Relion® 620 series

Motor Protection and Control REM620 Application Manual

Power and productivity for a better world™

ABB

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

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Section 1 Introduction

1.1 This manual

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

1.2 Intended audience

This manual addresses the protection and control engineer responsible for planning, pre-engineering and engineering.

The protection and control engineer must be experienced in electrical power engineering and have knowledge of related technology, such as protection schemes and principles.

1.3 Product documentation

1.3.1 Product documentation set

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

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

The engineering guide provides information for IEC 61850 engineering of the protection IEDs with PCM600 and IET600. This guide concentrates especially on the configuration of GOOSE communication with these tools. The guide can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service. For more details on tool usage, see the PCM600 documentation.

The engineering manual contains instructions on how to engineer the IEDs using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also

recommends a sequence for engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 61850 and other supported protocols.

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

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

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

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

1.3.2 Document revision history

Document revision/date	Product version	History
A/2013-05-07	2.0	First release

Download the latest documents from the ABB Website http://www.abb.com/substationautomation.

1.3.3 Related documentation

Name of the document	Document ID
Modbus Communication Protocol Manual	1MRS757645
DNP3 Communication Protocol Manual	1MRS757646
IEC 60870-5-103 Communication Protocol Manual	1MRS757647
IEC 61850 Engineering Guide	1MRS757650
Engineering Manual	1MRS757642
Installation Manual	1MRS757641
Operation Manual	1MRS757643
Technical Manual	1MRS757644

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 in this manual are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push-button navigation in the LHMI menu structure is presented by using the push-button icons.
  To navigate between the options, use  and  .
- HMI 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 non-volatile memory, select Yes and press .

- Parameter names are shown in italics.
  The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks.
  The corresponding parameter values are "On" and "Off".
- IED input/output messages and monitored data names are shown in Courier font.
  When the function starts, the START output is set to TRUE.

1.4.3 Functions, codes and symbols

Table 1: REM620 functions, codes and symbols

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	3I> -> (1)	67-1 (1)
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, high stage, instance 1	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage, instance 1	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Residual overvoltage protection, instance 1	ROVPTOV1	Uo> (1)	59G (1)
Residual overvoltage protection, instance 2	ROVPTOV2	Uo> (2)	59G (2)
Residual overvoltage protection, instance 3	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	3U< (2)	27 (2)
Three-phase undervoltage protection, instance 3	PHPTUV3	3U< (3)	27 (3)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Three-phase overvoltage protection, instance 1	PHPTOV1	3U> (1)	59 (1)
Three-phase overvoltage protection, instance 2	PHPTOV2	3U> (2)	59 (2)
Three-phase overvoltage protection, instance 3	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection, instance 1	PSPTUV1	U1< (1)	47U+ (1)
Positive-sequence undervoltage protection, instance 2	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection, instance 1	NSPTOV1	U2> (1)	47O- (1)
Negative-sequence overvoltage protection, instance 2	NSPTOV2	U2> (2)	47O- (2)
Frequency protection, instance 1	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
Frequency protection, instance 2	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
Frequency protection, instance 3	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Frequency protection, instance 4	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
Frequency protection, instance 5	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
Frequency protection, instance 6	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Negative-sequence overcurrent protection for motors, instance 1	MNSPTOC1	I2>M (1)	46M (1)
Negative-sequence overcurrent protection for motors, instance 2	MNSPTOC2	I2>M (2)	46M (2)
Loss of load supervision, instance 1	LOFLPTUC1	3I< (1)	37M (1)
Loss of load supervision, instance 2	LOFLPTUC2	3I< (2)	37M (2)
Motor load jam protection	JAMPTOC1	Ist> (1)	51LR (1)
Motor start-up supervision	STTPMSU1	Is2t>, n> (1)	49,66,48,51LR (1)
Phase reversal protection	PREVPTOC1	I2>> (1)	46R (1)
Thermal overload protection for motors	MPTTR1	3Ith>M (1)	49M (1)
Motor differential protection	MPDIF1	3dI>M (1)	87M (1)
Circuit breaker failure protection, instance 1	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Circuit breaker failure protection, instance 2	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
Master trip, instance 1	TRPPTRC1	Master Trip (1)	94/86 (1)
Master trip, instance 2	TRPPTRC2	Master Trip (2)	94/86 (2)
Arc protection, instance 1	ARCSARC1	ARC (1)	50L/50NL (1)
Arc protection, instance 2	ARCSARC2	ARC (2)	50L/50NL (2)
Arc protection, instance 3	ARCSARC3	ARC (3)	50L/50NL (3)
Multipurpose analog protection, instance 1	MAPGAPC1	MAP (1)	MAP (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Multipurpose analog protection, instance 2	MAPGAPC2	MAP (2)	MAP (2)
Multipurpose analog protection, instance 3	MAPGAPC3	MAP (3)	MAP (3)
Multipurpose analog protection, instance 4	MAPGAPC4	MAP (4)	MAP (4)
Multipurpose analog protection, instance 5	MAPGAPC5	MAP (5)	MAP (5)
Multipurpose analog protection, instance 6	MAPGAPC6	MAP (6)	MAP (6)
Multipurpose analog protection, instance 7	MAPGAPC7	MAP (7)	MAP (7)
Multipurpose analog protection, instance 8	MAPGAPC8	MAP (8)	MAP (8)
Multipurpose analog protection, instance 9	MAPGAPC9	MAP (9)	MAP (9)
Multipurpose analog protection, instance 10	MAPGAPC10	MAP (10)	MAP (10)
Multipurpose analog protection, instance 11	MAPGAPC11	MAP (11)	MAP (11)
Multipurpose analog protection, instance 12	MAPGAPC12	MAP (12)	MAP (12)
Control			
Circuit-breaker control, instance 1	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Circuit-breaker control, instance 2	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
Disconnector control, instance 1	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
Disconnector control, instance 2	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control, instance 1	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector control, instance 3	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
Disconnector control, instance 4	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control, instance 2	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
Disconnector position indication, instance 1	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
Disconnector position indication, instance 2	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
Earthing switch position indication, instance 1	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Disconnector position indication, instance 3	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Disconnector position indication, instance 4	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch position indication, instance 2	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Emergergency startup	ESMGAPC1	ESTART (1)	ESTART (1)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)
Condition monitoring			

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Circuit-breaker condition monitoring, instance 1	SSCBR1	CBCM (1)	52CM (1)
Circuit-breaker condition monitoring, instance 2	SSCBR2	CBCM (2)	52CM (2)
Trip circuit supervision, instance 1	TCSSCBR1	TCS (1)	TCM (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision, instance 1	CCRDIF1	MCS 3I (1)	CSM 3I (1)
Fuse failure supervision	SEQRFUF1	FUSEF (1)	60 (1)
Runtime counter for machines and devices, instance 1	MDSOPT1	OPTS (1)	OPTM (1)
Runtime counter for machines and devices, instance 2	MDSOPT2	OPTS (2)	OPTM (2)
Measurement			
Three-phase current measurement, instance 1	CMMXU1	3I (1)	3I (1)
Three-phase current measurement, instance 2	CMMXU2	3I(B) (1)	3I(B) (1)
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement, instance 1	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vn (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
Frequency measurement	FMMXU1	f (1)	f (1)
Other			
Minimum pulse timer (2 pcs), instance 1	TPGAPC1	TP (1)	TP (1)
Minimum pulse timer (2 pcs), instance 2	TPGAPC2	TP (2)	TP (2)
Minimum pulse timer (2 pcs), instance 3	TPGAPC3	TP (3)	TP (3)
Minimum pulse timer (2 pcs), instance 4	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution), instance 1	TPSGAPC1	TPS (1)	TPS (1)
Minimum pulse timer (2 pcs, second resolution), instance 2	TPSGAPC2	TPS (2)	TPS (2)
Minimum pulse timer (2 pcs, minute resolution), instance 1	TPMGAPC1	TPM (1)	TPM (1)
Minimum pulse timer (2 pcs, minute resolution), instance 2	TPMGAPC2	TPM (2)	TPM (2)
Pulse timer (8 pcs), instance 1	PTGAPC1	PT (1)	PT (1)
Pulse timer (8 pcs), instance 2	PTGAPC2	PT (2)	PT (2)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF (1)	TOF (1)
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF (2)	TOF (2)
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF (3)	TOF (3)
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs), instance 1	TONGAPC1	TON (1)	TON (1)
Time delay on (8 pcs), instance 2	TONGAPC2	TON (2)	TON (2)
Time delay on (8 pcs), instance 3	TONGAPC3	TON (3)	TON (3)
Time delay on (8 pcs), instance 4	TONGAPC4	TON (4)	TON (4)
Set reset (8 pcs), instance 1	SRGAPC1	SR (1)	SR (1)
Set reset (8 pcs), instance 2	SRGAPC2	SR (2)	SR (2)
Set reset (8 pcs), instance 3	SRGAPC3	SR (3)	SR (3)
Set reset (8 pcs), instance 4	SRGAPC4	SR (4)	SR (4)
Move (8 pcs), instance 1	MVGAPC1	MV (1)	MV (1)
Move (8 pcs), instance 2	MVGAPC2	MV (2)	MV (2)
Move (8 pcs), instance 3	MVGAPC3	MV (3)	MV (3)
Move (8 pcs), instance 4	MVGAPC4	MV (4)	MV (4)
Generic control points, instance 1	SPCGGIO1	SPCGGIO (1)	SPCGGIO (1)
Generic control points, instance 2	SPCGGIO2	SPCGGIO (2)	SPCGGIO (2)
Generic control points, instance 3	SPCGGIO3	SPCGGIO (3)	SPCGGIO (3)
Remote Generic control points	SPCRGGIO1	SPCRGGIO (1)	SPCRGGIO (1)
Local Generic control points	SPCLGGIO1	SPCLGGIO (1)	SPCLGGIO (1)
Generic Up-Down Counters, instance 1	UDFCNT1	UDCNT (1)	UDCNT (1)
Generic Up-Down Counters, instance 2	UDFCNT2	UDCNT (2)	UDCNT (2)
Generic Up-Down Counters, instance 3	UDFCNT3	UDCNT (3)	UDCNT (3)
Generic Up-Down Counters, instance 4	UDFCNT4	UDCNT (4)	UDCNT (4)
Generic Up-Down Counters, instance 5	UDFCNT5	UDCNT (5)	UDCNT (5)
Generic Up-Down Counters, instance 6	UDFCNT6	UDCNT (6)	UDCNT (6)
Generic Up-Down Counters, instance 7	UDFCNT7	UDCNT (7)	UDCNT (7)
Generic Up-Down Counters, instance 8	UDFCNT8	UDCNT (8)	UDCNT (8)
Generic Up-Down Counters, instance 9	UDFCNT9	UDCNT (9)	UDCNT (9)
Generic Up-Down Counters, instance 10	UDFCNT10	UDCNT (10)	UDCNT (10)
Generic Up-Down Counters, instance 11	UDFCNT11	UDCNT (11)	UDCNT (11)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Generic Up-Down Counters, instance 12	UDFCNT12	UDCNT (12)	UDCNT (12)
Programmable buttons(16 buttons)	FKEYGGIO1	FKEY (1)	FKEY (1)
Logging functions			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Fault recorder	FLTMSTA1	FR (1)	FR (1)
Sequence event recorder	SER1	SER (1)	SER (1)
Load profile	LDPMSTA1	LOADPROF (1)	LOADPROF (1)

Section 2 REM620 overview

2.1 Overview

REM620 is a dedicated motor IED perfectly aligned for the protection, control, measurement and supervision of medium-size and large asynchronous motors, requiring also differential protection, in the manufacturing and process industry. REM620 is a member of ABB's Relion® protection and control product family and its 620 series. The 620 series IEDs are characterized by their functional scalability and withdrawable-unit design.

The 620 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability of substation automation devices.

2.1.1 Product version history

Product version	Product history
2.0	Product released

2.1.2 PCM600 and IED connectivity package version

- Protection and Control IED Manager PCM600 Ver. 2.5 or later
- REM620 Connectivity Package Ver. 2.0 or later
    - Parameter Setting
    - Signal Monitoring
    - Event Viewer
    - Disturbance Handling
    - Application Configuration
    - Signal Matrix
    - Graphical Display Editor
    - Communication Management
    - IED User Management
    - IED Compare
    - Firmware Update
    - Fault Record Tool
    - Load Record Profile
    - Differential Characteristics Tool
    - Lifecycle Traceability
    - Configuration Wizard

- AR Sequence Visualizer
- Label Printing
- IEC 61850 Configuration

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

2.2 Operation functionality

2.2.1 Optional functions

- Arc protection
- IEC 61850
- Modbus TCP/IP or RTU/ASCII
- IEC 60870-5-103
- DNP3 TCP/IP or serial

2.3 Physical hardware

The IED consists of two main parts: plug-in unit and case. The content depends on the ordered functionality.

Table 2: Plug-in unit and case

Main unit	Slot ID	Content	Module ID	Details
Plug-in unit	-	HMI	DIS0009	Large (10 rows, 20 characters)
	X100	Auxiliary power/ BO module	PSM0003 or PSM0004	48...250 V DC/100...240 V AC or 24...60 V DC 2 normally-open PO contacts 1 change-over SO contact 1 normally-open SO contact 2 double-pole PO contacts with TCS 1 dedicated internal fault output contact
	X105	Empty		Not equipped if not needed, but alternatively may be equipped as indicated below
		Optional BI/O module	BIO0005	Optional for configurations A 8 binary inputs 4 SO contacts
			BIO0007	Optional for configurations A 8 binary inputs 3 High-speed SO contacts
		Optional RTD/mA module	RTD0003	Optional for configurations A 2 generic mA inputs 6 RTD sensor inputs
	X110	RTD/mA module	RTD0003	With configurations A 2 generic mA inputs 6 RTD sensor inputs
	X115	BI/O module	BIO0005	With configurations A 8 binary inputs 4 SO contacts
	X120	AI module	AIM0005 or AIM0015	With configuration A 3 phase current inputs (1/5A) 3 phase current inputs (1/5A) 1 residual current input (1/5 A or 0.2/1 A)[1)]
Case	X130	AI/BI module	AIM0006	With configuration A 5 voltage inputs 4 binary inputs
	X000	Optional communication module		See the technical manual for details about the different types of communication modules

1) The 0.2/1 A input is normally used in applications requiring sensitive earth-fault protection and featuring core-balance current transformers

Rated values of the current and voltage inputs are basic setting parameters of the IED. The binary input thresholds are selectable within the range 18…176 V DC by adjusting the binary input setting parameters.

The connection diagrams of different hardware modules are presented in this manual.

See the installation manual for more information about the case and the plug-in unit.

Table 3: Number of physical connections in default configurations

Conf.	Analog channels			Binary channels	
	CT	VT	RTD/mA	BI	BO
A	7	5	6/2	12(20)[1]	10(14)[1]
			6/2	12(20)[2]	10(13)[2]
			6/2(12/4)[3]	12	10

1) With optional BIO0005 module
2) With optional BIO0007 module
3) With optional RTD0003 module

2.4 Local HMI

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

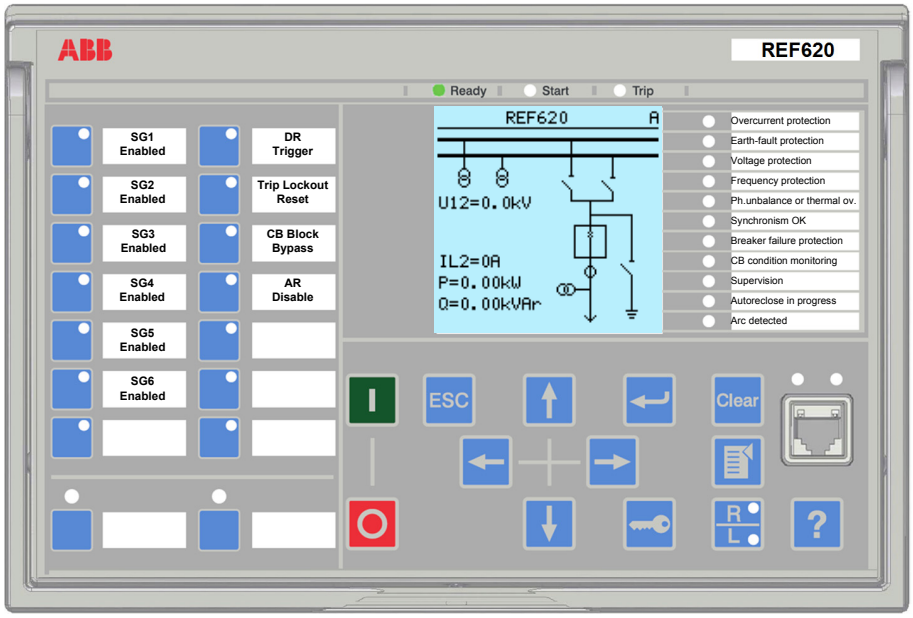

Figure 1: Example of the LHMI

2.4.1 Display

The LHMI includes a graphical display that supports two character sizes. The character size depends on the selected language. The amount of characters and rows fitting the view depends on the character size.

Table 4: Display

Character size[1)]	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)	10	20
Large, variable width (13x14 pixels)	7	8 or more

1) Depending on the selected language

The display view is divided into four basic areas.

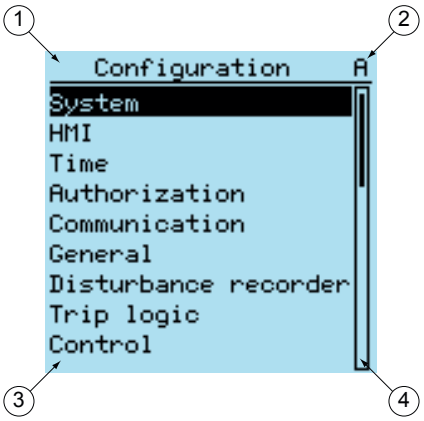

Figure 2: Display layout

1 Header
2 Icon
3 Content
4 Scroll bar (displayed when needed)

2.4.2 LEDs

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

There are 11 matrix programmable LEDs and 16 programmable push-buttons with LEDs on front of the LHMI. The LEDs can be configured with PCM600 and the operation mode can be selected with the LHMI, WHMI or PCM600.

2.4.3 Keypad

The LHMI keypad contains push-buttons which are used to navigate in different views or menus. With the push-buttons you can give open or close commands to objects in the primary circuit, for example, a circuit breaker, a contactor or a

disconnector. The push-buttons are also used to acknowledge alarms, reset indications, provide help and switch between local and remote control mode.

