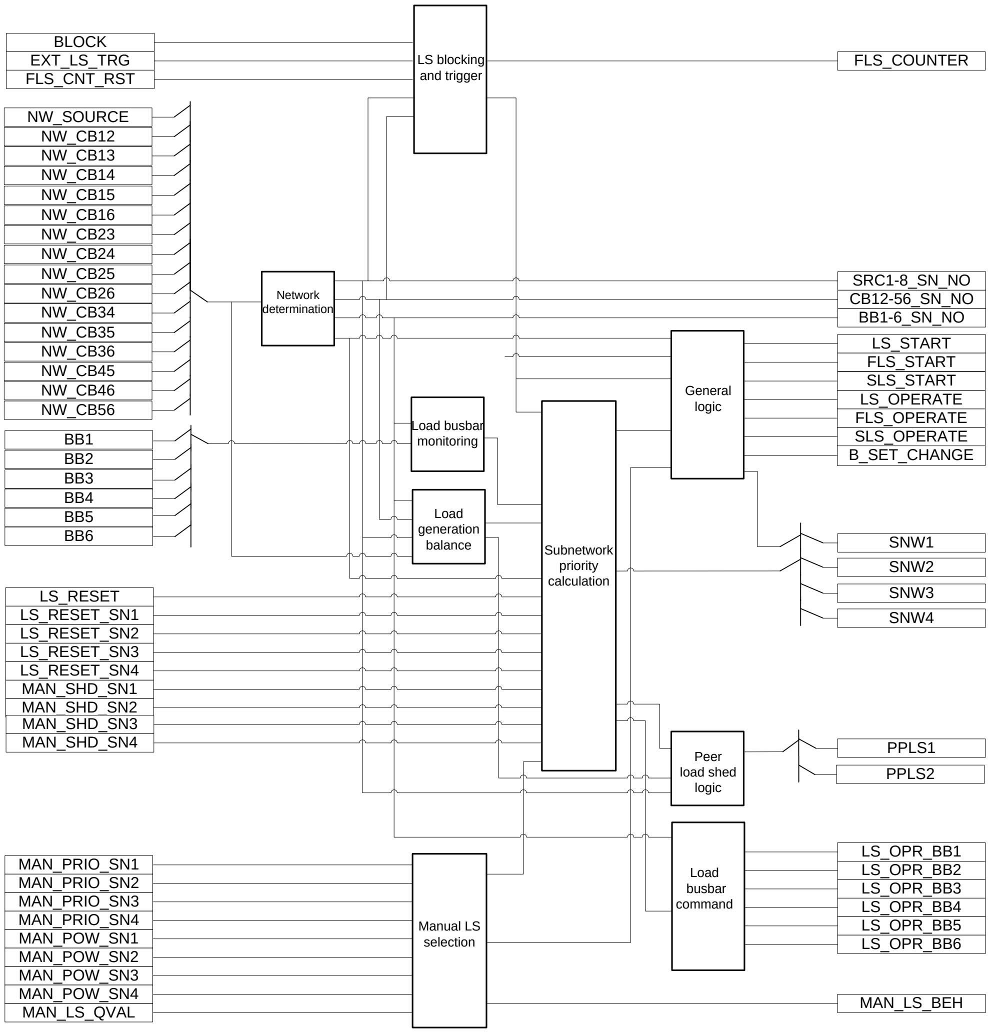


Figure 150: Functional module diagram

This function receives the load-shedding data for the power sources from NPMMXU through the `NW_SOURCE` group input.

This function receives load-shedding data for the network circuit breakers from the corresponding instances of NCBDCSWI through the `NW_CB12`, `NW_CB13`… `NW_CB56` group inputs.

This function also receives the load-shedding data from the different instances of LDMMXU through the `BB1`...`BB6` group inputs.

7.8.4.1 Network determination

This module receives the following data from NPMMXU function.

- Compensated circuit breaker status of power sources `COMP_STS_SRC<n>`
- Each power source busbar number (busbar 1…4)

This module receives the compensated circuit breaker status of network CB COMP_STS_CB$_{ij}$ (i = 1 to 5 and j = 2 to 6 ∀ i<j) from the respective NCBDCSWI function.

The module identifies group of various busbars connected together and calculates the subnetwork number. The subnetwork number of the group is same as the lowest busbar number in the group. The power sources, network circuit breakers and busbars in the group are assigned the same subnetwork number.

The subnetwork is active if minimum one compensated circuit breaker status of power source is TRUE, else subnetwork is inactive. If subnetwork is inactive, the subnetwork number of the group is zero.

As power sources can be configured in the busbar 1, busbar 2, busbar 3 or busbar 4, the module can determine a maximum of four subnetworks, that is, subnetwork 1, subnetwork 2, subnetwork 3 and subnetwork 4.

The subnetwork numbers of eight power sources are provided by outputs SRC1_SN_NO...SRC8_SN_NO. The subnetwork numbers of 15 network circuit breakers are provided by outputs CB12_SN_NO...CB56_SN_NO. The subnetwork numbers of six busbars are provided by outputs BB1_SN_NO...BB6_SN_NO. These data are available in the monitoring data view.

If the compensated circuit breaker status of the network circuit breaker is FALSE (OPEN), the subnetwork number of the respective network circuit breaker is zero.

The module determines the various active subnetworks and the subnetwork number of power sources, network circuit breakers and busbars as explained in the example below.

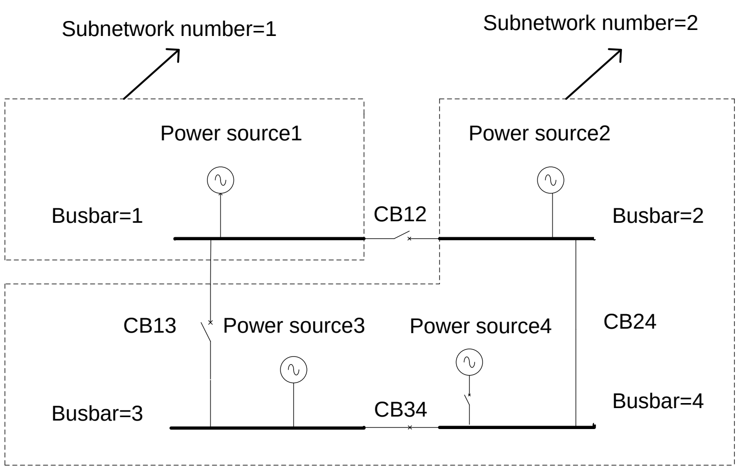


Figure 151: Subnetwork determination scenario

COMP_STS_SRC1...COMP_STS_SRC4 represent the compensated circuit breaker status of power source 1...4 respectively. COMP_STS_SRC1...COMP_STS_SRC3 are TRUE and COMP_STS_SRC3 is FALSE.

COMP_STS_CB12, COMP_STS_CB13, COMP_STS_CB24 and COMP_STS_CB34 represent the compensated circuit breaker status of network circuit breakers CB12, CB13, CB24 and CB34 respectively. COMP_STS_CB12 and COMP_STS_CB13 are FALSE. COMP_STS_CB24 and COMP_STS_CB34 are TRUE.

The first busbar group contains the busbar 1 with lowest busbar number as 1 and the second busbar group contains the busbar 2, busbar 3 and busbar 4 with lowest busbar number as 2.

Table 323: Outputs related to subnetwork equipment

Equipment	Output	Subnetwork number
Power source	SRC1_SN_NO	1
	SRC2_SN_NO SRC3_SN_NO SRC4_SN_NO	2
Network circuit breaker	CB12_SN_NO CB13_SN_NO	0
	CB24_SN_NO CB34_SN_NO	2
Busbar	BB1_SN_NO	1
	BB2_SN_NO BB3_SN_NO BB4_SN_NO	2

The subnetwork numbers of the power sources SRC1_SN_NO...SRC8_SN_NO and network circuit breakers CB12_SN_NO...CB56_SN_NO are provided to the LS blocking and trigger module and the Load generation balance module.

The subnetwork numbers of the busbars BB1_SN_NO...BB6_SN_NO are provided to the Load generation balance module.

The active or inactive status of the subnetworks SN_ACTIVE_z (z = 1...4) are provided to the Subnetwork priority calculation module and General logic module.

The subnetwork numbers of the power source 1 and power source 2, that is, SRC1_SN_NO and SRC2_SN_NO are provided to the Peer load-shed logic module.

7.8.4.2 LS blocking and trigger

This module calculates fast load-shed blocking, fast load-shed trigger, slow load-shed trigger and extended load-shed trigger for subnetwork 1...4.

Depending on fast load-shed blocking signals received from NCBDCSWI, NPMMXU functions and subnetwork number of busbars, the load-shed blocking for particular subnetwork is calculated as follows.

The module receives the fast load-shed block signal `FLS_BLK_BB1...FLS_BLK_BB4` for busbar 1...4 from the NPMMXU function. If any of the busbar fast load-shed block signal is active, the corresponding subnetwork is blocked.

If the `FLS_BLK_BB1` signal is active, the load-shed blocking is active for subnetwork corresponding to `BB1_SN_NO`, for example, if `FLS_BLK_BB1` is TRUE and `BB1_SN_NO` = 1, subnetwork 1 load-shed blocking is active.

The module receives the fast load-shed block signals `FLS_BLK_CB`$_{ij}$ and test mode blocking signals `TST_BLK_CB`$_{ij}$ from the respective NCBDCSWI functions.

If `FLS_BLK_CB`$_{ij}$ is active or `TST_BLK_CB`$_{ij}$ is active, the subnetwork number of busbar "i" and busbar "j" is blocked, for example, if `FLS_BLK_CB12` is TRUE and `BB1_SN_NO` = 1 and `BB1_SN_NO` = 2, subnetwork 1 and subnetwork 2 load-shed blocking is active.

If the `BLOCK` input is TRUE, all subnetworks load-shedding blocking signal is active.

Figure 152 shows load-shed blocking signals for different subnetworks for various conditions.

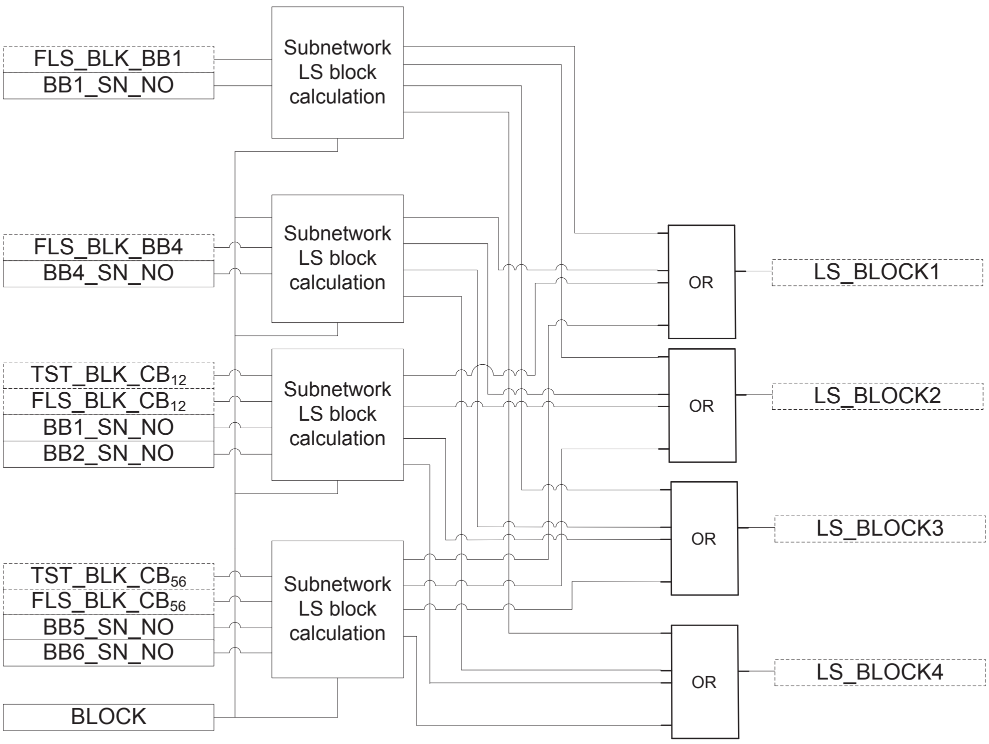


Figure 152: Calculation of load-shed blocking signal for subnetworks

The module receives the fast load-shed trigger signals SRC_FLS_TRG from the NPMMXU function and $FLS\_TRG\_CB_{ij}$ from the respective NCBDCSWI functions.

Figure 153 shows fast load-shed trigger signals for different subnetworks for various conditions.

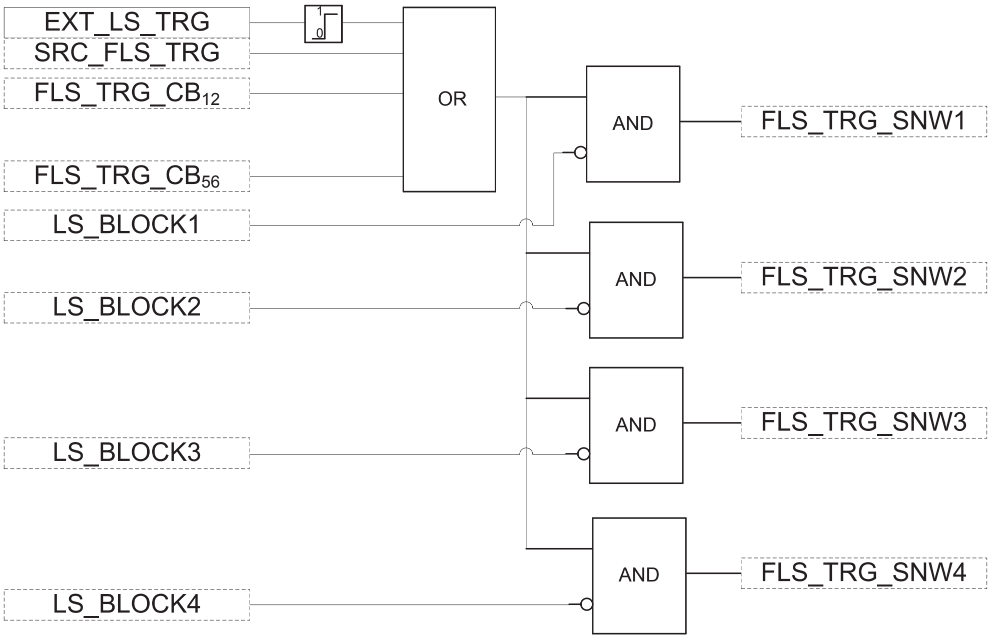


Figure 153: Calculation of fast load-shed trigger signal for subnetworks

The module counts the number of times the fast load-shedding trigger signal is generated and the FLS_COUNTER (fast load-shedding counter) output provides the count. The FLS_COUNTER output can be reset through the FLS_CNT_RST (fast load-shedding counter reset) input. The FLS_COUNTER output is provided in the monitoring view.

The module receives the slow load-shed trigger signals, SLS_TRG_BB1...SLS_TRG_BB4, for busbar 1...4 from NPMMXU function. If any of the busbar slow load-shed trigger signal is active, slow load-shed action is initiated in corresponding subnetwork.

Figure 154 shows slow load-shed trigger signals for different subnetworks for various conditions.

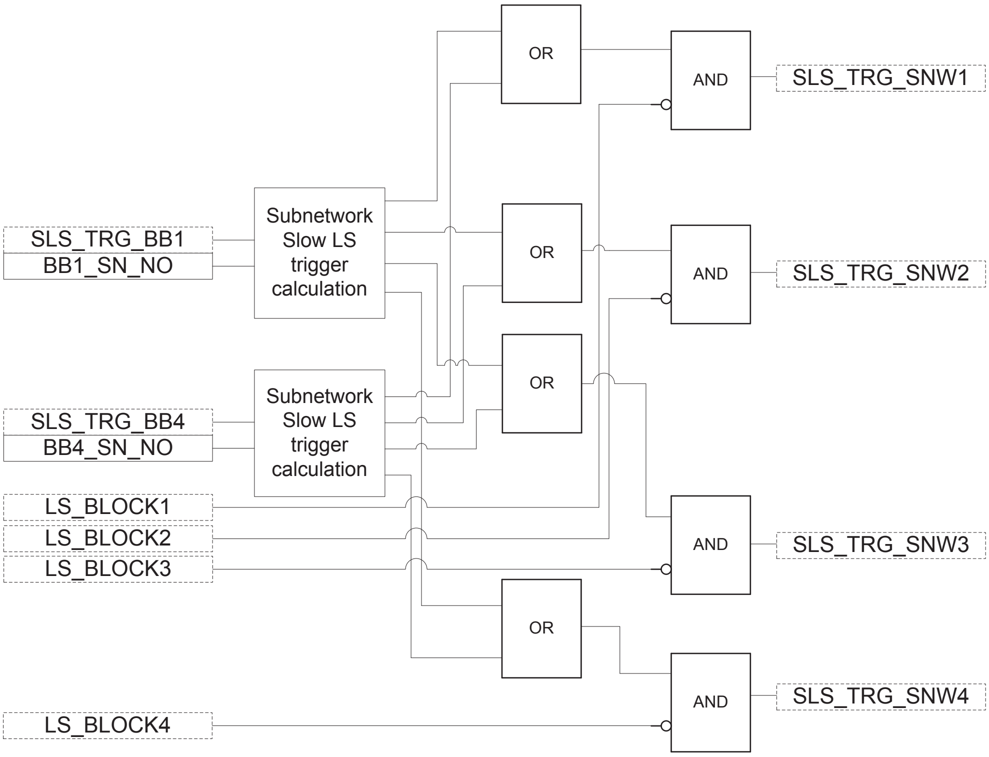


Figure 154: Calculation of slow load-shed trigger signal for subnetworks

The module receives the slow load-shed enable signals, `SLS_ENA_BB1...SLS_ENA_BB4`, for busbar 1...4 from NPMMXU function. If any of the busbar slow load-shed enable signal is active, slow load-shed is enabled in corresponding subnetwork. If slow load enable signal is inactive for all busbars in a subnetwork, slow load-shed trigger is inhibited for corresponding subnetwork.

Figure 155 shows slow load-shed enable signals for different subnetworks for various conditions.

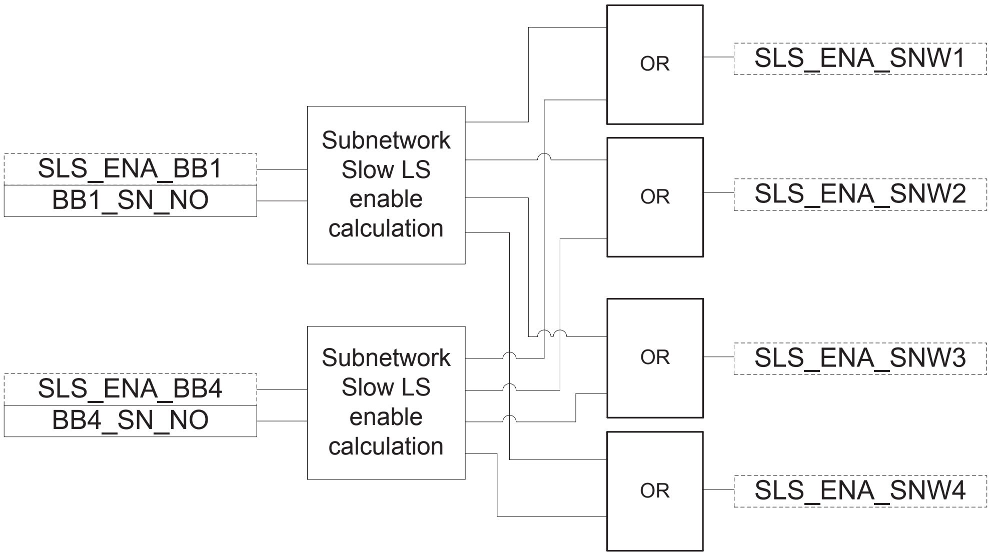


Figure 155: Calculation of slow load-shed enable signal for subnetworks

The module receives the must shed status, `RCV_MS_STS1` and `RCV_MS_STS2`, from NPMMXU function corresponding to adjacent electrical areas connected through power source 1 and power source 2. If must shed status gets active, extended load-shed trigger is generated corresponding to the subnetwork of the power source 1 or power source 2.

Figure 156 shows extended load-shed triggers for different subnetworks for various conditions.

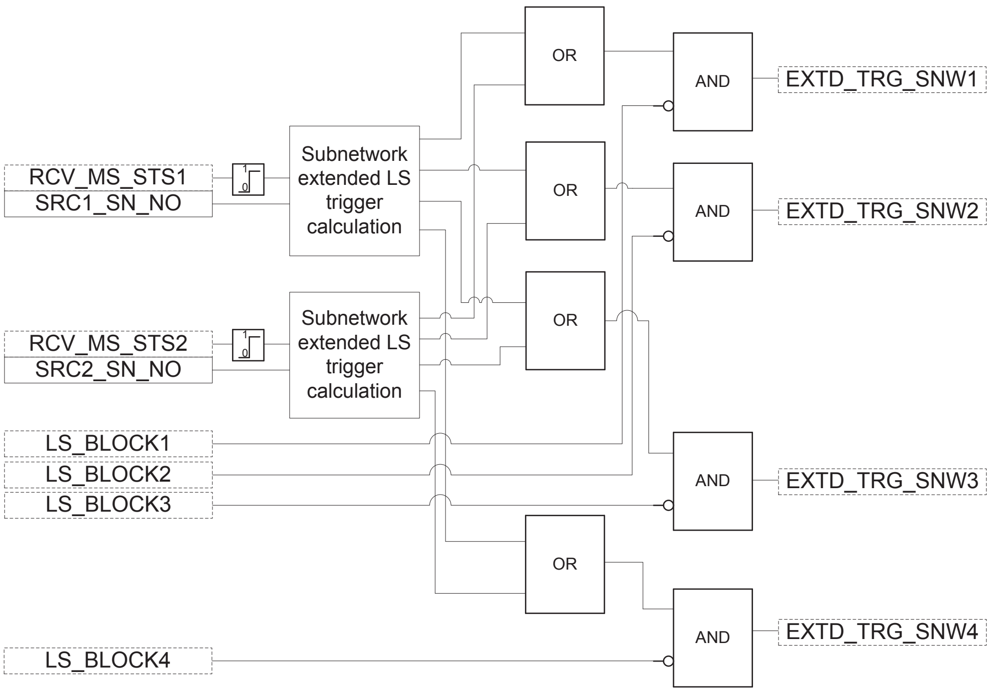


Figure 156: Calculation of extended load-shed triggers for subnetworks

The fast load-shed blocking signals LS_BLOCK<z>, FLS_TRG_SNW<z>, SLS_TRG_SNW<z> and EXTD_TRG_SNW<z> for each subnetwork are provided to Subnetwork priority calculation module and General logic module.

7.8.4.3 Load busbar monitoring

The Load busbar monitoring module calculates the sheddable power corresponding to each priority, total shed load inhibited by system and total shed load inhibited by operator for each subnetwork.

This module receives the power value L<m>_POWER (m = 1...10) for ten sheddable loads from each LDMMXU function.

Shed priority p (p = 1...19) of sheddable load 1...5 and sheddable load 6 ...10 are received through PRIO_L1_5 and PRIO_L6_10 respectively from each LDMMXU function.

Equation 10 shows the calculation of the sheddable powers for priority p for busbar x, here $L<m>\_POWER^{p}$ is power of sheddable load <m> with priority p.

$$SHD\_POW^{p}{}_{x} = \sum_{m=1}^{10} L<m>\_POWER^{p}$$

(Equation 10)

Equation 11 shows the calculation of the powers for priority p for each subnetwork z.

$$SHD\_POW^{p}{}_{z} = \sum_{q=1}^{6} SHD\_POW^{p}{}_{x}$$

(Equation 11)

In Equation 11, $SHD\_POW^{p}{}_{x}$ is considered zero if BB<x>_SN_NO output is not equal to z.

Similarly, module calculates the total system inhibited load $TOT\_INH\_SYS_{z}$ and operator inhibited load $TOT\_INH\_OPR_{z}$ for each subnetwork.

The sheddable power for each priority $SHD\_POW^{p}{}_{x}$, total load inhibited by operator $TOT\_INH\_OPR_{z}$ and total load inhibited by system $TOT\_INH\_SYS_{z}$ for each subnetwork are provided to the Subnetwork priority calculation module.

7.8.4.4 Load generation balance

This module calculates the total available power, total load, total overload amount, power balance and effective power balance for subnetwork 1...4.

This module receives following data from NPMMXU function.

- Available powers AVA_POW_SRC<n> for power sources
- Running powers ACT_POW_SRC<n> for power sources
- Compensated circuit breaker status COMP_STS_SRC<n> for power sources

- Island-parallel status ISL_PAR_BB1...ISL_PAR_BB4 for busbar 1...4
- Overload amount OV_LOAD_BB1...OV_LOAD_BB4 for busbar 1...4
- Load-shed power RCV_SR_POW1 and RCV_SR_POW2 for adjacent electrical areas
- Spinning reserve status RCV_SR_STS1 and RCV_SR_STS2 for adjacent electrical areas
- Must shed status RCV_MS_STS1 and RCV_MS_STS2 for adjacent electrical areas

This module receives the network circuit breaker power $POWER\_CB_{ij}$ from the corresponding instances of NCBDCSWI functions.

If COMP_STS_SRC<n> is inactive for a power source, the available power for corresponding power source is zero.

If island-parallel status ISL_PAR_BB<x> (x = 1, 2, 3 and 4) is active for any busbar in a subnetwork, the corresponding subnetwork is considered as in parallel mode else the subnetwork is considered as in island mode.

Based on the island or parallel mode of the subnetwork and the governor mode of the generator, the available power of a generator in the corresponding subnetwork is calculated as shown in Table 324.

