Relion® 620 series

Transformer Protection and Control RET620 ANSI

Application Manual

Power and productivity
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This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-6 and EN 60255-27 for the low voltage directive. The IED is designed in accordance with the international standards of the IEC 60255 series and ANSI C37.90. This IED complies with the UL 508 certification.

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 communication and protocols.

1.3 Product documentation

1.3.1 Product documentation set

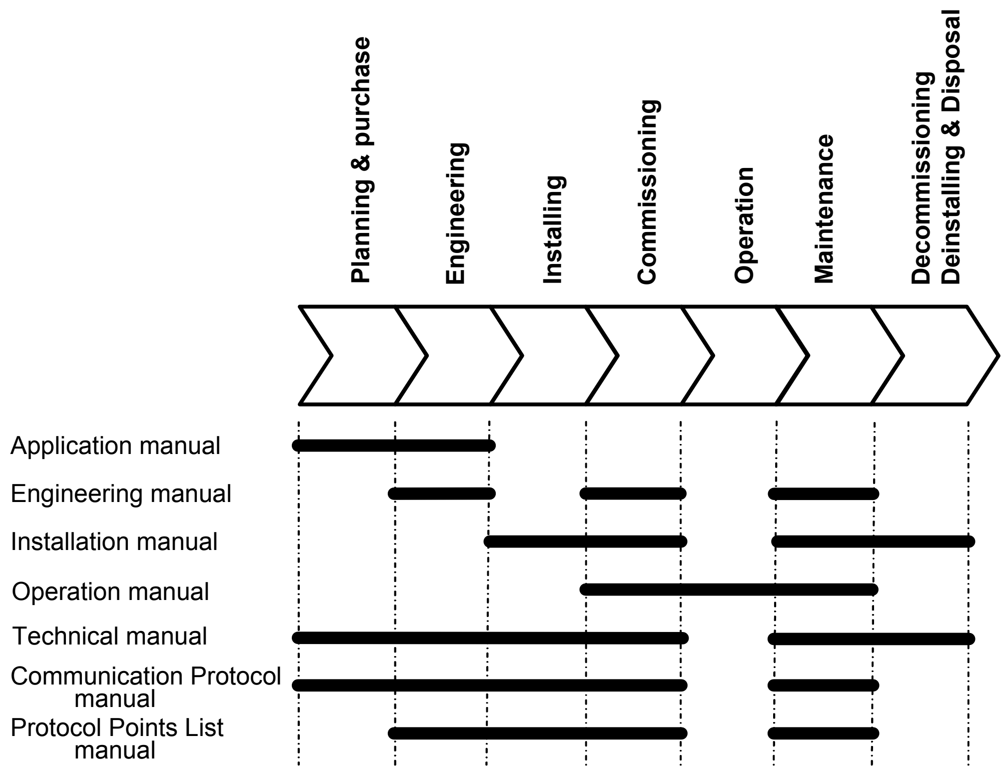


Figure 1: The intended use of manuals in different life cycles

The engineering manual contains instructions on how to engineer the IEDs using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert IEDs to the project structure. The manual also recommends a sequence for engineering of protection and control functions, LHMI functions as well as communication engineering for IEC 61850 and other supported protocols.

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

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

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

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

The communication protocol manual describes a communication protocol supported by the IED. The manual concentrates on vendor-specific implementations. The point list manual describes the outlook and properties of the data points specific to the IED. The manual should be used in conjunction with the corresponding communication protocol manual.

1.3.2 Document revision history

Document revision/date	Product version	History
A/10/26/2012	2.0	First release

Download the latest documents from the ABB web site http://www.abb.com/substation automation.

1.3.3 Related documentation

Name of the document	Document ID
Modbus Communication Protocol Manual	1MAC458836-IB
DNP3 Communication Protocol Manual	1MAC459571-IB
IEC 61850 Engineering Guide	1MAC454732-IB
Installation Manual	1MAC457436-IB
Operation Manual	1MAC456939-IB
Technical Manual	1MAC504801-IB

1.4 Symbols and conventions

1.4.1 Safety indication 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 to 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 should be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.4.2 Manual conventions

Conventions used in IED manuals. A particular convention may not be used in this manual.

- Abbreviations and acronyms in this manual are spelled out in the glossary. The glossary also contains definitions of important terms.
- Pushbutton navigation in the LHMI menu structure is presented by using the pushbutton icons, for example:
  To navigate between the options, use ↑ and ↓.
- HMI menu paths are presented in bold, for example:
  Select **Main menu** > **Settings**.
- LHMI messages are shown in Courier font, for example:
  To save the changes in non-volatile memory, select `Yes` and press ↵.
- Parameter names are shown in italics, for example:
  The function can be enabled and disabled with the *Operation* setting.
- Parameter values are indicated with quotation marks, for example:
  The corresponding parameter values are "Enabled" and "Disabled".
- IED input/output messages and monitored data names are shown in Courier font, for example:
  When the function picks up, the `PICKUP` output is set to TRUE.
- Dimensions are provided both in inches and mm. If it is not specifically mentioned then the dimension is in mm.

1.4.3 Functions, codes and symbols

All available functions are listed in the table. All of them may not be applicable to all products.

Table 1: Functions included in standard configurations, RET620

Function	IEC61850	ANSI/C37.2	IEC60617
Protection			
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	51P(1)	3I> (1)
Three-phase non-directional overcurrent protection, low stage, instance 2	PHLPTOC2	51P(2)	3I> (2)
Three-phase non-directional overcurrent protection, low stage, instance 3	PHLPTOC3	51P(3)	3I> (3)
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	50P-1(1)	3I>> (1)
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	50P-2(1)	3I>> (2)
Three-phase non-directional overcurrent protection, high stage, instance 3	PHHPTOC3	50P-1(2)	3I>> (3)
Three-phase non-directional overcurrent protection, high stage, instance 4	PHHPTOC4	50P-2(2)	3I>> (4)
Three-phase non-directional overcurrent protection, high stage, instance 5	PHHPTOC5	50P-1(3)	3I>> (5)
Three-phase non-directional overcurrent protection, high stage, instance 6	PHHPTOC6	50P-2(3)	3I>> (6)
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	67/51P(1)	3I> -> (1)
Three-phase directional overcurrent protection, low stage, instance 2	DPHLPDOC2	67/51P(2)	3I> -> (2)
Non-directional ground-fault protection, low stage, instance 1	EFLPTOC1	51G	Io> (1)
Non-directional ground-fault protection, low stage, instance 2	EFLPTOC2	51N(1)	Io> (2)
Non-directional ground-fault protection, low stage, instance 3	EFLPTOC3	51N(2)	Io> (3)
Non-directional ground-fault protection, low stage, instance 4	EFLPTOC4	51N(3)	Io> (4)
Non-directional ground-fault protection, high stage, instance 1	EFHPTOC1	50G	Io>> (1)
Non-directional ground-fault protection, high stage, instance 3	EFHPTOC3	50N-1(1)	Io>> (3)
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC4	50N-1(2)	Io>> (4)
Non-directional ground-fault protection, high stage, instance 5	EFHPTOC5	50N-1(3)	Io>> (5)
Directional ground-fault protection, low stage, instance 1	DEFLPDEF1	67/51N(1)	Io> -> (1)
Directional ground-fault protection, low stage, instance 2	DEFLPDEF2	67/51N(2)	Io> -> (2)
Three phase directional power protection, instance 1	DPSRDIR1	32P(1)	I1-> (1)
Three phase directional power protection, instance 2	DPSRDIR2	32P(2)	I1-> (2)
Ground directional power protection, instance 1	DNZSRDIR1	32N(1)	I2 ->, Io-> (1)
Ground directional power protection, instance 2	DNZSRDIR2	32N(2)	I2 ->, Io-> (2)
Negative-sequence overcurrent protection, instance 1	NSPTOC1	46(1)	I2> (1)

Function	IEC61850	ANSI/C37.2	IEC60617
Negative-sequence overcurrent protection, instance 2	NSPTOC2	46(2)	I2> (2)
Negative-sequence overcurrent protection, instance 3	NSPTOC3	46(3)	I2> (3)
Residual overvoltage protection, instance 1	ROVPTOV1	59G	Uo> (1)
Residual overvoltage protection, instance 2	ROVPTOV2	59N (1)	Uo> (2)
Residual overvoltage protection, instance 3	ROVPTOV3	59N (2)	Uo> (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	27-1(1)	3U< (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	27-2(1)	3U< (2)
Three-phase undervoltage protection, instance 3	PHPTUV3	27-1(2)	3U< (3)
Three-phase undervoltage protection, instance 4	PHPTUV4	27-2(2)	3U< (4)
Three-phase overvoltage protection, instance 1	PHPTOV1	59-1(1)	3U> (1)
Three-phase overvoltage protection, instance 2	PHPTOV2	59-2(1)	3U> (2)
Three-phase overvoltage protection, instance 3	PHPTOV3	59-1(2)	3U> (3)
Three-phase overvoltage protection, instance 4	PHPTOV4	59-2(2)	3U> (4)
Negative-sequence overvoltage protection, instance 1	NSPTOV1	47-1(1)	U2> (1)
Negative-sequence overvoltage protection, instance 2	NSPTOV2	47-2(1)	U2> (2)
Negative-sequence overvoltage protection, instance 3	NSPTOV3	47-1(2)	U2> (3)
Negative-sequence overvoltage protection, instance 4	NSPTOV4	47-2(2)	U2> (4)
Frequency protection, instance 1	FRPFRQ1	81-1(1)	f>/f<,df/dt (1)
Frequency protection, instance 2	FRPFRQ2	81-2(1)	f>/f<,df/dt (2)
Frequency protection, instance 3	FRPFRQ3	81-1(2)	f>/f<,df/dt (3)
Frequency protection, instance 4	FRPFRQ4	81-2(2)	f>/f<,df/dt (4)
Voltage per hertz protection, instance 1	OEPVPH1	24-1(1)	U/f> (1)
Voltage per hertz protection, instance 2	OEPVPH2	24-2(1)	U/f> (2)
Voltage per hertz protection, instance 3	OEPVPH3	24-1(2)	U/f> (3)
Voltage per hertz protection, instance 4	OEPVPH4	24-2(2)	U/f> (4)
Three-phase thermal overload protection for power transformers, two time constants	T2PTTR1	49T(1)	3Ith>T
Stabilized and instantaneous differential protection for 3W -Transformers	TR3PTDF1	87T	3dI>T
Numerical stabilized low impedance restricted ground-fault protection	LREFPNDF1	87LOZREF (2)	dIoLo>
Circuit breaker failure protection, instance 1	CCBRBRF1	50BF(1)	3I>/Io>BF (1)
Circuit breaker failure protection, instance 2	CCBRBRF2	50BF(2)	3I>/Io>BF (2)
Circuit breaker failure protection, instance 3	CCBRBRF3	50BF(3)	3I>/Io>BF (3)
Master trip, instance 1	TRPPTRC1	86/94-1	Master Trip (1)
Master trip, instance 2	TRPPTRC2	86/94-2	Master Trip (2)

Function	IEC61850	ANSI/C37.2	IEC60617
Master trip, instance 3	TRPPTRC3	86/94-3	Master Trip (3)
Arc protection, instance 1	ARCSARC1	AFD-1(2)	ARC (1)
Arc protection, instance 2	ARCSARC2	AFD-2(2)	ARC (2)
Arc protection, instance 3	ARCSARC3	AFD-3(2)	ARC (3)
Load shedding and restoration, instance 1	LSHDPFRQ1	81LSH-1(1)	UFLS/R (1)
Load shedding and restoration, instance 2	LSHDPFRQ2	81LSH-2(1)	UFLS/R (2)
Load shedding and restoration, instance 3	LSHDPFRQ3	81LSH-3(1)	UFLS/R (3)
Load shedding and restoration, instance 4	LSHDPFRQ4	81LSH-4(1)	UFLS/R (4)
Load shedding and restoration, instance 5	LSHDPFRQ5	81LSH-1(2)	UFLS/R (5)
Load shedding and restoration, instance 6	LSHDPFRQ6	81LSH-2(2)	UFLS/R (6)
Load shedding and restoration, instance 7	LSHDPFRQ7	81LSH-3(2)	UFLS/R (7)
Load shedding and restoration, instance 8	LSHDPFRQ8	81LSH-4(2)	UFLS/R (8)
RTD based thermal protection, instance 1	MAPGAPC1	38-1	ThA> ThB>
RTD based thermal protection, instance 2	MAPGAPC2	38-2	ThA> ThB>
RTD based thermal protection, instance 3	MAPGAPC3	38-3	ThA> ThB>
Loss of phase, instance 1	PHPTUC1	37(1)	3I< (1)
Loss of phase, instance 2	PHPTUC2	37(2)	3I< (2)
Loss of phase, instance 3	PHPTUC3	37(3)	3I< (3)
Control			
Circuit-breaker control, instance 1	CBXCBR1	52(1)	I <-> O CB (1)
Circuit-breaker control, instance 2	CBXCBR2	52(2)	I <-> O CB (2)
Circuit-breaker control, instance 3	CBXCBR3	52(3)	I <-> O CB (3)
Condition Monitoring			
Circuit-breaker condition monitoring, instance 1	SSCBR1	52CM(1)	CBCM (1)
Circuit-breaker condition monitoring, instance 2	SSCBR2	52CM(2)	CBCM (2)
Circuit-breaker condition monitoring, instance 3	SSCBR3	52CM(3)	CBCM (3)
Trip circuit supervision, instance 1	TCSSCBR1	TCM-1	TCS (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCM-2	TCS (2)
Trip circuit supervision, instance 3	TCSSCBR3	TCM-3	TCS (3)
Advanced current circuit supervision for transformers	CTSRCTF1	MCS 3I, I2	MCS 3I, I2
Fuse failure supervision, instance 1	SEQRFUF1	60(1)	FUSEF (1)
Fuse failure supervision, instance 2	SEQRFUF2	60(2)	FUSEF (2)
Measurement			

Function	IEC61850	ANSI/C37.2	IEC60617
Three-phase current measurement, instance 1	CMMXU1	IA, IB, IC(1)	3I
Three-phase current measurement, instance 2	CMMXU2	IA, IB, IC(2)	3I(B)
Three-phase current measurement, instance 3	CMMXU3	IA, IB, IC(3)	3I(C)
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0(1)	I1, I2, I0
Sequence current measurement, instance 2	CSMSQI2	I1, I2, I0(2)	I1, I2, I0(B)
Sequence current measurement, instance 3	CSMSQI3	I1, I2, I0(3)	I1, I2, I0(C)
Residual current measurement, instance 1	RESCMMXU1	IG	Io
Three-phase voltage measurement, instance 1	VMMXU1	VA, VB, VC(1)	3U
Three-phase voltage measurement, instance 2	VMMXU2	VA, VB, VC (2)	3U(B)
Residual voltage measurement, instance 1	RESVMMXU1	VG	Uo
Residual voltage measurement, instance 2	RESVMMXU2	VG	Uo(B)
Sequence voltage measurement, instance 1	VSMSQI1	V1, V2, V0(1)	U1, U2, U0
Sequence voltage measurement, instance 2	VSMSQI2	V1, V2, V0 (2)	U1, U2, U0(B)
Single-phase power and energy measurement, instance 1	SPEMMXU1	SP, SE(1)	SP, SE
Single-phase power and energy measurement, instance 2	SPEMMXU2	SP, SE(2)	SP, SE(B)
Three-phase power and energy measurement, instance 1	PEMMXU1	P, E(1)	P, E
Three-phase power and energy measurement, instance 2	PEMMXU2	P, E(2)	P, E(B)
Load profile	LDPMSTA1	LoadProf	-
Frequency measurement, instance 1	FMMXU1	f	f
Frequency measurement, instance 2	FMMXU2	f	f
Tap changer position indication	TPOSSLTC1	84T	TPOSM
Recorder			
Disturbance recorder	RDRE1	DFR	DR
Fault recorder	FLTMSTA1	FR	FR
Sequence event recorder	SER	SER	SER
Other Functions			
Minimum pulse timer (2 pcs), instance 1	TPGAPC1	TP-1	TP (1)
Minimum pulse timer (2 pcs), instance 2	TPGAPC2	TP-2	TP (2)
Minimum pulse timer (2 pcs), instance 3	TPGAPC3	TP-3	TP (3)
Minimum pulse timer (2 pcs), instance 4	TPGAPC4	TP-4	TP (4)
Pulse timer (8 pcs), instance 1	PTGAPC1	PT-1	PT (1)
Pulse timer (8 pcs), instance 2	PTGAPC2	PT-2	PT (2)
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF-1	TOF (1)
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF-2	TOF (2)
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF-3	TOF (3)
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF-4	TOF (4)

Function	IEC61850	ANSI/C37.2	IEC60617
Time delay on (8 pcs), instance 1	TONGAPC1	TON -1	TON (1)
Time delay on (8 pcs), instance 2	TONGAPC2	TON -2	TON (2)
Time delay on (8 pcs), instance 3	TONGAPC3	TON -3	TON (3)
Time delay on (8 pcs), instance 4	TONGAPC4	TON -4	TON (4)
Set reset (8 pcs), instance 1	SRGAPC1	SR-1	SR (1)
Set reset (8 pcs), instance 2	SRGAPC2	SR-2	SR (2)
Set reset (8 pcs), instance 3	SRGAPC3	SR-3	SR (3)
Set reset (8 pcs), instance 4	SRGAPC4	SR-4	SR (4)
Move (8 pcs), instance 1	MVGAPC1	MV-1	MV (1)
Move (8 pcs), instance 2	MVGAPC2	MV-2	MV (2)
Move (8 pcs), instance 3	MVGAPC3	MV-3	MV (3)
Move (8 pcs), instance 4	MVGAPC4	MV-4	MV (4)
Move (8 pcs), instance 5	MVGAPC5	MV-5	MV (5)
Move (8 pcs), instance 6	MVGAPC6	MV-6	MV (6)
Move (8 pcs), instance 7	MVGAPC7	MV-7	MV (7)
Move (8 pcs), instance 8	MVGAPC8	MV-8	MV (8)
Generic control points, instance 1	SPCGGIO1	CNTRL-1	SPC(1)
Generic control points, instance 2	SPCGGIO2	CNTRL-2	SPC(2)
Generic control points, instance 3	SPCGGIO3	CNTRL-3	SPC(3)
Remote Generic control points, instance 1	SPCRGGIO1	RCNTRL-1	SPCR(1)
Local Generic control points, instance 1	SPCLGGIO1	LCNTRL-1	SPCL(1)
Generic Up-Down Counters, instance 1	UDFCNT1	CTR-1	CTR(1)
Generic Up-Down Counters, instance 2	UDFCNT2	CTR-2	CTR(2)
Generic Up-Down Counters, instance 3	UDFCNT3	CTR-3	CTR(3)
Generic Up-Down Counters, instance 4	UDFCNT4	CTR-4	CTR(4)
Generic Up-Down Counters, instance 5	UDFCNT5	CTR-5	CTR(5)
Generic Up-Down Counters, instance 6	UDFCNT6	CTR-6	CTR(6)
Generic Up-Down Counters, instance 7	UDFCNT7	CTR-7	CTR(7)
Generic Up-Down Counters, instance 8	UDFCNT8	CTR-8	CTR(8)
Generic Up-Down Counters, instance 9	UDFCNT9	CTR-9	CTR(9)
Generic Up-Down Counters, instance 10	UDFCNT10	CTR-10	CTR(10)
Generic Up-Down Counters, instance 11	UDFCNT11	CTR-11	CTR(11)
Generic Up-Down Counters, instance 12	UDFCNT12	CTR-12	CTR(12)
Programmable buttons (16 buttons), instance 1	FKEYGGIO1	FKEY	FKEY

Section 2 RET620 overview

2.1 Overview

RET620 is a dedicated transformer protection and control IED (intelligent electronic device) designed for power transformers, unit and step-up transformers including power generator transformer blocks in utility and industrial distribution systems. RET620 is a member of ABB's Relion® product family and part of its 620 protection and control product series. The 620 series IEDs are characterized by their compactness and withdrawable design.

Re-engineered from the ground up, the 620 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices.

The IED provides main protection for 2 winding and 3 winding Power transformers in distribution networks. The IED is also used as back-up protection in applications, where an independent and redundant protection system is required.

Once the standard configuration IED has been given the application-specific settings, it can directly be put into service.

The 620 series IEDs support a range of communication protocols including IEC 61850 with GOOSE messaging, Modbus® and DNP3.

2.1.1 Product version history

Product version	Product history
2.0	Product released

2.1.2 PCM600 and IED connectivity package version

- Protection and Control IED Manager PCM600 Ver. 2.4.1
- IED Connectivity Package RET620 Ver. 2.0 ANSI or later
  - Parameter Setting
  - Application Configuration
  - Firmware Update
  - Disturbance Handling
  - Signal Monitoring
  - Lifecycle Traceability
  - Signal Matrix

- Communication Management
- Configuration Wizard
- Label Printing
- IED User Management
- IED Users

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

2.2 Physical hardware

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

Figure 2: Front view of RET620

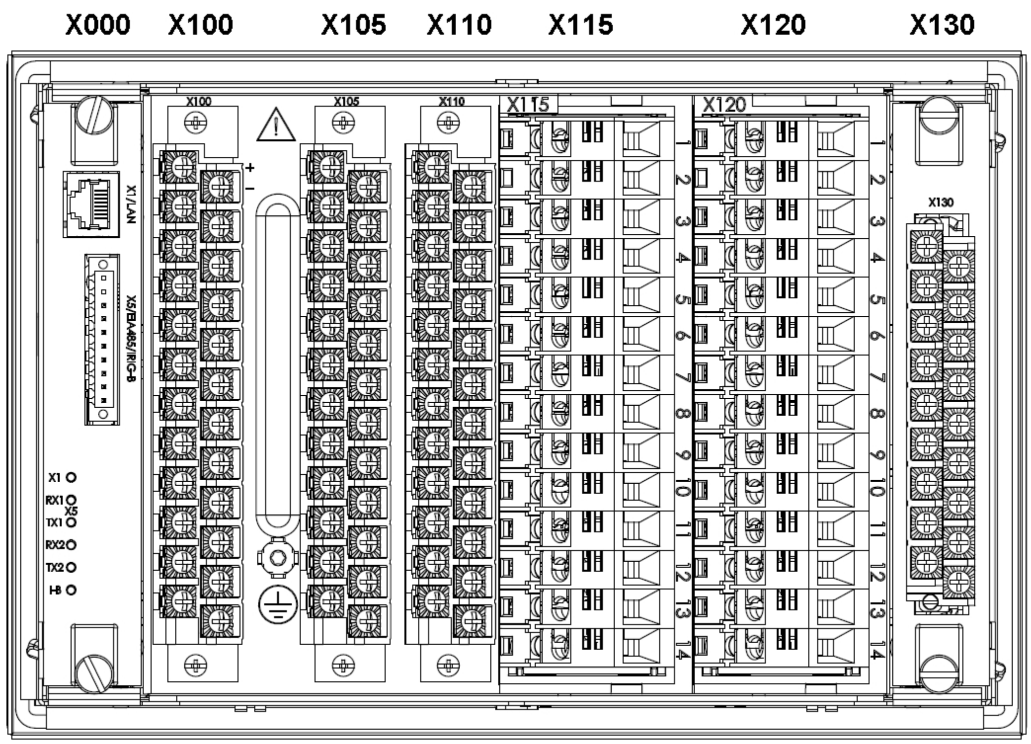


Figure 3: Rear view of RET620 with all slots equipped, with slot ID's indicated on top

Table 2: Plug-in unit and case (RET620)

Main unit	Slot ID	Module ID	Content options	
Plug in unit	-	DISxxxx	HMI	128/128 LCD large display with text and graphics
	X100	PSM0004 Or PSM0003	Auxiliary power/BO module	48-250V DC/ 80-240V AC; or 24-60V DC 2 normally-open PO contacts 2 normally-open SO contacts 2 double-pole PO contacts with TCS 1 dedicated internal fault output contact
	X105	Blank Module		Not equipped by default but alternatively may be equipped either of the two options indicated below
		BIO0005	BI/O module	Optional with some of the ordering codes 8 Binary Inputs 4 Binary Outputs
		BIO0007	BI/O module	May be alternatively equipped with high-speed BIO module (only when X110 is equipped with high-speed BIO) 8 Binary Inputs 3 High speed PO contacts
	X110	BIO0005	BI/O module	Equipped as default minimum; 8 Binary Inputs 4 Binary Outputs
		BIO0007		May be alternatively equipped with high-speed BIO card 8 Binary Inputs 3 High speed PO contacts
	X115	AIM0010	AI module	With all configurations as standard 3 phase current Inputs (1/5A) 3 phase voltage inputs 1 phase voltage input
	X120	AIM0005	AI module	With all Configurations as standard 3 phase current Inputs (1/5A) 3 phase current Inputs (1/5A) 1 phase current input (1/5A)
Case	X130	RTD0002	RTD, mA input, BO module	With configuration BA and BB 2 RTD inputs 1 low current (0.1ma-20mA) inputs 2 normally open signal outputs 1 Normally open TO contact with TCS
				With configuration AA and AB 2 normally open signal outputs 1 normally open TO contact with TCS
	X000		Communication module	See technical manual for details about different type of communication modules. IEC61850 DNP3 Modbus

Order Code Digit	Ex: NATBBABA…..	1	2	3	4	5	6	7	8
	Description	N	A	T	B	B	A	B	A
1) Product Series	620 series (Includes case)	N							
2) Standard	ANSI		A						
3) Main Appl	Transformer protection and control			T					
4) Configuration	A: Differential, overexcitation, overcurrent, voltage (winding 1 or 2) and frequency protection and power system metering for two- or three-winding transformers				A				
	B: Differential, overexcitation overcurrent, voltage (winding 1 or 2), frequency and RTD protection and power system metering for two- or three-winding transformers				B				

5-6) Analog Inputs		Slot X130 Type		Slot X120 Type		Slot X115 Type		5	6
	10 CT + 4 VT [W2]	RTD 0002	1TO (TCS,M25) + 2*SO	AIM 0005	7 CT	AIM 0010	3 CT + 4VT	A	A
	10 CT + 4 VT [W1]	RTD 0002	1TO (TCS,M25) + 2*SO	AIM 0005	7 CT	AIM 0010	3 CT + 4VT	A	B
	10 CT + 4 VT [W2] + 2 RTD	RTD 0002	2*RTD+1mA + 1TO (TCS,M25) + 2*SO	AIM 0005	7 CT	AIM 0010	3 CT + 4 VT	B	A
	10 CT + 4 VT [W1] + 2 RTD	RTD 0002	2*RTD+1mA + 1TO (TCS,M25) + 2*SO	AIM 0005	7 CT	AIM 0010	3 CT + 4 VT	B	B

7-8) Binary I/O	1)	Slot X110 Type		Slot X105 Type		7	8
	8 BI + 9 BO + 3 HSO	BIO0 007	8 BI + 3 HSO			A	1
	8 BI + 13 BO	BIO0 005	8 BI + 4 BO			A	A
	16 BI + 9 BO + 6 HSO	BIO0 007	8 BI + 3 HSO	BIO 0007	8 BI + 3 HSO	A	2
	16 BI + 13 BO + 3 HSO	BIO0 007	8 BI + 3 HSO	BIO 0005	8 BI + 4 BO	A	3
	16 BI + 17 BO	BIO0 005	8 BI + 4 BO	BIO 0005	8 BI + 4 BO	A	B
	8 BI + 9 BO + 3 HSO	BIO0 007	8 BI + 3 HSO			B	1
	8 BI + 13 BO	BIO0 005	8 BI + 4 BO			B	A
	16 BI + 9 BO + 6 HSO	BIO0 007	8 BI + 3 HSO	BIO 0007	8 BI + 3 HSO	B	2
	16 BI + 13 BO + 3 HSO	BIO0 007	8 BI + 3 HSO	BIO 0005	8 BI + 4 BO	B	3
	16 BI + 17 BO	BIO0 005	8 BI + 4 BO	BIO 0005	8 BI + 4 BO	B	B

Notes: 1) Total Binary I/O includes those provided in Power Supply card (Slot X100) and Analog input card (Slot X130) in addition to IO cards (Slots X105 and X110) as applicable

Figure 4: Ordering and corresponding equipment in various slot ID's

The rated input levels are selected in the IED software for phase current and ground current. The binary input thresholds 18...176 V DC are selected by adjusting the IED's parameter settings.

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.

2.3 Local HMI

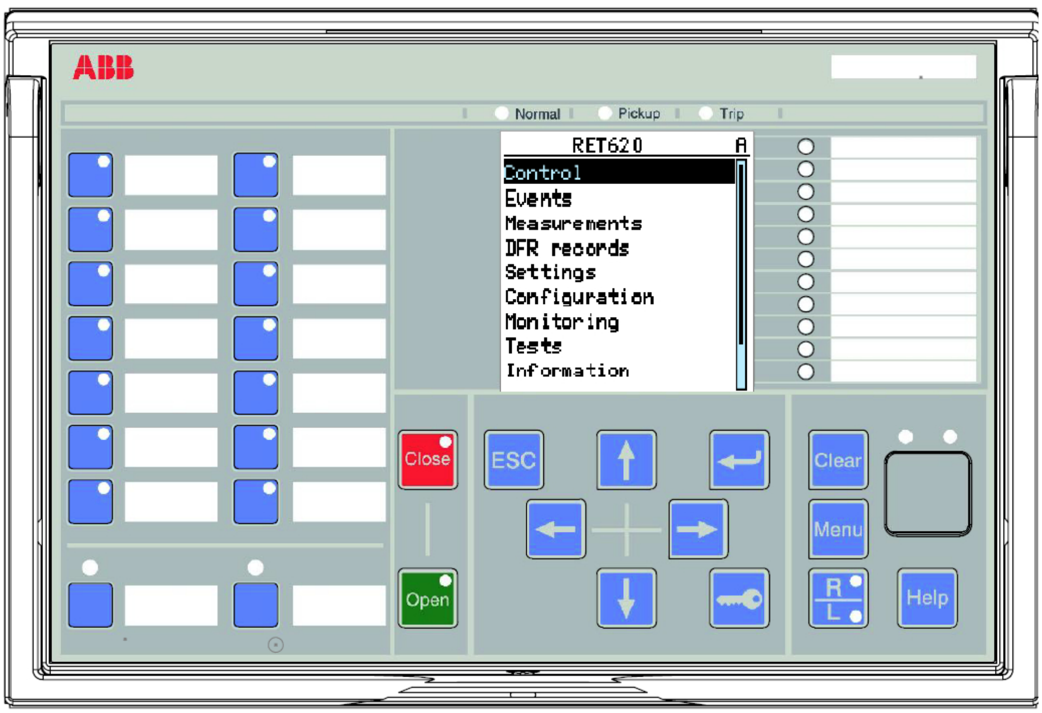


Figure 5: LHMI

The LHMI of the IED contains the following elements:

- Display
- Buttons
- LED indicators
- Communication port

The LHMI is used for setting, monitoring and controlling.

2.3.1 LCD

The LHMI includes a graphical LCD that supports two character sizes. The character size depends on the selected language.

Table 3: Characters and rows on the view

Character size	Rows in view	Characters on row
Large, variable width (13x14 pixels)	10 rows 8 rows with large screen	min 8

The display view is divided into four basic areas.

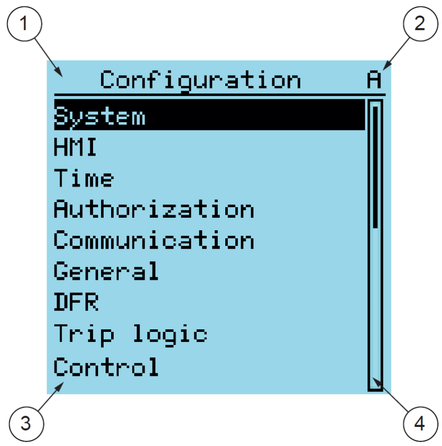


Figure 6: Display layout

1. Header

2. Icon

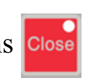
3. Content

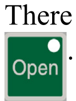
4. Scroll bar (displayed when needed)

2.3.2 LEDs

The LHMI includes three protection indicators above the display: Normal, Pickup and Trip.

There are also 11 matrix programmable alarm 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.

There are two additional LEDs which are embedded into the control buttons 

and 

. They represent the status of the circuit breaker.

2.3.3 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 one primary object, for example, a circuit breaker, disconnector or switch. The push-buttons are also used to acknowledge alarms, reset indications, provide help and switch between local and remote control mode.

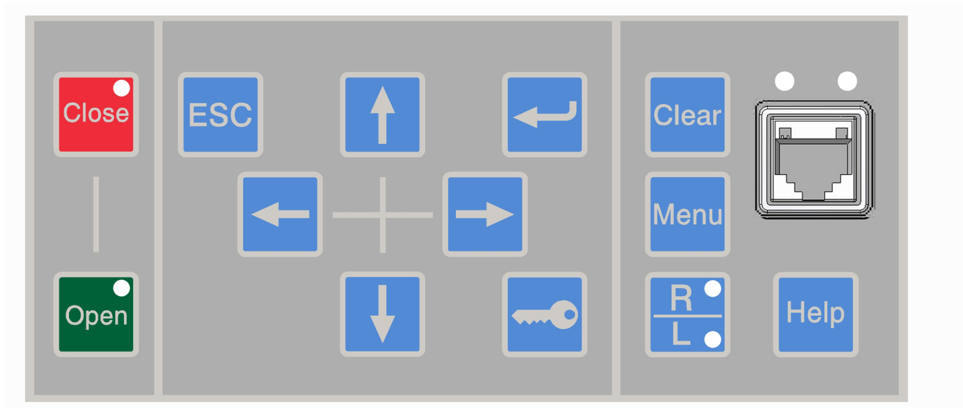


Figure 7: LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port

2.3.4 Programmable pushbuttons and LEDs

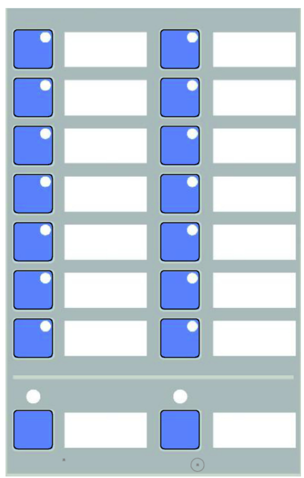


Figure 8: Programmable pushbuttons with LEDs

On the left portion of the IED, the LHMI keypad has totally sixteen programmable pushbuttons with 'Red' LEDs.   Two of these pushbuttons, located at the bottom portion, have the LEDs located on top of the buttons, while the remaining fourteen buttons have the LEDs embedded on top right corners within the pushbuttons.

The pushbuttons and the lamps are freely programmable and can be configured to not only select an operation but also get acknowledgement back from the internal logic that the action has been executed through the LEDs associated with the pushbuttons. The combination is very useful, typically for quickly selecting or changing setting groups, selection and operation of equipment, indicating field contact status, indication and acknowledging of individual alarms etc. Independent of the pushbuttons, the LEDs may also be independently configured for general indication or important alarms to draw operator's attention

The bottom two buttons with lamps are typically used for Hotline Tag and emergency operation of the circuit which is controlled by the IED.

The space to the right side of the buttons is meant for providing a description of the functionality of each button. One can insert a sheet of paper with appropriate text behind a transparent film provided on the LHMI for this purpose.

2.4 Web HMI

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

WHMI is enabled by default.

WHMI offers several functions.

- Alarm indications and event lists
- System supervision
- Parameter settings
- Measurement display
- Oscillographic records
- Phasor diagram

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

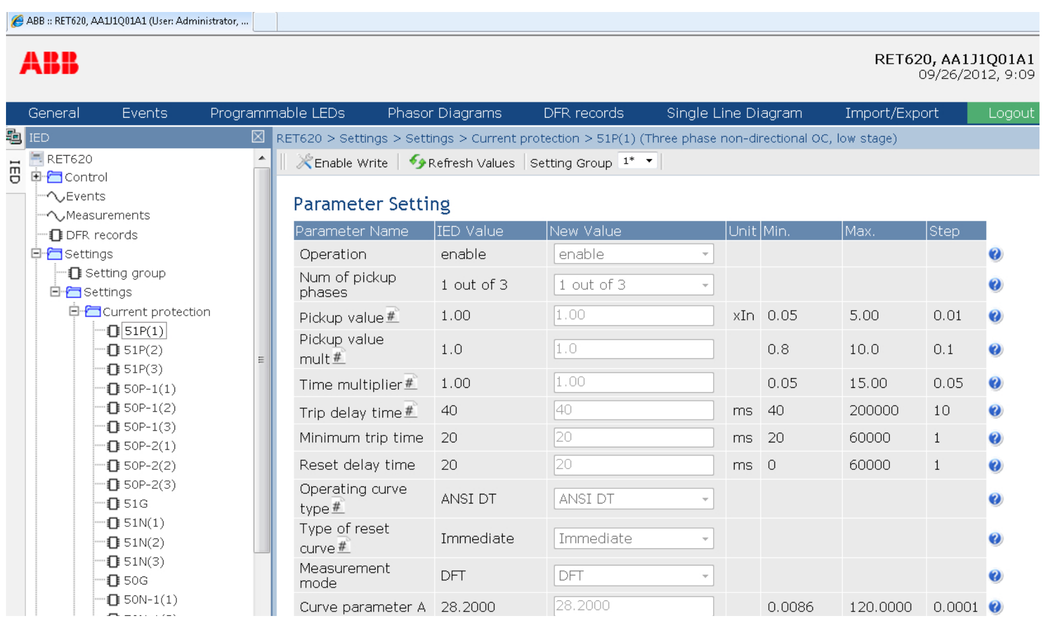


Figure 9: Example view of the WHMI

The WHMI can be accessed locally and remotely.

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

2.5 Authorization

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

The default passwords can be changed with Administrator user rights.

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

Table 4: Predefined user categories

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

For user authorization for PCM600, see PCM600 documentation.

2.6 Communication

The IED supports different communication protocols: IEC 61850, Modbus® and DNP 3.0 Level 2 - all using TCP/IP. DNP3 and Modbus also support serial communication. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal peer-to-peer communication between the IEDs and parameters setting, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter setting and DFR records can be accessed using the IEC 61850 protocol. Oscillographic files are available to any Ethernet-based application in the standard COMTRADE format. Further, the IED can send and receive binary signals from other IEDs (so called horizontal communication) using the IEC61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported.

Also, the IED supports sending and receiving of analog values using GOOSE messaging. The IED meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. The IED can simultaneously report events to five different clients on the station bus.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The IED can be connected to Ethernet-based communication systems via the RJ-45 connector (100BASE-TX) or the fiber-optic LC connector (100BASE-FX). An optional serial interface is available for RS-232/RS-485 communication.

Section 3 RET620 configurations

3.1 RET620 variant list

RET620 is intended for protection and control mainly in MV transformer applications. The product has four standard configurations covering a wide range of primary circuit configurations in such networks based on different system grounding methods.

Some of the functions included in the IED's standard configurations are optional at the time of placing the order. The description of standard configurations covers the full functionality including options, presenting the functionality, flexibility and external connections of RET620 with a specific configuration as delivered from the factory.

3.2 Presentation of standard configurations

Functional diagrams

The functional diagrams describe the IED's functionality from the protection, measuring, condition monitoring, 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 is towards the outgoing transformer, away from the bus bar.

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 ANSI function number/acronym, but the IEC based symbol and the IEC 61850 names are also included. Some function blocks are used several times in the configuration. To separate the blocks from each other, the IEC 61850 name and ANSI function number are appended with a running number, that is an instance number, from one upwards. The IED's internal functionality and the external connections are separated with a dashed line presenting the IED's physical casing.

Signal matrix

With Signal Matrix in PCM600 the user can modify the standard configuration according to the actual needs. The IED is delivered from the factory with default connections described in the functional diagrams for BI's, BO's, function to function connections and alarm LEDs. Signal Matrix has a number of different page views, designated as follows:

- Binary input
- Binary output
- Functions

There are six IED variant-specific setting groups. Parameters can be set independently for each setting group.

The active setting group (1...6) can be changed with a parameter. The active setting group can also be changed via a binary input if the binary input is enabled for this. To enable the change of the active setting group via a binary input, connect a free binary input with PCM600 to the BI_SG_x input of the Protection block.

Table 5: Binary input states and corresponding active setting groups

BI state	Active setting group
OFF	1
ON	2

The active setting group defined by a parameter is overridden when a binary input is enabled for changing the active setting group.

3.2.1 Standard configurations

The transformer protection IED RET620 is available with four alternative standard configurations.

Table 6: Standard configurations (RET620)

Description	Functional application configuration
Differential, overexcitation, overcurrent, voltage (winding 1 or 2) and frequency protection and power system metering for two- or three-winding transformers	A
Differential, overexcitation, overcurrent, voltage (winding 1 or 2) and frequency and RTD protection and power system metering for two- or three-winding transformers	B

Table 7: Supported functions

Standard configuration functionality	A	B	A	B	ANSI/C37.2 - 2008
	AA	BA	AB	BB	RET
Protection					
Three-phase non-directional overcurrent protection, low stage, instance 1	•	•	•	•	51P(1)
Three-phase non-directional overcurrent protection, low stage, instance 2	•	•	•	•	51P(2)
Three-phase non-directional overcurrent protection, low stage, instance 3	•	•	•	•	51P(3)
Three-phase non-directional overcurrent protection, high stage, instance 1	•	•	•	•	50P-1(1)
Three-phase non-directional overcurrent protection, high stage, instance 2	•	•	•	•	50P-2(1)
Three-phase non-directional overcurrent protection, high stage, instance 3	•	•	•	•	50P-1(2)
Three-phase non-directional overcurrent protection, high stage, instance 4	•	•	•	•	50P-2(2)
Three-phase non-directional overcurrent protection, high stage, instance 5	•	•	•	•	50P-1(3)
Three-phase non-directional overcurrent protection, high stage, instance 6	•	•	•	•	50P-2(3)
Three-phase directional overcurrent protection, low stage, instance 1	-	-	•	•	67/51P(1)
Three-phase directional overcurrent protection, low stage, instance 2	•	•	-	-	67/51P(2)
Non-directional ground-fault protection, low stage, instance 1	•	•	•	•	51G
Non-directional ground-fault protection, low stage, instance 2	•	•	•	•	51N(1)
Non-directional ground-fault protection, low stage, instance 3	•	•	•	•	51N(2)
Non-directional ground-fault protection, low stage, instance 4	•	•	•	•	51N(3)
Non-directional ground-fault protection, high stage, instance 1	•	•	•	•	50G
Non-directional ground-fault protection, high stage, instance 3	•	•	•	•	50N-1(1)
Non-directional ground-fault protection, high stage, instance 4	•	•	•	•	50N-1(2)
Non-directional ground-fault protection, high stage, instance 5	•	•	•	•	50N-1(3)
Directional ground-fault protection, low stage, instance 1	-	-	•	•	67/51N(1)
Directional ground-fault protection, low stage, instance 2	•	•	-	-	67/51N(2)
Three phase directional power protection, instance 1	-	-	•	•	32P(1)
Three phase directional power protection, instance 2	•	•	-	-	32P(2)
Ground directional power protection, instance 1	-	-	•	•	32N(1)
Ground directional power protection, instance 2	•	•	-	-	32N(2)
Negative-sequence overcurrent protection, instance 1	•	•	•	•	46(1)

Standard configuration functionality	A	B	A	B	ANSI/C37.2 - 2008
	AA	BA	AB	BB	RET
Negative-sequence overcurrent protection, instance 2	●	●	●	●	46(2)
Negative-sequence overcurrent protection, instance 3	●	●	●	●	46(3)
Residual overvoltage protection, instance 1	●	●	●	●	59G
Residual overvoltage protection, instance 2	-	-	●	●	59N(1)
Residual overvoltage protection, instance 3	●	●	-	-	59N(2)
Three-phase undervoltage protection, instance 1	-	-	●	●	27-1(1)
Three-phase undervoltage protection, instance 2	-	-	●	●	27-2(1)
Three-phase undervoltage protection, instance 3	●	●	-	-	27-1(2)
Three-phase undervoltage protection, instance 4	●	●	-	-	27-2(2)
Three-phase overvoltage protection, instance 1	-	-	●	●	59-1(1)
Three-phase overvoltage protection, instance 2	-	-	●	●	59-2(1)
Three-phase overvoltage protection, instance 3	●	●	-	-	59-1(2)
Three-phase overvoltage protection, instance 4	●	●	-	-	59-2(2)
Negative-sequence overvoltage protection, instance 1	-	-	●	●	47-1(1)
Negative-sequence overvoltage protection, instance 2	-	-	●	●	47-2(1)
Negative-sequence overvoltage protection, instance 3	●	●	-	-	47-1(2)
Negative-sequence overvoltage protection, instance 4	●	●	-	-	47-2(2)
Frequency protection, instance 1	-	-	●	●	81-1(1)
Frequency protection, instance 2	-	-	●	●	81-2(1)
Frequency protection, instance 3	●	●	-	-	81-1(2)
Frequency protection, instance 4	●	●	-	-	81-2(2)
Voltage per hertz protection, instance 1	-	-	●	●	24-1(1)
Voltage per hertz protection, instance 2	-	-	●	●	24-2(1)
Voltage per hertz protection, instance 3	●	●	-	-	24-1(2)
Voltage per hertz protection, instance 4	●	●	-	-	24-2(2)
Three-phase thermal protection for power transformer, two time constants	●	●	●	●	49T
Stabilized and instantaneous differential protection for 3W-Transformers	●	●	●	●	87T
Numerical stabilized low impedance restricted ground-fault protection	●	●	●	●	87LOZREF(2)
Circuit breaker failure protection, instance 1	●	●	●	●	50BF(1)
Circuit breaker failure protection, instance 2	●	●	●	●	50BF(2)
Circuit breaker failure protection, instance 3	●	●	●	●	50BF(3)
Master trip, instance 1	●	●	●	●	86/94-1
Master trip, instance 2	●	●	●	●	86/94-2
Master trip, instance 3	●	●	●	●	86/94-3
Arc protection, instance 1	●	●	●	●	AFD-1(2)
Arc protection, instance 2	●	●	●	●	AFD-2(2)
Arc protection, instance 3	●	●	●	●	AFD-3(2)
Load shedding and restoration, instance 1	-	-	●	●	81LSH-1(1)

Standard configuration functionality	A	B	A	B	ANSI/C37.2 - 2008
	AA	BA	AB	BB	RET
Load shedding and restoration, instance 2	-	-	•	•	81LSH-2(1)
Load shedding and restoration, instance 3	-	-	•	•	81LSH-3(1)
Load shedding and restoration, instance 4	-	-	•	•	81LSH-4(1)
Load shedding and restoration, instance 5	•	•	-	-	81LSH-1(2)
Load shedding and restoration, instance 6	•	•	-	-	81LSH-2(2)
Load shedding and restoration, instance 7	•	•	-	-	81LSH-3(2)
Load shedding and restoration, instance 8	•	•	-	-	81LSH-4(2)
Loss of phase, instance 1	•	•	•	•	37(1)
Loss of phase, instance 2	•	•	•	•	37(2)
Loss of phase, instance 3	•	•	•	•	37(3)
RTD based thermal protection, instance 1	-	-	•	•	38-1
RTD based thermal protection, instance 2	-	-	•	•	38-2
RTD based thermal protection, instance 3	-	-	•	•	38-3
Control					
Circuit-breaker control, instance 1	•	•	•	•	52(1)
Circuit-breaker control, instance 2	•	•	•	•	52(2)
Circuit-breaker control, instance 3	•	•	•	•	52(3)
Condition Monitoring					
Circuit-breaker condition monitoring, instance 1	•	•	•	•	52CM(1)
Circuit-breaker condition monitoring, instance 2	•	•	•	•	52CM(2)
Circuit-breaker condition monitoring, instance 3	•	•	•	•	52CM(3)
Trip circuit supervision, instance 1	•	•	•	•	TCM-1
Trip circuit supervision, instance 2	•	•	•	•	TCM-2
Trip circuit supervision, instance 3	•	•	•	•	TCM-3
Advanced current circuit supervision for transformers	•	•	•	•	MCS, 3I, I2
Fuse failure supervision, instance 1	-	-	•	•	60(1)
Fuse failure supervision, instance 2	•	•	-	-	60(2)
Measurement					
Three-phase current measurement, instance 1	•	•	•	•	IA, IB, IC (1)
Three-phase current measurement, instance 2	•	•	•	•	IA, IB, IC (2)
Three-phase current measurement, instance 3	•	•	•	•	IA, IB, IC (3)
Sequence current measurement, instance 1	•	•	•	•	I1, I2, I0(1)
Sequence current measurement, instance 2	•	•	•	•	I1, I2, I0(2)
Sequence current measurement, instance 3	•	•	•	•	I1, I2, I0(3)
Residual current measurement, instance 1	•	•	•	•	IG
Three-phase voltage measurement, instance 1	-	-	•	•	VA, VB, VC(1)
Three-phase voltage measurement, instance 2	•	•	-	-	VA, VB, VC (2)
Residual voltage measurement, instance 1	-	-	•	•	VG
Residual voltage measurement, instance 1	•	•	-	-	VG

Standard configuration functionality	A	B	A	B	ANSI/C37.2 - 2008
	AA	BA	AB	BB	RET
Sequence voltage measurement, instance 1	-	-	•	•	V1, V2, V0(1)
Sequence voltage measurement, instance 2	•	•	-	-	V1, V2, V0 (2)
Single-phase power and energy measurement, instance 1	-	-	•	•	SP, SE(1)
Single-phase power and energy measurement, instance 2	•	•	-	-	SP, SE(2)
Three-phase power and energy measurement, instance 1	-	-	•	•	P, E(1)
Three-phase power and energy measurement, instance 2	•	•	-	-	P, E(2)
Load profile	•	•	•	•	LoadProf
Frequency measurement, instance 1	-	-	•	•	f
Frequency measurement, instance 2	•	•	-	-	f
Tap Changer Position Indication	•	•	•	•	84T
Other functions					
Minimum pulse timer (2 pcs), instance 1	•	•	•	•	TP-1
Minimum pulse timer (2 pcs), instance 2	•	•	•	•	TP-2
Minimum pulse timer (2 pcs), instance 3	•	•	•	•	TP-3
Minimum pulse timer (2 pcs), instance 4	•	•	•	•	TP-4
Pulse timer (8 pcs), instance 1	•	•	•	•	PT-1
Pulse timer (8 pcs), instance 2	•	•	•	•	PT-2
Time delay off (8 pcs), instance 1	•	•	•	•	TOF-1
Time delay off (8 pcs), instance 2	•	•	•	•	TOF-2
Time delay off (8 pcs), instance 3	•	•	•	•	TOF-3
Time delay off (8 pcs), instance 4	•	•	•	•	TOF-4
Time delay on (8 pcs), instance 1	•	•	•	•	TON -1
Time delay on (8 pcs), instance 2	•	•	•	•	TON -2
Time delay on (8 pcs), instance 3	•	•	•	•	TON -3
Time delay on (8 pcs), instance 4	•	•	•	•	TON -4
Set reset (8 pcs), instance 1	•	•	•	•	SR-1
Set reset (8 pcs), instance 2	•	•	•	•	SR-2
Set reset (8 pcs), instance 3	•	•	•	•	SR-3
Set reset (8 pcs), instance 4	•	•	•	•	SR-4
Move (8 pcs), instance 1	•	•	•	•	MV-1
Move (8 pcs), instance 2	•	•	•	•	MV-2
Move (8 pcs), instance 3	•	•	•	•	MV-3
Move (8 pcs), instance 4	•	•	•	•	MV-4
Move (8 pcs), instance 5	•	•	•	•	MV-5
Move (8 pcs), instance 6	•	•	•	•	MV-6
Move (8 pcs), instance 7	•	•	•	•	MV-7
Move (8 pcs), instance 8	•	•	•	•	MV-8
Generic control points, instance 1	•	•	•	•	CNTRL-1
Generic control points, instance 2	•	•	•	•	CNTRL-2
Generic control points, instance 3	•	•	•	•	CNTRL-3

Standard configuration functionality	A	B	A	B	ANSI/C37.2 - 2008
	AA	BA	AB	BB	RET
Remote Generic control points, instance 1	•	•	•	•	RCNTRL-1
Local Generic control points, instance 1	•	•	•	•	LCNTRL-1
Generic Up-Down Counters, instance 1	•	•	•	•	CTR-1
Generic Up-Down Counters, instance 2	•	•	•	•	CTR-2
Generic Up-Down Counters, instance 3	•	•	•	•	CTR-3
Generic Up-Down Counters, instance 4	•	•	•	•	CTR-4
Generic Up-Down Counters, instance 5	•	•	•	•	CTR-5
Generic Up-Down Counters, instance 6	•	•	•	•	CTR-6
Generic Up-Down Counters, instance 7	•	•	•	•	CTR-7
Generic Up-Down Counters, instance 8	•	•	•	•	CTR-8
Generic Up-Down Counters, instance 9	•	•	•	•	CTR-9
Generic Up-Down Counters, instance 10	•	•	•	•	CTR-10
Generic Up-Down Counters, instance 11	•	•	•	•	CTR-11
Generic Up-Down Counters, instance 12	•	•	•	•	CTR-12
Programmable buttons(16 buttons), instance 1	•	•	•	•	FKEY
Logging functions					
Disturbance recorder	•	•	•	•	DFR
Fault recorder	•	•	•	•	FR
Sequence event recorder	•	•	•	•	SER

Each of the configurations can be re-configured to suit individual applications. Typically optional IO and some of the functions may not be configured at delivery. Only key functions such as tripping, breaker status inputs etc. are connected through the signal matrix tool.