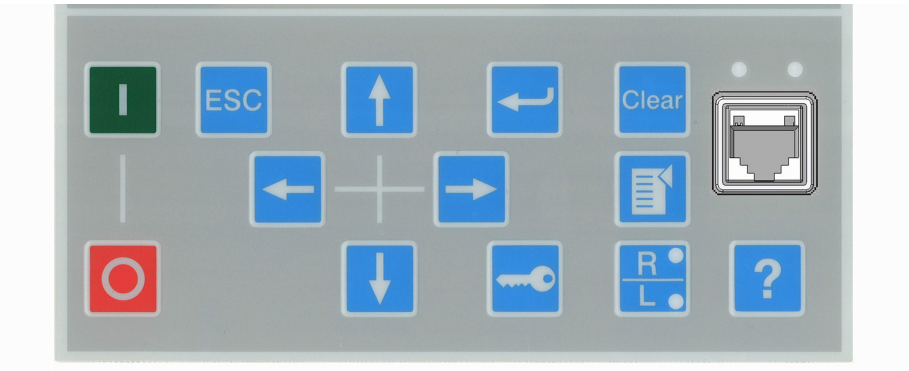

Figure 3: LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port

2.4.3.1 Programmable push-buttons with LEDs

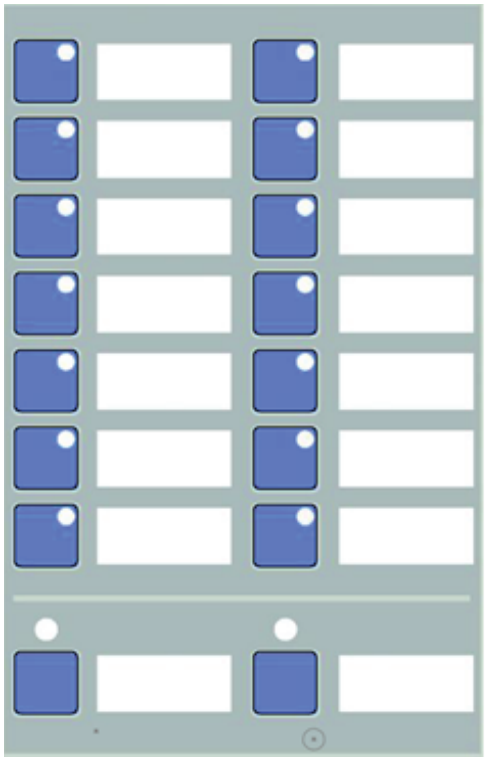

Figure 4: Programmable push-buttons with LEDs

The LHMI keypad on the left side of the IED contains 16 programmable push-buttons with red LEDs.

The buttons and LEDs are freely programmable, and they can be configured both for operation and acknowledgement purposes. That way, it is possible to get acknowledgements of the executed actions associated with the buttons. This combination can be useful, for example, for quickly selecting or changing a setting group, selecting or operating equipment, indicating field contact status or indicating or acknowledging individual alarms.

The LEDs can also be independently configured to bring general indications or important alarms to the operator's attention.

To provide a description of the button function, it is possible to insert a paper sheet behind the transparent film next to the button.

2.5 Web HMI

The WHMI allows accessing the IED via a Web browser. The supported Web browser versions are Internet Explorer 7.0, 8.0 and 9.0.

WHMI is disabled by default.

Control operations are not allowed by WHMI.

WHMI offers several functions.

- Programmable LEDs and event lists
- System supervision
- Parameter settings
- Measurement display
- Disturbance records
- Phasor diagram
- Single-line diagram
- Importing/Exporting parameters

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

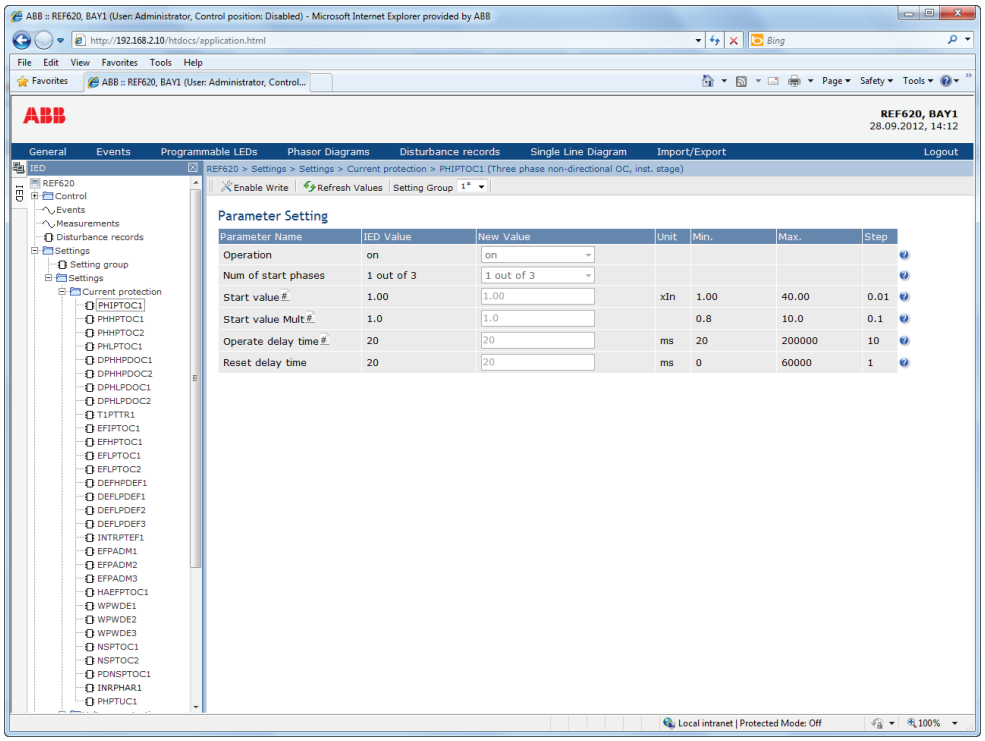

Figure 5: Example view of the WHMI

The WHMI can be accessed locally and remotely.

- Locally by connecting the laptop to the IED via the front communication port.
- Remotely over LAN/WAN.

2.6 Authorization

The user categories have been predefined for the LHMI and the WHMI, each with different rights and default passwords.

The default passwords can be changed with Administrator user rights.

If the IED-specific Administrator password is forgotten, ABB can provide a one-time reliable key to access the IED. For support, please contact ABB. The recovery of the Administrator password takes a few days.

User authorization is disabled by default for LHMI but WHMI always uses authorization.

Table 5: Predefined user categories

Username	User rights
VIEWER	Read only access
OPERATOR	• Selecting remote or local state with (only locally) • Changing setting groups • Controlling • Clearing indications
ENGINEER	• Changing settings • Clearing event list • Clearing disturbance records • Changing system settings such as IP address, serial baud rate or disturbance recorder settings • Setting the IED to test mode • Selecting language
ADMINISTRATOR	• All listed above • Changing password • Factory default activation

For user authorization for PCM600, see PCM600 documentation.

2.6.1 Audit trail

The IED offers a large set of event-logging functions. Normal process-related events can be viewed by the normal user with Event Viewer in PCM600. Critical system and IED security-related events are logged to a separate nonvolatile audit trail for the administrator.

Audit trail is a chronological record of system activities that allows the reconstruction and examination of the sequence of events and changes in an event. Past user and process events can be examined and analyzed in a consistent method with the help of Event List and Event Viewer in PCM600. The IED stores 2048 system events to the nonvolatile audit trail. Additionally, 1024 process events are stored in a nonvolatile event list. Both the audit trail and event list work according to the FIFO principle.

User audit trail is defined according to the selected set of requirements from IEEE 1686. The logging is based on predefined usernames or user categories. The user audit trail events are supported in IEC 61850-8-1, PCM600, LHMI and WHMI.

Table 6: Audit trail events

Audit trail event	Description
Configuration change	Configuration files changed
Firmware change	
Setting group remote	User changed setting group remotely
Table continues on next page	

Audit trail event	Description
Setting group local	User changed setting group locally
Control remote	DPC object control remote
Control local	DPC object control local
Test on	Test mode on
Test off	Test mode off
Setting commit	Settings have been changed
Time change	
View audit log	Administrator accessed audit trail
Login	
Logout	
Firmware reset	Reset issued by user or tool
Audit overflow	Too many audit events in the time period

PCM600 Event Viewer can be used to view the audit trail events together with normal events. Since only the administrator has the right to read audit trail, authorization must be properly configured in PCM600. The audit trail cannot be reset but PCM600 Event Viewer can filter data. Some of the audit trail events are interesting also as normal process events.

To expose the audit trail events also as normal process events, define the level parameter via **Configuration/Authorization/ Authority logging.**

Table 7: Comparison of authority logging levels

Audit trail event	Authority logging level					
	None	Configuration change	Setting group	Setting group, control	Settings edit	All
Configuration change		•	•	•	•	•
Firmware change		•	•	•	•	•
Setting group remote			•	•	•	•
Setting group local			•	•	•	•
Control remote				•	•	•
Control local				•	•	•
Test on				•	•	•
Test off				•	•	•
Setting commit					•	•
Time change						•
View audit log						•
Login						•

Table continues on next page

Audit trail event	Authority logging level					
Logout						•
Firmware reset						•
Audit overflow						•

2.7 Communication

The IED supports a range of communication protocols including IEC 61850, IEC 60870-5-103, Modbus® and DNP3. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the IEDs, is only enabled by the IEC 61850 communication protocol.

The 620 series IEDs can run with two protocols simultaneously when one of the protocols is always IEC61850 and the other one is any of the other available protocols (IEC 60870-5-103, Modbus or DNP3) based on the order code.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter settings, disturbance recordings and fault records can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the standard COMTRADE file format. The IED can send and receive binary signals from other IEDs (so called horizontal communication) using the IEC61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. Further, the IED supports sending and receiving of analog values using GOOSE messaging. The IED meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. The IED can simultaneously report events to five different clients on the station bus.

The IED can support five simultaneous clients. If PCM600 reserves one client connection, only four client connections are left, for example, for IEC 61850 and Modbus.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The IED can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fibre-optic LC connector (100Base-FX).

The Ethernet ring solution supports the connection of up to 30 IEDs. If more than 30 IEDs are to be connected, it is recommended that the network is split into several rings with no more than 30 IEDs per ring.

2.7.1 Ethernet redundancy

IEC 61850 specifies a network redundancy scheme that improves the system availability for substation communication. It is based on two complementary protocols defined in the IEC 62439-3 standard: parallel redundancy protocol PRP and high-availability seamless redundancy HSR protocol. Both the protocols rely on the duplication of all transmitted information via two Ethernet ports for one logical network connection. Therefore, both are able to overcome the failure of a link or switch with a zero-switchover time, thus fulfilling the stringent real-time requirements for the substation automation horizontal communication and time synchronization.

PRP specifies that each device is connected in parallel to two local area networks. HSR applies the PRP principle to rings and to the rings of rings to achieve cost-effective redundancy. Thus, each device incorporates a switch element that forwards frames from port to port.

PRP

Each PRP node, called a doubly attached node with PRP (DANP), is attached to two independent LANs operated in parallel. These parallel networks in PRP are called LAN A and LAN B. The networks are completely separated to ensure failure independence, and they can have different topologies. Both networks operate in parallel, thus providing zero-time recovery and continuous checking of redundancy to avoid communication failures. Non-PRP nodes, called singly attached nodes (SANs), are either attached to one network only (and can therefore communicate only with DANPs and SANs attached to the same network), or are attached through a redundancy box, a device that behaves like a DANP.

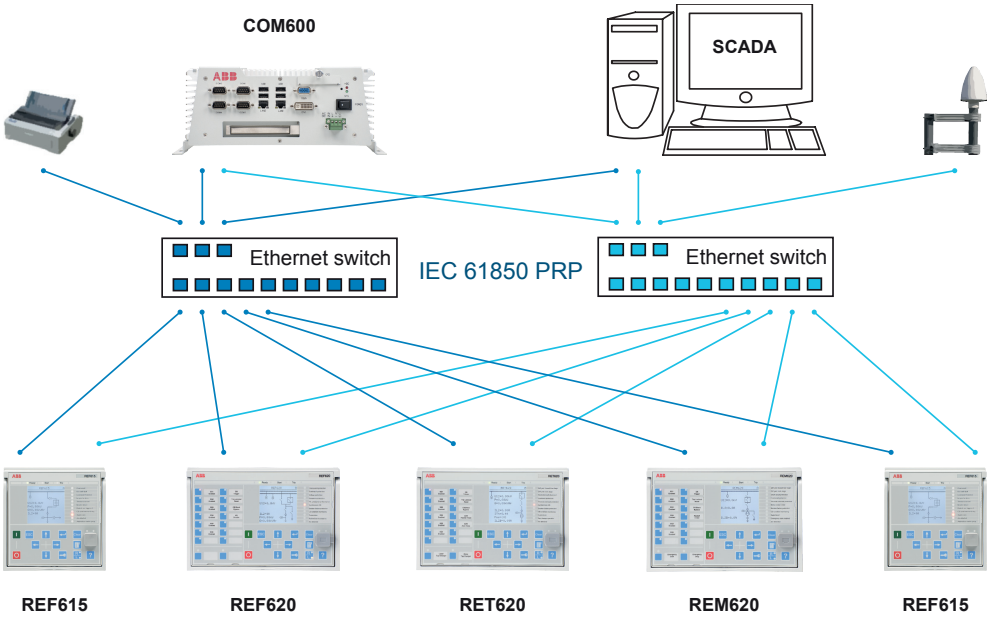

Figure 6: PRP solution

In case a laptop or a PC workstation is connected as a non-PRP node to one of the PRP networks, LAN A or LAN B, it is recommended to use a redundancy box device or an Ethernet switch with similar functionality between the PRP network and SAN to remove additional PRP information from the Ethernet frames. In some cases, default PC workstation adapters are not able to handle the maximum-length Ethernet frames with the PRP trailer.

There are three alternative ways to connect a laptop or a workstation as SAN to the PRP network.

- Via an external redundancy box or a switch capable of connecting to PRP and normal networks
- By connecting the node directly to the IED interlink port (IED operates as a redundancy box)
- By using an Ethernet adapter compatible with the PRP frame, and connecting directly to one of the PRP networks

HSR

HSR applies the PRP principle of parallel operation to a single ring, treating the two directions as two virtual LANs. For each frame sent, a node, DANH, sends two frames, one over each port. Both frames circulate in opposite directions over the ring and each node forwards the frames it receives, from one port to the other. When the originating node receives a frame sent to itself, it discards that to avoid loops; therefore, no ring protocol is needed. Individually attached nodes, SANs, such as laptops and printers, must be attached through a “redundancy box” that acts as a ring element. For example, a 615 or 620 series IED with HSR support can be used as a redundancy box.

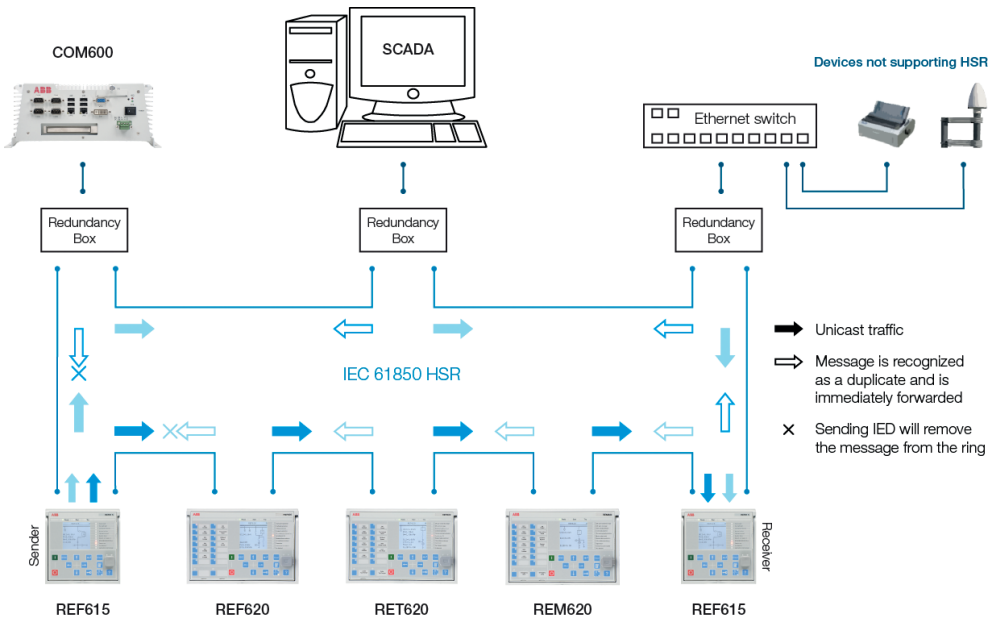

Figure 7: HSR solution

RSTP

For the correct operation of redundant loop topology, it is essential that the external switches in the network support the RSTP protocol and that it is enabled in the switches. Otherwise, connecting the loop topology can cause problems to the network. The IED itself does not support link-down detection or RSTP. The ring recovery process is based on the aging of MAC addresses and link-up/link-down events can cause temporary breaks in communication. For better performance of the self-healing loop, it is recommended that the external switch furthest from the IED loop is assigned as the root switch (bridge priority = 0) and the bridge priority increases towards the IED loop. The end links of the IED loop can be attached to the same external switch or to two adjacent external switches. Self-healing Ethernet ring requires a communication module with at least two Ethernet interfaces for all IEDs.

PRP and HSR are zero-delay protocols but RSTP has a small switching delay.

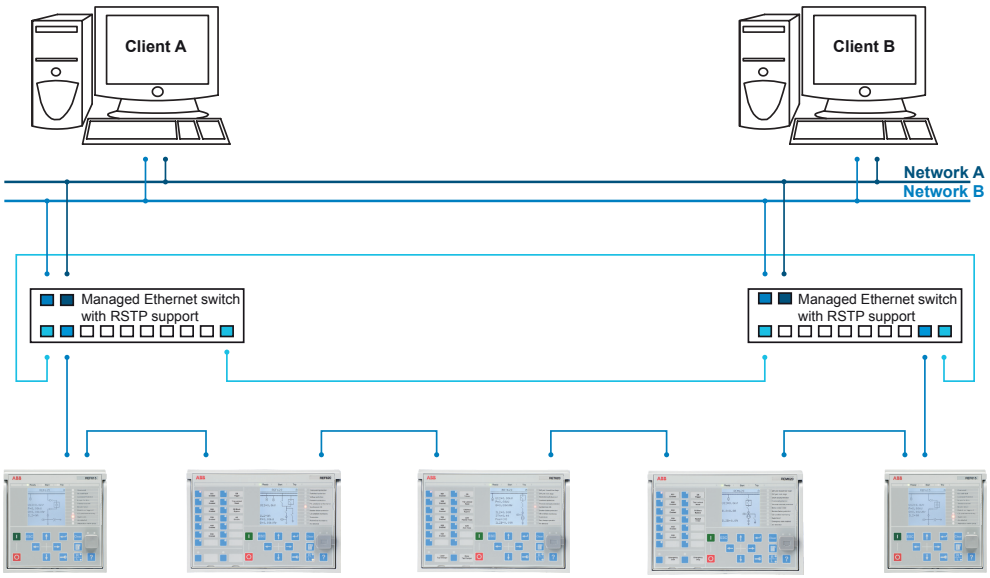

Figure 8: Self-healing Ethernet ring solution

Section 3 REM620 default configurations

3.1 Default configuration

The 620 series IEDs are configured with default configurations, which can be used as examples of the 620 series engineering with different function blocks. The default configurations are not aimed to be used as real end-user applications. The end-users always need to create their own application configuration with the configuration tool. However, the default configuration can be used as a starting point by modifying it according to the requirements.

