Relion® 620 series

Feeder Protection and Control REF620 ANSI
Application Manual

Power and productivity
for a better world™

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 50263 and EN 60255-26 for the EMC directive, and with the product standards EN 60255-6 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

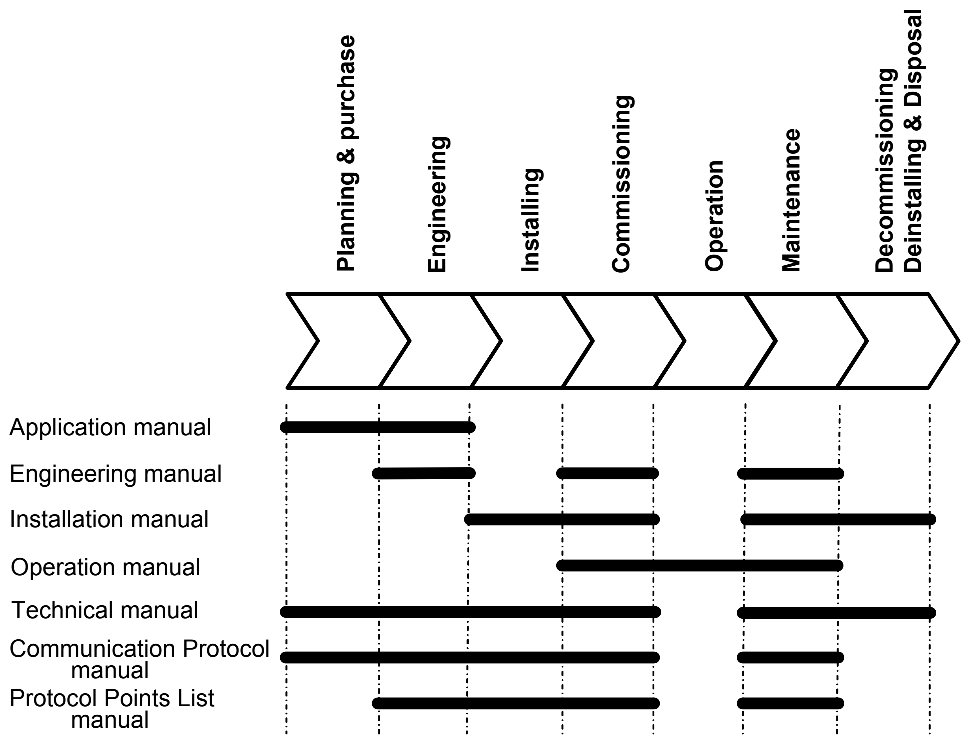


Figure 1: The intended use of manuals in different life cycles

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 website http://www.abb.com/substationautomation.

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, REF620

Function	IEC61850	ANSI/C37.2 -2008	IEC60617
Protection			
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	51P	3I> (1)

Function	IEC61850	ANSI/C37.2-2008	IEC60617
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	50P-1	3I>> (1)
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	50P-2	3I>> (2)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	50P-3	3I>>> (1)
Three-phase non-directional long time overcurrent protection, low stage, instance 1	PHLTPTOC1	51LT	3I> (3)
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	67/51P	3I> -> (1)
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	67/50P-1	3I>> -> (1)
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	67/50P-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 4	EFLPTOC4	50SEF	Io> (4)
Non-directional ground-fault protection, high stage, instance 1	EFHPTOC1	50G-1	Io>> (1)
Non-directional ground-fault protection, high stage, instance 2	EFHPTOC2	50G-2	Io>> (2)
Non-directional ground-fault protection, high stage, instance 3	EFHPTOC3	50N-1	Io>> (3)
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC4	50N-2	Io>> (4)
Non-directional ground-fault protection, instantaneous stage, instance 1	EFIPTOC1	50G-3	Io>>> (1)
Non-directional ground-fault protection, instantaneous stage, instance 2	EFIPTOC2	50N-3	Io>>> (2)
Directional ground-fault protection, low stage, instance 1	DEFLPDEF1	67/51N	Io> -> (1)
Directional ground-fault protection, high stage, instance 1	DEFHPDEF1	67/50N-1	Io>> -> (1)
Directional ground-fault protection, high stage, instance 2	DEFHPDEF2	67/50N-2	Io>> -> (2)
Three phase directional power protection, instance 1	DPSRDIR1	32P-1	I1-> (1)
Ground directional power protection, instance 1	DNZSRDIR1	32N-1	I2 ->, Io-> (1)
Phase distance protection, instance 1	PHDSTPDIS1	21P	Z<
Negative-sequence overcurrent protection, instance 1	NSPTOC1	46-1	I2> (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	46-2	I2> (2)
Phase discontinuity protection	PDNSPTOC1	46PD	I2/I1>
Residual overvoltage protection, instance 1	ROVPTOV1	59G	Uo> (1)
Residual overvoltage protection, instance 2	ROVPTOV2	59N-1(1)	Uo> (2)
Residual overvoltage protection, instance 3	ROVPTOV3	59N-1(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)

Function	IEC61850	ANSI/C37.2 -2008	IEC60617
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	f>/f<,df/dt (1)
Frequency protection, instance 2	FRPFRQ2	81-2	f>/f<,df/dt (2)
Voltage per hertz protection, instance 1	OEPVPH1	24	U/f> (1)
Three-phase thermal protection for feeders, cables and distribution transformers, Instance 1	T1PTTR1	49F	3Ith>F (1)
Phase current sets summing function	CMSUM1	CSUM	CSUM
Three phase measurement switching	VMSWI1	VSWI	VSWI
Numerical stabilized low impedance restricted ground-fault protection	LREFPNDF1	87LOZREF	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)
Three-phase inrush detector, instance 1	INRPHAR1	INR	3I2f> (1)
Master trip, instance 1	TRPPTRC1	86/94-1	Master Trip (1)
Master trip, instance 2	TRPPTRC2	86/94-2	Master Trip (2)
Arc protection, instance 1	ARCSARC1	AFD-1	ARC (1)
Arc protection, instance 2	ARCSARC2	AFD-2	ARC (2)
Arc protection, instance 3	ARCSARC3	AFD-3	ARC (3)
High impedance fault detection	PHIZ1	HIZ	PHIZ1
Load shedding and restoration, instance 1	LSHDPFRQ1	81LSH-1	UFLS/R (1)
Load shedding and restoration, instance 2	LSHDPFRQ2	81LSH-2	UFLS/R (2)
Loss of phase, instance 1	PHPTUC1	37-1	3I< (1)
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)
Auto-reclosing, instance 1	DARREC1	79-1	O -> I(1)
Auto-reclosing, instance 2	DARREC2	79-2	O -> I(2)
Synchronism and energizing check, instance 1	SECRSYN1	25-1	SYNC(1)
Synchronism and energizing check, instance 2	SECRSYN2	25-2	SYNC(2)
Synchronism and energizing check, instance 3	SECRSYN3	25-3	SYNC(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)

Function	IEC61850	ANSI/C37.2-2008	IEC60617
Trip circuit supervision, instance 1	TCSSCBR1	TCM-1	TCS (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCM-2	TCS (2)
Current circuit supervision	CCRDIF1	CCM	MCS 3I
Fuse failure supervision, instance 1	SEQRFUF1	60-1	FUSEF (1)
Fuse failure supervision, instance 2	SEQRFUF2	60-2	FUSEF (2)
Cable fault detection	RCFD1	CFD	CFD
Measurement			
Three-phase current measurement, instance 1	CMMXU1	IA, IB, IC	3I
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0	I1, I2, I0
Residual current measurement, instance 1	RESCMMXU1	IG	Io
Three-phase voltage measurement, instance 1	VMMXU1	VA, VB, VC	3U
Three-phase voltage measurement, instance 2	VMMXU2	VA, VB, VC (2)	3U(B)
Residual voltage measurement	RESVMMXU1	VG	Uo
Sequence voltage measurement, instance 1	VSMSQI1	V1, V2, V0	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	SP, SE
Three-phase power and energy measurement, instance 1	PEMMXU1	P, E	P, E
Current total demand distortion, instance 1	CMHAI1	PQI-1	PQM3I
Voltage total harmonic distortion, instance 1	VMHAI1	PQVPH-1	PQM3U(1)
Voltage total harmonic distortion, instance 2	VMHAI2	PQVPH-2	PQM3U(2)
Voltage variation, instance 1	PHQVVR1	PQSS-1	PQ 3U<>(1)
Voltage unbalance, instance 1	VSQVUB1	PQVUB-1	PQMUBU(1)
Voltage unbalance, instance 2	VSQVUB2	PQVUB-2	PQMUBU(2)
Load profile	LDPMSTA1	LoadProf	LoadProf
Frequency measurement	FMMXU1	f	f
Recorder			
Disturbance recorder	RDRE1	DFR	DR
Fault recorder	FLTMSTA1	FR	FR
Sequence event recorder	SER	SER	SER
Fault location	DRFLO	FLO	DRFLO
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)
Minimum pulse timer (2 pcs, second resolution), instance 1	TPSGAPC1	62CLD-1	TPS (1)
Minimum pulse timer (2 pcs, second resolution), instance 2	TPSGAPC2	62CLD-3	TPS (2)

Function	IEC61850	ANSI/C37.2 -2008	IEC60617
Minimum pulse timer (2 pcs, minute resolution), instance 1	TPMGAPC1	62CLD-2	TPM (1)
Minimum pulse timer (2 pcs, minute resolution), instance 2	TPMGAPC2	62CLD-4	TPM (2)
Pulse timer (8 pcs), instance 1	PTGAPC1	PT-1	PT (1)
Pulse timer (8 pcs), instance 2	PTGAPC2	PT-2	PT (2)
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF-1	TOF (1)
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF-2	TOF (2)
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF-3	TOF (3)
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF-4	TOF (4)
Time delay on (8 pcs), instance 1	TONGAPC1	TON-1	TON (1)
Time delay on (8 pcs), instance 2	TONGAPC2	TON-2	TON (2)
Time delay on (8 pcs), instance 3	TONGAPC3	TON-3	TON (3)
Time delay on (8 pcs), instance 4	TONGAPC4	TON-4	TON (4)
Set reset (8 pcs), instance 1	SRGAPC1	SR-1	SR (1)
Set reset (8 pcs), instance 2	SRGAPC2	SR-2	SR (2)
Set reset (8 pcs), instance 3	SRGAPC3	SR-3	SR (3)
Set reset (8 pcs), instance 4	SRGAPC4	SR-4	SR (4)
Move (8 pcs), instance 1	MVGAPC1	MV-1	MV (1)
Move (8 pcs), instance 2	MVGAPC2	MV-2	MV (2)
Move (8 pcs), instance 3	MVGAPC3	MV-3	MV (3)
Move (8 pcs), instance 4	MVGAPC4	MV-4	MV (4)
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)

Function	IEC61850	ANSI/C37.2-2008	IEC60617
Generic Up-Down Counters, instance 12	UDFCNT12	CTR-12	CTR(12)
Programmable buttons (16 buttons), instance 1	FKEYGGIO1	FKEY	FKEY

Section 2 REF620 overview

2.1 Overview

REF620 is a dedicated feeder IED (intelligent electronic device) designed for the protection, control, measurement and supervision of utility substations and industrial power systems. REF620 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 overhead lines and cable feeders in distribution networks. The IED is also used as back-up protection in applications, where an independent and redundant protection system is required.

Depending on the chosen standard configuration, the IED is adapted for the protection of overhead line and cable feeders in isolated neutral, resistance grounded, compensated and solidly grounded networks. 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 or later
- IED Connectivity Package REF620 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 website 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 REF620

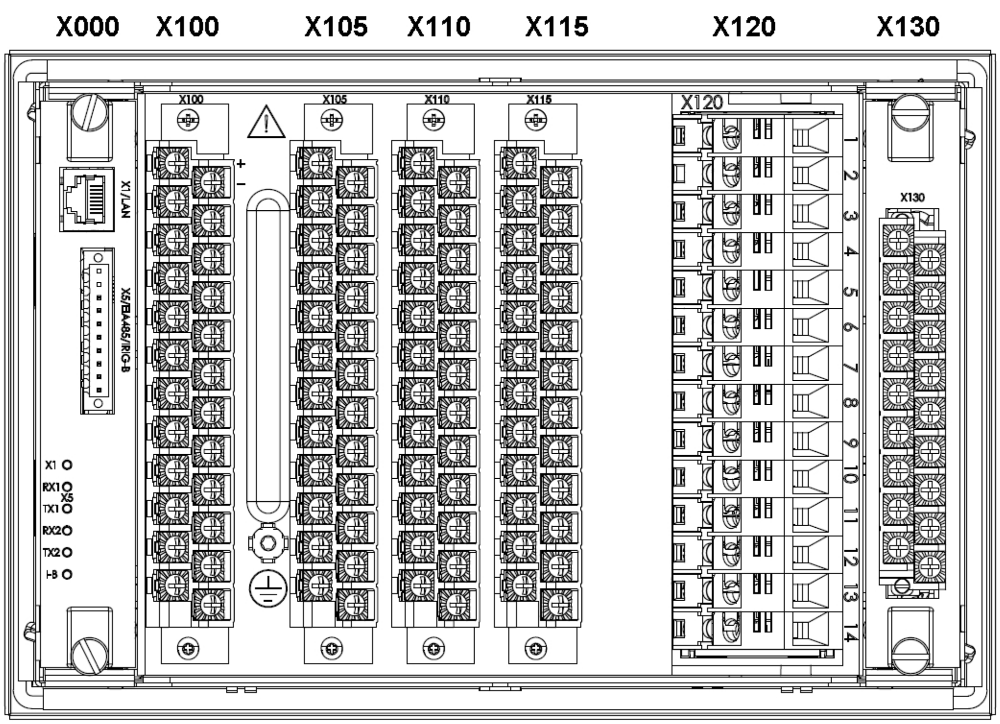


Figure 3: Rear view of REF620 with all slots equipped, with slot ID's indicated on top

Table 2: Plug-in unit and case (REF620)

Main unit	Slot ID	Module ID	Content options	
Plug-in unit	-	DIS0008	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 as indicated below
		BIO0005	BI/O module	Optional with some of the ordering codes 8 Binary Inputs 4 Binary Outputs
	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	Blank Module		Not equipped by default but may alternatively be equipped as indicated below
		BIO0005	BI/O module	Optional with some of the ordering codes 8 Binary Inputs 4 Binary Outputs
		BIO0007		May be alternatively equipped with high-speed BIO card, only with Config B & C and when slot X110 is equipped with high-speed BIO card 8 Binary Inputs 3 High speed PO contacts
	X120	AIM0016	AI/BI module	With Configuration AA 3 phase current Inputs (1/5A) 1 phase current input (1/5A) 4 Binary Inputs
		AIM0017		With Configuration AB 3 phase current Inputs (1/5A) 1 phase current input (0.2/1A) 4 Binary Inputs
		AIM0005		With Configuration BA and CA 3 phase current Inputs (1/5A) 3 phase current Inputs (1/5A) 1 phase current input (1/5A)
		AIM0015		With Configuration CB 3 phase current Inputs (1/5A) 3 phase current Inputs (1/5A) 1 phase current input (0.2/1A)
Case	X130	AIM0006	AI/BI Module (Voltage sensor)	With Configuration AA and AB 5 Voltage Inputs 4 Binary Outputs
		AIM0008		With Configuration BA, CA and CB 8 Voltage Inputs
	X000		Optional communication module	See technical manual for details about different type of communication modules. IEC61850 DNP3 Modbus

Order Code	Ex: NAFCCBCB…	1 N	2 A	3 F	4 C			5 C	6 B	7 C	8 B
Digit	Description										
1) Product Series	620 series (Includes case)										
2) Standard	ANSI										
3) Main Appl	Feeder protection and control										
4) Configuration	A: Advanced distribution feeder protection and control with single breaker				A						
	B: Advanced distribution feeder protection and control with one-and-a-half breakers				B						
	C: Advanced distribution feeder protection and control with two or one-and-a-half breakers				C						
5-6) Analog Inputs		Slot X130		Slot X120							
		Type		Type							
	3 CT + Ground CT + 5 VT + Reclosing	AIM0006	5 VT + 4 BI	AIM0016	4 CT + 4 BI			A	A		
	3 CT + SEF/HIZ CT + 5 VT + Reclosing	AIM0006	5 VT + 4 BI	AIM0017	4 CT + 4 BI			A	B		
	6 CT + 8 VT + Reclosing	AIM0008	8 VT	AIM0005	7 CT			B	A		
	6 CT + Ground CT + 7 VT + Reclosing	AIM0008	8 VT	AIM0005	7 CT			C	A		
	6 CT + SEF/HIZ CT + 7 VT + Reclosing	AIM0008	8 VT	AIM0015	7 CT			C	B		
7-8) Binary I/O		Slot X115		Slot X 110		Slot X105					
	1)	Type		Type		Type					
	16 BI + 6 BO + 3 HSO			BIO0007	8 BI + 3 HSO					A	1
	16 BI + 10 BO			BIO0005	8 BI + 4 BO					A	A
	24 BI + 10 BO + 3 HSO	BIO0005	8 BI + 4 BO	BIO0007	8 BI + 3 HSO					A	2
	24 BI + 14 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO					A	B
	32 BI + 14 BO + 3 HSO	BIO0005	8 BI + 4 BO	BIO0007	8 BI + 3 HSO	BIO0005	8 BI + 4 BO			A	3
	32 BI + 18 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO			A	C
	16 BI + 6 BO + 6 HSO	BIO0007	8 BI + 3 HSO	BIO0007	8 BI + 3 HSO					B	1
	16 BI + 10 BO + 3 HSO	BIO0005	8 BI + 4 BO	BIO0007	8 BI + 3 HSO					B	2
	16 BI + 14 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO					B	A
	24 BI + 10 BO + 6 HSO	BIO0007	8 BI + 3 HSO	BIO0007	8 BI + 3 HSO	BIO0005	8 BI + 4 BO			B	3
	24 BI + 14 BO + 3 HSO	BIO0005	8 BI + 4 BO	BIO0007	8 BI + 3 HSO	BIO0005	8 BI + 4 BO			B	4
	24 BI + 18 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO			B	B
	16 BI + 6 BO + 6 HSO	BIO0007	8 BI + 3 HSO	BIO0007	8 BI + 3 HSO					C	1
	16 BI + 10 BO + 3 HSO	BIO0005	8 BI + 4 BO	BIO0007	8 BI + 3 HSO					C	2
	16 BI + 14 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO					C	A
	24 BI + 10 BO + 6 HSO	BIO0007	8 BI + 3 HSO	BIO0007	8 BI + 3 HSO	BIO0005	8 BI + 4 BO			C	3
	24 BI + 14 BO + 3 HSO	BIO0005	8 BI + 4 BO	BIO0007	8 BI + 3 HSO	BIO0005	8 BI + 4 BO			C	4
	24 BI + 18 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO	BIO0005	8 BI + 4 BO			C	B
	Notes: 1) Total Binary I/O includes those provided in Power Supply card (Slot X100) and Analog input cards (Slot X120, 130) in addition to IO cards (Slots X105, X110 and X115) as applicable										

Figure 4: Ordering codes 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

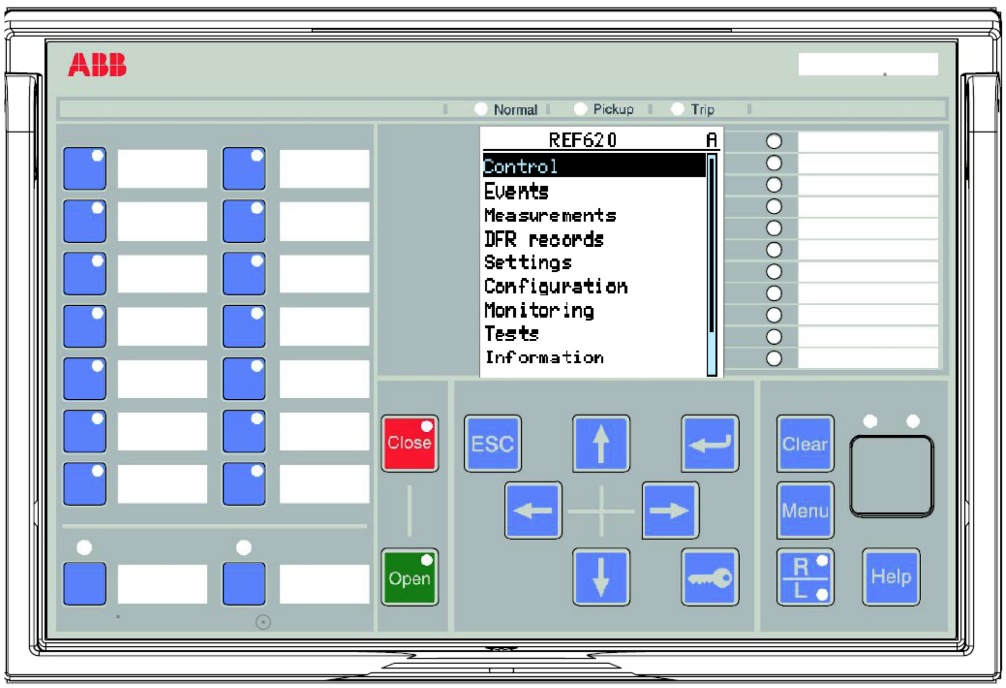


Figure 5: LHMI REF620

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.

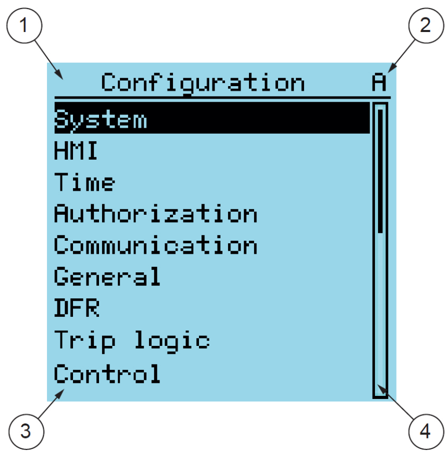


Figure 6: Display layout

1. Header

2. Icon

3. Content

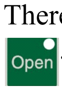
4. Scroll bar (displayed when needed)

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.

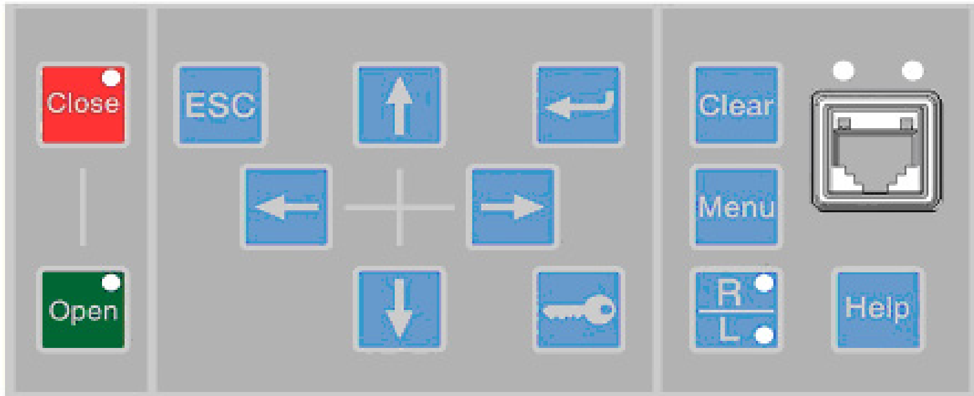


Figure 7: *LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port*

2.3.4 Programmable pushbuttons and LEDs

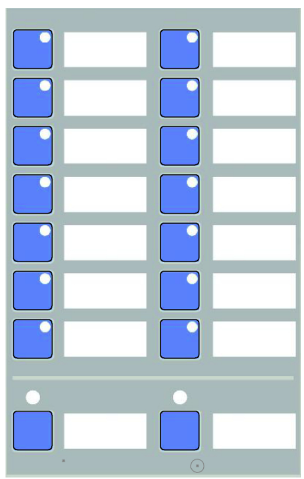


Figure 8: *Programmable pushbuttons with LEDs*

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.

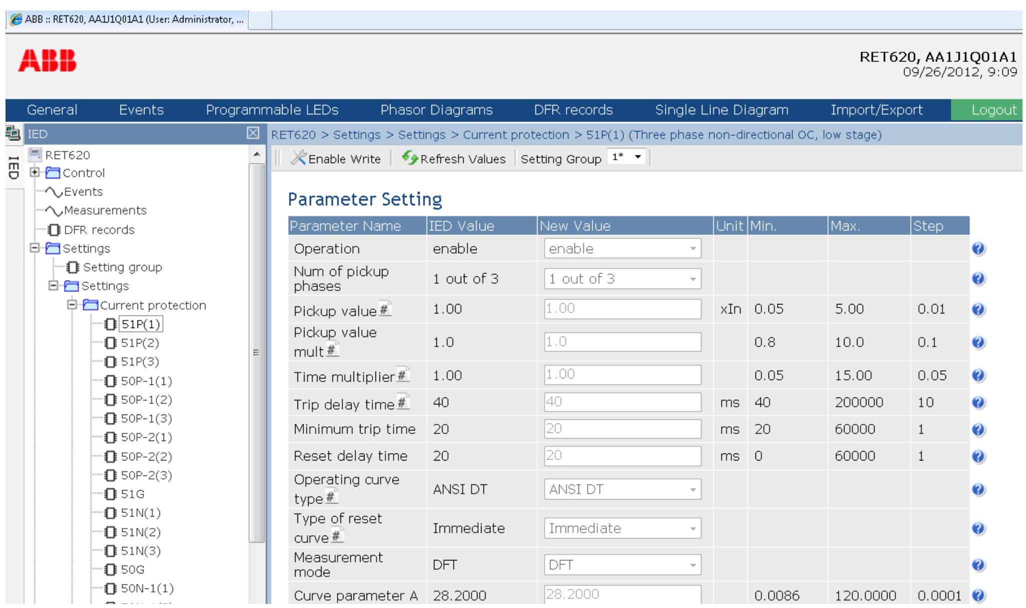


Figure 9: Example view of the WHMI

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

User name	User rights
VIEWER	Read only access
OPERATOR	• Selecting remote or local state with  (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 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 REF620 configurations

3.1 REF620 variant list

REF620 is intended for protection and control mainly in MV and sub-transmission feeder applications. The product has three 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 REF620 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 feeder, 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 feeder protection IED REF620 is available with three alternative standard configurations.

Table 6: Standard configurations (REF620)

Description	Functional application configuration
Advanced distribution feeder protection and control with single breaker.	A
Advanced distribution feeder protection and control with breaker-and-a-half bus system.	B
Advanced distribution feeder protection and control with two breakers or breaker-and-a-half bus system.	C

Table 7: Supported functions (REF620)

Standard Configuration Functionality	Std config A		Std config B	Std config C		ANSI/C37.2 - 2008
Function	AA	AB	BA	CA	CB	REF
Protection						
Three-phase non-directional overcurrent protection, low stage, instance 1	•	•	•	•	•	51P
Three-phase non-directional overcurrent protection, high stage, instance 1	•	•	•	•	•	50P-1
Three-phase non-directional overcurrent protection, high stage, instance 2	•	•	•	•	•	50P-2
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	•	•	•	•	•	50P-3
Three-phase non-directional long time overcurrent protection, low stage, instance 1	•	•	•	•	•	51LT
Three-phase directional overcurrent protection, low stage, instance 1	•	•	•	•	•	67/51P
Three-phase directional overcurrent protection, high stage, instance 1	•	•	•	•	•	67/50P-1
Three-phase directional overcurrent protection, high stage, instance 2	•	•	•	•	•	67/50P-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 4	-	•	-	-	•	50SEF
Non-directional ground-fault protection, high stage, instance 1	•	-	-	•	-	50G-1
Non-directional ground-fault protection, high stage, instance 2	•	-	-	•	-	50G-2
Non-directional ground-fault protection, high stage, instance 3	•	•	•	•	•	50N-1
Non-directional ground-fault protection, high stage, instance 4	•	•	•	•	•	50N-2
Non-directional ground-fault protection, instantaneous stage, instance 1	•	-	-	•	-	50G-3
Non-directional ground-fault protection, instantaneous stage, instance 2	•	•	•	•	•	50N-3
Directional ground-fault protection, low stage, instance 1	•	•	•	•	•	67/51N
Directional ground-fault protection, high stage, instance 1	•	•	•	•	•	67/50N-1
Directional ground-fault protection, high stage, instance 2	•	•	•	•	•	67/50N-2
Three phase directional power protection, instance 1	•	•	•	•	•	32P-1
Ground directional power protection, instance 1	•	•	•	•	•	32N-1
Phase Distance Protection, instance 1	•	•	•	•	•	21P
Negative-sequence overcurrent protection, instance 1	•	•	•	•	•	46-1

Standard Configuration Functionality	Std config A		Std config B	Std config C		ANSI/C37.2 - 2008
Function	AA	AB	BA	CA	CB	REF
Negative-sequence overcurrent protection, instance 2	•	•	•	•	•	46-2
Phase discontinuity protection	•	•	•	•	•	46PD
Residual overvoltage protection, instance 1	•	•	-	-	-	59G
Residual overvoltage protection, instance 2	•	•	•	•	•	59N-1(1)
Residual overvoltage protection, instance 3	-	-	•	•	•	59N-1(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
Frequency protection, instance 2	•	•	•	•	•	81-2
Voltage per hertz protection, instance 1	•	•	•	•	•	24
Three-phase thermal protection for feeders, cables and distribution transformers, Instance 1	•	•	•	•	•	49F
Numerical stabilized low impedance restricted ground-fault protection	•	-	-	-	-	87LOZREF
Phase current sets summing function	-	-	•	•	•	CSUM
Three phase measurement switching	-	-	•	•	•	VSWI
Circuit breaker failure protection, instance 1	•	•	•	•	•	50BF-1
Circuit breaker failure protection, instance 2	-	-	•	•	•	50BF-2
Three-phase inrush detector, instance 1	•	•	•	•	•	INR
Master trip, instance 1	•	•	•	•	•	86/94-1
Master trip, instance 2	•	•	•	•	•	86/94-2
Arc protection, instance 1	•	•	•	•	•	AFD-1
Arc protection, instance 2	•	•	•	•	•	AFD-2

Standard Configuration Functionality	Std config A		Std config B	Std config C		ANSI/C37.2 - 2008
Function	AA	AB	BA	CA	CB	REF
Arc protection, instance 3	●	●	●	●	●	AFD-3
High impedance fault detection	-	●	-	-	●	HIZ
Load shedding and restoration, instance 1	●	●	●	●	●	81LSH-1
Load shedding and restoration, instance 2	●	●	●	●	●	81LSH-2
Loss of phase, instance 1	●	●	●	●	●	37-1
Control						
Circuit-breaker control, instance 1	●	●	●	●	●	52-1
Circuit-breaker control, instance 2	-	-	●	●	●	52-2
Auto-reclosing, instance 1	●	●	●	●	●	79-1
Auto-reclosing, instance 2	-	-	●	●	●	79-2
Synchronism and energizing check, instance 1	●	●	●	●	●	25-1
Synchronism and energizing check, instance 2	-	-	●	●	●	25-2
Synchronism and energizing check, instance 3	-	-	●	●	●	25-3
Condition Monitoring						
Circuit-breaker condition monitoring, instance 1	●	●	●	●	●	52CM-1
Circuit-breaker condition monitoring, instance 2	-	-	●	●	●	52CM-2
Trip circuit supervision, instance 1	●	●	●	●	●	TCM-1
Trip circuit supervision, instance 2	●	●	●	●	●	TCM-2
Current circuit supervision	●	●	-	●	●	CCM
Fuse failure supervision, instance 1	●	●	●	●	●	60-1
Fuse failure supervision, instance 2	-	-	●	●	●	60-2
Cable fault detection	●	●	●	●	●	CFD
Measurement						
Three-phase current measurement, instance 1	●	●	●	●	●	IA, IB, IC
Sequence current measurement, instance 1	●	●	●	●	●	I1, I2, I0
Residual current measurement, instance 1	●	●	-	●	●	IG
Three-phase voltage measurement, instance 1	●	●	●	●	●	VA, VB, VC
Three-phase voltage measurement, instance 2	-	-	●	●	●	VA, VB, VC (2)
Residual voltage measurement, instance 1	●	●	-	-	-	VG
Sequence voltage measurement, instance 1	●	●	●	●	●	V1, V2, V0
Sequence voltage measurement, instance 2	-	-	●	●	●	V1, V2, V0 (2)
Single-phase power and energy measurement, instance 1	●	●	●	●	●	SP, SE-1

Standard Configuration Functionality	Std config A		Std config B	Std config C		ANSI/C37.2 - 2008
Function	AA	AB	BA	CA	CB	REF
Three-phase power and energy measurement, instance 1	•	•	•	•	•	P, E-1
Current total demand distortion, instance 1	•	•	•	•	•	PQI-1
Voltage total harmonic distortion, instance 1	•	•	•	•	•	PQVPH-1
Voltage total harmonic distortion, instance 2	-	-	•	•	•	PQVPH-2
Voltage variation, instance 1	•	•	•	•	•	PQSS-1
Voltage unbalance, instance 1	•	•	•	•	•	PQVUB-1
Voltage unbalance, instance 2	-	-	•	•	•	PQVUB-2
Load profile	•	•	•	•	•	LoadProf
Frequency measurement, instance 1	•	•	•	•	•	f
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
Minimum pulse timer (2 pcs, second resolution), instance 1	•	•	•	•	•	62CLD-1
Minimum pulse timer (2 pcs, second resolution), instance 2	•	•	•	•	•	62CLD-3
Minimum pulse timer (2 pcs, minute resolution), instance 1	•	•	•	•	•	62CLD-2
Minimum pulse timer (2 pcs, minute resolution), instance 2	•	•	•	•	•	62CLD-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

Standard Configuration Functionality	Std config A		Std config B	Std config C		ANSI/C37.2 - 2008
Function	AA	AB	BA	CA	CB	REF
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
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	•	•	•	•	•	FKEY1
Logging functions						
Disturbance recorder	•	•	•	•	•	DFR
Fault recorder	•	•	•	•	•	FR
Sequence event recorder	•	•	•	•	•	SER
Fault location	•	•	•	•	•	FLO

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, multiple zone Phase distance protections, thermal overload, undervoltage / overvoltage functions, frequency functions etc., coupled with Auto-reclose and check synch functionalities allow the user to fulfill any application requirement in protection and control of MV feeders. The IED is also provided with full control and interlocking functionality including co-operation with the synchrocheck function to allow integration of the main or back-up control.

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.

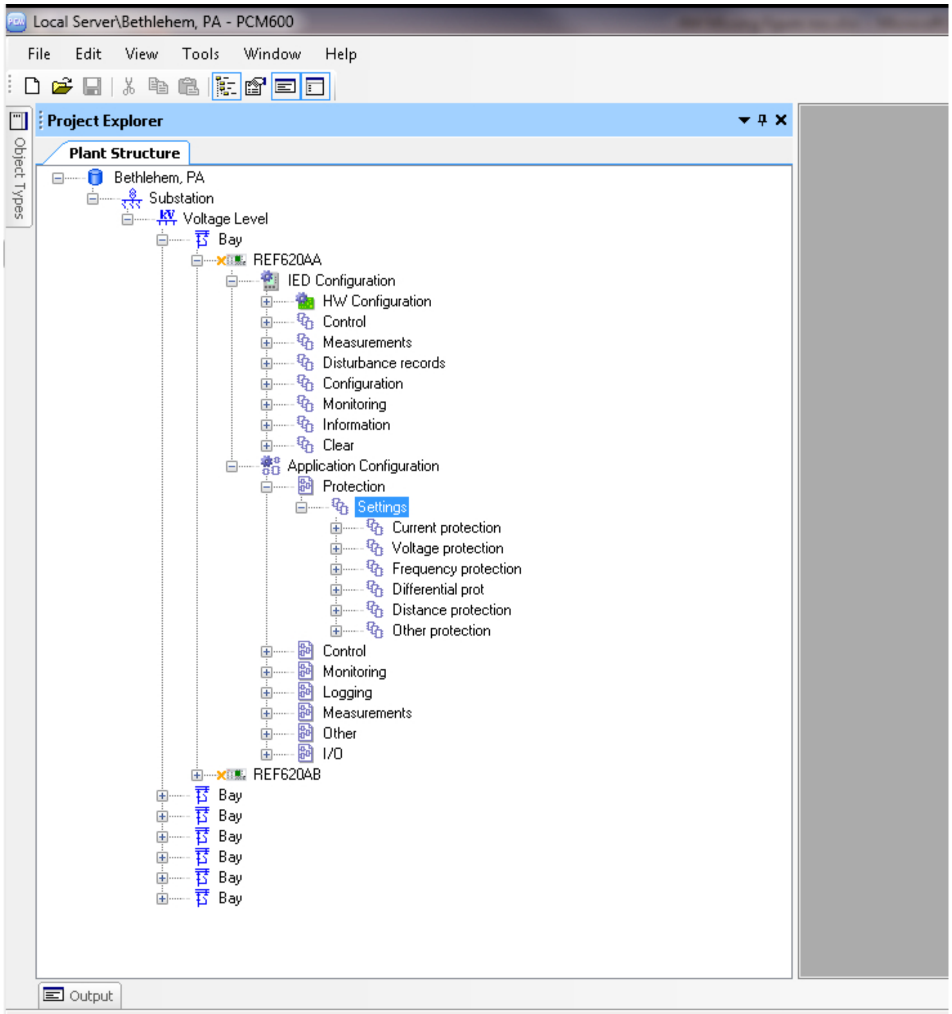


Figure 10: Example View of selecting settings under the plant structure of an IED in PCM600.

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:

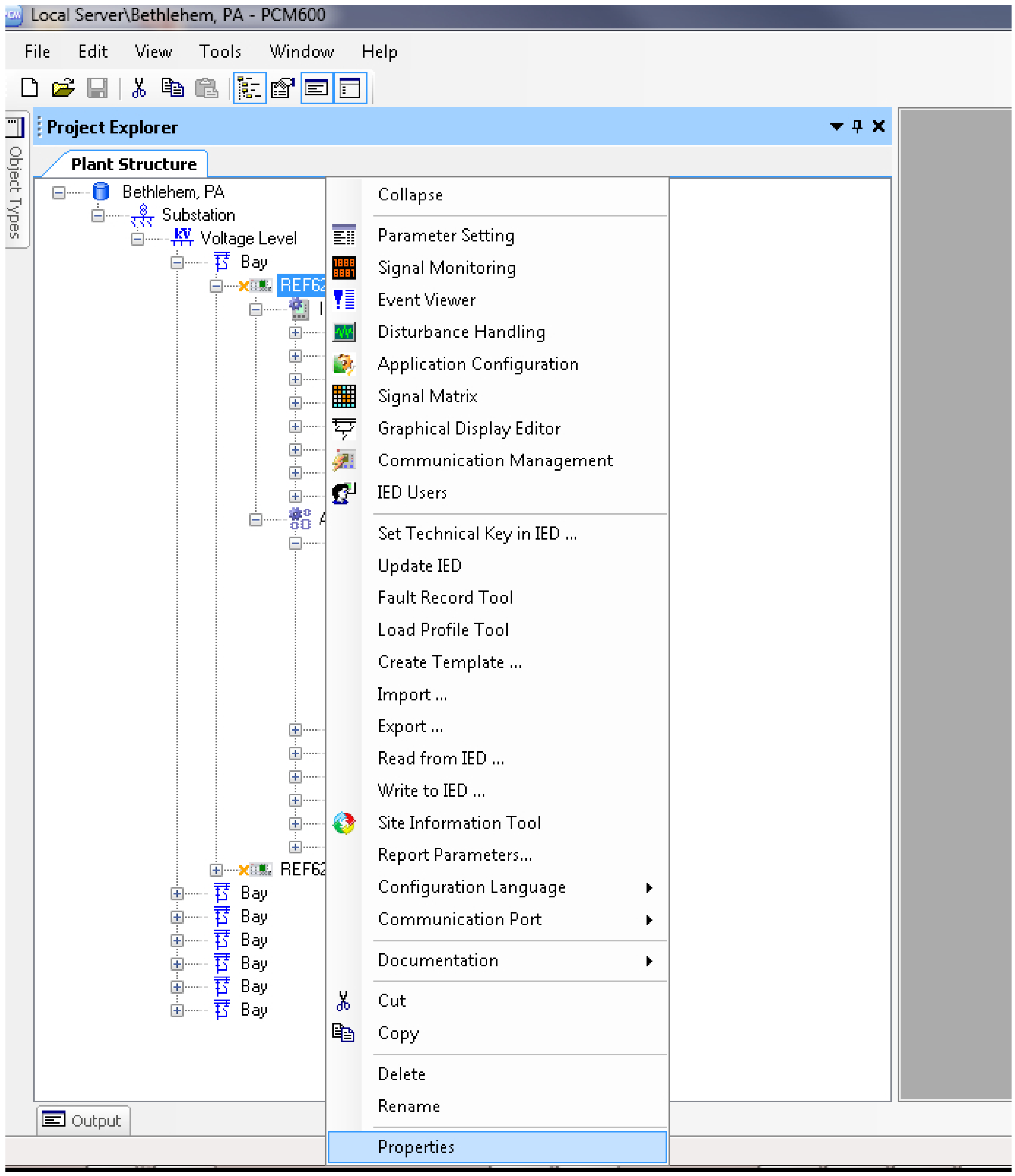


Figure 11: PCM600 display with IED selected with a right click to display the menu and 'Properties' line of the menu just to be selected

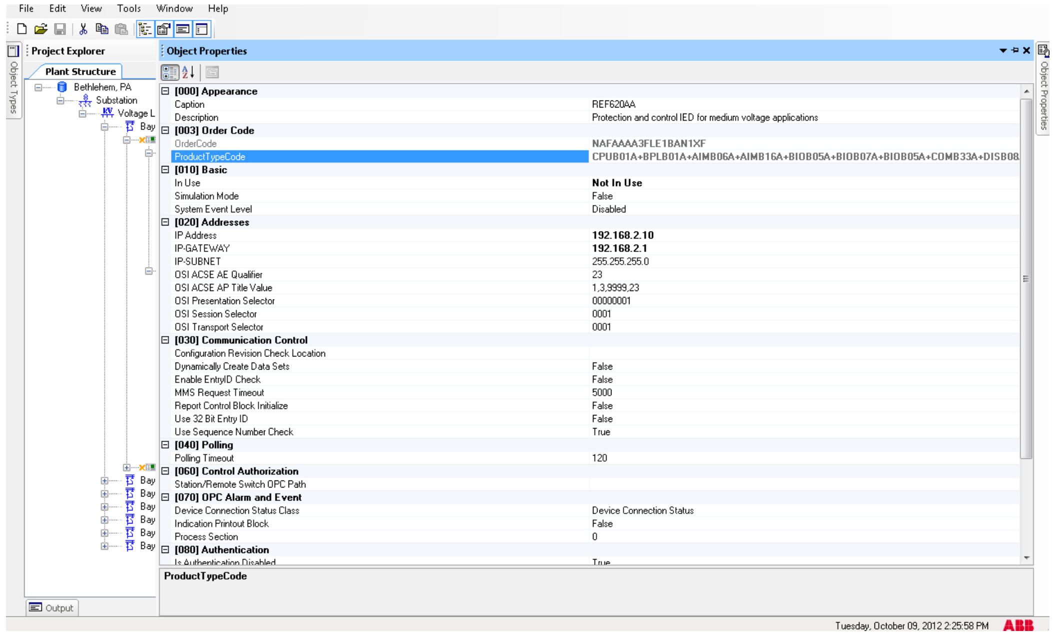


Figure 12: Display of product code when 'properties' of an IED is selected

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 Figure 13 and Figure 14.

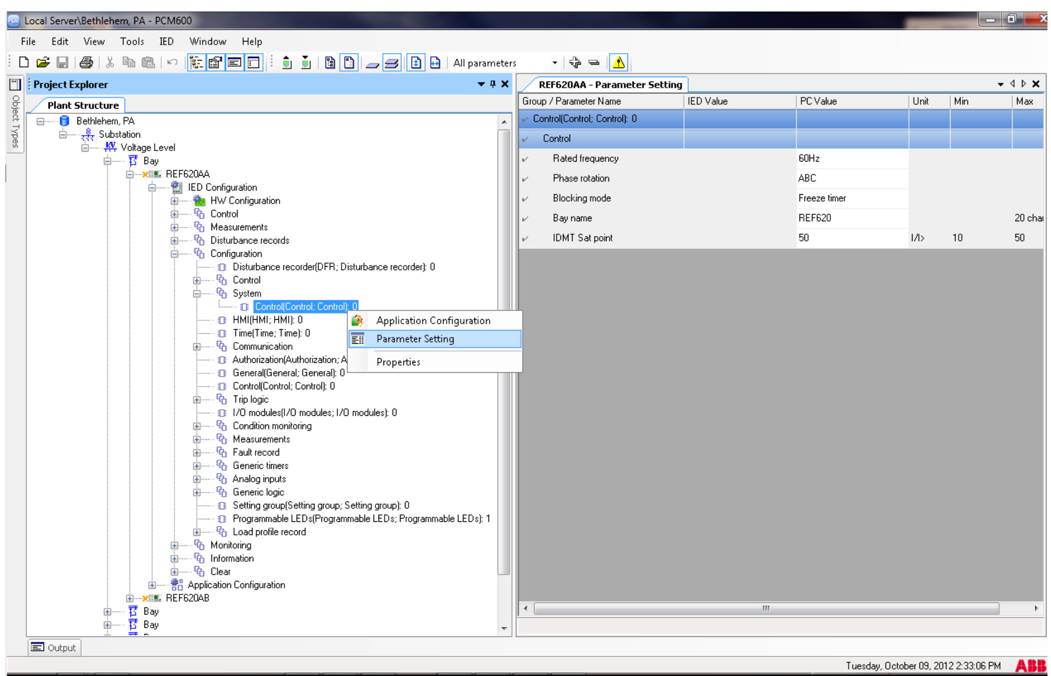


Figure 13: Display of common system configuration settings

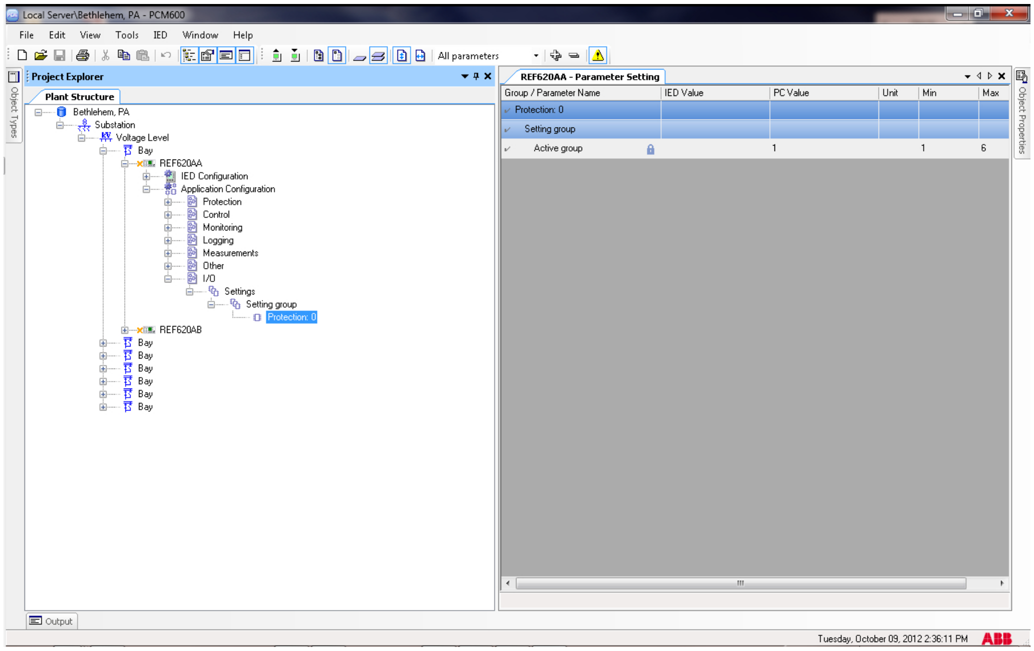


Figure 14: Display or setting of Setting Group

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.