Typical connection diagram for the default configuration as delivered from the factory is available for each alternative configuration. The diagrams show how to connect the primary apparatus to the IED assuming control functionality is also included in the IED. The configurations are prepared to cover for the most common applications but not all possibilities.

The number of protection elements including directional and non-directional Phase and Ground OC protections, differential protection for 3 winding transformers, thermal overload, undervoltage / overvoltage functions, frequency functions etc., allow the user to fulfill any application requirement in protection and control of MV transformers.

The advanced logic capability, where the user logic is prepared with a graphical tool, allows special applications including automatic opening, sequencing etc. The graphical configuration tool ensures simple and fast testing and commissioning.

Various modes of communication including optical connections ensure integration of the IED with the rest of the power system protection, control and automation.

The wide application flexibility makes this product an excellent choice for both new installations and the refurbishment of existing installations.

It is strongly suggested that reference to Engineering Manual be made at this stage for details on PCM600 and organizing a project with various IEDs, uploading settings to IED etc. It is recommended to familiarize oneself with the grouping of various functions under PCM600, IED to configure, change settings connected with various functions. A typical screen shot is given below for ready reference. The next few paragraphs highlight a few steps to verify some of the important things in connection with analog inputs. The next sections give some of the settings suggestions and configuration possibilities which the users may navigate and set them as suggested by themselves.

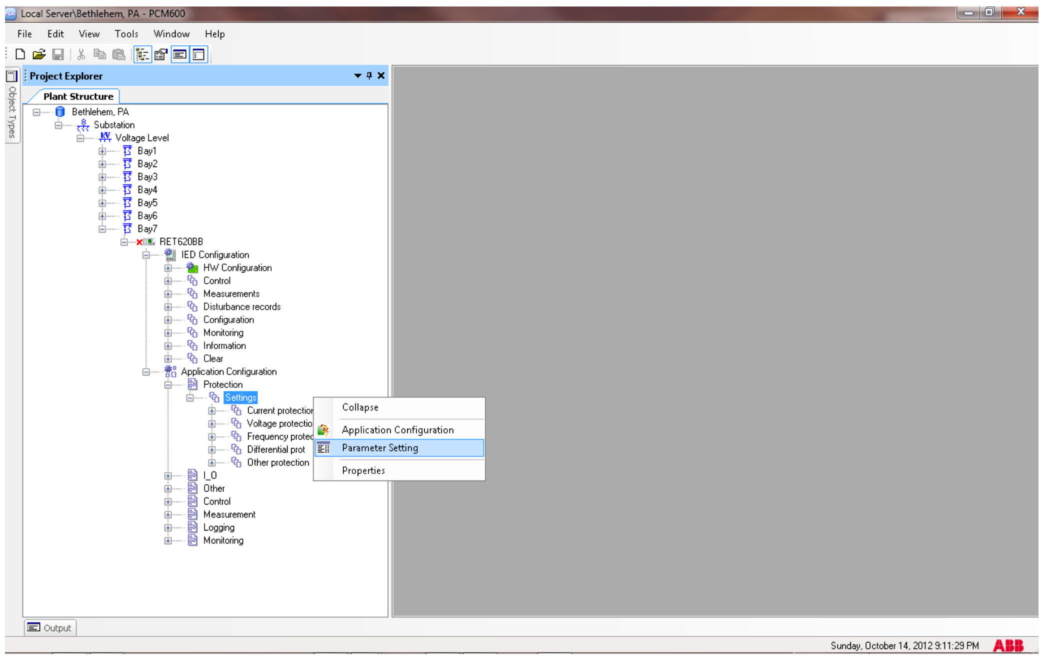


Figure 10: Example View of selecting settings under the plant structure of an IED in PCM600.

3.2.2 Verifying the order code and some of the most important configurations of IED in project tree:

Once the PCM600 project with the correct IED ordering code is up and running the IED details may be verified by right clicking on the IED name and selecting 'properties'.

Details of the ordering code, technical key etc. are displayed as follows:

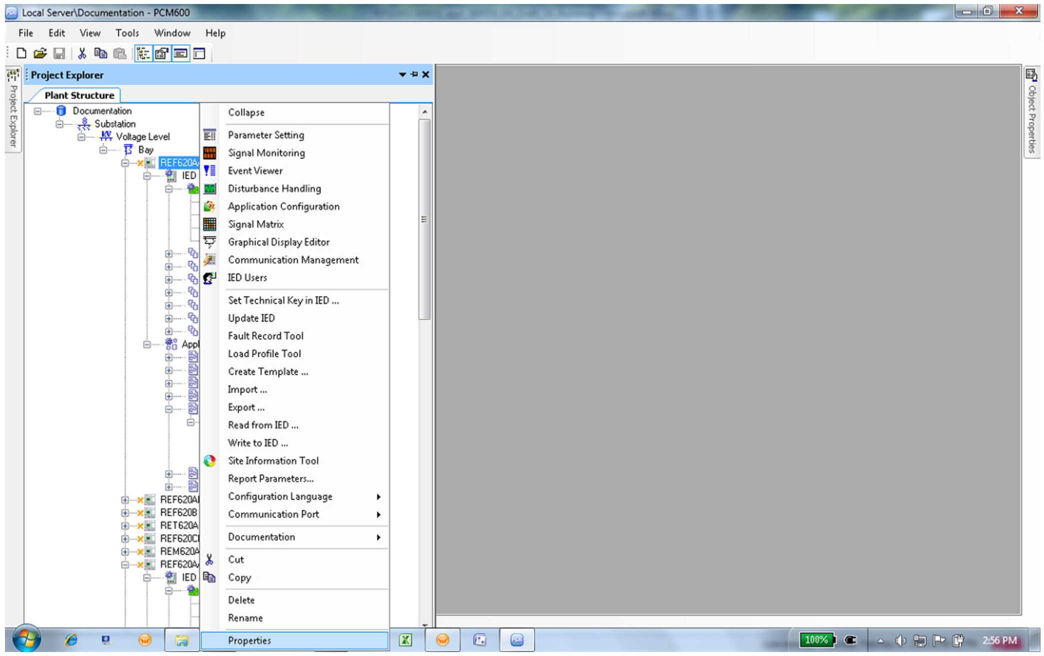


Figure 11: PCM600 display with IED selected with a right click to display the menu and 'Properties' line of the menu just to be selected

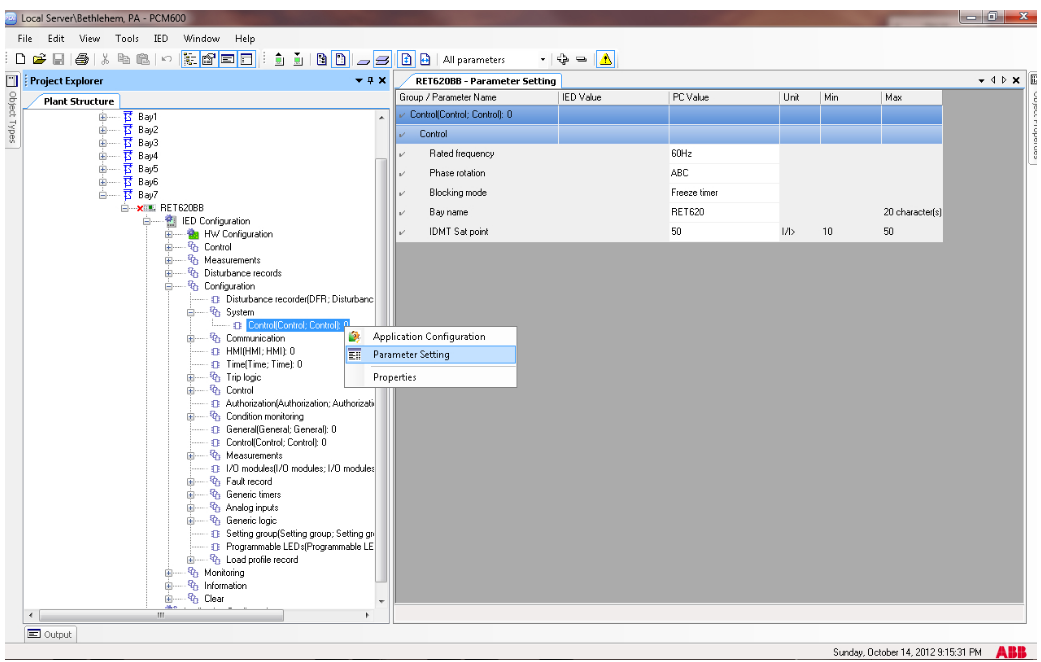


Figure 12: Display of common system configuration settings

It is also important that common system configurations such as frequency, phase sequence and group settings are also set properly and verified as shown in the following figures:

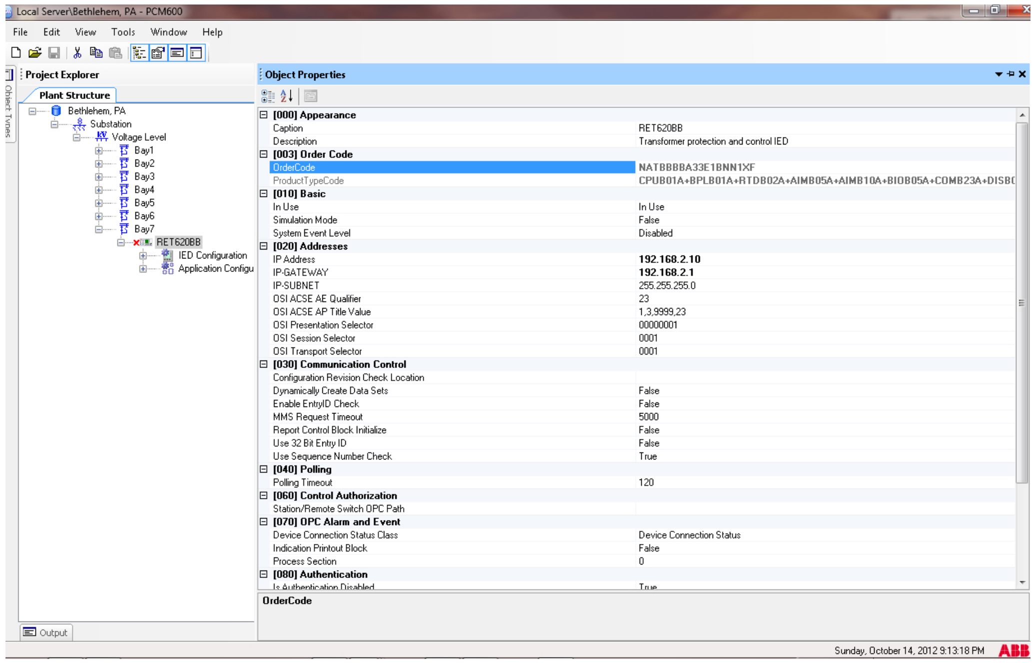


Figure 13: *PCM600 display with IED selected with a right click to display the menu and 'Properties' line of the menu just to be selected*

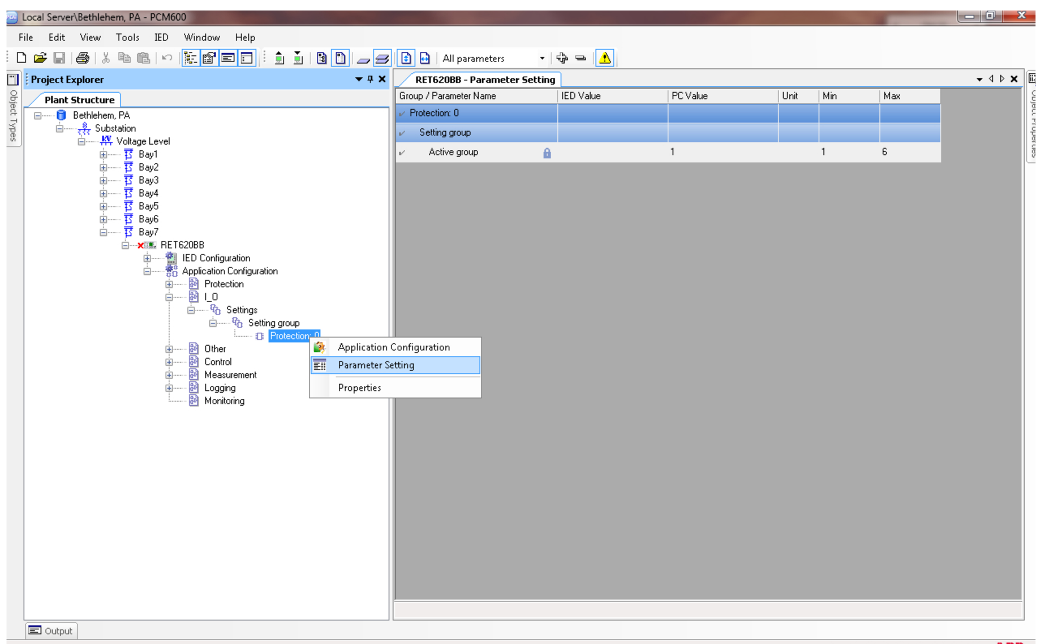


Figure 14: *Display or setting of Setting Group*

3.2.3 Analog Inputs configuration

In order to get correct measurement results as well as correct protection operations, the analog input channels must be configured and/or, especially with respect to the polarity. The polarity shown in the suggested connection diagrams have to be strictly followed.

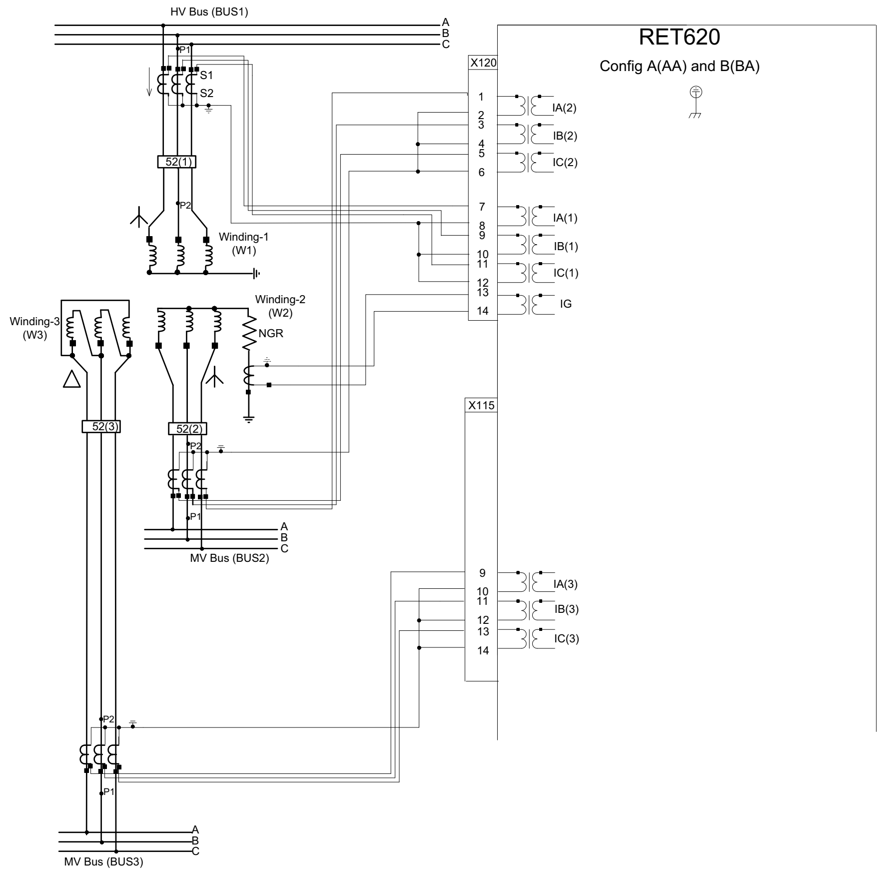


Figure 15: RET620 Typical CT connection diagram, marked with polarity

The polarity of CT and the internal connection are arranged in the above figure in such a way that for a fault in the transformer, indicated by an arrow in the picture, a proportional current would flow into terminal 7 of the IED with the same phase angle. If the actual CT polarity is found reversed, it is best to correct it at the installation. Polarity of CT inputs is very important not only for directional protection but also for metering, differential and restricted earth fault protections. When two breaker applications are involved, adequate care has to be exercised to ensure that the IED registers a current consistent with the power flow in the protected system under all circumstances both with respect to phase as well as ground fault protection measurements.

In case it is not possible to change the connections in field installation, it is possible to reverse the connections say at terminals 7 and 8 at the relay end provided documentation is corrected for the whole installation. Alternatively it is possible to correct polarity error inside the relay using PCM600. Select the IED→ IED Configuration → Configuration→ Analog inputs-Current

Then select the setting "Reverse Polarity" to "TRUE" as shown in the figure below.

In the same window, one can input the rated primary current rating of the CT. The secondary rated current is 5A by default but can be changed to 1A if required.

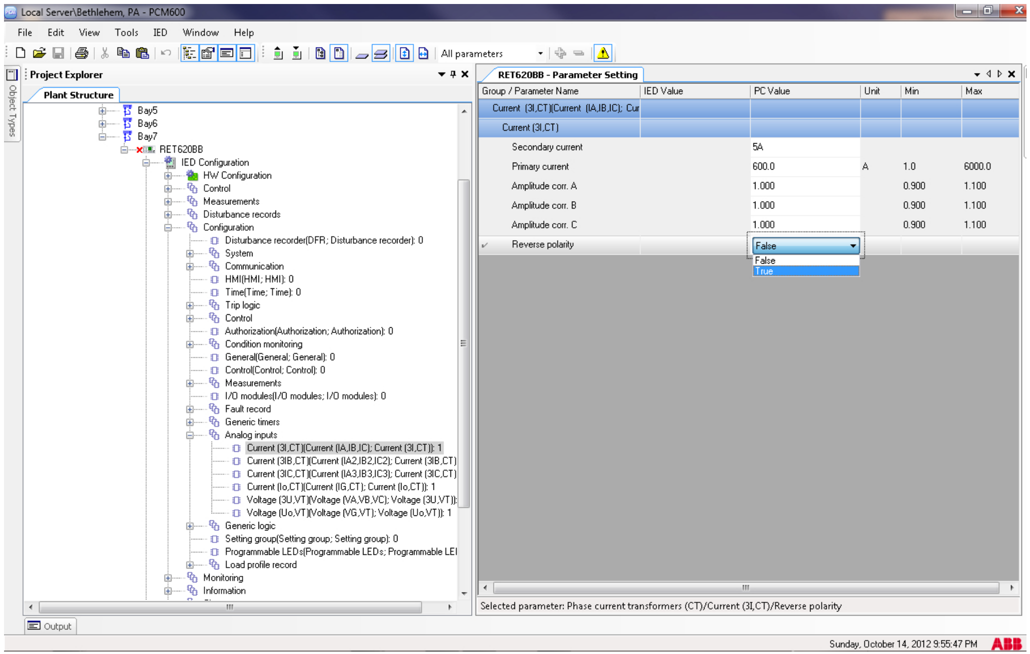


Figure 16: Modifying Reverse Polarity setting of CT input to IED

Just as CTs inputs, it is also important to verify the VT input configurations and settings before going ahead with further setting the IED. In the PCM tool, for selected IED, verify the VT connection setting is *Delta* (alternatively *WYE*) and appropriate primary and secondary values are input both for main bus VT inputs as well as Synchronizing VT input. The next figure indicates various possibilities of connecting the VT input to the relay.

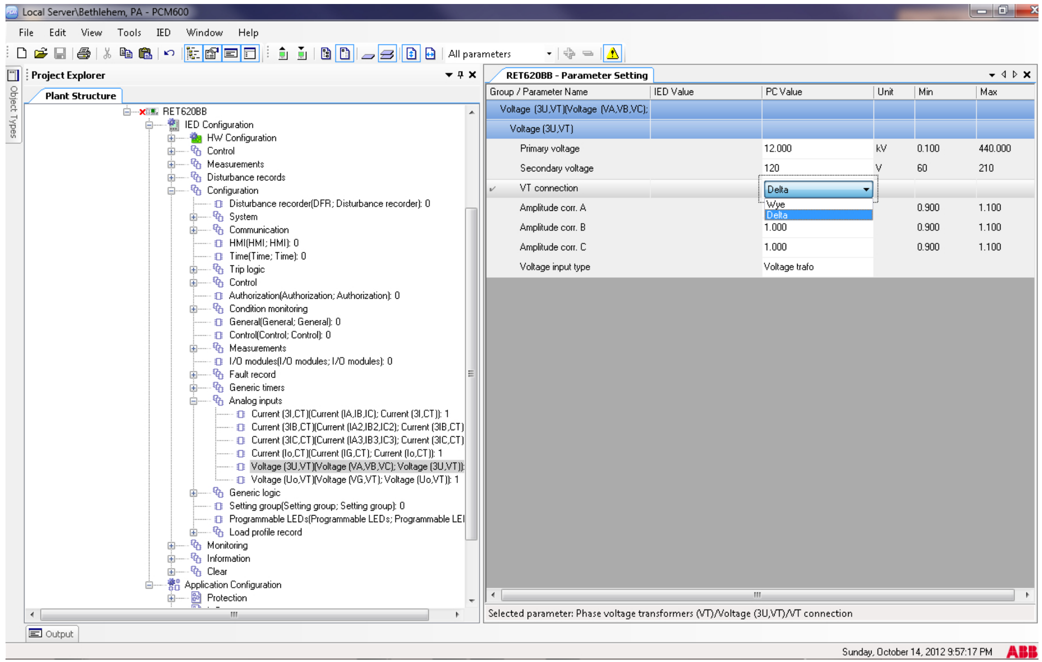
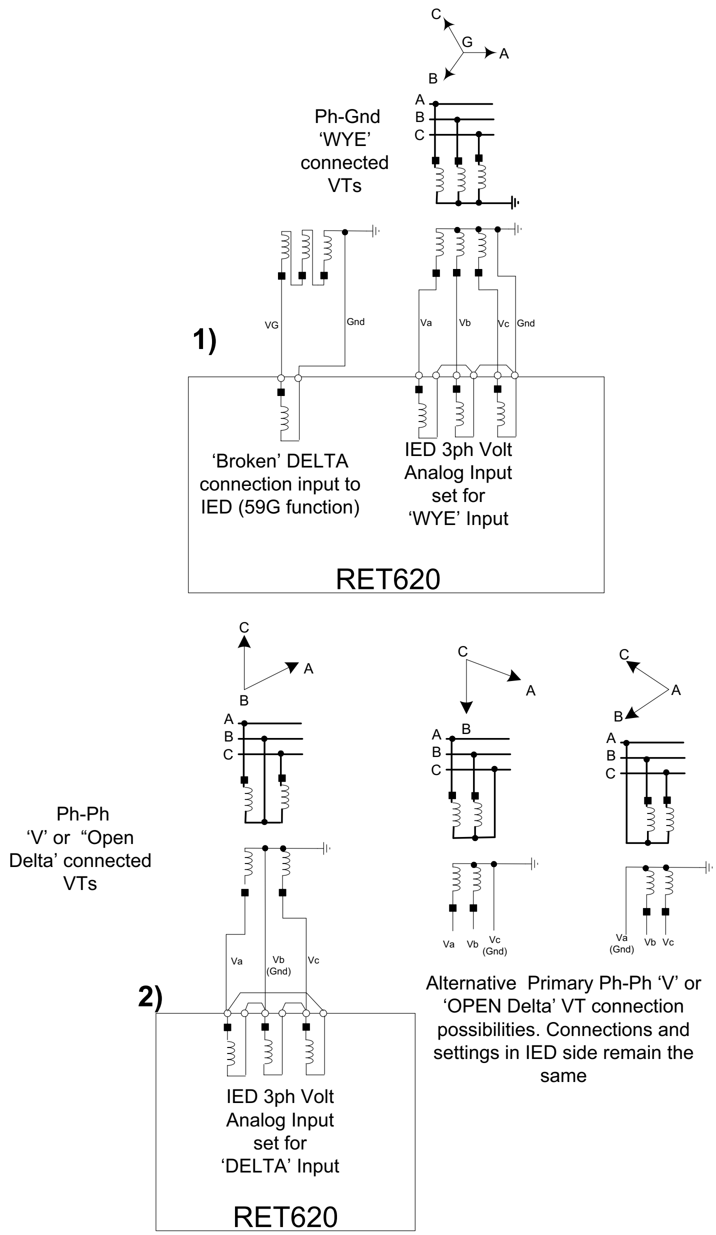


Figure 17: Selecting 'Wye' or 'Delta' setting of VT input to IED

Delta configuration has to be selected when the primary PT is connected in Open Delta (V connected) configuration. Different possibilities of connections of VTs are possible as detailed below. In case of Wye connected winding, grounded through a resistor, a VT might be used to measure the voltage across the grounding resistor and feed to VG input of the IED, as suggested in Figure 18.



Notes:

1) With WYE VT input with all four wires A, B,C and N brought to the IED, the unit's 3ph voltage analog input can be 'wired' and 'set' for "WYE' . It is possibl to set the polarization of Directional Ground Protection (67N etc.) to either Zero sequence OR Negative Sequence, depending on application.

2) When V (Open Delta) VT is available in the system the 3ph voltage analog input has to be 'wired' and 'set' for "DELTA". It is necessary to set the polarization of Directional Ground Protection (67N etc.) to only Negative Sequence.

Figure 18: VT Input Possibilities in RET620

3.2.4 Application Choice:

All configurations of RET620 are well suited for most of the applications that involve stepping down or stepping up transformers that have connection from HV system (Primary-W1) to MV (Secondary- W2; also referred to LV system interchangeably as a relative term with respect to the HV system) that may also have a tertiary winding (Tertiary-W3) or a tap off from HV or LV side of the transformer.

The smallest of the three winding rating is usually treated as tertiary for this IED application but may sometimes be rated same as the secondary. The winding type (WYE or Delta) of tertiary may be different than that of the secondary.

The primary and secondary (W1 and W2) may be two physically different windings but may be of autotransformer winding type (WYE connected). The IED can also be applied for a two winding transformer fed from dual HV breakers, or dual MV breakers, typical of Doublebus-Double breaker systems, Breaker-and-a-half systems and Ring-bus systems. Since bias input is taken from each current input of the breaker, the IED should be more stable for through faults across dual breakers.

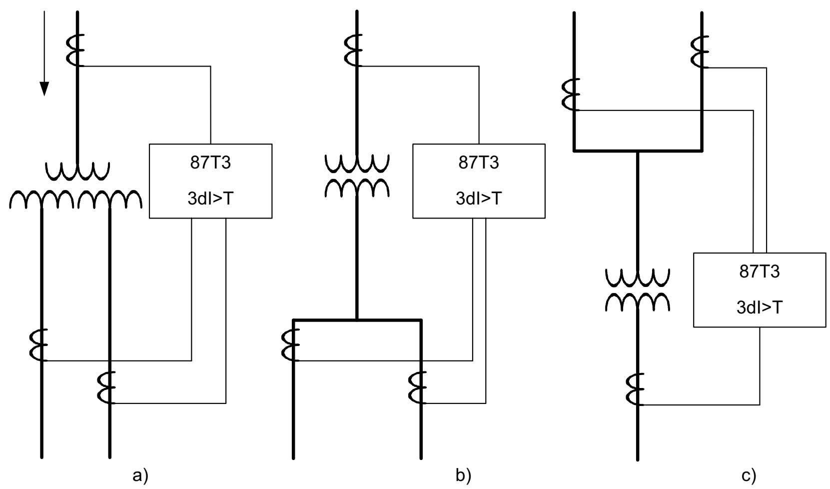


Figure 19: Differential protection of three-winding transformer, transformer with two output feeders and transformer with two-input feeders

RET620 can be applied for Generator Block overall differential protection with CT connected on HV side of the Generator Step-up transformer, Generator neutral and Unit Auxiliary transformer tap, as suggested in figure below. The IED can also be used to protect a short feeder, less than say 500m, limited by CT secondary lead resistances. Care shall be taken to make sure the CT ratios and CT ratings are adequate and not saturate for through faults, DC transients and sustained in-rush currents. It is possible to provide auxiliary CTs at either side of the protected feeder to reduce the burden loss along the CT pilot wires.

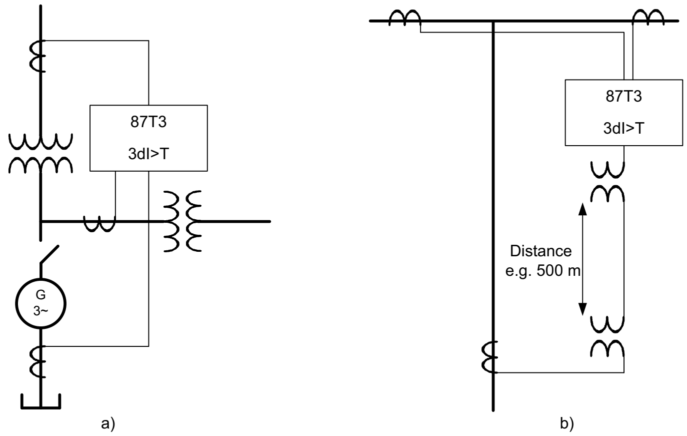


Figure 20: Differential protection of generator-transformer block and short cable or line

3.2.4.1 Configuration AA, BA:

These configurations can be applied for applications with VT connected on the LV side (W2) of the transformer. This configuration is applicable for most of the applications since VTs are available on the LV side mostly for On Load Tap Changer (OLTC) control, metering billing etc. When transformers are paralleled with power source from LV side, Directional Overcurrent (67/51P and 67/51N) protections energized off the LV side of the transformer, looking into the transformer can be set to operate with very low operating time, providing relatively quick back up protection for faults within the transformer.

Configuration BA has two RTD inputs to measure the oil and winding temperatures and take appropriate alarm or trip decisions, independent of the other electrical protection functions within the IED.

3.2.4.2 Configuration AB, BB:

These configurations are similar to the configurations AA and BA above but with VT input fed from the HV side of the transformer. All the voltage related functionalities are thus related to the HV winding of the transformer. The directional ground fault protection 67/51N has a special application with this configuration, should the delta tertiary of the transformer provide adequate zero sequence shunt path for HV system ground faults. The protection can be set to look into the transformer and prevent mis-operation of HV residual ground fault protection for external system ground faults. Since the source is typically from HV system in industrial power systems, the overfluxing protection can also be set in a conservative mode, ignoring the transformer HV side leakage impedance.

The total energy and power consumed by the transformer and downstream loads are accounted by the HV side metering system. The downside of this connection would be that for a smaller installation, a three phase VT on HV side would be a costlier proposition.

Config BB has two RTD inputs to measure the transformer winding and top oil temperatures, similar to config BA above.

In exceptional cases, based on application, it is always possible to designate MV as W1 and HV as W2 and work around the situation of whichever side the VT is connected. It is however to be noted that the low impedance Restricted Earth Fault (REF) is always tied with W2 winding, assuming it to be WYE connected.

3.2.5 Application examples

A few application examples and required settings based on connection arrangements are suggested here for general guidance. It is recommended to go through Technical manual for full details of various settings, ranges and other details. The examples center around the differential protection, the heart of RET620. A snapshot of the common non-group settings is presented here.

Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
87T; TR3PTDF1(87T; 3dI>3W): 1					
3dI>3W					
Operation		**on**			
Current group 3 type		Winding 3			
CT connection 1-2		Type 1			
CT connection 1-3		Type 1			
Phase Ref winding		Winding 1			
Zro A elimination		Not eliminated			
Phase shift Wnd 1-2		**30.0**	deg	0.0	359.9
Phase shift Wnd 1-3		0.0	deg	0.0	359.9
Min winding tap		36		-36	36
Max winding tap		0		-36	36
Tap nominal		18		-36	36
Tapped winding		Not in use			
Step of tap		**1.25**	%	0.60	9.00
CT ratio Cor Wnd 1		1.00		0.20	5.00
CT ratio Cor Wnd 2		1.00		0.20	5.00
CT ratio Cor 3		1.00		0.20	5.00

Figure 21: Application example

The examples all assume Phase sequence ABC for the system. Similar discussions are applicable for sequence ACB as well except the phases B and C in the pictures have to be interchanged with phases C and B respectively. The IED has to be configured for ACB sequence.

One of the important settings above is the Phase shift between windings 1 and 2. (Also 1 and 3 for three winding transformers). RET620 has a phase shift setting varying between 0 and 359.9 degrees to cover not only regular power transformer connections but also special applications such as cyclo converters, which may need setting angle corrections down to tenths of a degree. We will discuss further about regular power applications which may involve phase angle corrections in multiples of 30 degrees.

The setting is to take care of a combination of phase angles that are introduced by the winding and external connections of the power transformer as well as those introduced by the way the CT secondary leads are formed and connected to the IED.

Phase shift introduced by transformer windings and connections:

This setting depends on not only the transformer phase shift (typically 0 degrees for Wye/Wye and Delta/Delta transformers and 30 degrees for Delta/Wye or Wye/Delta transformers), but also external connection of phase connections A, B and C to terminals of the transformer.

In ANSI Delta/Wye or Wye/Delta transformers, the HV side is set to lead the LV side by 30 degrees. This may be understood as follows:

Example 1:
Delta(HV) Connection A-B = 30º
Wye(LV) Connection A = 0º
So the HV leads LV by 30º

Example 2:
Wye(HV) Connection A = 0º
Delta(LV) Connection A-C = 330º
So the HV leads LV by 30º

Phase shift introduced by CT connections and additional considerations:

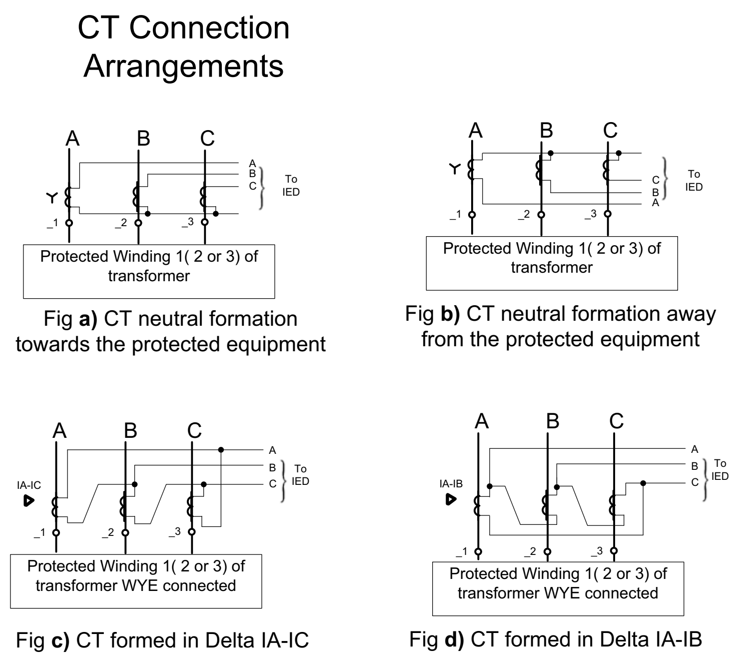


Figure 22: Phase shift introduced by CT connection arrangement

There are four different ways the CTs can be connected before being connected to IED, with reference to applications involving differential protection.

Fig. a) is the most preferred connection.

Fig. b) may need to be carefully analyzed with respect to directional protections, metering as well as differential protection.

From differential protection perspective, typically for 2 winding transformers, if both side connections are as per Fig **a**) or Fig **b**), no further considerations are required. However if one side is as per Fig **a**) and the other side as per Fig **b**), the setting "CT Connection 1-2" has to be changed from default setting of Type 1 to new setting **Type 2.**

Fig **c**) and **d**) represent connection arrangements, sometimes done for WYE connected power winding to compensate for phase shift of Delta/Wye transformers in earlier generation of electromechanical / static designs of protective relays.

Phase shift as per Fig **c**) for IA-IC CT connection: 30 Degrees

Phase shift as per Fig **d**) for IA-IB CT connection: 330 Degrees

Also the line side currents of the delta connected CTs are √3 times that of CT secondary currents. This has to be accounted for while setting the IED

CT ratio cor Wnd 1 (or 2 or 3 as appropriate) as required.

In most of the installations, the phase shift of the main delta winding of the transformer on one side and that of the delta connected CT on Wye connected winding of the transformer are such that they cancel off each other.

So net phase shift of such winding is typically 0 degrees, which is set in the IED.

It is good idea to change the connection to Fig **a**) preferably and compensate the phase shift within the IED.

3.2.5.1 Procedure for setting the phase angle shift setting:

1. Connect CT leads to IED CT inputs (refer to appropriate connection diagram)
2. Choose respective winding phase angle shift between Winding 1 and Winding 2 (or Winding 3 as appropriate) (Say they are 30 degrees and 0 degrees respectively for HV and LV)

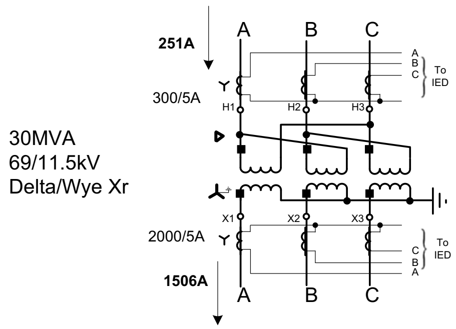
For ANSI transformers typically the phase shift is 30 degrees, so set "Phase Shift Wnd 1-2" to 30 degrees.

Zero Sequence Current elimination:

It may be necessary to eliminate Zero sequence current from one or more side current inputs to the differential protection. Typically this is done for Wye connected CTs, which may measure zero sequence currents flowing into a winding through a ground path (Wye, neutral grounded OR Delta with zig-zag). Should the CT be connected in Delta for phase angle correction purposes, they inherently trap zero sequence currents and hence additional zero sequence filtering within the IED is not essential though not harmful.

For example, for a two winding transformer Delta/Wye with both side CTs connected in Wye, set:

Zro A elimination **Winding 2**



Example 1A:
ANSI Delta-Wye Transformer (IEC Dyn1)

Winding 1 (W1)
Connection type: **A-B**

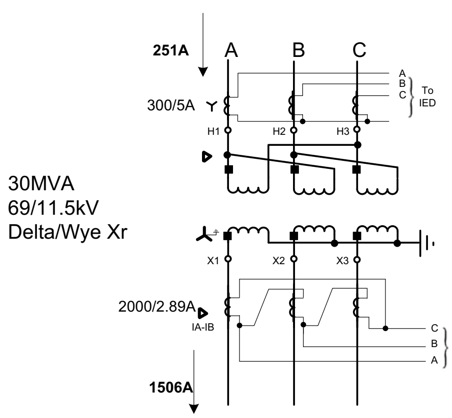
Winding 2 (W2)
Connection type: **A**
Phase Shift 1-2: **30** Degrees

CTs are in Wye, neutral formed towards the tranformer. Settings in RET620, based on the connections:

Current Grp 3 Type = **Not in use**

CT Connection 1-2: **Type 1**
Phase Shift Wnd 1-2: **30** Degrees
Zro A elimination: **Winding 2**

CT Ratio Cor Wdg 1 =300/251
=**1.20**
CT Ratio Cor Wdg 2 =2000/1506
=**1.33**



Example 1B:
ANSI Delta-Wye Transformer (IEC Dyn1)

Winding 1 (W1)
Connection type: **A-B**

Winding 2 (W2)
Phase Shift 1-2: **30** degrees

Observations:
W1 CTs are Wye, neutral formed towards the transformer.
W2 CTs are connected in Delta (IA-IB)
Phase angle introduced= **30** Degrees.

Settings in RET620, based on the connections:

Current Grp 3 Type = **Not in use**

CT Connection 1-2: **Type 1**
Phase Shift Wnd 1-2: 30-30 =**0** Degrees

Zro A elimination: **Not Eliminated**

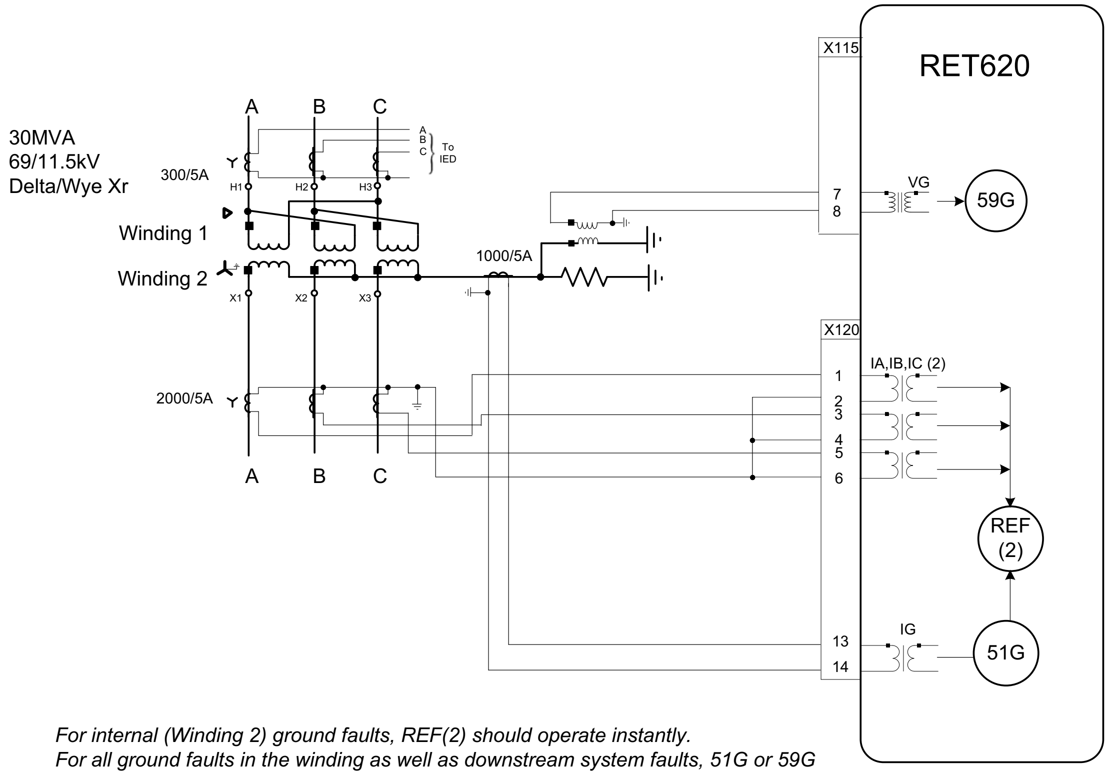
CT Ratio Cor Wdg 1 =300/251
=**1.20**

Since the delta connected CT produces √3 times line current which is fed to the IED, the effective CT ratio for W2 has to be modified. Note the CT secondary is 2.89A, while the IED nominal input current is considered as 5A. Considering the above,

CT Ratio Cor Wdg 2 = (2000/2.89*5)/(1506*√3)
=**1.33**

Figure 23: Typical Connection arrangements and some important settings for a Delta/Wye Transformer

Example 1C:
Restricted Earth Fault Protection and Standby Ground fault protection for Wye winding



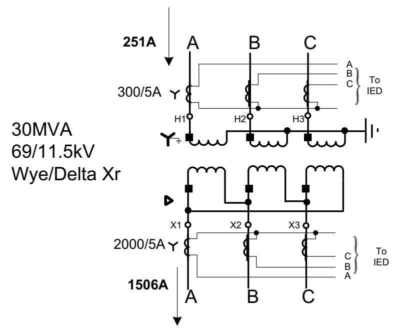
For internal (Winding 2) ground faults, REF(2) should operate instantly.
For all ground faults in the winding as well as downstream system faults, 51G or 59G can be set to provide backup protection with adequate delay.
The VT input shown for 59G is the most preferred connection to detect faults in the winding. Alternatively Broken Delta VT, connected to the transformer terminals can be given. Broken delta VT from bus VT is to be avoided since the protection will be out of service with the LV breaker open.