REM620 is available with one default configuration targeting for differential protection. The default signal configuration can be altered by means of the graphical signal matrix or the graphical application functionality of the Protection and Control IED Manager PCM600. Furthermore, the application configuration functionality of the IED supports the creation of multi-layer logic functions using various logical elements including timers and flip-flops. By combining protection functions with logic function blocks, the IED configuration can be adapted to user-specific application requirements.

Table 8: Supported functions

Functionality	CTs & VTs
Protection	
Three-phase non-directional overcurrent protection, low stage, instance 1	•
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	•
Three-phase directional overcurrent protection, low stage, instance 1	•
Three-phase directional overcurrent protection, high stage, instance 1	•
Three-phase directional overcurrent protection, high stage, instance 2	•
Non-directional earth-fault protection, low stage, instance 1	•
Non-directional earth-fault protection, high stage, instance 1	•
Non-directional earth-fault protection, instantaneous stage, instance 1	•
Directional earth-fault protection, low stage, instance 1	•
Directional earth-fault protection, high stage	•
Residual overvoltage protection, instance 1	•
Residual overvoltage protection, instance 2	•
Residual overvoltage protection, instance 3	•
Three-phase undervoltage protection, instance 1	•
Three-phase undervoltage protection, instance 2	•
Three-phase undervoltage protection, instance 3	•
Table continues on next page	

Functionality	CTs & VTs
Three-phase overvoltage protection, instance 1	●
Three-phase overvoltage protection, instance 2	●
Three-phase overvoltage protection, instance 3	●
Positive-sequence undervoltage protection, instance 1	●
Positive-sequence undervoltage protection, instance 2	●
Negative-sequence overvoltage protection, instance 1	●
Negative-sequence overvoltage protection, instance 2	●
Frequency protection, instance 1	●
Frequency protection, instance 2	●
Frequency protection, instance 3	●
Frequency protection, instance 4	●
Frequency protection, instance 5	●
Frequency protection, instance 6	●
Negative-sequence overcurrent protection for motors, instance 1	●
Negative-sequence overcurrent protection for motors, instance 2	●
Loss of load supervision, instance 1	●
Loss of load supervision, instance 2	●
Motor load jam protection	●
Motor startup supervision	●
Phase reversal protection	●
Thermal overload protection for motors	●
Motor differential protection	●
Circuit breaker failure protection, instance 1	●
Circuit breaker failure protection, instance 2	●
Master trip, instance 1	●
Master trip, instance 2	●
Arc protection, instance 1	○
Arc protection, instance 2	○
Arc protection, instance 3	○
Multipurpose analog protection, instance 1	●
Multipurpose analog protection, instance 2	●
Multipurpose analog protection, instance 3	●
Multipurpose analog protection, instance 4	●
Multipurpose analog protection, instance 5	●
Multipurpose analog protection, instance 6	●
Multipurpose analog protection, instance 7	●
Multipurpose analog protection, instance 8	●
Multipurpose analog protection, instance 9	●
Multipurpose analog protection, instance 10	●

Table continues on next page

Functionality	CTs & VTs
Multipurpose analog protection, instance 11	●
Multipurpose analog protection, instance 12	●
Control	
Circuit-breaker control, instance 1	●
Circuit-breaker control, instance 2	●
Disconnector control, instance 1	●
Disconnector control, instance 2	●
Earthing switch control, instance 1	●
Disconnector control, instance 3	●
Disconnector control, instance 4	●
Earthing switch control, instance 2	●
Disconnector position indication, instance 1	●
Disconnector position indication, instance 2	●
Earthing switch position indication, instance 1	●
Disconnector position indication, instance 3	●
Disconnector position indication, instance 4	●
Earthing switch position indication, instance 2	●
Emergency startup	●
Synchronism and energizing check	●
Condition monitoring	
Circuit-breaker condition monitoring, instance 1	●
Circuit-breaker condition monitoring, instance 2	●
Trip circuit supervision, instance 1	●
Trip circuit supervision, instance 2	●
Current circuit supervision	●
Fuse failure supervision	●
Runtime counter for machines and devices, instance 1	●
Runtime counter for machines and devices, instance 2	●
Measurement	
Three-phase current measurement, instance 1	●
Three-phase current measurement, instance 2	●
Sequence current measurement	●
Residual current measurement	●
Three-phase voltage measurement	●
Residual voltage measurement	●
Sequence voltage measurement	●
Three-phase power and energy measurement	●
Frequency measurement	●
Other	

Table continues on next page

Functionality	CTs & VTs
Minimum pulse timer (2 pcs), instance 1	●
Minimum pulse timer (2 pcs), instance 2	●
Minimum pulse timer (2 pcs), instance 3	●
Minimum pulse timer (2 pcs), instance 4	●
Minimum pulse timer (2 pcs, second resolution), instance 1	●
Minimum pulse timer (2 pcs, second resolution), instance 2	●
Minimum pulse timer (2 pcs, minute resolution), instance 1	●
Minimum pulse timer (2 pcs, minute resolution), instance 2	●
Pulse timer (8 pcs), instance 1	●
Pulse timer (8 pcs), instance 2	●
Time delay off (8 pcs), instance 1	●
Time delay off (8 pcs), instance 2	●
Time delay off (8 pcs), instance 3	●
Time delay off (8 pcs), instance 4	●
Time delay on (8 pcs), instance 1	●
Time delay on (8 pcs), instance 2	●
Time delay on (8 pcs), instance 3	●
Time delay on (8 pcs), instance 4	●
Set reset (8 pcs), instance 1	●
Set reset (8 pcs), instance 2	●
Set reset (8 pcs), instance 3	●
Set reset (8 pcs), instance 4	●
Move (8 pcs), instance 1	●
Move (8 pcs), instance 2	●
Move (8 pcs), instance 3	●
Move (8 pcs), instance 4	●
Generic control points, instance 1	●
Generic control points, instance 2	●
Generic control points, instance 3	●
Remote generic control points	●
Local generic control points	●
Generic up-down counters, instance 1	●
Generic up-down counters, instance 2	●
Generic up-down counters, instance 3	●
Generic up-down counters, instance 4	●
Generic up-down counters, instance 5	●
Generic up-down counters, instance 6	●
Generic up-down counters, instance 7	●
Generic up-down counters, instance 8	●

Table continues on next page

Functionality	CTs & VTs
Generic up-down counters, instance 9	●
Generic up-down counters, instance 10	●
Generic up-down counters, instance 11	●
Generic up-down counters, instance 12	●
Programmable buttons (16 buttons)	●
Logging functions	
Disturbance recorder	●
Fault recorder	●
Sequence event recorder	●
Load profile	●
● = Included, ○ = Optional at the time of the order	

3.1.1 Addition of control functions for primary devices and the use of binary inputs and outputs

If extra control functions intended for controllable primary devices are added to the configuration, additional binary inputs and/or outputs are needed to complement the default configuration.

If the number of inputs and/or outputs in a default configuration is not sufficient, it is possible either to modify the chosen IED default configuration in order to release some binary inputs or binary outputs which have originally been configured for other purposes, or to connect an external input/output module, for example RIO600, to the IED.

The external I/O module's binary inputs and outputs can be used for the less time-critical binary signals of the application. The integration enables releasing some initially reserved binary inputs and outputs of the IED's default configuration.

The suitability of the IED's binary outputs which have been selected for primary device control should be carefully verified, for example make and carry and breaking capacity. If the requirements for the primary device control circuit are not met, using external auxiliary relays should be considered.

3.1.2 LED functionality

The IED has dynamic programmable LEDs. The presentation of the LEDs in this manual differs from the actual function blocks in the configurations.

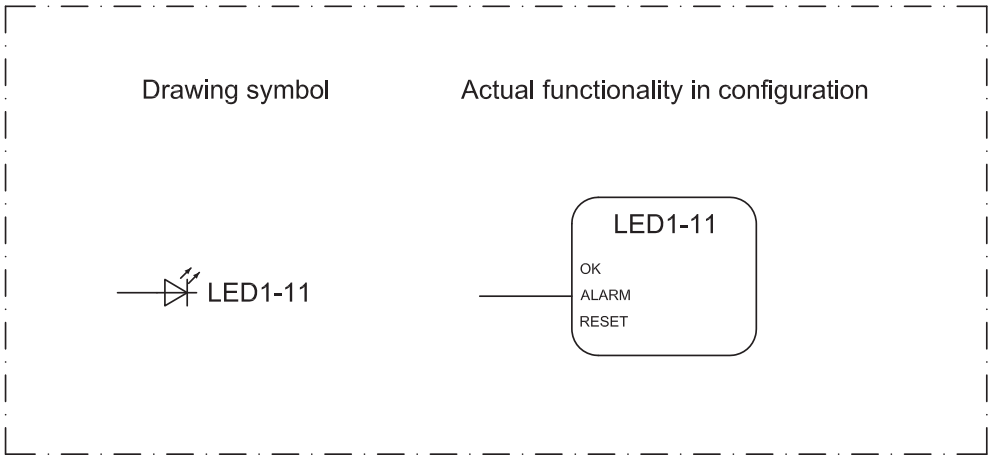

Figure 9: Drawing symbol used in the manual and the default connection of the LED function blocks in the configurations

3.2 Connection diagrams

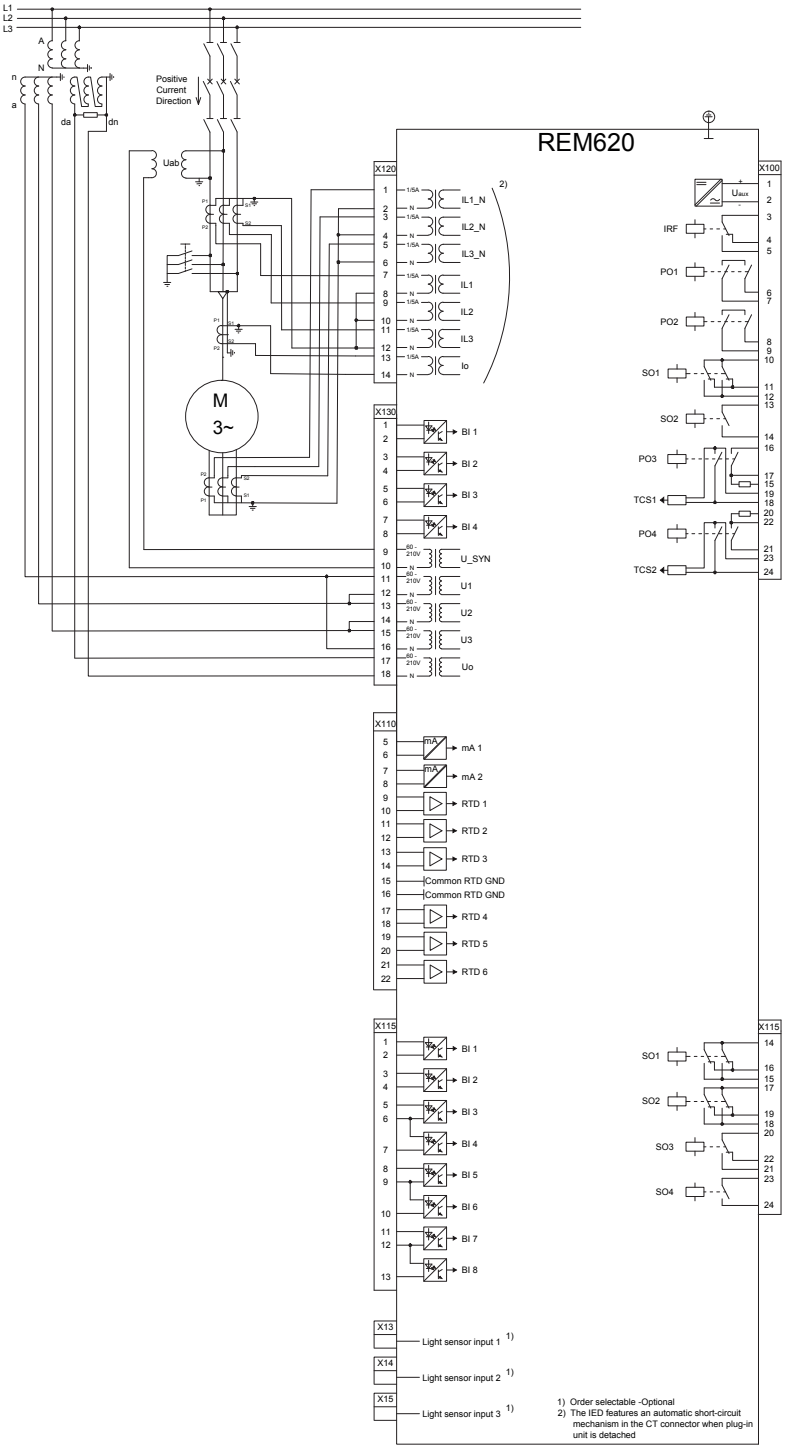

Figure 10: Connection diagram for the A configuration

3.3 Optional modules

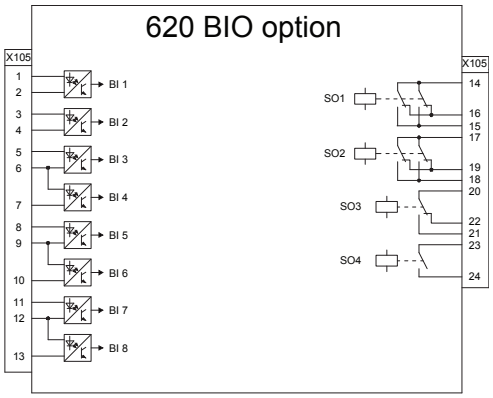

Figure 11: Optional BIO0005 module (slot X105)

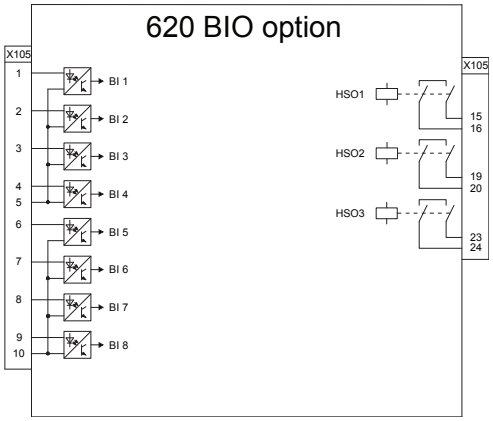

Figure 12: Optional BIO0007 module for fast outputs (slot X105)

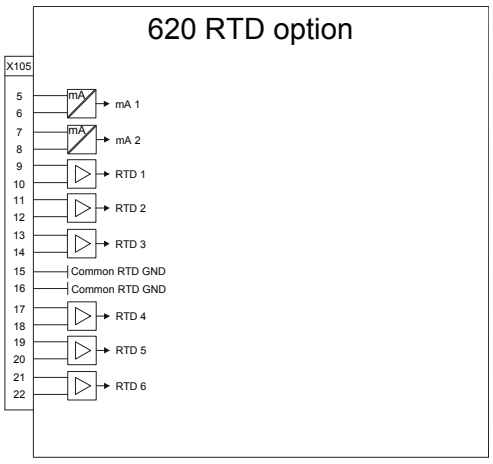

Figure 13: Optional RTD0003 module (slot X105)

3.4 Presentation of default configurations

Functional diagrams

The functional diagrams describe the IED's functionality from the protection, measuring, condition monitoring, disturbance recording, control and interlocking perspective. Diagrams show the default functionality with simple symbol logics forming principle diagrams. The external connections to primary devices are also shown, stating the default connections to measuring transformers.The positive measuring direction of directional protection functions is towards the outgoing feeder.

The functional diagrams are divided into sections with each section constituting one functional entity. The external connections are also divided into sections. Only the relevant connections for a particular functional entity are presented in each section.

Protection function blocks are part of the functional diagram. They are identified based on their IEC 61850 name but the IEC based symbol and the ANSI function number are also included. Some function blocks, such as PHHPTOC, are used several times in the configuration. To separate the blocks from each other, the IEC 61850 name, IEC symbol and ANSI function number are appended with a running number, that is an instance number, from one upwards.

Signal Matrix and Application Configuration

With Signal Matrix and Application Configuration in PCM600, it is possible to modify the default configuration according to the actual needs. The IED is delivered from the factory with default connections described in the functional diagrams for binary inputs, binary outputs, function-to-function connections and alarm LEDs. The Signal Matrix is used for GOOSE signal input engineering and for making cross-references between the physical I/O signals and the function blocks. The Signal Matrix tool cannot be used for adding or removing function blocks, for example, GOOSE receive function blocks. The Application Configuration tool is used for these kind of operations. If a function block is removed with Application Configuration, the function related data disappears from the menus as well as from the 61850 data model, with the exception of some basic function blocks, which are mandatory and thus cannot be removed from the IED configuration by removing them from the Application Configuration.

3.5 Default configuration A

3.5.1 Applications

The default configuration is designed for differential protection and mainly intended for comprehensive protection and control functionality of circuit breaker controlled asynchronous motors. With minor modifications this default configuration can be applied also for contactor controlled motors.

The IED with a default configuration is delivered from the factory with default settings and parameters. The end-user flexibility for incoming, outgoing and internal signal designation within the IED enables this configuration to be further adapted to different primary circuit layouts and the related functionality needs by modifying the internal functionality using PCM600.

The default configuration can also be used with double bus arrangements. If the voltages are measured form the bus side in adouble busbar configuration, an external voltage switch is needed to bring the right voltage set to the IED.

The configuration can also be modified to be used with several different start connection schemes by utilizing the available controllable blocks.