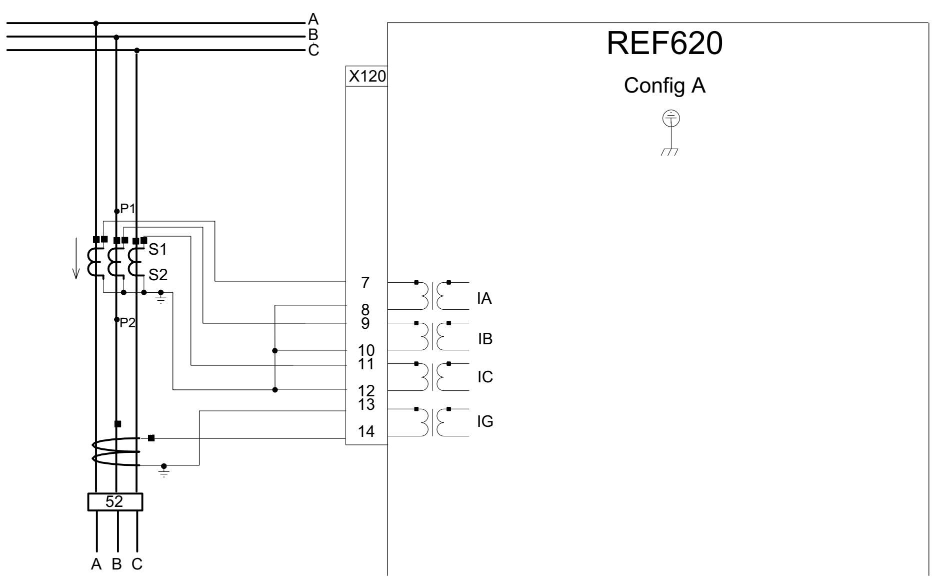


Figure 15: REF620 Typical CT connection diagram, marked with polarity

The polarity of CT and the internal connection are arranged in Figure 15 in such a way that for a fault in the feeder, 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 (3I,CT) as appropriate.

Then select the setting "Reverse Polarity" to "TRUE" as shown in Figure 16 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.

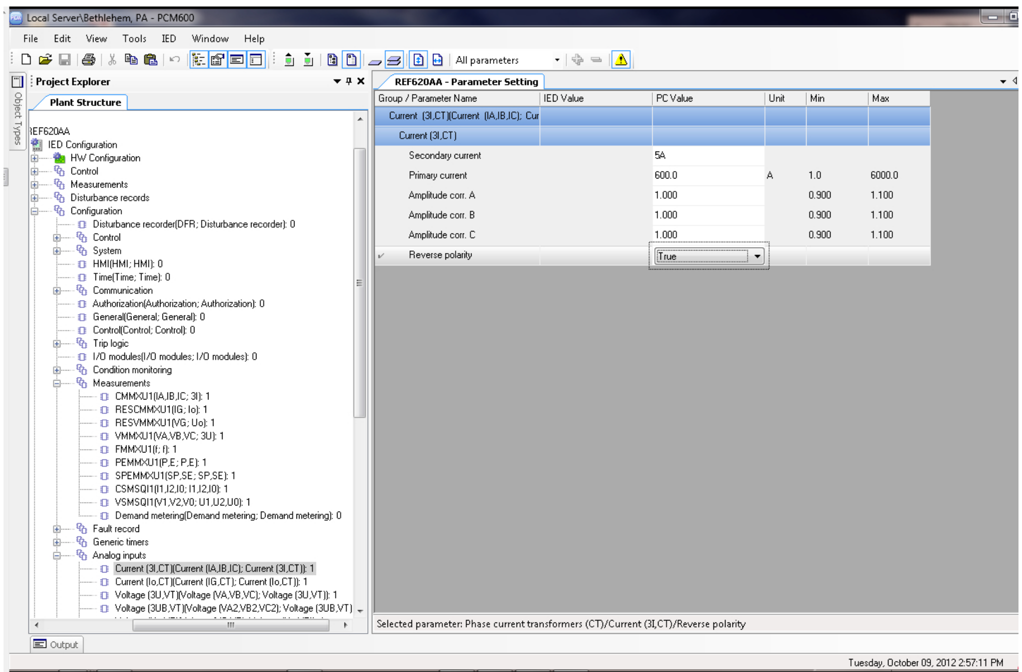


Figure 16: Modifying Reverse Polarity setting of CT input to IED

It may be noted that configurations A and C have an additional input current for ground fault protection, with alternative ordering options of 5A/1A OR 1A/0.2A.

When ordered with 5A/1A option, IG input may be fed from either residual connection of the phase CTs or from Core Balance CT (CBCT / Window type CT). When CBCT or when incoming transformer WYE grounding CT is connected to this input, provision is made to set the primary and secondary input ratings independent of the phase CTs.

Whenever a sensitive ground fault protection is required or when the protected feeder is provided with a core-balance CT, (which is highly recommended with non-effectively grounded systems,) the IED can be ordered with more sensitive IG input rated for 1A/0.2A. Instead of the functions 51G, 50G-1, 50G-2 and 50G-3, the IED is equipped with High Impedance Fault detection system HIZ and highly sensitive ground fault protection 50-SEF.

When applied on LV side of a power transformer, the IG input can be connected to CT on the transformer neutral to provide standby ground fault protection or as input for Low Impedance Restricted Earth Fault protection.

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 PCM600 tool, on the concerned IED, select VT inputs and make sure the connection inputs chosen are Delta (alternatively WYE) and appropriate primary and secondary values are input both for main bus VT inputs as well as Synchronizing VT input. Figure 18 indicates various possibilities of connecting the VT input to the relay.

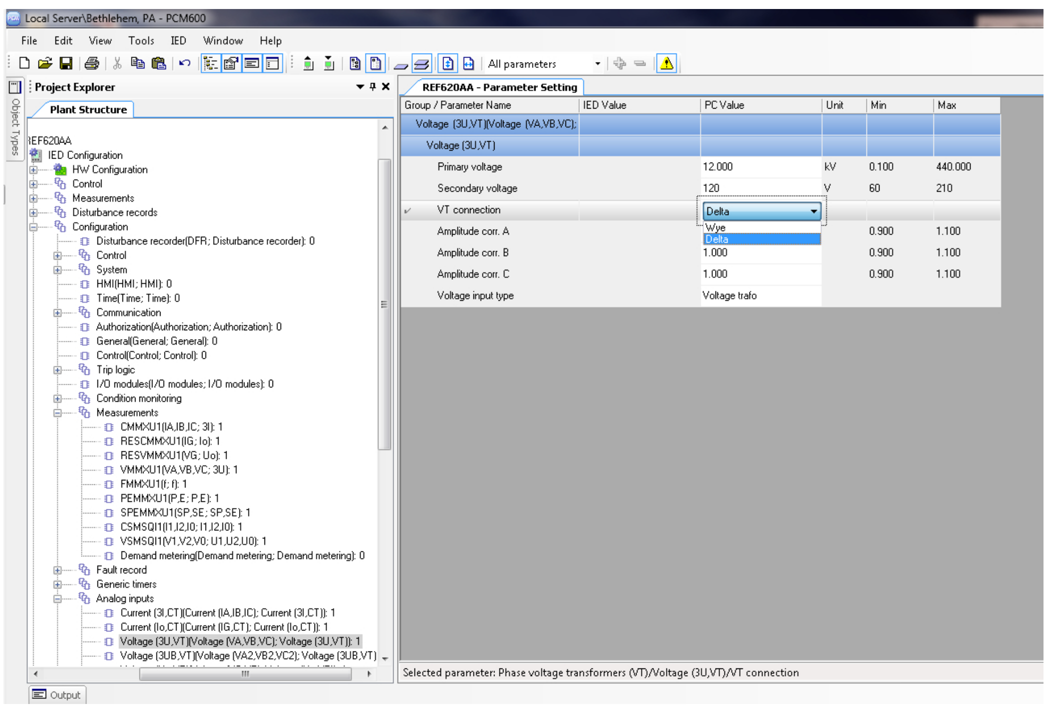
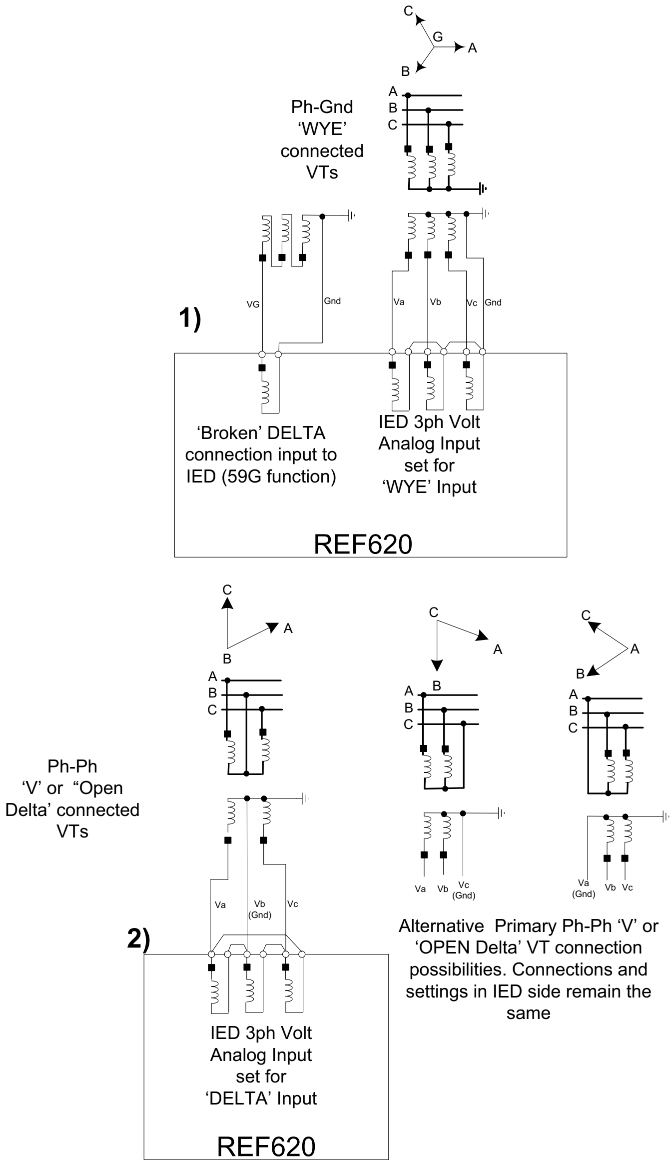


Figure 17: Selecting 'Wye' or 'Delta' setting of VT input to IED

Delta configuration has to be selected when the primary PT is connected in Open Delta (V) configuration. Different possibilities of connections of VTs are possible as detailed in Figure 18 below.



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. When synchro check function is used, synch Input from the Line side has to be phase-ground connected in Phase A (V_{AG})

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. When synchro check function is used, synch Input from the feeder side has to be phase-phase connected across phases A-B (V_{AB})

Figure 18: VT input possibilities in REF620

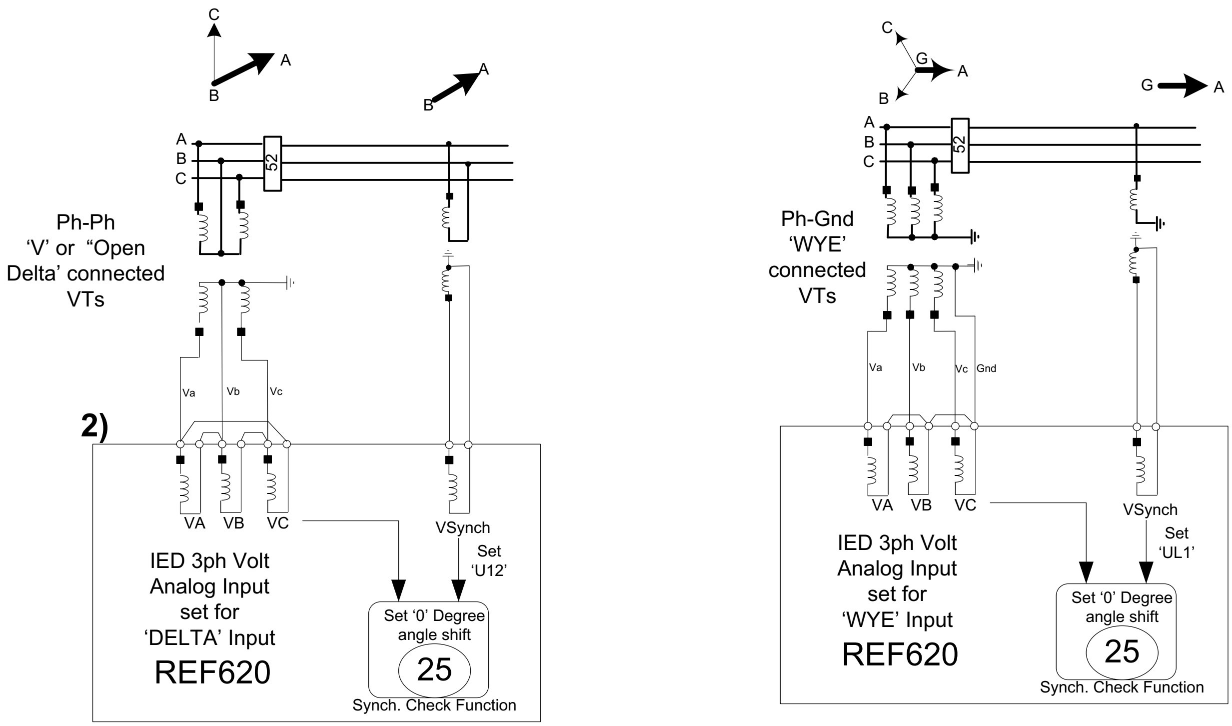


Figure 19: VT Inputs to REF620 for synchronizing purposes

If the VT on the bus side is V(Delta), phase-phase connections are configured for the three phase VT inputs as detailed in the earlier sections. It is expected that the feeder side of the breaker shall similarly one ph-ph (Phases A and B) connected VT for synchronizing purposes.

Similarly when WYE connected VT is available (3no Ph-Gnd Connected VT) on the bus side, it is required to have Ph-Gnd connected VT on the feeder side in Ph A.

From synchronizing perspective, depending on application, three phase VTs are on the feeder side with a single phase VT on the bus for synchronizing could be configured. Care shall be exercised while setting Dead Bus/ Dead Line setting with a clear understanding of which side is bus and line.

Depending on voltage selected for synchronizing voltage input, the phase shift setting under check synch function shall also be properly set, especially when voltage on one side of a transformer with a vector shift is used for synchronizing with a voltage on the other side of the transformer.

3.2.4 Application choice:

3.2.4.1 Configuration A:

This configuration is eminently suitable for most of the applications in MV systems involving single breaker control, protection and autoreclose fed off a single bus bar system.

Configuration A with ground CT input is specially suitable for switchgear incoming breaker. The IG current input of the IED is set to measure the incoming WYE transformer neutral current. The low impedance restricted earth fault protection can be enabled to detect uncleared ground faults. The 51G function, operated off the IG input can be set to operate for all uncleared downstream fault as well as internal transformer ground faults on the MV system.

In the outgoing feeders with single breaker control, Configuration A with SEF/HIZ protection is eminently suitable for detecting very low ground faults as well detect high impedance ground faults in the feeders. A Core Balance CT (Window Type CT) is highly recommended for connection to this input, especially in non-effectively grounded system. The phase impedance protection (21P) can be enabled for medium to long feeders to instantaneously clear severe ph-ph short circuits. Additional zones of the distance protection can be enabled to operate after a delay or enable some of the time graded protection to grade with downstream protection of the system.

3.2.4.2 Configuration B:

Configuration B is ideally suited for "Breaker-and-a-half" (One-and-a-half) systems with VT inputs brought in from either of the buses as well as the other feeder in the 'diameter' for synchronizing purposes.

Through an external control, it is possible to change the VT supply to most of the voltage dependent protection, control and automation from one bus VT supply to the other.

The unit is suitable to control one bus breaker and one tie breaker. The feeder current is the vectorial sum of currents fed from each of the breaker. The IED has an inbuilt three-phase current summation function.

Two number REF620, Config B are provided one for each feeder in a breaker-and-a-half system. Necessary co-ordination between the IEDs has to be engineered to have common control and reclose of the tie (middle) breaker. This can be done either using physical wiring of binary IOs or through IEC61850 goose messages. No ground or sensitive ground current input option is available with this option.

This configuration can also be applied with Ring bus as well as double bus configurations, see below. Please also refer to configurations B and C description in this manual for more configuration and application details.

3.2.4.3 Configuration C:

Configuration C is applicable typically for Double bus, double breaker applications. This configuration is available with either Ground CT or Sensitive EF/HIZ CT input option. This configuration can be also applied to 'Breaker-and-a-half' with some minor limitation of switching in of synchronizing VT from the second feeder of the diameter. The configuration is well suited for ring bus system, with the breaker control, autoreclose for the breaker applied cyclically across the bus system. The second breaker control becomes redundant. Other details are similar to configuration B above.

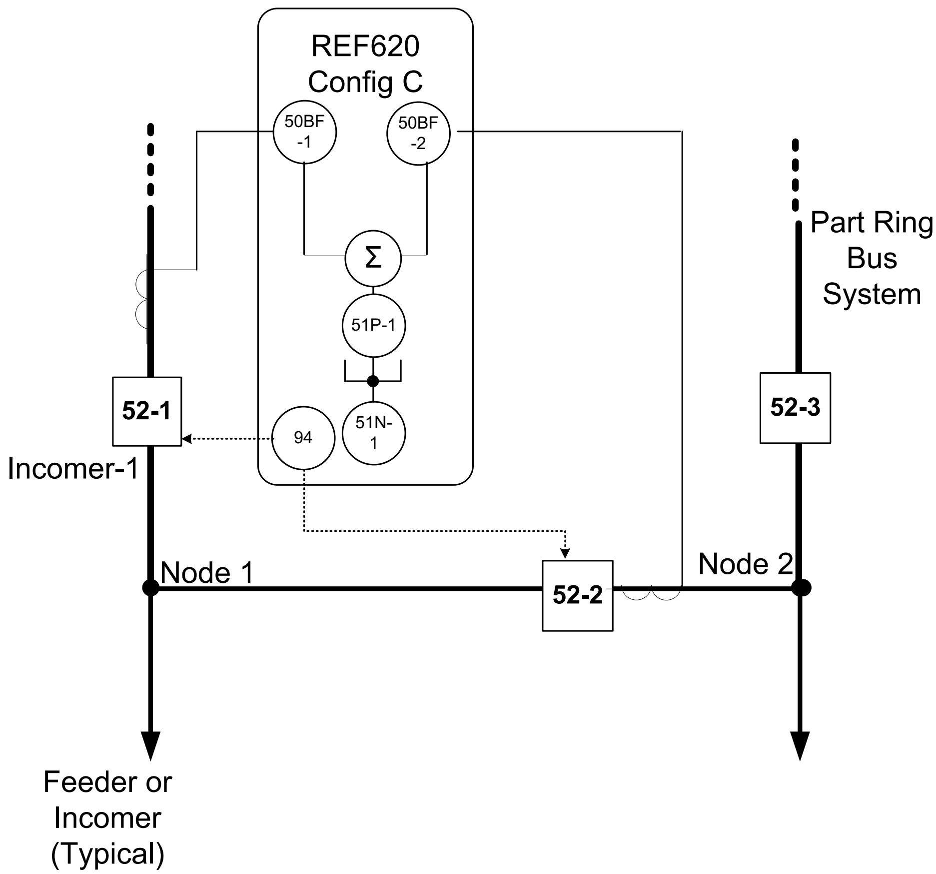


Figure 20: REF620 Config C, applied to Ring Bus system

It is possible to configure REF620, configuration A alternatively for the above application, externally summing up the currents by paralleling. However the internal breaker fail protection would sense summated current and hence will not be able to discriminate the failed breaker and take selective back up tripping.

Either Config B or Config C can also be applied to provide 'Partial' differential protection of typical industrial systems with two incomers feeding two bus systems with a number of feeders in each bus and with a buscoupler. With reference to Figure 21 below, the CT from typically an incomer and CT from the bus coupler are connected to REF620. The currents get summed internal to the relay. TOC protections fed off this summated current, can be graded with downstream feeder TOC protections directly, thereby avoiding an additional stage in grading, accelerating tripping times at the incomer level. One of the incomer REF620 can control and monitor the bus-coupler breaker, eliminating the need for installing any IED in the buscoupler.

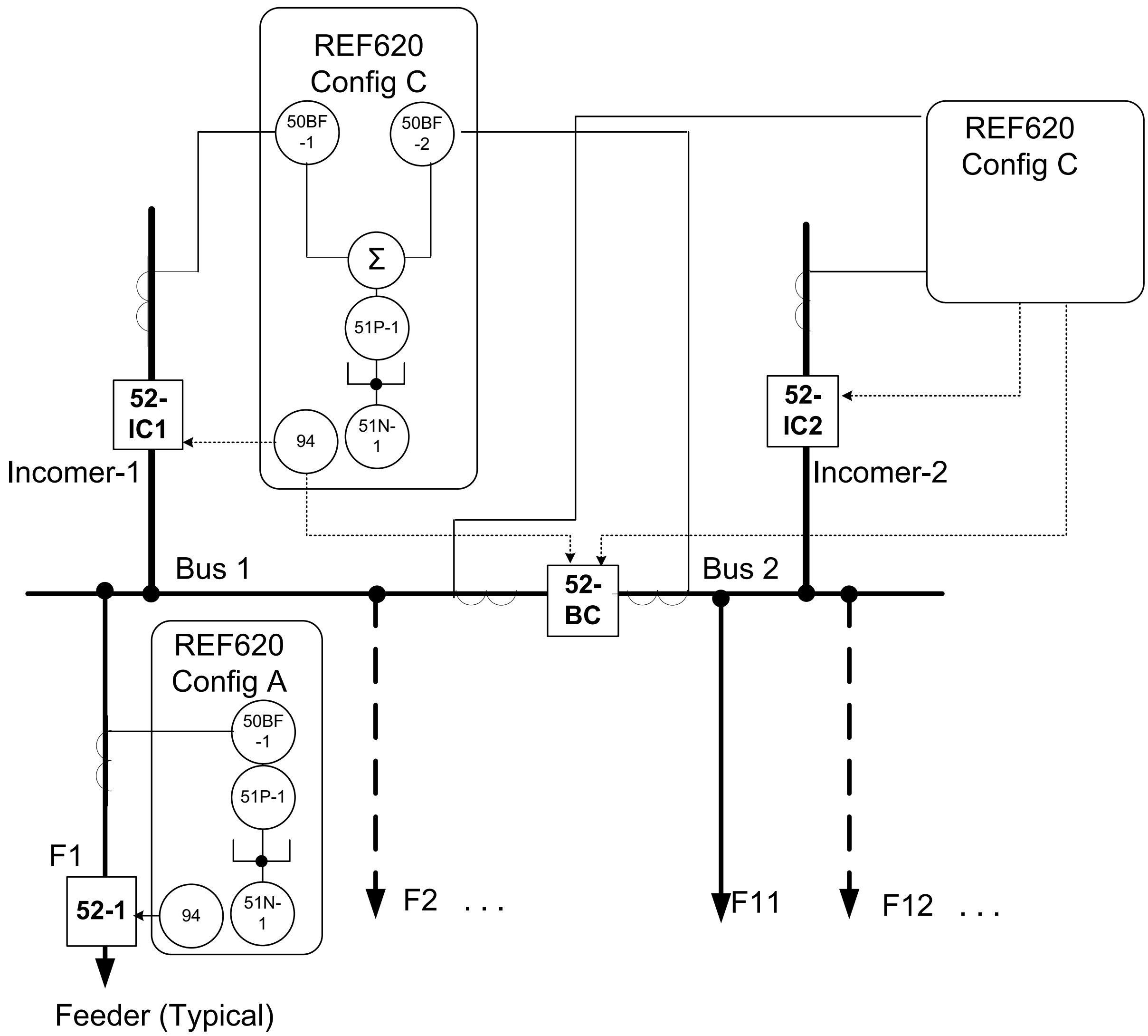


Figure 21: REF620 Config C, applied to provide partial differential protection for an industrial bus system

3.3 Standard configuration for order code functional application A

3.3.1 Applications

This standard configuration is mainly intended for distribution feeders and a single breaker with power and energy metering provided as standard. This configuration includes non-directional and directional phase and ground overcurrent, phase distance, voltage and frequency protection. When ordered with the option of sensitive ground CT input, the IED is configured with High Impedance fault detection and sensitive earth fault protections.

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

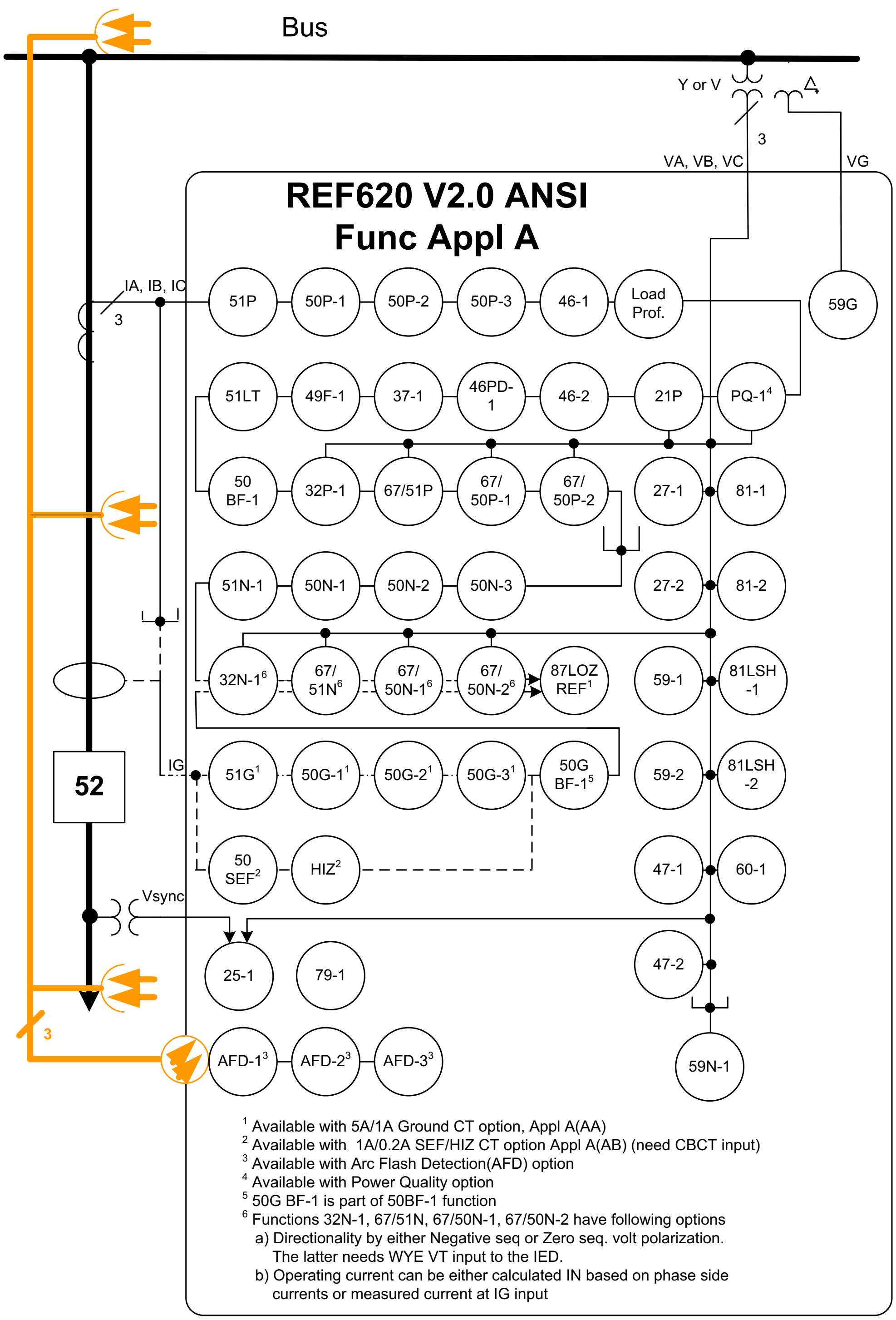


Figure 22: Functions included in the REF620 standard configuration A

Table 8: Functions included in the REF620 standard configuration

Application configuration	A				
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	AA	AB
Protection					
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	51P	3I> (1)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	50P-1	3I>> (1)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	50P-2	3I>> (2)	•	•
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	50P-3	3I>>> (1)	•	•
Three-phase non-directional long time overcurrent protection, low stage, instance 1	PHLTPTOC1	51LT	3I> (3)	•	•
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	67/51P	3I> -> (1)	•	•
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	67/50P-1	3I>> -> (1)	•	•
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	67/50P-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 4	EFLPTOC4	50SEF	Io> (4)	-	•
Non-directional ground-fault protection, high stage, instance 1	EFHPTOC1	50G-1	Io>> (1)	•	-
Non-directional ground-fault protection, high stage, instance 2	EFHPTOC2	50G-2	Io>> (2)	•	-
Non-directional ground-fault protection, high stage, instance 3	EFHPTOC3	50N-1	Io>> (3)	•	•
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC4	50N-2	Io>> (4)	•	•
Non-directional ground-fault protection, instantaneous stage, instance 1	EFIPTOC1	50G-3	Io>>> (1)	•	-
Non-directional ground-fault protection, instantaneous stage, instance 2	EFIPTOC2	50N-3	Io>>> (2)	•	•
Directional ground-fault protection, low stage, instance 1	DEFLPDEF1	67/51N	Io> -> (1)	•	•
Directional ground-fault protection, high stage, instance 1	DEFHPDEF1	67/50N-1	Io>> -> (1)	•	•
Directional ground-fault protection, high stage, instance 2	DEFHPDEF2	67/50N-2	Io>> -> (2)	•	•
Three phase directional power protection, instance 1	DPSRDIR1	32P-1	I1-> (1)	•	•
Ground directional power protection, instance 1	DNZSRDIR1	32N-1	I2 ->, Io-> (1)	•	•
Phase Distance Protection, instance 1	PHDSTPDIS1	21P	Z<	•	•
Negative-sequence overcurrent protection, instance 1	NSPTOC1	46-1	I2> (1)	•	•

Application configuration		A			
Function	**IEC 61850**	**ANSI C37.2-2008**	**IEC 60617**	**AA**	**AB**
Negative-sequence overcurrent protection, instance 2	NSPTOC2	46-2	I2> (2)	•	•
Phase discontinuity protection	PDNSPTOC1	46PD	I2/I1>	•	•
Residual overvoltage protection, instance 1	ROVPTOV1	59G	Uo> (1)	•	•
Residual overvoltage protection, instance 2	ROVPTOV2	59N-1 (1)	Uo> (2)	•	•
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 overvoltage protection, instance 1	PHPTOV1	59-1(1)	3U> (1)	•	•
Three-phase overvoltage protection, instance 2	PHPTOV2	59-2(1)	3U> (2)	•	•
Negative-sequence overvoltage protection, instance 1	NSPTOV1	47-1(1)	U2> (1)	•	•
Negative-sequence overvoltage protection, instance 2	NSPTOV2	47-2(1)	U2> (2)	•	•
Frequency protection, instance 1	FRPFRQ1	81-1	f>/f<,df/dt (1)	•	•
Frequency protection, instance 2	FRPFRQ2	81-2	f>/f<,df/dt (2)	•	•
Voltage per hertz protection, instance 1	OEPVPH1	24	U/f> (1)	•	•
Three-phase thermal protection for feeders, cables and distribution transformers, Instance 1	T1PTTR1	49F	3Ith>F	•	•
Numerical stabilized low impedance restricted ground-fault protection	LREFPNDF1	87LOZREF	dIoLo>	•	-
Circuit breaker failure protection, instance 1	CCBRBRF1	50BF-1	3I>/Io>BF (1)	•	•
Master trip, instance 1	TRPPTRC1	86/94-1	Master Trip (1)	•	•
Master trip, instance 2	TRPPTRC2	86/94-2	Master Trip (2)	•	•
Arc protection, instance 1	ARCSARC1	AFD-1	ARC (1)	•	•
Arc protection, instance 2	ARCSARC2	AFD-2	ARC (2)	•	•
Arc protection, instance 3	ARCSARC3	AFD-3	ARC (3)	•	•
High impedance fault detection	PHIZ1	HIZ	PHIZ1	-	•
Load shedding and restoration, instance 1	LSHDPFRQ1	81LSH-1	UFLS/R (1)	•	•
Load shedding and restoration, instance 2	LSHDPFRQ2	81LSH-2	UFLS/R (2)	•	•
Loss of phase, instance 1	PHPTUC1	37-1	3I< (1)	•	•
Control					
Circuit-breaker control, instance 1	CBXCBR1	52-1	I <-> O CB (1)	•	•
Auto-reclosing, instance 1	DARREC1	79-1	O -> I	•	•
Synchronism and energizing check, instance 1	SECRSYN1	25-1	SYNC(1)	•	•
Condition Monitoring					
Circuit-breaker condition monitoring, instance 1	SSCBR1	52CM-1	CBCM (1)	•	•

Application configuration				A	
Function	**IEC 61850**	**ANSI C37.2-2008**	**IEC 60617**	**AA**	**AB**
Trip circuit supervision, instance 1	TCSSCBR1	TCM-1	TCS (1)	•	•
Trip circuit supervision, instance 2	TCSSCBR2	TCM-2	TCS (2)	•	•
Current circuit supervision	CCRDIF1	CCM	MCS 3I	•	•
Fuse failure supervision, instance 1	SEQRFUF1	60-1	FUSEF (1)	•	•
Cable fault detection	RCFD1	CFD	CFD	•	•
Measurement					
Three-phase current measurement, instance 1	CMMXU1	IA, IB, IC	3I	•	•
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0	I1, I2, I0	•	•
Residual current measurement, instance 1	RESCMMXU1	IG	Io	•	•
Three-phase voltage measurement, instance 1	VMMXU1	VA, VB, VC	3U	•	•
Residual voltage measurement, instance 1	RESVMMXU1	VG	Uo	•	•
Sequence voltage measurement, instance 1	VSMSQI1	V1, V2, V0	U1, U2, U0	•	•
Single-phase power and energy measurement, instance 1	SPEMMXU1	SP, SE	SP, SE	•	•
Three-phase power and energy measurement, instance 1	PEMMXU1	P, E-1	P, E	•	•
Current total demand distortion, instance 1	CMHAI1	PQI-1	PQM3I	•	•
Voltage total harmonic distortion, instance 1	VMHAI1	PQVPH-1	PQM3U(1)	•	•
Voltage variation, instance 1	PHQVVR1	PQSS-1	PQ 3U<>(1)	•	•
Voltage unbalance, instance 1	VSQVUB1	PQVUB-1	PQMUBU(1)	•	•
Load profile	LDPMSTA1	LoadProf	LoadProf	•	•
Frequency measurement, instance 1	FMMXU1	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)	•	•
Minimum pulse timer (2 pcs, second resolution), instance 1	TPSGAPC1	62CLD-1	TPS (1)	•	•
Minimum pulse timer (2 pcs, second resolution), instance 2	TPSGAPC2	62CLD-3	TPS (2)	•	•
Minimum pulse timer (2 pcs, minute resolution), instance 1	TPMGAPC1	62CLD-2	TPM (1)	•	•
Minimum pulse timer (2 pcs, minute resolution), instance 2	TPMGAPC2	62CLD-4	TPM (2)	•	•
Pulse timer (8 pcs), instance 1	PTGAPC1	PT-1	PT (1)	•	•
Pulse timer (8 pcs), instance 2	PTGAPC2	PT-2	PT (2)	•	•
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF-1	TOF (1)	•	•
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF-2	TOF (2)	•	•
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF-3	TOF (3)	•	•

Application configuration		A			
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	AA	AB
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	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	•	•
Logging Functions					
Disturbance recorder	RDRE1	DFR	DFR	•	•
Fault recorder	FLMSTA1	FR	FR	•	•
Sequence event recorder	SER	SER	SER	•	•
Fault location	DRFLO1	FLO	FLO	•	•

3.3.3 Default input/output (I/O) assignments

Table 9: Default connections for analog inputs

Analog input	Default usage	Connector pins
IA	Phase A current	X120-7, 8
IB	Phase B current	X120-9, 10
IC	Phase C current	X120-11, 12
IG	Ground current	X120-13,14
VA	Phase A voltage	X130-11,12
VB	Phase B voltage	X130-13,14
VC	Phase C voltage	X130-15,16
VG	Broken Delta Voltage	X130-17,18
VSync	Feeder Voltage	X130-9,10

Table 10: Default connections for binary inputs

Binary input	Default usage	Connector pins
X120-BI2	Circuit breaker closed position	X120-3, 2
X120-BI3	Circuit breaker open position	X120-4, 2
X120-BI4	Autoreclose blocking	X120-5,6

Table 11: Default connections for binary outputs

Binary output	Default usage	Connector pins
X100-PO1	Close circuit breaker	X100 – 6,7
X100-PO2	Breaker failure backup trip to upstream breaker	X100 – 8,9
X100-SO1		
X100-SO2		
X100-PO3	Open circuit breaker / Master Trip -1	X100 – 15,16,17,18,19
X100-PO4	Open circuit breaker / Master Trip -2	X100 – 20,21,22,23,24

*Table 12: High speed binary output connections**

Binary output	Default usage		Connector pins
X110-HSO1	Open circuit breaker / Master Trip -1	X110 – 15,16	X110-HSO1
X110-HSO2	Trip from ARC-2 protection	X110 – 19,20	X110-HSO2
X110-HSO3	Trip from ARC-3 protection	X110 – 23,24	X110-HSO3
*Available only if IED has been ordered with High speed power output (HSO) card and ARC protection.			