Table 324: Available power calculation of the generator

Governor mode	Source available power	
	Island Mode	Parallel Mode
Not applicable	Available power	Available power
Droop	Available power	Active power
MW	Active power	Active power
ISO	Available power	Active power
P-Control	Available power	Available power
Optimize	Available power	Active power
Base load	Active power	Active power
Peak load	Active power	Active power

Based on the subnetwork number of power sources, the module calculates total available power AVA_POWER_z in subnetwork z. AVA_POWER_z is the sum of available power of all power sources in the subnetwork z.

The total active power ACT_POWER_z in subnetwork z is the sum of active powers of the power sources with the subnetwork number z.

Based on the subnetwork number of power source 1 and power source 2, the module processes the spinning reserve and must-shed received from adjacent electrical areas for corresponding subnetwork z as follows.

The spinning reserve for subnetwork z $RCV\_SR\_POW_z$ is same as RCV_LS_POW1 or RCV_LS_POW2 provided spinning reserve status is active for corresponding electrical area. If both power source 1 and power source 2 are in same subnetwork, $RCV\_SR\_POW_z$ is the sum of RCV_LS_POW1 and RCV_LS_POW2.

The must-shed for subnetwork z $RCV\_MS\_POW_z$ is same as RCV_LS_POW1 or RCV_LS_POW2 provided must-shed status is active for corresponding electrical area. If both power source 1 and power source 2 are in same subnetwork, $RCV\_MS\_POW_z$ is sum of RCV_LS_POW1 and RCV_LS_POW2.

Based on the active powers and power flow direction of network circuit breakers and subnetwork number of the busbar, the module calculates the total active power for each busbar in the subnetwork z as $POWER\_BB_z$.

Equation 12 calculates the total running load $RUNNING\_LOAD_z$ of each subnetwork z.

$$RUNNING\_LOAD_z = ACT\_POWER_z + POWER\_BB_z$$

(Equation 12)

Equation 13 calculates the load imbalance $LOAD\_IMBALANCE_z$ of each subnetwork z.

$$LOAD\_IMBALANCE_z = AVA\_POWER_z - RUNNING\_LOAD_z$$

(Equation 13)

Equation 14 calculates the power balance $POWER\_BAL_z$ of each subnetwork z by using *SubNetw Abs offset* and *SubNetw Rel offset* settings.

$$POWER\_BAL_z = \left(1.0 + SubNet\,\mathrm{Re}l\,offset \cdot \frac{1}{100}\right) \cdot LOAD\_IMBALANCE_z - SubNet\,\mathrm{Re}l\,offset$$

(Equation 14)

Equation 15 calculates the effective power balance $EFF\_POW\_BAL_z$ for subnetwork z.

$$EFF\_POW\_BAL_z = POWER\_BAL_z + RCV\_SR\_POW_z$$

(Equation 15)

Based on the subnetwork number of busbar 1...4, this module calculates the total amount of overload power OV_LOAD_z for subnetwork z. The OV_LOAD_z is calculated as the sum of all overload amounts for busbars in the corresponding subnetwork.

The calculated AVA_POWER_z, $RUNNING\_LOAD_z$, $POWER\_BAL_z$, $EFF\_POW\_BAL_z$, OV_LOAD_z and $RCV\_MS\_PO_z$ are provided to the Subnetwork priority calculation module.

7.8.4.5 Manual LS selection

This module calculates manual load-shed priority and manual load-shed power for each subnetwork.

Table 325 shows the manual load-shedding priority and manual load-shedding power calculated for subnetwork z and the `MAN_LS_BEH` output.

Table 325: Calculation of manual LS priority, manual LS power and MAN_LS_BEH output

Man load-shed mode setting	Calculated manual LS priority (MAN_SHD_PRIO$_z$)	Calculated manual LS power (MAN_SHD_POW$_z$)	Output MAN_LS_BEH
Disable manual LS	0	0	Manual LS disable
SN Man Prio setting	SubNetw<z> Man Prio setting	0	Manual Prio setting
SN Man Pow setting	0	SubNetw<z> Man Pow setting	Manual power setting
SN Man Prio input	Input MAN_PRIO_SN<z>	0	Communicate priority
SN Man Pow input	0	Input MAN_POW_SN<z>	Communicate power

If the *Man load shed mode* setting is “SN Man Prio input” and `MAN_LS_QVAL` is FALSE, the manual LS priority is the same as the *SubNetw<z> Man Prio* setting and `MAN_LS_BEH` output set to “Set Prio Comm bad”.
Similarly, if the *Man load shed mode* setting is “SN Man Pow input” and `MAN_LS_QVAL` is FALSE, the manual LS power is the same as the *SubNetw<z> Man Pow* setting and `MAN_LS_BEH` output set to “Set power Comm bad”.

The `MAN_LS_BEH` output is provided in the monitoring view.

The calculated manual LS priority MAN_LS_POW$_z$ and manual LS power MAN_LS_PRIO$_z$ are reported to the Subnetwork priority calculation module.

7.8.4.6 Subnetwork priority calculation

This module calculates the load-shedding priority for a subnetwork.

Disable LS SubNetw setting disables the load-shedding of all the four subnetworks. *Enable LS SubNetw1* .. *Enable LS SubNetw4* settings enables the load-shedding in an individual subnetwork.

If *Disable LS SubNetw* setting = "Yes", the load-shedding is disabled in all four subnetworks else the load-shedding is enabled or disabled according to *Enable LS SubNetw1*, *Enable LS SubNetw2*, *Enable LS SubNetw3* and *Enable LS SubNetw4* settings.

If *Enable LS SubNetw1* setting = "Yes", the load-shedding is enabled in the subnetwork 1 and if *Enable LS SubNetw1* setting = "No", the load-shedding is disabled in the subnetwork 1. Similarly, *Enable LS SubNetw2*, *Enable LS SubNetw3* and *Enable LS SubNetw4* settings are used to enable or disable load-shedding in the subnetwork 2, subnetwork 3 and subnetwork 4 respectively.

The load-shed disable status of the subnetwork is provided by $\texttt{DISABLE\_LS}_Z$.

If $\texttt{SN\_ACTIVE}_Z$ is inactive or LS_BLOCK<z> is active for the subnetwork, no load-shed priority is calculated for the corresponding subnetwork. However, it is possible to perform load-shedding action by manual load-shedding operation even if load-shedding is blocked for the subnetwork.

The logic explained below is identical for all the subnetworks.

Based on various triggers, this module calculates the load-shed power and effective load-shed power as follows.

If ($\texttt{FLS\_TRG\_SNW}_Z$ or $\texttt{SLS\_TRG\_SNW}_Z$ is active) and ($\texttt{EFF\_POW\_BAL}_z$ <0), $|\texttt{EFF\_POW\_BAL}_Z|$ is considered for load-shed power $\texttt{LS\_POWER}_z$ calculation.

If MAN_SHD_SN<z> input is active, $\texttt{MAN\_LS\_POW}_Z$ is considered for required load-shed power $\texttt{LS\_POWER}_z$ calculation. The acknowledgement of manual load-shed trigger is provided by $\texttt{MAN\_LS\_TRG}_Z$ signal.

If $\texttt{EXTD\_TRG\_SNW}_Z$ is active, $\texttt{RCV\_MS\_POW}_z$ is considered for load-shed power $\texttt{LS\_POWER}_z$ calculation.

Equation 16 shows the calculation of required load-shed power $\texttt{LS\_POWER}_Z$.

$$LS\_POWER_z = |EFF\_POW\_BAL_z| + MAN\_SHD\_POW_z + RCV\_MS\_POW_z \qquad \text{(Equation 16)}$$

Equation 17 shows the calculation of effective load-shed power $\texttt{MUST\_SHD\_LOD}_z$ by considering $\texttt{LS\_POWER}_Z$ and $\texttt{OV\_LOAD}_Z$.

$$MUST\_SHD\_LOD_z = MAX(LS\_POWER_z,\ OV\_LOAD_z) \qquad \text{(Equation 17)}$$

If no load-shed triggers are active, $\texttt{LS\_POWER}_Z$ and $\texttt{MUST\_SHD\_LOD}_Z$ are zero.

Equation 18 shows the calculation of cumulative sheddable load power $CUM\_LOD\_PR^p_z$ for each priority p in the subnetwork z.

$$CUM\_LOD\_PR^p_z = SHD\_POW^p_z + SHD\_POW^{p-1}_z$$

(Equation 18)

Where, $CUM\_LOD\_PR^1_z = SHD\_POW^1_z$

This module calculates the load-shed priority in subnetwork z by comparing the effective load-shed power MAN_SHD_SN<z> input with the cumulative sheddable load power $CUM\_LOD\_PR^p_z$ for each priority in incremental order of p. The load-shed priority corresponds to the first pth priority so that the cumulative load-shed power $CUM\_LOD\_PR^p_z$ is greater than or equal to $MUST\_SHD\_LOD_z$. This cumulative shed power for the pth priority is actual load-shed power $ACT\_SHD\_LOD_z$. This module can record up to 3 consecutive load-shed priorities, that is, record1 priority $SHD\_PRIO\_RC1_z$, record2 priority $SHD\_PRIO\_RC2_z$ and record3 priority $SHD\_PRIO\_RC3_z$ for the subnetwork. Here, the record1 priority refers to the most recent load-shedding priority, and record2 priority and record3 priority refer to the old and older load-shedding priorities respectively.

The priority based manual load-shed action is performed by activation of $MLS\_TRG\_SN_Z$ input which calculates the load-shed priority same as $MAN\_SHD\_PRIO_Z$.

Equation 19 shows the calculation of total sheddable load power $SHDABL\_LOAD_z$ in subnetwork z.

$$SHDABL\_LOAD_z = \sum_{p=1}^{p=19} SHD\_POW^p_z$$

(Equation 19)

The load mismatch $LOD\_MISMATCH_z$ in the subnetwork is calculated as the difference of $SHDABL\_LOAD_z$ and $RUNNING\_LOAD_z$.

If the calculated load-shed priority is greater than zero, this module calculates the cause of load-shed $LS\_OPR\_STS_Z$ based on the load-shed trigger received from the Block and trigger module. The cause of load-shed is send to the subnetwork monitoring function block.

Table 326: The cause of load-shed action

Preference No	load-shed trigger	Cause of load-shed ($LS\_OPR\_STS_Z$)
1	No trigger	No load-shed
2	Extended load-shed trigger	Extended load-shed
3	Fast load-shed trigger	Fast load-shed
4	Slow load-shed trigger	Slow load-shed
5	Manual load-shed trigger	Manual load-shed

If multiple load-shed triggers are activated at the same time, the cause of load-shed corresponds to the lowest preference number.

If priority-based manual load-shed action is performed along with any other trigger getting activated at the same instance, the cause of load-shed is manual load-shed provided manual load-shed priority is greater than the load-shed priority calculated due to any other trigger for the subnetwork z.

If slow load-shed trigger is active along with any other trigger at the same instance, the cause of load-shed is slow load-shed provided the load-shed priority calculated due to $\mathtt{OV\_LOAD}_z$ is greater than the load-shed priority calculated due to $\mathtt{LS\_POWER}_z$.

The module calculates the must-shedding status $\mathtt{MUST\_SHD\_STS}_z$ and spinning reserve status $\mathtt{SP\_RESV\_STS}_z$ for adjacent electrical area as shown in Figure 157.

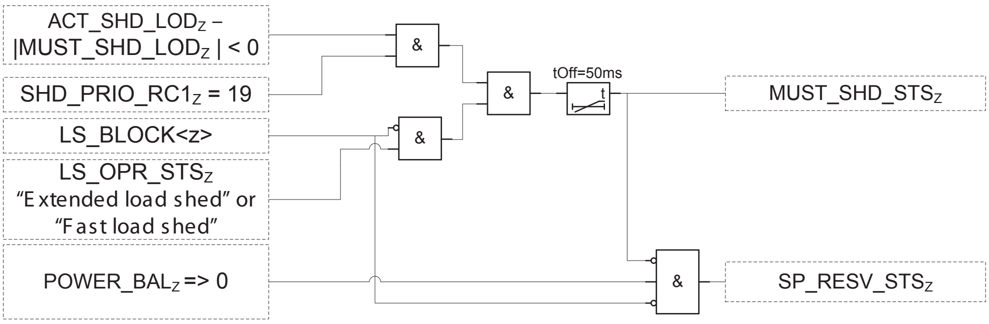


Figure 157: Must-shedding status and spinning reserve status calculation

If $\mathtt{MUST\_SHD\_STS}_z$ is active, extended must-shedding power $MUST\_SHD\_POW_z$ is the difference of the $|\mathtt{MUST\_SHD\_LOD}_z|$ and $\mathtt{ACT\_SHD\_LOD}_z$.

If $\mathtt{SP\_RESV\_STS}_z$ is active, the extended spinning reserve power $\mathtt{SP\_RESV\_POW}_z$ is same as the power balance $\mathtt{POWER\_BAL}_z$.

The module reports the $\mathtt{MUST\_SHD\_STS}_z$, $\mathtt{SP\_RESV\_STS}_z$, $\mathtt{MUST\_SHD\_POW}_z$ and $\mathtt{SP\_RESV\_POW}_z$ to the Peer load-shed logic module.

The reset inputs, that is, RESET_SN1, RESET_SN2, RESET_SN3 and RESET_SN4, are provided to reset the load-shed data in respective subnetwork. For example, if RESET_SN1 or RESET input is active, the power balance, effective load-shedding power, actual load-shedding, load-shedding operation and recorded priorities are reset.

The reset acknowledged status, record1 priority, cause of load-shed and load-shedding enabling status for the subnetworks are provided to the General logic module.

7.8.4.7 Peer load shed logic

This module receives the must-shedding mode `MUST_SHD_MOD` and spinning reserve mode `SP_RESV_MOD` from the NPMMXU function.

The module processes the load-shed data of the subnetwork corresponding to the subnetworks of power source 1 and power source 2 for adjacent electrical areas.

- Calculation of `SND_LS_POW1` and `SND_LS_POW2` when power source 1 and power source 2 subnetworks are different
  The load-shed power `SND_LS_POW1` is calculated as must-shedding power or spinning reserve power based on must-shedding status or spinning reserve status of power source 1 subnetwork.
  If $MUST\_SHD\_STS_z$ is active, `SND_LS_POW1` is same as $MUST\_SHD\_POW_z$.
  If $SP\_RESV\_STS_z$ is active, `SND_LS_POW1` is same as $SP\_RESV\_POW_z$.

  Similarly, `SND_LS_POW2` is calculated as must shedding power or spinning reserve power based on must-shedding status or spinning reserve status of power source 2 subnetwork.

- Calculation of `SND_LS_POW1` and `SND_LS_POW2` when power source 1 and power source 2 subnetworks are same.

Table 327: Calculation of load-shed powers for adjacent electrical areas

Must-shedding status or spinning reserve status	Must-shedding mode or spinning reserve mode	SND_LS_POW1	SND_LS_POW2
$MUST\_SHD\_STS_z$ = Active	MUST_SHD_MOD = 1 (Half-Half)	$MUST\_SHD\_POW_z$*0.5	$MUST\_SHD\_POW_z$*0.5
	MUST_SHD_MOD = 2 (Zero-Full)	$MUST\_SHD\_POW_z$*0	$MUST\_SHD\_POW_z$*1
	MUST_SHD_MOD = 3 (Full-Zero)	$MUST\_SHD\_POW_z$*1	$MUST\_SHD\_POW_z$*0
$SP\_RESV\_STS_z$ = Active	SP_RESV_MOD = 2	($SP\_RESV\_POW_z$ + $RCV\_SR\_POW_2$) *1	($SP\_RESV\_POW_z$ + $RCV\_SR\_POW_1$) *1
	SP_RESV_MOD = 3	($SP\_RESV\_POW_z$ + $RCV\_SR\_POW_2$) *0	($SP\_RESV\_POW_z$ + $RCV\_SR\_POW_1$) *1
	SP_RESV_MOD = 4	($SP\_RESV\_POW_z$ + $RCV\_SR\_POW_2$) *1	($SP\_RESV\_POW_z$ + $RCV\_SR\_POW_1$) *0

7.8.4.8 General logic

This module calculates the load-shedding start and load-shedding operation outputs based on the load-shedding triggers and the cause of load-shed.

The FLS_START output is TRUE if any of the condition is true.

- FLS_TRG_SNW1 is active.
- FLS_TRG_SNW2 is active.
- FLS_TRG_SNW3 is active.
- FLS_TRG_SNW4 is active.

If the above conditions are not true, the FLS_START output is FALSE.

If the slow load start for power sources is active, the SLS_START output is TRUE else the SLS_START output is FALSE.

The LS_START output is TRUE if any of the condition is satisfied.

- If the FLS_START output is TRUE
- If the SLS_START output is TRUE
- If EXTD_TRG_SNW1 is active or EXTD_TRG_SNW2 is active or EXTD_TRG_SNW3 is active or EXTD_TRG_SNW4 is active

If the above conditions are not true, the LS_START output is FALSE.

If LS_OPR_STS$_z$ is fast load-shed, FLS_OPERATE output is TRUE.

If LS_OPR_STS$_z$ is slow load-shed, SLS_OPERATE output is TRUE.

If LS_OPR_STS$_z$ is fast load-shed or slow load-shed or manual load-shed or extended load-shed, LS_OPERATE output is TRUE.

The B_SET_CHANGE output indicates the change in the *Block override* setting from one value to another value by the operator. The B_SET_CHANGE output is TRUE for 500 ms from the time of change. After 500 ms has elapsed, the B_SET_CHANGE output is FALSE.

7.8.4.9 Load busbar command

This module calculates the load-shedding operation information for the sheddable loads of each busbar. Based on the load-shedding priority calculated for the subnetwork, the load-shedding operation is activated for sheddable loads in the corresponding busbar of the subnetwork.

If the set priority of the sheddable load is less than or equal to the load-shedding priority, the load-shedding operation for the corresponding sheddable load is activated.

The load-shedding operation command for different busbars is provided by the LS_OPR_BB1, LS_OPR_BB2, LS_OPR_BB3, LS_OPR_BB4, LS_OPR_BB5 and LS_OPR_BB6 outputs.

Table 328: Bits information for LS_OPR_BB1

Bit No	Bit description
1	Load-shed operate sheddable load 1
2	Load-shed operate sheddable load 2
3	Load-shed operate sheddable load 3
4	Load-shed operate sheddable load 4
5	Load-shed operate sheddable load 5
6	Load-shed operate sheddable load 6
7	Load-shed operate sheddable load 7
8	Load-shed operate sheddable load 8
9	Load-shed operate sheddable load 9
10	Load-shed operate sheddable load 10

Bits information for `LS_OPR_BB2...LS_OPR_BB6` are identical to `LS_OPR_BB1`.

These outputs are reported to the corresponding instances of the load-shedding trip command function LSPTRC.

The load-shedding operation command for the busbar is a hold value. The load-shedding operation information for the busbars can be reset by the `RESET_SN1`, `RESET_SN2`, `RESET_SN3` or `RESET_SN4` inputs for the respective subnetworks.

The load-shedding operation commands for all six busbars can be reset by the `RESET` input.

If the subnetwork number of a busbar is changed, the load-shedding operation command for the respective busbar is reset.

Table 329 shows the signals provided to respective SNWRCLS functions through group output `SNW1`, `SNW2`, `SNW3` and `SNW4`.

Table 329: The group signal for SNW$_z$

Signal description	Group signal description for SNW<z>
Cumulative shed power for priority p = 1,2,3,..19	CUM_LOD_PR$^{p}_{z}$
Available power of the subnetwork	AVA_POWER$_z$
Running load of the subnetwork	RUNNING_LOAD$_z$
Total sheddable power of the subnetwork	SHDABL_LOAD$_z$
Power balance of the subnetwork	POWER_BAL$_z$
Total load inhibited by system in the subnetwork	TOT_INH_SYS$_z$
Total load inhibited by operator in the subnetwork	TOT_INH_OPR$_z$
Table continues on next page	

Signal description	Group signal description for SNW<z>
Load mismatch in the subnetwork	$LOD\_MISMATCH_z$
Manual load-shed power	$MAN\_SHD\_POW_z$
Manual load-shed priority	$MAN\_SHD\_PRIO_z$
Effective power balance in the subnetwork	$EFF\_POW\_BAL_z$
Effective must-shed power of the subnetwork	$MUST\_SHD\_LOD_z$
Actual load-shed in the subnetwork	$ACT\_SHD\_LOD_z$
Load-shed operate status of the subnetwork	$LS\_OPR\_STS_z$
Load-shed disable status of the subnetwork	$DISABLE\_LS_z$
Subnetwork active status	SN_ACTIVE_z
Fast load-shed blocking status of the subnetwork	LS_BLOCK_z
Slow load-shed enable status of the subnetwork	$SLS\_ENA\_SNW_z$
Load-shed reset status of the subnetwork	LS_RESET_z
Manual load-shed trigger for the subnetwork	$MAN\_LS\_TRG_z$
Load-shed priority 1	$SHD\_PRIO\_RC1_z$
Load-shed priority 2	$SHD\_PRIO\_RC2_z$
Load-shed priority 3	$SHD\_PRIO\_RC3_z$

Table 330 shows the signals provided to respective PPLSGGIO functions through group outputs, `PPLS1` and `PPLS2`.

Table 330: The group signal for PPLS1/PPLS2

Signal description	Group signal description for PPLS1/PPLS2
Load-shed power for power source 1/power source 2 subnetworks	SND_LS_POW1/SND_LS_POW2
Spinning reserve status for power source 1/power source 2 subnetwork	$SP\_RESV\_STS_z$
Must-shedding status for power source 1/power source 2 subnetwork	$MUST\_SHD\_STS_z$

7.8.5 Signals

Table 331: LSCACLS Input signals

Name	Type	Default	Description
NW_SOURCE	GROUP SIGNAL	-	Group signal from network power source
NW_CB12	GROUP SIGNAL	-	Group signal from network CB connecting BB1 and BB2
NW_CB13	GROUP SIGNAL	-	Group signal from network CB connecting BB1 and BB3
NW_CB14	GROUP SIGNAL	-	Group signal from network CB connecting BB1 and BB4
Table continues on next page			

Name	Type	Default	Description
NW_CB15	GROUP SIGNAL	-	Group signal from network CB connecting BB1 and BB5
NW_CB16	GROUP SIGNAL	-	Group signal from network CB connecting BB1 and BB6
NW_CB23	GROUP SIGNAL	-	Group signal from network CB connecting BB2 and BB3
NW_CB24	GROUP SIGNAL	-	Group signal from network CB connecting BB2 and BB4
NW_CB25	GROUP SIGNAL	-	Group signal from network CB connecting BB2 and BB5
NW_CB26	GROUP SIGNAL	-	Group signal from network CB connecting BB2 and BB6
NW_CB34	GROUP SIGNAL	-	Group signal from network CB connecting BB3 and BB4
NW_CB35	GROUP SIGNAL	-	Group signal from network CB connecting BB3 and BB5
NW_CB36	GROUP SIGNAL	-	Group signal from network CB connecting BB3 and BB6
NW_CB45	GROUP SIGNAL	-	Group signal from network CB connecting BB4 and BB5
NW_CB46	GROUP SIGNAL	-	Group signal from network CB connecting BB4 and BB6
NW_CB56	GROUP SIGNAL	-	Group signal from network CB connecting BB5 and BB6
BB1	GROUP SIGNAL	-	Group signal from sheddable loads for load busbar 1
BB2	GROUP SIGNAL	-	Group signal from sheddable loads for load busbar 2
BB3	GROUP SIGNAL	-	Group signal from sheddable loads for load busbar 3
BB4	GROUP SIGNAL	-	Group signal from sheddable loads for load busbar 4
BB5	GROUP SIGNAL	-	Group signal from sheddable loads for load busbar 5
BB6	GROUP SIGNAL	-	Group signal from sheddable loads for load busbar 6
MAN_PRIO_SN1	INTEGER	0	Priority for manual load shed in subnetwork 1
MAN_POW_SN1	REAL	0.0	Power in kW for manual load shed in subnetwork 1
MAN_SHD_SN1	BOOLEAN	0	Manual load shed trigger for subnetwork 1
MAN_PRIO_SN2	INTEGER	0	Priority for manual load shed in subnetwork 2
MAN_POW_SN2	REAL	0.0	Power in kW for manual load shed in subnetwork 2
MAN_SHD_SN2	BOOLEAN	0	Manual load shed trigger for subnetwork 2
MAN_PRIO_SN3	INTEGER	0	Priority for manual load shed in subnetwork 3
MAN_POW_SN3	REAL	0.0	Power in kW for manual load shed in subnetwork 3
MAN_SHD_SN3	BOOLEAN	0	Manual load shed trigger for subnetwork 3
MAN_PRIO_SN4	INTEGER	0	Priority for manual load shed in subnetwork 4

Table continues on next page

Name	Type	Default	Description
MAN_POW_SN4	REAL	0.0	Power in kW for manual load shed in subnetwork 4
MAN_SHD_SN4	BOOLEAN	0	Manual load shed trigger for subnetwork 4
MAN_LS_QVAL	BOOLEAN	1	Manual load shed communicated data quality
BLOCK	BOOLEAN	0	Block for fast load shed and slow load shed
EXT_LS_TRG	BOOLEAN	0	External load shed trigger
LS_RESET	BOOLEAN	0	Load shed reset for all subnetworks
LS_RESET_SN1	BOOLEAN	0	Load shed reset for subnetwork 1
LS_RESET_SN2	BOOLEAN	0	Load shed reset for subnetwork 2
LS_RESET_SN3	BOOLEAN	0	Load shed reset for subnetwork 3
LS_RESET_SN4	BOOLEAN	0	Load shed reset for subnetwork 4
FLS_CNT_RST	BOOLEAN	0	Signal for fast load shed counter reset