3.5.2 Functions

Table 9: Functions included in the default configuration A

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	3I> -> (1)	67-1 (1)
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, high stage, instance 1	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage, instance 1	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Residual overvoltage protection, instance 1	ROVPTOV1	Uo> (1)	59G (1)
Residual overvoltage protection, instance 2	ROVPTOV2	Uo> (2)	59G (2)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Residual overvoltage protection, instance 3	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	3U< (2)	27 (2)
Three-phase undervoltage protection, instance 3	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection, instance 1	PHPTOV1	3U> (1)	59 (1)
Three-phase overvoltage protection, instance 2	PHPTOV2	3U> (2)	59 (2)
Three-phase overvoltage protection, instance 3	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection, instance 1	PSPTUV1	U1< (1)	47U+ (1)
Positive-sequence undervoltage protection, instance 2	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection, instance 1	NSPTOV1	U2> (1)	47O- (1)
Negative-sequence overvoltage protection, instance 2	NSPTOV2	U2> (2)	47O- (2)
Frequency protection, instance 1	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
Frequency protection, instance 2	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
Frequency protection, instance 3	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Frequency protection, instance 4	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
Frequency protection, instance 5	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
Frequency protection, instance 6	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Negative-sequence overcurrent protection for motors, instance 1	MNSPTOC1	I2>M (1)	46M (1)
Negative-sequence overcurrent protection for motors, instance 2	MNSPTOC2	I2>M (2)	46M (2)
Loss of load supervision, instance 1	LOFLPTUC1	3I< (1)	37M (1)
Loss of load supervision, instance 2	LOFLPTUC2	3I< (2)	37M (2)
Motor load jam protection	JAMPTOC1	Ist> (1)	51LR (1)
Motor start-up supervision	STTPMSU1	Is2t>, n> (1)	49,66,48,51LR (1)
Phase reversal protection	PREVPTOC1	I2>> (1)	46R (1)
Thermal overload protection for motors	MPTTR1	3Ith>M (1)	49M (1)
Motor differential protection	MPDIF1	3dI>M (1)	87M (1)
Circuit breaker failure protection, instance 1	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Circuit breaker failure protection, instance 2	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
Master trip, instance 1	TRPPTRC1	Master Trip (1)	94/86 (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Master trip, instance 2	TRPPTRC2	Master Trip (2)	94/86 (2)
Arc protection, instance 1	ARCSARC1	ARC (1)	50L/50NL (1)
Arc protection, instance 2	ARCSARC2	ARC (2)	50L/50NL (2)
Arc protection, instance 3	ARCSARC3	ARC (3)	50L/50NL (3)
Multipurpose analog protection, instance 1	MAPGAPC1	MAP (1)	MAP (1)
Multipurpose analog protection, instance 2	MAPGAPC2	MAP (2)	MAP (2)
Multipurpose analog protection, instance 3	MAPGAPC3	MAP (3)	MAP (3)
Multipurpose analog protection, instance 4	MAPGAPC4	MAP (4)	MAP (4)
Multipurpose analog protection, instance 5	MAPGAPC5	MAP (5)	MAP (5)
Multipurpose analog protection, instance 6	MAPGAPC6	MAP (6)	MAP (6)
Multipurpose analog protection, instance 7	MAPGAPC7	MAP (7)	MAP (7)
Multipurpose analog protection, instance 8	MAPGAPC8	MAP (8)	MAP (8)
Multipurpose analog protection, instance 9	MAPGAPC9	MAP (9)	MAP (9)
Multipurpose analog protection, instance 10	MAPGAPC10	MAP (10)	MAP (10)
Multipurpose analog protection, instance 11	MAPGAPC11	MAP (11)	MAP (11)
Multipurpose analog protection, instance 12	MAPGAPC12	MAP (12)	MAP (12)
Control			
Circuit-breaker control, instance 1	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Circuit-breaker control, instance 2	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
Disconnector control, instance 1	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
Disconnector control, instance 2	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control, instance 1	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector control, instance 3	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
Disconnector control, instance 4	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control, instance 2	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
Disconnector position indication, instance 1	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
Disconnector position indication, instance 2	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
Earthing switch position indication, instance 1	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Disconnector position indication, instance 3	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Disconnector position indication, instance 4	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch position indication, instance 2	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Emergergency startup	ESMGAPC1	ESTART (1)	ESTART (1)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)
Condition monitoring			
Circuit-breaker condition monitoring, instance 1	SSCBR1	CBCM (1)	52CM (1)
Circuit-breaker condition monitoring, instance 2	SSCBR2	CBCM (2)	52CM (2)
Trip circuit supervision, instance 1	TCSSCBR1	TCS (1)	TCM (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision, instance 1	CCRDIF1	MCS 3I (1)	CSM 3I (1)
Fuse failure supervision	SEQRFUF1	FUSEF (1)	60 (1)
Runtime counter for machines and devices, instance 1	MDSOPT1	OPTS (1)	OPTM (1)
Runtime counter for machines and devices, instance 2	MDSOPT2	OPTS (2)	OPTM (2)
Measurement			
Three-phase current measurement, instance 1	CMMXU1	3I (1)	3I (1)
Three-phase current measurement, instance 2	CMMXU2	3I(B) (1)	3I(B) (1)
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement, instance 1	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vn (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
Frequency measurement	FMMXU1	f (1)	f (1)
Other			
Minimum pulse timer (2 pcs), instance 1	TPGAPC1	TP (1)	TP (1)
Minimum pulse timer (2 pcs), instance 2	TPGAPC2	TP (2)	TP (2)
Minimum pulse timer (2 pcs), instance 3	TPGAPC3	TP (3)	TP (3)
Minimum pulse timer (2 pcs), instance 4	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution), instance 1	TPSGAPC1	TPS (1)	TPS (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Minimum pulse timer (2 pcs, second resolution), instance 2	TPSGAPC2	TPS (2)	TPS (2)
Minimum pulse timer (2 pcs, minute resolution), instance 1	TPMGAPC1	TPM (1)	TPM (1)
Minimum pulse timer (2 pcs, minute resolution), instance 2	TPMGAPC2	TPM (2)	TPM (2)
Pulse timer (8 pcs), instance 1	PTGAPC1	PT (1)	PT (1)
Pulse timer (8 pcs), instance 2	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF (1)	TOF (1)
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF (2)	TOF (2)
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF (3)	TOF (3)
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs), instance 1	TONGAPC1	TON (1)	TON (1)
Time delay on (8 pcs), instance 2	TONGAPC2	TON (2)	TON (2)
Time delay on (8 pcs), instance 3	TONGAPC3	TON (3)	TON (3)
Time delay on (8 pcs), instance 4	TONGAPC4	TON (4)	TON (4)
Set reset (8 pcs), instance 1	SRGAPC1	SR (1)	SR (1)
Set reset (8 pcs), instance 2	SRGAPC2	SR (2)	SR (2)
Set reset (8 pcs), instance 3	SRGAPC3	SR (3)	SR (3)
Set reset (8 pcs), instance 4	SRGAPC4	SR (4)	SR (4)
Move (8 pcs), instance 1	MVGAPC1	MV (1)	MV (1)
Move (8 pcs), instance 2	MVGAPC2	MV (2)	MV (2)
Move (8 pcs), instance 3	MVGAPC3	MV (3)	MV (3)
Move (8 pcs), instance 4	MVGAPC4	MV (4)	MV (4)
Generic control points, instance 1	SPCGGIO1	SPCGGIO (1)	SPCGGIO (1)
Generic control points, instance 2	SPCGGIO2	SPCGGIO (2)	SPCGGIO (2)
Generic control points, instance 3	SPCGGIO3	SPCGGIO (3)	SPCGGIO (3)
Remote Generic control points	SPCRGGIO1	SPCRGGIO (1)	SPCRGGIO (1)
Local Generic control points	SPCLGGIO1	SPCLGGIO (1)	SPCLGGIO (1)
Generic Up-Down Counters, instance 1	UDFCNT1	UDCNT (1)	UDCNT (1)
Generic Up-Down Counters, instance 2	UDFCNT2	UDCNT (2)	UDCNT (2)
Generic Up-Down Counters, instance 3	UDFCNT3	UDCNT (3)	UDCNT (3)
Generic Up-Down Counters, instance 4	UDFCNT4	UDCNT (4)	UDCNT (4)
Generic Up-Down Counters, instance 5	UDFCNT5	UDCNT (5)	UDCNT (5)
Generic Up-Down Counters, instance 6	UDFCNT6	UDCNT (6)	UDCNT (6)
Generic Up-Down Counters, instance 7	UDFCNT7	UDCNT (7)	UDCNT (7)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Generic Up-Down Counters, instance 8	UDFCNT8	UDCNT (8)	UDCNT (8)
Generic Up-Down Counters, instance 9	UDFCNT9	UDCNT (9)	UDCNT (9)
Generic Up-Down Counters, instance 10	UDFCNT10	UDCNT (10)	UDCNT (10)
Generic Up-Down Counters, instance 11	UDFCNT11	UDCNT (11)	UDCNT (11)
Generic Up-Down Counters, instance 12	UDFCNT12	UDCNT (12)	UDCNT (12)
Programmable buttons(16 buttons)	FKEYGGIO1	FKEY (1)	FKEY (1)
Logging functions			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Fault recorder	FLTMSTA1	FR (1)	FR (1)
Sequence event recorder	SER1	SER (1)	SER (1)
Load profile	LDPMSTA1	LOADPROF (1)	LOADPROF (1)

3.5.2.1 Default I/O connections

Table 10: Default connections for analog inputs

Analog input	Default usage	Connector pins
IL1_N	Phase A current,neutral side	X120-1,2
IL2_N	Phase B current,neutral side	X120-3,4
IL3_N	Phase C current,neutral side	X120-5,6
IL1	Phase A current,terminal side	X120-7,8
IL2	Phase B current,terminal side	X120-9,10
IL3	Phase C current,terminal side	X120-11,12
Io	Residual current	X120-13,14
U_SYN	Phase-to-phase voltage U12, terminal side	X130-9,10
U1	Phase-to-phase voltage U12, bus side	X130-11,12
U2	Phase-to-phase voltage U23, bus side	X130-13,14
U3	Phase-to-phase voltage U31, bus side	X130-15,16
Uo	Residual voltage, bus side	X130-17,18
X110-RTD1	Motor winding U temperature	X110-9,10
X110-RTD2	Motor winding V temperature	X110-11,12
X110-RTD3	Motor winding W temperature	X110-13,14
X110-RTD4	Motor cooling air temperature	X110-17,18
X110-RTD5	Motor bearing temperature	X110-19,20
X110-RTD6	Motor ambient temperature	X110-21,22

Table 11: Default connections for binary inputs

Binary input	Default usage	Connector pins
X105-BI1	Rotation direction	X105-1,2
X105-BI2	Emergency start enable	X105-3,4
X105-BI3	External restart inhibit	X105-5,6
X105-BI4	External trip	X105-7,6
X105-BI5	Emergency start	X105-8,9
X105-BI6	Emergency stop	X105-10,9
X105-BI7	Line MCB open position indication	X105-11,12
X105-BI8	-	X105-13,12
X115-BI1	Circuit breaker closed position indication	X115-1,2
X115-BI2	Circuit breaker open position indication	X115-3,4
X115-BI3	Circuit breaker low gas pressure alarm	X115-5,6
X115-BI4	Circuit breaker spring charged indication	X115-7,6
X115-BI5	Earthing switch 1 closed position indication	X115-8,9
X115-BI6	Earthing switch 1 open position indication	X115-10,9
X115-BI7	Speed switch (motor running)	X115-11,12
X115-BI8	Bus MCB open position indication	X115-13,12
X130-BI1	Disconnector 1 closed position indication	X130-1,2
X130-BI2	Disconnector 1 open position indication	X130-3,4
X130-BI3	Disconnector 2 closed position indication	X130-5,6
X130-BI4	Disconnector 2 open position indication	X130-7,8

Table 12: Default connections for binary outputs

Binary input	Default usage	Connector pins
X100-PO1	Restart enable	X100-6,7
X100-PO2	Breaker failure backup trip to upstream breaker	X100-8,9
X100-SO1	General start indication	X100-10,11,(12)
X100-SO2	General operate indication	X100-13,14
X100-PO3	Open circuit breaker/trip	X100-15,19
X100-PO4	Close circuit breaker	X100-20,24
X115-SO1	Motor startup indication	X115-14,15,16
X115-SO2	Open command (for contactor applications)	X115-17,18,19
X115-SO3	Thermal overload alarm	X115-20,21,22
X115-SO4	Motor differential protection operate alarm	X115-23,24

Table 13: Default connections for LEDs

LED	Default usage
1	Motor differential protection biased stage operate
2	Motor differential protection instantaneous stage operate
3	Short circuit protection operate
4	Combined protection indication of the other protection functions
5	Thermal overload protection operate
6	Motor restart inhibit
7	Circuit breaker failure protection backup protection operate
8	Circuit breaker condition monitoring alarm
9	Supervision alarm
10	Emergency start enabled
11	Arc fault detected

Table 14: Default connections for function keys

FK_Left	Default usage	FK_Right	Default usage
1	Setting Group 1 Enabled	9	Disturbance Recorder Manual Trigger
2	Setting Group 2 Enabled	10	Trip Lockout Reset
3	Setting Group 3 Enabled	11	Circuit Breaker Block Bypass
4	Setting Group 4 Enabled	12	Restart Inhibit
5	Setting Group 5 Enabled	13	-
6	Setting Group 6 Enabled	14	-
7	-	15	-
8	Emergency Start	16	Emergency Stop

3.5.2.2 Default disturbance recorder settings

Table 15: Default disturbance recorder settings binary channels

Channel	Id text	Level trigger mode
1	PHLPTOC1_START	1
2	PHIPTOC1_START	1
3	DPHLPDOC1_START	1
4	DPHHPDOC1_START	1
5	DPHHPDOC2_START	1
6	PHxPTOC or DPHxPDOC_OPERATE	4
7	EFLPTOC1_START	1
8	EFHPTOC1_START	1
9	EFIPTOC1_START	1

Table continues on next page

Channel	Id text	Level trigger mode
10	DEFLPDEF1_START	1
11	DEFHPDEF1_START	1
12	EFxPTOC or DEFxPDEF_OPERATE	4
13	ROVPTOV1/2/3_START	1
14	ROVPTOV1/2/3_OPERATE	4
15	PHPTUV or PHPTOV or PSPTUVor NSPTOV_START	1
16	PHPTUV or PHPTOV or PSPTUV or NSPTOV_OPERATE	4
17	FRPFRQ_START	1
18	FRPFRQ_OPERATE	4
19	MNSPTOC1_START	1
20	MNSPTOC2_START	1
21	MNSPTOC1/2_BLK_RESTART	1
22	MNSPTOC1/2_OPERATE	4
23	LOFLPTUC1_START	1
24	LOFLPTUC2_START	1
25	LOFPTUC1/2_OPERATE	4
26	MPTTR1_ALARM	4
27	MPTTR1_BLK_RESTART	1
28	MPTTR1_OPERATE	4
29	PREVPTOC1_START	1
30	PREVPTOC1_OPERATE	4
31	ESMGAPC_ST_EMERG_ENA	1
32	MPDIF1_OPERATE	4
33	MPDIF1_OPR_LS	4
34	MPDIF1_OPR_HS	4
35	MPDIF1_INT_BLKD	4
36	JAMPTOC1_OPERATE	4
37	STTPMSU1_MOT_START	1
38	STTPMSU1_LOCK_START	1
39	STTPMSU1_OPR_IIT	4
40	STTPMSU1_OPR_STALL	4
41	ARCSARC1_ARC_FLT_DET	4
42	ARCSARC2_ARC_FLT_DET	4
43	ARCSARC3_ARC_FLT_DET	4
44	ARCSARC1/2/3_OPERATE	4
45	SEQRFUF1_FUSEF_3PH	4
46	SEQRFUF1_FUSEF_U	4
47	CCRDIF1_FAIL	4

Table continues on next page

Channel	Id text	Level trigger mode
48	CCBRBRF1_TRRET	4
49	CCBRBRF1_TRBU	4
50	CB Closed	4
51	CB Open	4
52	Emergency Start Enable	4
53	Bus MCB Open	4
54	Line MCB Open	4
55	External Restart Inhibit	4
56	Speed Switch	4
57	Rotation Direction	4
58	MDSOPT1_ALARM	4
59	MAPGAPC1_START	1
60	MAPGAPC2_START	1
61	MAPGAPC3_START	1
62	MAPGAPC1/2/3_OPERATE	4
63	-	-
64	FKEY K9_DR Manual Trigger	1

Additionally, all the digital inputs that are connected by default are also enabled with the setting. Default triggering settings are selected depending on the connected input signal type. Typically all protection START signals are selected to trigger the disturbance recorded by default.

Table 16: Default analog channel selection and text settings

Channel	Selection and text
1	IL1
2	IL2
3	IL3
4	IL1B[1)]
5	IL2B[1)]
6	IL3B[1)]
7	I0
8	U0
9	U1
10	U2
11	U3
12	U1B

1) ILxB in this table refers to ILx_N in the connection diagrams.

3.5.2.3 Default operation mode for generic control point

Table 17: Default operation modes

Channel	Signal name	Value	Pulse length
1	SG1 Enabled	Pulsed	150 ms
2	SG2 Enabled	Pulsed	150 ms
3	SG3 Enabled	Pulsed	150 ms
4	SG4 Enabled	Pulsed	150 ms
5	SG5 Enabled	Pulsed	150 ms
6	SG6 Enabled	Pulsed	150 ms
7		Off	1000 ms
8	Emergency Start	Pulsed	150 ms
9	DR Trigger	Pulsed	150 ms
10	Trip Lockout Reset	Pulsed	150 ms
11	CB Block Bypass	Toggle	1000 ms
12	Restart Inhibit	Toggle	1000 ms
13		Off	1000 ms
14		Off	1000 ms
15		Off	1000 ms
16	Emergency Stop	Pulsed	150 ms
Grey cells indicate different default settings.			

3.5.3 Functional diagrams

The functional diagrams describe the default input, output, programmable LED, and function-to-function connections of default configuration. The default connections can be viewed and changed with PCM600 according to the application requirements, if necessary.

The analog channels, measurements from CTs and VTs have fixed connections to the different function blocks inside the IED. Exceptions from this rule are the 12 analog channels available for the disturbance recorder function. These channels are freely selectable and a part of the disturbance recorder’s parameter settings.

The signal marked with 3I represents the three phase currents from the terminal side of the motor. The signal marked with 3IB represents the three phase currents from the neutral side of the motor. The signal Io represents the measured residual current, fed from either residually connected CTs or an external core balance CT or neutral CT, depending on application.

The signal marked with 3U represents the three phase system voltages on the bus. These inputs are connected in Delta, which are typically fed from open-delta (V connected) VTs from the system. When star connected VT is available in the system, the VT inputs in the IED are star connected and configuration setting is

suitably changed. In addition, the signal marked with Uo represents the measured residual voltage via open-delta connected VTs.

The signal marked Usyn is measured from the VT on the terminal side of the motor. This signal is used to check synchronizing purposes. The input is fixed to phase-to-phase voltage U12 from motor terminal.