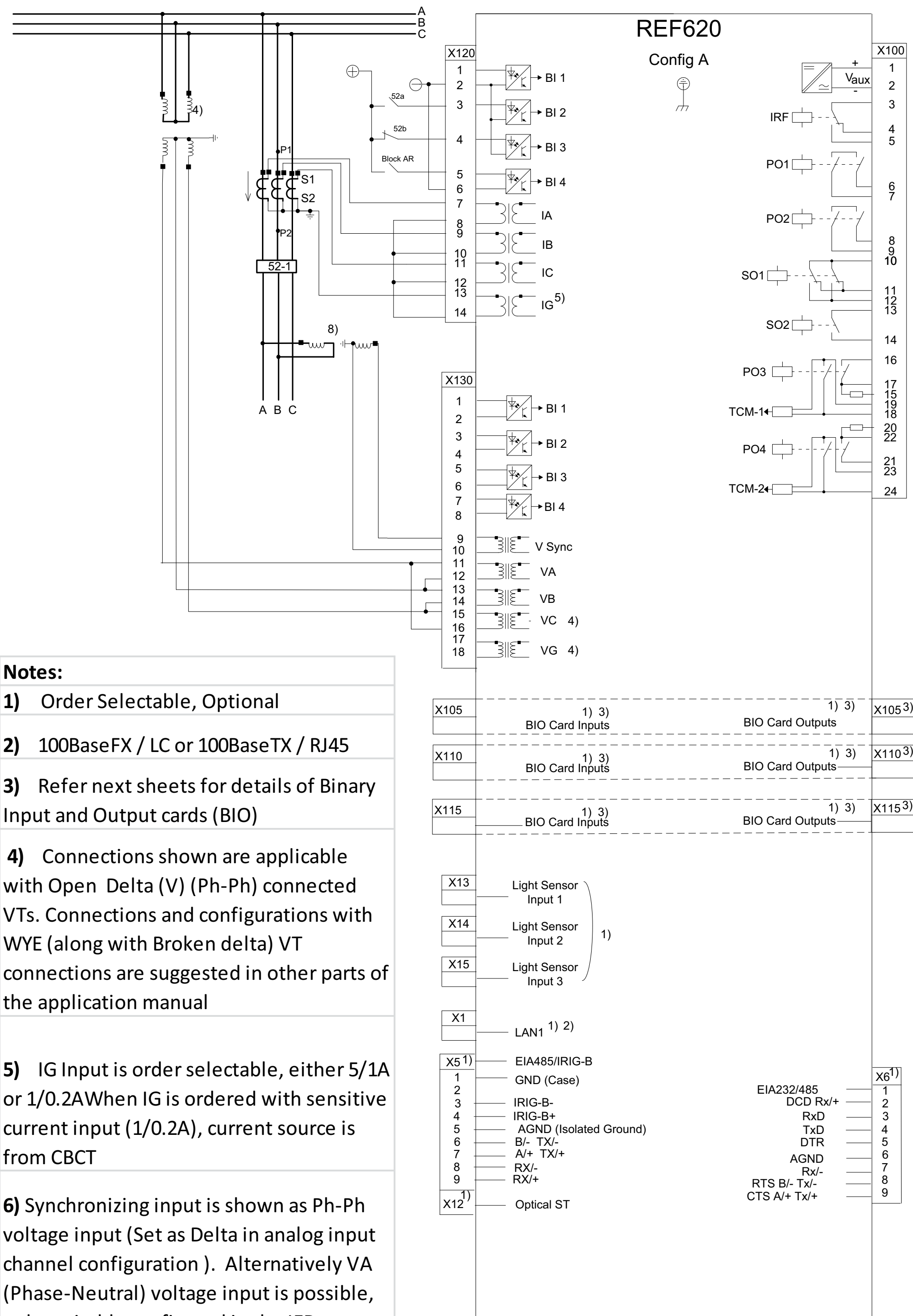
Table 13: Default connections for LEDs

LED	LED label
LED 1	Phase A
LED 2	Phase B
LED 3	Phase C
LED 4	Neutral, Neutral / Ground, Neutral / SEF

LED	LED label
LED 5	Time
LED 6	Instantaneous
LED 7	Recloser lockout
LED 8	Voltage protection
LED 9	Synch. Alarm
LED 10	Arc Flash Detection
LED 11	HIZ 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

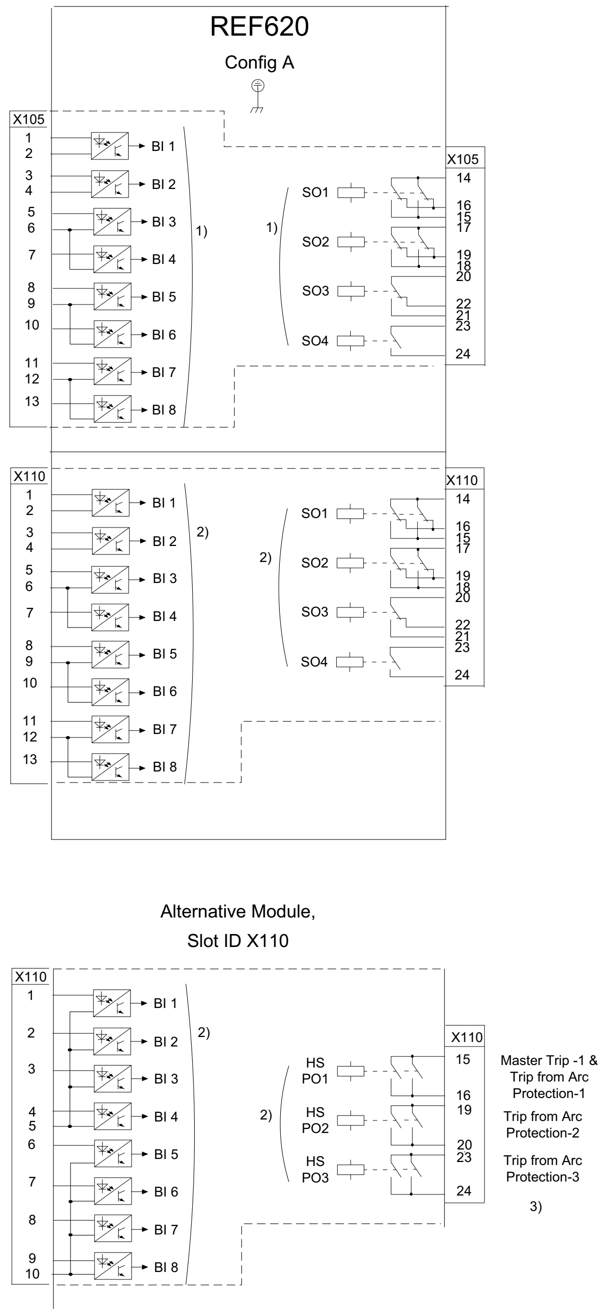
3) Refer next sheets for details of Binary Input and Output cards (BIO)

4) Connections shown are applicable with Open Delta (V) (Ph-Ph) connected VTs. Connections and configurations with WYE (along with Broken delta) VT connections are suggested in other parts of the application manual

5) IG Input is order selectable, either 5/1A or 1/0.2AWhen IG is ordered with sensitive current input (1/0.2A), current source is from CBCT

6) Synchronizing input is shown as Ph-Ph voltage input (Set as Delta in analog input channel configuration). Alternatively VA (Phase-Neutral) voltage input is possible, to be suitably configured in the IED

Figure 23: Typical connection diagram of REF620 (Config A, with Ground CT)



1) Order Selectable, Optional
2) Order Selectable, Optional alternatives
3) Default outputs configured with High Speed Outputs when Arc protection option is chosen

Figure 24: *Typical BIO module equipment arrangement and connections for REF620, Config A (Slot X105 and X110)*

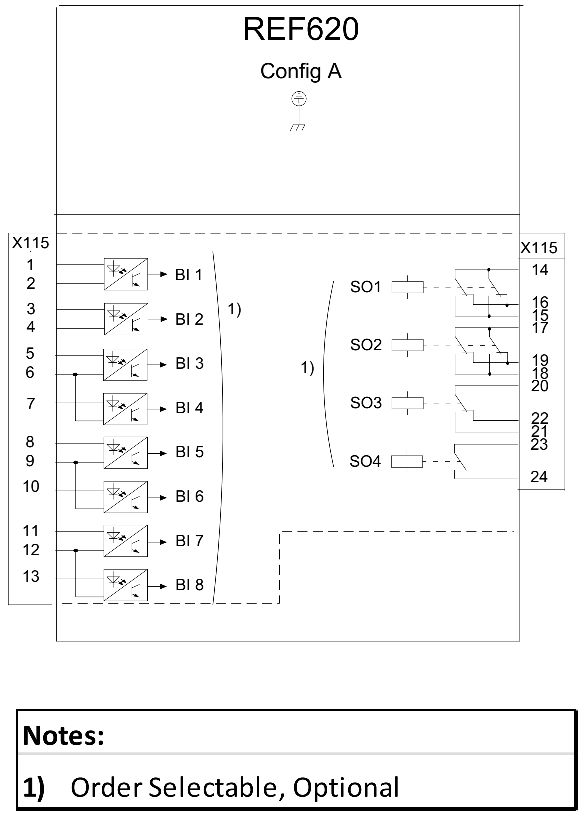


Figure 25: Typical BIO module equipment arrangement and connections for REF620, Config A (Slot X115)

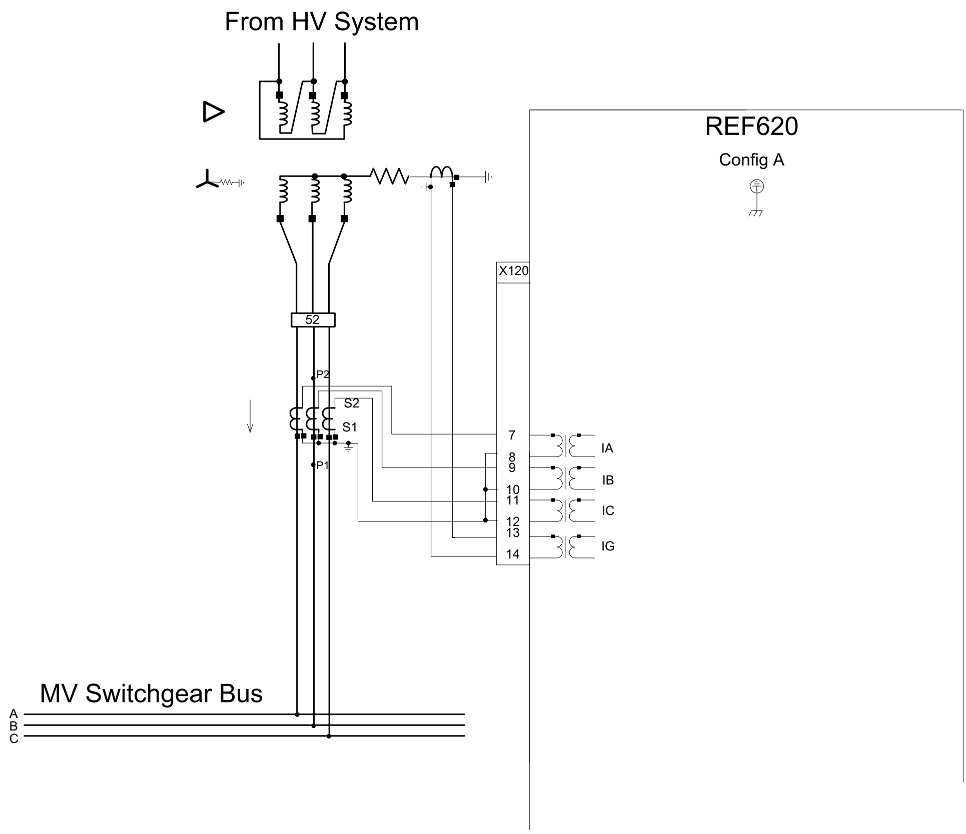


Figure 26: Analog current inputs when REF620 is applied on a transformer feeder with Restricted Earth Fault protection

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

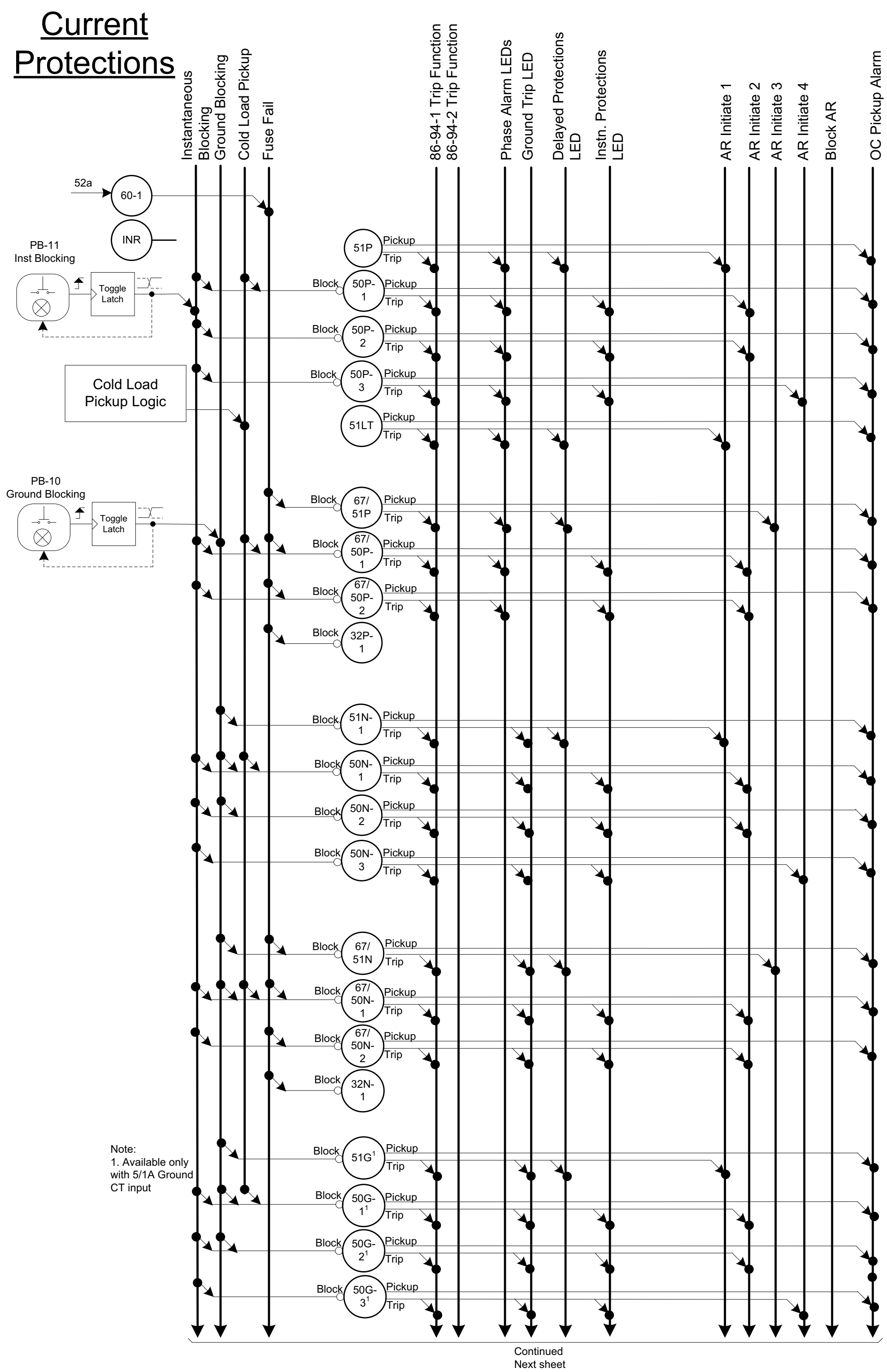


Figure 27: Simplified Logic Diagram for Current Protections, REF620,Config A

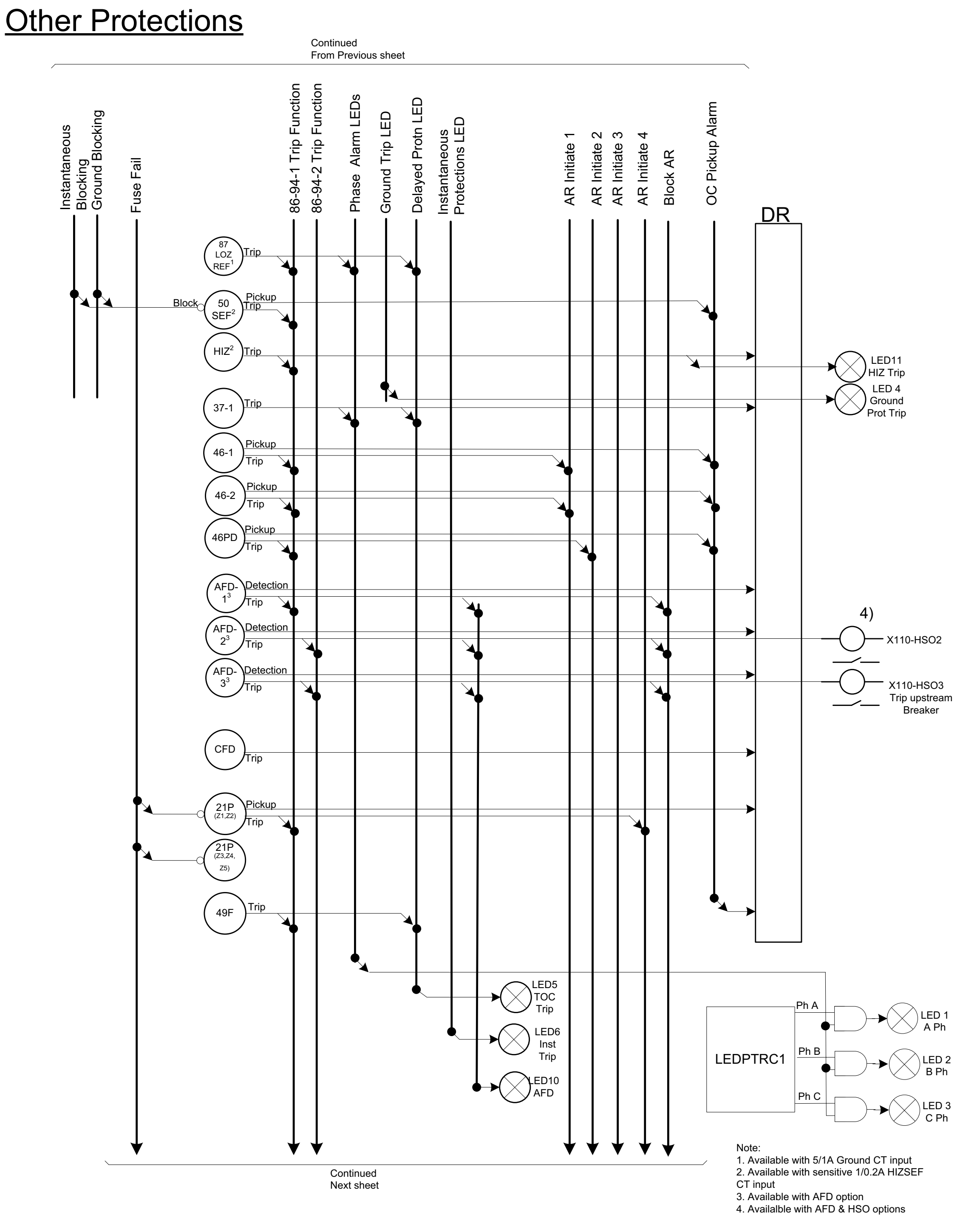


Figure 28: Simplified Logic Diagram for Other Protections, REF620, Config A

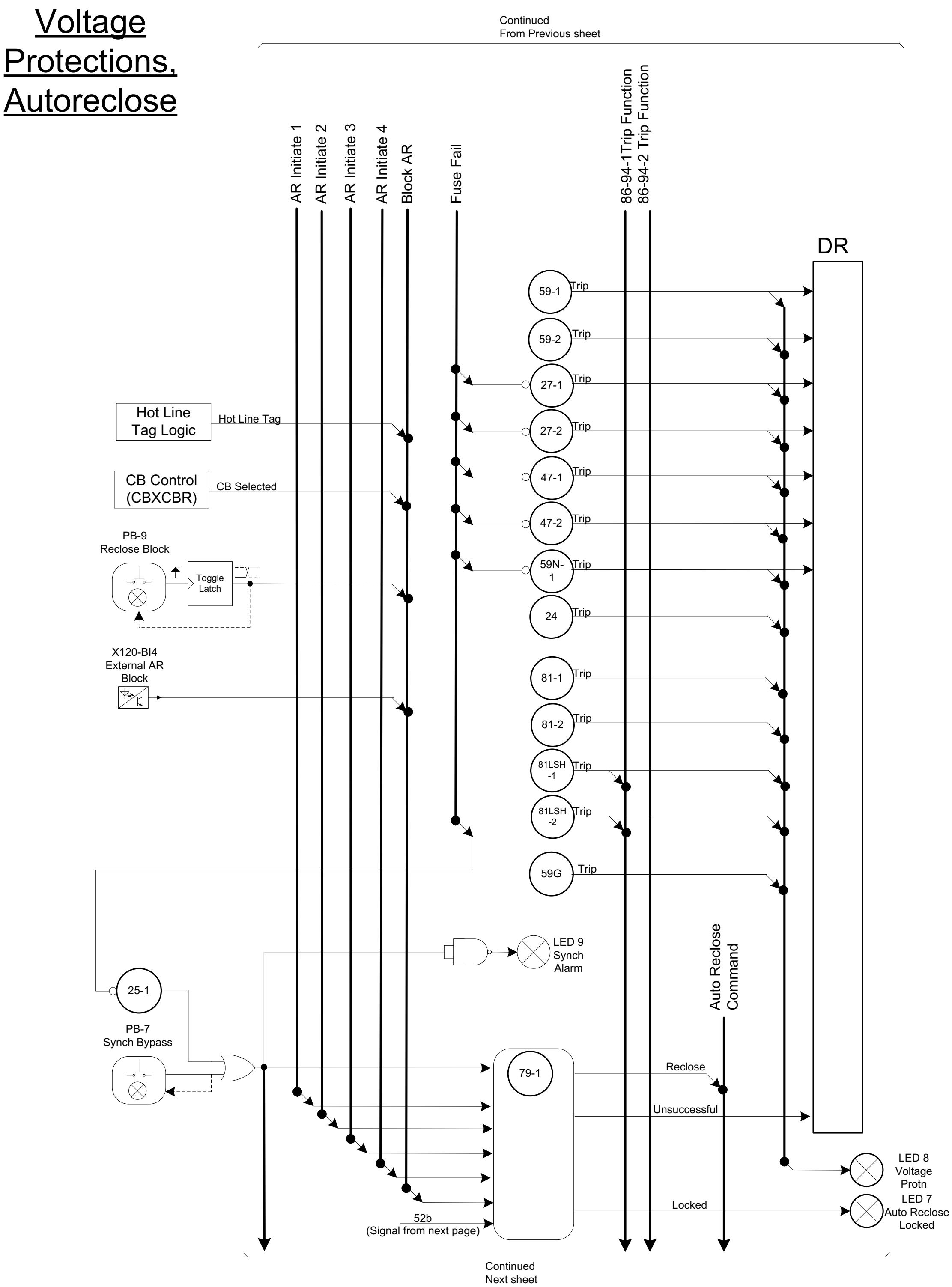


Figure 29: *Simplified Logic Diagram for Voltage Protections and Reclose, REF620, Config A*

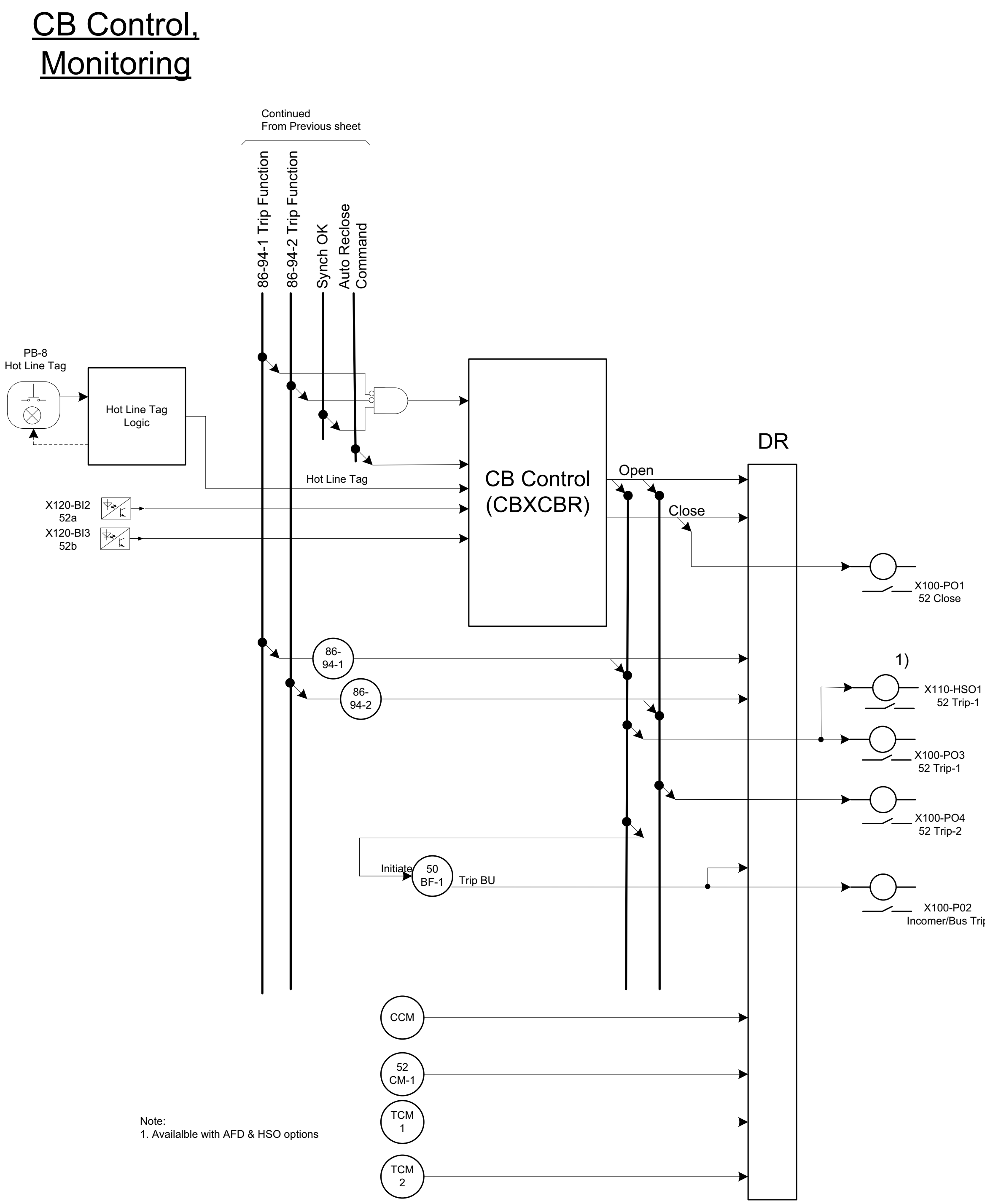


Figure 30: Simplified Logic Diagram for CB Control and Monitoring, REF620, Config A

3.3.5 Functional diagrams

The functional diagrams describe the default input, output, 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 signal marked with IA, IB and IC represents the three phase currents. The signal IG represents the measured ground current, fed from either residually connected CTs or an external Core Balance CT or neutral CT depending on the application.

The signal marked with VA, VB and VC represents the three phase system voltages on the bus. These inputs are connected in Delta, which are typically fed from open delta (V connected) VTs from the system. When 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.

The signal marked VSync is measured from the VT on the feeder side of the breaker. This signal is used for check synchronizing purposes. The input again is configured for Ph-Ph input from the system by default, but can be suitably configured to take input from Ph-G voltage input as well. Care shall be taken in setting the synchrocheck function with correct phase angle correction, especially in applications such as voltages fed to synchrocheck across a transformer with vector shift.

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.

REF 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, hot line tag, sensitive earth fault detection, etc. Figure 31 shows the default mapping for the available programmable buttons. Figure 32 shows the hot line tag logic.

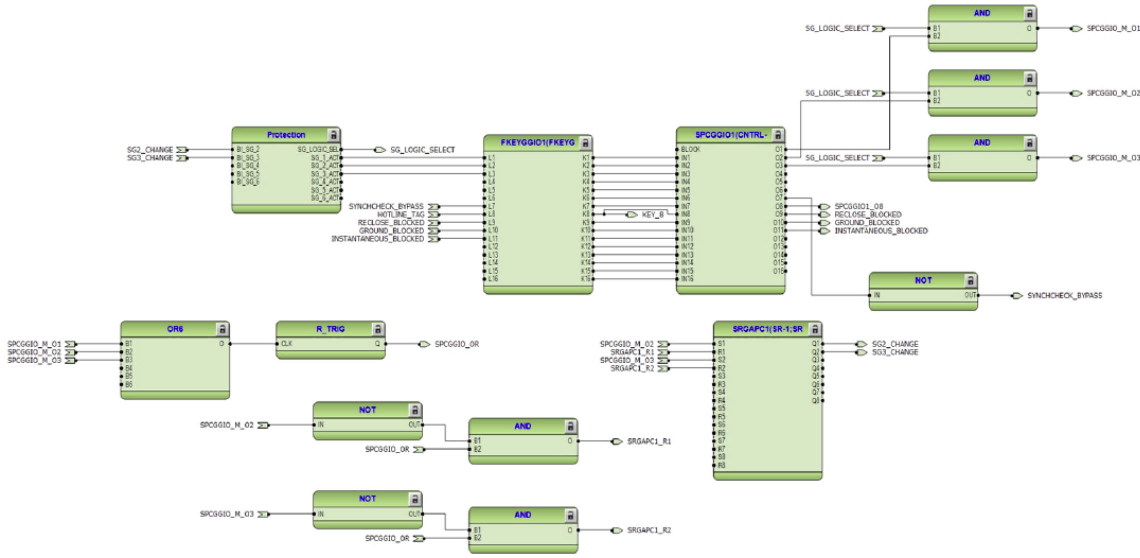


Figure 31: *Default mapping on programmable buttons*

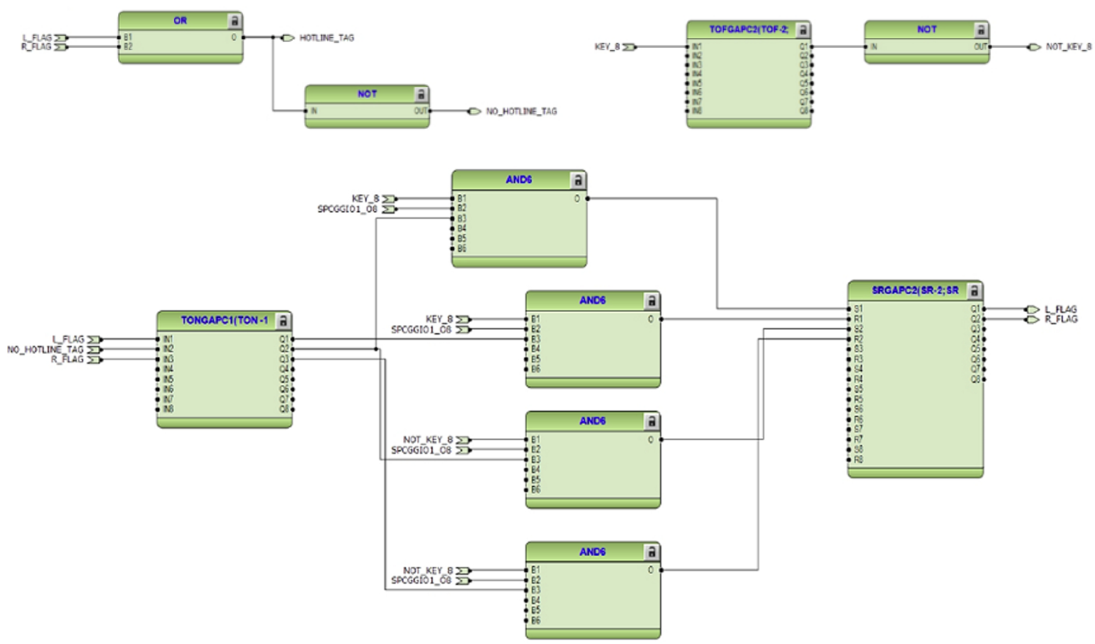


Figure 32: *Hot line Tag logic*

3.3.6 Functional diagrams for protection

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

Eight overcurrent stages (51P, 50P-1, 50P-2, 50P-3, 51LT, 67/51P, 67/50P-1, 67/50P-2) totally are offered for overcurrent and short-circuit protection. Three of them include directional functionality. The non directional high stage (50P-1) and directional high stage

(67/50P-1) will be blocked by cold load detection logic. The cold load detection logic starts from closing of the circuit breaker and is active during set time. The cold load detection logic's active time can be set in a resolution of minutes or seconds to the functions TPSGAPC and TPMGAPC.

The operation of 50P-1, 50P-2, 50P-3, 67/50P-1 and 67/50P-2 will be blocked if Instantaneous Blocking signal is active.

The directional overcurrent and short circuit protection will be blocked by default also if the fuse failure situation is detected.

The inrush detection block's (INR-1) output BLK2H offers the possibility to either block the function or multiply the active settings for any of the shown protection function blocks.

All trip signals are connected to the Master Trip and also to the alarm LEDs. Alarm LEDs 1, 2 and 3 are used for phase segregated information of faults. The alarm LED 5 is used to indicate time delayed trips and the alarm LED 6 instantaneous trips of the current based protection functions.

The pickup information of all overcurrent functions is collected to the variable OC_PICKUP_ALARM and connected to the disturbance recorder. This signal can be mapped to the signal outputs depending on the application needs.

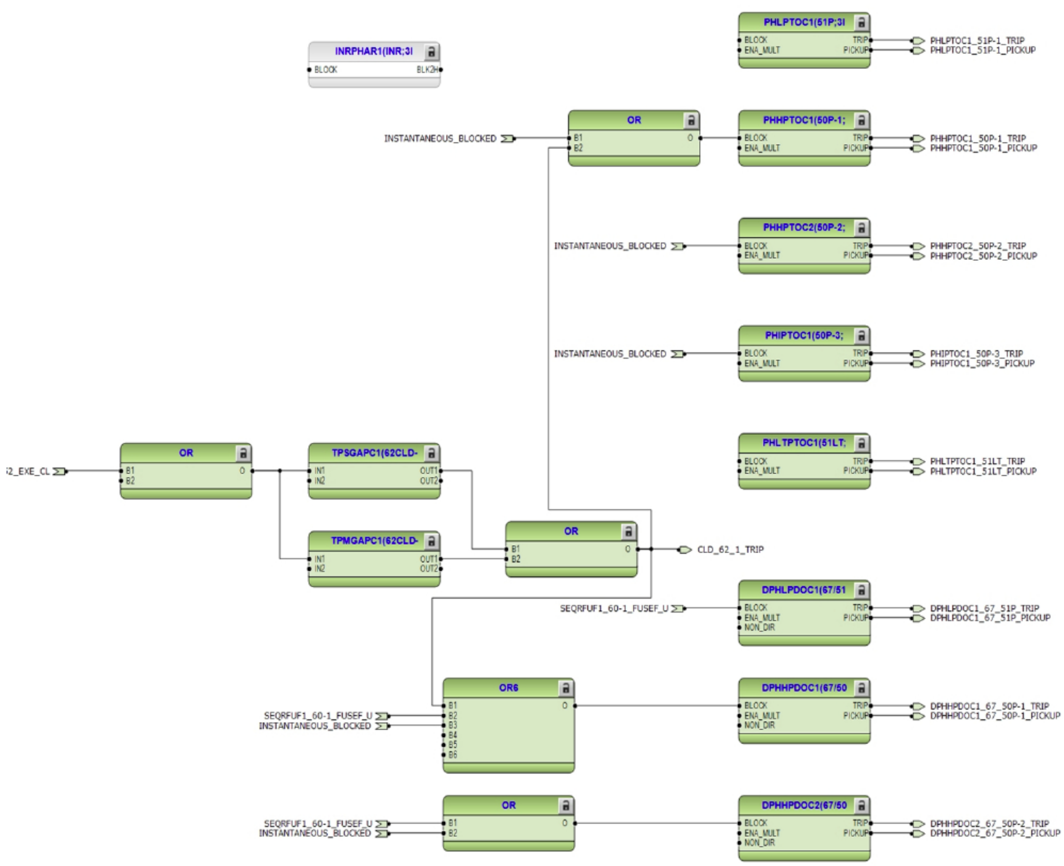


Figure 33: Three phase overcurrent protection

Four stages are provided to non-directional neutral overcurrent protection (51N-1, 50N-1, 50N-2, 50N-3). The neutral overcurrent protection uses calculated residual current component.

Four stages of ground overcurrent protections (51G, 50G-1, 50G-2 and 50G-3) are operated off standard IG input (rated 5/1A) when ordered. When sensitive ground input (1/0.2A) is ordered sensitive ground fault protection 50SEF is provided (instead of four ground overcurrent protections).

The operation of 51N-1, 50N-1, 50N-2 and 50SEF will be blocked if GROUND_BLOCKING is active. The 50N-1 will also be blocked if the cold load detection logic is activated. The operation of neutral overcurrent protection functions is connected to alarm LED 4.

The alarm LED 5 is used to indicate time delayed trips and the alarm LED 6 instantaneous trips of the current based protection functions.

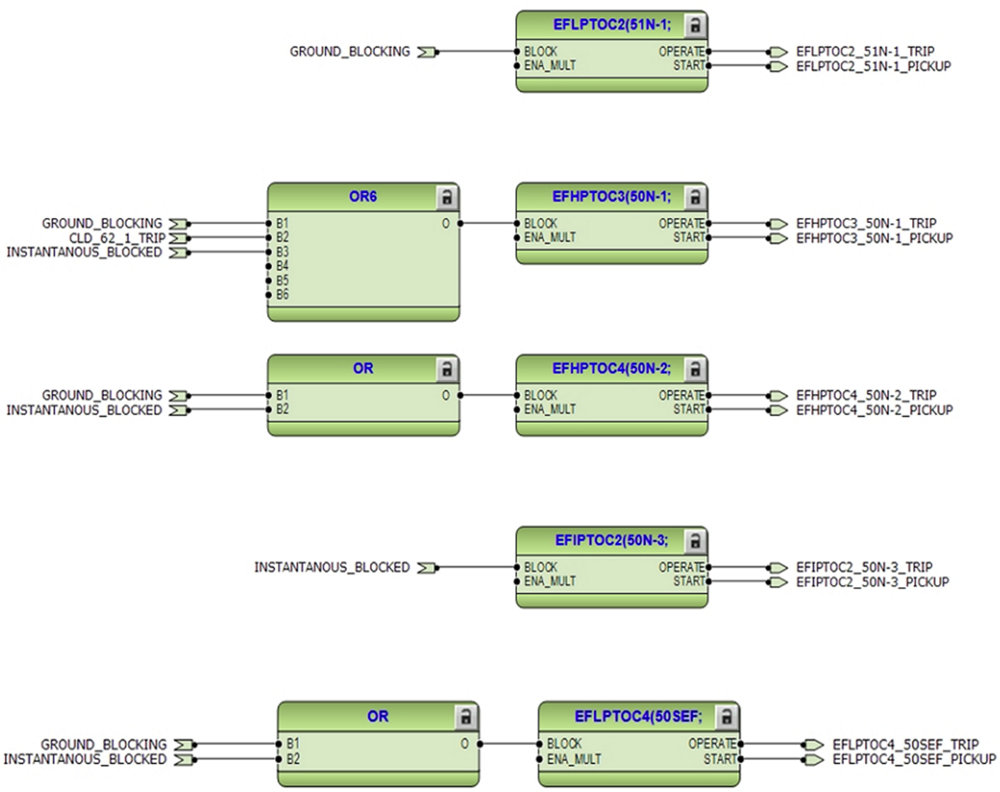


Figure 34: Non-directional neutral overcurrent protection

SEF and HIZ functions are included if sensitive SEF/HIZ measuring option is used.

The operation of 51G, 50G-1 and 50G-2 will be blocked if GROUND_BLOCKING input is active. The 50G-1 will also be blocked if the cold load detection logic is activated. The operation of ground overcurrent protection functions is connected to alarm LED 4.

The alarm LED 5 is used to indicate time delayed trips and the alarm LED 6 instantaneous trips of the current based protection functions.

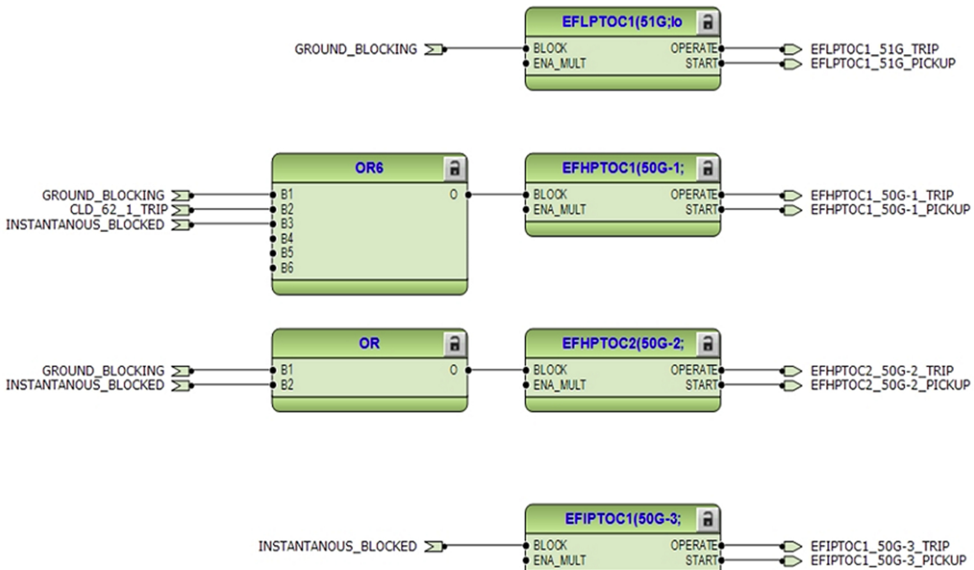


Figure 35: Non-directional ground overcurrent protection

51G, 50G-1, 50G-2 and 50G-3 are included if ground measuring option is used.

Three stages are offered for directional ground-fault protection (67/51N, 67/50N-1, 67/50N2). By default the stages (67/51N) and (67/50N-1) will be blocked by activating the GROUND_BLOCKING input. If the cold load situation is detected the (67/50N-1) function will be blocked. Also if the fuse failure situation is detected all directional ground-fault protection functions will be blocked. While setting the directional element, it is necessary to choose either Vo calculated or Negative sequence voltage polarization. While either one may be selected with WYE connected VT, it is essential to choose negative sequence voltage polarization with V (Delta) connected VT input from which zero sequence voltage cannot be derived.

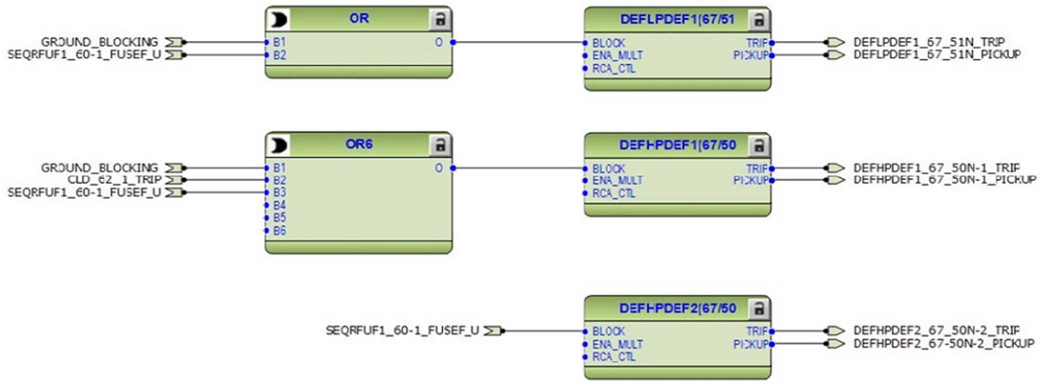


Figure 36: Directional neutral overcurrent protection

Two negative-sequence overcurrent protection (46-1 and 46-2) stages are provided for phase unbalance protection. These functions are used to protect the feeder against phase unbalance.

The phase discontinuity protection (46PD) provides protection for interruptions in the normal three-phase load supply, like in downed conductor situations.

The operation of 46-1, 46-2 and 46PD is not blocked as default by any functionality. The pickup signals are connected to OC_PICKUP_ALARM variable in logic.

The undercurrent protection function (37-1) is offered for protection against loss of phase situations. The trip signal is connected to the disturbance recorder by default.

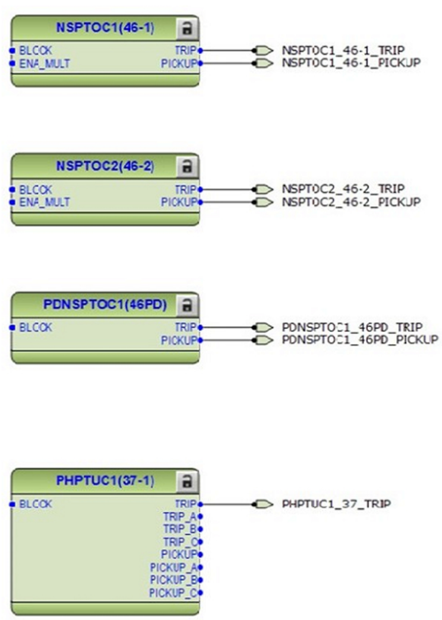


Figure 37: Negative sequence, phase discontinuity and undercurrent protection

All overcurrent pickup signals are merged together as variable OC_PICKUP_ALARM. This alarm is by default connected to disturbance recorder channel. It can be mapped also e.g. for alarming or blocking purposes to the binary output relays.

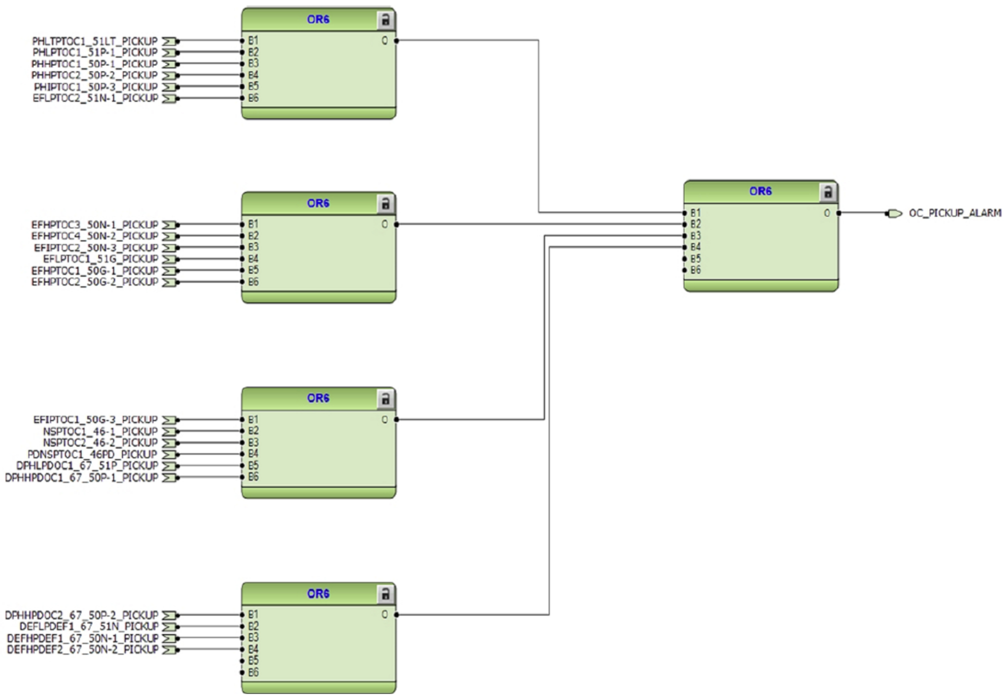


Figure 38: Overcurrent pickup alarm

The directional positive sequence power protection (32P-1) and directional negative sequence power protection (32N-1) are offered in configuration. The output information of these functions can be used e.g. releasing or blocking purposes but by default those are not connected. Directional power protection functions are blocked by default configuration connection if fuse failure is detected.

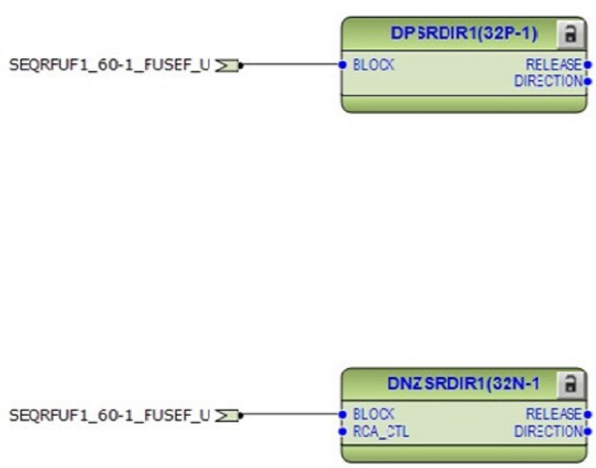


Figure 39: Directional power protection

Two overvoltage and undervoltage protection stages (27-1, 27-2 and 59-1, 59-2) 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 and 47-2) 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-1) provides ground-fault protection by detecting abnormal level of residual voltage. It can be used, for example, as a nonselective backup protection for the selective directional ground-fault functionality. The operation signal is connected to alarm LED 8.

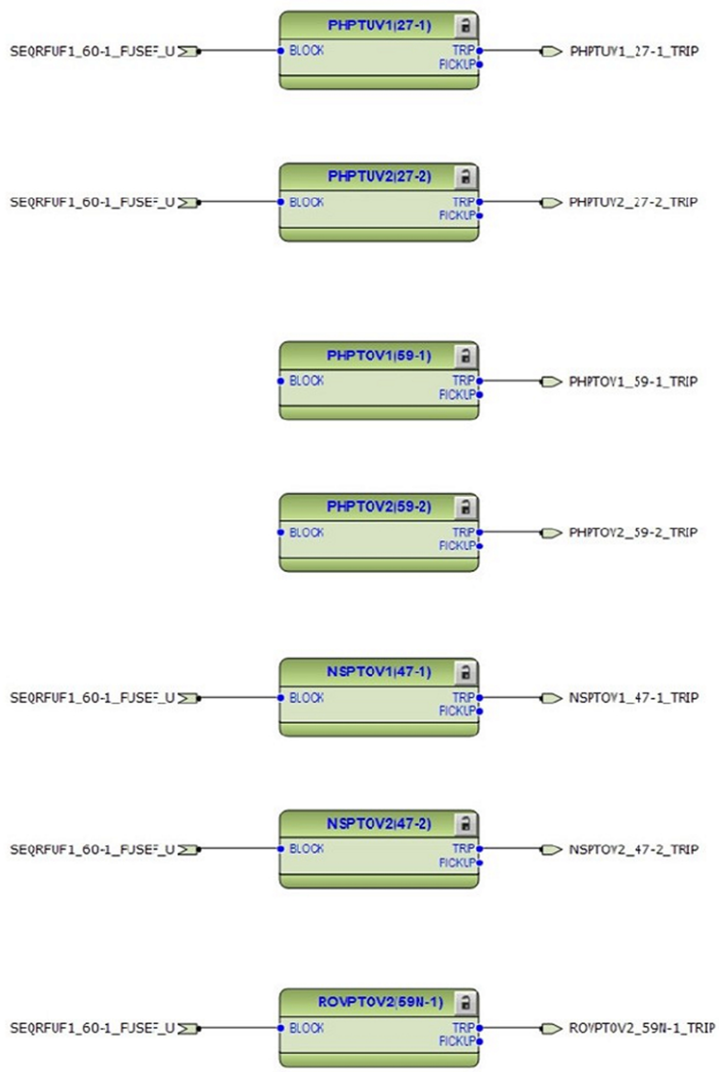


Figure 40: Voltage protection functions

The over excitation protection function (24) is offered as standard. By the default the TRIP output is connected only to alarm LED 8.

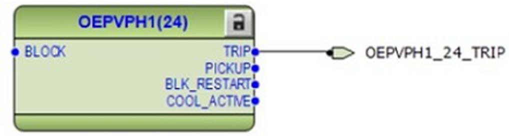


Figure 41: Over excitation protection

The thermal overload protection function (49F-1) detects short and long term overloads under varying load conditions.

The trip of the thermal overload protection function is connected to the Master Trip 1. The alarm and trip signals are connected to alarm LED 5.