Table 332: LSCACLS Output signals

Name	Type	Description
SNW1	GROUP SIGNAL	Group signal for subnetwork 1
SNW2	GROUP SIGNAL	Group signal for subnetwork 2
SNW3	GROUP SIGNAL	Group signal for subnetwork 3
SNW4	GROUP SIGNAL	Group signal for subnetwork 4
PPLS1	GROUP SIGNAL	Group signal of electrical area connected with power source1
PPLS2	GROUP SIGNAL	Group signal of electrical area connected with power source2
LS_OPERATE	BOOLEAN	Load shed operate
LS_START	BOOLEAN	Load shed start
FLS_OPERATE	BOOLEAN	Fast load shed operate
FLS_START	BOOLEAN	Fast load shed start
SLS_OPERATE	BOOLEAN	Slow load shed operate
SLS_START	BOOLEAN	Slow load shed start
OPERATE_BB1	INTEGER	Load shed operate for loads in busbar1
OPERATE_BB2	INTEGER	Load shed operate for loads in busbar2
OPERATE_BB3	INTEGER	Load shed operate for loads in busbar3
OPERATE_BB4	INTEGER	Load shed operate for loads in busbar4
OPERATE_BB5	INTEGER	Load shed operate for loads in busbar5
OPERATE_BB6	INTEGER	Load shed operate for loads in busbar6
B_SET_CHANGE	BOOLEAN	One or many basic settings changed

7.8.6 Settings

Table 333: LSCACLS Non group settings (basic)

Name	Values (Range)	Unit	Step	Default	Description
Disable LS SubNetw	Yes No	-	-	No	Disable load-shedding in all subneworks
Enable LS SubNetw1	No Yes	-	-	Yes	Enable load-shedding in subnetwork 1
Enable LS SubNetw2	No Yes	-	-	Yes	Enable load-shedding in subnetwork 2
Enable LS SubNetw3	No Yes	-	-	Yes	Enable load-shedding in subnetwork 3
Enable LS SubNetw4	No Yes	-	-	Yes	Enable load-shedding in subnetwork 4
SubNetw1 Man Prio	0 - 19	-	1	0	Manual load shed priority for subnetwork 1
SubNetw2 Man Prio	0 - 19	-	1	0	Manual load shed priority for subnetwork 2
SubNetw3 Man Prio	0 - 19	-	1	0	Manual load shed priority for subnetwork 3
SubNetw4 Man Prio	0 - 19	-	1	0	Manual load shed priority for subnetwork 4
SubNetw1 Man Pow	0.0 - 999999.9	kW	0.1	0.0	Manual load shed power in kilo watt for subnetwork 1
SubNetw2 Man Pow	0.0 - 999999.9	kW	0.1	0.0	Manual load shed power in kilo watt for subnetwork 2
SubNetw3 Man Pow	0.0 - 999999.9	kW	0.1	0.0	Manual load shed power in kilo watt for subnetwork 3
SubNetw4 Man Pow	0.0 - 999999.9	kW	0.1	0.0	Manual load shed power in kilo watt for subnetwork 4

Table 334: LSCACLS Non group settings (advanced)

Name	Values (Range)	Unit	Step	Default	Description
Operation	Off On	-	-	Off	Operation Mode Off / On
SubNetw Abs offset	-1000.00 - 1000.00	kW	0.01	0.0	Absolute safety margin for power balance
SubNetw Rel offset	-100.0 - 100.0	%	1.0	0.0	Relative safety margin for power balance
Man load shed mode	Disable manual LS SN Man Prio setting SN Man Pow setting SN Man Prio input SN Man Pow input	-	-	Disable manual LS	Manual load shed mode selection

7.8.7 Measured values

Table 335: LSCACLS Measured values

Name	Type	Default	Description
MAN_PRIO_SN1	INTEGER	0	Priority for manual load shed in subnetwork 1
MAN_POW_SN1	REAL	0.0	Power in kW for manual load shed in subnetwork 1
MAN_SHD_SN1	BOOLEAN	0	Manual load shed trigger for subnetwork 1
MAN_PRIO_SN2	INTEGER	0	Priority for manual load shed in subnetwork 2
MAN_POW_SN2	REAL	0.0	Power in kW for manual load shed in subnetwork 2
MAN_SHD_SN2	BOOLEAN	0	Manual load shed trigger for subnetwork 2
MAN_PRIO_SN3	INTEGER	0	Priority for manual load shed in subnetwork 3
MAN_POW_SN3	REAL	0.0	Power in kW for manual load shed in subnetwork 3
MAN_SHD_SN3	BOOLEAN	0	Manual load shed trigger for subnetwork 3
MAN_PRIO_SN4	INTEGER	0	Priority for manual load shed in subnetwork 4
MAN_POW_SN4	REAL	0.0	Power in kW for manual load shed in subnetwork 4
MAN_SHD_SN4	BOOLEAN	0	Manual load shed trigger for subnetwork 4
MAN_LS_QVAL	BOOLEAN	1	Manual load shed communicated data quality
BLOCK	BOOLEAN	0	Block for fast load shed and slow load shed
EXT_LS_TRG	BOOLEAN	0	External load shed trigger
LS_RESET	BOOLEAN	0	Load shed reset for all subnetworks
LS_RESET_SN1	BOOLEAN	0	Load shed reset for subnetwork 1
LS_RESET_SN2	BOOLEAN	0	Load shed reset for subnetwork 2
LS_RESET_SN3	BOOLEAN	0	Load shed reset for subnetwork 3
LS_RESET_SN4	BOOLEAN	0	Load shed reset for subnetwork 4
FLS_CNT_RST	BOOLEAN	0	Signal for fast load shed counter reset

7.8.8 Monitored data

Table 336: LSCACLS Monitored data

Name	Type	Values (Range)	Unit	Description
LS_OPERATE	BOOLEAN	0=FALSE 1=TRUE	-	Load shed operate
LS_START	BOOLEAN	0=FALSE 1=TRUE	-	Load shed start
FLS_OPERATE	BOOLEAN	0=FALSE 1=TRUE	-	Fast load shed operate
FLS_START	BOOLEAN	0=FALSE 1=TRUE	-	Fast load shed start
SLS_OPERATE	BOOLEAN	0=FALSE 1=TRUE	-	Slow load shed operate
SLS_START	BOOLEAN	0=FALSE 1=TRUE	-	Slow load shed start

Table continues on next page

Name	Type	Values (Range)	Unit	Description
B_SET_CHANGE	BOOLEAN	0=FALSE 1=TRUE	-	One or many basic settings changed
MAN_LS_BEH	INTEGER	1=Manual LS disable 2=Manual Prio setting 3=Manual power setting 4=Communicate priority 5=Communicate power 6=Set Prio Comm bad 7=Set power Comm bad	-	Manual load shed behaviour
FLS_COUNTER	INTEGER	-	-	Counter for number of fast load shed triggers generated
CB12_SN_NO	INTEGER	-	-	Subnetwork number of network CB12
CB13_SN_NO	INTEGER	-	-	Subnetwork number of network CB13
CB14_SN_NO	INTEGER	-	-	Subnetwork number of network CB14
CB15_SN_NO	INTEGER	-	-	Subnetwork number of network CB15
CB16_SN_NO	INTEGER	-	-	Subnetwork number of network CB16
CB23_SN_NO	INTEGER	-	-	Subnetwork number of network CB23
CB24_SN_NO	INTEGER	-	-	Subnetwork number of network CB24
CB25_SN_NO	INTEGER	-	-	Subnetwork number of network CB25
CB26_SN_NO	INTEGER	-	-	Subnetwork number of network CB26
CB34_SN_NO	INTEGER	-	-	Subnetwork number of network CB34
CB35_SN_NO	INTEGER	-	-	Subnetwork number of network CB35
CB36_SN_NO	INTEGER	-	-	Subnetwork number of network CB36
CB45_SN_NO	INTEGER	-	-	Subnetwork number of network CB45
CB46_SN_NO	INTEGER	-	-	Subnetwork number of network CB46
CB56_SN_NO	INTEGER	-	-	Subnetwork number of network CB56
SRC1_SN_NO	INTEGER	-	-	Subnetwork number of source1

Table continues on next page

Name	Type	Values (Range)	Unit	Description
SRC2_SN_NO	INTEGER	-	-	Subnetwork number of source2
SRC3_SN_NO	INTEGER	-	-	Subnetwork number of source3
SRC4_SN_NO	INTEGER	-	-	Subnetwork number of source4
SRC5_SN_NO	INTEGER	-	-	Subnetwork number of source5
SRC6_SN_NO	INTEGER	-	-	Subnetwork number of source6
SRC7_SN_NO	INTEGER	-	-	Subnetwork number of source7
SRC8_SN_NO	INTEGER	-	-	Subnetwork number of source8
BB1_SN_NO	INTEGER	-	-	Subnetwork number of busbar1
BB2_SN_NO	INTEGER	-	-	Subnetwork number of busbar2
BB3_SN_NO	INTEGER	-	-	Subnetwork number of busbar3
BB4_SN_NO	INTEGER	-	-	Sub network number of busbar4
BB5_SN_NO	INTEGER	-	-	Subnetwork number of busbar5
BB6_SN_NO	INTEGER	-	-	Subnetwork number of busbar6

7.9 Load-shed trip command LSPTRC

7.9.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE identification
Load-shed trip command	LSPTRC	-	LSPTRC

7.9.2 Function block

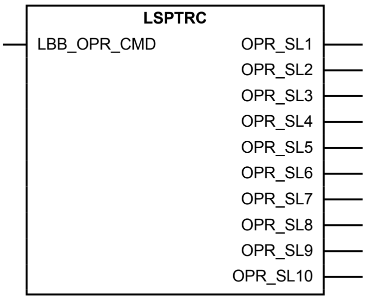


Figure 158: Function block

7.9.3 Functionality

The load-shedding trip command function LSPTRC is the output interface function. Based on the operating input received from LSCACLS, LSPTRC provides the load-shedding trip signals for individual sheddable loads of each load busbar.

7.9.4 Operation principle

The functional module diagram describes the operation of LSPTRC.

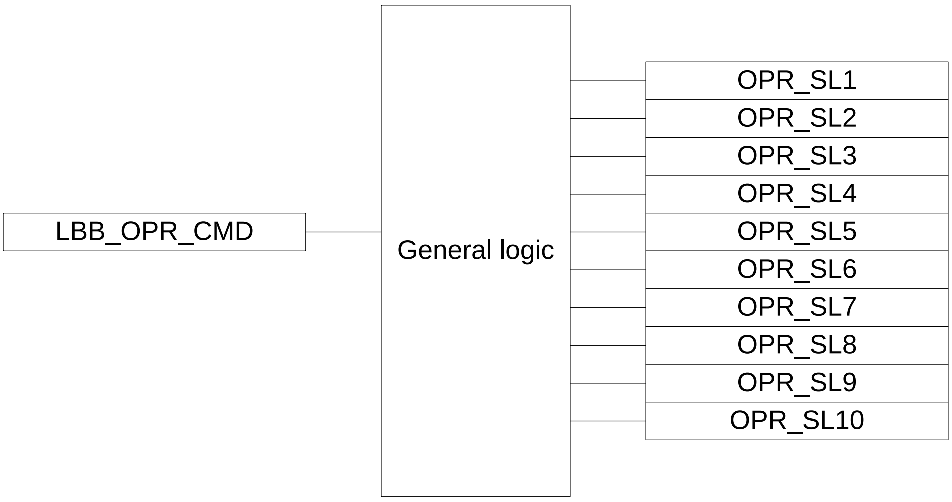


Figure 159: Functional module diagram

7.9.4.1 General logic

Based on the LBB_OPR_CMD input, the general logic calculates the load-shedding trip information for each sheddable load (that is, sheddable load 1, sheddable load 2...sheddable load 10).

The OPR_SL1, OPR_SL2…OPR_SL10 outputs provide the load-shedding trip information for sheddable load 1, sheddable load 2...sheddable load10 respectively.

Table 337 shows the OPR_SL1, OPR_SL2…OPR_SL10 outputs with respect to the individual bits of the LBB_OPR_CMD input.

Table 337: Load busbar operating command

Bits information of input LBB_OPR_CMD	Outputs
1	OPR_SL1
2	OPR_SL2
3	OPR_SL3
4	OPR_SL4
5	OPR_SL5
6	OPR_SL6
7	OPR_SL7
8	OPR_SL8
9	OPR_SL9
10	OPR_SL10

If any bit value is active, the corresponding output is active. For example, if the bit 1 is active, the OPR_SL1 output is TRUE, else OPR_SL1 output is FALSE. Similarly, this applies to all other bits and corresponding outputs.

7.9.5 Signals

Table 338: LSPTRC Input signals

Name	Type	Default	Description
LBB_OPR_CMD	INTEGER	0	Load bus bar operate command for ten sheddable loads

Table 339: LSPTRC Output signals

Name	Type	Description
OPR_SL1	BOOLEAN	Operate command for the sheddable load1
OPR_SL2	BOOLEAN	Operate command for the sheddable load2
OPR_SL3	BOOLEAN	Operate command for the sheddable load3
OPR_SL4	BOOLEAN	Operate command for the sheddable load4
OPR_SL5	BOOLEAN	Operate command for the sheddable load5
Table continues on next page		

Name	Type	Description
OPR_SL6	BOOLEAN	Operate command for the sheddable load6
OPR_SL7	BOOLEAN	Operate command for the sheddable load7
OPR_SL8	BOOLEAN	Operate command for the sheddable load8
OPR_SL9	BOOLEAN	Operate command for the sheddable load9
OPR_SL10	BOOLEAN	Operate command for the sheddable load10

7.9.6 Measured values

Table 340: LSPTRC Measured values

Name	Type	Default	Description
LBB_OPR_CMD	INTEGER	0	Load bus bar operate command for ten sheddable loads

7.9.7 Monitored data

Table 341: LSPTRC Monitored data

Name	Type	Values (Range)	Unit	Description
OPR_SL1	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load1
OPR_SL2	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load2
OPR_SL3	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load3
OPR_SL4	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load4
OPR_SL5	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load5
OPR_SL6	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load6
OPR_SL7	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load7
OPR_SL8	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load8
OPR_SL9	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load9
OPR_SL10	BOOLEAN	0=Reset 1=Operate	-	Operate command for the sheddable load10

7.10 Output interface for subnetworks SNWRCLS

7.10.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE identification
Subnetwork output	SNWRCLS	-	SNWRCLS

7.10.2 Function block

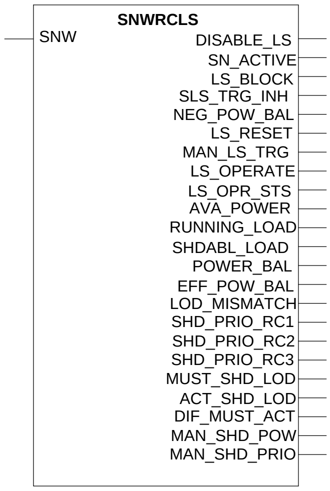


Figure 160: Function block

7.10.3 Functionality

The subnetwork output function SNWRCLS is an interface function for a subnetwork. SNWRCLS receives the subnetwork information from the contingency based load-shedding function LSCACLS. Based on this, SNWRCLS provides the outputs for display, for example, load-shedding operating status, load-shedding priority available power, active power, power balance and effective power balance.

7.10.4 Operation principle

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

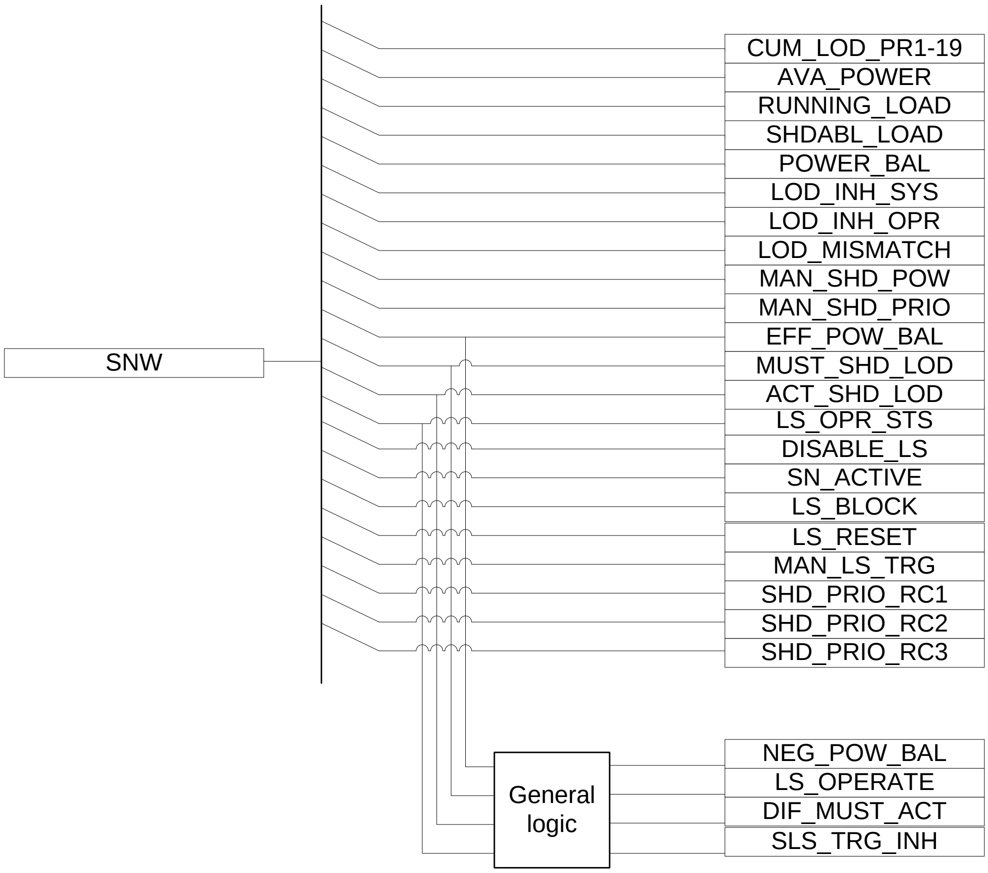


Figure 161: Functional module diagram

SNWRCLS receives different load-shedding data of the subnetwork from LSCACLS through the `SNW` group input.

The function provides various load-shedding information for the subnetwork corresponding to the inputs received from the LSCACLS function.

Table 342: Load-shedding information provided by SNWRCLS for the subnetwork

Output	Load-shedding information
CUM_LOD_PR1-19	This output provides the cumulative load-shedding power for priority = 1. Similarly, the cumulative load-shedding power for the priority = 2, 3...19 are provided by the CUM_LOD_PR2, CUM_LOD_PR3…CUM_LOD_PR19 outputs respectively.
AVA_POWER	This output provides the total available power of the subnetwork.
RUNNING_LOAD	This output provides the total load of the subnetwork.
SHDABL_LOAD	This output provides the total load of the subnetwork available for the load-shedding.
POWER_BAL	This output provides the load generation balance of the subnetwork.
LOD_INH_SYS	This output provides the total system inhibition (Auto inhibition) of the sheddable load feeders in the subnetwork.
Table continues on next page	

Output	Load-shedding information
LOD_INH_OPR	This output provides the total operator inhibited (Manual inhibition) of the sheddable load feeders in the subnetwork.
LOD_MISMATCH	This output provides the load mismatch in the subnetwork.
MAN_SHD_POW	This output provides the amount of load to be shed by the operator in the subnetwork during manual load-shed action.
MAN_SHD_PRIO	This output provides the load shed priority to be executed by the operator in the subnetwork during manual load-shed action.
EFF_POW_BAL	This output provides the effective load generation balance of the subnetwork considering power balance of the subnetwork and spinning reserve power received from adjacent electrical areas.
MUST_SHD_LOD	This output provides the must be shed power of the subnetwork.
ACT_SHD_LOD	This output provides the actual load-shed power of the subnetwork.
LS_OPR_STS	This output provides load shed operated status such as “No Load shed”/“Fast Load shed”/“Slow Load shed”/“Manual Load shed”/ “Extended Load shed”
DISABLE_LS	This output provides load-shed disable status in the subnetwork.
SN_ACTIVE	This output provides the subnetwork active information.
LS_BLOCK	This output provides the load-shed block information of the subnetwork.
LS_RESET	This output provides the load-shed reset information of the subnetwork.
MAN_LS_TRG	This output provides the manual load-shed trigger information.
SHD_PRIO_RC1	Latest load-shed priority
SHD_PRIO_RC2	Old load-shed priority
SHD_PRIO_RC3	Older load-shed priority These outputs show the three load-shed priority generated in the subnetwork. After load-shed reset action the shed priority resets to zero.

For more information on the above mention inputs, see the LSCACLS function.

7.10.4.1 General logic

The General logic module calculates the load-shedding information of the subnetwork.

Table 343: Load-shedding information of the subnetwork calculated by the General logic module

Output	Load-shedding information
LS_OPERATE	If LS_OPR_STS output is Fast Load shed, Slow Load shed, Manual Load shed or Extended Load shed, then the LS_OPERATE output is TRUE, else the LS_OPERATE output is FALSE.
NEG_POW_BAL	This output is calculated as TRUE if the EFF_POW_BAL value is less than zero (that is, negative).
DIF_MUST_ACT	This output provides the difference in the must-shedding and the actual loadshedding of the subnetwork, that is, DIF_MUST_ACT = MUST_SHD_LOD - ACT_SHD_LOD.
SLS_TRG_INH	If SLS_ENA_SNW signal is activated, SLS_TRG_INH is inactive else SLS_TRG_INH is active.

7.10.5 Signals

Table 344: SNWRCLS Input signals

Name	Type	Default	Description
SNW	GROUP SIGNAL	-	Group signal for subnetwork

Table 345: SNWRCLS Output signals

Name	Type	Description
DISABLE_LS	BOOLEAN	Load shed disable
SN_ACTIVE	BOOLEAN	Subnetwork active status
LS_BLOCK	BOOLEAN	Load shed block
SLS_TRG_INH	BOOLEAN	Slow load shed trigger inhibit
NEG_POW_BAL	BOOLEAN	Negative power balance status
LS_RESET	BOOLEAN	Load shed reset
MAN_LS_TRG	BOOLEAN	Manual load shed trigger
LS_OPERATE	BOOLEAN	Load shed operate
LS_OPR_STS	INTEGER	Load shed operated status
AVA_POWER	REAL	Total Available power
RUNNING_LOAD	REAL	Total load
SHDABL_LOAD	REAL	Total sheddable load
POWER_BAL	REAL	Power balance in the subnetwork
EFF_POW_BAL	REAL	Effective power balance in the subnetwork
LOD_MISMATCH	REAL	Total load mismatch
SHD_PRIO_RC1	INTEGER	Record-1 subnetwork shed priority
SHD_PRIO_RC2	INTEGER	Record-2 subnetwork shed priority
SHD_PRIO_RC3	INTEGER	Record-3 subnetwork shed priority
MUST_SHD_LOD	REAL	Must be load shed
ACT_SHD_LOD	REAL	Actually shed load
Table continues on next page		

Name	Type	Description
DIF_MUST_ACT	REAL	Difference between the must be load shed and actual load shed
MAN_SHD_POW	REAL	Manual load shed power settings
MAN_SHD_PRIO	INTEGER	Manual load shed Priority settings

7.10.6 Monitored data

Table 346: SNWRCLS Monitored data

Name	Type	Values (Range)	Unit	Description
DISABLE_LS	BOOLEAN	0=FALSE 1=TRUE	-	Load shed disable
SN_ACTIVE	BOOLEAN	0=FALSE 1=TRUE	-	Subnetwork active status
LS_BLOCK	BOOLEAN	0=FALSE 1=TRUE	-	Load shed block
SLS_TRG_INH	BOOLEAN	0=FALSE 1=TRUE	-	Slow load shed trigger inhibit
NEG_POW_BAL	BOOLEAN	0=FALSE 1=TRUE	-	Negative power balance status
LS_RESET	BOOLEAN	0=FALSE 1=TRUE	-	Load shed reset
MAN_LS_TRG	BOOLEAN	0=FALSE 1=TRUE	-	Manual load shed trigger
LS_OPERATE	BOOLEAN	0=FALSE 1=TRUE	-	Load shed operate
LS_OPR_STS	INTEGER	0=No Load shed 1=Fast Load shed 2=Slow Load shed 3=Manual Load shed 4=Plant level Load shed 5=Extended Load shed	-	Load shed operated status
AVA_POWER	REAL	-	kW	Total Available power
RUNNING_LOAD	REAL	-	kW	Total load
SHDABL_LOAD	REAL	-	kW	Total sheddable load
POWER_BAL	REAL	-	kW	Power balance in the subnetwork
EFF_POW_BAL	REAL	-	kW	Effective power balance in the subnetwork
LOD_MISMATCH	REAL	-	kW	Total load mismatch
MUST_SHD_LOD	REAL	-	kW	Must be load shed
ACT_SHD_LOD	REAL	-	kW	Actually shed load
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
DIF_MUST_ACT	REAL	-	kW	Difference between the must be load shed and actual load shed
MAN_SHD_POW	REAL	-	kW	Manual load shed power settings
LOD_INH_OPR	REAL	-	kW	Amount of load inhibited by operator
LOD_INH_SYS	REAL	-	kW	Amount of load inhibited by system
CUM_LOD_PR1	REAL	-	kW	Cumulative load priority 1
CUM_LOD_PR2	REAL	-	kW	Cumulative load priority 2
CUM_LOD_PR3	REAL	-	kW	Cumulative load priority 3
CUM_LOD_PR4	REAL	-	kW	Cumulative load priority 4
CUM_LOD_PR5	REAL	-	kW	Cumulative load priority 5
CUM_LOD_PR6	REAL	-	kW	Cumulative load priority 6
CUM_LOD_PR7	REAL	-	kW	Cumulative load priority 7
CUM_LOD_PR8	REAL	-	kW	Cumulative load priority 8
CUM_LOD_PR9	REAL	-	kW	Cumulative load priority 9
CUM_LOD_PR10	REAL	-	kW	Cumulative load priority 10
CUM_LOD_PR11	REAL	-	kW	Cumulative load priority 11
CUM_LOD_PR12	REAL	-	kW	Cumulative load priority 12
CUM_LOD_PR13	REAL	-	kW	Cumulative load priority 13
CUM_LOD_PR14	REAL	-	kW	Cumulative load priority 14
CUM_LOD_PR15	REAL	-	kW	Cumulative load priority 15
CUM_LOD_PR16	REAL	-	kW	Cumulative load priority 16
CUM_LOD_PR17	REAL	-	kW	Cumulative load priority 17
CUM_LOD_PR18	REAL	-	kW	Cumulative load priority 18
CUM_LOD_PR19	REAL	-	kW	Cumulative load priority 19

7.11 Peer-to-peer load-shedding PPLSGGIO

7.11.1 Identification

Function description	IEC 61850 identification	IEC 60617 identification	ANSI/IEEE identification
Peer-to-peer load-shedding	PPLSGGIO	-	PPLSGGIO

7.11.2 Function block

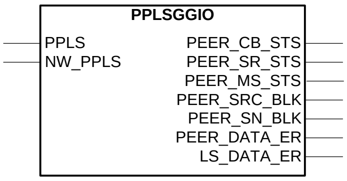


Figure 162: Function block

7.11.3 Functionality

PPLSGGIO is the output interface for the load-shedding data for an adjacent electrical area connected with the power source. The load-shedding information is converted into weighted integer data. This function also provides outputs for the load-shedding information received from the corresponding connected electrical area.