When power system is provided with open-delta VT (V connected), since there is no way to measure or estimate the system zero sequence voltage, directional earth-fault protection is polarized by negative-sequence voltage polarization method only.

There are 16 programmable push buttons offered in the front panel of the unit. The IED offers six different settings group which the user can set based on individual needs. Each group can then, be activated or deactivated by using a programmable button. In addition to this, the programmable button can be also used for emergency start and emergency stop, manual trigger of disturbance recorder, master trip lockout reset, circuit breaker control interlocking bypass, restart inhibit, and so on.

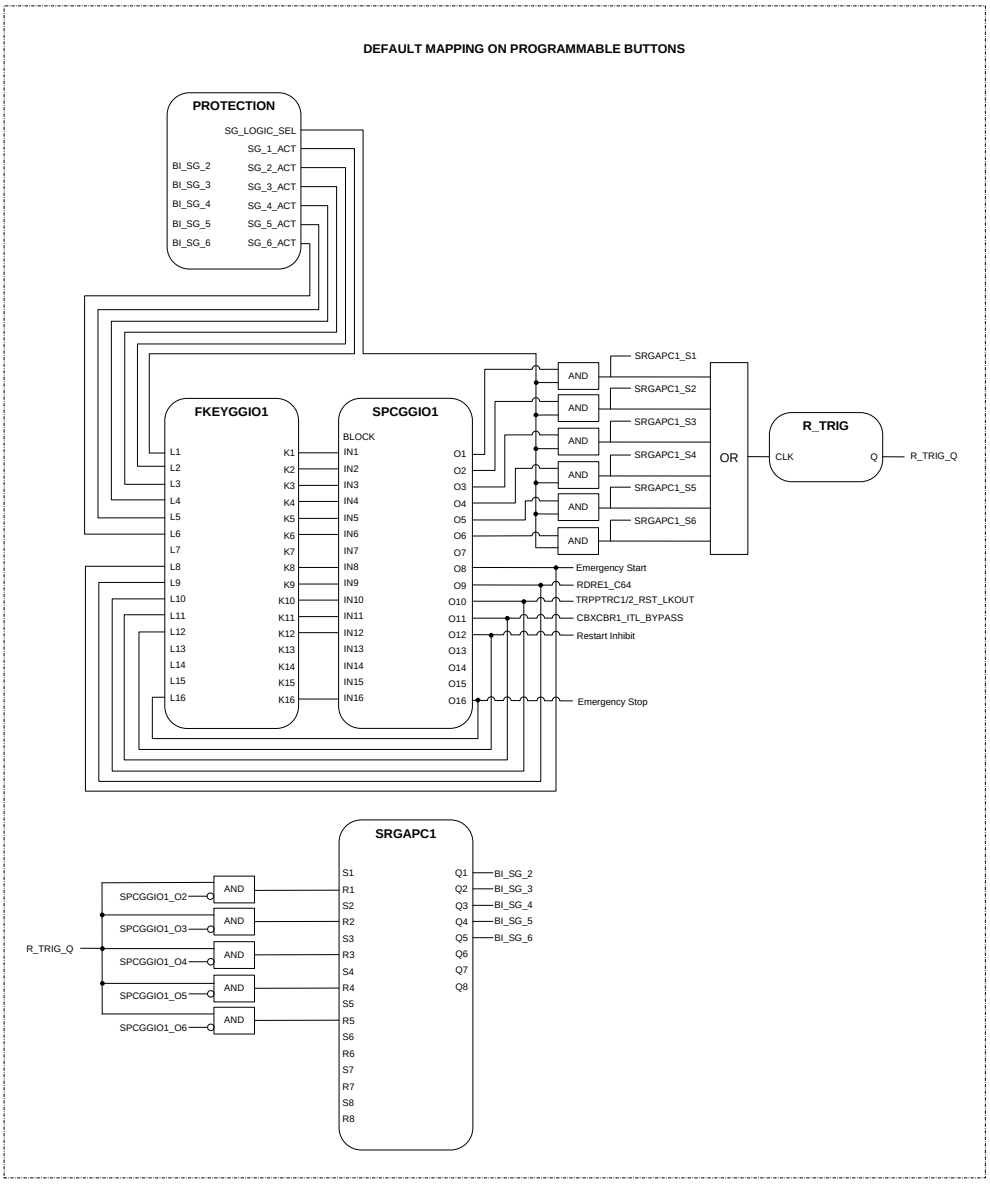

Figure 14: Default mapping on programmable buttons

3.5.3.1 Functional diagrams for protection

The functional diagrams describe the IED's protection functionality in detail and picture the default connections.

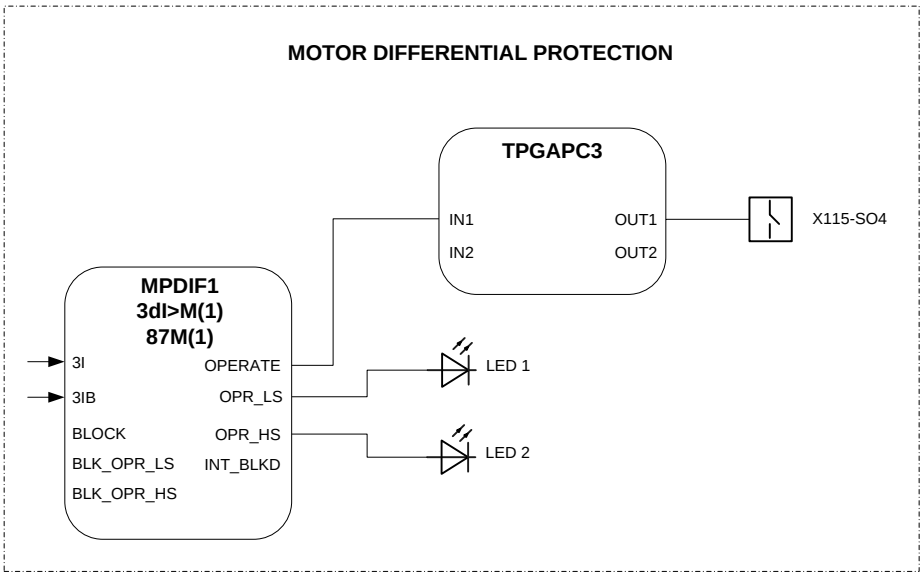

Figure 15: Motor differential protection

The motor differential protection MPDIF1 is used to detect motor internal winding faults. The OPERATE output is connected to the Master Trip and also connected to signal output 4 (X110-SO4:23-24) via generic timer TPGAPC3 .The OPR_LS output is connected to alarm LED 1 and the OPR_HS output is connected to alarm LED 2.

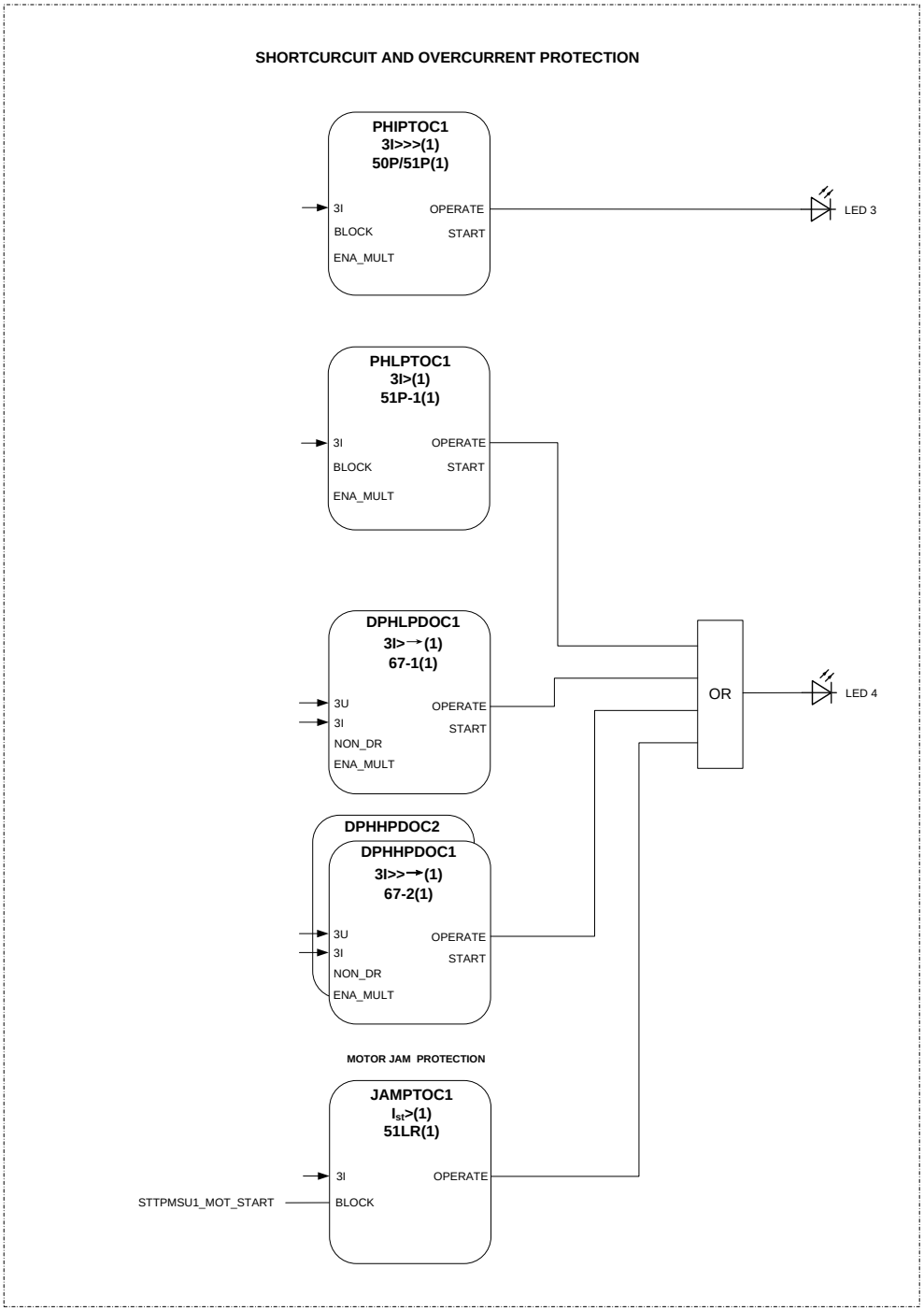

Figure 16: Overcurrent and motor jam protection

Five overcurrent stages in total are offered for overcurrent and short-circuit protection. Three of them (DPHxPDOC) include directional functionality, while two others (PHxPTOC) are only for non-directional overcurrent protection.

PHLPTOC1 is used for overcurrent protection, and PHIPTOC1 for the short-circuit protection. The operation of PHIPTOC1 is not blocked as default by any functionality and it should be set over the motor start current level to avoid unnecessary operation.

The motor load jam protection JAMPTOC1 is used for protecting the motor in stall or mechanical jam situations during the running state. The motor jam protection function JAMPTOC1 is blocked by the motor startup protection function.

The OPERATE outputs are connected to the Master Trip. The OPERATE outputs are also connected to the alarm LED 4, except for PHIPTOC1 is connected to the alarm LED 3. LED 3 is used for short-circuit protection alarm indication; LED 4 is used for combined protection alarm indication, including overcurrent protection, earth-fault protection, phase unbalance protection, voltage protection, motor jam protection, loss of load protection, and frequency protection.

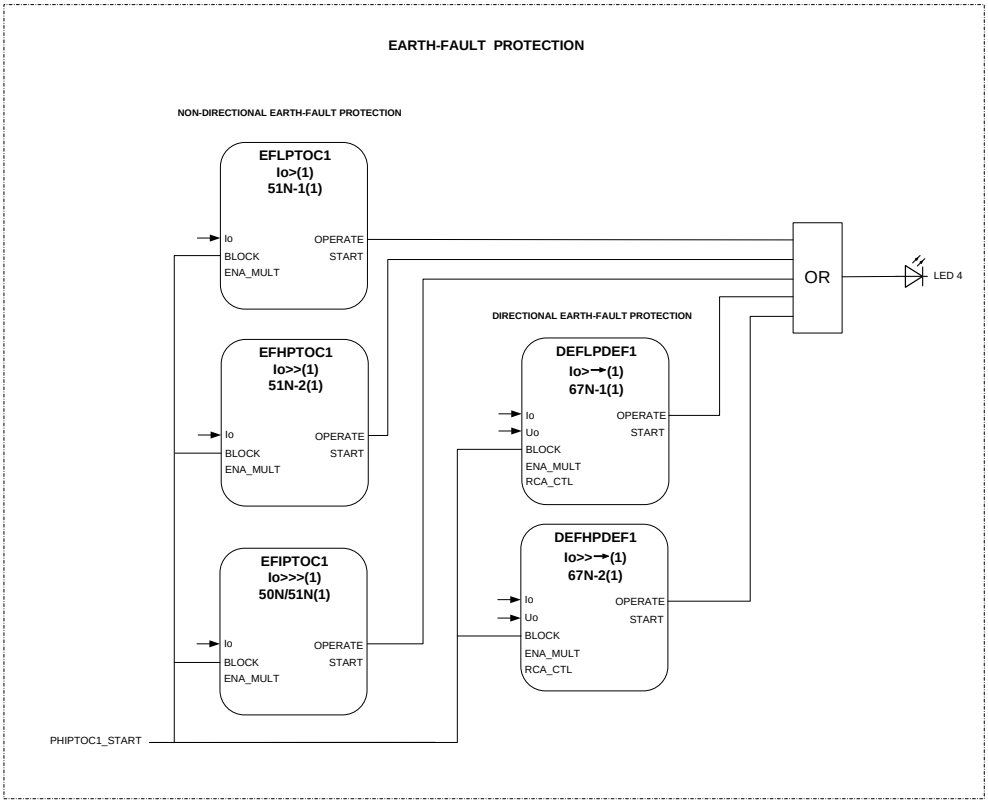

Figure 17: Earth-fault protection

Three stage non-directional earth-fault protection (EFxPTOC) is offered to detect phase-to-earth faults that may be a result of, for example, insulation ageing. In addition, there are two directional protection stages (DEFxPDEF) which can be used as non-directional earth-fault protection without residual voltage requirement. However, the residual voltage can help to detect earth faults at a low fault current level selectively and to discriminate the apparent residual current caused, for example, by partial current transformer saturation at motor startup.

The earth-fault protection is blocked when the short-circuit protection PHIPTOC1 is started. The OPERATE outputs of the earth-fault protection functions are connected to the Master Trip and alarm LED 4.

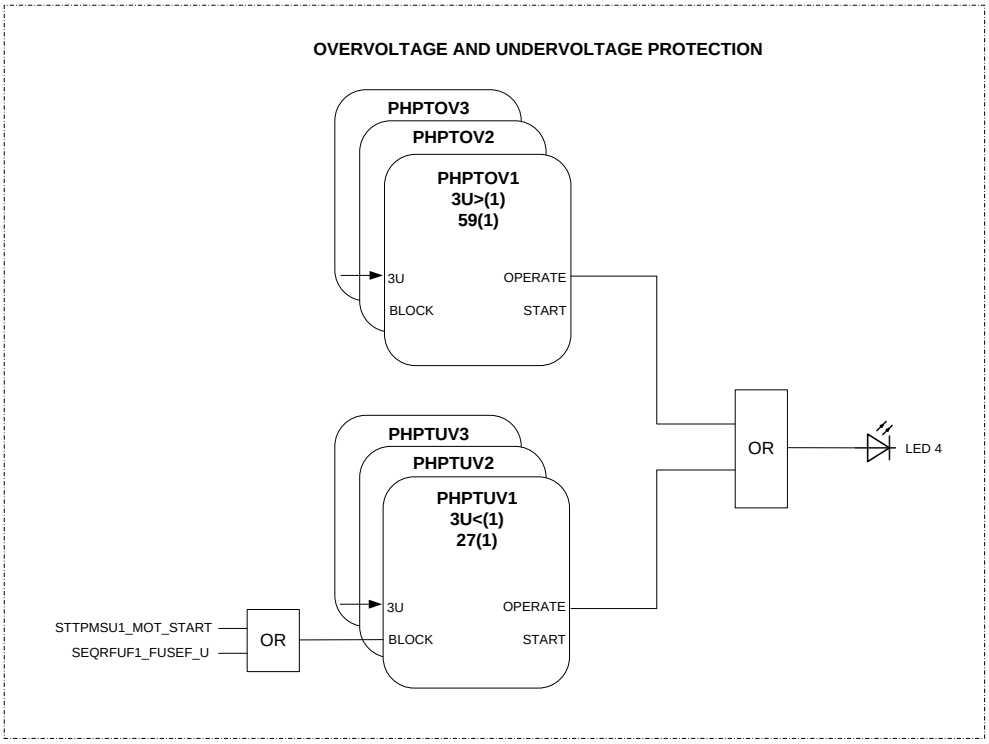

Figure 18: Overvoltage and undervoltage protection

Three overvoltage and undervoltage protection stages PHPTOV and PHPTUV offer protection against abnormal phase voltage conditions. The three-phase undervoltage protection is blocked during motor startup to prevent unwanted operation, in case there is a short voltage drop. Also if the fuse failure is detected, the undervoltage function is blocked.

The OPERATE outputs of voltage functions are connected to the Master Trip and alarm LED 4.

