Relion® 620 series

Feeder Protection and Control
REF620
Application Manual

Power and productivity
for a better world™

ABB

Document ID: 1MRS757651
Issued: 2013-05-07
Revision: A
Product version: 2.0

Copyright

Trademarks

Warranty

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

http://www.abb.com/substationautomation

Disclaimer

The data, examples and diagrams in this manual are included solely for the concept or product description and are not to be deemed as a statement of guaranteed properties. All persons responsible for applying the equipment addressed in this manual must satisfy themselves that each intended application is suitable and acceptable, including that any applicable safety or other operational requirements are complied with. In particular, any risks in applications where a system failure and/or product failure would create a risk for harm to property or persons (including but not limited to personal injuries or death) shall be the sole responsibility of the person or entity applying the equipment, and those so responsible are hereby requested to ensure that all measures are taken to exclude or mitigate such risks.

This document has been carefully checked by ABB but deviations cannot be completely ruled out. In case any errors are detected, the reader is kindly requested to notify the manufacturer. Other than under explicit contractual commitments, in no event shall ABB be responsible or liable for any loss or damage resulting from the use of this manual or the application of the equipment.

Conformity

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

Table of contents

Section 1 Introduction

1.1 This manual

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

1.2 Intended audience

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

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

1.3 Product documentation

1.3.1 Product documentation set

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

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

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

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

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

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

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

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

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

1.3.2 Document revision history

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

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

1.3.3 Related documentation

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

1.4 Symbols and conventions

1.4.1 Symbols

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

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

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

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

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

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

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms in this manual are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push-button navigation in the LHMI menu structure is presented by using the push-button icons.
  To navigate between the options, use  and  .
- HMI menu paths are presented in bold.
  Select **Main menu/Settings**.
- WHMI menu names are presented in bold.
  Click **Information** in the WHMI menu structure.
- LHMI messages are shown in Courier font.

To save the changes in non-volatile memory, select Yes and press .

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

1.4.3 Functions, codes and symbols

Table 1: REF620 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, 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 directional overcurrent protection, low stage, instance 1	DPHLPDOC1	3I> -> (1)	67-1 (1)
Three-phase directional overcurrent protection, low stage, instance 2	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, 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, instantaneous stage, instance 1	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, low stage, instance 3	DEFLPDEF3	Io> -> (3)	67N-1 (3)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Admittance based earth-fault protection, instance 1	EFPADM1	Yo> -> (1)	21YN (1)
Admittance based earth-fault protection, instance 2	EFPADM2	Yo> -> (2)	21YN (2)
Admittance based earth-fault protection, instance 3	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric based earth-fault protection, instance 1	WPWDE1	Po> -> (1)	32N (1)
Wattmetric based earth-fault protection, instance 2	WPWDE2	Po> -> (2)	32N (2)
Wattmetric based earth-fault protection, instance 3	WPWDE3	Po> -> (3)	32N (3)
Transient / intermittent earth-fault protection	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Harmonics based earth-fault protection	HAEFPTOC1	Io>HA (1)	51NHA (1)
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection, instance 1	ROVPTOV1	Uo> (1)	59G (1)
Residual overvoltage protection, instance 2	ROVPTOV2	Uo> (2)	59G (2)
Residual overvoltage protection, instance 3	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	3U< (2)	27 (2)
Three-phase undervoltage protection, instance 3	PHPTUV3	3U< (3)	27 (3)
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)
Table continues on next page			

Function	IEC 61850	IEC 60617	IEC-ANSI
Frequency protection, instance 2	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
Frequency protection, instance 3	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Frequency protection, instance 4	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
Frequency protection, instance 5	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
Frequency protection, instance 6	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F (1)	49F (1)
Loss of phase (undercurrent), instance 1	PHPTUC1	3I< (1)	37F (1)
Circuit breaker failure protection, instance 1	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Circuit breaker failure protection, instance 2	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
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)
High impedance fault detection	PHIZ1	PHIZ (1)	PHIZ (1)
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			

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Circuit-breaker control, instance 1	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Circuit-breaker control, instance 2	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
Disconnector control, instance 1	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
Disconnector control, instance 2	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control, instance 1	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector control, instance 3	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
Disconnector control, instance 4	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control, instance 2	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
Disconnector position indication, instance 1	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
Disconnector position indication, instance 2	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
Earthing switch position indication, instance 1	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Disconnector position indication, instance 3	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Disconnector position indication, instance 4	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch position indication, instance 2	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Auto-reclosing, instance 1	DARREC1	O -> I (1)	79 (1)
Auto-reclosing, instance 2	DARREC2	O -> I (2)	79 (2)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (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)
Fuse failure supervision	SEQRFUF1	FUSEF (1)	60 (1)
Measurement			

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Three-phase current measurement, instance 1	CMMXU1	3I (1)	3I (1)
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement, instance 1	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vn (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
Frequency measurement	FMMXU1	f (1)	f (1)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (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)
Time delay on (8 pcs), instance 4	TONGAPC4	TON (4)	TON (4)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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 REF620 overview

2.1 Overview

REF620 is a dedicated feeder IED perfectly aligned for the protection, control, measurement and supervision of utility and industrial power distribution systems, including radial, looped and meshed distribution networks. REF620 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
- REF620 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
    - Lifecycle Traceability
    - Configuration Wizard
    - AR Sequence Visualizer
    - Label Printing
    - IEC 61850 Configuration

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

2.2 Operation functionality

2.2.1 Optional functions

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

2.3 Physical hardware

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

Table 2: Plug-in unit and case

Main unit	Slot ID	Content	Module ID	Details
Plug-in unit	-	HMI	DIS0009	Large (10 rows, 20 characters)
	X100	Auxiliary power/ BO module	PSM0003 or PSM0004	48...250 V DC/100...240 V AC or 24...60 V DC 2 normally-open PO contacts 1 change-over SO contact 1 normally-open SO contact 2 double-pole PO contacts with TCS 1 dedicated internal fault output contact
	X105	Empty		Not equipped by default but alternatively may be equipped as indicated below
		Optional BI/O module	BIO0005	Optional for configurations A and B 8 binary inputs 4 SO contacts
			BIO0007	Optional for configurations A and B 8 binary inputs 3 High-speed SO contacts
		Optional RTD/mA module	RTD0003	Optional for configurations A and B 2 generic mA inputs 6 RTD sensor inputs
	X110	BI/O module	BIO0005	With configurations A and B 8 binary inputs 4 SO contacts
	X115	BI/O module	BIO0005	With configurations A and B 8 binary inputs 4 SO contacts
	X120	AI/BI module	AIM0016 or AIM0017	With configuration A 4 binary inputs 3 phase current inputs (1/5A) 1 residual current input (1/5 A or 0.2/1 A)[1)]
Case	X130	AI/BI module	AIM0006	With configuration A 5 voltage inputs 4 binary inputs
		Sensor input module	SIM0002	With configuration B 3 combi sensor inputs (three-phase current and voltage) 1 residual current input (0.2/1 A)[1)]
	X000	Optional communication module		See the technical manual for details about the different types of communication modules.

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

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

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

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

Table 3: Number of physical connections in default configurations

Conf.	Analog channels				Binary channels	
	CT	VT	Combi sensor	RTD/mA	BI	BO
A	4	5	-	-	24(32)[1)]	14(18)[1)]
				-	24(32)[2)]	14(17)[2)]
				(6/2)[3)]	24	14
B	1	-	3[4)]	-	16(24)[1)]	14(18)[1)]
				-	16(24)[2)]	14(17)[2)]
				(6/2)[3)]	16	14

1) With optional BIO0005 module
2) With optional BIO0007 module
3) With optional RTD0003 module
4) Combi sensor inputs for three-phase currents and voltages

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.

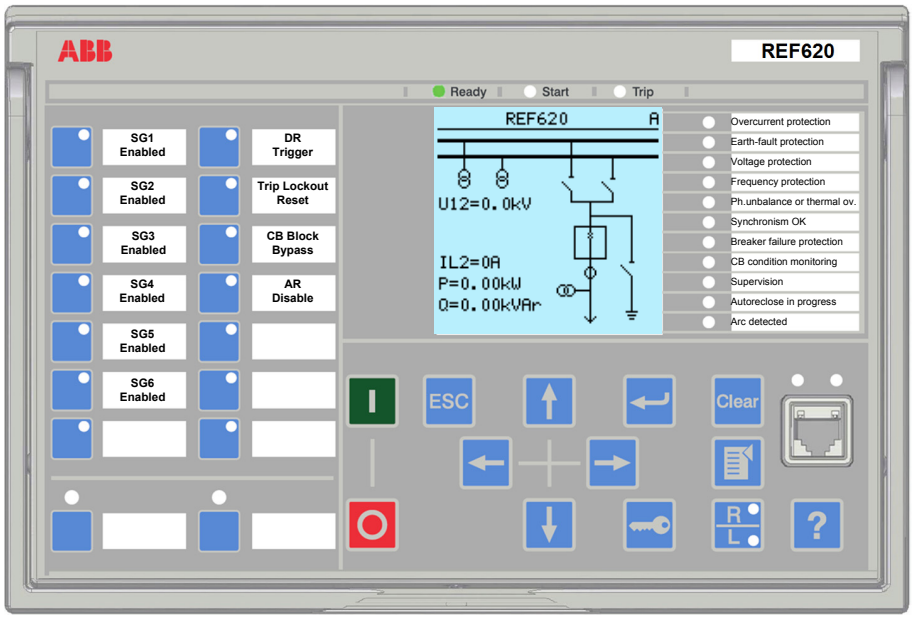

Figure 1: Example of the LHMI

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.

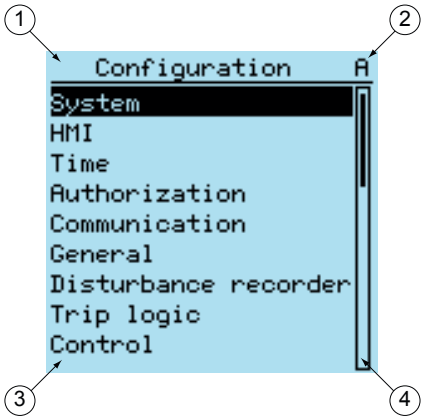

Figure 2: Display layout

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.

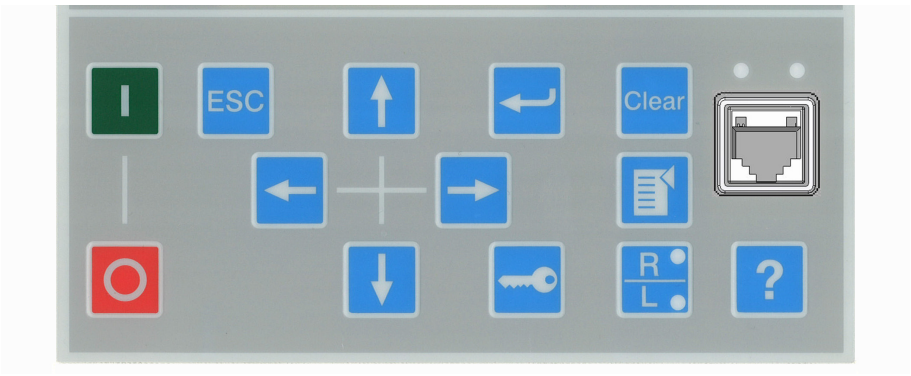

Figure 3: LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port

2.4.3.1 Programmable push-buttons with LEDs

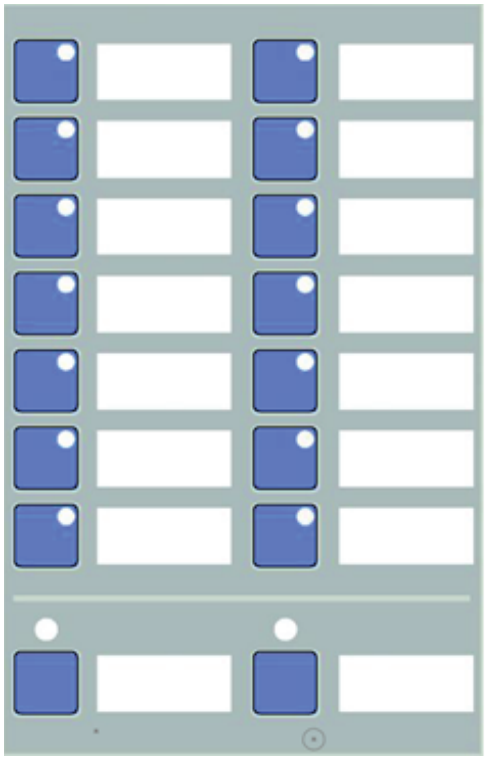

Figure 4: Programmable push-buttons with LEDs

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.

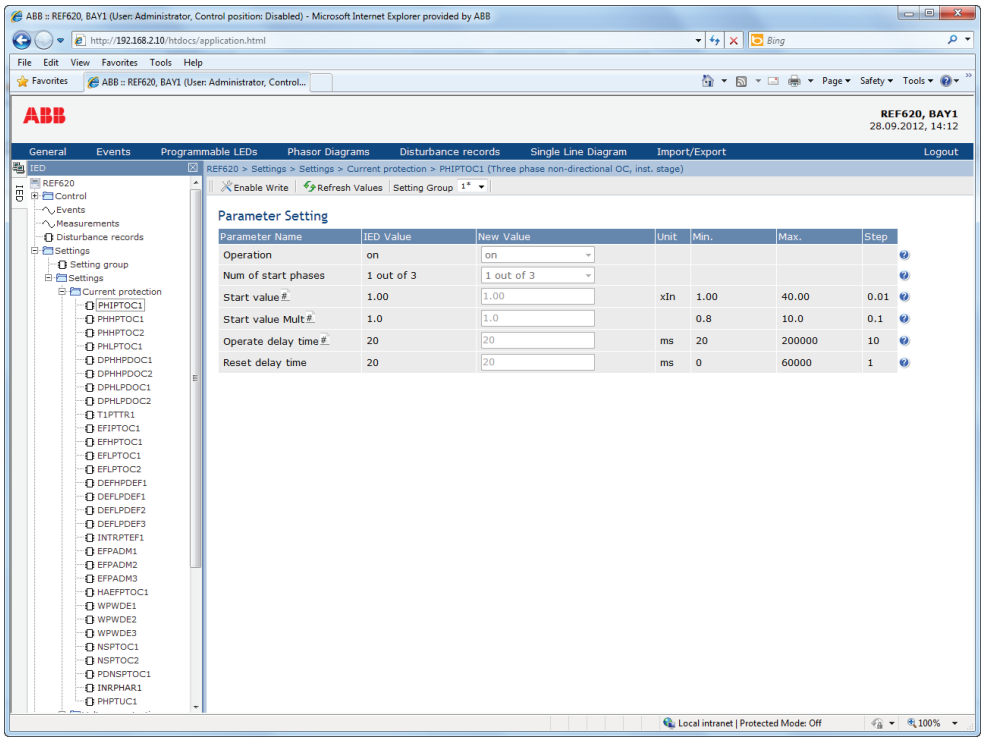

Figure 5: Example view of the WHMI

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). An optional serial interface is available for RS-232/RS-485 communication.

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.

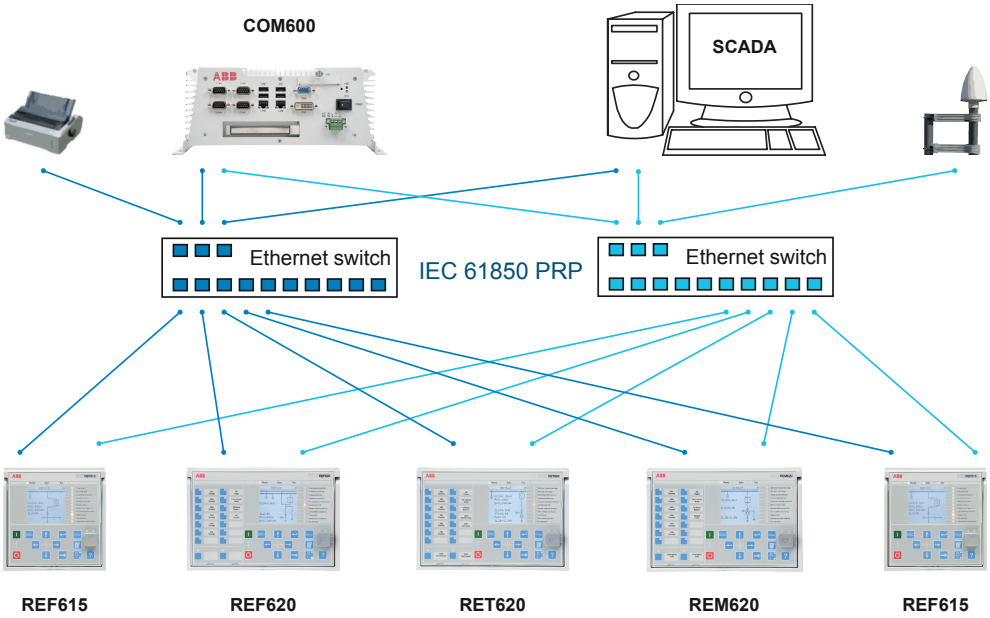

Figure 6: PRP solution

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.

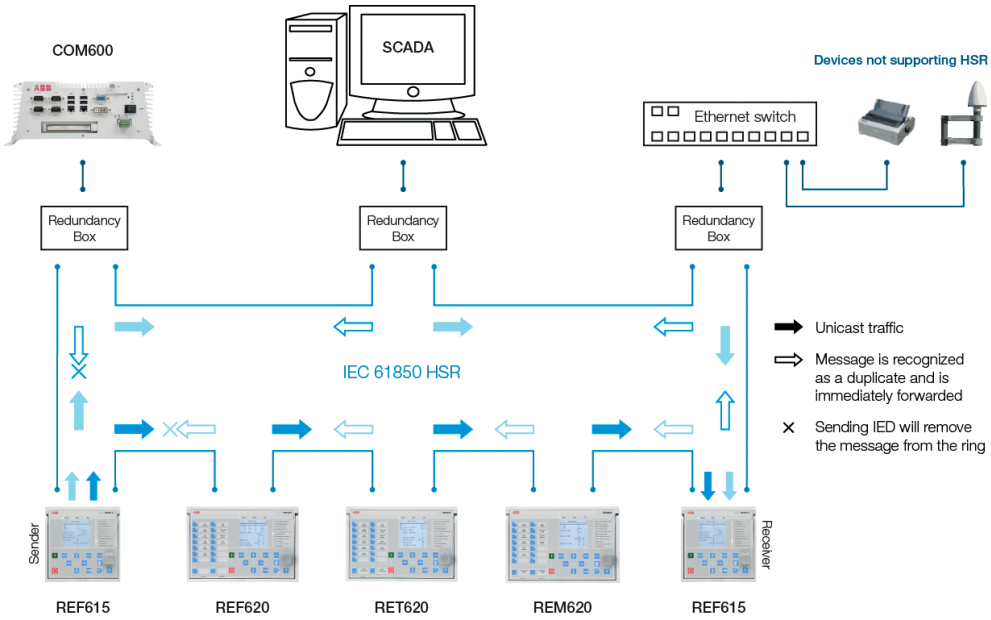

Figure 7: HSR solution

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.

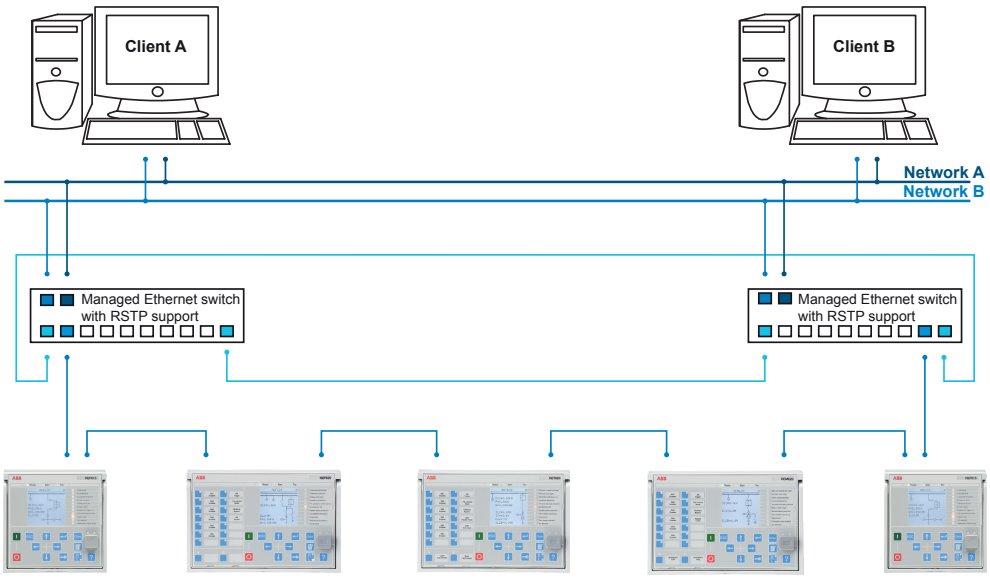

Figure 8: Self-healing Ethernet ring solution

Section 3 REF620 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.

REF620 is available in two alternative default configurations: configuration A with traditional current and voltage measurement transducers and configuration B with current and voltage sensors. The default 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 using various logical elements, including timers and flip-flops. By combining protection functions with logic function blocks, the IED configuration can be adapted to user-specific application requirements.