7.11.4 Operation principle

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

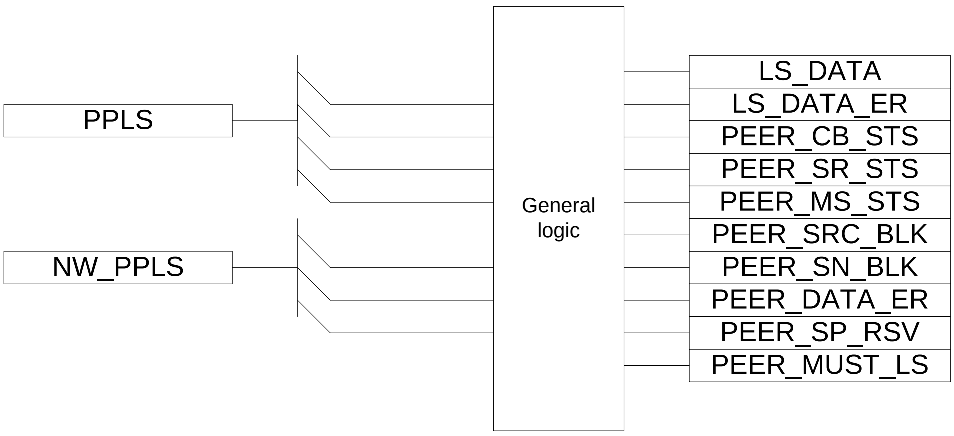


Figure 163: Functional module diagram

PPLSGGIO receives the different load-shedding data of the subnetwork from LSCACLS through the group input `PPLS`.

PPLSGGIO receives the circuit breaker information for external connection and load-shedding data of the connected adjacent electrical area from NPMMXU function through the group input `NW_PPLS`.

7.11.4.1 General logic

This module calculates an error signal if the load-shed power of the subnetwork SND_LS_POW exceeds 33554431 kW. This error is indicated by the LS_DATA_ER output.

Based on various load shed information, the module calculates the LS_DATA for adjacent electrical area. Table 347 shows the LS_DATA output bit-wise information.

Table 347: Output LS_DATA bits information sent to adjacent electrical area

Bit No.	Signals	Signal description
1	CCB_OPN_SRC	Compensated CB open status for power source 1 or power source 2
2	SP_RESV_STS	Spinning reserve status of subnetwork for power source 1 or power source 2
3	MUST_SHD_STS	Must-shedding status of subnetwork for power source 1 or power source 2
4	LS_DATA_ER	Error
5...29	SND_LS_POW	Load-shed power of subnetwork for power source 1 or power source 2
30	CB_BLK_SRC	Fast load-shed CB blocking status for power source 1 or power source 2
31	LS_BLOCK	Load-shedding blocking status of subnetwork for power source 1 or power source 2

See NPMMXU and LSCACLS function for more information of the signals.

Based on PPLS1_DATA or PPLS2_DATA received for adjacent electrical areas, this module provides various load-shedding information as shown in Table 348.

Table 348: The load-shedding information received from adjacent electrical area

Bits of PPLS1_DATA or PPLS2_DATA	Outputs
1	PEER_CB_STS
2	PEER_SR_STS
3	PEER_MS_STS
4	PEER_DATA_ER
30	PEER_SRC_BLK
31	PEER_SN_BLK

If PEER_MS_STS of PPLS1_DATA or PPLS2_DATA is active, MUST_SHD_STS of LS_DATA remains inactive.

The spinning reserve and must-shedding power of adjacent electrical area is calculated as follows.

If PEER_SR_STS is TRUE, the spinning reserve of the adjacent electrical area is provided by PEER_SP_RSV output. If PEER_SR_STS is FALSE, the PEER_SP_RSV output is zero.

If PEER_MS_STS is TRUE, the must-shedding power of the adjacent electrical area is provided by PEER_MUST_LS output. If the PEER_MS_STS is FALSE, the PEER_MUST_LS output is zero.

Once PEER_MS_STS is TRUE, PEER_MUST_LS is on hold until the subnetwork is reset. The PEER_MUST_LS is reset with activation of LS_RESET signal for corresponding subnetwork.

7.11.5 Signals

Table 349: PPLSGGIO Input signals

Name	Type	Default	Description
PPLS	GROUP SIGNAL	-	Group signal from load shed function
NW_PPLS	GROUP SIGNAL	-	Group signal from network power source

Table 350: PPLSGGIO Output signals

Name	Type	Description
PEER_CB_STS	BOOLEAN	CB status of adjacent electrical area
PEER_SR_STS	BOOLEAN	Spinning reserve status of adjacent electrical area
PEER_MS_STS	BOOLEAN	Must shed status extended from adjacent electrical area
PEER_SRC_BLK	BOOLEAN	Connectivity and CB block status of adjacent electrical area
PEER_SN_BLK	BOOLEAN	Subnetwork LS block status of adjacent electrical area
PEER_DATA_ER	BOOLEAN	Data error of adjacent electrical area
LS_DATA_ER	BOOLEAN	Load shed data error for adjacent electrical area

7.11.6 Monitored data

Table 351: PPLSGGIO Monitored data

Name	Type	Values (Range)	Unit	Description
PEER_CB_STS	BOOLEAN	0=Open 1=Close	-	CB status of adjacent electrical area
PEER_SR_STS	BOOLEAN	0=FALSE 1=TRUE	-	Spinning reserve status of adjacent electrical area
PEER_MS_STS	BOOLEAN	0=FALSE 1=TRUE	-	Must shed status extended from adjacent electrical area
Table continues on next page				

Name	Type	Values (Range)	Unit	Description
PEER_SRC_BLK	BOOLEAN	0=FALSE 1=TRUE	-	Connectivity and CB block status of adjacent electrical area
PEER_SN_BLK	BOOLEAN	0=FALSE 1=TRUE	-	Subnetwork LS block status of adjacent electrical area
PEER_DATA_ER	BOOLEAN	0=FALSE 1=TRUE	-	Data error of adjacent electrical area
LS_DATA_ER	BOOLEAN	0=FALSE 1=TRUE	-	Load shed data error for adjacent electrical area
LS_DATA	INTEGER	-	-	Load shed data error for adjacent electrical area
PEER_SP_RSV	REAL	-	kW	Spinning reserve of adjacent electrical area
PEER_MUST_LS	REAL	-	kW	Must shed power extended from adjacent electrical area

Section 8 Control functions

8.1 Position evaluation POS_EVAL

8.1.1 Identification

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

8.1.2 Function block

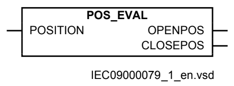


Figure 164: POS_EVAL function block

8.1.3 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.

8.1.4 Operation principle

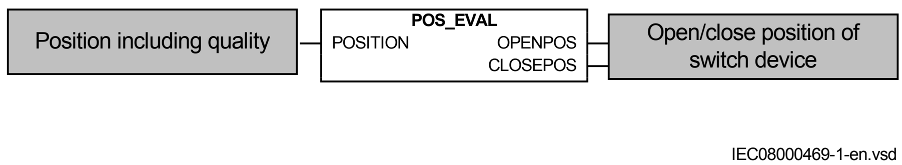


Figure 165: Logic diagram

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

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

8.1.5 Signals

Table 352: POS_EVAL Input signals

Name	Type	Default	Description
POSITION	INTEGER	0	Position status including quality

Table 353: POS_EVAL Output signals

Name	Type	Description
OPENPOS	BOOLEAN	Open position
CLOSEPOS	BOOLEAN	Close position

8.1.6 Settings

The function does not have any parameters available in LHMI or PCM600.

Section 9 General function block features

9.1 Definite time characteristics

9.1.1 Definite time operation

The DT mode is enabled when the *Operating curve type* setting is selected either as "ANSI Def. Time" or "IEC Def. Time". In the DT mode, the `OC_OPR` (Overcurrent operate) output of the function is activated when the time calculation exceeds the set *Operate delay time*.

The user can determine the reset in the DT mode with the *Reset delay time* setting, which provides the delayed reset property when needed.

The *Type of reset curve* setting has no effect on the reset method when the DT mode is selected, but the reset is determined solely with the *Reset delay time* setting.

The purpose of the delayed reset is to enable fast clearance of intermittent faults, for example self-sealing insulation faults, and severe faults which may produce high asymmetrical fault currents that partially saturate the current transformers. It is typical for an intermittent fault that the fault current contains so called drop-off periods, during which the fault current falls below the set start current, including hysteresis. Without the delayed reset function, the operate timer would reset when the current drops off. In the same way, an apparent drop-off period of the secondary current of the saturated current transformer can also reset the operate timer.

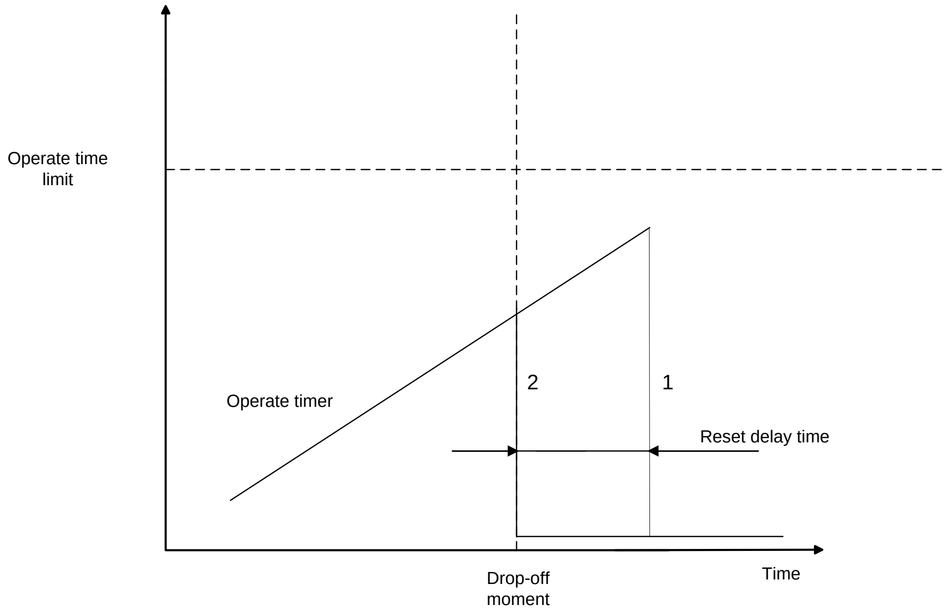


Figure 166: Operation of the counter in drop-off

In case 1, the reset is delayed with the *Reset delay time* setting and in case 2, the counter is reset immediately, because the *Reset delay time* setting is set to zero.

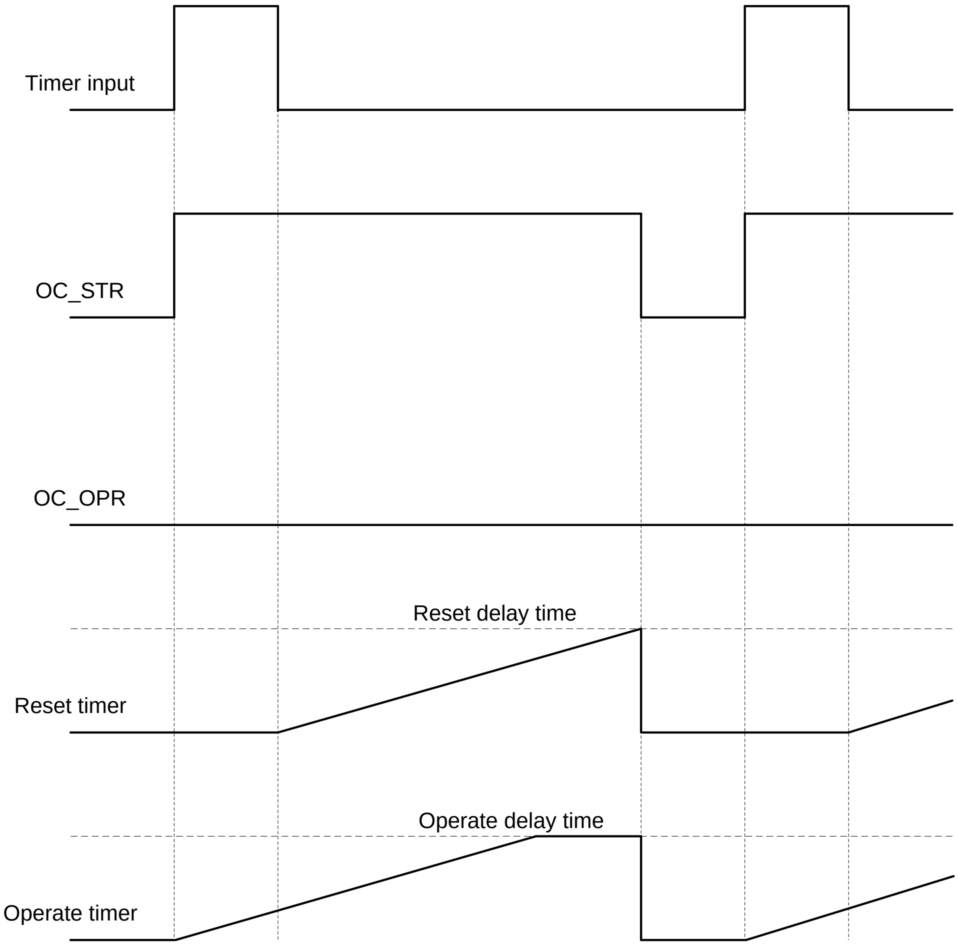


Figure 167: Drop-off period is longer than the set Reset delay time

When the drop-off period is longer than the set *Reset delay time*, as described in Figure 167, the input signal for the definite timer (here: timer input) is active, provided that the current is above the set Start value. The input signal is inactive when the current is below the set Start value and the set hysteresis region. The timer input rises when a fault current is detected. The definite timer activates the `OC_STR` output and the operate timer starts elapsing. The reset (drop-off) timer starts when the timer input falls, that is, the fault disappears. When the reset (drop-off) timer elapses, the operate timer is reset. Since this happens before another start occurs, the `OC_OPR` output is not activated.

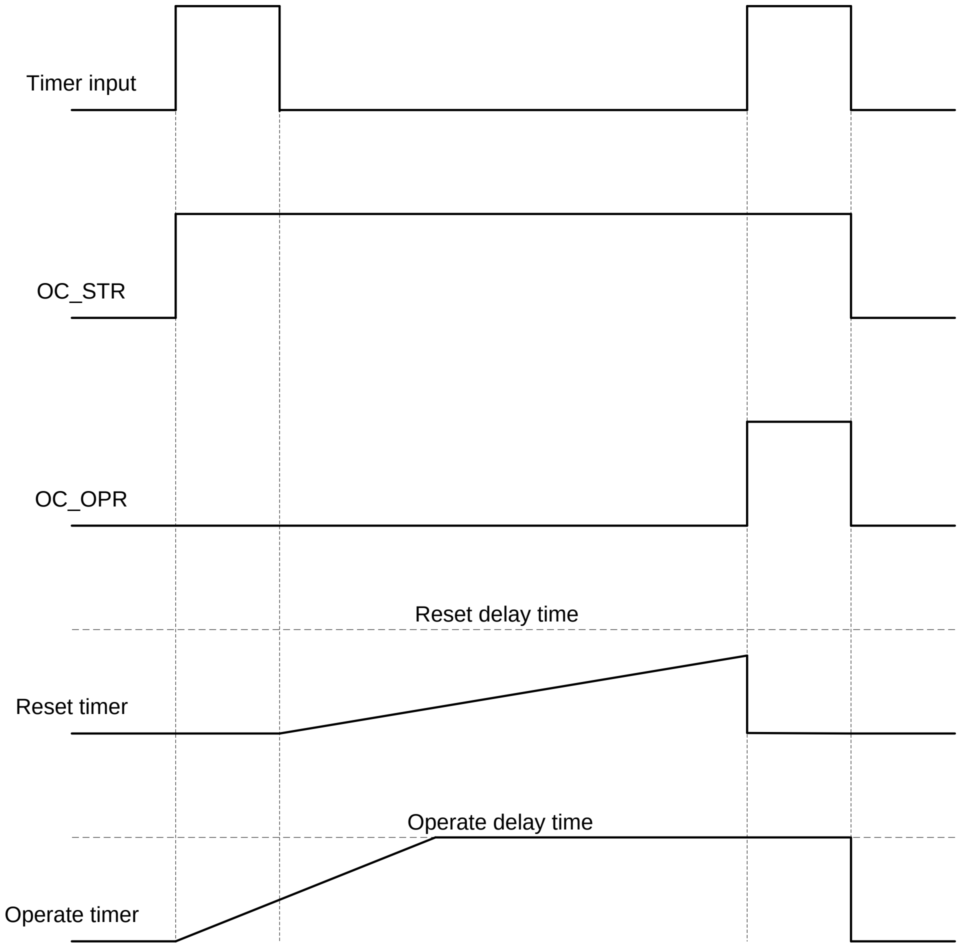


Figure 168: Drop-off period is shorter than the set Reset delay time

When the drop-off period is shorter than the set Reset delay time, as described in Figure 168, the input signal for the definite timer (here: timer input) is active, provided that the current is above the set *Start value*. The input signal is inactive when the current is below the set *Start value* and the set hysteresis region. The timer input rises when a fault current is detected. The definite timer activates the `OC_STR` output and the operate timer starts elapsing. The Reset (drop-off) timer starts when the timer input falls, that is, the fault disappears. Another fault situation occurs before the reset (drop-off) timer has elapsed. This causes the activation of the `OC_OPR` output, since the operate timer already has elapsed.

If the `RESET_OC` (Overcurrent reset) input is activated when the operate timer is running as described in Figure 169, the operate timer and the reset timer reset. It also resets the `OC_STR` and `OC_OPR` outputs.

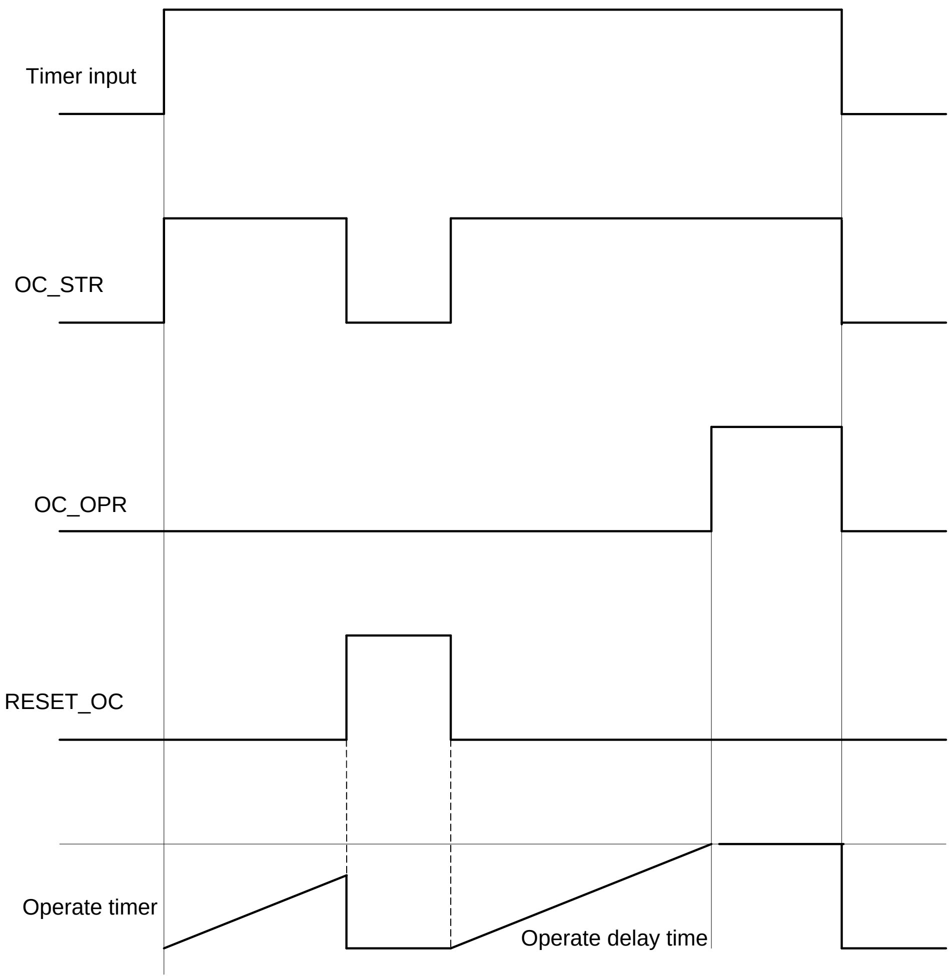


Figure 169: Operating effect of the `RESET_OC` input

`INHIBIT_TRG` or `SLS_DISABLE` or load-shedding blocking conditions of power source PSCSWI function can be used to individually block the `OC_STR` and `OC_OPR` signals.

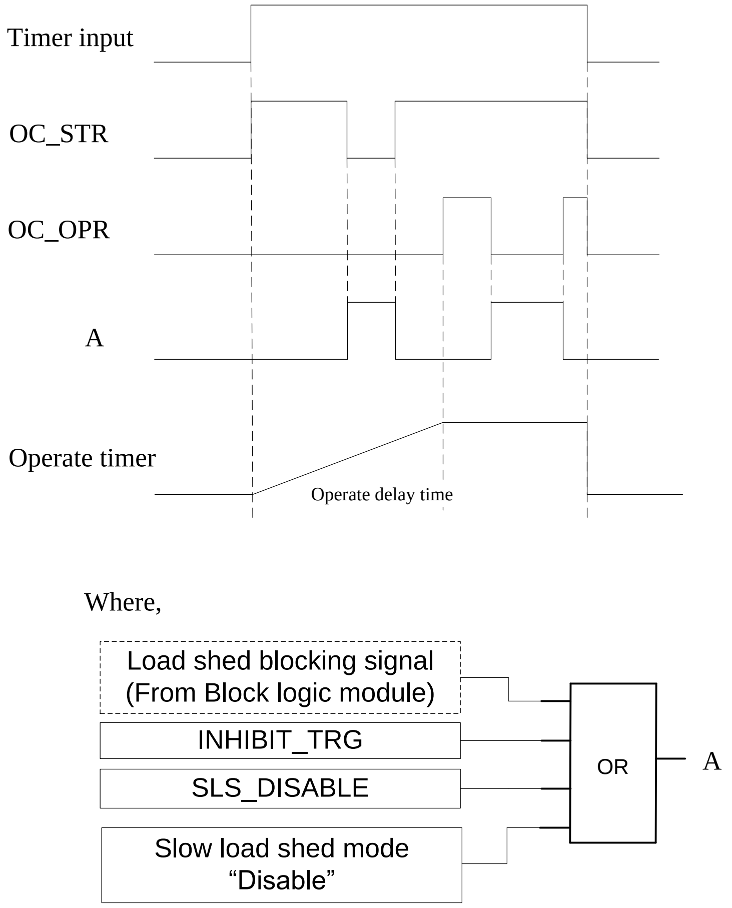


Figure 170: Operating effect of the slow load shed disable signal

Activation of `INHIBIT_TRG` or `SLS_DISABLE` or load-shed blocking conditions of power source PSCSWI function does not reset the timer

9.2 Current-based inverse definite minimum time (IDMT) characteristics

9.2.1 IDMT curves for overcurrent protection

The inverse-time modes, the operation time depends on the momentary value of the current: the higher the current, the faster the operation time. The operation time calculation or integration starts immediately when the current exceeds the set *Start value* and the `OC_STR` output is activated.

The `OC_OPR` output of the component is activated when the cumulative sum of the integrator calculating the overcurrent situation exceeds the value set by the inverse-time mode. The set value depends on the selected curve type and the setting values used. The curve scaling is determined with the *Time multiplier* setting.

The *Minimum operate time* setting defines the minimum operate time for the IDMT mode, that is, it is possible to limit the IDMT based operate time for not becoming too short.