Based on the connections, the settings of Function REF(2) in the IED can be set as below:

CT Connection Type: **Type 1** The current transformer ratio mismatch between the phase currenttransformer and neutral current transformer (residual current in theanalog input settings) is taken into account by the function with theproperly set analog input setting values. In this case: Function (IA2,IB2,IC2,CT): *Secondary current* : **5A** *Primary Current* : **2000A** Function (IG, CT): *Secondary current* : **5A** *Primary Current* : **1000A**

Figure 24: Typical Connection arrangements and some important settings for a Delta/Wye Transformer, Wye winding Restricted-Earth-Fault protection and Standby Ground Fault protection

Example 2A: ANSI Wye-Delta Transformer (IEC YNd1)



Winding 1 (W1)
Connection type: **A**

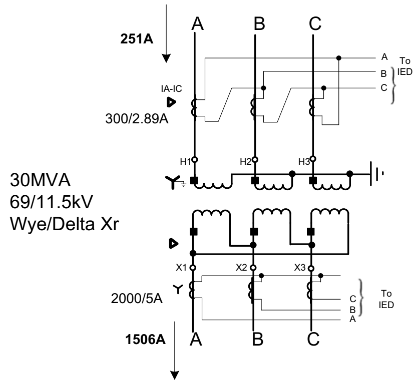
Winding 2 (W2)
Connection type: **A-C**
Phase Shift 1-2: 30 Degrees
Observations:
CTs are in Wye, neutral formed towards the tranformer. Settings in RET620, based on the connections:

Current Grp 3 Type = **Not in use**

CT Connection 1-2: **Type 1**
Phase Shift Wnd 1-2: **30** Degrees
Zro A elimination: **Winding 1**

CT Ratio Cor Wdg 1 =300/251
=**1.20**
CT Ratio Cor Wdg 2 =2000/1506
=**1.33**

Example 2B: ANSI Wye-Delta Transformer (IEC YNd1)



Winding 1 (W1)
Connection type: **A**

Winding 2 (W2)
Connection type: **A-C**
Phase Shift 1-2: **30** Degrees

Observations:
W1 CTs are connected in Delta (IA-IC)
Phase angle introduced= **30** Degrees.
Net Phase Shift 1-2= 0 degrees

W2 CTs are connected in Wye, neutral formed towards the transformer.

Settings in RET620, based on the connections:

Current Grp 3 Type = **Not in use**

CT Connection 1-2: **Type 1**

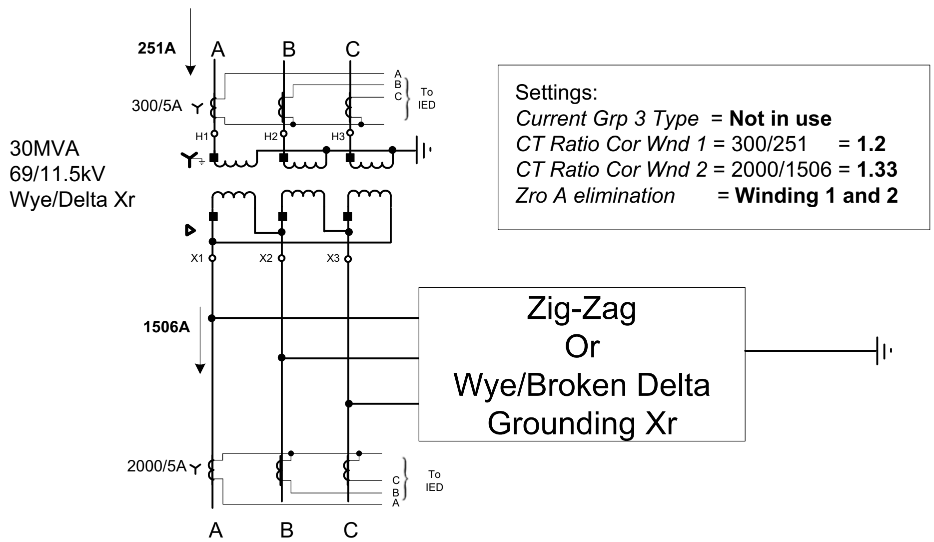
Zro A elimination: **Not Eliminated**

Since the delta connected CT produces √3 times line current which is fed to the IED, the effective CT ratio for W2 has to be modified. Note the CT secondary is 2.89A, while the IED nominal input current is considered as 5A. Considering the above,

CT Ratio Cor Wdg 1 = (300/2.89*5)/(251*√3)
=**1.20**

CT Ratio Cor Wdg 2 =2000/1506
=**1.33**

Figure 25: Typical Connection arrangements and some important settings for a Wye/Delta Transformer



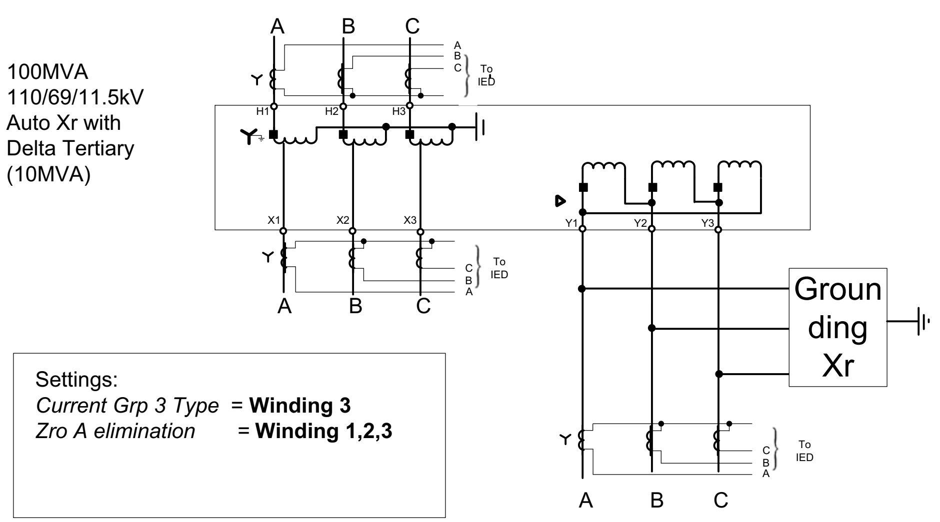
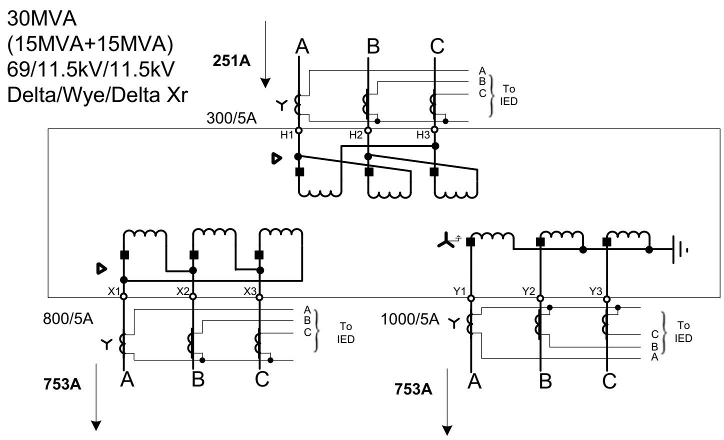


Figure 26: *Typical Connection arrangements and some important settings transformers with Delta windings, grounded through Zig-Zag transformers*



Example 3:
Delta-Wye-Delta Transformer

Winding 1 (W1)
Connection type: **A-B**

Winding 2 (W2)
Connection type: A
Phase Shift 1-2: **30** Degrees

Winding 3 (W3)
Connection type: **A-C**
Phase Shift 1-3: **60** Degrees

In W1 and W2 CT s are in Wye, neutral formed towards the tranformer.
In W3 CTs are in Wye, but neutral is formed away from the tranformer.

Settings in RET620, based on the connections:

Current Grp 3 Type = **Winding 3**

CT Connection 1-2: **Type 1**
CT Connection 1-3: **Type 2**

Phase Shift Wnd 1-2: **30** Degrees
Phase Shift Wnd 1-3: **60** Degrees

Zro A elimination: **Winding 2**

CT Ratio Cor Wdg 1 =300/251
=**1.20**

Note:
CT ratios of Winding 2 and 3 are set for full ratings of respective winding. However for differential protection balancing, consider full MVA rating of HV winding

Full 25MVA rating at 11.5kV
= 30000/(√3 x 11.5)
=1506A

CT Ratio Cor Wdg 2 =1000/1506
=**0.67**

CT Ratio Cor 3 =800/1506
=**0.50**

Figure 27: Typical Connection arrangements and some important settings in a Three winding transformer

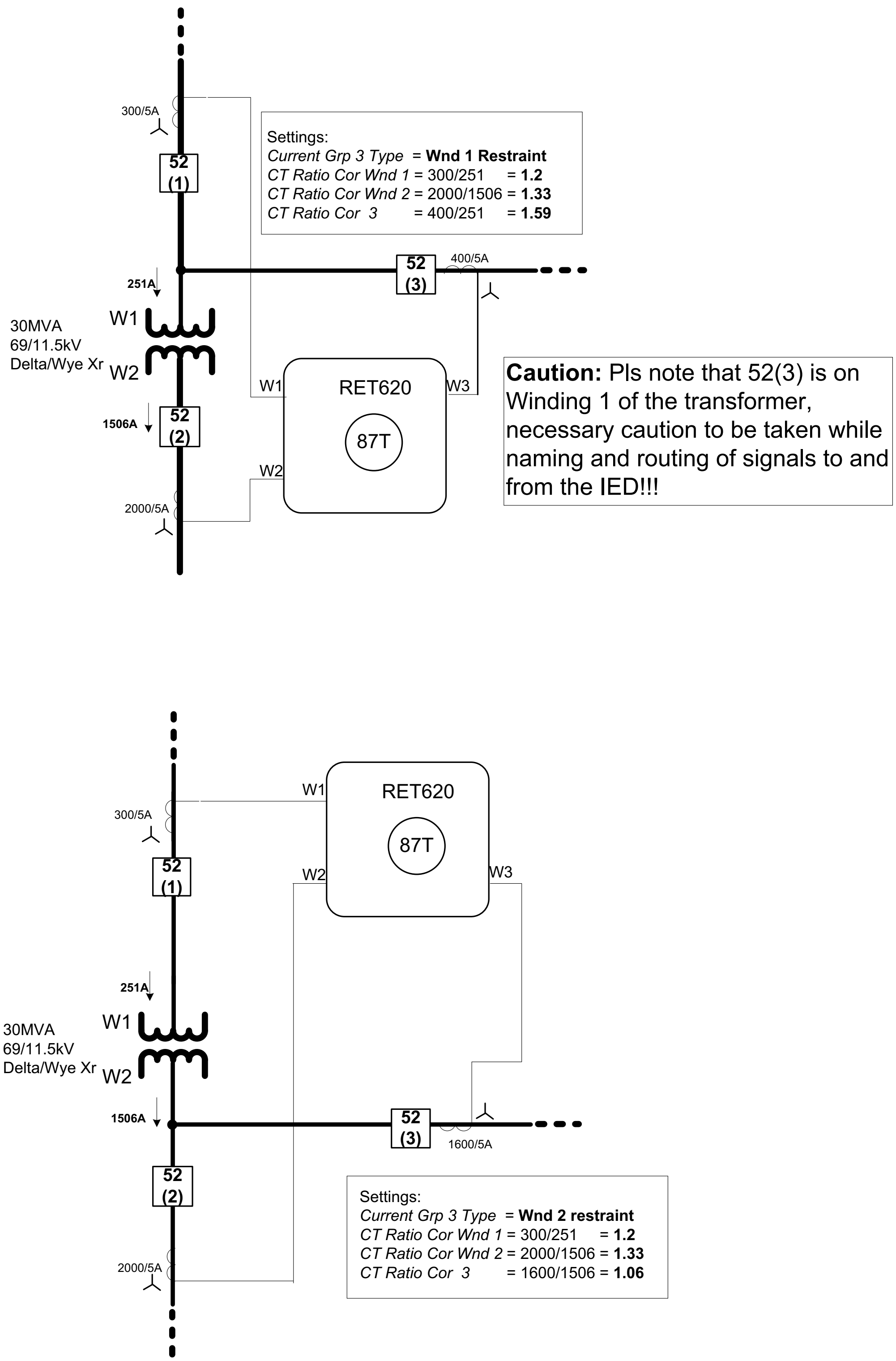


Figure 28: Typical Connection arrangements and some important settings in a two winding transformer with dual breakers either on HV or LV side

3.3 Standard configuration for order code functional applications A(AA) and B(BA) {Voltage transformer input from LV winding (2) side of transformer}

3.3.1 Applications

This standard configuration is mainly intended for three-winding transformers with breaker control on each winding with phase differential, restricted ground fault protection, non- directional and directional phase and ground overcurrent, voltage and frequency protection. Since each winding current is fed to add to the bias input of the differential protection, the differential protection is stabilized for external faults of a winding fed from any two of the other windings.

The IED with this standard 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 enable this configuration to be further adapted to different primary power system layouts and the related functionality needs by modifying the internal functionality using PCM600.

3.3.2 Functions

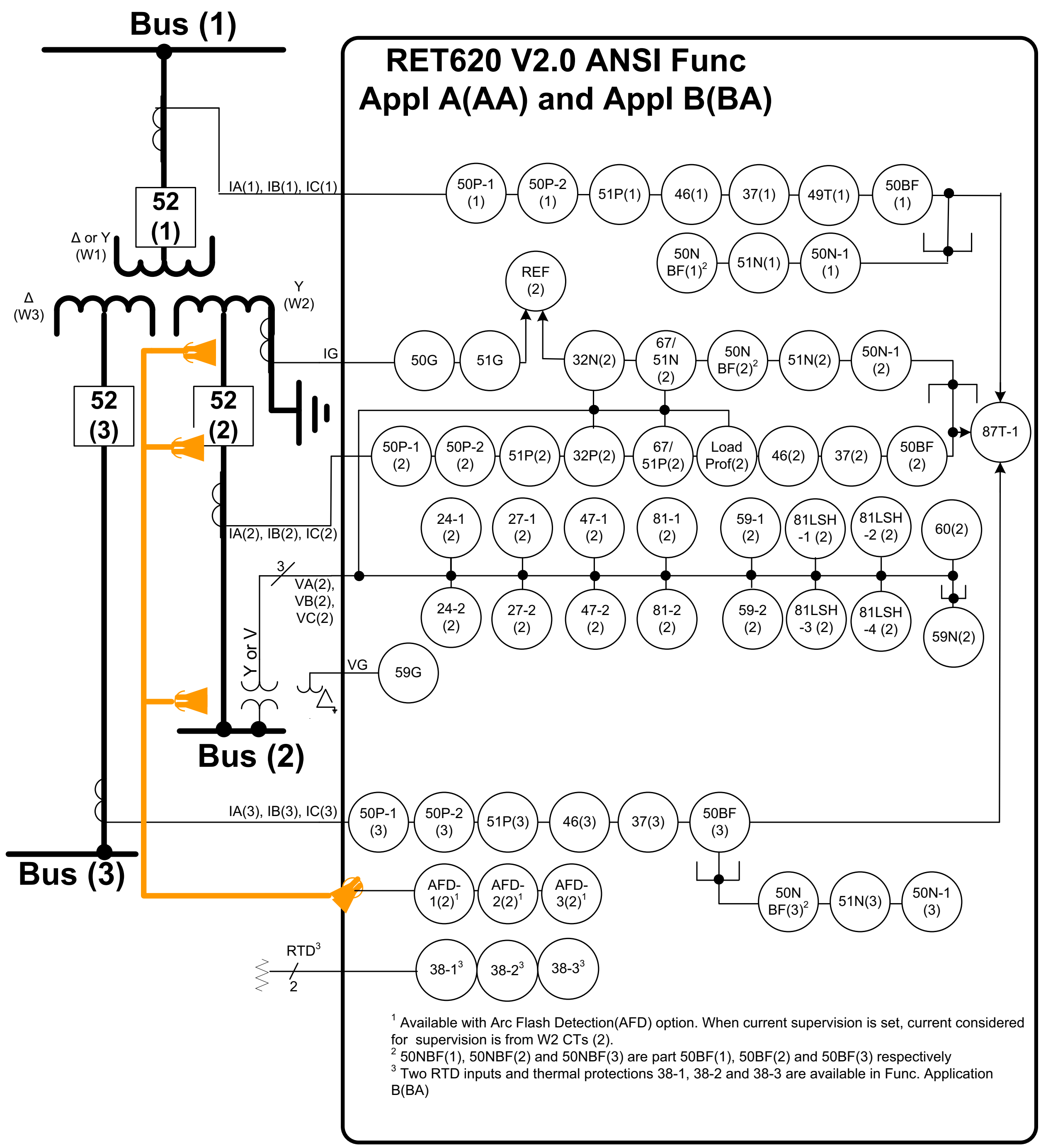


Figure 29: Functions included in the RET620 standard configuration AA and BA

Table 8: Functions included in the RET620 standard configuration

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AA)	B(BA)
Protection					
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	51P(1)	3I> (1)	•	•
Three-phase non-directional overcurrent protection, low stage, instance 2	PHLPTOC2	51P(2)	3I> (2)	•	•
Three-phase non-directional overcurrent protection, low stage, instance 3	PHLPTOC3	51P(3)	3I> (3)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	50P-1(1)	3I>> (1)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	50P-2(1)	3I>> (2)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 3	PHHPTOC3	50P-1(2)	3I>> (3)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 4	PHHPTOC4	50P-2(2)	3I>> (4)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 5	PHHPTOC5	50P-1(3)	3I>> (5)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 6	PHHPTOC6	50P-2(3)	3I>> (6)	•	•
Three-phase directional overcurrent protection, low stage, instance 2	DPHLPDOC2	67/51P(2)	3I> -> (2)	•	•
Non-directional ground-fault protection, low stage, instance 1	EFLPTOC1	51G	Io> (1)	•	•
Non-directional ground-fault protection, low stage, instance 2	EFLPTOC2	51N(1)	Io> (2)	•	•
Non-directional ground-fault protection, low stage, instance 3	EFLPTOC3	51N(2)	Io> (3)	•	•
Non-directional ground-fault protection, low stage, instance 4	EFLPTOC4	51N(3)	Io> (4)	•	•
Non-directional ground-fault protection, high stage, instance 1	EFHPTOC1	50G	Io>> (1)	•	•
Non-directional ground-fault protection, high stage, instance 3	EFHPTOC3	50N-1(1)	Io>> (3)	•	•
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC4	50N-1(2)	Io>> (4)	•	•
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC5	50N-1(3)	Io>> (5)	•	•
Directional ground-fault protection, low stage, instance 2	DEFLPDEF2	67/51N(2)	Io> -> (2)	•	•
Three phase directional power protection, instance 2	DPSRDIR2	32P(2)	I1-> (2)	•	•
Ground directional power protection, instance 2	DNZSRDIR2	32N(2)	I2 ->, Io-> (2)	•	•
Negative-sequence overcurrent protection, instance 1	NSPTOC1	46(1)	I2> (1)	•	•
Negative-sequence overcurrent protection, instance 2	NSPTOC2	46(2)	I2> (2)	•	•

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AA)	B(BA)
Negative-sequence overcurrent protection, instance 3	NSPTOC3	46(3)	I2> (3)	•	•
Residual overvoltage protection, instance 1	ROVPTOV1	59G	Uo> (1)	•	•
Residual overvoltage protection, instance 3	ROVPTOV3	59N(2)	Uo> (3)	•	•
Three-phase undervoltage protection, instance 3	PHPTUV3	27-1(2)	3U< (3)	•	•
Three-phase undervoltage protection, instance 4	PHPTUV4	27-2(2)	3U< (4)	•	•
Three-phase overvoltage protection, instance 3	PHPTOV3	59-1(2)	3U> (3)	•	•
Three-phase overvoltage protection, instance 4	PHPTOV4	59-2(2)	3U> (4)	•	•
Negative-sequence overvoltage protection, instance 3	NSPTOV3	47-1(2)	U2> (3)	•	•
Negative-sequence overvoltage protection, instance 4	NSPTOV4	47-2(2)	U2> (4)	•	•
Frequency protection, instance 3	FRPFRQ3	81-1(2)	f>/f<,df/dt (3)	•	•
Frequency protection, instance 4	FRPFRQ4	81-2(2)	f>/f<,df/dt (4)	•	•
Voltage per hertz protection, instance 3	OEPVPH3	24-1(2)	U/f> (3)	•	•
Voltage per hertz protection, instance 4	OEPVPH4	24-2(2)	U/f> (4)	•	•
Three-phase thermal overload protection for power transformers, two time constants	T2PTTR1	49T(1)	3Ith>T	•	•
Stabilized and instantaneous differential protection for 3W-Transformers	TR3PTDF1	87T	3dI>T	•	•
Numerical stabilized low impedance restricted earth-fault protection	LREFPNDF1	87LOZREF(2)	dIoLo>	•	•
Circuit breaker failure protection, instance 1	CCBRBRF1	50BF(1)	3I>/Io>BF (1)	•	•
Circuit breaker failure protection, instance 2	CCBRBRF2	50BF(2)	3I>/Io>BF (2)	•	•
Circuit breaker failure protection, instance 3	CCBRBRF3	50BF(3)	3I>/Io>BF (3)	•	•
Master trip, instance 1	TRPPTRC1	86/94-1	Master Trip (1)	•	•
Master trip, instance 2	TRPPTRC2	86/94-2	Master Trip (2)	•	•
Master trip, instance 3	TRPPTRC3	86/94-3	Master Trip (3)	•	•
Arc protection, instance 1	ARCSARC1	AFD-1(2)	ARC (1)	•	•
Arc protection, instance 2	ARCSARC2	AFD-2(2)	ARC (2)	•	•
Arc protection, instance 3	ARCSARC3	AFD-3(2)	ARC (3)	•	•
Load shedding and restoration, instance 5	LSHDPFRQ5	81LSH-1(2)	UFLS/R (5)	•	•
Load shedding and restoration, instance 6	LSHDPFRQ6	81LSH-2(2)	UFLS/R (6)	•	•
Load shedding and restoration, instance 7	LSHDPFRQ7	81LSH-3(2)	UFLS/R (7)	•	•
Load shedding and restoration, instance 8	LSHDPFRQ8	81LSH-4(2)	UFLS/R (8)	•	•

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AA)	B(BA)
Loss of phase, instance 1	PHPTUC1	37(1)	3I< (1)	•	•
Loss of phase, instance 2	PHPTUC2	37(2)	3I< (2)	•	•
Loss of phase, instance 3	PHPTUC3	37(3)	3I< (3)	•	•
RTD based thermal protection, instance 1	MAPGAPC1	38-1	ThA> ThB>	-	•
RTD based thermal protection, instance 2	MAPGAPC2	38-2	ThA> ThB>	-	•
RTD based thermal protection, instance 3	MAPGAPC3	38-3	ThA> ThB>	-	•
Control					
Circuit-breaker control, instance 1	CBXCBR1	52(1)	I <-> O CB (1)	•	•
Circuit-breaker control, instance 2	CBXCBR2	52(2)	I <-> O CB (2)	•	•
Circuit-breaker control, instance 3	CBXCBR3	52(3)	I <-> O CB (3)	•	•
Condition Monitoring					
Circuit-breaker condition monitoring, instance 1	SSCBR1	52CM(1)	CBCM (1)	•	•
Circuit-breaker condition monitoring, instance 2	SSCBR2	52CM(2)	CBCM (2)	•	•
Circuit-breaker condition monitoring, instance 3	SSCBR3	52CM(3)	CBCM (3)	•	•
Trip circuit supervision, instance 1	TCSSCBR1	TCM-1	TCS (1)	•	•
Trip circuit supervision, instance 2	TCSSCBR2	TCM-2	TCS (2)	•	•
Trip circuit supervision, instance 3	TCSSCBR3	TCM-3	TCS (3)	•	•
Advanced current circuit supervision for transformers	CTSRCTF1	MCS 3I, I2	MCS 3I, I2	•	•
Fuse failure supervision, instance 2	SEQRFUF2	60(2)	FUSEF (2)	•	•
Measurement					
Three-phase current measurement, instance 1	CMMXU1	IA, IB, IC(1)	3I	•	•
Three-phase current measurement, instance 2	CMMXU2	IA, IB, IC(2)	3I(B)	•	•
Three-phase current measurement, instance 3	CMMXU3	IA, IB, IC(3)	3I(C)	•	•
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0(1)	I1, I2, I0	•	•
Sequence current measurement, instance 2	CSMSQI2	I1, I2, I0(2)	I1, I2, I0(B)	•	•
Sequence current measurement, instance 3	CSMSQI3	I1, I2, I0(3)	I1, I2, I0(C)	•	•
Residual current measurement, instance 1	RESCMMXU1	IG	Io	•	•
Three-phase voltage measurement, instance 2	VMMXU2	VA, VB, VC(2)	3U(B)	•	•
Residual voltage measurement, instance 2	RESVMMXU2	VG	Uo(B)	•	•
Sequence voltage measurement, instance 2	VSMSQI2	V1, V2, V0(2)	U1, U2, U0(B)	•	•
Single-phase power and energy measurement, instance 1	SPEMMXU2	SP, SE(2)	SP, SE(B)	•	•

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AA)	B(BA)
Three-phase power and energy measurement, instance 2	PEMMXU2	P, E(2)	P, E(B)	•	•
Tap changer position indication	TPOSSLTC1	84T	TPOSM	•	•
Load profile	LDPMSTA1	LoadProf	-	•	•
Frequency measurement, instance 2	FMMXU2	f	f	•	•
Other functions					
Minimum pulse timer (2 pcs), instance 1	TPGAPC1	TP-1	TP (1)	•	•
Minimum pulse timer (2 pcs), instance 2	TPGAPC2	TP-2	TP (2)	•	•
Minimum pulse timer (2 pcs), instance 3	TPGAPC3	TP-3	TP (3)	•	•
Minimum pulse timer (2 pcs), instance 4	TPGAPC4	TP-4	TP (4)	•	•
Pulse timer (8 pcs), instance 1	PTGAPC1	PT-1	PT (1)	•	•
Pulse timer (8 pcs), instance 2	PTGAPC2	PT-2	PT (2)	•	•
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF-1	TOF (1)	•	•
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF-2	TOF (2)	•	•
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF-3	TOF (3)	•	•
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF-4	TOF (4)	•	•
Time delay on (8 pcs), instance 1	TONGAPC1	TON -1	TON (1)	•	•
Time delay on (8 pcs), instance 2	TONGAPC2	TON -2	TON (2)	•	•
Time delay on (8 pcs), instance 3	TONGAPC3	TON -3	TON (3)	•	•
Time delay on (8 pcs), instance 4	TONGAPC4	TON -4	TON (4)	•	•
Set reset (8 pcs), instance 1	SRGAPC1	SR-1	SR (1)	•	•
Set reset (8 pcs), instance 2	SRGAPC2	SR-2	SR (2)	•	•
Set reset (8 pcs), instance 3	SRGAPC3	SR-3	SR (3)	•	•
Set reset (8 pcs), instance 4	SRGAPC4	SR-4	SR (4)	•	•
Move (8 pcs), instance 1	MVGAPC1	MV-1	MV (1)	•	•
Move (8 pcs), instance 2	MVGAPC2	MV-2	MV (2)	•	•
Move (8 pcs), instance 3	MVGAPC3	MV-3	MV (3)	•	•
Move (8 pcs), instance 4	MVGAPC4	MV-4	MV (4)	•	•
Move (8 pcs), instance 1	MVGAPC5	MV-5	MV (5)	•	•
Move (8 pcs), instance 2	MVGAPC6	MV-2	MV (6)	•	•
Move (8 pcs), instance 3	MVGAPC7	MV-7	MV (7)	•	•
Move (8 pcs), instance 4	MVGAPC8	MV-8	MV (8)	•	•
Generic control points, instance 1	SPCGGIO1	CNTRL-1	SPC(1)	•	•
Generic control points, instance 2	SPCGGIO2	CNTRL-2	SPC(2)	•	•
Generic control points, instance 3	SPCGGIO3	CNTRL-3	SPC(3)	•	•
Remote Generic control points, instance 1	SPCRGGIO1	RCNTRL-1	SPCR(1)	•	•
Local Generic control points, instance 1	SPCLGGIO1	LCNTRL-1	SPCL(1)	•	•
Generic Up-Down Counters, instance 1	UDFCNT1	CTR-1	CTR(1)	•	•
Generic Up-Down Counters, instance 2	UDFCNT2	CTR-2	CTR(2)	•	•
Generic Up-Down Counters, instance 3	UDFCNT3	CTR-3	CTR(3)	•	•

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AA)	B(BA)
Generic Up-Down Counters, instance 4	UDFCNT4	CTR-4	CTR(4)	•	•
Generic Up-Down Counters, instance 5	UDFCNT5	CTR-5	CTR(5)	•	•
Generic Up-Down Counters, instance 6	UDFCNT6	CTR-6	CTR(6)	•	•
Generic Up-Down Counters, instance 7	UDFCNT7	CTR-7	CTR(7)	•	•
Generic Up-Down Counters, instance 8	UDFCNT8	CTR-8	CTR(8)	•	•
Generic Up-Down Counters, instance 9	UDFCNT9	CTR-9	CTR(9)	•	•
Generic Up-Down Counters, instance 10	UDFCNT10	CTR-10	CTR(10)	•	•
Generic Up-Down Counters, instance 11	UDFCNT11	CTR-11	CTR(11)	•	•
Generic Up-Down Counters, instance 12	UDFCNT12	CTR-12	CTR(12)	•	•
Programmable buttons (16 buttons), instance 1	FKEYGGIO1	FKEY	FKEY	•	•
Logging functions					
Disturbance recorder	RDRE1	DFR	DFR	•	•
Fault recorder	FLMSTA1	FR	FR	•	•
Sequence event recorder	SER	SER	SER	•	•

3.3.3 Default Input/Output (I/O) assignments

Table 9: Default connections for analog inputs

Analog input	Default usage	Connector pins
IA(1)	Phase A current, Winding 1	X120-7, 8
IB(1)	Phase B current, Winding 1	X120-9, 10
IC(1)	Phase C current, Winding 1	X120-11, 12
IA(2)	Phase A current, Winding 2	X120-1,2
IB(2)	Phase B current, Winding 2	X120-3,4
IC(2)	Phase C current, Winding 2	X120-5,6
IG	Ground current, Winding 2	X120-13,14
IA(3)	Phase A current, Winding 3	X115-9, 10
IB(3)	Phase B current, Winding 3	X115-11, 12
IC(3)	Phase C current, Winding 3	X115-13,14
VA(2)	Phase A voltage, Winding 2	X115-1,2
VB(2)	Phase B voltage, Winding 2	X115-3,4
VC(2)	Phase C voltage, Winding 2	X115-5,6
VG(2)	Broken Delta Voltage, Winding 2	X115-7,8
RTD-1	Winding Temperature	X130-3,4,5*
RTD-2	Top Oil Temperature	X130-6,7,8*
*RTD inputs available with configurations B(BA) and B(BB) only		

*Table 10: Default connections for binary inputs (Alternative 1)**

Binary input	Default usage	Connector pins
X110-BI3	Circuit breaker(3) closed position	X110-5,6
X110-BI4	Circuit breaker(3) open position	X110-7,6
X110-BI5	Circuit breaker(2) closed position	X110-8,9
X110-BI6	Circuit breaker(2) open position	X110-10,9
X110-BI7	Circuit breaker(1) closed position	X110-11,12
X110-BI8	Circuit breaker(1) open position	X110-13,12
*Binary inputs when slot ID X110 is ordered with 8BI+4BO BIO card		

*Table 11: Default connections for binary inputs (Alternative 2)**

Binary input	Default usage	Connector pins
X110-BI3	Circuit breaker(3) closed position	X110-3,5
X110-BI4	Circuit breaker(3) open position	X110-4,5
X110-BI5	Circuit breaker(2) closed position	X110-6,10
X110-BI6	Circuit breaker(2) open position	X110-7,10
X110-BI7	Circuit breaker(1) closed position	X110-8,10
X110-BI8	Circuit breaker(1) open position	X110-9,10
*Alternative binary inputs when IED has been ordered with High speed binary output (HSO) card		

Table 12: Default connections for binary outputs

Binary output	Default usage	Connector pins
X100-PO1	87T & 87LOZREF Trip	X100 – 6,7
X100-PO2	Breaker Fail	X100 – 8,9
X100-SO1	Close circuit breaker(1)	X100 – 10,12
X100-PO3	Open circuit breaker(1)	X100 – 15,16,17,18,19
X100-PO4	Open circuit breaker (2)	X100 – 20,21,22,23,24
X130-SO3/TO1	Open circuit breaker(3)	X130 – 16,17
X110-SO1	Close circuit breaker (2)	X110 – 14,15
X110-S02	Close circuit breaker (3)	X110 – 17,18

*Table 13: High speed binary output connections**

Binary output	Default usage	Connector pins
X110-HSO1	Close circuit breaker(2)	X110 – 15,16
X110-HSO2	Close circuit breaker (3)	X110 – 19,20
*Available only if IED has been ordered with High speed binary output (HSO) card		

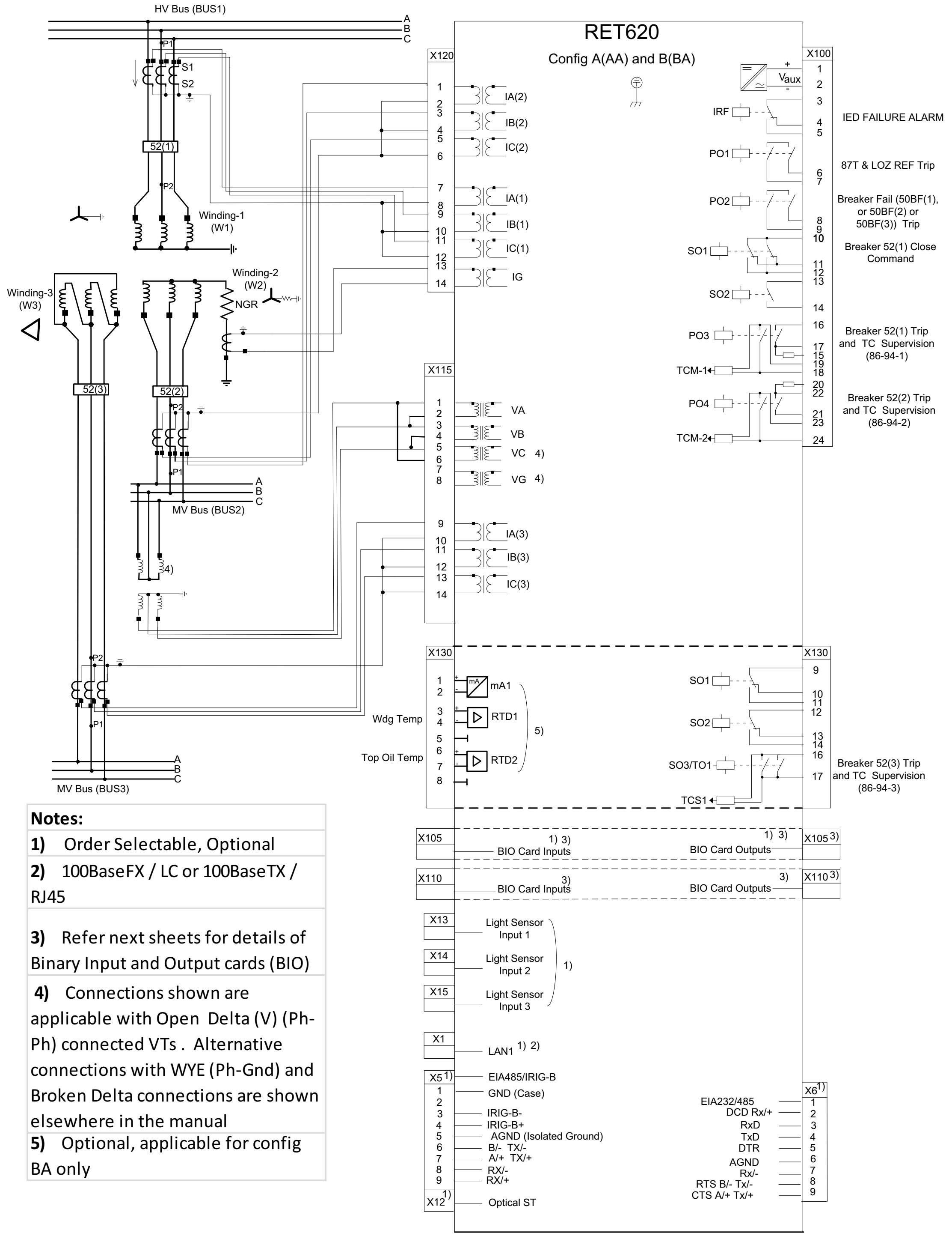
Table 14: Default connections for LEDss

LED	LED label
LED 1	Phase A
LED 2	Phase B
LED 3	Phase C
LED 4	Neutral / Ground
LED 5	Time

LED 6	Instantaneous
LED 7	Differential / REF
LED 8	Voltage
LED 9	Breaker Alarm
LED 10	Overload Alarm/Trip
LED 11	Arc Flash Detection

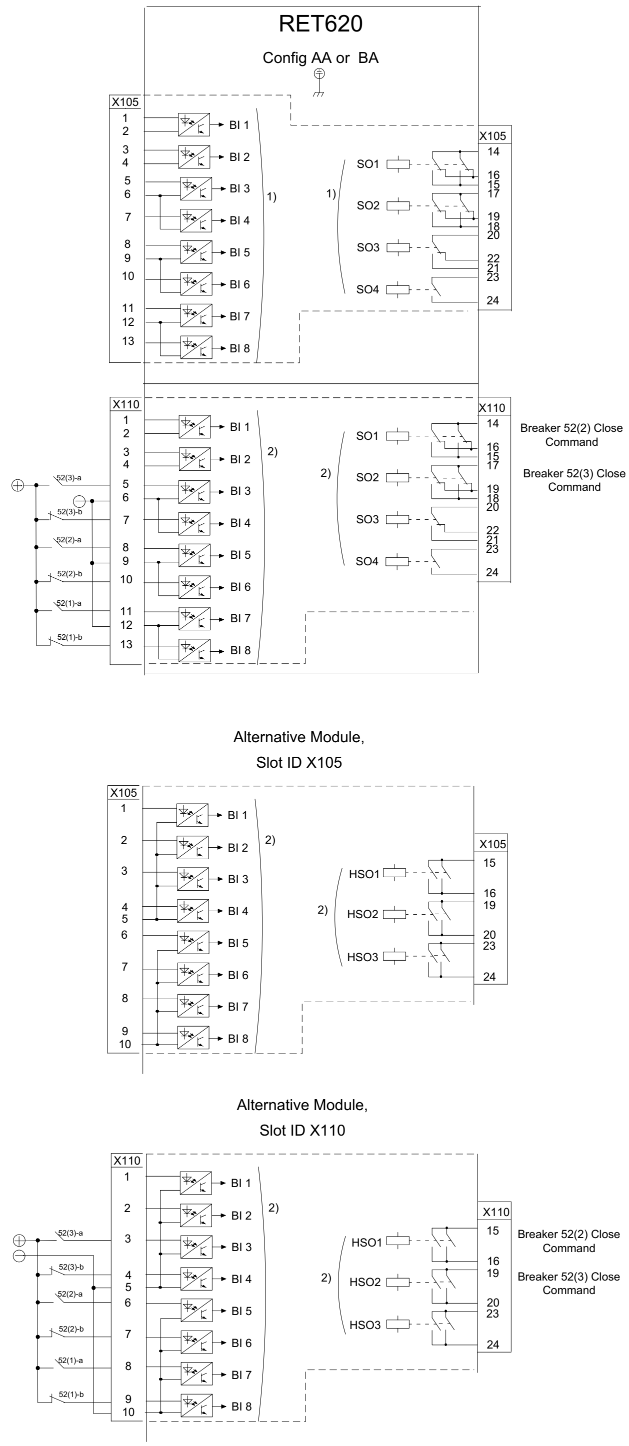
Some of the alarm led channel connections in the standard configuration depends on the optional functionality and are available according to order code

3.3.4 Typical connection diagrams



Notes:
1) Order Selectable, Optional
2) 100BaseFX / LC or 100BaseTX / RJ45
3) Refer next sheets for details of Binary Input and Output cards (BIO)
4) Connections shown are applicable with Open Delta (V) (Ph-Ph) connected VTs . Alternative connections with WYE (Ph-Gnd) and Broken Delta connections are shown elsewhere in the manual
5) Optional, applicable for config BA only

Figure 30: Typical connection diagram of RET620 (Config AA and BA)



1) Order Selectable, Optional
2) Order Selectable, Optional alternatives

Figure 31: Typical BIO module equipment arrangement and connections for RET620, Config AA and BA (Slot X105 and X110)

The logics and routing of signals inside the IED with respect to protection and tripping are summarized in the next few sheets.

