Relion® 620 series

Transformer Protection and Control RET620 Application Manual

Power and productivity for a better world™

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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
B/2013-07-01	2.0	Content updated

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: RET620 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, low stage, instance 2	PHLPTOC2	3I> (2)	51P-1 (2)
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	3I>> (1)	51P-2 (1)
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 2	PHIPTOC2	3I>>> (2)	50P/51P (2)
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)
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, low stage, instance 2	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage, instance 1	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, high stage, instance 2	EFHPTOC2	Io>> (2)	51N-2 (2)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I2> (2)	46 (2)
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)
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)
Voltage per hertz protection, instance 1	OEPVPH1	U/f> (1)	24 (1)
Voltage per hertz protection, instance 2	OEPVPH2	U/f> (2)	24 (2)
Three-phase thermal overload protection for power transformers, two time constants	T2PTTR1	3Ith>T (1)	49T (1)
Loss of phase (undercurrent), instance 1	PHPTUC1	3I< (1)	37F (1)
Loss of phase (undercurrent), instance 2	PHPTUC2	3I< (2)	37F (2)
Stabilized and instantaneous differential protection for 2-winding transformers	TR2PTDF1	3dI>T (1)	87T (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Numerical stabilized low impedance restricted earth-fault protection, instance 1	LREFPNDF1	dIoLo> (1)	87NL (1)
Numerical stabilized low impedance restricted earth-fault protection, instance 2	LREFPNDF2	dIoLo> (2)	87NL (2)
High impedance based restricted earth-fault protection, instance 1	HREFPDIF1	dIoHi> (1)	87NH (1)
High impedance based restricted earth-fault protection, instance 2	HREFPDIF2	dIoHi> (2)	87NH (2)
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)
Three-phase inrush detector	INRPHAR1	3I2f> (1)	68 (1)
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)
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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)
Tap changer position indication	TPOSSLTC1	TPOSM (1)	84M (1)
Tap changer control with voltage regulator	OLATCC1	COLTC (1)	90V (1)
Load shedding and restoration, instance 1	LSHDPFRQ1	UFLS/R (1)	81LSH (1)
Load shedding and restoration, instance 2	LSHDPFRQ2	UFLS/R (2)	81LSH (2)
Load shedding and restoration, instance 3	LSHDPFRQ3	UFLS/R (3)	81LSH (3)
Load shedding and restoration, instance 4	LSHDPFRQ4	UFLS/R (4)	81LSH (4)
Load shedding and restoration, instance 5	LSHDPFRQ5	UFLS/R (5)	81LSH (5)
Load shedding and restoration, instance 6	LSHDPFRQ6	UFLS/R (6)	81LSH (6)
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)
Current circuit supervision, instance 2	CCRDIF2	MCS 3I (2)	CSM 3I (2)
Advanced current circuit supervision for transformers	CTSRCTF1	MCS 3I, I2 (1)	CSM 3I, I2 (1)
Fuse failure supervision	SEQRFUF1	FUSEF (1)	60 (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
Sequence current measurement, instance 2	CSMSQI2	I1, I2, I0 (B) (1)	I1, I2, I0 (B) (1)
Residual current measurement, instance 1	RESCMMXU1	Io (1)	In (1)
Residual current measurement, instance 2	RESCMMXU2	Io(B) (1)	In(B) (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)
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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
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 RET620 overview

2.1 Overview

RET620 is a dedicated transformer IED perfectly aligned for the protection, control, measurement and supervision of both power and step-up transformers, including power generator-transformer blocks, in utility and industrial power distribution systems. RET620 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
- RET620 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
- Automatic Voltage Regulator
- 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 configuration A 8 binary inputs 4 SO contacts
			BIO0007	Optional for configuration A 8 binary inputs 3 High-speed SO contacts
		Optional RTD/mA module	RTD0003	Optional for configuration A 2 generic mA inputs 6 RTD sensor inputs
	X110	BI/O module	BIO0005	With configuration A 8 binary inputs 4 SO contacts
	X115	AI module	AIM0004	With configuration A 3 phase current inputs (1/5A) 1 residual current input (1/5A) 3 phase voltagt inputs (1/5A)
	X120	AI module	AIM0004	With configuration A 3 phase current Inputs (1/5A) 1 residual current input (1/5A) 3 phase voltage inputs (1/5A)
Case	X130	RTD/mA module	RTD0002	With configuration A 1 generic mA input 2 RTD sensor inputs 3 SO contacts
	X000	Optional communication module		See the technical manual for details about the different types of communication modules

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	8	6	2/1	8(16)[1)]	13(17)[1)]
			2/1	8(16)[2)]	13(16)[2)]
			2/1(8/3)[3)]	8	13

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.

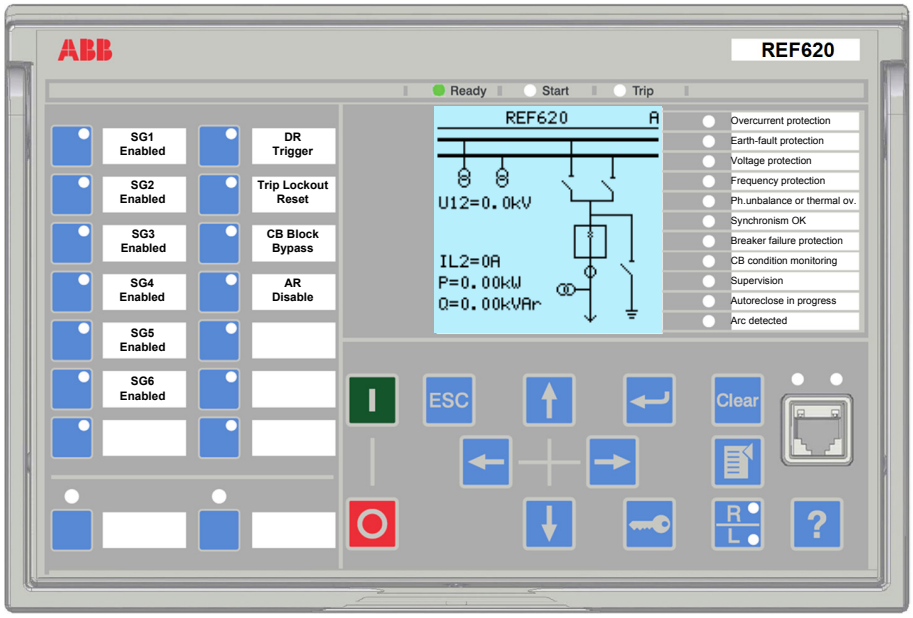

Figure 1: Example of the LHMI

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.

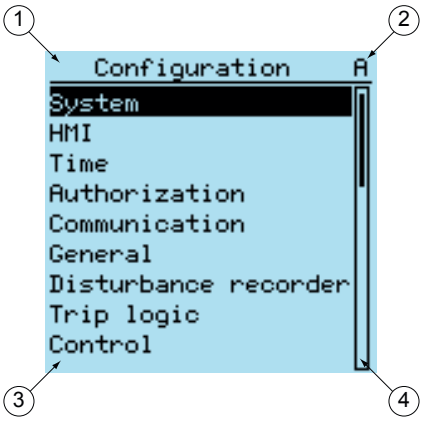

Figure 2: Display layout

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.

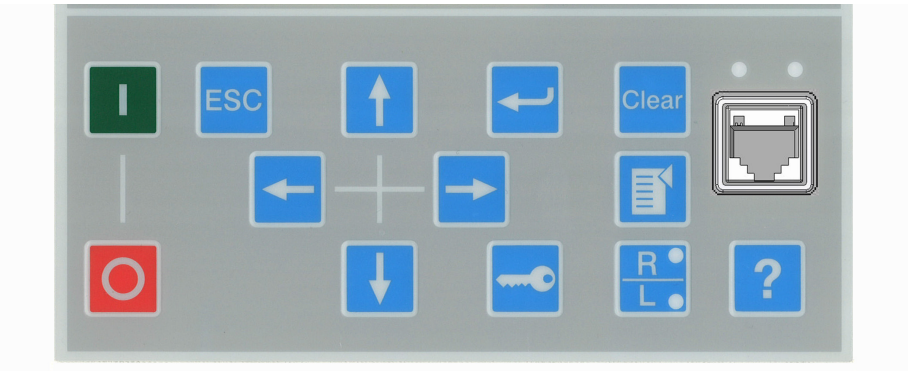

Figure 3: LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port

2.4.3.1 Programmable push-buttons with LEDs

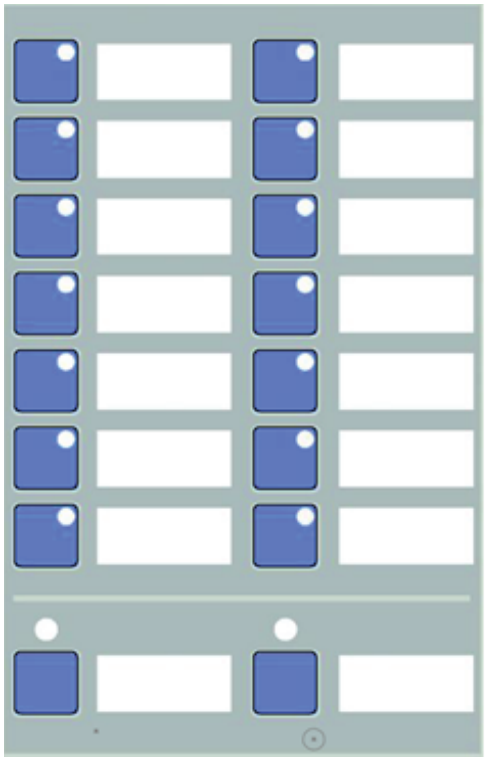

Figure 4: Programmable push-buttons with LEDs

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.

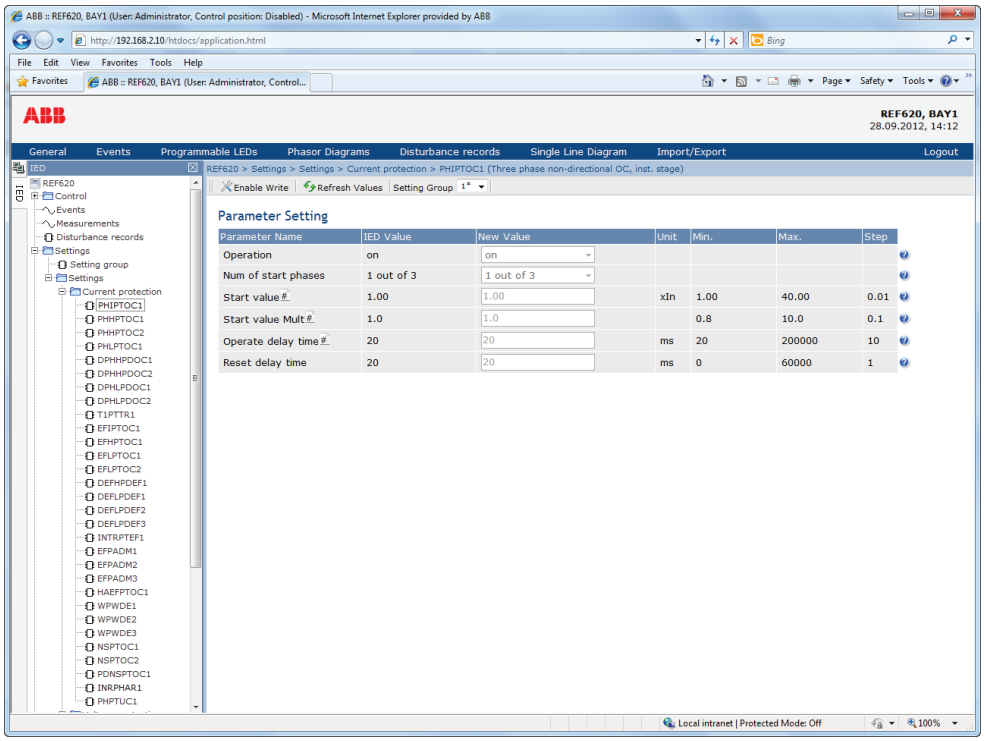

Figure 5: Example view of the WHMI

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.

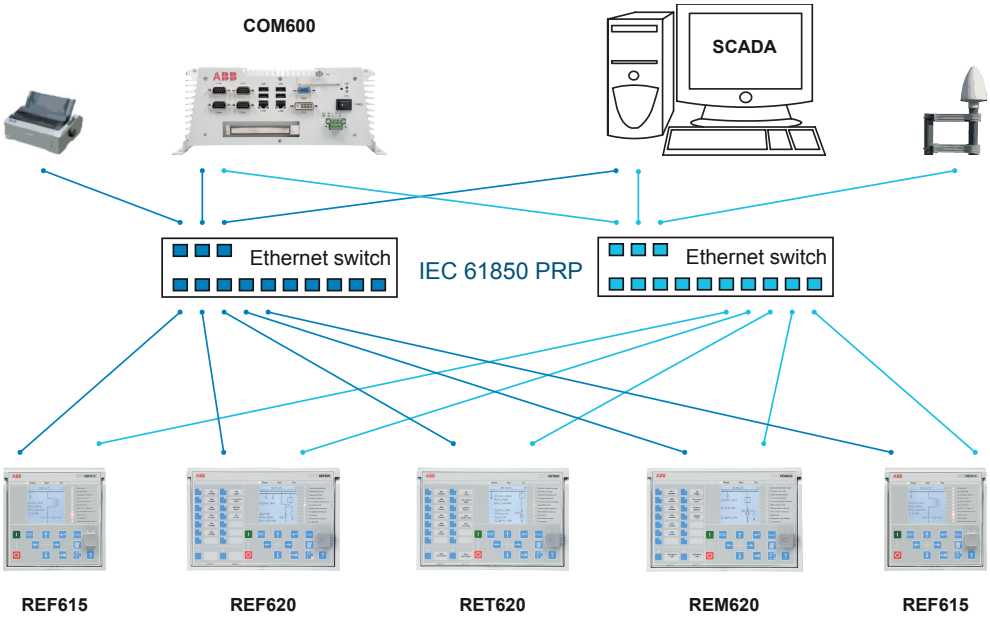

Figure 6: PRP solution

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.

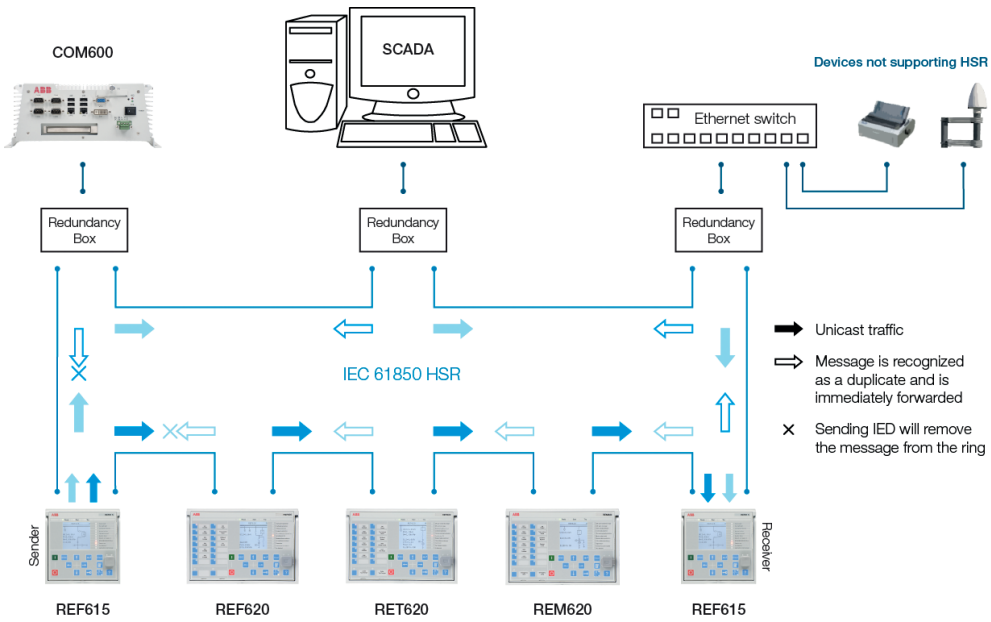

Figure 7: HSR solution

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.