For example

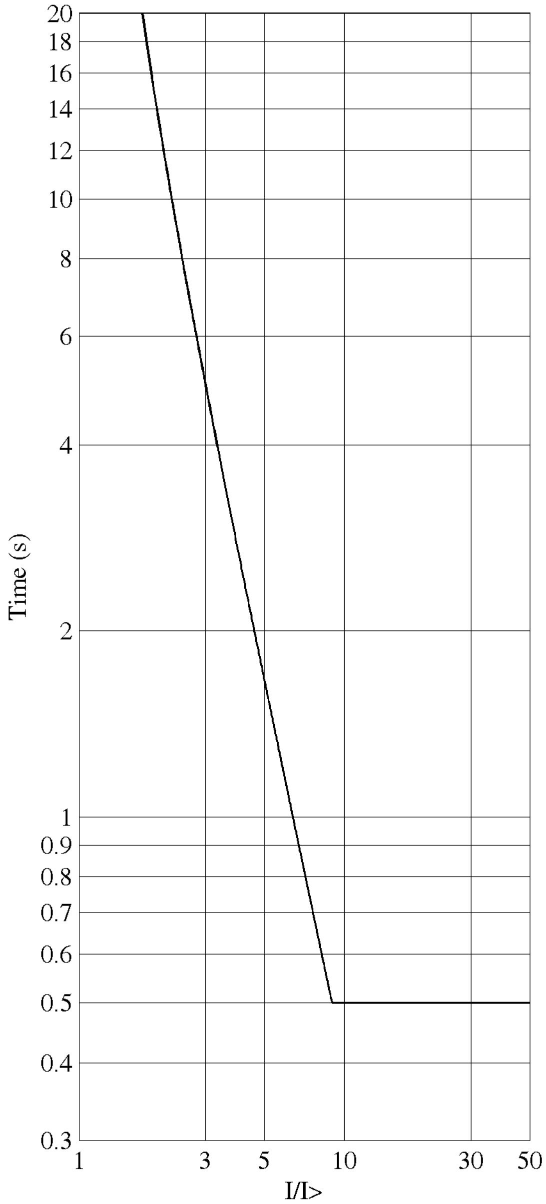


Figure 171: Operate time curves based on IDMT characteristic with the value of the Minimum operate time setting = 0.5 second

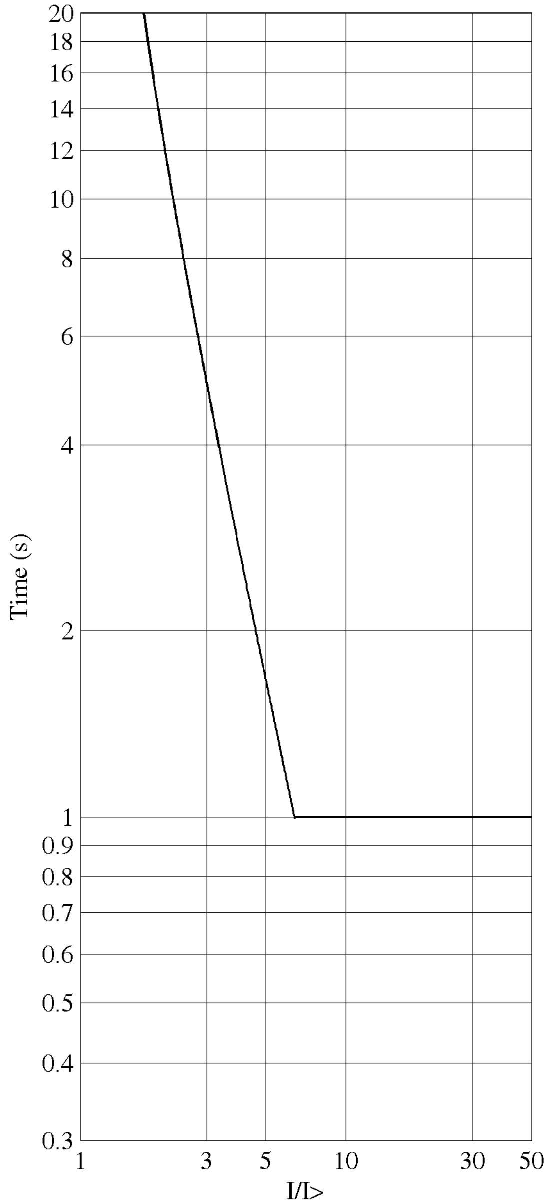


Figure 172: Operate time curves based on IDMT characteristic with the value of the Minimum operate time setting = 1 second

9.2.1.1 Standard inverse-time characteristics

For inverse-time operation, both IEC and ANSI/IEEE standardized inverse-time characteristics are supported.

The operate times for the ANSI and IEC IDMT curves are defined with the coefficients A, B and C.

The values of the coefficients can be calculated according to the formula.

$$t[s] = \left(\frac{A}{\left(\frac{I}{I>} \right)^{C} - 1} + B \right) \cdot k$$

(Equation 20)

t[s] Operate time in seconds

I measured current

I> set *Start value*

k set *Time multiplier*

Curve name	A	B	C
(1) ANSI Extremely Inverse	28.2	0.1217	2.0
(2) ANSI Very Inverse	19.61	0.491	2.0
(3) ANSI Normal Inverse	0.0086	0.0185	0.02
(4) ANSI Moderately Inverse	0.0515	0.1140	0.02
(6) Long Time Extremely Inverse	64.07	0.250	2.0
(7) Long Time Very Inverse	28.55	0.712	2.0
(8) Long Time Inverse	0.086	0.185	0.02
(9) IEC Normal Inverse	0.14	0.0	0.02
(10) IEC Very Inverse	13.5	0.0	1.0
(11) IEC Inverse	0.14	0.0	0.02
(12) IEC Extremely Inverse	80.0	0.0	2.0
(13) IEC Short Time Inverse	0.05	0.0	0.04
(14) IEC Long Time Inverse	120	0.0	1.0

The maximum guaranteed measured current is 50 x In for the current protection. When the set *Start value* exceeds 1.00 x In, the turn point where the theoretical IDMT characteristics are leveling out to the definite time can be calculated with the formula as shown in the Equation 21.

$$Turn\ po\,int = \frac{50 \times In}{Start\,value}$$

(Equation 21)

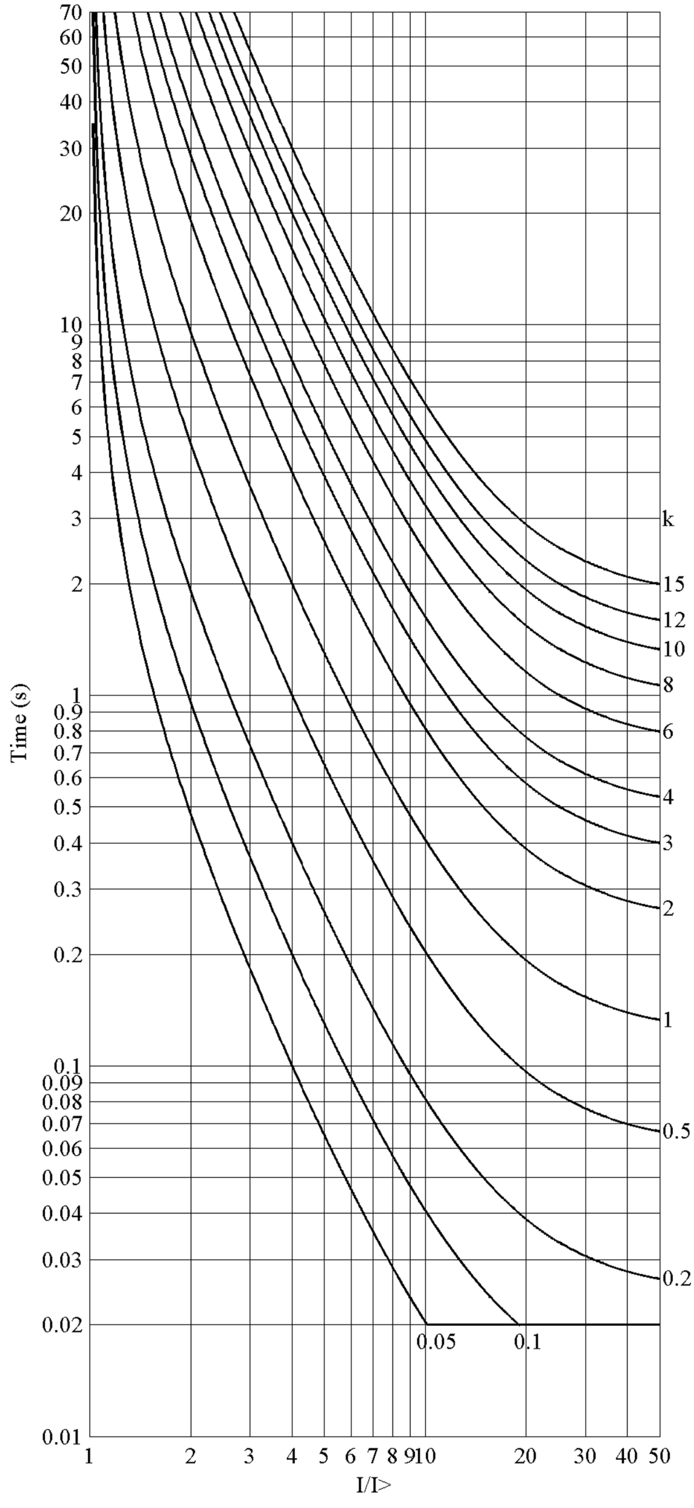


Figure 173: ANSI extremely inverse-time characteristics

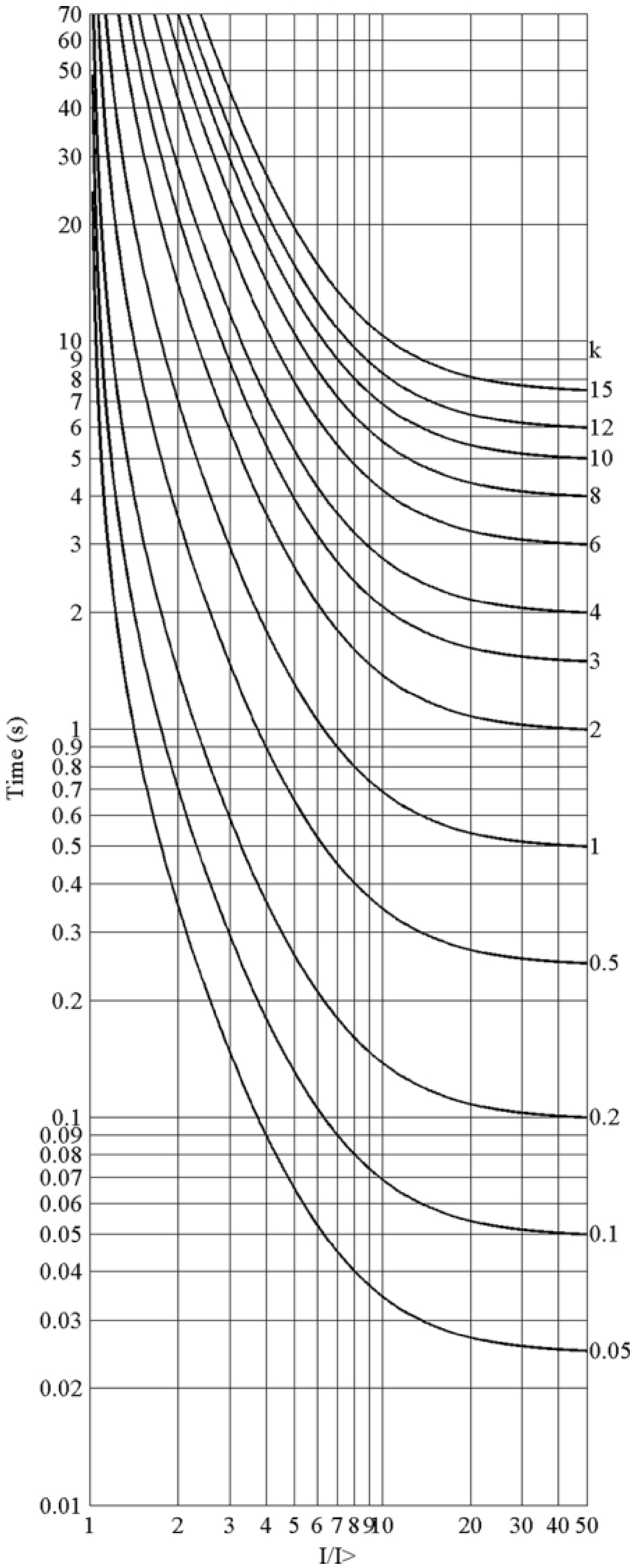

Time (s)
I/I>
k
15
12
10
8
6
4
3
2
1
0.5
0.2
0.1
0.05
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
1
2
3
4
5
6
7
8
9
10
20
30
40
50

