RELION® 620 SERIES

Transformer Protection and Control RET620

Application Manual

Document ID: 1MRS757659
Issued: 2019-06-19
Revision: D
Product version: 2.0 FP1

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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

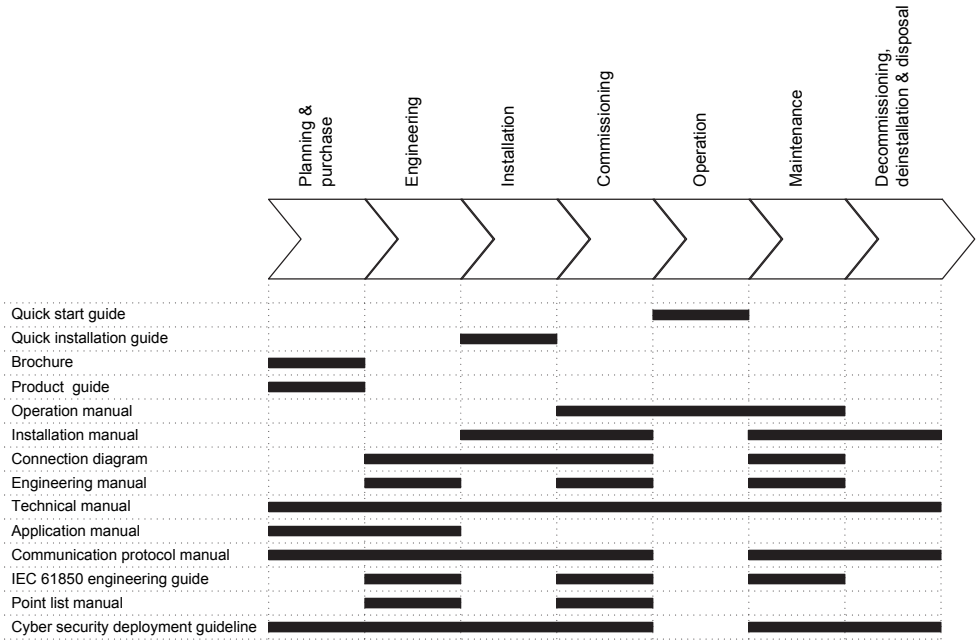


Figure 1: The intended use of documents during the product life cycle

Product series- and product-specific manuals can be downloaded from the ABB Web site http://www.abb.com/relion.

1.3.2 Document revision history

Document revision/date	Product version	History
A/2013-05-07	2.0	First release
B/2013-07-01	2.0	Content updated
C/2015-12-11	2.0 FP1	Content updated to correspond to the product version
D/2019-06-19	2.0 FP1	Content updated

Download the latest documents from the ABB Web site 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 are spelled out in the glossary. The glossary also contains definitions of important terms.
- Push button navigation in the LHMI menu structure is presented by using the push button icons.
  To navigate between the options, use and .
- Menu paths are presented in bold.
  Select **Main menu/Settings**.
- LHMI messages are shown in Courier font.
  To save the changes in nonvolatile memory, select `Yes` and press .
- Parameter names are shown in italics.
  The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks.
  The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font.
  When the function starts, the `START` output is set to TRUE.
- This document assumes that the parameter setting visibility is "Advanced".

1.4.3 Functions, codes and symbols

Table 1: Functions included in the relay

Function	IEC 61850	IEC 60617	ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I> (1)	51P-1 (1)
	PHLPTOC2	3I> (2)	51P-1 (2)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	3I>> (1)	51P-2 (1)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
	PHIPTOC2	3I>>> (2)	50P/51P (2)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	3I> -> (1)	67-1 (1)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Non-directional earth-fault protection, low stage	EFLPTOC1	Io> (1)	51N-1 (1)
	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	Io>> (1)	51N-2 (1)
	EFHPTOC2	Io>> (2)	51N-2 (2)
Directional earth-fault protection, low stage	DEFLPDEF1	Io> -> (1)	67N-1 (1)
	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)

Table continues on next page

Function	IEC 61850	IEC 60617	ANSI
Negative-sequence overcurrent protection	NSPTOC1	I2> (1)	46 (1)
	NSPTOC2	I2> (2)	46 (2)
Residual overvoltage protection	ROVPTOV1	Uo> (1)	59G (1)
	ROVPTOV2	Uo> (2)	59G (2)
	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
	PHPTUV3	3U< (3)	27 (3)
	PHPTUV4	3U< (4)	27 (4)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection	PSPTUV1	U1< (1)	47U+ (1)
	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O- (1)
	NSPTOV2	U2> (2)	47O- (2)
Frequency protection	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Overexcitation protection	OEPVPH1	U/f> (1)	24 (1)
	OEPVPH2	U/f> (2)	24 (2)
Three-phase thermal overload protection, two time constants	T2PTTR1	3Ith>T/G/C (1)	49T/G/C (1)
Loss of phase (undercurrent)	PHPTUC1	3I< (1)	37 (1)
	PHPTUC2	3I< (2)	37 (2)
Stabilized and instantaneous differential protection for two-winding transformers	TR2PTDF1	3dI>T (1)	87T (1)
Numerical stabilized low-impedance restricted earth-fault protection	LREFPNDF1	dIoLo> (1)	87NL (1)
	LREFPNDF2	dIoLo> (2)	87NL (2)
High-impedance based restricted earth-fault protection	HREFPDIF1	dIoHi> (1)	87NH (1)
	HREFPDIF2	dIoHi> (2)	87NH (2)
Circuit breaker failure protection	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
	CCBRBRF3	3I>/Io>BF (3)	51BF/51NBF (3)
Three-phase inrush detector	INRPHAR1	3I2f> (1)	68 (1)
Master trip	TRPPTRC1	Master Trip (1)	94/86 (1)
	TRPPTRC2	Master Trip (2)	94/86 (2)
	TRPPTRC3	Master Trip (3)	94/86 (3)
	TRPPTRC4	Master Trip (4)	94/86 (4)

Table continues on next page

Function	IEC 61850	IEC 60617	ANSI
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)
Load-shedding and restoration	LSHDPFRQ1	UFLS/R (1)	81LSH (1)
	LSHDPFRQ2	UFLS/R (2)	81LSH (2)
	LSHDPFRQ3	UFLS/R (3)	81LSH (3)
	LSHDPFRQ4	UFLS/R (4)	81LSH (4)
	LSHDPFRQ5	UFLS/R (5)	81LSH (5)
	LSHDPFRQ6	UFLS/R (6)	81LSH (6)
Multipurpose protection	MAPGAPC1	MAP (1)	MAP (1)
	MAPGAPC2	MAP (2)	MAP (2)
	MAPGAPC3	MAP (3)	MAP (3)
	MAPGAPC4	MAP (4)	MAP (4)
	MAPGAPC5	MAP (5)	MAP (5)
	MAPGAPC6	MAP (6)	MAP (6)
	MAPGAPC7	MAP (7)	MAP (7)
	MAPGAPC8	MAP (8)	MAP (8)
	MAPGAPC9	MAP (9)	MAP (9)
	MAPGAPC10	MAP (10)	MAP (10)
	MAPGAPC11	MAP (11)	MAP (11)
	MAPGAPC12	MAP (12)	MAP (12)
	MAPGAPC13	MAP (13)	MAP (13)
	MAPGAPC14	MAP (14)	MAP (14)
	MAPGAPC15	MAP (15)	MAP (15)
	MAPGAPC16	MAP (16)	MAP (16)
	MAPGAPC17	MAP (17)	MAP (17)
	MAPGAPC18	MAP (18)	MAP (18)
Automatic switch-onto-fault logic (SOF)	CVPSOF1	CVPSOF (1)	SOFT/21/50 (1)
Underpower protection	DUPPDPR1	P< (1)	32U (1)
	DUPPDPR2	P< (2)	32U (2)
Reverse power/directional overpower protection	DOPPDPR1	P>/Q> (1)	32R/32O (1)
	DOPPDPR2	P>/Q> (2)	32R/32O (2)
	DOPPDPR3	P>/Q> (3)	32R/32O (3)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
	CBXCBR3	I <-> O CB (3)	I <-> O CB (3)

Table continues on next page

Function	IEC 61850	IEC 60617	ANSI
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
	ESXSWI3	I <-> O ESC (3)	I <-> O ESC (3)
Disconnector position indication	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
	ESSXSWI3	I <-> O ES (3)	I <-> O ES (3)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)
Tap changer position indication	TPOSYLTC1	TPOSM (1)	84M (1)
Tap changer control with voltage regulator	OLATCC1	COLTC (1)	90V (1)
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
	SSCBR2	CBCM (2)	CBCM (2)
	SSCBR3	CBCM (3)	CBCM (3)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
	CCSPVC2	MCS 3I (2)	MCS 3I (2)
Advanced current circuit supervision for transformers	CTSRCTF1	MCS 3I,I2 (1)	MCS 3I,I2 (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Runtime counter for machines and devices	MDSOPT1	OPTS (1)	OPTM (1)
	MDSOPT2	OPTS (2)	OPTM (2)
Measurement			
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
	CMMXU2	3I (2)	3I (2)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
	CSMSQI2	I1, I2, I0 (B) (1)	I1, I2, I0 (B) (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
	RESCMMXU2	Io (2)	In (2)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)

Table continues on next page

Function	IEC 61850	IEC 60617	ANSI
Single-phase voltage measurement	VAMMXU2	U_A (2)	V_A (2)
	VAMMXU3	U_A (3)	V_A (3)
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)
Load profile record	LDPRLRC1	LOADPROF (1)	LOADPROF (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)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
	TPSGAPC2	TPS (2)	TPS (2)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
	TPMGAPC2	TPM (2)	TPM (2)
Pulse timer (8 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs)	TOFGAPC1	TOF (1)	TOF (1)
	TOFGAPC2	TOF (2)	TOF (2)
	TOFGAPC3	TOF (3)	TOF (3)
	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs)	TONGAPC1	TON (1)	TON (1)
	TONGAPC2	TON (2)	TON (2)
	TONGAPC3	TON (3)	TON (3)
	TONGAPC4	TON (4)	TON (4)
Set-reset (8 pcs)	SRGAPC1	SR (1)	SR (1)
	SRGAPC2	SR (2)	SR (2)
	SRGAPC3	SR (3)	SR (3)
	SRGAPC4	SR (4)	SR (4)
Move (8 pcs)	MVGAPC1	MV (1)	MV (1)
	MVGAPC2	MV (2)	MV (2)
	MVGAPC3	MV (3)	MV (3)
	MVGAPC4	MV (4)	MV (4)

Table continues on next page

Function	IEC 61850	IEC 60617	ANSI
Integer value move	MVI4GAPC1	MVI4 (1)	MVI4 (1)
	MVI4GAPC2	MVI4 (2)	MVI4 (2)
	MVI4GAPC3	MVI4 (3)	MVI4 (3)
	MVI4GAPC4	MVI4 (4)	MVI4 (4)
Analog value scaling	SCA4GAPC1	SCA4 (1)	SCA4 (1)
	SCA4GAPC2	SCA4 (2)	SCA4 (2)
	SCA4GAPC3	SCA4 (3)	SCA4 (3)
	SCA4GAPC4	SCA4 (4)	SCA4 (4)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
	SPCGAPC3	SPC (3)	SPC (3)
Remote generic control points	SPCRGAPC1	SPCR (1)	SPCR (1)
Local generic control points	SPCLGAPC1	SPCL (1)	SPCL (1)
Generic up-down counters	UDFCNT1	UDCNT (1)	UDCNT (1)
	UDFCNT2	UDCNT (2)	UDCNT (2)
	UDFCNT3	UDCNT (3)	UDCNT (3)
	UDFCNT4	UDCNT (4)	UDCNT (4)
	UDFCNT5	UDCNT (5)	UDCNT (5)
	UDFCNT6	UDCNT (6)	UDCNT (6)
	UDFCNT7	UDCNT (7)	UDCNT (7)
	UDFCNT8	UDCNT (8)	UDCNT (8)
	UDFCNT9	UDCNT (9)	UDCNT (9)
	UDFCNT10	UDCNT (10)	UDCNT (10)
	UDFCNT11	UDCNT (11)	UDCNT (11)
	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	FLTRFRC1	FAULTREC (1)	FAULTREC (1)
Sequence event recorder	SER1	SER (1)	SER (1)

Section 2 RET620 overview

2.1 Overview

RET620 is a dedicated two-winding power transformer management relay perfectly aligned for the protection, control, measurement and supervision of both power and step-up transformers, including power generator-transformer blocks, in utility and industrial power distribution systems. RET620 is a member of ABB's Relion® protection and control product family and its 620 series. The 620 series relays 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.

The 620 series relays support a range of communication protocols including IEC 61850 with Edition 2 support, process bus according to IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. Profibus DPV1 communication protocol is supported by using the protocol converter SPA-ZC 302.

2.1.1 Product version history

Product version	Product history
2.0	Product released
2.0 FP1	• IEC 61850 Edition 2 • Support for IEC 61850-9-2 LE • Synchronism and energizing check support with IEC 61850-9-2 LE • IEEE 1588 v2 time synchronization • Configuration migration support • Software closable Ethernet ports • Report summary via WHMI • Multifrequency admittance-based E/F • Fault locator • Profibus adapter support • Setting usability improvements

2.1.2 PCM600 and IED connectivity package version

- Protection and Control IED Manager PCM600 2.6 (Rollup 20150626) or later
- RET620 Connectivity Package Ver.2.1 or later
    - Parameter Setting
    - Signal Monitoring
    - Event Viewer
    - Disturbance Handling
    - Application Configuration

- Signal Matrix
- Graphical Display Editor
- Communication Management
- IED User Management
- IED Compare
- Firmware Update
- Fault Record Tool
- Load Record Profile
- Differential Characteristics Tool
- Lifecycle Traceability
- Configuration Wizard
- AR Sequence Visualizer
- Label Printing
- IEC 61850 Configuration
- IED Configuration Migration

Download connectivity packages from the ABB Web site http://www.abb.com/substationautomation or directly with Update Manager in PCM600.

2.2 Operation functionality

2.2.1 Optional functions

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

2.3 Physical hardware

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

Table 2: Plug-in unit and case

Main unit	Slot ID	Content	Module ID	Details
Plug-in unit	-	HMI	DIS0009	Large (10 rows, 20 characters)
	X100	Auxiliary power/BO module	PSM0003 or PSM0004	48...250 V DC/100...240 V AC or 24...60 V DC 2 normally-open PO contacts 1 change-over SO contact 1 normally-open SO contact 2 double-pole PO contacts with TCS 1 dedicated internal fault output contact
	X105	Empty		Not equipped if not needed, but alternatively may be equipped as indicated below
		Optional BI/O module	BIO0005	Optional for configuration A 8 binary inputs 4 SO contacts
			BIO0007	Optional for configuration A 8 binary inputs 3 High-speed SO contacts
		Optional RTD/mA module	RTD0003	Optional for configuration A 2 generic mA inputs 6 RTD sensor inputs
	X110	BI/O module	BIO0005	With configuration A 8 binary inputs 4 SO contacts
	X115	AI module	AIM0004	With configuration A 3 phase current inputs (1/5A) 1 residual current input (1/5A) 3 phase voltagt inputs (1/5A)
	X120	AI module	AIM0004	With configuration A 3 phase current Inputs (1/5A) 1 residual current input (1/5A) 3 phase voltage inputs (1/5A)
Case	X130	RTD/mA module	RTD0002	With configuration A 1 generic mA input 2 RTD sensor inputs 3 SO contacts
	X000	Optional communication module		See the technical manual for details about the different types of communication modules

Rated values of the current and voltage inputs are basic setting parameters of the protection relay. The binary input thresholds are selectable within the range 16…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: Input/output overview

Default conf.	Order code digit		Analog channels		Binary channels			
	5-6	7-8	CT	VT	BI	BO	RTD	mA
A	AA	AA	8	6	16	4 PO + 13 SO	2	1
		AB			8	4 PO + 9 SO	8	3
		AC			16	4 PO + 9 SO + 3 HSO	2	1
		NN			8	4 PO + 9 SO	2	1

2.4 Local HMI

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

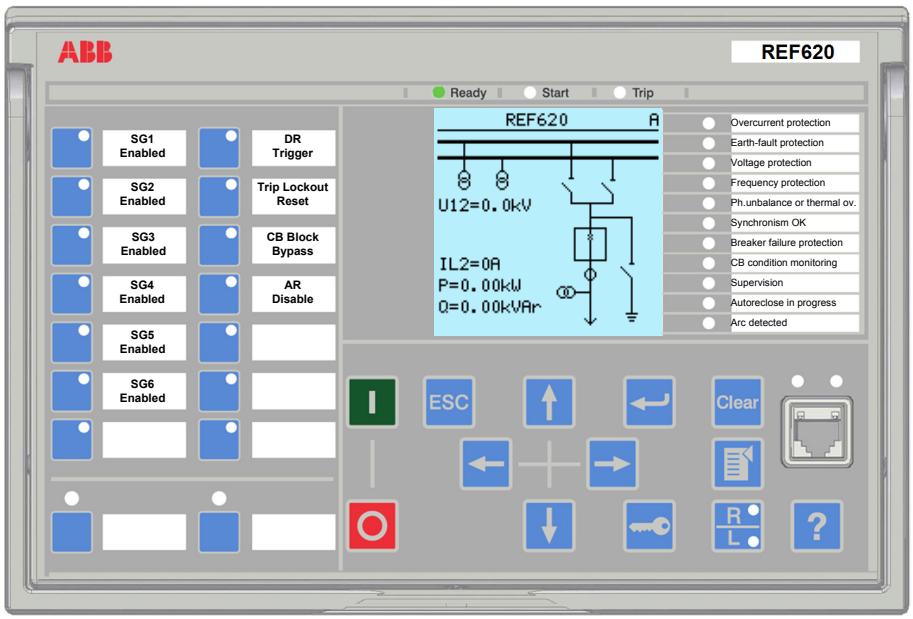


Figure 2: Example of the LHMI

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 (6 × 12 pixels)	10	20
Large, variable width (13 × 14 pixels)	7	8 or more

1) Depending on the selected language

The display view is divided into four basic areas.

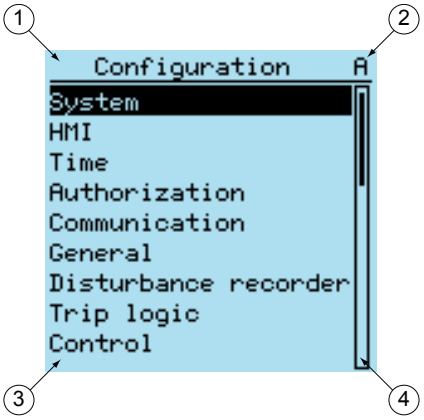


Figure 3: Display layout

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.

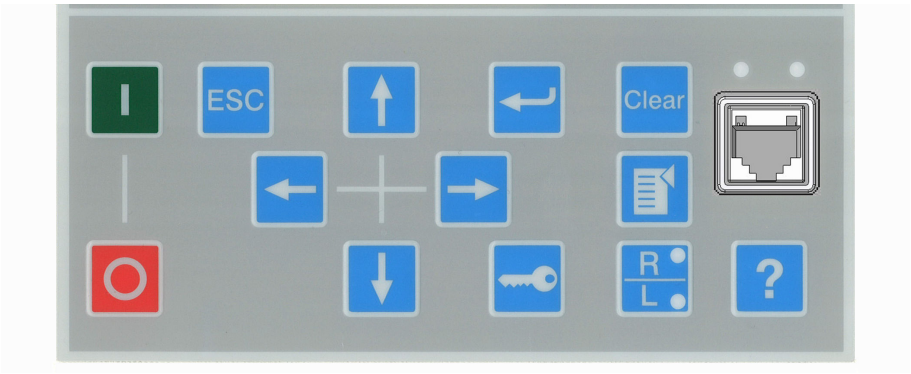


Figure 4: LHMI keypad with object control, navigation and command push buttons and RJ-45 communication port

2.4.3.1 Programmable push buttons with LEDs

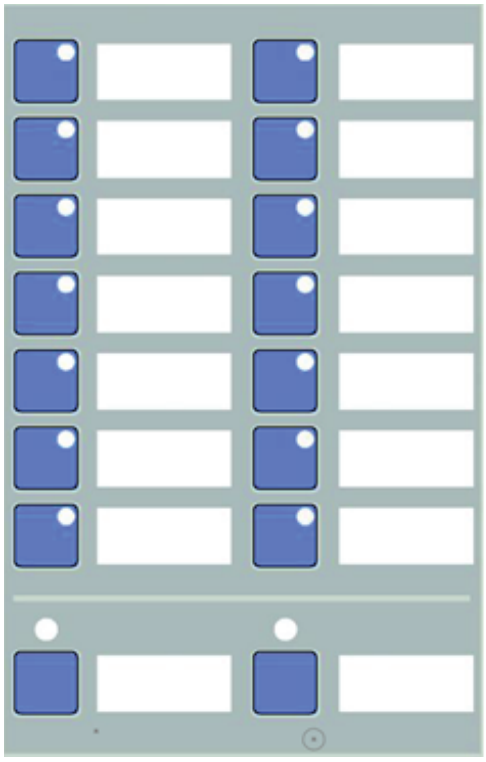


Figure 5: Programmable push buttons with LEDs

The LHMI keypad on the left side of the protection relay 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 secure access to the protection relay via a Web browser. When the *Secure Communication* parameter in the protection relay is activated, the Web server is forced to take a secured (HTTPS) connection to WHMI using TLS encryption.The WHMI is verified with Internet Explorer 8.0, 9.0, 10.0 and 11.0.