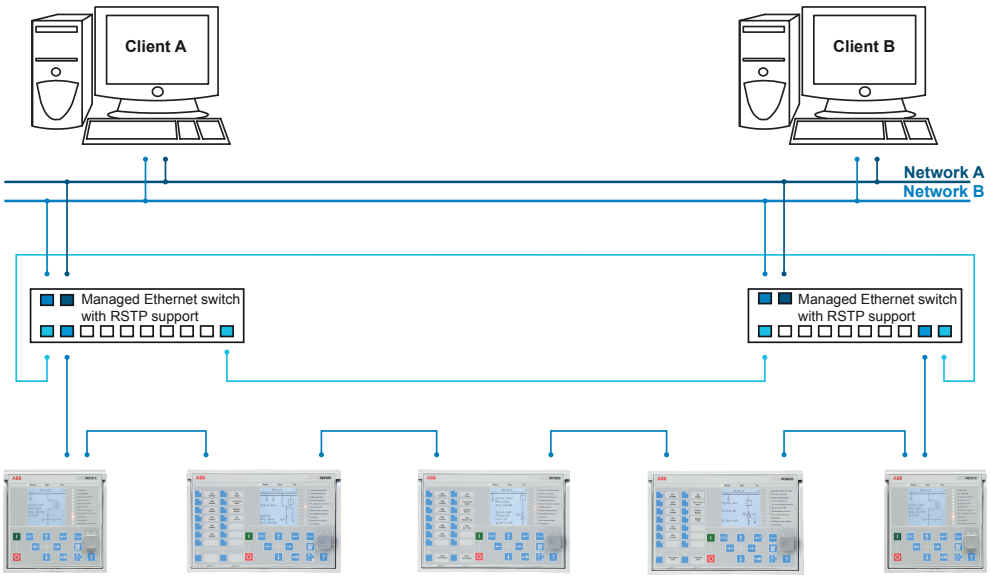

Figure 8: Self-healing Ethernet ring solution

Section 3 RET620 default configurations

3.1 Default configurations

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.

RET620 is available with one default configuration. 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 PCM600 supports the creation of multi-layer logic functions utilizing 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.

The default configuration can be used for several purposes; the configuration either already contains the required functionality or it can be easily modified to suit the requirements.

- The configuration can be used with 2-winding transformer in different star/ delta connection configurations.
- The main protection is stabilized differential protection.
- Protection is allocated for both sides of transformer, mainly on the high side.
- Both traditional high-impedance earth-fault protection as well as the numerical method are included in the configuration.
- Syncrocheck
- The configuration can be used with or without the integrated AVR with an on-line tap changer.
    - RET620 controlling the network voltage on load side of the transformer
    - Tap changer position via mA inputs or binary inputs

Table 8: Supported functions

Functionality	CTs & VTs
Protection	
Three-phase non-directional overcurrent protection, low stage, instance 1	●[1)]
Three-phase non-directional overcurrent protection, low stage, instance 2	●[2)]
Table continues on next page	

Functionality	CTs & VTs
Three-phase non-directional overcurrent protection, high stage, instance 1	●1)
Three-phase non-directional overcurrent protection, high stage, instance 2	●2)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	●1)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 2	●2)
Three-phase directional overcurrent protection, low stage, instance 1	●1)
Three-phase directional overcurrent protection, high stage, instance 1	●1)
Non-directional earth-fault protection, low stage, instance 1	●3)
Non-directional earth-fault protection, low stage, instance 2	●4)
Non-directional earth-fault protection, high stage, instance 1	●3)
Non-directional earth-fault protection, high stage, instance 2	●4)
Directional earth-fault protection, low stage, instance 1	●3)
Directional earth-fault protection, low stage, instance 2	●3)
Directional earth-fault protection, high stage, instance 1	●3)
Negative-sequence overcurrent protection, instance 1	●1)
Negative-sequence overcurrent protection, instance 2	●2)
Residual overvoltage protection, instance 1	●1)
Residual overvoltage protection, instance 2	●1)
Residual overvoltage protection, instance 3	●1)
Three-phase undervoltage protection, instance 1	●1)
Three-phase undervoltage protection, instance 2	●1)
Three-phase undervoltage protection, instance 3	●1)
Three-phase overvoltage protection, instance 1	●1)
Three-phase overvoltage protection, instance 2	●1)
Three-phase overvoltage protection, instance 3	●1)
Positive-sequence undervoltage protection, instance 1	●1)
Positive-sequence undervoltage protection, instance 2	●1)
Negative-sequence overvoltage protection, instance 1	●1)
Negative-sequence overvoltage protection, instance 2	●1)
Frequency protection, instance 1	●1)
Frequency protection, instance 2	●1)
Frequency protection, instance 3	●1)
Voltage per hertz protection, instance 1	●1)
Voltage per hertz protection, instance 2	●1)
Three-phase thermal overload protection for power transformers, two time constants	●1)
Loss of phase (undercurrent), instance 1	●1)
Loss of phase (undercurrent), instance 2	●2)

Table continues on next page

Functionality	CTs & VTs
Stabilized and instantaneous differential protection for 2-winding transformers	●
Numerical stabilized low impedance restricted earth-fault protection, instance 1	●[1)]
Numerical stabilized low impedance restricted earth-fault protection, instance 2	●[2)]
High impedance based restricted earth-fault protection, instance 1	●[1)]
High impedance based restricted earth-fault protection, instance 2	●[2)]
Circuit breaker failure protection, instance 1	●[1)]
Circuit breaker failure protection, instance 2	●[2)]
Three-phase inrush detector	●[1)]
Master trip, instance 1	●
Master trip, instance 2	●
Arc protection, instance 1	○[5)]
Arc protection, instance 2	○[5)]
Arc protection, instance 3	○[5)]
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	●
Multipurpose analog protection, instance 11	●
Multipurpose analog protection, instance 12	●
Control	
Circuit-breaker control, instance 1	●[1)]
Circuit-breaker control, instance 2	●[2)]
Disconnector control, instance 1	●[1)]
Disconnector control, instance 2	●[1)]
Earthing switch control, instance 1	●[1)]
Disconnector control, instance 3	●[2)]
Disconnector control, instance 4	●[2)]
Earthing switch control, instance 2	●[2)]
Disconnector position indication, instance 1	●[1)]
Disconnector position indication, instance 2	●[1)]
Earthing switch position indication, instance 1	●[1)]
Disconnector position indication, instance 3	●[2)]

Table continues on next page

Functionality	CTs & VTs
Disconnector position indication, instance 4	●2)
Earthing switch position indication, instance 2	●2)
Synchronism and energizing check	●1)
Tap changer position indication	●
Tap changer control with voltage regulator	○2)
Load shedding and restoration, instance 1	●1)
Load shedding and restoration, instance 2	●1)
Load shedding and restoration, instance 3	●1)
Load shedding and restoration, instance 4	●1)
Load shedding and restoration, instance 5	●1)
Load shedding and restoration, instance 6	●1)
Condition monitoring	
Circuit-breaker condition monitoring, instance 1	●1)
Circuit-breaker condition monitoring, instance 2	●2)
Trip circuit supervision, instance 1	●1)
Trip circuit supervision, instance 2	●2)
Current circuit supervision, instance 1	●1)
Current circuit supervision, instance 2	●2)
Advanced current circuit supervision for transformers	●
Fuse failure supervision	●1)
Measurement	
Three-phase current measurement, instance 1	●1)
Three-phase current measurement, instance 2	●2)
Sequence current measurement, instance 1	●1)
Sequence current measurement, instance 2	●2)
Residual current measurement, instance 1	●1)
Residual current measurement, instance 2	●2)
Three-phase voltage measurement	●1)
Residual voltage measurement	●1)
Sequence voltage measurement	●1)
Three-phase power and energy measurement	●1)
Frequency measurement	●1)
Other	
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	●
Table continues on next page	

Functionality	CTs & VTs
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	●
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)	●

Table continues on next page

Functionality	CTs & VTs
Logging functions	
Disturbance recorder	•
Fault recorder	•
Sequence event recorder	•
Load profile	•
• = Included, ○ = Optional at the time of the order	

1) The function is to be used on high voltage winding side in the application
2) The function is to be used on low voltage winding side in the application
3) The function is to be used on high voltage winding side in the application,and uses calculated Io when HREF and varistor connection used
4) The function is to be used on low voltage winding side in the applicationand,and uses calculated Io when HREF and varistor connection used
5) Calculated Io is used for the residual current criteria

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.

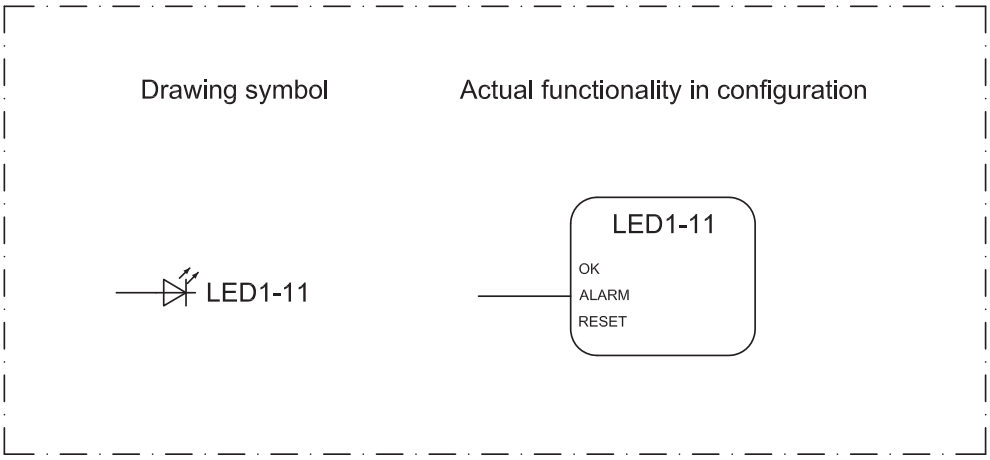

Figure 9: Drawing symbol used in the manual and the default connection of the LED function blocks in the configurations

3.2 Connection diagrams

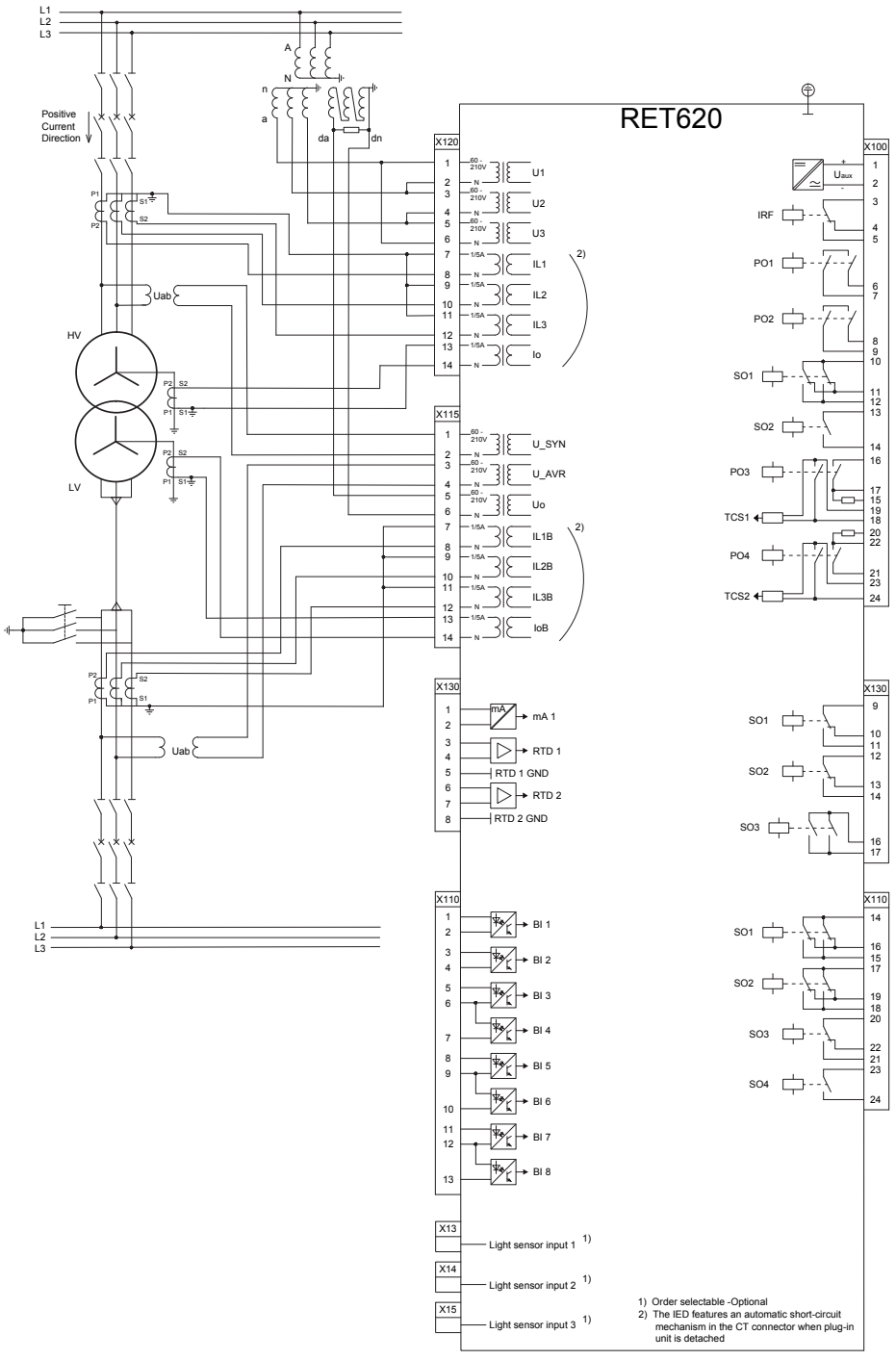

Figure 10: Connection for the A configuration

3.3 Optional modules

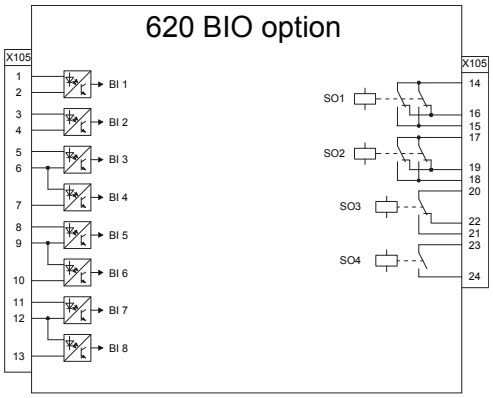

Figure 11: Optional BIO0005 module (slot X105)

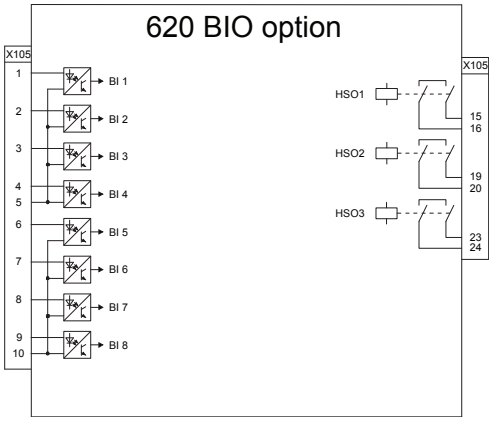

Figure 12: Optional BIO0007 module for fast outputs (slot X105)

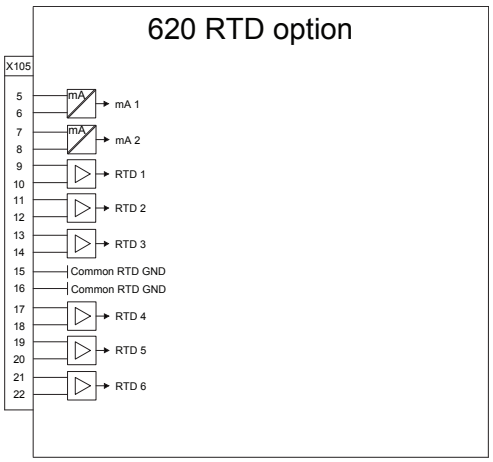

Figure 13: Optional RTD0003 module (slot X105)

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 mainly intended for the protection of two-winding power transformers. The default configuration includes three-phase transformer differential protection for two-winding transformers, numerical restricted earth-

fault protection for both the HV side and the LV side. Additionally, voltage regulation via automatic control of an on-line tap changer is included.

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.