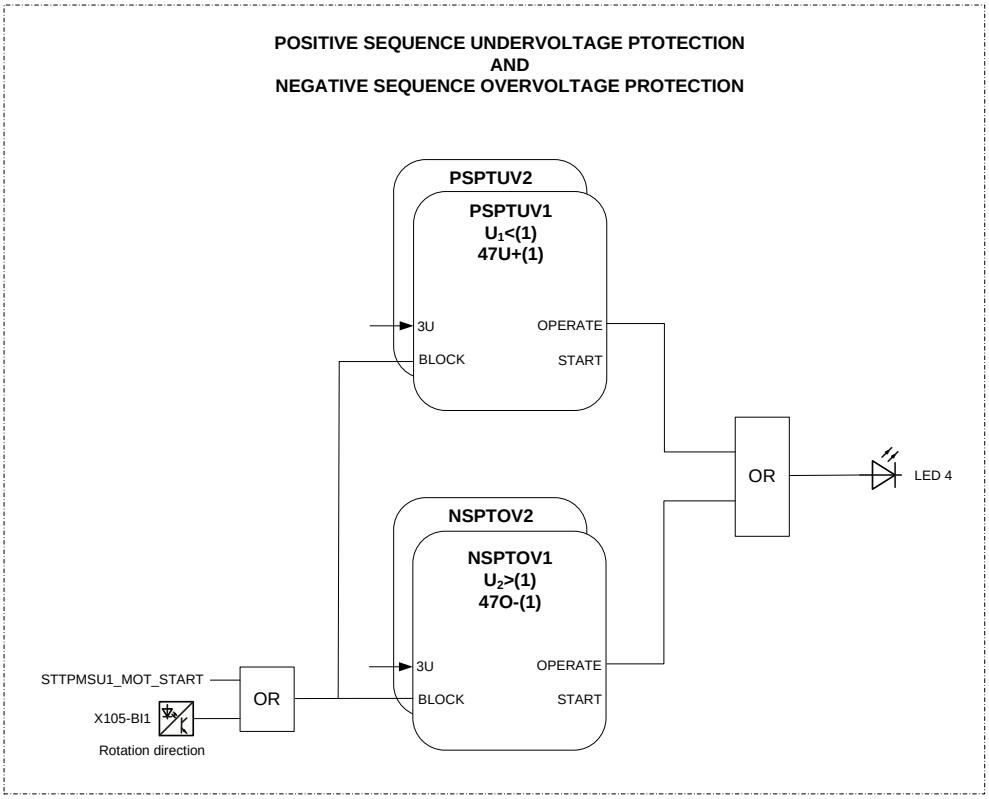

Figure 19: Positive-sequence undervoltage and negative-sequence overvoltage protection

The positive-sequence undervoltage PSPTUV1/2 and negative-sequence overvoltage NSPTOV1/2 protections are included to protect the machine against single-phasing, excessive unbalance between phases and abnormal phase order. The positive-sequence undervoltage and negative-sequence overvoltage functions are blocked during motor startup to prevent unwanted operation, in case there is a short voltage drop. Also the binary input (X105-BI1:1-2) which indicates the motor rotation direction, is used to block these functions by default.

The OPERATE outputs of voltage-sequence functions are connected to the Master Trip and alarm LED 4.

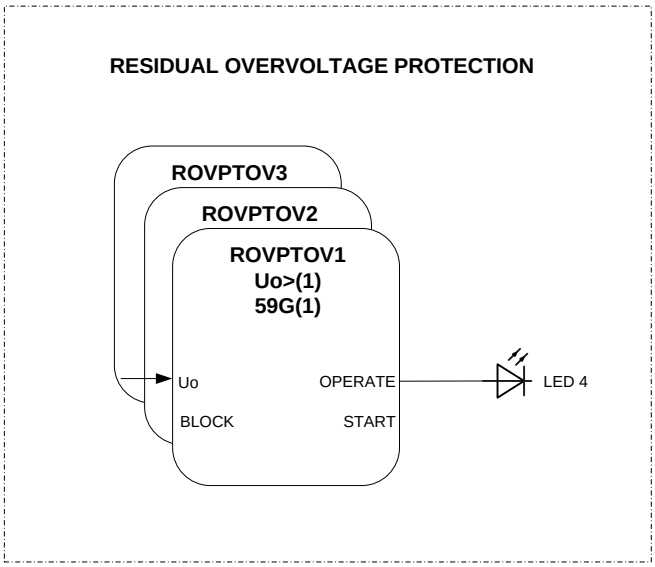

Figure 20: Residual overvoltage protection

The residual overvoltage protection ROVPTOV1...3 provides earth-fault protection by detecting abnormal level of residual voltage. It can be used, for example, as a nonselective backup protection for the selective directional earth-fault functionality. The OPERATE outputs are connected to the Master Trip and alarm LED 4.

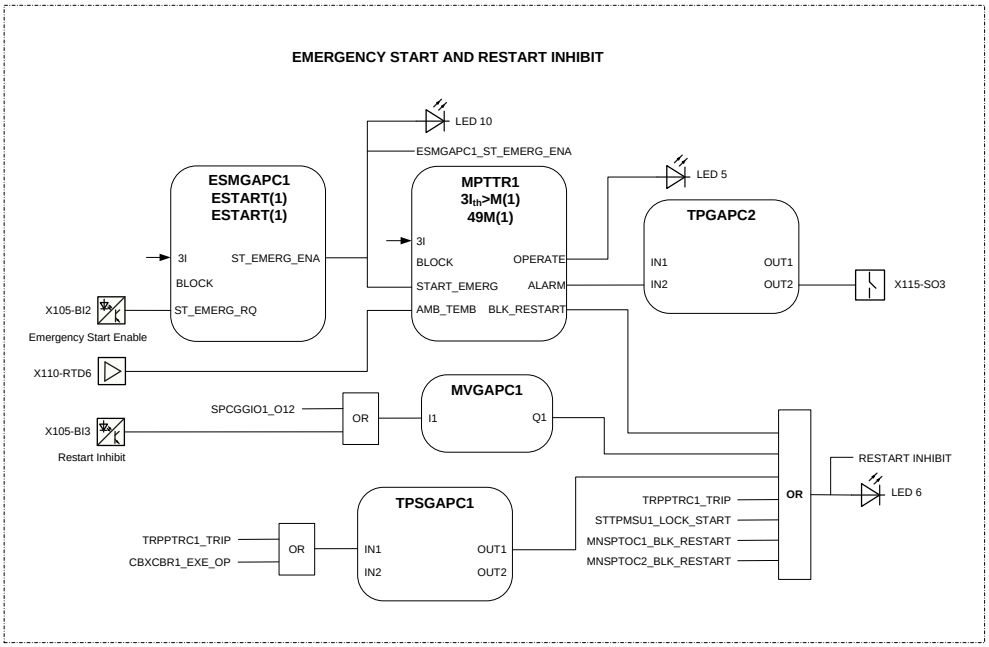

Figure 21: Emergency start and restart inhibit

The emergency start function ESMGAPC1 allows motor startups, although the calculated thermal level or cumulative startup time counter is blocking the restart. The emergency start is enabled for ten minutes after the selected binary input (X105-BI2:3-4) is energized. On the rising edge of the emergency start signal:

- Calculated thermal level in MPTTR1 is set slightly below the restart inhibit level to allow at least one motor startup.
- Value of the cumulative startup time counter STTPMSU1 is set slightly below the set restart inhibit value to allow at least one motor startup.
- Set start value of the MAPGAPC1 function is increased (or decreased) depending on the *Start value Add* setting.
- Alarm LED 10 is activated.

A new emergency start cannot be made until the emergency start signal has been reset and the emergency start time of ten minutes has expired.

The thermal overload protection function MPTTR1 detects short- and long term overloads under varying load conditions. When the emergency start request is issued for the emergency start function, it activates the corresponding input of the thermal overload function. When the thermal overload function has issued a restart blocking, which inhibits the closing of the breaker when the machine is overloaded, the emergency start request removes this blocking and enables the restarting of the motor. The `OPERATE` output of MPTTR1 is connected to alarm LED 5, which is used for thermal overload protection alarm indication. The `ALARM` output of MPTTR1 is connected to signal output 3 (X115-SO3:20-22) via generic timer TPGAPC2.

The restart inhibit is activated for a set period when a circuit breaker is opened. This is called remanence voltage protection, where the motor has damping remanence voltage after circuit breaker opening. Reclosing after a too short period of time can lead to stress for the machine and other apparatuses. The remanence voltage protection waiting time can be set to a timer function TPSGAPC1. The alarm LED 6 is used for restart inhibit alarm indication.

The restart inhibit is also activated when one of four conditions is met.

- An active trip command
- Motor startup supervision has issued lockout
- Motor unbalance function has issued restart blocking
- An external restart inhibit is activated by one push button through `SPCGGIO1_O12` or by a binary input 3 (X105-BI3:5-6) via MVGAPC1

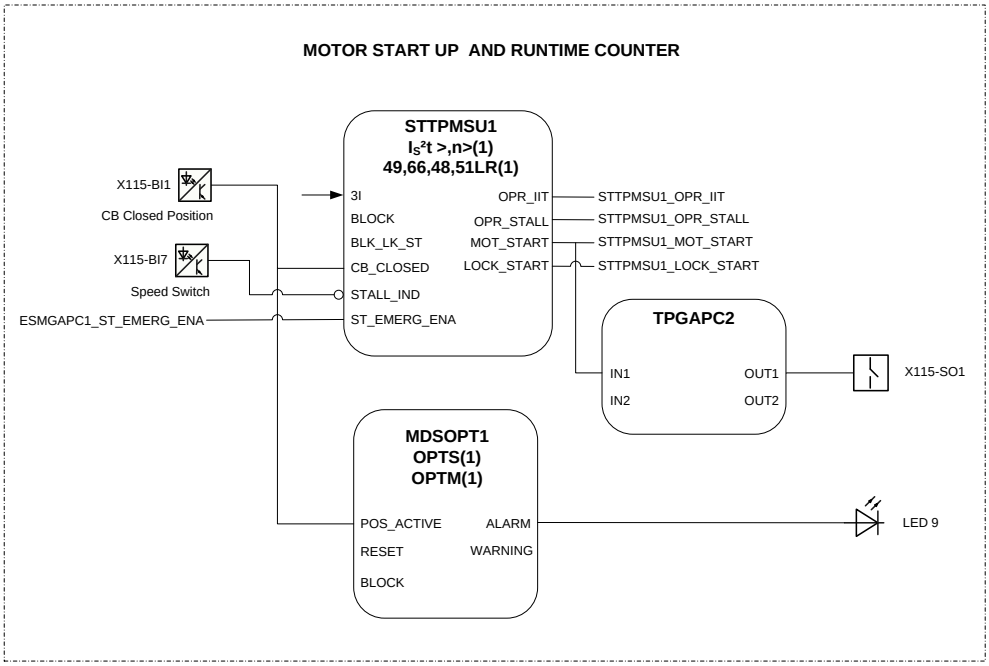

Figure 22: Motor startup supervision

With the motor startup supervision function STTPMSU1, the starting of the motor is supervised by monitoring three-phase currents or the status of the energizing circuit breaker of the motor.

When the emergency start request is activated by ESMGAPC1 and STTPMSU1 is in lockout state, the lockout `LOCK_START` is deactivated and emergency start is available. The `MOT_START` output of STTPMSU1 is connected to signal output 1 (X115-SO1:14-16) via generic timer TPGAPC2.

The motor running time counter MDSOPT1 provides history data since last commissioning. The counter counts the total number of motor running hours and is incremented when the energizing circuit breaker is closed. The alarm of the runtime counter is connected to alarm LED 9. LED 9 is used for general supervision of trip circuit, current measurement circuit, voltage measurement circuit and motor operation time.

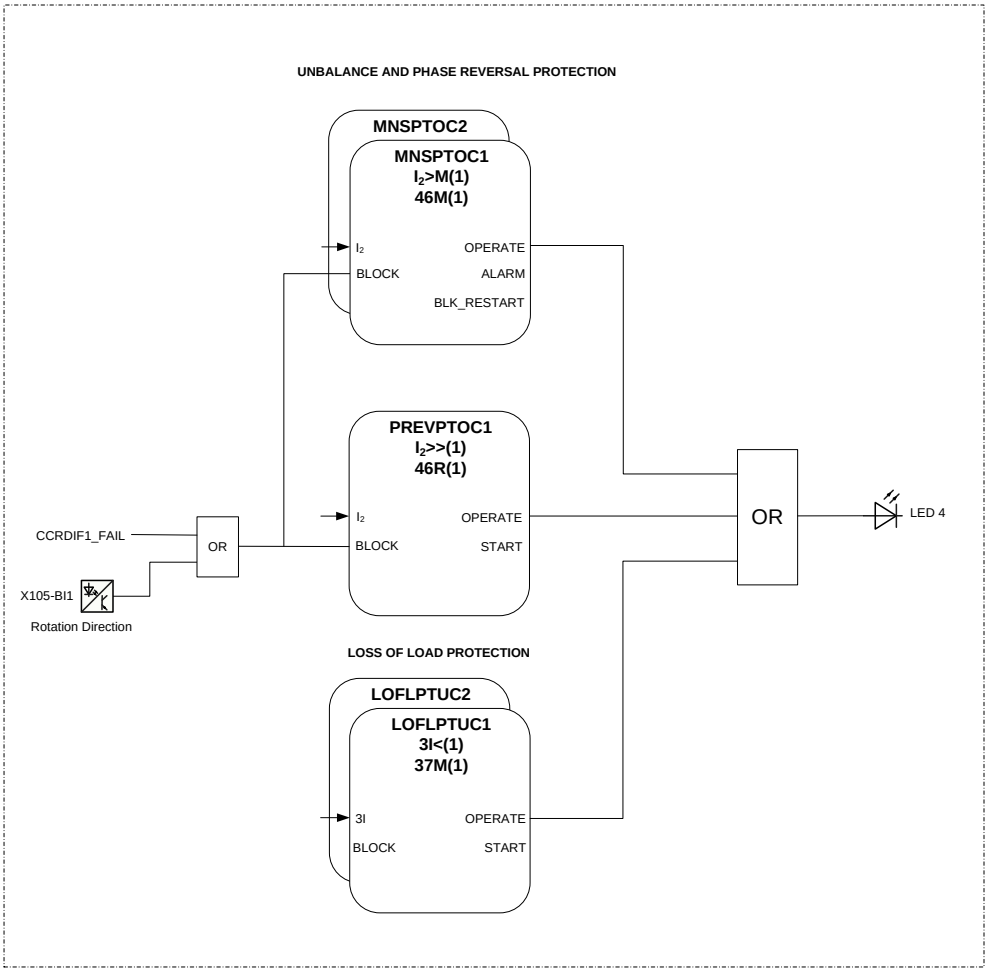

Figure 23: Phase unbalance and loss of load protection

Two negative-sequence overcurrent stages MNSPTOC1 and MNSPTOC2 are offered for phase unbalance protection. These functions are used to protect the motor against phase unbalance caused by, for example, a broken conductor. Phase unbalance in network feeding of the motor causes overheating of the motor.

The phase reversal protection PREVPTOC1 is based on the calculated negative phase-sequence current. It detects too high NPS current values during motor start up, caused by incorrectly connected phases, which in turn causes the motor to rotate in the opposite direction.

The negative-sequence protection and phase reversal protection are blocked if the current circuit supervision detects failure in the current measuring circuit. The binary input (X105-BI1:1-2), which indicates the motor rotation direction, is also used to block these functions by default.

Two stages LOFLPTUC1 and LOFLPTUC2 are offered for loss of load situation protection. The loss of load situation can happen, for example, if there is damaged pump or a broken conveyor.

The OPERATE outputs of above protections are connected to the Master Trip and alarm LED 4.

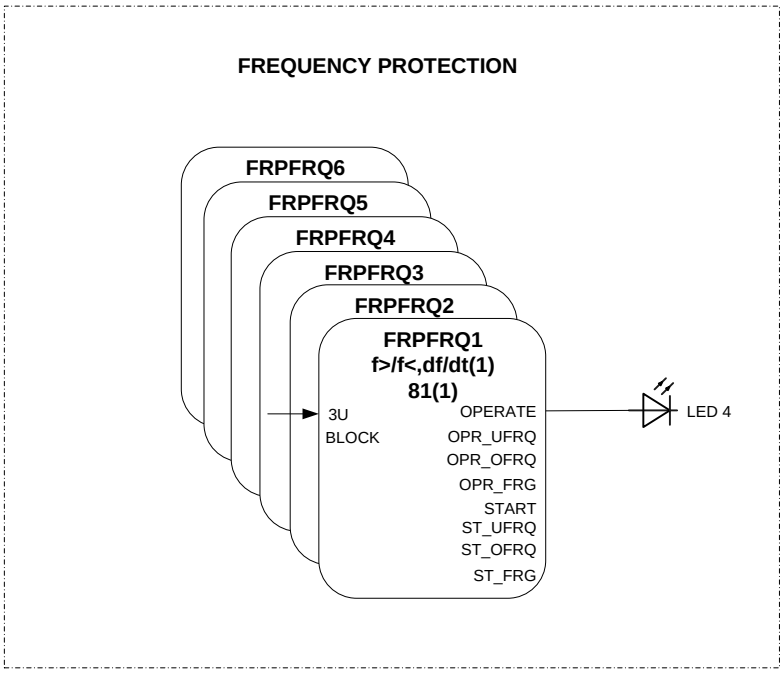

Figure 24: Frequency protection

Six underfrequency or overfrequency protection FRPFRQ1…6 stages are offered to prevent damage to network components under unwanted frequency conditions. The function contains a selectable rate of change of the frequency (gradient) protection to detect an increase or decrease in the fast power system frequency at an early stage. This can be used as an early indication of a disturbance in the system.

The OPERATE outputs are connected to the Master Trip and alarm LED 4.

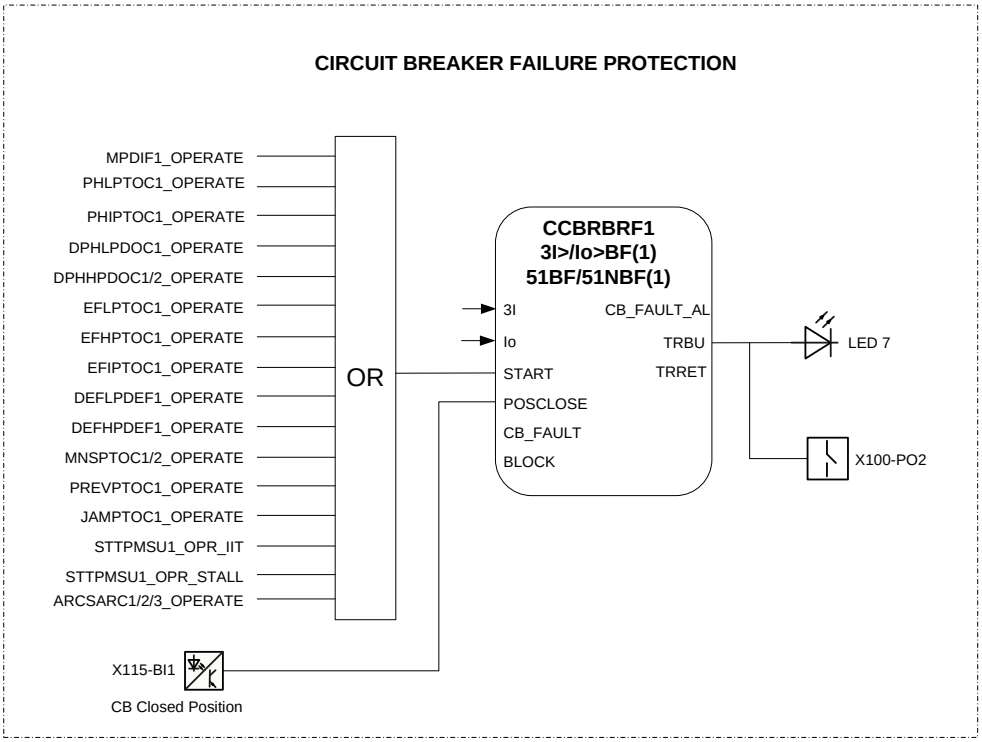

Figure 25: Circuit breaker failure protection

The breaker failure protection CCBRBRF1 is initiated via the START input by a number of different protection stages in the IED. The breaker failure protection function offers different operating modes associated with the circuit breaker position and the measured phase and residual currents.