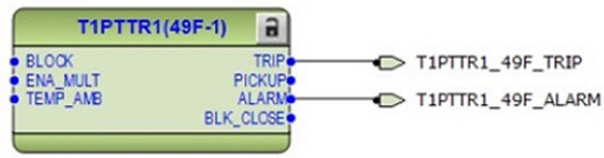


Figure 42: Thermal overload protection

According to the order code the configuration includes restricted low-impedance ground-fault protection function (87LOZREF). The function is available with 1/5A ground CT input with functional application AA.

The numerical differential current stage operates exclusively on ground faults occurring in the protected area, that is, in the area between the phase and ground 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 star-point of the transformer and ground.

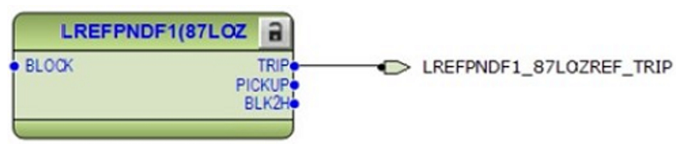


Figure 43: Low impedance restricted ground fault protection

The circuit-breaker failure protection (50BF) is initiated via the PICKUP input by a functions connected to the Master Trip 1 and by opening command of the circuit breaker. 50BF offers different operating modes associated with the circuit-breaker position and the measured phase and the measured ground (IG) current in this configuration.
50BF has two operating outputs: TRRET and TRBU. The TRBU output can be used to give a backup trip to the circuit breaker feeding upstream. In the configuration the TRBU output signal is connected to the output PO2 (X100: 8-9).

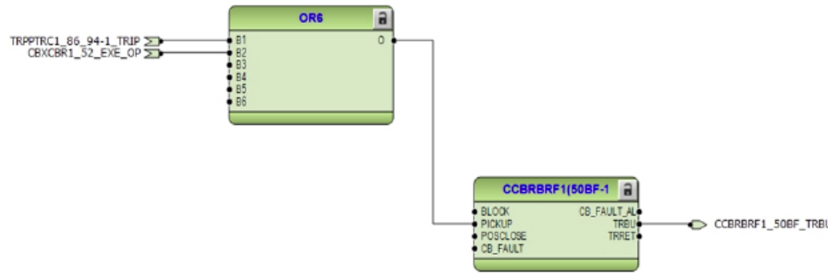


Figure 44: Circuit breaker failure protection

Three arc protection (AFD-1, AFD-2 and AFD-3) 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.

Trip signal from AFD-1 is connected to Master Trip 1, available at PO3 (X100: 15-19), whereas the trip signal from AFD-2 and AFD-3 is connected to Master Trip 2, available at PO4 (X100: 20-24). The operation of these protection functions is connected to alarm LED 11.

If the IED has been ordered with high speed binary outputs, then trip signal from AFD-2 and AFD-3 are connected directly to high speed output HSO2 (X110:19-20) and HS P03(X110:23-24) respectively. HSO1(X110:15-16) is also mapped from Master Trip 1 to derive a high speed trip output from AFD1.

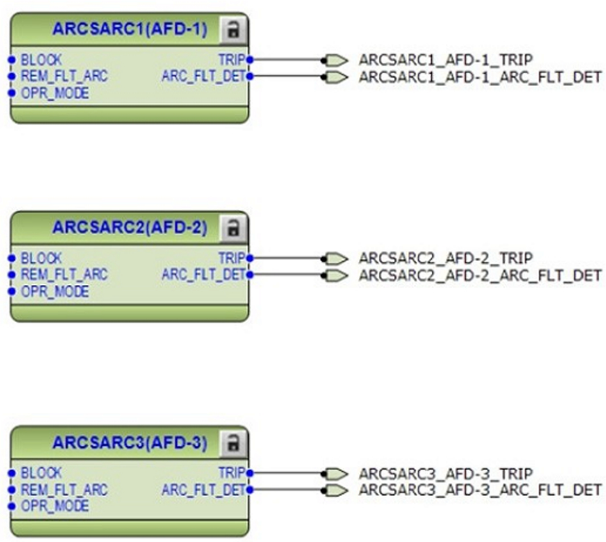


Figure 45: Arc protection

According to the order code the configuration includes high impedance fault protection function (HIZ). The function is available with functional application AB which is with sensitive 0.2/1A CT input. The trip of the high impedance protection function is connected to the disturbance recorder and to the alarm LED 11.

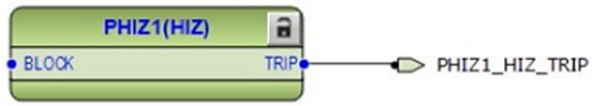


Figure 46: High impedance fault protection

The selectable under frequency or over frequency protection (81-1 and 81-2) prevents damage to network components 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.

Two load shedding and restoration stages are offered in the standard configuration.

The load shedding and restoration function (81LSH-1 and 81LSH-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.

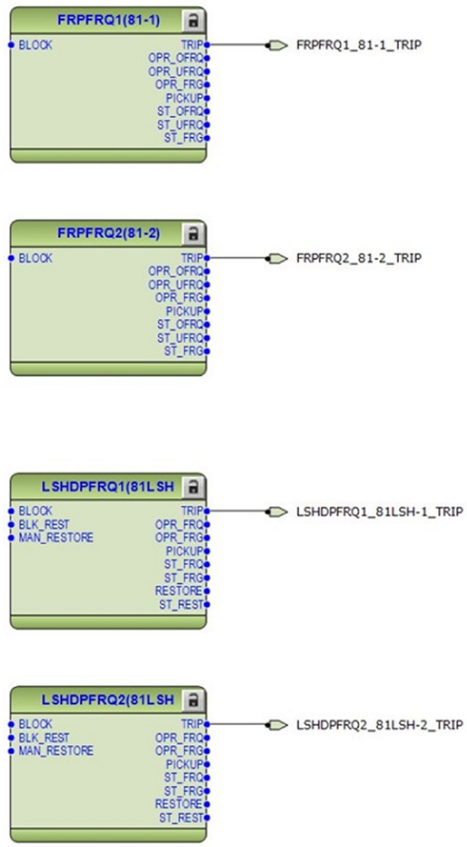


Figure 47: Frequency and Load shedding functions

A phase distance protection function (21P) is included as a standard function. It provides a fast and reliable protection for overhead lines and power cables. It is applied in distribution and sub-transmission networks where three-phase tripping is allowed for phase-to-phase / three-phase faults. Typically these networks are operated in ring or meshed type of configurations. It is also characteristic for these networks that the switching state is changed frequently due to daily operation and load flow considerations. The networks also include varying capacities of distributed generation. This makes it impossible to apply simple overcurrent based schemes. In these kinds of networks, 21P is used to provide a fast and selective protection for overhead lines and power cables. It can also be applied for radial feeders to increase the sensitivity of the protection, especially if the short circuit power of the source is low or it is changing due to network operation.

The protection has five distance phase elements Z1, Z2, Z3, Z4 and Z5 which may be set, depending on the application. When called in to protect medium to long length feeders, the distance relay may be set to trip a feeder based on set impedance and time. Typically, Z1 may be set to protect 80% of the feeder, arranged to trip instantly. Zone 2 is set with a delay of about 500 mSec is set to trip faults up to 120% of the line. The Zone 3 may be set to provide backup protection for the protected feeder as well as adjoining components of the power system. If infeed from the remote end of the feeder is available, one of the zones Z5 can be set in reverse direction with adequate delay to provide backup protection for bus bar faults.

Very often, it is possible to utilize the instantaneous (Start / Pickup) output of one of the distance element to torque control one of the Overcurrent elements to grade with a downstream OC protection, typically on the LV side of a step down transformer at the tail of a transformer feeder protected by REF620.

From selectivity point of view, it is advantageous that in the protection chain all functions in different positions trip according to the same measuring principle. Therefore, 21P can also be applied for the backup protection of main transformers and buses. This way the selectivity with the distance protection of the outgoing lines is easier to achieve.

21P is suitable as a basic protection function against two and three phase faults in all kinds of networks, regardless of the treatment of the neutral point.

In the default configuration, the trip outputs of Z1 and Z2 are connected to trip the feeder through Master Trip logic. The Start / Pickup signals of the same elements are connected for fault record.

It is necessary to block the distance elements misoperating on loss of fuse. A signal from Fuse fail function is always wired to block the distance element. Care shall be taken while setting the distance element so that it does not operate under normal load flow conditions. Provision is made in the function to discriminate load condition and avoid operation of the element for such conditions.

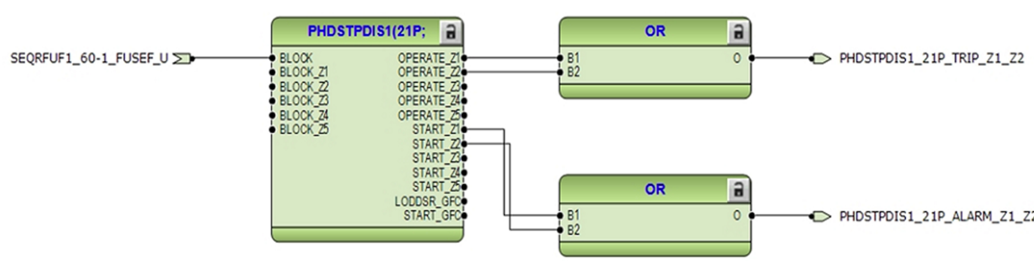


Figure 48: Distance Protection function

A forward direction full load power flow, with 65V VT secondary and 5A CT secondary would pose an apparent impedance to the relay of 13 Ohms, along the resistive direction.

Two Master Trip logics (86/94-1 and 86/94-2) are provided as a trip command collector. 86/94-1 collects the trip signals from 46, 46PD, 49F, 50P, 50N, 50G, 51LT, 51P, 51N, 51G, 67P, 67N, 81LSH-1, 87LOZREF, AFD-1 and SEF protection functions and is connected to trip output contact PO3 (X100:16-19) and also to high speed output HS01 (X110:15-16) for IEDs ordered with high speed binary output cards.

Open control commands to the circuit breaker from the local or remote is also connected directly to the output PO3 (X100:16-19) from circuit breaker control (52) function block.

86/94-2 collects the trip signals from AFD-2 and AFD-3 protection functions and is connected to trip output contact PO4 (X100:20-24).

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

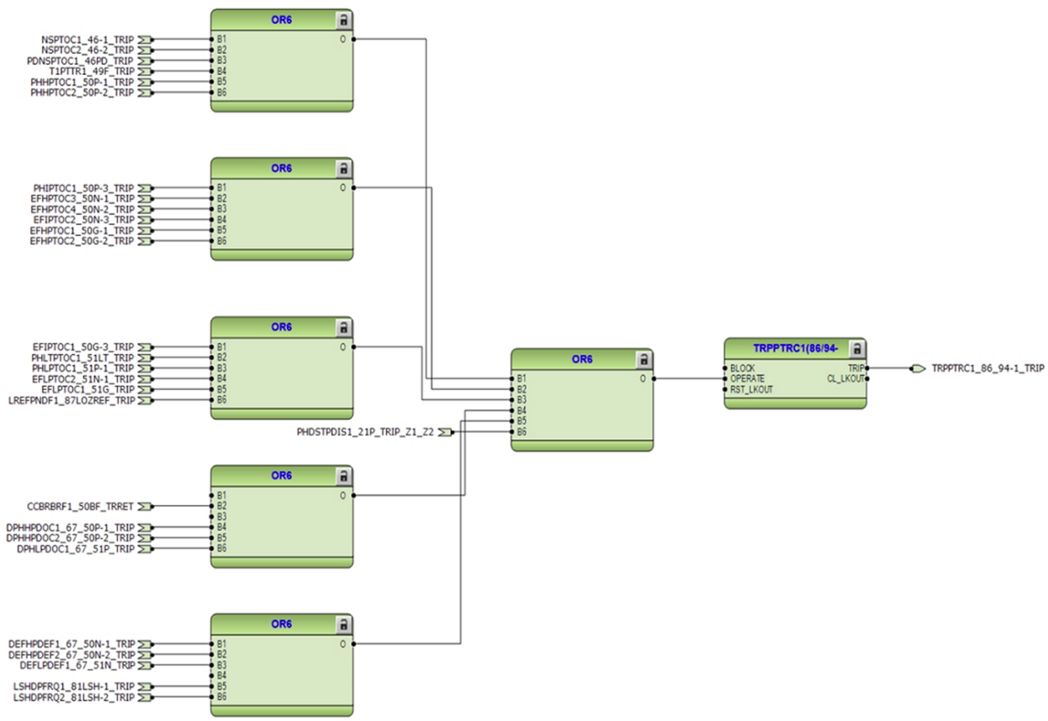


Figure 49: Master trip logic 1

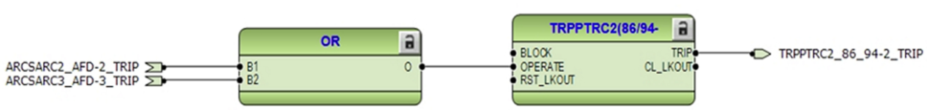


Figure 50: Master trip logic 2

3.3.7 Functional diagrams for control functions

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

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 of the interlocking conditions being active when the circuit breaker truck is closed in service position.

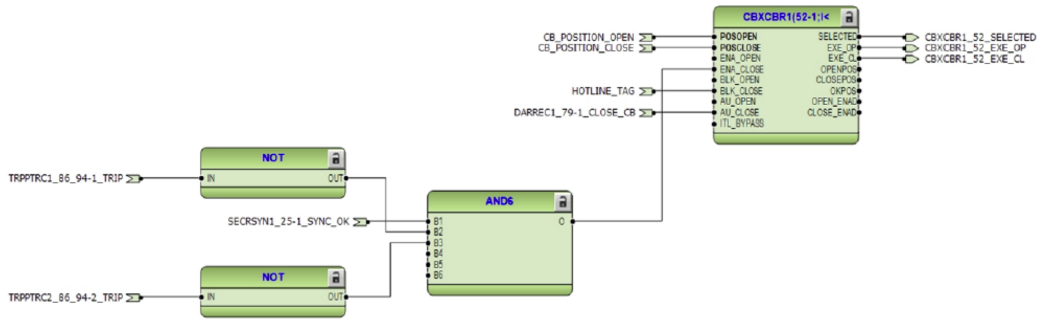


Figure 51: Circuit breaker control

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.

The autorecloser functionality (79) is configured to be initiated by operate signals from a number of protection stages through the INIT1...5 inputs. It is possible to create individual autoreclose sequences for each input.

The autoreclose function can be blocked with the INHIBIT_RECL input. By default, the operation of selected protection functions is connected to this input. A control command to the circuit breaker, either local or remote, also blocks the autoreclose function via the CBXCBR-selected signal. The circuit breaker availability for the autoreclosure sequence is expressed with the CB_READY input in DARREC1.

The autoreclose locked status is connected to the alarm LED 7. The unsuccessful autoreclosing UNSUC_RECL is connected to the disturbance recorder.

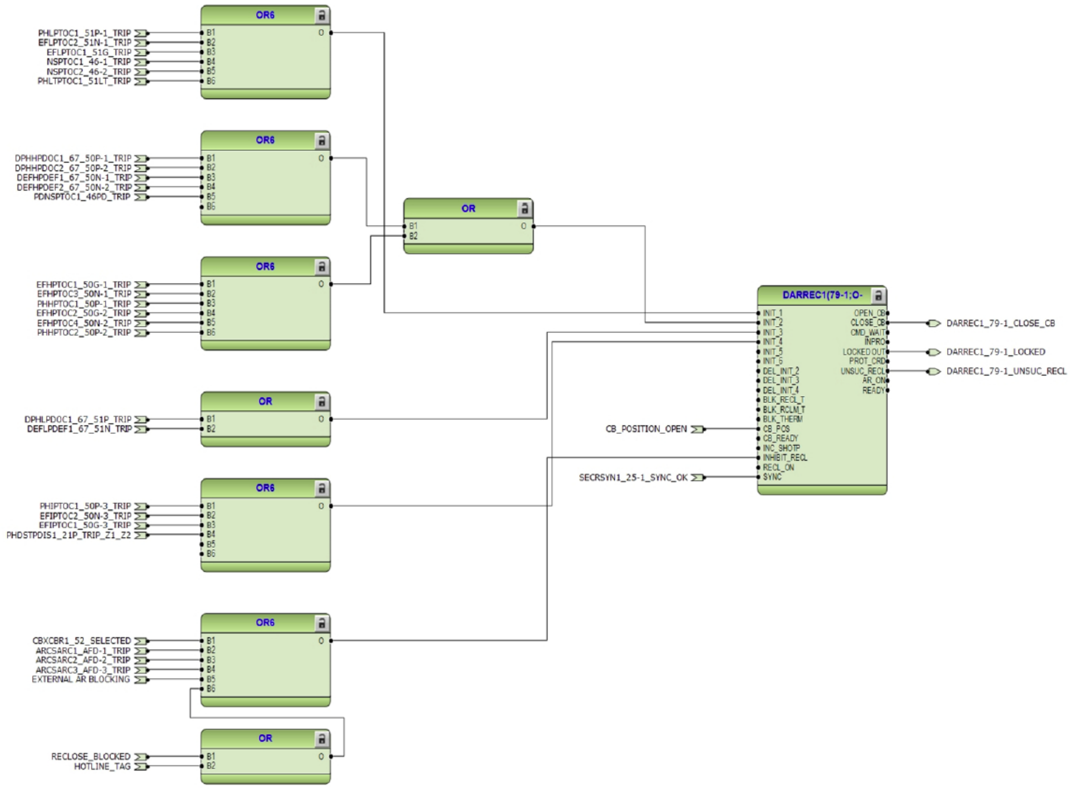


Figure 52: Autoreclosing

3.3.8 Functional diagrams for condition monitoring

Two trip circuit monitoring (TCM-1 and TCM-2) stages are provided to supervise the trip circuit of the circuit breaker connected at PO3 (X100:15-19) and PO4 (X100:20-24).

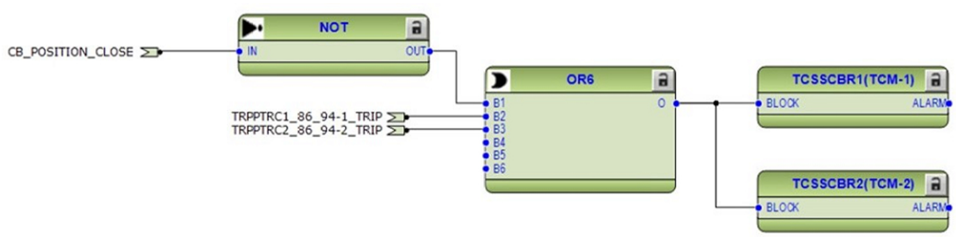


Figure 53: Trip circuit monitoring

The TCM-1 and TCM-2 functions are blocked by 86/94-1, 86/94-2 and when the circuit-breaker is not in closed position.

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 (CCM). When a failure is detected, function activates and can be used to block protection functions which operates using calculated sequence component currents for example 46, thus avoiding mal-operation.

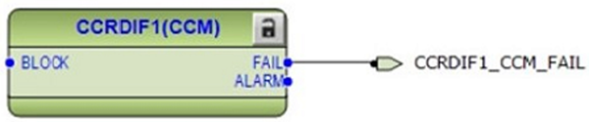


Figure 54: Current circuit supervision

By default the FAIL output from CCM 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 55: Fuse failure monitoring

The circuit breaker condition monitoring function (52CM) supervises the circuit breaker status based on the binary input information connected and measured current levels. The function introduces various supervision alarms.

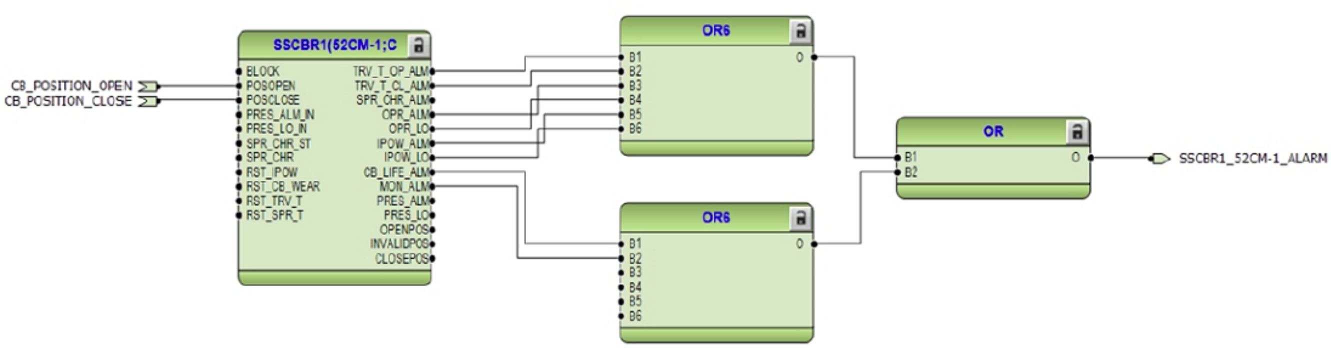


Figure 56: Circuit breaker condition monitoring

Cable fault detector (CFD) is offered for detecting self clearing in the feeder.

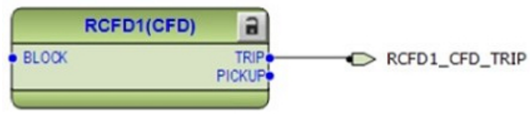


Figure 57: Cable fault detector

By default the TRIP output from CFD function is only connected to disturbance recorder.

3.3.9 Functional diagrams for measurements

The phase current inputs to the IED are measured by three-phase current measurement (IA, IB, IC) function block. The current input is connected to the X120 card in the back panel. Similarly the sequence and residual current are measured by sequence current measurement (I1, I2, I0) and residual current measurement (IG) function blocks respectively.

The phase voltage input is connected to the X130 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 measurements can be seen from the LHMI and is available using the measurement option in the menu selection. Based on the settings, function blocks can generate low alarm/warning, high alarm/warning signals for the measured current values.

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

The power quality function (PQI-1) is used to measure the harmonic contents of the phase current. This functionality is included according to ordercode selection.

The power quality function (PQVPH-1) is used to measure the harmonic contents of the phase voltages. This functionality is included according to ordercode selection.

The power quality function (PQSS-1) is used to measure the voltage variation i.e. sags and swells. This functionality is included according to ordercode selection.

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

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 corresponding feeder.

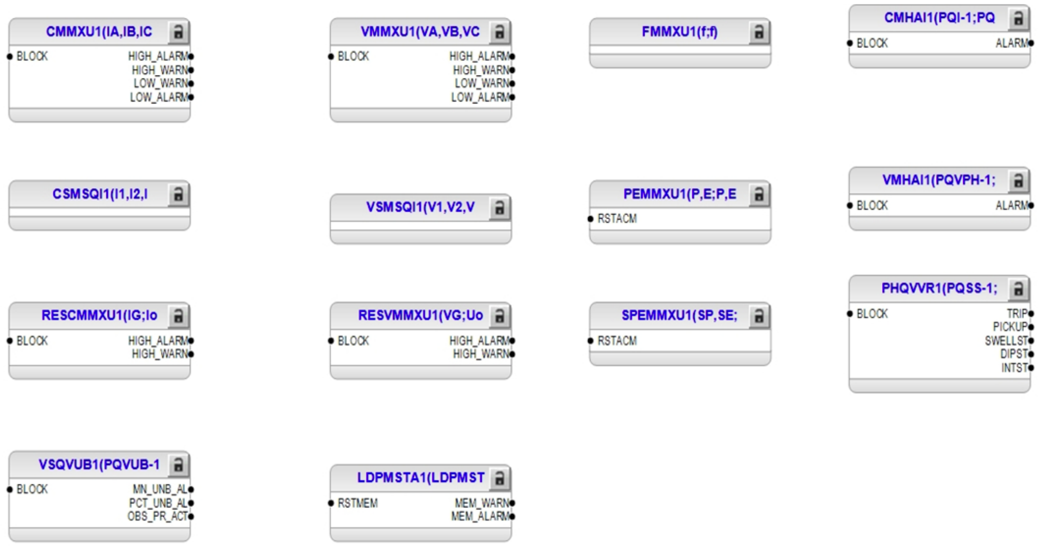


Figure 58: Current, voltage, power and energy measurements and load profile function

3.3.10 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 off TOF-1, TOF-2, TOF-3 and TOF-4,
- Four instance of Time delay on TON-1, TON-2, TON3 and TON-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.

3.3.11 Functional diagrams for logging functions

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

Table 14: List of analog channels connected to DFR (REF620 Config A)

Ch. No	Channel
1	IA
2	IB
3	IC
4	IG
5	VA
6	VB
7	VC
8	VG
9	VA2
10	
11	
12	

A few channels of the binary channel are connected to trigger the digital fault recorder as shown in Figure 59. More connection can be made as per individual need. Also when disturbance recorder is triggered the analog values available at the analog inputs are recorded by fault recorder FR.

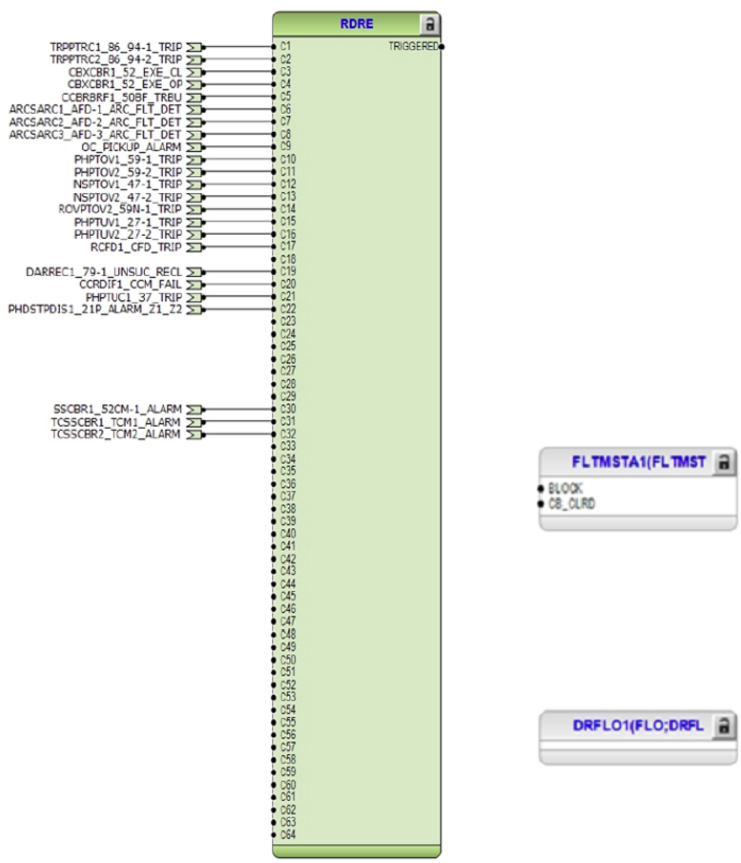


Figure 59: 64 channel Disturbance fault recorder and locator

3.3.12 Functional diagrams for I/O and Alarm LEDs

The default binary I/O connected in the configuration and Alarm LEDs are indicated in Figure 60 to Figure 63.

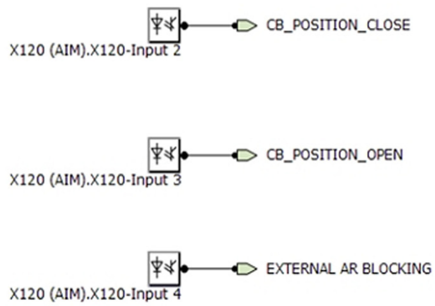


Figure 60: Binary inputs

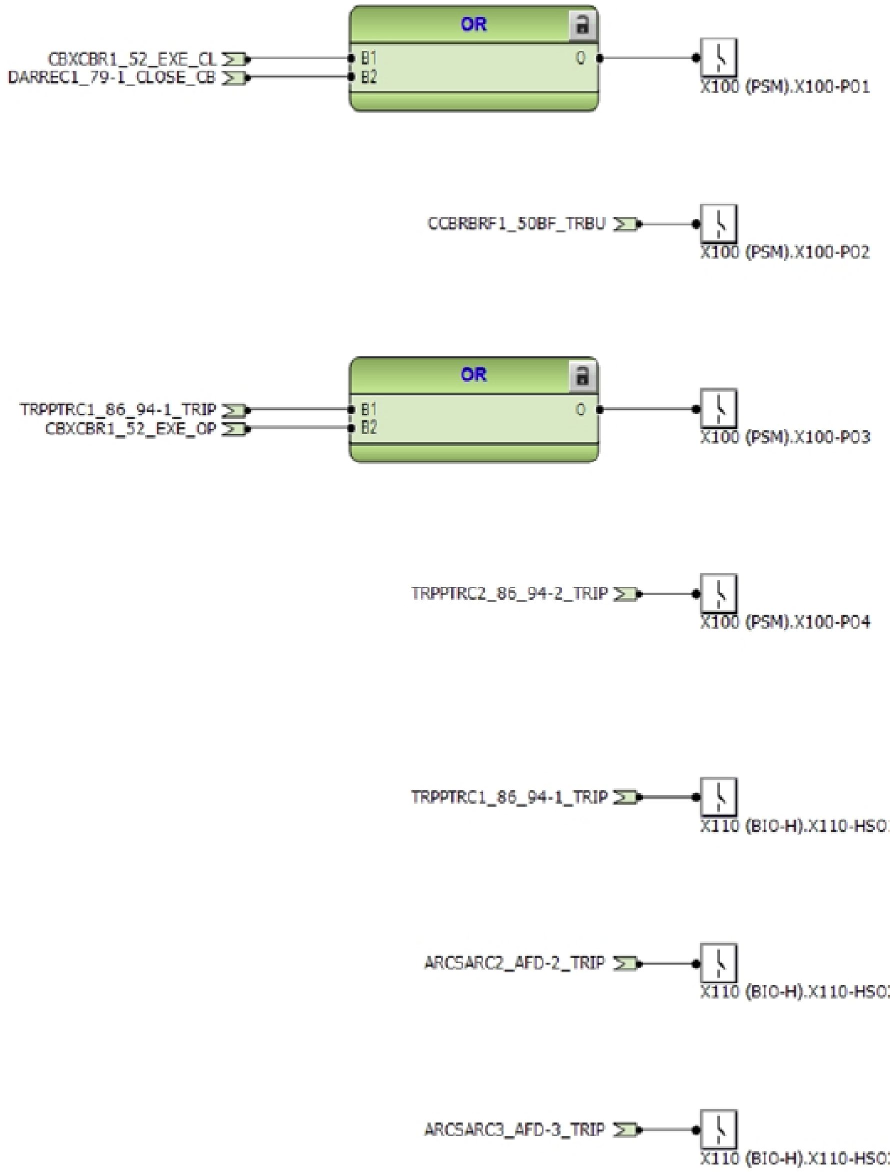


Figure 61: Binary outputs

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

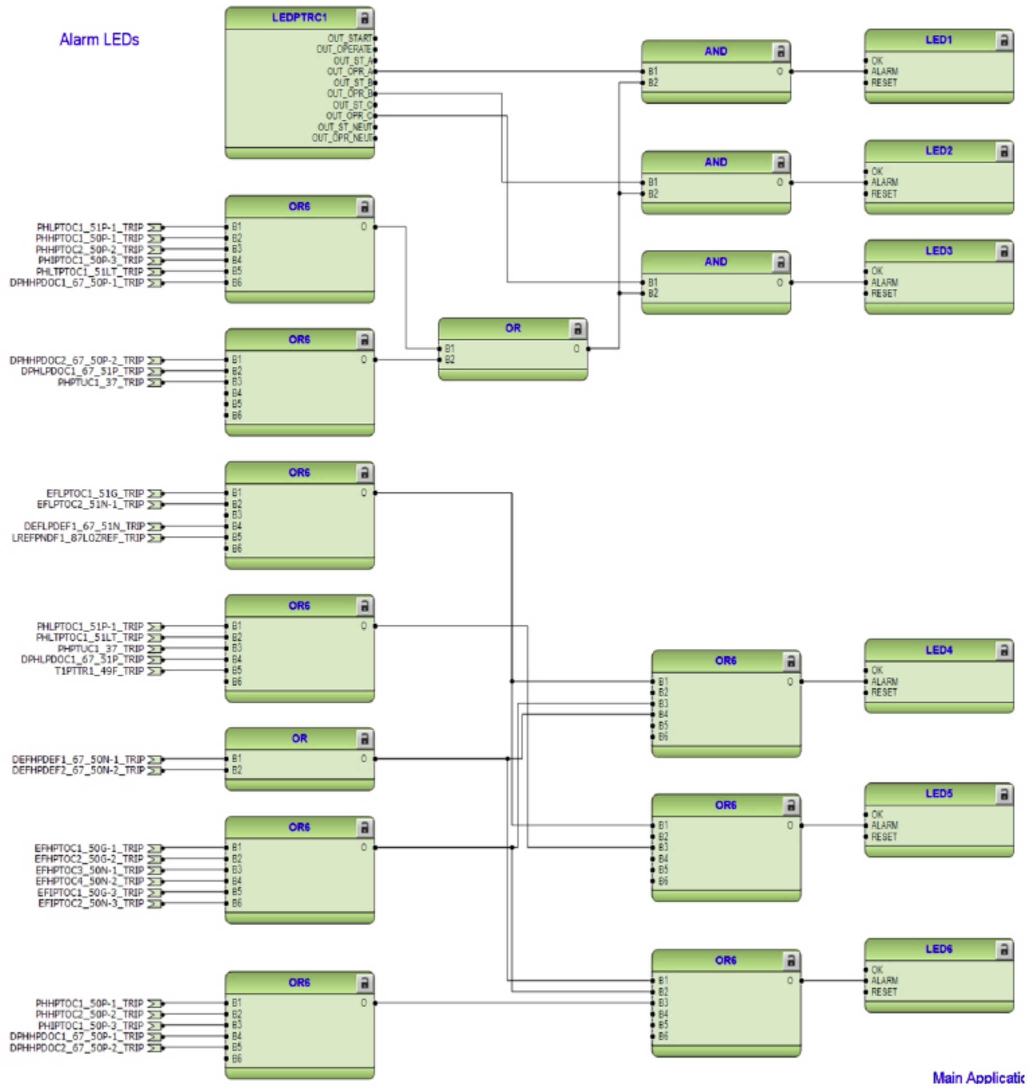


Figure 62: Alarm LEDs 1 – 6

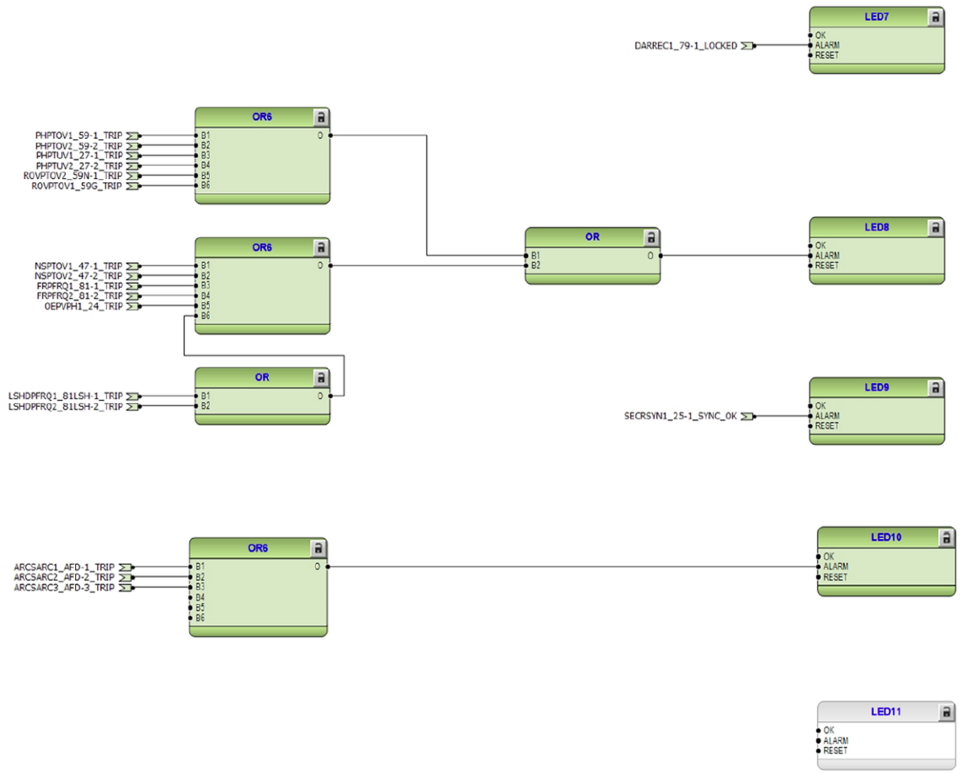


Figure 63: Alarm LEDs 7 – 11

3.4 Standard configuration for order code functional application B

3.4.1 Applications

This standard configuration is mainly intended for distribution feeders with dual breakers, with special consideration for 'Breaker-and-a-half' system, with power and energy metering provided as standard. This configuration includes non-directional and directional phase and ground overcurrent, phase distance, voltage and frequency protection.

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

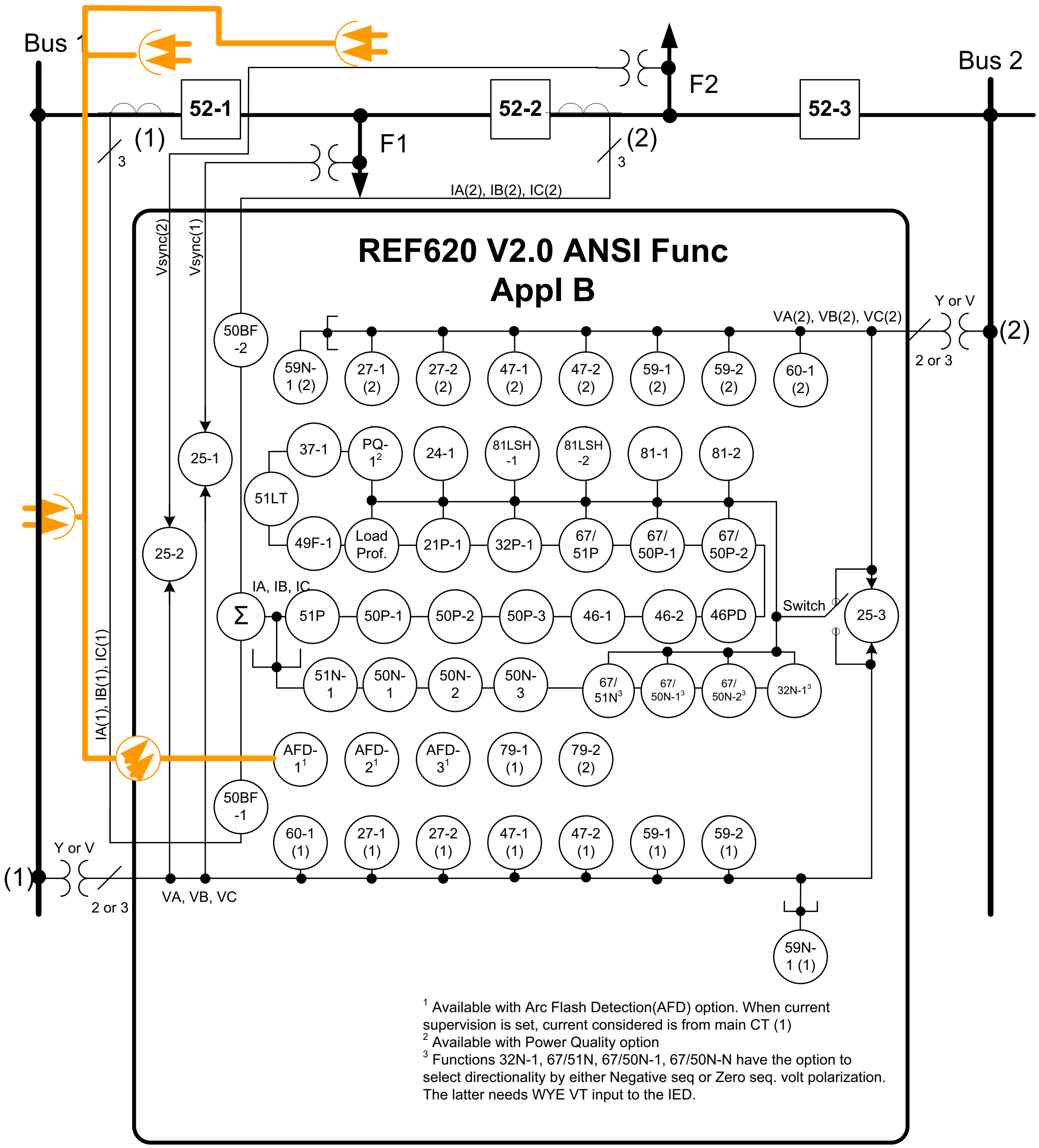


Figure 64: Functions included in the REF620 standard configuration B

3.4.3 Functions

Table 15: Functions included in the REF620 standard configuration

Software Configuration				B
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	BA
Protection				
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	51P	3I> (1)	•
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	50P-1	3I>> (1)	•
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	50P-2	3I>> (2)	•
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	50P-3	3I>>> (1)	•
Three-phase non-directional long time overcurrent protection, low stage, instance 1	PHLTPTOC1	51LT	3I> (3)	•
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	67/51P	3I> -> (1)	•
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	67/50P-1	3I>> -> (1)	•
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	67/50P-2	3I>> -> (2)	•
Non-directional ground-fault protection, low stage, instance 2	EFLPTOC2	51N-1	Io> (2)	•
Non-directional ground-fault protection, high stage, instance 3	EFHPTOC3	50N-1	Io>> (3)	•
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC4	50N-2	Io>> (4)	•
Non-directional ground-fault protection, instantaneous stage, instance 2	EFIPTOC2	50N-3	Io>>> (2)	•
Directional ground-fault protection, low stage, instance 1	DEFLPDEF1	67/51N	Io> -> (1)	•
Directional ground-fault protection, high stage, instance 1	DEFHPDEF1	67/50N-1	Io>> -> (1)	•
Directional ground-fault protection, high stage, instance 2	DEFHPDEF2	67/50N-2	Io>> -> (2)	•
Three phase directional power protection, instance 1	DPSRDIR1	32P-1	I1-> (1)	•
Ground directional power protection, instance 1	DNZSRDIR1	32N-1	I2 ->, Io-> (1)	•
Phase Distance Protection, instance 1	PHDSTPDIS1	21P	Z<	•
Negative-sequence overcurrent protection, instance 1	NSPTOC1	46-1	I2> (1)	•
Negative-sequence overcurrent protection, instance 2	NSPTOC2	46-2	I2> (2)	•
Phase discontinuity protection	PDNSPTOC1	46PD	I2/I1>	•
Residual overvoltage protection, instance 2	ROVPTOV2	59N-1 (1)	Uo> (2)	•
Residual overvoltage protection, instance 3	ROVPTOV2	59N-1 (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)	•

Software Configuration				B
Function	**IEC 61850**	**ANSI C37.2-2008**	**IEC 60617**	**BA**
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	f>/f<,df/dt (1)	•
Frequency protection, instance 2	FRPFRQ2	81-2	f>/f<,df/dt (2)	•
Voltage per hertz protection, instance 1	OEPVPH1	24	U/f> (1)	•
Three-phase thermal protection for feeders, cables and distribution transformers, Instance 1	T1PTTR1	49F	3Ith>F	•
Phase current sets summing function	CMSUM1	CSUM	CSUM	•
Three phase measurement switching	VMSWI1	VSWI	VSWI	•
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)	•
Three-phase inrush detector, instance 1	INRPHAR1	INR	3I2f> (1)	•
Master trip, instance 1	TRPPTRC1	86/94-1	Master Trip (1)	•
Master trip, instance 2	TRPPTRC2	86/94-2	Master Trip (2)	•
Arc protection, instance 1	ARCSARC1	AFD-1	ARC (1)	•
Arc protection, instance 2	ARCSARC2	AFD-2	ARC (2)	•
Arc protection, instance 3	ARCSARC3	AFD-3	ARC (3)	•
Load shedding and restoration, instance 1	LSHDPFRQ1	81LSH-1	UFLS/R (1)	•
Load shedding and restoration, instance 2	LSHDPFRQ2	81LSH-2	UFLS/R (2)	•
Loss of phase, instance 1	PHPTUC1	37-1	3I< (1)	•
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)	•
Auto-reclosing, instance 1	DARREC1	79-1	O -> I	•
Auto-reclosing, instance 2	DARREC2	79-2	O -> I	•
Synchronism and energizing check, instance 1	SECRSYN1	25-1	SYNC(1)	•
Synchronism and energizing check, instance 2	SECRSYN2	25-2	SYNC(2)	•
Synchronism and energizing check, instance 3	SECRSYN3	25-3	SYNC(3)	•
Condition Monitoring				
Circuit-breaker condition monitoring, instance 1	SSCBR1	52CM-1	CBCM (1)	•

Software Configuration				B
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	BA
Circuit-breaker condition monitoring, instance 2	SSCBR2	52CM-2	CBCM (2)	•
Trip circuit supervision, instance 1	TCSSCBR1	TCM-1	TCS (1)	•
Trip circuit supervision, instance 2	TCSSCBR2	TCM-2	TCS (2)	•
Fuse failure supervision, instance 1	SEQRFUF1	60-1	FUSEF (1)	•
Fuse failure supervision, instance 2	SEQRFUF2	60-2	FUSEF (2)	•
Cable fault detection	RCFD1	CFD	CFD	•
Measurement				
Three-phase current measurement, instance 1	CMMXU1	IA, IB, IC	3I	•
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0	I1, I2, I0	•
Three-phase voltage measurement, instance 1	VMMXU1	VA, VB, VC	3U	•
Three-phase voltage measurement, instance 2	VMMXU2	VA, VB, VC(2)	3U(B)	•
Sequence voltage measurement, instance 1	VSMSQI1	V1, V2, V0	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	SP, SE	•
Three-phase power and energy measurement, instance 1	PEMMXU1	P, E-1	P, E	•
Current total demand distortion, instance 1	CMHAI1	PQI-1	PQM3I	•
Voltage total harmonic distortion, instance 1	VMHAI1	PQVPH-1	PQM3U(1)	•
Voltage total harmonic distortion, instance 2	VMHAI2	PQVPH-2	PQM3U(2)	•
Voltage variation, instance 1	PHQVVR1	PQSS-1	PQ 3U<>(1)	•
Voltage unbalance, instance 1	VSQVUB1	PQVUB-1	PQMUBU(1)	•
Voltage unbalance, instance 2	VSQVUB2	PQVUB-2	PQMUBU(2)	•
Load profile	LDPMSTA1	LoadProf	LoadProf	•
Frequency measurement, instance 1	FMMXU1	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)	•
Minimum pulse timer (2 pcs, second resolution), instance 1	TPSGAPC1	62CLD-1	TPS (1)	•
Minimum pulse timer (2 pcs, second resolution), instance 2	TPSGAPC2	62CLD-3	TPS (2)	•
Minimum pulse timer (2 pcs, minute resolution), instance 1	TPMGAPC1	62CLD-2	TPM (1)	•
Minimum pulse timer (2 pcs, minute resolution), instance 2	TPMGAPC2	62CLD-4	TPM (2)	•
Pulse timer (8 pcs), instance 1	PTGAPC1	PT-1	PT (1)	•
Pulse timer (8 pcs), instance 2	PTGAPC2	PT-2	PT (2)	•
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF-1	TOF (1)	•

Software Configuration				B
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	BA
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF-2	TOF (2)	•
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF-3	TOF (3)	•
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF-4	TOF (4)	•
Time delay on (8 pcs), instance 1	TONGAPC1	TON-1	TON (1)	•
Time delay on (8 pcs), instance 2	TONGAPC2	TON-2	TON (2)	•
Time delay on (8 pcs), instance 3	TONGAPC3	TON-3	TON (3)	•
Time delay on (8 pcs), instance 4	TONGAPC4	TON-4	TON (4)	•
Set reset (8 pcs), instance 1	SRGAPC1	SR-1	SR (1)	•
Set reset (8 pcs), instance 2	SRGAPC2	SR-2	SR (2)	•
Set reset (8 pcs), instance 3	SRGAPC3	SR-3	SR (3)	•
Set reset (8 pcs), instance 4	SRGAPC4	SR-4	SR (4)	•
Move (8 pcs), instance 1	MVGAPC1	MV-1	MV (1)	•
Move (8 pcs), instance 2	MVGAPC2	MV-2	MV (2)	•
Move (8 pcs), instance 3	MVGAPC3	MV-3	MV (3)	•
Move (8 pcs), instance 4	MVGAPC4	MV-4	MV (4)	•
Generic control points, instance 1	SPCGGIO1	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	•
Logging functions				
Disturbance recorder	RDRE1	DFR	DFR	•
Fault recorder	FLMSTA1	FR	FR	•
Sequence event recorder	SER	SER	SER	•
Fault location	DRFLO1	FLO	FLO	•

3.4.4 Default input/output (I/O) assignments

Table 16: Default connections for analog inputs

Analog inputs	Default usage	Connector pins
IA(1)	Phase A current, CT(1)	X120-7, 8
IB(1)	Phase B current, CT(1)	X120-9, 10
IC(1)	Phase C current, CT(1)	X120-11, 12
IA(2)	Phase A current, CT(2)	X120-1,2
IB(2)	Phase B current, CT(2)	X120-3,4
IC(2)	Phase C current, CT(2)	X120-5,6
VA(1)	Phase A voltage, VT(1)	X130-13,14
VB(1)	Phase B voltage, VT(1)	X130-15,16
VC(1)	Phase C voltage, VT(1)	X130-17,18
VA(2)	Phase A voltage, VT(2)	X130-7,8
VB(2)	Phase B voltage, VT(2)	X130-9,10
VC(2)	Phase C voltage, VT(2)	X130-11,12
VSync	Feeder-1 Voltage	X130-5,6
VSync(2)	Feeder-2 Voltage	X130-3,4

*Table 17: Default connections for binary inputs (Alternative 1)**

Binary output	Default usage	Connector pins
X110-BI2	Circuit breaker-2 closed position	X110-3,4
X110-BI3	Circuit breaker-2 open position	X110-5,6
X110-BI4	Circuit breaker-1 closed position	X110-7,6
X110-BI5	Circuit breaker-1 open position	X110-8,9
*Binary inputs when slot ID X110 is ordered with 8BI+4BO BIO card.		