Table 8: Supported functions

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

Functionality	CTs & VTs	Sensors
Non-directional earth-fault protection, instantaneous stage, instance 1	●	●
Directional earth-fault protection, low stage, instance 1	●	●[1)]
Directional earth-fault protection, low stage, instance 2	●	●[1)]
Directional earth-fault protection, low stage, instance 3	●	●[1)]
Directional earth-fault protection, high stage, instance 1	●	●[1)]
Admittance based earth-fault protection, instance 1	●	●[1)]
Admittance based earth-fault protection, instance 2	●	●[1)]
Admittance based earth-fault protection, instance 3	●	●[1)]
Wattmetric based earth-fault protection, instance 1	●	●[1)]
Wattmetric based earth-fault protection, instance 2	●	●[1)]
Wattmetric based earth-fault protection, instance 3	●	●[1)]
Transient / intermittent earth-fault protection	●	-
Harmonics-based earth-fault protection	●	●
Negative-sequence overcurrent protection, instance 1	●	●
Negative-sequence overcurrent protection, instance 2	●	●
Phase discontinuity protection	●	●
Residual overvoltage protection, instance 1	●	●[1)]
Residual overvoltage protection, instance 2	●	●[1)]
Residual overvoltage protection, instance 3	●	●[1)]
Three-phase undervoltage protection, instance 1	●	●
Three-phase undervoltage protection, instance 2	●	●
Three-phase undervoltage protection, instance 3	●	●
Three-phase overvoltage protection, instance 1	●	●
Three-phase overvoltage protection, instance 2	●	●
Three-phase overvoltage protection, instance 3	●	●
Positive-sequence undervoltage protection, instance 1	●	●
Positive-sequence undervoltage protection, instance 2	●	●
Negative-sequence overvoltage protection, instance 1	●	●
Negative-sequence overvoltage protection, instance 2	●	●
Frequency protection, instance 1	●	●
Frequency protection, instance 2	●	●
Frequency protection, instance 3	●	●
Frequency protection, instance 4	●	●
Frequency protection, instance 5	●	●
Frequency protection, instance 6	●	●
Three-phase thermal protection for feeders, cables and distribution transformers	●	●
Loss of phase (undercurrent)	●	●

Table continues on next page

Functionality	CTs & VTs	Sensors
Circuit breaker failure protection, instance 1	●	●
Circuit breaker failure protection, instance 2	●	●
Three-phase inrush detector	●	●
Master trip, instance 1	●	●
Master trip, instance 2	●	●
Arc protection, instance 1	○	○
Arc protection, instance 2	○	○
Arc protection, instance 3	○	○
High-impedance fault detection	●	●
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	●	●
Circuit-breaker control, instance 2	●	●
Disconnector control, instance 1	●	●
Disconnector control, instance 2	●	●
Earthing switch control, instance 1	●	●
Disconnector control, instance 3	●	●
Disconnector control, instance 4	●	●
Earthing switch control, instance 2	●	●
Disconnector position indication, instance 1	●	●
Disconnector position indication, instance 2	●	●
Earthing switch position indication, instance 1	●	●
Disconnector position indication, instance 3	●	●
Disconnector position indication, instance 4	●	●
Earthing switch position indication, instance 2	●	●
Auto-reclosing, instance 1	●	●
Auto-reclosing, instance 2	●	●
Synchronism and energizing check, instance 1	●	-

Table continues on next page

Functionality	CTs & VTs	Sensors
Load shedding and restoration, instance 1	●	●
Load shedding and restoration, instance 2	●	●
Load shedding and restoration, instance 3	●	●
Load shedding and restoration, instance 4	●	●
Load shedding and restoration, instance 5	●	●
Load shedding and restoration, instance 6	●	●
Condition monitoring		
Circuit-breaker condition monitoring, instance 1	●	●
Circuit-breaker condition monitoring, instance 2	●	●
Trip circuit supervision, instance 1	●	●
Trip circuit supervision, instance 2	●	●
Current circuit supervision	●	●
Fuse failure supervision	●	●
Measurement		
Three-phase current measurement	●	●
Sequence current measurement	●	●
Residual current measurement	●	●
Three-phase voltage measurement	●	●
Residual voltage measurement	●	-
Sequence voltage measurement	●	●
Three-phase power and energy measurement	●	●
Frequency measurement	●	●
Power quality		
Current total demand distortion	●	●
Voltage total harmonic distortion	●	●
Voltage variation	●	●
Voltage unbalance	●	●
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	●	●
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	●	●

Table continues on next page

Functionality	CTs & VTs	Sensors
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)	●	●
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 with calculated Uo only

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

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

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

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

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

3.1.2 LED functionality

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

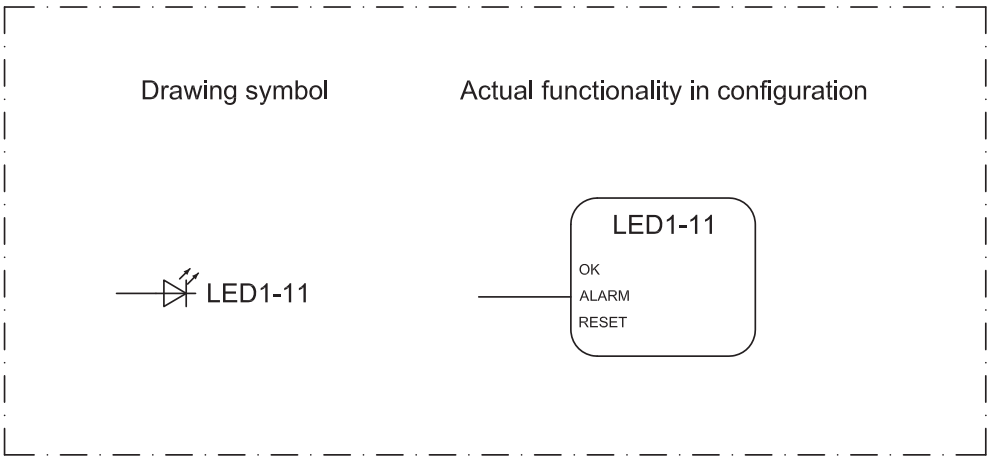

Figure 9: Drawing symbol used in the manual and the default connection of the LED function blocks in the configurations

3.2 Connection diagrams

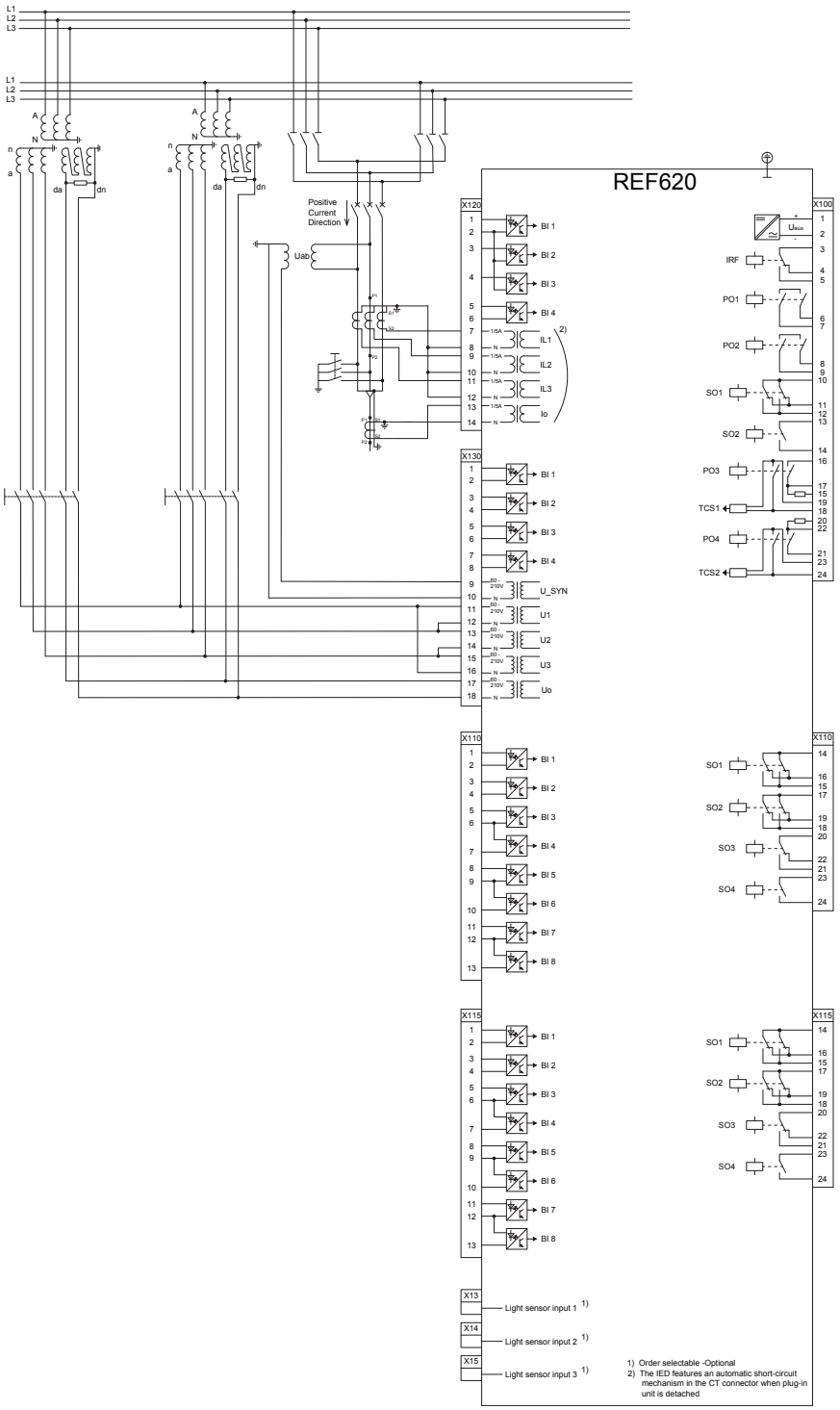

Figure 10: Connection diagram for the configuration with CTs and VTs

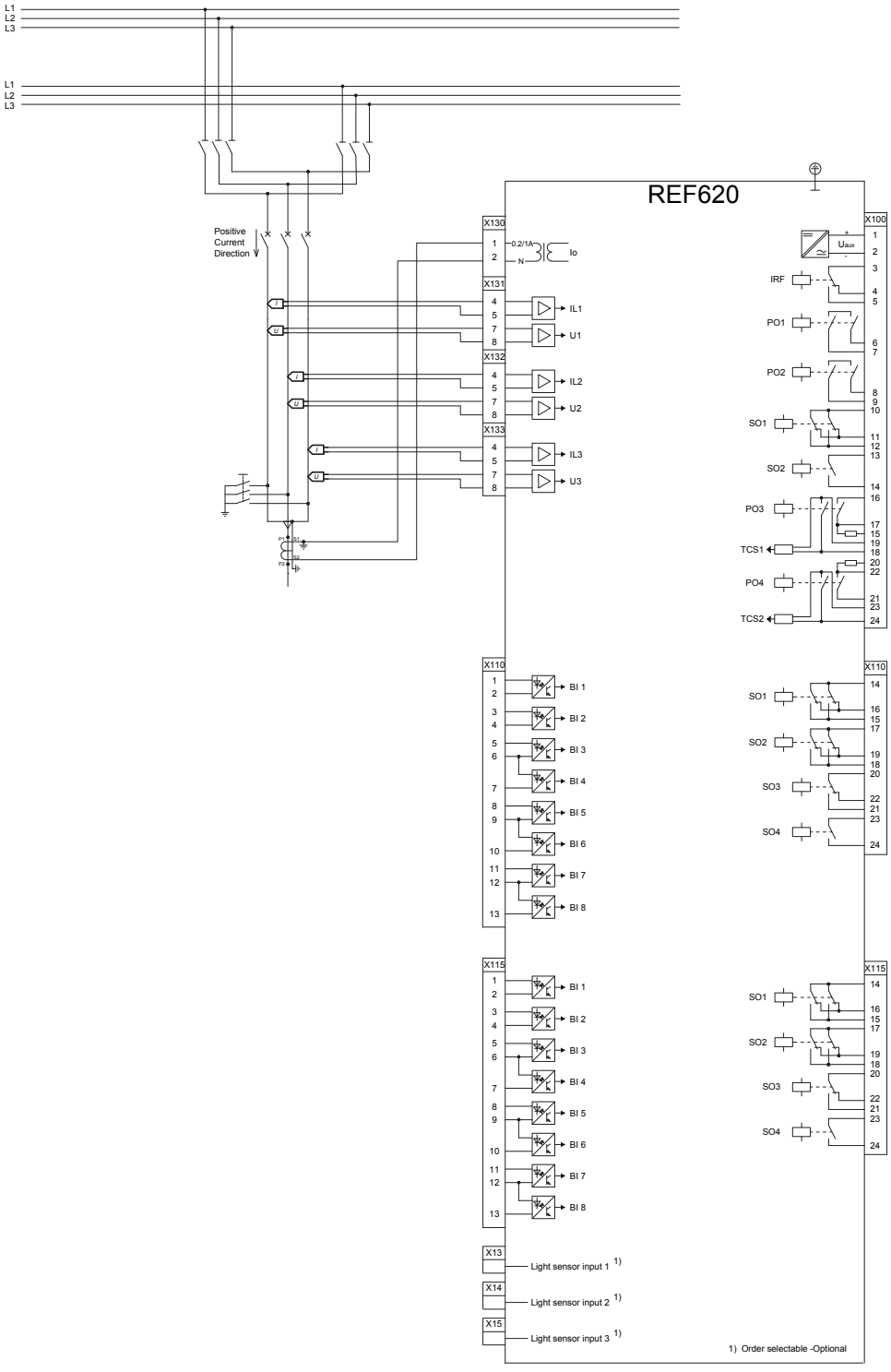

Figure 11: Connection diagram for the configuration with sensors

3.3 Optional modules

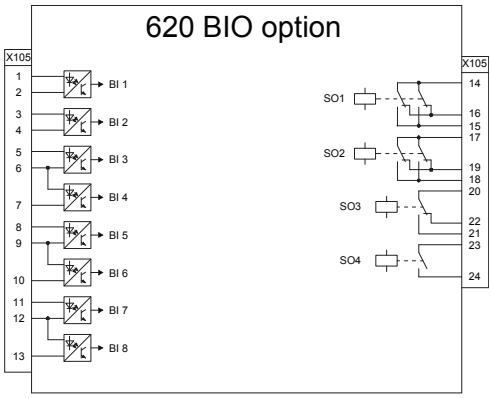

Figure 12: Optional BIO0005 module (slot X105)

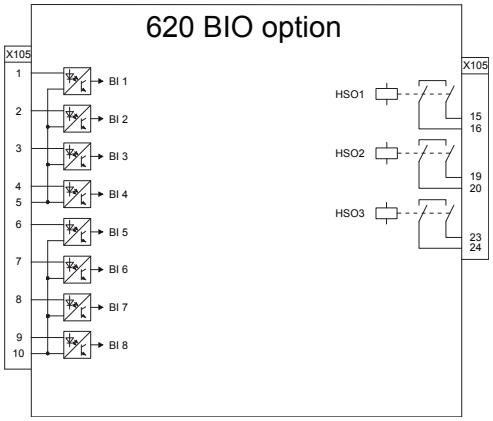

Figure 13: Optional BIO0007 module for fast outputs (slot X105)

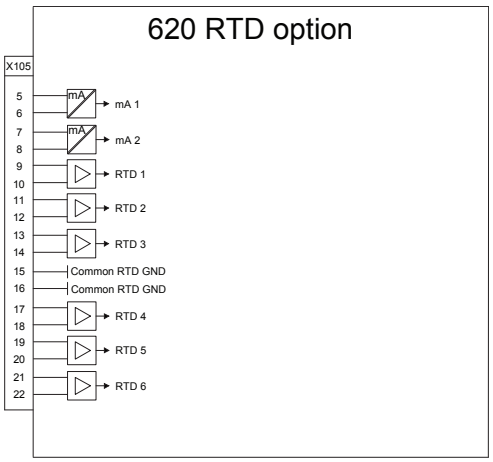

Figure 14: Optional RTD0003 module (slot X105)

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 for non-directional overcurrent and directional earthfault protection is mainly intended for cable and overhead-line feeder applications in isolated and resonant-earthed distribution networks. The configuration also

includes additional options to select earth-fault protection based on admittance or wattmetric based principle.

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.

This configuration utilizes traditional current and voltage transducers.

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, 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 directional overcurrent protection, low stage, instance 1	DPHLPDOC1	3I> -> (1)	67-1 (1)
Three-phase directional overcurrent protection, low stage, instance 2	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, 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, instantaneous stage, instance 1	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Table continues on next page			

Function	IEC 61850	IEC 60617	IEC-ANSI
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, low stage, instance 3	DEFLPDEF3	Io> -> (3)	67N-1 (3)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Admittance based earth-fault protection, instance 1	EFPADM1	Yo> -> (1)	21YN (1)
Admittance based earth-fault protection, instance 2	EFPADM2	Yo> -> (2)	21YN (2)
Admittance based earth-fault protection, instance 3	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric based earth-fault protection, instance 1	WPWDE1	Po> -> (1)	32N (1)
Wattmetric based earth-fault protection, instance 2	WPWDE2	Po> -> (2)	32N (2)
Wattmetric based earth-fault protection, instance 3	WPWDE3	Po> -> (3)	32N (3)
Transient / intermittent earth-fault protection	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Harmonics based earth-fault protection	HAEFPTOC1	Io>HA (1)	51NHA (1)
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection, instance 1	ROVPTOV1	Uo> (1)	59G (1)
Residual overvoltage protection, instance 2	ROVPTOV2	Uo> (2)	59G (2)
Residual overvoltage protection, instance 3	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	3U< (2)	27 (2)
Three-phase undervoltage protection, instance 3	PHPTUV3	3U< (3)	27 (3)
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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Negative-sequence overvoltage protection, instance 1	NSPTOV1	U2> (1)	47O- (1)
Negative-sequence overvoltage protection, instance 2	NSPTOV2	U2> (2)	47O- (2)
Frequency protection, instance 1	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
Frequency protection, instance 2	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
Frequency protection, instance 3	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Frequency protection, instance 4	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
Frequency protection, instance 5	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
Frequency protection, instance 6	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F (1)	49F (1)
Loss of phase (undercurrent), instance 1	PHPTUC1	3I< (1)	37F (1)
Circuit breaker failure protection, instance 1	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Circuit breaker failure protection, instance 2	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
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)
High impedance fault detection	PHIZ1	PHIZ (1)	PHIZ (1)
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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Multipurpose analog protection, instance 11	MAPGAPC11	MAP (11)	MAP (11)
Multipurpose analog protection, instance 12	MAPGAPC12	MAP (12)	MAP (12)
Control			
Circuit-breaker control, instance 1	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Circuit-breaker control, instance 2	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
Disconnector control, instance 1	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
Disconnector control, instance 2	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control, instance 1	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector control, instance 3	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
Disconnector control, instance 4	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control, instance 2	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
Disconnector position indication, instance 1	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
Disconnector position indication, instance 2	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
Earthing switch position indication, instance 1	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Disconnector position indication, instance 3	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Disconnector position indication, instance 4	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch position indication, instance 2	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Auto-reclosing, instance 1	DARREC1	O -> I (1)	79 (1)
Auto-reclosing, instance 2	DARREC2	O -> I (2)	79 (2)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Trip circuit supervision, instance 2	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision, instance 1	CCRDIF1	MCS 3I (1)	CSM 3I (1)
Fuse failure supervision	SEQRFUF1	FUSEF (1)	60 (1)
Measurement			
Three-phase current measurement, instance 1	CMMXU1	3I (1)	3I (1)
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement, instance 1	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vn (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
Frequency measurement	FMMXU1	f (1)	f (1)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (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)

Table continues on next page

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

Function	IEC 61850	IEC 60617	IEC-ANSI
Fault recorder	FLTMSTA1	FR (1)	FR (1)
Sequence event recorder	SER1	SER (1)	SER (1)
Load profile	LDPMSTA1	LOADPROF (1)	LOADPROF (1)

3.5.2.1 Default I/O connections

Table 10: Default connections for analog inputs

Analog input	Default usage	Connector pins
IL1	Phase A current	X120-7,8
IL2	Phase B current	X120-9,10
IL3	Phase C current	X120-11,12
Io	Residual current	X120-13,14
U_SYN	Phase-to-phase voltage U12, line side	X130-9,10
U1	Phase-to-phase voltage U12, bus side	X130-11,12
U2	Phase-to-phase voltage U23, bus side	X130-13,14
U3	Phase-to-phase voltage U31, bus side	X130-15,16
Uo	Residual voltage, bus side	X130-17,18

Table 11: Default connections for binary inputs

Binary input	Default usage	Connector pins
X110-BI1	Circuit breaker closed position indication	X110-1,2
X110-BI2	Circuit breaker open position indication	X110-3,4
X110-BI3	Circuit breaker low gas pressure alarm	X110-5,6
X110-BI4	Circuit breaker spring charged indication	X110-7,6
X110-BI5	Disconnector 1 closed position indication	X110-8,9
X110-BI6	Disconnector 1 open position indication	X110-10,9
X110-BI7	Earthing switch 1 closed position indication	X110-11,12
X110-BI8	Earthing switch 1 open position indication	X110-13,12
X115-BI1	Disconnector 2 closed position indication	X115-1,2
X115-BI2	Disconnector 2 open position indication	X115-3,4
X115-BI3	Blocking of overcurrent instantaneous stage	X115-5,6
X115-BI4	Directional earth fault protection's basic angle control	X115-7,6
X115-BI5	Bus MCB open position indication	X115-8,9
X115-BI6	Line MCB open position indication	X115-10,9
X115-BI7	-	X115-11,12
X115-BI8	-	X115-13,12

Table 12: Default connections for binary outputs

Binary input	Default usage	Connector pins
X100-PO1	Close circuit breaker	X100-6,7
X100-PO2	Circuit breaker failure protection trip to upstream breaker	X100-8,9
X100-SO1	General start indication	X100-10,11,(12)
X100-SO2	General operate indication	X100-13,14,15
X100-PO3	Open circuit breaker/trip coil 1	X100-15,16,17,18,19
X100-PO4	Open circuit breaker/trip coil 2	X100-20,21,22,23,24
X110-SO1	Close disconnector 1	X110-14,15,16
X110-SO2	Open disconnector 1	X110-17,18,19
X110-SO3	Close earthing switch 1	X110-20,21,22
X110-SO4	Open earthing switch 1	X110-23,24
X115-SO1	Close disconnector 2	X115-14,15,16
X115-SO2	Open disconnector 2	X115-17,18,19
X115-SO3	Upstream overcurrent blocking	X115-20,21,22
X115-SO4	-	X115-23,24

Table 13: Default connections for LEDs

LED	Default usage
1	Overcurrent protection operate
2	Earth-fault protection operate
3	Voltage protection operate
4	Frequency protection operate
5	Negative seq. overcurrent/phase discontinuity/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	Autoreclose in progress
11	Arc fault detected

Table 14: Default connections for function keys

FK_Left	Default usage	FK_Right	Default usage
1	Setting Group 1 Enabled	9	Disturbance Recorder Manual Trigger
2	Setting Group 2 Enabled	10	Trip Lockout Reset
3	Setting Group 3 Enabled	11	Circuit Breaker Block Bypass

Table continues on next page

FK_Left	Default usage	FK_Right	Default usage
4	Setting Group 4 Enabled	12	Autorecloser Disable
5	Setting Group 5 Enabled	13	-
6	Setting Group 6 Enabled	14	-
7	-	15	-
8	-	16	-

3.5.2.2 Default disturbance recorder settings

Table 15: Default disturbance recorder binary channels

Channel	Id text	Level trigger mode
1	PHLPTOC1_START	1
2	PHLPTOC1_OPERATE	4
3	PHHPTOC1_START	1
4	PHHPTOC2_START	1
5	PHHPTOC1/2_OPERATE	4
6	PHIPTOC1_START	1
7	PHIPTOC1_OPERATE	4
8	DPHLPDOC1_START	1
9	DPHLPDOC2_START	1
10	DPHLPDOC1/2_OPERATE	4
11	DPHHPDOC1_START	1
12	DPHHPDOC2_START	1
13	DPHHPDOC1/2_OPERATE	4
14	EFLPTOC1 or EFPADM1 or WPWDE1_START	1
15	EFLPTOC2 or EFPADM2 or WPWDE2_START	1
16	EFHPTOC1 or EFPADM3 or WPWDE3_START	1
17	EFIPTOC1_START	1
18	EFxPTOC or EFPADM or WPWDE_OPERATE	4
19	DEFLPDEF1_START	1
20	DEFLPDEF2_START	1
21	DEFLPDEF3_START	1
22	DEFHPDEF1_START	1
23	DEFxPDEF_OPERATE	4
24	ROVPTOV1/2/3_START	1
25	ROVPTOV1/2/3_OPERATE	4
26	INTRPTEF1_START	1
27	INTRPTEF1_OPERATE	4
28	HAEFPTOC1_START	1
29	HAEFPTOC1_OPERATE	4

Table continues on next page

Channel	Id text	Level trigger mode
30	NSPTOC1_START	1
31	NSPTOC2_START	1
32	PDNSPTOC1_START	1
33	NSPTOC1/2 or PDNSPTOC1_OPERATE	4
34	PHPTUV or PHPTOV or PSPTUV or NSPTOV_START	1
35	PHPTUV or PHPTOV or PSPTUV or NSPTOV_OPERATE	4
36	FRPFRQ or LSHDPFRQ_START	1
37	FRPFRQ or LSHDPFRQ_OPERATE	4
38	T1PTTR1_START	1
39	T1PTTR1_OPERATE	4
40	PHPTUC1_START	1
41	PHPTUC1_OPERATE	4
42	ARCSARC1_ARC_FLT_DET	4
43	ARCSARC2_ARC_FLT_DET	4
44	ARCSARC3_ARC_FLT_DET	4
45	ARCSARC1/2/3_OPERATE	4
46	INRPHAR1_BLK2H	4
47	SEQRFUF1_FUSEF_3PH	4
48	SEQRFUF1_FUSEF_U	4
49	CCRDIF1_FAIL	4
50	CCBRBRF1_TRRET	4
51	CCBRBRF1_TRBU	4
52	DARREC1_INPRO	4
53	DARREC1_CLOSE_CB	4
54	DARREC1_UNSUC_RECL	4
55	BI Blocking	4
56	CB Closed	4
57	CB Open	4
58	Bus MCB Open	4
59	Line MCB Open	4
60	PHIZ1_OPERATE	4
61	-	-
62	-	-
63	-	-
64	FKEY K9_DR Manual Trigger	1

Additionally, all the digital inputs that are connected by default are also enabled with the setting. Default triggering settings are selected depending on the

connected input signal type. Typically all protection START signals are selected to trigger the disturbance recorded by default.

Table 16: Default analog channel selection and text settings

Channel	Selection and text
1	IL1
2	IL2
3	IL3
4	I0
5	U0
6	U1
7	U2
8	U3
9	U1B
10	-
11	-
12	-

3.5.2.3 Default operation mode for generic control point

Table 17: Default operation modes

Channel	Signal name	Value	Pulse length
1	SG1 Enabled	Pulsed	150 ms
2	SG2 Enabled	Pulsed	150 ms
3	SG3 Enabled	Pulsed	150 ms
4	SG4 Enabled	Pulsed	150 ms
5	SG5 Enabled	Pulsed	150 ms
6	SG6 Enabled	Pulsed	150 ms
7		Off	1000ms
8		Off	1000ms
9	DR Trigger	Pulsed	150 ms
10	Trip Lockout Reset	Pulsed	150 ms
11	CB Block Bypass	Toggle	1000ms
12	AR Disable	Toggle	1000ms
13		Off	1000ms
14		Off	1000ms
15		Off	1000ms
16		Off	1000ms
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.