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
- Fault records
- Load profile record
- Phasor diagram
- Single-line diagram
- Importing/Exporting parameters
- Report summary

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

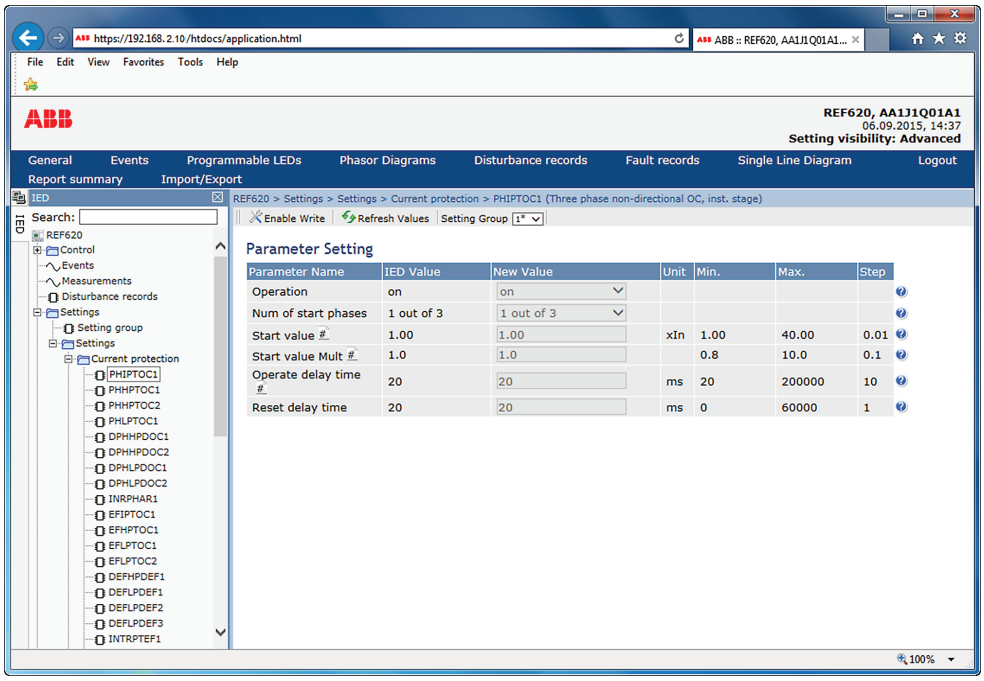


Figure 6: Example view of the WHMI

The WHMI can be accessed locally and remotely.

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

2.6 Authorization

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

The default passwords in the protection relay delivered from the factory can be changed with Administrator user rights.

If the relay-specific Administrator password is forgotten, ABB can provide a one-time reliable key to access the protection relay. For support, 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 protection relay 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 protection relay offers a large set of event-logging functions. Critical system and protection relay 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 system and security-related events and changes in the protection relay. Both audit trail events and process related events can be examined and analyzed in a consistent method with the help of Event List in LHMI and WHMI and Event Viewer in PCM600.

The protection relay stores 2048 audit trail 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. Nonvolatile memory is based on a memory type which does not need battery backup nor regular component change to maintain the memory storage.

Audit trail events related to user authorization (login, logout, violation remote and violation local) are defined according to the selected set of requirements from IEEE 1686. The logging is based on predefined user names or user categories. The user audit trail events are accessible with IEC 61850-8-1, PCM600, LHMI and WHMI.

Table 6: Audit trail events

Audit trail event	Description
Configuration change	Configuration files changed
Firmware change	Firmware changed
Firmware change fail	Firmware change failed
Setting group remote	User changed setting group remotely
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
Reset trips	Reset latched trips (TRPPTRC*)
Setting commit	Settings have been changed
Time change	Time changed directly by the user. Note that this is not used when the protection relay is synchronised properly by the appropriate protocol (SNTP, IRIG-B, IEEE 1588 v2).
View audit log	Administrator accessed audit trail
Login	Successful login from IEC 61850-8-1 (MMS), WHMI, FTP or LHMI.
Logout	Successful logout from IEC 61850-8-1 (MMS), WHMI, FTP or LHMI.
Password change	Password changed
Firmware reset	Reset issued by user or tool
Audit overflow	Too many audit events in the time period
Violation remote	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI, FTP or LHMI.
Violation local	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI, FTP or LHMI.

PCM600 Event Viewer can be used to view the audit trail events and process related events. Audit trail events are visible through dedicated Security events view. Since only the administrator has the right to read audit trail, authorization must be used in PCM600. The audit trail cannot be reset, but PCM600 Event Viewer can filter data. Audit trail events can be configured to be visible also in LHMI/WHMI Event list together with process related events.

To expose the audit trail events through Event list, define the *Authority logging* level parameter via **Configuration/ Authorization/Security**. This exposes audit trail events to all users.

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		•	•	•	•	•
Firmware change fail		•	•	•	•	•
Setting group remote			•	•	•	•
Setting group local			•	•	•	•
Control remote				•	•	•
Control local				•	•	•
Test on				•	•	•
Test off				•	•	•
Reset trips				•	•	•
Setting commit					•	•
Time change						•
View audit log						•
Login						•
Logout						•
Password change						•
Firmware reset						•
Violation local						•
Violation remote						•

2.7 Communication

The protection relay supports a range of communication protocols including IEC 61850, IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. Profibus DPV1 communication protocol is supported by using the protocol converter SPA-ZC 302. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the protection relays, is only enabled by the IEC 61850 communication protocol.

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 IEC 60255-24 standard COMTRADE file format. The protection relay can send and receive binary signals from other devices (so-called horizontal communication) using the IEC 61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. Furthermore, the protection relay supports sending and receiving of analog values using GOOSE messaging. The protection relay meets the GOOSE

performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard.

The protection relay 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 protection relay can be connected to Ethernet-based communication systems via the RJ-45 connector (100Base-TX) or the fiber-optic LC connector (100Base-FX).

2.7.1 Self-healing Ethernet ring

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

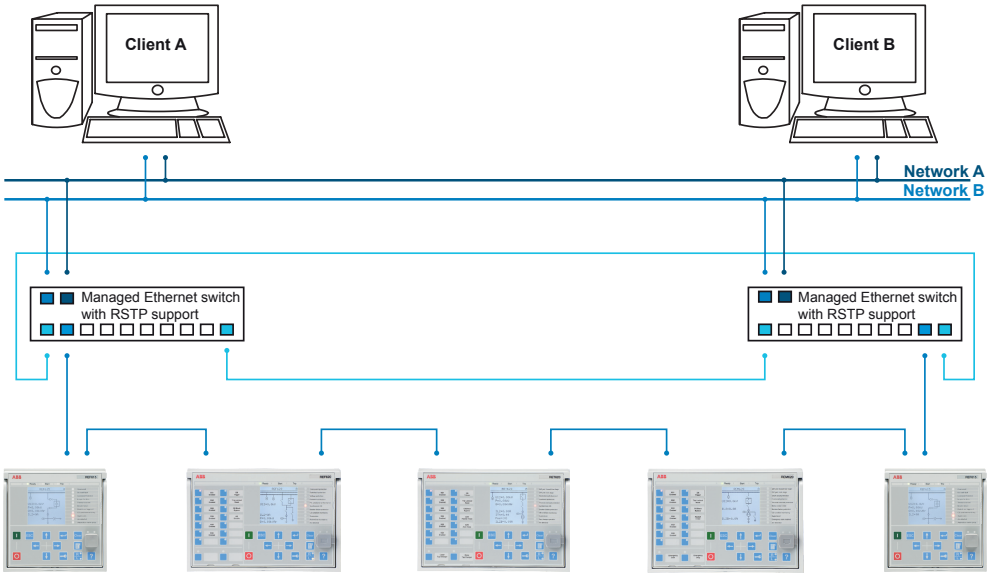


Figure 7: Self-healing Ethernet ring solution

The Ethernet ring solution supports the connection of up to 30 protection relays. If more than 30 protection relays are to be connected, it is recommended that the network is split into several rings with no more than 30 protection relays per ring. Each protection relay has a 50-µs store-and-forward delay, and to fulfil the performance requirements for fast horizontal communication, the ring size is limited to 30 protection relays.

2.7.2 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 62439-3:2012 standard: parallel redundancy protocol PRP and high-availability seamless redundancy HSR protocol. Both 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. The HSR/PRP option is available for all 620 series protection relays.

IEC 62439-3:2012 cancels and replaces the first edition published in 2010. These standard versions are also referred to as IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2. The protection relay supports IEC 62439-3:2012 and it is not compatible with IEC 62439-3:2010.

PRP

Each PRP node, called a double attached node with PRP (DAN), 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 single attached nodes (SANs), are either attached to one network only (and can therefore communicate only with DANs and SANs attached to the same network), or are attached through a redundancy box, a device that behaves like a DAN.

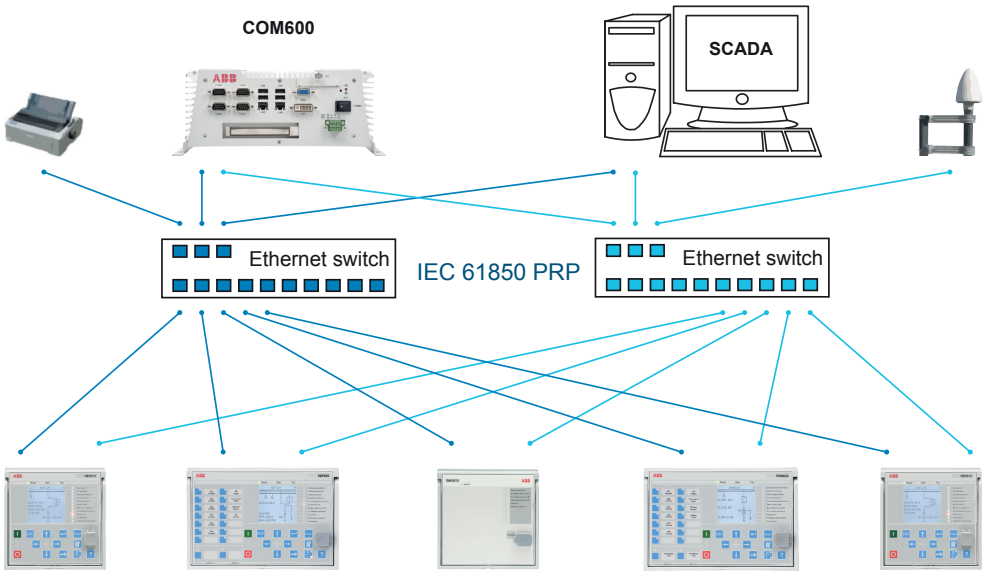


Figure 8: PRP solution

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 different alternative ways to connect a laptop or a workstation as SAN to a PRP network.

- Via an external redundancy box (RedBox) or a switch capable of connecting to PRP and normal networks
- By connecting the node directly to LAN A or LAN B as SAN
- By connecting the node to the protection relay's interlink port

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, DAN, 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 protection relay with HSR support can be used as a redundancy box.

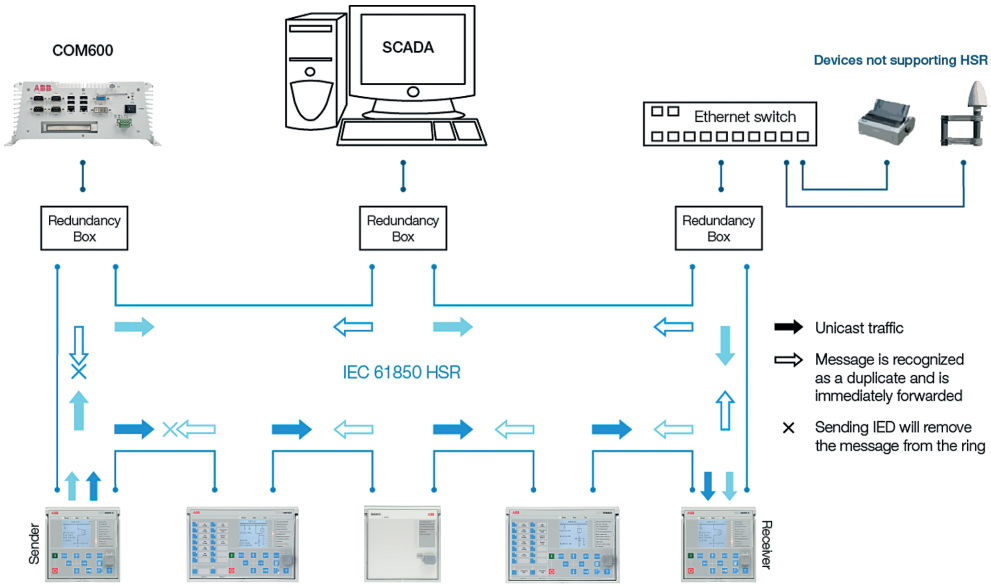


Figure 9: HSR solution

2.7.3 Process bus

Process bus IEC 61850-9-2 defines the transmission of Sampled Measured Values within the substation automation system. International Users Group created a guideline IEC 61850-9-2 LE that defines an application profile of IEC 61850-9-2 to facilitate implementation and enable interoperability. Process bus is used for distributing process data from the primary circuit to all process bus compatible devices in the local network in a real-time manner. The data can then be processed by any protection relay to perform different protection, automation and control functions.

UniGear Digital switchgear concept relies on the process bus together with current and voltage sensors. The process bus enables several advantages for the UniGear Digital like simplicity with reduced wiring, flexibility with data availability to all devices, improved diagnostics and longer maintenance cycles.

With process bus the galvanic interpanel wiring for sharing busbar voltage value can be replaced with Ethernet communication. Transmitting measurement samples over process bus brings also higher error detection because the signal transmission is automatically supervised. Additional contribution to the higher availability is the possibility to use redundant Ethernet network for transmitting SMV signals.

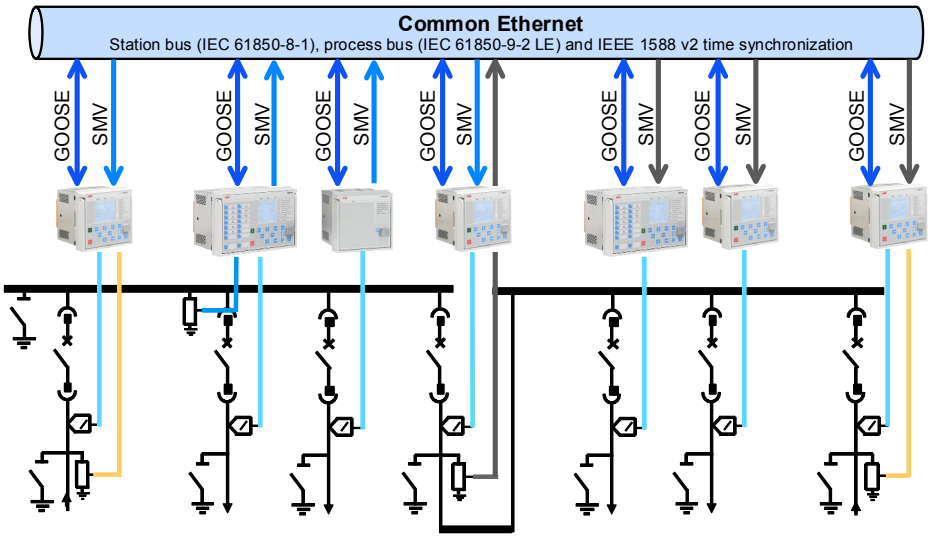


Figure 10: Process bus application of voltage sharing and synchrocheck

The 620 series supports IEC 61850 process bus with sampled values of analog currents and voltages. The measured values are transferred as sampled values using the IEC 61850-9-2 LE protocol which uses the same physical Ethernet network as the IEC 61850-8-1 station bus. The intended application for sampled values is sharing the measured voltages from one 620 series protection relay to other devices with phase voltage based functions and 9-2 support.

The 620 series protection relays with process bus based applications use IEEE 1588 v2 Precision Time Protocol (PTP) according to IEEE C37.238-2011 Power Profile for high accuracy time synchronization. With IEEE 1588 v2, the cabling infrastructure requirement is reduced by allowing time synchronization information to be transported over the same Ethernet network as the data communications.

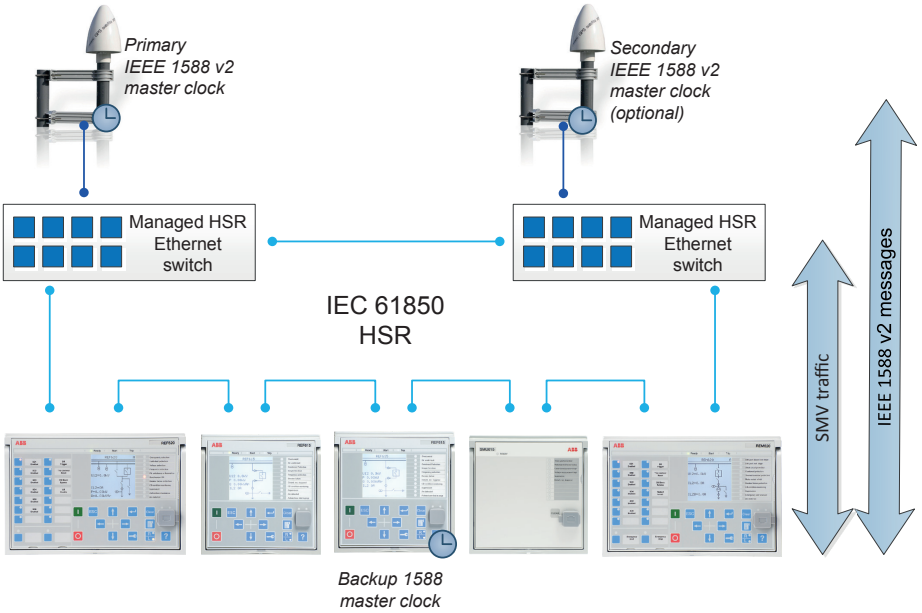


Figure 11: Example network topology with process bus, redundancy and IEEE 1588 v2 time synchronization

The process bus option is available for all 620 series protection relays equipped with phase voltage inputs. Another requirement is a communication card with IEEE 1588 v2 support (COM0031...COM0034 or COM0037). See the IEC 61850 engineering guide for detailed system requirements and configuration details.

2.7.4 Secure communication

The protection relay supports secure communication for WHMI and file transfer protocol. If the *Secure Communication* parameter is activated, protocols require TLS based encryption method support from the clients. In this case WHMI must be connected from a Web browser using the HTTPS protocol and in case of file transfer the client must use FTPS.

Section 3 RET620 default configurations

3.1 Default configurations

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

RET620 is available with one default configuration. The default signal configuration can be altered by means of the graphical signal matrix or the graphical application functionality of the Protection and Control IED Manager PCM600. Furthermore, the application configuration functionality of PCM600 supports the creation of multi-layer logic functions utilizing various logical elements including timers and flip-flops. By combining protection functions with logic function blocks the relay configuration can be adapted to user specific application requirements.