*Table 18: Default connections for binary inputs (Alternative 2)**

Binary output	Default usage	Connector pins
X110-BI2	Circuit breaker-2 closed position	X110-2,5
X110-BI3	Circuit breaker-2 open position	X110-3,5
X110-BI4	Circuit breaker-1 closed position	X110-4,5
X110-BI5	Circuit breaker-1 open position	X110-6,10
*Alternative binary inputs when IED has been ordered with High speed binary output (HSO) card.		

Table 19: Default connections for binary outputs

Binary output	Default usage	Connector pins
X100-PO1	Close circuit breaker-1	X100 – 6,7
X100-PO2	Close circuit breaker-2	X100 – 8,9
X100-SO1	Breaker-1 failure, trip upstream breaker	X100 – 10,12
X100-SO2	Breaker-2 failure, trip upstream breaker	X100 – 13,14
X100-PO3	Open circuit breaker-1 / Master Trip -1	X100 – 15,16,17,18,19
X100-PO4	Open circuit breaker-2 / Master Trip -2	X100 – 20,21,22,23,24

*Table 20: High speed binary output connections**

Binary output	Default usage	Connector pins
X110-HSO1	Open circuit breaker / Master Trip -1	X110 – 15,16
X110-HSO2	Master Trip -2	X110 – 19,20
X110-HSO3	Trip from ARC-3 protection	X110 – 23,24
*Available only if IED has been ordered with High speed binary output (HSO) card and ARC protection		

Table 21: Default connections for LEDs

LED	LED label
LED 1	Phase A
LED 2	Phase B
LED 3	Phase C
LED 4	Neutral, Neutral / Ground, Neutral / SEF
LED 5	Time
LED 6	Instantaneous
LED 7	Recloser lockout
LED 8	Voltage
LED 9	25-1 Alarm
LED 10	25-2 Alarm
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.

3.4.5 Typical connection diagrams

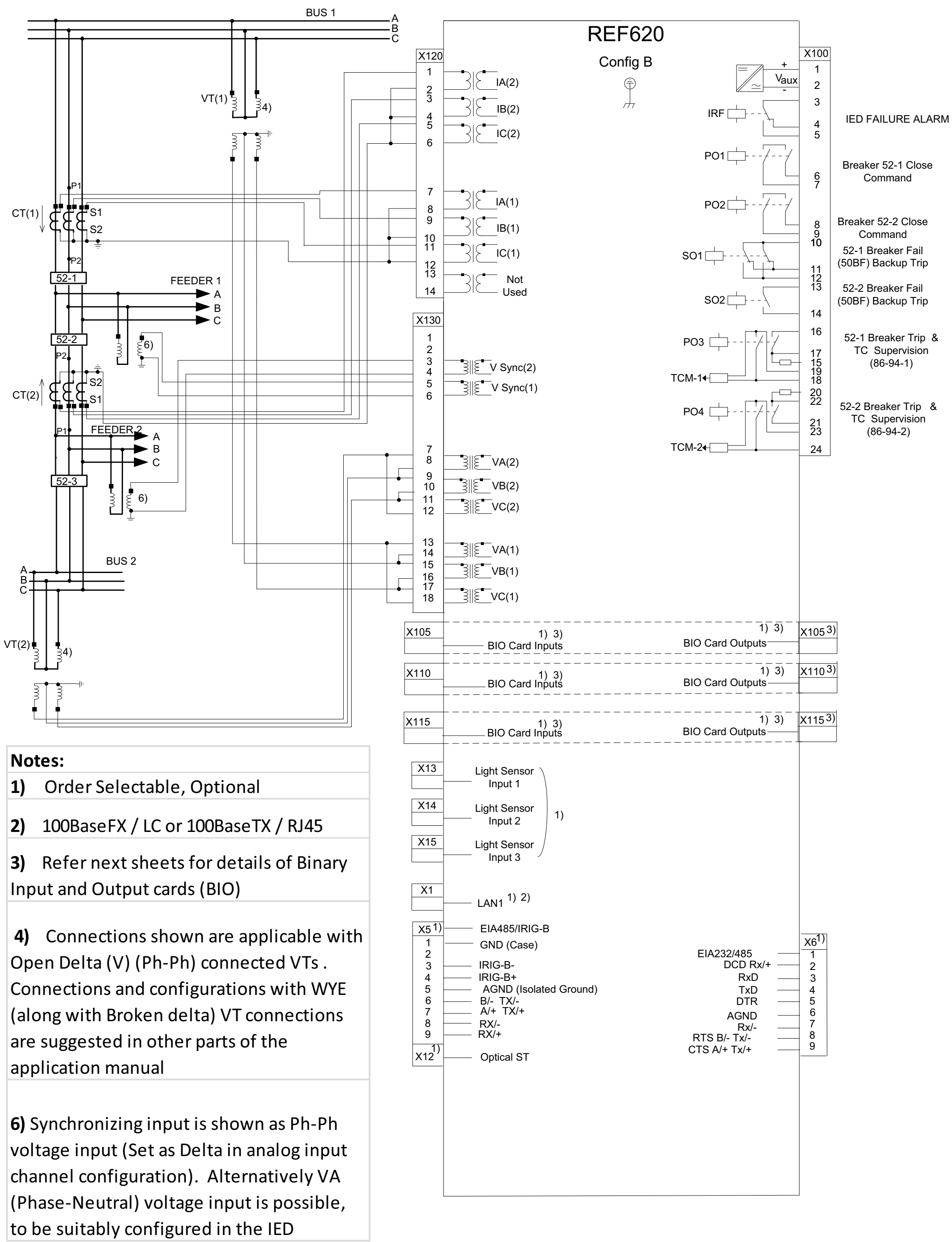
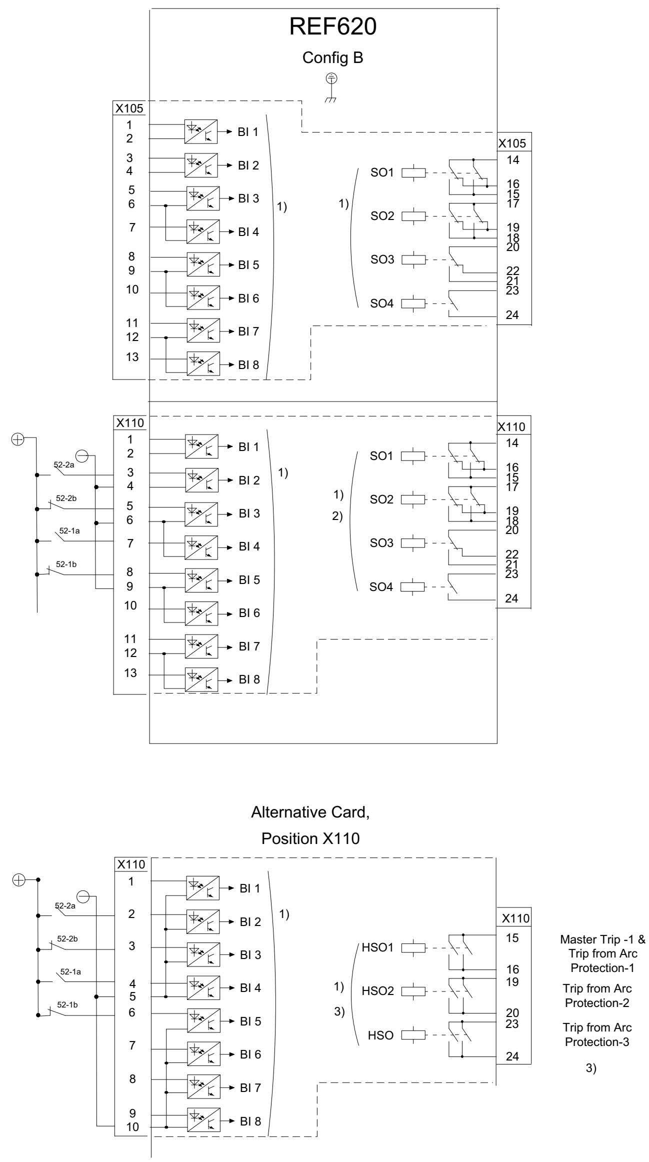
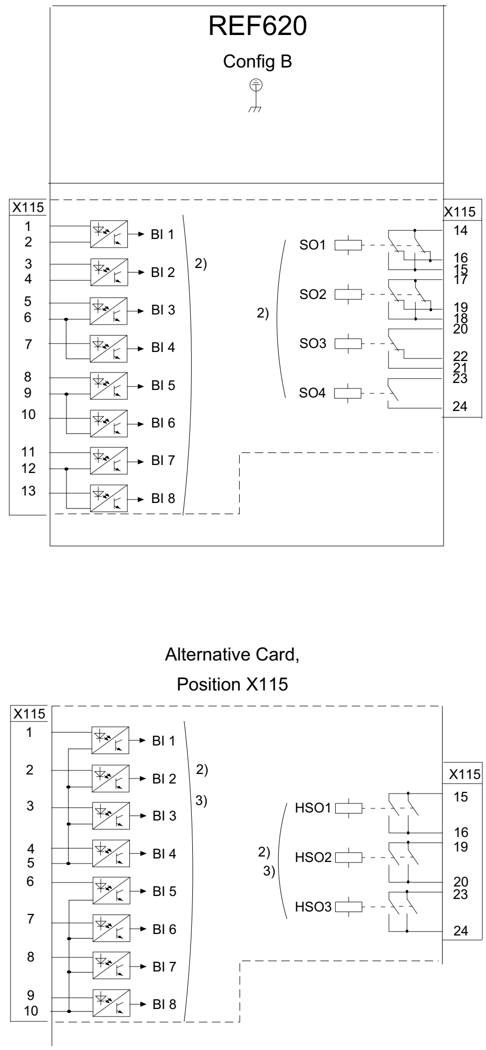


Figure 65: Typical connection diagram of REF620 (Config B)



1) Order Selectable, Optional
2) Order Selectable, Optional alternatives
3) Default outputs configured with High Speed Outputs when Arc protection option is chosen

Figure 66: Typical BIO module equipment arrangement and connections for REF620, Config B (Slot X105 and X110)



Notes:

2) Order Selectable, Optional alternatives

3) High speed BIO card in this slot only when X110 slot is equipped with High speed BIO card

Figure 67: Typical BIO module equipment arrangement and connections for REF620, Config B (Slot X115)

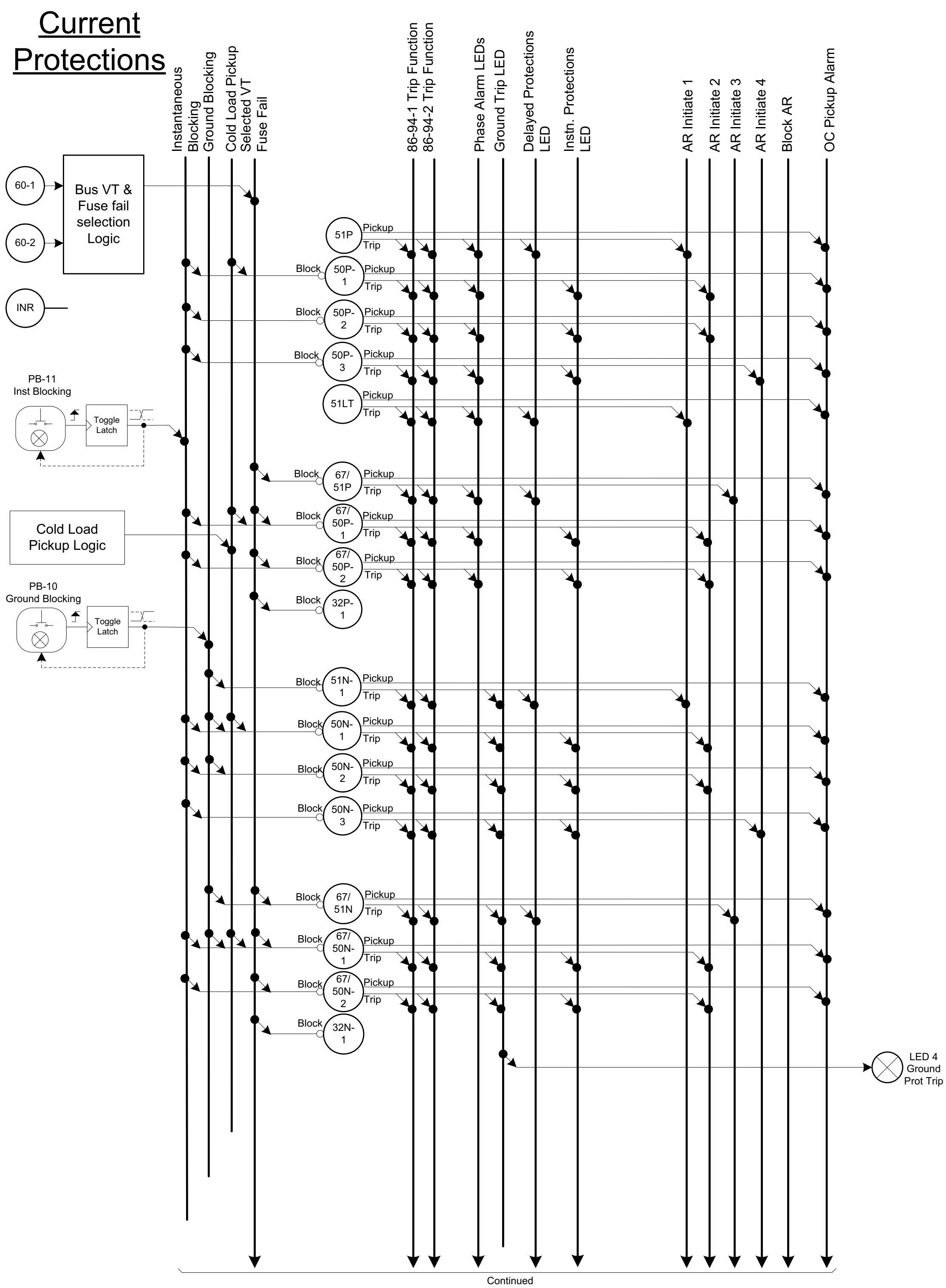


Figure 68: Simplified Logic Diagram for Current Protections, REF620, Config B

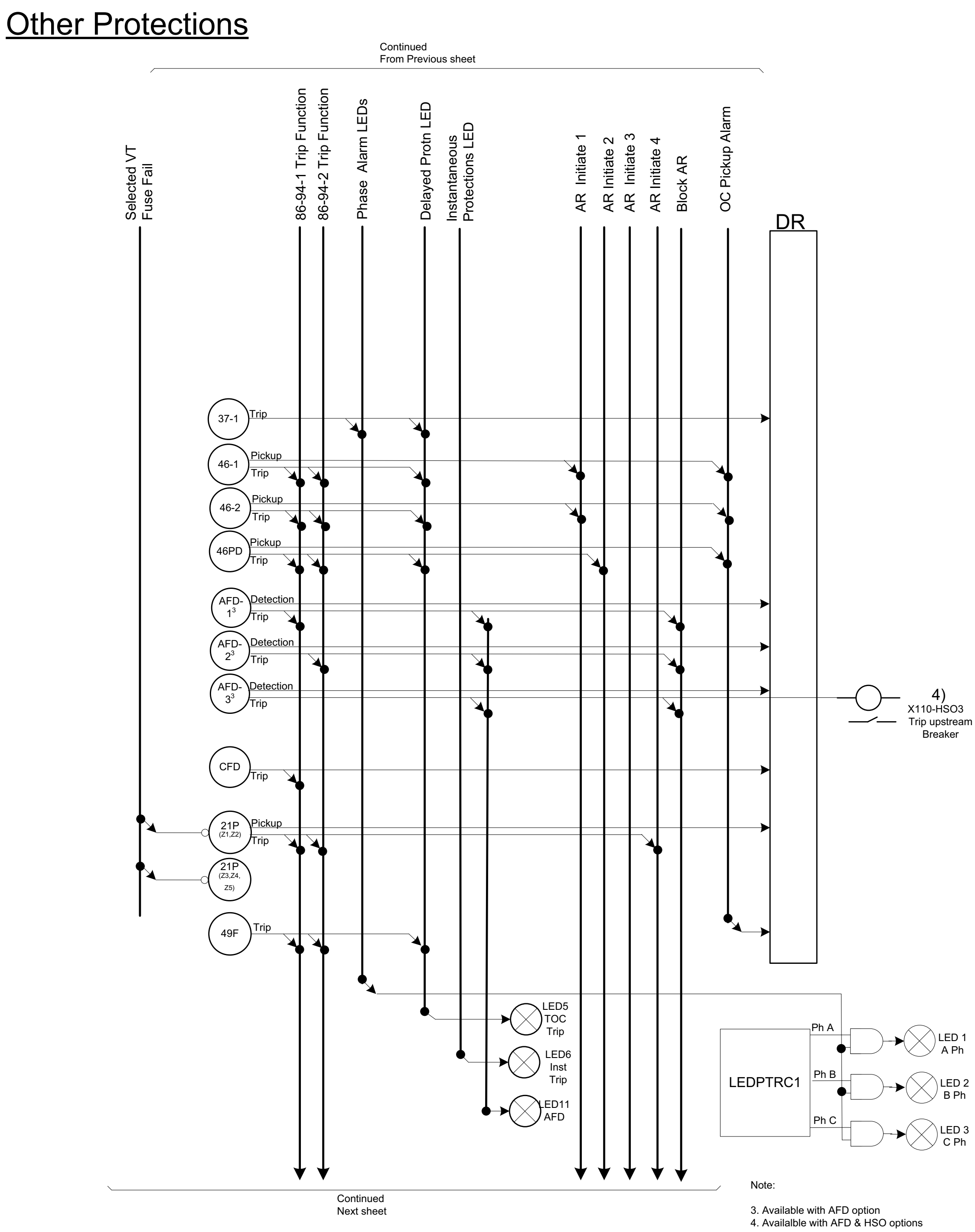


Figure 69: Simplified Logic Diagram for Other Protections, REF620, Config B

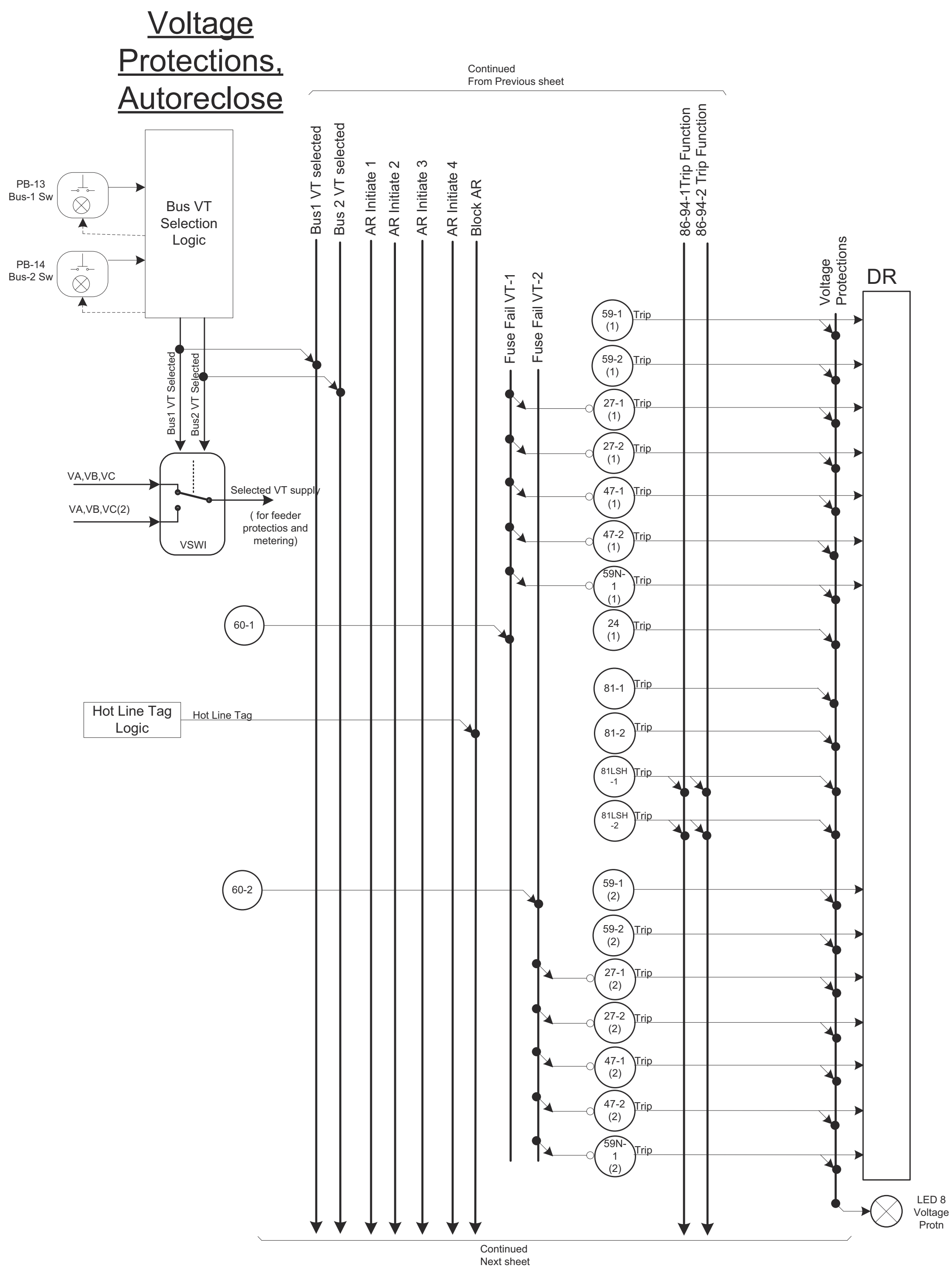


Figure 70: Simplified Logic Diagram for Voltage Protections , REF620, Config B

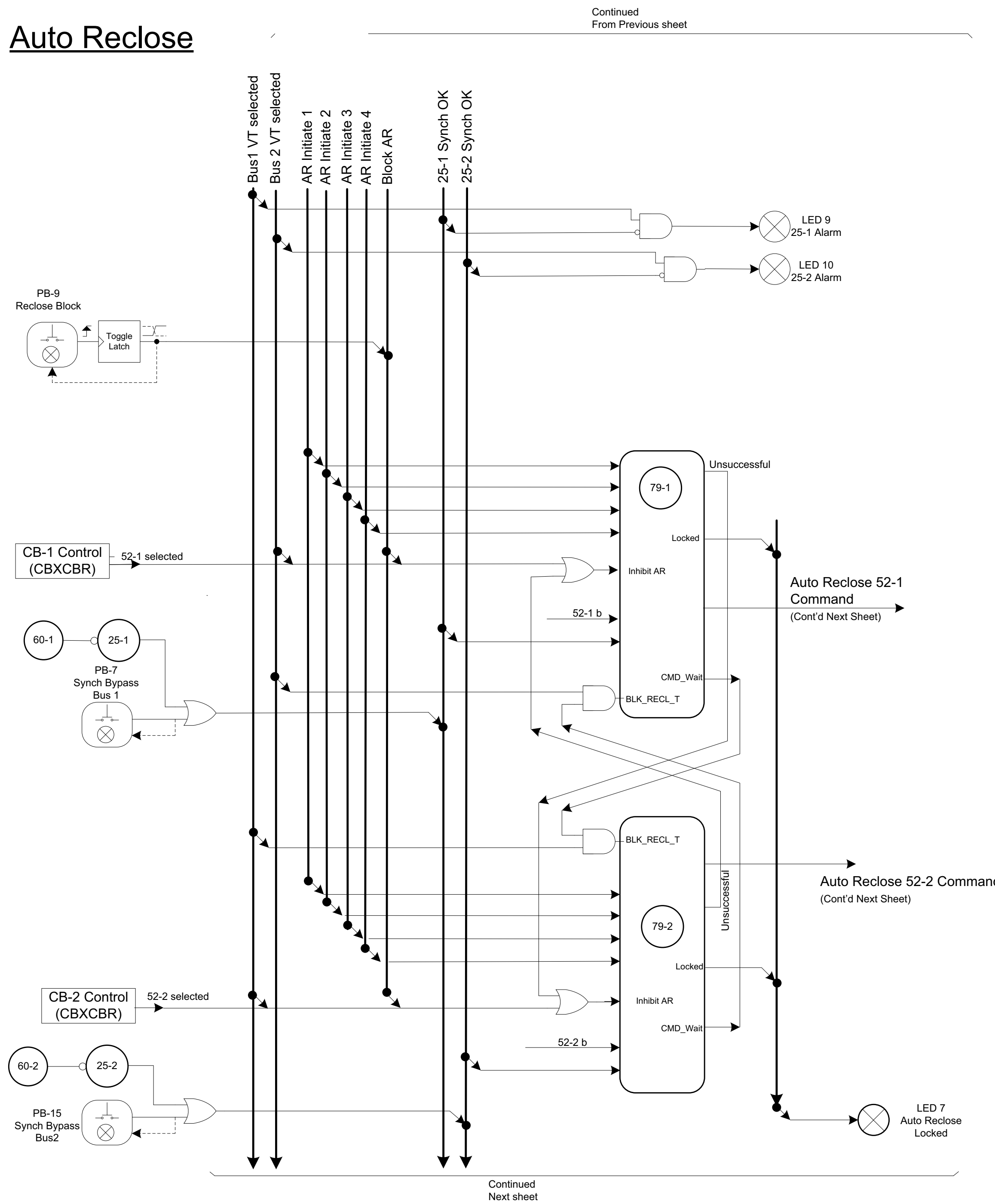


Figure 71: Simplified Logic Diagram for CB Autoreclose, REF620, Config B

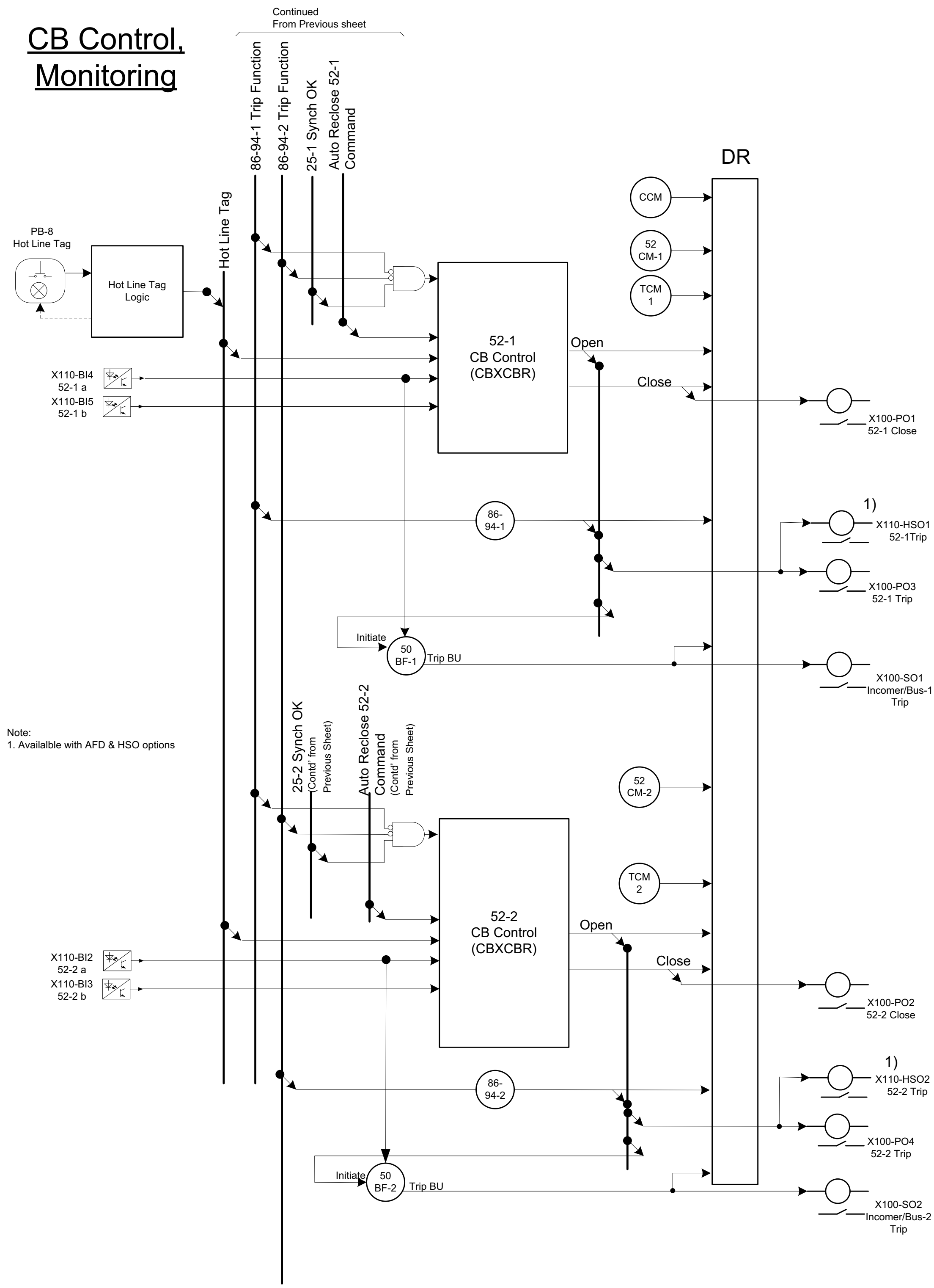


Figure 72: Simplified Logic Diagram for CB Control and Monitoring, REF620, Config B

3.4.6 Functional diagrams

The functional diagrams describe the default input, output, 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.

In double breaker (and CT) fed feeders such as in breaker-and-a-half system, double-bus-double-breaker system and ring bus systems, the protected feeder is electrically tied up with both the breakers and Current Transformers. Traditionally, the CTs were externally paralleled with appropriate polarities, to get resultant current flowing through the feeder and was thus used to measure and protect the feeder. This configuration allows currents from each breaker to be individually fed to the IED. An internal function (CMSUM1), sums up the currents before being fed to the feeder protection and measurement functions.

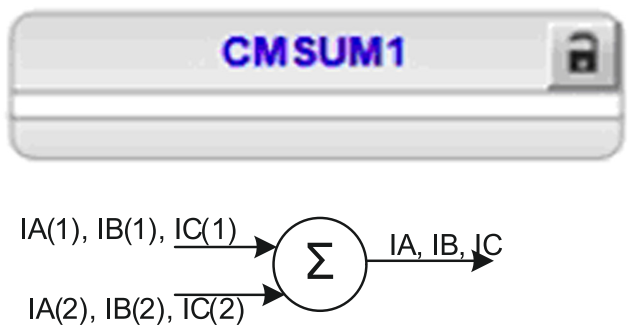


Figure 73: CT Input currents summation Function

One major advantage of this approach is that it is possible to measure and record individual breaker currents which is very important to get better insight into the system. The IED has additionally the breaker fail protection functions connected to each of the current input, so in case of failure of one of the breakers, selective action can be taken to identify and isolate only the faulted breaker, which is the very purpose of providing multiple breakers feeding a feeder.

The signal marked with IA, IB and IC represents the three phase current from bus side breaker (52-1) and the signal IA(2), IB(2), IC(2) represent the current fed from the second (Tie / Middle in breaker-and-a-half system) breaker.

The signal marked with VA, VB and VC represents the three phase system voltages on the bus-1, to which the feeder is connected through breaker 52-1. The signal marked with VA(2), VB(2) and VC(2) represents the three phase system voltages on the other bus (Bus-2), to which the feeder is connected through breaker 52-2 (and further through 52-3 in case of breaker-and-a-half system). These 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.

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.

The signal marked VSync is measured from the VT on the feeder side of the breaker. This signal is used for check synchronizing purposes. The input again is configured for Ph-Ph input from the system by default, but can be suitably configured to take input from Ph-G voltage input as well. Care shall be taken in setting the synchrocheck function with correct phase angle correction, especially in applications such as voltages fed to synchrocheck across a transformer with vector shift.

In 'breaker-and-a-half' systems, additional voltage from the second feeder (in the diameter) is brought to the IED as Vsync(2). This along with respective signals from the bus or the concerned feeder can be suitably selected to close appropriate breaker in the diameter. Synchro check logic gets quite complex in some of the applications. Typically in breaker-and-a-half system, because of primary system switching flexibilities, it is possible that a particular synchronizing reference voltage may not be available. Hence it is necessary to choose a different live point of the system to tap reference voltage for synchronizing purposes. REF620 allows full flexibility in selecting the appropriate logic, by providing three sycnhro check function in the IED. The first is connected across Bus-1 and protected feeder voltages. The second one is connected across the protected feeder and the second feeder voltages. The third one is connected across the two bus voltages.

Should the three phase bus VT voltage fail, say on fuse failure, it is possible to switch the critical voltage dependent protection, control and metering functions to the second bus VT (and back to the main bus) through a VT selection function block (VMSWI), within the IED. The IED is configured to have this selection done manually through a pushbutton in the front of the IED.

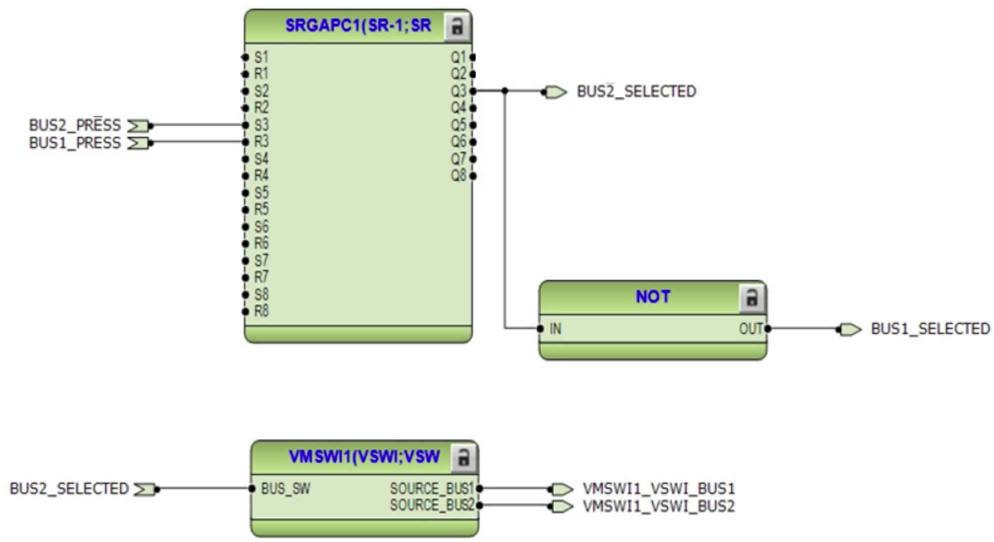


Figure 74: Bus Voltage selection

REF 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, hot line tag, sensitive earth fault detection, bus voltage selection (when provided), etc. Figure 75 shows the default mapping for the available programmable buttons. Figure 76 shows the hot line tag logic.

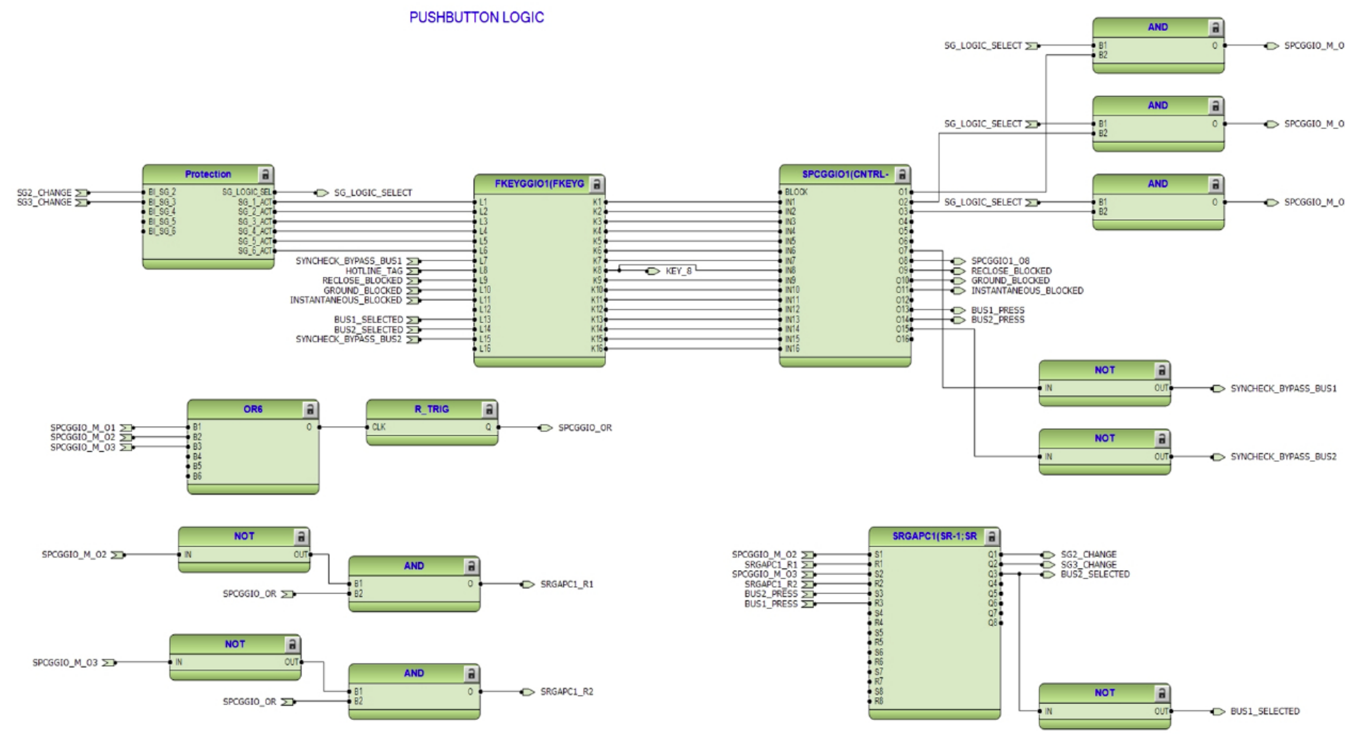


Figure 75: *Default mapping on programmable buttons*

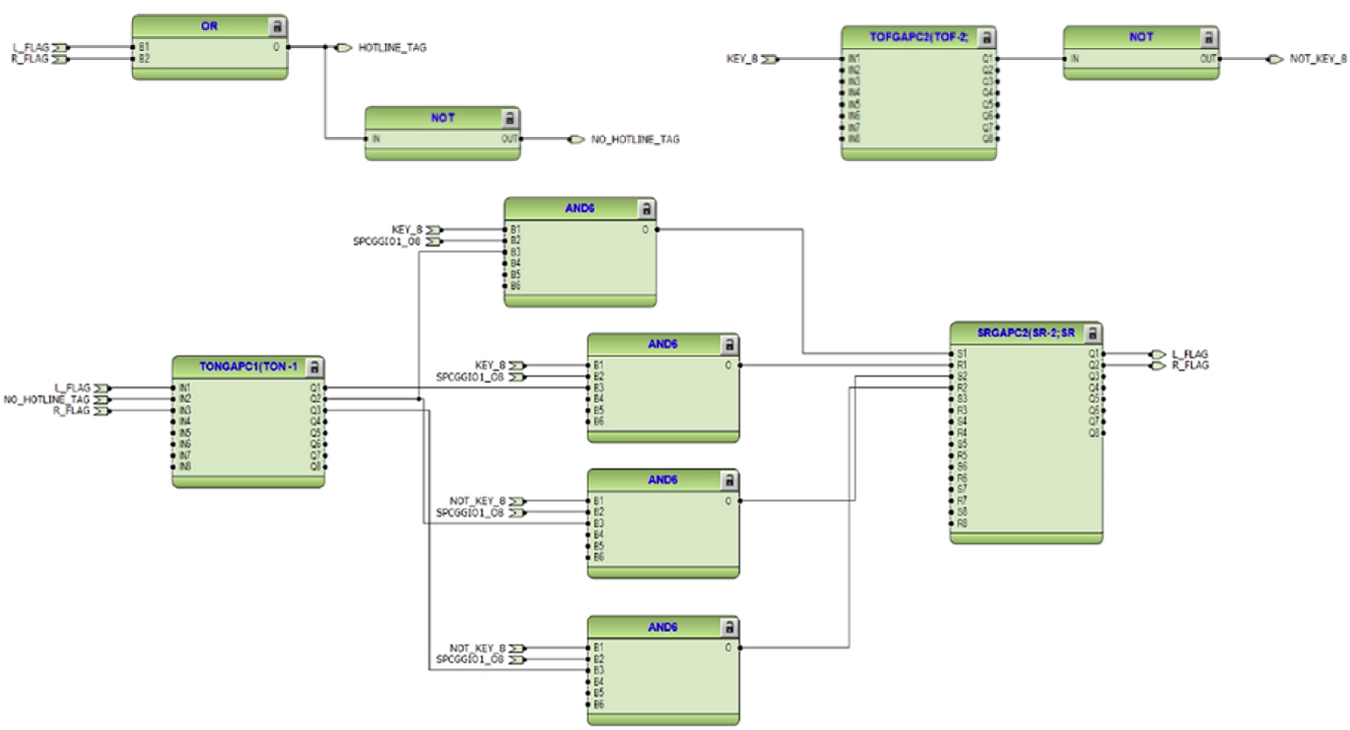


Figure 76: *Hot line Tag logic*

3.4.7 Functional diagrams for protection

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

Eight overcurrent stages (51P, 50P-1, 50P-2, 50P-3, 51LT, 67/51P, 67/50P-1, 67/50P-2) in total are offered for overcurrent and short-circuit protection. Three of them include directional functionality. The non-directional high stage (50P-1) and directional high stage (67/50P-1) will be blocked by cold load detection logic. The cold load detection logic starts from closing of the circuit breaker and is active during set time. The cold load detection logic's active time can be set in a resolution of minutes or seconds to the functions TPSGAPC and TPMGAPC.

The directional overcurrent and short circuit protection will be blocked by default also if the fuse failure situation is detected.

The inrush detection block's (INR-1) output BLK2H offers the possibility to either block the function or multiply the active settings for any of the shown protection function blocks.

All trip signals are connected to the Master Trip and also to the alarm LEDs. Alarm LEDs 1, 2 and 3 are used for phase segregated information of faults. The alarm LED 5 is used to indicate time delayed trips and the alarm LED 6 instantaneous trips of the current based protection functions.