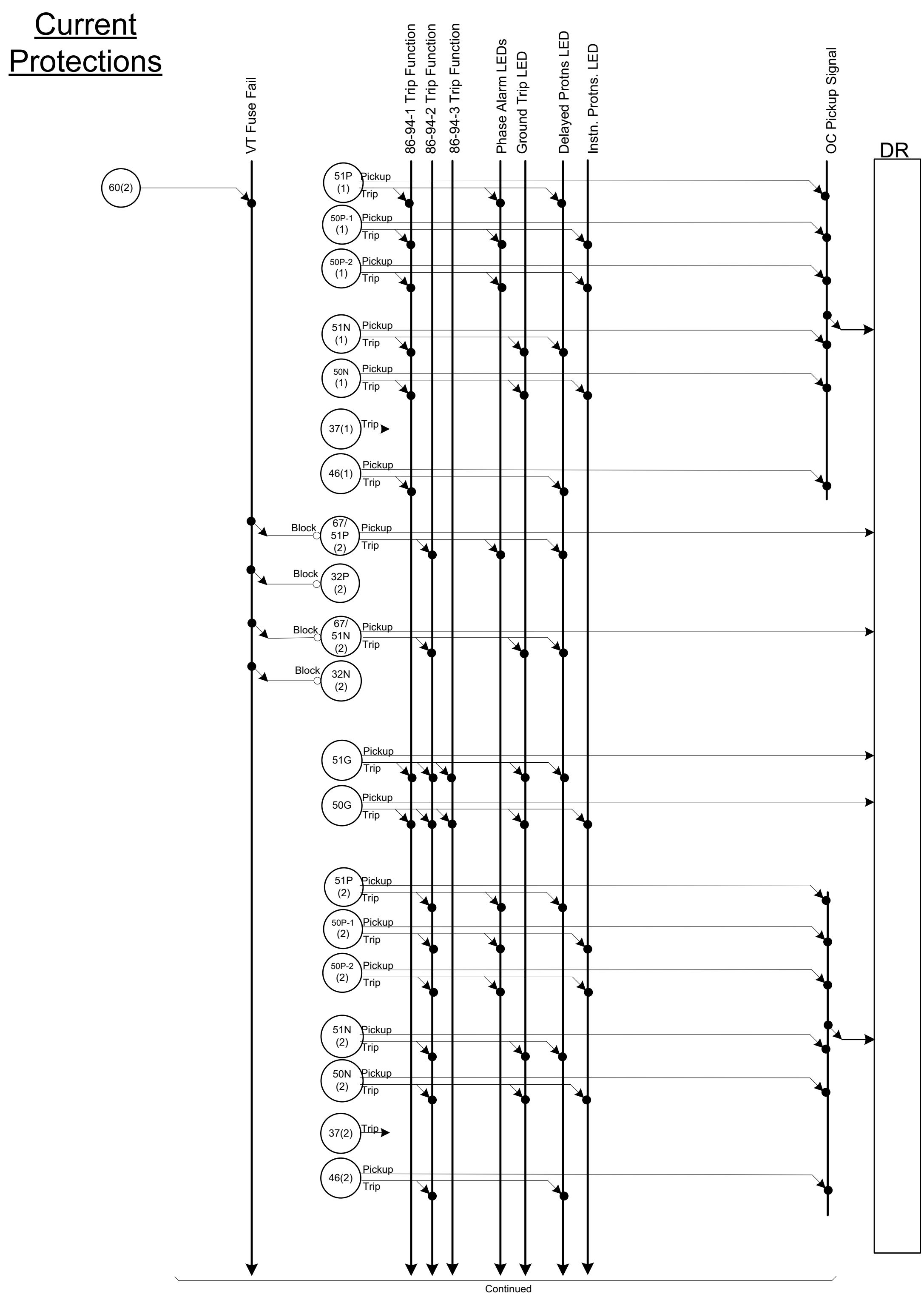
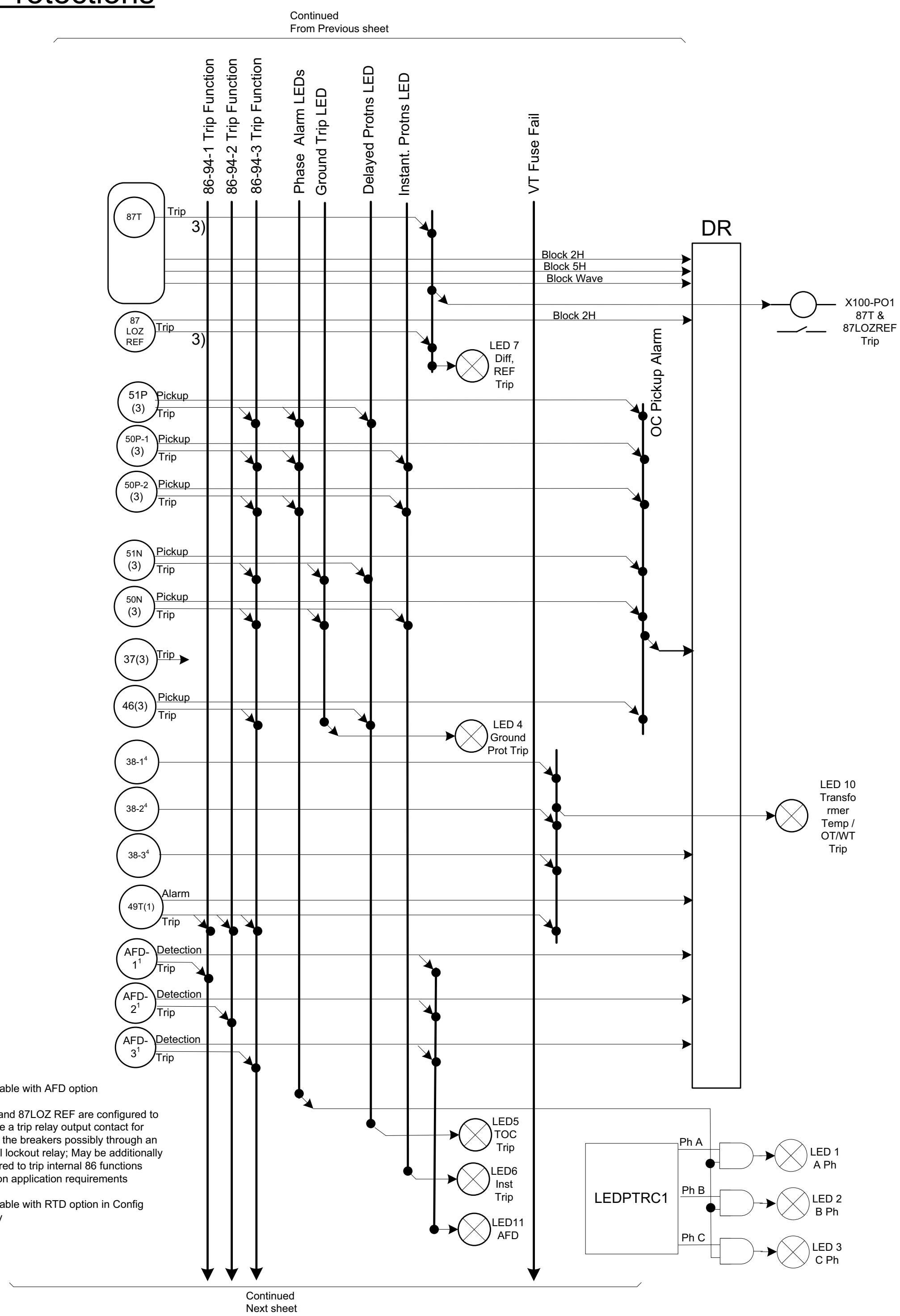


Figure 32: Simplified Logic Diagram for Current Protections,RET620, Config AA or BA

Other Protections



Notes:

1. Available with AFD option

3. 87T and 87LOZ REF are configured to energize a trip relay output contact for tripping the breakers possibly through an external lockout relay; May be additionally configured to trip internal 86 functions based on application requirements

4. Available with RTD option in Config **BA** only

Figure 33: Simplified Logic Diagram for Differential and OtherProtections, RET620, Config AA or BA

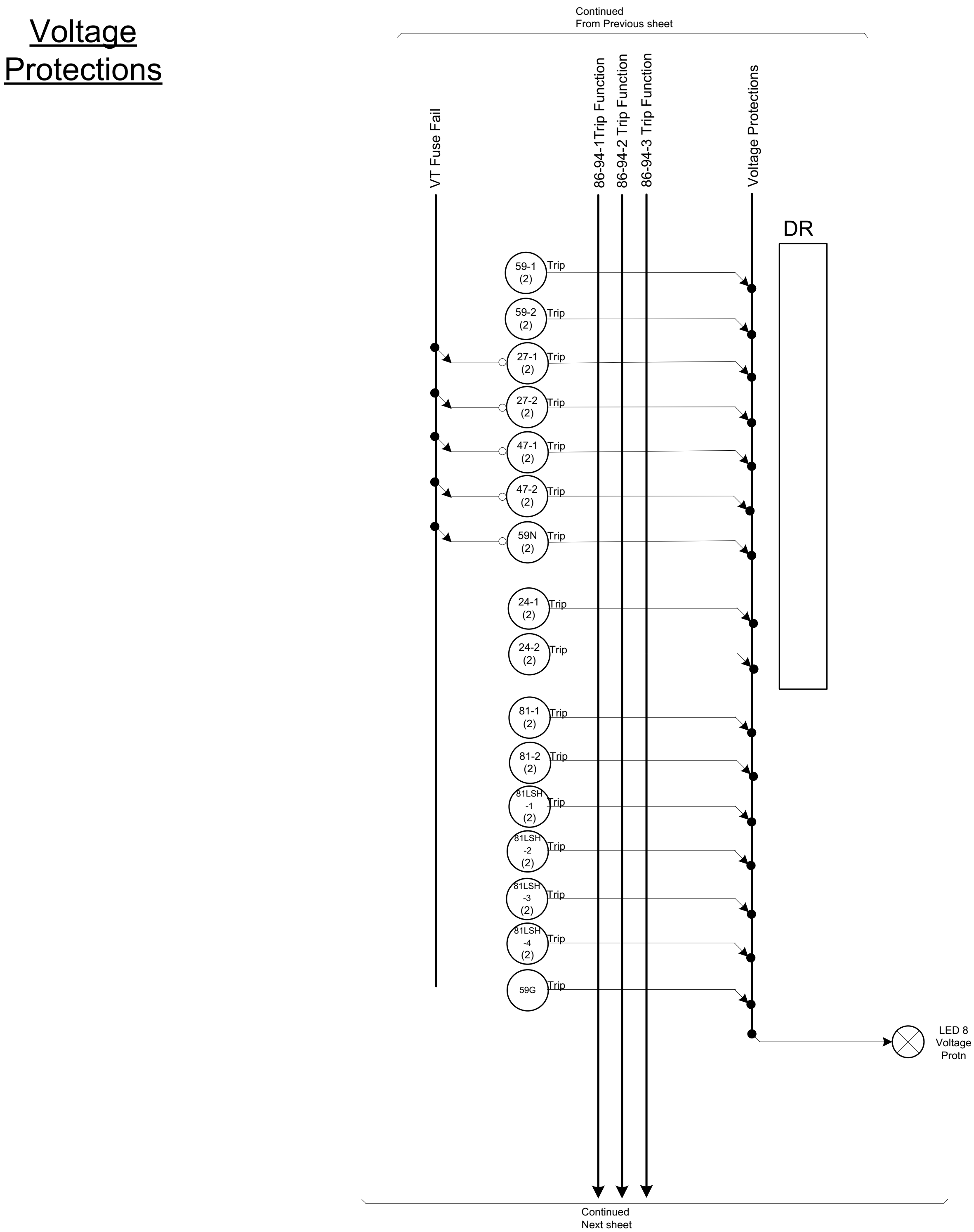


Figure 34: Simplified Logic Diagram, RET620 Config__

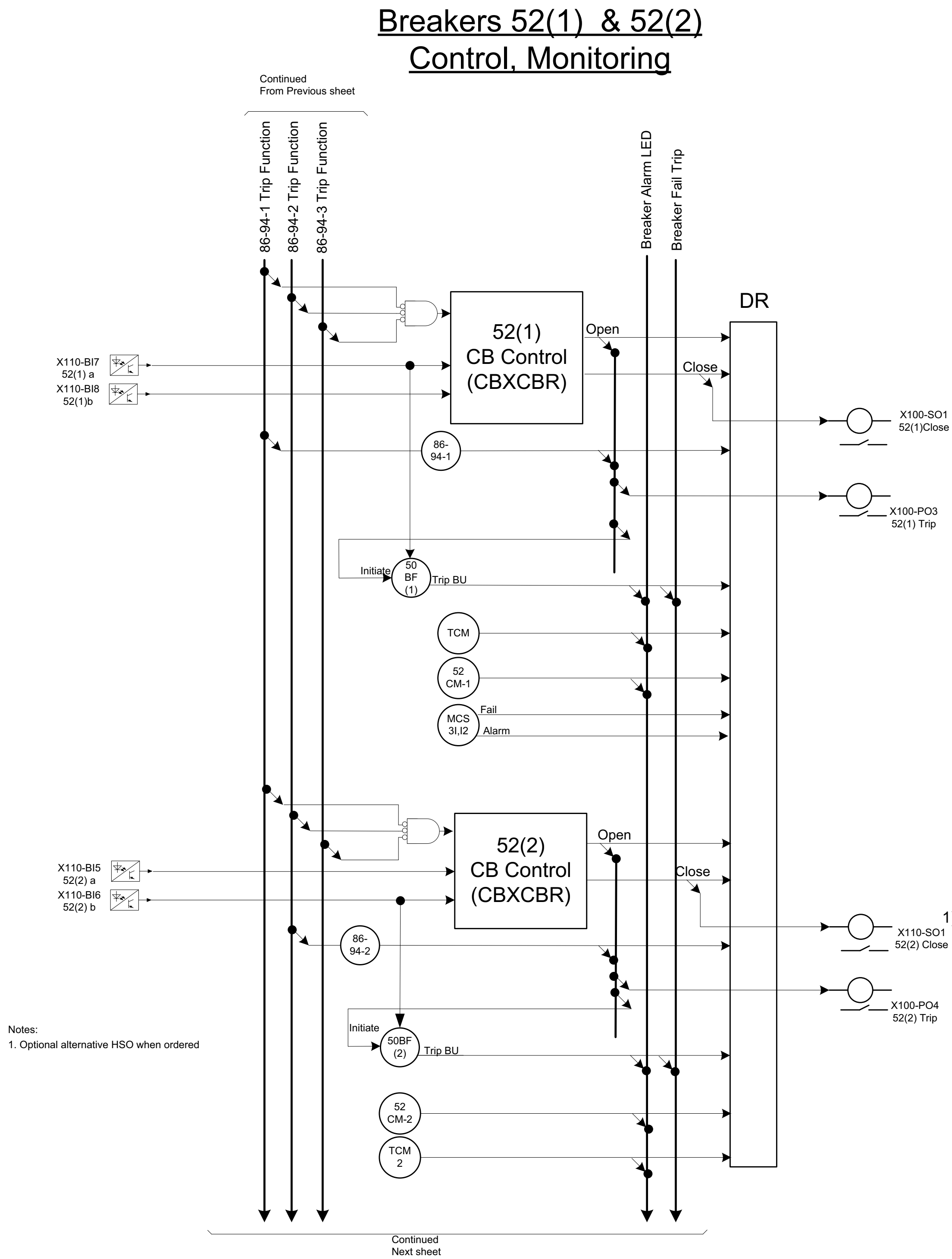


Figure 35: Simplified Logic Diagram for CB-1 and CB-2 Control and Monitoring, RET620, Config AA and BA

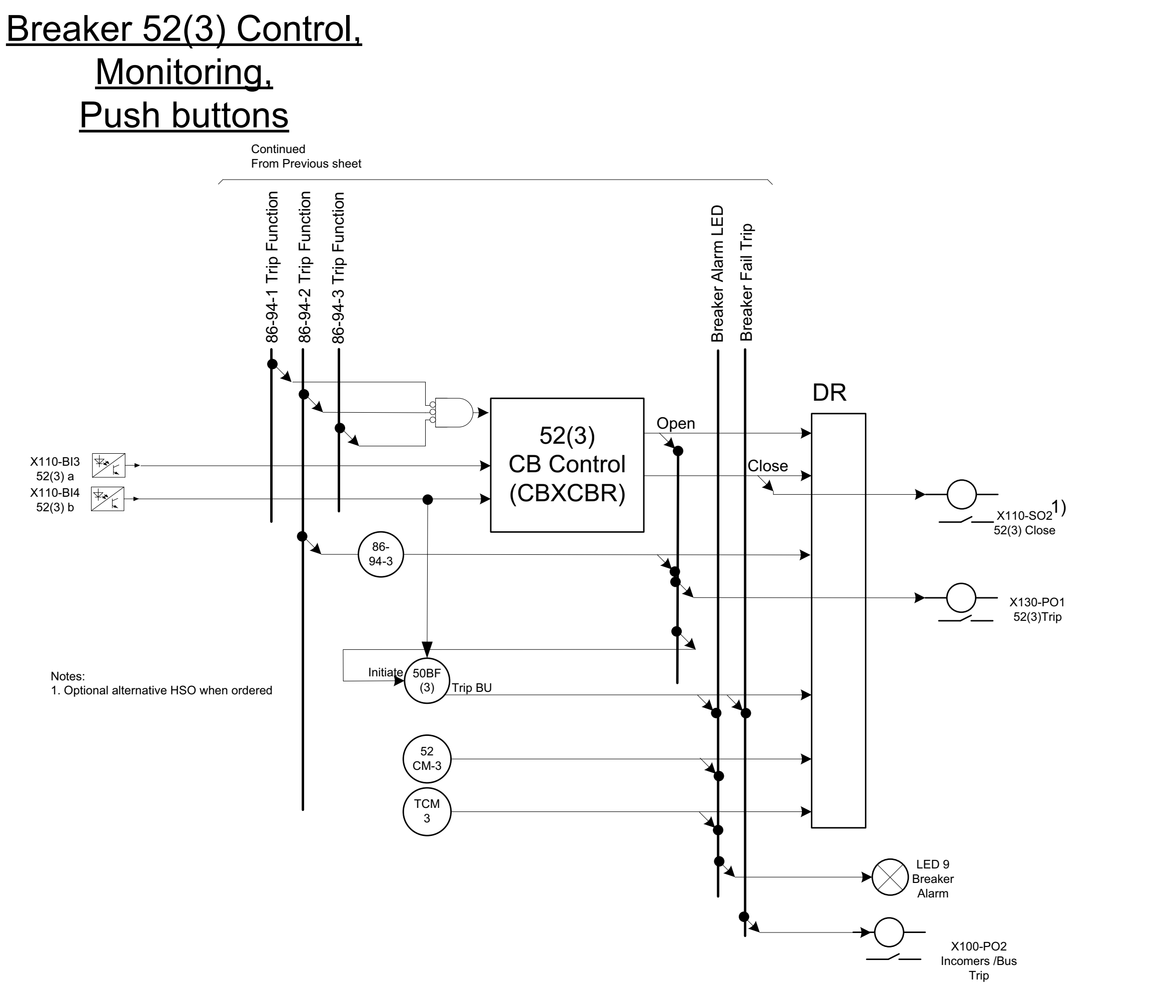


Figure 36: Simplified Logic Diagram for CB-3 Control and Monitoring, RET620, Config AA and BA

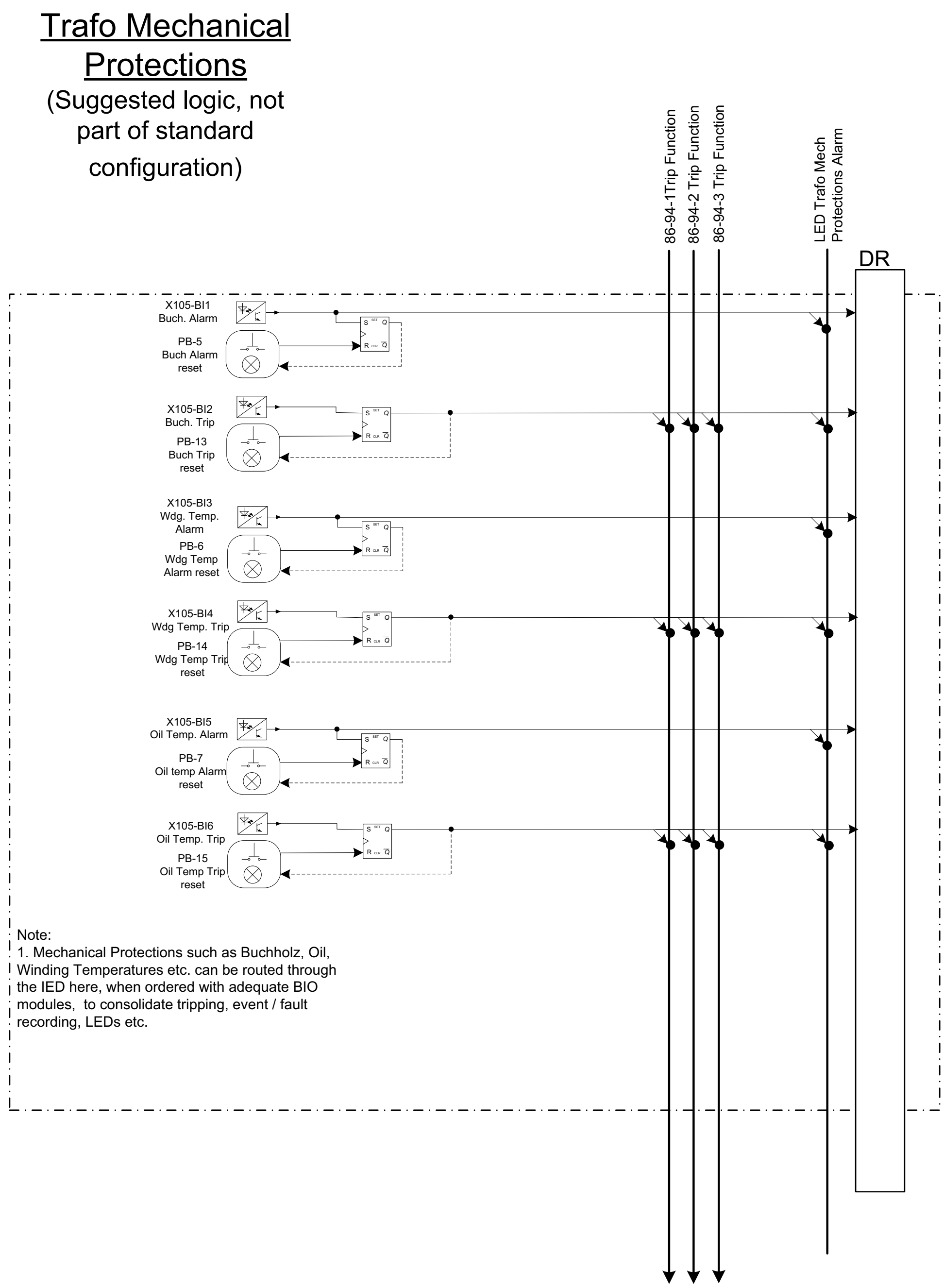


Figure 37: Suggested logic diagram if Transformer mechanical alarm / trip functions are routed through RET620

3.3.5 Functional diagrams

The functional diagrams describe the default input, output, RTD inputs, alarm LED and function-to-function connections. The default connections can be viewed and changed with PCM 600 according to the application requirements, if necessary.

The analog channels, measurements from CTs and VTs, have fixed connections to the different function blocks inside the IED's standard configuration.

The analog channels are assigned to different functions as shown in functional diagrams. The function and analog signal marked with (1) represents the function and analog signals (three phase currents/voltages) on the high-voltage side of the transformer and (2) represents the function and analog signals (three phase currents/voltage) on the low-voltage side of the transformer. The signal marked with IG represents the ground current measured between the neutral point of the transformer and grounding. The function and analog signal marked with (3) represents the function and analog signals (three phase currents) on the tertiary side of the transformer.

The three phase voltage inputs are connected in Delta, which are typically fed from Open Delta (V connected) VTs from the system. When WYE connected VT is available in the system, the VT inputs in the IED are WYE connected and configuration setting is suitably changed. In addition, the signal VG can be energized by the tertiary winding of the VTs, connected in broken delta.

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

RET 620 offers six different settings group which the user can set based on individual needs. Each group can then be activated/ deactivated by using the programmable button offered in the front panel of the unit. In addition to this, the programmable button can also be used for enabling/disabling switch mode, etc. Figure 38 shows the default mapping for the available programmable buttons.

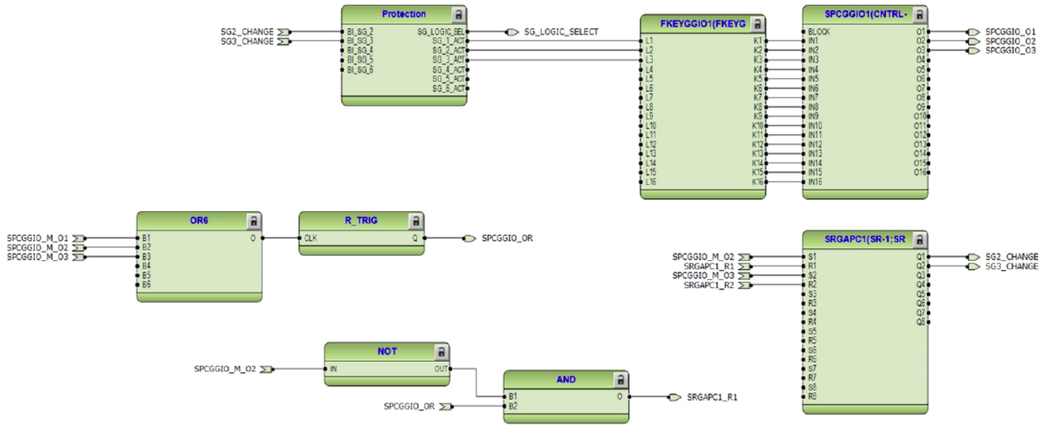


Figure 38: *Default mapping on programmable buttons*

3.3.5.1 Functional diagrams for protection

The functional diagrams for protection describe the IED's protection functionality in detail and according to the factory set default connections.

Three stages for each high-voltage, low-voltage and tertiary side as a total of nine, three-phase overcurrent protection (51P(1), 50P-1(1), 50P-2(1), 51P(2), 50P-1(2), 50P-2(2), 51P(3), 50P-1(3), 50P-2(3)) stages are provided for overcurrent and short-circuit protection.

The operation of these functions is not blocked as default by any functionality and so setting should be set such as to avoid unnecessary false trip or alarm.

The operation of 51P(1), 51P(2) and 51P(3) is connected to alarm LED 5, and 50P-1(1), 50P-2(1), 50P-1(2),50P-2(2), 50P-1(3) and 50P-2(3) is connected to alarm LED 6

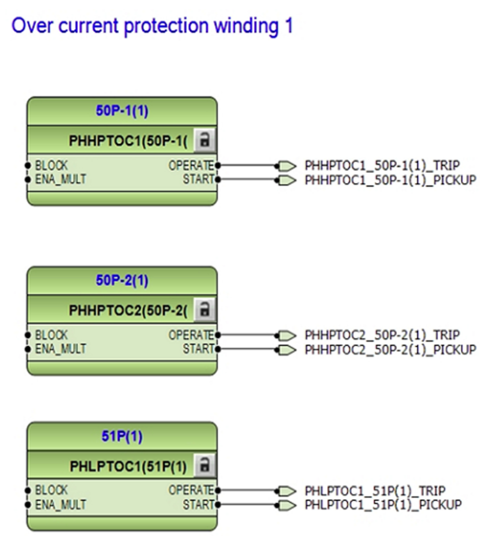


Figure 39: *Three phase overcurrent protection – HV side*

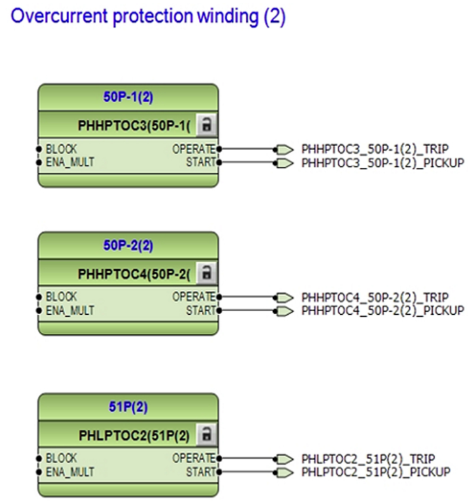


Figure 40: Three phase overcurrent protection – LV side

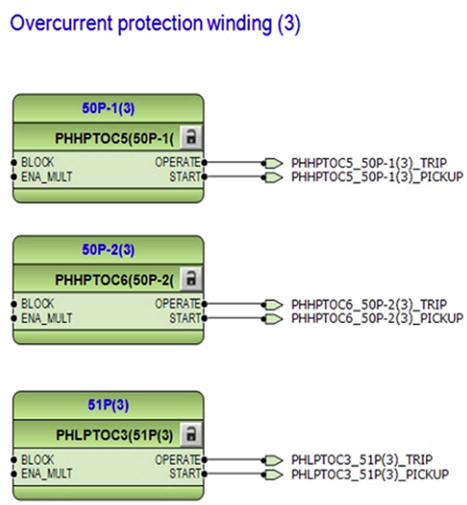


Figure 41: Three phase overcurrent protection - Tertiary side

A directional overcurrent protection (67/51P) is provided on low voltage side on which side the VT connection is configured. The function is blocked on loss of fuse, detected by fuse failure detection function (60).

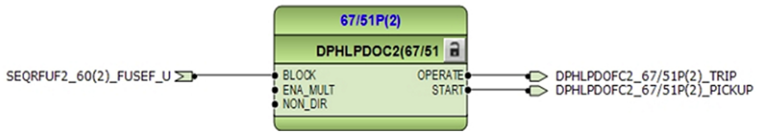


Figure 42: Three phase Directional overcurrent protection - LV side

Alarm LEDs 1, 2 and 3 are configured so as to indicate which phase has resulted into tripping of overcurrent protection. Overcurrent faults in Phase A, B and C is mapped to Alarm LEDs 1, 2 and 3 respectively.

Two stages for high-voltage, low-voltage and tertiary side as a total of six, ground fault (51N(1), 50N-1(1), 51N(2), 50N-1(2), 51N(3), 50N-1(3)) stages are provided for ground fault protection.

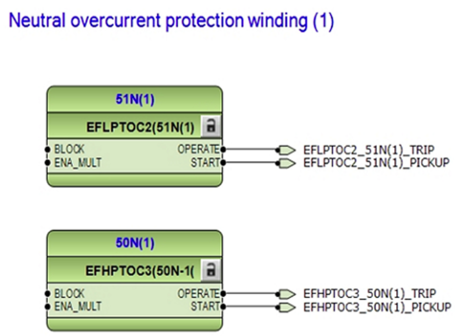


Figure 43: *Ground fault protection - HV side*

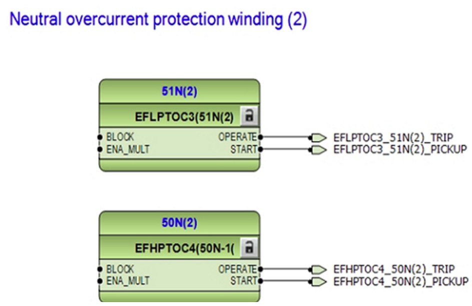


Figure 44: *Ground fault protection - LV side*

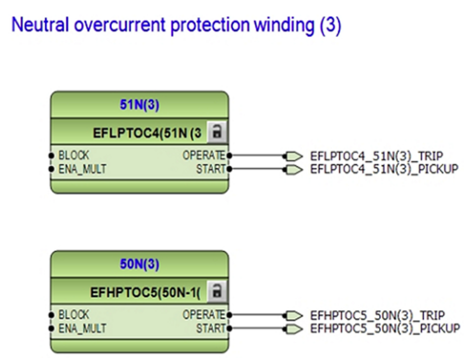


Figure 45: *Ground fault protection - Tertiary side*

Configuration also includes two stages of ground fault protection (51G, 50G), fed off the IG input of the IED. These can be set to provide standby earth fault protection for the transformer, for uncleared ground faults in the LV system

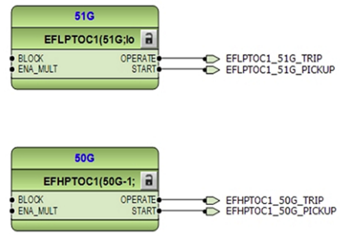


Figure 46: Non-directional ground fault protection

A directional ground overcurrent protection (67/51N) is provided on Low voltage. The function is blocked on loss of fuse, detected by fuse failure detection function(60). The polarization of the directional ground function is set by default to negative sequence which is suitable for VT input with Delta (open V) or WYE configurations. In the latter case, the polarization of the directional ground element can be set for zero sequence.

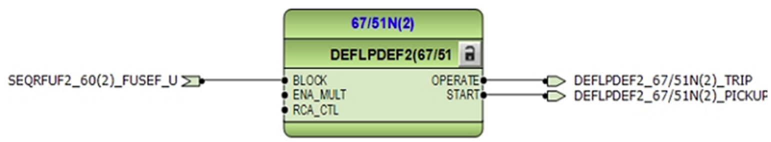


Figure 47: Directional Ground overcurrent protection - LV side

The operation of 51N(1), 51N(2), 51G and 67/51N is connected to alarm LED 4 and 5, and 50N-1(1), 50N-2(1), 50N-1(2), 50N-2(2) and 50G is connected to alarm LED 4 and 6.

The operation of the non-directional functions is not blocked as default by any functionality.

One stage of negative-sequence overcurrent protection (46(1), 46(2) and 46(3)) for each high-voltage, low-voltage and tertiary sides is provided for protecting transformer against thermal stress and damage. The operation of 46(1), 46(2) and 46(3) is not blocked as default by any functionality.

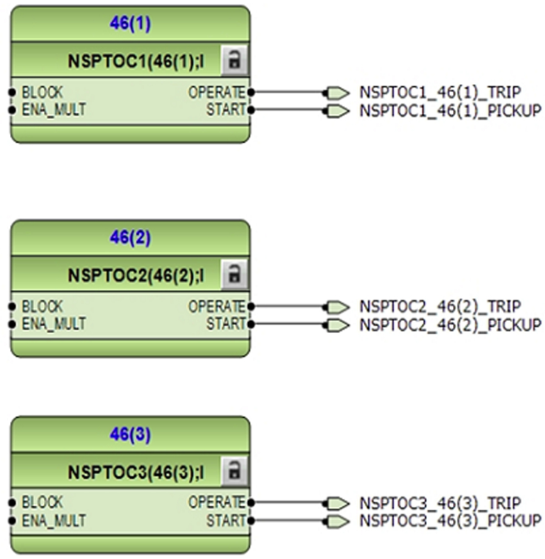


Figure 48: Negative sequence protection -HV, LV and tertiary side

Configuration also includes a general pickup alarm, the pickup outputs from respective 50P-1, 50P-2, 51P, 51N, 50N-1 and 46 are connected together to have a combined overcurrent high voltage side, low voltage and tertiary side pickup alarm which is connected to disturbance recorder as default.

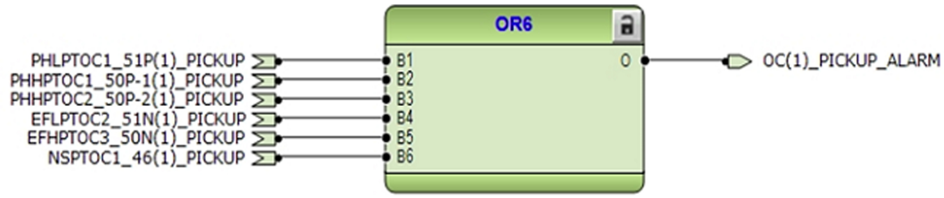


Figure 49: Overcurrent pickup alarms - HV side

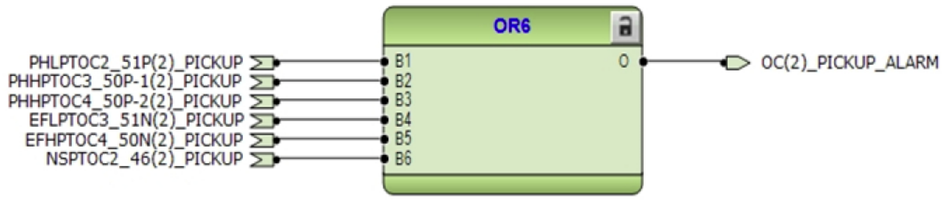


Figure 50: Overcurrent pickup alarms - LV side

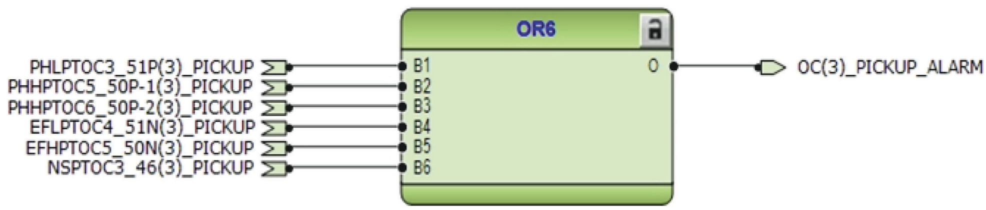


Figure 51: Overcurrent pickup alarms - Tertiary side

The directional positive sequence over power protection (32P(2)) and directional negative/zero sequence over power protection (32N(2)) are offered in configuration, on the LV side, on which side voltage transformer input is configured. Directional power protection functions are blocked by default configuration connection if fuse failure is detected.

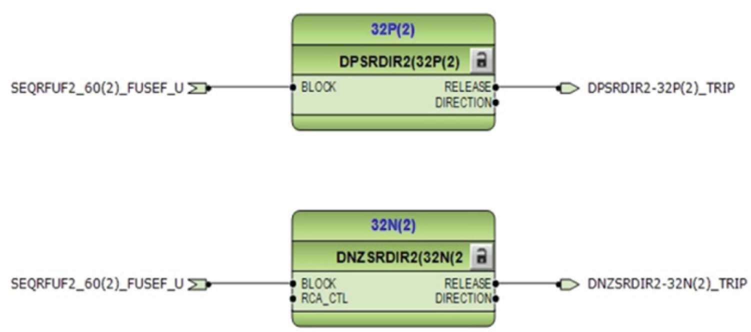


Figure 52: Directional Power protection

The configuration includes restricted low-impedance ground-fault (87LOZREF(2)) protection function for low-voltage side of power transformers. The numerical differential current stage operates exclusively on ground faults occurring in the protected area, that is, in the area between the phase and neutral current transformers. A ground 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 neutral of the transformer and ground.

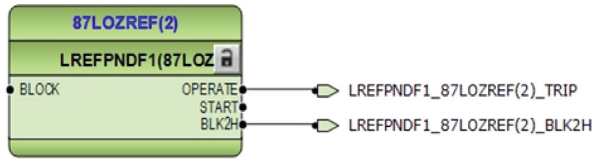


Figure 53: Restricted low impedance ground fault protection - LV side

The restrained (Low Stage) and unrestrained (High Stage) differential protection for three winding transformers (87T) provides protection of power transformer unit including, for example, winding short-circuit and inter-turn faults. The IED compares the phase currents on all HV, LV and tertiary sides of the transformer. If the differential current of the phase currents in one of the phases exceed the setting of the restrained (low stage) operation characteristic or the instantaneous protection stage of the function, the function provides a trip signal.

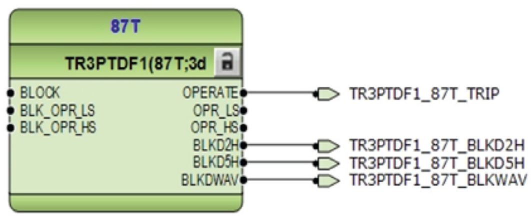


Figure 54: Transformer differential protection

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 87T.

The operation of 87LOZREF(2) and 87T is not blocked as default by any functionality. The operation of these protection functions is connected to alarm LED 7, as well as binary trip output PO1. This output may be used to energize an external lockout relay to generate contacts for tripping HV, LV and tertiary breakers. Presently the IED is not configured to energize other internal trip outputs such as 86/94 elements but may be added based on actual application requirements.

The thermal overload protection function (49T(1)) on HV side detects short and long term overloads under varying load conditions.

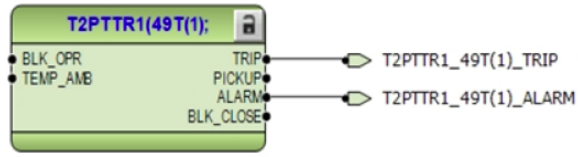


Figure 55: Transformer thermal overload protection - HV side

By default 49T(1) is configured to trip all the HV, LV and tertiary breakers isolating the transformer. Based on the thermal limit settings, it may alternatively be considered to trip out only the load side breaker, keeping the transformer energized from source side.

The IED is provided with two RTD inputs in Config BA, each one to measure winding and oil temperatures. All RET620 configurations have level detectors 38-1, 38-2 and 38-3 as standard. When RTD input is available as part of the configuration, the RTD can be connected to (38) functions to create alarms and trip signals based on the temperature input measured through RTD

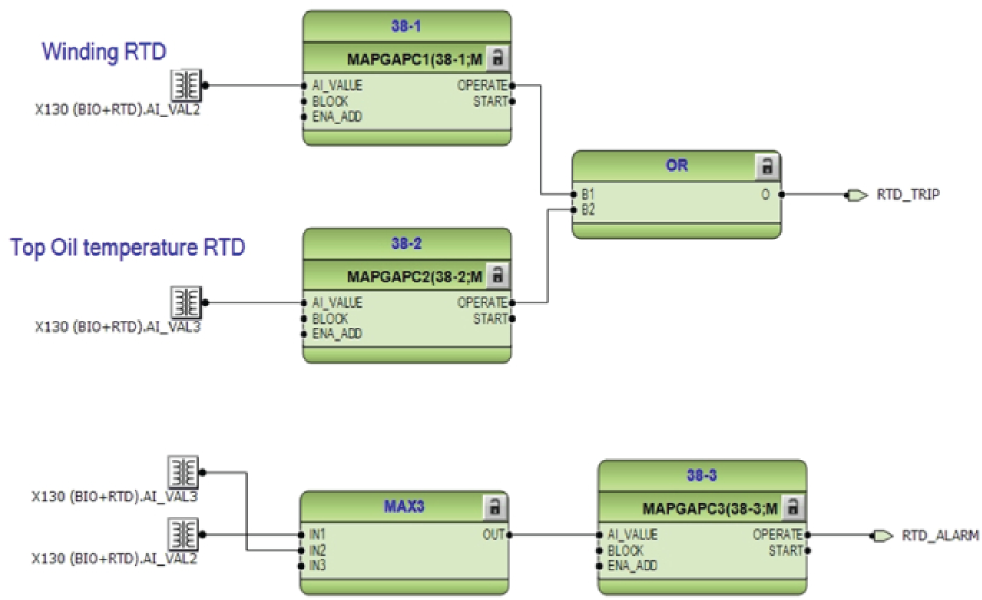


Figure 56: Level detection of temperature based on RTD inputs

The higher of the two RTD inputs are connected to level detector function 38-3, generating an alarm when the input signal exceeds the set limit.

Level detectors 38-1 and 38-2 are independently set for trip levels corresponding to winding and top oil temperature limits of the transformer. Operation of either of these would generate RTD trip output, which can be arranged to disconnect the transformer.

By default, RTD trip output is not configured to trip the breaker(s).

Transformer mechanical trip and alarm devices such as Buchholz Alarm / Trip, Pressure relief device operation, transformer built-in Oil / Winding temperature Alarm / Trip contacts are, by default, are not configured to be received into the IED since they may have own indication alarms and trip outputs to directly trip the breakers. This is usually in step with the traditional philosophy of two parallel paths to trip an electrical equipment without a common path. If necessary a repeat contact of those signals may be wired to the IED and configured for event recording.

Should it become necessary to route the mechanical alarm/trip functions through RET620, such as when backup protection is provided by a second IED, Function pushbuttons and associated LEDs on the LHMI could be configured for receiving and latching such inputs, routing them for tripping as well as having individual acknowledging of such inputs.

Loss of load protection (37(1), 37(2) and 37(3)) is provided, one on each winding of the transformer for detecting sudden loss of load on the transformer.

The operation of 37(1), 37(2) and 37(3) is not blocked as default by any functionality.

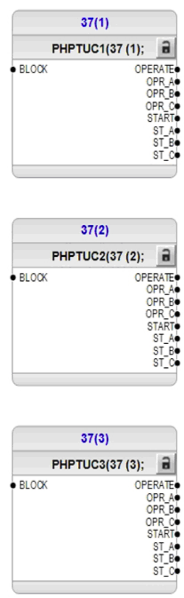


Figure 57: Loss of load protection - One on each transformer winding

By default 37(1), 37(2) and 37(3) are not configured to trip.

A number of voltage protection functions are included in the IED.

Two overvoltage and undervoltage protection stages (27-1(2), 27-2(2) and 59-1(2), 59-2(2)) offer protection against abnormal phase voltage conditions.

The operation of voltage functions is connected to alarm LED 8.

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.

Negative-sequence overvoltage (47-1(2) and 47-2(2)) protection functions enable voltage-based unbalance protection. The operation signals of voltage-sequence functions are connected to alarm LED 8, which is a combined voltage protection alarm LED.

The residual overvoltage protection (59N(2)) provides ground-fault protection by detecting abnormal level of residual voltage.

When broken delta input is wired to VG input of the IED, the ground overvoltage function (59G) also provides protection against abnormal levels of residual voltages.

Either 59N(2) and 59G can be used, for example, as nonselective backup protections. The operation signal is connected to alarm LED 8.

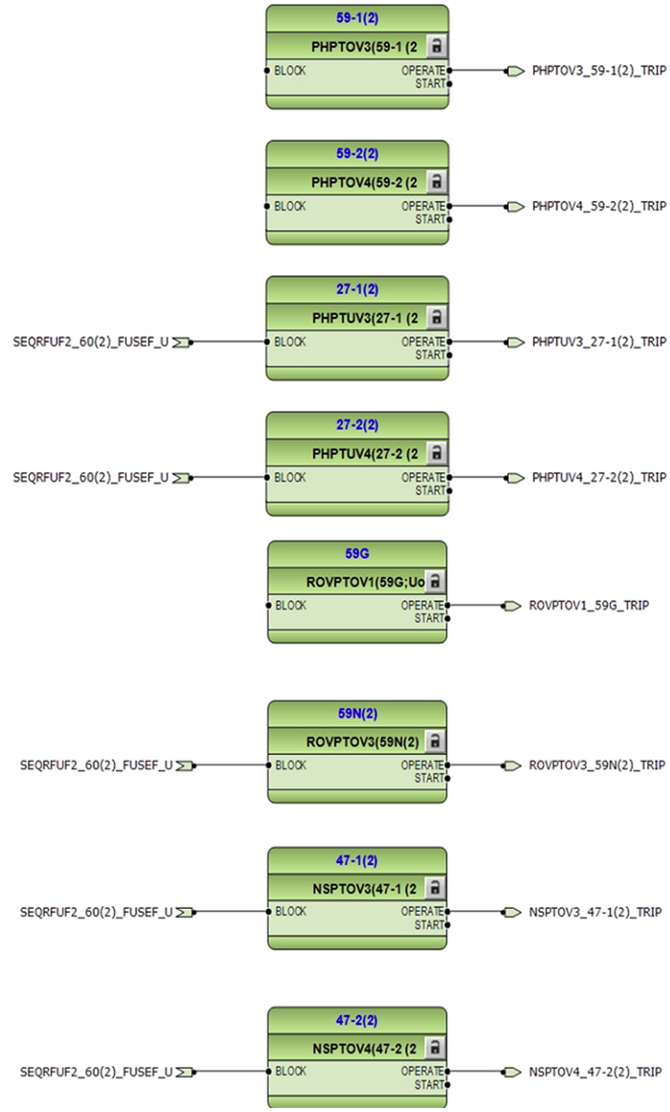


Figure 58: Voltage protection functions

The over excitation protection functions (24-1(2) and 24-2(2)) are offered as standard. (24-1(2)) may be set and arranged to give alarm while the second stage 24-2(2) may be arranged to provide trip function of the transformer.

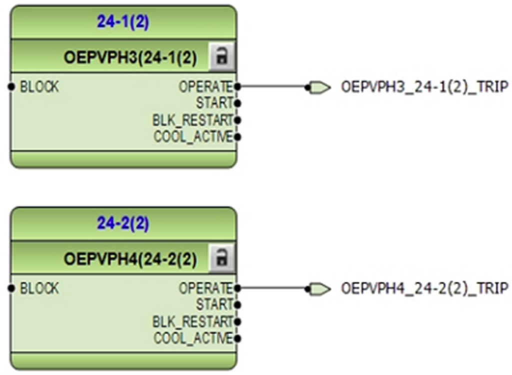


Figure 59: Over excitation protection

The selectable under frequency or over frequency protection (81-1(2) and 81-2(2)) prevents damage to transformer and associated network under unwanted frequency conditions.

Both functions contain 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 operation signals are connected to alarm LED 8.

Four load shedding and restoration stages are offered in the standard configuration. Each load shedding and restoration function (81LSH-1(2), 81LSH-2(2), 81LSH-(2), and 81LSH-4(2)) is capable of shedding load based on under frequency and the rate of change of the frequency. The load that is shed during the frequency disturbance can be restored once the frequency is stabilized to the normal level. Also manual restore commands can be given via binary inputs but by the default it is not connected. The operation signal is connected to the alarm LED 8.

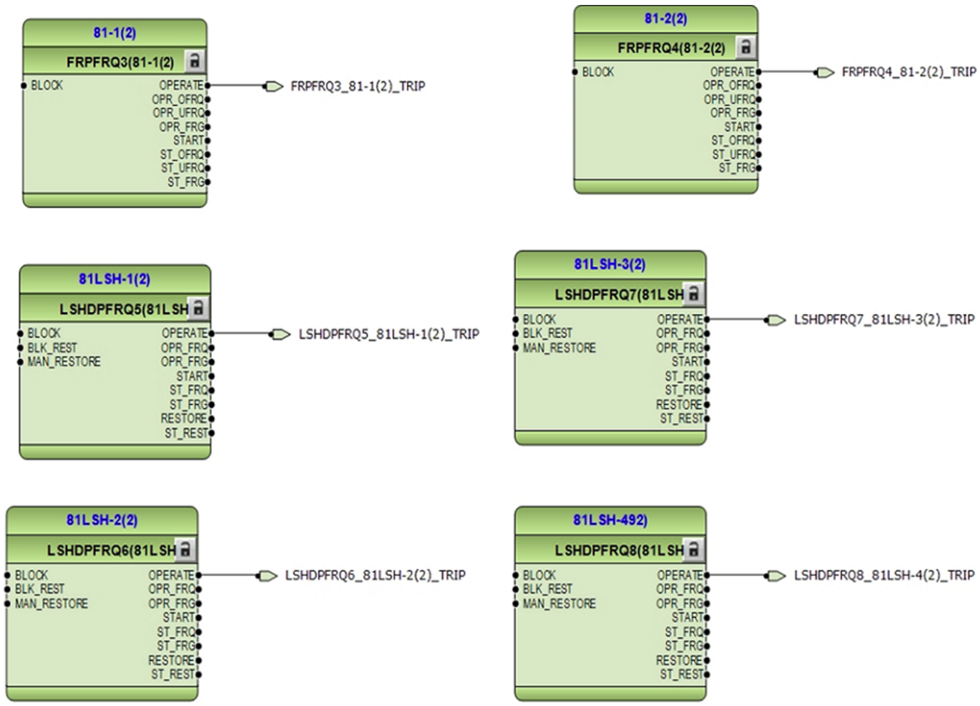


Figure 60: Frequency and Load shedding functions

None of the voltage based protections are configured by default to trip the transformer.

The circuit-breaker failure protection (50BF(1), 50BF(2) and 50BF(3)), one for each high-voltage, low-voltage and tertiary side is initiated via the pickup input by a number of different protection functions in the IED. 50BF(1), 50BF(2) and 50BF(3) offers different operating modes associated with the circuit-breaker position and the measured phase and residual currents.

50BF(1), 50BF(2) and 50BF(3) each has two operating outputs: TRRET and TRBU. The TRBU output from each side is used to give a backup trip to the circuit breaker feeding upstream. For this purpose, the TRBU output signal from both the function is connected to the output PO2 (X100: 8,9).

The TRBU output from 50BF(1), 50BF(2) and 50BF(3) is connected to a comm alarm LED 9.

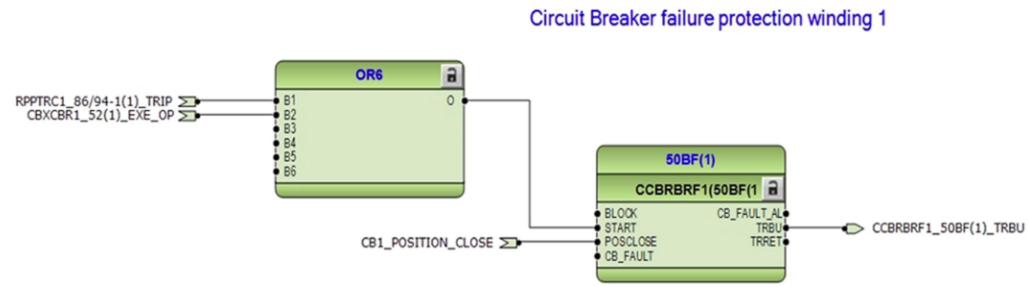


Figure 61: Circuit breaker failure protection - HV side

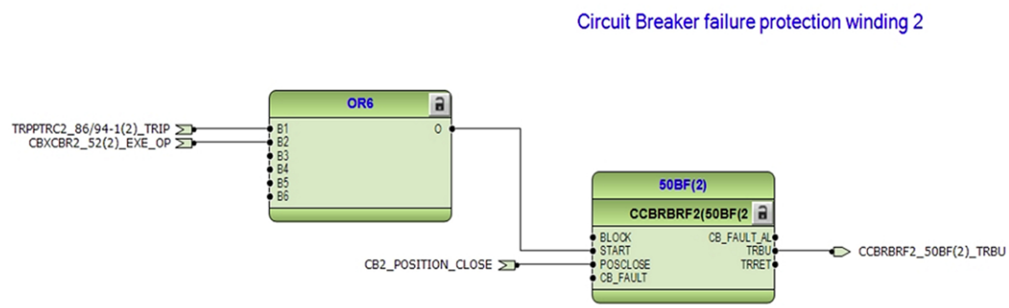


Figure 62: Circuit breaker failure protection - LV side

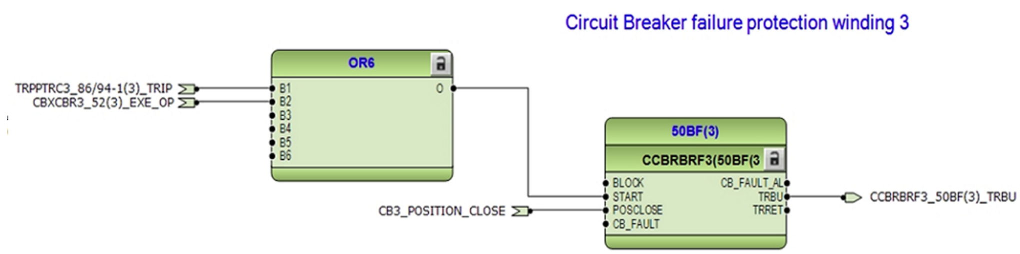


Figure 63: Circuit breaker failure protection - Tertiary side

Three arc protection (AFD-1(2), AFD-2(2) and AFD-3(2)) stages are included as an optional function. The arc protection offers individual function blocks for three ARC sensors that can be connected to the IED. Each arc protection function block has two different operation modes, with or without the phase and residual current check.