Figure 174: ANSI very inverse-time characteristics

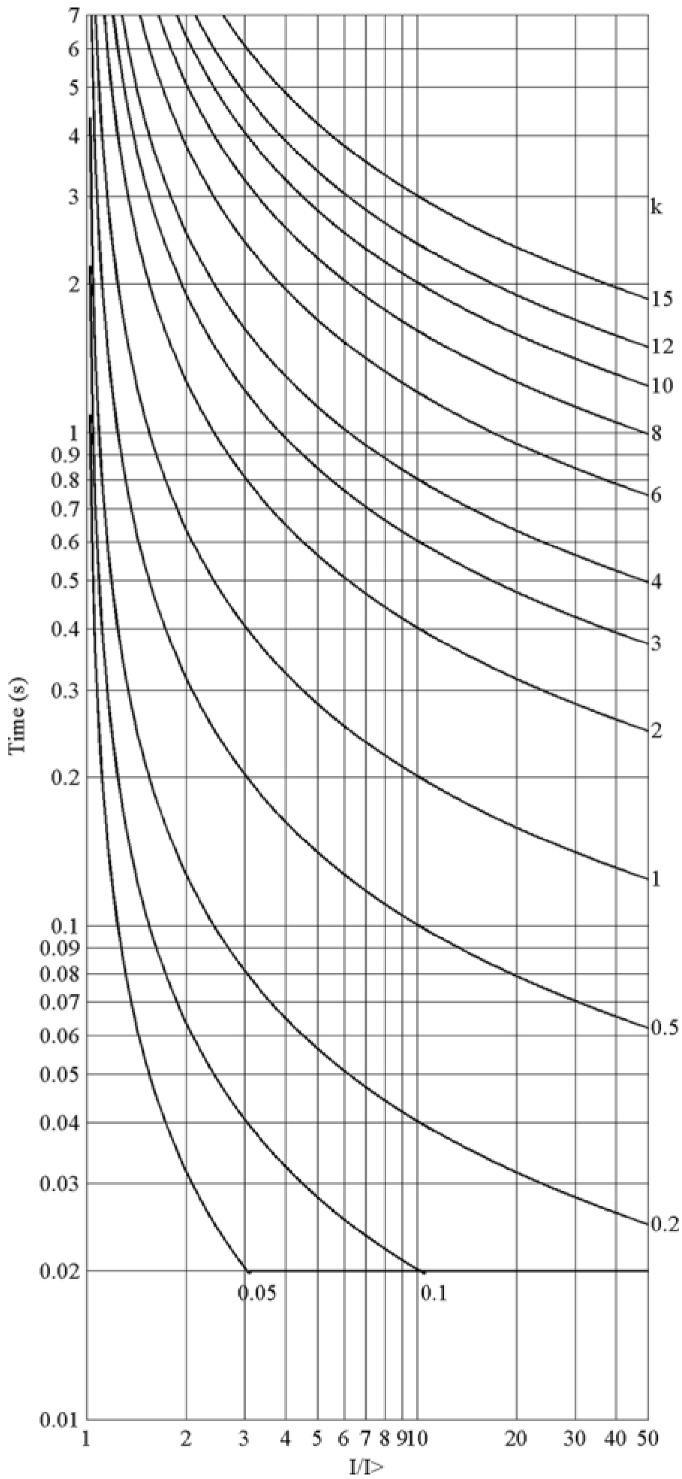


Figure 175: ANSI normal inverse-time characteristics

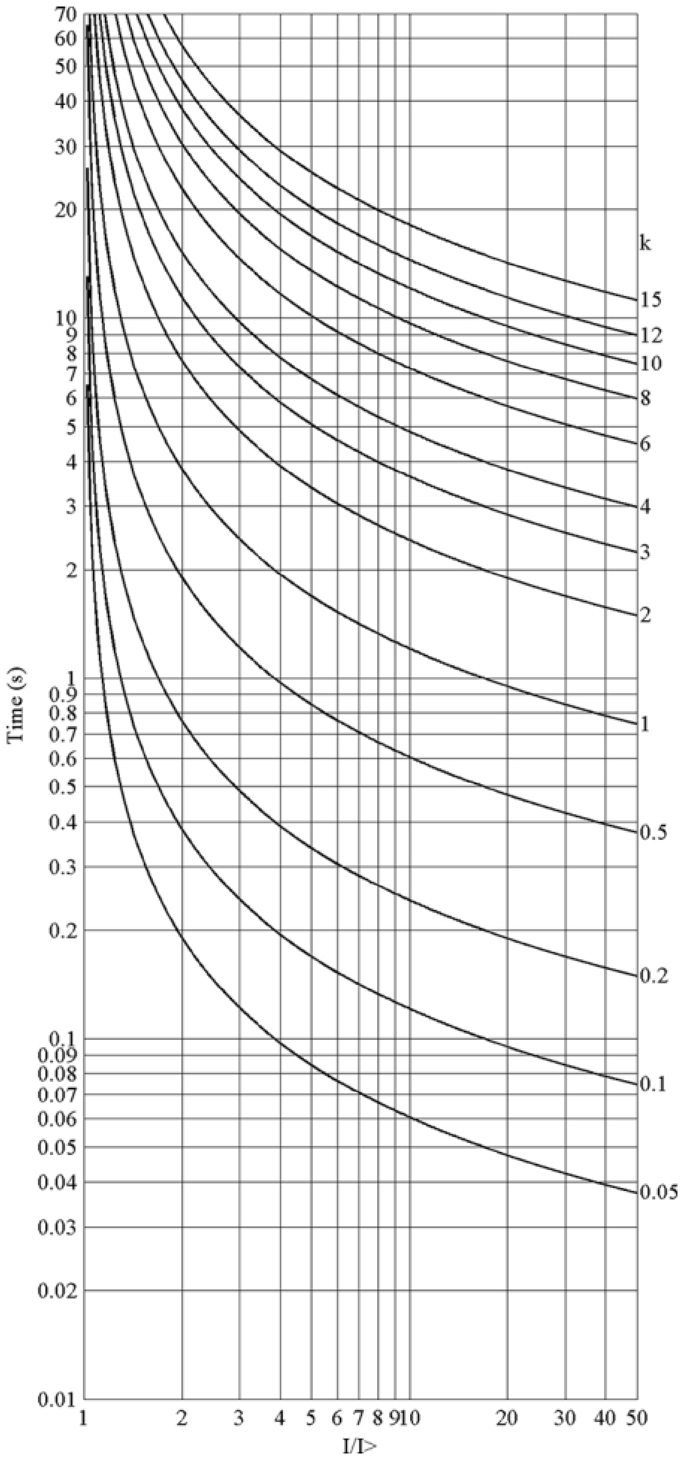


Figure 176: ANSI moderately inverse-time characteristics

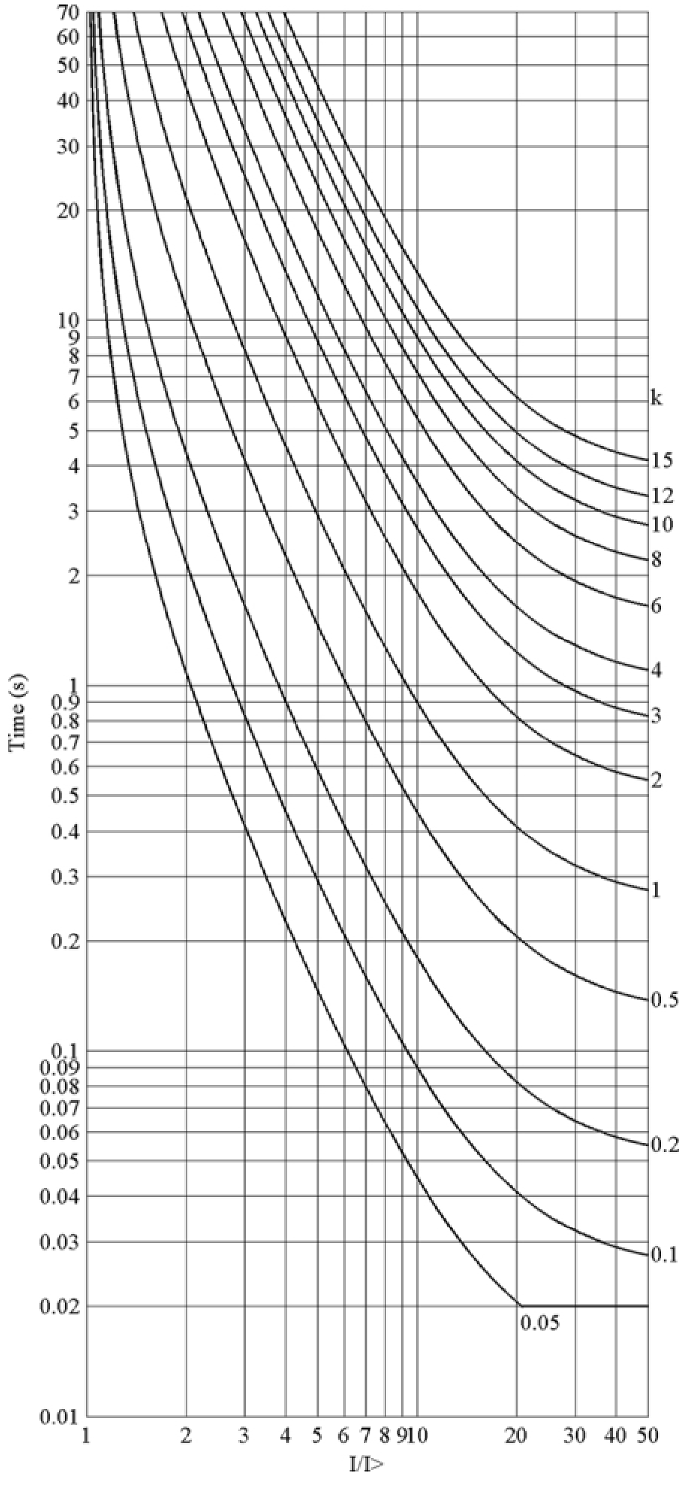


Figure 177: ANSI long-time extremely inverse-time characteristics

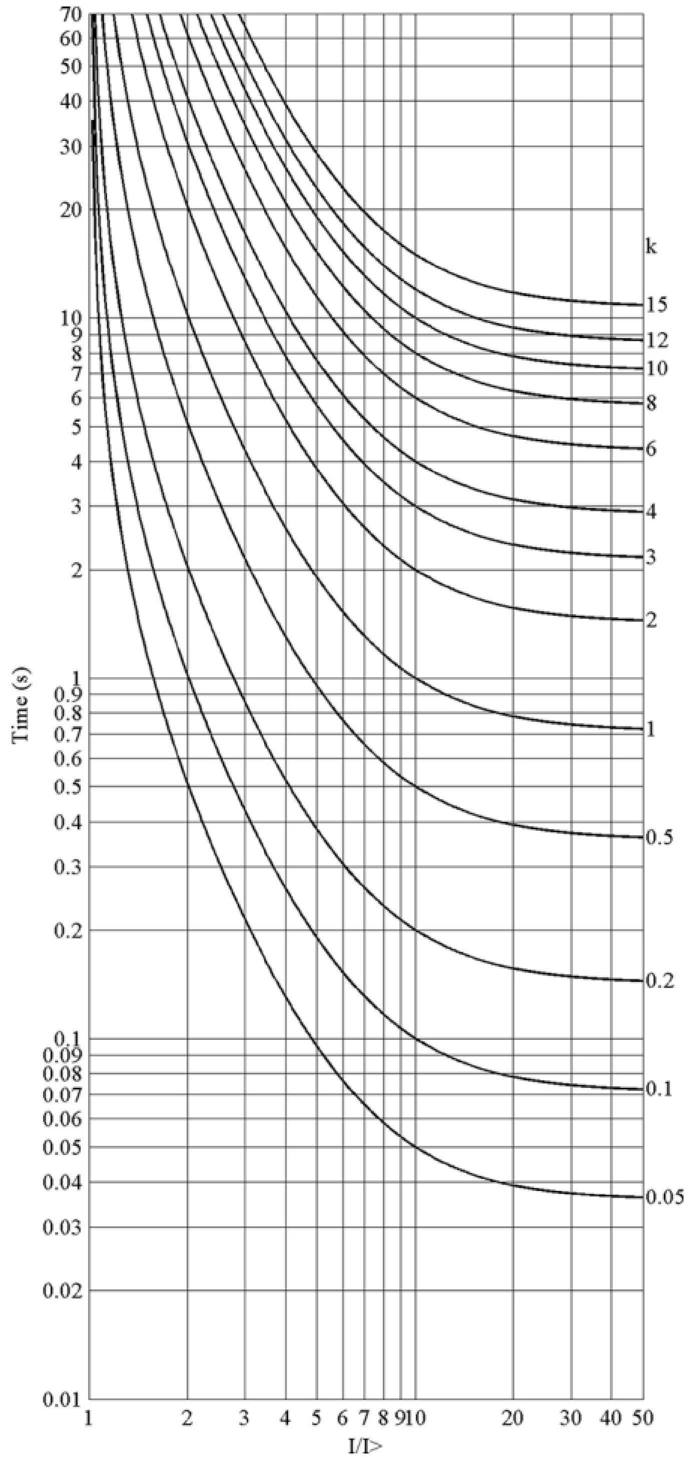


Figure 178: ANSI long-time very inverse-time characteristics

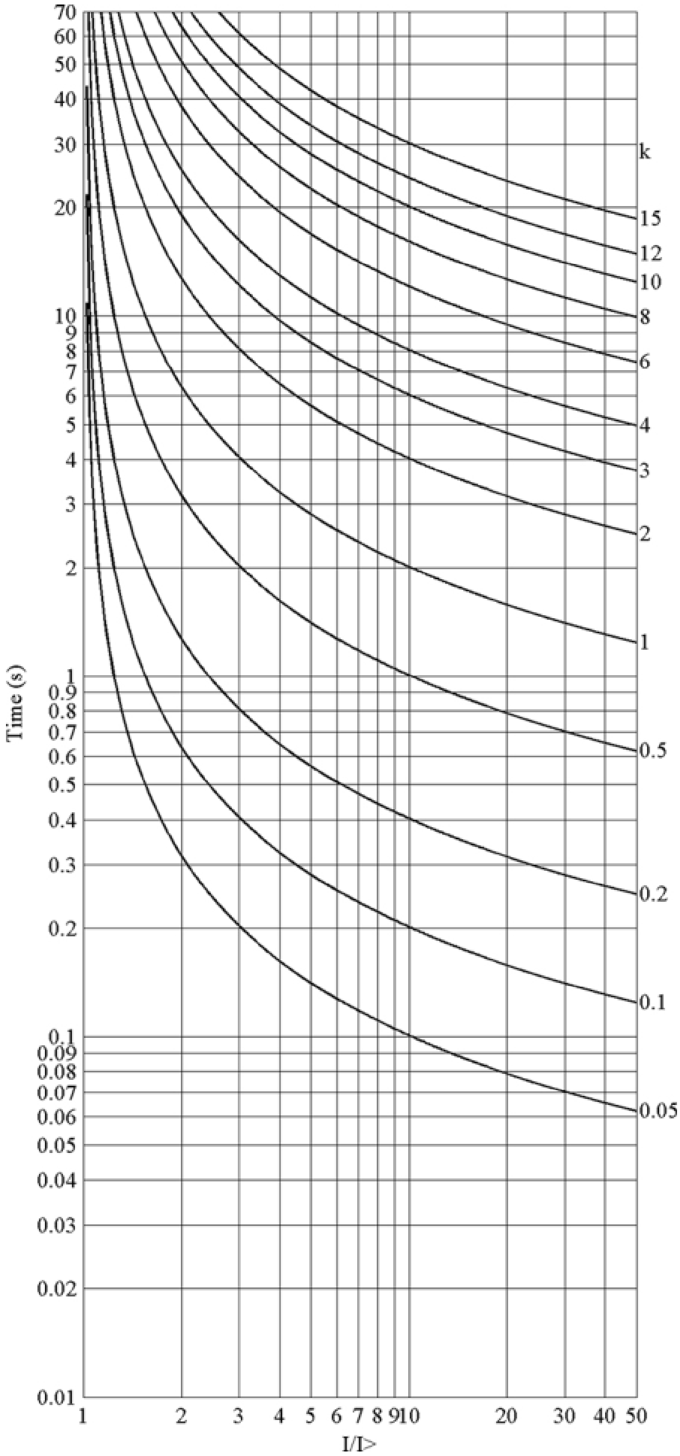


Figure 179: ANSI long-time inverse-time characteristics

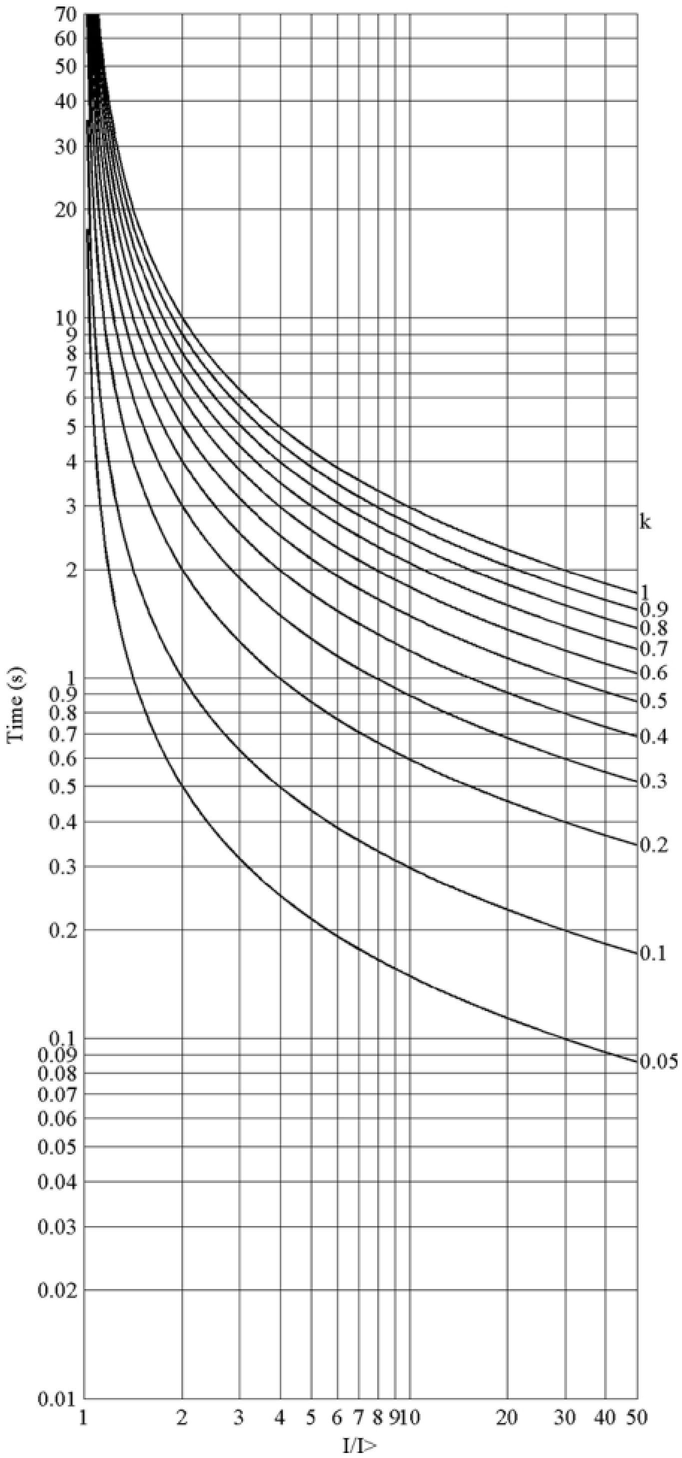


Figure 180: IEC normal inverse-time characteristics

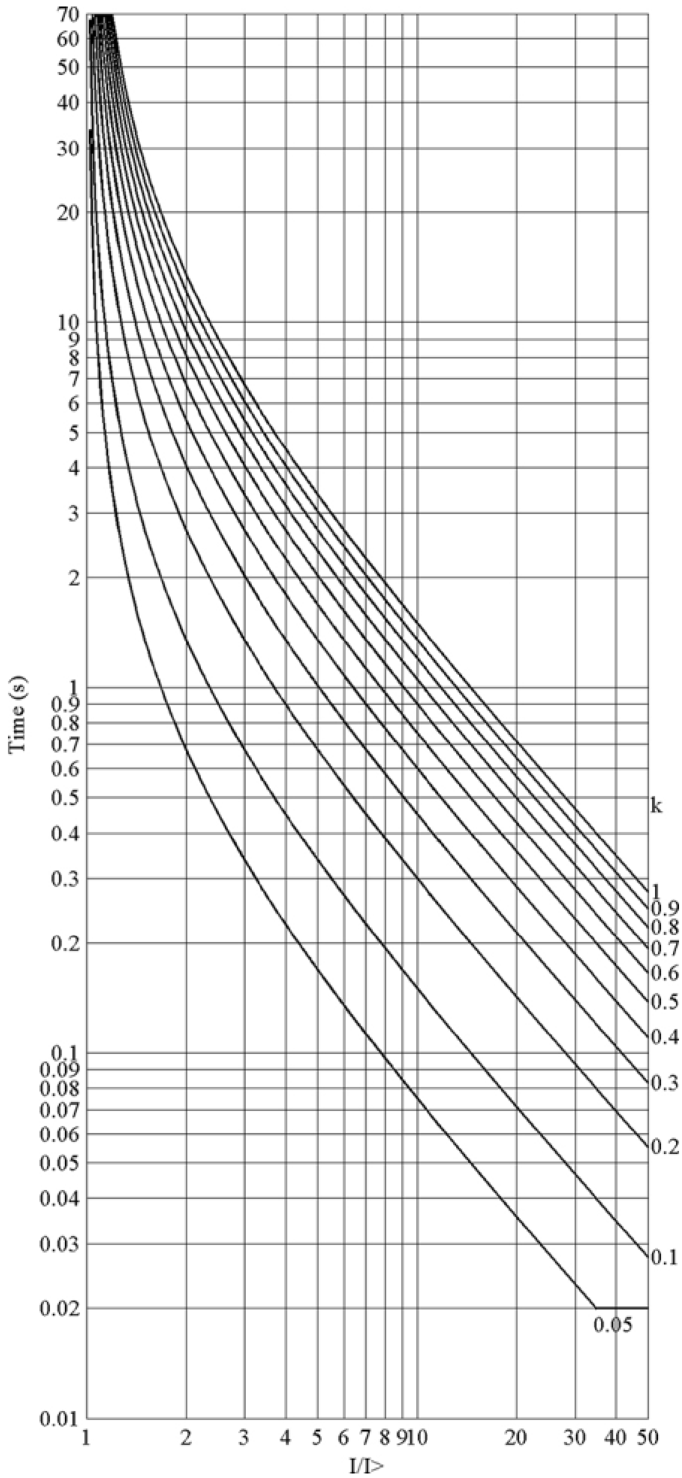


Figure 181: IEC very inverse-time characteristics

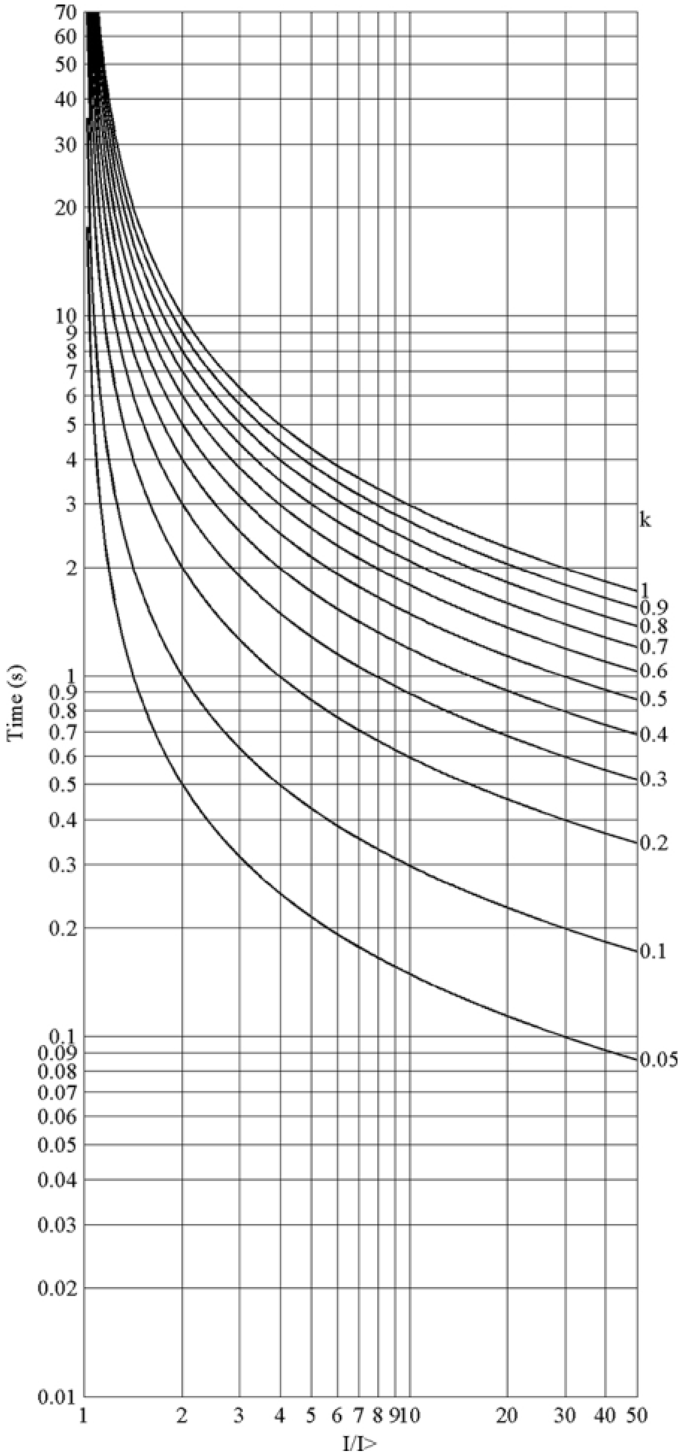


Figure 182: IEC inverse-time characteristics

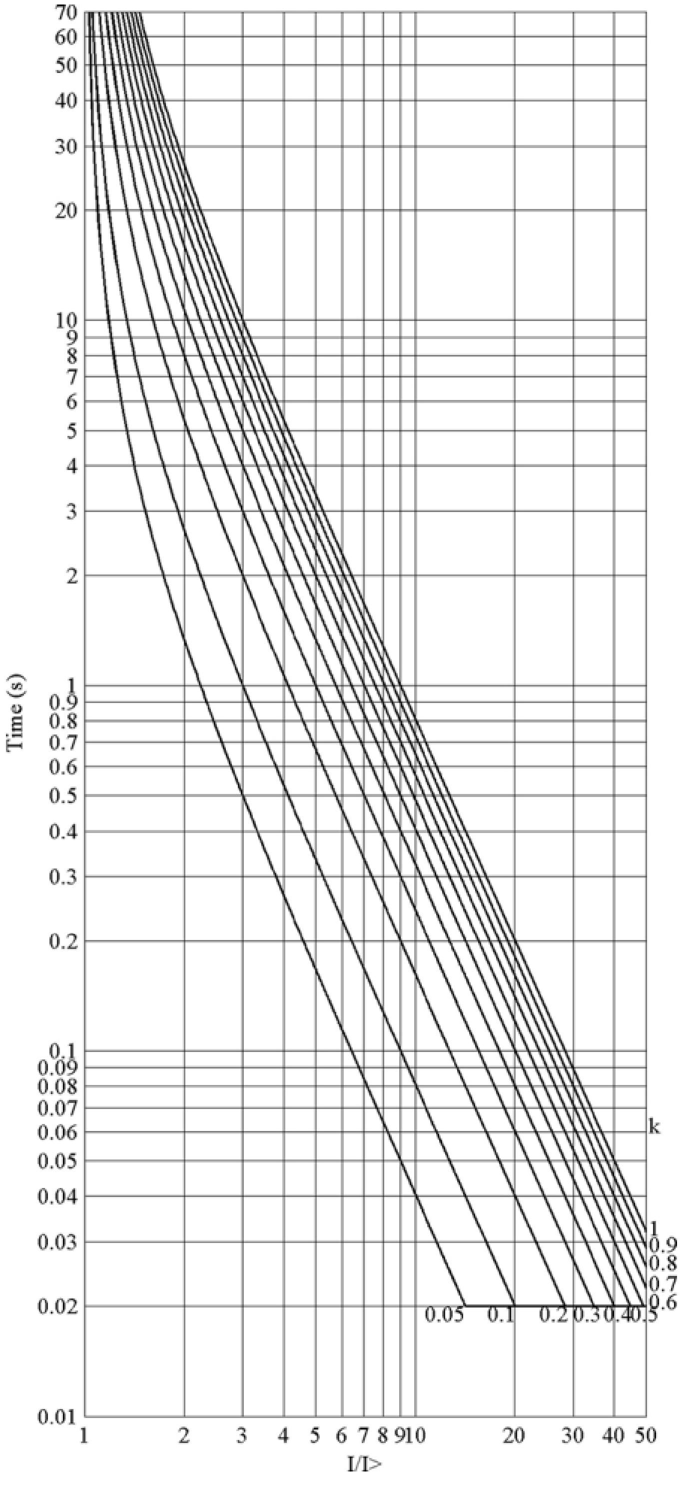


Figure 183: IEC extremely inverse-time characteristics

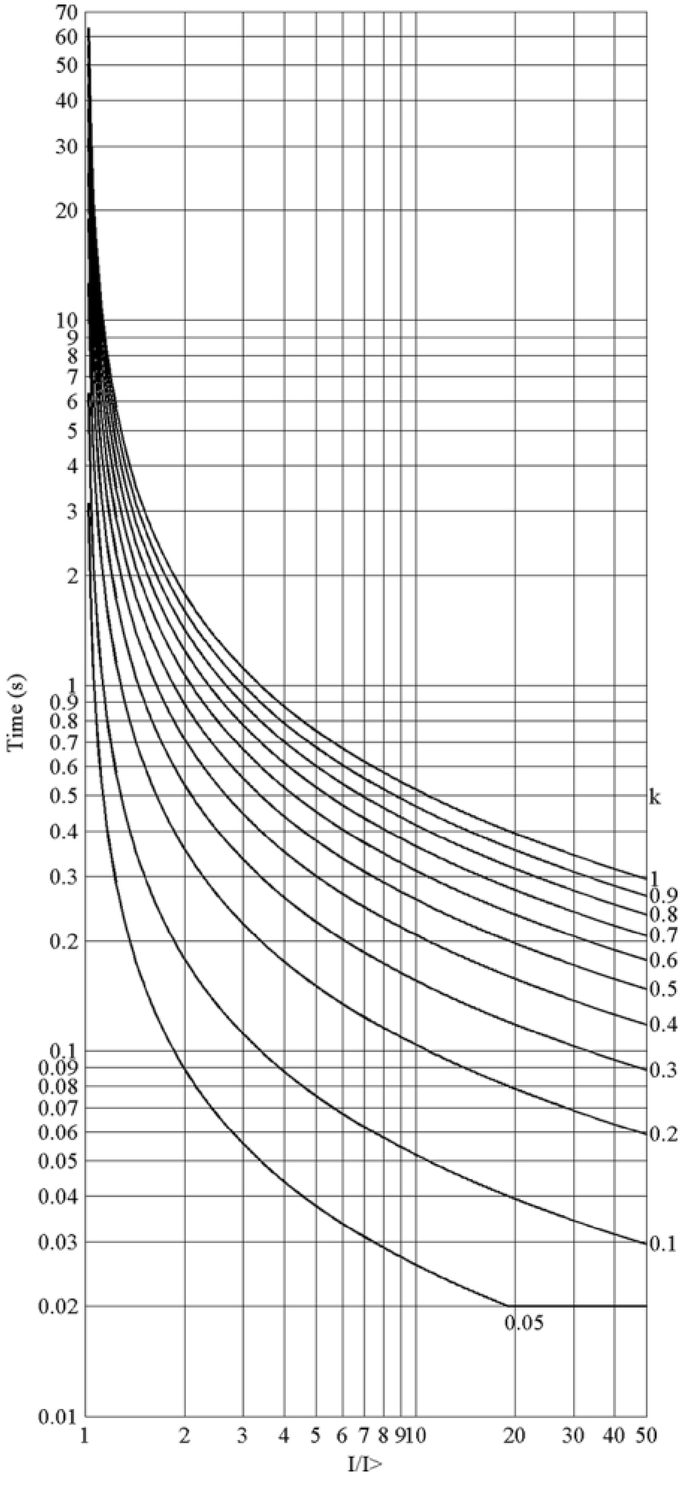


Figure 184: IEC short-time inverse-time characteristics

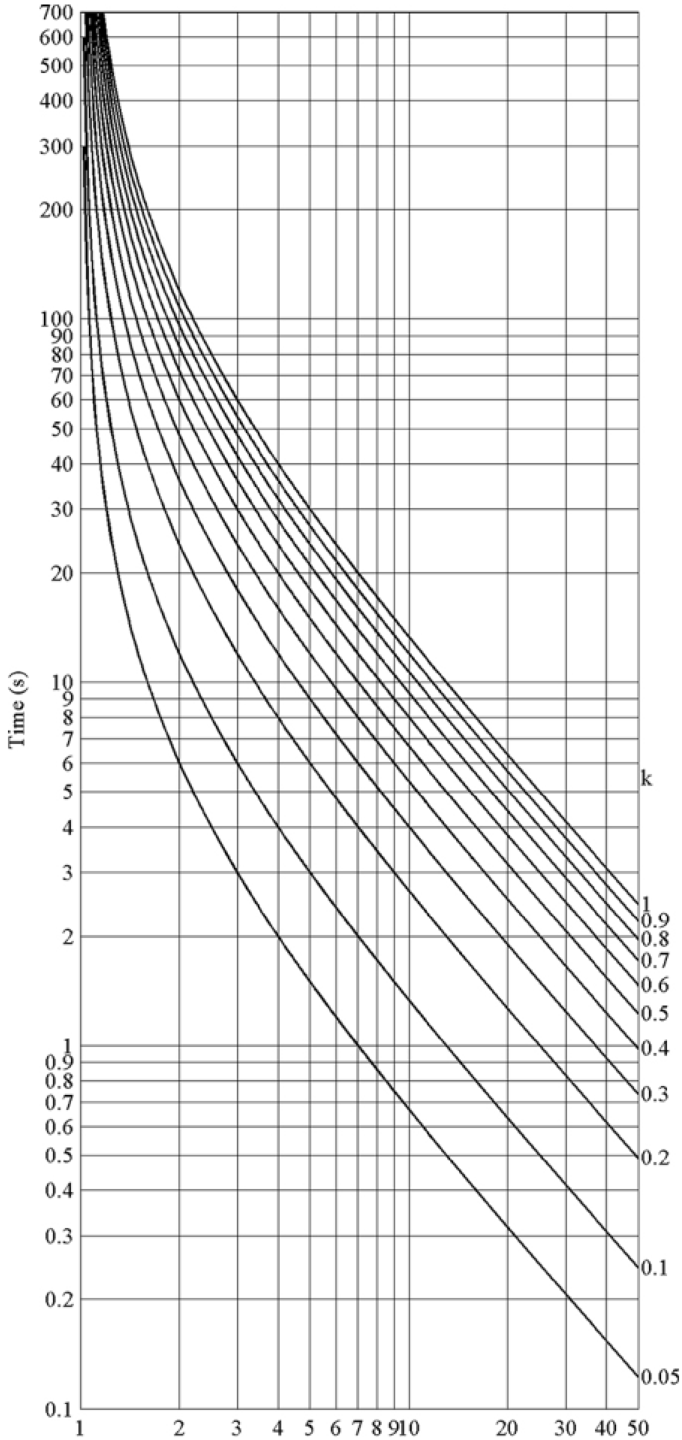


Figure 185: IEC long-time inverse-time characteristics

9.2.1.2 User-programmable inverse-time characteristics

The user can define curves by entering parameters into the following standard formula.

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

(Equation 22)

t[s]	Operate time (in seconds)
A	set *Curve parameter A*
B	set *Curve parameter B*
C	set *Curve parameter C*
E	set *Curve parameter E*
I	Measured current
I>	set *Start value*
k	set *Time multiplier*

9.2.1.3 RI and RD-type inverse-time characteristics

The RI-type simulates the behavior of electromechanical relays. The RD-type is an earth-fault specific characteristic.