The analog channels and the 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. The signal Io represents the measured residual current, fed from either residually connected CTs or an external core balance CT or neutral CT depending on application.

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

The signal marked Usyn is measured from the VT on the feeder side of the breaker. 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 the correct phase angle correction, especially in applications such as voltages fed to synchrocheck across a transformer with vector shift.

There are 16 programmable push buttons offered in the front panel of the unit. The IED offers six different setting groups which can be set based on individual needs. Each group can then be activated or deactivated with a programmable button. In addition, the programmable button can be used for example for the manual trigger of disturbance recorder, circuit breaker control interlocking bypass, master trip lockout reset or for setting the autoreclosing function on or off.

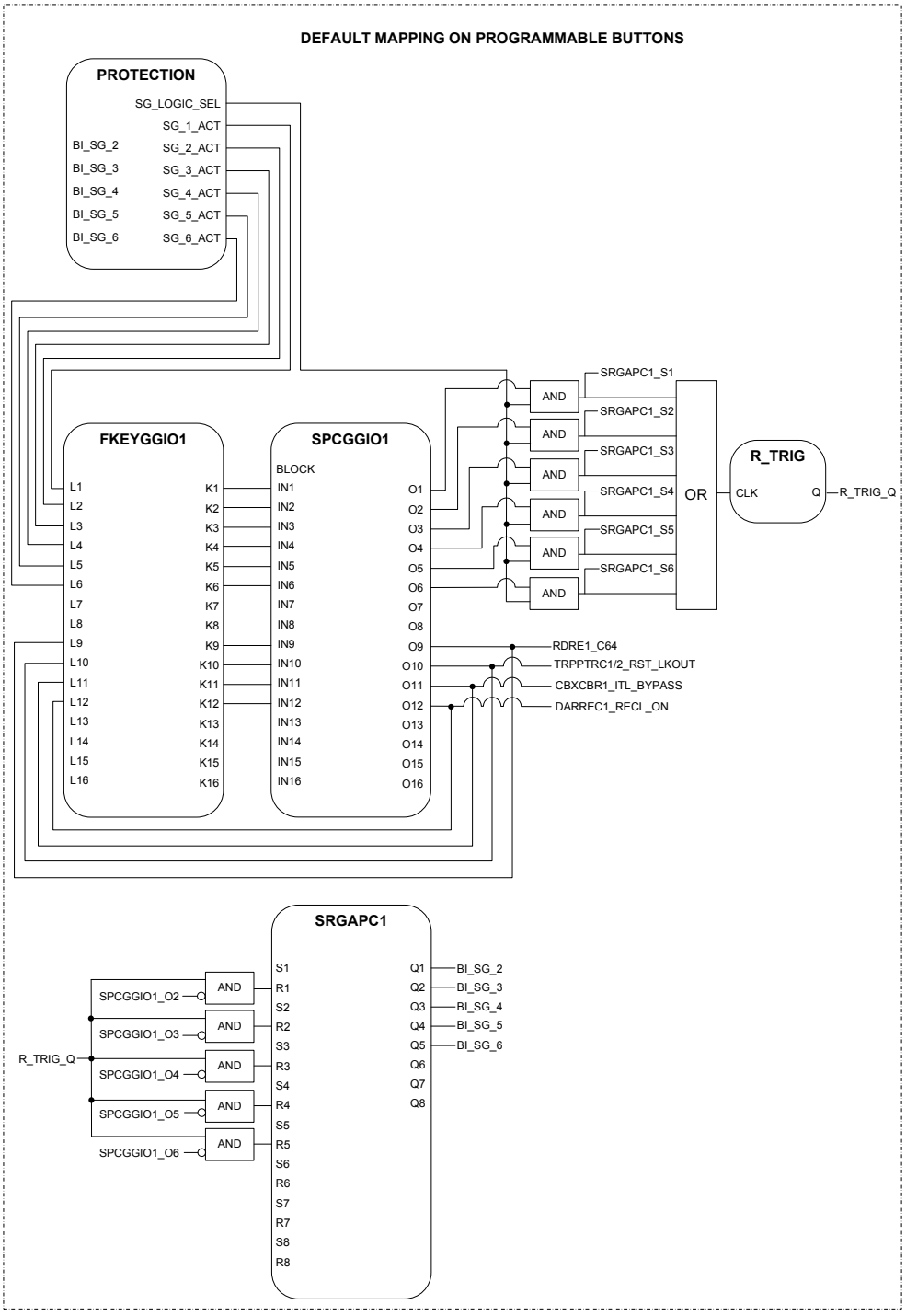

Figure 15: Default mapping on programmable buttons

3.5.3.1 Functional diagrams for protection

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

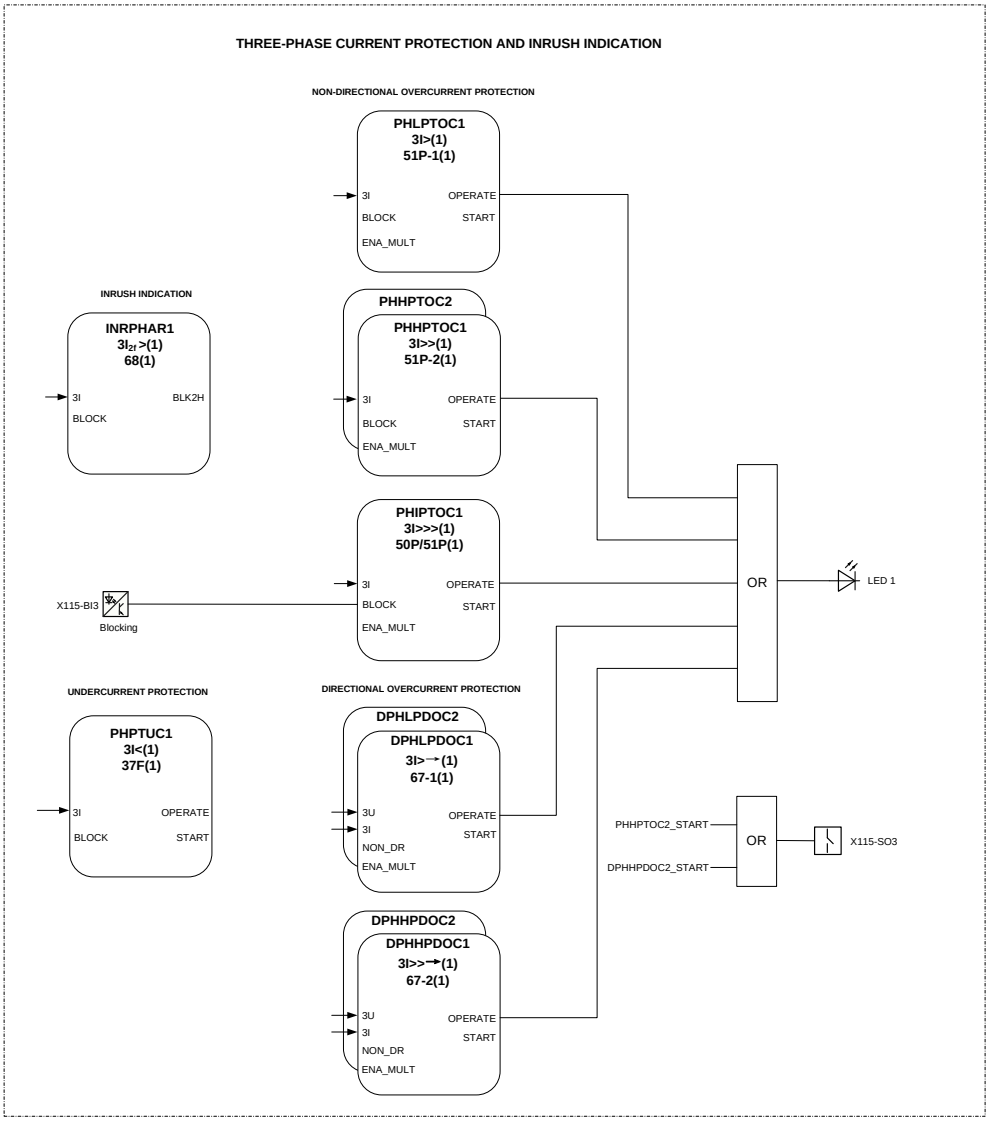

Figure 16: Overcurrent and undercurrent protection

Eight overcurrent stages in total 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 instantaneous stage PHIPTOC1 can be blocked by energizing the binary input (X115:5-6). 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.

One undercurrent stage PHPTUC1 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 1, except for those specially mentioned earlier. LED 1 is used for overcurrent protection indication.

The upstream blocking from the START signals of the overcurrent second high stage PHHPTOC2 and DPHLPDOC2 is connected to signal output 3(X115-SO3:20-22). This output is used for sending a blocking signal to the relevant overcurrent protection stage of the IED at the infeeding bay.

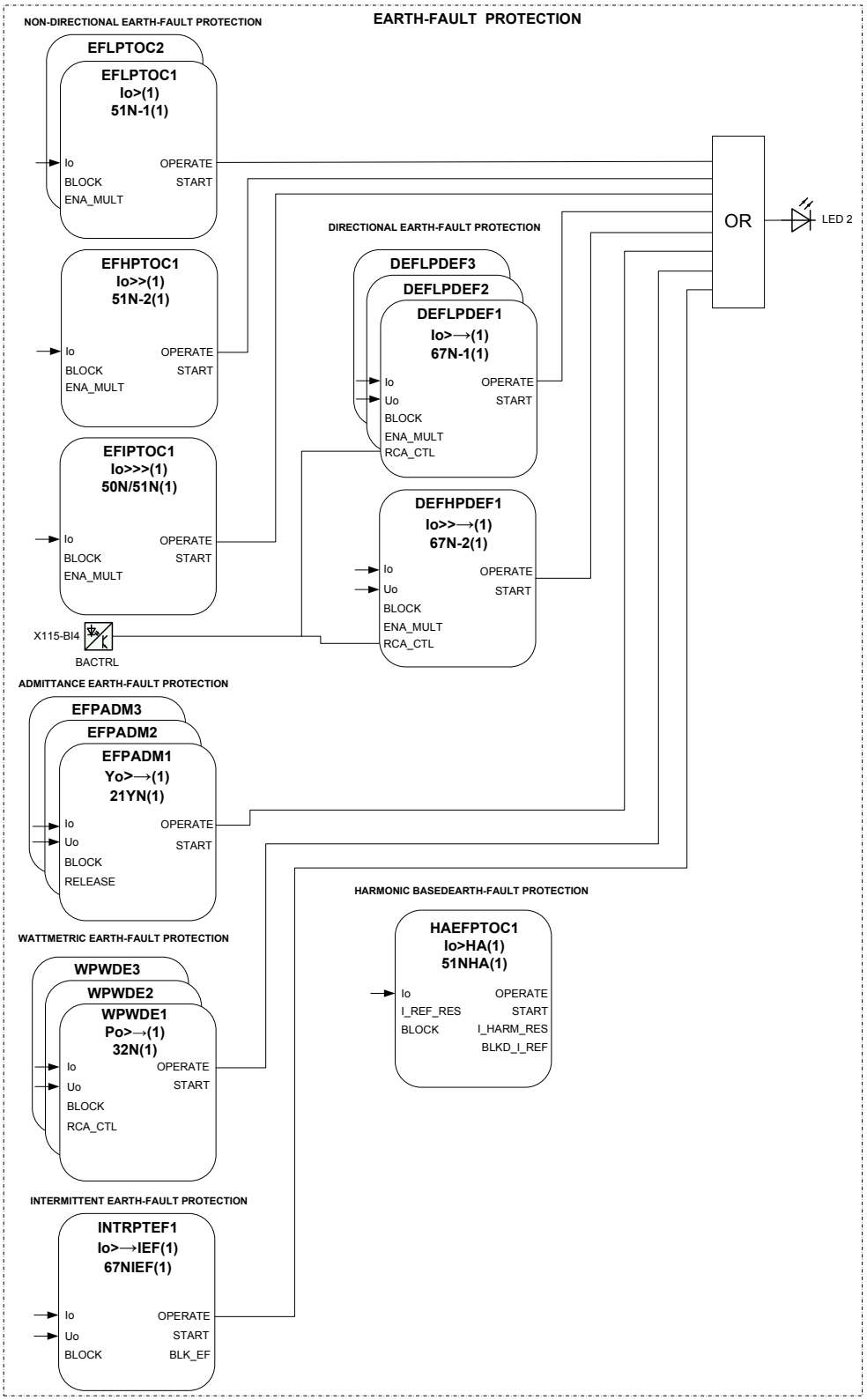

Figure 17: Earth-fault protection

Eight stages in total are offered for earth-fault protection. Four of them (DEFxPDEF) include directional functionality, while the others (EFxPTOC) are only for non-directional earth-fault protection. The directional earth-fault protection method is based on conventional directional earth-fault DEFxPDEF together with admittance criteria EFPADM1...3 and wattmetric earth-fault protection WPWDE1...3. In addition, there is a dedicated protection stage INTRPTEF1 either for transient-based earth-fault protection or for cable intermittent earth-fault protection in compensated networks.

A harmonic-based earth-fault protection HAEFPTOC1 is offered. 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 binary input (X115:7-6) is intended for either directional earth-fault protection blocks' relay characteristic angle (RCA: 0°/-90°) or operation mode (IoSinφ/ IoCosφ) change.

OPERATE outputs are connected to the Master Trip and alarm LED 2, except for those specially mentioned previously. LED 2 is used for earth-fault protection indication.

All of these functions are normally not used in the same application. Different functions have different suitability and operability in different electrical network types such as the earthed, isolated and compensated networks. Especially in some network types and applications the earth-fault currents are so small that they cannot be detected by the normal earth-fault protection functions. In these cases, it is recommended to use a hardware variant with a sensitive Io channel to better reach operational sensitivity for low earth-fault currents.

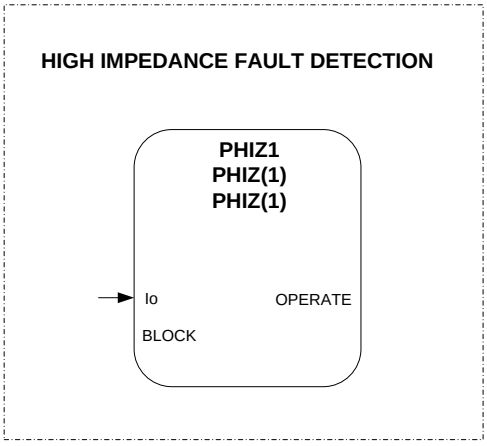

Figure 18: High-impedance fault protection

The high-impedance fault protection PHIZ1 is offered with a sensitive 0.2/1A CT input. The OPERATE output from this function is connected to disturbance recorder, but this function is not configured to trip the circuit breaker by default.

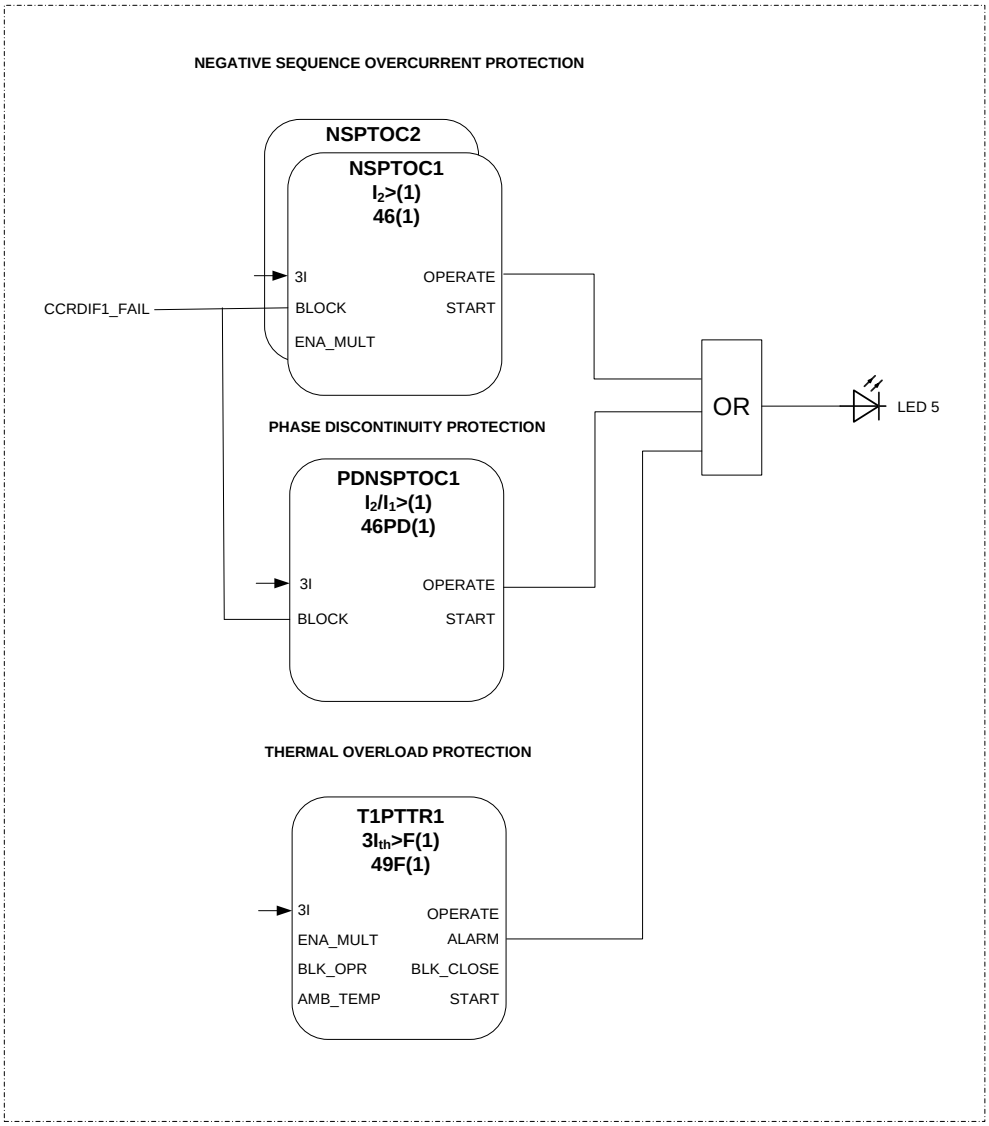

Figure 19: Negative-sequence current protection, phase discontinuity and thermal overload protection

The OPERATE outputs of NSPTOC1/2 and PDNSPTOC1 are connected to the Master Trip and alarm LED 5. The ALARM output of T1PTTR1 is also connected to LED 5. LED 5 is used for unbalance protection and thermal overload protection alarm indication.

A failure in the current measurement circuit is detected by current circuit supervision function and is used to block phase unbalance protections to avoid faulty tripping.

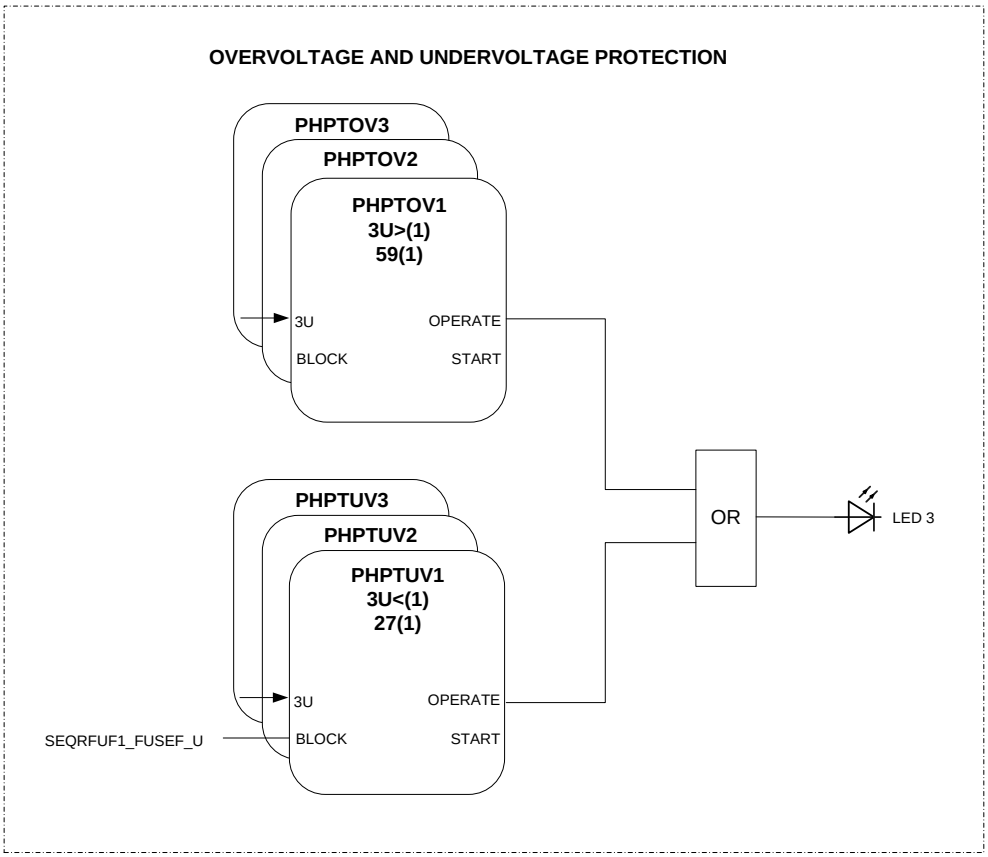

Figure 20: Overvoltage and undervoltage protection

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.

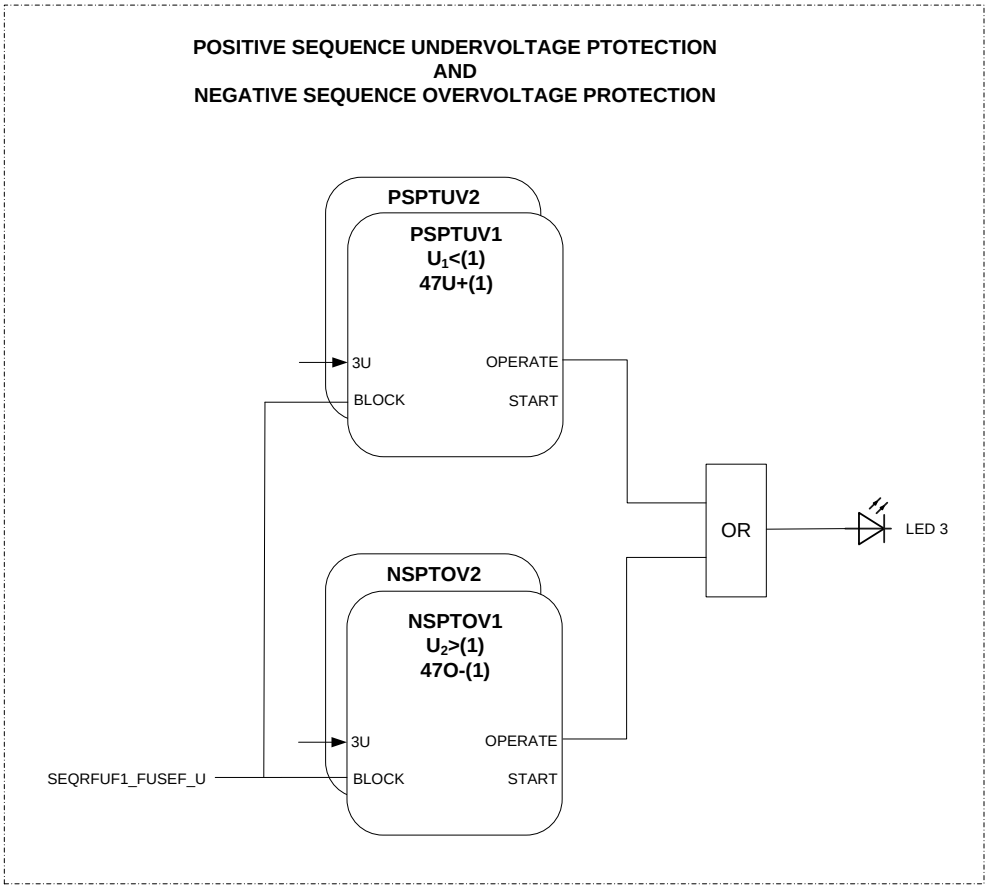

Figure 21: Positive-sequence undervoltage and negative-sequence overvoltage protection

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

The OPERATE outputs of the voltage-sequence functions are also connected to alarm LED 3.