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

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

Table 8: Supported functions

Function	IEC 61850	A (CTs/VTs)
Protection		
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	1 HV
	PHLPTOC2	1 LV
Table continues on next page		

Function	IEC 61850	A (CTs/VTs)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	1 HV
	PHHPTOC2	1 LV
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	1 HV
	PHIPTOC2	1 LV
Three-phase directional overcurrent protection, low stage	DPHLPDOC	1 HV
Three-phase directional overcurrent protection, high stage	DPHHPDOC	1 HV
Non-directional earth-fault protection, low stage	EFLPTOC1	1 HV1)
	EFLPTOC2	1 LV1)
Non-directional earth-fault protection, high stage	EFHPTOC1	1 HV1)
	EFHPTOC2	1 LV1)
Directional earth-fault protection, low stage	DEFLPDEF	2 HV1)
Directional earth-fault protection, high stage	DEFHPDEF	1 HV1)
Negative-sequence overcurrent protection	NSPTOC1	1 HV
	NSPTOC2	1 LV
Residual overvoltage protection	ROVPTOV	3 HV
Three-phase undervoltage protection	PHPTUV	4 HV
Three-phase overvoltage protection	PHPTOV	3 HV
Positive-sequence undervoltage protection	PSPTUV	2 HV
Negative-sequence overvoltage protection	NSPTOV	2 HV
Frequency protection	FRPFRQ	3 HV
Overexcitation protection	OEPVPH	2 HV
Three-phase thermal overload protection, two time constants	T2PTTR	1 HV
Loss of phase (undercurrent)	PHPTUC1	1 HV
	PHPTUC2	1 LV
Stabilized and instantaneous differential protection for two-winding transformers	TR2PTDF	1
Numerical stabilized low-impedance restricted earth-fault protection	LREFPNDF1	1 HV
	LREFPNDF2	1 LV
High-impedance based restricted earth-fault protection	HREFPDIF1	1 HV
	HREFPDIF2	1 LV
Circuit breaker failure protection	CCBRBRF1	1 HV
	CCBRBRF2	1 LV
	CCBRBRF3	1 HV
Three-phase inrush detector	INRPHAR	1 HV
Master trip	TRPPTRC	4
Arc protection	ARCSARC	(3)2)
Load-shedding and restoration	LSHDPFRQ	6 HV

Table continues on next page

Function	IEC 61850	A (CTs/VTs)
Multipurpose protection	MAPGAPC	18
Automatic switch-onto-fault logic (SOF)	CVPSOF	1 HV
Underpower protection	DUPPDPR	2 HV
Reverse power/directional overpower protection	DOPPDPR	3 HV
Control		
Circuit-breaker control	CBXCBR1	1 HV
	CBXCBR2	1 LV
	CBXCBR3	1 HV
Disconnector control	DCXSWI1	1 HV
	DCXSWI2	1 HV
	DCXSWI3	1 LV
	DCXSWI4	1 LV
Earthing switch control	ESXSWI1	1 HV
	ESXSWI2	1 LV
	ESXSWI3	1 HV
Disconnector position indication	DCSXSWI1	1 HV
	DCSXSWI2	1 HV
	DCSXSWI3	1 LV
	DCSXSWI4	1 LV
Earthing switch indication	ESSXSWI1	1 HV
	ESSXSWI2	1 LV
	ESSXSWI3	1 HV
Synchronism and energizing check	SECRSYN	1 HV
Tap changer position indication	TPOSYLTC	1
Tap changer control with voltage regulator	OLATCC	(1) LV
Condition monitoring and supervision		
Circuit-breaker condition monitoring	SSCBR1	1 HV
	SSCBR2	1 LV
	SSCBR3	1 HV
Trip circuit supervision	TCSSCBR1	1 HV
	TCSSCBR2	1 LV
Current circuit supervision	CCSPVC1	1 HV
	CCSPVC2	1 LV
Advanced current circuit supervision for transformers	CTSRCTF	1
Fuse failure supervision	SEQSPVC	1 HV
Runtime counter for machines and devices	MDSOPT	2
Measurement		

Table continues on next page

Function	IEC 61850	A (CTs/VTs)
Three-phase current measurement	CMMXU1	1 HV
	CMMXU2	1 LV
Sequence current measurement	CSMSQI1	1 HV
	CSMSQI2	1 LV
Residual current measurement	RESCMMXU1	1 HV
	RESCMMXU2	1 LV
Three-phase voltage measurement	VMMXU	1 HV
Single-phase voltage measurement	VAMMXU2	1 LV
	VAMMXU3	1 HV
Residual voltage measurement	RESVMMXU	1 HV
Sequence voltage measurement	VSMSQI	1 HV
Three-phase power and energy measurement	PEMMXU	1 HV
Load profile record	LDPRLRC	1 HV
Frequency measurement	FMMXU	1 HV
Power quality		
Current total demand distortion	CMHAI	1 HV
Voltage total harmonic distortion	VMHAI	1 HV
Voltage variation	PHQVVR	1 HV
Voltage unbalance	VSQVUB	1 HV
Other		
Minimum pulse timer (2 pcs)	TPGAPC	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	2
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	2
Pulse timer (8 pcs)	PTGAPC	2
Time delay off (8 pcs)	TOFGAPC	4
Time delay on (8 pcs)	TONGAPC	4
Set-reset (8 pcs)	SRGAPC	4
Move (8 pcs)	MVGAPC	4
Integer value move	MVI4GAPC	4
Analog value scaling	SCA4GAPC	4
Generic control point (16 pcs)	SPCGAPC	3
Remote generic control points	SPCRGAPC	1
Local generic control points	SPCLGAPC	1
Generic up-down counters	UDFCNT	12
Programmable buttons (16 buttons)	FKEYGGIO	1
Logging functions		
Disturbance recorder	RDRE	1

Table continues on next page

Function	IEC 61850	A (CTs/VTs)
Fault recorder	FLTRFRC	1
Sequence event recorder	SER	1
1, 2, ... = Number of included instances. The instances of a protection function represent the number of identical protection function blocks available in the standard configuration. () = optional HV = The function block is to be used on the high-voltage side in the application. LV = The function block is to be used on the low-voltage side in the application.		

1) Function uses calculated value when the high-impedance based restricted earth-fault protection is used
2) Io is calculated from the measured phase currents

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 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 protection relay.

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 protection relay's default configuration.

The suitability of the protection relay'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 protection relay has dynamic programmable LEDs. The presentation of the LEDs in this manual differs from the actual function blocks in the configurations.

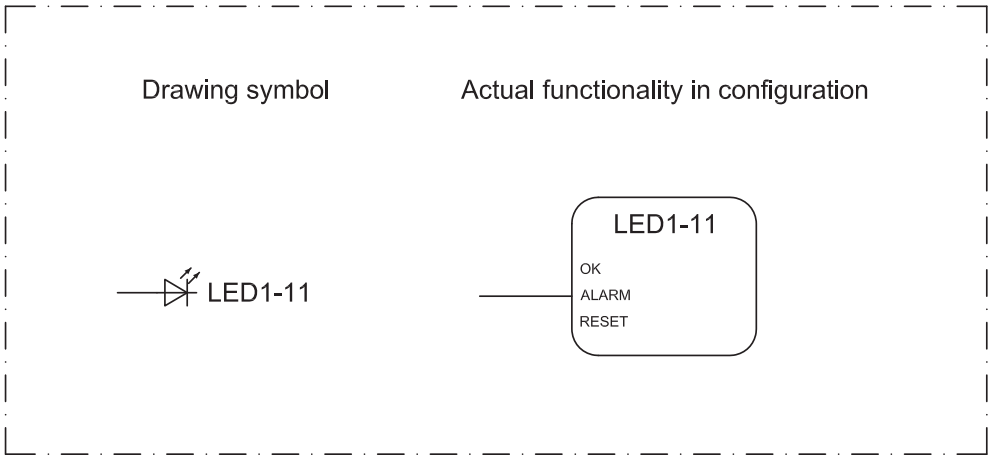
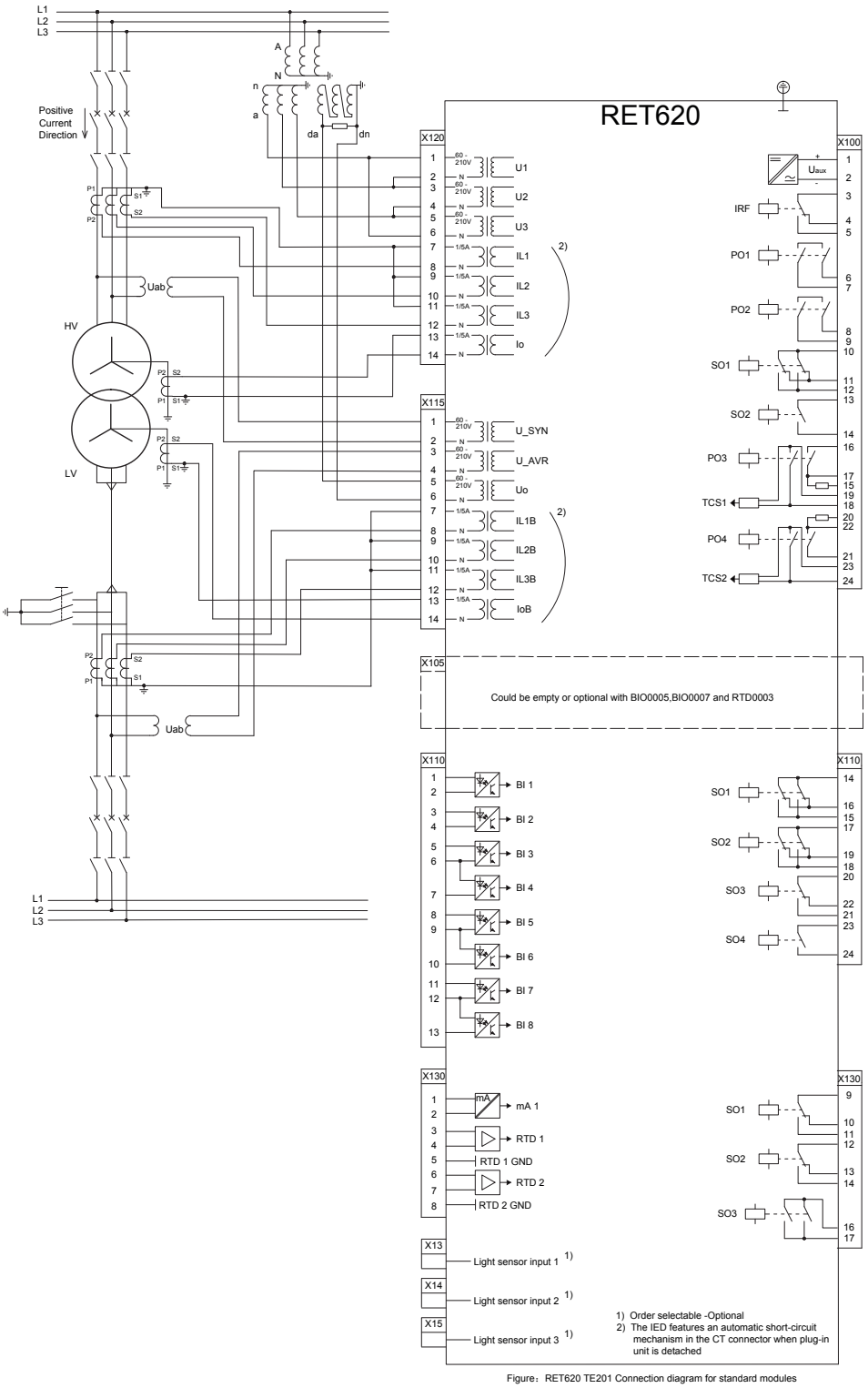


Figure 12: Drawing symbol used in the manual and the default connection of the LED function blocks in the configurations

3.2 Connection diagrams



Figure：RET620 TE201 Connection diagram for standard modules

Figure 13: Connection for the A configuration

3.3 Optional modules

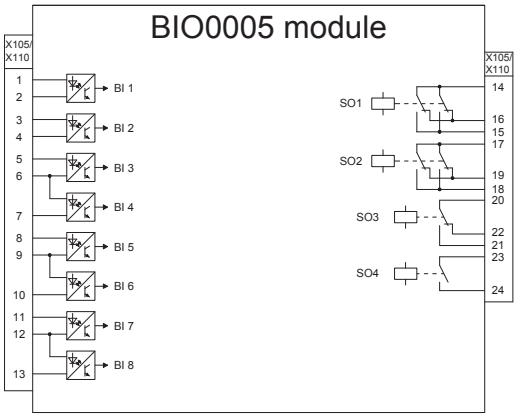


Figure 14: Optional BIO0005 module (slot X105)

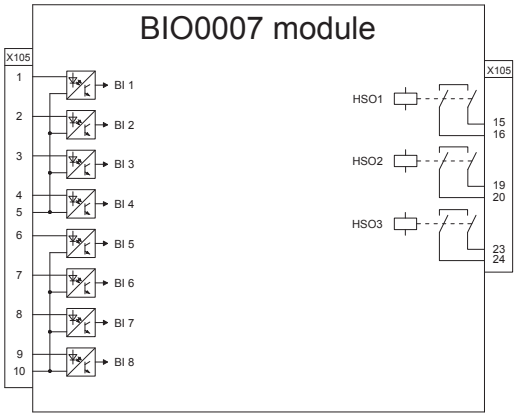


Figure 15: Optional BIO0007 module for fast outputs (slot X105)

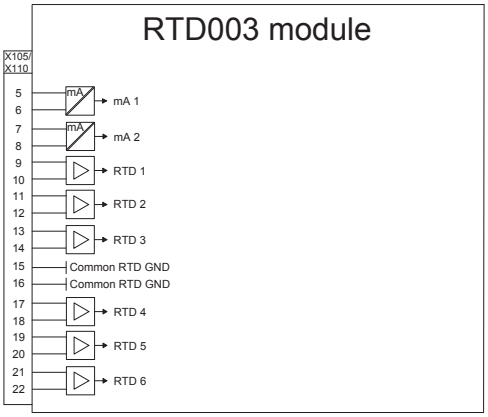


Figure 16: Optional RTD0003 module (slot X105)

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 tool 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 receiving 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 Application Configuration.

3.5 Default configuration A

3.5.1 Applications

The default configuration is mainly intended for the protection of two-winding power transformers. The default configuration includes three-phase transformer differential protection for two-winding transformers, numerical restricted earth-fault protection for both the HV side and the LV side. Additionally, voltage regulation via automatic control of an on-line tap changer is included.

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

3.5.2 Functions

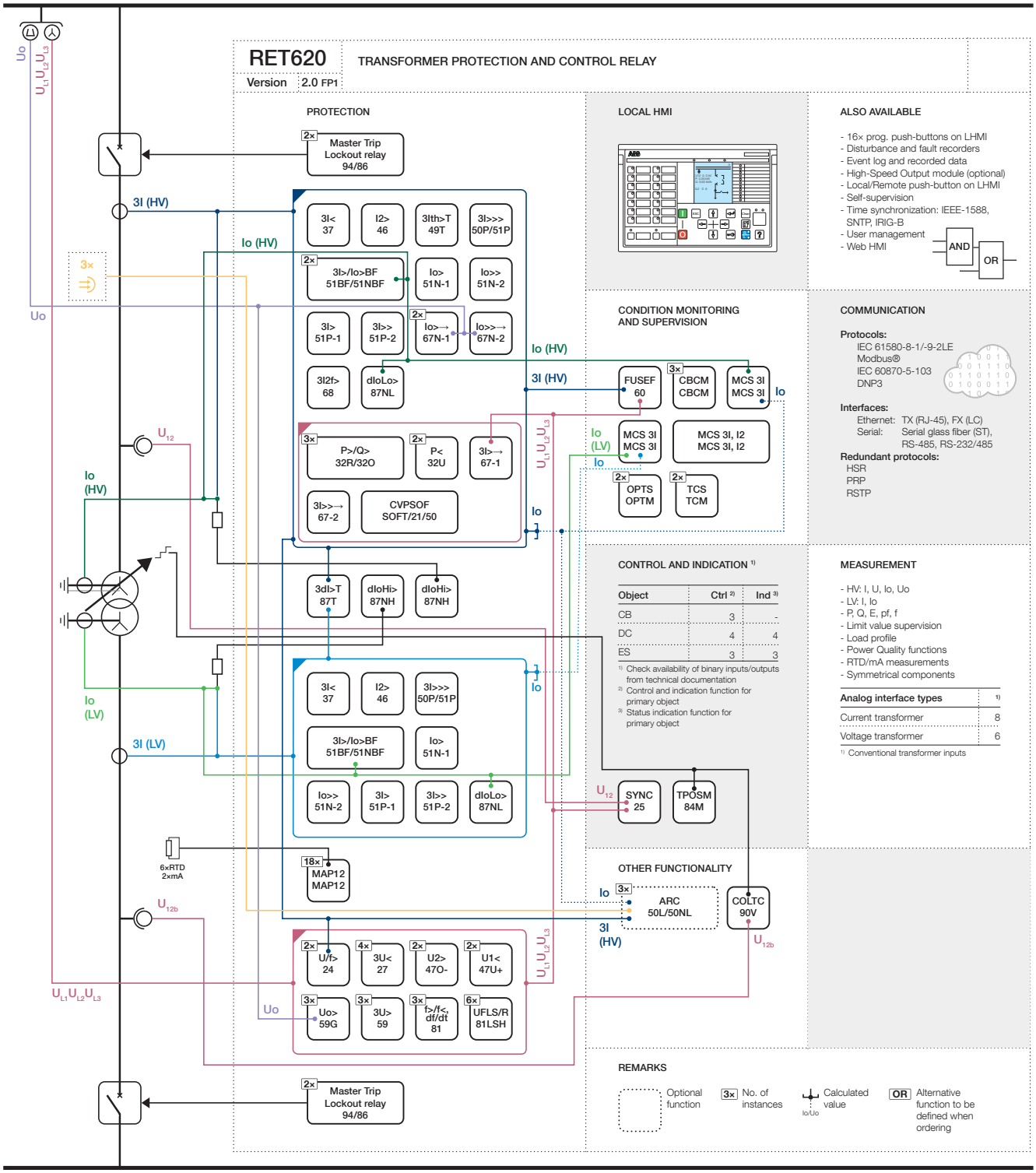


Figure 17: Functionality overview of default configuration with conventional instrument transformer inputs

3.5.2.1 Default I/O connections

Table 9: Default connections for analog inputs

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

Table 10: Default connections for binary inputs

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

Table 11: Default connections for binary outputs

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

Table 12: Default connections for RIO600 inputs

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

Table 13: Default connections for RIO600 outputs

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

Table 14: Default connections for LEDs

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

Table 15: Default connections for function keys

FK/SPCGAPC number	Default usage	Operation mode	Pulsed length
1	Setting Group 1 Enabled	Pulsed	150 ms
2	Setting Group 2 Enabled	Pulsed	150 ms
3	Setting Group 3 Enabled	Pulsed	150 ms
4	Setting Group 4 Enabled	Pulsed	150 ms
5	Setting Group 5 Enabled	Pulsed	150 ms
6	Setting Group 6 Enabled	Pulsed	150 ms
7	–	Off	1000 ms
8	Lower Tap Changer	Pulsed	150 ms

Table continues on next page

FK/SPCGAPC number	Default usage	Operation mode	Pulsed length
9	Disturbance Recorder Manual Trigger	Pulsed	150 ms
10	Trip Lockout Reset	Pulsed	150 ms
11	Circuit Breaker Block Bypass	Toggle	1000 ms
12	Automatic Voltage Regulation Parallel Mode	Toggle	1000 ms
13	Automatic Voltage Regulation Auto Mode	Toggle	1000 ms
14	–	Off	1000 ms
15	–	Off	1000 ms
16	Raise Tap Changer	Pulsed	150 ms

3.5.2.2 Default disturbance recorder settings

Table 16: Default disturbance recorder settings binary channel

Channel	Id text	Level trigger mode
1	TR2PTDF1_OPERATE	Positive or Rising
2	TR2PTDF1_OPR_LS	Level trigger off
3	TR2PTDF1_OPR_HS	Level trigger off
4	TR2PTDF1_BLKD2H	Level trigger off
5	TR2PTDF1_BLKD5H	Level trigger off
6	TR2PTDF1_BLKDWAV	Level trigger off
7	HREFPDIF1 or LREFPNDF1_START	Positive or Rising
8	HREFPDIF2 or LREFPNDF2_START	Positive or Rising
9	HREFPDIF1/2 or LREFPNDF1/2_OPERATE	Level trigger off
10	PHLPTOC1_START	Positive or Rising
11	PHHPTOC1_START	Positive or Rising
12	PHIPTOC1_START	Positive or Rising
13	DPHLPDOC1_START	Positive or Rising
14	DPHHPDOC1_START	Positive or Rising
15	PHxPTOC (HV) or DPHxPDOC (HV)_OPERATE	Level trigger off
16	PHLPTOC2_START	Positive or Rising
17	PHHPTOC2_START	Positive or Rising
18	PHIPTOC2_START	Positive or Rising
19	PHxPTOC (LV)_OPERATE	Level trigger off
20	EFLPTOC1_START	Positive or Rising
21	EFHPTOC1_START	Positive or Rising
22	DEFLPDEF1_START	Positive or Rising
23	DEFLPDEF2_START	Positive or Rising

Table continues on next page

Channel	Id text	Level trigger mode
24	DEFHPDEF1_START	Positive or Rising
25	EFxPTOC (HV) or DEFxPDEF_OPERATE	Level trigger off
26	EFLPTOC2_START	Positive or Rising
27	EFHPTOC2_START	Positive or Rising
28	EFxPTOC (LV)_OPERATE	Level trigger off
29	NSPTOC1_START	Positive or Rising
30	NSPTOC2_START	Positive or Rising
31	NSPTOC1/2_OPERATE	Level trigger off
32	ROVPTOV or PHPTUV or PHPTOV or PSPTUV or NSPTOV_START	Positive or Rising
33	ROVPTOV or PHPTUV or PHPTOV or PSPTUV or NSPTOV_OPERATE	Level trigger off
34	FRPFRQ or LSHDPFRQ_START	Positive or Rising
35	FRPFRQ or LSHDPFRQ_OPERATE	Level trigger off
36	OEPVPH1/2_START	Positive or Rising
37	OEPVPH1/2_OPERATE	Level trigger off
38	T2PTTR1_START	Positive or Rising
39	T2PTTR1_OPERATE	Level trigger off
40	T2PTTR1_ALARM	Level trigger off
41	T2PTTR1_BLK_CLOSE	Level trigger off
42	PHPTUC1/2_START	Positive or Rising
43	PHPTUC1/2_OPERATE	Level trigger off
44	ARCSARC1/2/3_ARC_FLT_DET	Level trigger off
45	ARCSARC1_OPERATE	Positive or Rising
46	ARCSARC2_OPERATE	Positive or Rising
47	ARCSARC3_OPERATE	Positive or Rising
48	INRPHAR1_BLK2H	Level trigger off
49	SEQSPVC1_FUSEF_3PH	Level trigger off
50	SEQSPVC1_FUSEF_U	Level trigger off
51	CCSPVC1/2_FAIL	Level trigger off
52	CCBRBRF1/2_TRRET	Level trigger off
53	CCBRBRF1/2_TRBU	Level trigger off
54	HV CB Closed	Level trigger off
55	HV CB Open	Level trigger off
56	LV CB Closed	Level trigger off
57	LV CB Open	Level trigger off
58	MCB Open (HV)	Level trigger off
59	MCB Open (LV/AVR)	Level trigger off
60	MCB Open (SYN)	Level trigger off
61	Tap Changer Operating	Level trigger off

Table continues on next page

Channel	Id text	Level trigger mode
62	OLATCC1_RAISE_OWN	Level trigger off
63	OLATCC1_LOWER_OWN	Level trigger off
64	FKEY K9_DR Manual Trigger	Positive or Rising

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 17: Default analog channel selection and text settings

Channel	Selection and text
1	IL1
2	IL2
3	IL3
4	Io A
5	IL1B
6	IL2B
7	IL3B
8	Io B
9	Uo
10	U1
11	U2
12	U3

3.5.2.3 Default operation mode for generic control point

Table 18: Default operation modes

Channel	Signal name	Value	Pulse length
1	SG1 Enabled	Pulsed	150 ms
2	SG2 Enabled	Pulsed	150 ms
3	SG3 Enabled	Pulsed	150 ms
4	SG4 Enabled	Pulsed	150 ms
5	SG5 Enabled	Pulsed	150 ms
6	SG6 Enabled	Pulsed	150 ms
7		Off	1000 ms
8	Lower Tap Changer	Pulsed	150 ms
9	DR Trigger	Pulsed	150 ms
10	Trip Lockout Reset	Pulsed	150 ms
11	CB Block Bypass	Toggle	1000 ms
12	AVR Parallel Mode	Toggle	1000 ms

Table continues on next page

Channel	Signal name	Value	Pulse length
13	AVR Auto Mode	Toggle	1000 ms
14		Off	1000 ms
15		Off	1000 ms
16	Raise Tap Changer	Pulsed	150 ms
Grey cells indicate different default settings.			