The pickup information of all overcurrent functions is collected to the variable OC_PICKUP_ALARM and connected to the disturbance recorder. This signal can be mapped to the signal outputs depending on the application needs.

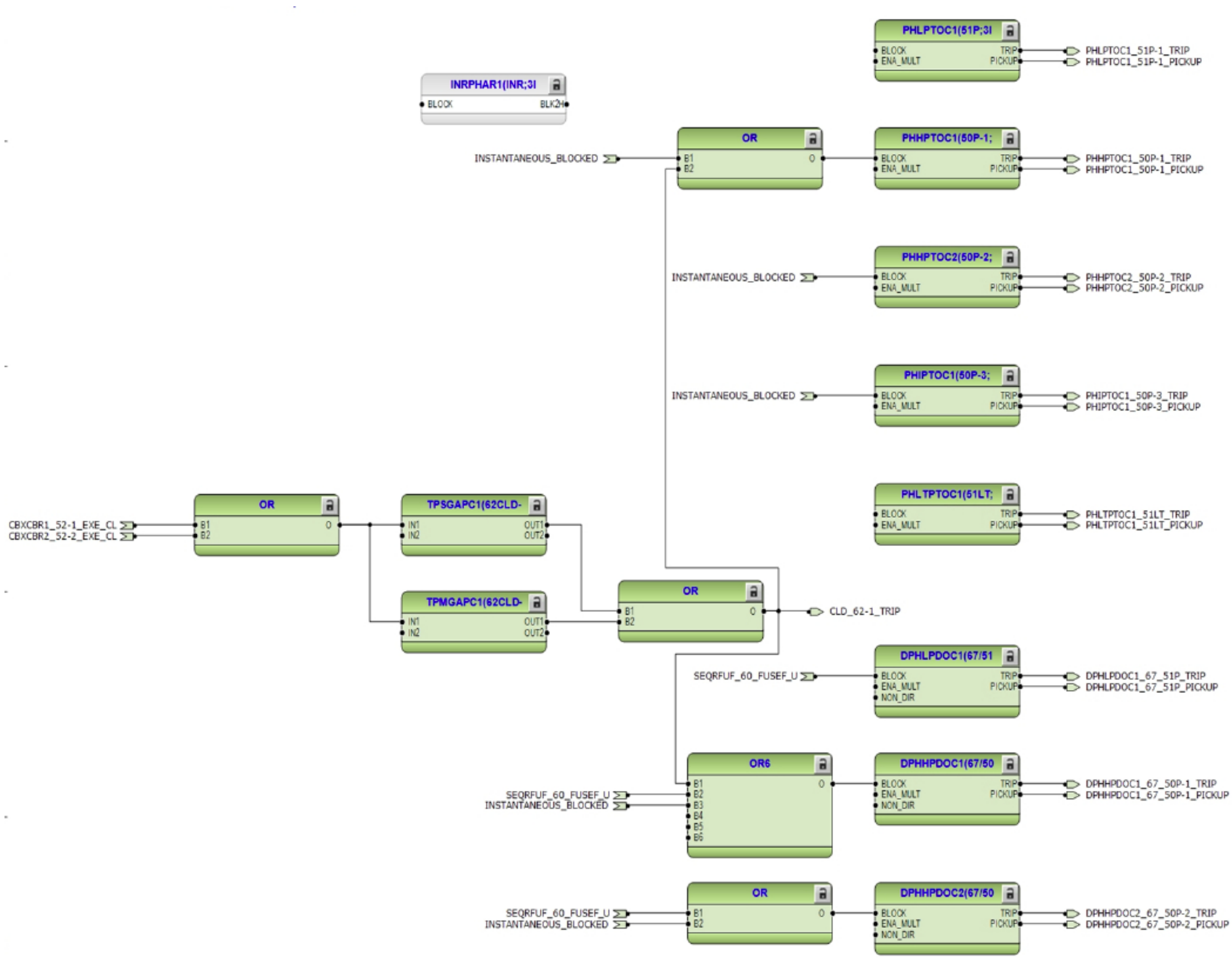


Figure 77: Three phase overcurrent protection

Four stages are provided to non-directional neutral overcurrent protection (51N-1, 50N-1, 50N-2, 50N-3). The neutral overcurrent protection uses calculated residual current component.

The operation of 51N-1, 50N-1 and 50N-2 and 50N-3 will be blocked if GROUND_BLOCKING input is active. The 50N-1 will also be blocked if the cold load detection logic is activated. The operation of neutral overcurrent protection functions is connected to alarm LED 4.

The alarm LED 5 is used to indicate time delayed trips and the alarm LED 6 instantaneous trips of the current based protection functions.

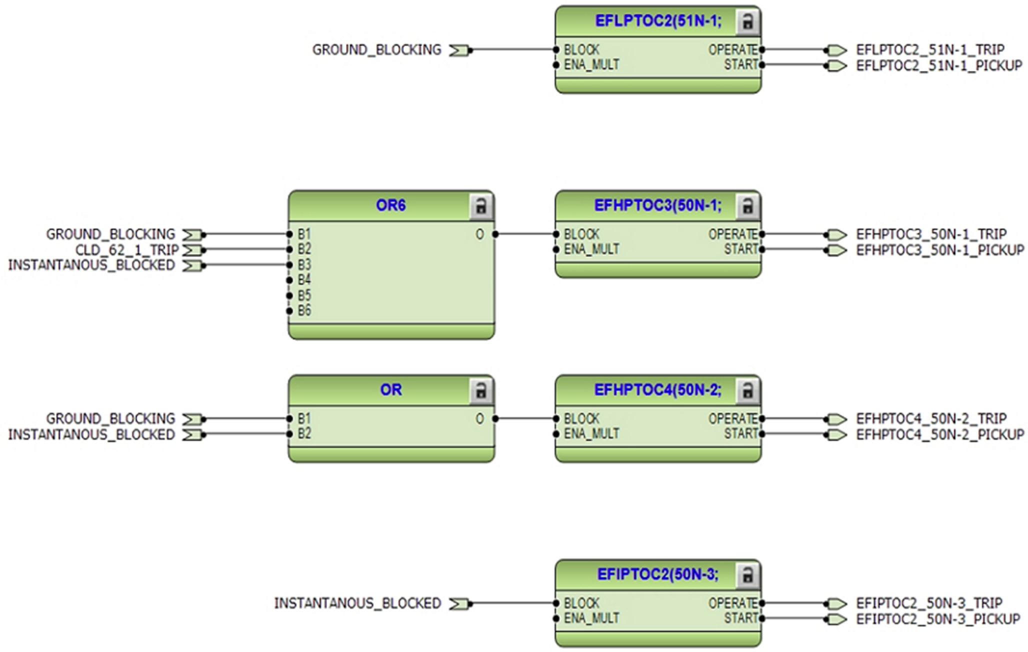


Figure 78: Non-directional neutral overcurrent protection

Three stages are offered for directional ground-fault protection (67/51N, 67/50N-1, 67/50N2). By default the stages (67/51N) and (67/50N-1) will be blocked by activating the GROUND_BLOCKING input. If the cold load situation is detected the (67/50N-1) function will be blocked. Also if the fuse failure situation is detected all directional ground-fault protection functions will be blocked. While setting the directional element, it is necessary to choose either V0 calculated or Negative sequence voltage polarization. While either one may be selected with WYE connected VT, it is essential to choose negative sequence voltage polarization with V (Delta) connected VT input from which zero sequence voltage cannot be derived.

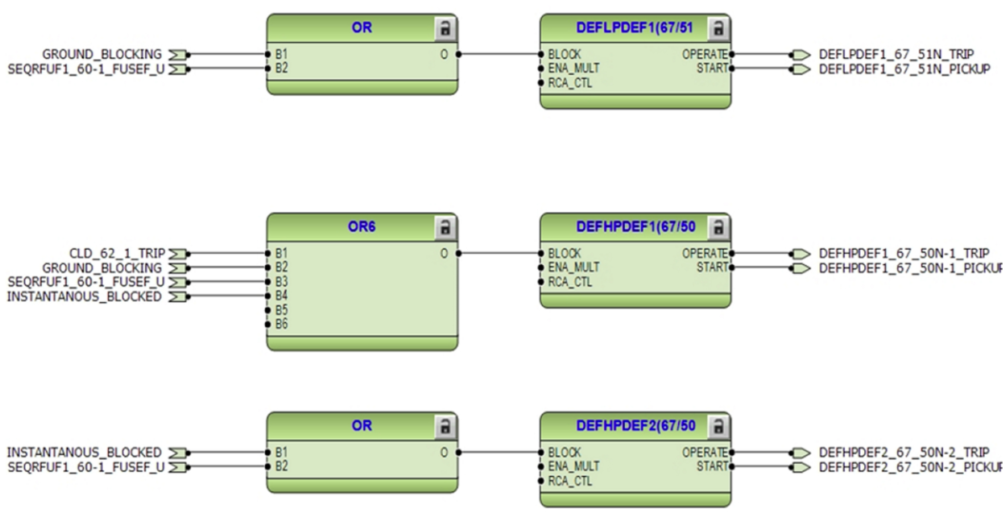


Figure 79: Directional neutral overcurrent protection

Two negative-sequence overcurrent protection (46-1 and 46-2) stages are provided for phase unbalance protection. These functions are used to protect the feeder against phase unbalance.

The phase discontinuity protection (46PD) provides protection for interruptions in the normal three-phase load supply, like in downed conductor situations.

The operation of 46-1, 46-2 and 46PD is not blocked as default by any functionality. The operation of these protection functions is connected to alarm LED 5. The pickup signals are connected to OC_PICKUP_ALARM variable in logic.

The undercurrent protection function (37-1) is offered for protection against loss of phase situations. The trip signal is connected to the disturbance recorder only by default.

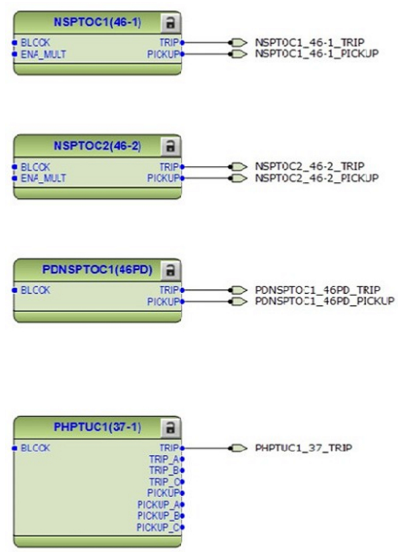


Figure 80: Negative sequence, phase discontinuity and undercurrent protection

All overcurrent pickup signals are merged together as variable OC_PICKUP_ALARM. This alarm is by default connected to disturbance recorder channel. It can be mapped also e.g. for alarming or blocking purposes to the binary output relays.

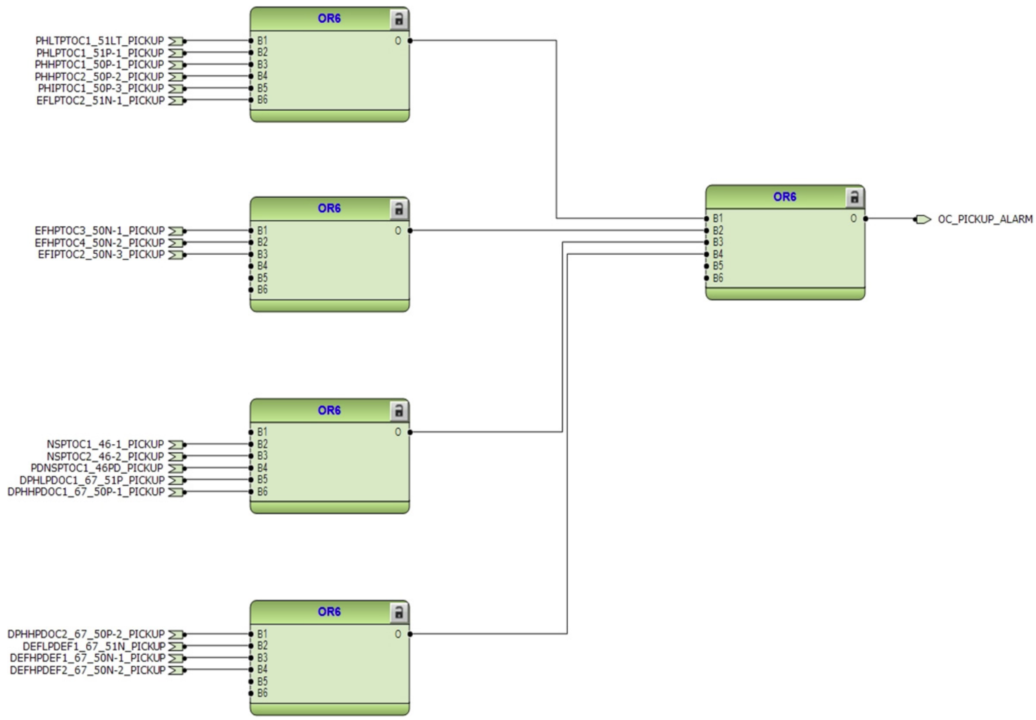


Figure 81: *Overcurrent pickup alarm*

The directional positive sequence power protection (32P-1) and directional negative sequence power protection (32N-1) are offered in configuration. The output information of these functions can be used e.g. releasing or blocking purposes but by default those are not connected. Directional power protection functions are blocked by default configuration connection if fuse failure is detected.

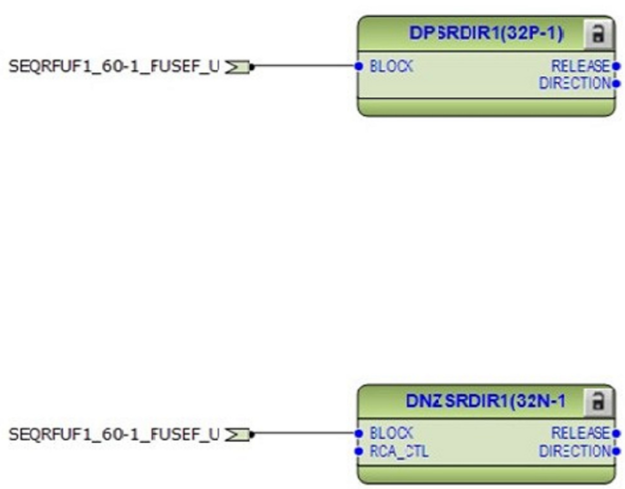


Figure 82: *Directional power protection*

Each bus input voltage is provided with a pair of overvoltage and undervoltage protection stages {27-1(1), 27-2(1) and 59-1(1), 59-2(1) for bus 1 and 27-1(2), 27-2(2) and 59-1(2), 59-2(2) for bus 2} which 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.

Similarly, each bus voltage is provided with negative-sequence overvoltage {47-1(1) and 47-2(1) for bus 1 and 47-1(2) and 47-2(2) for bus 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.

Each bus is also with a residual overvoltage protection, {59N-1(1) for bus 1 and 59N-1(2) for bus 2) which provide ground-fault protection by detecting abnormal level of residual voltage. They can be used, for example, as a nonselective backup protection for the selective directional ground-fault functionality. The operation signal is connected to alarm LED 8.

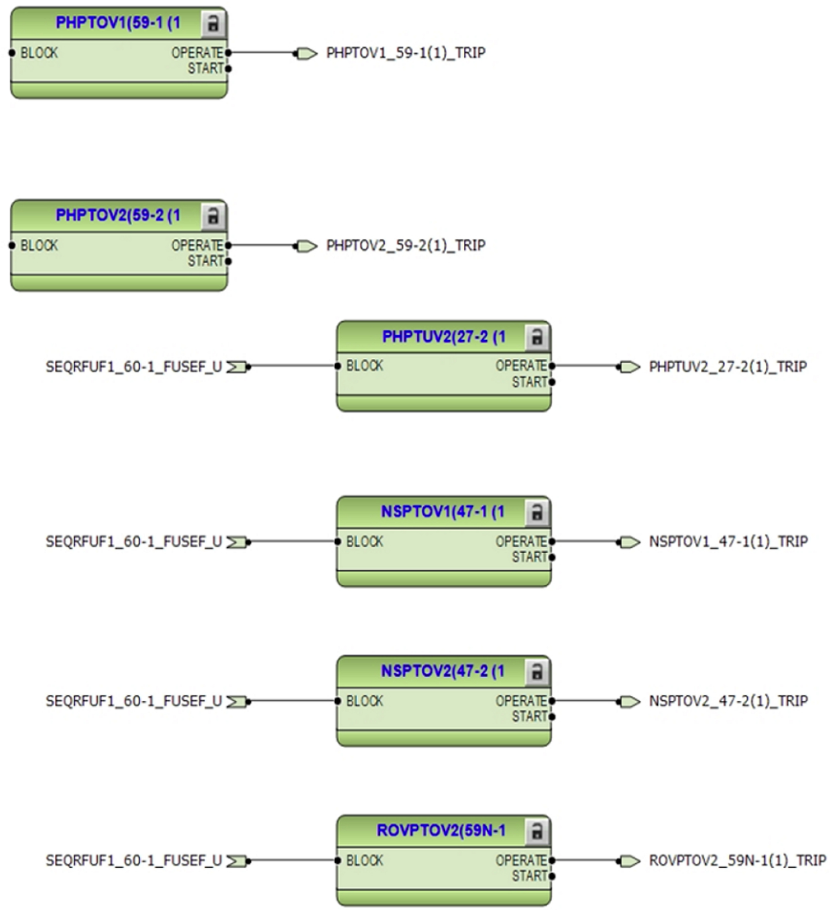


Figure 83: Voltage protection functions (Bus1, typical)

The over excitation protection function (24) is offered as standard. By default the TRIP output is connected only to alarm LED 8.

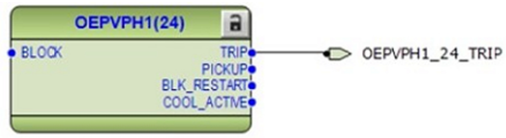


Figure 84: Over excitation protection

The thermal overload protection function (49F-1) detects short and long term overloads under varying load conditions.

The trip of the thermal overload protection function is connected to the Master Trip 1. The alarm and trip signals are connected to alarm LED 5.

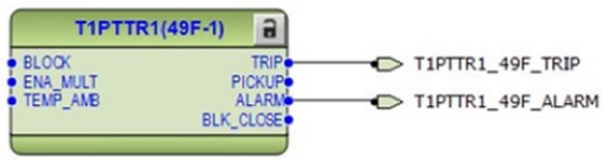


Figure 85: Thermal overload protection

Since the IED caters to two breaker control and protection, there are dual circuit-breaker failure protection (50BF-1 and 50BF-2) initiated via the PICKUP input of respective breaker fail function from protection outputs / commands that open the respective circuit breaker.

50BF offers different operating modes associated with the circuit-breaker position and the measured phase and calculated residual currents.

50BF-1 has two operating outputs: TRRET and TRBU. The TRBU output can be used to give a backup trip to the circuit breaker feeding upstream. In the configuration the TRBU output signal is connected to the output S01 (X100: 10-12) for CB1 and S02 (X100: 13-14) for CB2.

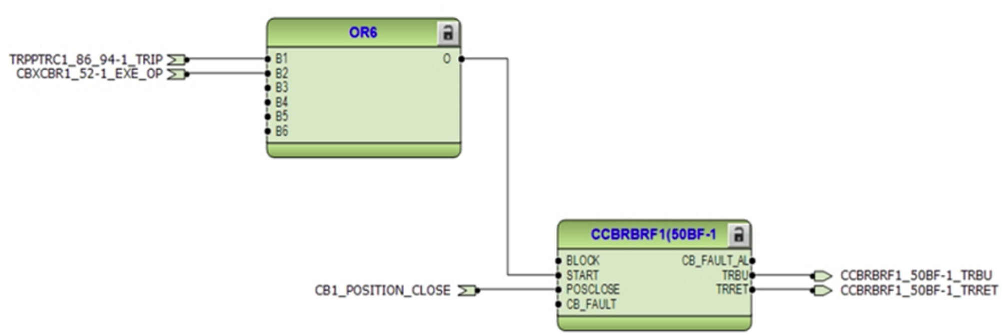


Figure 86: Circuit breaker-1 failure protection (Typical, similar scheme applicable for circuit breaker-2)

Three arc protection (AFD-1, AFD-2 and AFD-3) 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.

Trip signal from AFD-1 is connected to Master Trip 1 available at PO3(X100:15-19) and trip signal from AFD-2 is connected to Master Trip 2 available at PO4 (X100:20-24).

When HSO option is ordered, the Master Trips 1&2 are also arranged to trip HSO1 and HSO2 respectively at slot X110. AFD3 is also arranged to energize HSO3 at slot X110. This contact which may be wired to trip the bus and / or the incoming breaker as appropriate. The operation of these protection functions is connected to alarm LED 11.

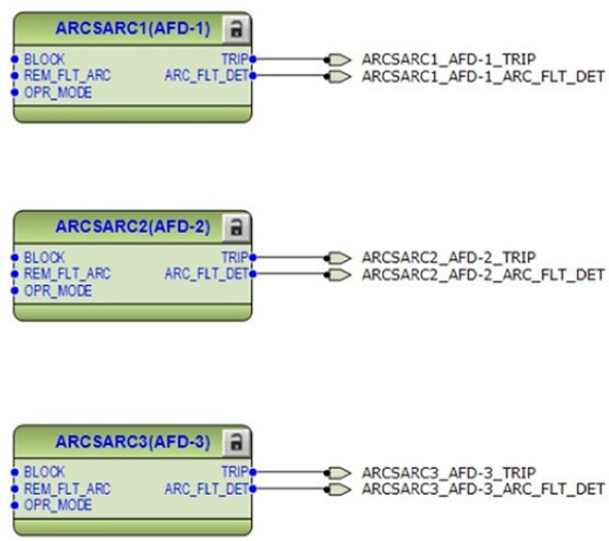


Figure 87: Arc protection

The under frequency or over frequency protections (81-1 and 81-2) prevents damage to network components 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.

Two load shedding and restoration stages are offered in the standard configuration. The load shedding and restoration function (81LSH-1 and 81LSH-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.

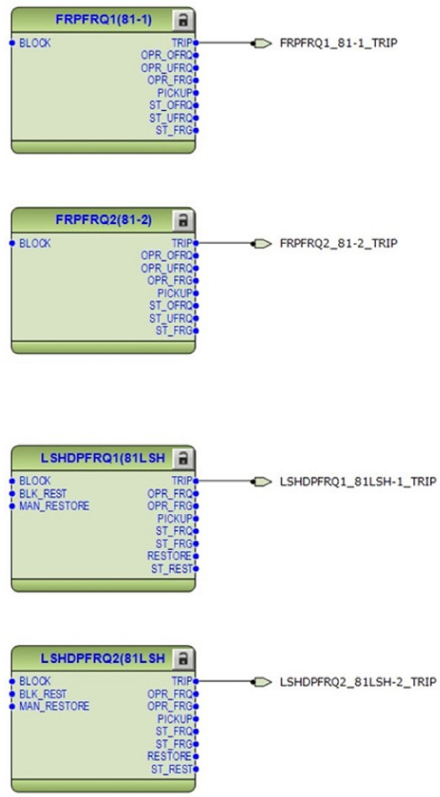


Figure 88: *Frequency and Load shedding functions*

A phase distance protection function (21P) is included as a standard function. It provides a fast and reliable protection for overhead lines and power cables. It is applied in distribution and sub-transmission networks where three-phase tripping is allowed for phase-to-phase / three-phase faults. Typically these networks are operated in ring or meshed type of configurations. It is also characteristic for these networks that the switching state is changed frequently due to daily operation and load flow considerations. The networks also include varying capacities of distributed generation. This makes it impossible to apply simple overcurrent based schemes. In these kinds of networks, 21P is used to provide a fast and selective protection for overhead lines and power cables. It can also be applied for radial feeders to increase the sensitivity of the protection, especially if the short circuit power of the source is low or it is changing due to network operation.

The protection has five distance phase elements Z1, Z2, Z3, Z4 and Z5 which may be set, depending on the application. When called in to protect a medium to long length feeders, the distance relay may be set to trip a feeder based on set impedance and time. Typically, Z1 may be set to protect 80% of the feeder, arranged to trip instantly. Zone 2 is set with a delay of about 500 mSec is set to trip faults up to 120% of the line. The Zone 3 may be set to provide backup protection for the protected feeder as well as adjoining components of the power system. If infeed from the remote end of the feeder is available, one of the zones Z5 can be set in reverse direction with adequate delay to provide backup protection for bus bar faults.

Very often, it is possible to utilize the instantaneous (Start/Pickup) output of one of the distance element to torque control one of the Overcurrent elements to grade with a downstream OC protection, typically on the LV side of a step down transformer at the tail of a transformer feeder protected by REF620.

From selectivity point of view, it is advantageous that in the protection chain all functions in different positions trip according to the same measuring principle. Therefore, 21P can also be applied for the backup protection of main transformers and buses. This way the selectivity with the distance protection of the outgoing lines is easier to achieve.

21P is suitable as a basic protection function against two and three phase faults in all kinds of networks, regardless of the treatment of the neutral point.

In the default configuration, the trip outputs of Z1 and Z2 are connected to trip the feeder through Master Trip logic. The Start/Pickup signals of the same elements are connected for fault record.

It is necessary to block the distance elements misoperating on loss of fuse. A signal from Fuse fail function is always wired to block the distance element. Since the bus voltage selection could be either from Bus1 or from Bus2, the appropriate bus voltage fuse failure blocking is directed to the distance element.

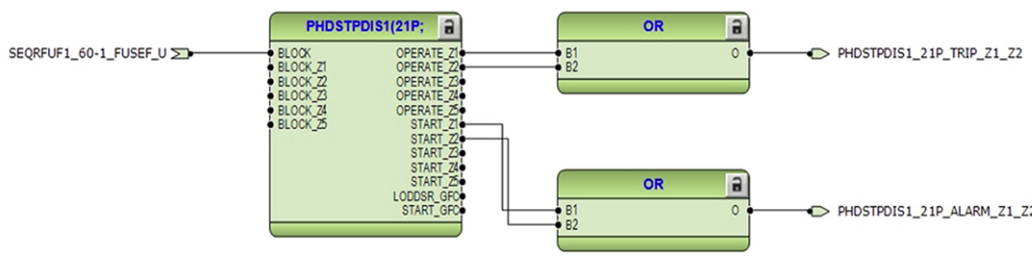


Figure 89: Distance Protection function

Care shall be taken while setting the distance element not to make the distance element so large as to make it operate for load flow condition. Provision is made in the function to discriminate load condition and avoid operation of the element for such conditions.

A forward direction full load power flow, with 65V VT secondary and 5A CT secondary would pose an apparent impedance to the relay of 13 Ohms, along the resistive direction.

Two Master Trip logics (86/94-1 and 86/94-2) are provided as a trip command collector. 86/94-1 collects the trip signals from 46, 46PD, 49F, 50P, 50N, 50G, 51LT, 51P, 51N, 51G, 67P, 67N, 81LSH-1, 87LOZREF, AFD-1 and SEF protection functions and is connected to trip output contact PO3 (X100:16-19) and also to high speed output HS01 (X110:15-16) for IEDs ordered with high speed binary output cards.

Open control commands to the circuit breaker from the local or remote is also connected directly to the output PO3 (X100:16-19) from circuit breaker control (52) function block.

86/94-2 collects the trip signals similar to Master Trip 1 except for AFD-1. Instead it collects input from AFD-2. It is connected to trip output contact PO4 (X100:20-24).

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

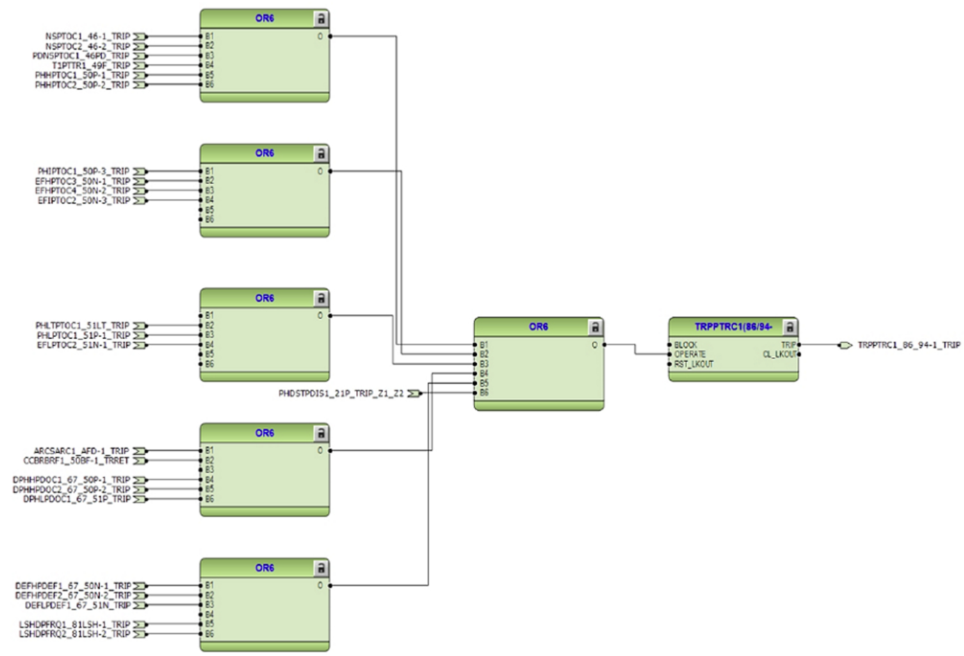


Figure 90: *Master trip logic 1*

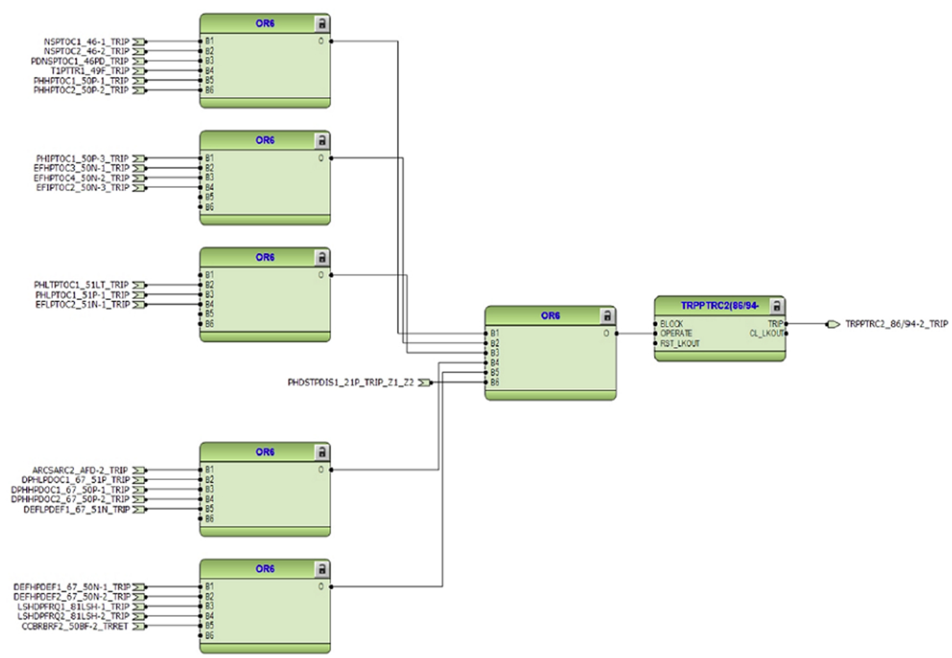


Figure 91: *Master trip logic 2*

3.4.8 Functional diagrams for control functions

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

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 of the interlocking conditions being active when the circuit breaker truck is closed in service position.

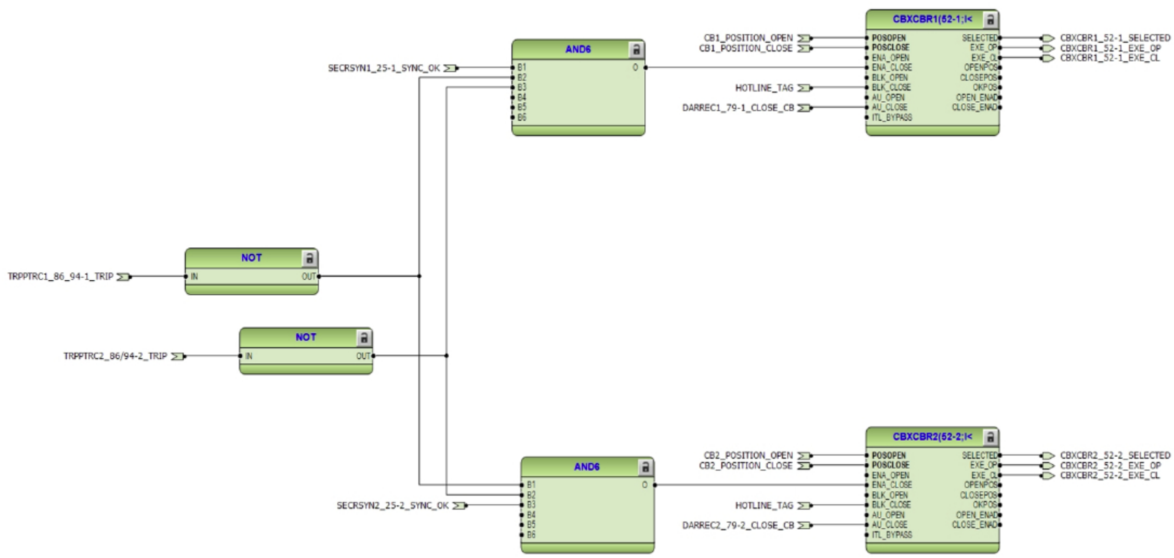


Figure 92: Circuit breaker control

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.

The autorecloser functionality (79) is configured to be initiated by operate signals from a number of protection stages through the INIT1...5 inputs. It is possible to create individual autoreclose sequences for each input.

The autoreclose function can be blocked with the INHIBIT_RECL input. By default, the operation of selected protection functions is connected to this input. A control command to the circuit breaker, either local or remote, also blocks the autoreclose function via the CBXCBR-selected signal. The circuit breaker availability for the autoreclosure sequence is expressed with the CB_READY input in DARREC1. In the configuration, this signal is not connected to any of the binary inputs. As a result, the function assumes that the breaker is available all the time.

The autoreclose locked status is connected to the alarm LED 7. The unsuccessful autoreclosing UNSUC_RECL is connected to the disturbance recorder.

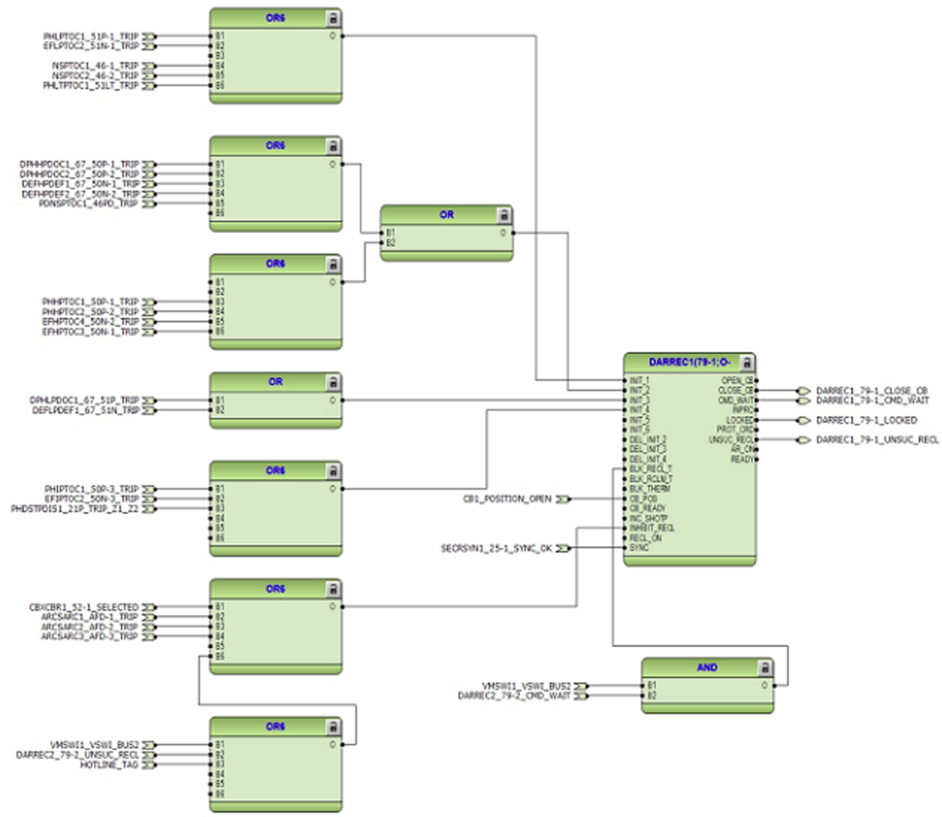


Figure 93: Autoreclosing, Breaker 52-1

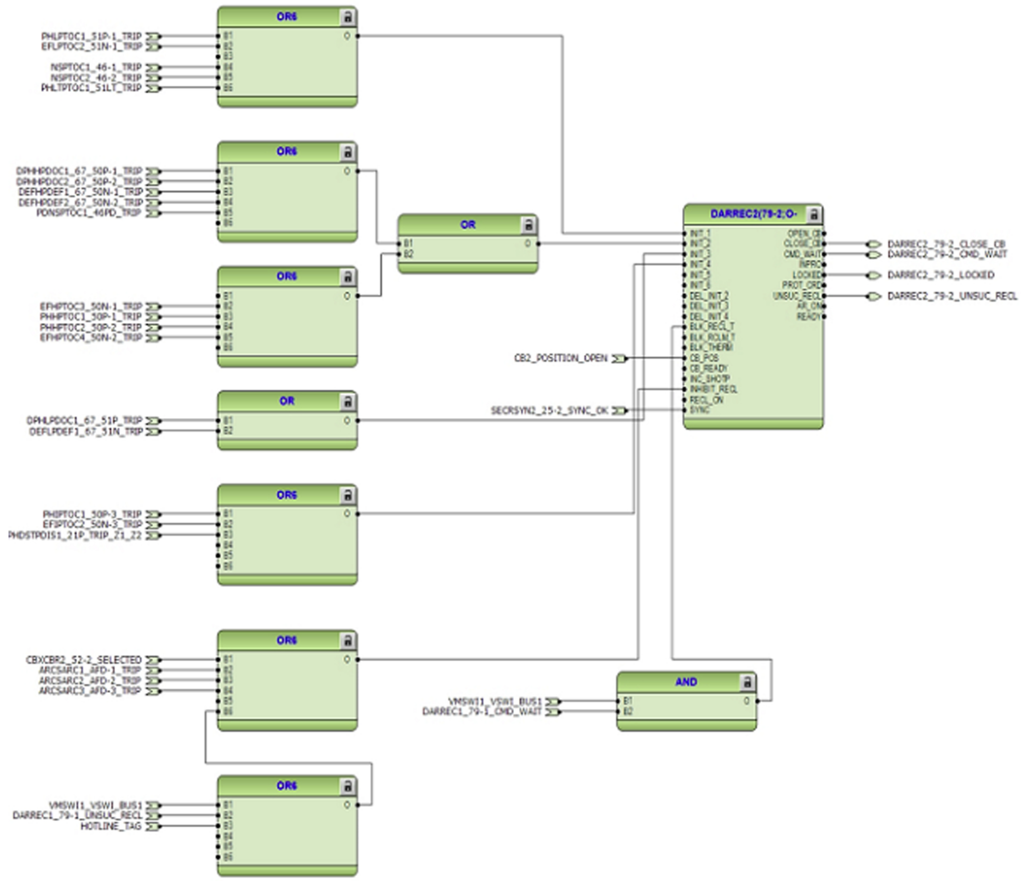


Figure 94: Autoreclosing, Breaker 52-2

3.4.9 Functional diagrams for condition monitoring

Two trip circuit monitoring (TCM-1 and TCM-2) stages are provided to supervise the trip circuit of the circuit breakers connected at PO3 (X100:15-19) and PO4 (X100:20-24).

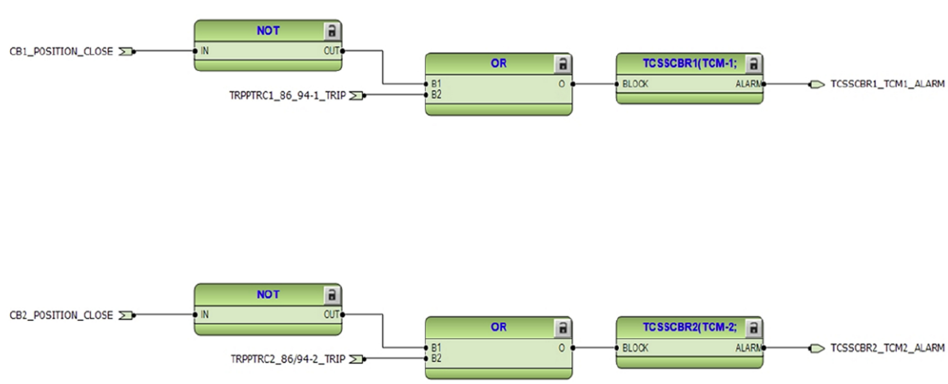


Figure 95: Trip circuit monitoring

The TCM-1 and TCM-2 functions are blocked by 86/94-1, 86/94-2 and when the circuit-breaker is not in closed position.

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.

The fuse failure supervision SEQRFUF1 and SEQRFUF2 detect failures in voltage measurement circuits in respective buses Bus1 and Bus2 VT inputs. 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.

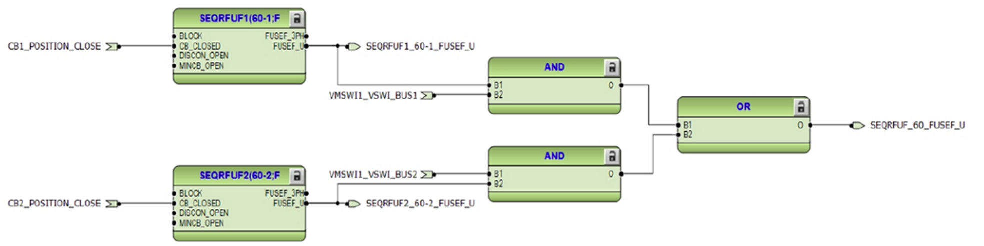


Figure 96: *Fuse failure monitoring*

The circuit breaker condition monitoring functions (52CM-1 and 52CM-2) supervise the circuit breakers' status based on the binary input information connected and measured current levels. The function introduces various supervision alarms.

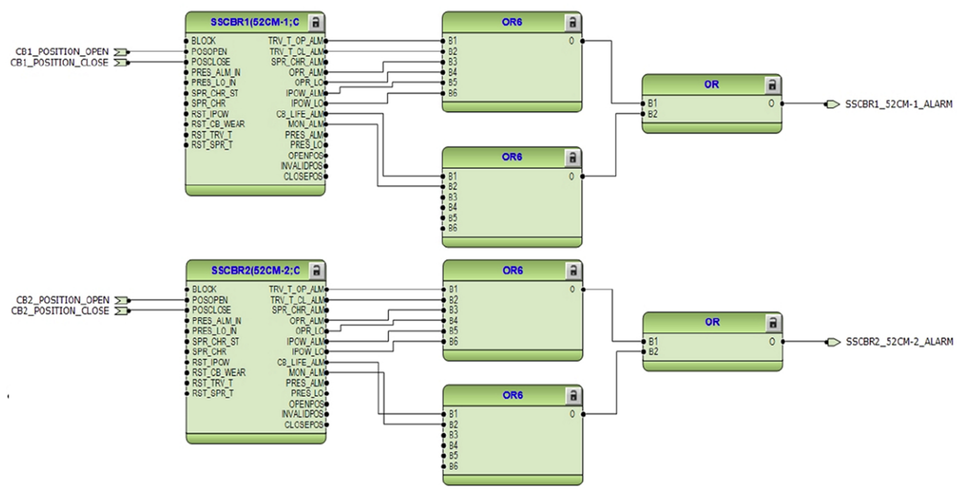


Figure 97: *Circuit breaker condition monitoring*

Cable fault detector (CFD) is offered for detecting self clearing in the feeder.

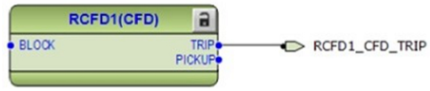


Figure 98: Cable fault detector

By default the TRIP output from CFD function is only connected to disturbance recorder.

3.4.10 Functional diagrams for measurements

The phase current inputs to the IED are measured by three-phase current measurement (IA, IB, IC) function block. The current input is connected to the X120 card in the back panel. Similarly the sequence and residual currents are measured by sequence current measurement (I1, I2, I0).

Both the buses' phase voltage inputs are connected to the X130 card in the back panel. The voltages are measured by (VA,VB,VC), (VA,VB,VC(2)) function blocks. Similarly the sequence voltages are measured by sequence voltage measurement (V1, V2, V0) and (V1,V2,V0(2)) function blocks respectively.

The measurements can be seen from the LHMI and is available using the measurement option in the menu selection. Based on the settings, function blocks can generate low alarm/warning, high alarm/warning signals for the measured current values.

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

The power quality function (PQI-1) is used to measure the harmonic contents of the phase current. This functionality is included according to ordercode selection.

The power quality function (PQVPH-1) is used to measure the harmonic contents of the phase voltages. This functionality is included according to ordercode selection.

The power quality function (PQSS-1) is used to measure the voltage variation i.e. sags and swells. This functionality is included according to ordercode selection.

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

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 corresponding feeder.