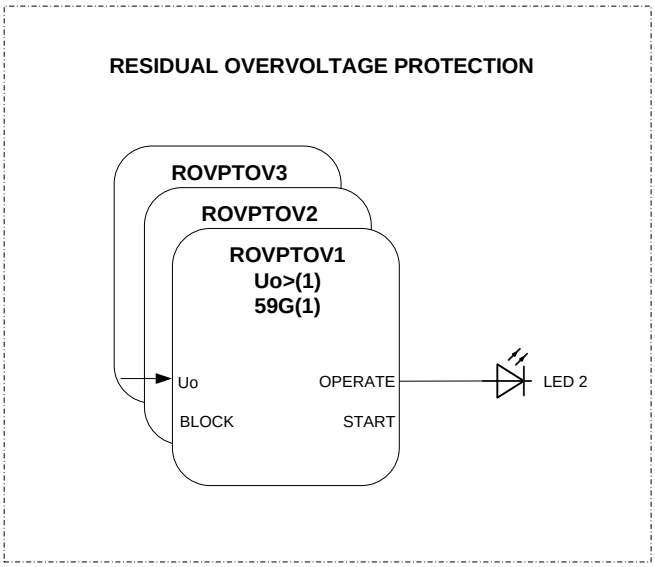

Figure 22: Residual overvoltage protection

The residual overvoltage protection ROVPTOV1...3 provides earth-fault protection by detecting an abnormal level of residual voltage. It can be used, for example, as a nonselective backup protection for the selective directional earth-fault functionality. The OPERATE outputs are connected to the Master Trip and alarm LED 2.

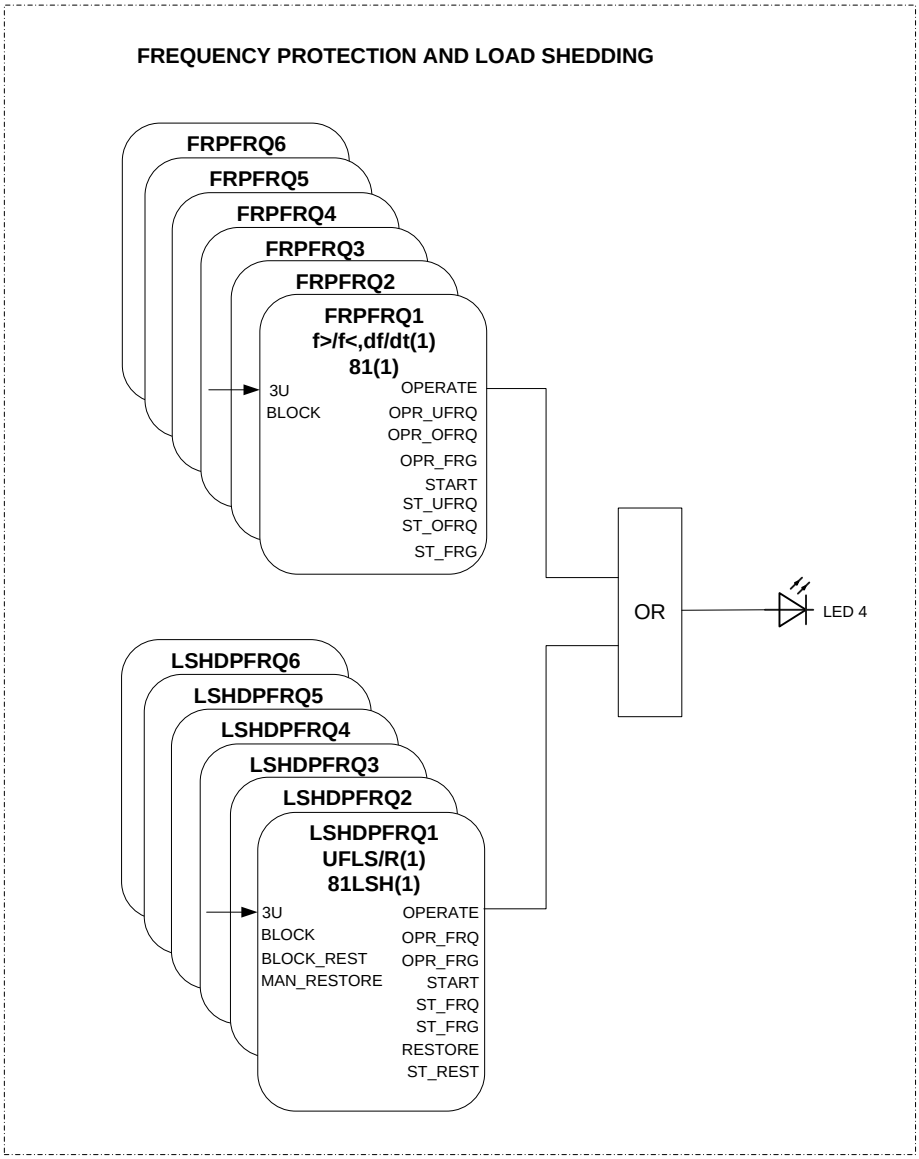

Figure 23: Frequency and load-shedding protection

Six underfrequency or overfrequency protection FRPFRQ1…6 stages are offered to prevent damage to the 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 alarm LED 4. LED 4 is used for frequency protection operating indication.

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 the load based on underfrequency and the rate of change of the frequency. The load that is shed during frequency disturbance can be restored once the

frequency is stabilized to the normal level. Also manual restoring commands can be given via binary inputs, but by default, they are not connected. The OPERATE outputs signal is also connected to the alarm LED 4.

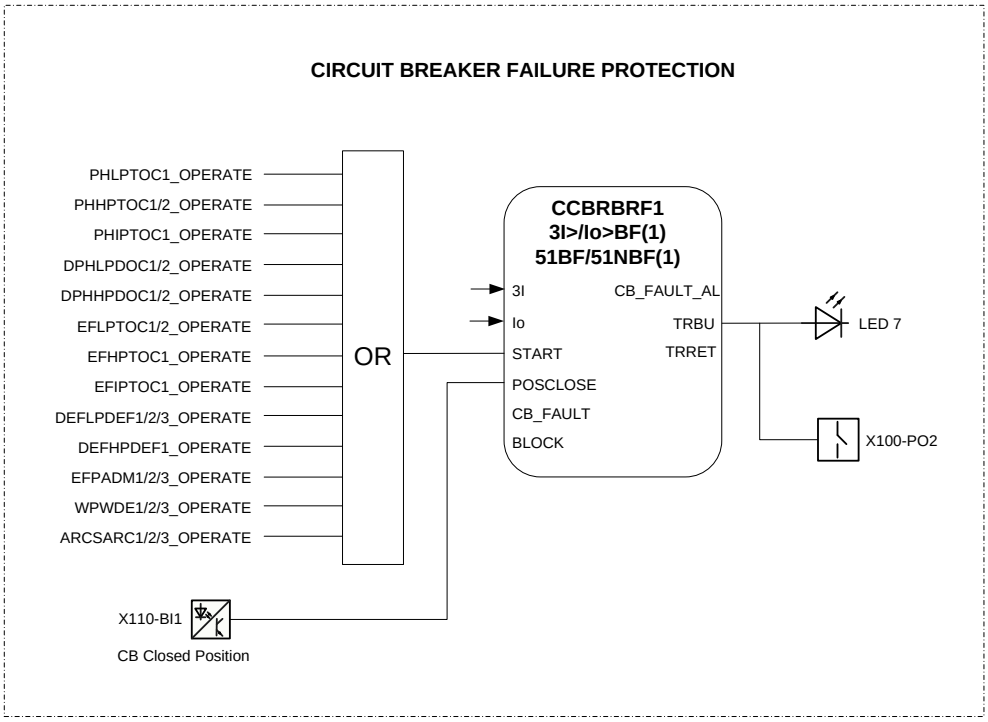

Figure 24: Circuit breaker failure protection

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

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

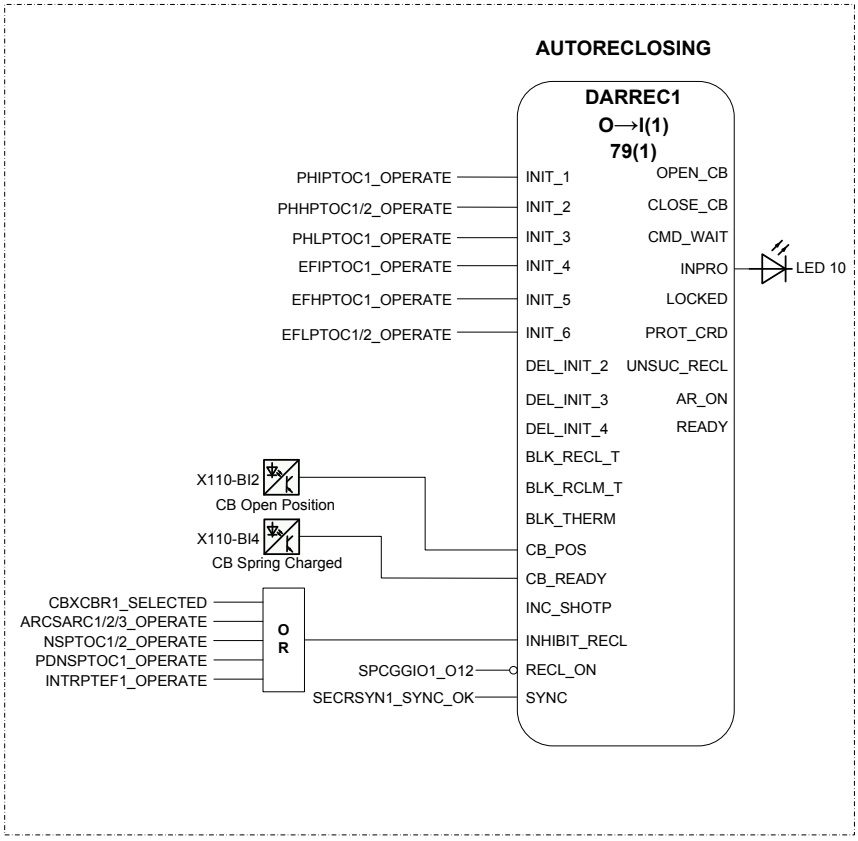

Figure 25: Autoreclosing

The autoreclosing function is configured to be initiated by the operating signals from a number of protection stages through the INIT_1...6. It is possible to create individual autoreclosing sequences for each input.

The autoreclosing function can be blocked with the INHIBIT_RECL input. By default, the operations of the selected protection functions are connected to this input. A control command to the circuit breaker, either local or remote, also blocks the autoreclosing function via the CBXCBR1_SELECTED signal.

The autoreclosing function could be disabled with one push-button through SPCGGIO1_O12, which is connected to the RECL_ON input of DARREC1.

The circuit breaker availability for the autoreclosing sequence is expressed with the CB_READY input in DARREC1. In the default configuration, this signal is connected to CB spring charged binary input (X110:6-7). As a result, the function is available only when CB spring is charged.

The autoreclosing sequence in progress indication INPRO is connected to the alarm LED 10.

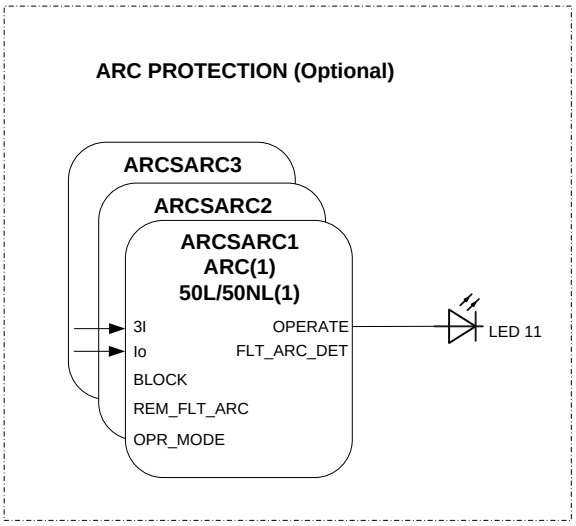

Figure 26: Arc protection

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

The arc protection offers individual function blocks for three arc sensors that can be connected to the IED. Each arc protection function block has two different operation modes that is, 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

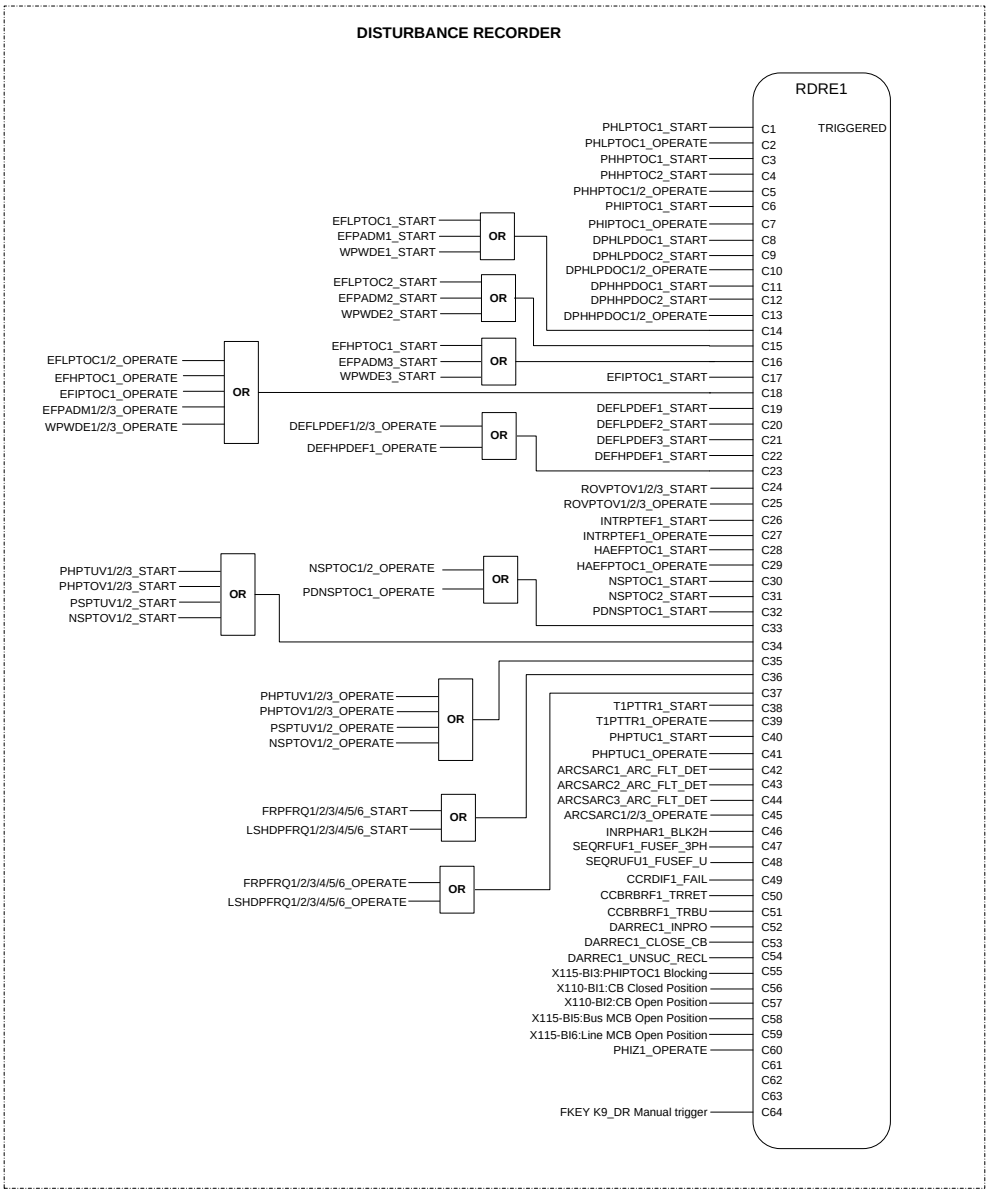

Figure 27: Disturbance recorder

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 five binary inputs totally from X110 and X115 are also connected.

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

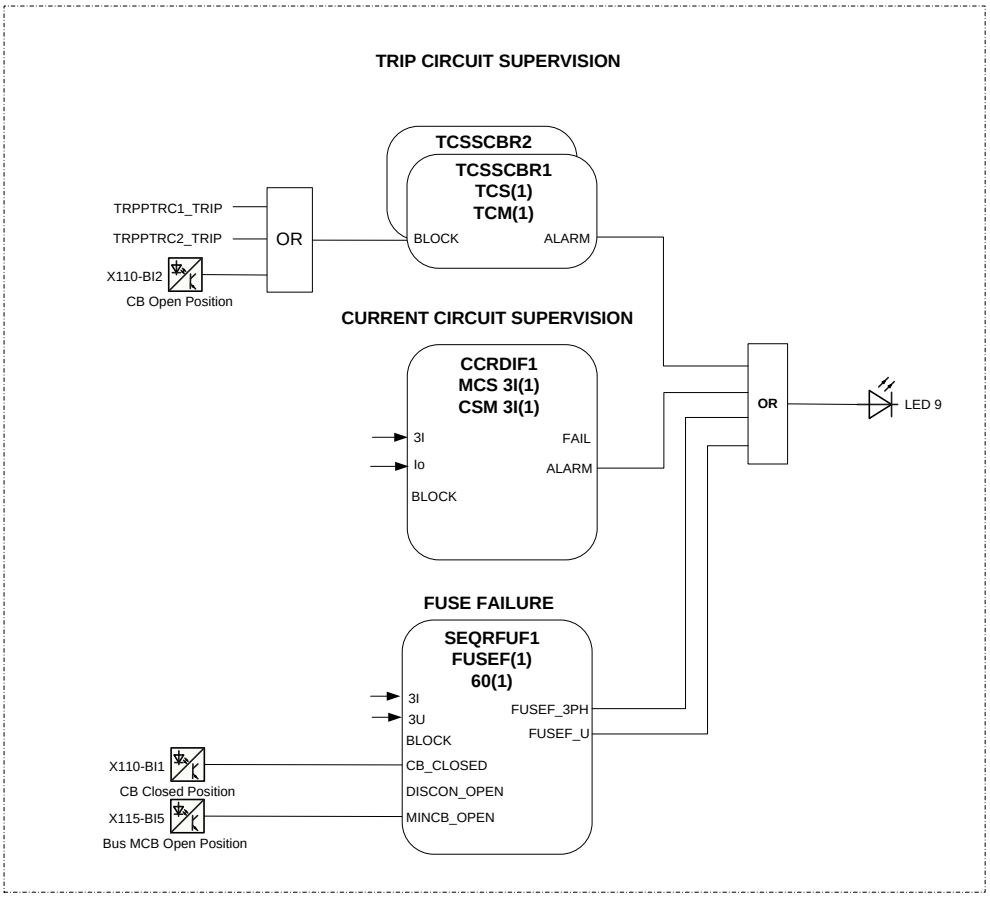

Figure 28: Circuit supervision

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 CCRDIF1. 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.

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. When a failure is detected, blocking signal is activated in voltage protection functions that are measuring calculated

sequence component voltages, undervoltage protection and synchrocheck, and unnecessary operation can be avoided.

3.5.3.3 Functional diagrams for control and interlocking

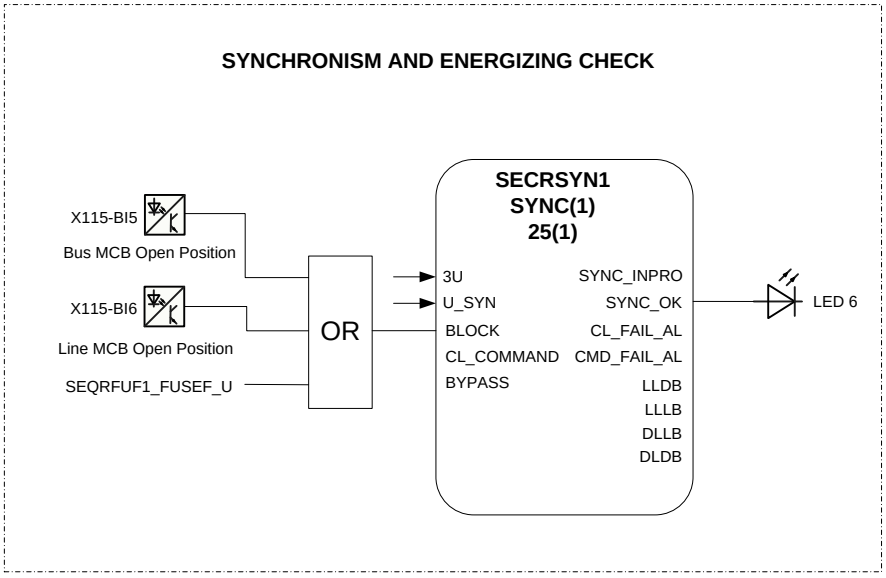

Figure 29: Synchronism and energizing check

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

SECRSYN1 measures the bus and line voltages and compares them to the set conditions. When all the measured quantities are within 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 through control logic and also to the 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, `Bus MCB Open Position` (X115-BI5:8-9), `Line MCB Open Position` (X115-BI6:9-10) and `SEQRFUF1_FUSEF_U` are connected to block SECRSYN1.

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

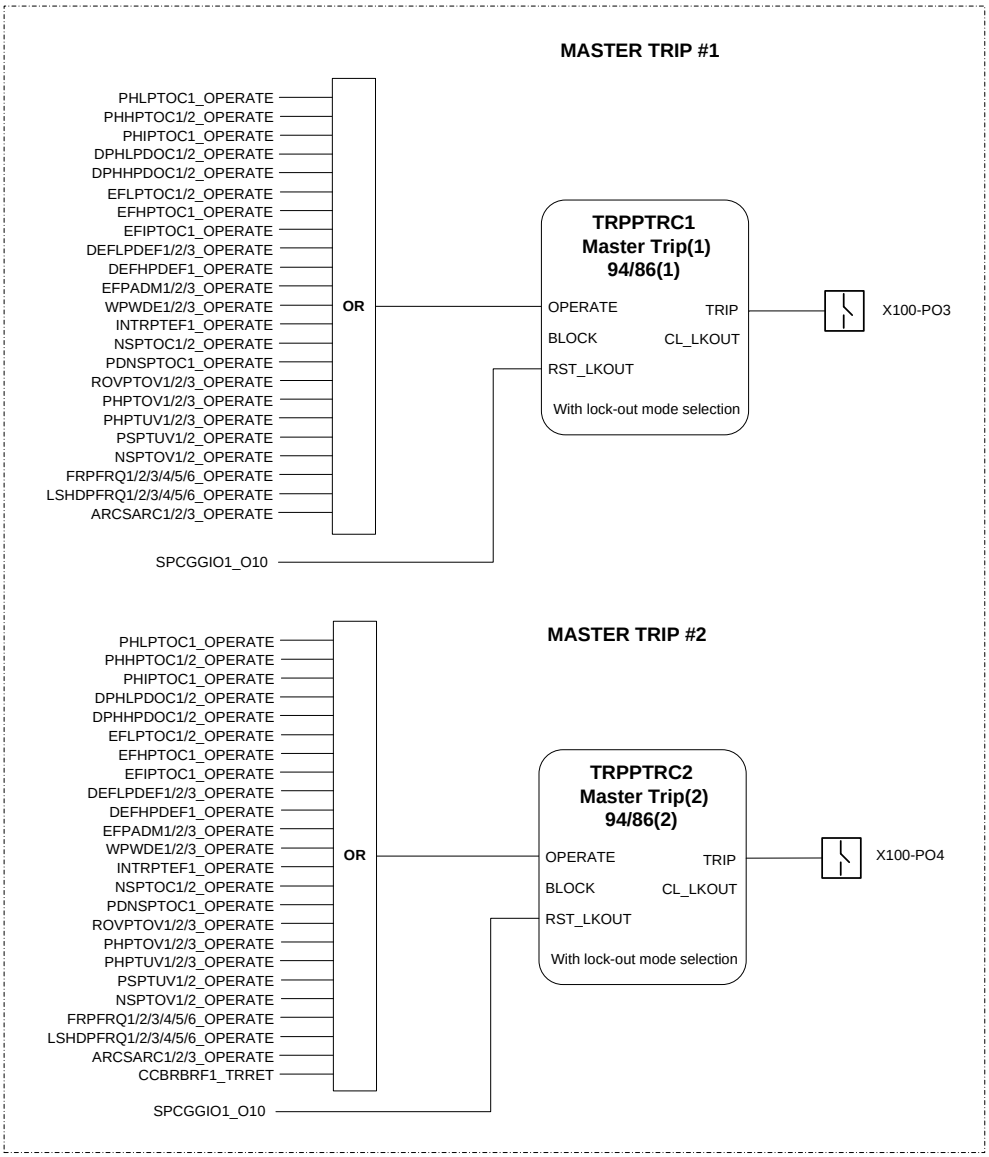

Figure 30: Master trip

The operating signals from the protections 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 through `SPCGGIO1_O10`.