3.5.2.4 Physical analog channels

There are eight current channels and six voltage channels in this configuration.

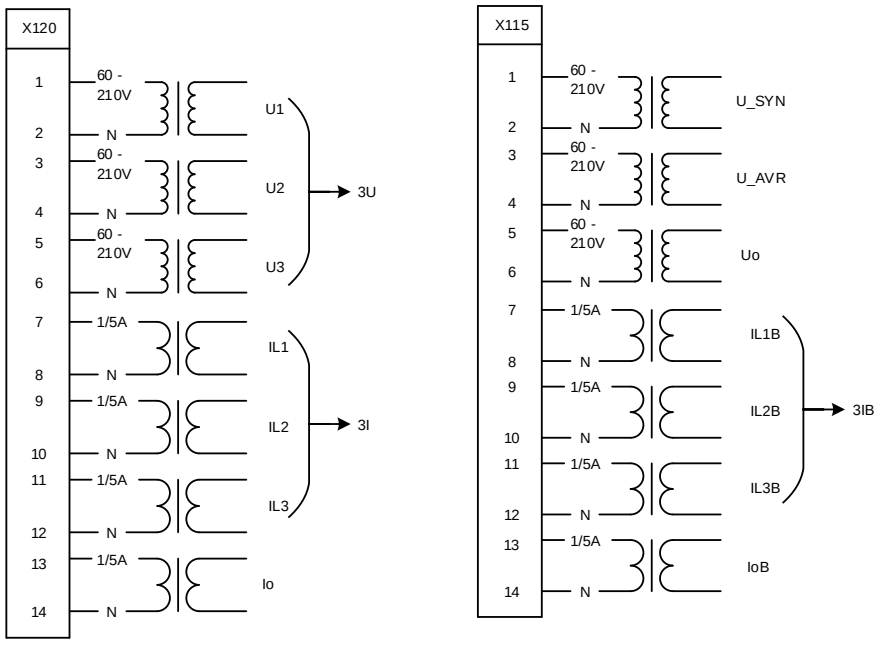


Figure 18: Physical analog channels in default configuration A

The physical analog channels of all functions which require current or voltage inputs in this configuration are listed in Table 20. Meaning of the symbols is explained in Table 19.

Table 19: Explanations of symbols in the physical analog channel table

Symbol	Description
x	The analog channel is assigned to the function by default.
C	The function can be set to use residual voltage or current calculated based on the three-phase input. Only applicable for functions which need residual voltage or current as input.
D	The analog channel is dedicated to the function. When the corresponding function is taken into use, other functions cannot use this analog channel any more. The other functions can be set to use calculated values instead of physical measured value or select an alternative operation mode not requiring this physical measured channel. However, some functions might not have such operation modes and might become unusable in the configuration. All functions marked to use the same HW channel under the same column should be checked to make sure the functions work.

Table 20: Physical analog channels of functions

IEC61850	3I	3U	Io	Uo	3IB	IoB	U_SYN	U_AVR
Protection								
PHLPTOC1	x							
PHLPTOC2					x			
PHHPTOC1	x							
PHHPTOC2					x			
PHIPTOC1	x							
PHIPTOC2					x			
DPHLPDOC1	x	x						
DPHHPDOC1	x	x						
EFLPTOC1	C		x					
EFLPTOC2					C	x		
EFHPTOC1								
EFHPTOC2					C	x		
DEFLPDEF1	C	C	x	x				
DEFLPDEF2	C	C	x	x				
DEFHPDEF1	C	C	x	x				
NSPTOC1	x							
NSPTOC2					x			
ROVPTOV1		C		x				
ROVPTOV2		C		x				
ROVPTOV3		C		x				
PHPTUV1		x						
PHPTUV2		x						
PHPTUV3		x						
PHPTUV4		x						
PHPTOV1		x						
PHPTOV2		x						

Table continues on next page

IEC61850	3I	3U	Io	Uo	3IB	IoB	U_SYN	U_AVR
PHPTOV3		x						
PSPTUV1		x						
PSPTUV2		x						
NSPTOV1		x						
NSPTOV2		x						
FRPFRQ1		x						
FRPFRQ2		x						
FRPFRQ3		x						
OEPVPH1		x						
OEPVPH2		x						
T2PTTR1	x							
PHPTUC1	x							
PHPTUC2					x			
TR2PTDF1	x				x			
LREFPNDF1	x		x					
LREFPNDF2					x	x		
HREFPDIF1			D					
HREFPDIF2						D		
CCBRBRF1	x		x					
CCBRBRF2					x	x		
CCBRBRF3	x		x					
INRPHAR1	x							
ARCSARC1	x							
ARCSARC2	x							
ARCSARC3	x							
LSHDPFRQ1		x						
LSHDPFRQ2		x						
LSHDPFRQ3		x						
LSHDPFRQ4		x						
LSHDPFRQ5		x						
LSHDPFRQ6		x						
CVPSOF1	x	x						
DUPPDPR1	x	x						
DUPPDPR2	x	x						
DOPPDPR1	x	x						
DOPPDPR2	x	x						
DOPPDPR3	x	x						
Control								
SECRSYN1		x					x	

Table continues on next page

IEC61850	3I	3U	Io	Uo	3IB	IoB	U_SYN	U_AVR
OLATCC1					x			x
Condition Monitoring								
SSCBR1	x							
SSCBR2					x			
SSCBR3	x							
TCSSCBR1								
TCSSCBR2								
CCSPVC1	x		x					
CCSPVC2					x	x		
CTSRCTF1	x				x			
SEQSPVC1	x	x						
Measurement								
CMMXU1	x							
CMMXU2					x			
CSMSQI1	x							
CSMSQI2					x			
RESCMMXU1			x					
RESCMMXU2						x		
VMMXU1		x						
VAMMXU2								x
VAMMXU3							x	
RESVMMXU1				x				
VSMSQI1		x						
PEMMXU1	x	x						
FMMXU1		x						
Power quality								
CMHAI1	x							
VMHAI1		x						
PHQVVR1	x	x						
VSQVUB1		x						

3.5.3 Functional diagrams

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

The analog channels, measurements from CTs and VTs have fixed connections to the different function blocks inside the relay. Exceptions from this rule are the 12 analog

channels available for the disturbance recorder function. These channels are freely selectable and a part of the disturbance recorder's parameter settings.

The signal marked with 3I represents the three phase currents from the high-voltage side of the transformer. The signal marked with 3IB represents the three phase currents from the low-voltage side of the transformer. The signal marked with Io represents the ground current measured between the neutral point of the transformer and grounding on the high-voltage side, and the signal marked with IoB represents the ground current measured between the neutral point of the transformer and earthing on the low-voltage side.

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

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

See the technical manual for voltage angle difference adjustment.

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

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

The relay offers six different setting groups which can be set based on individual needs. Each group can be activated or deactivated using the setting group settings available in the relay.

There are 16 programmable push buttons offered in the front panel of the unit. The relay offers six different setting groups which the user can set based on individual needs. Each group can then be activated or deactivated by using a programmable button. In addition to this, the programmable button can be also used for manual trigger of disturbance recorder, lower or raise tap changer, transformer control mode changing, circuit breaker control interlocking bypass, master trip lockout reset, and so on.

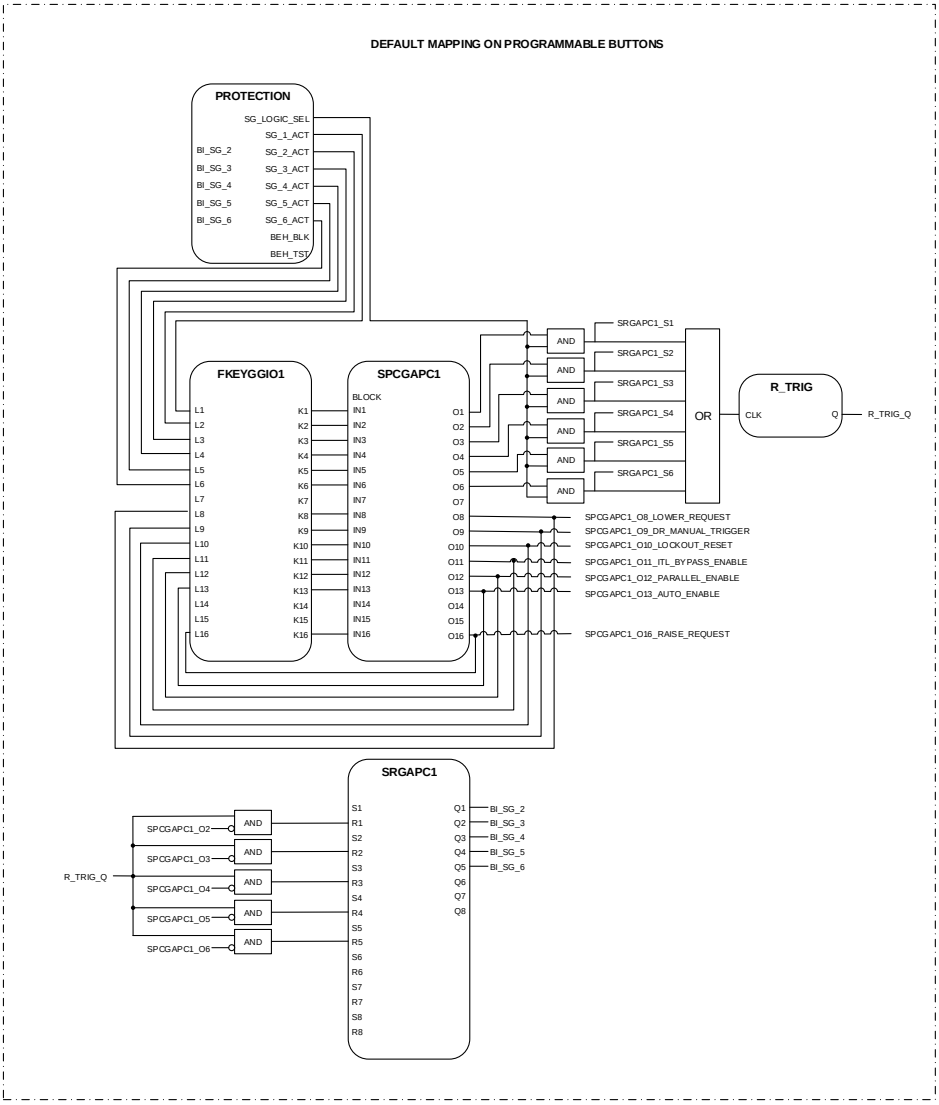


Figure 19: Default mapping on programmable buttons

3.5.3.1 Functional diagrams for protection

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

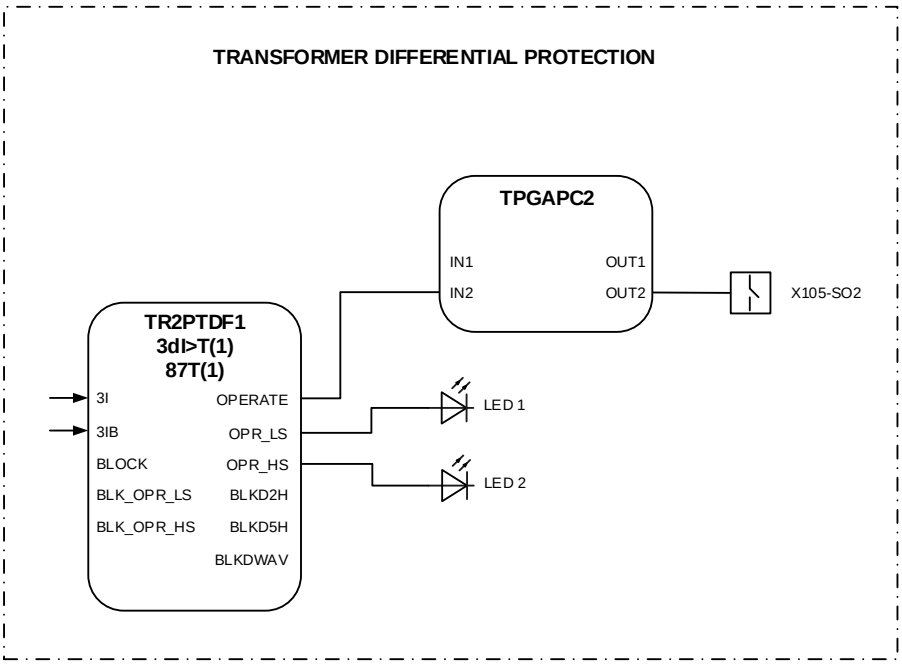


Figure 20: Transformer differential protection

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

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

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

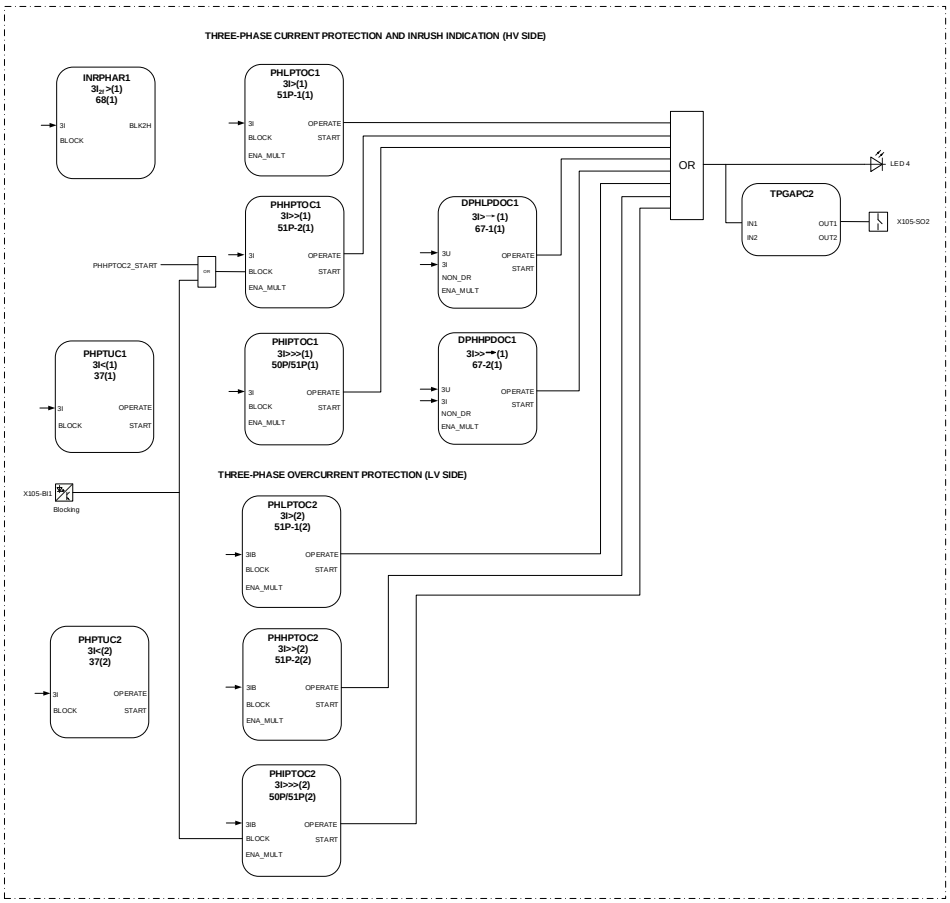


Figure 21: Three-phase current protection and inrush indication

Five stages for high-voltage side and three stages for low-voltage side as a total of eight overcurrent stages are offered for overcurrent and short-circuit protection. Three stages are for directional functionality DPHxPDOC, while the others are only for non-directional overcurrent protection PHxPTOC. The high stage of high-voltage side PHHPTOC1 and instantaneous stage of low-voltage side PHIPTOC2 can be blocked by energizing the binary input X105-BI1. The inrush detection block's INRPHAR1 output BLK2H enables either blocking the function or multiplying the active settings for any of the described protection function blocks.

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

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

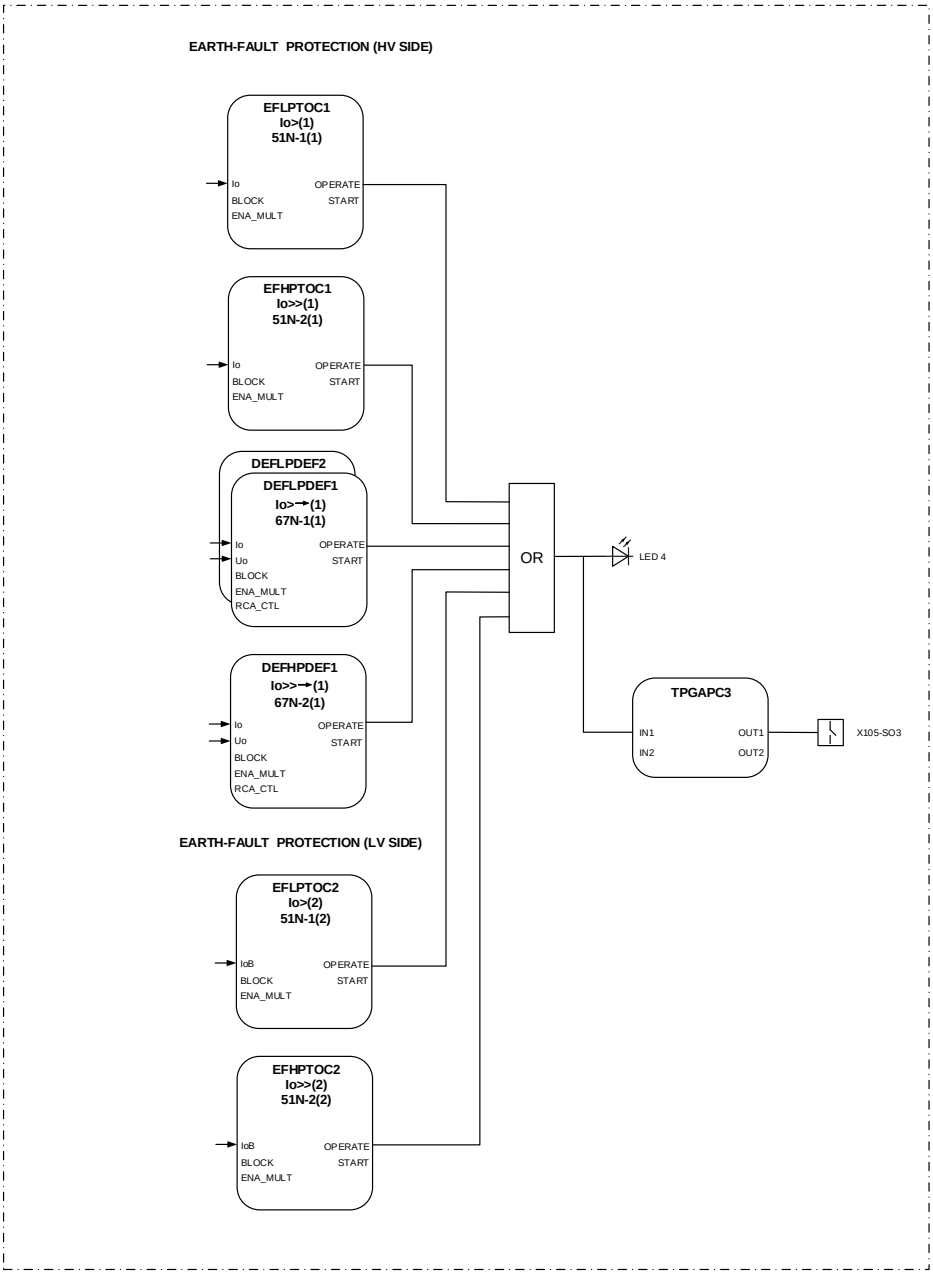


Figure 22: Earth-fault protection

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

The OPERATE outputs are connected to the Master Trip and output X105-SO3 via generic timer TPGAPC3, and also to the alarm LED 4.