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, low stage, instance 2	PHLPTOC2	3I> (2)	51P-1 (2)
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	3I>> (1)	51P-2 (1)
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 2	PHIPTOC2	3I>>> (2)	50P/51P (2)
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)
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, low stage, instance 2	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage, instance 1	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, high stage, instance 2	EFHPTOC2	Io>> (2)	51N-2 (2)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Table continues on next page			

Function	IEC 61850	IEC 60617	IEC-ANSI
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I2> (2)	46 (2)
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)
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)
Voltage per hertz protection, instance 1	OEPVPH1	U/f> (1)	24 (1)
Voltage per hertz protection, instance 2	OEPVPH2	U/f> (2)	24 (2)
Three-phase thermal overload protection for power transformers, two time constants	T2PTTR1	3Ith>T (1)	49T (1)
Loss of phase (undercurrent), instance 1	PHPTUC1	3I< (1)	37F (1)
Loss of phase (undercurrent), instance 2	PHPTUC2	3I< (2)	37F (2)
Stabilized and instantaneous differential protection for 2-winding transformers	TR2PTDF1	3dI>T (1)	87T (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Numerical stabilized low impedance restricted earth-fault protection, instance 1	LREFPNDF1	dIoLo> (1)	87NL (1)
Numerical stabilized low impedance restricted earth-fault protection, instance 2	LREFPNDF2	dIoLo> (2)	87NL (2)
High impedance based restricted earth-fault protection, instance 1	HREFPDIF1	dIoHi> (1)	87NH (1)
High impedance based restricted earth-fault protection, instance 2	HREFPDIF2	dIoHi> (2)	87NH (2)
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)
Three-phase inrush detector	INRPHAR1	3I2f> (1)	68 (1)
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)
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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)
Tap changer position indication	TPOSSLTC1	TPOSM (1)	84M (1)
Tap changer control with voltage regulator	OLATCC1	COLTC (1)	90V (1)
Load shedding and restoration, instance 1	LSHDPFRQ1	UFLS/R (1)	81LSH (1)
Load shedding and restoration, instance 2	LSHDPFRQ2	UFLS/R (2)	81LSH (2)
Load shedding and restoration, instance 3	LSHDPFRQ3	UFLS/R (3)	81LSH (3)
Load shedding and restoration, instance 4	LSHDPFRQ4	UFLS/R (4)	81LSH (4)
Load shedding and restoration, instance 5	LSHDPFRQ5	UFLS/R (5)	81LSH (5)
Load shedding and restoration, instance 6	LSHDPFRQ6	UFLS/R (6)	81LSH (6)
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)
Current circuit supervision, instance 2	CCRDIF2	MCS 3I (2)	CSM 3I (2)
Advanced current circuit supervision for transformers	CTSRCTF1	MCS 3I, I2 (1)	CSM 3I, I2 (1)
Fuse failure supervision	SEQRFUF1	FUSEF (1)	60 (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
Sequence current measurement, instance 2	CSMSQI2	I1, I2, I0 (B) (1)	I1, I2, I0 (B) (1)
Residual current measurement, instance 1	RESCMMXU1	Io (1)	In (1)
Residual current measurement, instance 2	RESCMMXU2	Io(B) (1)	In(B) (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)
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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
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
U_SYN	Phase-to-phase voltage U12, HV side	X115-1,2
U_AVR	Phase-to-phase voltage U12, LV side	X115-3,4
Uo	Residual voltage, HV side	X115-5,6
IL1B	Phase A current, LV side	X115-7,8
IL2B	Phase B current, LV side	X115-9,10
IL3B	Phase C current, LV side	X115-11,12
IoB	Residual current, LV side	X115-13,14
U1	Phase-to-phase voltage U12, HV bus side	X120-1,2
U2	Phase-to-phase voltage U23, HV bus side	X120-3,4
U3	Phase-to-phase voltage U31, HV bus side	X120-5,6
IL1	Phase A current, HV side	X120-7,8
IL2	Phase B current, HV side	X120-9,10
IL3	Phase C current, HV side	X120-11,12
Io	Residual current, HV side	X120-13,14
X130-mA1	Tap changer position	X130-1,2
X130-RTD1	Transformer ambient temperature	X130-3,4
X130-RTD2	Transformer top oil temperature	X130-6,7

Table 11: Default connections for binary inputs

Binary input	Default usage	Connector pins
X105-BI1	Protection blocking	X105-1,2
X105-BI2	Tap changer operate	X105-3,4
X105-BI3	Circuit breaker gas pressure alarm, HV side	X105-5,6
X105-BI4	Circuit breaker spring charged indication, HV side	X105-7,6
X105-BI5	Circuit breaker gas pressure alarm, LV side	X105-8,9
X105-BI6	Circuit breaker spring charged indication, LV side	X105-10,9
X105-BI7	Earthing switch closed position indication, LV side	X105-11,12
X105-BI8	Earthing switch open position indication, LV side	X105-13,12
X110-BI1	Circuit breake closed position indication, HV side	X110-1,2
X110-BI2	Circuit breake open position indication, HV side	X110-3,4
X110-BI3	Circuit breaker closed position indication, LV side	X110-5,6
X110-BI4	Circuit breaker open position indication, LV side	X110-7,6
X110-BI5	Disconnector 1 closed position indication, HV side	X110-8,9
X110-BI6	Disconnector 1 open position indication, HV side	X110-10,9
X110-BI7	Disconnector 2 closed position indication, HV side	X110-11,12
X110-BI8	Disconnector 2 open position indication, HV side	X110-13,12

Table 12: Default connections for binary outputs

Binary input	Default usage	Connector pins
X100-PO1	Close circuit breaker, HV side	X100-6,7
X100-PO2	Close circuit breaker, LV side	X100-8,9
X100-SO1	Close earthing switch, LV side	X100-10,11,(12)
X100-SO2	Open earthing switch, LV side	X100-13,14,15
X100-PO3	Open circuit breaker/trip coil 1, HV side	X100-15,16,17,18,19
X100-PO4	Open circuit breaker/trip coil 2, LV side	X100-20,21,22,23,24
X105-SO1	Overcurrent protection operate alarm	X105-14,15,16
X105-SO2	Differential protection operate alarm	X105-17,18,19
X105-SO3	Earth fault protection operate alarm	X105-20,21,22
X105-SO4	Thermal overload and NPS protection operate alarm	X105-23,24
X110-SO1	Close disconnector 1, HV side	X110-14,15,16
X110-SO2	Open disconnector 1, HV side	X110-17,18,19
X110-SO3	Close disconnector 2, HV side	X110-20,21,22
X110-SO4	Open disconnector 2, HV side	X110-23,24
X130-SO1	Lower own command	X130-9,10,11
X130-SO2	Raise own command	X130-12,13,14
X130-SO3	Breaker failure backup to upstream breaker	X130-16,17

Table 13: Default connections for RIO600 inputs

GOOSE input	Default usage
GOOSERCV_BIN0_OUT	Disconnector 1 closed position indication, LV side
GOOSERCV_BIN1_OUT	Disconnector 1 open position indication, LV side
GOOSERCV_BIN2_OUT	Disconnector 2 closed position indication, LV side
GOOSERCV_BIN3_OUT	Disconnector 2 open position indication, LV side
GOOSERCV_BIN4_OUT	MCB open position indication, HV side
GOOSERCV_BIN5_OUT	MCB open position indication , LV side/U_AVR
GOOSERCV_BIN6_OUT	MCB open position indication, U_SYN
GOOSERCV_BIN7_OUT	-
GOOSERCV_BIN8_OUT	Cool fan 1 status
GOOSERCV_BIN9_OUT	Cool fan 2 status
GOOSERCV_BIN10_OUT	Transformer gas relay alarm
GOOSERCV_BIN11_OUT	Transformer gas relay external trip
GOOSERCV_BIN12_OUT	-
GOOSERCV_BIN13_OUT	-
GOOSERCV_BIN14_OUT	-
GOOSERCV_BIN15_OUT	-

Table 14: Default connections for RIO600 outputs

GOOSE output	Default usage
MVGAPC2_Q1	Close disconnector 1, LV side
MVGAPC2_Q2	Open disconnector 1, LV side
MVGAPC2_Q3	Close disconnector 2, LV side
MVGAPC2_Q4	Open disconnector 2, LV side
MVGAPC2_Q5	General start indication
MVGAPC2_Q6	General operate indication
MVGAPC2_Q7	Tap changer control alarm
MVGAPC2_Q8	-

Table 15: Default connections for LEDs

LED	Default usage
1	Transformer differential protection biased stage operate
2	Transformer differential protection instantaneous stage operate
3	Restricted earth-fault protection operate
4	Combined protection indication of the other protection functions
5	Thermal overload protection operate
6	Synchronism or energizing check OK
7	Circuit breaker failure protection backup protection operate
8	Circuit breaker condition monitoring alarm
9	Supervision alarm
10	Tap changer operate
11	Arc fault detected

Table 16: 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	Automatic Voltage Regulation Parallel Mode
5	Setting Group 5 Enabled	13	Automatic Voltage Regulation Auto Mode
6	Setting Group 6 Enabled	14	
7		15	
8	Lower Tap Changer	16	Raise Tap Changer

3.5.2.2 Default disturbance recorder settings

Table 17: Default disturbance recorder settings binary channel

Channel	Id text	Level trigger mode
1	TR2PTDF1_OPERATE	4
2	TR2PTDF1_OPR_LS	4
3	TR2PTDF1_OPR_HS	4
4	TR2PTDF1_BLKD2H	4
5	TR2PTDF1_BLKD5H	4
6	TR2PTDF1_BLKDWAV	4
7	HREFPDIF1 or LREFPNDF1_START	1
8	HREFPDIF2 or LREFPNDF2_START	1
9	HREFPDIF1/2 or LREFPNDF1/2_OPERATE	4
10	PHLPTOC1_START	1
11	PHHPTOC1_START	1
12	PHIPTOC1_START	1
13	DPHLPDOC1_START	1
14	DPHHPDOC1_START	1
15	PHxPTOC (HV) or DPHxPDOC (HV)_OPERATE	4
16	PHLPTOC2_START	1
17	PHHPTOC2_START	1
18	PHIPTOC2_START	1
19	PHxPTOC (LV)_OPERATE	4
20	EFLPTOC1_START	1
21	EFHPTOC1_START	1
22	DEFLPDEF1_START	1
23	DEFLPDEF2_START	1
24	DEFHPDEF1_START	1
25	EFxPTOC (HV) or DEFxPDEF_OPERATE	4
26	EFLPTOC2_START	1
27	EFHPTOC2_START	1
28	EFxPTOC (LV)_OPERATE	4
29	NSPTOC1_START	1
30	NSPTOC2_START	1
31	NSPTOC1/2_OPERATE	4
32	ROVPTOV or PHPTUV or PHPTOV or PSPTUV or NSPTOV_START	1
33	ROVPTOV or PHPTUV or PHPTOV or PSPTUV or NSPTOV_OPERATE	4
34	FRPFRQ or LSHDPFRQ_START	1

Table continues on next page

Channel	Id text	Level trigger mode
35	FRPFRQ or LSHDPFRQ_OPERATE	4
36	OEPVPH1/2_START	1
37	OEPVPH1/2_OPERATE	4
38	T2PTTR1_START	1
39	T2PTTR1_OPERATE	4
40	T2PTTR1_ALARM	4
41	T2PTTR1_BLK_CLOSE	4
42	PHPTUC1/2_START	1
43	PHPTUC1/2_OPERATE	4
44	ARCSARC1_ARC_FLT_DET	4
45	ARCSARC2_ARC_FLT_DET	4
46	ARCSARC3_ARC_FLT_DET	4
47	ARCSARC1/2/3_OPERATE	4
48	INRPHAR1_BLK2H	4
49	SEQRFUF1_FUSEF_3PH	4
50	SEQRFUF1_FUSEF_U	4
51	CCRDIF1_FAIL	4
52	CCBRBRF1/2_TRRET	4
53	CCBRBRF1/2_TRBU	4
54	HV CB Closed	4
55	HV CB Open	4
56	LV CB Closed	4
57	LV CB Open	4
58	MCB Open (HV)	4
59	MCB Open (LV/AVR)	4
60	MCB Open (SYN)	4
61	Tap Changer Operating	4
62	OLATCC1_RAISE_OWN	4
63	OLATCC1_LOWER_OWN	4
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 18: Default analog channel selection and text settings

Channel	Selection and text
1	IL1
2	IL2
3	IL3
4	I0A
5	IL1B
6	IL2B
7	IL3B
8	I0B
9	U0
10	U1
11	U2
12	U3

3.5.2.3 Default operation mode for generic control point

Table 19: 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	Lower Tap Changer	Pulsed	150 ms
9	DR Trigger	Pulsed	150 ms
10	Trip Lockout Reset	Pulsed	150 ms
11	CB Block Bypass	Toggle	1000 ms
12	AVR Parallel Mode	Toggle	1000 ms
13	AVR Auto Mode	Toggle	1000 ms
14		Off	1000 ms
15		Off	1000 ms
16	Raise Tap Changer	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 high-voltage side of the transformer. The signal marked with `3IB` represents the three phase currents from the low-voltage side of the transformer. The signal marked with `Io` represents the ground current measured between the neutral point of the transformer and grounding on the high-voltage side, and the signal marked with `IoB` represents the ground current measured between the neutral point of the transformer and earthing on the low-voltage side.

The signal marked with `3U` represents the three phase system voltages from the high-voltage side of the transformer. These inputs are typically connected in Delta. Star connection is also possible. In addition, the signal marked with `Uo` represents the measured residual voltage via VT open-delta connection.

The signal marked `Usyn` is measured from the VT on the high-voltage side of the transformer. This signal is used to check synchronizing purposes. The input is fixed to phase-to-phase voltage U12 from the system. Care is taken in setting the synchrocheck function with correct phase angle correction, especially in applications such as voltages, fed to synchrocheck across a transformer with vector shift.

See the technical manual for voltage angle difference adjustment.

The signal marked `Uavr` is measured from the VT on the low-voltage side of the transformer. This signal is used for tap changer control purposes. The input is fixed to phase-to-phase voltage U12.

Calculated Uo can be used only when using phase-to-neutral voltages, that is star connection. When no measured or calculated Uo is available, set the directional earth-fault protection to use negative-sequence voltage as the voltage polarization method.

There are 16 programmable push-buttons offered in the front panel of the unit. The IED offers six different setting groups 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 manual

trigger of disturbance recorder, lower/raise tap changer, transformer control mode changing, circuit breaker control interlocking bypass, master trip lockout reset, and so on.