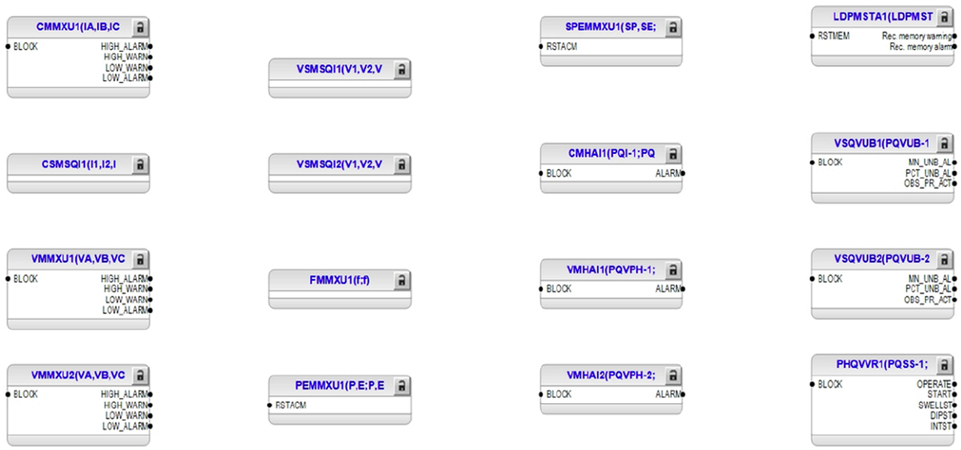


Figure 99: Current, voltage, power and energy measurements and load profile function

3.4.11 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 off TOF-1, TOF-2, TOF-3 and TOF-4,
- Four instance of Time delay on TON-1, TON-2, TON3 and TON-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.

3.4.12 Function diagrams for logging functions

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

Table 22: List of analog channels connected to DFR (REF620 Config B)

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

A few channels of the binary channel are connected to trigger the digital fault recorder as shown in Figure 100. More connection can be made as per individual need. Also when disturbance recorder is triggered the analog values available at the analog inputs are recorded by fault recorder FR

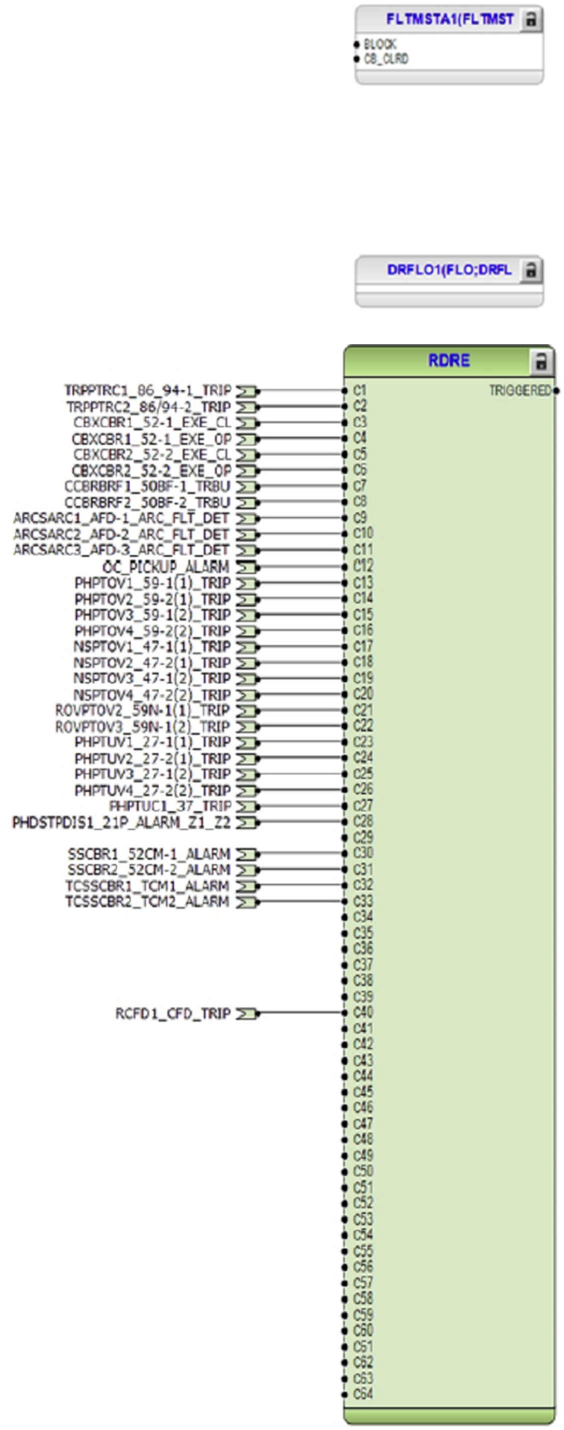


Figure 100: 64 channel Disturbance fault recorder and locator

3.4.13 Functional diagrams for I/O and Alarm LEDs

The default binary I/O connected in the configuration and Alarm LEDs are indicated in Figure 101 to Figure 105.

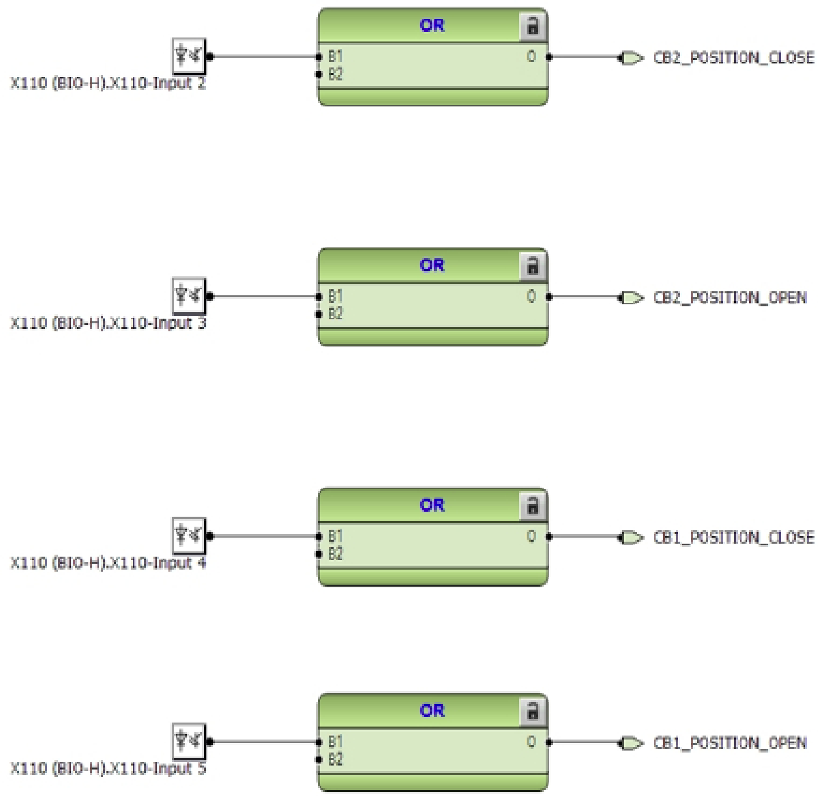


Figure 101: Binary inputs

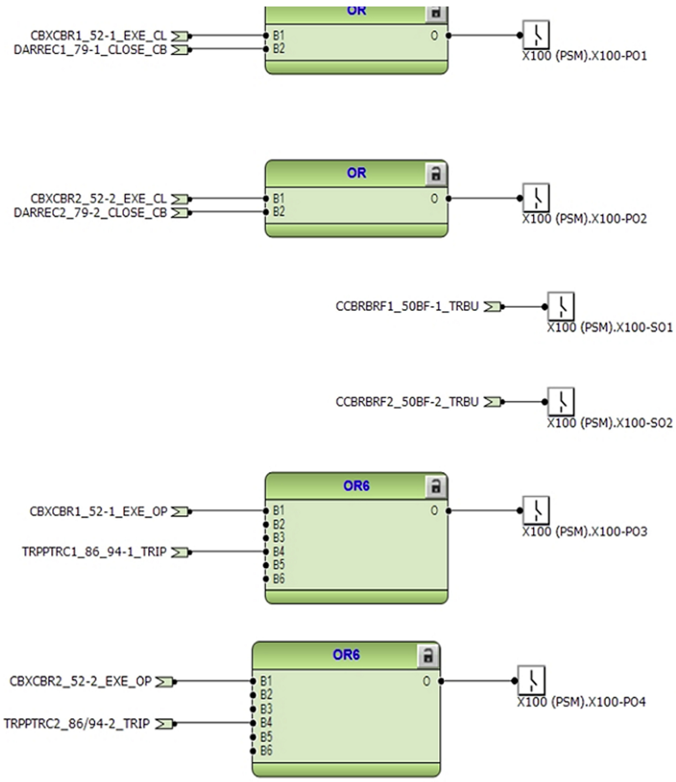


Figure 102: Binary outputs

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

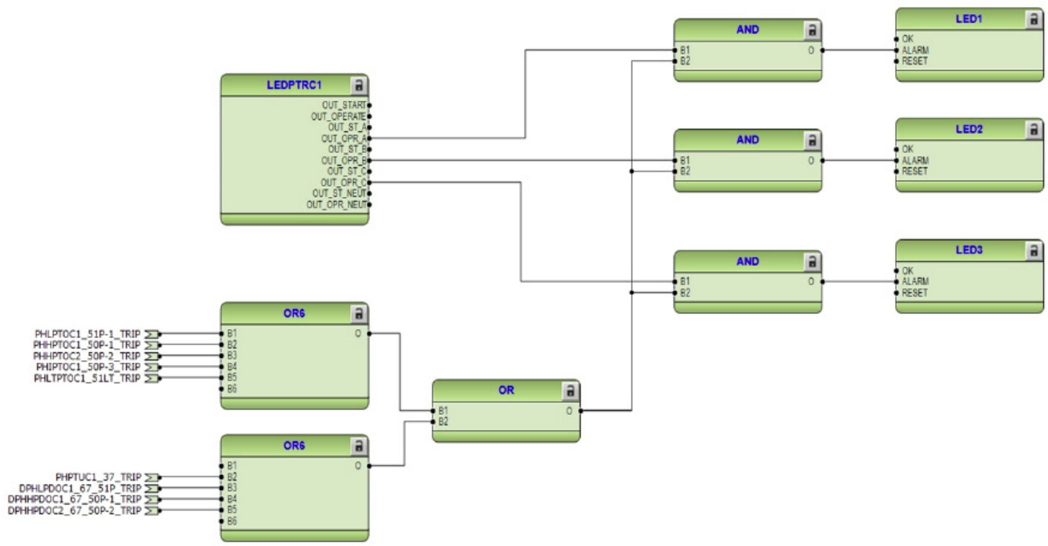


Figure 103: *Alarm LEDs 1 - 3*

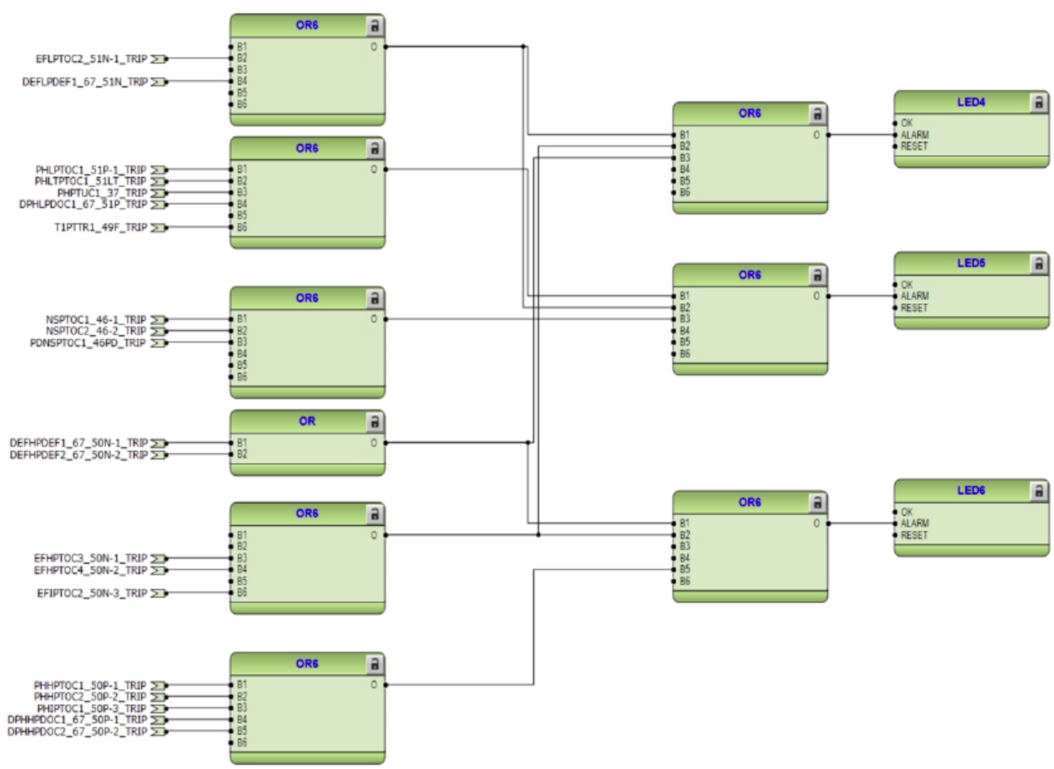


Figure 104: *Alarm LEDs 4 - 6*

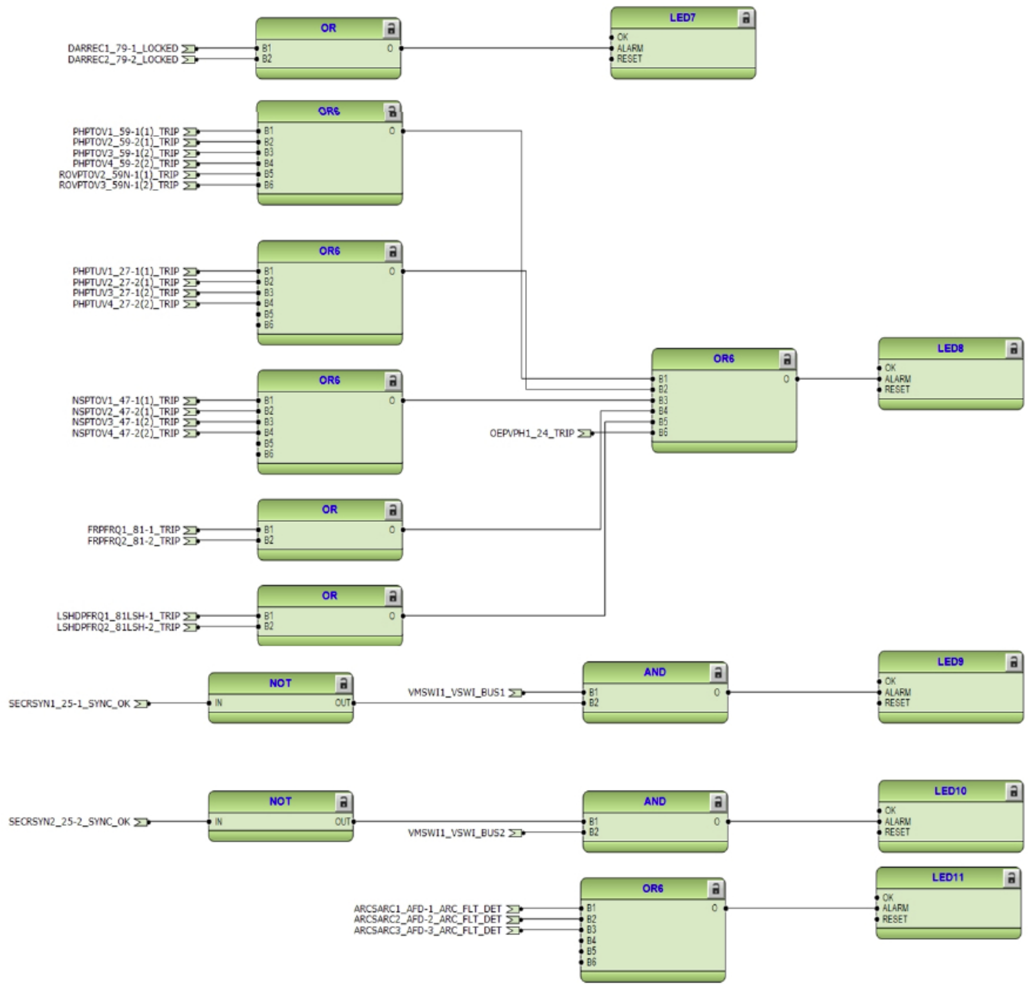


Figure 105: Alarm LEDs 7 - 11

3.5 Standard configuration for order code functional application C

3.5.1 Applications

This standard configuration is mainly intended for distribution feeders with dual breakers, with special consideration for 'Double Bus, Double Breaker' system, with power and energy metering provided as standard. This configuration includes non-directional and directional phase and ground overcurrent, phase distance, voltage and frequency protection.

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.

3.5.2 Functions

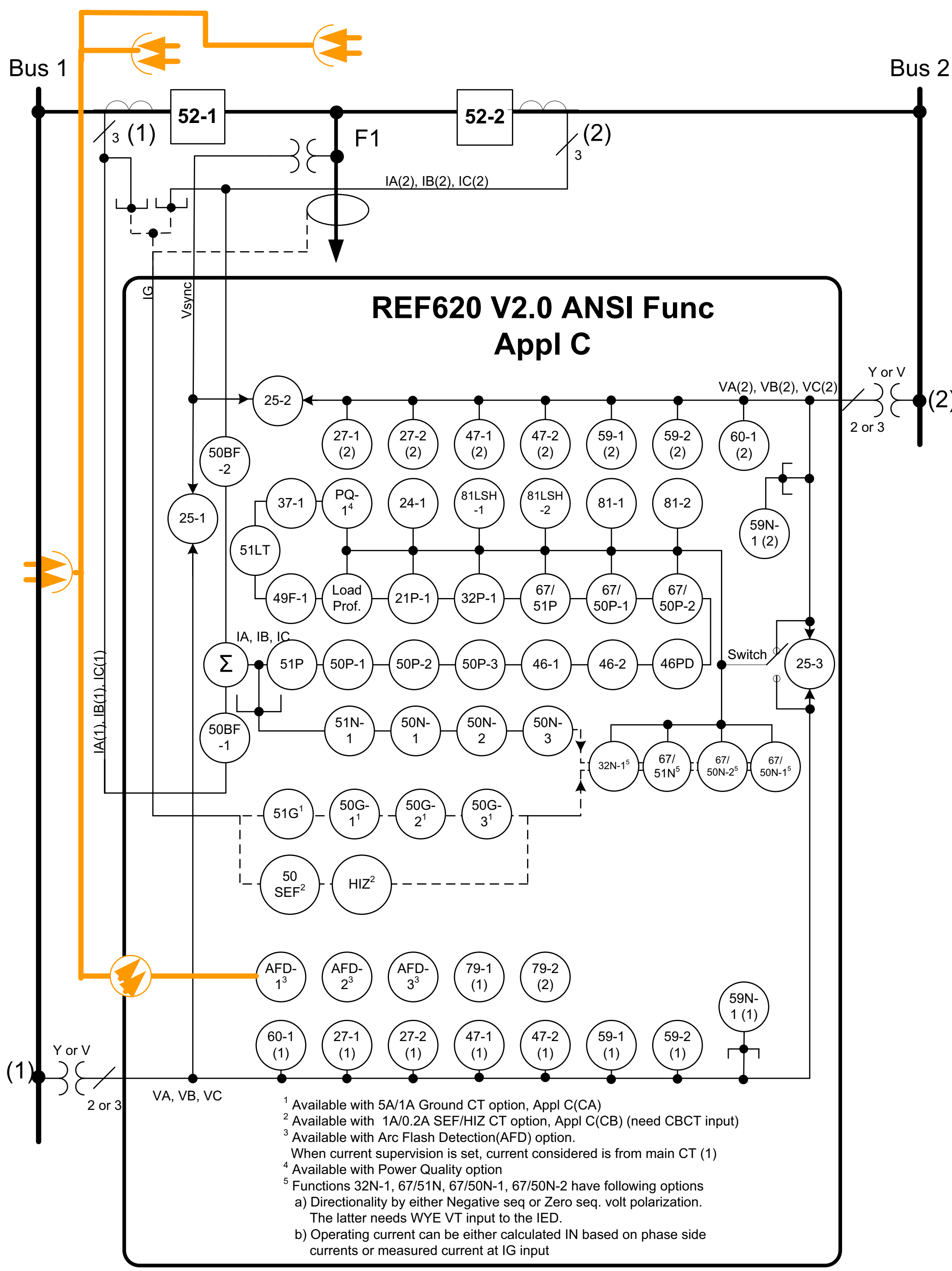


Figure 106: Functions included in the REF620 standard configuration C

3.5.3 Functions

Table 23: Functions included in the REF620 standard configuration

Software Configuration				C	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	CA	CB
Protection					
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	51P	3I> (1)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	50P-1	3I>> (1)	•	•
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	50P-2	3I>> (2)	•	•
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	50P-3	3I>>> (1)	•	•
Three-phase non-directional long time overcurrent protection, low stage, instance 1	PHLTPTOC1	51LT	3I> (3)	•	•
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	67/51P	3I> -> (1)	•	•
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	67/50P-1	3I>> -> (1)	•	•
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	67/50P-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 4	EFLPTOC4	50SEF	Io> (4)	-	•
Non-directional ground-fault protection, high stage, instance 1	EFHPTOC1	50G-1	Io>> (1)	•	-
Non-directional ground-fault protection, high stage, instance 2	EFHPTOC2	50G-2	Io>> (2)	•	-
Non-directional ground-fault protection, high stage, instance 3	EFHPTOC3	50N-1	Io>> (3)	•	•
Non-directional ground-fault protection, high stage, instance 4	EFHPTOC4	50N-2	Io>> (4)	•	•
Non-directional ground-fault protection, instantaneous stage, instance 1	EFIPTOC1	50G-3	Io>>> (1)	•	-
Non-directional ground-fault protection, instantaneous stage, instance 2	EFIPTOC2	50N-3	Io>>> (2)	•	•
Directional ground-fault protection, low stage, instance 1	DEFLPDEF1	67/51N	Io> -> (1)	•	•
Directional ground-fault protection, high stage, instance 1	DEFHPDEF1	67/50N-1	Io>> -> (1)	•	•
Directional ground-fault protection, high stage, instance 2	DEFHPDEF2	67/50N-2	Io>> -> (2)	•	•
Three phase directional power protection, instance 1	DPSRDIR1	32P-1	I1-> (1)	•	•
Ground directional power protection, instance 1	DNZSRDIR1	32N-1	I2 ->, Io-> (1)	•	•

Software Configuration				C	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	CA	CB
Phase Distance Protection, instance 1	PHDSTPDIS 1	21P	Z<	•	•
Negative-sequence overcurrent protection, instance 1	NSPTOC1	46-1	I2> (1)	•	•
Negative-sequence overcurrent protection, instance 2	NSPTOC2	46-2	I2> (2)	•	•
Phase discontinuity protection	PDNSPTOC1	46PD	I2/I1>	•	•
Residual overvoltage protection, instance 2	ROVPTOV2	59N-1 (1)	Uo> (2)	•	•
Residual overvoltage protection, instance 3	ROVPTOV2	59N-1 (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	f>/f<,df/dt (1)	•	•
Frequency protection, instance 2	FRPFRQ2	81-2	f>/f<,df/dt (2)	•	•
Voltage per hertz protection, instance 1	OEPVPH1	24	U/f> (1)	•	•
Three-phase thermal protection for feeders, cables and distribution transformers, Instance 1	T1PTTR1	49F	3Ith>F	•	•
Phase current sets summing function	CMSUM1	CSUM	CSUM	•	•
Three phase measurement switching	VMSWI1	VSWI	VSWI	•	•
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)	•	•
Three-phase inrush detector, instance 1	INRPHAR1	INR	3I2f> (1)	•	•
Master trip, instance 1	TRPPTRC1	86/94-1	Master Trip (1)	•	•

Software Configuration				C	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	CA	CB
Master trip, instance 2	TRPPTRC2	86/94-2	Master Trip (2)	•	•
Arc protection, instance 1	ARCSARC1	AFD-1	ARC (1)	•	•
Arc protection, instance 2	ARCSARC2	AFD-2	ARC (2)	•	•
Arc protection, instance 3	ARCSARC3	AFD-3	ARC (3)	•	•
High impedance fault detection	PHIZ1	HIZ	PHIZ1	-	•
Load shedding and restoration, instance 1	LSHDPFRQ1	81LSH-1	UFLS/R (1)	•	•
Load shedding and restoration, instance 2	LSHDPFRQ2	81LSH-2	UFLS/R (2)	•	•
Loss of phase, instance 1	PHPTUC1	37-1	3I< (1)	•	•
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)	•	•
Auto-reclosing, instance 1	DARREC1	79-1	O -> I	•	•
Auto-reclosing, instance 2	DARREC2	79-2	O -> I	•	•
Synchronism and energizing check, instance 1	SECRSYN1	25-1	SYNC(1)	•	•
Synchronism and energizing check, instance 2	SECRSYN2	25-2	SYNC(2)	•	•
Synchronism and energizing check, instance 3	SECRSYN3	25-3	SYNC(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)	•	•
Trip circuit supervision, instance 1	TCSSCBR1	TCM-1	TCS (1)	•	•
Trip circuit supervision, instance 2	TCSSCBR2	TCM-2	TCS (2)	•	•
Current circuit supervision	CCRDIF1	CCM	MCS 3I	•	•
Fuse failure supervision, instance 1	SEQRFUF1	60-1	FUSEF (1)	•	•
Fuse failure supervision, instance 2	SEQRFUF2	60-2	FUSEF (2)	•	•
Cable fault detection	RCFD1	CFD	CFD	•	•
Measurement					
Three-phase current measurement, instance 1	CMMXU1	IA, IB, IC	3I	•	•
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0	I1, I2, I0	•	•
Residual current measurement, instance 1	RESCMMXU1	IG	Io	•	•
Three-phase voltage measurement, instance 1	VMMXU1	VA, VB, VC	3U	•	•
Three-phase voltage measurement, instance 2	VMMXU2	VA, VB, VC(2)	3U(B)	•	•
Sequence voltage measurement, instance 1	VSMSQI1	V1, V2, V0	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	SP, SE	•	•

Software Configuration				C	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	CA	CB
Three-phase power and energy measurement, instance 1	PEMMXU1	P, E-1	P, E	•	•
Current total demand distortion, instance 1	CMHAI1	PQI-1	PQM3I	•	•
Voltage total harmonic distortion, instance 1	VMHAI1	PQVPH-1	PQM3U(1)	•	•
Voltage total harmonic distortion, instance 2	VMHAI2	PQVPH-2	PQM3U(2)	•	•
Voltage variation, instance 1	PHQVVR1	PQSS-1	PQ 3U<>(1)	•	•
Voltage unbalance, instance 1	VSQVUB1	PQVUB-1	PQMUBU(1)	•	•
Voltage unbalance, instance 2	VSQVUB2	PQVUB-2	PQMUBU(2)	•	•
Load profile	LDPMSTA1	LoadProf	LoadProf	•	•
Frequency measurement, instance 1	FMMXU1	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)	•	•
Minimum pulse timer (2 pcs, second resolution), instance 1	TPSGAPC1	62CLD-1	TPS (1)	•	•
Minimum pulse timer (2 pcs, second resolution), instance 2	TPSGAPC2	62CLD-3	TPS (2)	•	•
Minimum pulse timer (2 pcs, minute resolution), instance 1	TPMGAPC1	62CLD-2	TPM (1)	•	•
Minimum pulse timer (2 pcs, minute resolution), instance 2	TPMGAPC2	62CLD-4	TPM (2)	•	•
Pulse timer (8 pcs), instance 1	PTGAPC1	PT-1	PT (1)	•	•
Pulse timer (8 pcs), instance 2	PTGAPC2	PT-2	PT (2)	•	•
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF-1	TOF (1)	•	•
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF-2	TOF (2)	•	•
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF-3	TOF (3)	•	•
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF-4	TOF (4)	•	•
Time delay on (8 pcs), instance 1	TONGAPC1	TON-1	TON (1)	•	•
Time delay on (8 pcs), instance 2	TONGAPC2	TON-2	TON (2)	•	•
Time delay on (8 pcs), instance 3	TONGAPC3	TON-3	TON (3)	•	•
Time delay on (8 pcs), instance 4	TONGAPC4	TON-4	TON (4)	•	•
Set reset (8 pcs), instance 1	SRGAPC1	SR-1	SR (1)	•	•
Set reset (8 pcs), instance 2	SRGAPC2	SR-2	SR (2)	•	•
Set reset (8 pcs), instance 3	SRGAPC3	SR-3	SR (3)	•	•
Set reset (8 pcs), instance 4	SRGAPC4	SR-4	SR (4)	•	•
Move (8 pcs), instance 1	MVGAPC1	MV-1	MV (1)	•	•
Move (8 pcs), instance 2	MVGAPC2	MV-2	MV (2)	•	•

Software Configuration				C	
Function	IEC 61850	ANSI C37.2-2008	IEC 60617	CA	CB
Move (8 pcs), instance 3	MVGAPC3	MV-3	MV (3)	•	•
Move (8 pcs), instance 4	MVGAPC4	MV-4	MV (4)	•	•
Generic control points, instance 1	SPCGGIO1	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	•	•
Logging functions					
Disturbance recorder	RDRE1	DFR	DFR	•	•
Fault recorder	FLMSTA1	FR	FR	•	•
Sequence event recorder	SER	SER	SER	•	•
Fault location	DRFLO1	FLO	FLO	•	•

3.5.4 Default input/output (I/O) assignments

Table 24: Default connections for analog inputs

Analog input	Default usage	Connector pins
IA(1)	Phase A current, CT(1)	X120-7, 8
IB(1)	Phase B current, CT(1)	X120-9, 10
IC(1)	Phase C current, CT(1)	X120-11, 12
IG	Ground Current	X120-13,14
IA(2)	Phase A current, CT(2)	X120-1,2
IB(2)	Phase B current, CT(2)	X120-3,4
IC(2)	Phase C current, CT(2)	X120-5,6
VA(1)	Phase A voltage, VT(1)	X130-13,14
VB(1)	Phase B voltage, VT(1)	X130-15,16
VC(1)	Phase C voltage, VT(1)	X130-17,18
VA(2)	Phase A voltage, VT(2)	X130-7,8
VB(2)	Phase B voltage, VT(2)	X130-9,10
VC(2)	Phase C voltage, VT(2)	X130-11,12
VSync	Feeder Voltage	X130-5,6

*Table 25: Default connections for binary inputs (Alternative 1)**

Binary output	Default usage	Connector pins
X110-BI2	Circuit breaker-2 closed position	X110-3,4
X110-BI3	Circuit breaker-2 open position	X110-5,6
X110-BI4	Circuit breaker-1 closed position	X110-7,6
X110-BI5	Circuit breaker-1 open position	X110-8,9
*Binary inputs when slot ID X110 is ordered with 8BI+4BO BIO card		

*Table 26: Default connections for binary inputs (Alternative 2)**

Binary output	Default usage	Connector pins
X110-BI2	Circuit breaker-2 closed position	X110-2,5
X110-BI3	Circuit breaker-2 open position	X110-3,5
X110-BI4	Circuit breaker-1 closed position	X110-4,5
X110-BI5	Circuit breaker-1 open position	X110-6,10
*Alternative binary inputs when IED has been ordered with High speed binary output (HSO) card		

Table 27: Default connections for binary outputs

Binary output	Default usage	Connector pins
X100-PO1	Close circuit breaker-1	X100 – 6,7
X100-PO2	Close circuit breaker-2	X100 – 8,9
X100-SO1	Breaker-1 failure, trip upstream breaker	X100 – 10,12
X100-SO2	Breaker-2 failure, trip upstream breaker	X100 – 13,14
X100-PO3	Open circuit breaker-1 / Master Trip -1	X100 – 15,16,17,18,19
X100-PO4	Open circuit breaker-2 / Master Trip -2	X100 – 20,21,22,23,24

*Table 28: High speed binary output connections**

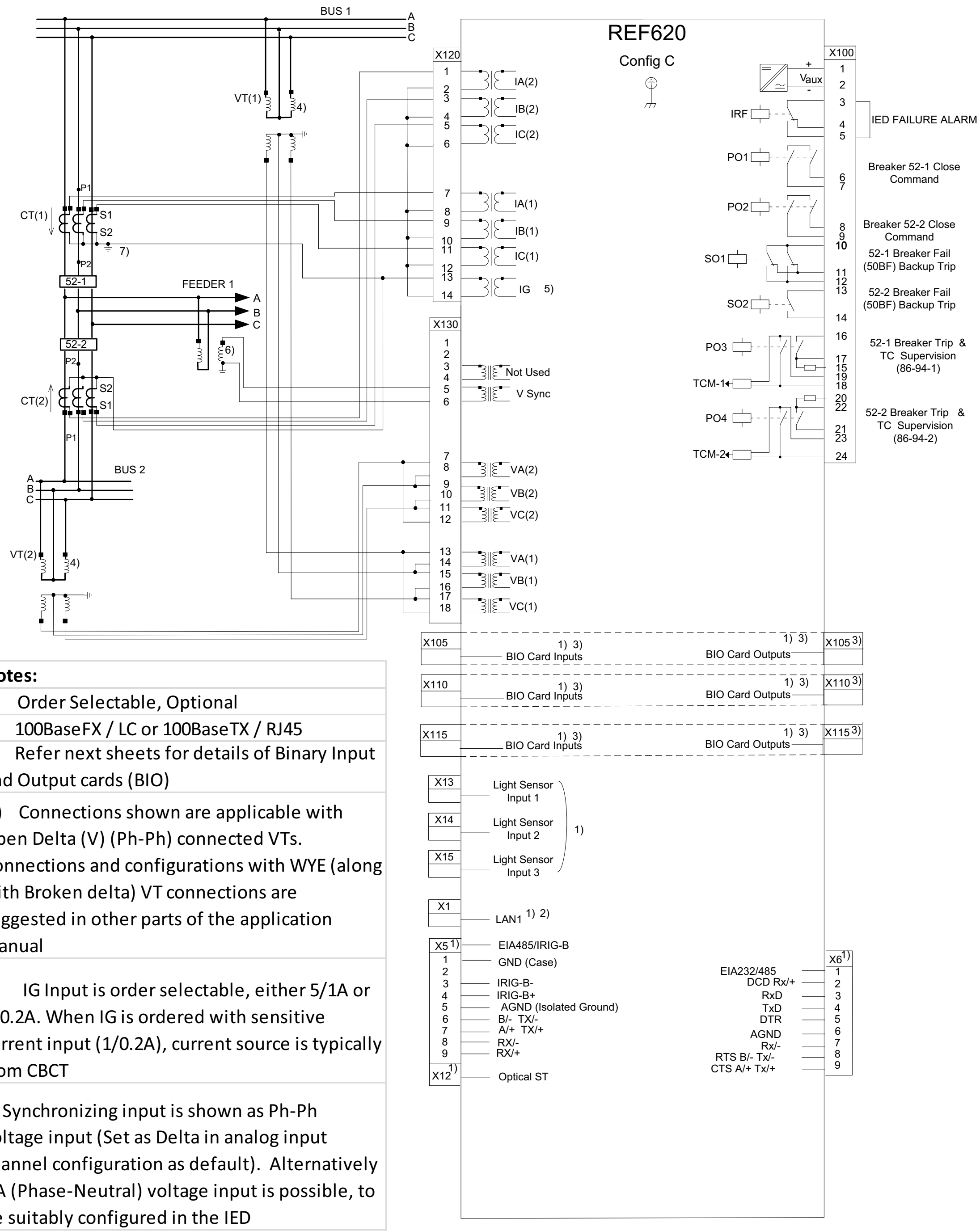
Binary output	Default usage	Connector pins
X110-HSO1	Open circuit breaker / Master Trip -1	X110 – 15,16
X110-HSO2	Master Trip-2	X110 – 19,20
X110-HSO3	Trip from ARC-3 protection	X110 – 23,24
*Available only if IED has been ordered with High speed binary output (HSO) card		

Table 29: Default connections for LEDs

LED	LED label
LED 1	Phase A
LED 2	Phase B
LED 3	Phase C
LED 4	Neutral, Neutral / Ground,
LED 5	Time
LED 6	Instantaneous
LED 7	Recloser lockout
LED 8	Voltage protection
LED 9	Synch. Alarm
LED 10	Arc Flash Detection
LED 11	HIZ Detection

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

3.5.5 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. Connections and configurations with WYE (along with Broken delta) VT connections are suggested in other parts of the application manual
5) IG Input is order selectable, either 5/1A or 1/0.2A. When IG is ordered with sensitive current input (1/0.2A), current source is typically from CBCT
6) Synchronizing input is shown as Ph-Ph voltage input (Set as Delta in analog input channel configuration as default). Alternatively VA (Phase-Neutral) voltage input is possible, to be suitably configured in the IED
7) With paralleled CTs, CT neutral Point shall be grounded only at one point in the installation

Figure 107: Typical connection diagram of REF620 (Config C)

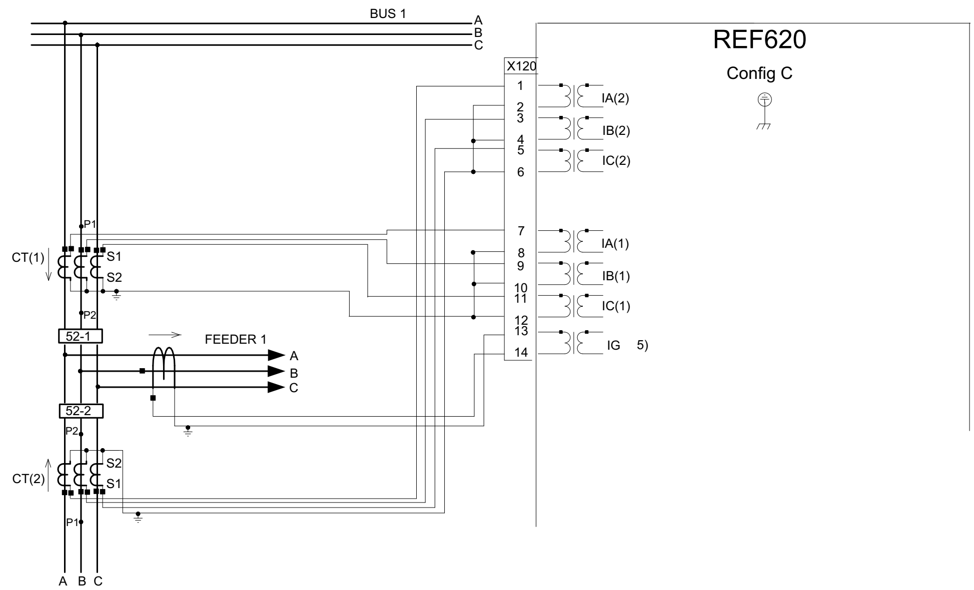
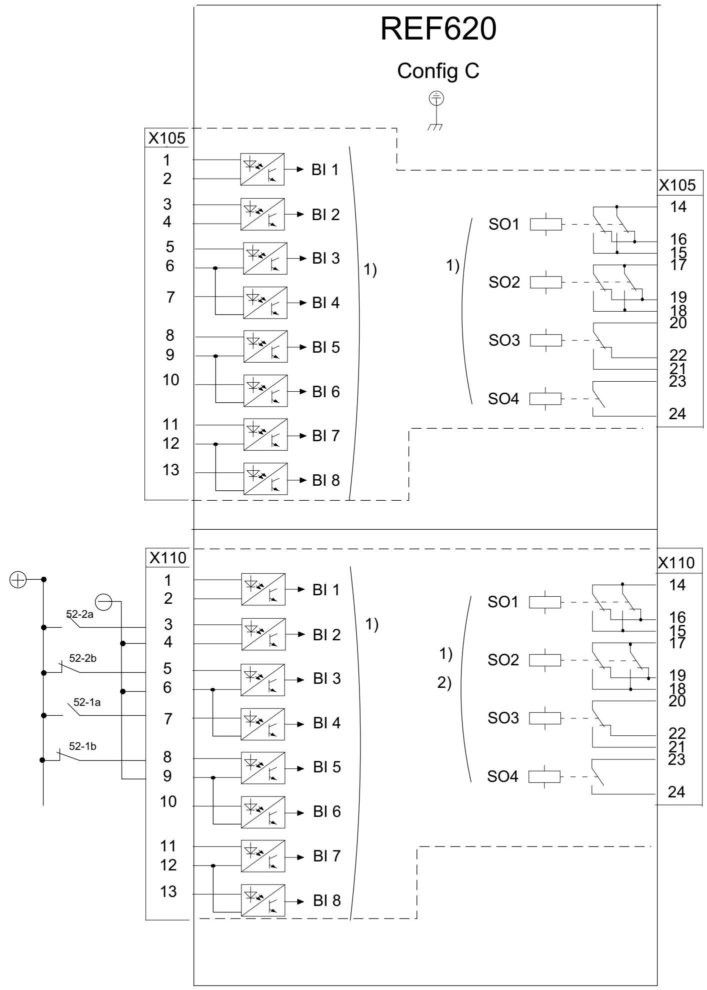


Figure 108: Typical CT input connections to REF620, Config C, with Core Balance Current Transformer Input



Alternative Card,
Position X110

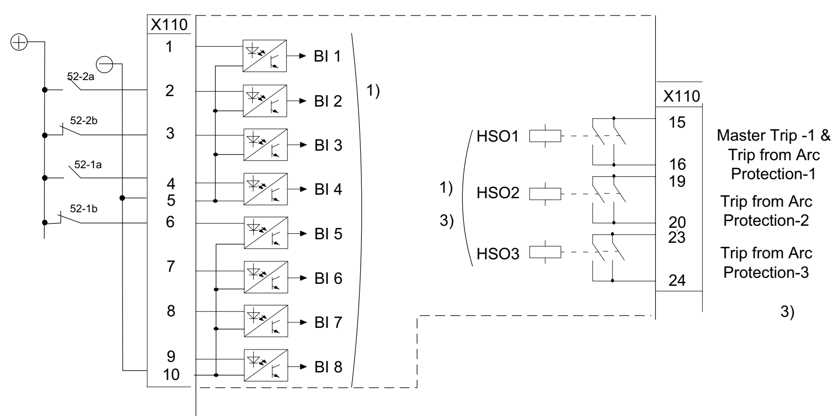
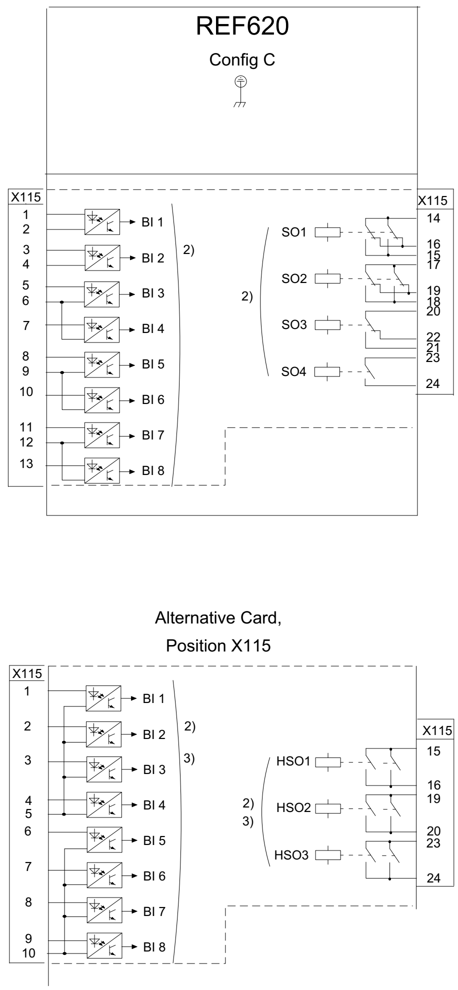


Figure 109: Typical BIO module equipment arrangement and connections for REF620, Config B (Slot X105 and X110)



Notes:
2) Order Selectable, Optional alternatives
3) High speed BIO card in this slot only when X110 slot is equipped with High speed BIO card

Figure 110: Typical BIO module equipment arrangement and connections for REF620, Config C (Slot X115)