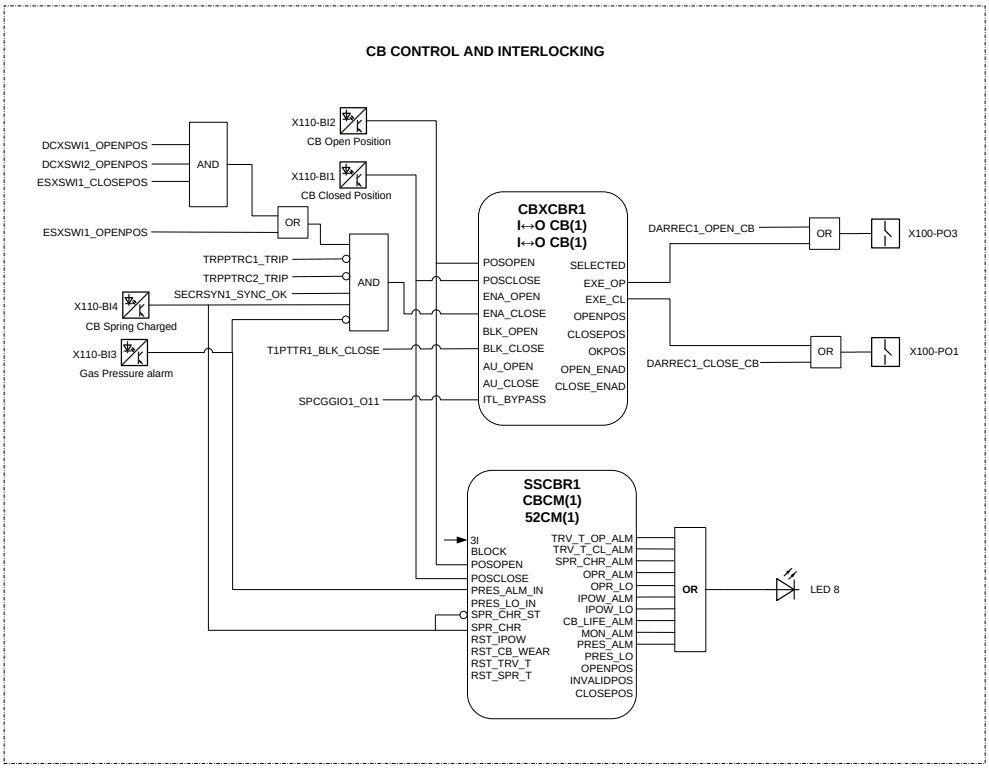

Figure 31: Circuit breaker control and interlocking

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

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

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

The circuit breaker closing is blocked when BLK_CLOSE input is activated. This input is activated when the BLK_CLOSE output of T1PTTR1 is active.

One push button can be used through SPCGGIO1_O11, which is connected to the ITL_BYPASS input of CBXCBR1 to ignore the status of the ENA_CLOSE input. However, the BLK_CLOSE input signals 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 with PCM600, the function assumes that the breaker-closing commands are allowed continuously.

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

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

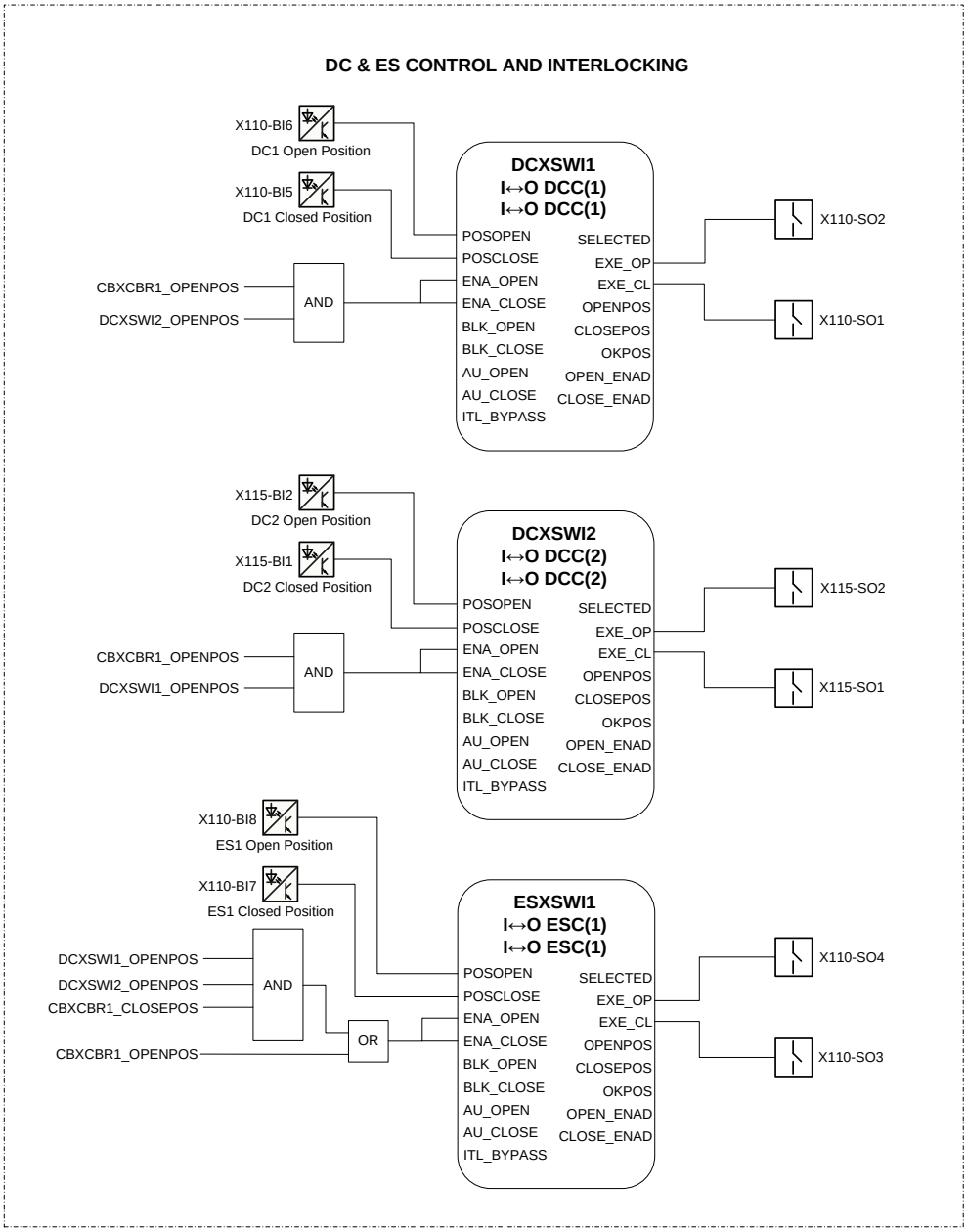

Figure 32: Disconnector and earthing switch control and interlocking

There are two types of disconnector and earthing switch blocks available. DCXSWI1...4 and ESXSWI1…2 are of the controllable type, and DCSXSWI1...4 and ESSXSWI1...2 are status-only type. By default, the controllable blocks are connected in the default configuration logic. If 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 with PCM600.

The binary inputs 5 and 6 of the card X110 are used for the busbar disconnector 1 (DCXSWI1) position indication. The binary inputs 1 and 2 of the card X115 are used for the busbar disconnector 2 (DCXSWI2) position indication.

Table 18: Disconnector 1 position indicated by binary inputs

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

Table 19: Disconnector 2 position indicated by binary inputs

Primary device position	Input to be energized	
	Input 1 (X115:1-2)	Input 2 (X115:3-4)
Busbar disconnector 2 closed	•	
Busbar disconnector 2 open		•

Table 20: Earthing-switch position indicated by binary inputs

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

The control (opening or closing) of disconnector 1 and disconnector 2 is enabled only when both the circuit breaker and the other disconnector is in the open position.

The control (opening or closing) of the earthing switch is enabled under either of the two conditions:

- The circuit breaker is in the open position
- The circuit breaker is in the closed position, while both disconnector 1 and disconnector 2 are in the open position

With this simplified default disconnector control logic, the busbar is transferred by opening the circuit breaker. In a normal double-busbar system, the busbar is transferred without a power supply break.

Cooperation is needed on the bus coupler bay to support live busbar transfer, so necessary information exchange between different bays and bus coupler bay is also required. The control logic for disconnector 1 and disconnector 2 mentioned earlier needs to be revised accordingly. The information exchange can be done either with binary inputs or through a GOOSE message.

The general rule for live busbar transfer is to have the two busbars interconnected, as shown in figure 33. The outgoing feeder has been connected to busbar I. Under

this condition, DC11 and CB1 are closed while DC12 is open. The busbar coupler bay apparatuses (DC21, DC22 and CB2) are also open.

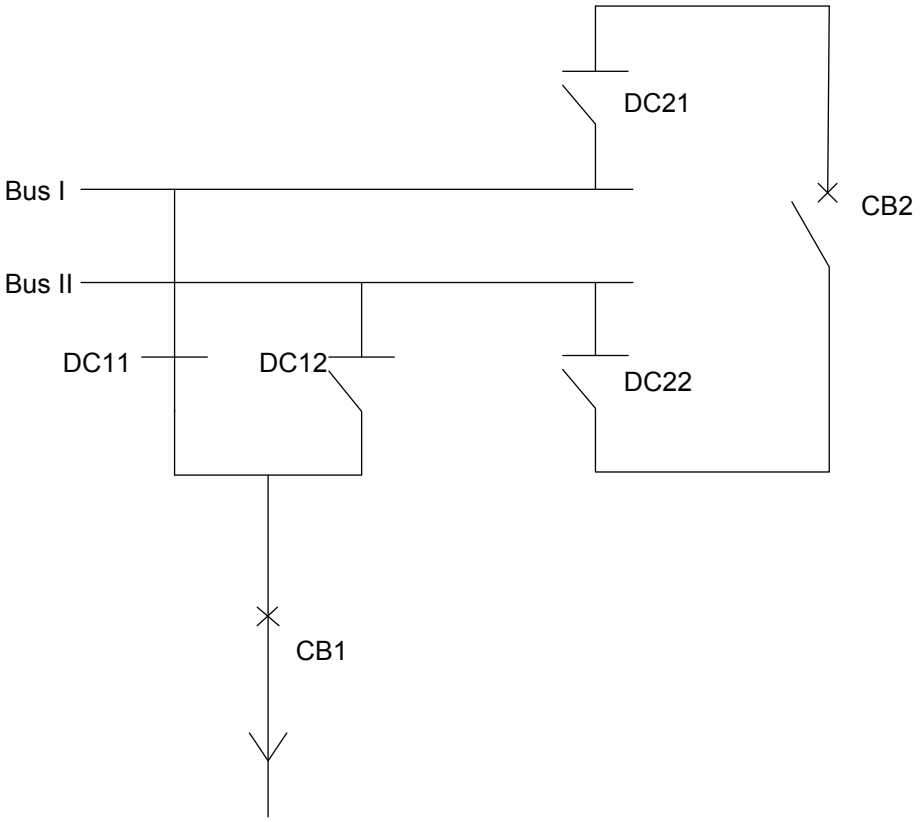

Figure 33: Disconnector control logic

There are four general steps to transfer the power supply from busbar I to busbar II.

1. DC21, DC2 and CB2 in the bus coupler bay have to be closed to have busbar I and busbar II connected.
2. DC12 has to be closed to have the feeder connected to busbar II.
3. DC11 has to opened to disconnect the feeder from busbar I.
4. CB2, DC21 and DC22 have to be opened to disconnect the two busbars. This transfers the load of the outgoing feeder to busbar II.

These four steps assure that there is no power supply interruption on the feeder. After step 1, the two busbars are connected to ensure that the operation on DC12 and DC11, in steps 2 and 3, is safe.

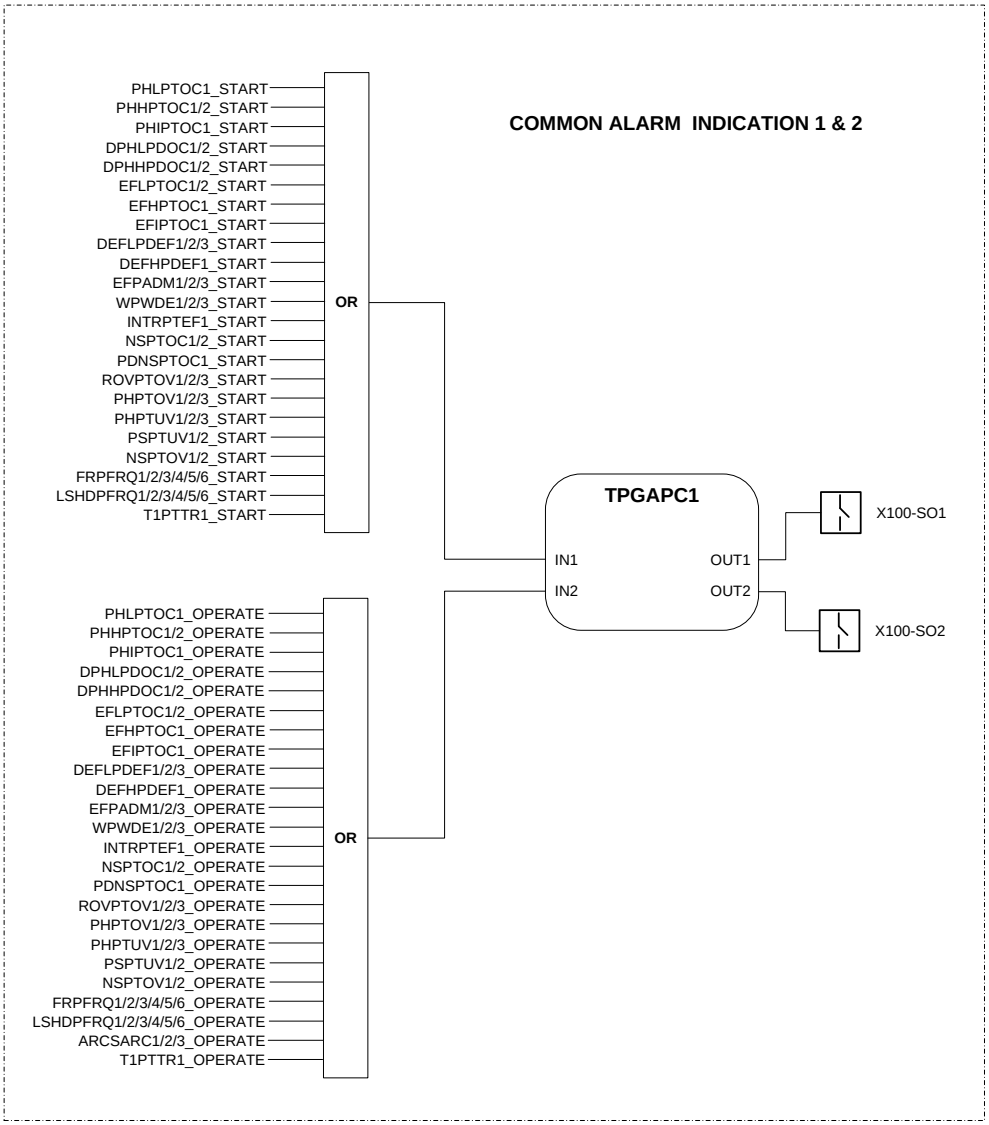

Figure 34: Common alarm indication

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

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

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

3.5.3.4 Functional diagrams for power quality measurements

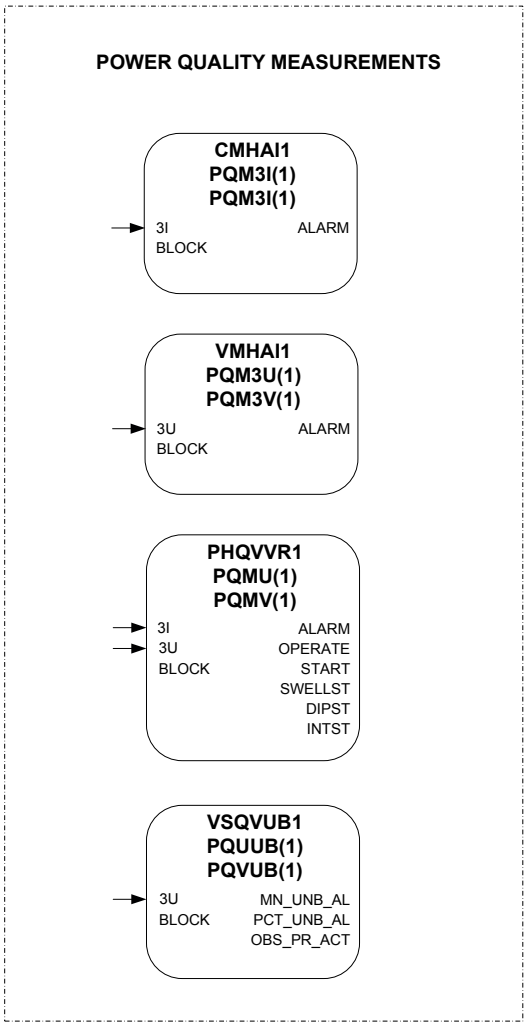

Figure 35: Power quality measurement function

The power quality function CMHAI1 is used to measure the harmonic contents of the phase current.

The power quality function VMHAI1 is used to measure the harmonic contents of the phase voltages.

The power quality function PHQVVR1 is used to measure the voltage variation, that is, sags and swells.

The voltage unbalance power quality function VSQVUB1 monitors the voltage unbalance conditions in power networks. It is used to monitor the commitment of power supply utility of providing a balanced voltage supply on a continuous basis. VSQVUB provides statistics which can be used to verify the compliance of the power quality.

The above functions are included in default configuration for demonstration purposes only, but not configured by default. The functions can be configured as needed.

3.6 Default configuration B

3.6.1 Applications

The default configuration for non-directional overcurrent and directional earth-fault protection is mainly intended for cable and overhead-line feeder applications in isolated and resonant-earthed distribution networks. The configuration is used with sensor measurements - phase currents and voltages measured with sensors and Io with a traditional ring core CT. The configuration also includes additional options to select earth-fault protection based on admittance or wattmetric based principle.

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.

This configuration can be utilized in single and double busbar arrangements where the measurements are located on the feeder side.

3.6.2 Functions

Table 21: Functions included in the default configuration B

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, 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 directional overcurrent protection, low stage, instance 1	DPHLPDOC1	3I> -> (1)	67-1 (1)
Three-phase directional overcurrent protection, low stage, instance 2	DPHLPDOC2	3I> -> (2)	67-1 (2)
Table continues on next page			

Function	IEC 61850	IEC 60617	IEC-ANSI
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, 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, instantaneous stage, instance 1	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, low stage, instance 3	DEFLPDEF3	Io> -> (3)	67N-1 (3)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Admittance based earth-fault protection, instance 1	EFPADM1	Yo> -> (1)	21YN (1)
Admittance based earth-fault protection, instance 2	EFPADM2	Yo> -> (2)	21YN (2)
Admittance based earth-fault protection, instance 3	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric based earth-fault protection, instance 1	WPWDE1	Po> -> (1)	32N (1)
Wattmetric based earth-fault protection, instance 2	WPWDE2	Po> -> (2)	32N (2)
Wattmetric based earth-fault protection, instance 3	WPWDE3	Po> -> (3)	32N (3)
Harmonics based earth-fault protection	HAEFPTOC1	Io>HA (1)	51NHA (1)
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection, instance 1	ROVPTOV1	Uo> (1)	59G (1)
Residual overvoltage protection, instance 2	ROVPTOV2	Uo> (2)	59G (2)
Residual overvoltage protection, instance 3	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	3U< (2)	27 (2)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Three-phase undervoltage protection, instance 3	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection, instance 1	PHPTOV1	3U> (1)	59 (1)
Three-phase overvoltage protection, instance 2	PHPTOV2	3U> (2)	59 (2)
Three-phase overvoltage protection, instance 3	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection, instance 1	PSPTUV1	U1< (1)	47U+ (1)
Positive-sequence undervoltage protection, instance 2	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection, instance 1	NSPTOV1	U2> (1)	47O- (1)
Negative-sequence overvoltage protection, instance 2	NSPTOV2	U2> (2)	47O- (2)
Frequency protection, instance 1	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
Frequency protection, instance 2	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
Frequency protection, instance 3	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Frequency protection, instance 4	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
Frequency protection, instance 5	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
Frequency protection, instance 6	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F (1)	49F (1)
Loss of phase (undercurrent), instance 1	PHPTUC1	3I< (1)	37F (1)
Circuit breaker failure protection, instance 1	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Circuit breaker failure protection, instance 2	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
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)
High impedance fault detection	PHIZ1	PHIZ (1)	PHIZ (1)
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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Multipurpose analog protection, instance 5	MAPGAPC5	MAP (5)	MAP (5)
Multipurpose analog protection, instance 6	MAPGAPC6	MAP (6)	MAP (6)
Multipurpose analog protection, instance 7	MAPGAPC7	MAP (7)	MAP (7)
Multipurpose analog protection, instance 8	MAPGAPC8	MAP (8)	MAP (8)
Multipurpose analog protection, instance 9	MAPGAPC9	MAP (9)	MAP (9)
Multipurpose analog protection, instance 10	MAPGAPC10	MAP (10)	MAP (10)
Multipurpose analog protection, instance 11	MAPGAPC11	MAP (11)	MAP (11)
Multipurpose analog protection, instance 12	MAPGAPC12	MAP (12)	MAP (12)
Control			
Circuit-breaker control, instance 1	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Circuit-breaker control, instance 2	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
Disconnector control, instance 1	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
Disconnector control, instance 2	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control, instance 1	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector control, instance 3	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
Disconnector control, instance 4	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control, instance 2	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
Disconnector position indication, instance 1	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
Disconnector position indication, instance 2	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
Earthing switch position indication, instance 1	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Disconnector position indication, instance 3	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Disconnector position indication, instance 4	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch position indication, instance 2	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Auto-reclosing, instance 1	DARREC1	O -> I (1)	79 (1)
Auto-reclosing, instance 2	DARREC2	O -> I (2)	79 (2)
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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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)
Fuse failure supervision	SEQRFUF1	FUSEF (1)	60 (1)
Measurement			
Three-phase current measurement, instance 1	CMMXU1	3I (1)	3I (1)
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement, instance 1	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
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)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (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)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
Minimum pulse timer (2 pcs, minute resolution), instance 1	TPMGAPC1	TPM (1)	TPM (1)
Minimum pulse timer (2 pcs, minute resolution), instance 2	TPMGAPC2	TPM (2)	TPM (2)
Pulse timer (8 pcs), instance 1	PTGAPC1	PT (1)	PT (1)
Pulse timer (8 pcs), instance 2	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF (1)	TOF (1)
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF (2)	TOF (2)
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF (3)	TOF (3)
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs), instance 1	TONGAPC1	TON (1)	TON (1)
Time delay on (8 pcs), instance 2	TONGAPC2	TON (2)	TON (2)
Time delay on (8 pcs), instance 3	TONGAPC3	TON (3)	TON (3)
Time delay on (8 pcs), instance 4	TONGAPC4	TON (4)	TON (4)
Set reset (8 pcs), instance 1	SRGAPC1	SR (1)	SR (1)
Set reset (8 pcs), instance 2	SRGAPC2	SR (2)	SR (2)
Set reset (8 pcs), instance 3	SRGAPC3	SR (3)	SR (3)
Set reset (8 pcs), instance 4	SRGAPC4	SR (4)	SR (4)
Move (8 pcs), instance 1	MVGAPC1	MV (1)	MV (1)
Move (8 pcs), instance 2	MVGAPC2	MV (2)	MV (2)
Move (8 pcs), instance 3	MVGAPC3	MV (3)	MV (3)
Move (8 pcs), instance 4	MVGAPC4	MV (4)	MV (4)
Generic control points, instance 1	SPCGGIO1	SPCGGIO (1)	SPCGGIO (1)
Generic control points, instance 2	SPCGGIO2	SPCGGIO (2)	SPCGGIO (2)
Generic control points, instance 3	SPCGGIO3	SPCGGIO (3)	SPCGGIO (3)
Remote Generic control points	SPCRGGIO1	SPCRGGIO (1)	SPCRGGIO (1)
Local Generic control points	SPCLGGIO1	SPCLGGIO (1)	SPCLGGIO (1)
Generic Up-Down Counters, instance 1	UDFCNT1	UDCNT (1)	UDCNT (1)
Generic Up-Down Counters, instance 2	UDFCNT2	UDCNT (2)	UDCNT (2)
Generic Up-Down Counters, instance 3	UDFCNT3	UDCNT (3)	UDCNT (3)
Generic Up-Down Counters, instance 4	UDFCNT4	UDCNT (4)	UDCNT (4)
Generic Up-Down Counters, instance 5	UDFCNT5	UDCNT (5)	UDCNT (5)
Generic Up-Down Counters, instance 6	UDFCNT6	UDCNT (6)	UDCNT (6)
Generic Up-Down Counters, instance 7	UDFCNT7	UDCNT (7)	UDCNT (7)
Generic Up-Down Counters, instance 8	UDFCNT8	UDCNT (8)	UDCNT (8)