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

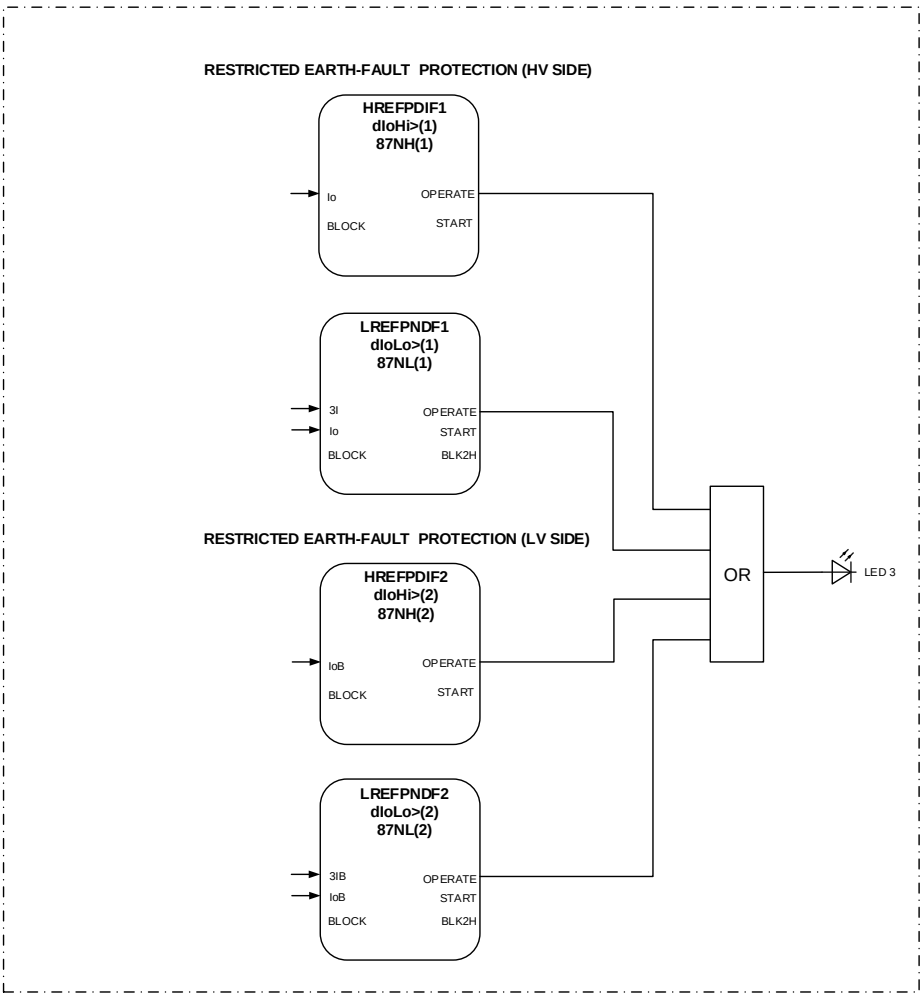


Figure 23: Restricted earth-fault protection

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

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

differential current between the residual current of the phase currents and the neutral current of the conductor between the star-point of the transformer and earth.

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

High-impedance based restricted earth-fault protection needs a dedicated differential current measurement channel, so when it is used, it is not possible to choose other functions which need measured Io.

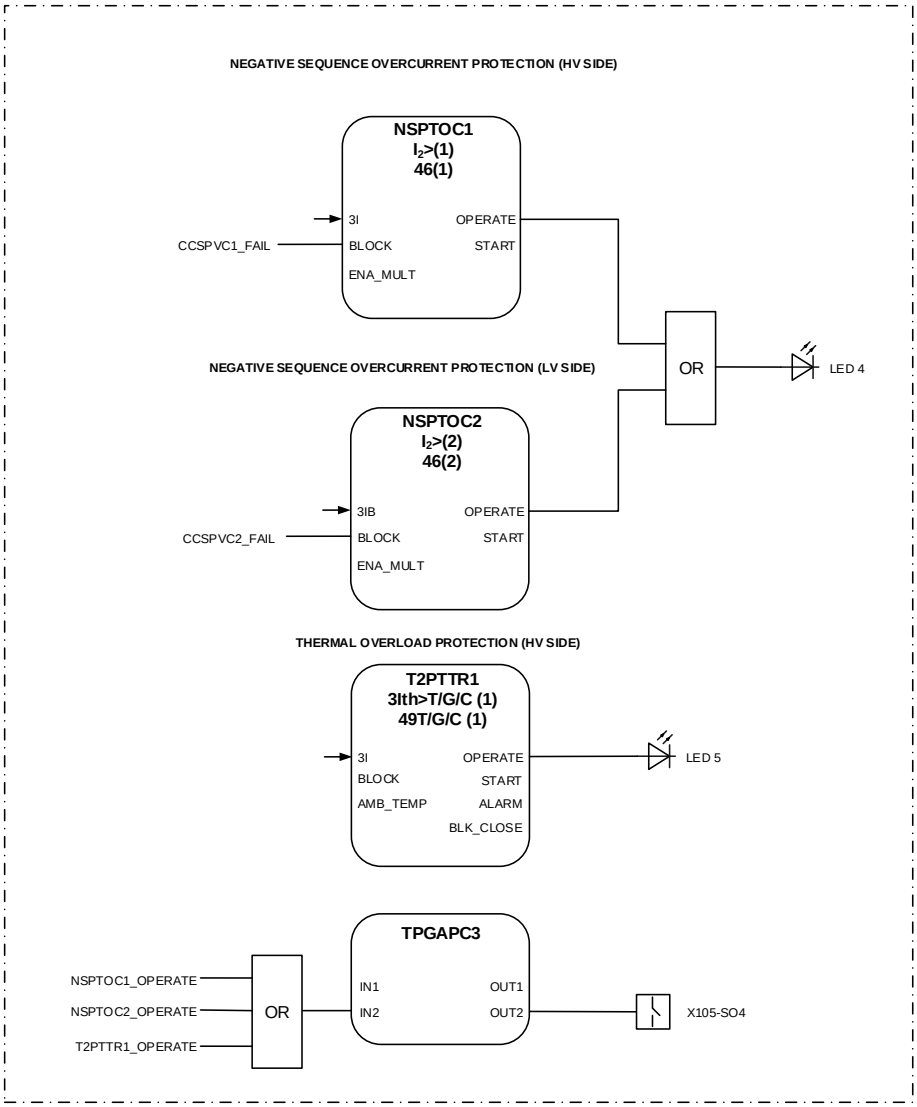


Figure 24: Negative sequence current protection and thermal overload protection

NSPTOC1/2 is designed for negative-phase sequence protection whenever the operating characteristic is appropriate. It is applied for the protection of transformers against thermal stress and damage. NSPTOC1 measures negative-sequence current from the high-voltage side; NSPTOC2 from the low-voltage side. A failure in the current measuring circuit is detected by the current circuit supervision function CCSPVC1/2 to avoid faulty tripping.

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

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

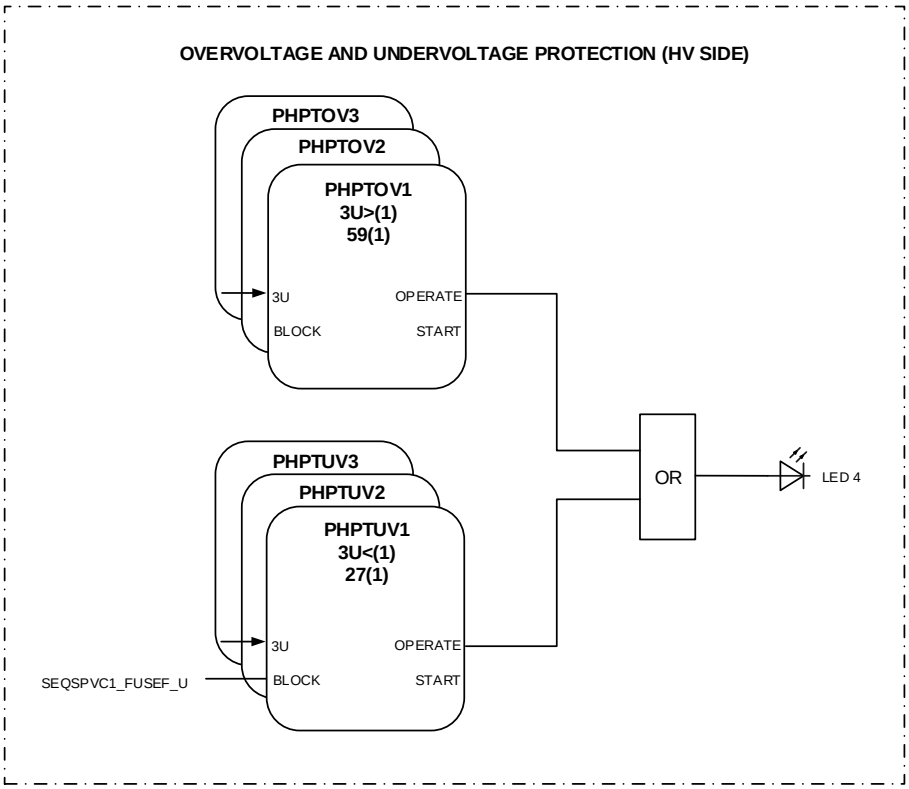


Figure 25: Overvoltage and undervoltage protection

Three overvoltage and three undervoltage protection stages PHPTOV1/2/3 and PHPTUV1/2/3 offer protection against abnormal phase voltage conditions. A failure in the voltage measuring circuit is detected by the fuse failure function and the activation is connected to undervoltage protection functions, to avoid faulty undervoltage tripping.

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

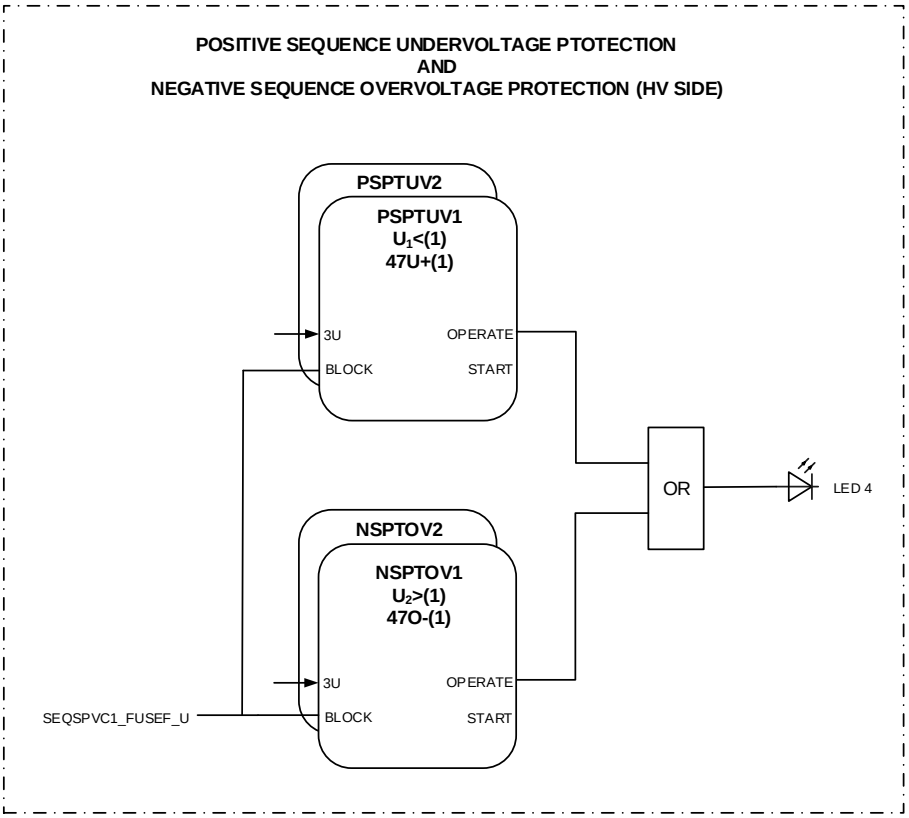


Figure 26: Positive-sequence undervoltage and negative-sequence overvoltage protection

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

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

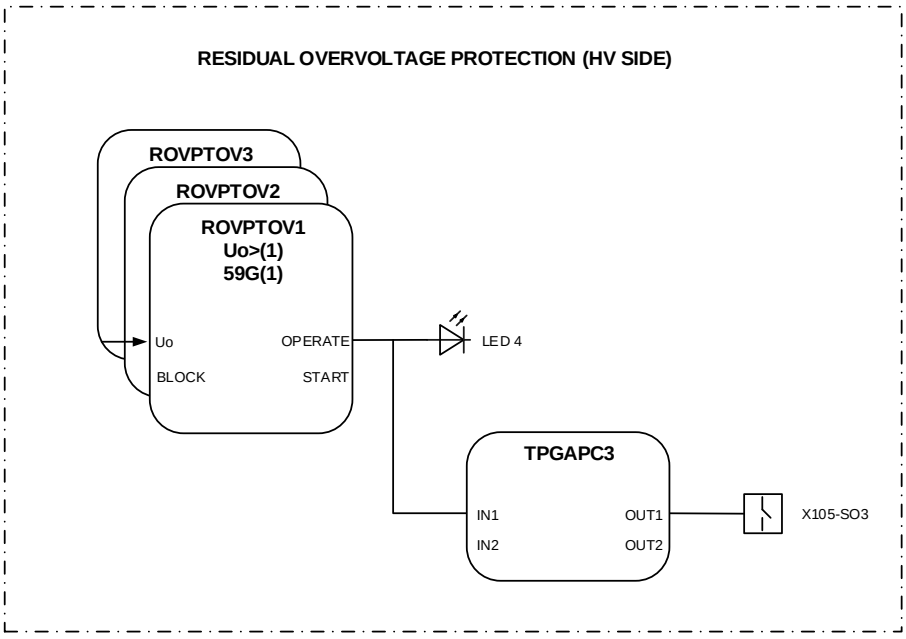


Figure 27: Residual overvoltage protection

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 non-selective backup protection for the selective directional earth-fault functionality. The OPERATE outputs are connected to the Master Trip and output X105-SO3 via generic timer TPGAPC3 and also alarm LED 4.

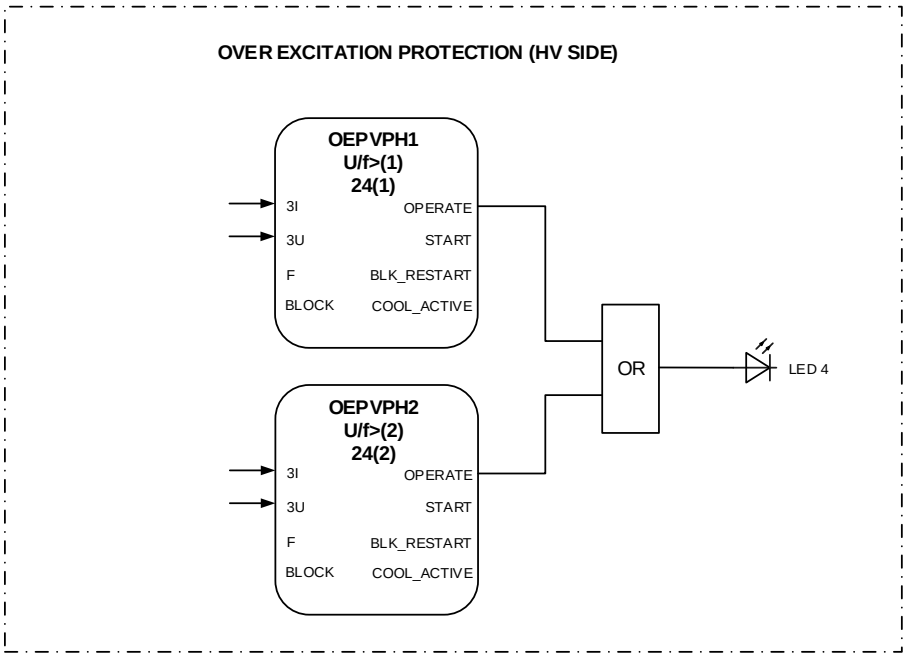


Figure 28: Overexcitation protection

Two overexcitation protection stages OEPVPH1/2 are offered against power transformers excessive flux density and saturation of magnetic core.

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

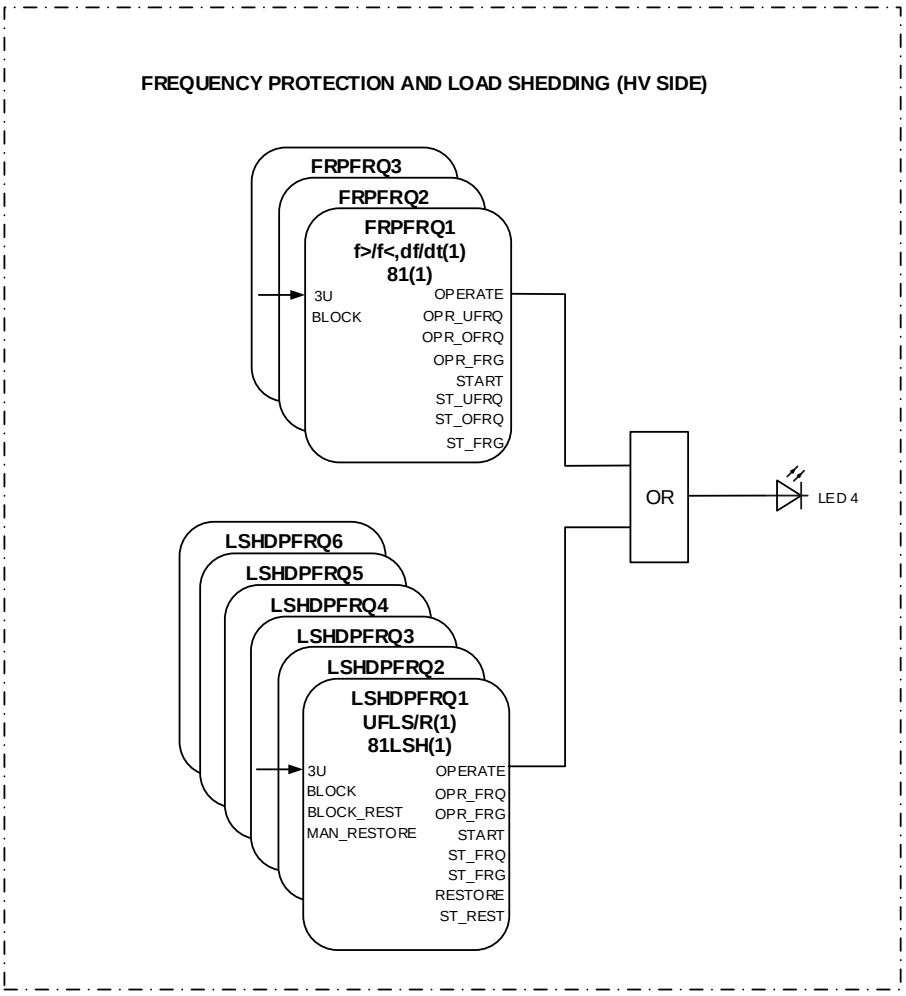


Figure 29: Frequency and load shedding protection

Three underfrequency or overfrequency protection FRPFRQ1…3 stages are offered to prevent damage to network components under unwanted frequency conditions. The function contains a selectable rate of change of the frequency (gradient) protection to detect an increase or decrease in the fast power system frequency at an early stage. This can be used as an early indication of a disturbance in the system. The OPERATE outputs signal is connected to the Master Trip and alarm LED 4.

Six load-shedding and restoration protection LSHDPFRQ1…6 stages are offered in the default configuration. The load-shedding and restoration function is capable of shedding load based on underfrequency and the rate of change of the frequency. The load that is shed during the frequency disturbance can be restored once the frequency is stabilized to the normal level. Also manual restore commands can be given via binary inputs but, by default, it is not connected. The OPERATE outputs signal is also connected to the Master Trip and alarm LED 4.