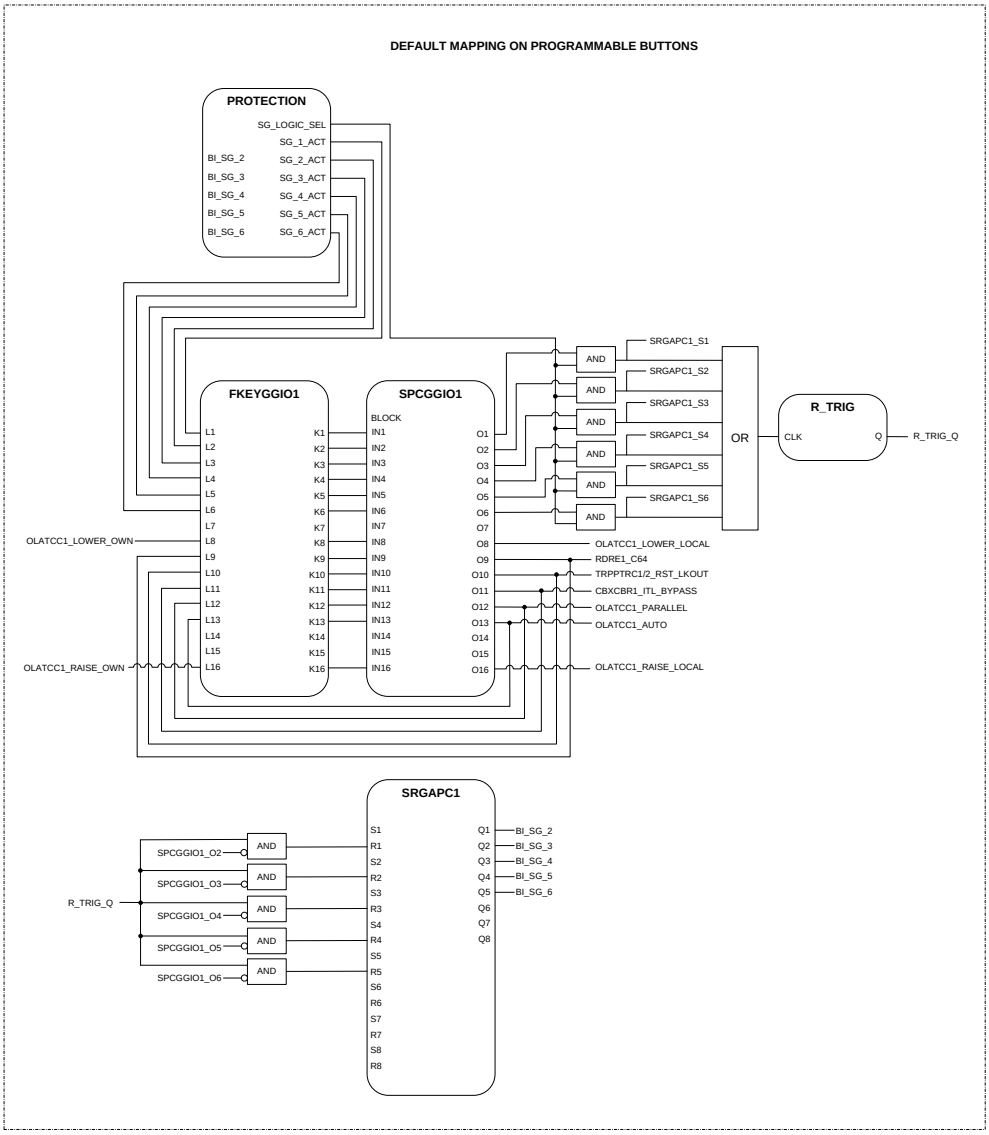

Figure 14: Default mapping on programmable buttons

3.5.3.1 Functional diagrams for protection

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

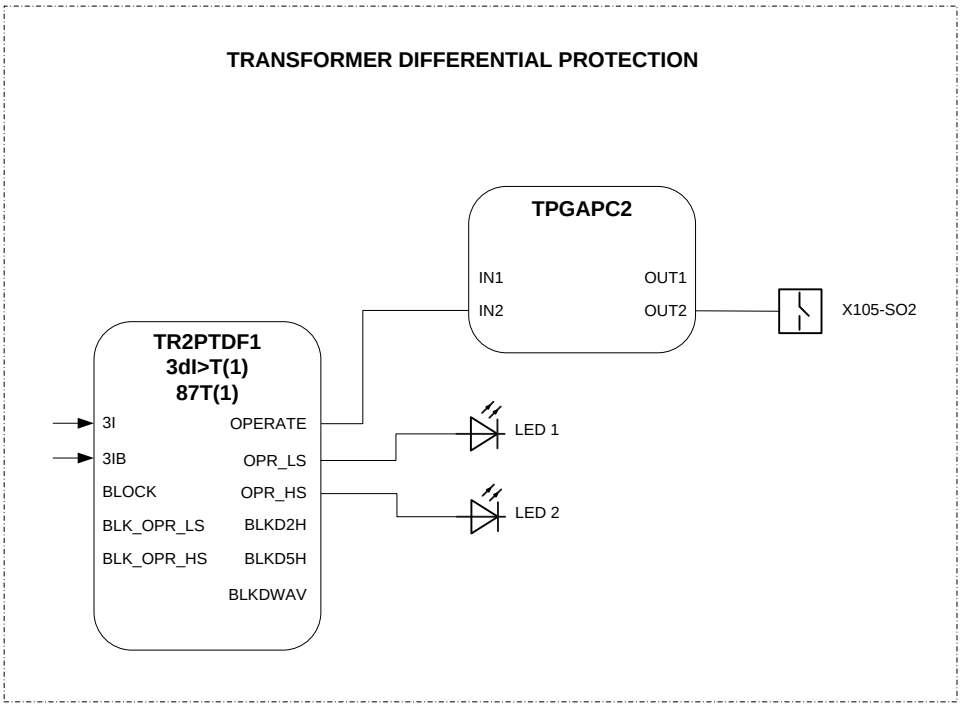

Figure 15: Transformer differential protection

The stabilized and instantaneous differential protection for 2W-transformers TR2PTDF1 provides protection of the power transformer unit including, for example, winding short circuit and interturn faults. The IED compares the phase currents on both sides of the object to be protected. If the differential current of the phase currents in one of the phases exceeds the setting of the stabilized operation characteristic or the instantaneous protection stage of TR2PTDF1, it provides an operating signal.

For transformers having an on-line tap changer, the tap position information is recommended to be used in differential protection, as the ratio difference of tap changer movements can be corrected in TR2PTDF1.

The tap changer position is internally provided from TPOSSLTC to OLATCC and TR2PTDF1. Thus, no tap changer position input is present within the functions. The related settings define if the compensation of tap changer position is taken into use.

The OPERATE signal is connected to the Master Trip and signal output 2 (X105-SO2:17-19) via generic timer TPGAPC2. The OPR_LS output is connected to alarm LED 1, which is used for biased low-stage operation indication, and the OPR_HS output is connected to alarm LED 2, which is used for instantaneous high-stage operation indication.

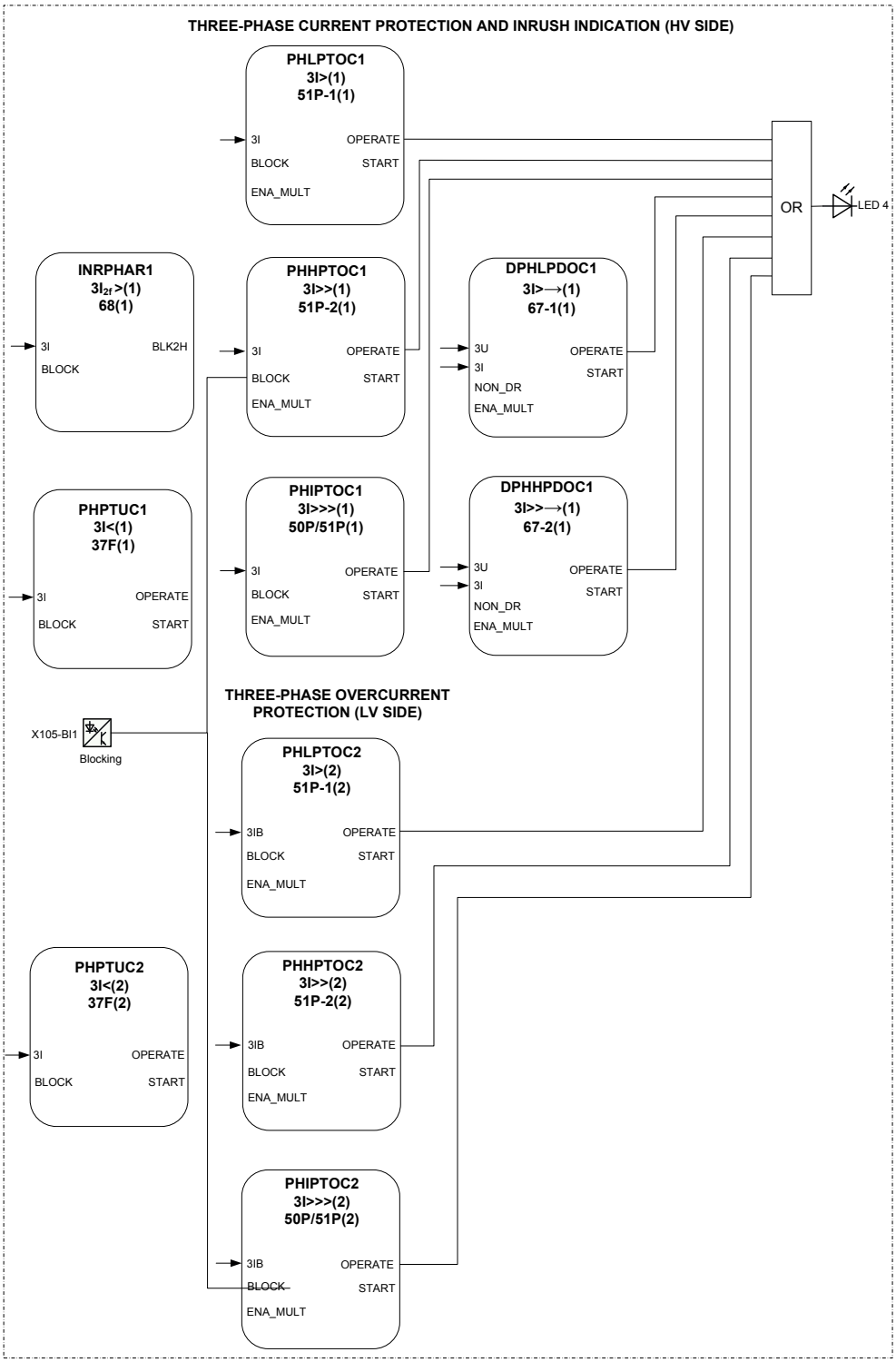

Figure 16: Three-phase current protection and inrush indication

Eight overcurrent stages in total, five stages for high-voltage side and three stages for low-voltage side, are offered for overcurrent and short-circuit protection. Three of them (DPHxPDOC) include directional functionality, while the others

(PHxPTOC) are only for non-directional overcurrent protection. The high stage of high-voltage side PHHPTOC1 and instantaneous stage of low-voltage side PHIPTOC2 can be blocked by energizing the binary input 1 (X105-BI1:1-2). The inrush detection block's (INRPHAR1) output BLK2H enables either blocking the function or multiplying the active settings for any of the described protection function blocks.

Two undercurrent stages (PHPTUC1/2) is offered for undercurrent protection. The START and OPERATE outputs from this function are connected to disturbance recorder, but this function is not configured to trip the circuit breaker by default.

The OPERATE outputs are connected to the Master Trip and alarm LED 4, except for those specially mentioned previously. LED 4 is used for combined protection operate indication.

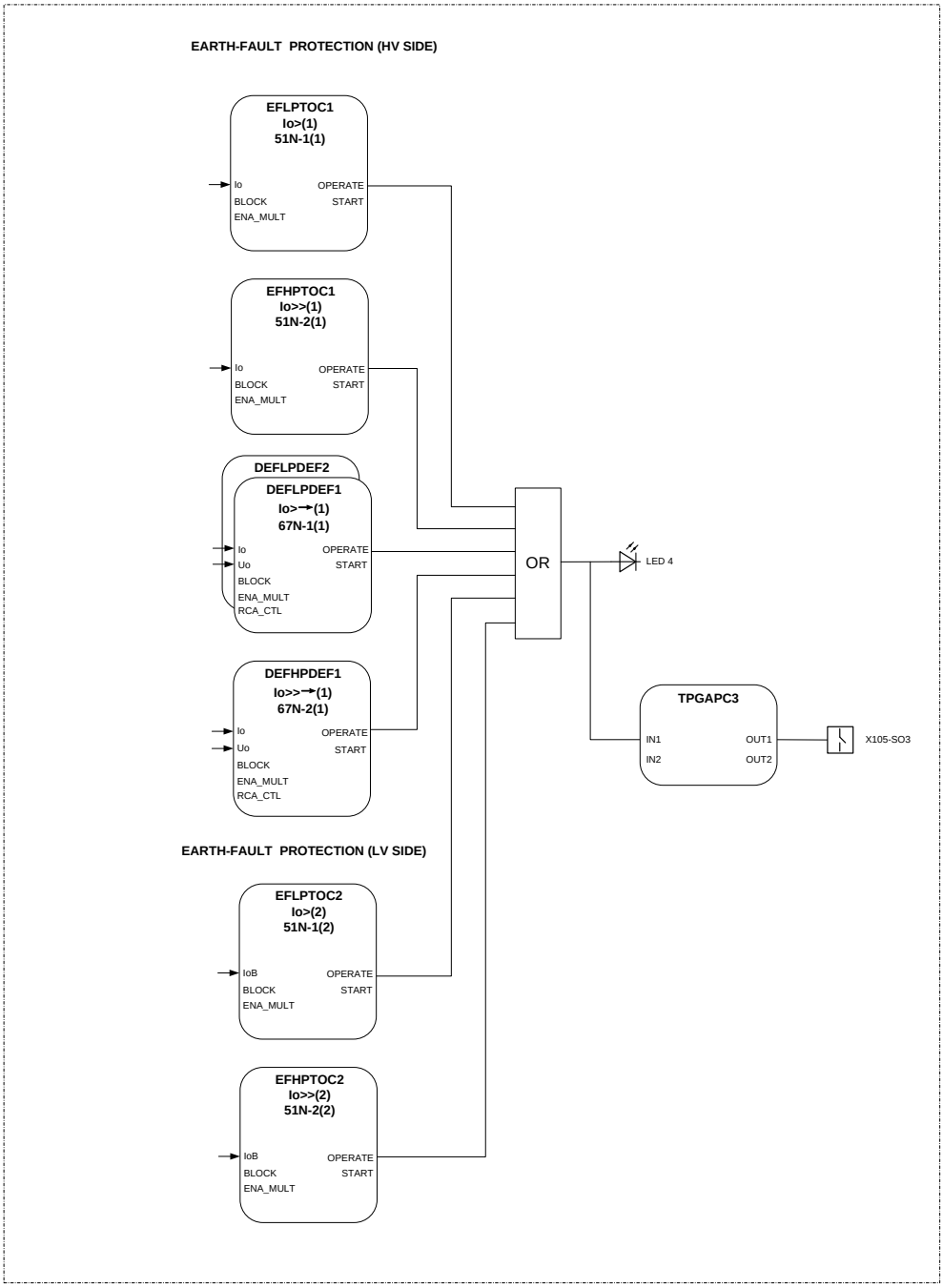

Figure 17: Earth-fault protection

Five stages for high-voltage side and two stages for low-voltage side, as a total of seven stages, are offered for earth-fault protection. Two of them (DEFxPDEF) include directional functionality, while the others (EFxPTOC) are only for non-directional earth-fault protection.

When 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 when a power system is provided with an open-delta VT (V-connected).

The OPERATE outputs are connected to the Master Trip and signal output 3 (X105-SO3:20-22) via generic timer TPGAPC3, and also to the alarm LED 4.

It is selectable by parameter whether the earth-fault protection function uses measured or calculated Io. However, when high-impedance based restricted earth-fault protection (HREFPDIF1/2), which needs dedicated differential current measurement channel, is used on the high-voltage side or low-voltage side, the earth-fault protections mentioned here should use only calculated Io from three-phase currents.

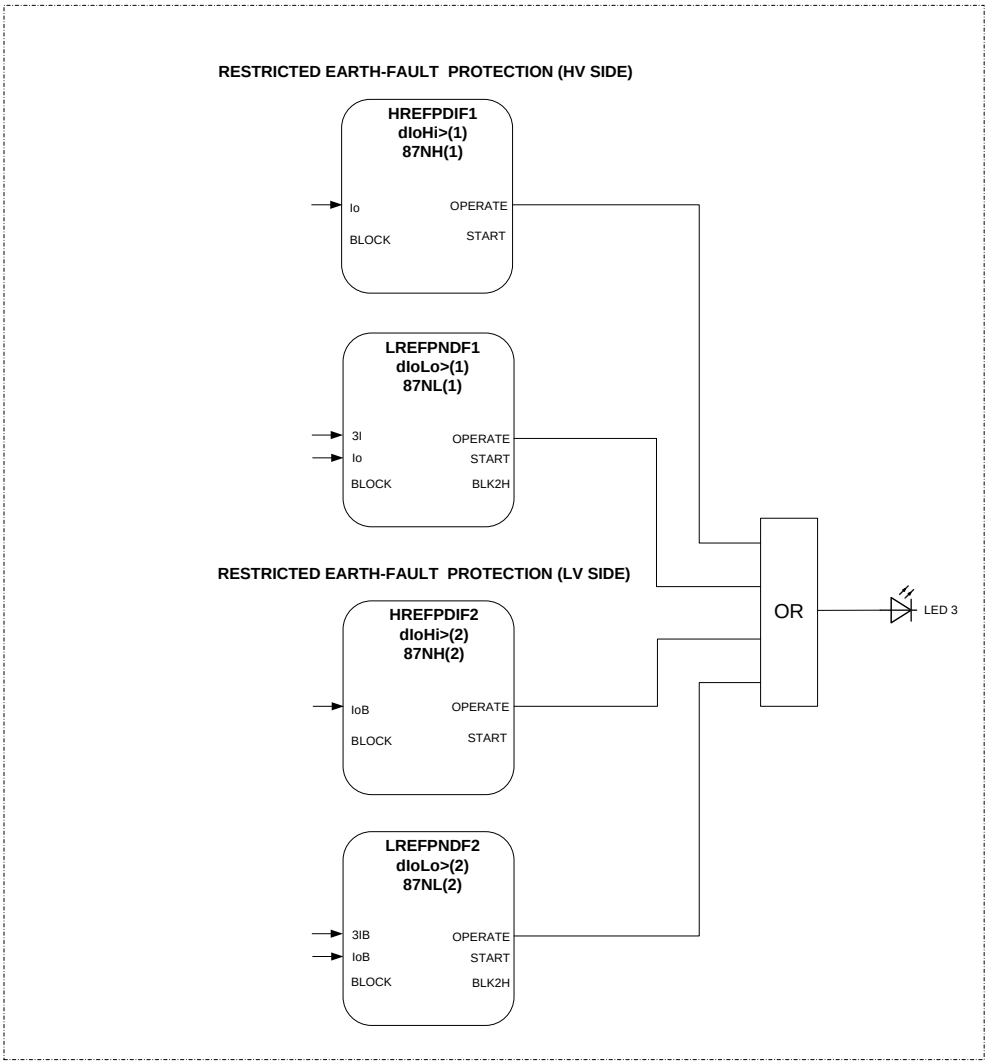

Figure 18: Restricted earth-fault protection

The configuration includes restricted high-impedance earth-fault protection HREFPDIF1/2 and low-impedance earth-fault protection LREFPNDF1/2 function, for both high-voltage side and low-voltage side of two-winding power transformers.