Table continues on next page

Function	IEC 61850	IEC 60617	IEC-ANSI
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)

3.6.2.1 Default I/O connections

Table 22: Default connections for analog inputs

Analog input	Default usage	Connector pins
IL1	Phase A current	X131-4,5
IL2	Phase B current	X132-4,5
IL3	Phase C current	X133-4,5
Io	Residual current	X130-1,2
U1	Phase voltage U1, feeder side	X131-7,8
U2	Phase voltage U2, feeder side	X132-7,8
U3	Phase voltage U3, feeder side	X133-7,8

Table 23: Default connections for binary inputs

Binary input	Default usage	Connector pins
X110-BI1	Circuit breaker closed position indication	X110-1,2
X110-BI2	Circuit breaker open position indication	X110-3,4
X110-BI3	Circuit breaker low gas pressure alarm	X110-5,6
X110-BI4	Circuit breaker spring charged indication	X110-7,6
X110-BI5	Disconnector 1 closed position indication	X110-8,9
X110-BI6	Disconnector 1 open position indication	X110-10,9
X110-BI7	Earthing switch 1 closed position indication	X110-11,12
X110-BI8	Earthing switch 1 open position indication	X110-13,12
X115-BI1	Disconnector 2 closed position indication	X115-1,2
X115-BI2	Disconnector 2 open position indication	X115-3,4
X115-BI3	Blocking of overcurrent instantaneous stage	X115-5,6

Table continues on next page

Binary input	Default usage	Connector pins
X115-BI4	Directional earth fault protection's basic angle control	X115-7,6
X115-BI5	-	X115-8,9
X115-BI6	-	X115-10,9
X115-BI7	-	X115-11,12
X115-BI8	-	X115-13,12

Table 24: Default connections for binary outputs

Binary input	Default usage	Connector pins
X100-PO1	Close circuit breaker	X100-6,7
X100-PO2	Circuit breaker failure protection trip to upstream breaker	X100-8,9
X100-SO1	General start indication	X100-10,11,(12)
X100-SO2	General operate indication	X100-13,14,15
X100-PO3	Open circuit breaker/trip coil 1	X100-15,16,17,18,19
X100-PO4	Open circuit breaker/trip coil 2	X100-20,21,22,23,24
X110-SO1	Close disconnector 1	X110-14,15,16
X110-SO2	Open disconnector 1	X110-17,18,19
X110-SO3	Close earthing switch 1	X110-20,21,22
X110-SO4	Open earthing switch 1	X110-23,24
X115-SO1	Close disconnector 2	X115-14,15,16
X115-SO2	Open disconnector 2	X115-17,18,19
X115-SO3	Upstream overcurrent blocking	X115-20,21,22
X115-SO4	-	X115-23,24

Table 25: Default connections for LEDs

LED	Default usage
1	Overcurrent protection operate
2	Earth-fault protection operate
3	Voltage protection operate
4	Frequency protection operate
5	Negative seq. overcurrent/phase discontinuity
6	Thermal overload protection operate
7	Circuit breaker failure protection backup protection operate
8	Circuit breaker condition monitoring alarm
9	Supervision alarm
10	Autoreclose in progress
11	Arc fault detected

Table 26: 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	Autorecloser Disable
5	Setting Group 5 Enabled	13	-
6	Setting Group 6 Enabled	14	-
7	-	15	-
8	-	16	-

3.6.2.2 Default disturbance recorder settings

Table 27: Default disturbance recorder binary channels

Channel	Id text	Level trigger mode
1	PHLPTOC1_START	1
2	PHLPTOC1_OPERATE	4
3	PHHPTOC1_START	1
4	PHHPTOC2_START	1
5	PHHPTOC1/2_OPERATE	4
6	PHIPTOC1_START	1
7	PHIPTOC1_OPERATE	4
8	DPHLPDOC1_START	1
9	DPHLPDOC2_START	1
10	DPHLPDOC1/2_OPERATE	4
11	DPHHPDOC1_START	1
12	DPHHPDOC2_START	1
13	DPHHPDOC1/2_OPERATE	4
14	EFLPTOC1 or EFPADM1 or WPWDE1_START	1
15	EFLPTOC2 or EFPADM2 or WPWDE2_START	1
16	EFHPTOC1 or EFPADM3 or WPWDE3_START	1
17	EFIPTOC1_START	1
18	EFxPTOC or EFPADM or WPWDE_OPERATE	4
19	DEFLPDEF1_START	1
20	DEFLPDEF2_START	1
21	DEFLPDEF3_START	1
22	DEFHPDEF1_START	1
23	DEFxPDEF_OPERATE	4
24	ROVPTOV1/2/3_START	1

Table continues on next page

Channel	Id text	Level trigger mode
25	ROVPTOV1/2/3_OPERATE	4
26	-	-
27	-	-
28	HAEFPTOC1_START	1
29	HAEFPTOC1_OPERATE	4
30	NSPTOC1_START	1
31	NSPTOC2_START	1
32	PDNSPTOC1_START	1
33	NSPTOC1/2 or PDNSPTOC1_OPERATE	4
34	PHPTUV or PHPTOV or PSPTUV or NSPTOV_START	1
35	PHPTUV or PHPTOV or PSPTUV or NSPTOV_OPERATE	4
36	FRPFRQ or LSHDPFRQ_START	1
37	FRPFRQ or LSHDPFRQ_OPERATE	4
38	T1PTTR1_START	1
39	T1PTTR1_OPERATE	4
40	PHPTUC1_START	1
41	PHPTUC1_OPERATE	4
42	ARCSARC1_ARC_FLT_DET	4
43	ARCSARC2_ARC_FLT_DET	4
44	ARCSARC3_ARC_FLT_DET	4
45	ARCSARC1/2/3_OPERATE	4
46	INRPHAR1_BLK2H	4
47	SEQRFUF1_FUSEF_3PH	4
48	SEQRFUF1_FUSEF_U	4
49	CCRDIF1_FAIL	4
50	CCBRBRF1_TRRET	4
51	CCBRBRF1_TRBU	4
52	DARREC1_INPRO	4
53	DARREC1_CLOSE_CB	4
54	DARREC1_UNSUC_RECL	4
55	BI Blocking	4
56	CB Closed	4
57	CB Open	4
58	-	-
59	-	-
60	PHIZ1_OPERATE	4
61	-	4

Table continues on next page

Channel	Id text	Level trigger mode
62	-	4
63	-	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 28: Default analog channel selection and text settings

Channel	Selection and text
1	IL1
2	IL2
3	IL3
4	I0
5	U0
6	U1
7	U2
8	U3
9	-
10	-
11	-
12	-

3.6.2.3 Default operation mode for generic control point

Table 29: 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	1000ms
8		Off	1000ms
9	DR Trigger	Pulsed	150 ms
10	Trip Lockout Reset	Pulsed	150 ms
11	CB Block Bypass	Toggle	1000ms
12	AR Disable	Toggle	1000ms

Table continues on next page

Channel	Signal name	Value	Pulse length
13		Off	1000ms
14		Off	1000ms
15		Off	1000ms
16		Off	1000ms
Grey cells indicate different default settings.			

3.6.2.4 Sensor settings

Rogowski sensor setting example

In this example, a **80 A/0.150 V at 50 Hz** sensor is used and the application has a **150 A** nominal current (In). As the Rogowski sensor is linear and does not saturate, the 80 A/0.150 V at 50 Hz sensor also works as a 150 A/0.28125 V at 50 Hz sensor. When defining another primary value for the sensor, also the nominal voltage has to be redefined to maintain the same transformation ratio. However, the setting in the IED (*Rated Secondary Value*) is not in V but in mV/Hz, which makes the same setting value valid for both 50 and 60 Hz nominal frequency. *Rated Secondary Value* is calculated with the formula:

$$\frac{\frac{I_n}{I_{pr}} * K_r}{f_n} = RSV$$

I_n	the application nominal current
I_{pr}	the sensor rated primary current
f_n	network nominal frequency
K_r	the sensor rated voltage (in mV) at the rated current
RSV	the *Rated Secondary Value* in mV/Hz

In this example, this is then:

$$\frac{\frac{150A}{80A} * 150mV}{50Hz} = 5.625\frac{mV}{Hz}$$

With this information, the IED Rogowski sensor settings can be set.

Table 30: *Example setting values*

Primary Current	150 A
Rated Secondary Value	5.625 mV/Hz
Nominal Current	150 A

Unless otherwise specified, the *Nominal Current* setting should always be the same as the *Primary Current* setting.

3.6.3 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 have fixed connections towards the different function blocks inside the IED's default configuration. 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.

Phase currents and phase voltages are measured with sensors, either with combisensors or with separate current and voltage sensors. The signal marked with `3I` represents the three phase currents from sensors, and the signal `Io` represents the measured residual current from current transformer. The signal marked with `3U` represents the three phase system voltages from sensors. Uo is always a calculated value.

As there is no dedicated physical channel to measure the residual voltage, for all functions which need the residual voltage as input, it is forced to use the calculated residual voltage.

There are 16 programmable push-buttons offered in the front panel of the unit. The IED offers six different settings group which can be 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 also be used, for example, for the manual trigger of disturbance recorder, enabling/disabling the autoreclosing function, circuit breaker control interlocking bypass or master trip lockout reset.

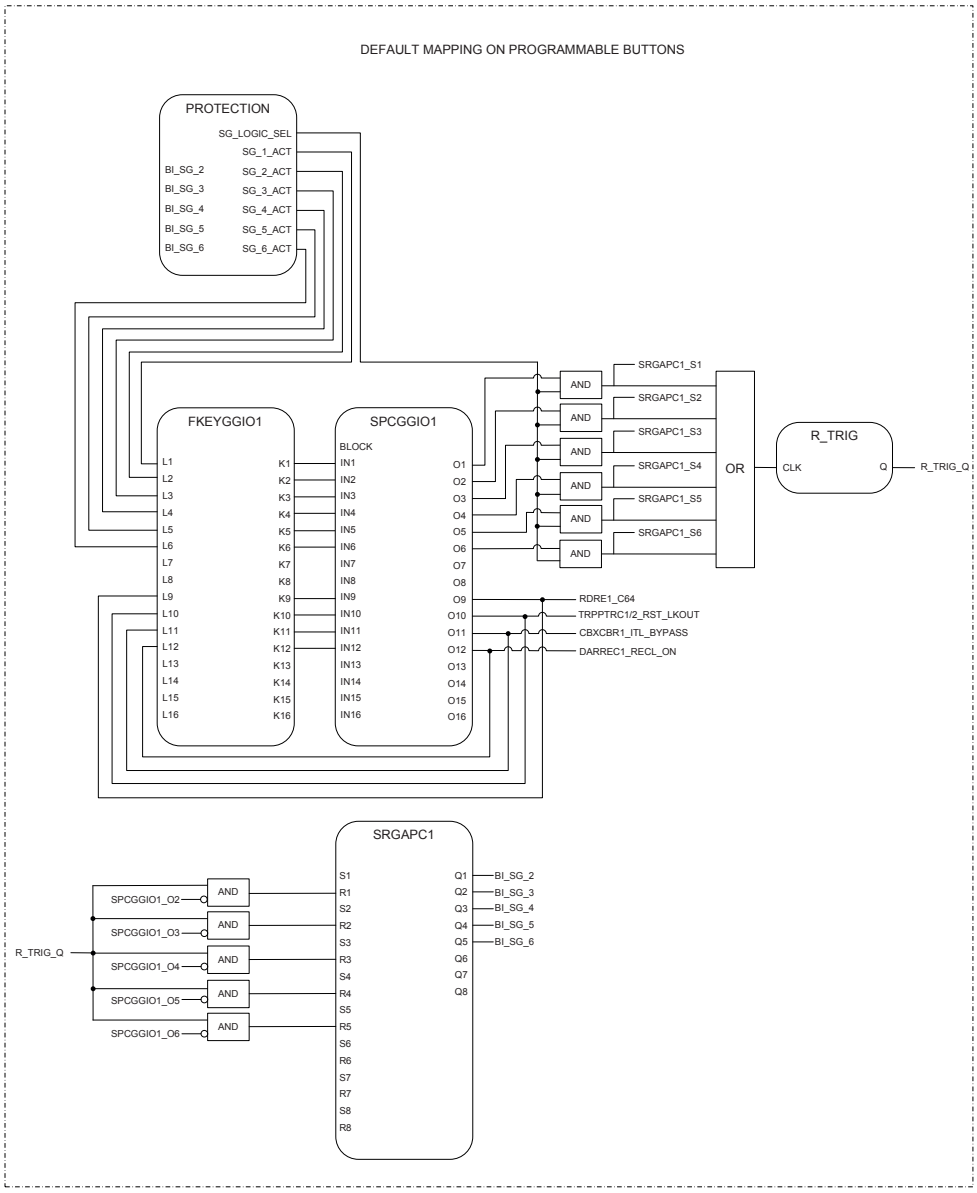

Figure 36: Default mapping on programmable buttons

3.6.3.1 Functional diagrams for protection

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

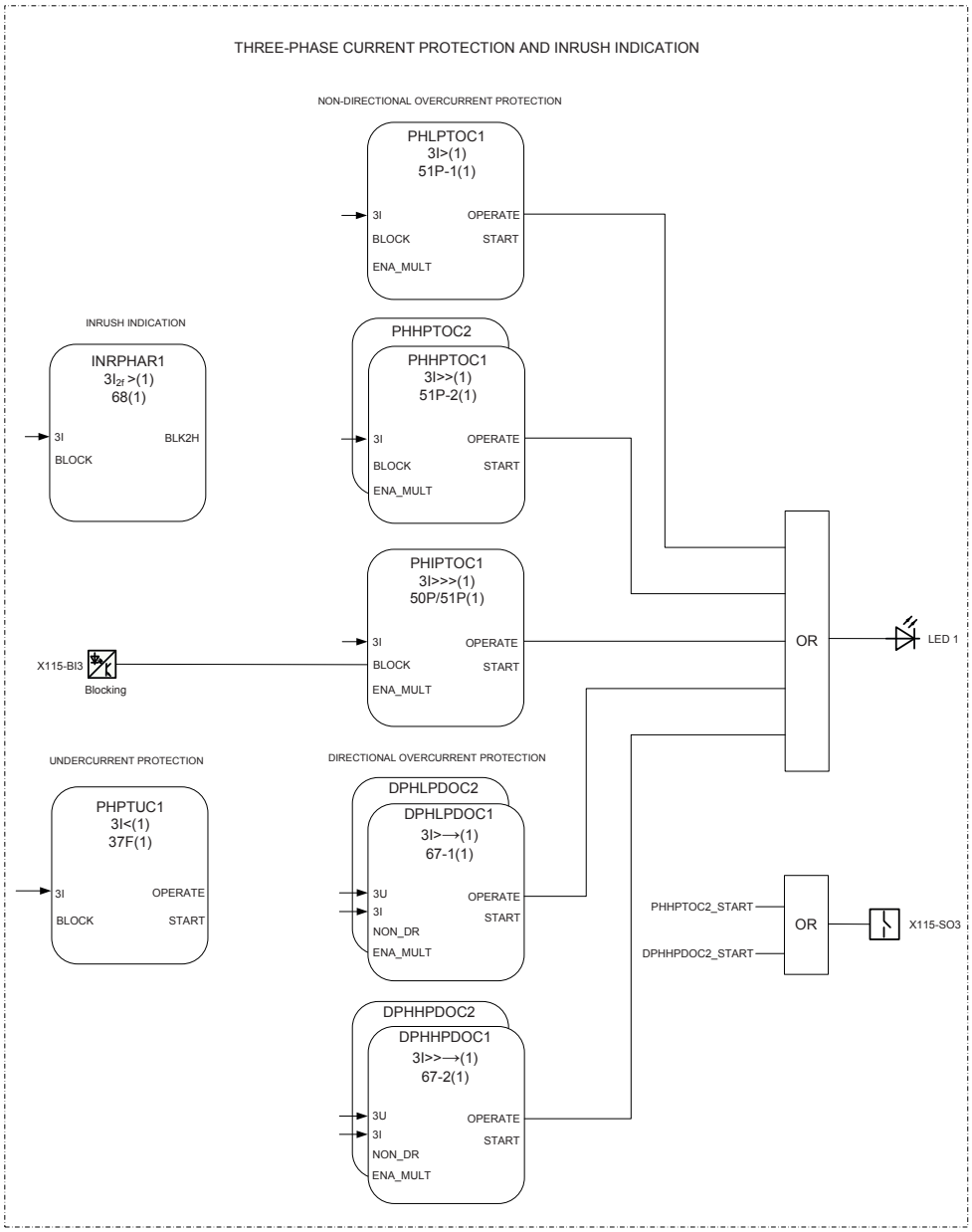

Figure 37: Overcurrent and undercurrent protection

Eight overcurrent stages in total 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 instantaneous stage PHIPTOC1 can be blocked by energizing the binary input (X115:5-6). 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.

One undercurrent stage PHPTUC1 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 1, except for those specially mentioned previously. LED 1 is used for overcurrent protection indication.

The upstream blocking from the START signals of the overcurrent second high stage PHHPTOC2 and DPHLPDOC2 are connected to signal output 3 (X115-SO3:20-22). This output is used for sending a blocking signal to the relevant overcurrent protection stage of the IED at the infeeding bay.

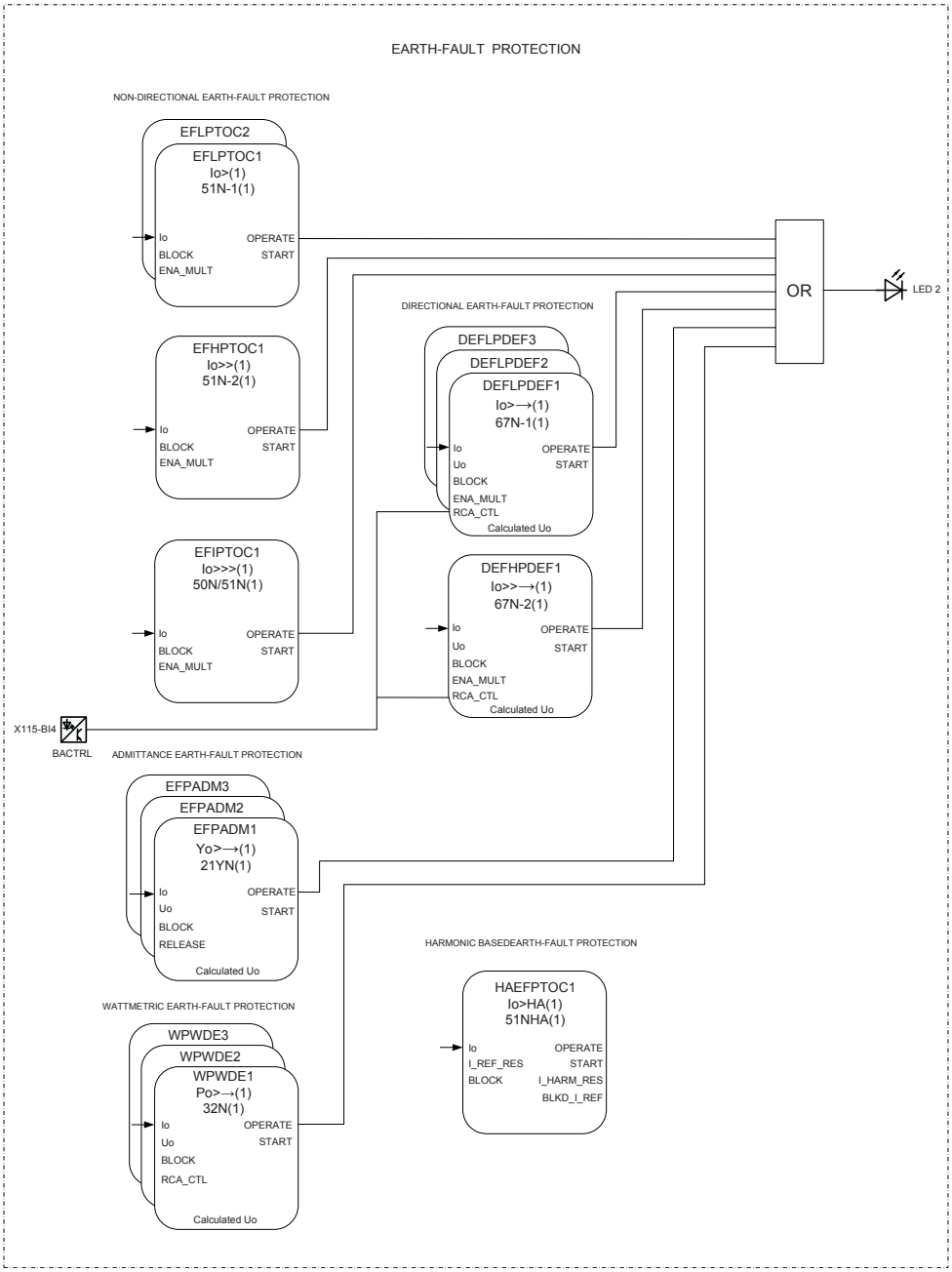

Figure 38: Earth-fault protection

Eight stages in total are offered for earth-fault protection. Four of them (DEFxPDEF) include directional functionality, while the others (EFxPTOC) are only for non-directional earth-fault protection. The directional earth-fault protection method is based on conventional directional earth-fault DEFxPDEF together with admittance criteria EFPADM1...3 and wattmetric earth-fault protection WPWDE1...3.

A harmonic based earth-fault protection HAEFPTOC1 is offered. 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 binary input (X115:7-6) is intended for either directional earth-fault protection blocks' relay characteristic angle (RCA: 0°/-90°) or operation mode (IoSinφ/ IoCosφ) change.

OPERATE outputs are connected to the Master Trip and alarm LED 2, except for those specially mentioned previously. LED 2 is used for earth-fault protection indication.

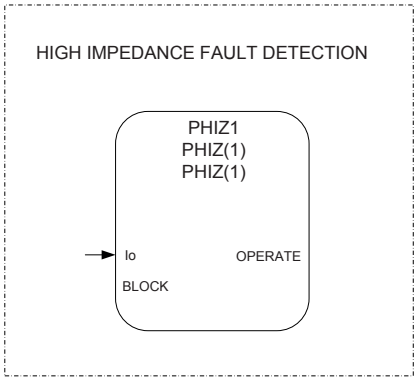

Figure 39: High impedance fault protection

The high impedance fault protection PHIZ1 is offered with sensitive 0.2/1A CT input. The OPERATE output from this function is connected to disturbance recorder, but this function is not configured to trip the circuit breaker by default.