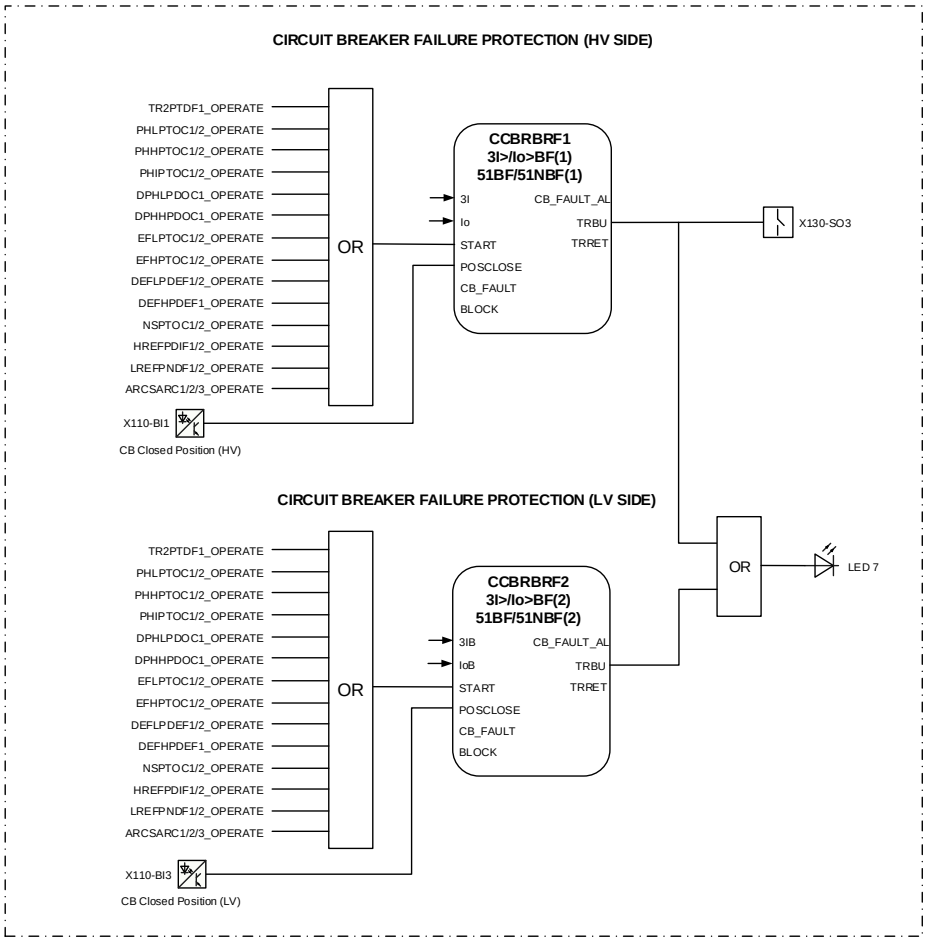


Figure 30: Circuit breaker failure protection

The breaker failure protection CCBRBRF1/2 is initiated via the START input by a number of different protection stages in the relay. The breaker failure protection function offers different operating modes associated with the circuit breaker position and the measured phase and residual currents.

The breaker failure protection has two operating outputs: TRRET and TRBU. The TRRET output is used for retripping its own breaker, CCBRBRF1 for high-voltage side through the Master Trip 1 and CCBRBRF2 for low-voltage side through the Master Trip 2. The TRBU output is used to give a backup trip to the breaker feeding upstream. For this purpose, the TRBU output signal of CCBRBRF1 is connected to output X130-SO3. The TRBU outputs of both functions are connected to alarm LED 7. LED 7 is used for backup (TRBU) operate indication.

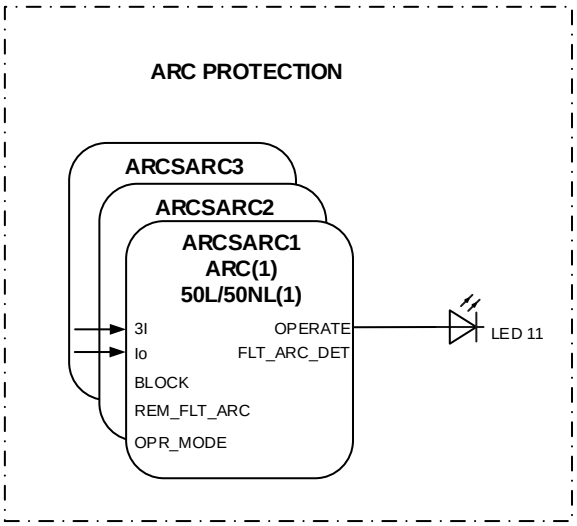


Figure 31: Arc protection

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 relay. Each arc protection function block has two different operation modes, with or without phase and residual current check. The `OPERATE` outputs from the arc protection function blocks are connected to the Master Trip and alarm LED 11.

3.5.3.2 Functional diagrams for disturbance recorder and trip circuit supervision

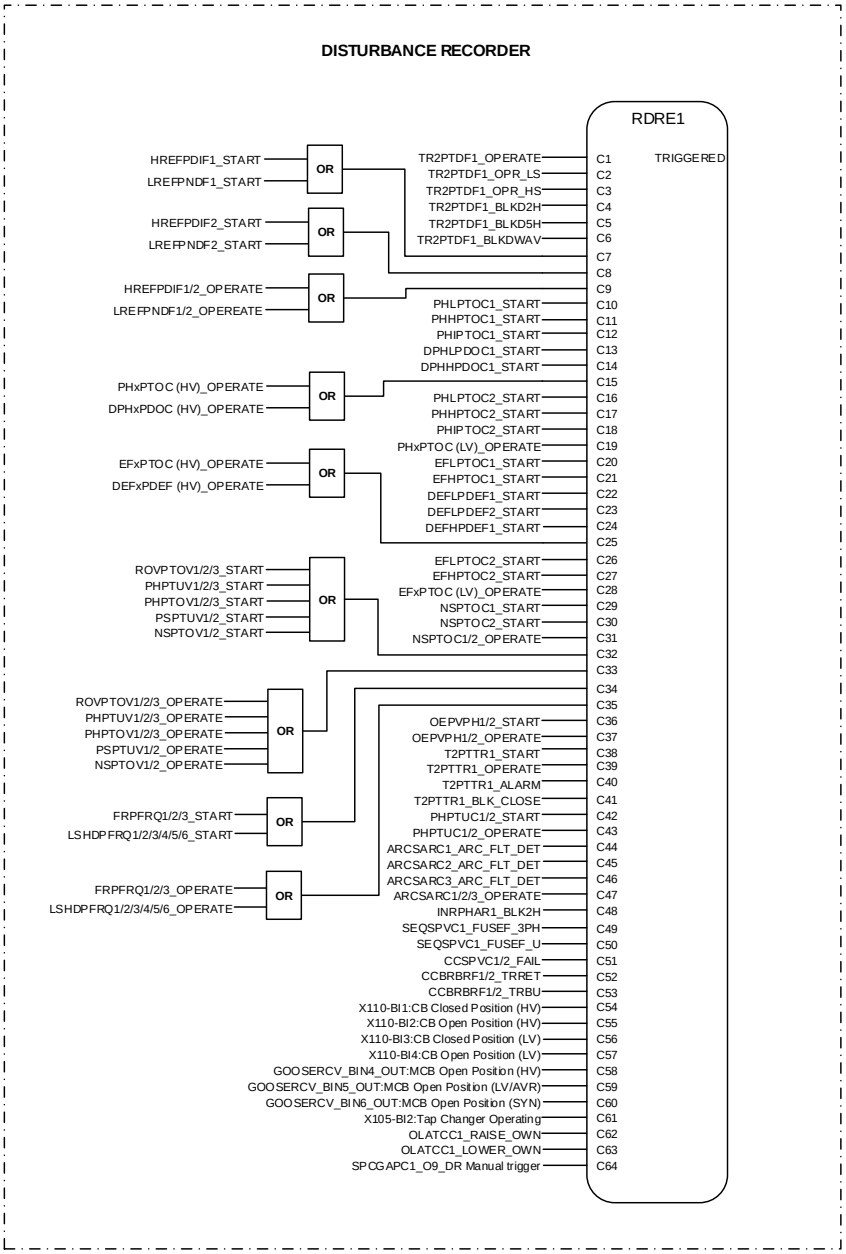


Figure 32: Disturbance recorder

All START and OPERATE outputs from the protection stages are routed to trigger the disturbance recorder or, alternatively, only to be recorded by the disturbance recorder, depending on the parameter settings. Additionally, some selected signals from different functions and some binary inputs from X110 and X105 are also connected.

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

The disturbance recorder main application sheet contains the disturbance recorder function block and the connections to variables.

When the order of signals connected to binary inputs of RDRE is changed, the changes must be made in the Parameter Setting tool.

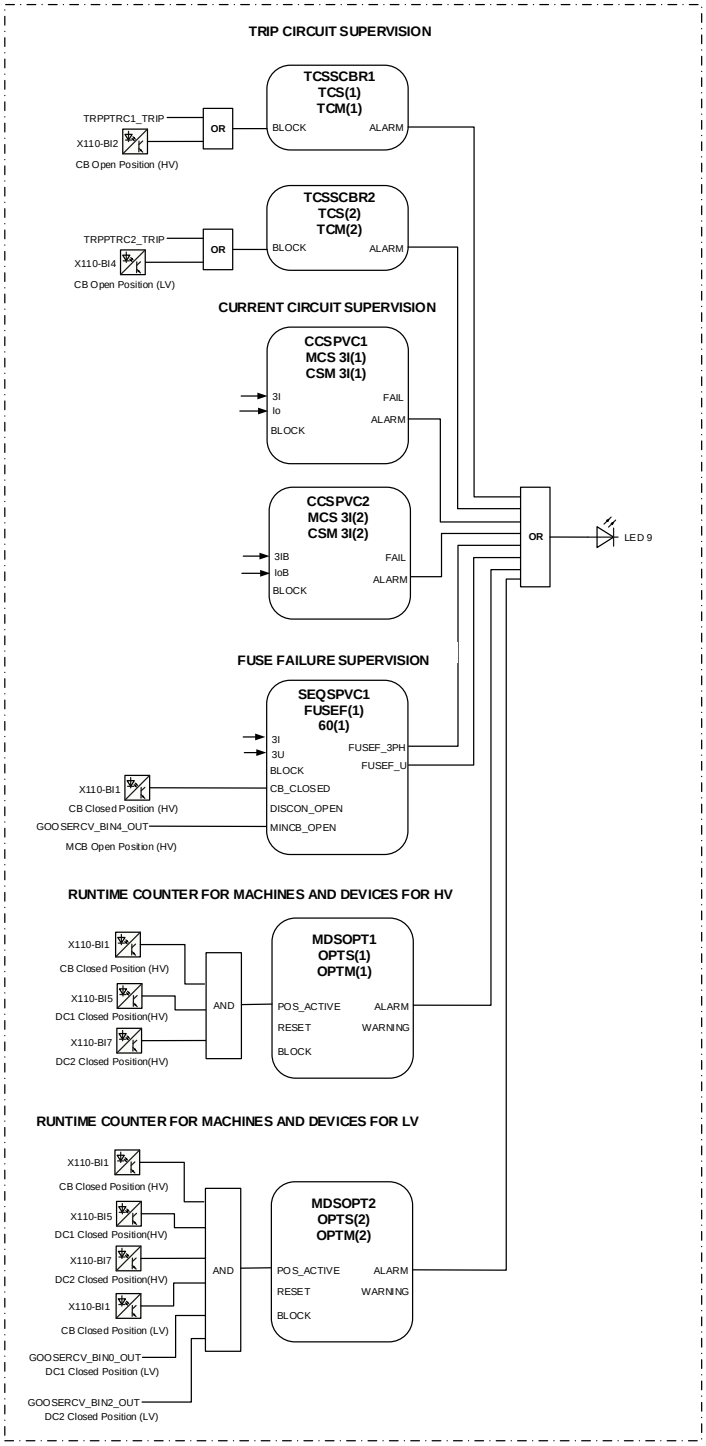


Figure 33: Circuit supervision

Two separate trip circuit supervision functions are included, TCSSCBR1 for output X100-PO3 and TCSSCBR2 for output X100-PO4. 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.

Parameters for TCSSCBR1 must be set properly.

Failures in current measuring circuits are detected by CCSPVC, both in high-voltage side CCSPVC1 and low-voltage side CCSPVC2. 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 SEQSPVC1 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.

The running time counter MDSOPT1/2 provides history data since last commissioning. The alarm of the runtime counter is connected to alarm LED 9.

3.5.3.3 Functional diagrams for control and interlocking

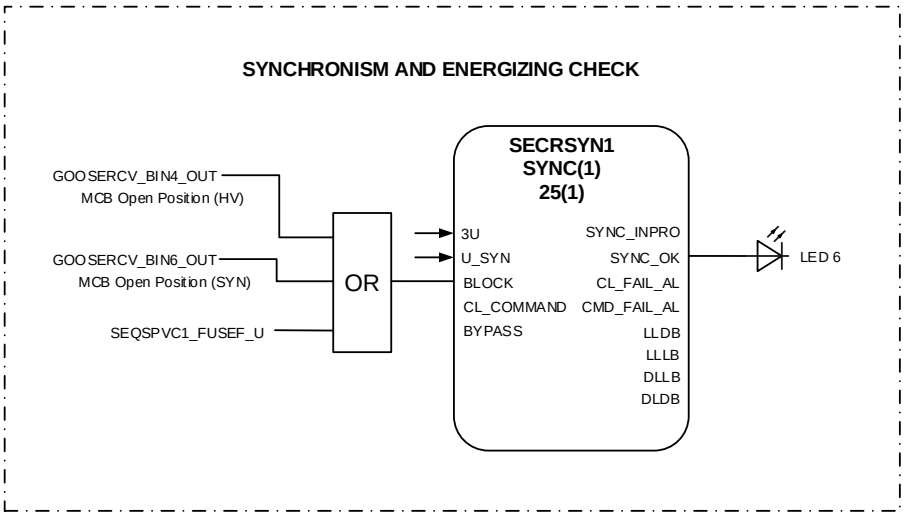


Figure 34: Synchronism and energizing check

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

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

To ensure the validity of the measured voltages on both sides, MCB Open Position (HV), MCB Open Position (SYN) and FUSEF_U from SEQSPVC1 are connected to block SECRSYN1. HV and SYN MCB Open Position come from the received GOOSE signal.

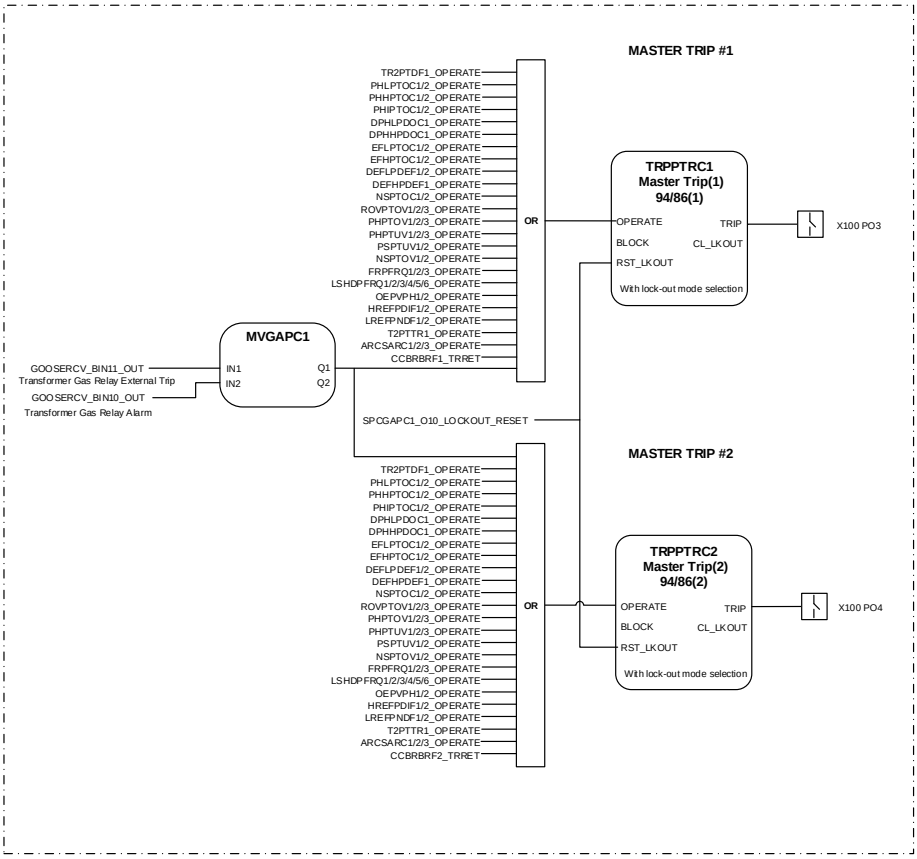


Figure 35: Master trip

The operating signals from the protections and two GOOSE binary inputs are connected to the two trip output contacts, output X100-PO3 and output X100-PO4, via the corresponding Master Trips TRPPTRC1 and TRPPTRC2.

TRPPTRC1 and TRPPTRC2 provide lockout/latching function, event generation and trip signal duration setting. If the lockout operation mode is selected, one push button can be used to reset the lockout status through SPCGAPC1_O10.

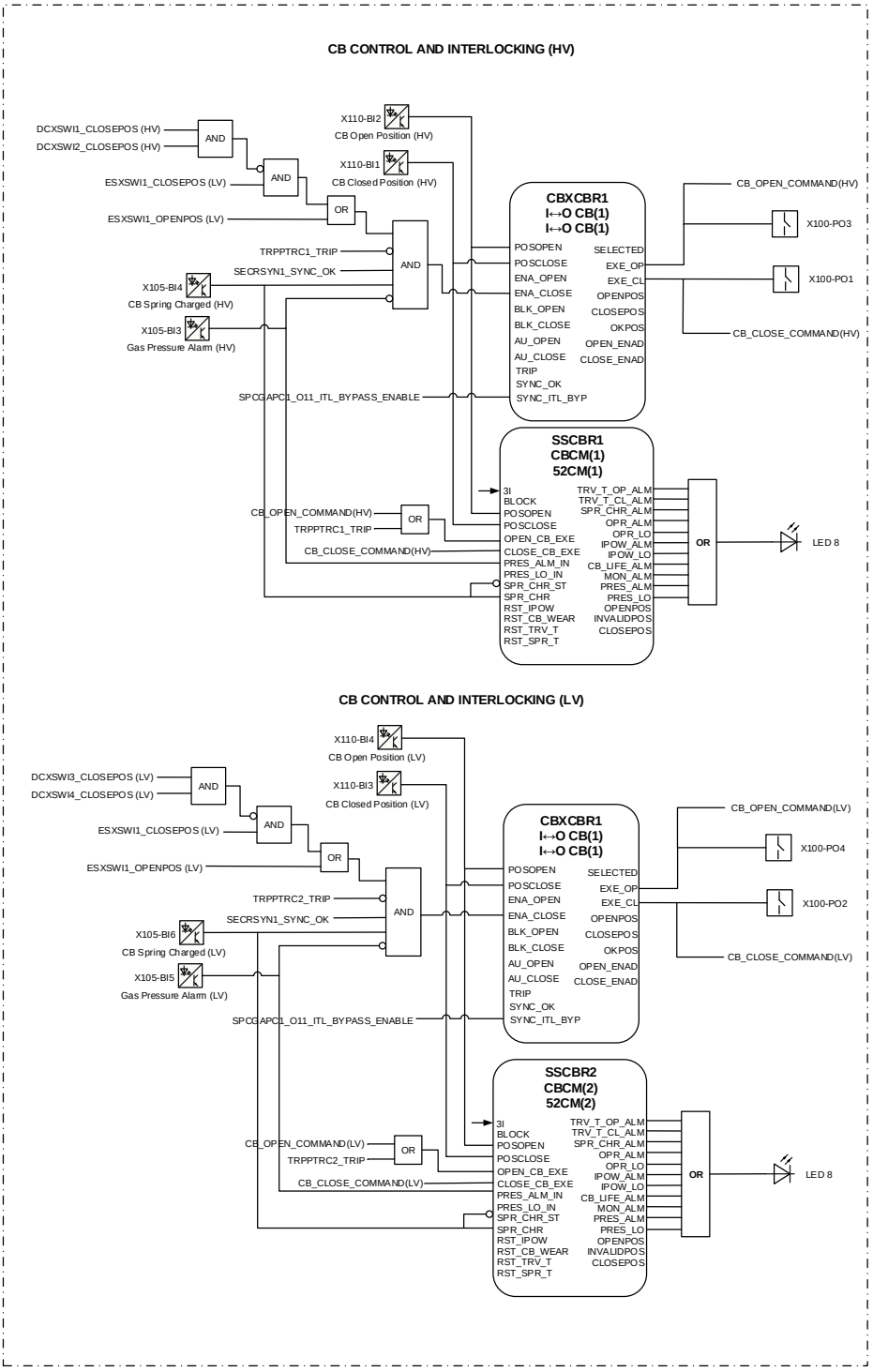


Figure 36: Circuit breaker control and interlocking

The circuit breaker closing is blocked when the ENA_CLOSE input is activated. The input can be activated by the configuration logic, which is a combination of the

position statuses of related primary equipment disconnector and earthing switch, the condition of the circuit breaker (CB gas pressure alarm, CB spring charged), the master trip logics and the result of synchronism/energizing check. This, together with non-active trip signal, activates the ENA_CLOSE signal to the circuit breaker control function block.

One push button can be used through SPCGAPC1_O11, which is connected to the SYNC_ITL_BYP inputs of CBXCBR1 and CBXCBR2, to ignore the status of the ENA_CLOSE inputs. 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 or CBXCBR2 with PCM600, the function assumes that the breaker-closing commands are allowed continuously.