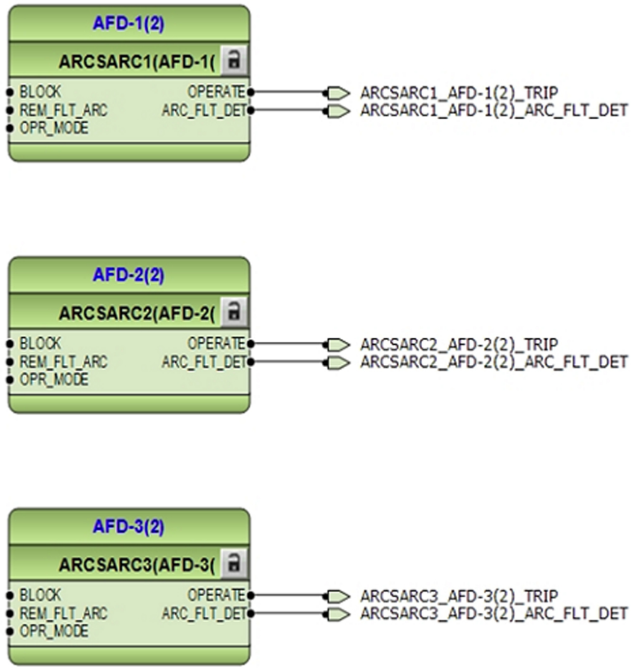


Figure 64: Arc protection

Trip output of each of the AFD-1,2 and 3 are configured to energize master trip functions that trip respective breakers by default. This may however be suitably changed based on actual requirements and placement of the arc detectors.

When High Speed trip output is required from the AFD functions, BIO card with high speed power output can be optionally ordered.

Note in the board in slot X110 the first and second outputs are configured by default to do second and third breaker closing functions. The third high speed output from this board and/or three HSO in slot X105 can be optionally ordered and configured for Arc protection high speed trip purposes.

The detection of arc fault is connected to alarm LED 11.

Three master trip logics (86/94-1, 86/94-2 and 86/94-3) are provided as trip command collectors.

The functions collect the trip signals from various protections and are connected to binary outputs to trip HV, LV and tertiary breakers of the transformer.

Open control commands to HV, LV and Tertiary circuit breaker from the local or remote are also connected directly to appropriate binary outputs.

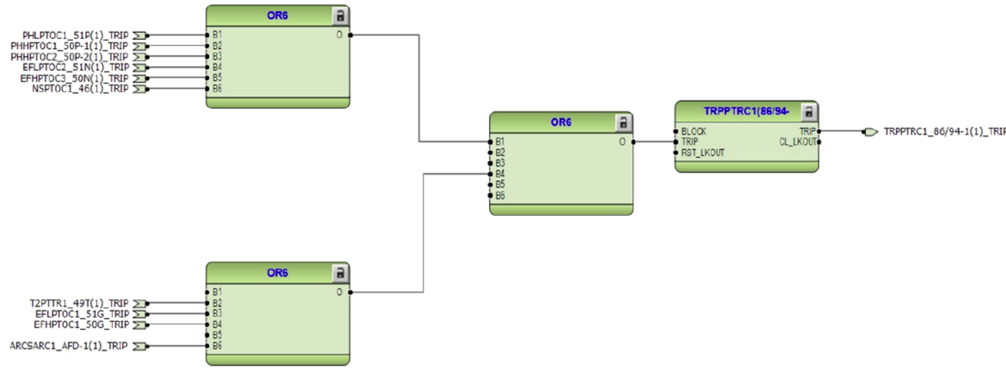


Figure 65: *Master trip logic - HV side*

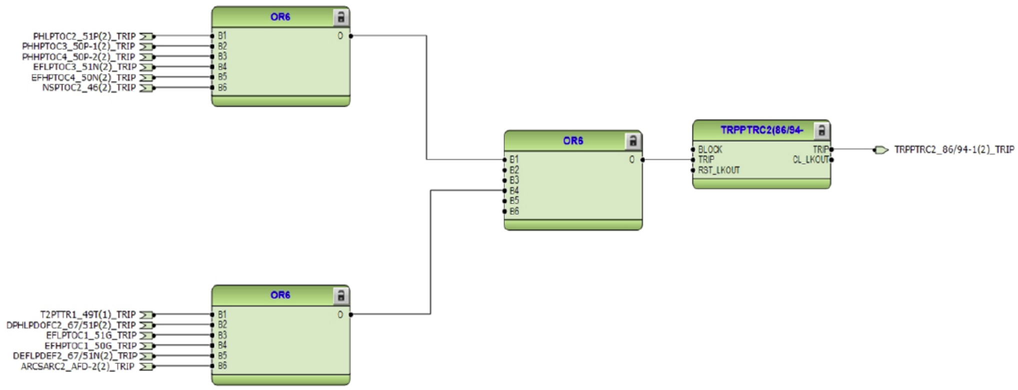


Figure 66: *Master trip logic - LV side*

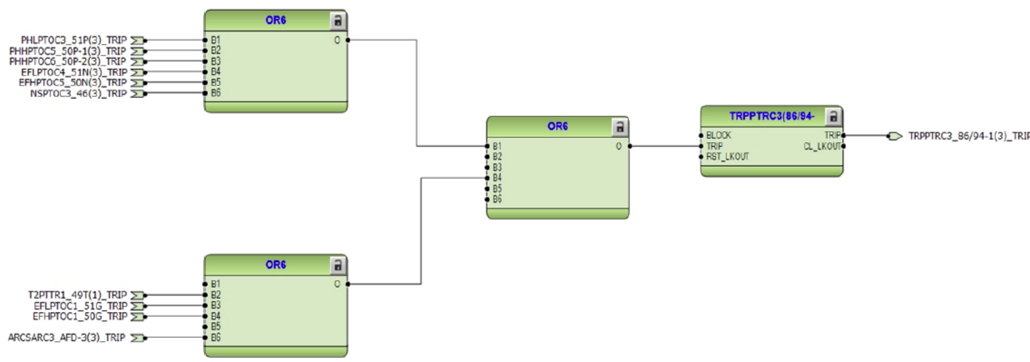


Figure 67: *Master trip logic - Tertiary side*

86/94-1, 86/94-2 and 86/94-3 provide the lockout/latching function, event generation and the trip signal duration setting. If the lockout operation mode is selected, one binary input can be reassigned to the RST_LKOUT input of the Master Trip to enable external reset with a pushbutton.

3.3.5.2 Functional diagrams for control functions

The functional diagrams for control describe the IED's control functionality in detail and according to the factory set default connections.

The circuit breaker closing is enabled when the respective ENA_CLOSE input is activated. The input can be activated by the configuration logic, which is a combination of the disconnector or breaker truck and ground switch position status and the status of the Master Trip logics, gas pressure alarm and circuit-breaker spring charging. With the present configuration, the activation of respective ENA_CLOSE input is configured using only Master Trip logic 86/94-1, 86/94-2 and 86/94-3 i.e. the circuit breaker cannot be closed in case master trip is active.

When all conditions of the respective breaker closing are fulfilled, the EXE_CL output of appropriate 52(1), 52(2) or 52(3) and close output contact (configured) of the respective breaker closes if closing command is given.

The ITL_BYPASS input can be used, for example, to always enable the closing of the circuit breaker when the circuit breaker truck is in the test position, despite the interlocking conditions being active when the circuit breaker truck is closed in service position.

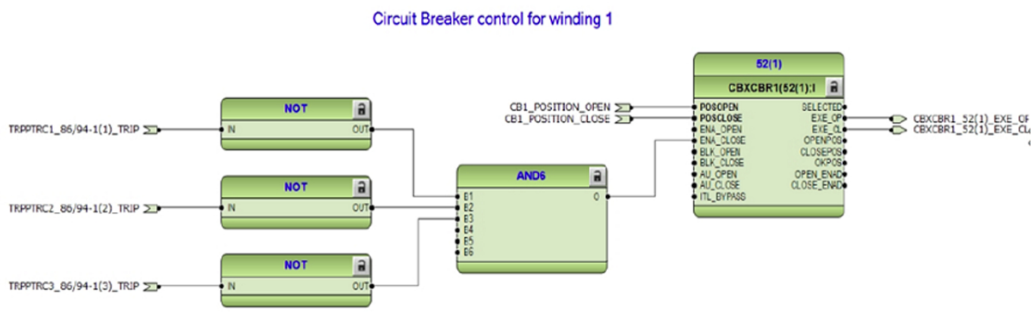


Figure 68: Circuit breaker control - HV side

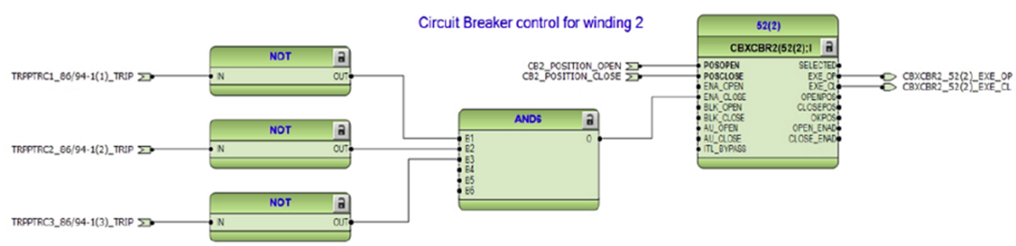


Figure 69: Circuit breaker control - LV side

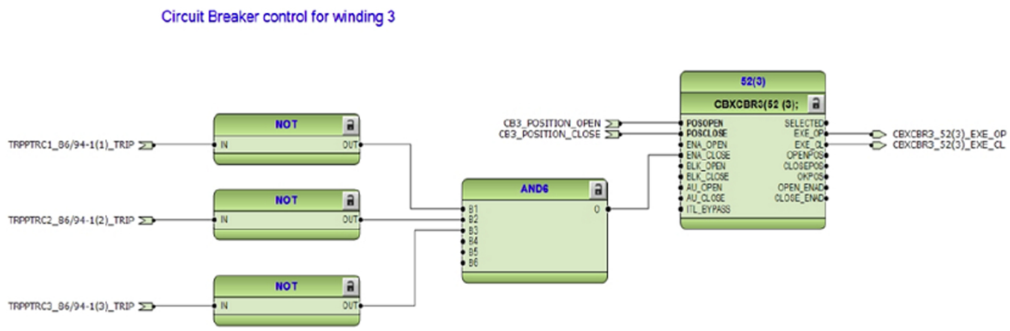


Figure 70: *Circuit breaker control - Tertiary side*

If the ENA_CLOSE and BLK_CLOSE signals are completely removed from the breaker control function block 52 with PCM600, the function assumes that the breaker close commands are allowed continuously.

3.3.5.3 Functional diagrams for condition monitoring

The functional diagrams for condition monitoring describe the IED's condition monitoring functionality in detail and according to the factory set default connections.

Configuration also includes tap changer position indicator (84T), however by default it is not configured.

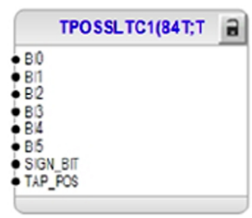


Figure 71: Tap changer position indicator

Three trip circuit monitoring (TCM-1, TCM-2 and TCM-3) stages are provided to supervise the trip circuit of the high voltage, low voltage, and tertiary circuit breakers.

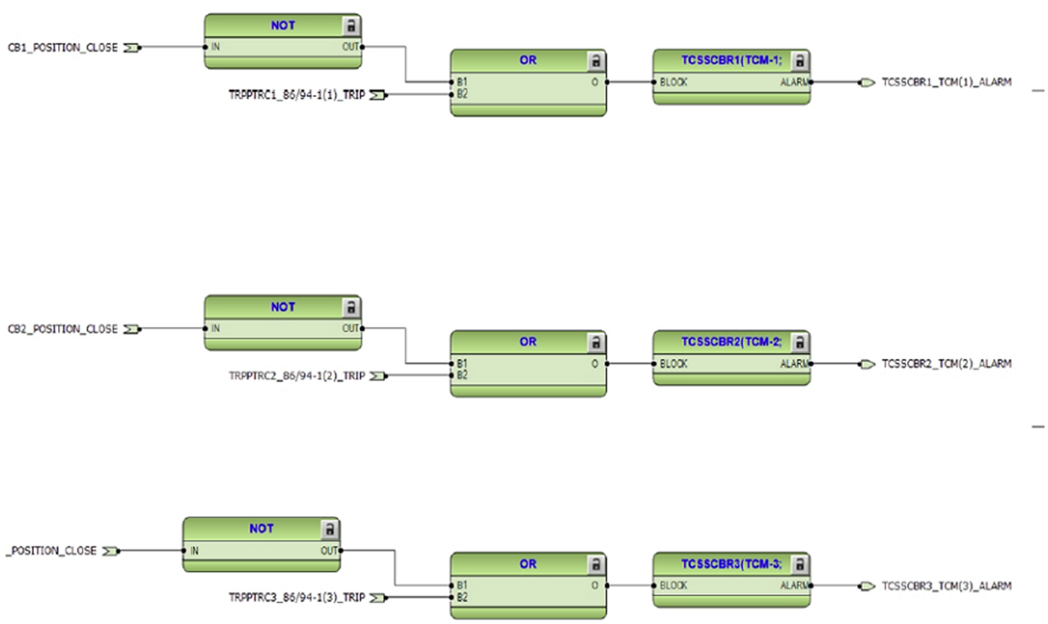


Figure 72: Trip circuit monitoring HV,LV and Tertiary- side

The TCM functions are blocked by respective trip signals and the respective circuit-breaker open position signal.

The supervision alarm from TCM is connected to alarm LED 9.

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

A failure in current measuring circuits is detected by current circuit supervision function (MCS 3I, I2). When a failure is detected, function activates and can be used to block protection functions for example 87T, thus avoiding mal-operation.

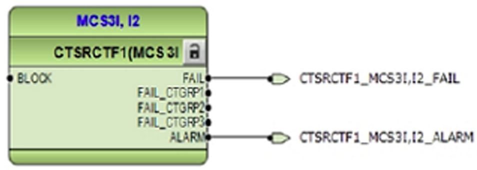


Figure 73: Current circuit supervision

By default the FAIL output from MCS 3I, I2 function is only connected to disturbance recorder.

The fuse failure supervision SEQRFUF1 detects failures in voltage measurement circuits. Failures, such as an open miniature circuit breaker, are detected and the alarm is connected to the few voltage based protection functions to avoid misoperation.

Figure 74: Fuse failure monitoring

Three circuit breaker condition monitoring function (52CM(1),52CM(2) and 52CM(3)) one each is configured to supervise high voltage side, low voltage side and tertiary side circuit breaker status based on the binary input information connected and measured current levels. The function introduces various supervision alarms.

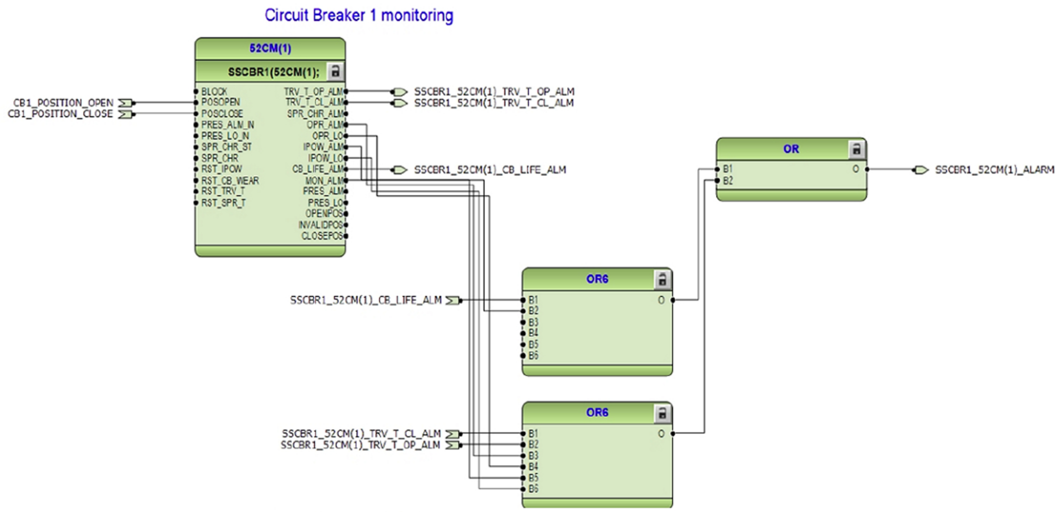


Figure 75: *Circuit breaker condition monitoring HV side*

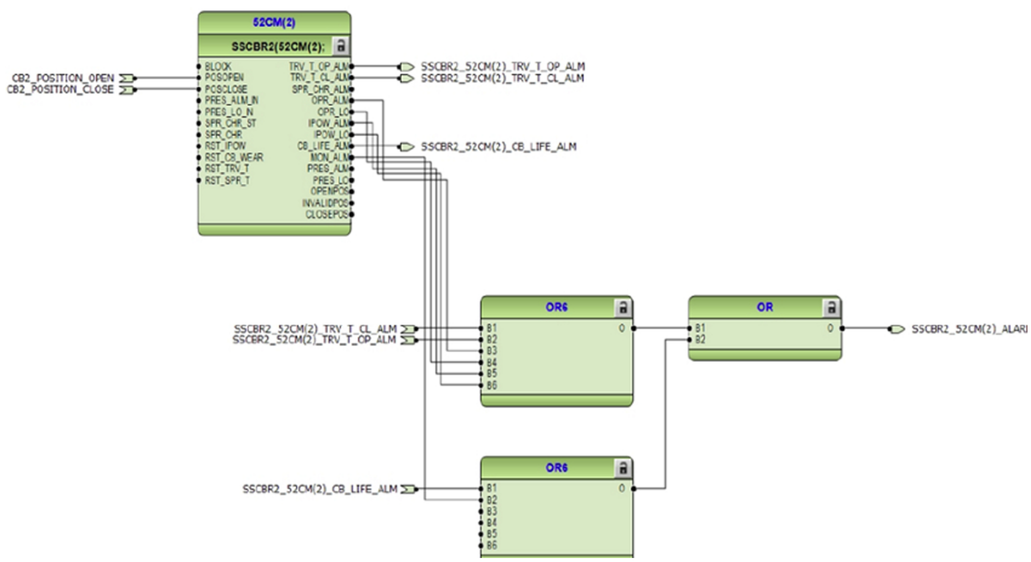


Figure 76: *Circuit breaker condition monitoring LV side*

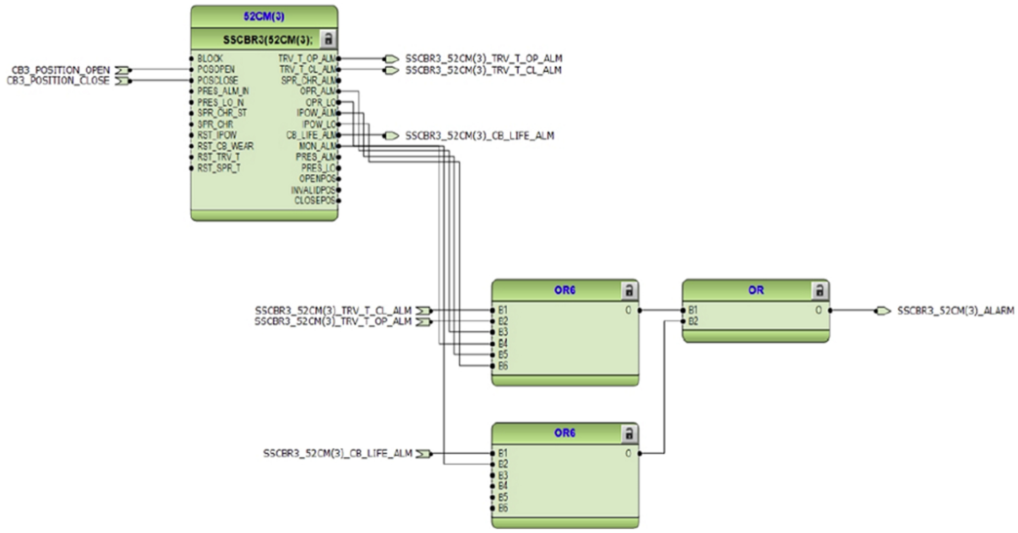


Figure 77: Circuit breaker condition monitoring Tertiary side

By default only POSOPEN and POSCLOSE information is available to 52CM(1),52CM(2) and 52CM(3).

3.3.5.4 Functional diagrams for measurements

The functional diagrams for measurement describe the IED's measurement functionality in detail and according to the factory set default connections.

The phase current inputs from high voltage and low voltage side are connected to the IED and are measured by high voltage, low voltage side and tertiary three-phase current measurement [IA, IB, IC(1), IA,IB,IC(2) and IA,IB,IC(3)] function block respectively. The current input are connected to the X120 card in the back panel for windings W1 and W2 and to X115 for winding W3. Similarly the sequence current component for the currents measured by sequence current measurement [I1, I2, I0(1), I1,I2,I0(2) and I1,I2,I0(3)] function blocks. The residual current is measured by residual current measurement (IG) function block.

The phase voltage input is connected to the X115 card in the back panel. The voltages are measured by (VA,VB,VC) function block. Similarly the sequence voltages are measured by sequence voltage measurement (V1, V2, V0) function block respectively.

The frequency measurement of the power system (f) is available. Also single (SPEMMXU2) and three phase (PEMMXU2) power measurements are available.

The load profile (LoadProf) function is also included into measurements sheet. The load profile function offers ability to observe the history of the loading of the equipment.

The measurements can be seen from the LHMI and is available using the measurement option in the menu selection. Based on the settings, "IA, IB, IC(1)", "IA,IB, IC(2)", "IA,IB,IC(3)" and IG function block can generate low alarm/warning, high alarm/warning signals for the measured current values.

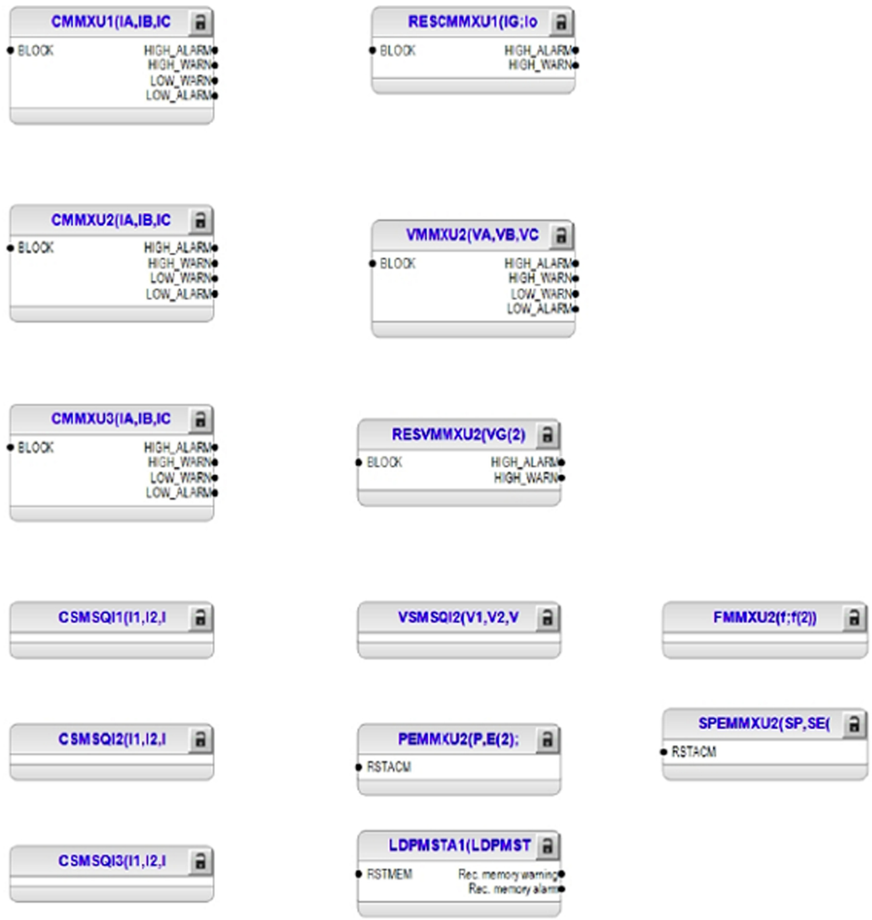


Figure 78: Measurements

3.3.5.5 Functional diagrams for other functions

Configuration also includes other miscellaneous basic functions which are not configured, but can be used for creating general purpose logics. These functions include:

- Four instance of Minimum Pulse Timer TP-1, TP-2, TP-3 and TP-4,
- Two instance of Pulse Timer PT-1 and PT-2,
- Four instance of Time delay on TON-1, TON-2, TON3 and TON-4,
- Four instance of Time delay off TOF-1, TOF-2, TOF-3 and TOF-4,
- Four instance of Set reset logic SR-1, SR-2, SR-3 and SR-4,
- Eight instance of Move logic MV-1, MV-2, MV-3, MV-4, MV-5, MV-6, MV-7 and MV-8,
- Three instance of Generic control points CNTRL-1, CNTRL-2 and CNTRL-3,
- One Remote Generic Control Points, RCNTRL-1,
- One Local Generic Control Points, LCNTRL-1,
- Twelve Generic Up-Down counters UDFNCT1, UDFCNT2, UDFCNT12 and,
- One Programmable buttons (16 buttons) FKEY.

3.3.5.6 Function diagrams for logging functions

The functional diagrams for logging describe the IED's default disturbance recorder connections.

The disturbance recorder DFR consists of 12 analog and 64 channels. The analog channels are pre configured in the IED as follows for this specific configuration:

Table 15: List of analog channels connected to DFR (RET Config AA and Config BA)

Ch. No	Channel
1	IA
2	IB
3	IC
4	IG
5	IA2
6	IB2
7	IC2
8	VA2
9	VB2
10	VC2
11	VG2
12	IA3

A few channels of the binary channel are connected to trigger the digital fault recorder and are shown in Figure 79. More connection can be made as per individual needs. Also, when disturbance recorder is triggered, the analog values available at the analog inputs are recorded by the fault recorder FR.

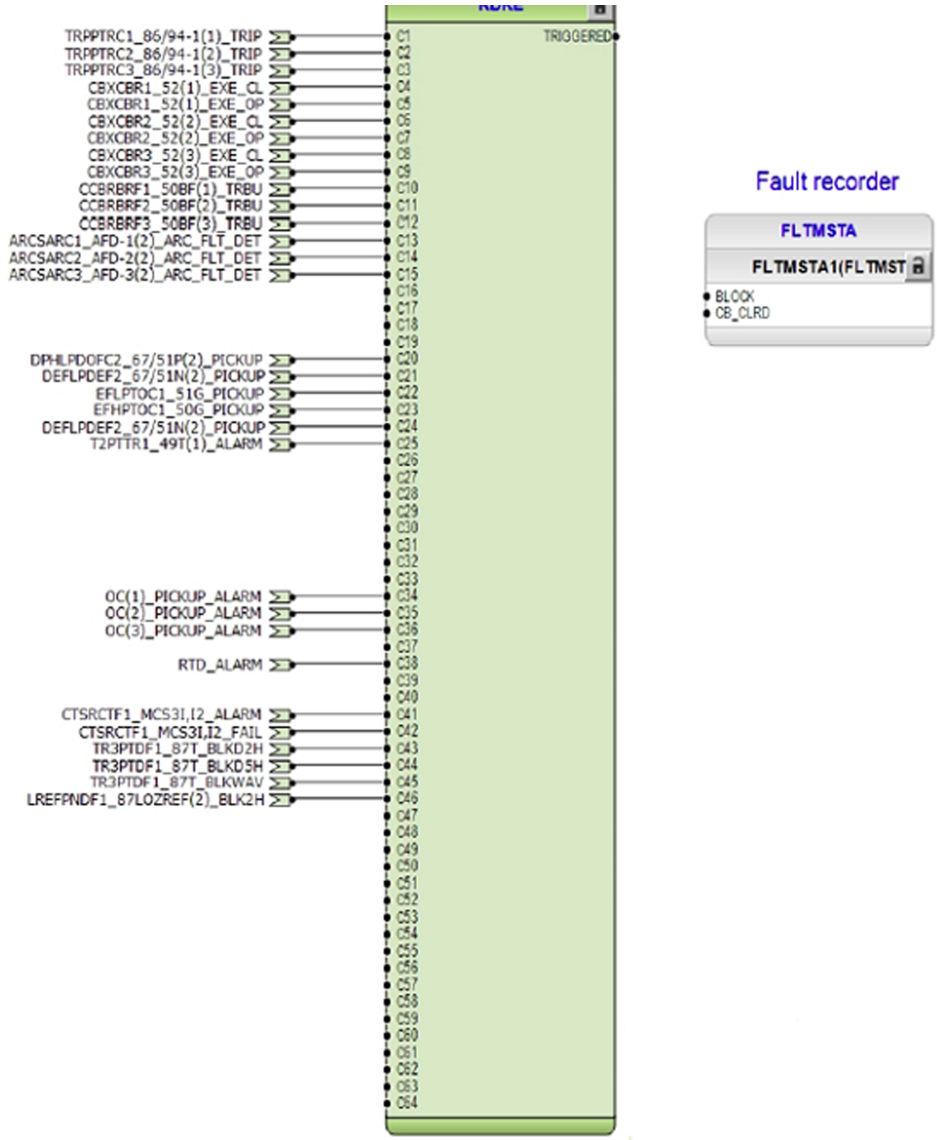


Figure 79: 64 channel Disturbance and fault recorder

3.3.5.7 Functional diagrams for I/O and alarm LEDs

The functional diagrams for I/O and Alarm LEDs describe the IED's default input/output and alarm LEDs connections.

The default binary I/O connected in the configuration and Alarm LEDs are indicated in Figure 80 to Figure 82.

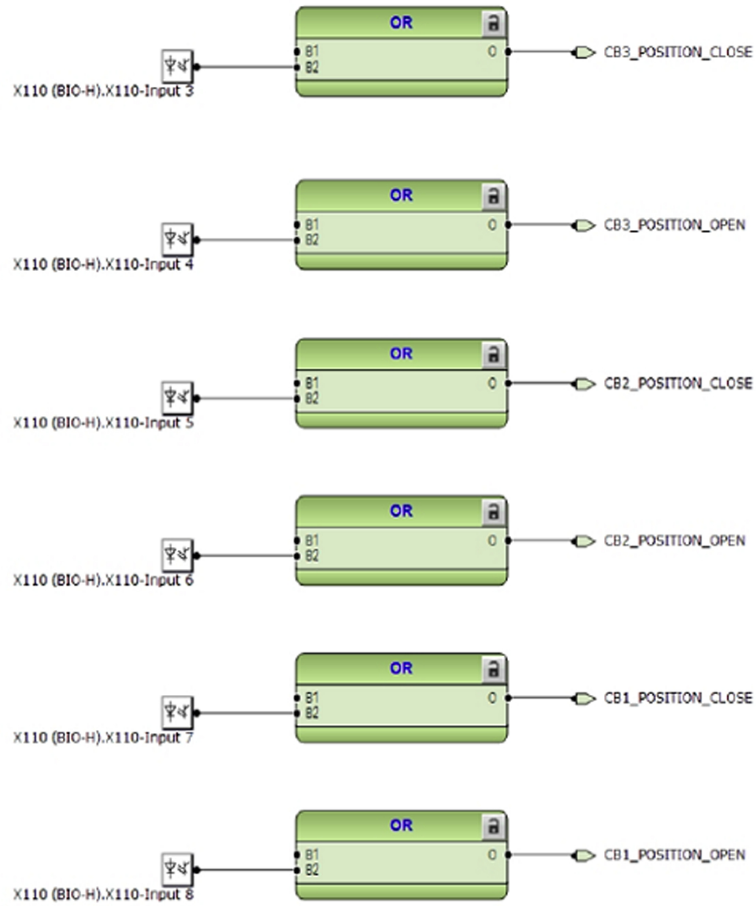


Figure 80: Binary inputs

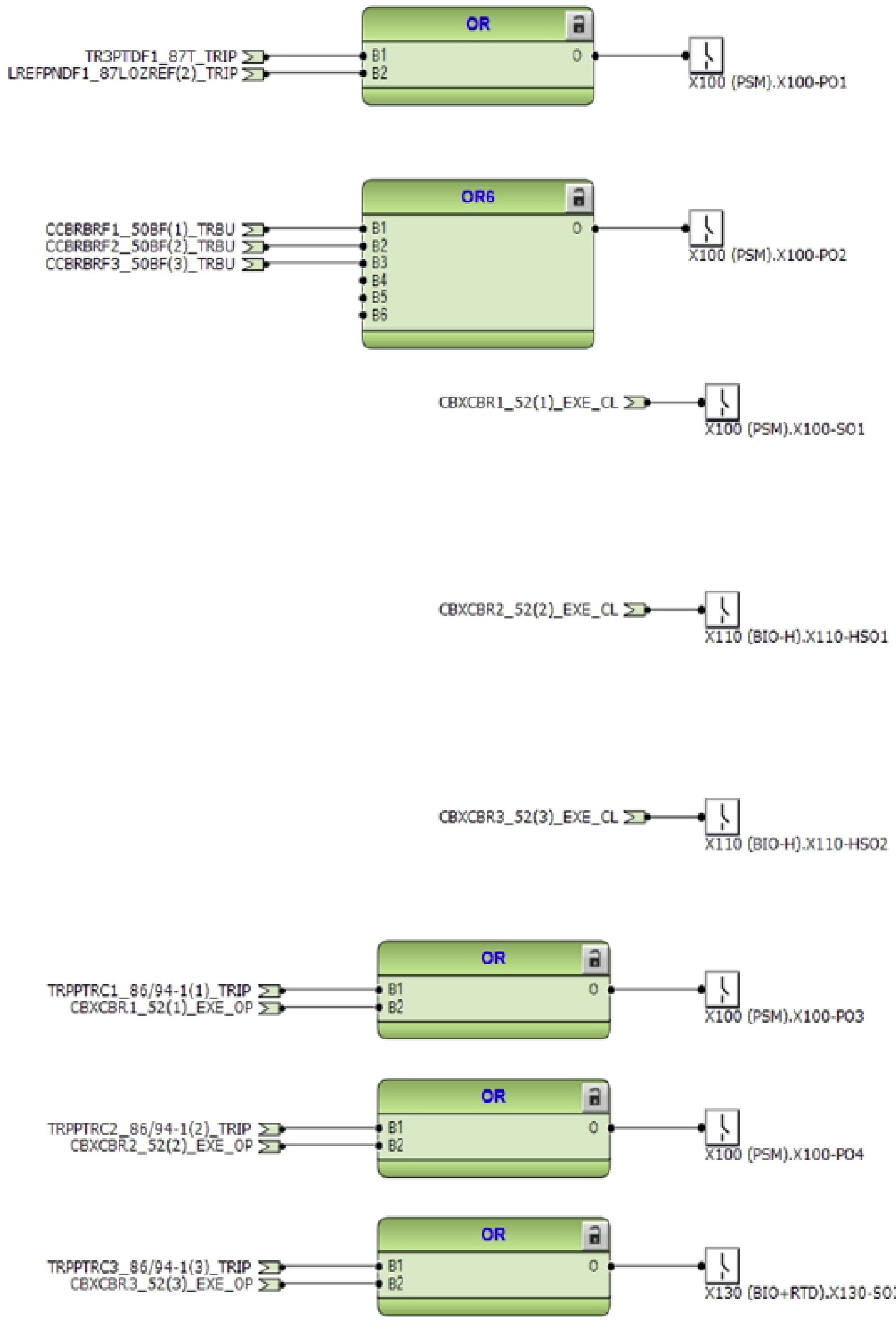


Figure 81: Binary outputs

High speed binary outputs (HSO) are available only if IED with High speed binary card has been ordered.

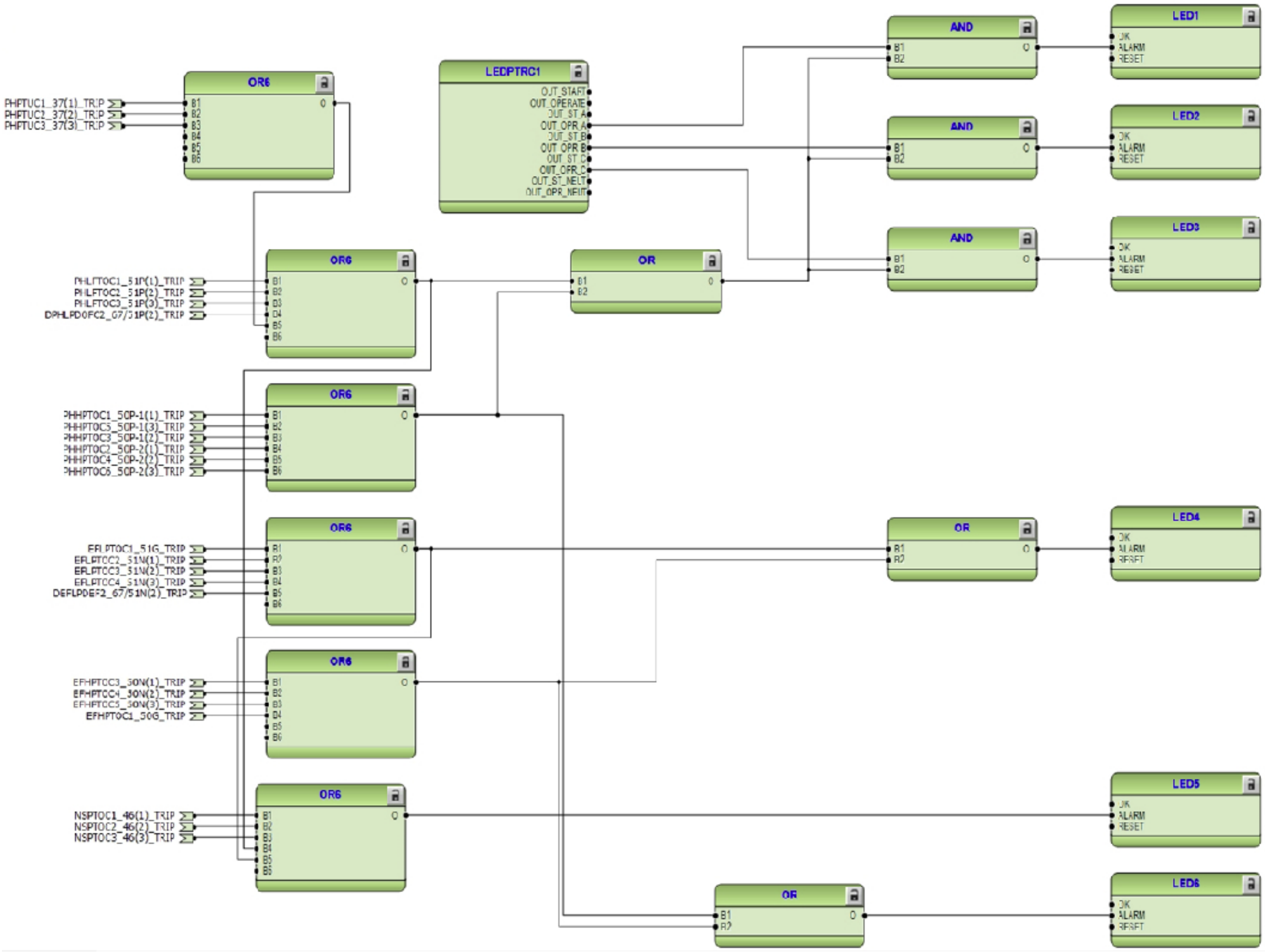


Figure 82: Alarm LED 1-6

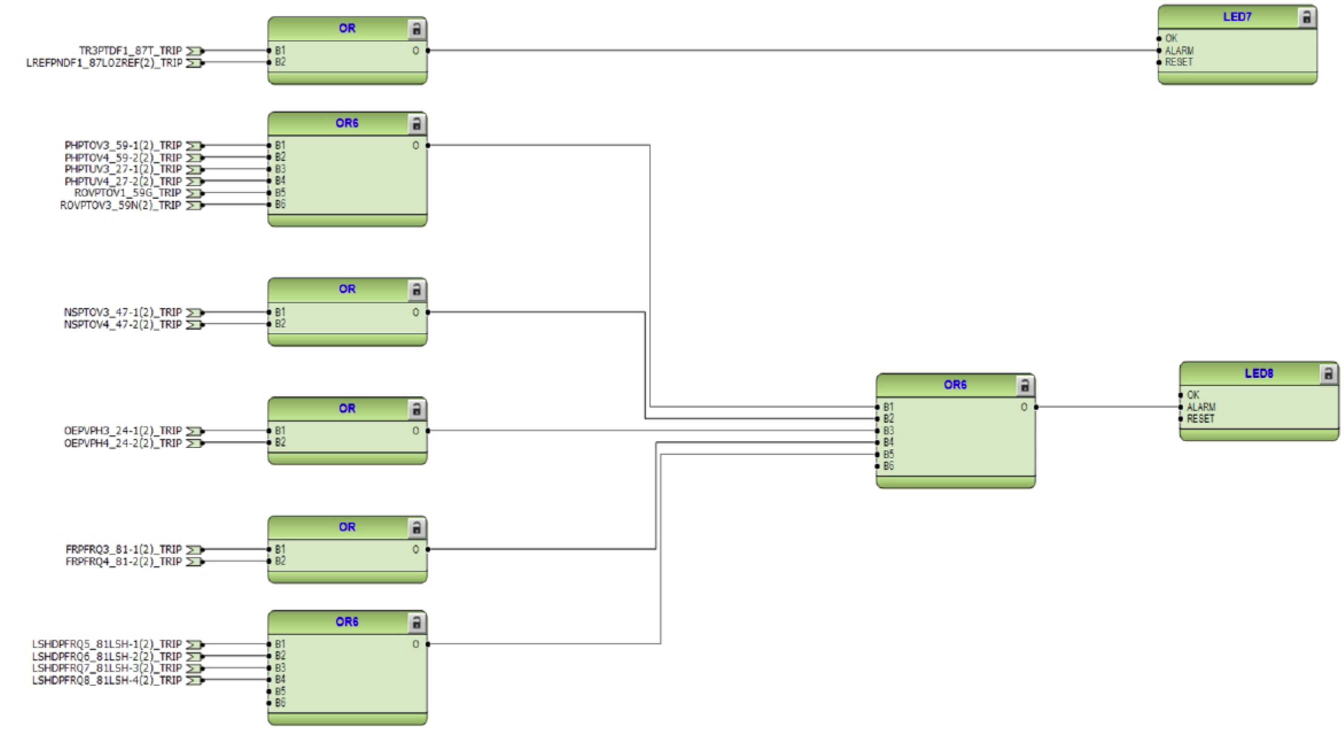


Figure 83: Alarm LED 7,8

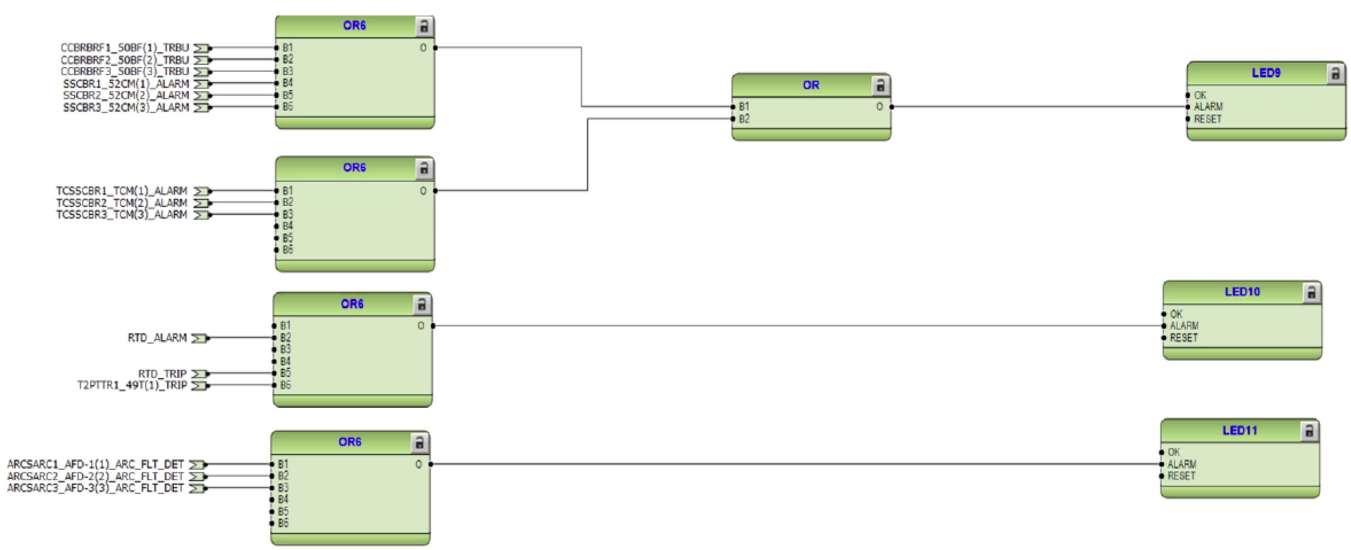


Figure 84: Alarm LED 9-11

3.4 Standard configuration for order code functional applications A(AB) and B(BB) {Voltage transformer input from HV winding (1) side of transformer}

3.4.1 Applications

This standard configuration is mainly intended for three-winding transformers with breaker control on each winding with phase differential, restricted ground fault protection, non- directional and directional phase and ground overcurrent, voltage and frequency protection. Since each winding current is fed to add to the bias input of the differential protection, the differential protection is stabilized for external faults of a winding fed from any two of the other windings.

The IED with this standard 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 enable this configuration to be further adapted to different primary power system layouts and the related functionality needs by modifying the internal functionality using PCM600.