The RI-type is calculated using the formula

$$t[s] = \left(\frac{k}{0.339 - 0.236 \times \frac{I>}{I}} \right)$$

(Equation 23)

The RD-type is calculated using the formula

$$t[s] = 5.8 - 1.35 \times \mathrm{In}\left(\frac{I}{k \times I>} \right)$$

(Equation 24)

t[s]	Operate time (in seconds)
k	set *Time multiplier*
I	Measured current
I>	set *Start value*

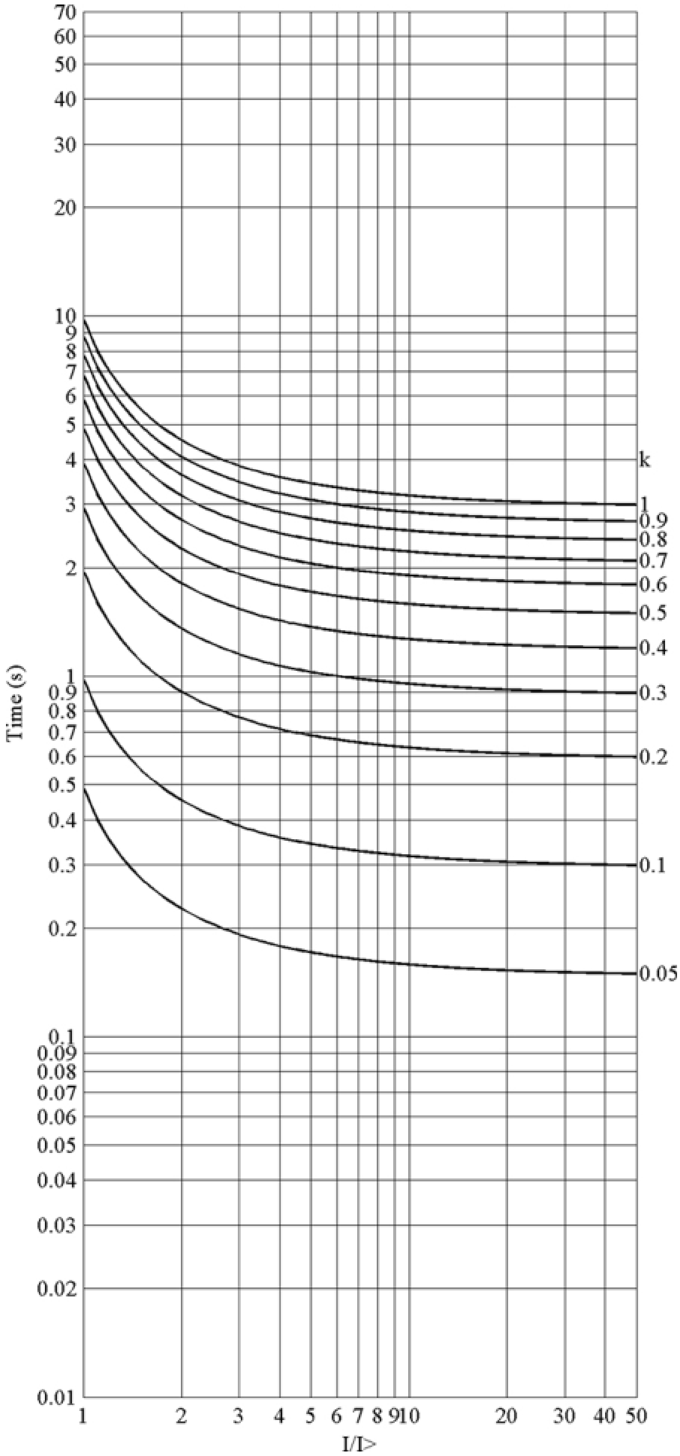


Figure 186: RI-type inverse-time characteristics

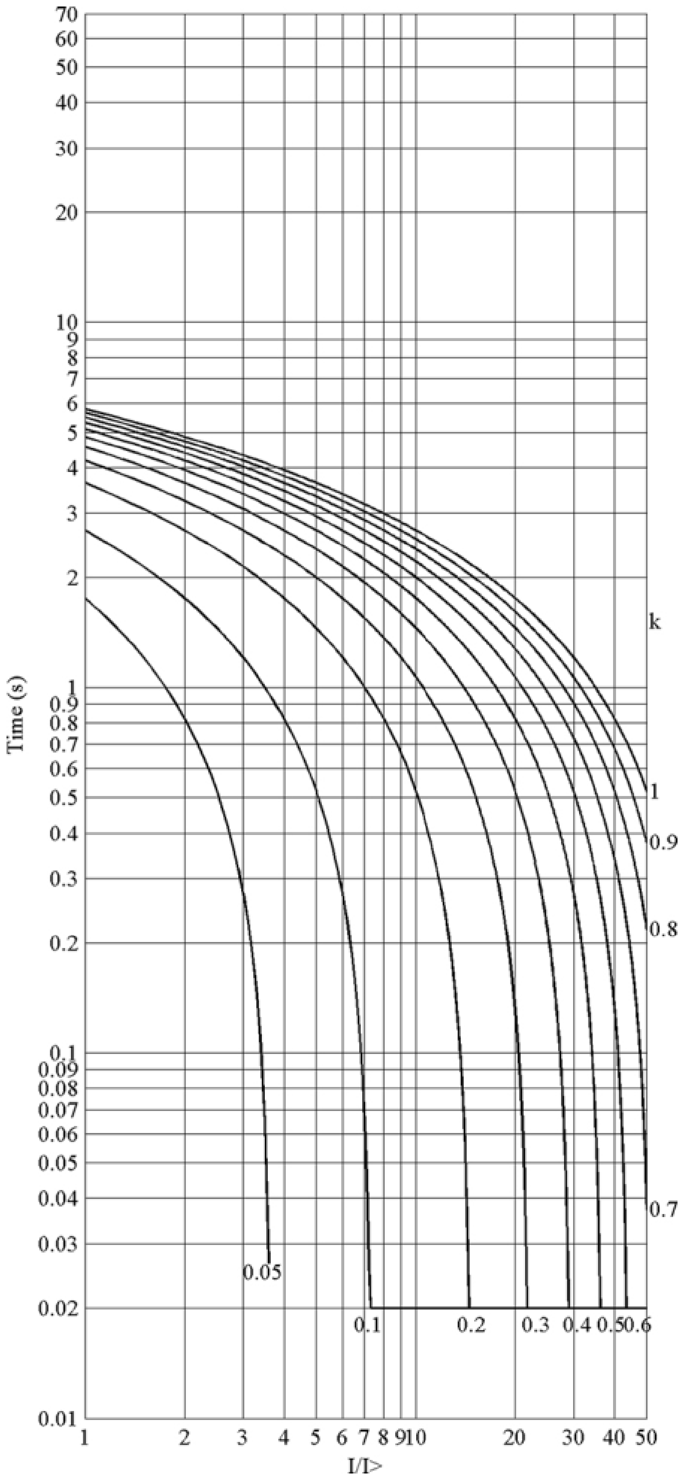


Figure 187: RD-type inverse-time characteristics

9.2.2 Reset in inverse-time modes

The user can select the reset characteristics by using the *Type of reset curve* setting.

Table 354: Values for reset mode

Setting name	Possible values
Type of reset curve	1=Immediate 2=Def time reset 3=Inverse reset

Immediate reset

If the *Type of reset curve* setting in a drop-off case is selected as "Immediate", the inverse timer resets immediately.

Definite time reset

The definite type of reset in the inverse-time mode can be achieved by setting the *Type of reset curve* parameter to “Def time reset”. As a result, the operate inverse-time counter is frozen for the time determined with the *Reset delay time* setting after the current drops below the set *Start value*, including hysteresis.The integral sum of the inverse-time counter is reset, if another start does not occur during the reset delay.

If the *Type of reset curve* setting is selected as “Def time reset”, the current level has no influence on the reset characteristic.

Inverse reset

Inverse reset curves are available only for ANSI and user-programmable curves. If you use other curve types, immediate reset occurs.

Standard delayed inverse reset

The reset characteristic required in ANSI (IEEE) inverse-time modes is provided by setting the *Type of reset curve* parameter to “Inverse reset”. In this mode, the time delay for reset is given with the following formula using the coefficient D, which has its values defined in the table below.

$$t[s] = \left(\frac{D}{\left(\frac{I}{I>}\right)^2 - 1} \right) \cdot k$$

(Equation 25)

t[s] Reset time (in seconds)

k set *Time multiplier*

I Measured current

I> set *Start value*

Table 355: Coefficients for ANSI delayed inverse reset curves

Curve name	D
(1) ANSI Extremely Inverse	29.1
(2) ANSI Very Inverse	21.6
(3) ANSI Normal Inverse	0.46
(4) ANSI Moderately Inverse	4.85
(6) Long Time Extremely Inverse	30
(7) Long Time Very Inverse	13.46
(8) Long Time Inverse	4.6

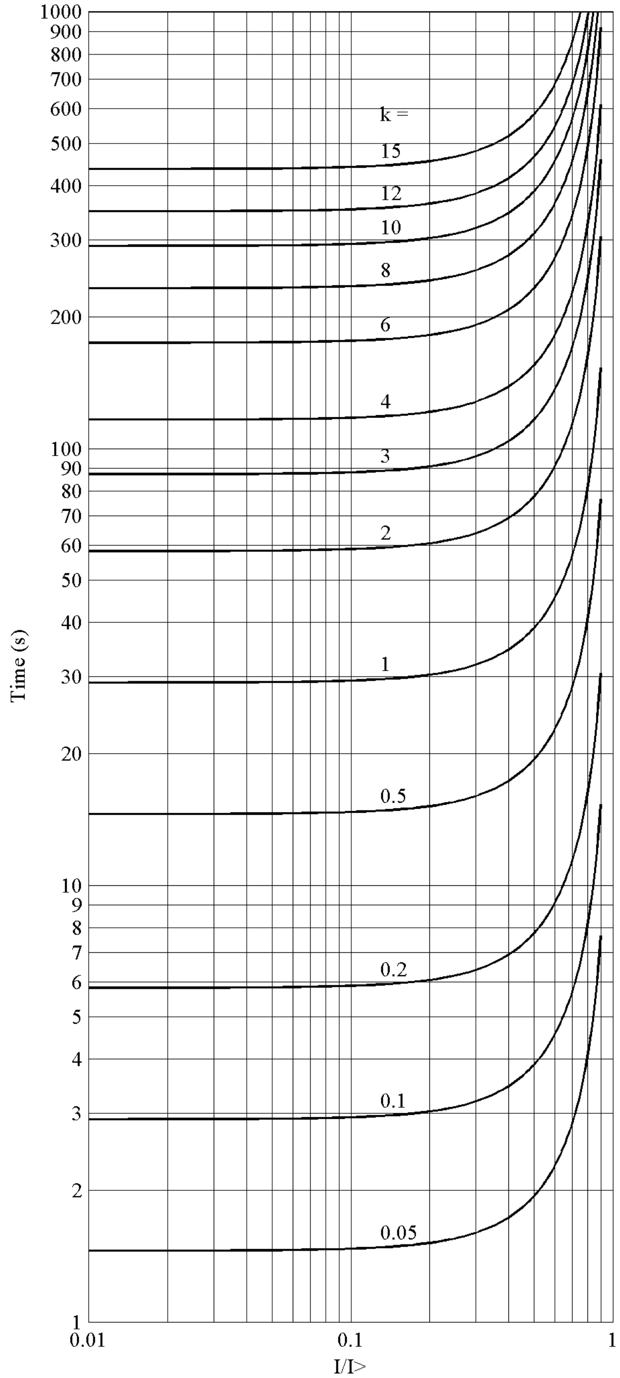


Figure 188: ANSI extremely inverse reset time characteristics

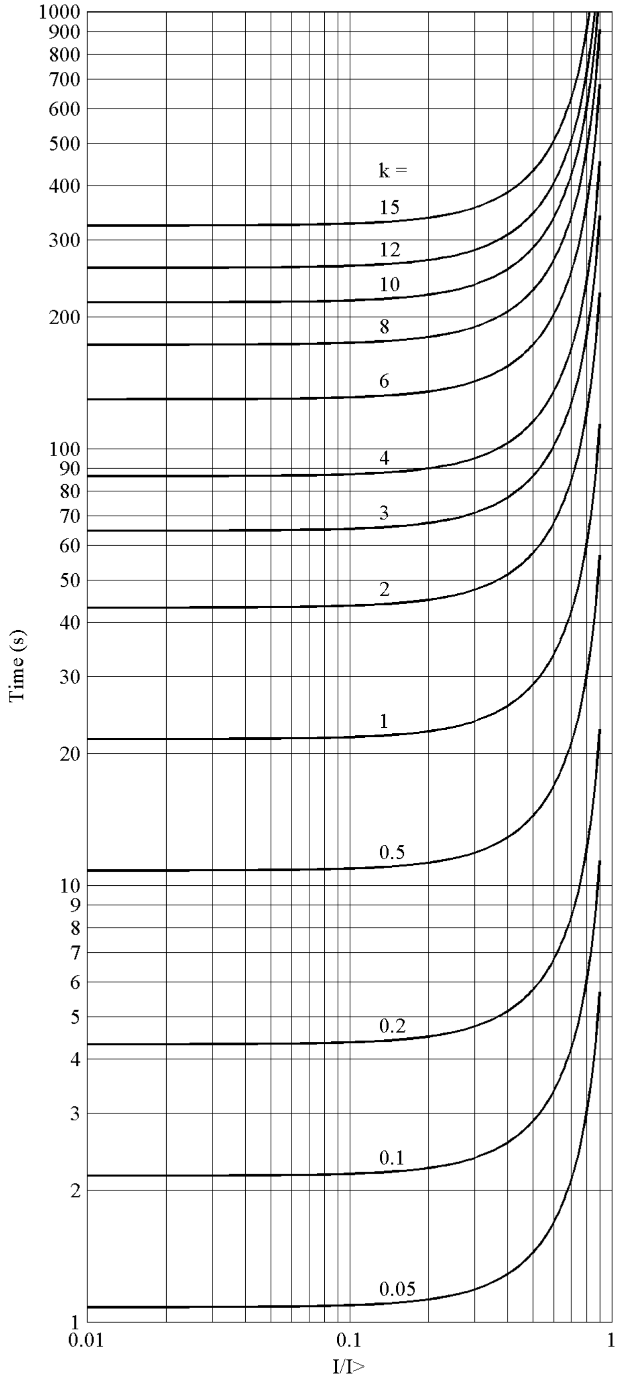


Figure 189: ANSI very inverse reset time characteristics

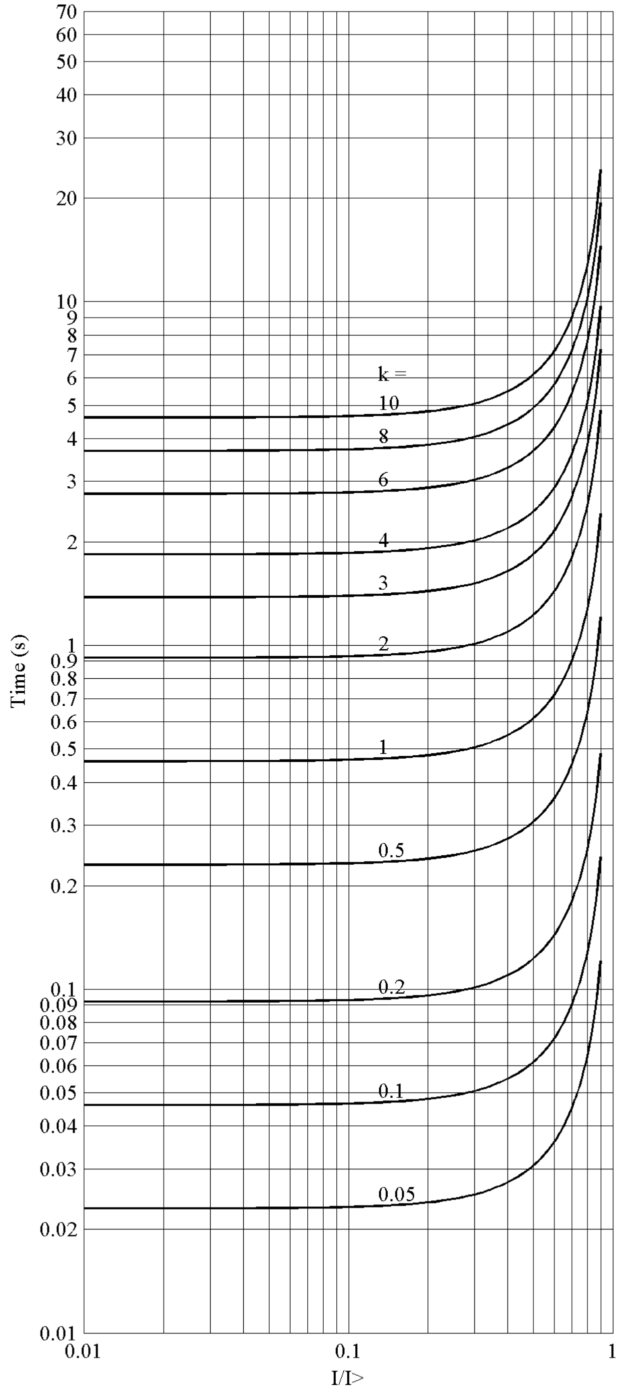


Figure 190: ANSI normal inverse reset time characteristics

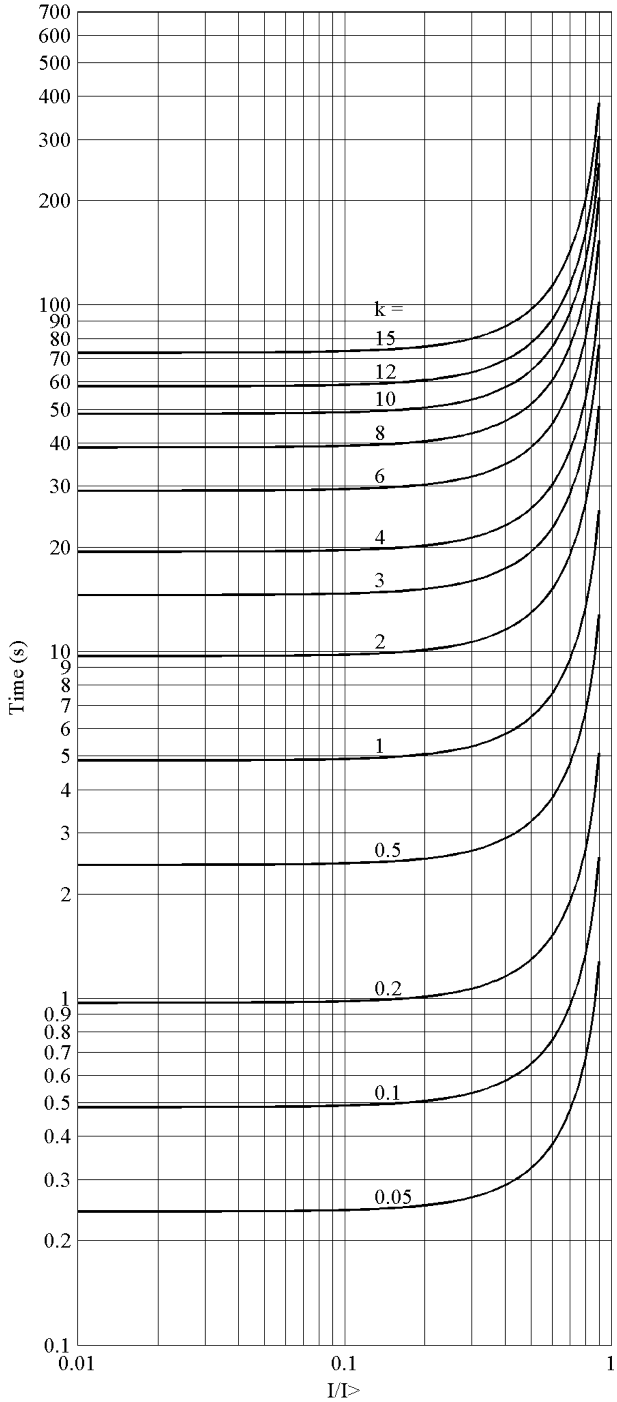


Figure 191: ANSI moderately inverse reset time characteristics

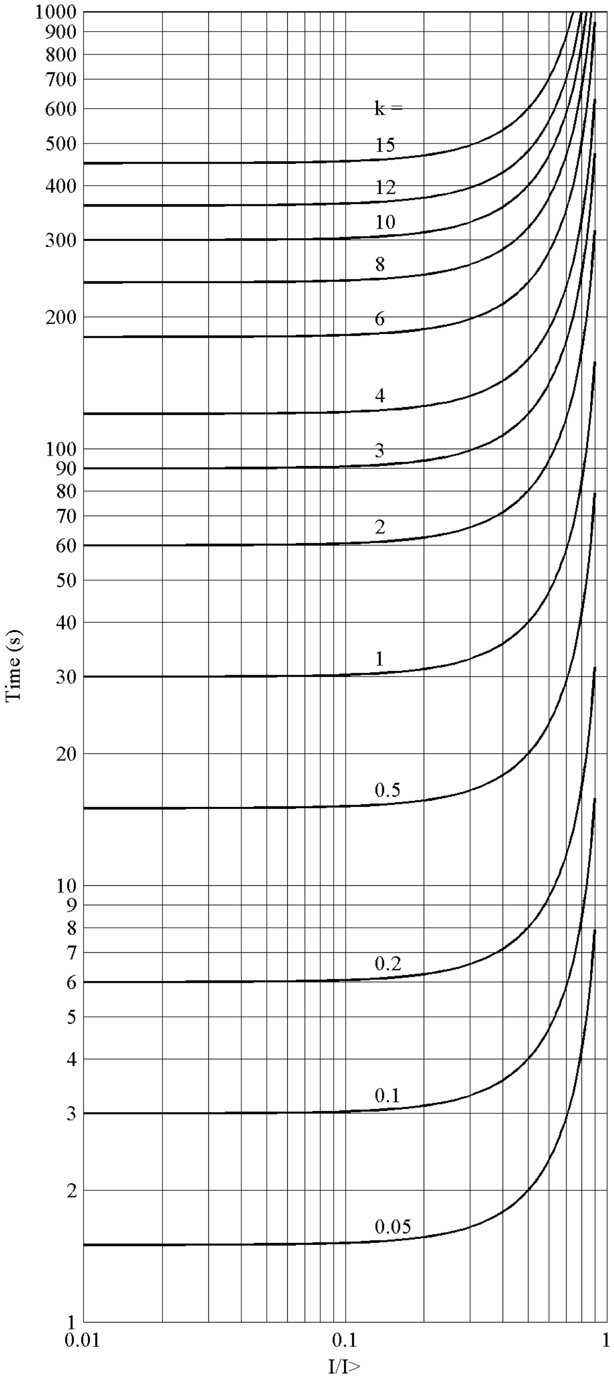


Figure 192: ANSI long-time extremely inverse reset time characteristics

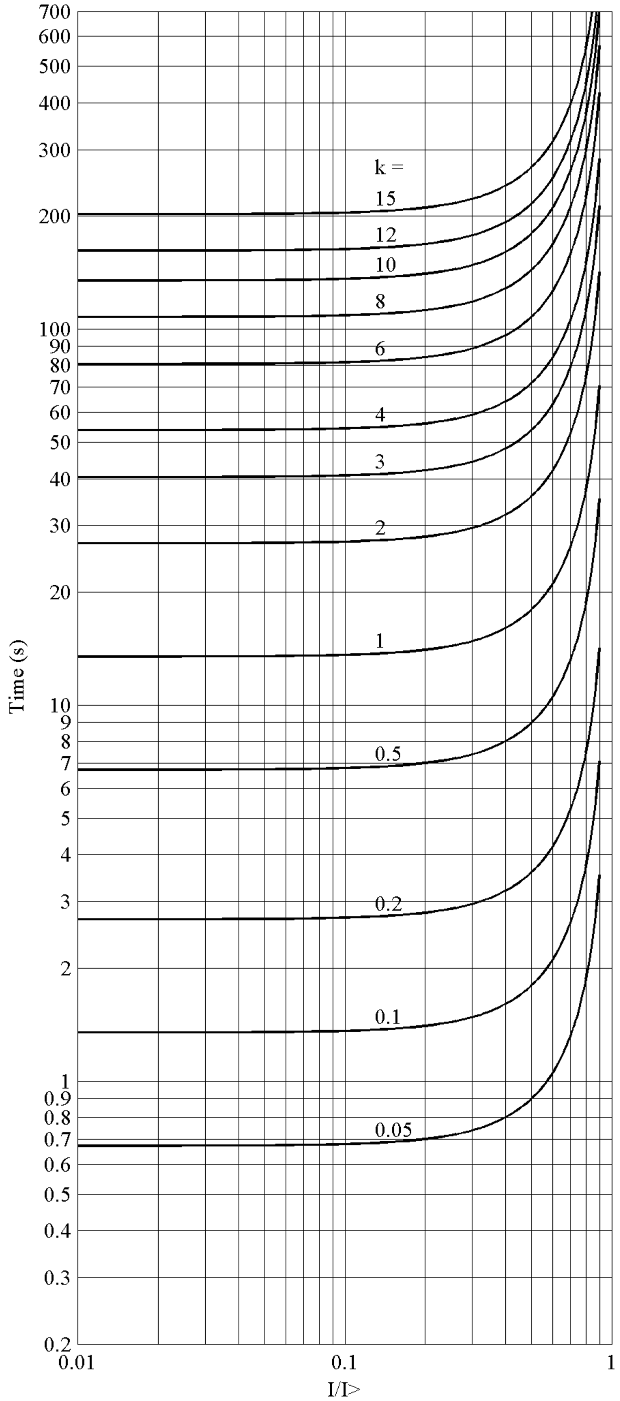


Figure 193: ANSI long-time very inverse reset time characteristics

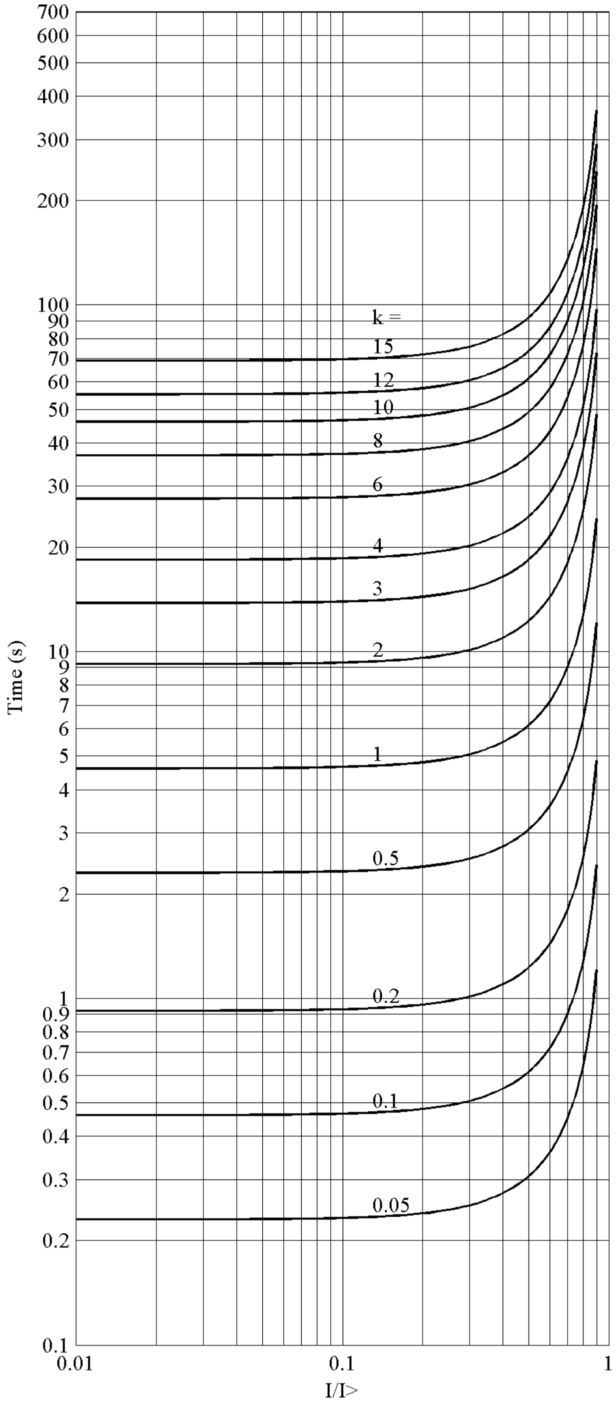


Figure 194: ANSI long-time inverse reset time characteristics

The delayed inverse-time reset is not available for IEC-type inverse time curves.