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

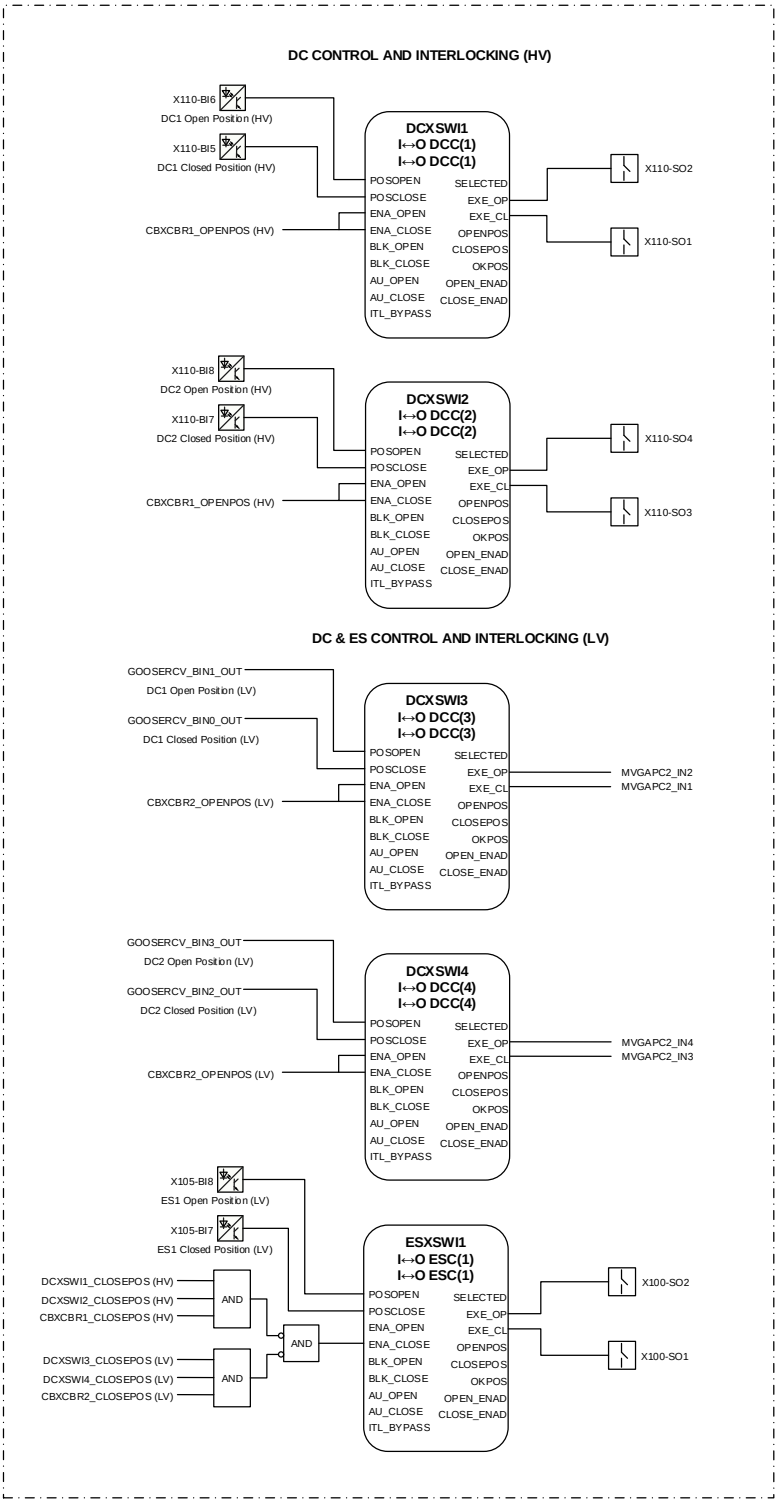


Figure 37: Disconnector and earthing switch control and interlocking

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

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

Table 21: HV disconnector 1 position indicated by binary inputs

Primary device position	Input to be energized	
	X110-BI5	X110-BI6
HV disconnector 1 closed	•	
HV disconnector 1 open		•

Table 22: HV disconnector 2 position indicated by binary inputs

Primary device position	Input to be energized	
	X110-BI7	X110-BI8
HV disconnector 2 closed	•	
HV disconnector 2 open		•

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

Table 23: LV disconnector 1 position indicated by binary inputs

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

Table 24: LV disconnector 2 position indicated by binary inputs

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

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

Table 25: Earthing switch position indicated by binary inputs

Primary device position	Input to be energized	
	X105-BI7	X105-BI8
Earthing switch closed	•	
Earthing switch open		•

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

Closing of the earthing switch is enabled when the conditions are met.

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

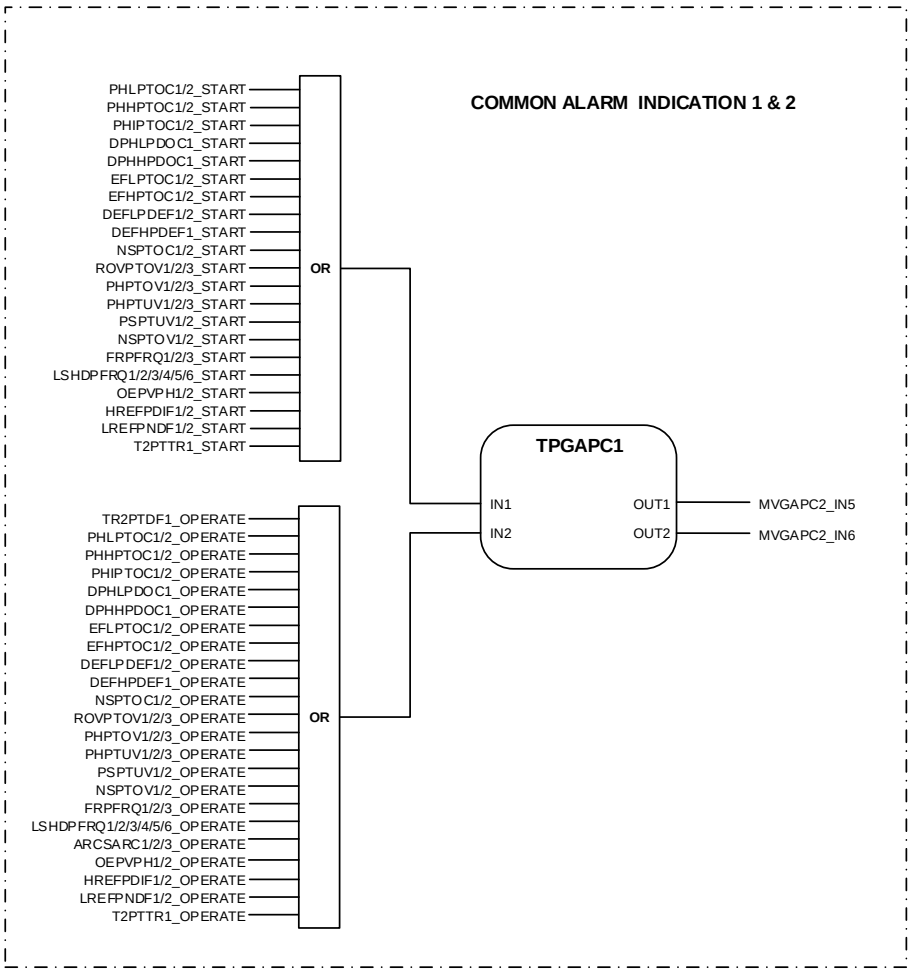


Figure 38: Common alarm indication

The signal outputs from the relay are connected to give dedicated information.

- Start of any protection function `MVGAPC2_IN5`
- Operation (trip) of any protection function `MVGAPC2_IN6`

TPGAPC functions are timers and they are used for setting the minimum pulse length for the outputs. There are four generic timers TPGAPC1…4 available in the relay. The remaining ones not described in the functional diagram are available in PCM600 for connection where applicable.

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

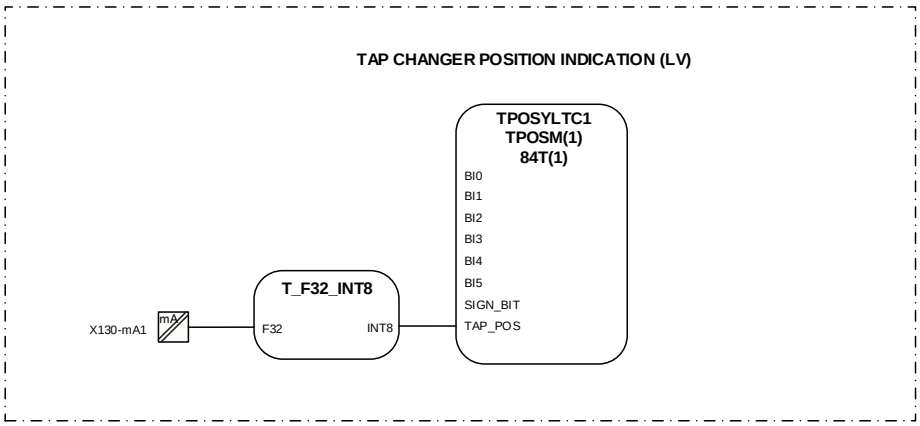


Figure 39: Tap changer position indication

To increase the sensitivity of the stabilized differential function, the tap position information from the tap changer is connected to the relay via the tap changer position indication function TPOSYLTC1. TPOSYLTC1 is connected to the mA input of the RTD card.

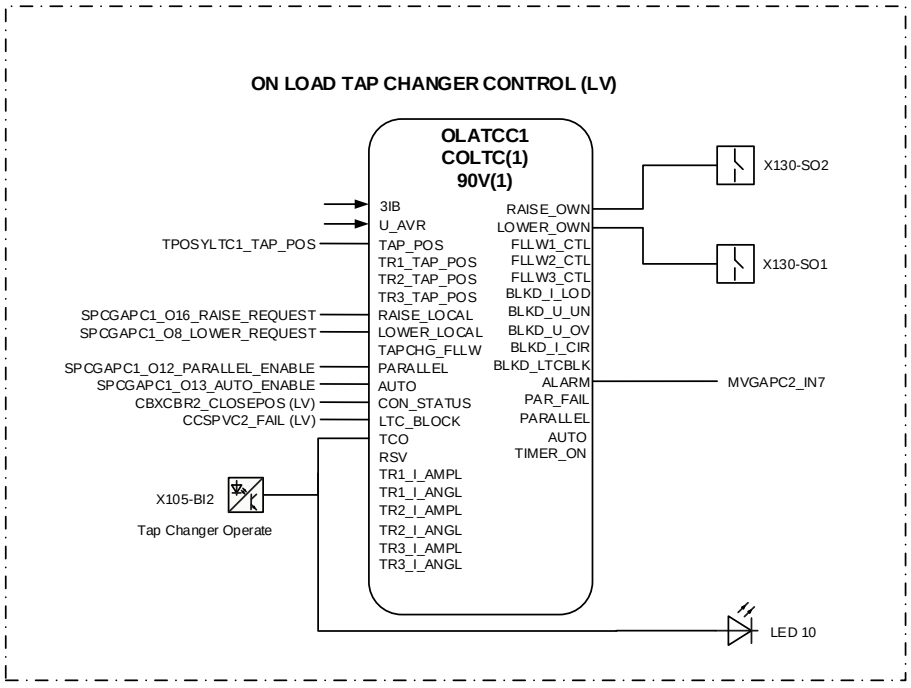


Figure 40: On-load tap changer control

Tap changer control with voltage regulator function is included as an optional function. The on-load tap changer control functionality is provided with OLATCC1.

Both manual and automatic controlling of the on-load tap changer is done via OLATCC1. The controlling of the local tap changer can be done through external push button via SPCGAPC1, SPCGAPC1_O8 input for lower request and SPCGAPC1_O16 for raise request. The operation mode of OLATCC1 can be controlled externally by push buttons, via SPCGAPC_12 and SPCGAPC_13.

The binary input X105-BI2 indicating the tap changer operating information can be connected to TCO and the alarm LED 10.

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

The output commands are routed to the binary outputs, the raising command is connected to X130-SO2 and the lower command is connected to X130-SO1.

The common alarm signal of OLATCC1 is connected to the GOOSE binary output MVGAPC2_IN7.

3.5.3.4 Functional diagrams for power quality measurements

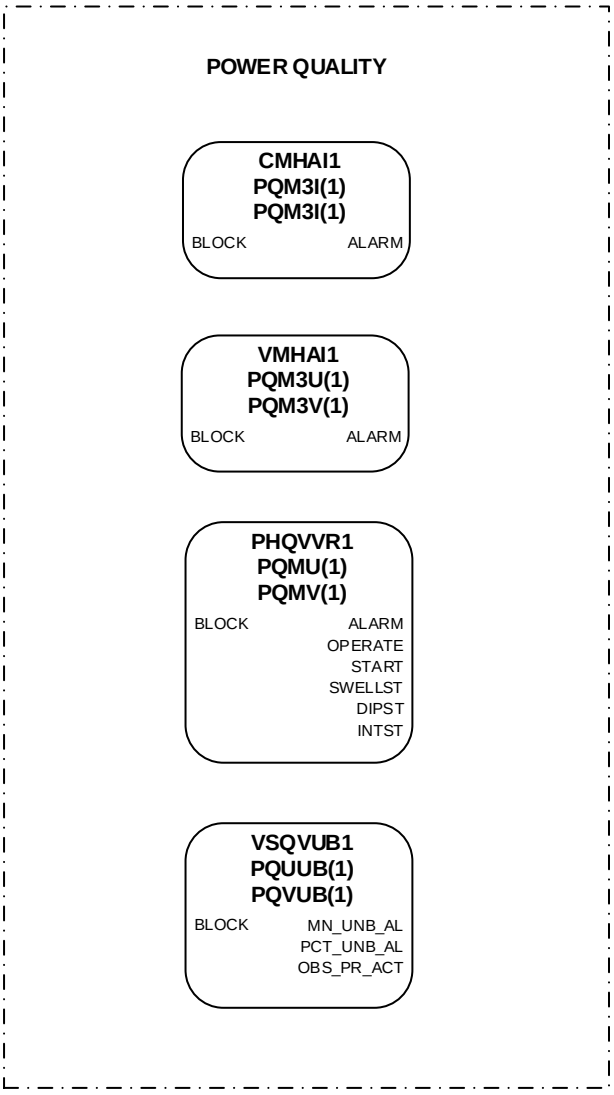


Figure 41: Power quality measurement function

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.

3.5.3.5 Functional diagrams for measurement functions

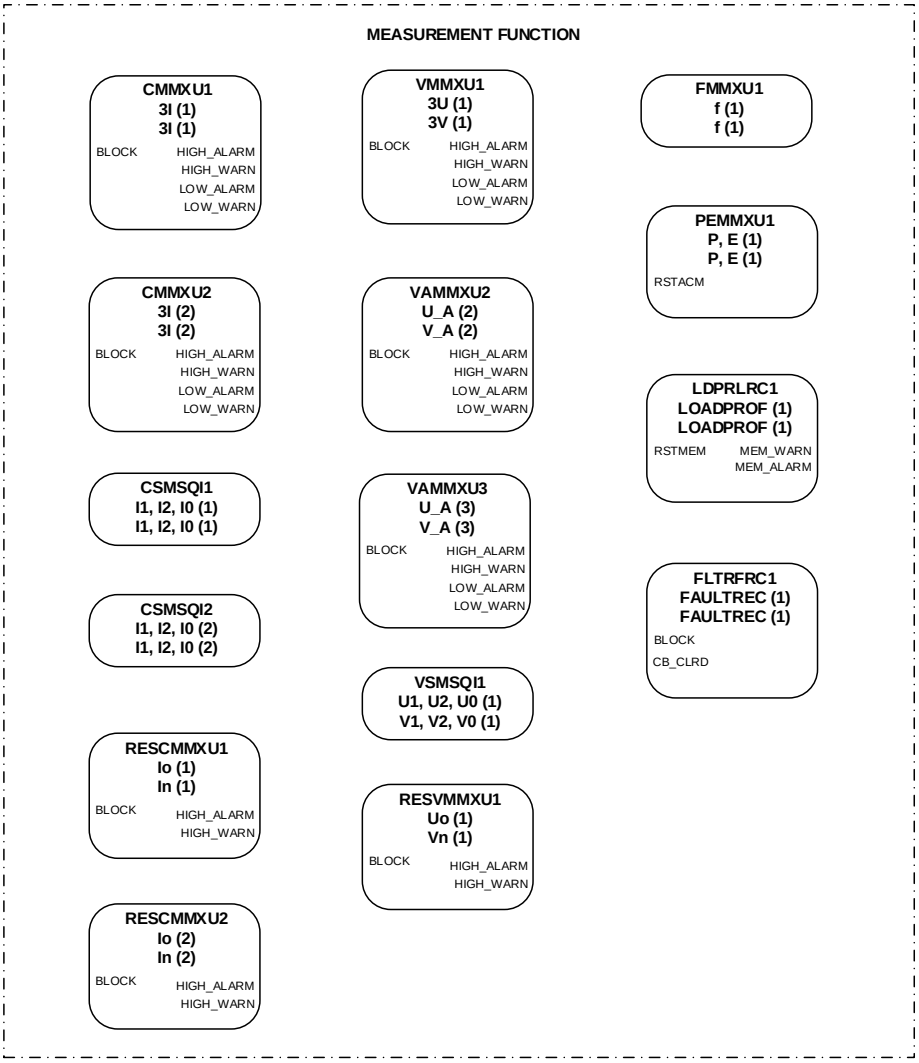


Figure 42: Measurement function

The high-voltage side and low-voltage side phase current inputs to the relay are measured by three-phase current measurement CMMXU1 and CMMXU2. The

current input is connected to the X120 and X115 cards in the back panel. The sequence current measurement CSMSQI1 and CSMSQI2 measures the high-voltage side and low-voltage side sequence current respectively and the residual current measurement RESCMMXU1 and RESCMMXU2 measures the high-voltage side and low-voltage side residual current.

The three-phase bus side phase voltage inputs to the relay are measured by three-phase voltage measurement VMMXU1. The voltage input is connected to the X120 card in the back panel. The sequence voltage measurement VSMSQI1 measures the sequence voltage and the residual voltage measurement RESVMMXU1 measures the residual voltage. The single-phase voltage measurement VAMMXU2 and VAMMXU3 measures the voltage of the transformer high-voltage side and low-voltage side respectively.

The measurements can be seen in the LHMI and they are available under the measurement option in the menu selection. Based on the settings, function blocks can generate low alarm or warning and high alarm or warning signals for the measured current values.

The frequency measurement FMMXU1 of the power system and the three-phase power and energy measurement PEMMXU1 are available. Load profile record LDPRLRC1 is included in the measurements sheet. LDPRLRC1 offers the ability to observe the loading history of the corresponding bay. FLTRFRC1 is used to record the monitor data during the fault condition. The records enable the analysis of recent power system events.

3.5.3.6 Functional diagrams for optional functions

Optional functions are available in the relay default content when a corresponding option is selected while ordering the relay. However, the functions are not pre-engineered to be part of the default configuration. The functions can be engineered into use.

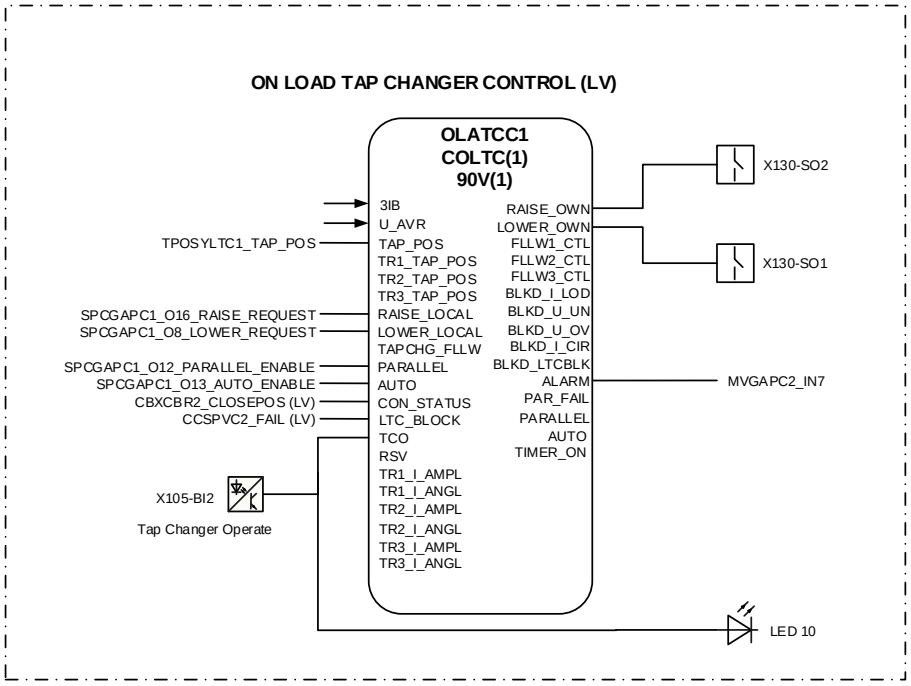


Figure 43: On load tap changer control

Tap changer control with voltage regulator function is included as optional function.

The on load tap changer control functionality is provided with the OLATCC1 function. Both manual and automatic controlling of the on load tap changer is done via OLATCC1. The controlling of the local tap changer can be done through external push button via SPCGAPC1; `SPCGAPC1_O8` input for lower request and `SPCGAPC1_O16` for raise request. The operation mode of OLATCC1 can be controlled externally by push buttons via `SPCGAPC_12` and `SPCGAPC_13`.

The binary input X105-BI2 indicating the tap changer operating information can be connected to TCO the alarm LED 10.

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

The output commands are routed to the binary outputs, the raise command is connected to X130-SO2 and the lower command is connected to X130-SO1.

The common alarm signal of OLATCC1 is connected to GOOSE binary output `MVGAPC2_IN7`.

3.5.4 Application configuration of SMV receiver

This chapter describes how to configure configuration A as an SMV receiver. For overall information about SMV engineering, see the IEC 61850 engineering guide.