3.4.2 Functions

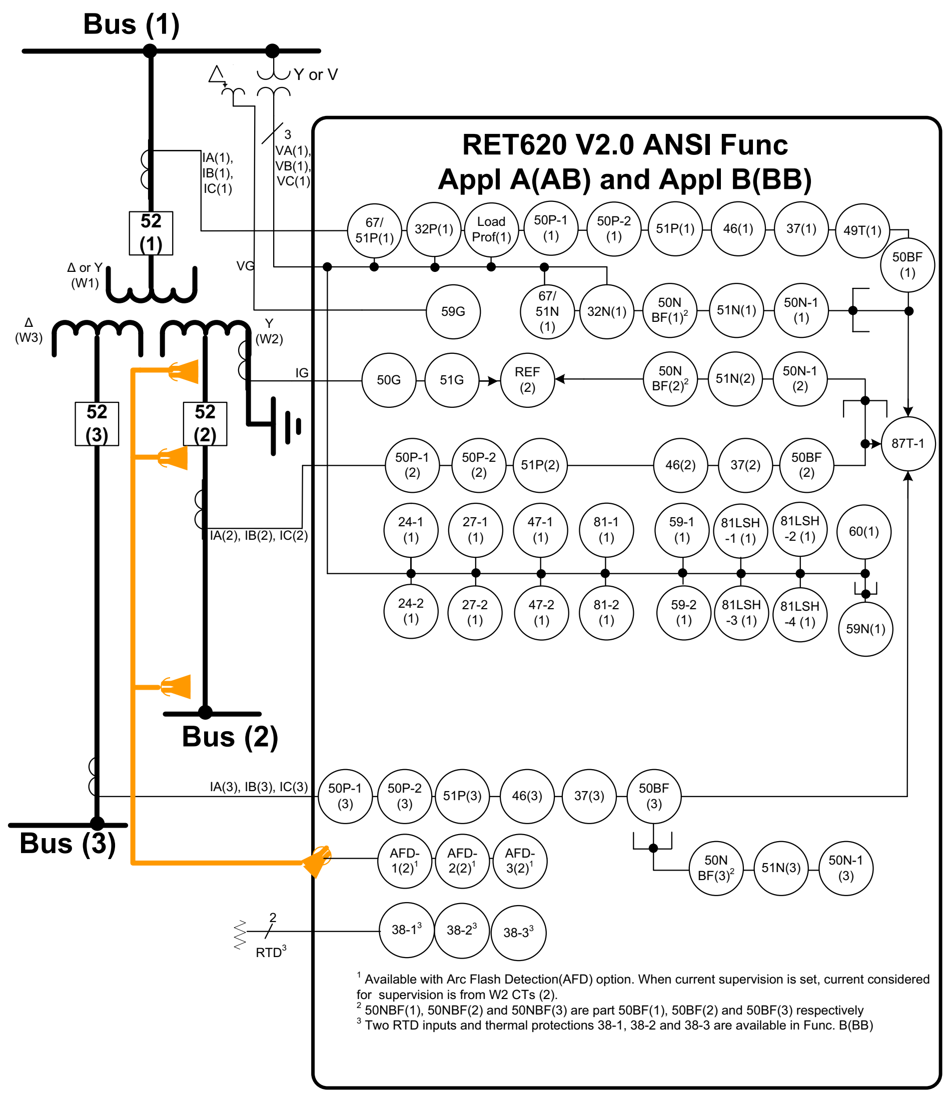


Figure 85: Functions included in the RET620 standard configuration AB and BB

Table 16: Functions included in the RET620 standard configuration

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AB)	B(BB)
Protection					
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	51P(1)	3I> (1)	●	●
Three-phase non-directional overcurrent protection, low stage, instance 2	PHLPTOC2	51P(2)	3I> (2)	●	●
Three-phase non-directional overcurrent protection, low stage, instance 3	PHLPTOC3	51P(3)	3I> (3)	●	●
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	50P-1(1)	3I>> (1)	●	●
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	50P-2(1)	3I>> (2)	●	●
Three-phase non-directional overcurrent protection, high stage, instance 3	PHHPTOC3	50P-1(2)	3I>> (3)	●	●
Three-phase non-directional overcurrent protection, high stage, instance 4	PHHPTOC4	50P-2(2)	3I>> (4)	●	●
Three-phase non-directional overcurrent protection, high stage, instance 5	PHHPTOC5	50P-1(3)	3I>> (5)	●	●
Three-phase non-directional overcurrent protection, high stage, instance 6	PHHPTOC6	50P-2(3)	3I>> (6)	●	●
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC 1	67/51P(1)	3I> -> (1)	●	●
Non-directional ground-fault protection, low stage, instance 1	EFLPTOC1	51G	Io> (1)	●	●
Non-directional ground-fault protection, low stage, instance 2	EFLPTOC2	51N(1)	Io> (2)	●	●
Non-directional ground-fault protection, low stage, instance 3	EFLPTOC3	51N(2)	Io> (3)	●	●
Non-directional ground-fault protection, low stage, instance 4	EFLPTOC4	51N(3)	Io> (4)	●	●
Non-directional ground-fault protection, high stage, instance 1	EFHPTOC1	50G	Io>> (1)	●	●
Non-directional ground-fault protection, high stage, instance 3	EFHPTOC3	50N-1(1)	Io>> (3)	●	●
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC4	50N-1(2)	Io>> (4)	●	●
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC5	50N-1(3)	Io>> (5)	●	●
Directional ground-fault protection, low stage, instance 1	DEFLPDEF 1	67/51N(1)	Io> -> (1)	●	●
Three phase directional power protection,	DPSRDIR1	32P(1)	I1-> (1)	●	●
Ground directional power protection,	DNZSRDIR1	32N(1)	I2 ->, Io->	●	●
Negative-sequence overcurrent protection,	NSPTOC1	46(1)	I2> (1)	●	●
Negative-sequence overcurrent protection,	NSPTOC2	46(2)	I2> (2)	●	●
Negative-sequence overcurrent protection,	NSPTOC3	46(3)	I2> (3)	●	●
Residual overvoltage protection, instance 1	ROVPTOV1	59G	Uo> (1)	●	●

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AB)	B(BB)
Residual overvoltage protection, instance 2	ROVPTOV2	59N(1)	Uo> (2)	•	•
Three-phase undervoltage protection,	PHPTUV1	27-1(1)	3U< (1)	•	•
Three-phase undervoltage protection,	PHPTUV2	27-2(1)	3U< (2)	•	•
Three-phase overvoltage protection,	PHPTOV1	59-1(1)	3U> (1)	•	•
Three-phase overvoltage protection,	PHPTOV2	59-2(1)	3U> (2)	•	•
Negative-sequence overvoltage protection,	NSPTOV1	47-1(1)	U2> (1)	•	•
Negative-sequence overvoltage protection,	NSPTOV2	47-2(1)	U2> (2)	•	•
Frequency protection, instance 1	FRPFRQ1	81-1(1)	f>/f<,df/dt	•	•
Frequency protection, instance 2	FRPFRQ2	81-2(1)	f>/f<,df/dt	•	•
Voltage per hertz protection, instance 1	OEPVPH1	24-1(1)	U/f> (1)	•	•
Voltage per hertz protection, instance 2	OEPVPH2	24-2(1)	U/f> (2)	•	•
Three-phase thermal overload protection for power transformers, two time constants	T2PTTR1	49T(1)	3Ith>T	•	•
Stabilized and instantaneous differential protection for 3W-Transformers	TR3PTDF1	87T	3dI>T	•	•
Numerical stabilized low impedance restricted earth-fault protection	LREFPNDF 1	87LOZREF (2)	dIoLo>	•	•
Circuit breaker failure protection, instance 1	CCBRBRF1	50BF(1)	3I>/Io>BF	•	•
Circuit breaker failure protection, instance 2	CCBRBRF2	50BF(2)	3I>/Io>BF	•	•
Circuit breaker failure protection, instance 3	CCBRBRF3	50BF(3)	3I>/Io>BF	•	•
Master trip, instance 1	TRPPTRC1	86/94-1	Master Trip	•	•
Master trip, instance 2	TRPPTRC2	86/94-2	Master Trip	•	•
Master trip, instance 3	TRPPTRC3	86/94-3	Master Trip	•	•
Arc protection, instance 1	ARCSARC1	AFD-1(2)	ARC (1)	•	•
Arc protection, instance 2	ARCSARC2	AFD-2(2)	ARC (2)	•	•
Arc protection, instance 3	ARCSARC3	AFD-3(2)	ARC (3)	•	•
Load shedding and restoration, instance 1	LSHDPFRQ	81LSH-1(1	UFLS/R (1)	•	•
Load shedding and restoration, instance 2	LSHDPFRQ	81LSH-2(1	UFLS/R (2)	•	•
Load shedding and restoration, instance 3	LSHDPFRQ	81LSH-3(1	UFLS/R (3)	•	•
Load shedding and restoration, instance 4	LSHDPFRQ	81LSH-4(1	UFLS/R (4)	•	•
Loss of phase, instance 1	PHPTUC1	37(1)	3I< (1)	•	•
Loss of phase, instance 2	PHPTUC2	37(2)	3I< (2)	•	•
Loss of phase, instance 3	PHPTUC3	37(3)	3I< (3)	•	•
RTD based thermal protection, instance 1	MAPGAPC1	38-1	ThA> ThB>	-	•
RTD based thermal protection, instance 2	MAPGAPC2	38-2	ThA> ThB>	-	•

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AB)	B(BB)
RTD based thermal protection, instance 3	MAPGAPC3	38-3	ThA> ThB>	-	•
Control					
Circuit-breaker control, instance 1	CBXCBR1	52(1)	I <-> O CB	•	•
Circuit-breaker control, instance 2	CBXCBR2	52(2)	I <-> O CB	•	•
Circuit-breaker control, instance 3	CBXCBR3	52(3)	I <-> O CB	•	•
Condition Monitoring					
Circuit-breaker condition monitoring,	SSCBR1	52CM(1)	CBCM (1)	•	•
Circuit-breaker condition monitoring,	SSCBR2	52CM(2)	CBCM (2)	•	•
Circuit-breaker condition monitoring,	SSCBR3	52CM(3)	CBCM (3)	•	•
Trip circuit supervision, instance 1	TCSSCBR1	TCM-1	TCS (1)	•	•
Trip circuit supervision, instance 2	TCSSCBR2	TCM-2	TCS (2)	•	•
Trip circuit supervision, instance 3	TCSSCBR3	TCM-3	TCS (3)	•	•
Advanced current circuit supervision for	CTSRCTF1	MCS 3I, I2	MCS 3I, I2	•	•
Fuse failure supervision, instance 1	SEQRFUF1	60(1)	FUSEF (1)	•	•
Measurement					
Three-phase current measurement,	CMMXU1	IA, IB,	3I	•	•
Three-phase current measurement,	CMMXU2	IA, IB,	3I(B)	•	•
Three-phase current measurement,	CMMXU3	IA, IB,	3I(C)	•	•
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0(1)	I1, I2, I0	•	•
Sequence current measurement, instance 2	CSMSQI2	I1, I2, I0(2)	I1, I2, I0(B)	•	•
Sequence current measurement, instance 3	CSMSQI3	I1, I2, I0(3)	I1, I2, I0(C)	•	•
Residual current measurement, instance 1	RESCMMX	IG	Io	•	•
Three-phase voltage measurement, instance 1	VMMXU1	VA, VB, VC(1)	3U	•	•
Residual voltage measurement, instance 1	RESVMMX	VG	Uo	•	•
Sequence voltage measurement, instance 1	VSMSQI1	V1, V2, V0(1)	U1, U2, U0	•	•
Single-phase power and energy measurement, instance 1	SPEMMXU1	SP, SE(1)	SP, SE	•	•
Three-phase power and energy measurement, instance 1	PEMMXU1	P, E(1)	P, E	•	•
Tap changer position indication	TPOSSLTC	84T	TPOSM	•	•
Load profile	LDPMSTA1	LoadProf	-	•	•
Frequency measurement, instance 1	FMMXU1	f	f	•	•
Other functions					
Minimum pulse timer (2 pcs), instance 1	TPGAPC1	TP-1	TP (1)	•	•

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AB)	B(BB)
Minimum pulse timer (2 pcs), instance 2	TPGAPC2	TP-2	TP (2)	•	•
Minimum pulse timer (2 pcs), instance 3	TPGAPC3	TP-3	TP (3)	•	•
Minimum pulse timer (2 pcs), instance 4	TPGAPC4	TP-4	TP (4)	•	•
Pulse timer (8 pcs), instance 1	PTGAPC1	PT-1	PT (1)	•	•
Pulse timer (8 pcs), instance 2	PTGAPC2	PT-2	PT (2)	•	•
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF-1	TOF (1)	•	•
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF-2	TOF (2)	•	•
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF-3	TOF (3)	•	•
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF-4	TOF (4)	•	•
Time delay on (8 pcs), instance 1	TONGAPC1	TON -1	TON (1)	•	•
Time delay on (8 pcs), instance 2	TONGAPC2	TON -2	TON (2)	•	•
Time delay on (8 pcs), instance 3	TONGAPC3	TON -3	TON (3)	•	•
Time delay on (8 pcs), instance 4	TONGAPC4	TON -4	TON (4)	•	•
Set reset (8 pcs), instance 1	SRGAPC1	SR-1	SR (1)	•	•
Set reset (8 pcs), instance 2	SRGAPC2	SR-2	SR (2)	•	•
Set reset (8 pcs), instance 3	SRGAPC3	SR-3	SR (3)	•	•
Set reset (8 pcs), instance 4	SRGAPC4	SR-4	SR (4)	•	•
Move (8 pcs), instance 1	MVGAPC1	MV-1	MV (1)	•	•
Move (8 pcs), instance 2	MVGAPC2	MV-2	MV (2)	•	•
Move (8 pcs), instance 3	MVGAPC3	MV-3	MV (3)	•	•
Move (8 pcs), instance 4	MVGAPC4	MV-4	MV (4)	•	•
Move (8 pcs), instance 5	MVGAPC5	MV-5	MV (5)	•	•
Move (8 pcs), instance 6	MVGAPC6	MV-6	MV (6)	•	•
Move (8 pcs), instance 7	MVGAPC7	MV-7	MV (7)	•	•
Move (8 pcs), instance 8	MVGAPC8	MV-8	MV (8)	•	•
Generic control points, instance 1	SPCGGIO1	CNTRL-1	SPC(1)	•	•
Generic control points, instance 2	SPCGGIO2	CNTRL-2	SPC(2)	•	•
Generic control points, instance 3	SPCGGIO3	CNTRL-3	SPC(3)	•	•
Remote Generic control points, instance 1	SPCRGGIO	RCNTRL-1	SPCR(1)	•	•
Local Generic control points, instance 1	SPCLGGIO	LCNTRL-1	SPCL(1)	•	•
Generic Up-Down Counters, instance 1	UDFCNT1	CTR-1	CTR(1)	•	•
Generic Up-Down Counters, instance 2	UDFCNT2	CTR-2	CTR(2)	•	•
Generic Up-Down Counters, instance 3	UDFCNT3	CTR-3	CTR(3)	•	•

Function Application Configuration				Config	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	A(AB)	B(BB)
Generic Up-Down Counters, instance 4	UDFCNT4	CTR-4	CTR(4)	•	•
Generic Up-Down Counters, instance 5	UDFCNT5	CTR-5	CTR(5)	•	•
Generic Up-Down Counters, instance 6	UDFCNT6	CTR-6	CTR(6)	•	•
Generic Up-Down Counters, instance 7	UDFCNT7	CTR-7	CTR(7)	•	•
Generic Up-Down Counters, instance 8	UDFCNT8	CTR-8	CTR(8)	•	•
Generic Up-Down Counters, instance 9	UDFCNT9	CTR-9	CTR(9)	•	•
Generic Up-Down Counters, instance 10	UDFCNT10	CTR-10	CTR(10)	•	•
Generic Up-Down Counters, instance 11	UDFCNT11	CTR-11	CTR(11)	•	•
Generic Up-Down Counters, instance 12	UDFCNT12	CTR-12	CTR(12)	•	•
Programmable buttons (16 buttons),	FKEYGGIO	FKEY	FKEY	•	•
Logging functions					
Disturbance recorder	RDRE1	DFR	DFR	•	•
Fault recorder	FLMSTA1	FR	FR	•	•
Sequence event recorder	SER	SER	SER	•	•

3.4.3 Default Input/Output (I/O) assignments

Table 17: Default connections for analog inputs

Analog input	Default usage	Connector pins
IA(1)	Phase A current, Winding 1	X120-7,8
IB(1)	Phase B current, Winding 1	X120-9,10
IC(1)	Phase C current, Winding 1	X120-11,12
IA(2)	Phase A current, Winding 2	X120-1,2
IB(2)	Phase B current, Winding 2	X120-3,4
IC(2)	Phase C current, Winding 2	X120-5,6
IG	Ground current, Winding 2	X120-13,14
IA(3)	Phase A current, Winding 3	X115-9,10
IB(3)	Phase B current, Winding 3	X115-11,12
IC(3)	Phase C current, Winding 3	X115-13,14
VA(1)	Phase A voltage, Winding 1	X115-1,2
VB(1)	Phase B voltage, Winding 1	X115-3,4
VC(1)	Phase C voltage, Winding 1	X115-5,6
VG	Broken Delta Voltage, Winding 2	X115-7,8
RTD-1	Winding Temperature	X130-3,4,5*
RTD-2	Top Oil Temperature	X130-6,7,8*
*RTD inputs available with configurations B(BA) and B(BB) only.		

*Table 18: Default connections for binary inputs (Alternative 1)**

Binary input	Default usage	Connector pins
X110-BI3	Circuit breaker(3) closed position	X110-5,6
X110-BI4	Circuit breaker(3) open position	X110-7,6
X110-BI5	Circuit breaker(2) closed position	X110-8,9
X110-BI6	Circuit breaker(2) open position	X110-10,9
X110-BI7	Circuit breaker(1) closed position	X110-11,12
X110-BI8	Circuit breaker(1) open position	X110-13,12
*Binary inputs when slot ID X110 is ordered with 8BI+4BO BIO card		

*Table 19: Default connections for binary inputs (Alternative 2)**

Binary input	Default usage	Connector pins
X110-BI3	Circuit breaker(3) closed position	X110-3,5
X110-BI4	Circuit breaker(3) open position	X110-4,5
X110-BI5	Circuit breaker(2) closed position	X110-6,10
X110-BI6	Circuit breaker(2) open position	X110-7,10
X110-BI7	Circuit breaker(1) closed position	X110-8,10

Binary input	Default usage	Connector pins
X110-BI8	Circuit breaker(1) open position	X110-9,10
*Alternative binary inputs when IED has been ordered with High speed binary output (HSO) card		

Table 20: Default connections for binary outputs

Binary output	Default usage	Connector pins
X100-PO1	87T & 87LOZREF Trip	X100 – 6,7
X100-PO2	Breaker Fail	X100 – 8,9
X100-SO1	Close circuit breaker(1)	X100 – 10,12
X100-PO3	Open circuit breaker(1)	X100 – 15,16,17,18,19
X100-PO4	Open circuit breaker (2)	X100 – 20,21,22,23,24
X130-SO3/TO1	Open circuit breaker(3)	X130 – 16,17
X110-SO1	Close circuit breaker (2)	X110 – 14,15
X110-S02	Close circuit breaker (3)	X110 – 17,18

*Table 21: High speed binary output connections**

Binary output	Default usage	Connector pins
X110-HSO1	Close circuit breaker(2)	X110 – 15,16
X110-HSO2	Close circuit breaker (3)	X110 – 19,20
*Available only if IED has been ordered with High speed binary output (HSO) card		

Table 22: Default connections for LEDs

LED	LED label
LED 1	Phase A
LED 2	Phase B
LED 3	Phase C
LED 4	Neutral / Ground
LED 5	Time
LED 6	Instantaneous
LED 7	Differential / REF
LED 8	Voltage
LED 9	Breaker Alarm
LED 10	Overload Alarm/Trip
LED 11	Arc Flash Detection

Some of the alarm led channel connections in the standard configuration depends on the optional functionality and are available according to order code.

3.4.4 Typical connection diagrams

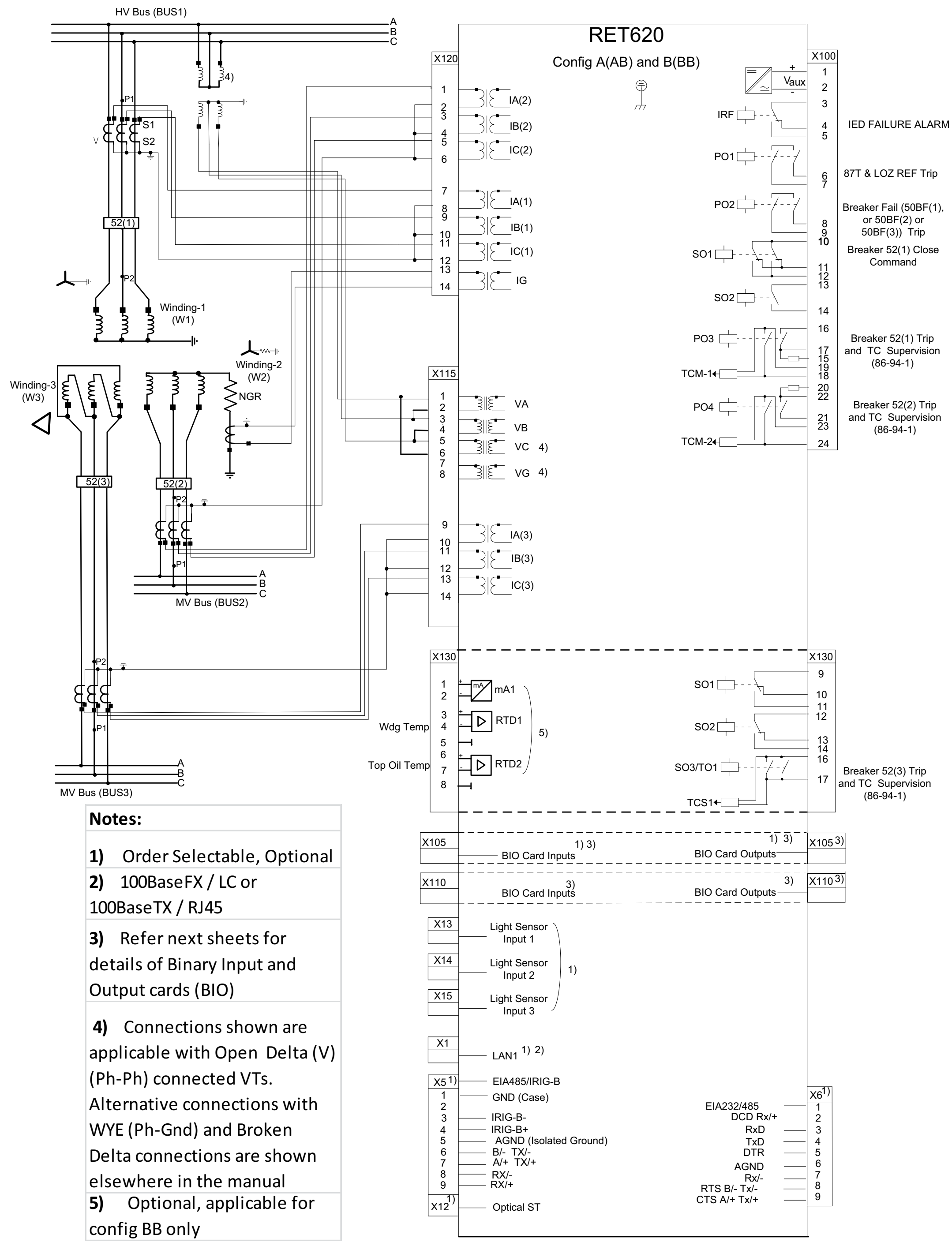
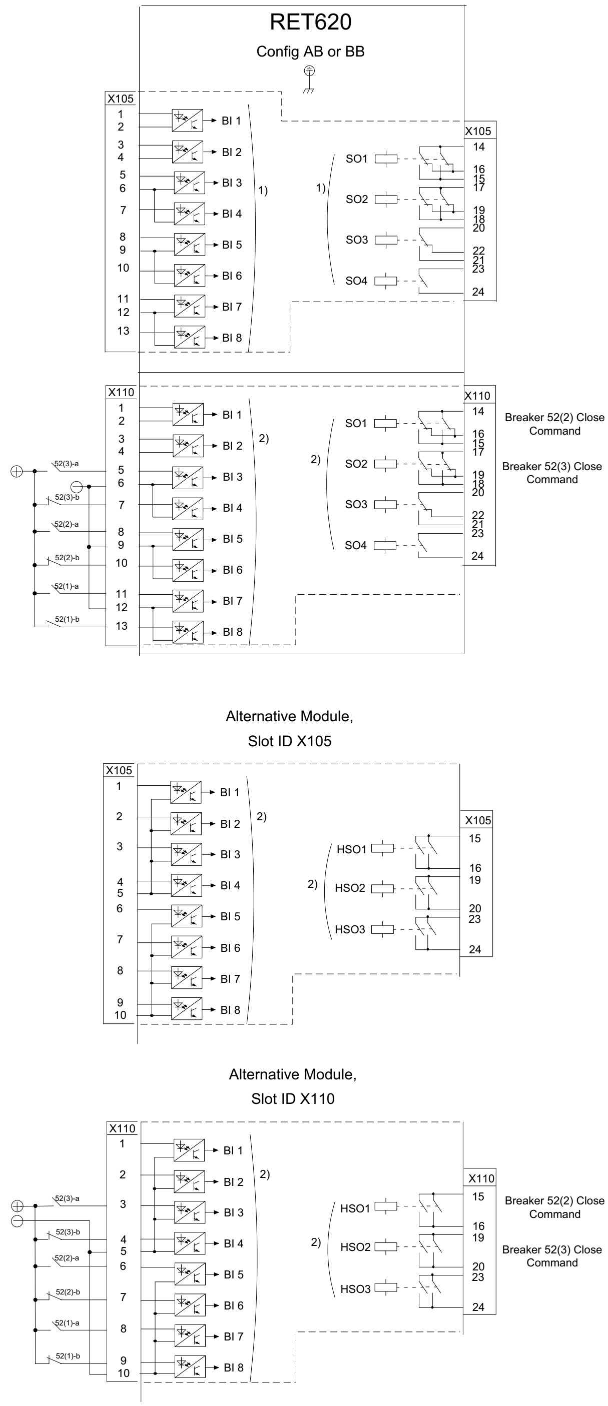


Figure 86: Typical connection diagram of RET620 (Config AB and BB)



1) Order Selectable, Optional
2) Order Selectable, Optional alternatives

Figure 87: Typical BIO module equipment arrangement and connections for RET620, Config AB and BB (Slot X105 and X110)

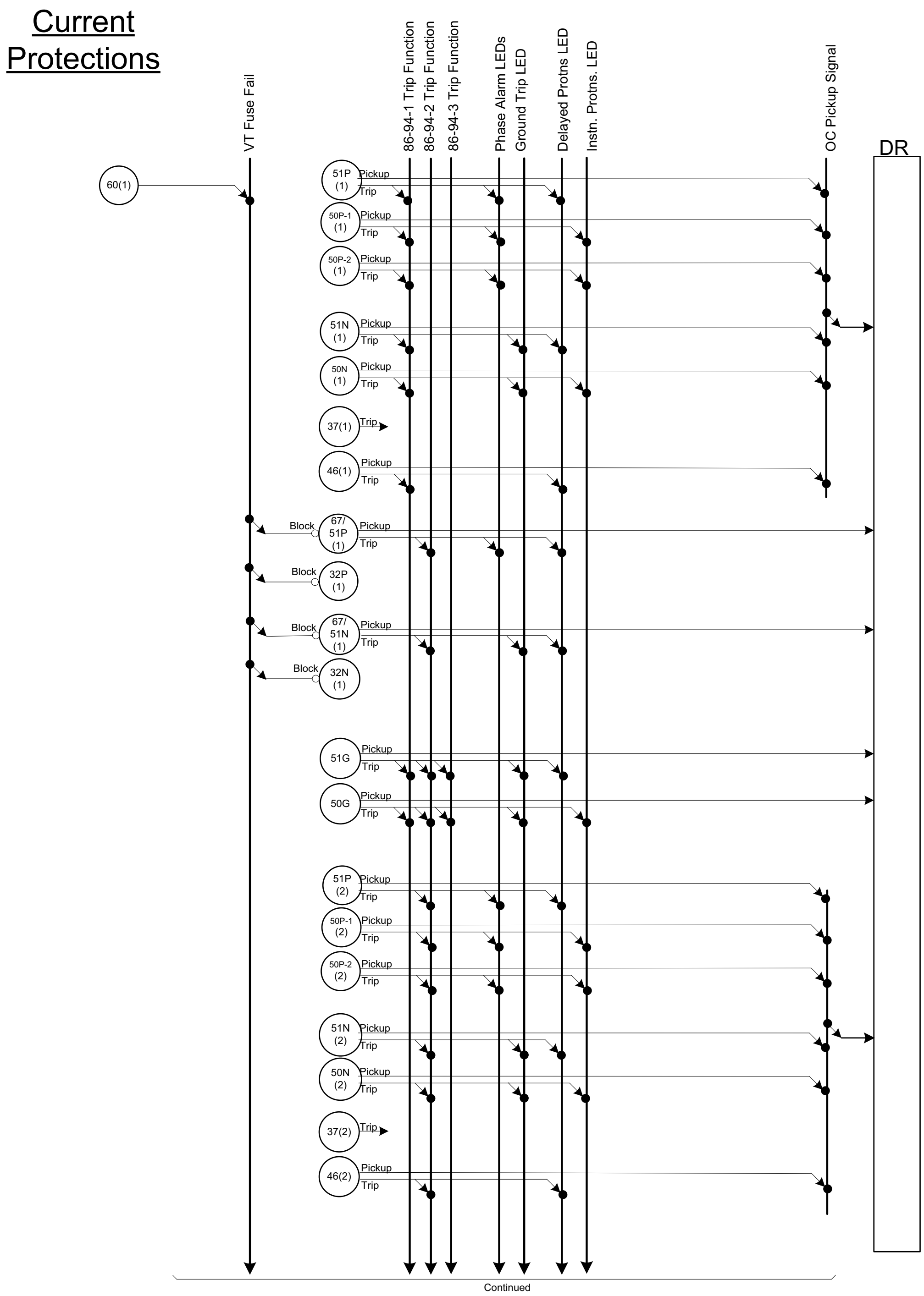
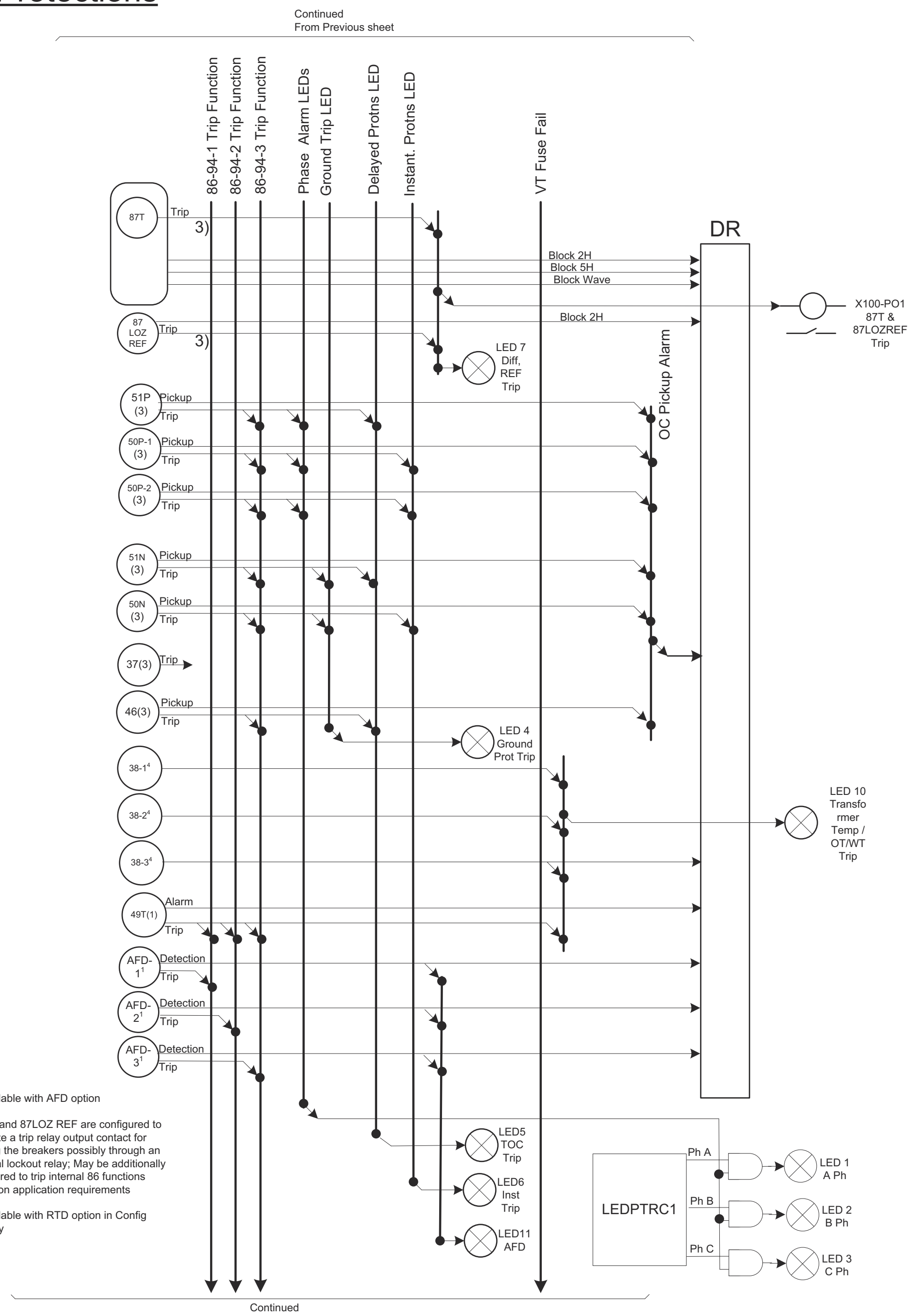


Figure 88: Simplified Logic Diagram for Current Protections,RET620, Config AB or BB

Other Protections



Notes:

1. Available with AFD option

3. 87T and 87LOZ REF are configured to energize a trip relay output contact for tripping the breakers possibly through an external lockout relay; May be additionally configured to trip internal 86 functions based on application requirements

4. Available with RTD option in Config **BB** only

Figure 89: *Simplified Logic Diagram for Differential and OtherProtections, RET620, Config AB or BB*

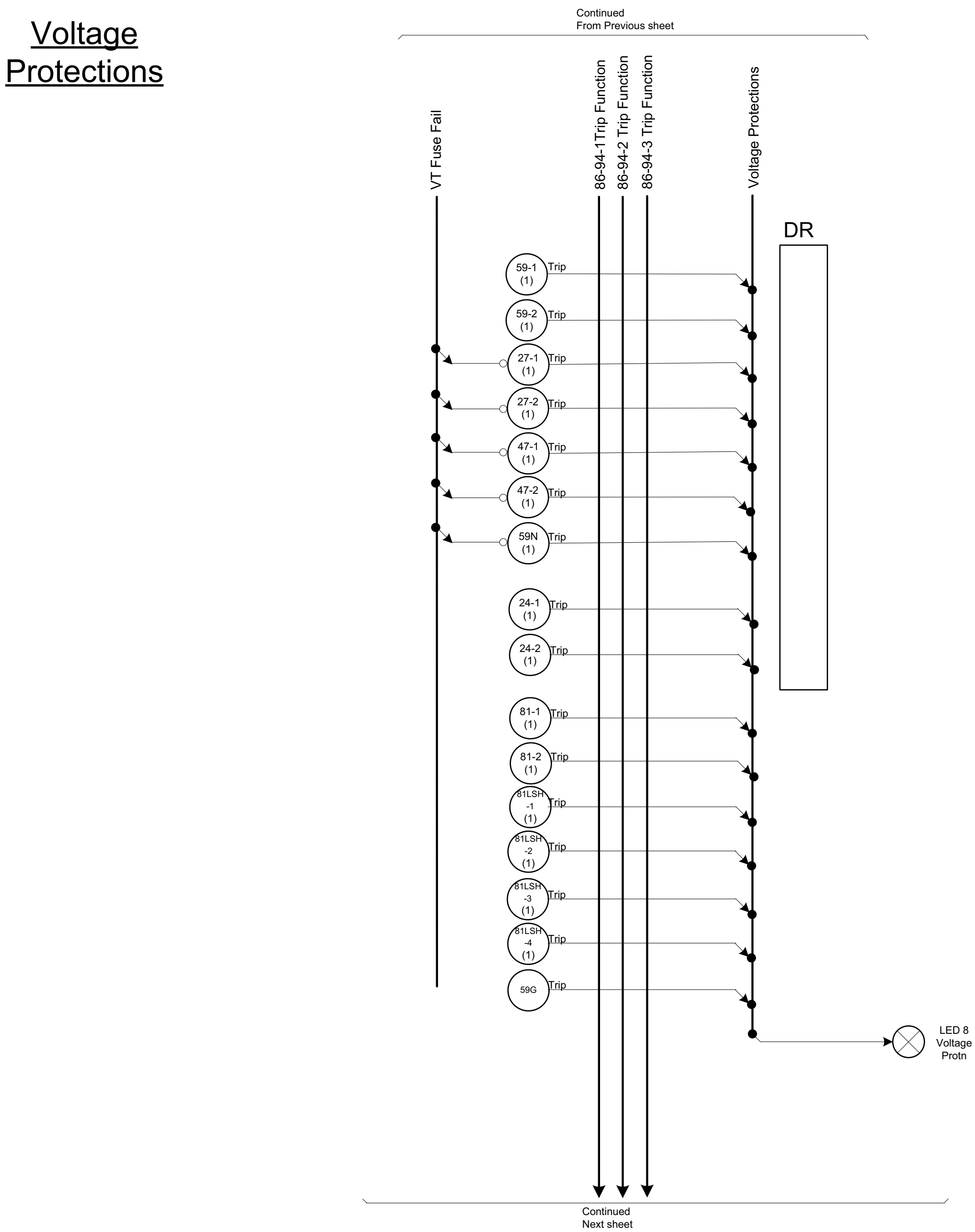


Figure 90: Simplified Logic Diagram, RET620 Config AB and BB

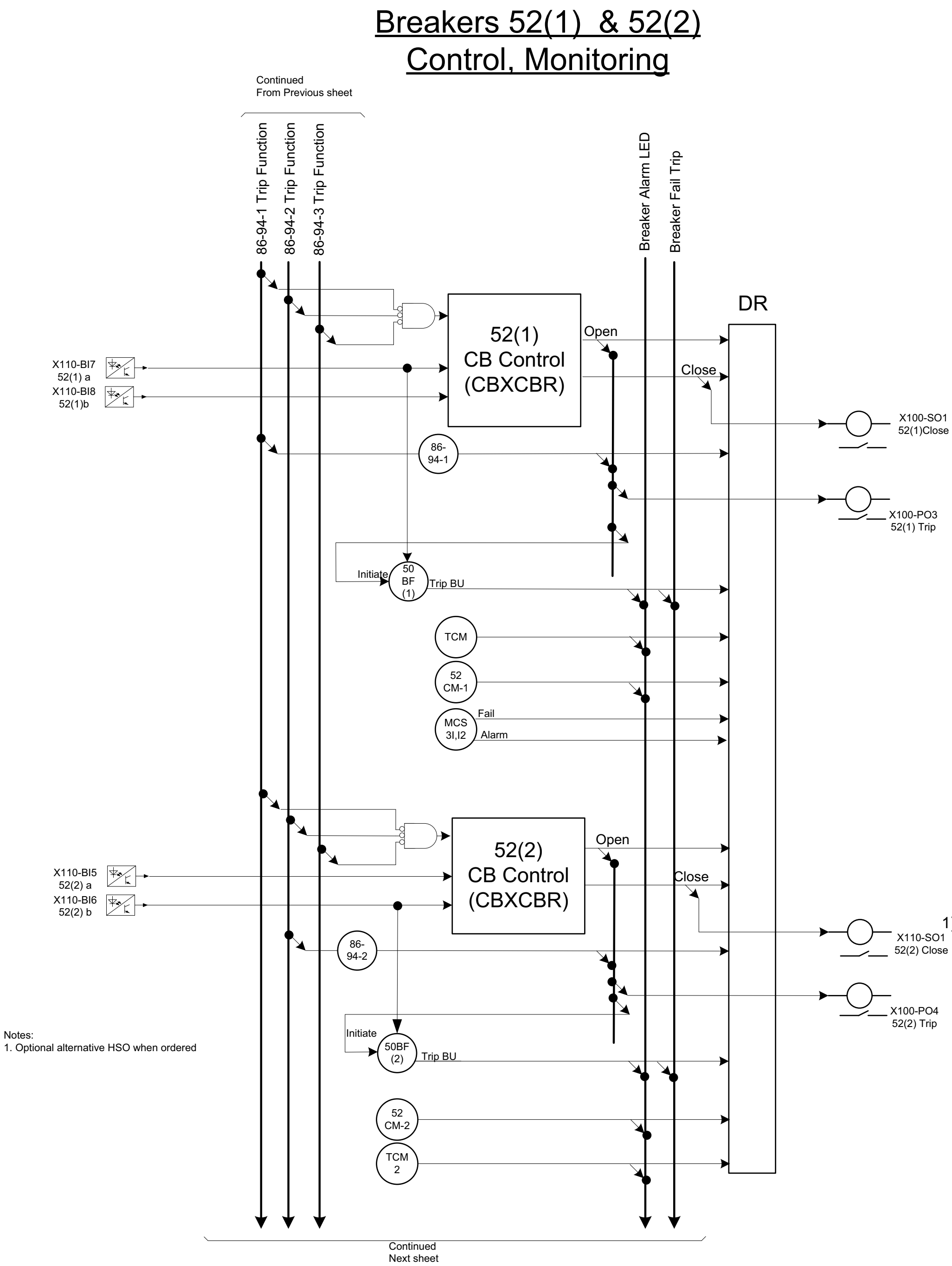


Figure 91: Simplified Logic Diagram for CB-1 and CB-2 Control and Monitoring, RET620, Config AB and BB

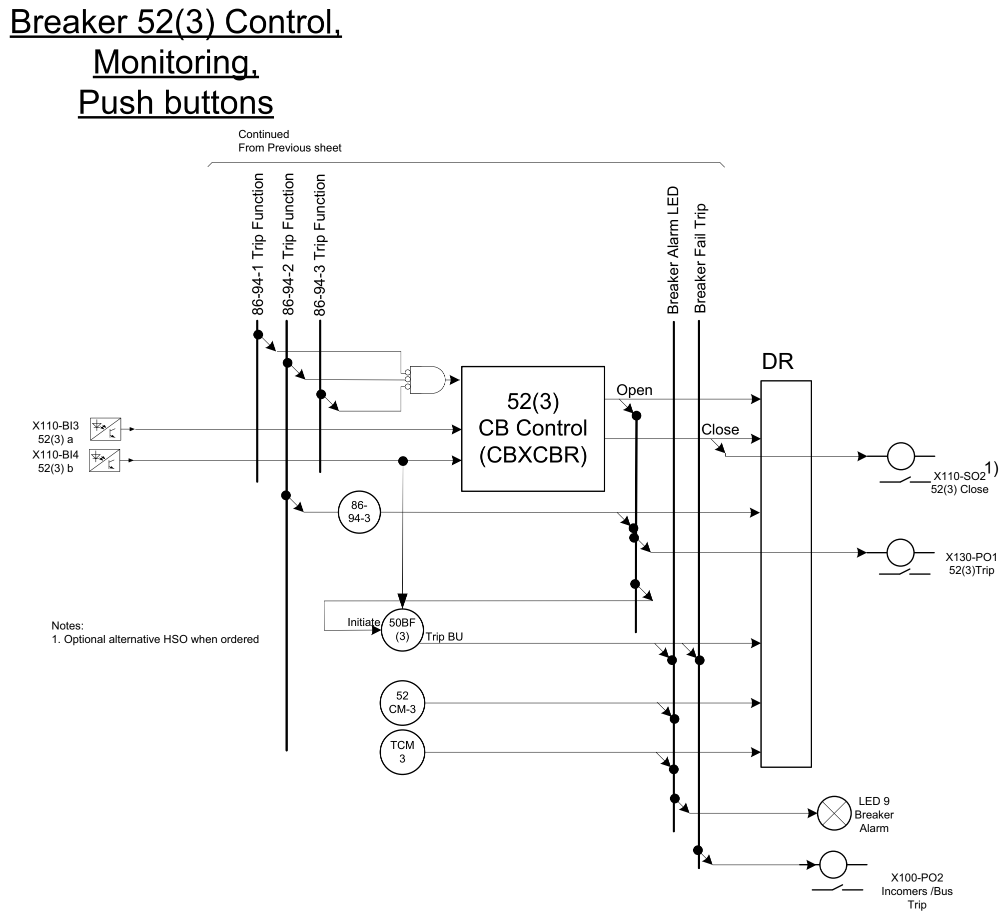


Figure 92: Simplified Logic Diagram for CB-3 Control and Monitoring, RET620, Config AB and BB

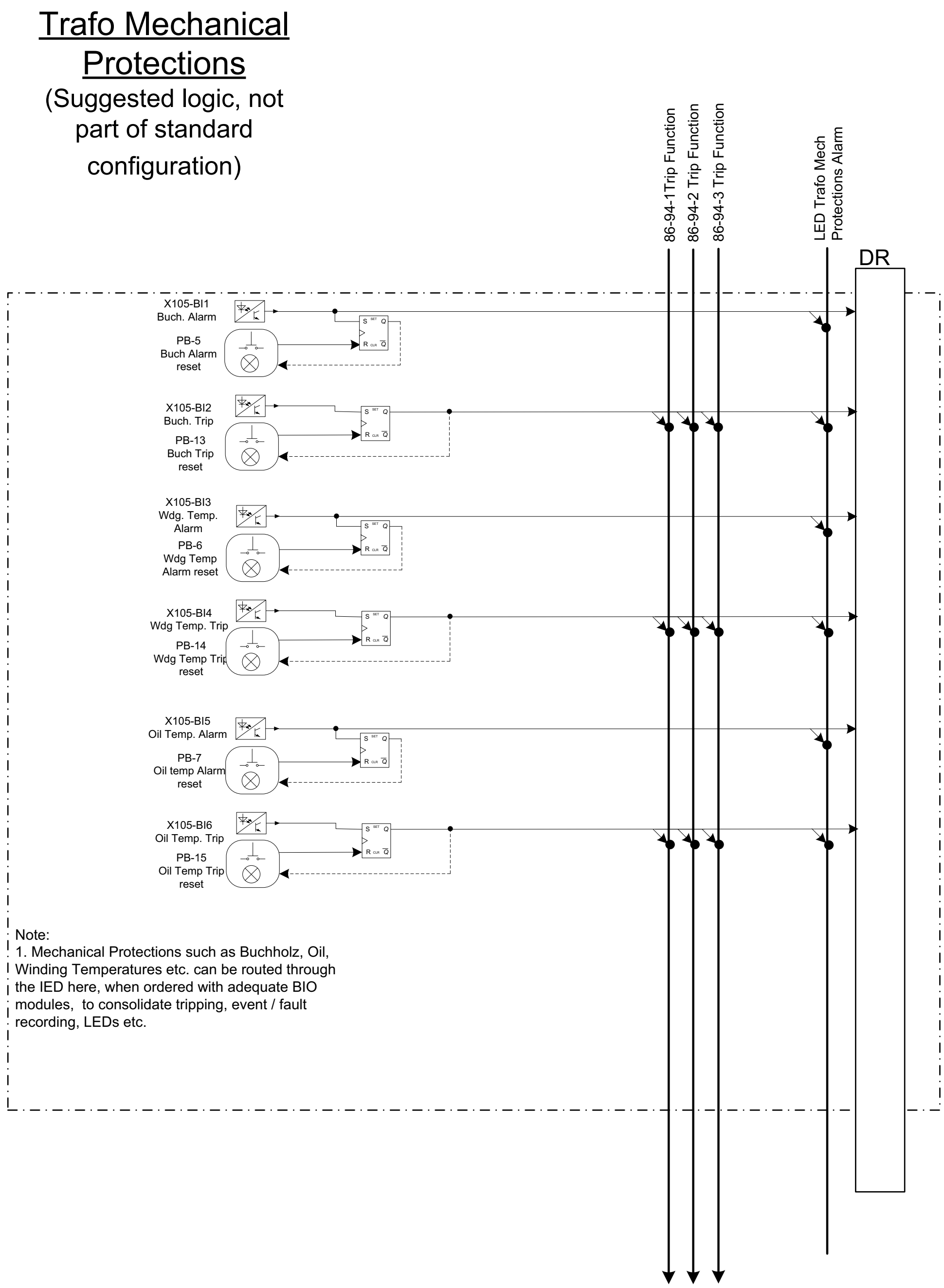


Figure 93: *Suggested logic diagram if Transformer mechanical alarm / trip functions are routed through RET620*

3.4.5 Functional diagrams

The functional diagrams describe the default input, output, RTD inputs, alarm LED and function-to-function connections. The default connections can be viewed and changed with PCM 600 according to the application requirements, if necessary.