User-programmable delayed inverse reset

The user can define the delayed inverse reset time characteristics with the following formula using the set *Curve parameter D*.

$$t[s] = \left(\frac{D}{\left(\frac{I}{I>} \right)^2 - 1} \right) \cdot k$$

(Equation 26)

t[s]	Reset time (in seconds)
k	set *Time multiplier*
D	set *Curve parameter D*
I	Measured current
I>	set *Start value*

Section 10 Device's physical connections

10.1 Protective earth connections

The IED shall be earthed with a 16.0 mm^2 flat copper cable.

The earth lead should be as short as possible, distance to nearest eartning point shall be less than 1500 mm.

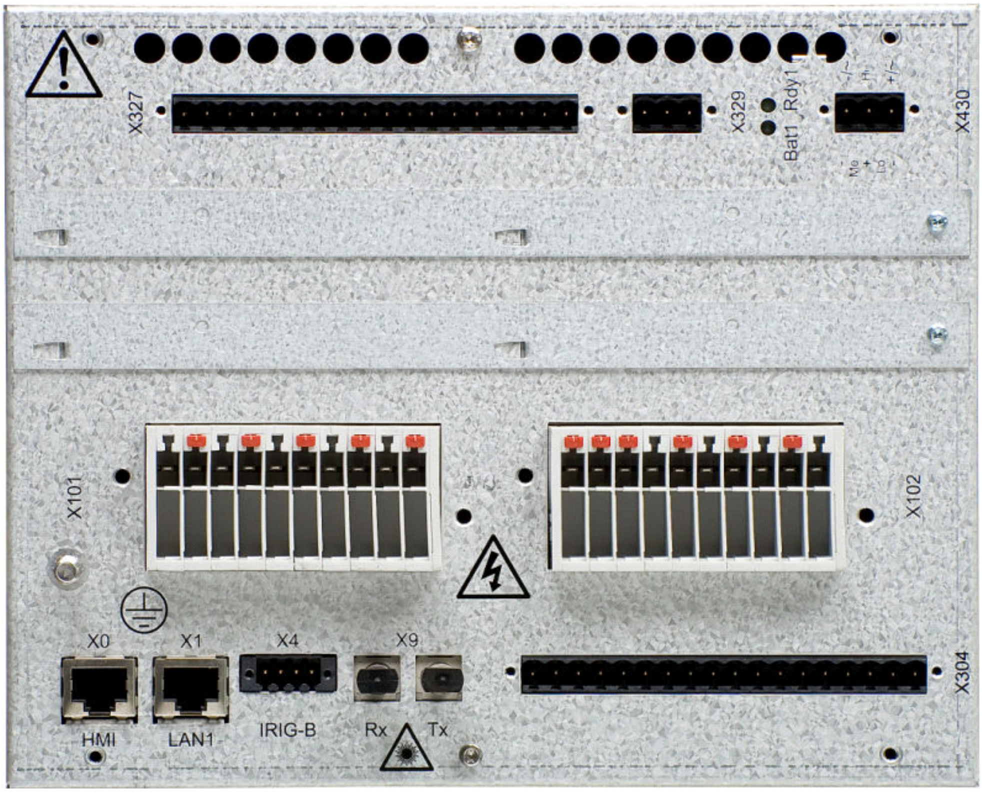


Figure 195: Protective earth pin is located to the left of connector X101 on the 4U half 19” case

10.2 Inputs

10.2.1 Measuring inputs

Each terminal for CTs/VTs is dimensioned for one wire of 0.5...6.0 mm^2 or for two wires of maximum 2.5 mm^2.

Table 356: PML630 modules

Terminal	AIMA01A 1KHL178083R0008	AIMA05A 1KHL178083R0013
X101-1, 2	CT	CT
X101-3, 4	CT	CT
X101-5, 6	CT	CT
X101-7, 8	CT	CT
X101-9, 10	None	CT
X102-1, 2	VT	CT
X102-3, 4	VT	CT
X102-5, 6	VT	CT
X102-7, 8	VT	VT
X102-9, 10	VT	VT

10.2.2 Auxiliary supply voltage input

The auxiliary voltage of the IED is connected to terminals X430-1 and X430-2/3 or X410-1 and X410-2/3. The terminals used depend on the power supply and the IED case size.

The permitted auxiliary voltage range of the IED is marked on the device label on the side of the IED.

Table 357: Auxiliary voltage supply of 110...250 V DC or 100...240 V AC

Case	Terminal	Description
4U half 19”	X430-1	- Input
	X430-3	+ Input

Table 358: Auxiliary voltage supply of 48-125 V DC

Case	Terminal	Description
4U half 19”	X430-1	- Input
	X430-2	+ Input

10.2.3 Binary inputs

The binary inputs can be used, for example, for status indications, to generate a blocking signal, to unlatch output contacts, to trigger the disturbance recorder or for remote control of IED settings.

Each signal connector terminal is dimensioned for one 0.5...2.5 mm^2 wire or for two 0.5...1.0 mm^2 wires.

Use only DC power for the binary inputs. Use of AC power, including full- or half-wave rectified AC power, may cause damage to the binary input modules.

Table 359: Binary inputs X304,4U half 19”

Terminal	Description	ACT info	
		Hardware module instance	Hardware channel
X304-1	Common - for inputs 1-4		
X304-2	Binary input 1 +	COM_101	BI1
X304-3	Binary input 2 +	COM_101	BI2
X304-4	Binary input 3 +	COM_101	BI3
X304-5	Binary input 4 +	COM_101	BI4
X304-6	Common - for inputs 5-8		
X304-7	Binary input 5 +	COM_101	BI5
X304-8	Binary input 6 +	COM_101	BI6
X304-9	Binary input 7 +	COM_101	BI7
X304-10	Binary input 8 +	COM_101	BI8
X304-11	Common - for inputs 9-11		
X304-12	Binary input 9 +	COM_101	BI9
X304-13	Binary input 10 +	COM_101	BI10
X304-14	Binary input 11 +	COM_101	BI11
X304-15	Common - for inputs 12-14		
X304-16	Binary input 12 +	COM_101	BI12
X304-17	Binary input 13 +	COM_101	BI13
X304-18	Binary input 14 +	COM_101	BI14

10.3 Outputs

10.3.1 IRF

The IRF contact functions as a change-over output contact for the self-supervision system of the IED. Under normal operating conditions, the IED is energized and one of the two contacts is closed. When a fault is detected by the self-supervision system or the auxiliary voltage is disconnected, the closed contact drops off and the other contact closes.

Each signal connector terminal is dimensioned for one 0.5...2.5 mm^2 wire or for two 0.5...1.0 mm^2 wires.

Table 360: IRF contact X329

Case	Terminal	Description
4U half 19”	X329-1	Closed; no IRF, and U_{aux} connected
	X329-2	Closed; IRF, or U_{aux} disconnected
	X329-3	IRF, common

10.4 Communication connections

The IED's LHMI is provided with an RJ-45 connector. The connector is intended for configuration and setting purposes.

Rear communication via the X1/LAN1 connector uses a communication module with the galvanic RJ-45 or optical LC Ethernet connection.

The HMI connector X0 is used for connecting an external HMI to the IED. The X0/ HMI connector must not be used for any other purpose. An external HMI can be used only when the IED has no integrated HMI.

10.4.1 Ethernet RJ-45 front connection

The IED's LHMI is provided with an RJ-45 connector designed for point-to-point use. The connector is intended for configuration and setting purposes. The interface on the PC side has to be configured in a way that it obtains the IP address automatically. There is a DHCP server inside IED for the front interface only.

The events and setting values and all input data such as memorized values and disturbance records can be read via the front communication port.

Only one of the possible clients can be used for parametrization at a time.

- PCM600
- LHMI
- WHMI

The default IP address of the IED through this port is 192.168.0.254.

The front port supports TCP/IP protocol. A standard Ethernet CAT 5 crossover cable is used with the front port.

If IED is ordered without LHMI then LAN1 port has to be used for configuration and setting purposes. The default IP address for the LAN1 port is 192.168.2.10. DHCP is not available from LAN1 port.

10.4.2 Ethernet connection for station communication

The default IP address of the IED through the Ethernet connection is 192.168.2.10. The physical connector is X1/LAN1. The interface speed is 100 Mbps both for the 100BASE-FX LC alternative and for the 100BASE-TX RJ-45 alternative.

10.4.3 Optical serial rear connection

Serial communication can be used via optical connection in star topology. Connector type is glass (ST connector). Connection's idle state is indicated either with light on or light off. The physical connector is X9/Rx,Tx.

10.4.4 Communication interfaces and protocols

Table 361: Supported station communication interfaces and protocols

Protocol	Ethernet		Serial
	100BASE-TX RJ-45	100BASE-FX LC	Glass fibre (ST connector)
IEC 61850–8–1	●	●	-
● = Supported			

10.4.5 Recommended third-party industrial Ethernet switches

- RuggedCom RS900
- RuggedCom RS1600
- RuggedCom RSG2100

10.5 Terminal diagrams

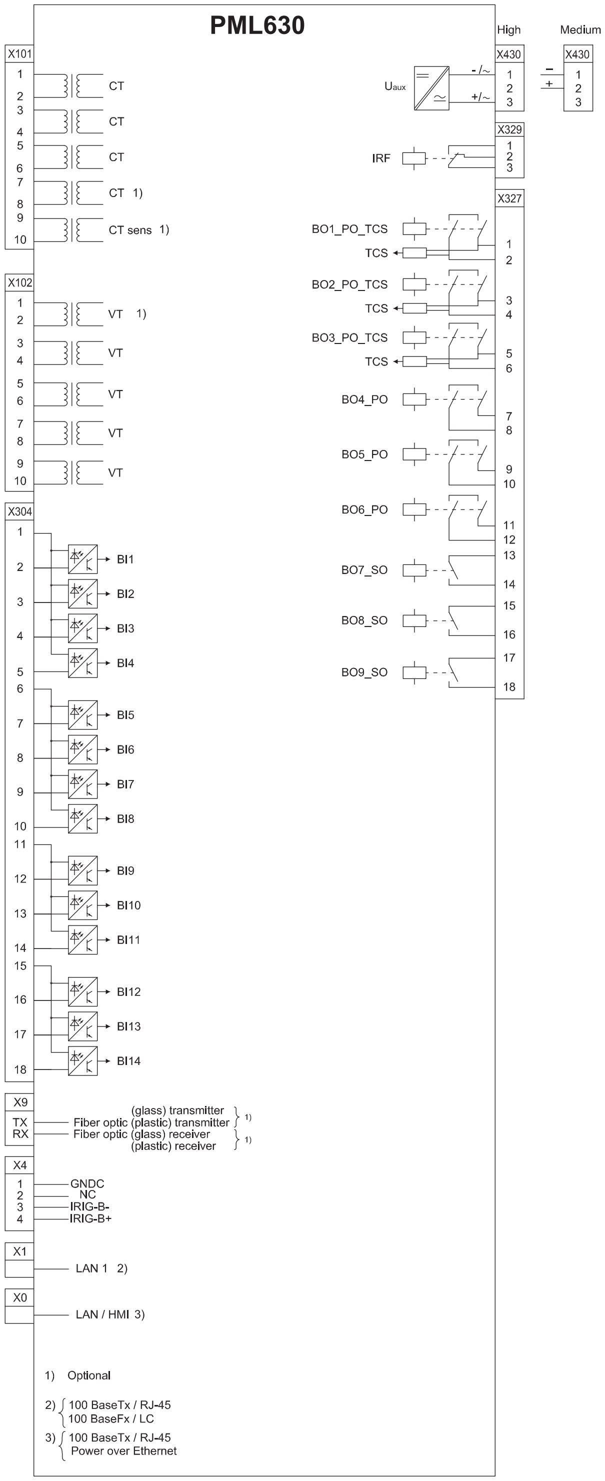


Figure 196: PML630 terminal diagram (4 CT, 5 VT)

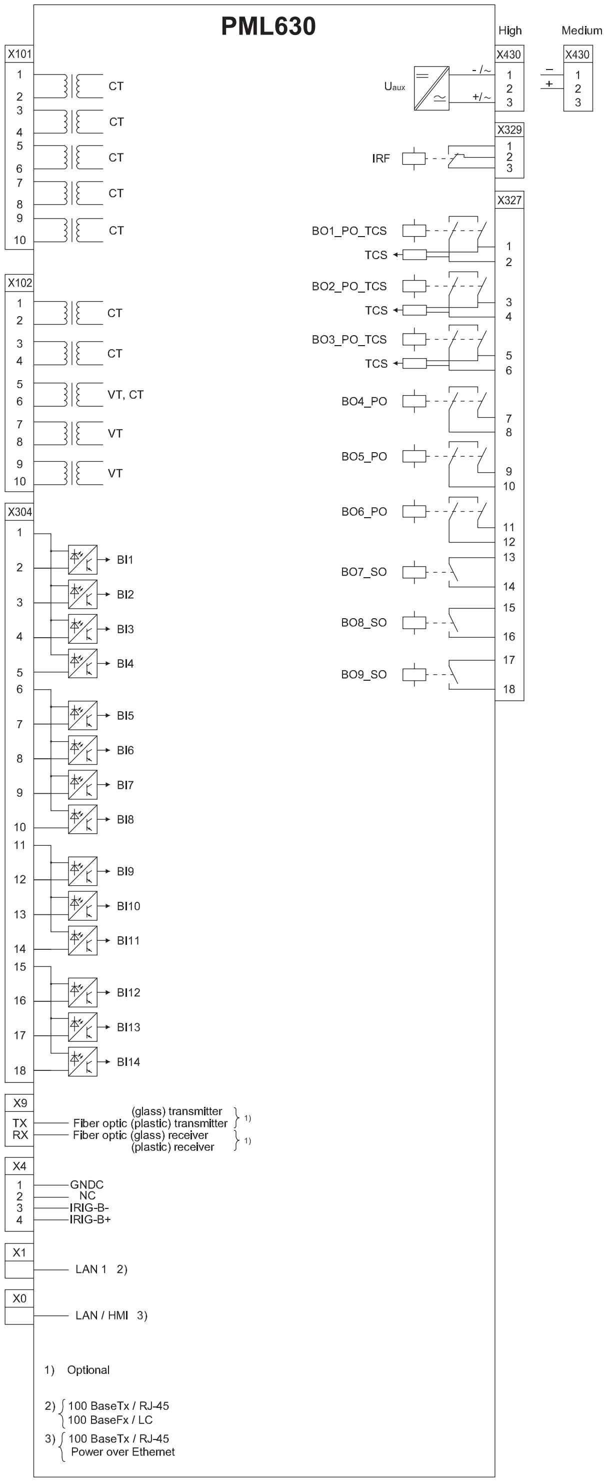


Figure 197: PML630 terminal diagram (8 CT, 2 VT)

Section 11 Technical data

Table 362: Dimensions of the IED - half 19" rack

Description	Value
Width	220 mm
Height	177 mm
Depth	249.5 mm
Weight box	6.2 kg
Weight LHMI	1.0 kg

Table 363: Power supply

<table>
<tr><th>Description</th><th>600PSM03</th><th>600PSM02</th></tr>
<tr><td rowspan="2">U_{aux}nominal</td><td>100, 110, 120, 220, 240 V AC, 50 and 60 Hz</td><td rowspan="2">48, 60, 110, 125 V DC</td></tr>
<tr><td>110, 125, 220, 250 V DC</td></tr>
<tr><td rowspan="2">U_{aux}variation</td><td>85...110% of U_n (85...264 V AC)</td><td rowspan="2">80...120% of U_n (38.4...150 V DC)</td></tr>
<tr><td>80...120% of U_n (88...300 V DC)</td></tr>
<tr><td>Maximum load of auxiliary voltage supply</td><td colspan="2">35 W</td></tr>
<tr><td>Ripple in the DC auxiliary voltage</td><td colspan="2">Max 15% of the DC value (at frequency of 100 Hz)</td></tr>
<tr><td>Maximum interruption time in the auxiliary DC voltage without resetting the device</td><td colspan="2">50 ms at U_{aux}</td></tr>
<tr><td>Power supply input must be protected by an external miniature circuit breaker</td><td colspan="2">For example, type S282 UC-K.
The rated maximum load of aux voltage which is given as 35 watts. Depending on the voltage used, select a suitable MCB based on the respective current. Type S282 UC-K has a rated current of 0.75 A at 400 V AC.</td></tr>
</table>

Table 364: Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Operating range		Rated frequency ± 5 Hz	
Current inputs	Rated current, I_n	0.1/0.5 A1)	1/5 A2)
	Thermal withstand capability: • Continuously • For 1 s • For 10 s	 4 A 100 A 25 A	 20 A 500 A 100 A
	Dynamic current withstand: • Half-wave value	 250 A	 1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage, U_n	100 V AC/ 110 V AC/ 115 V AC/ 120 V AC	
	Voltage withstand: • Continuous • For 10 s	 425 V AC 450 V AC	
	Burden at rated voltage	<0.05 VA	

1) Residual current
2) Phase currents or residual current

Table 365: Binary inputs

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	24...250 V DC
Current drain	1.6...1.8 mA
Power consumption/input	<0.3 W
Threshold voltage	15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)
Threshold accuracy	±3.0%
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)

Adjust the binary input threshold voltage correctly. It is recommended to set the threshold voltage to 70% of the nominal auxiliary voltage. The factory default is 16 V to ensure the binary inputs' operation regardless of the auxiliary voltage used (24, 48, 60, 110, 125, 220 or 250 V DC). However, the default value is not optimal for the higher auxiliary voltages. The binary input threshold voltage should be set as high as possible to prevent any inadvertent activation of the binary inputs due to possible external disturbances. At the same time, the threshold should be set so that the correct operation is not jeopardized in case of undervoltage of the auxiliary voltage.

Table 366: Signal output and IRF output

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	15 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at U< 48/110/220 V DC	≤0.5 A/≤0.1 A/≤0.04 A
Minimum contact load	100 mA at 24 V AC/DC

Table 367: Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
LAN1 (X1)	TCP/IP protocol	Fibre-optic cable with LC connector or shielded twisted pair CAT 5e cable or better	100 MBits/s

Table 368: LAN (X1) fibre-optic communication link

Wave length	Fibre type	Connector	Permitted path attenuation[1)]	Distance
1300 nm	MM 62.5/125 μm or MM 50/125 μm glass fibre core	LC	<7.5 dB	2 km

1) Maximum allowed attenuation caused by connectors and cable together

Table 369: X4/IRIG-B interface

Type	Protocol	Cable
Screw terminal, pin row header	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841-9844) or Alpha Wire (Alpha 6222-6230)

Table 370: X9 Optical serial interface characteristics

Wave length	Fibre type	Connector	Permitted path attenuation	Distance
820 nm	MM 62.5/125	ST	4 dB/km	1000 m
820 mm	MM 50/125	ST	4 dB/km	400 m
660 mm	1 mm	Snap-in		10 m

Table 371: Degree of protection of flush-mounted device

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

Table 372: Degree of protection of the LHMI

Description	Value
Front and side	IP 42

Table 373: Environmental conditions

Description	Value
Operating temperature range	-25...+55ºC (continuous)
Short-time service temperature range	-40...+85ºC (<16 h) Note: Degradation in MTBF and HMI performance outside the temperature range of -25...+55ºC
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85ºC

Table 374: Environmental tests

Description	Type test value	Reference
Dry heat test (humidity <50%)	• 96 h at +55ºC • 16 h at +85ºC	IEC 60068-2-2
Cold test	• 96 h at -25ºC • 16 h at -40ºC	IEC 60068-2-1
Damp heat test, cyclic	• 6 cycles at +25…55°C, Rh >93%	IEC 60068-2-30
Storage test	• 96 h at -40ºC • 96 h at +85ºC	IEC 60068-2-1 IEC 60068-2-2

Section 12 Device and functionality tests

Table 375: 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
• Common mode	2.5 kV	
• Differential mode	1.0 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-22-1, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2, level 4 IEC 60255-22-2 IEEE C37.90.3.2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference tests		
• Conducted, common mode	10 V (rms), f=150 kHz...80 MHz	IEC 61000-4-6 , level 3 IEC 60255-22-6
• Radiated, pulse-modulated	10 V/m (rms), f=900 MHz	ENV 50204 IEC 60255-22-3
• Radiated, amplitude-modulated	10 V/m (rms), f=80...2700 MHz	IEC 61000-4-3, level 3 IEC 60255-22-3
Fast transient disturbance tests		IEC 61000-4-4 IEC 60255-22-4, class A
• All ports	4 kV	
Surge immunity test		IEC 61000-4-5, level 3/2 IEC 60255-22-5
• Communication	1 kV line-to-earth	
• Binary inputs, voltage inputs	2 kV line-to-earth 1 kV line-to-line	
• Other ports	4 kV line-to-earth, 2 kV line-to-line	
Power frequency (50 Hz) magnetic field		IEC 61000-4-8

Table continues on next page

Description	Type test value	Reference
• 1...3 s • Continuous	1000 A/m 300 A/m	
Pulse magnetic field immunity test	1000 A/m 6.4/16 μs	IEC 61000-4-9
Damped oscillatory magnetic field immunity test • 2 s • 1 MHz	 100 A/m 400 transients/s	IEC 61000-4-10
Power frequency immunity test • Common mode • Differential mode	Binary inputs only 300 V rms 150 V rms	IEC 60255-22-7, class A IEC 61000-4-16
Conducted common mode disturbances	15 Hz...150 kHz Test level 3 (10/1/10 V rms)	IEC 61000-4-16
Voltage dips and short interruptions	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11
Electromagnetic emission tests • Conducted, RF-emission (mains terminal) 0.15...0.50 MHz 0.5...30 MHz • Radiated RF-emission 30...230 MHz 230...1000 MHz	 < 79 dB(μV) quasi peak < 66 dB(μV) average < 73 dB(μV) quasi peak < 60 dB(μV) average < 40 dB(μV/m) quasi peak, measured at 10 m distance < 47 dB(μV/m) quasi peak, measured at 10 m distance	EN 55011, class A IEC 60255-25

Table 376: Insulation tests

Description	Type test value	Reference
Dielectric tests: • Test voltage	 2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min, communication	IEC 60255-5 IEC 60255-27
Impulse voltage test:		IEC 60255-5 IEC 60255-27

Table continues on next page

Description	Type test value	Reference
• Test voltage	5 kV, 1.2/50 μs, 0.5 J 1 kV, 1.2/50 μs, 0.5 J, communication	
Insulation resistance measurements • Isolation resistance	 >100 MΩ, 500 V DC	IEC 60255-5 IEC 60255-27
Protective bonding resistance • Resistance	 <0.1Ω, 4 A, 60 s	IEC 60255-27

Table 377: Mechanical tests

Description	Reference	Requirement
Vibration tests (sinusoidal)	IEC 60068-2-6 (test Fc) IEC 60255-21-1	Class 1
Shock and bump test	IEC 60068-2-27 (test Ea shock) IEC 60068-2-29 (test Eb bump) IEC 60255-21-2	Class 1
Seismic test	IEC 60255-21-3 (method A)	Class 1

Table 378: Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005) EN 60255-1 (2009)

Table 379: EMC compliance

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

Table 380: RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Section 13 Applicable standards and regulations

EN 60255-1

EN 60255-26

EN 60255-27

EMC council directive 2004/108/EC

EU directive 2002/96/EC/175

IEC 60255

Low-voltage directive 2006/95/EC

IEC 61850

Section 14 Glossary

100BASE-FX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fiber optic cabling
100BASE-TX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses twisted-pair cabling category 5 or higher with RJ-45 connectors
ACT	1. Application Configuration tool in PCM600 2. Trip status in IEC 61850
AIM	Analog input module
BIO	Binary input and output
CAT 5	A twisted pair cable type designed for high signal integrity
CAT 5e	An enhanced version of CAT 5 that adds specifications for far end crosstalk
CMT	Communication Management tool in PCM600
COMTRADE	Common format for transient data exchange for power systems. Defined by the IEEE Standard.
cPMS	Compact power management solution
CPU	Central processing unit
Data set	The content basis for reporting and logging containing references to the data and data attribute values
DHCP	Dynamic Host Configuration Protocol
DNP3	A distributed network protocol originally developed by Westronic. The DNP3 Users Group has the ownership of the protocol and assumes responsibility for its evolution.
DT	Definite time
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
FIFO	First in, first out
GDE	Graphical Display Editor in PCM600
GOOSE	Generic Object-Oriented Substation Event
GPS	Global Positioning System
HMI	Human-machine interface

HSI	Human-system interface
I/O	Input/output
IDMT	Inverse definite minimum time
IEC	International Electrotechnical Commission
IEC 61850	International standard for substation communication and modeling
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IED	Intelligent electronic device
IP	Internet protocol
IRF	1. Internal fault 2. Internal relay fault
IRIG-B	Inter-Range Instrumentation Group's time code format B
LAN	Local area network
LC	Connector type for glass fiber cable, IEC 61754-20
LED	Light-emitting diode
LHMI	Local human-machine interface
MCB	Miniature circuit breaker
MicroSCADA	Substation automation system
MMS	1. Manufacturing message specification 2. Metering management system
MTBF	Mean time between failures
OPC server	A software application that acts as an API or protocol converter
PC	1. Personal computer 2. Polycarbonate
PCM600	Protection and Control IED Manager
PSM	Power supply module
PST	1. Parameter Setting tool in PCM600 2. Product Selection Tool
RMS	Root-mean-square (value)
RS-485	Serial link according to EIA standard RS485
RTC	Real-time clock
RTD	Resistance temperature detector
Rx	Receive/Received
SCADA	Supervision, control and data acquisition

SCS	Station control system
SMAI	Signal matrix analog input
SMS	1. Short Message Service 2. Station monitoring system
SMT	Signal Matrix tool in PCM600
SNTP	Simple Network Time Protocol
ST	Connector type for glass fiber cable
SW	Software
TCP/IP	Transmission Control Protocol/Internet Protocol
TRM	Transformer input module
Tx	Transmit/Transmitted
WAN	Wide area network
WHMI	Web human-machine interface

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