The restricted earth-fault current and the numerical differential current stage operate exclusively on earth faults occurring in the protected area, that is, in the area between the phase and neutral current transformers. An earth-fault in this area appears as a differential current between the residual current of the phase currents and the neutral current of the conductor between the star-point of the transformer and earth.

The OPERATE outputs are connected to the Master Trip and alarm LED 3. LED 3 is used for restricted earth-fault protection operate indication.

The connection diagram in this manual is only suitable for LREFPNDF. The measurement circuit for HREFPDIF is different.

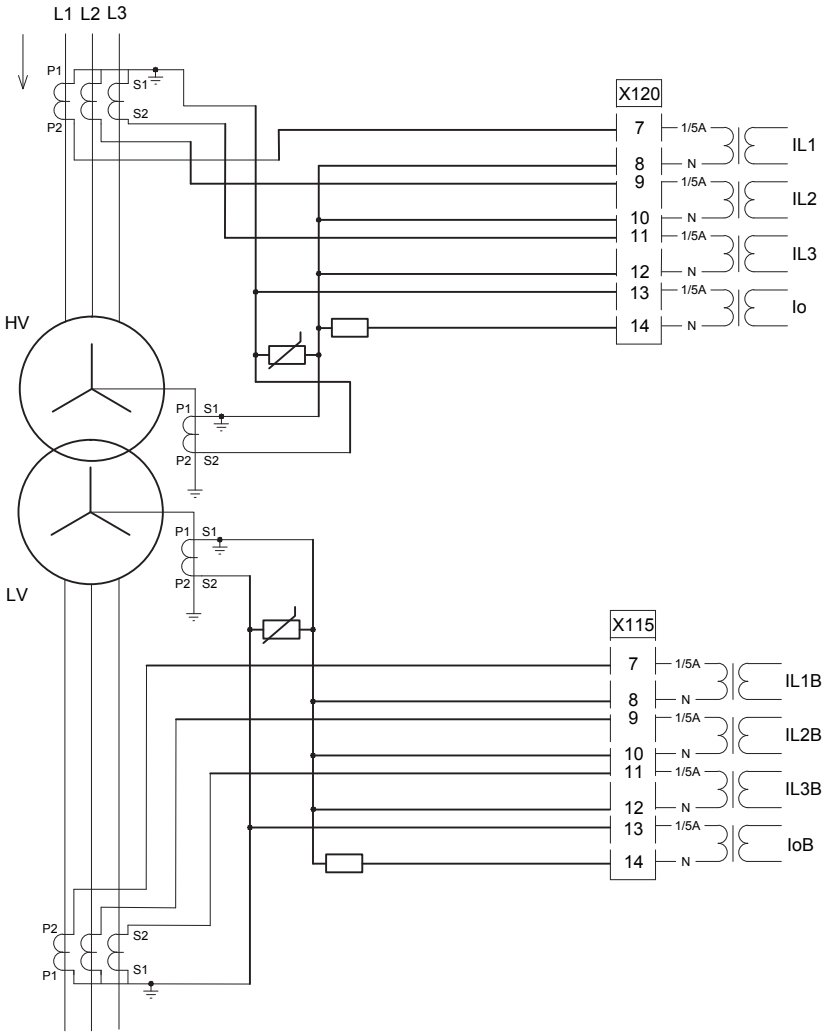

Figure 19: HREFPDIF measurement circuit

If HREFPDIF is used on HV or LV side , the Io measurement channel (Io or IoB) no longer measures the real residual current. This affects functions which need the Io measurement on the same side (HV or LV) in different ways.

- LREFPNDF and CCRDIF cannot be used, as they always need the measured Io.
- EFxPTOC, DEFxPDEF need to be set to use the calculated Io.
- With CCBRBRF, the residual current criteria is no longer applicable.
- Measured value from RESCMMXU is not the real residual current but the differential current for HREFPDIF.

When high-impedance based restricted earth-fault protection needs a dedicated differential current measurement channel, measured Io is not available for other functions that need it.

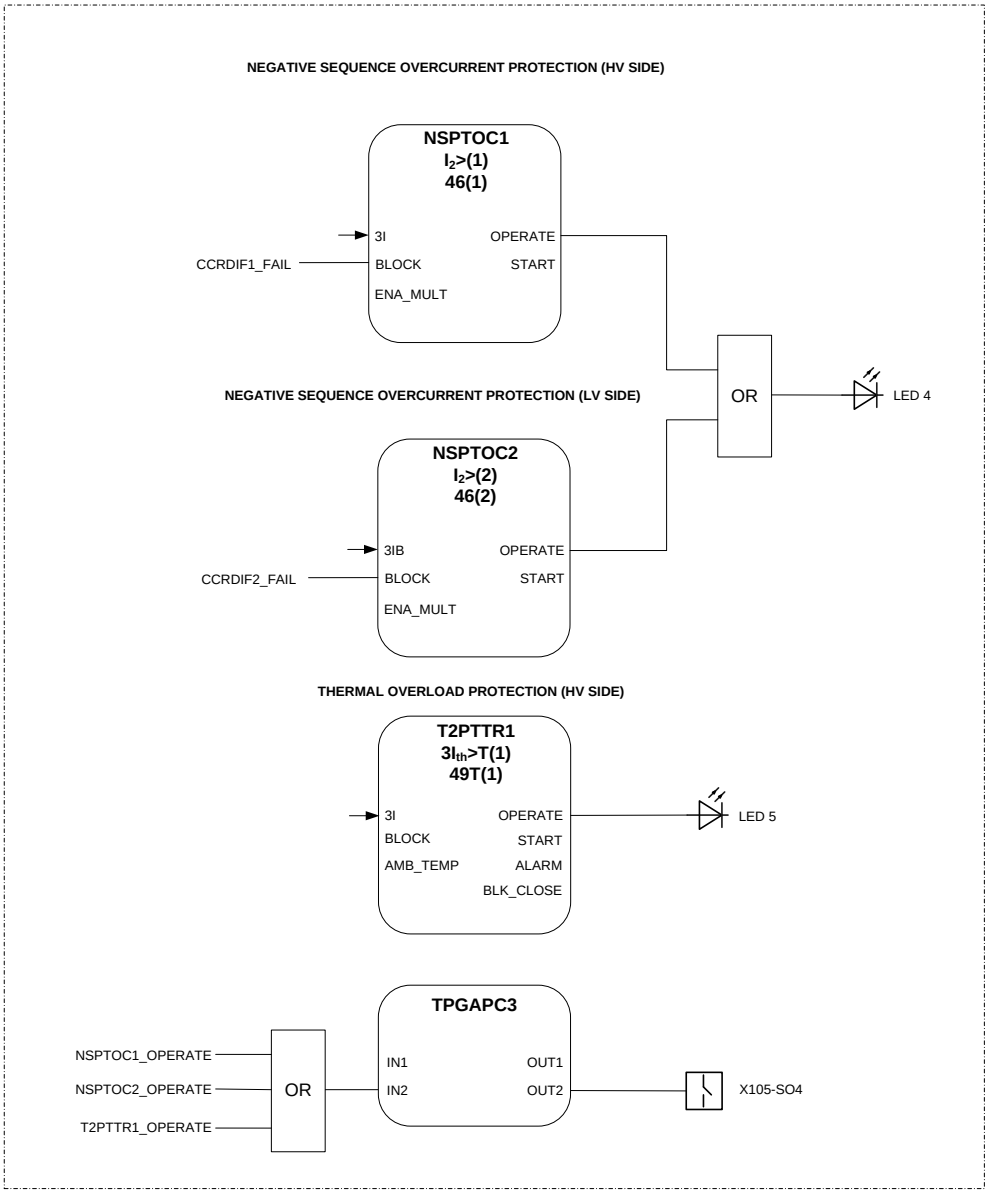

Figure 20: Negative sequence current protection and thermal overload protection

NSPTOC1/2 is designed for negative-phase sequence protection whenever the operating characteristic is appropriate. It is applied for the protection of transformers against thermal stress and damage. NSPTOC1 measures negative-sequence current from the high-voltage side; NSPTOC2 from the low-voltage side. A failure in the current measuring circuit is detected by the current circuit supervision function CCRDIF1/2 to avoid faulty tripping.

Three-phase thermal overload protection for power transformers T2PTTR1 provides indication on overload situations.

The OPERATE outputs of NSPTOC1/2 are connected to the Master Trip and alarm LED 4. The OPERATE output of T2PTTR1 is connected to the Master Trip and alarm LED 5. The OPERATE outputs of these function are also connected to signal output 4 (X105-SO4:23-24) via generic timer TPGAPC3.

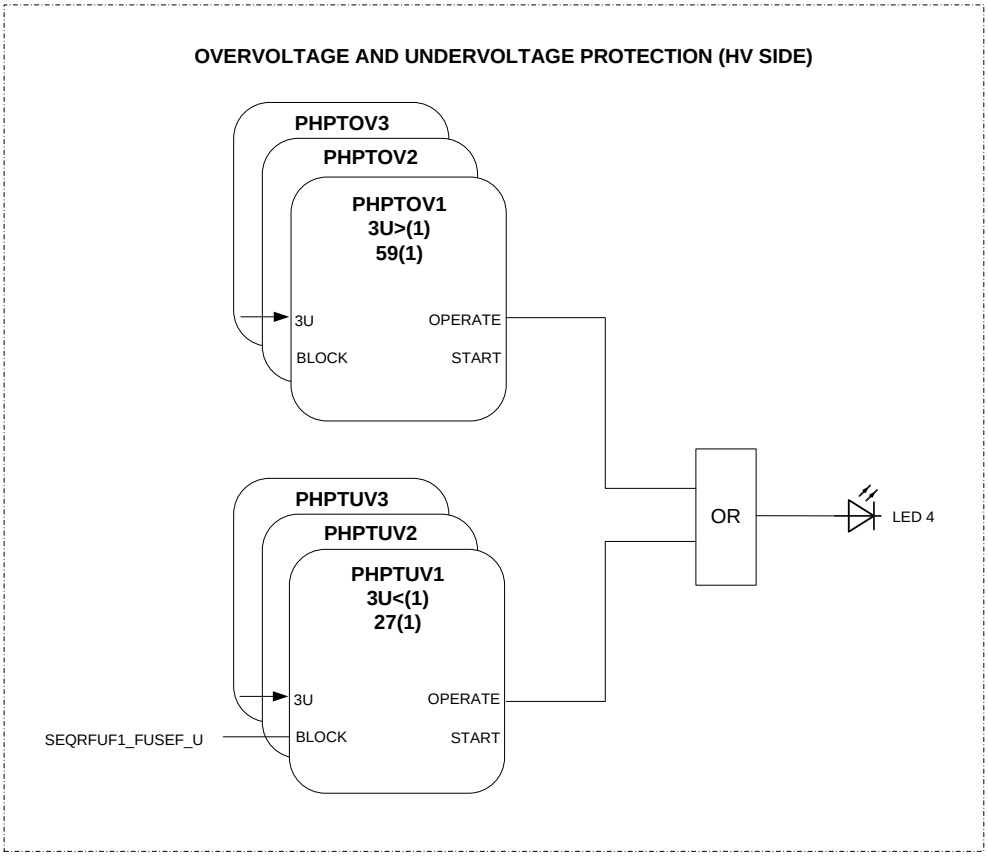

Figure 21: Overvoltage and undervoltage protection

Three overvoltage and undervoltage protection stages PHPTOV and PHPTUV offer protection against abnormal phase voltage conditions. A failure in the voltage measuring circuit is detected by the fuse failure function and the activation is connected to undervoltage protection functions, to avoid faulty undervoltage tripping.

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

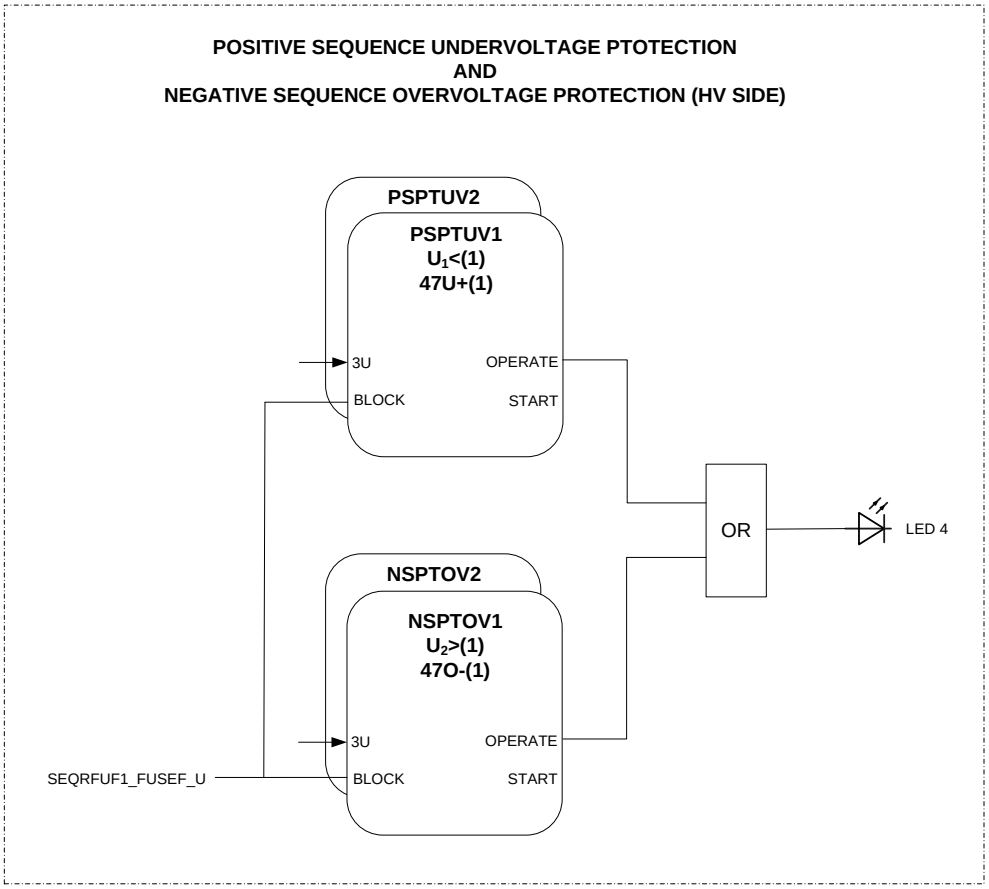

Figure 22: Positive-sequence undervoltage and negative-sequence overvoltage protection

Positive-sequence undervoltage PSPTUV1/2 and negative-sequence overvoltage NSPTOV1/2 protection functions enable voltage-based unbalance protection. A failure in the voltage measuring circuit is detected by the fuse failure function and the activation are connected to positive-sequence undervoltage PSPTUV1/2 and negative-sequence overvoltage NSPTOV1/2 protection functions, to avoid faulty tripping.

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

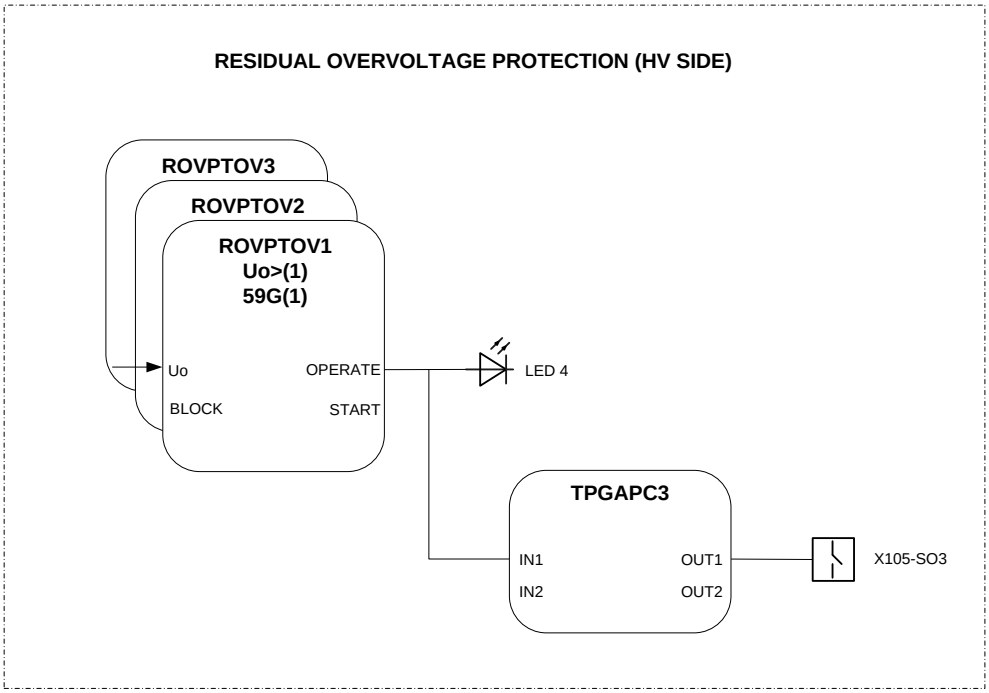

Figure 23: Residual overvoltage protection

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 signal output 3 (X105-SO3:20-22) via generic timer TPGAPC3 and also alarm LED 4.