The breaker failure protection has two operating outputs: TRRET and TRBU. The TRRET output is used for retripping its own breaker through the Master Trip 1. The TRBU output is used to give a backup trip to the breaker feeding upstream. For this purpose, the TRBU output signal is connected to power output 2 (X100-PO2: 8-9) and alarm LED 7. LED 7 is used for backup (TRBU) operate indication.

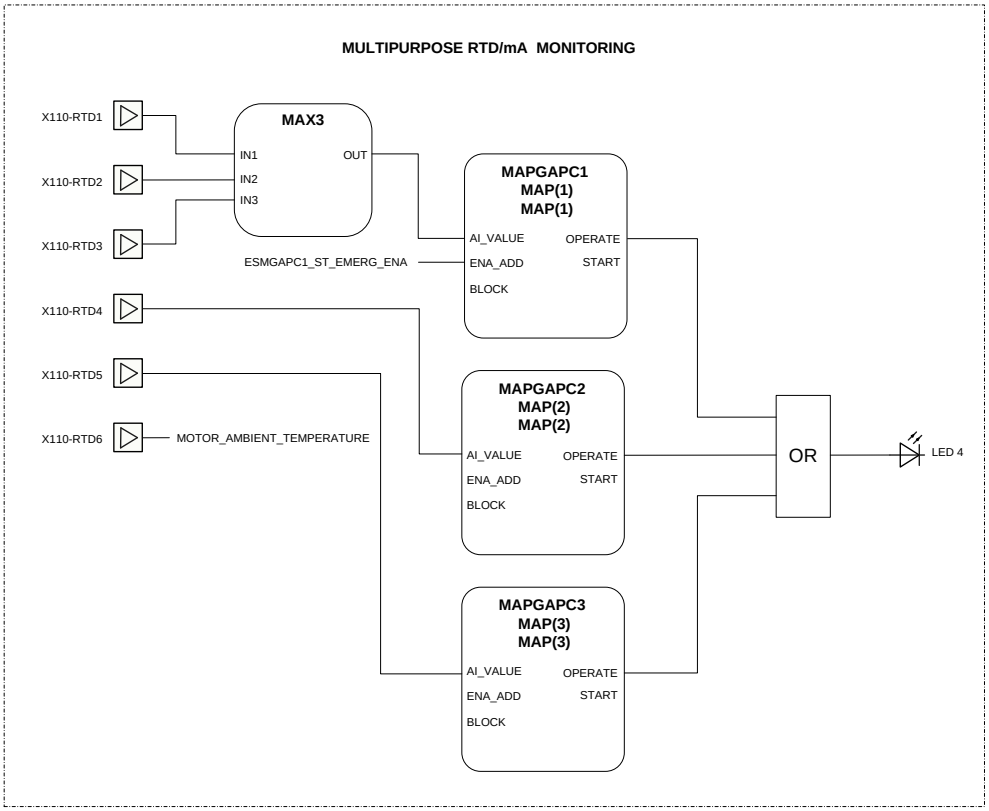

Figure 26: Multipurpose RTD/mA monitoring

RTD/mA monitoring functionality provides several temperature measurements for motor protection. Temperature of the motor windings U, V and W are measured with inputs X110-RTD1 (X110-5,6,11c), X110-RTD2 (X110-7,8,11c) and X110-RTD3 (X110-9,10,11c). Measured values are connected from function X110 (RTD) to function MAX3. Maximum temperature value is then connected to the multipurpose analog protection block MAPGAPC1.

Motor cooling air temperature and motor bearing temperature can be measured with inputs X110-RTD4 (X110-13,14,12c) and X110-RTD5 (X110-15,16,12c). The protection functionality from these temperatures are provided by MAPGAPC2 and MAPGAPC3 functions.

Motor ambient temperature can be measured with input X110-RTD6 (X110-17,18,12c) and it is connected to the thermal overload protection function MPTTR1.

The OPERATE outputs are connected to the Master Trip and alarm LED 4.

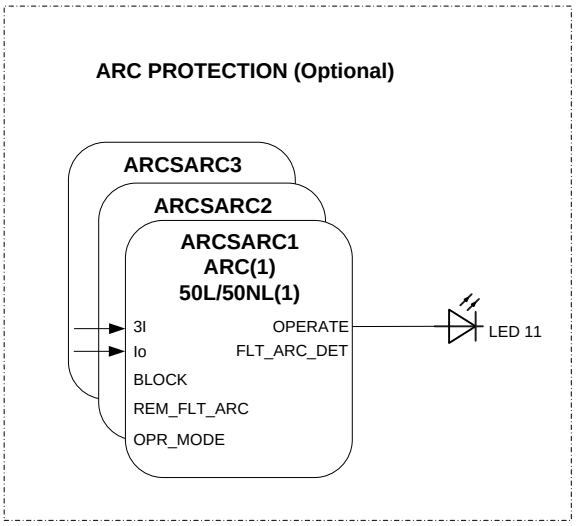

Figure 27: Arc protection

Arc protection ARCSARC1...3 is included as optional function.

The arc protection offers individual function blocks for three arc sensors that can be connected to the IED. Each arc protection function block has two different operation modes, with or without phase and residual current check. The OPERATE outputs from the arc protection function blocks are connected to the Master Trip and alarm LED 11.

3.5.3.2 Functional diagrams for disturbance recorder and trip circuit supervision

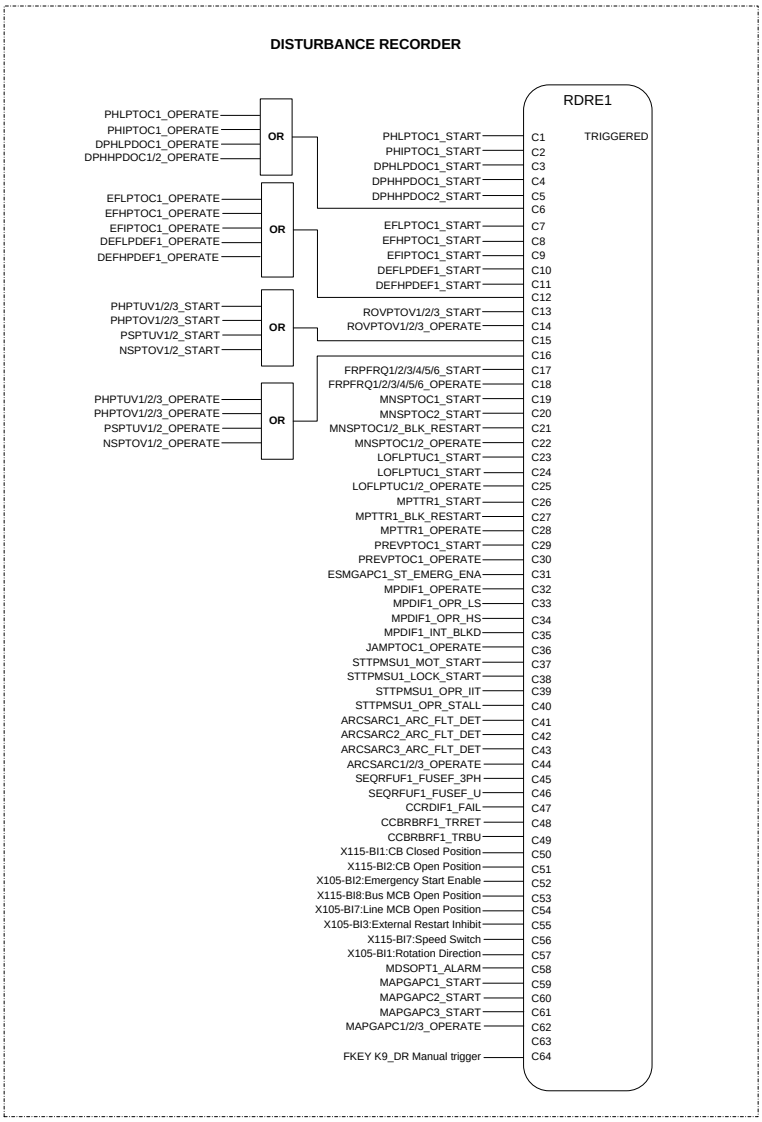

Figure 28: Disturbance recorder

All START and OPERATE outputs from the protection stages are routed to trigger the disturbance recorder or, alternatively, only to be recorded by the disturbance recorder, depending on the parameter settings. Additionally, some selected signals from different functions and eight binary inputs totally from X110 and X115 are also connected.

The manual trigger signal from push button is used to trigger disturbance recorder manually as needed.

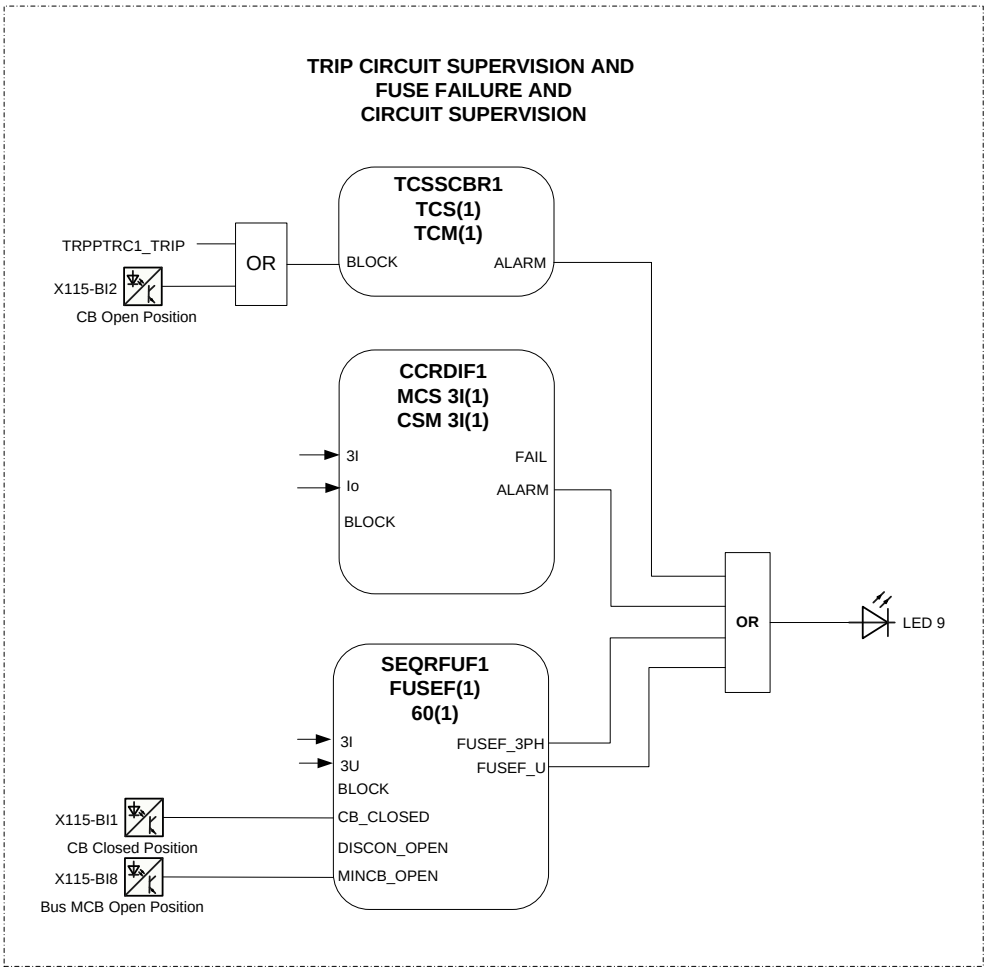

Figure 29: Circuit supervision

One trip circuit supervision function is in used by default, TCSSCBR1 for power output 3 (X100-PO3:15-19). Both functions are blocked by the Master Trip TRPPTRC1 and the circuit breaker open signal. The ALARM output indication is connected to the LED 9.

The fuse failure supervision SEQRFUF1 detects failures in voltage measurement circuits. Failures, such as an open miniature circuit breaker, are detected and the alarm is also connected to the alarm LED 9.

3.5.3.3 Functional diagrams for control and interlocking

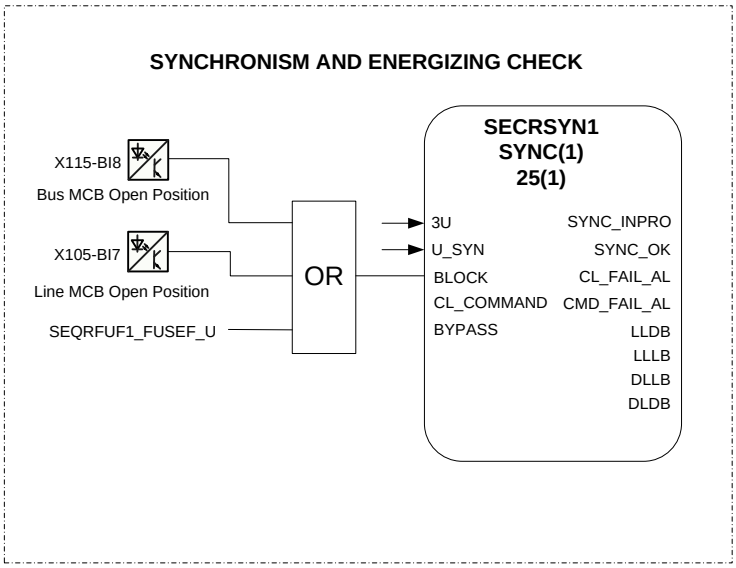

Figure 30: Synchronism and energizing check

The main purpose of the synchronism and energizing check SECRSYN1 is to provide control over the closing of the circuit breakers in power networks and prevent the closing if the conditions for synchronism are not fulfilled.

SECRSYN1 measures the bus and motor terminal voltages and compares them to set conditions. When all the measured quantities are within set limits, the SYNC_OK output is activated for allowing closing or closing the circuit breaker. The SYNC_OK output signal is connected to the ENA_CLOSE input of CBXCBR1 through control.

To ensure the validity of the measured voltages on both sides, Bus MCB Open Position (X115:13-12), Line MCB Open Position (X105:11-12) and SEQRFUF1_FUSEF_U are connected to block SECRSYN1.

SECRSYN can be set to the bypass mode by setting the parameters *Synchro check mode* and *Energizing check mode* to "Off" or alternatively, by activating the BYPASS input. In the bypass mode, the closing conditions are always considered to be fulfilled by SECRSYN function.

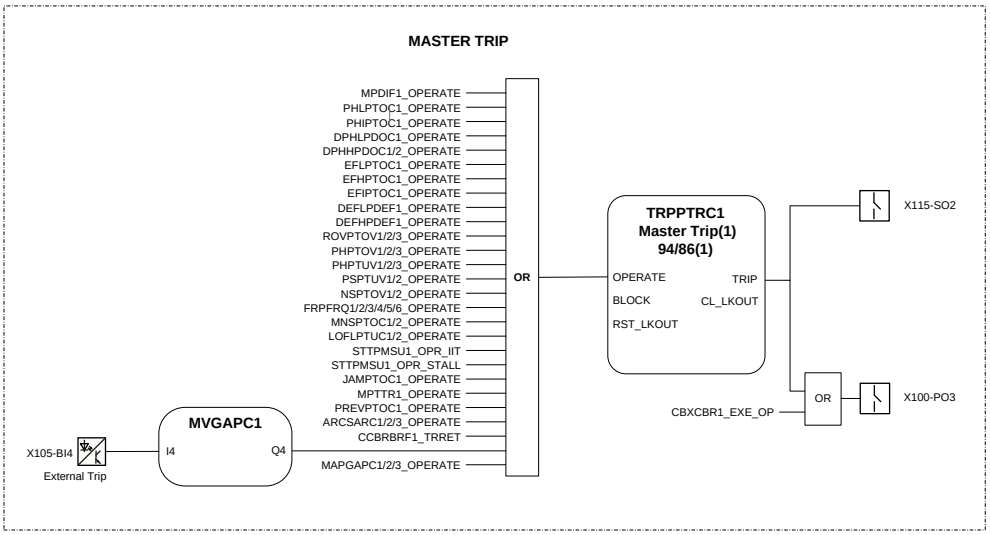

Figure 31: Master trip

The operating signals from the protections and an external trip (X105-BI4:7-6) via MVGAPC1 are connected to signal output 2 (X115-SO2:17-19) and the trip output contact power output 3 (X100-PO3:15-19) via the corresponding Master Trip TRPPTRC1. The opening control commands to the circuit breaker from the local or remote `CBXCBR1_EXE_OP` are connected directly to power output 3 (X100-PO3:15-19).

TRPPTRC1 provides the lockout/latching function, event generation and the trip signal duration setting. If the lockout operation mode is selected, one binary input can be reassigned to the `RST_LKOUT` input of the Master Trip to enable external reset with a push button.

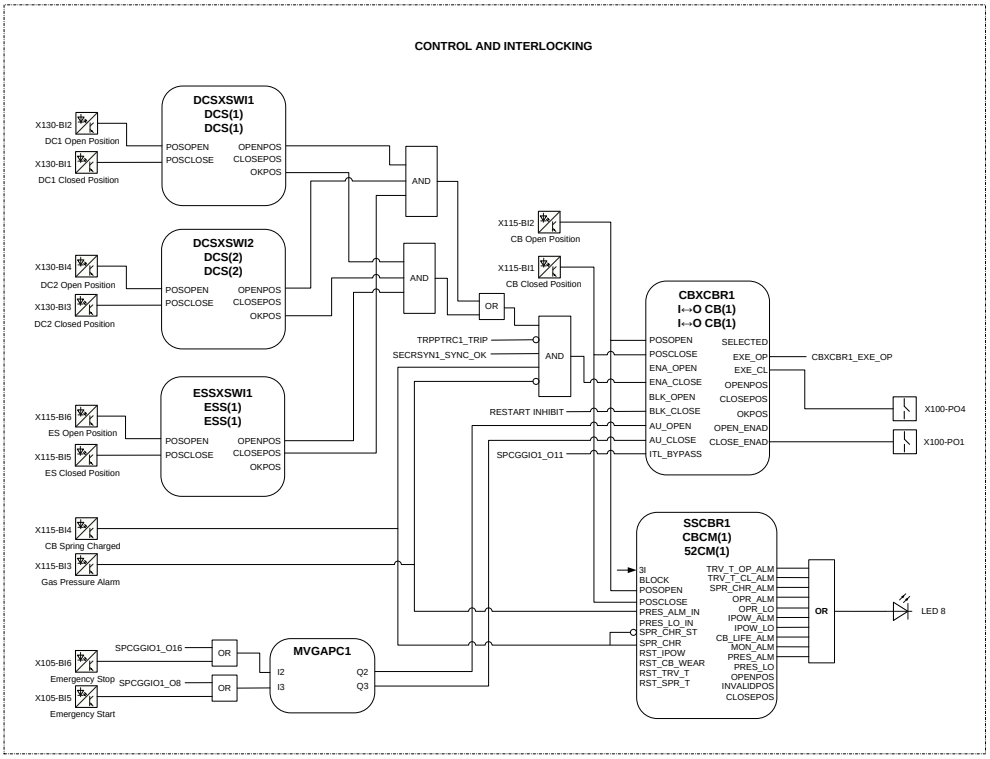

Figure 32: Circuit breaker control and interlocking

There are two types of disconnector and earthing-switch blocks available. DCSXSWI1...4 and ESSXSWI1...2 are status-only type, and DCXSWI1...4 and ESXSWI1…2 are controllable type. By default, the status-only blocks are connected in the default configuration logic. If a controllable operation is preferred, the controllable type of disconnector and earthing-switch blocks can be used, instead of the status-only type. The connection and configuration of the control blocks can be made using PCM600.