The analog channels, measurements from CTs and VTs, have fixed connections to the different function blocks inside the IED's standard configuration.

The analog channels are assigned to different functions as shown in functional diagrams. The function and analog signal marked with (1) represents the function and analog signals (three phase currents/voltages) on the high-voltage side of the transformer and (2) represents the function and analog signals (three phase currents/voltage) on the low-voltage side of the transformer. The signal marked with IG represents the ground current measured between the neutral point of the transformer and grounding. The function and analog signal marked with (3) represents the function and analog signals (three phase currents) on the tertiary side of the transformer.

The three phase voltage inputs are connected in Delta, which are typically fed from Open Delta (V connected) VTs from the system. When WYE connected VT is available in the system, the VT inputs in the IED are WYE connected and configuration setting is suitably changed. In addition, the signal VG can be energized by the tertiary winding of the VTs, connected in broken delta.

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

RET 620 offers six different settings group which the user can set based on individual needs. Each group can then be activated/ deactivated by using the programmable button offered in the front panel of the unit. In addition to this, the programmable button can also be used for enabling/disabling switch mode, etc. Figure 94 shows the default mapping for the available programmable buttons.

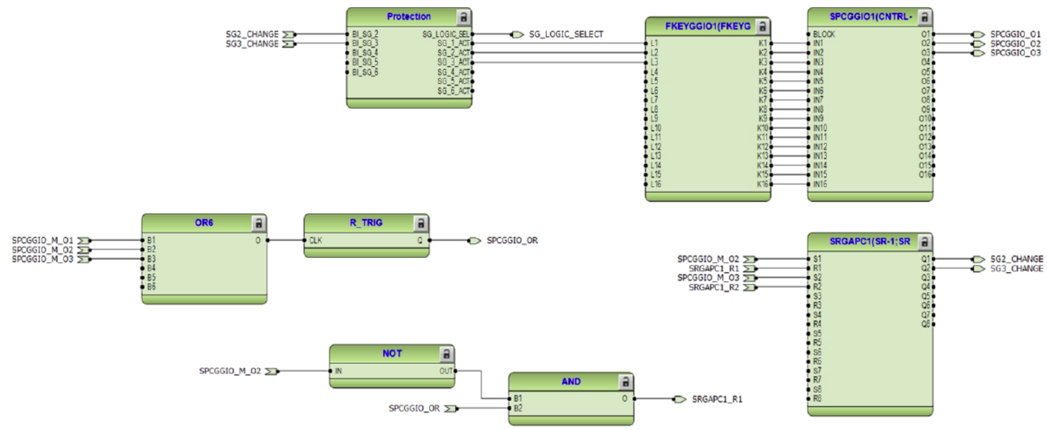


Figure 94: Default mapping on programmable buttons

3.4.5.1 Functional diagrams for protection

The functional diagrams for protection describe the IED's protection functionality in detail and according to the factory set default connections.

Three stages for each high-voltage, low-voltage and tertiary side as a total of nine, three-phase overcurrent protection (51P(1), 50P-1(1), 50P-2(1), 51P(2), 50P-1(2), 50P-2(2), 51P(3), 50P-1(3), 50P-2(3)) stages are provided for overcurrent and short-circuit protection.

The operation of these functions is not blocked as default by any functionality and so setting should be set such as to avoid unnecessary false trip or alarm.

The operation of 51P(1), 51P(2) and 51P(3) is connected to alarm LED 5, and 50P-1(1), 50P-2(1), 50P-1(2),50P-2(2), 50P-1(3) and 50P-2(3) is connected to alarm LED 6

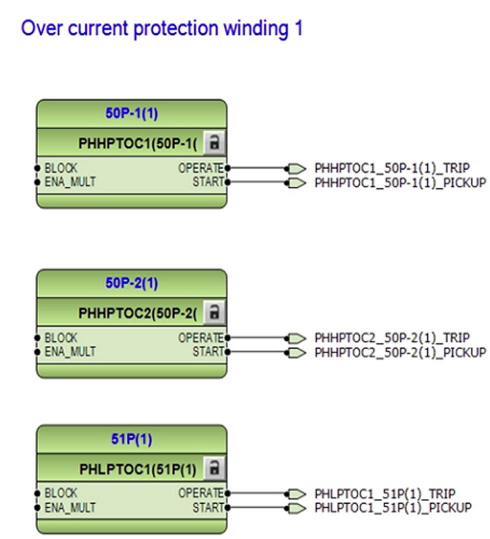


Figure 95: Three phase overcurrent protection – HV side

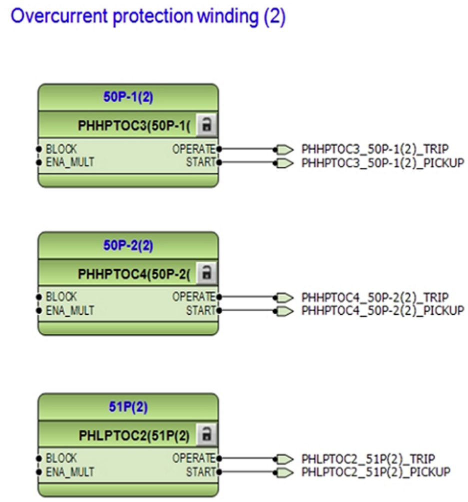


Figure 96: *Three phase overcurrent protection – LV side*

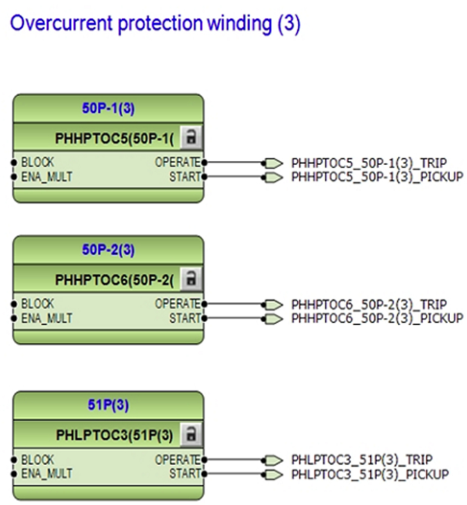


Figure 97: *Three phase overcurrent protection - Tertiary side*

A directional overcurrent protection (67/51P) is provided on high voltage side on which side the VT connection is configured. The function is blocked on loss of fuse, detected by fuse failure detection function (60).

Figure 98: *Three phase Directional overcurrent protection - HV side*

Alarm LEDs 1, 2 and 3 are configured so as to indicate which phase has resulted into tripping of overcurrent protection. Overcurrent faults in Phase A, B and C is mapped to Alarm LEDs 1, 2 and 3 respectively.

Two stages for high-voltage, low-voltage and tertiary side as a total of six, ground fault (51N(1), 50N-1(1), 51N(2), 50N-1(2), 51N(3), 50N-1(3)) stages are provided for ground fault protection.

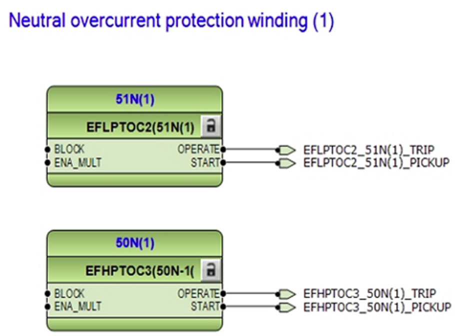


Figure 99: *Ground fault protection - HV side*

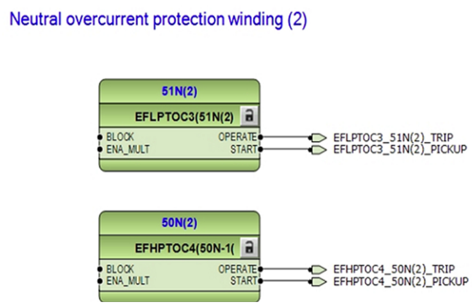


Figure 100: *Ground fault protection - LV side*

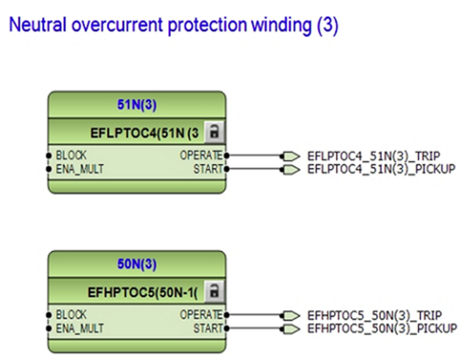


Figure 101: *Ground fault protection - Tertiary side*

Configuration also includes two stages of ground fault protection (51G, 50G), fed off the IG input of the IED. These can be set to provide standby earth fault protection for the transformer, for uncleared ground faults in the LV system

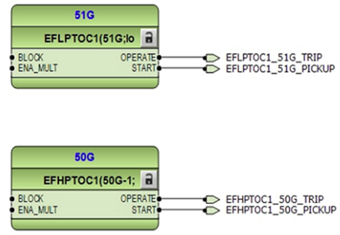


Figure 102: Non-directional ground fault protection

A directional ground overcurrent protection (67/51N) is provided on High voltage side. The function is blocked on loss of fuse, detected by fuse failure detection function(60). The polarization of the directional ground function is set by default to negative sequence which is suitable for VT input with Delta (open V) or WYE configurations. In the latter case, the polarization of the directional ground element can be set for zero sequence.

Figure 103: Directional Ground overcurrent protection - HV side

The operation of 51N(1), 51N(2), 51G and 67/51N is connected to alarm LED 4 and 5, and 50N-1(1), 50N-2(1), 50N-1(2), 50N-2(2) and 50G is connected to alarm LED 4 and 6.

The operation of the non-directional functions is not blocked as default by any functionality.

One stage of negative-sequence overcurrent protection (46(1), 46(2) and 46(3)) for each high-voltage, low-voltage and tertiary sides is provided for protecting transformer against thermal stress and damage. The operation of 46(1), 46(2) and 46(3) is not blocked as default by any functionality.

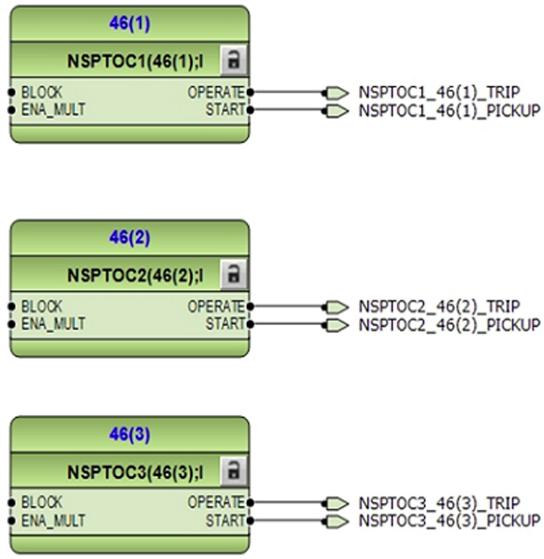


Figure 104: Negative sequence protection -HV, LV and tertiary side

Configuration also includes a general pickup alarm, the pickup outputs from respective 50P-1, 50P-2, 51P, 51N, 50N-1 and 46 are connected together to have a combined overcurrent high voltage side, low voltage and tertiary side pickup alarm which is connected to disturbance recorder as default.

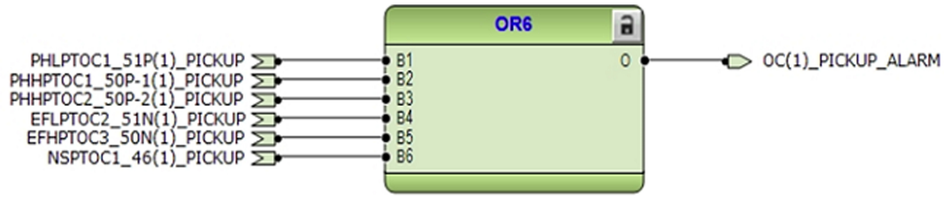


Figure 105: Overcurrent pickup alarms - HV side

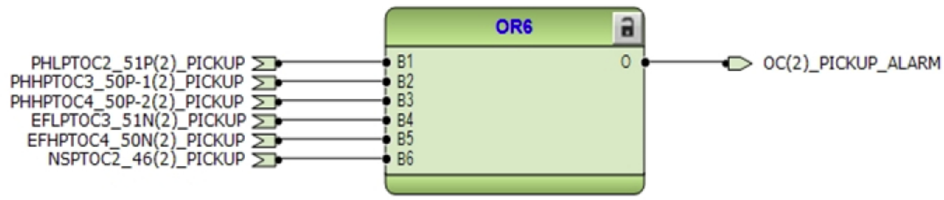


Figure 106: Overcurrent pickup alarms - LV side

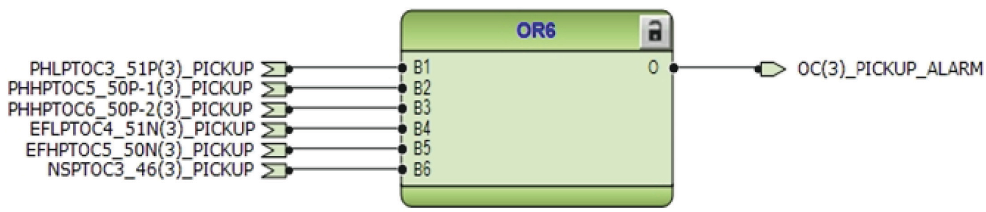


Figure 107: Overcurrent pickup alarms - Tertiary side

The directional positive sequence over power protection (32P(1)) and directional negative/zero sequence over power protection (32N(1)) are offered in configuration, on the HV side, on which side voltage transformer input is configured. Directional power protection functions are blocked by default configuration connection if fuse failure is detected.

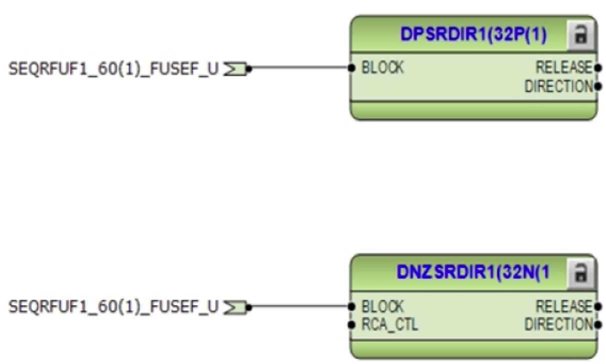


Figure 108: Directional Power protection

The configuration includes restricted low-impedance ground-fault (87LOZREF(2)) protection function for low-voltage side of power transformers. The numerical differential current stage operates exclusively on ground faults occurring in the protected area, that is, in the area between the phase and neutral current transformers. A ground 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 neutral of the transformer and ground.

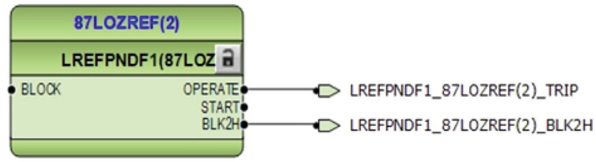


Figure 109: Restricted low impedance ground fault protection - LV side

The restrained (Low Stage) and unrestrained (High Stage) differential protection for three winding transformers (87T) provides protection of power transformer unit including, for example, winding short-circuit and inter-turn faults. The IED compares the phase currents on all HV, LV and tertiary sides of the transformer. If the differential current of the phase currents in one of the phases exceed the setting of the restrained (low stage) operation characteristic or the instantaneous protection stage of the function, the function provides a trip signal.

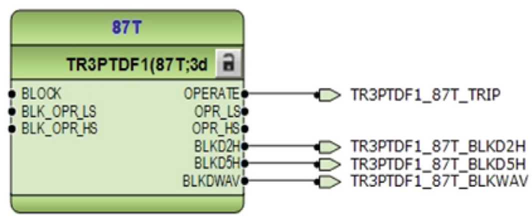


Figure 110: Transformer differential protection

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 87T.

The operation of 87LOZREF(2) and 87T is not blocked as default by any functionality. The operation of these protection functions is connected to alarm LED 7, as well as binary trip output PO1. This output may be used to energize an external lockout relay to generate contacts for tripping HV, LV and tertiary breakers. Presently the IED is not configured to energize other internal trip outputs such as 86/94 elements but may be added based on actual application requirements.

The thermal overload protection function (49T(1)) on HV side detects short and long term overloads under varying load conditions.

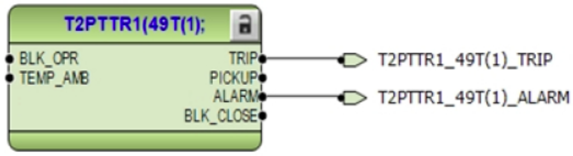


Figure 111: Transformer thermal overload protection - HV side

By default 49T(1) is configured to trip all the HV, LV and tertiary breakers isolating the transformer. Based on the thermal limit settings, it may alternatively be considered to trip out only the load side breaker, keeping the transformer energized from source side.

The IED is provided with two RTD inputs, in Config BB each one to measure winding and oil temperatures. All RET620 configurations have level detectors 38-1, 38-2 and 38-3 as standard. When RTD input is available as part of the configuration, the RTD can be connected to (38) functions to create alarms and trip signals based on the temperature input measured through RTD.

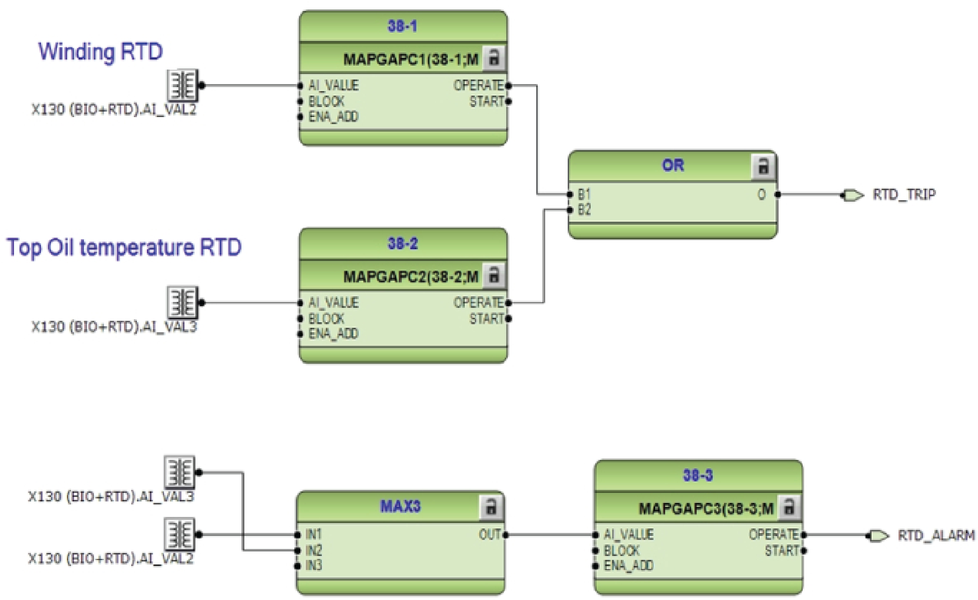


Figure 112: Level detection of temperature based on RTD inputs

The higher of the two RTD inputs are connected to level detector function 38-3, generating an alarm when the input signal exceeds the set limit.

Level detectors 38-1 and 38-2 are independently set for trip levels corresponding to winding and top oil temperature limits of the transformer. Operation of either of these would generate RTD trip output, which can be arranged to disconnect the transformer.

By default, RTD trip output is not configured to trip the breaker(s).

Transformer mechanical trip and alarm devices such as Buchholz Alarm / Trip, Pressure relief device operation, transformer built-in Oil / Winding temperature Alarm / Trip contacts are, by default, are not configured to be received into the IED since they may have own indication alarms and trip outputs to directly trip the breakers. This is usually in step with the traditional philosophy of two parallel paths to trip an electrical equipment without a common path. If necessary a repeat contact of those signals may be wired to the IED and configured for event recording.

Should it become necessary to route the mechanical alarm/trip functions through RET620, such as when backup protection is provided by a second IED, Function pushbuttons and associated LEDs on the LHMI could be configured for receiving and latching such inputs, routing them for tripping as well as having individual acknowledging of such inputs.

Loss of load protection (37(1), 37(2) and 37(3)) is provided, one on each winding of the transformer for detecting sudden loss of load on the transformer.

The operation of 37(1), 37(2) and 37(3) is not blocked as default by any functionality.

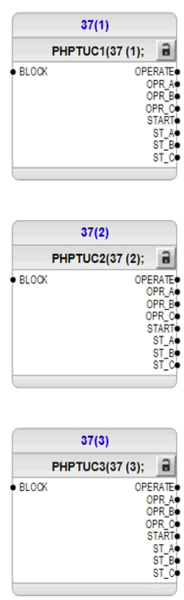


Figure 113: Loss of load protection - One on each transformer winding

By default 37(1), 37(2) and 37(3) are not configured to trip.

A number of voltage protection functions are included in the IED.

Two overvoltage and undervoltage protection stages (27-1(1), 27-2(1) and 59-1(1), 59-2(1)) offer protection against abnormal phase voltage conditions.

The operation of voltage functions is connected to alarm LED 8.

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.

Negative-sequence overvoltage (47-1(1) and 47-2(1)) protection functions enable voltage-based unbalance protection. The operation signals of voltage-sequence functions are connected to alarm LED 8, which is a combined voltage protection alarm LED.

The residual overvoltage protection (59N(1)) provides ground-fault protection by detecting abnormal level of residual voltage.

When broken delta input is wired to VG input of the IED, the ground overvoltage function (59G) also provides protection against abnormal levels of residual voltages.

Either 59N(1) and 59G can be used, for example, as nonselective backup protections. The operation signal is connected to alarm LED 8.

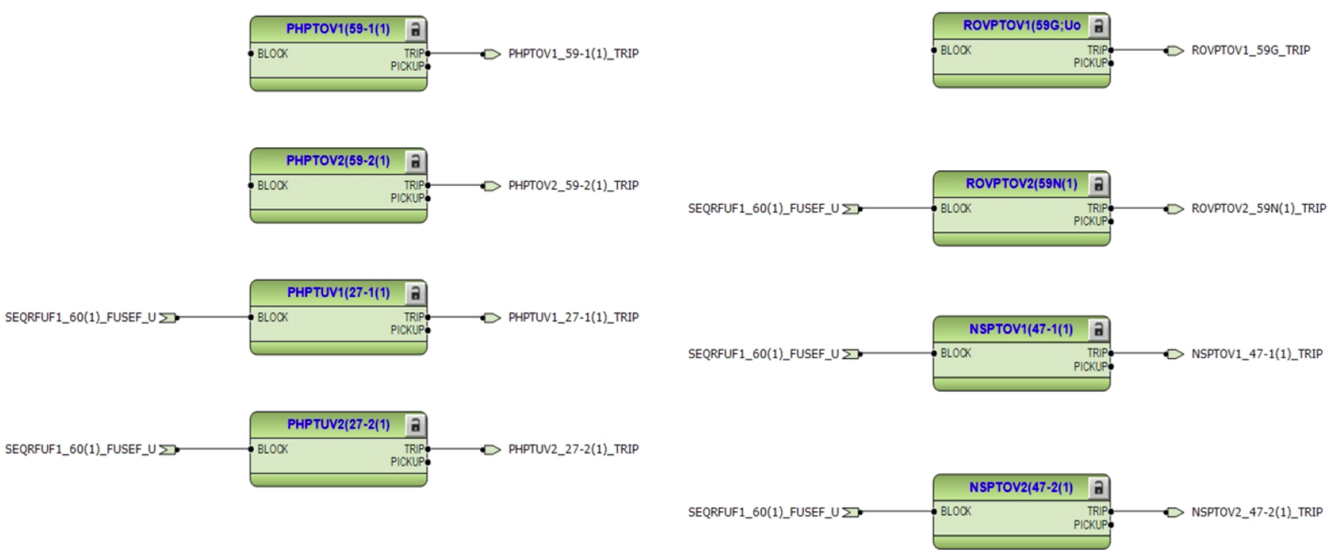


Figure 114: Voltage protection functions

The over excitation protection functions (24-1(1) and 24-2(1)) are offered as standard. (24-1(1)) may be set and arranged to give alarm while the second stage 24-2(1) may be arranged to provide trip function of the transformer.

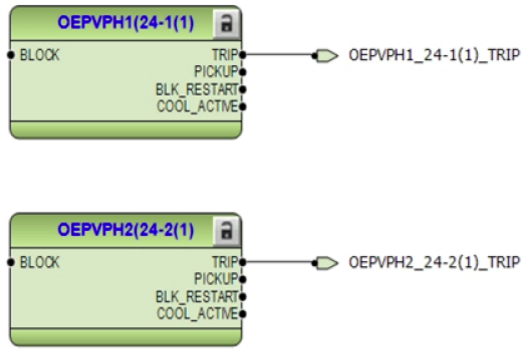


Figure 115: Over excitation protection

The selectable under frequency or over frequency protection (81-1(1) and 81-2(1)) prevents damage to transformer and associated network under unwanted frequency conditions.

Both functions contain 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 operation signals are connected to alarm LED 8.

Four load shedding and restoration stages are offered in the standard configuration. Each load shedding and restoration function (81LSH-1(1), 81LSH-2(1), 81LSH-(1), and 81LSH-4(1)) is capable of shedding load based on under frequency and the rate of change of the frequency. The load that is shed during the frequency disturbance can be restored once the frequency is stabilized to the normal level. Also manual restore commands can be given via binary inputs but by the default it is not connected. The operation signal is connected to the alarm LED 8.

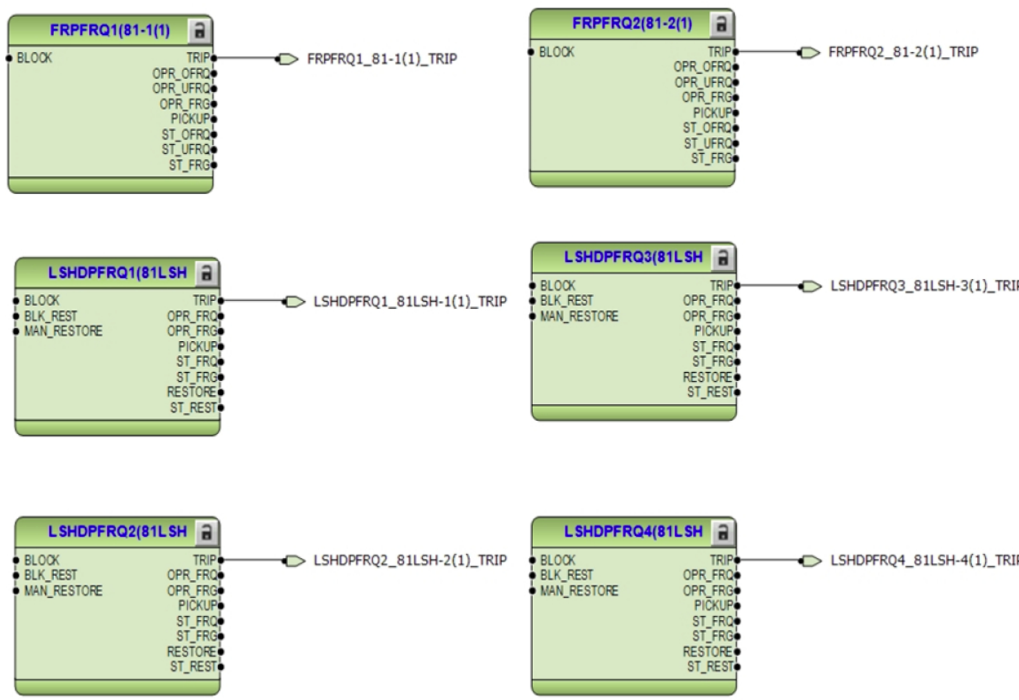


Figure 116: Frequency and Load shedding functions

None of the voltage based protections are configured by default to trip the transformer.

The circuit-breaker failure protection (50BF(1), 50BF(2) and 50BF(3)), one for each high-voltage, low-voltage and tertiary side is initiated via the pickup input by a number of different protection functions in the IED. 50BF(1), 50BF(2) and 50BF(3) offers different operating modes associated with the circuit-breaker position and the measured phase and residual currents.

50BF(1), 50BF(2) and 50BF(3) each has two operating outputs: TRRET and TRBU. The TRBU output from each side is used to give a backup trip to the circuit breaker feeding upstream. For this purpose, the TRBU output signal from both the function is connected to the output PO2 (X100: 8,9).

The TRBU output from 50BF(1), 50BF(2) and 50BF(3) is connected to a comm alarm LED 9.

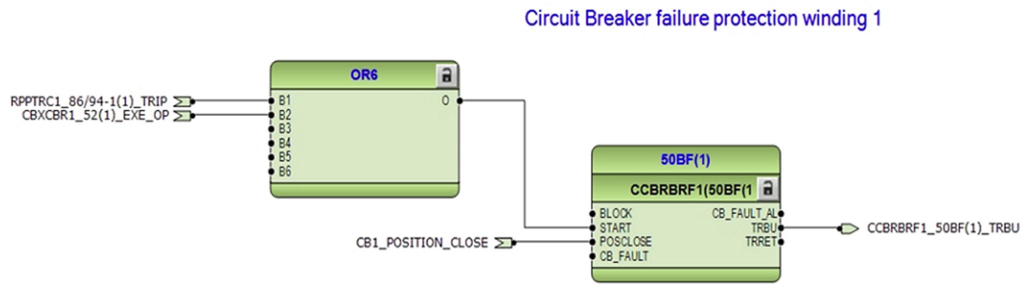


Figure 117: Circuit breaker failure protection - HV side

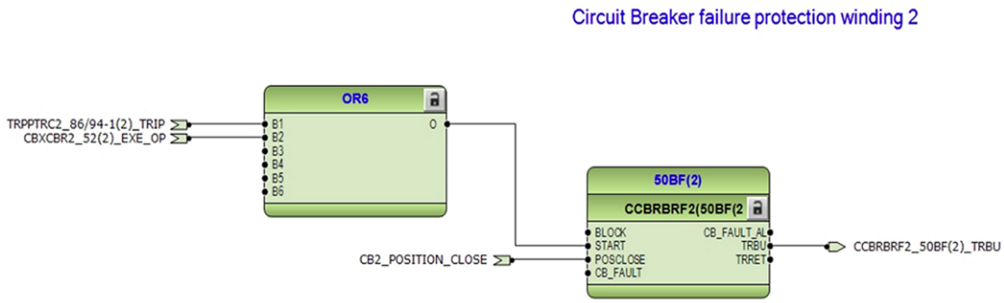


Figure 118: Circuit breaker failure protection - LV side

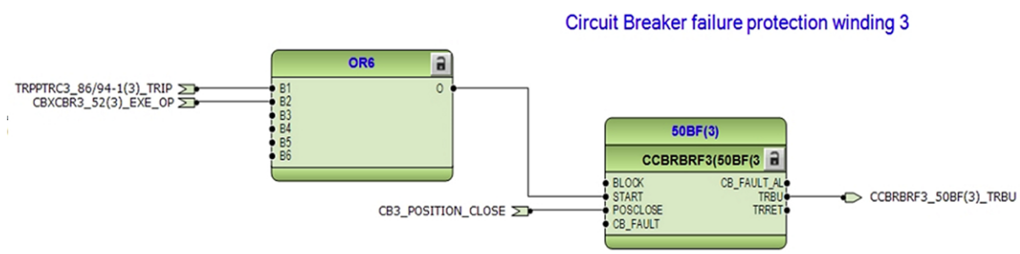


Figure 119: Circuit breaker failure protection - Tertiary side

Three arc protection (AFD-1(2), AFD-2(2) and AFD-3(2)) stages are included as an optional function. The arc protection offers individual function blocks for three ARC sensors that can be connected to the IED. Each arc protection function block has two different operation modes, with or without the phase and residual current check.

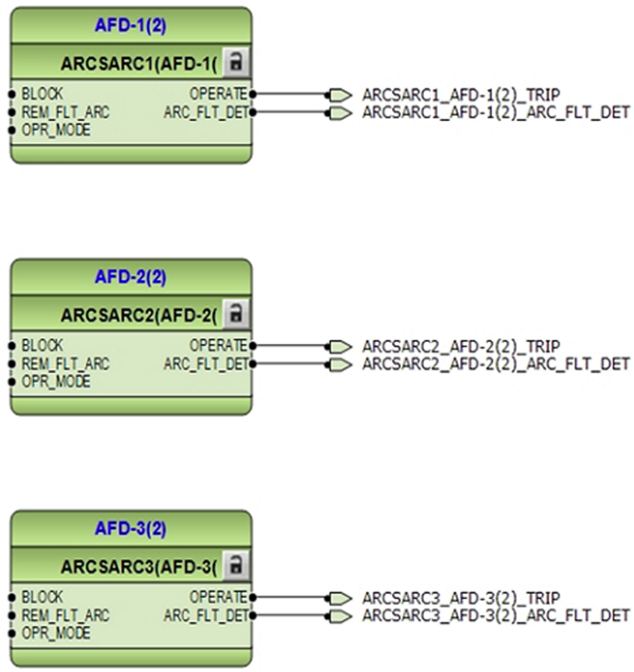


Figure 120: Arc protection

Trip output of each of the AFD-1,2 and 3 are configured to energize master trip functions that trip respective breakers by default. This may however be suitably changed based on actual requirements and placement of the arc detectors.

When High Speed trip output is required from the AFD functions, BIO card with high speed power output can be optionally ordered.

Note in the board in slot X110 the first and second outputs are configured by default to do second and third breaker closing functions. The third high speed output from this board and/or three HSO in slot X105 can be optionally ordered and configured for Arc protection high speed trip purposes.

The detection of arc fault is connected to alarm LED 11.

Three master trip logics (86/94-1, 86/94-2 and 86/94-3) are provided as trip command collectors.

The functions collect the trip signals from various protections and are connected to binary outputs to trip HV, LV and tertiary breakers of the transformer.

Open control commands to HV, LV and Tertiary circuit breaker from the local or remote are also connected directly to appropriate binary outputs.

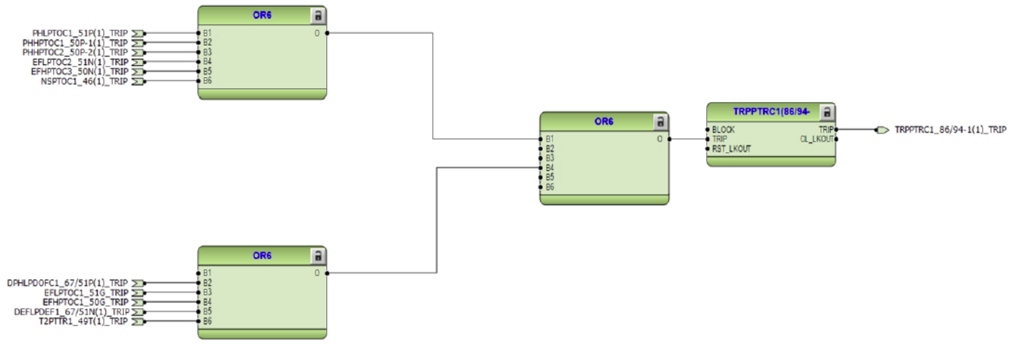


Figure 121: Master trip logic - HV side

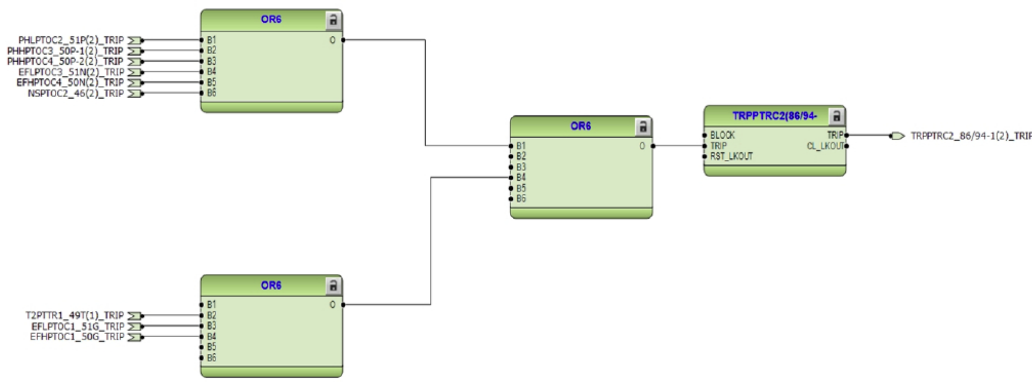


Figure 122: Master trip logic - LV side

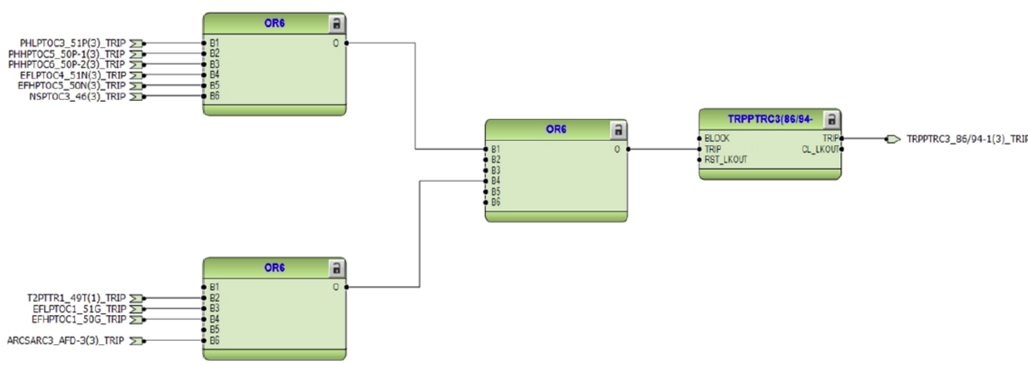


Figure 123: Master trip logic - Tertiary side

86/94-1, 86/94-2 and 86/94-3 provide the lockout/latching function, event generation and the trip signal duration setting. If the lockout operation mode is selected, one binary input can be reassigned to the RST_LKOUT input of the Master Trip to enable external reset with a pushbutton.

3.4.5.2 Functional diagrams for control functions

The functional diagrams for control describe the IED's control functionality in detail and according to the factory set default connections.

The circuit breaker closing is enabled when the respective ENA_CLOSE input is activated. The input can be activated by the configuration logic, which is a combination of the disconnector or breaker truck and ground switch position status and the status of the Master Trip logics, gas pressure alarm and circuit-breaker spring charging. With the present configuration, the activation of respective ENA_CLOSE input is configured using only Master Trip logic 86/94-1(1), 86/94-2(3) i.e. the circuit breaker cannot be closed in case master trip is active.

When all conditions of the respective breaker closing are fulfilled, the EXE_CL output of appropriate 52(1), 52(2) or 52(3) and close output contact (configured) of the respective breaker closes if closing command is given.

The ITL_BYPASS input can be used, for example, to always enable the closing of the circuit breaker when the circuit breaker truck is in the test position, despite the interlocking conditions being active when the circuit breaker truck is closed in service position.

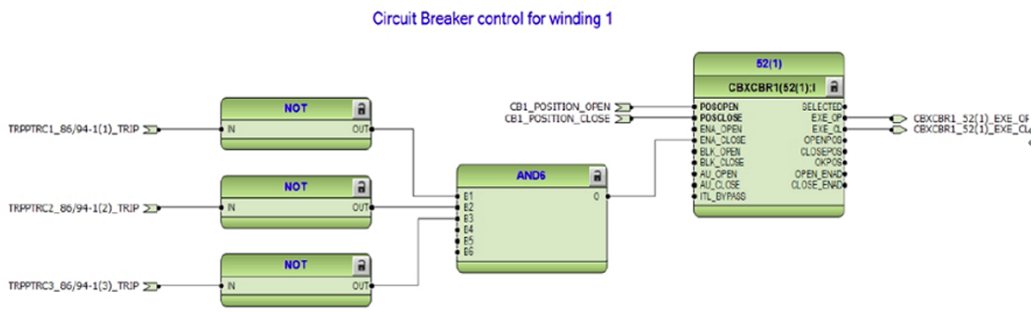


Figure 124: Circuit breaker control - HV side

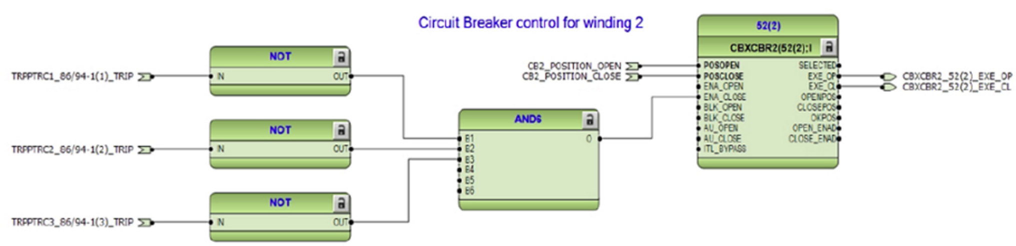


Figure 125: Circuit breaker control - LV side

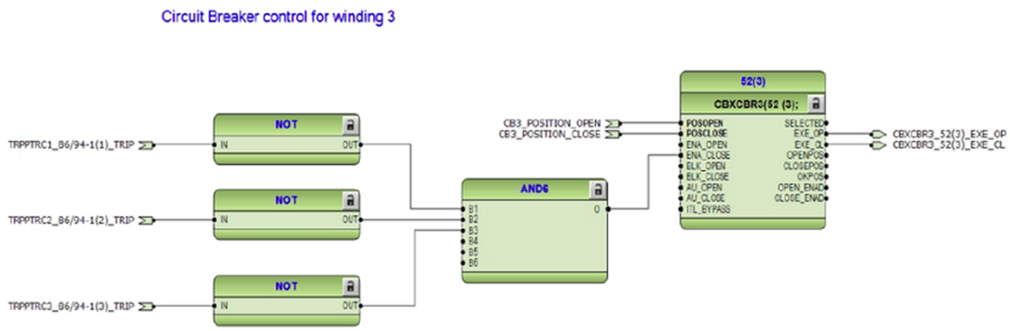


Figure 126: *Circuit breaker control - Tertiary side*

If the ENA_CLOSE and BLK_CLOSE signals are completely removed from the breaker control function block 52 with PCM600, the function assumes that the breaker close commands are allowed continuously.

3.4.5.3 Functional diagrams for condition monitoring

The functional diagrams for condition monitoring describe the IED's condition monitoring functionality in detail and according to the factory set default connections.

Configuration also includes tap changer position indicator (84T), however by default it is not configured.

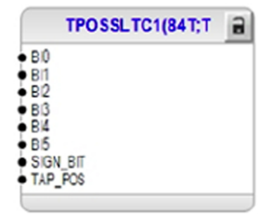


Figure 127: Tap changer position indicator

Three trip circuit monitoring (TCM-1, TCM-2 and TCM-3) stages are provided to supervise the trip circuit of the high voltage, low voltage, and tertiary circuit breakers.

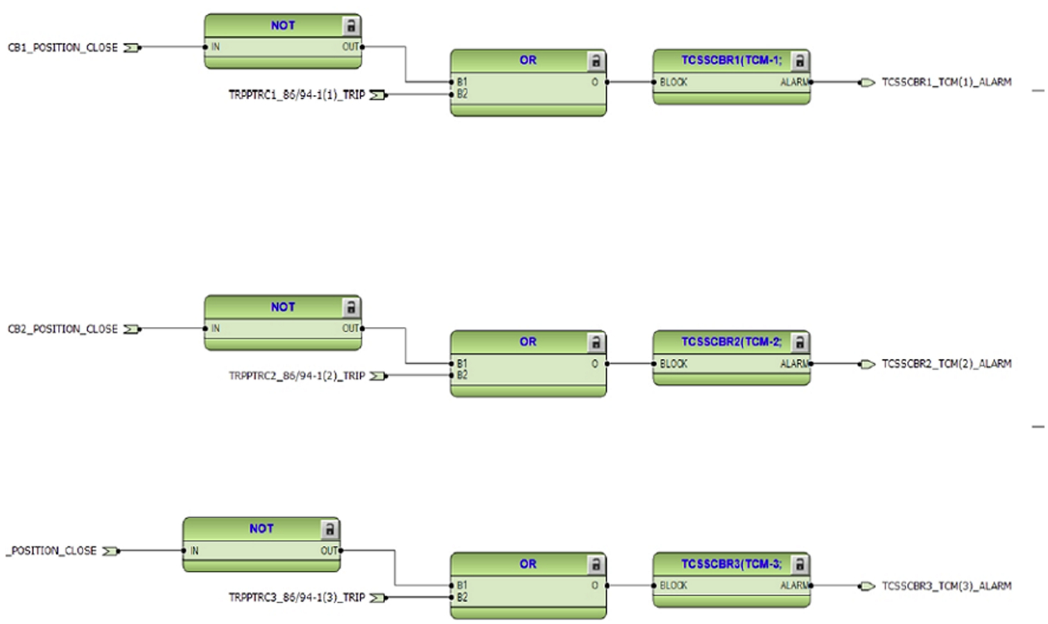


Figure 128: Trip circuit monitoring HV,LV and Tertiary- side

The TCM functions are blocked by respective trip signals and the respective circuit-breaker open position signal.

The supervision alarm from TCM is connected to alarm LED 9.

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

A failure in current measuring circuits is detected by current circuit supervision function (MCS 3I, I2). When a failure is detected, function activates and can be used to block protection functions for example 87T, thus avoiding mal-operation.

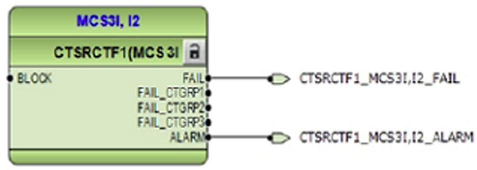


Figure 129: Current circuit supervision

By default the FAIL output from MCS 3I, I2 function is only connected to disturbance recorder.

The fuse failure supervision SEQRFUF1 detects failures in voltage measurement circuits. Failures, such as an open miniature circuit breaker, are detected and the alarm is connected to the few voltage based protection functions to avoid misoperation.

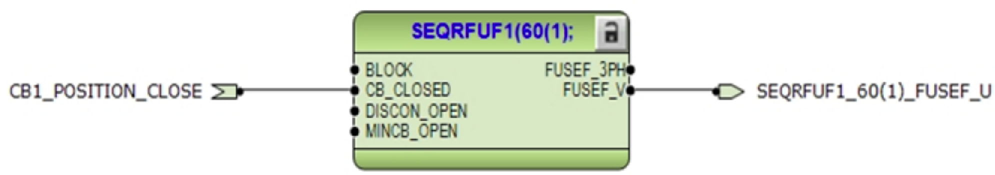


Figure 130: Fuse failure monitoring

Three circuit breaker condition monitoring function (52CM(1),52CM(2) and 52CM(3)) one each is configured to supervise high voltage side, low voltage side and tertiary side circuit breaker status based on the binary input information connected and measured current levels. The function introduces various supervision alarms.