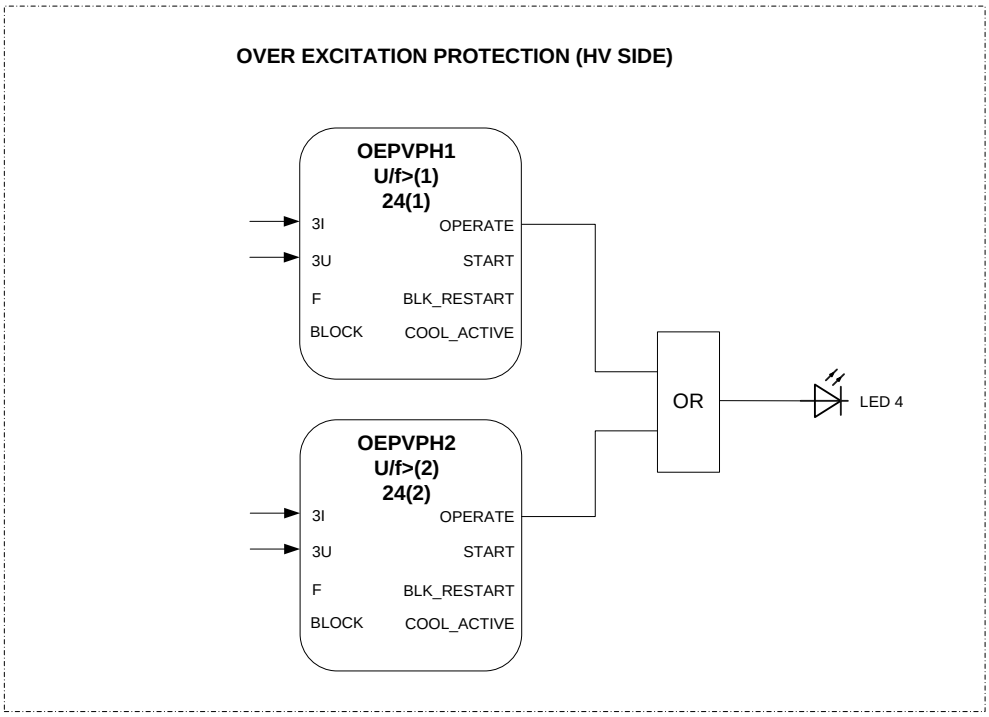

Figure 24: Over-excitation protection

Two over-excitation protections OEPVPH1/2 are offered against power transformers excessive flux density and saturation of magnetic core.

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

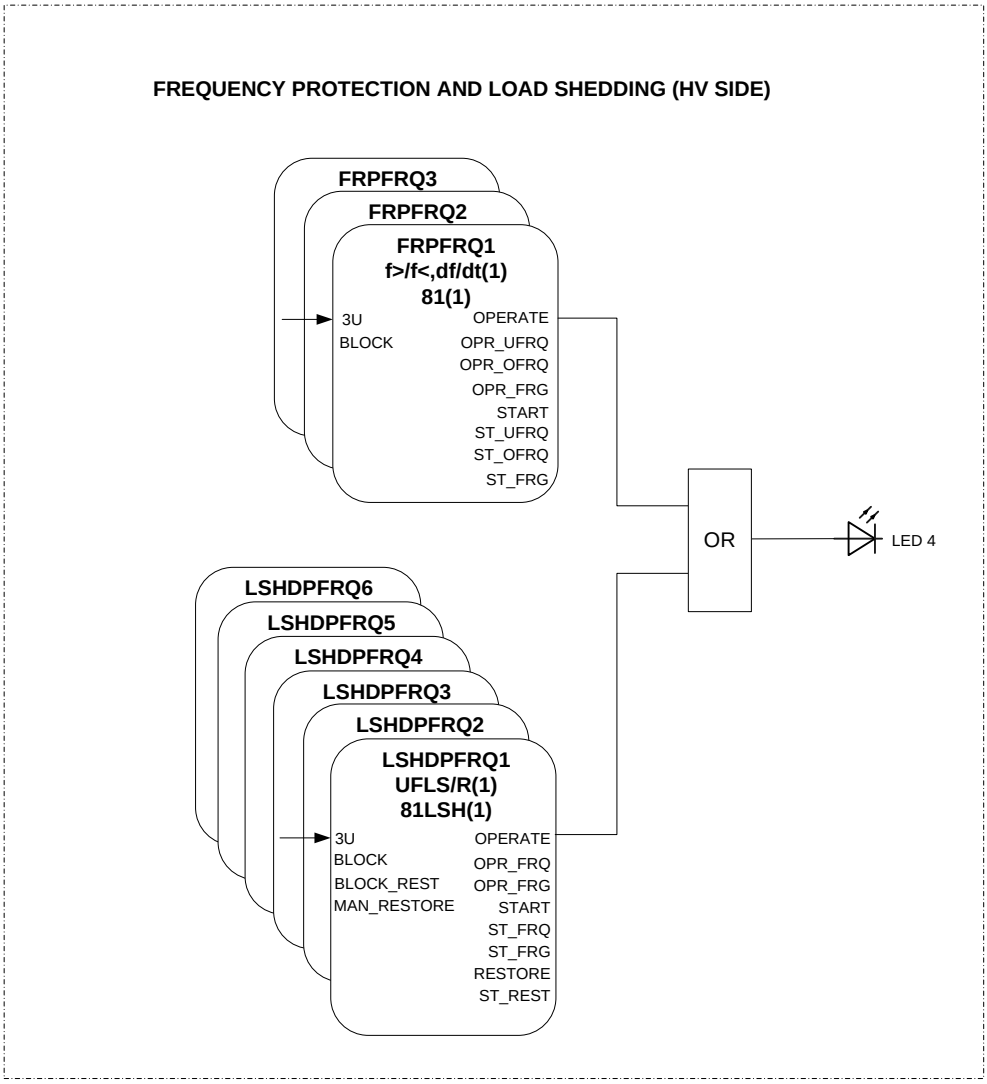

Figure 25: Frequency and load shedding protection

Three underfrequency or overfrequency protection FRPFRQ1…3 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 signal is connected to the Master Trip and alarm LED 4.

Six load shedding and restoration protection LSHDPFRQ1…6 stages are offered in the default configuration. The load shedding and restoration function is capable of shedding load based on under frequency and the rate of change of the frequency. The load that is shed during the frequency disturbance can be restored once the frequency is stabilized to the normal level. Also manual restore commands can be

given via binary inputs but, by default, it is not connected. The OPERATE outputs signal is also connected to the Master Trip and alarm LED 4.

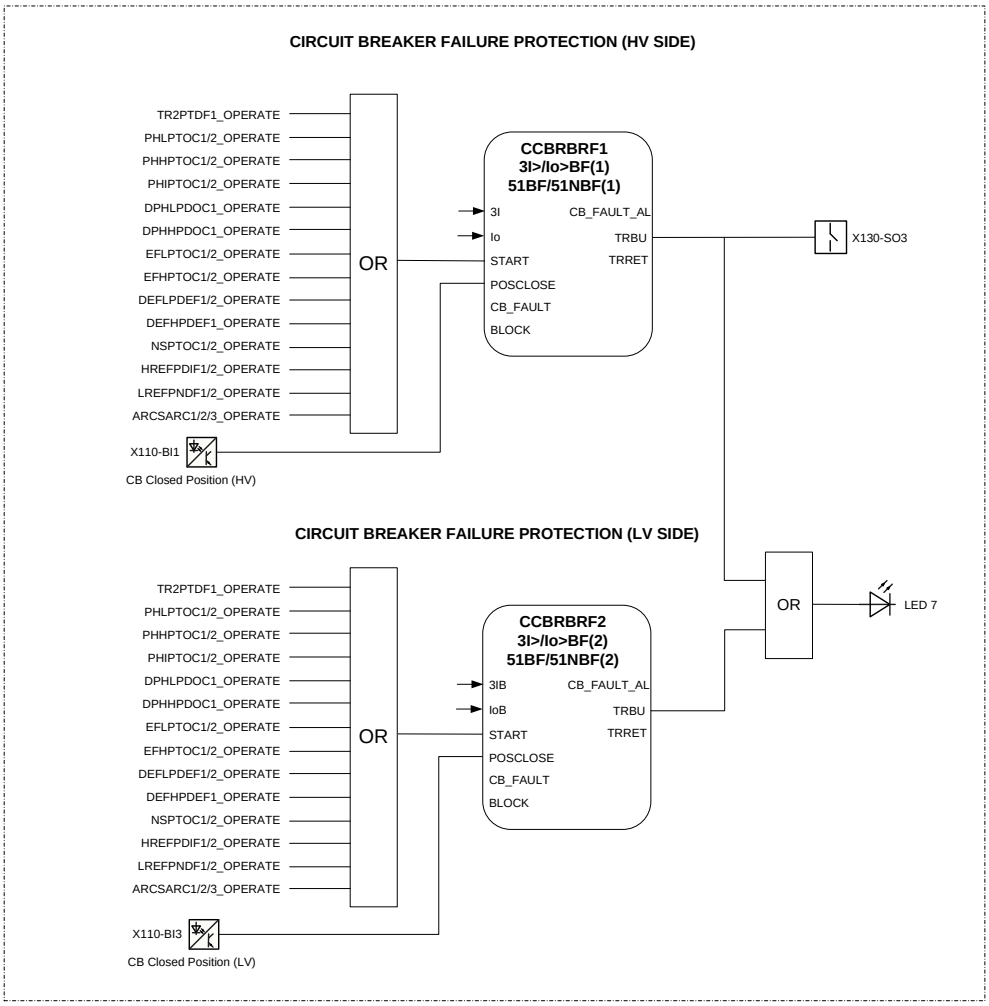

Figure 26: Circuit breaker failure protection

The breaker failure protection CCBRBRF1/2 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, CCBRBRF1 for high-voltage side through the Master Trip 1 and CCBRBRF2 for low-voltage side through the Master Trip 2. The TRBU output is used to give a backup trip to the breaker feeding upstream. For this purpose, the TRBU output signal of CCBRBRF1 is connected to signal output 3 (X130-SO3:16-17. Both functions TRBU outputs are connected to alarm LED 7. LED 7 is used for backup (TRBU) operate indication.

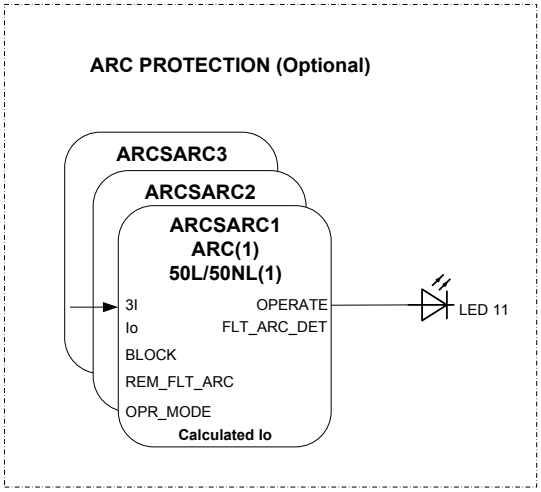

Figure 27: Arc protection

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

For RET620, arc protections functions, calculated Io is used for the residual current criteria.

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

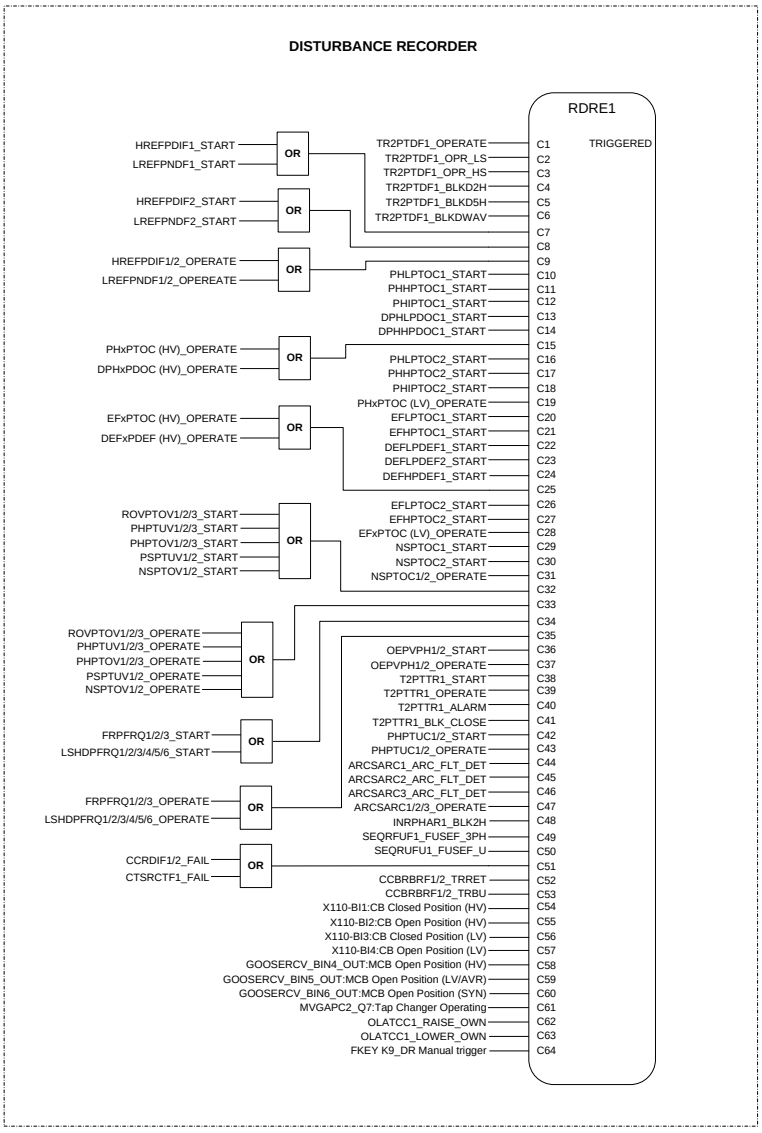

Figure 28: Disturbance recorder

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 some binary inputs from X110 are also connected. The manual trigger signal from push button is used to trigger disturbance recorder manually as needed.