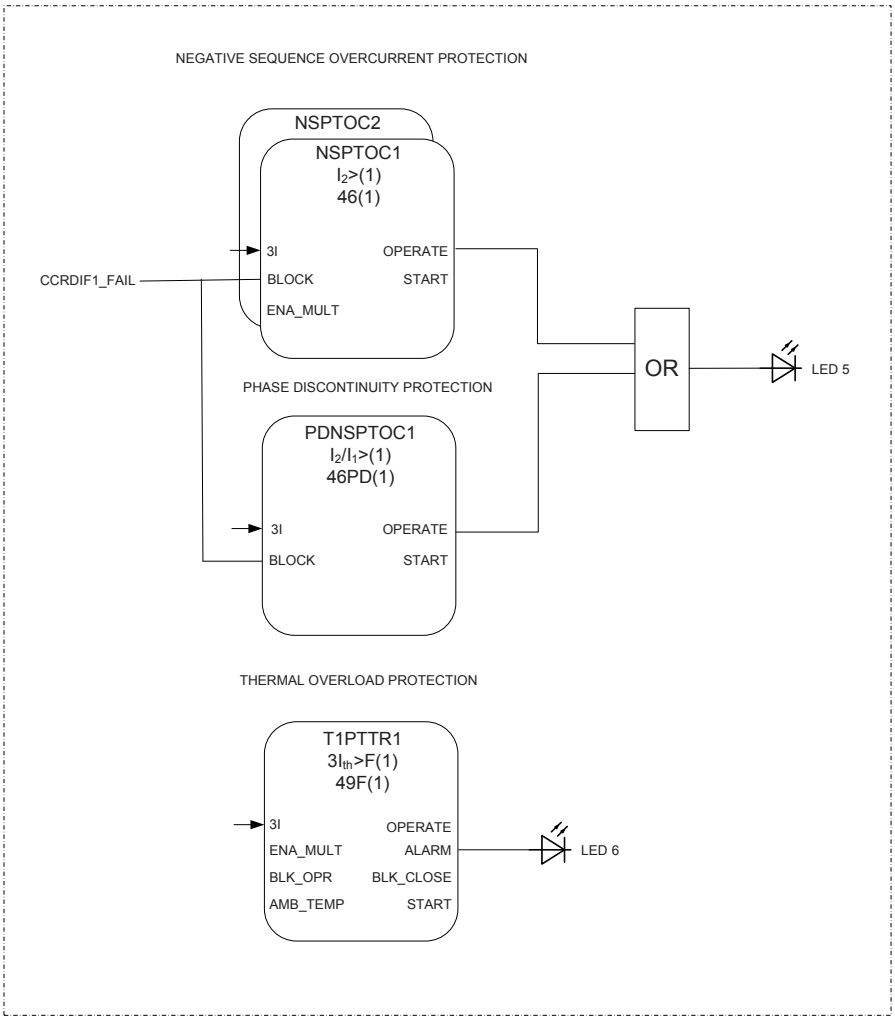

Figure 40: Negative-sequence current protection, phase discontinuity and thermal overload protection

Two negative sequence overcurrent stages NSPTOC1 and NSPTOC2 are offered for phase unbalance protection. A failure in the current measuring circuit is detected by the current circuit supervision function CCRDIF1 to avoid faulty tripping. The phase discontinuity protection PDNSTOC1 provides protection for interruptions in the normal three-phase load supply, for example, in downed conductor situations. The thermal overload protection T1PTTR1 provides indication on overload situations.

The OPERATE outputs of NSPTOC1/2 and PDNSPTOC1 are connected to the Master Trip and alarm LED 5. The ALARM output of T1PTTR1 is also connected to LED 6.

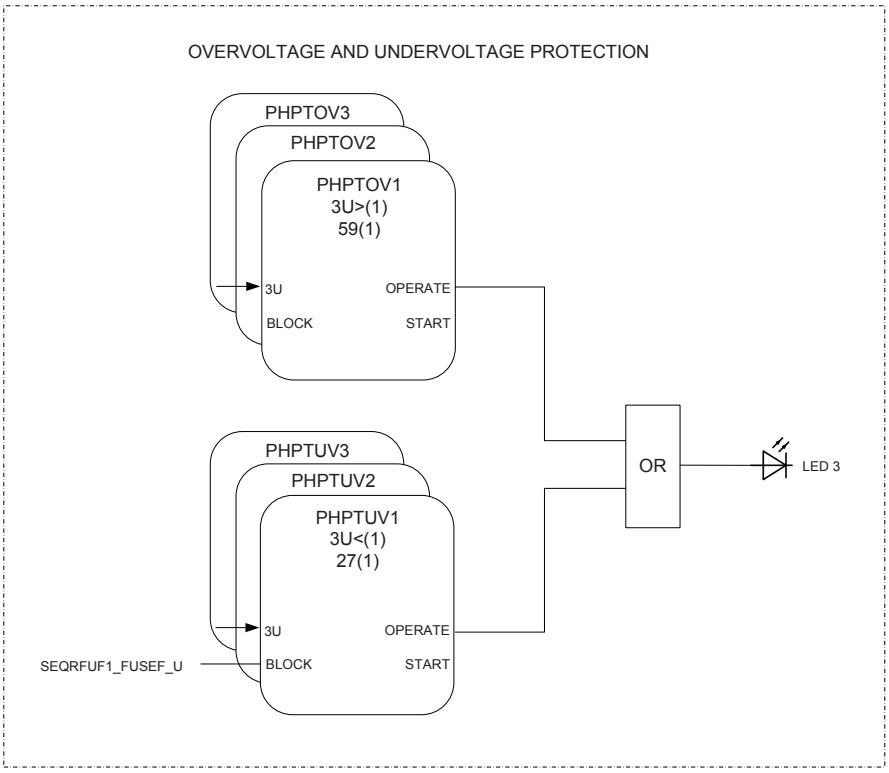

Figure 41: Overvoltage and undervoltage protection

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 alarm LED 3. LED 3 is used for combined voltage protection alarm indication.

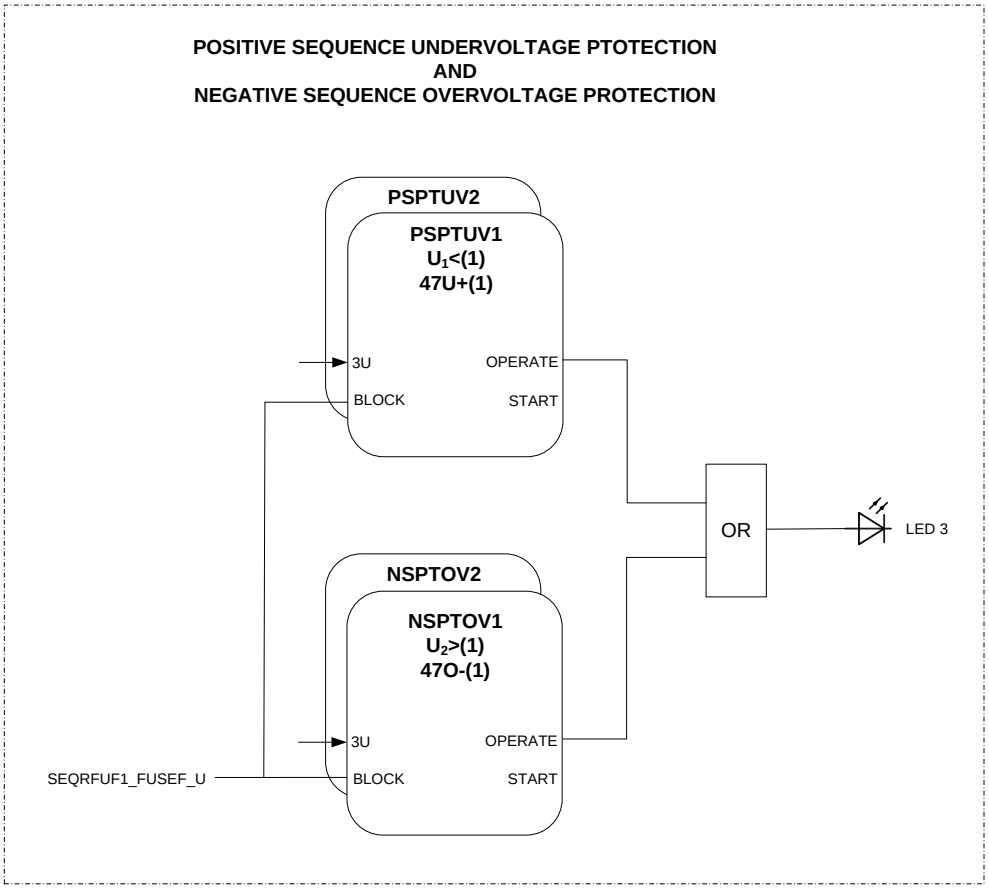

Figure 42: Positive-sequence undervoltage and negative-sequence overvoltage protection

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. The activation is 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 also connected to alarm LED 3.

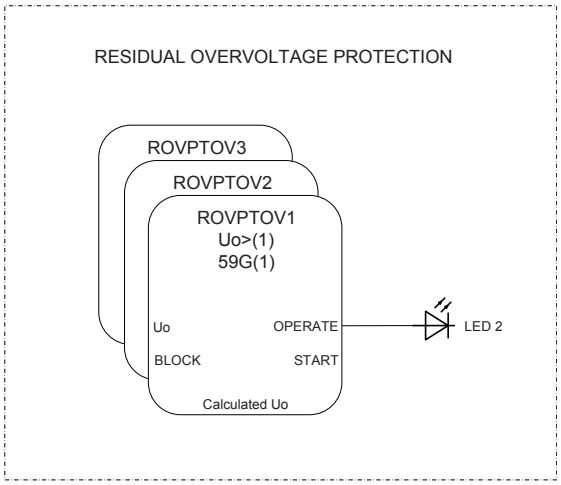

Figure 43: Residual overvoltage protection

The residual overvoltage protection ROVPTOV1...3 provides earth-fault protection by detecting abnormal level of residual voltage. It can be used, for example, as a nonselective backup protection for the selective directional earth-fault functionality. The OPERATE outputs are connected to the Master Trip and alarm LED 2.

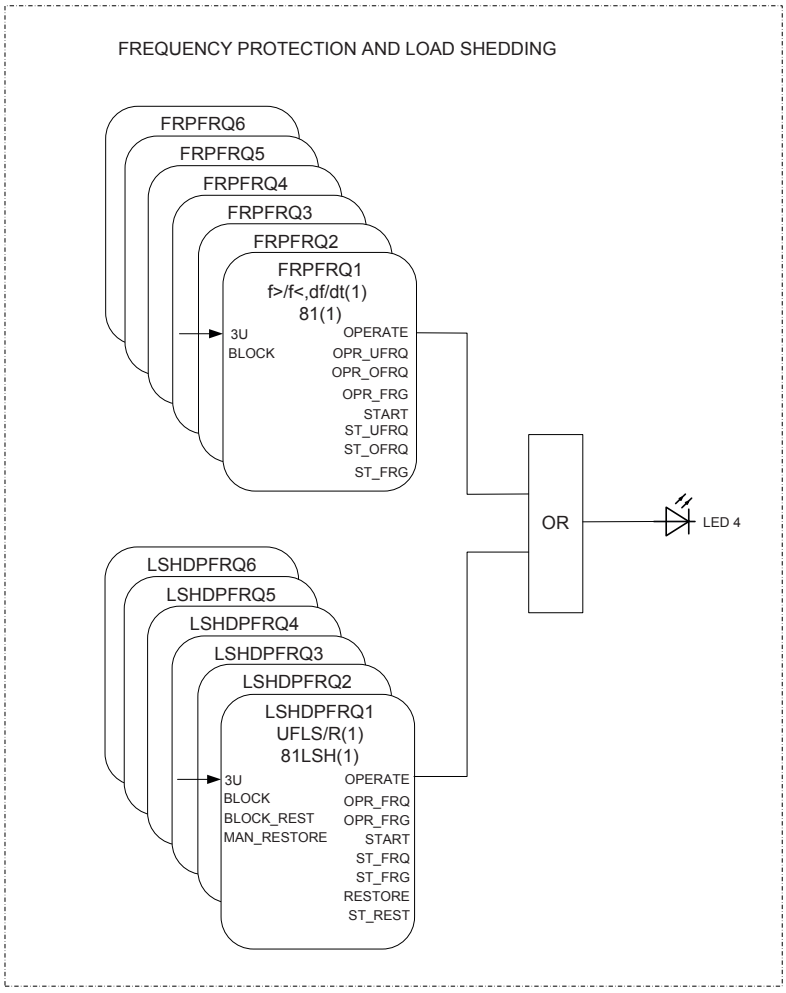

Figure 44: Frequency and load shedding protection

Six underfrequency or overfrequency protection FRPFRQ1…6 stages are offered to prevent damage to network components under unwanted frequency conditions. The function contains a selectable rate of change of the frequency (gradient) protection to detect an increase or decrease in the fast power system frequency at an early stage. This can be used as an early indication of a disturbance in the system. The OPERATE outputs signal is connected to the alarm LED 4. LED 4 is used for frequency protection operate indication.

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 alarm LED 4.

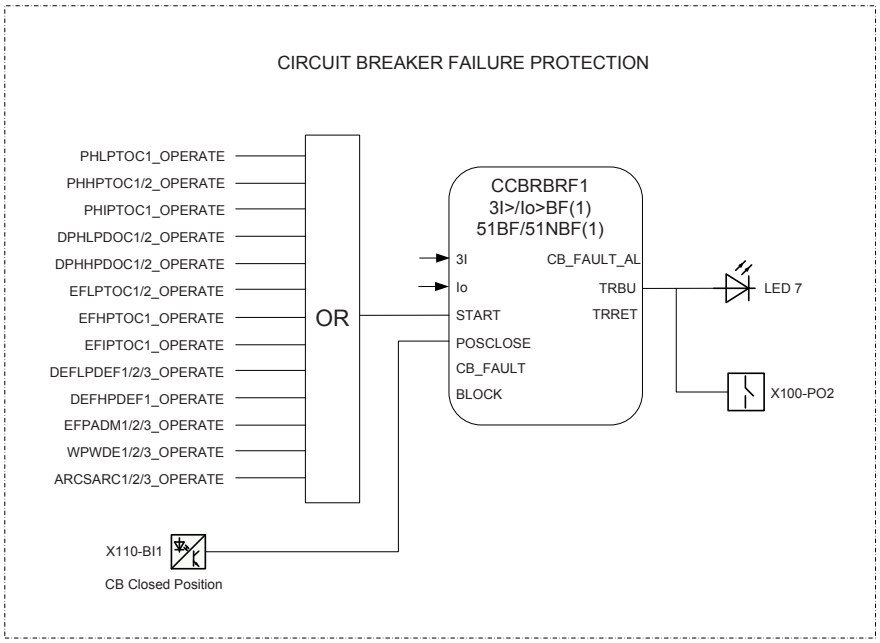

Figure 45: Circuit breaker failure protection

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

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

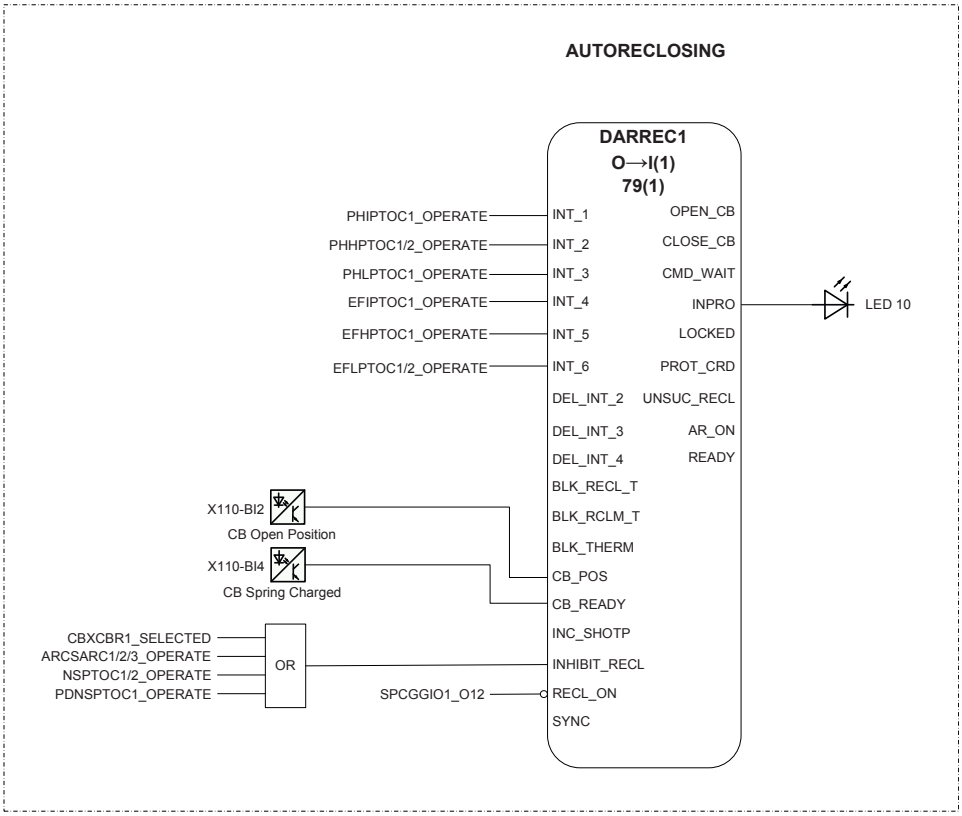

Figure 46: Autoreclosing

The autoreclosing function is configured to be initiated by operate signals from a number of protection stages through the INT_1...6. It is possible to create individual autoreclosing sequences for each input.

The autoreclosing function can be blocked with the INHIBIT_RECL input. By default, the operations of selected protection functions are connected to this input. A control command to the circuit breaker, either local or remote, also blocks the autoreclosing function via the CBXCBR1_SELECTED signal.

Autoreclosing function could be disabled via one push-button through SPCGGIO1_O12, which is connected to the RECL_ON input of the DARREC1.

The circuit breaker availability for the autoreclosing sequence is expressed with the CB_READY input in DARREC1. In the default configuration, this signal is connected to CB Spring Charged binary input (X110:6-7). As a result, the function is available only when CB spring is charged.

The autoreclosing sequence in progress indication INPRO is connected to the alarm LED 10.

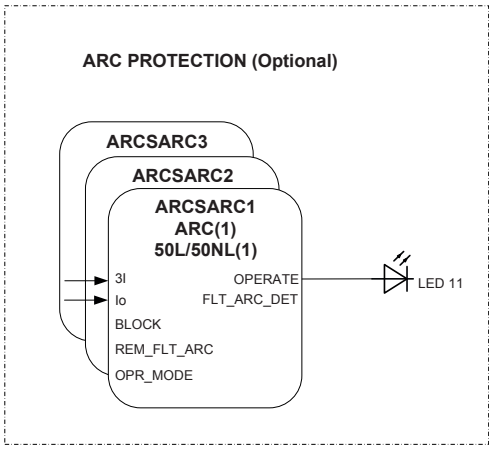

Figure 47: Arc protection

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

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

3.6.3.2 Functional diagrams for disturbance recorder and trip circuit supervision

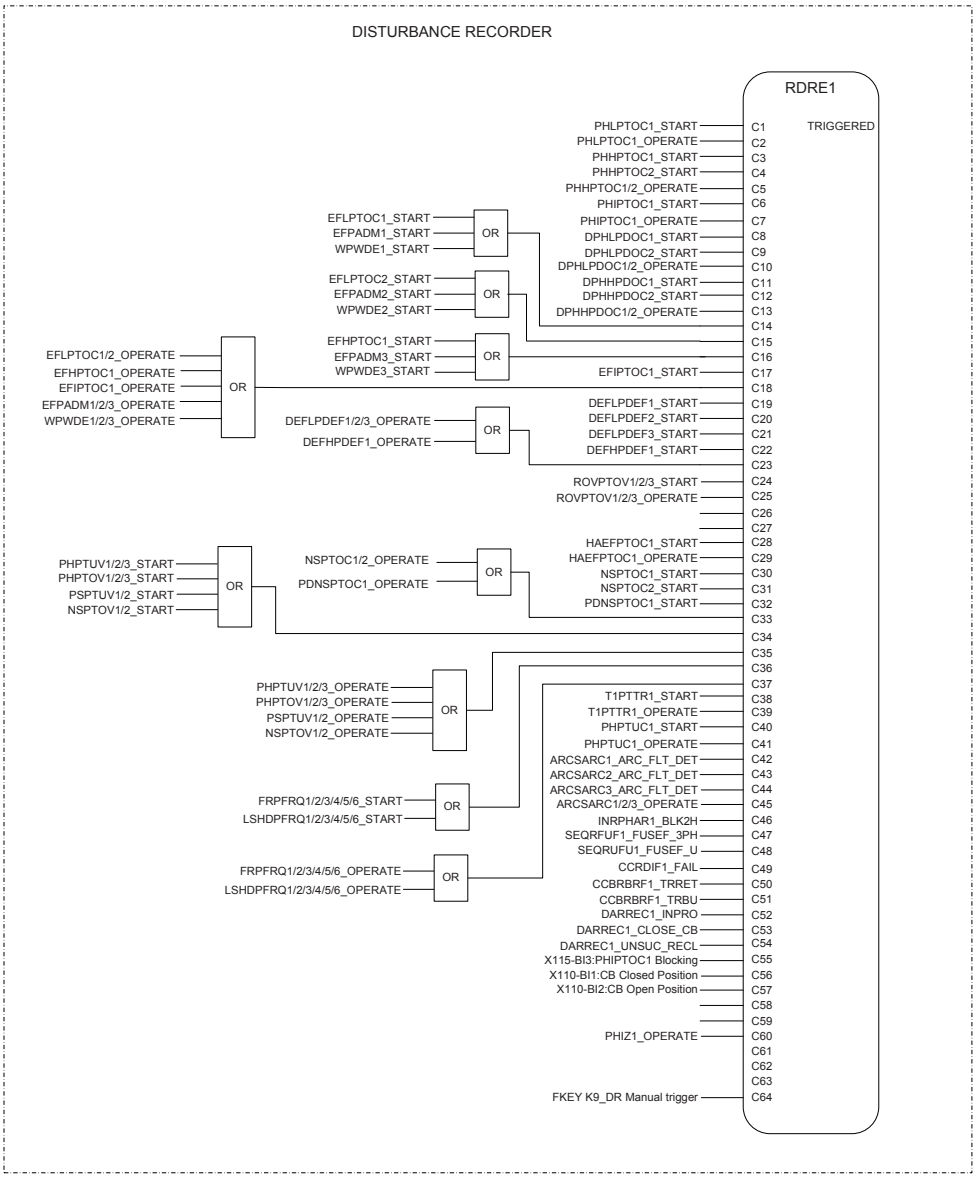

Figure 48: Disturbance recorder

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 five binary inputs totally from X110 and X115 are also connected.

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

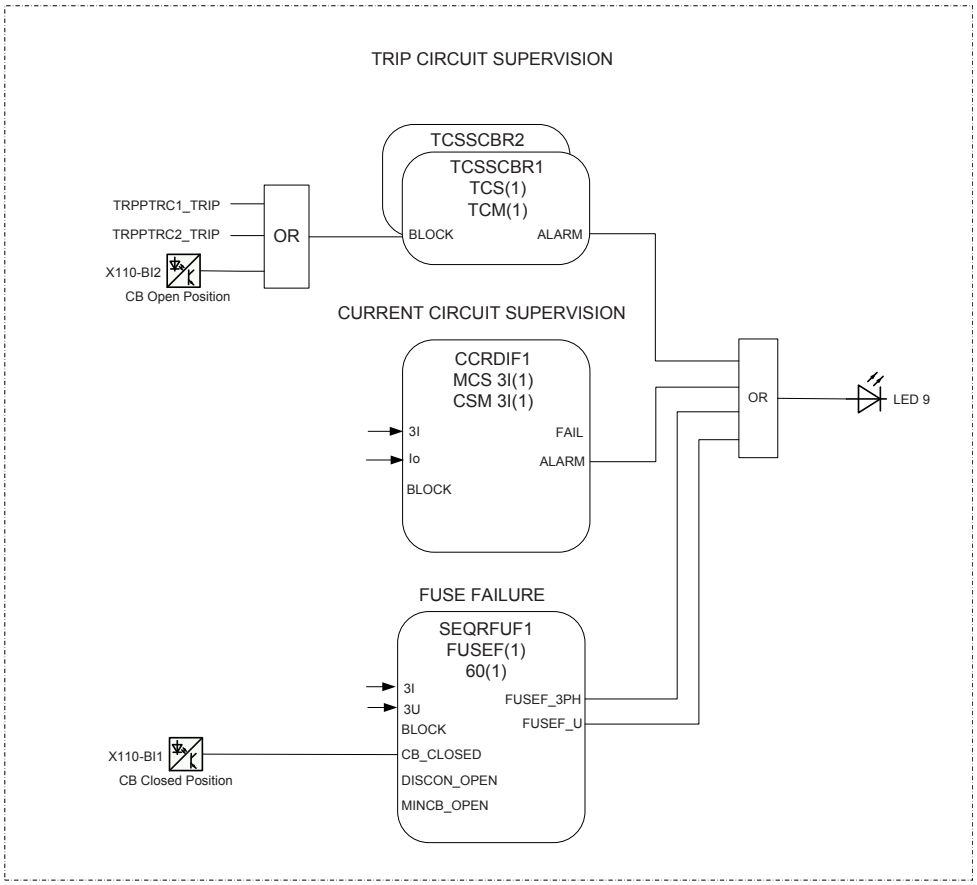

Figure 49: Circuit supervision

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 CCRDIF1. 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.

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. When a failure is detected, blocking signal is activated in voltage protection functions that are measuring calculated

sequence component voltages and undervoltage protection, and unnecessary operation can be avoided.