The binary inputs 1 and 2 of the card X130 are used for busbar disconnector 1 (DCSXSWI1) position indication. The binary inputs 3 and 4 of the card X130 are used for busbar disconnector 2 (DCSXSWI2) position indication.

Table 18: Disconnector 1 position indicated by binary inputs

Primary device position	Input to be energized	
	Input 1 (X130:1-2)	Input 2 (X130:3-4)
Busbar disconnector 1 closed	●	
Busbar disconnector 1 open		●

Table 19: Disconnector 2 position indicated by binary inputs

Primary device position	Input to be energized	
	Input 3 (X130:5-6)	Input 4 (X130:7-8)
Busbar disconnector 2 closed	•	
Busbar disconnector 2 open		•

The binary inputs 7 and 8 of card X110 are designed for the position indication of the earthing switch.

Table 20: Earthing-switch position indicated by binary inputs

Primary device position	Input to be energized	
	Input 5 (X115:8-9)	Input 6 (X115:10-9)
Earthing-switch closed	•	
Earthing-switch open		•

The circuit breaker opening is enabled when the ENA_OPEN is activated, but blocked when BLK_OPEN is activated. The CB opening allows this because, by default, ENA_OPEN is activated and BLK_OPEN is deactivated when they are left unconnected.

The circuit breaker closing is enabled when the ENA_CLOSE input is activated, and this input is activated when all the conditions are met.

- The CB condition check is OK (CB spring is charged, no gas pressure alarm).
- The synchronism/energizing check is OK.
- There is no active control trip signal.
- The position status check for related primary equipment is OK (Either the earthing switch is open or both disconnectors are open when the earthing switch is closed).

The circuit breaker closing is blocked when the BLK_CLOSE input is activated. This input is activated when the combined signal RESTART INHIBIT is active.

When all the conditions of the circuit breaker closing are fulfilled, the CLOSE_ENAD output of CBXCBR1 is activated and the X100-PO1 output is closed.

Emergency start and stop of the motor, either through push buttons or binary inputs, is configured in the same way.

For emergency start operation, the AU_CLOSE input is connected to the combined signal of a binary input (X105-BI5:8-9) and one push button through SPCGGIO1_O8.

For emergency stop operation, the AU_OPEN input is connected to the combined signal of a binary input (X105-BI6:10-9) and one push button through SPCGGIO1_O16.

The function MVGAPC1 is used to generate events when there is an emergency start or stop operation.

One push button can be used through SPCGGIO1_O11, which is connected to ITL_BYPASS input of the CBXCBR1, to ignore the status of the ENA_CLOSE input. However, the BLK_CLOSE input is not bypassed with the interlocking bypass functionality, as it always has the higher priority.

If the ENA_CLOSE signal is completely removed from the breaker control function block CBXCBR1 with PCM600, the function assumes that the breaker-closing commands are allowed continuously.

The IED also includes a second CB control block, with related second CB condition monitoring and CBFB functions, not used in the default configuration. The second instances use the same measurement values as the first instances.

The circuit breaker condition monitoring function SSCBR1 supervises the circuit breaker status based on the binary input information connected and the measured current levels. SSCBR introduces various supervision methods. The corresponding supervision alarm signals are routed to LED 8.

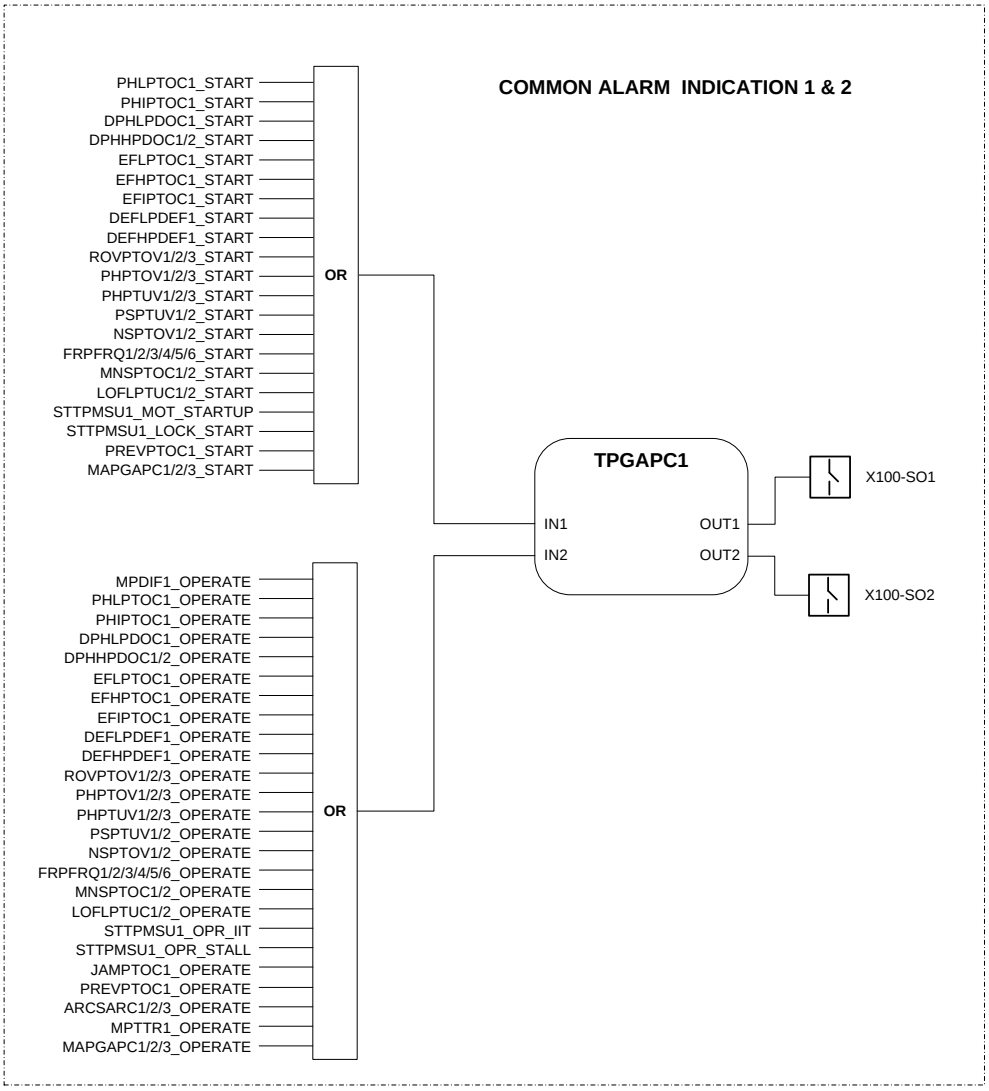

Figure 33: Common alarm indication

The signal outputs from the IED are connected to give dedicated information on:

- Start of any protection function SO1 (X100:10-12)
- Operation (trip) of any protection function SO2 (X100: 13-15)

TPGAPC function blocks are used for setting the minimum pulse length for the outputs. There are four generic timers TPGAPC1…4 available in the IED. The remaining ones, which are not described in the functional diagram, are available in PCM600 for connection where applicable.

Section 4 IED physical connections

4.1 Inputs

4.1.1 Energizing inputs

4.1.1.1 Phase currents

The IED can also be used in single or two-phase applications by leaving one or two energizing inputs unoccupied. However, at least terminals X120/7-8 must be connected.

Table 21: Phase current inputs included in configuration A

Terminal	Description
X120-1,2	IL1_N
X120-3,4	IL2_N
X120-5,6	IL3_N
X120-7,8	IL1
X120-9,10	IL2
X120-11,12	IL3

4.1.1.2 Residual current

Table 22: Residual current input included in configuration A

Terminal	Description
X120-13, 14	Io

4.1.1.3 Phase voltages

Table 23: Phase voltage input included in configuration A

Terminal	Description
X130-11,12	U1
X130-13,14	U2
X130-15,16	U3

Table 24: Reference voltage input for SECRSYN1 included in configuration A

Terminal	Description
X130-9,10	U_SYN

4.1.1.4 Residual voltage

Table 25: Additional residual voltage input included in configurations A

Terminal	Description
X130-17, 18	Uo

4.1.2 RTD/mA inputs

RTD/mA inputs is included in configuration A.

Table 26: RTD/mA inputs

Terminal	Description
X110-5,6	mA1 (AI1), + mA1 (AI1), -
X110-7,8	mA2 (AI2), + mA2 (AI2), -
X110-9,10	RTD1 (AI3), + RTD1 (AI3), -
X110-11,12	RTD2 (AI4), + RTD2 (AI4), -
X110-13,14	RTD3 (AI5), + RTD3 (AI5), -
X110-15	Common[1)]
X110-16	Common[2)]
X110-17,18	RTD4 (AI6), + RTD4 (AI6), -
X110-19,20	RTD5 (AI7), + RTD5 (AI7), -
X110-21,22	RTD6 (AI8), + RTD6 (AI8), -

1) Common ground for RTD channels 1-3.
2) Common ground for RTD channels 4-6

RTD/mA inputs of slot X105 are optional for configuration A.

Table 27: RTD/mA inputs

Terminal	Description
X105-5,6	mA1 (AI1), + mA1 (AI1), -
X105-7,8	mA2 (AI2), + mA2 (AI2), -
X105-9,10	RTD1 (AI3), + RTD1 (AI3), -
X105-11,12	RTD2 (AI4), + RTD2 (AI4), -
X105-13,14	RTD3 (AI5), + RTD3 (AI5), -
X105-15	Common[1)]
X105-16	Common[2)]
X105-17,18	RTD4 (AI6), + RTD4 (AI6), -
X105-19,20	RTD5 (AI7), + RTD5 (AI7), -
X105-21,22	RTD6 (AI8), + RTD6 (AI8), -

1) Common ground for RTD channels 1-3
2) Common ground for RTD channels 4-6

4.1.3 Auxiliary supply voltage input

The auxiliary voltage of the IED is connected to terminals X100/1-2. At DC supply, the positive lead is connected to terminal X100-1. The permitted auxiliary voltage range (AC/DC or DC) is marked on the top of the LHMI of the IED.

Table 28: Auxiliary voltage supply

Terminal	Description
X100-1	+ Input
X100-2	- Input

4.1.4 Binary inputs

The binary inputs can be used, for example, to generate a blocking signal, to unlatch output contacts, to trigger the disturbance recorder or for remote control of IED settings.

Binary inputs of slot X115 is available with configuration A.

Table 29: Binary input terminals X115-1...13

Terminal	Description
X115-1	BI1,+
X115-2	BI1,-
X115-3	BI2,+
X115-4	BI2,-
X115-5	BI3,+
X115-6	BI3,-
X115-6	BI4,-
X115-7	BI4,+
X115-8	BI5,+
X115-9	BI5,-
X115-9	BI6,-
X115-10	BI6,+
X115-11	BI7,+
X115-12	BI7,-
X115-12	BI8,-
X115-13	BI8,+

Binary inputs of slot X130 are available with configuration A.

Table 30: Binary input terminals X130-1...8

Terminal	Description
X130-1	BI1, +
X130-2	BI1, -
X130-3	BI2, +
X130-4	BI2, -
X130-5	BI3, +
X130-6	BI3, -
X130-7	BI4, +
X130-8	BI4, -

Binary inputs of slot X105 are optional for configuration A. One option is to use BIO0005 and the other one is to use BIO0007.

Table 31: Binary input terminals X105-1...13 (with optional BIO0005)

Terminal	Description
X105-1 X105-2	BI1,+ BI1,-
X105-3 X105-4	BI2,+ BI2,-
X105-5 X105-6	BI3,+ BI3,-
X105-6 X105-7	BI4,- BI4,+
X105-8 X105-9	BI5,+ BI5,-
X105-9 X105-10	BI6,- BI6,+
X105-11 X105-12	BI7,+ BI7,-
X105-12 X105-13	BI8,- BI8,+

Table 32: Binary input terminals X105-1...10 (with optional BIO0007)

Terminal	Description
X105-1 X105-5	BI1,+ BI1,-
X105-2 X105-5	BI2,+ BI2,-
X105-3 X105-5	BI3,+ BI3,-
X105-4 X105-5	BI4,- BI4,+
X105-6 X105-10	BI5,+ BI5,-
X105-7 X105-10	BI6,- BI6,+
X105-8 X105-10	BI7,+ BI7,-
X105-9 X105-10	BI8,- BI8,+

4.1.5 Optional light sensor inputs

If the IED is provided with the optional communication module with light sensor inputs, the pre-manufactured lens-sensor fibres are connected to inputs X13, X14 and X15, see the terminal diagrams.For further information, see arc protection.

The IED is provided with connection sockets X13, X14 and X15 only if the optional communication module with light sensor inputs has been installed. If the arc protection option is selected when

ordering an IED, the light sensor inputs are included in the communication module.

Table 33: Light sensor input connectors

Terminal	Description
X13	Input Light sensor 1
X14	Input Light sensor 2
X15	Input Light sensor 3

4.2 Outputs

4.2.1 Outputs for tripping and controlling

Output contacts PO1, PO2, PO3 and PO4 in slot X100 are heavy-duty trip contacts capable of controlling most circuit breakers. On delivery from the factory, the trip signals from all the protection stages are routed to PO3 and PO4.

Table 34: Output contacts

Terminal	Description
X100-6	PO1, NO
X100-7	PO1, NO
X100-8	PO2, NO
X100-9	PO2, NO
X100-15	PO3, NO (TCS resistor)
X100-16	PO3, NO
X100-17	PO3, NO
X100-18	PO3 (TCS1 input), NO
X100-19	PO3 (TCS1 input), NO
X100-20	PO4, NO (TCS resistor)
X100-21	PO4, NO
X100-22	PO4, NO
X100-23	PO4 (TCS2 input), NO
X100-24	PO4 (TCS2 input), NO

4.2.2 Outputs for signalling

All other outputs can be used for signaling on start and tripping of the IED. On delivery from the factory, the start and alarm signals from all the protection stages are routed to signaling outputs.

Table 35: Output contacts X100-10...14

Terminal	Description
X100-10	SO1, common
X100-11	SO1, NC
X100-12	SO1, NO
X100-13	SO2, NO
X100-14	SO2, NO

Output contacts of slot X115 are available with configuration A.

Table 36: Output contacts X115-14...24

Terminal	Description
X115-14 X115-15 X115-16	SO1,common SO1,NO SO1,NC
X115-17 X115-18 X115-19	SO2,common SO2,common SO2,common
X115-20 X115-21 X115-22	SO3,common SO3,NO SO3,NC
X115-23 X115-24	SO4,common SO4,NO

Output contacts of X105 are optional for configuration A. One option is to use BIO0005 and the other one is to use BIO0007.

Table 37: contacts X105-14...24 (with optional BIO0005)

Terminal	Description
X105-14 X105-15 X105-16	SO1,common SO1,NO SO1,NC
X105-17 X105-18 X105-19	SO2,common SO2,NO SO2,NC
X105-20 X105-21 X105-22	SO3,common SO3,NO SO3,NC
X105-23 X105-24	SO4,common SO4,NO

Table 38: High speed output contacts X105-15…24 (with optional BIO0007)

Terminal	Description
X105-15 X105-16	HSO1,NO HSO1,NO
X105-19 X105-20	HSO2,NO HSO2,NO
X105-23 X105-24	HSO3,NO HSO3,NO

4.2.3 IRF

The IRF contact functions as an output contact for the self-supervision system of the protection IED. Under normal operating conditions, the IED is energized and the contact is closed (X100/3-5). When a fault is detected by the self-supervision system or the auxiliary voltage is disconnected, the output contact drops off and the contact closes (X100/3-4).

Table 39: IRF contact

Terminal	Description
X100-3	IRF, common
X100-4	Closed; IRF, or U_{aux} disconnected
X100-5	Closed; no IRF, and U_{aux} connected

Section 5 Glossary

AC	Alternating current
ANSI	American National Standards Institute
AR	Autoreclosing
ASCII	American Standard Code for Information Interchange
BI	Binary input
BI/O	Binary input/output
BO	Binary output
CB	Circuit breaker
CT	Current transformer
DANP	Doubly attached node with PRP
DC	1. Direct current 2. Double command
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.
DPC	Double-point control
EMC	Electromagnetic compatibility
FIFO	First in, first out
GOOSE	Generic Object-Oriented Substation Event
HMI	Human-machine interface
HSR	High-availability seamless redundancy
I/O	Input/output
IEC	International Electrotechnical Commission
IEC 60870-5-103	1. Communication standard for protective equipment 2. A serial master/slave protocol for point-to-point communication
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

IET600	Integrated Engineering Toolbox in PCM600
IP address	A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned a unique IP address that specifies the location for the TCP/IP protocol.
LAN	Local area network
LC	Connector type for glass fibre cable
LCD	Liquid crystal display
LED	Light-emitting diode
LHMI	Local human-machine interface
Modbus	A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices.
Modbus TCP/IP	Modbus RTU protocol which uses TCP/IP and Ethernet to carry data between devices
NPS	Negative phase sequence
PCM600	Protection and Control IED Manager
PO	Power output
PRP	Parallel redundancy protocol
RIO600	Remote I/O unit
RJ-45	Galvanic connector type
RSTP	Rapid spanning tree protocol
RTD	Resistance temperature detector
RTU	Remote terminal unit
SAN	Singly attached node
Single-line diagram	Simplified notation for representing a three-phase power system. Instead of representing each of three phases with a separate line or terminal, only one conductor is represented.
SO	Signal output
TCS	Trip-circuit supervision
VT	Voltage transformer
WAN	Wide area network
WHMI	Web human-machine interface

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