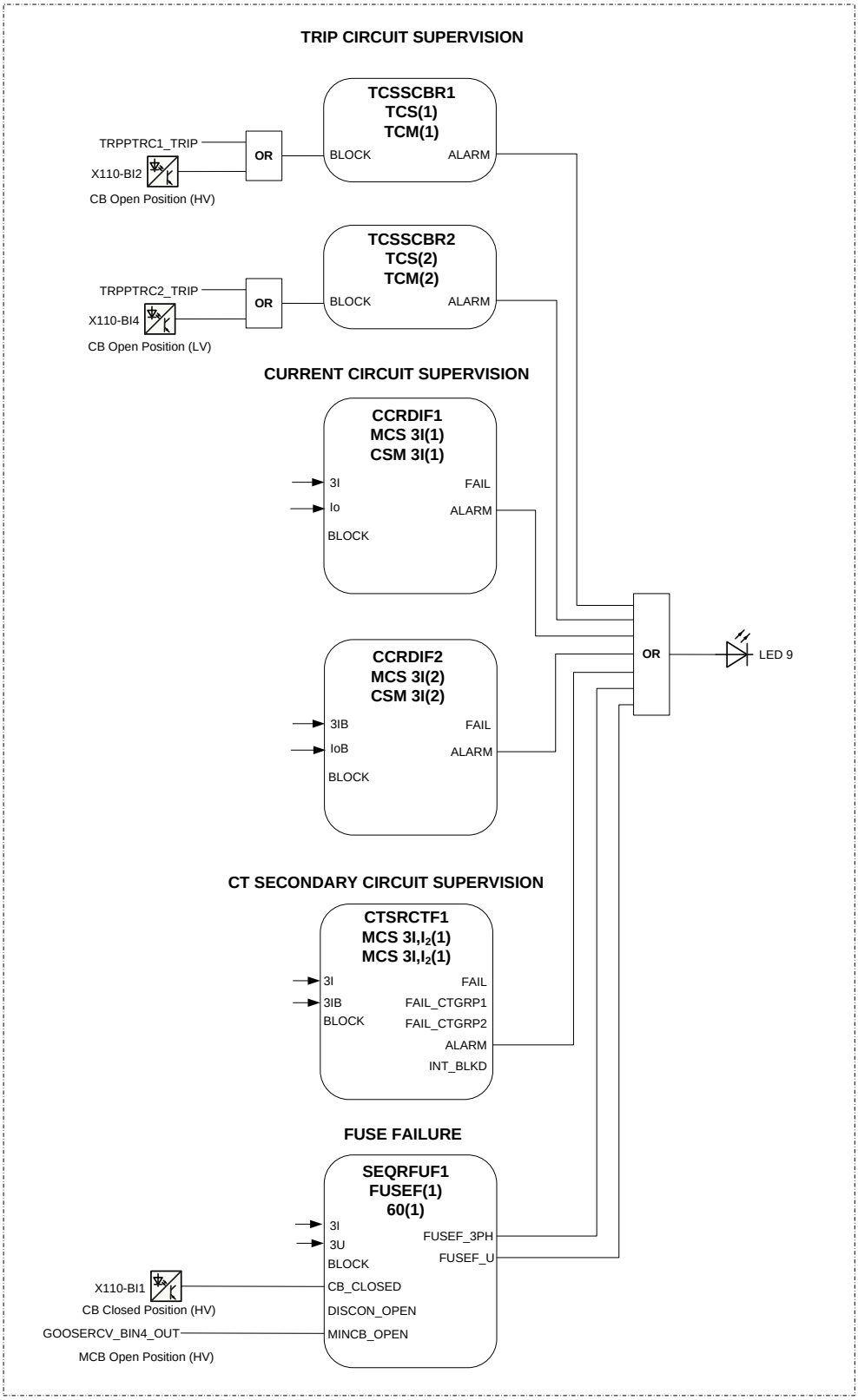

Figure 29: Circuit supervision

Two separate trip circuit supervision functions are included, TCSSCBR1 for power output 3 (X100-PO3:15-19) and TCSSCBR2 for power output 4 (X100-PO4:20-24). Both functions are blocked by the Master Trip TRPPTRC1 and TRPPTRC2, and the circuit breaker open signal. The TCS alarm indication is connected to the LED 9.

By default, it is expected that there is no external resistor in the circuit breaker tripping coil circuit connected parallel with circuit breaker normally open auxiliary contact.

Failures in current measuring circuits are detected by CCRDIF, both in high-voltage side (CCRDIF1) and low-voltage side (CCRDIF2). When a failure is detected, blocking signal is activated in current protection functions that are measuring calculated sequence component currents, and unnecessary operation can be avoided. The alarm signal is also connected to the alarm LED 9.

CCRDIF is internally blocked if any of the phase currents exceeds the set maximum limit.

In the default configuration, the current circuit supervision functions are not used to block the transformer main protection because these functions, too, react on the internal faults of transformers. Functions are mainly used for indication and alarm purposes only.

The CT secondary circuit supervision function CTSRCTF is used for monitoring the current transformer secondary circuit. CTSRCTF can be used for detecting the single-phase failure on the current transformer secondary for protection application involving two sets of the three-phase current transformers. CTSRCTF detects a fault in the measurement circuit and issues an alarm. In the default configuration, the `ALARM` output from CTSRCTF is only connected to the alarm LED 9, but it can also be used for blocking the protection functions, for example, differential protection, to avoid unwanted tripping.

CTSRCTF is internally blocked if the transformer under no-load condition is met or if any of the phase currents exceeds the set maximum limit.

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

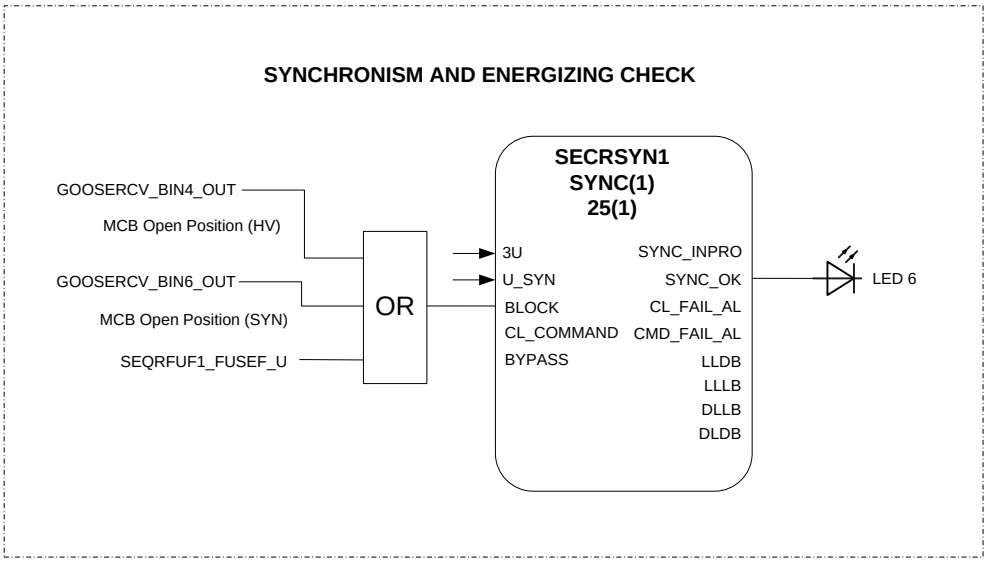

Figure 30: Synchronism and energizing check

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. The energizing function allows closing, for example, when one side of the breaker is dead.

SECRSYN1 measures voltages from high-voltage bus side and transformer high-voltage side and compares them to set conditions. When all the measured quantities are within the set limits, the output `SYNC_OK` is activated for allowing closing or closing the circuit breaker. The `SYNC_OK` output signal is connected to the `ENA_CLOSE` input of CBXCBR1/2, through control logic, and alarm LED 6. The colors of LED 6 indicate the status of `SYNC_OK`. If `SYNC_OK` is true, LED 6 is green, and if `SYNC_OK` is false, LED 6 is red.

To ensure the validity of the measured voltages on both sides, `MCB Open Position (HV)`, `MCB Open Position (SYN)` and `SEQRFUF1_FUSEF_U` are connected to block SECRSYN1. HV and SYN MCB Open Position come from the received GOOSE signal.

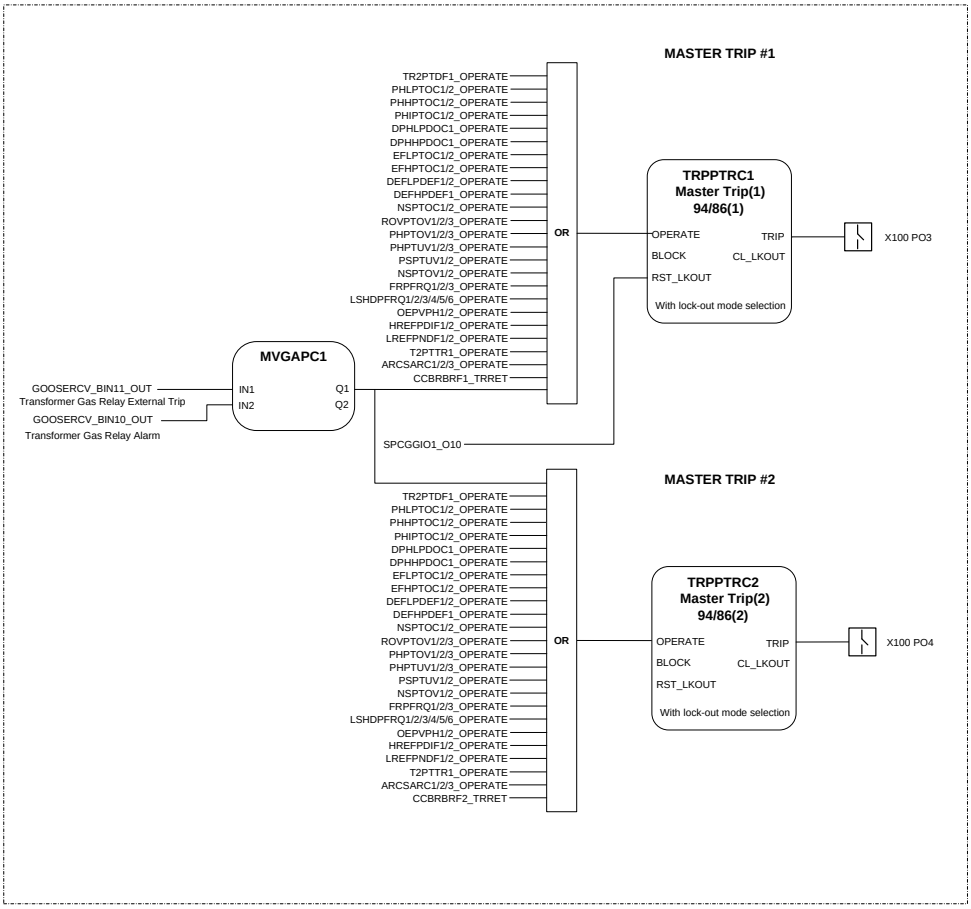

Figure 31: Master trip

The operating signals from the protections and two GOOSE binary inputs are connected to the two trip output contacts, power output 3 (X100 PO3:15-19) and power output 4 (X100 PO4:20-24), via the corresponding Master Trips TRPPTRC1 and TRPPTRC2.

TRPPTRC1 and TRPPTRC2 provide lockout/latching function, event generation and trip signal duration setting. If the lockout operation mode is selected, one push button can be used to reset the lockout status through `SPCGGIO1_O10`.

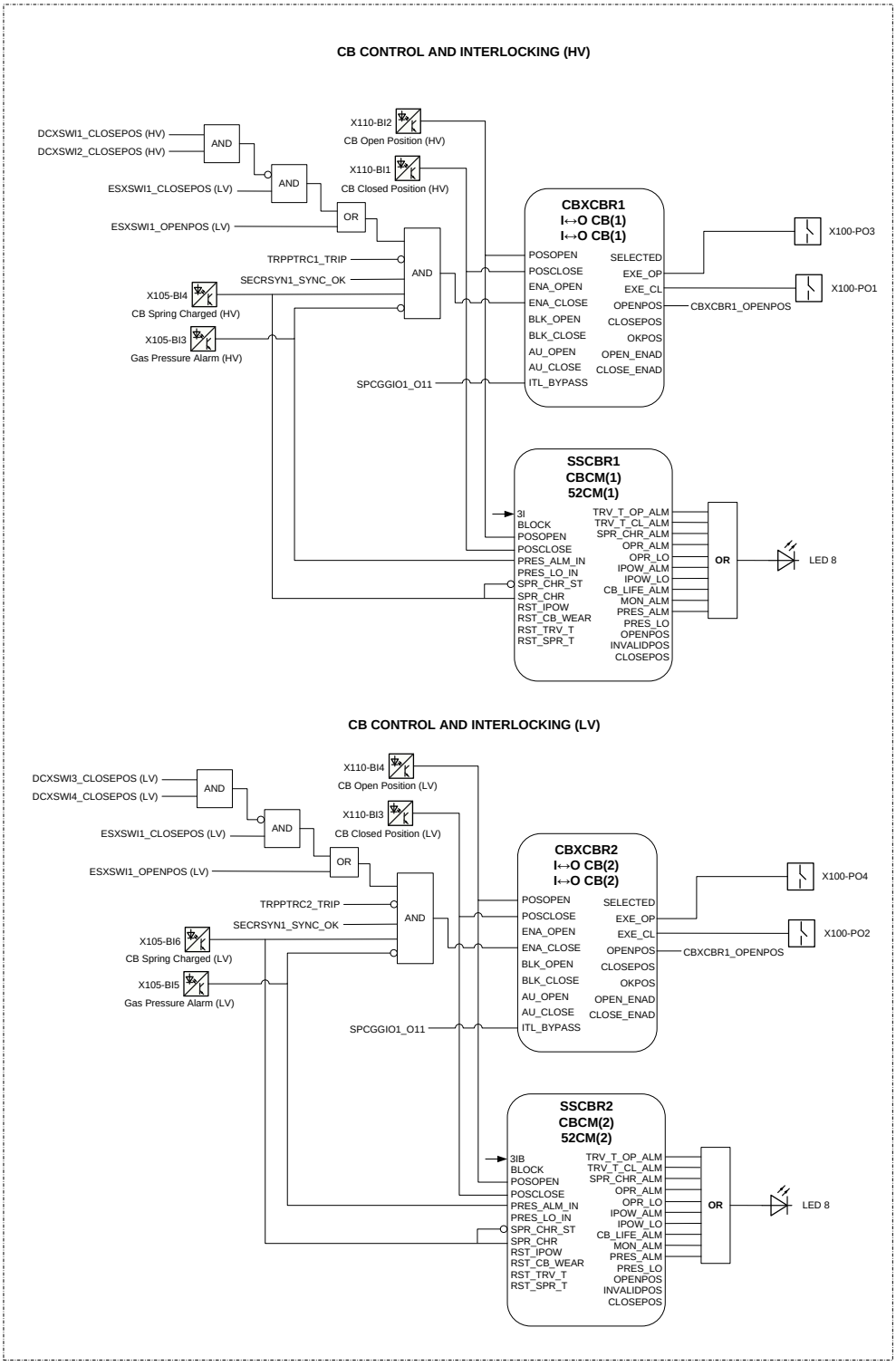

Figure 32: Circuit breaker control and interlocking

The circuit breaker opening is enabled when 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.

For high-voltage side CB, the closing is enabled when the ENA_CLOSE input of CBXCBR1 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 either disconnector on the high-voltage side is open when the earthing switch is closed).

For low-voltage side CB, the closing is enabled when the ENA_CLOSE input of CBXCBR2 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 either disconnector on the low-voltage side is open when the earthing switch is closed).

The circuit breaker closing is blocked when the BLK_CLOSE input is activated. As BLK_CLOSE is left unconnected, this signal is always deactivated.

One push button can be used through SPCGGIO1_O11, which is connected to the ITL_BYPASS inputs of the CBXCBR1 and CBXCBR2, to ignore the status of the ENA_CLOSE inputs. However, the BLK_CLOSE inputs are not bypassed with the interlocking bypass functionality, as they always have the higher priority.

If the ENA_CLOSE signal is completely removed from the breaker control function block CBXCBR1 or CBXCBR2 with PCM600, the function assumes that the breaker-closing commands are allowed continuously.

The circuit breaker condition monitoring function SSCBR1 or SSCBR2 supervises the circuit breaker status based on the connected binary input information and the measured current levels. The function introduces various supervision methods. The corresponding supervision alarm signals are routed to LED 8.