3.6.3.3 Functional diagrams for control and interlocking

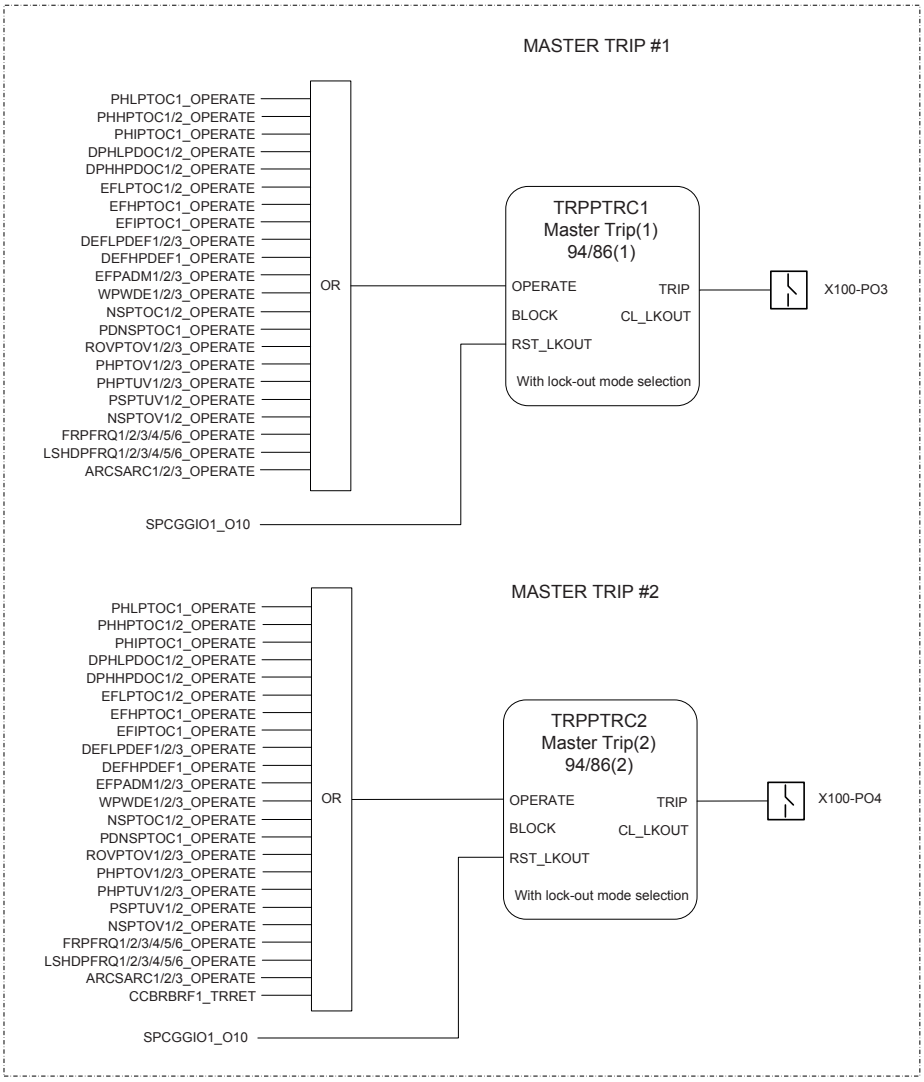

Figure 50: Master trip

The operating signals from the protections 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 2 provides 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 through `SPCGGIO1_O10`.

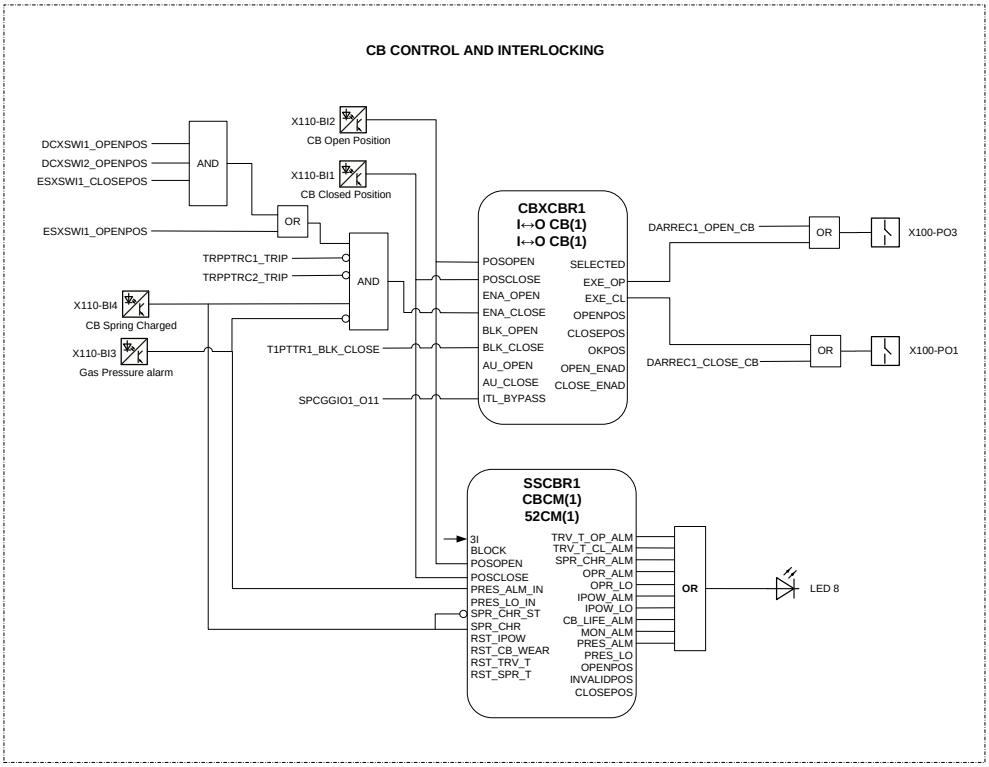

Figure 51: Circuit breaker control and interlocking

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

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

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

The circuit breaker closing is blocked when BLK_CLOSE input is activated. This input is activated when the BLK_CLOSE output of T1PTTR1 is active.

One push button can be used through SPCGGIO1_O11, which is connected to the ITL_BYPASS input of CBXCBR1 to ignore the status of the ENA_CLOSE input. However, the BLK_CLOSE input is 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 with PCM600, the function assumes that the breaker close commands are allowed continuously.

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

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

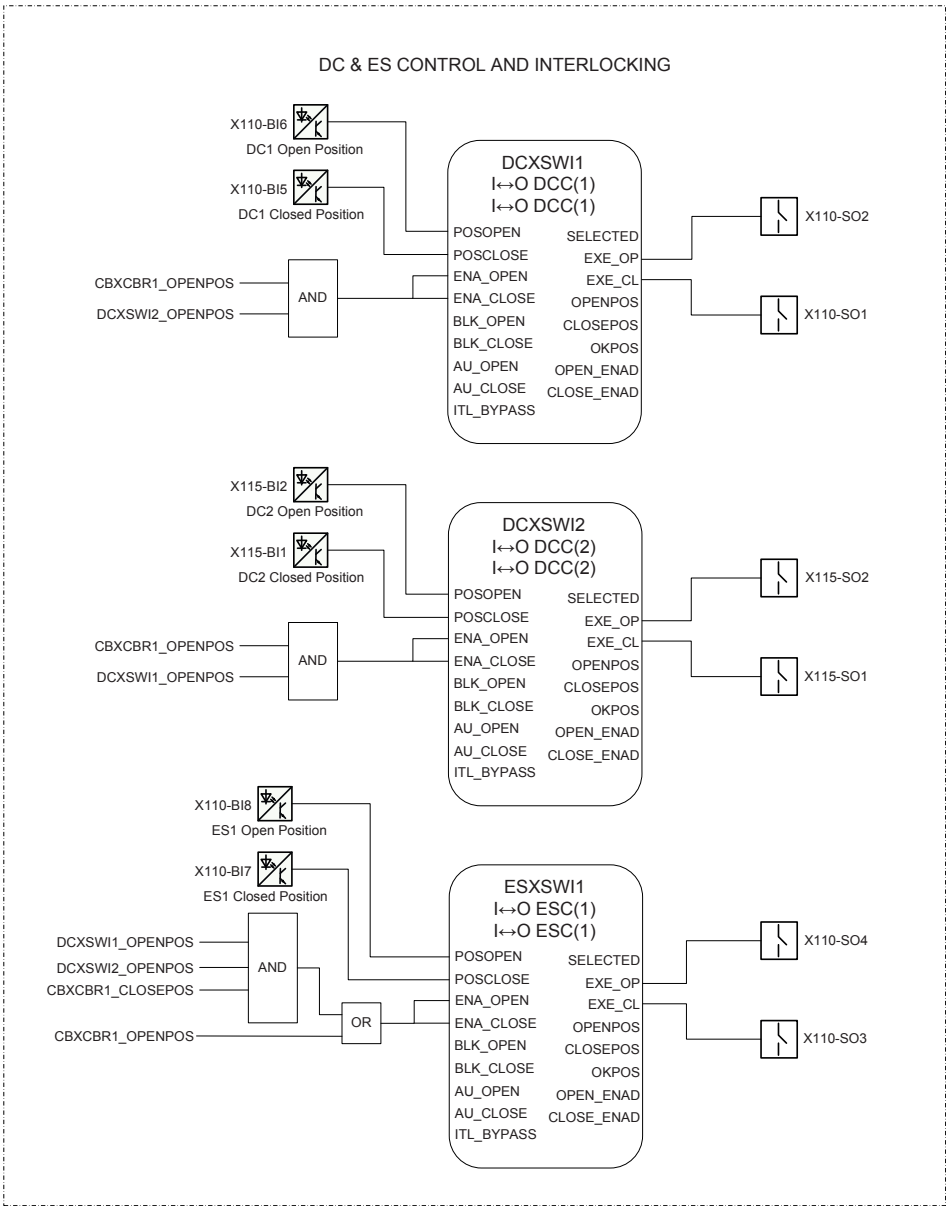

Figure 52: Disconnector and earthing-switch control and interlocking

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 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 done using PCM600.

The binary inputs 5 and 6 of the card X110 are used for busbar disconnector 1 (DCXSWI1) position indication. The binary inputs 1 and 2 of the card X115 are used for busbar disconnector 2 (DCXSWI2) position indication.

Table 31: Disconnector 1 position indicated by binary inputs

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

Table 32: Disconnector 2 position indicated by binary inputs

Primary device position	Input to be energized	
	Input 1 (X115:1-2)	Input 2 (X115:3-4)
Busbar disconnector 2 closed	•	
Busbar disconnector 2 open		•

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

Table 33: Earthing-switch position indicated by binary inputs

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

The control (opening or closing) of disconnector 1 and disconnector 2 is enabled only when both circuit breaker and the other disconnector is in open position.

The control (opening or closing) of earthing-switch is enabled under either of the two conditions.

- The circuit breaker is in open position.
- The circuit breaker is in closed position, while both disconnector 1 and disconnector 2 are in open position.

With this simplified default disconnector control logic, the busbar is transferred by opening the circuit breaker. In a normal double-busbar system, the busbar is transferred without a power supply break.

Cooperation is needed on the bus coupler bay to support live busbar transfer, so necessary information exchange between different bays and bus coupler bay is also required. The control logic for disconnector 1 and disconnector 2 mentioned earlier needs to be revised accordingly. The information exchange can be done either with binary inputs or through a GOOSE message.

The general rule for live busbar transfer is to have the two busbars interconnected, as shown in figure 53. The outgoing feeder has been connected to busbar I. Under

this condition, DC11 and CB1 are closed while DC12 is open. The busbar coupler bay apparatuses (DC21, DC22 and CB2) are also open.

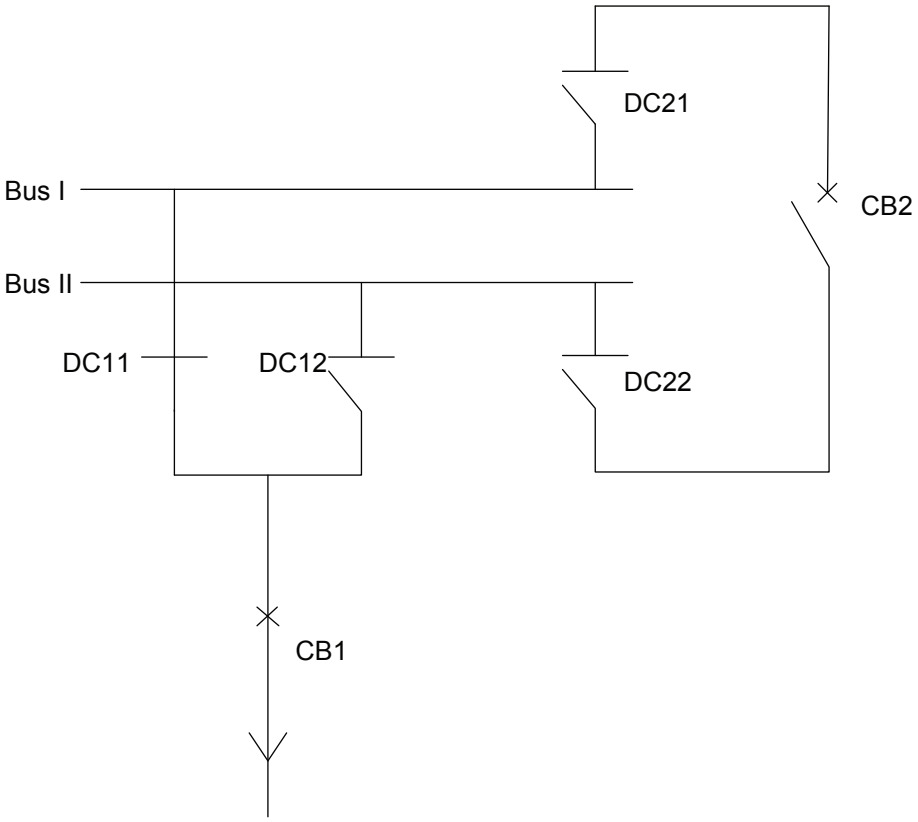

Figure 53: Disconnector control logic

There are four general steps to transfer the power supply from busbar I to busbar II.

1. DC21, DC2 and CB2 in the bus coupler bay have to be closed to have busbar I and busbar II connected.
2. DC12 has to be closed to have the feeder connected to busbar II.
3. DC11 has to opened to disconnect the feeder from busbar I.
4. CB2, DC21 and DC22 have to be opened to disconnect the two busbars. This transfers the load of the outgoing feeder to busbar II.

These four steps assure that there is no power supply interruption on the feeder. After step 1, the two busbars are connected to ensure that the operation on DC12 and DC11, in steps 2 and 3, is safe.

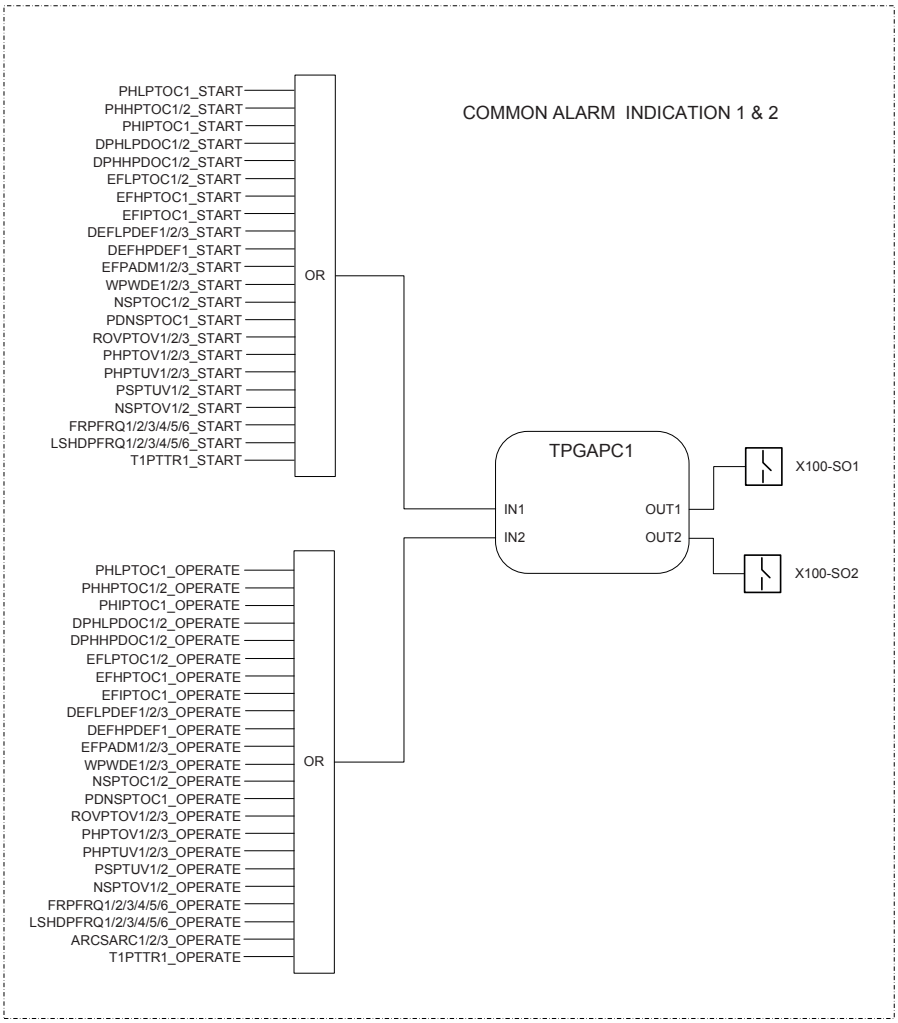

Figure 54: Common alarm indication

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

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

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

3.6.3.4 Functional diagrams for power quality measurements

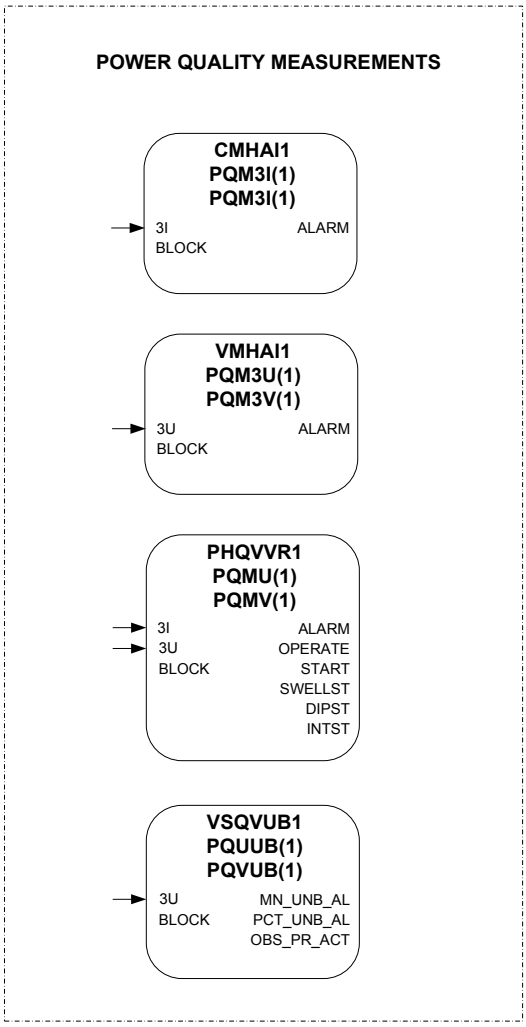

Figure 55: Power quality measurement function

The power quality function CMHAI1 is used to measure the harmonic contents of the phase current.

The power quality function VMHAI1 is used to measure the harmonic contents of the phase voltages.

The power quality function PHQVVR1 is used to measure the voltage variation, that is, sags and swells.

The voltage unbalance power quality function VSQVUB1 monitors the voltage unbalance conditions in power networks. It is used to monitor the commitment of power supply utility of providing a balanced voltage supply on a continuous basis. VSQVUB provides statistics which can be used to verify the compliance of the power quality.

The above functions are included in default configuration for demonstration purposes only, but not configured by default. The functions can be configured as needed.

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 34: Phase current inputs included in configuration A

Terminal	Description
X120-7,8	IL1
X120-9,10	IL2
X120-11,12	IL3

4.1.1.2 Residual current

Table 35: Residual current input included in configuration A

Terminal	Description
X120-13, 14	Io

Table 36: Residual current input included in configuration B

Terminal	Description
X130-1, 2	Io

4.1.1.3 Phase voltages

Table 37: Phase voltage input included in configuration A

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

Table 38: Reference voltage input for SECRSYN1 included in configuration A

Terminal	Description
X130-9,10	U_SYN

4.1.1.4 Residual voltage

Table 39: Additional residual voltage input included in configurations A

Terminal	Description
X130-17, 18	Uo

4.1.1.5 Sensor inputs

Table 40: Combi sensor inputs included in configuration B

Terminal	Description
X131-4,5 X131-7,8	IL1 U1
X132-4,5 X132-7,8	IL2 U2
X133-4,5 X133-7,8	IL3 U3

4.1.2 RTD/mA inputs

RTD/mA inputs of slot X105 are optional for configurations A and B.

Table 41: RTD/mA inputs

Terminal	Description
X105-5,6	mA1 (AI1), + mA1 (AI1), -
X105-7,8	mA2 (AI2), + mA2 (AI2), -
X105-9,10	RTD1 (AI3), + RTD1 (AI3), -
X105-11,12	RTD2 (AI4), + RTD2 (AI4), -
X105-13,14	RTD3 (AI5), + RTD3 (AI5), -
X105-15	Common[1)]
X105-16	Common[2)]
Table continues on next page	

Terminal	Description
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 42: 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 configurations A and B.

Table 43: 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, -
X110-10	BI6, +
X110-11	BI7, +

Table continues on next page

Terminal	Description
X110-12	BI7, -
X110-12	BI8, -
X110-13	BI8, +

Binary inputs of slot X115 are available with configurations A and B.

Table 44: Binary input terminals X115-1...13

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

Binary inputs of slot X120 are available with configuration A.

Table 45: Binary input terminals X120-1...6

Terminal	Description
X120-1	BI1, +
X120-2	BI1, -
X120-3	BI2, +
X120-2	BI2, -
X120-4	BI3, +
X120-2	BI3, -
X120-5	BI4, +
X120-6	BI4, -

Binary inputs of slot X130 are available with configuration A.

Table 46: Binary input terminals X130-1...8

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

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

Table 47: 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 48: 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,-
Table continues on next page	

Terminal	Description
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 49: 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 50: 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

Table continues on next page

Terminal	Description
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 51: 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 for configurations A and B.

Table 52: 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 contacts of slot X115 are available with configurations A and B.

Table 53: Output contacts X115-14...24

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

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

Table 54: 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 55: 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 56: 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
AI	Analog input
ANSI	American National Standards Institute
AR	Autoreclosing
ASCII	American Standard Code for Information Interchange
BI	Binary input
BI/O	Binary input/output
BO	Binary output
CB	Circuit breaker
CT	Current transformer
DANP	Doubly attached node with PRP
DC	1. Direct current 2. Double command
DNP3	A distributed network protocol originally developed by Westronic. The DNP3 Users Group has the ownership of the protocol and assumes responsibility for its evolution.
DPC	Double-point control
EMC	Electromagnetic compatibility
FIFO	First in, first out
GOOSE	Generic Object-Oriented Substation Event
HMI	Human-machine interface
HSR	High-availability seamless redundancy
I/O	Input/output
IEC	International Electrotechnical Commission
IEC 60870-5-103	1. Communication standard for protective equipment 2. A serial master/slave protocol for point-to-point communication

IEC 61850	International standard for substation communication and modeling
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IED	Intelligent electronic device
IET600	Integrated Engineering Toolbox in PCM600
IP address	A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned a unique IP address that specifies the location for the TCP/IP protocol.
LAN	Local area network
LC	Connector type for glass fibre cable
LCD	Liquid crystal display
LED	Light-emitting diode
LHMI	Local human-machine interface
Modbus	A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices.
Modbus TCP/IP	Modbus RTU protocol which uses TCP/IP and Ethernet to carry data between devices
PCM600	Protection and Control IED Manager
PO	Power output
PRP	Parallel redundancy protocol
REF620	Feeder protection and control IED
RIO600	Remote I/O unit
RJ-45	Galvanic connector type
RS-232	Serial interface standard
RS-485	Serial link according to EIA standard RS485
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

Contact us

ABB Oy
Medium Voltage Products,
Distribution Automation
P.O. Box 699
FI-65101 VAASA, Finland
Phone +358 10 22 11
Fax +358 10 22 41094

www.abb.com/substationautomation

Power and productivity
for a better world™