This configuration includes four TVTR function blocks. If no SMV receiver is defined, all TVTRs receive voltage inputs from physical channels and provide the value to different functions.

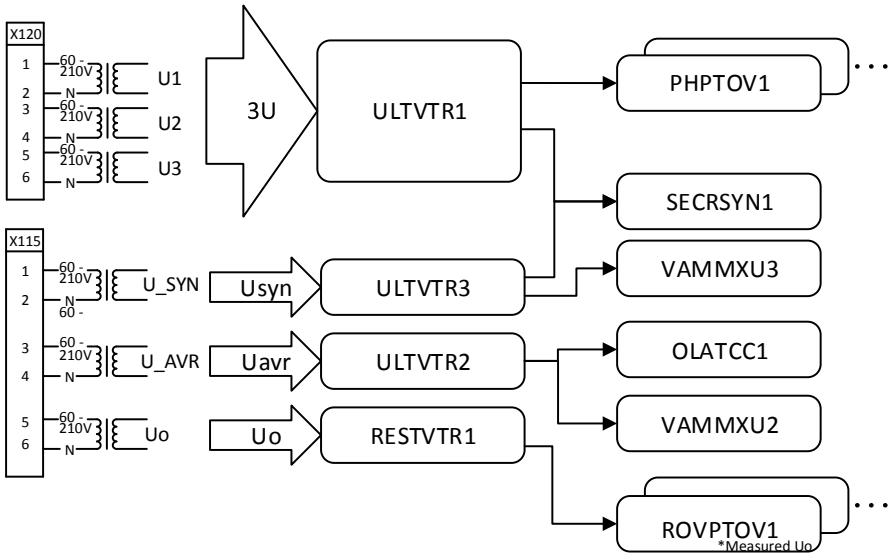


Figure 44: No SMV receiver configured

The SMV receiver application configuration is done with the Application Configuration tool in PCM600. Which physical voltage input channel is replaced by sample value voltage can be defined by connecting the SMVRCV output to different TVTR function inputs.

The IEC 61850-9-2 LE stream always contains UL1, UL2, UL3 and Uo. Thus, when the IEDs are used as senders, and the three phase-to-phase voltages and the residual voltage are connected to the hardware channels, the three phase-to-earth voltages are calculated from the input and sent through IEC 61850-9-2 LE.

The IEC 61850-9-2 LE configuration has to be done only according to the examples in this section, otherwise an engineering failure might follow.

3.5.4.1 Connection of SMVRCV to ULTVTR1

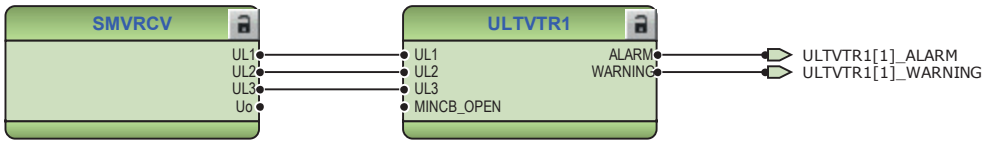


Figure 45: Connection of SMVRCV to ULTVTR1 in Application Configuration

When SMVRCV is connected to ULTVTR1 in the Application Configuration tool, ULTVTR1 is disconnected from the physical channels U1, U2 and U3 and uses three phase voltages from the received IEC 61850-9-2 LE sample value. All functions which have 3U input begin working with the IEC 61850-9-2 LE sample value.

All three signals UL1, UL2 and UL3 must always be connected between SMVRCV and ULTVTR1 in Application Configuration.

The IEC 61850-9-2 LE stream always contains UL1, UL2, UL3 and Uo. When the three phase voltage channels are received from IEC 61850-9-2 LE, the setting *VT connection* in **Configuration/Analog inputs/Voltage (3U,VT)** must be “Wye”.

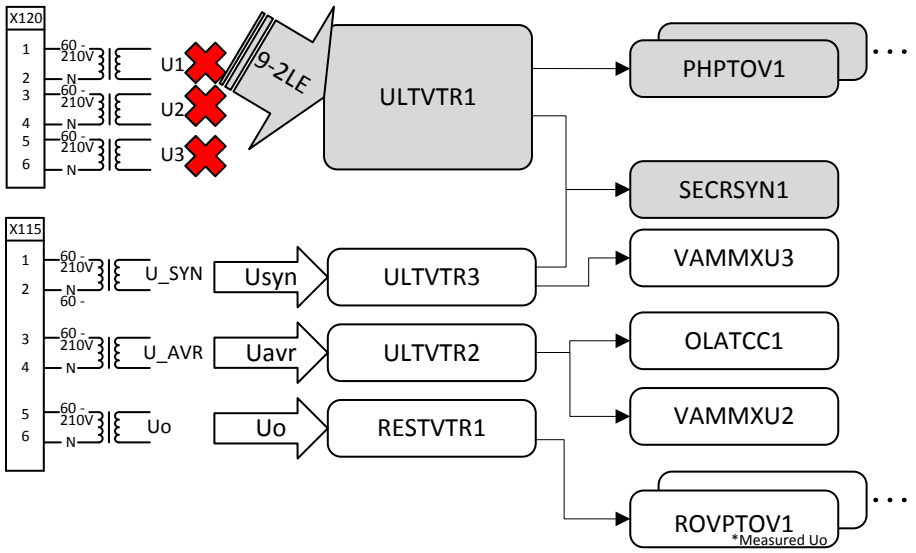


Figure 46: ULTVTR1 uses three phase voltages from received IEC 61850-9-2 LE sample value

3.5.4.2 Connection of SMVRCV to RESTVTR1

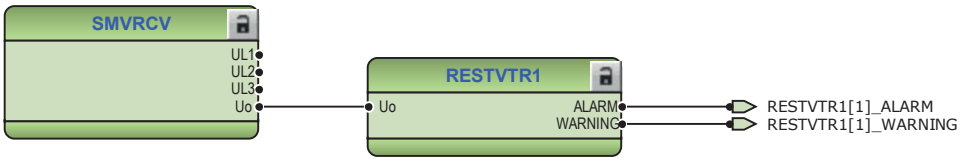


Figure 47: Connection of SMVRCV to RESTVTR1 in Application Configuration

When SMVRCV is connected to RESTVTR1 in the Application Configuration tool, RESTVTR1 is disconnected from the physical channel Uo and uses residual voltages from the received IEC 61850-9-2 LE sample value. All functions which have `Uo` input begin working with the IEC 61850-9-2 LE sample value.

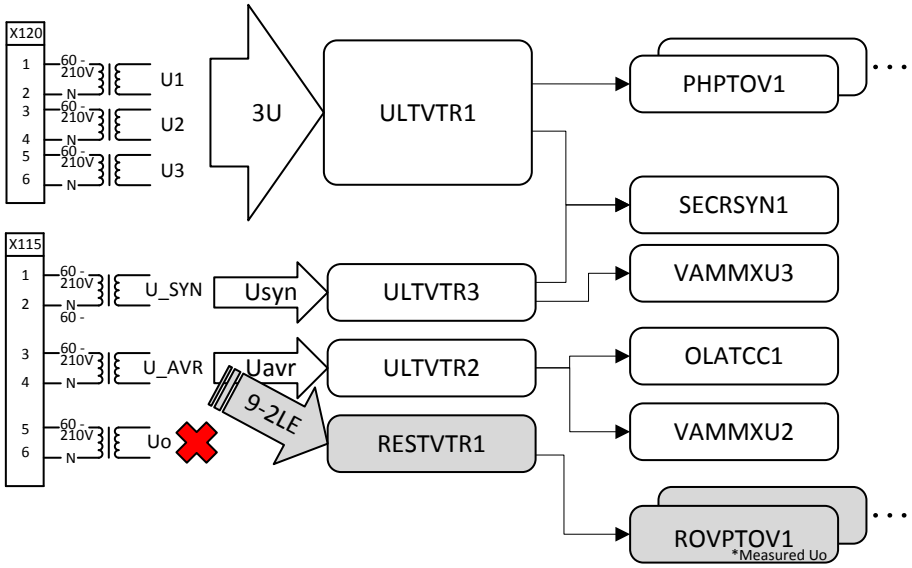


Figure 48: RESTVTR1 uses residual voltages from received IEC 61850-9-2 LE sample value

3.5.4.3 Connection of SMVRCV to both ULTVTR1 and RESTVTR1

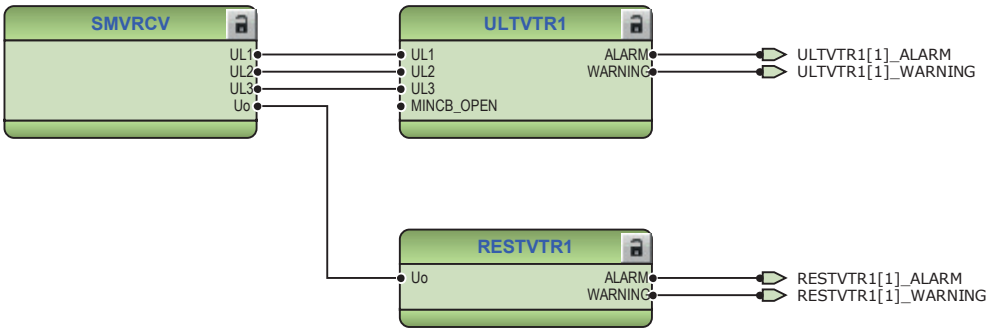


Figure 49: Connection of SMVRCV to both ULTVTR1 and RESTVTR1 in Application Configuration

SMVRCV can also be connected to both ULTVTR1 and RESTVTR1. This means that both the three phase voltages U1, U2, U3 and the residual voltage Uo are replaced by the received IEC 61850-9-2 LE sample value.

All three signals UL1, UL2 and UL3 must always be connected between SMVRCV and ULTVTR1 in Application Configuration.

The IEC 61850-9-2 LE stream always contains UL1, UL2, UL3 and Uo. When the three phase voltage channels are received from IEC 61850-9-2 LE, the setting *VT connection* in **Configuration/Analog inputs/Voltage (3U,VT)** must be “Wye”.

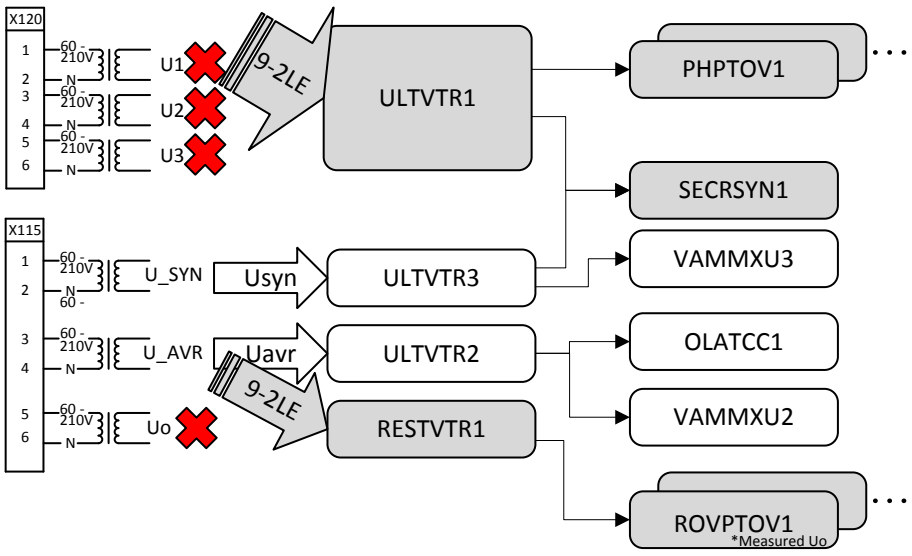


Figure 50: Both ULTVTR1 and RESTVTR1 use voltages from received IEC 61850-9-2 LE sample value

3.5.4.4 Connection of SMVRCV to ULTVTR2

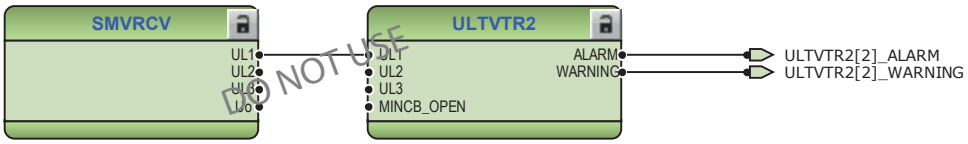


Figure 51: Connection of SMVRCV to ULTVTR2 is not supported

Connection of TVTR2 to IEC 61850-9-2 LE SMV is not supported in this release; connecting SMVRCV to TVTR2 causes a relay configuration failure.

3.5.4.5 Connection of SMVRCV to ULTVTR3

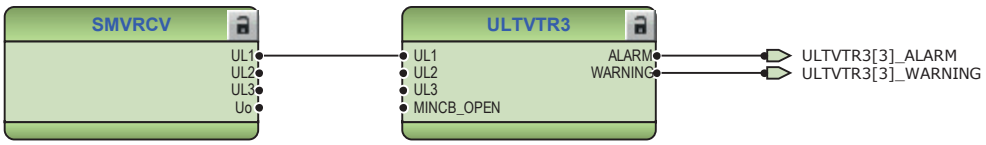


Figure 52: Connection of SMVRCV to ULTVTR3 in Application Configuration

When SMVRCV is connected to ULTVTR3 in the Application Configuration tool, ULTVTR3 is disconnected from the physical channel U_SYN and uses UL1 voltage from the received IEC 61850-9-2 LE sample value. All functions which have `U_SYN` input begin working with the IEC 61850-9-2 LE sample value.

Only UL1 must be connected between SMVRCV and ULTVTR3 in Application Configuration.

The IEC 61850-9-2 LE stream always contains UL1, UL2, UL3 and Uo. When `U_SYN` as a single channel input is received from IEC 61850-9-2 LE, the setting *VT connection* in **Configuration/Analog inputs/Voltage (3UC,VT)** must be “UL1”.

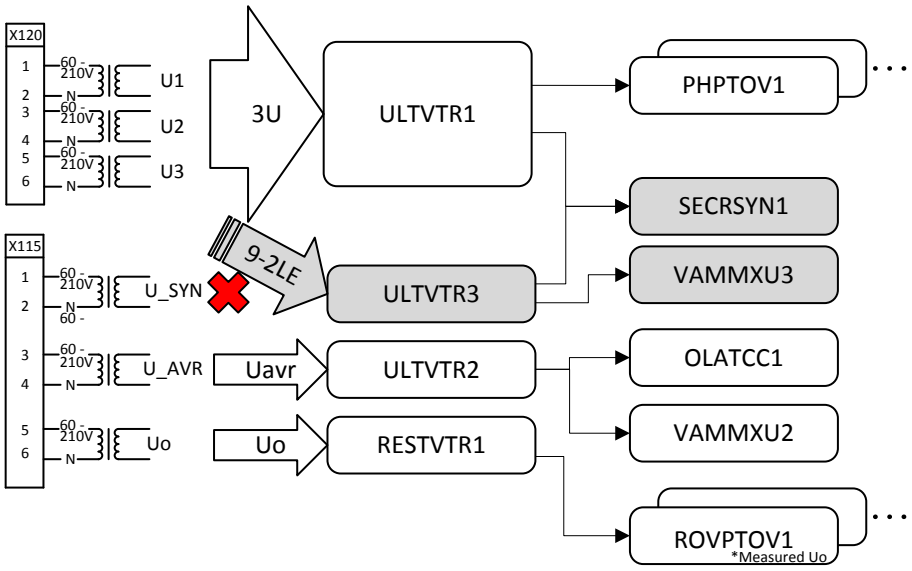


Figure 53: ULTVTR3 uses UL1 voltage from received IEC 61850-9-2 LE sample value

Section 4 IED physical connections

4.1 Inputs

4.1.1 Energizing inputs

4.1.1.1 Phase currents

The protection relay 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 26: Phase current inputs included in configuration A

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

4.1.1.2 Residual current

Table 27: Residual current input included in configuration A

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

4.1.1.3 Phase voltages

Table 28: Phase voltage inputs included in configuration A

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

Table 29: Reference voltage input for SECRSYN1 included in configuration A

Terminal	Description
X115:1-2	U_SYN

Table 30: Phase-to-phase voltage input for OLATCC1 included in configuration A

Terminal	Description
X115:3-4	U_AVR

4.1.1.4 Residual voltage

Table 31: Additional residual voltage input included in configuration A

Terminal	Description
X115:5-6	Uo

4.1.2 RTD/mA inputs

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

Table 32: RTD/mA inputs

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

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

Table 33: RTD/mA inputs

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

Terminal	Description
X105:15	Common[1)]
X105:16	Common[2)]
X105:17-18	RTD4 (AI6), + RTD4 (AI6), -
X105:19-20	RTD5 (AI7), + RTD5 (AI7), -
X105:21-22	RTD6 (AI8), + RTD6 (AI8), -

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

4.1.3 Auxiliary supply voltage input

The auxiliary voltage of the protection relay 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 protection relay.

Table 34: 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 protection relay's settings.

Binary inputs of slot X110 are available with configuration A.

Table 35: 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, -

Table continues on next page

Terminal	Description
X110:9	BI6, -
X110:10	BI6, +
X110:11	BI7, +
X110:12	BI7, -
X110:12	BI8, -
X110:13	BI8, +

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

Table 36: 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 37: 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 protection relay is provided with the optional communication module with light sensor inputs, the pre-manufactured lens-sensor fibers are connected to inputs X13, X14 and X15. See the connection diagrams.For further information, see arc protection.

The protection relay 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 a protection relay, the light sensor inputs are included in the communication module.

Table 38: 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. In the factory default configuration, the trip signals from all the protection stages are routed to PO3 and PO4.

Table 39: 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)

Table continues on next page

Terminal	Description
X100:16	PO3, NO
X100:17	PO3, NO
X100:18	PO3 (TCS1 input), NO
X100:19	PO3 (TCS1 input), NO
X100:20	PO4, NO (TCS resistor)
X100:21	PO4, NO
X100:22	PO4, NO
X100:23	PO4 (TCS2 input), NO
X100:24	PO4 (TCS2 input), NO

4.2.2 Outputs for signalling

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

Table 40: Output contacts X100:10-14

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

Output contacts of slot X110 are available with configuration A.

Table 41: Output contacts X110:14-24

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

Output contact of slot X130 is available with configuration A.

Table 42: Output contacts X130:9-18

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

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

Table 43: Output 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 44: 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 relay. Under normal operating conditions, the protection relay 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 contact X100:3-5 drops off and the contact X100:3-4 closes.

Table 45: 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

100BASE-FX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fiber optic cabling
100BASE-TX	A physical medium defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses twisted-pair cabling category 5 or higher with RJ-45 connectors
620 series	Series of numerical protection and control relays for high-end protection and supervision applications of utility substations, and industrial switchgear and equipment
AC	Alternating current
ANSI	American National Standards Institute
AR	Autoreclosing
ASCII	American Standard Code for Information Interchange
BI	Binary input
BI/O	Binary input/output
BO	Binary output
CT	Current transformer
DAN	Doubly attached node
DC	1. Direct current 2. Disconnector 3. 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
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
FIFO	First in, first out
FTP	File transfer protocol
FTPS	FTP Secure

GOOSE	Generic Object-Oriented Substation Event
HMI	Human-machine interface
HSO	High-speed output
HSR	High-availability seamless redundancy
HTTPS	Hypertext Transfer Protocol Secure
HV	High voltage
I/O	Input/output
IEC	International Electrotechnical Commission
IEC 60870-5-103	1. Communication standard for protective equipment 2. A serial master/slave protocol for point-to-point communication
IEC 61850	International standard for substation communication and modeling
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IEC 61850-9-2	A communication protocol based on the IEC 61850 standard series
IEC 61850-9-2 LE	Lite Edition of IEC 61850-9-2 offering process bus interface
IED	Intelligent electronic device
IEEE 1686	Standard for Substation Intelligent Electronic Devices' (IEDs') Cyber Security Capabilities
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.
IRIG-B	Inter-Range Instrumentation Group's time code format B
LAN	Local area network
LC	Connector type for glass fiber cable, IEC 61754-20
LCD	Liquid crystal display
LE	Light Edition
LED	Light-emitting diode
LHMI	Local human-machine interface
LV	Low voltage
MAC	Media access control
MCB	Miniature circuit breaker

MMS	1. Manufacturing message specification 2. Metering management system
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
NC	Normally closed
NO	Normally open
PCM600	Protection and Control IED Manager
PO	Power output
PRP	Parallel redundancy protocol
PTP	Precision Time Protocol
RET620	Transformer protection and control relay
RIO600	Remote I/O unit
RJ-45	Galvanic connector type
RSTP	Rapid spanning tree protocol
RTD	Resistance temperature detector
RTU	Remote terminal unit
SAN	Single 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.
SMV	Sampled measured values
SNTP	Simple Network Time Protocol
SO	Signal output
TCS	Trip-circuit supervision
VT	Voltage transformer
WAN	Wide area network
WHMI	Web human-machine interface

ABB Distribution Solutions
Distribution Automation
P.O. Box 699
FI-65101 VAASA, Finland
Phone +358 10 22 11

ABB
Nanjing SAC Power Grid Automation Co., Ltd.
No.39 Shuige Road, Jiangning District
211153 Nanjing, China
Phone +86 25 69832000
Fax +86 25 69833000

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