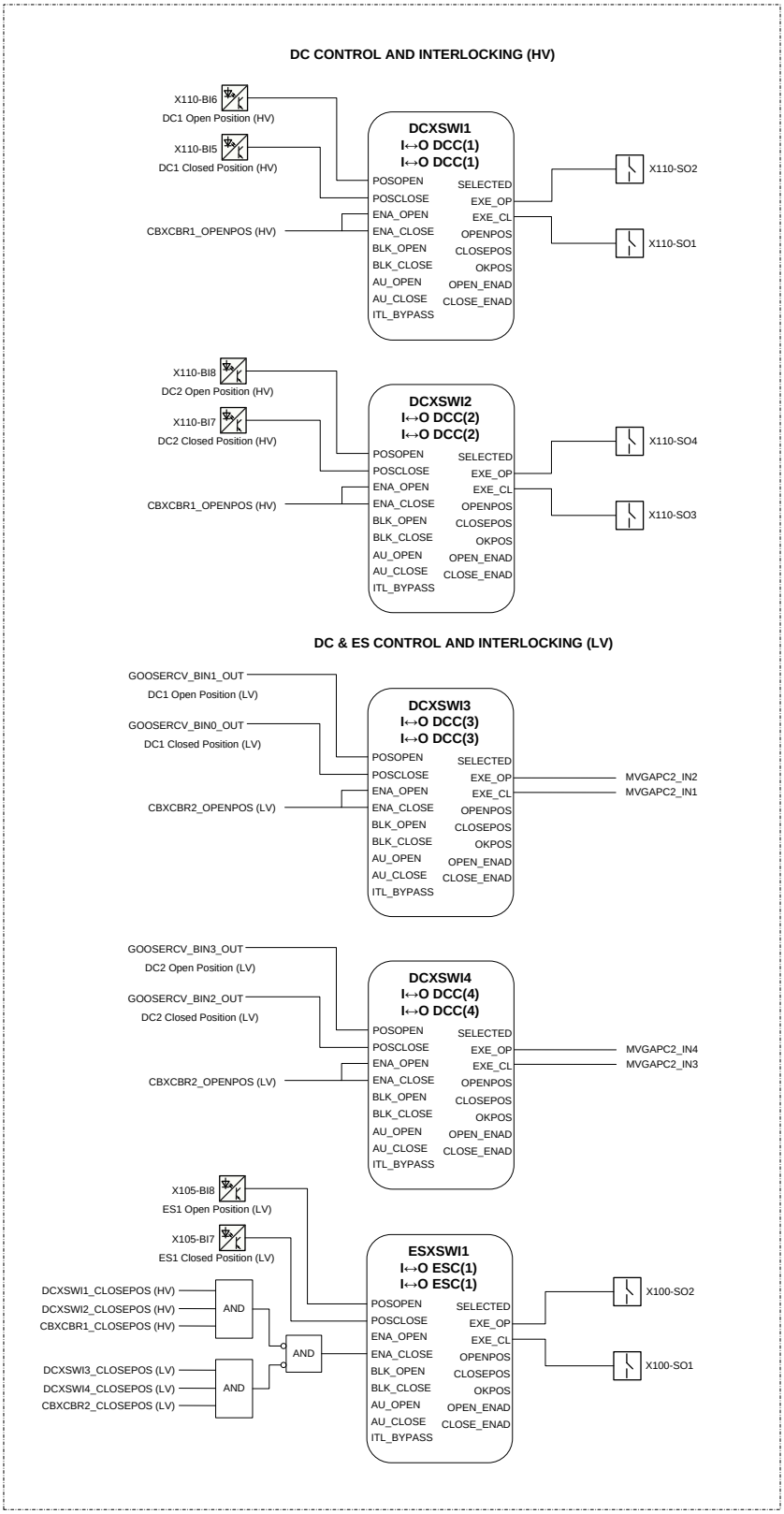

Figure 33: Disconnector and earthing-switch control and interlocking

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

The binary inputs 5 and 6 of the card X110 are used for high-voltage side busbar disconnector 1 (DCXSWI1) position indication. The binary inputs 7 and 8 of the card X110 are used for high-voltage side busbar disconnector 2 (DCXSWI2) position indication.

Table 20: HV disconnector 1 position indicated by binary inputs

Primary device position	Input to be energized	
	Input 5 (X110:8-9)	Input 6 (X110:10-9)
HV disconnector 1 closed	•	
HV disconnector 1 open		•

Table 21: HV disconnector 2 position indicated by binary inputs

Primary device position	Input to be energized	
	Input 7 (X110:11-12)	Input 8 (X110:13-12)
HV disconnector 2 closed	•	
HV disconnector 2 open		•

The GOOSE binary inputs `GOOSERCV_BIN0_OUT` and `GOOSERCV_BIN1_OUT` are used for low-voltage side busbar disconnector 1 (DCXSWI3) position indication. The GOOSE binary inputs `GOOSERCV_BIN2_OUT` and `GOOSERCV_BIN3_OUT` are used for low-voltage side busbar disconnector 2 (DCXSWI4) position indication.

Table 22: LV disconnector 1 position indicated by binary inputs

Primary device position	Input to be energized	
	GOOSERCV_BIN0_OUT	GOOSERCV_BIN1_OUT
LV disconnector 1 closed	•	
LV disconnector 1 open		•

Table 23: LV disconnector 2 position indicated by binary inputs

Primary device position	Input to be energized	
	GOOSERCV_BIN2_OUT	GOOSERCV_BIN3_OUT
LV disconnector 2 closed	•	
LV disconnector 2 open		•

The binary inputs 7 and 8 of card X105 are designed for the position indication of the earthing-switch.

Table 24: Earthing-switch position indicated by binary inputs

Primary device position	Input to be energized	
	Input 7 (X105:11-12)	Input 8 (X105:13-12)
Earthing-switch closed	•	
Earthing-switch open		•

Control of disconnector 1 and disconnector 2 is enabled only when the circuit breaker in the high-voltage side is in the open position. Control of disconnector 3 and disconnector 4 is enabled only when the circuit breaker in the low-voltage side is in the open position.

Closing of earthing-switch is enabled when the conditions are fulfilled.

- Disconnector 1, disconnector 2 and high-voltage side circuit breaker are not in the closed position at the same time.
- Disconnector 3, disconnector 4 and low-voltage side circuit breaker are not in the closed position at the same time.

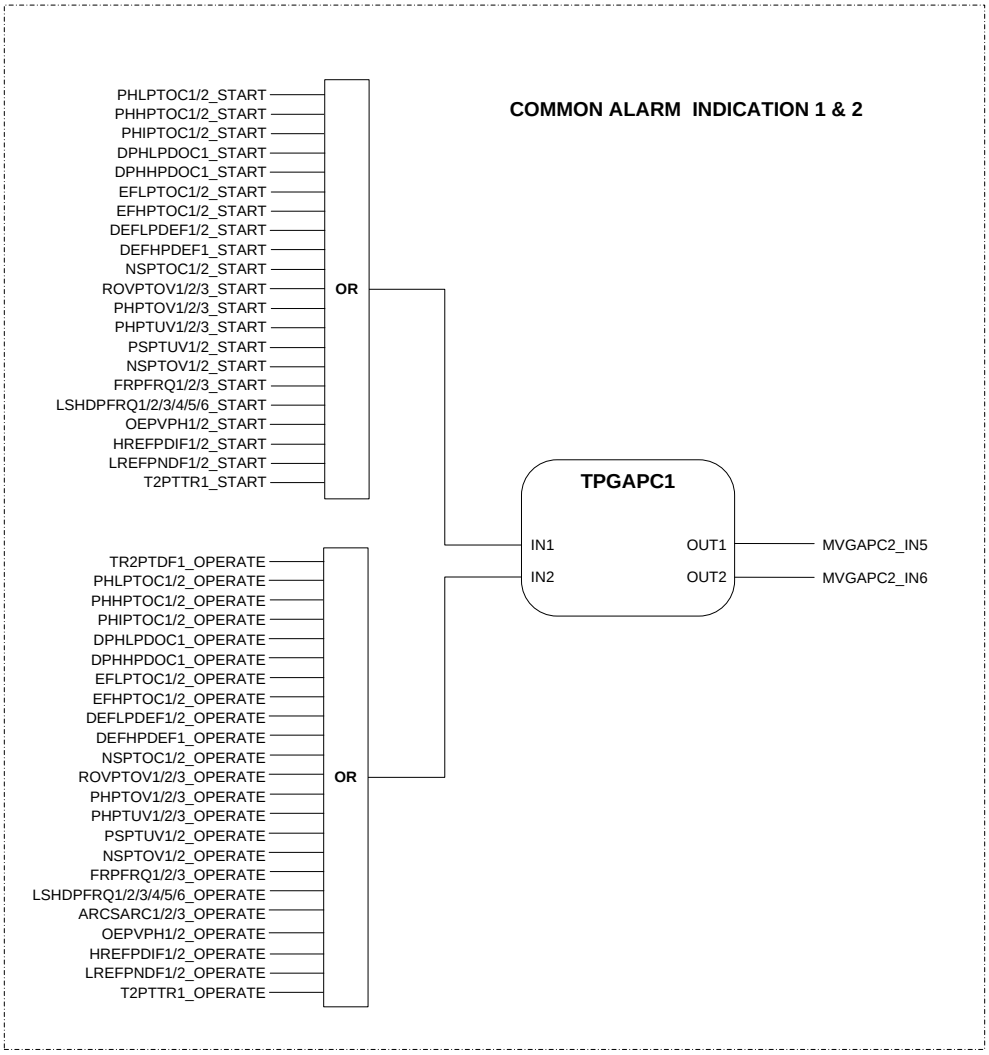

Figure 34: Common alarm indication

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

- Start of any protection function
- Operation (trip) of any protection

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 not described in the functional diagram are available in PCM600 for connection where applicable.

Common alarm indications are intended to be sent out by GOOSE. It is also connected to MVGPAC to generate local events.

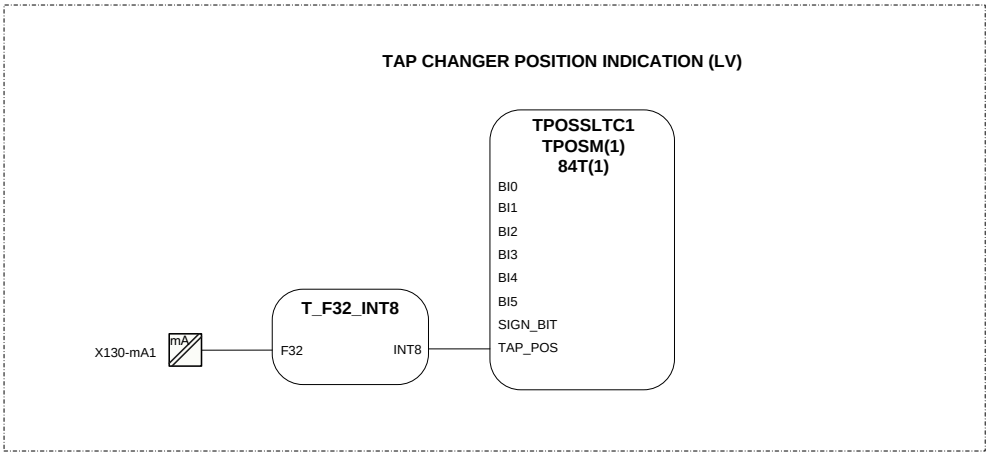

Figure 35: Tap changer position indication

To monitor tap changer operations and increase the sensitivity of the stabilized differential function, the tap position information from the tap changer is connected to the IED via the tap changer position indication function TPOSSLTC1. TPOSSLTC1 is connected to the mA input of the RTD card.

Tap changer status information can also be reached via binary information instead of mA information.

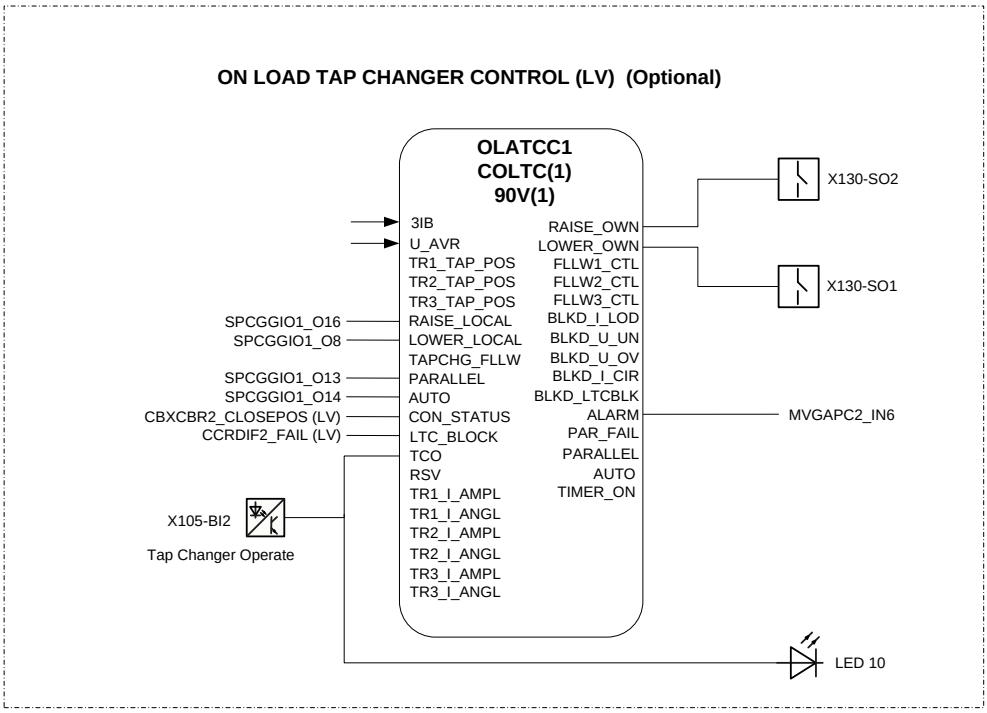

Figure 36: On-load tap changer control

Tap changer control with voltage regulator function is included as an optional function. The on-load tap changer control functionality is provided with OLATCC1. Both manual and automatic controlling of the on-load tap changer is done via OLATCC1. The local tap changer can be controlled via SPCGGIO1, the SPCGGIO1_O8 input for the lowering request and SPCGGIO1_O16 for the raising request. The operation mode of OLATCC1 can be controlled externally by push buttons, via SPCGGIO_O13 and SPCGGIO_O14.

The binary input 2 (X105-BI2:3-2) indicating the tap changer operating information can be connected to TCO, the alarm LED 10.

OLATCC1 is blocked in the automatic mode as a default setting if the LTC_BLOCK input is active.

The output commands are routed to the binary outputs, the raising command is connected to signal output 2 (X130-SO2:12-14) and the lower command is connected to signal output 1 (X130-SO1:9-11).

The common alarm signal of OLATCC1 is connected to the GOOSE binary output MVGAPC2_IN6.

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 25: Phase current inputs included in configuration A

Terminal	Description
X115-7,8	IL1B
X115-9,10	IL2B
X115-11,12	IL3B
X120-7,8	IL1
X120-9,10	IL2
X120-11,12	IL3

4.1.1.2 Residual current

Table 26: Residual current input included in configuration A

Terminal	Description
X115-13,14	IoB
X120-13, 14	Io

4.1.1.3 Phase voltages

Table 27: Phase voltage inputs included in configuration A

Terminal	Description
X120-1,2	U1
X120-3,4	U2
X120-5,6	U3

Table 28: Reference voltage input for SECRSYN1 included in configuration A

Terminal	Description
X115-1,2	U_SYN

Table 29: Phase-to-phase voltage input for OLATCC1 included in configuration A

Terminal	Description
X115-3,4	U_AVR

4.1.1.4 Residual voltage

Table 30: Additional residual voltage input included in configuration A

Terminal	Description
X115-5,6	Uo

4.1.2 RTD/mA inputs

RTD/mA inputs of slot X130 are available with configuration A.

Table 31: RTD/mA inputs

Terminal	Description
X130-1,2	mA1 (AI1), + mA1 (AI1), -
X130-3,4	RTD1 (AI2), + RTD1 (AI2), -
X130-5	ground for RTD1
X130-6,7	RTD2 (AI3), + RTD2 (AI3), -
X130-8	ground for RTD2

RTD/mA inputs of slot X105 are available in the optional RTD module (RTD0003).

Table 32: 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), -
Table continues on next page	

Terminal	Description
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 33: 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 X110 are available with configuration A.

Table 34: Binary input terminals X110-1...13

Terminal	Description
X110-1	BI1, +
X110-2	BI1, -
X110-3	BI2, +
X110-4	BI2, -
X110-5	BI3, +
X110-6	BI3, -
X110-6	BI4, -
X110-7	BI4, +
X110-8	BI5, +
X110-9	BI5, -
X110-9	BI6, -

Table continues on next page

Terminal	Description
X110-10	BI6, +
X110-11	BI7, +
X110-12	BI7, -
X110-12	BI8, -
X110-13	BI8, +

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 35: 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 36: 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 37: 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 38: 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 39: 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 X110 are available with configuration A.

Table 40: Output contacts X110-14...24

Terminal	Description
X110-14	SO1, common
X110-15	SO1, NO
X110-16	SO1, NC
X110-17	SO2, common
X110-18	SO2, NO
X110-19	SO2, NC
X110-20	SO3, common
X110-21	SO3, NO
X110-22	SO3, NC
X110-23	SO4, common
X110-24	SO4, NO

Output contact of slot X130 is available with configuration A.

Table 41: Output contacts X130-9…18

Terminal	Description
X130-9 X130-10 X130-11	SO1,common SO1,NO SO1,NC
X130-12 X130-13 X130-14	SO2,common SO2,NO SO2,NC
X130-17 X130-18	SO3,NO SO3,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 42: 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 43: 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 44: 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

620 series	Series of numerical IEDs for high-end protection and supervision applications of utility substations, and industrial switchgear and equipment
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
HV	High voltage
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
LV	Low voltage
MCB	Miniature circuit breaker
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
PCM600	Protection and Control IED Manager
PO	Power output
PRP	Parallel redundancy protocol
RET620	Transformer protection and control IED
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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