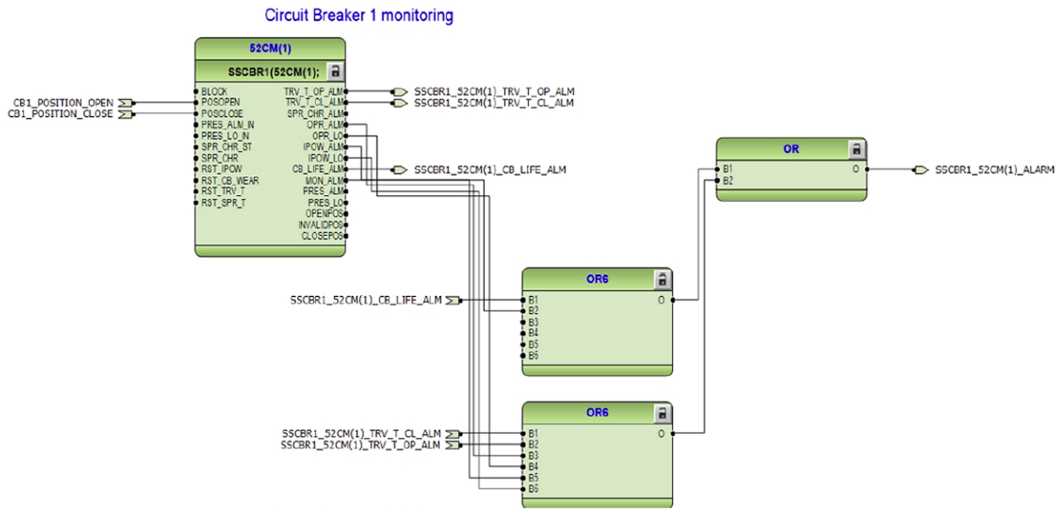


Figure 131: *Circuit breaker condition monitoring HV side*

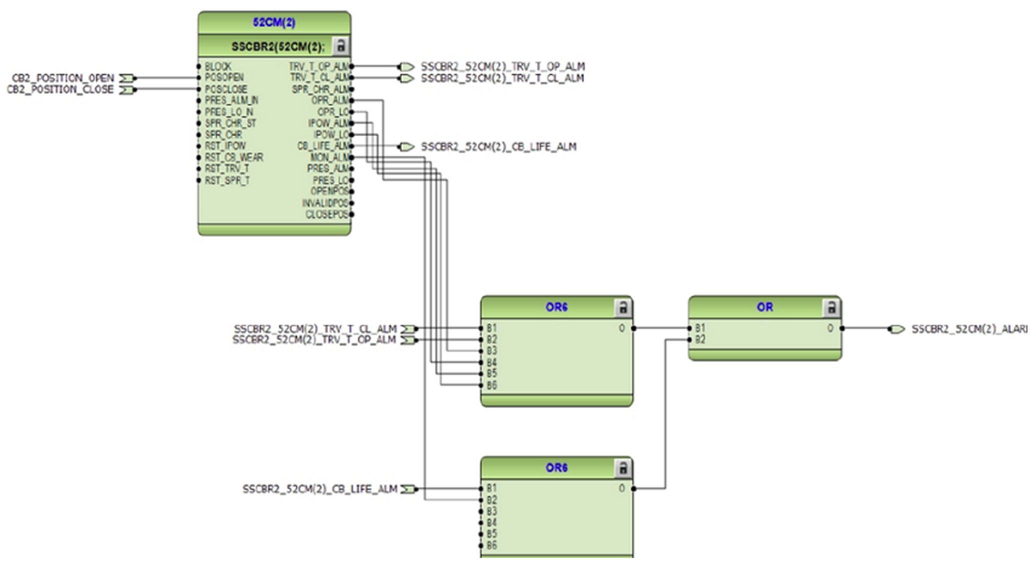


Figure 132: *Circuit breaker condition monitoring LV side*

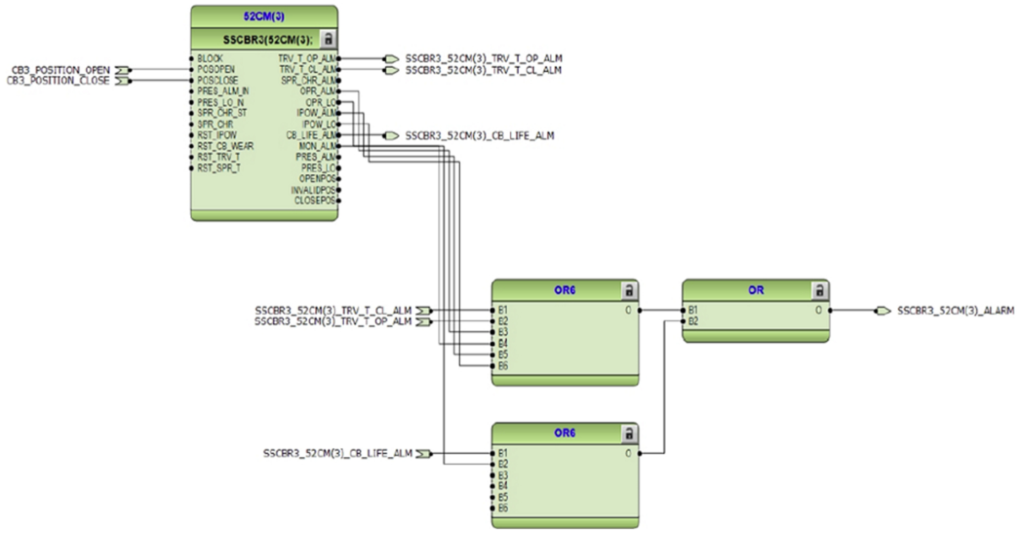


Figure 133: Circuit breaker condition monitoring Tertiary side

By default only POSOPEN and POSCLOSE information is available to 52CM(1),52CM(2) and 52CM(3).

3.4.5.4 Functional diagrams for measurements

The functional diagrams for measurement describe the IED's measurement functionality in detail and according to the factory set default connections.

The phase current inputs from high voltage and low voltage side are connected to the IED and are measured by high voltage, low voltage side and tertiary three-phase current measurement [IA, IB, IC(1), IA,IB,IC(2) and IA,IB,IC(3)] function block respectively. The current input are connected to the X120 card in the back panel for windings W1 and W2 and to X115 for winding W3. Similarly the sequence current component for the currents measured by sequence current measurement [I1, I2, I0(1), I1,I2,I0(2) and I1,I2,I0(3)] function blocks. The residual current is measured by residual current measurement (IG) function block.

The phase voltage input is connected to the X115 card in the back panel. The voltages are measured by (VA,VB,VC) function block. Similarly the sequence voltages are measured by sequence voltage measurement (V1, V2, V0) function block respectively.

The frequency measurement of the power system (f) is available. Also single (SPEMMXU1) and three phase (PEMMXU1) power measurements are available.

The load profile (LoadProf) function is also included into measurements sheet. The load profile function offers ability to observe the history of the loading of the equipment.

The measurements can be seen from the LHMI and is available using the measurement option in the menu selection. Based on the settings, "IA, IB, IC(1)", "IA,IB, IC(2)", "IA,IB,IC(3)" and IG function block can generate low alarm/warning, high alarm/warning signals for the measured current values.

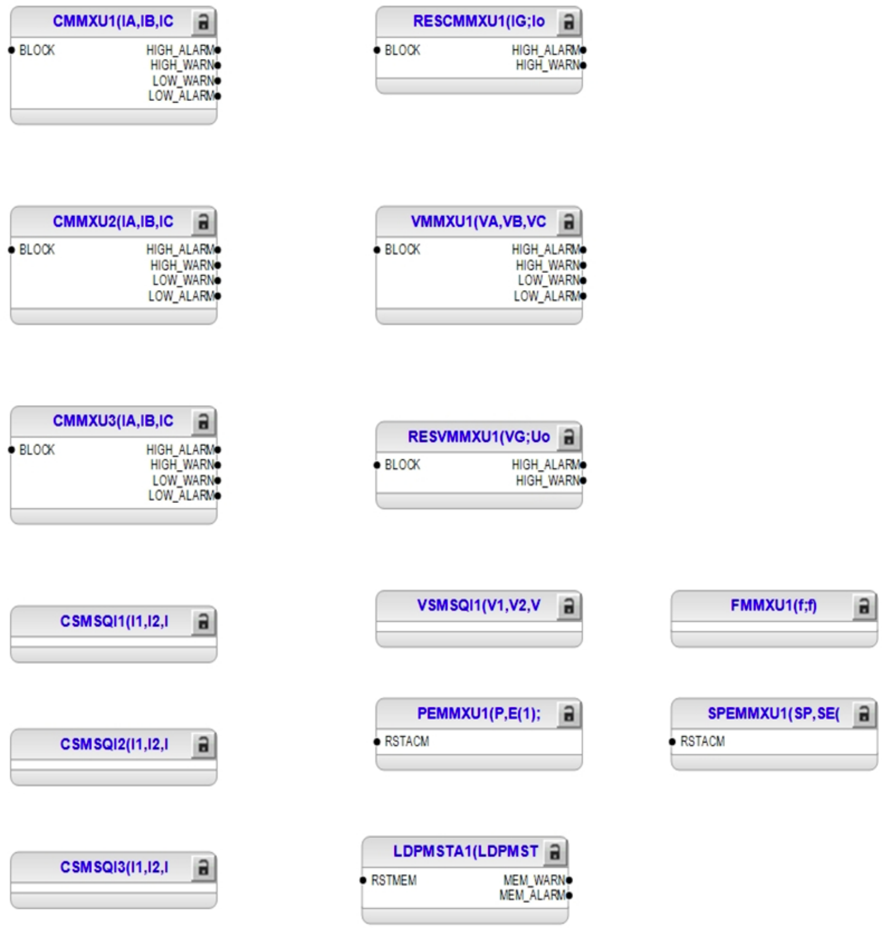


Figure 134: *Measurements*

3.4.5.5 Functional diagrams for other functions

Configuration also includes other miscellaneous basic functions which are not configured, but can be used for creating general purpose logics. These functions include:

- Four instance of Minimum Pulse Timer TP-1, TP-2, TP-3 and TP-4,
- Two instance of Pulse Timer PT-1 and PT-2,
- Four instance of Time delay on TON-1, TON-2, TON3 and TON-4,
- Four instance of Time delay off TOF-1, TOF-2, TOF-3 and TOF-4,
- Four instance of Set reset logic SR-1, SR-2, SR-3 and SR-4,
- Eight instance of Move logic MV-1, MV-2, MV-3, MV-4, MV-5, MV-6, MV-7 and MV-8,
- Three instance of Generic control points CNTRL-1, CNTRL-2 and CNTRL-3,
- One Remote Generic Control Points, RCNTRL-1,
- One Local Generic Control Points, LCNTRL-1,
- Twelve Generic Up-Down counters UDFNCT1, UDFCNT2, UDFCNT12 and,
- One Programmable buttons (16 buttons) FKEY.

3.4.5.6 Function diagrams for logging functions

The functional diagrams for logging describe the IED's default disturbance recorder connections.

The disturbance recorder DFR consists of 12 analog and 64 channels. The analog channels are pre configured in the IED as follows for this specific configuration:

Table 23: List of analog channels connected to DFR (RET Config AB and Config BB)

Ch. No	Channel
1	IA
2	IB
3	IC
4	IG
5	IA2
6	IB2
7	IC2
8	VA
9	VB
10	VC
11	VG
12	IA3

A few channels of the binary channel are connected to trigger the digital fault recorder and are shown in Figure 135. More connection can be made as per individual needs. Also, when disturbance recorder is triggered, the analog values available at the analog inputs are recorded by the fault recorder FR.

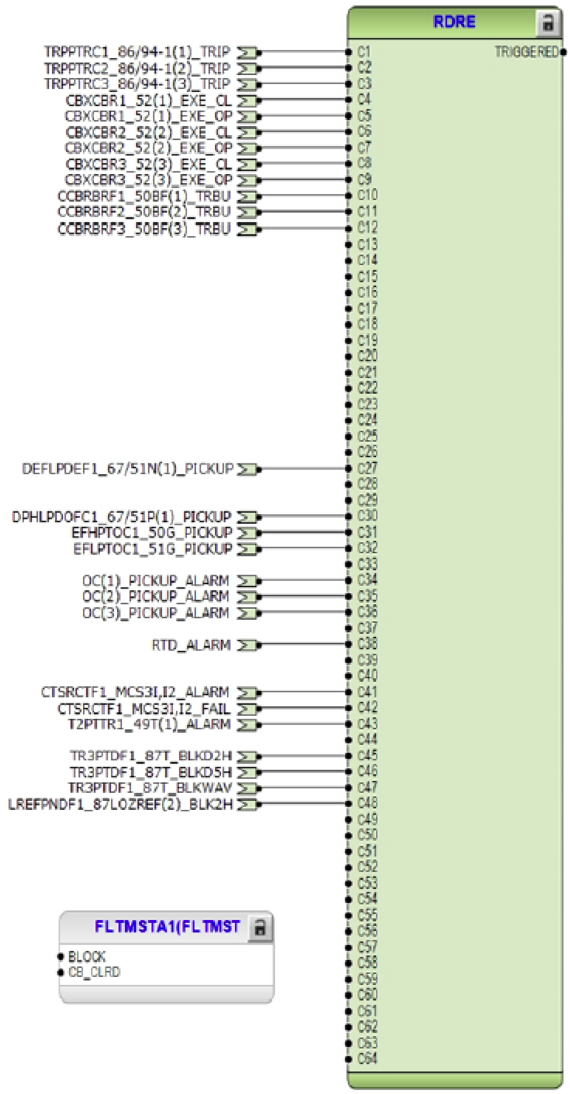


Figure 135: 64 channel Disturbance and fault recorder

3.4.5.7 Functional diagrams for I/O and alarm LEDs

The functional diagrams for I/O and Alarm LEDs describe the IED's default input/output and alarm LEDs connections.

The default binary I/O connected in the configuration and Alarm LEDs are indicated in Figure 136 to Figure 137.

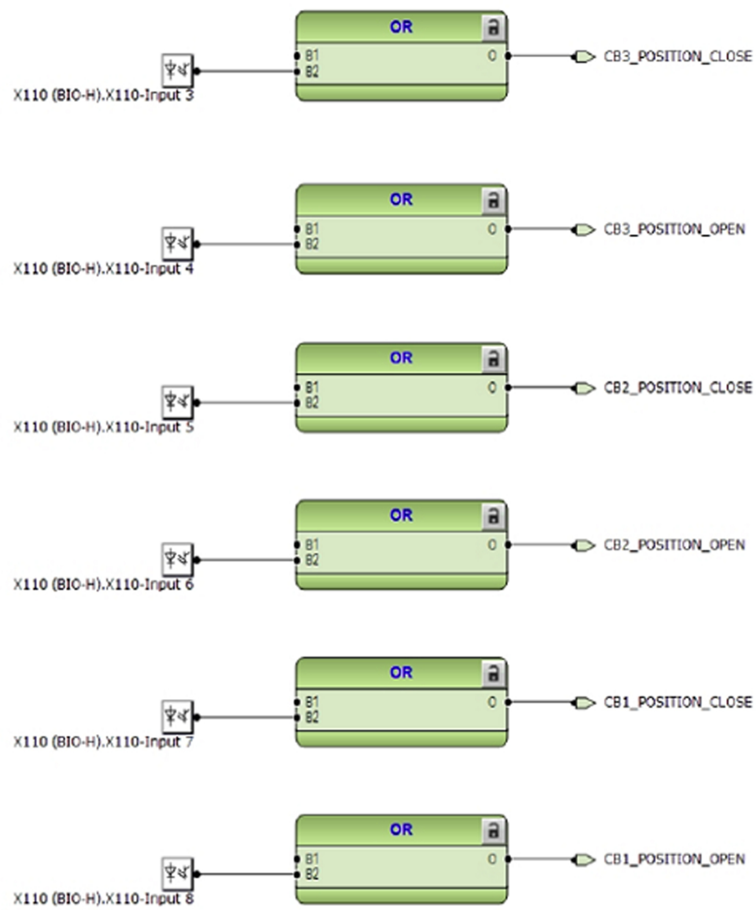


Figure 136: *Binary inputs*

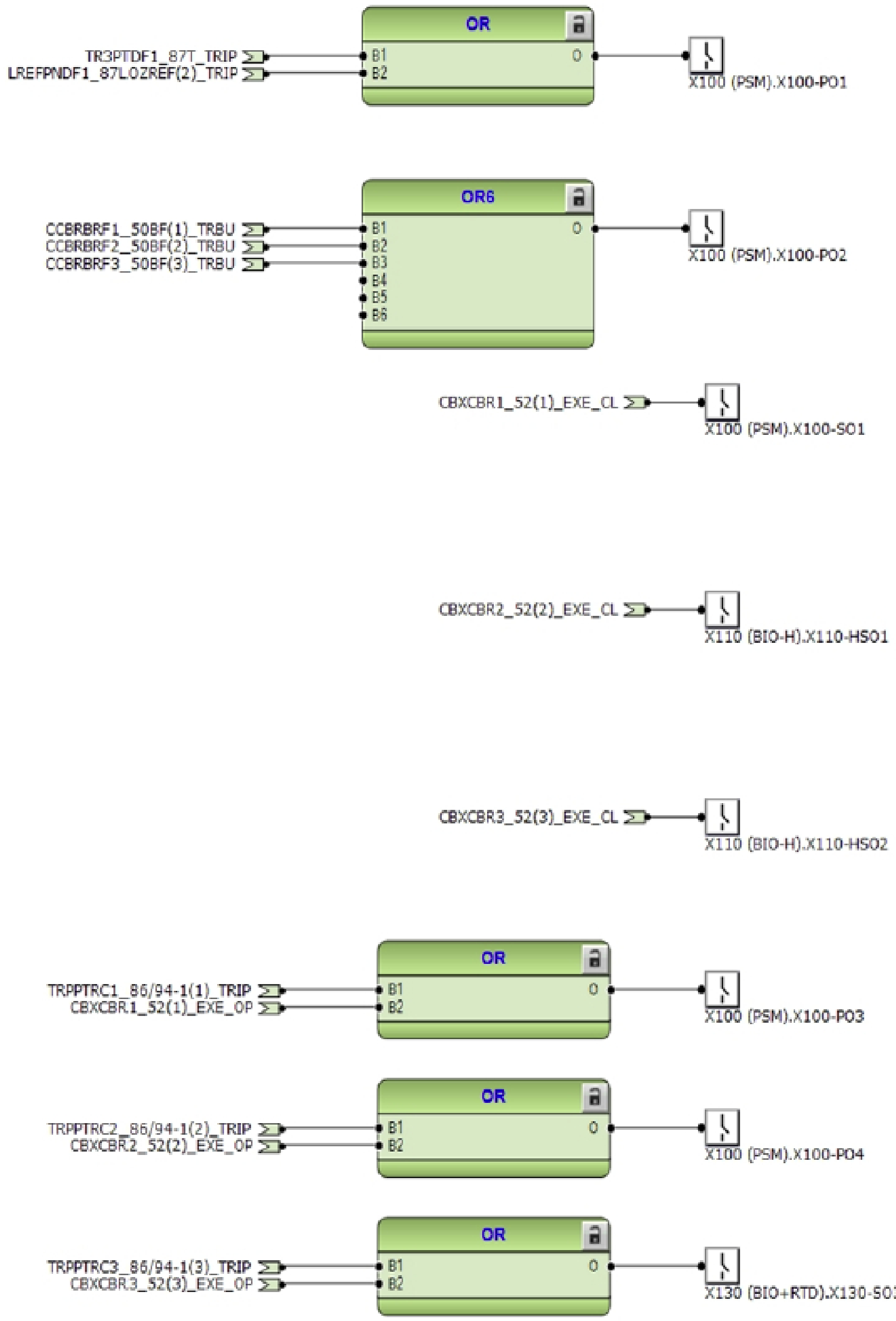


Figure 137: Binary outputs

High speed binary outputs (HSO) are available only if IED with High speed binary card has been ordered.

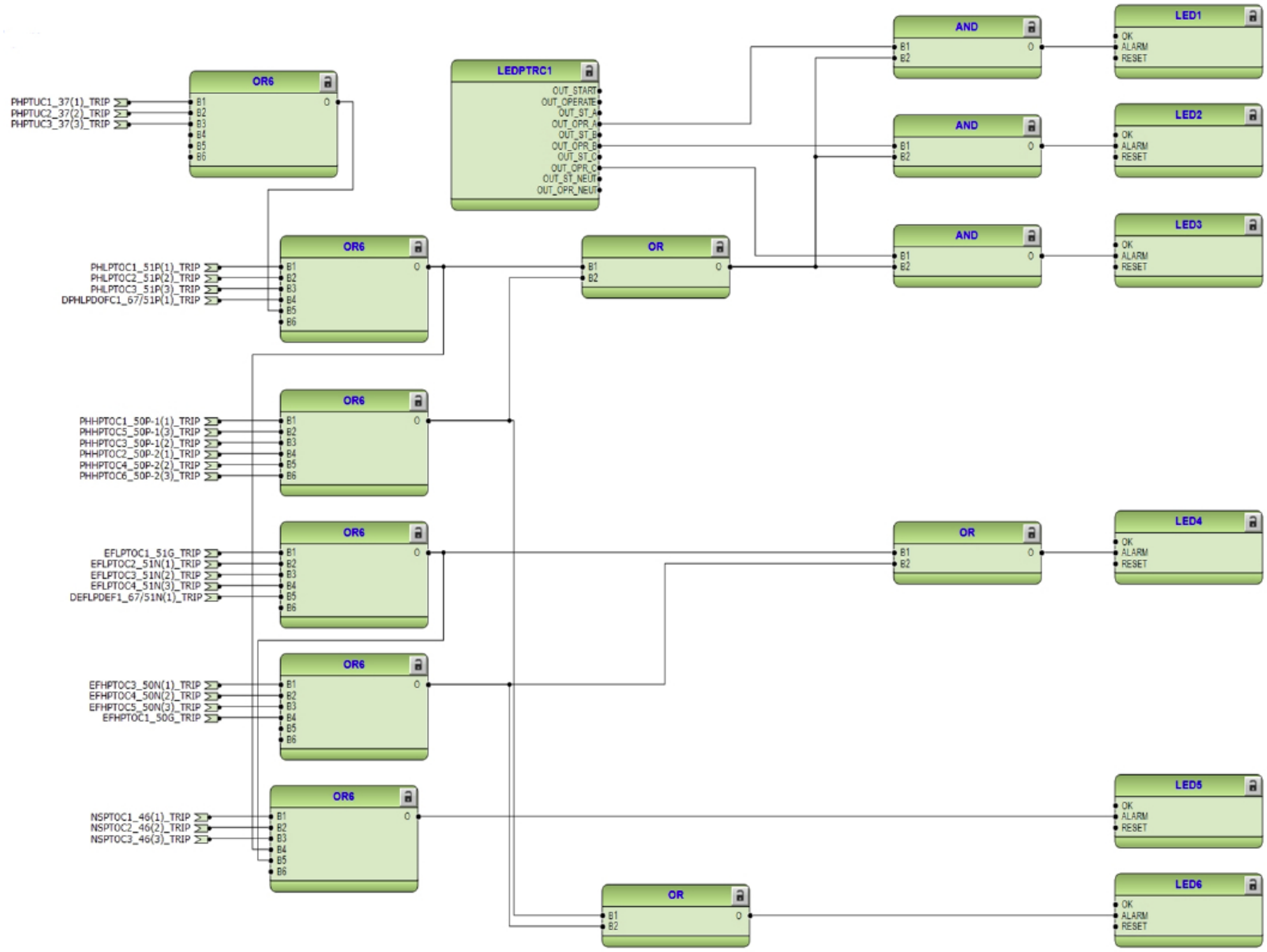


Figure 138: Alarm LED 1-6

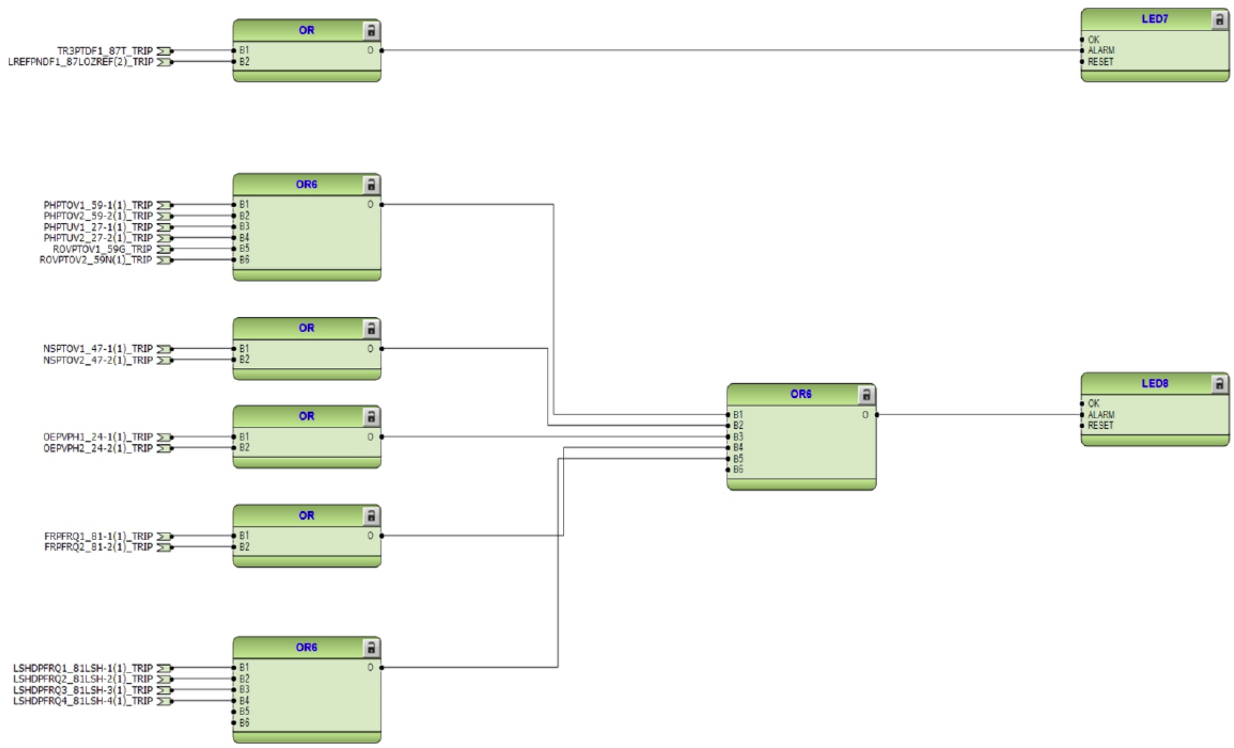


Figure 139: *Alarm LED 7-8*

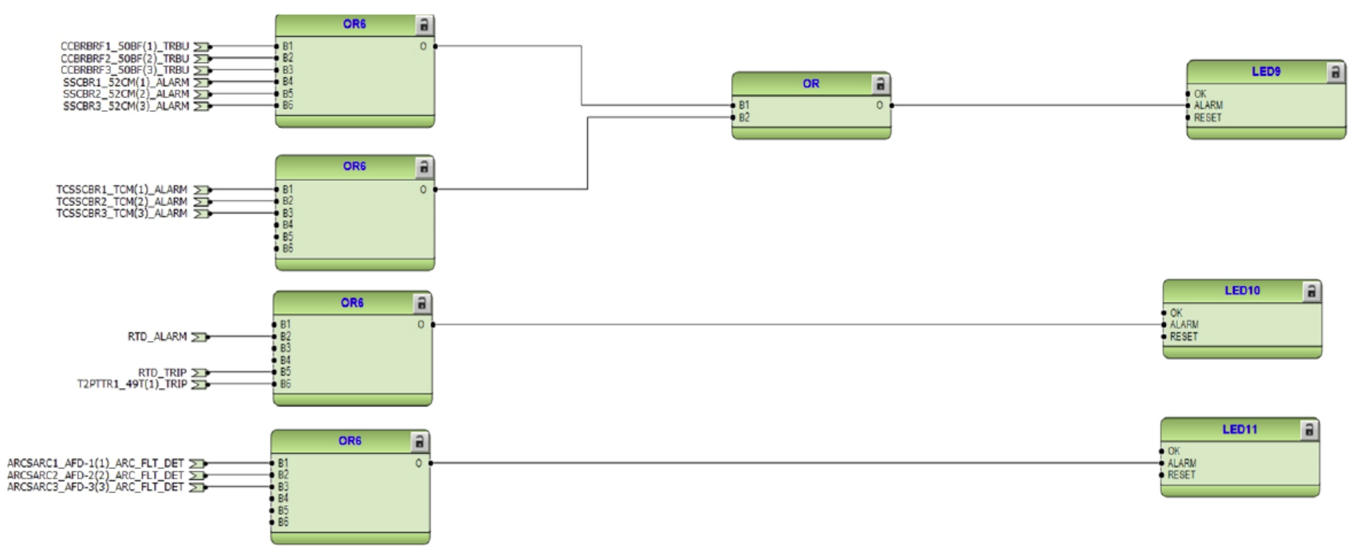


Figure 140: *Alarm LED 9-11*

Section 4 Requirement of current transformers

4.1 Current transformer requirement for protection

For reliable and correct operation of protection, the CT has to be chosen carefully. The distortion of the secondary current of a saturated CT may endanger the operation, selectivity, and co-ordination of protection. However, when the CT is correctly selected, a fast and reliable protection can be enabled. The selection of a CT depends not only on the CT specifications but also on the network fault current magnitude, desired protection objectives, and the actual CT burden. The protection settings of the IED should be defined in accordance with the CT performance as well as other factors. Appropriate 'C' class CT should be used based on the total resistances of the CT secondary circuit.

4.1.1 AC saturation:

The TOC curve of the earlier electromechanical relays was achieved by allowing partial saturation of the internal magnetic circuits. Currents much higher than the higher limits of the TOC relays, which cause 'partial' saturation of the CTs should not affect the applications. However, if an application involves severe CT saturation, the relay may not function. Where the CT ratio is very low, CT secondary currents could exceed 20 times rated current causing severe saturation. The net outputs of such CTs may become so low (Figure 141) that operation of most of the protections become impossible.

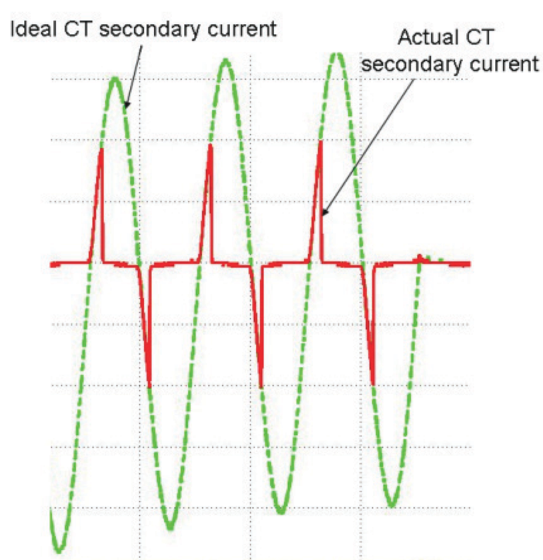


Figure 141: CT secondary waveform when severe AC saturation occurs

To avoid saturation, the CT shall develop adequate voltage such that

$$V_X > I_f (R_{CT}+R_L+R_B)- \quad \text{(Equation 1)}$$

where,

	I_f	= Fault current on CT secondary (Amps)
	R_{CT}	= CT Secondary resistance (Ohms)
	R_L	= CT Secondary total lead resistance (Ohms)
and	R_B	= CT secondary connected burden (Ohms)

The lead resistance R_L is the total secondary loop lead resistance. In case of single phase to ground faults, the current from the CT secondary flows through the phase connection and returns through the neutral wire. Hence twice the 'one-way' lead resistance shall be considered. In case of multi-phase faults, the phase currents cancel out with negligible current in the common neutral return lead. Hence the lead resistance for such faults will be just that of the 'one-way' lead. Special cases arise with delta connected CTs. In all such cases a very careful evaluation of how the CT under question drives currents through the leads would be necessary.

4.1.2 Transient saturation:

Transients, especially the decaying DC waveform in the primary current, cause the CT to go into saturation and produce distorted current waveform. Once the transients vanish the steady state performance of the CT gets restored.

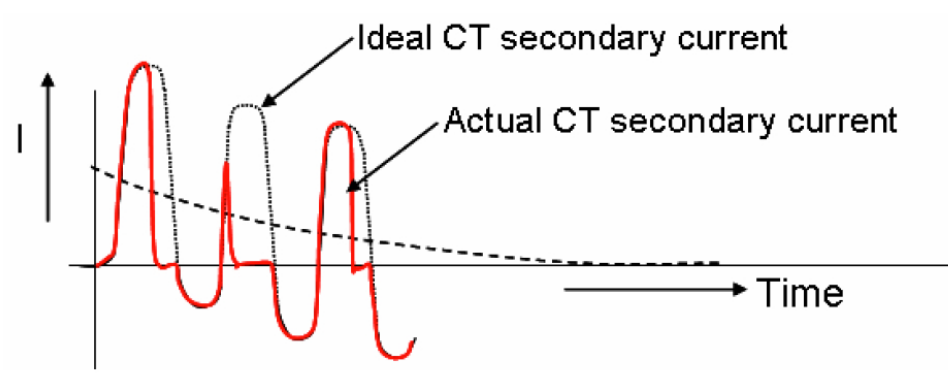


Figure 142: CT waveform when saturation occurs due to DC transients

It can be shown that the CT shall have enough capacity to develop the following voltage not to saturate at all for a combination of AC and DC transient.

$$V_X > I_f (1+X/R) (R_{CT}+R_L+R_B) \quad \text{(Equation 2)}$$

where,

	I_f	= Fault current on CT secondary (Amps)
	X	= System Primary Reactance (in Ohms)
	R	= System primary reactance (in Ohms)
	R_{CT}	= CT Secondary resistance (Ohms)
	R_L	= CT Secondary total lead resistance (Ohms)
and	R_B	= CT Secondaryconnected burden (Ohms)

Note that there is an additional factor (1+X/R) on the right side of the equation compared to the equation applied for AC saturation, Equation (1).

The ANSI specifies CTs for protection performance by a letter (See IEEE Std C57.13-1993). The classification codes are **C**, **K** and **T**. The classification **C** is widely used for protection. They indicate that the winding is uniformly wound around the core with negligible leakage flux. The **C** class CT is furnished with excitation characteristics which can be used to "**C**alculate" the CT performance. The standard ratings are C100, C200, C400, C800 corresponding to 100, 200, 400 and 800 volts respectively at 100A CT secondary. This would mean the design burdens are 1, 2, 4 and 8 Ohms respectively. Other burdens such as 0.1, 0.2 and 0.5 with corresponding voltages 10, 20, 50 are also specified but are not often used for HV and EHV applications. ANSI specifies the power factor of the burden at 0.5.

A steady state current error of 10% is allowed at 100A secondary, which translates into 10A excitation current. It is easy to look up the CT excitation characteristics corresponding to 10A excitation current and find out the induced voltage inside the CT. Subtracting the internal drop of R_{CT} through 100A fault current from the voltage should be above 100, 200, 400 or 800V to classify the CT as either C100, C200, 400 or 800.

The **K** classification is the same as C rating but the knee-point voltage must be at least 70% of the secondary terminal voltage rating. The letter **T** indicates the ratio error must be determined by '**T**est'. There are other classification types **H** and **L**, which are older specifications and are no longer in use.

An ANSI C800 CTs will have a saturation voltage of about,

$$Vx = 100(R_{CT} + 8)$$ (Equation 3)

Here 100 represents the recommended maximum CT secondary current of the CT during fault conditions (= 20 times nominal current of 5A), 8 is the burden expected to be connected to C800 class CT.

Comparing against the earlier equation (3), to avoid saturation,

$$100(R_{CT} + 8) > I_f\ (1+X/R)\ (R_{CT}+R_L+R_B)\ -$$ (Equation 4)

Define Ni = 100/If

$$Nr = \{R_{CT} + 8(\text{design burden for C800})\} / (R_{CT}+R_L+R_B)$$

Substituting in (4) above,

$$(1+X/R) < Ni\ Nr$$ (Equation 5)

4.1.3 Remanence flux:

An additional dimension to the above issue is the residual magnetizing field left over in the CT core on clearance of a fault. When a fault with a heavy DC transient occurs, the flux density may go to a very high level. Once the fault is cleared, due to magnetic retention of the excited material, a certain amount of magnetism is retained. This has been found to be as high as 90% in some of the magnetic material.

In other words, in order to design a CT which will always reproduce the currents accurately, it may be necessary to increase the CT size by a term **(1+X/R)/ (1-ψ)** where ψ represents the per unit of maximum flux remaining in the CT core after removal of the primary fault current.

For example if the residual flux is 25%, ψ = 0.25. So the resultant CT sizing requirement goes up by a factor **1/ (1- ψ)** = 1/ (1-0.25) =1.33. In other words the requirement goes up by 33%. In case the CT retains 90% residual flux, it can be seen that the requirement of the CT size goes up by a factor of 900%.

The continuity or polarity of a current transformer is tested before putting it into service. DC test current injected into the CT will cause a unidirectional flux build up, sufficient to cause adequate remanence magnetic flux that may interfere with relay operation. It is very difficult to get rid of the remanence flux once established. Special de-magnetizing procedure is adopted to reduce the remaining flux.

Various methods are used to reduce the effects of remanence (Std. IEEE C37.110):

a Using different grades of steel for the core

b Gapped core

c Biased core CTs.

Of the three, the second method is widely practiced

4.1.4 Practical CT sizing considering CT saturation:

The inequality considered earlier assumes no saturation. Modern high-speed relays operate quite fast, often taking an internal trip decision quite earlier than the onset of saturation even after considering remanence.

It is possible to calculate the time to saturate for any CT given the set of saturation voltage, remanence level, details of connected burden etc. Once the time to saturation is known a quick check against the time of operation of the protective relay would indicate whether the application would function properly with respect to the CT characteristics. Special care is needed when high speed autoreclose is concerned since the remanence magnetism and the CT secondary transient effects are the maximum when a reclose is attempted with a permanent fault on the line. Figure 143 provides a graphical representation of time to saturation of a CT. Detailed mathematical terms to calculate 'time-to-saturate' are available in IEEE C37.110.

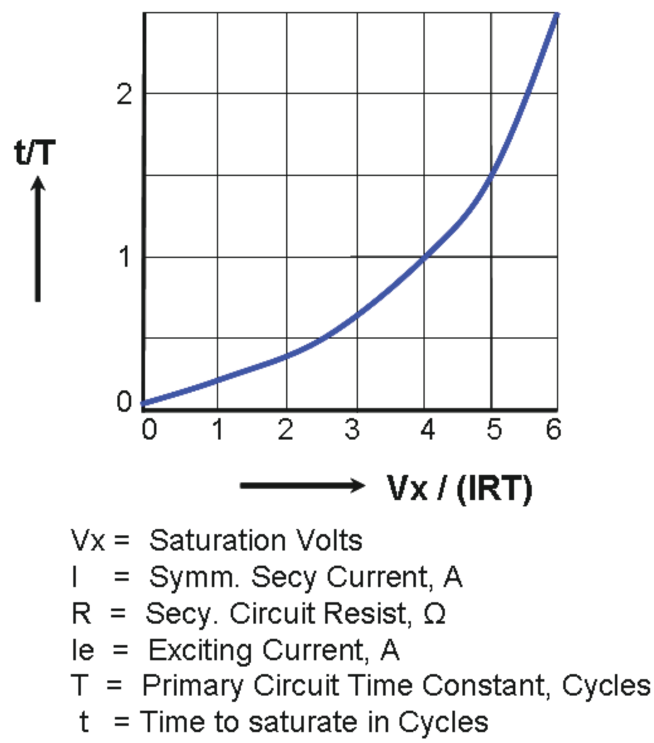


Figure 143: Time to saturate as a function of the saturation voltage and secondary circuit resistance

IEC standards have special classifications for CTs with gaps and specify their performance and remanence limits (IEC-60044-6).

4.1.5 CT requirements for various protection applications

Once the CT specifications are known, it is necessary to match against the requirements of the protections. The following highlight some of the most often used protections and how CTs are matched for proper performance.

4.1.5.1 Time OC protection

TOC protection demands currents up to about 20 to 30 times the set current. The transient saturation is not of concern since the protection operating times are much after the CT comes out of saturation. AC saturation is of concern and CT saturation voltage has to be checked against the voltage generated during maximum fault conditions at which grading with other protections are provided.

4.1.5.2 High Set

The operating times of High-set Phase or Ground OC elements are of the order of about a cycle. To ensure high speed of operation, it is essential to check both AC saturation as well as transient saturation of the CT. Where CT saturation cannot be avoided, it is necessary that the highset operates before the CT starts saturating on transients.

4.1.5.3 Distance protection

The lines usually carry higher primary amperes. The ratios are high resulting typically in currents much lower than 100A. Saturation during transient is of major concern. Saturation is accepted after the operation of the Zone-1 operation. Delayed elements of Zone-2 and Zone-3 can be given necessary logic circuits to ride through the saturation time of the current transformers before recovery occurs after the DC transients decay or some minor errors in their operating times are tolerated. In sub-transmission systems and distribution systems, when distance protection is applied, typically the feeder impedance would be much higher than the source impedance and have a lower X/R ratio than the step down sub-station energizing the feeder. The main concern of saturation is thus of close up forward faults. If the fault is very severe to be of concern of CT saturation, a CT design with a time to saturate time of 10-20msec works fine in most of the cases.

4.1.5.4 Differential & REF protection

Biased differential protection applications have operating characteristics with pickup increasing with higher through fault currents. This is defined by a slope of the bias characteristics. The higher the slope, the larger is the tolerance of the relay to errors and CT saturation. Some differential protections have multiple slope characteristics. A minimum time to saturate for the high speed protections such as the above would be about 10mSec, based on which the CT sizing can be verified.

Section 5 IED physical connections

5.1 Inputs

The auxiliary voltage of the IED is connected to terminals X100/1-2. At DC supply, the positive lead is connected to terminal X100-1. The permitted auxiliary voltage range is marked on the LHMI of the IED on the top of the HMI of the plug-in unit.

Table 24: Auxiliary voltage supply

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

5.1.1 Binary inputs

The binary inputs can be used, for example, to generate a blocking signal, to unlatch output contacts, to trigger the digital fault recorder or for remote control of IED settings. Binary inputs are available as are part of Binary Input and Output Modules (BIO)s located in Slot IDs X105 and X115 based on ordering code, as described in Table 25 when BIO card is equipped in the slot of interest or Table 26 when BIO card with High Speed Power output contacts is equipped in that slot.

Table 25: Binary input terminals in BIO (8BI+4BO) in slots X105 or X110
Note: Substitute Xnnn in the following table with appropriate Slot ID X105 or X110 as applicable.

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

Table 26: Binary input terminals in BIO (8BI+3HSO) in slots X110 or X105
Note: Substitute Xnnn in the following table with appropriate Slot ID X110 or X105 as applicable.

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

5.1.2 Optional light sensor inputs

If the IED 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 flash detector in installation manual.

The IED is provided with connection sockets X13, X14 and X15 only if the optional communication module with light sensor inputs has been installed. If the arc flash detector option is selected when ordering an IED, the light sensor inputs are included in the communication module.

Table 27: Light sensor input connectors

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

5.2 Outputs

5.2.1 Outputs for tripping and controlling

Output contacts PO1, PO2, PO3 and PO4 and High Speed Power Outputs (HSO) are heavy-duty trip contacts capable of controlling most circuit breakers. Some of the signal outputs are dual contacts in parallel, which may also be configured for breaker close commands. On delivery from the factory, the trip signals and close signals are typically routed to these contacts. In RET620, with minimum ordering BIO configuration, some of the close signals are wired to signal outputs. Interface requirements are to be ascertained in such a case. Ordering RET620 with HSO output could be a good solution.

Table 28: Output contacts

Terminal	Description
X100-6 X100-7	PO1, NO PO1, NO
X100-8 X100-9	PO2, NO PO2, NO
X100-15 X100-16 X100-17 X100-18 X100-19	PO3, NO (TCM resistor) PO3, NO PO3, NO PO3 (TCM1 input), NO PO3 (TCM1 input), NO
X100-20 X100-21 X100-22 X100-23 X100-24	PO4, NO (TCM resistor) PO4, NO PO4, NO PO4 (TCM2 input), NO PO4 (TCM2 input), NO
X130-16 X130-17	SO3/TO1, NO (TCM3 input) SO3/TO1, NO (TCM3 input)

Table 29: Binary High Speed Output terminals in BIO (8BI+3HSO) in slots X110 or X105 as alternative option
Note: Substitute Xnnn in the following table with appropriate Slot ID X110 or X105 as applicable.

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

5.2.2 Outputs for signaling

Output contacts SO1 and SO2 in slot X100 or SO1, SO2, SO3 and SO4 in slot X110 or SO1, SO2, SO3 and SO4 in slot X105 can be used for signaling on pickup and tripping of the IED. On delivery from the factory, the pickup and alarm signals from all the protection stages are routed to signaling outputs.

Table 30: Output contacts X100-10...14

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

Table 31: Binary signal output terminals in BIO (8BI+4BO) in slots X105 or X110
Note: Substitute Xnnn in the following table with appropriate Slot ID X105 or X110 as applicable.

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

Table 32: Output contacts X130

Terminal	Description
X130-9 X130-10 X130-11	SO1, C SO1, NC SO1, NO
X130-12 X130-13 X130-14	SO2, C SO2, NC SO2, NO

5.2.3 IRF

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

Table 33: IRF contact

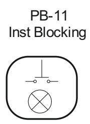
Terminal	Description
X100-3	IRF, common
X100-4	Closed; IRF, or V_{aux} disconnected
X100-5	Closed; no IRF, and V_{aux} connected

Section 6 Glossary

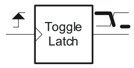
615/620 series	Series of numerical IEDs for basic, inexpensive and simple protection and supervision applications of utility substations, and industrial switchgear and equipment 100BASE-FXA physical media defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fibre-optic cabling
100BASE-TX	A physical media 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
ANSI	American National Standards Institute
BI	Binary input
BI/O	Binary input/output
BO	Binary output
CB	Circuit breaker
CT	Current transformer
CBCT	Core Balance Current Transformer
DFR	Digital fault recorder
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.
EMC	Electromagnetic compatibility
GOOSE	Generic Object Oriented Substation Event
HMI	Human-machine interface
HSO	High-speed output which is a hybrid discrete/electromechanical output that is rated as a power output
HW	Hardware
IEC 61850	International standard for substation communication and modelling
IED	Intelligent electronic device
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 LANLocal area network

LAN	Local area network
LC	Connector type for glass fiber cable
LCD	Liquid crystal display
LED	Light-emitting diode
LHMI	Local human-machine interface
Modbus	A serial communication protocol developed by the Modicon company in 1979. Originally used for communication in PLCs and RTU devices.
MV	Medium voltage
PCM600	Protection and Control IED Manager
PO	Power output
RJ-45	Galvanic connector type
RS-232	Serial interface standard
RS-485	Serial link according to EIA standard RS485
SO	Signal output
TCP/IP	Transmission Control Protocol/Internet Protocol
TCS	Trip-circuit supervision
SO/TO	Dual internally paralled Signal / Trip output with high make and carry current rating
WAN	Wide area network
WCT	Window Type CT (Also refer to CBCT)
WHMI	Web human-machine interface

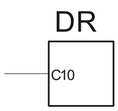
Legend



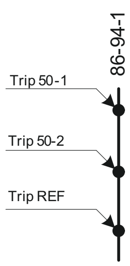
Push Button(with embedded LED) 11 on the front of the IED with legend 'Inst Blocking'



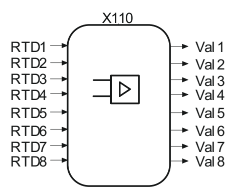
T Flip Flop
(output changes state on input rising edge)



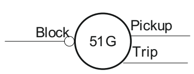
Disturbance Recorder
(C10 - Input Channel 10)



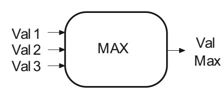
Signals *Trip 50-1, Trip 50-2* and *Trip REF* are ORed to form signal *86-94-1*



RTD Input Slot ID X110, Configured with signals from Bearing temp., Ambient Temperature etc.

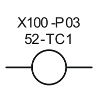


Protection Function 51G, with *Pickup* and *Trip* signal outputs, Protection blocked when input signal *Block* is high

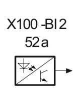


Val Max ouptut is the maximum of three analog input values Val1, Val2 and Val3

Alarm LED 1 on the front of the IED, with legend '*A Ph*'



Binary Output PO3, on Slot ID X100, configured with signal 52-TC1
(PO- Power contact, SO- Signal Contact, HSO- High Speed output)



Binary Input B12, on Slot ID X100, configured with signal Input *52a*

Contact us

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