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

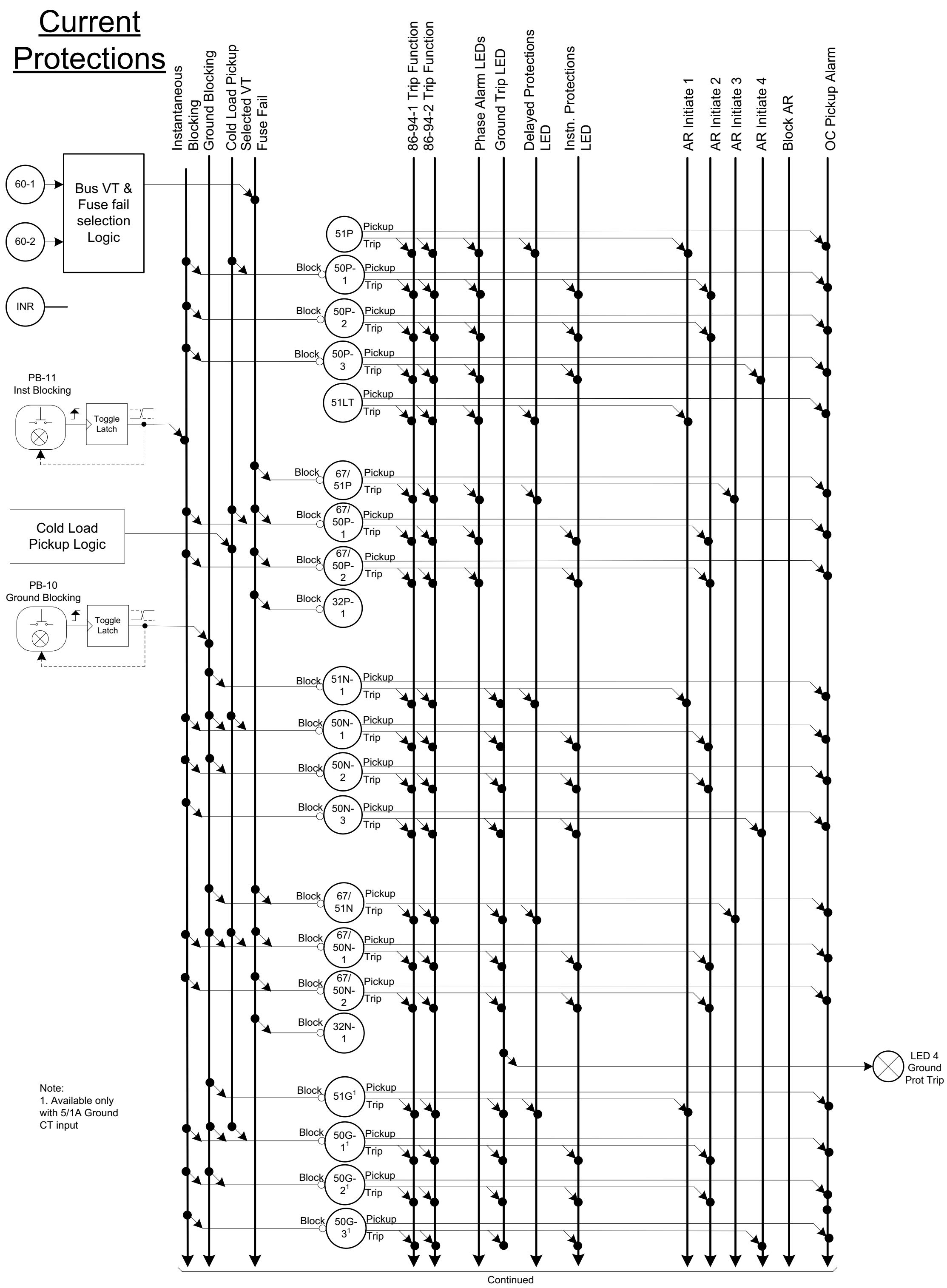


Figure 111: Simplified Logic Diagram for Current Protections, REF620, Config C

Other Protections

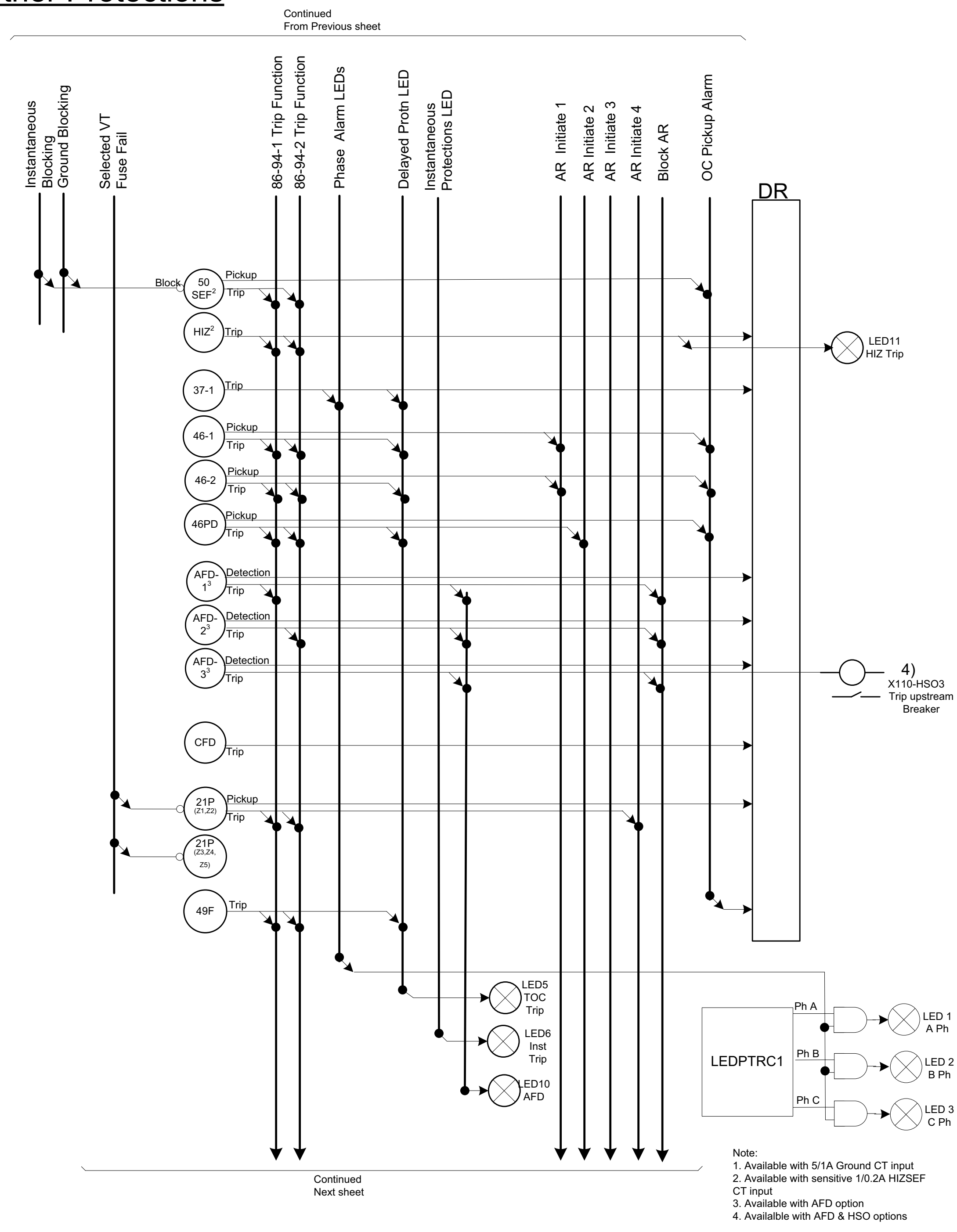


Figure 112: Simplified Logic Diagram for Other Protections, REF620, Config C

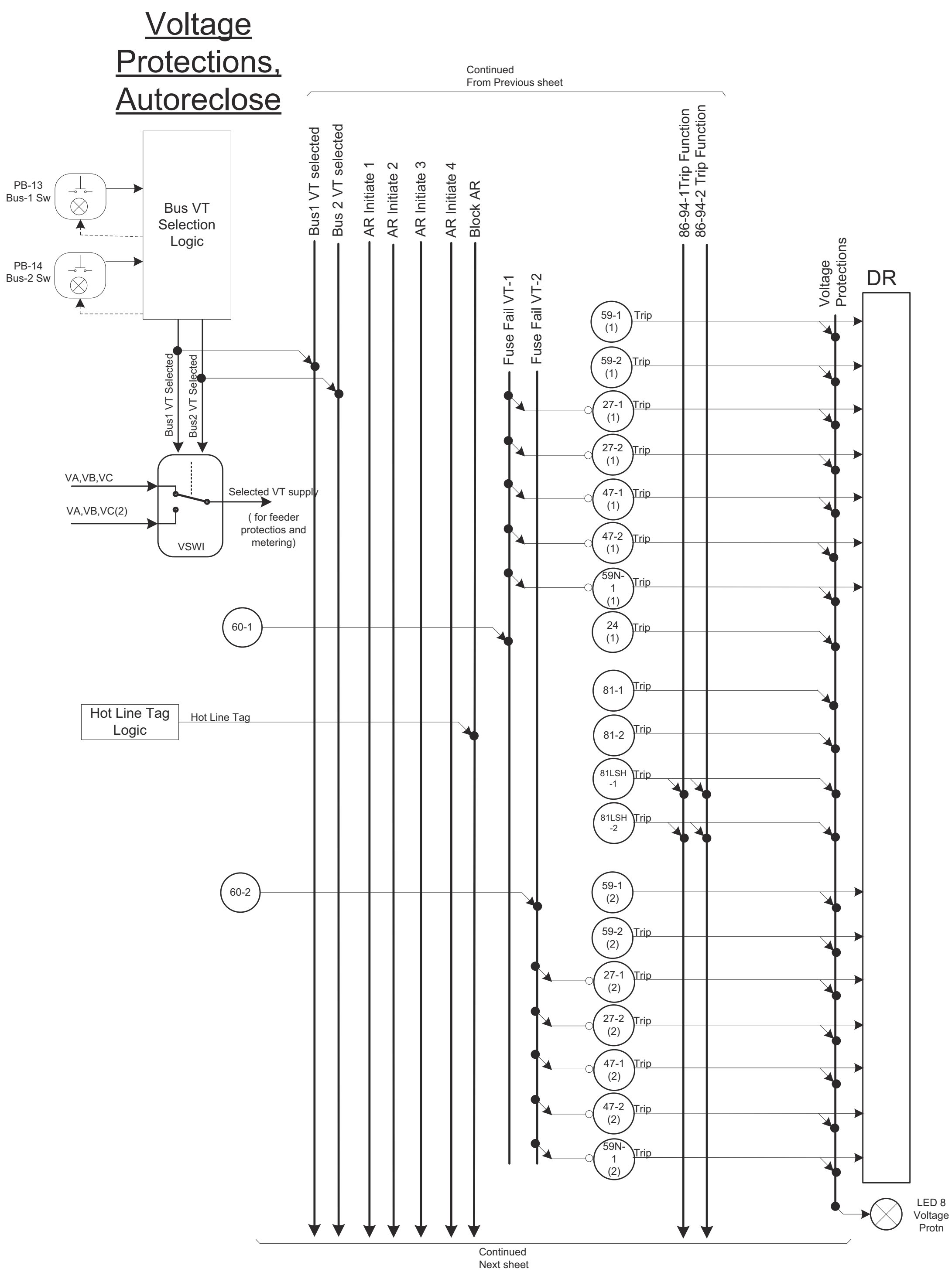


Figure 113: Simplified Logic Diagram for Voltage Protections , REF620, Config C

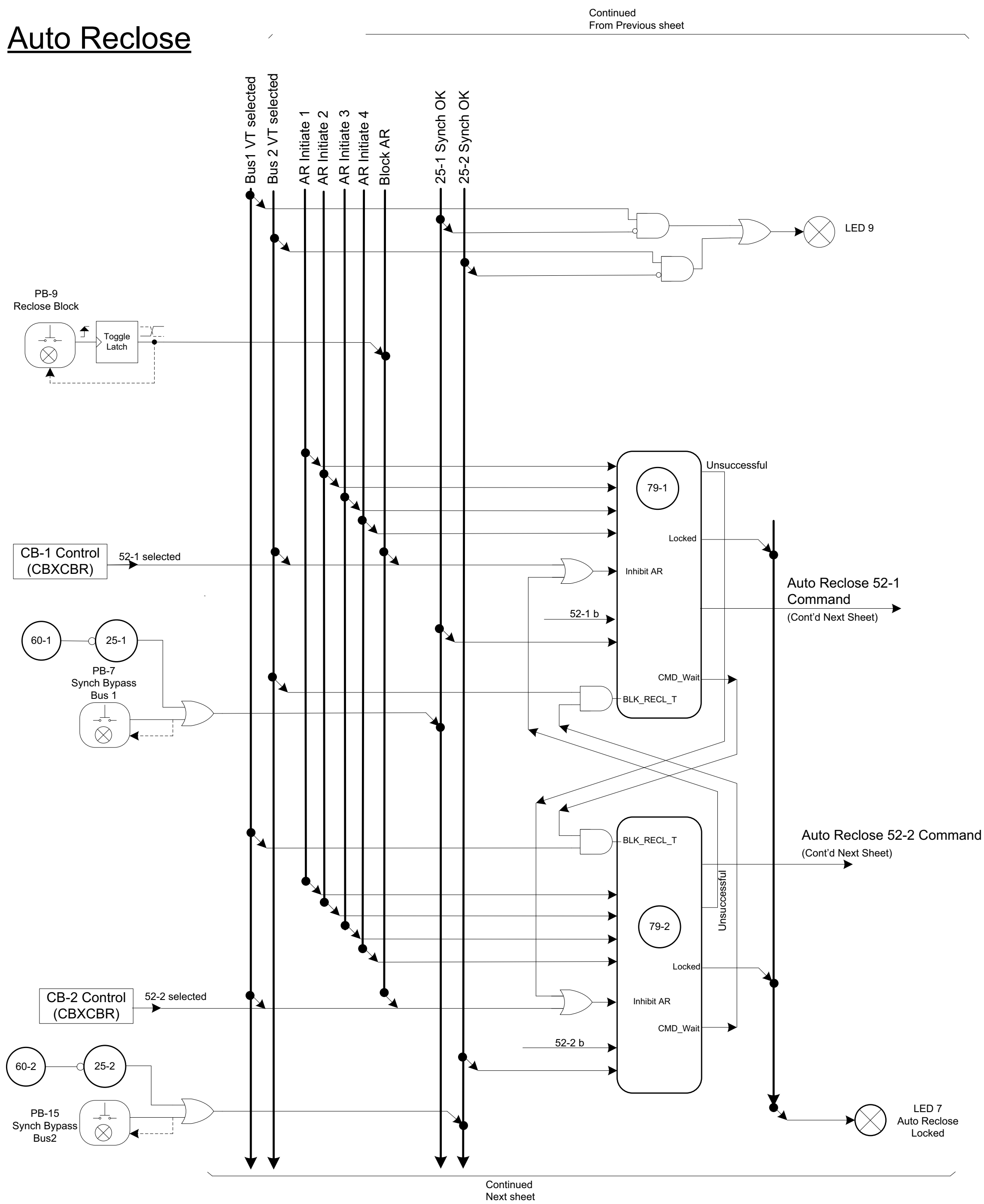


Figure 114: Simplified Logic Diagram for CB Autoreclose, REF620, Config C

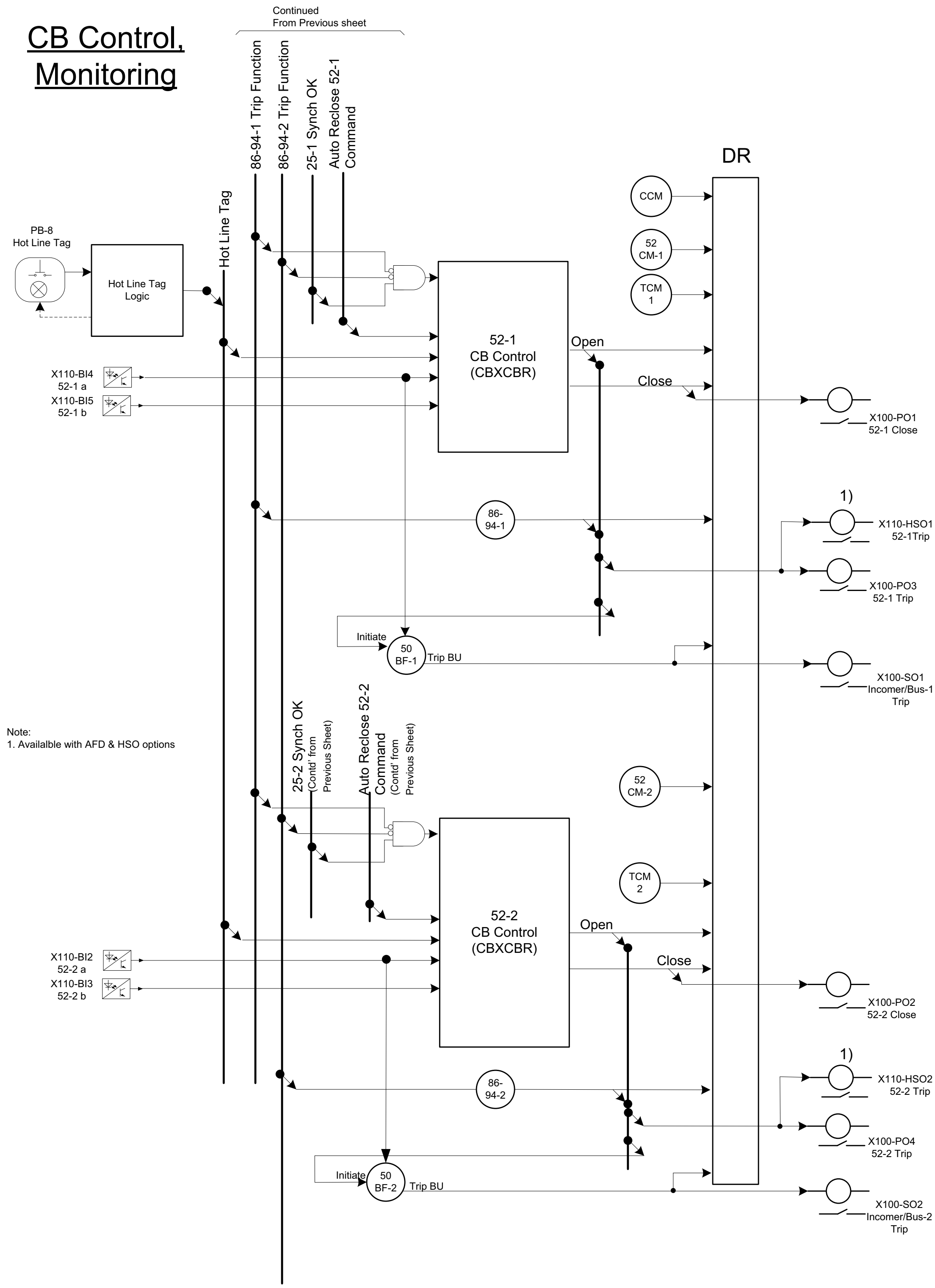


Figure 115: Simplified Logic Diagram for CB Control and Monitoring, REF620, Config C

3.5.6 Functional diagrams

The functional diagrams describe the default input, output, 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.

In double breaker (and CT) fed feeders such as in breaker-and-a-half system, double-bus-double-breaker system and ring bus systems, the protected feeder is electrically tied up with both the breakers and Current Transformers. Traditionally, the CTs were externally paralleled with appropriate polarities, to get resultant current flowing through the feeder and was thus used to measure and protect the feeder. This configuration allows currents from each breaker to be individually fed to the IED. An internal function (CMSUM1), sums up the currents before being fed to the feeder protection and measurement functions.

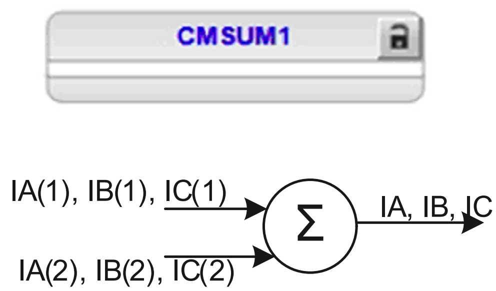


Figure 116: CT Input currents summation Function

One major advantage of this approach is that it is possible to measure and record individual breaker currents which is very important to get better insight into the system. The IED has additionally the breaker fail protection functions connected to each of the current input, so in case of failure of one of the breakers, selective action can be taken to identify and isolate only the faulted breaker, which is the very purpose of providing multiple breakers feeding a feeder.

The signal marked with IA, IB and IC represents the three phase current from bus side breaker (52-1) and the signal IA(2), IB(2) , IC(2) represent the current fed from the second (Tie / Middle in breaker-and-a-half system) breaker. The signal IG represents the measured ground current, fed either from residual connection or an external Core Balance CT.

The signal marked with VA, VB and VC represents the three phase system voltages on the bus-1, to which the feeder is connected through breaker 52-1. The signal marked with VA(2), VB(2) and VC(2) represents the three phase system voltages on the other bus (Bus-2), to which the feeder is connected through breaker 52-2 (and further through 52-3 in case of breaker-and-a-half system). These 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.

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.

The signal marked VSync is measured from the VT on the feeder side of the breaker. This signal is used for check synchronizing purposes. The input again is configured for Ph-Ph input from the system by default, but can be suitably configured to take input from Ph-G voltage input as well. Care shall be taken in setting the synchrocheck function with correct phase angle correction, especially in applications such as voltages fed to synchrocheck across a transformer with vector shift.

REF620 allows full flexibility in selecting the appropriate synchrocheck, by providing three sycnhro check function in the IED. The first is connected across Bus-1 and protected feeder voltages. The second one is connected across the protected feeder and the second bus voltages. The third one is connected across the two bus voltages.

Should the three phase bus VT voltage fail, say on fuse failure, it is possible to switch the critical voltage dependent protection, control and metering functions to the second bus VT (and back to the main bus) through a VT selection function block (VMSWI), within the IED. The IED is configured to have this selection done manually through a pushbutton in the front of the IED.

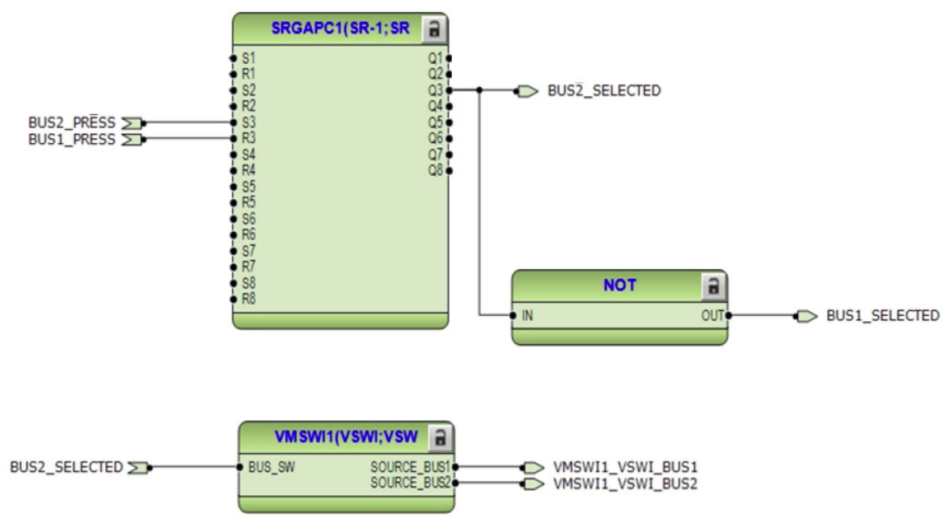


Figure 117: Bus Voltage selection

REF 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, hot line tag, sensitive earth fault detection, bus voltage selection (when provided), etc. Figure 118 shows the default mapping for the available programmable buttons. Figure 119 shows the hot line tag logic.

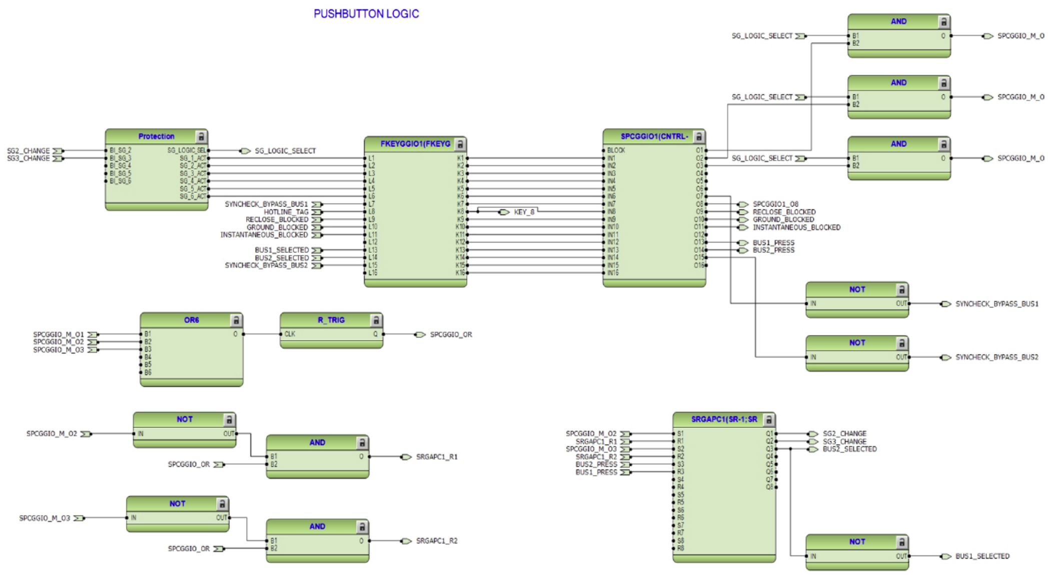


Figure 118: Default mapping on programmable buttons

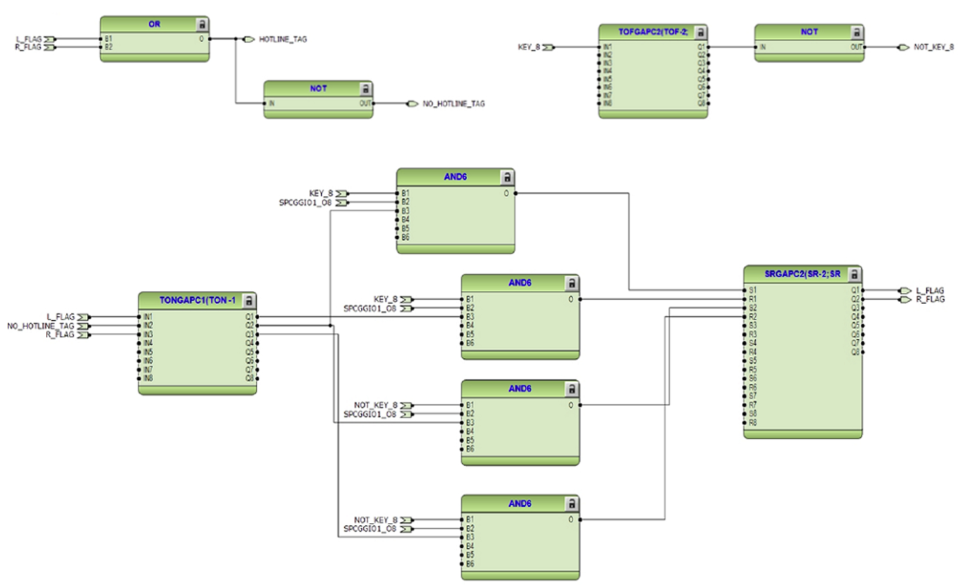


Figure 119: Hot line Tag logic

3.5.7 Functional diagrams for protection

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

Eight overcurrent stages (51P, 50P-1, 50P-2, 50P-3, 51LT, 67/51P, 67/50P-1, 67/50P-2) totally are offered for overcurrent and short-circuit protection. Three of them include directional functionality. The non directional high stage (50P-1) and directional high stage (67/50P-1) will be blocked by cold load detection logic. The cold load detection logic starts from closing of the circuit breaker and is active during set time. The cold load detection logic´s active time can be set in a resolution of minutes or seconds to the functions TPSGAPC and TPMGAPC.

The directional overcurrent and short circuit protection will be blocked by default also if the fuse failure situation is detected.

The inrush detection block's (INR-1) output BLK2H offers the possibility to either block the function or multiply the active settings for any of the shown protection function blocks.

All trip signals are connected to the Master Trip and also to the alarm LEDs. Alarm LEDs 1, 2 and 3 are used for phase segregated information of faults. The alarm LED 5 is used to indicate time delayed trips and the alarm LED 6 instantaneous trips of the current based protection functions.

The pickup information of all overcurrent functions is collected to the variable OC_PICKUP_ALARM and connected to the disturbance recorder. This signal can be mapped to the signal outputs depending on the application needs.

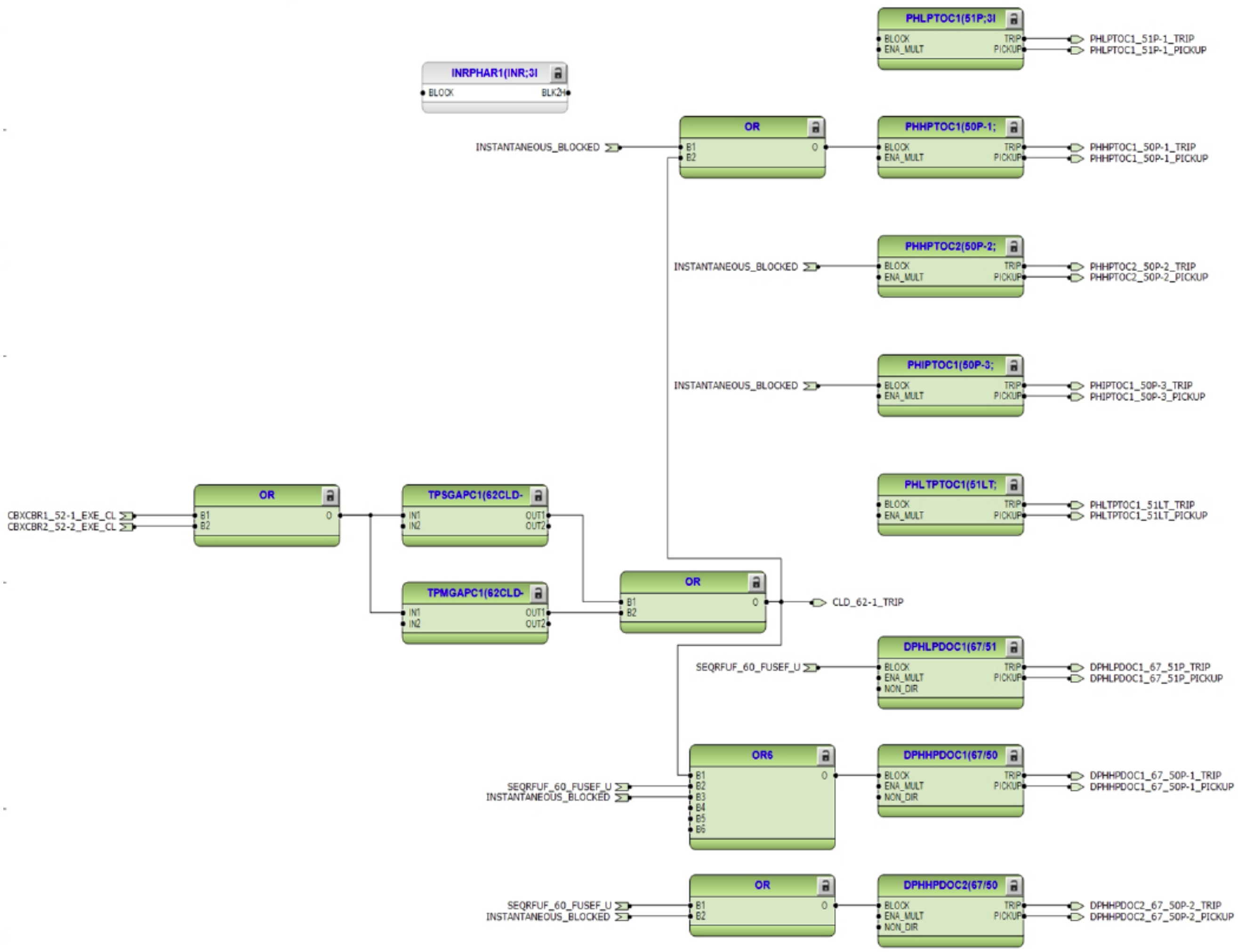


Figure 120: Three phase overcurrent protection

Four stages are provided to non-directional neutral overcurrent protection (51N-1, 50N-1, 50N-2, 50N-3). The neutral overcurrent protection uses calculated residual current component.

Four stages of ground overcurrent protections (51G, 50G-1, 50G-2 and 50G-3) are operated off standard IG input (rated 5/1A) when ordered. When sensitive ground input (1/0.2A) is ordered sensitive ground fault protection 50SEF is provided (instead of four ground overcurrent protections).

The operation of 51N-1, 50N-1, 50N-2, 50N-3 and 50SEF will be blocked if GROUND_BLOCKING input is active. The 50N-1 will also be blocked if the cold load detection logic is activated. The operation of neutral overcurrent protection functions is connected to alarm LED 4.

The operation of 51G, 50G-1 and 50G-2 will be blocked if GROUND_BLOCKING input is active. The 50G-1 will also be blocked if the cold load detection logic is activated. The operation of ground overcurrent protection functions is connected to alarm LED 4.

The alarm LED 5 is used to indicate time delayed trips and the alarm LED 6 instantaneous trips of the current based protection functions.

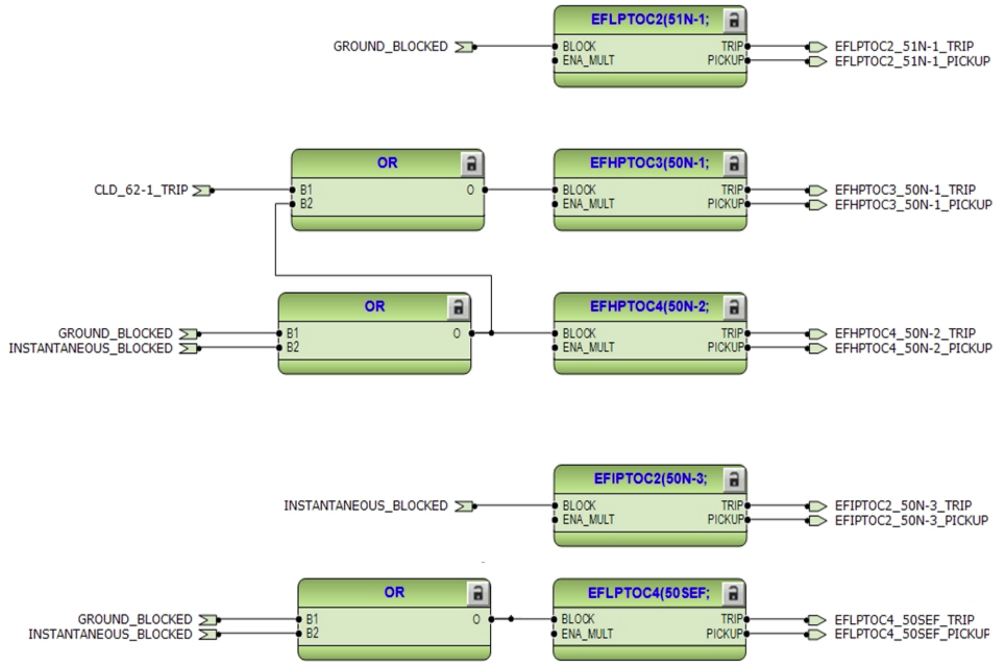


Figure 121: Non-directional neutral overcurrent protection

SEF and HIZ functions are included if sensitive SEF/HIZ measuring option is used.

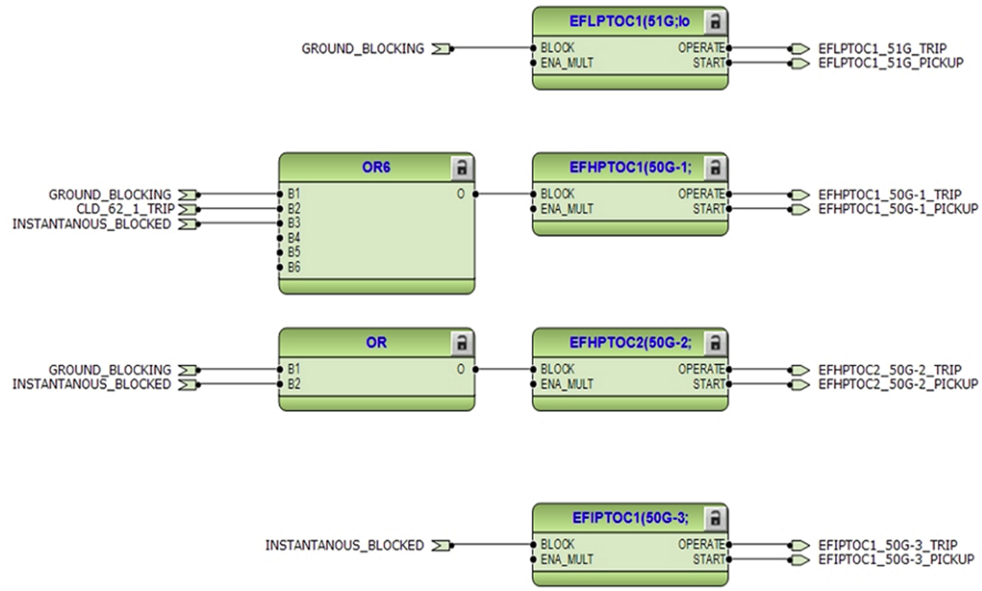


Figure 122: Non-directional ground overcurrent protection

51G, 50G-1, 50G-2 and 50G-3 are included if ground measuring option is used.

Three stages are offered for directional ground-fault protection(67/51N, 67/50N-1, 67/50N2). By default the stages (67/51N) and (67/50N-1) will be blocked by activating the GROUND_BLOCKING input. If the cold load situation is detected the (67/50N-1) function will be blocked. Also if the fuse failure situation is detected all directional ground-fault protection functions will be blocked. While setting the directional element, it is necessary to choose either V0 calculated or Negative sequence voltage polarization. While either one may be selected with WYE connected VT, it is essential to choose negative sequence voltage polarization with V (Delta) connected VT input from which zero sequence voltage cannot be derived.

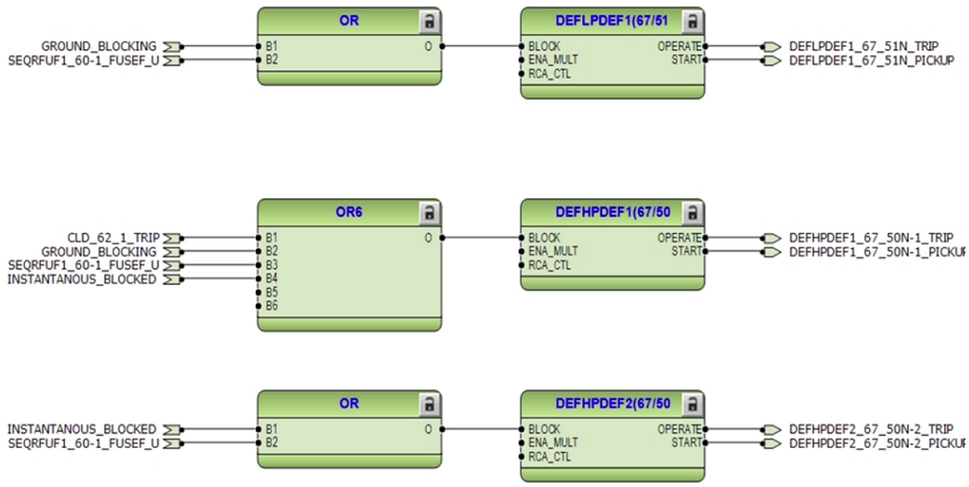


Figure 123: Directional neutral overcurrent protection

Two negative-sequence overcurrent protection (46-1 and 46-2) stages are provided for phase unbalance protection. These functions are used to protect the feeder against phase unbalance.

The phase discontinuity protection (46PD) provides protection for interruptions in the normal three-phase load supply, like in downed conductor situations.

The operation of 46-1, 46-2 and 46PD is not blocked as default by any functionality. The operation of these protection functions is connected to alarm LED 5. The pickup signals are connected to OC_PICKUP_ALARM variable in logic.

The undercurrent protection function (37-1) is offered for protection against loss of phase situations. The trip signal is connected to the disturbance recorder only by default.

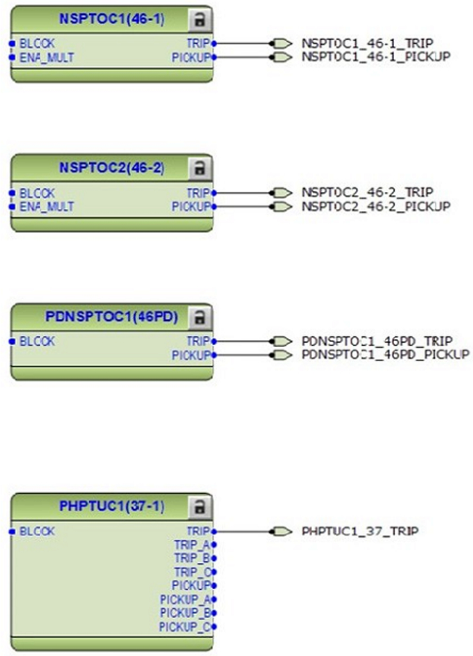


Figure 124: Negative sequence, phase discontinuity and undercurrent protection

All overcurrent pickup signals are merged together as variable OC_PICKUP_ALARM. This alarm is by default connected to disturbance recorder channel. It can be mapped also e.g. for alarming or blocking purposes to the binary output relays.

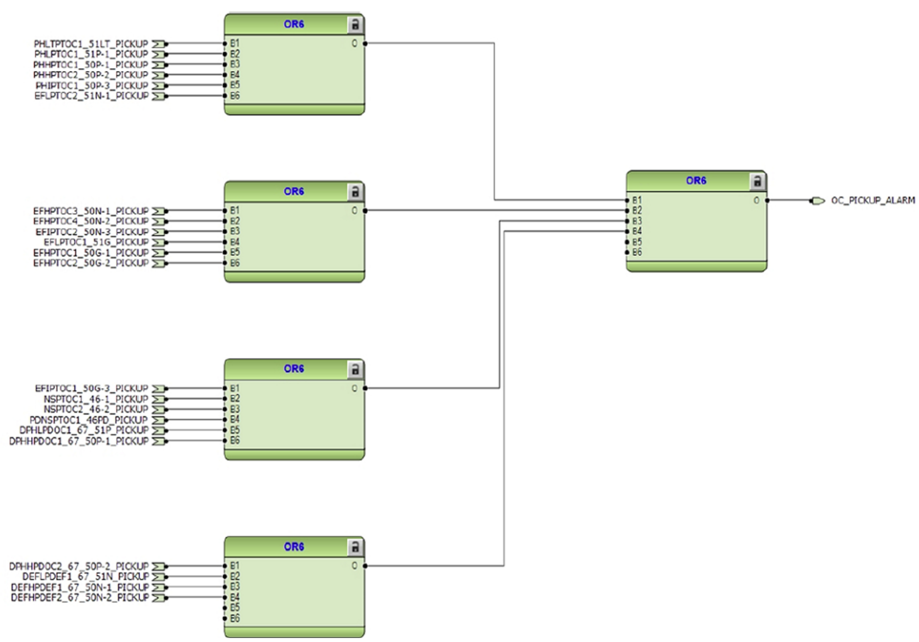


Figure 125: Overcurrent pickup alarm

The directional positive sequence power protection (32P-1) and directional negative sequence power protection (32N-1) are offered in configuration. The output information of these functions can be used e.g. releasing or blocking purposes but by default those are not connected. Directional power protection functions are blocked by default configuration connection if fuse failure is detected.

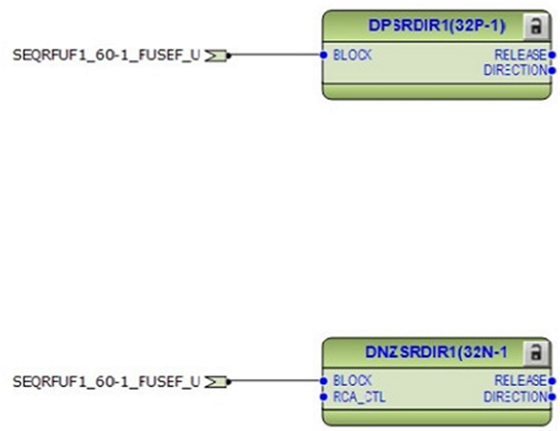


Figure 126: Directional power protection

Each bus input voltage is provided with a pair of overvoltage and undervoltage protection stages {27-1(1), 27-2(1) and 59-1(1), 59-2(1) for bus 1 and 27-1(2), 27-2(2) and 59-1(2), 59-2(2) for bus 2} which 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.

Similarly, each bus voltage is provided with negative-sequence overvoltage {47-1(1) and 47-2(1) for bus 1 and 47-1(2) and 47-2(2) for bus 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.

Each bus is also with a residual overvoltage protection, {59N-1(1) for bus 1 and 59N-1(2) for bus 2} which provide ground-fault protection by detecting abnormal level of residual voltage. They can be used, for example, as a nonselective backup protection for the selective directional ground-fault functionality. The operation signal is connected to alarm LED 8.

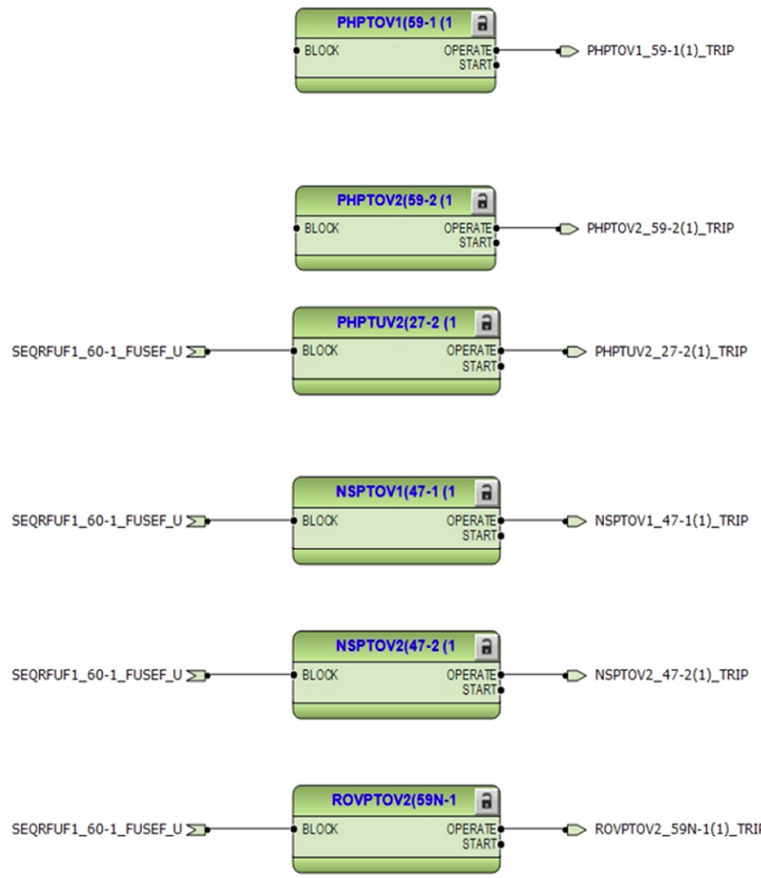


Figure 127: Voltage protection functions (Bus1, typical)

The over excitation protection function (24) is offered as standard. By the default the TRIP output is connected only to alarm LED 8.

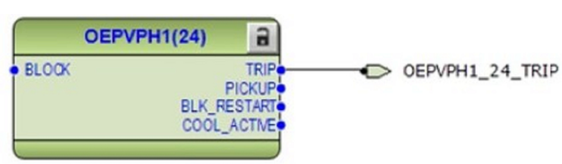


Figure 128: Over excitation protection

The thermal overload protection function (49F-1) detects short and long term overloads under varying load conditions.

The trip of the thermal overload protection function is connected to the Master Trip 1. The alarm and trip signals are connected to alarm LED 5.

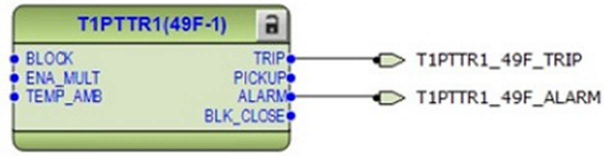


Figure 129: Thermal overload protection

Since the IED caters to two breaker control and protection, there are dual circuit-breaker failure protection (50BF-1 and 50BF-2) is initiated via the PICKUP input of respective breaker fail function from protection outputs/commands that open the respective circuit breaker.

50BF offers different operating modes associated with the circuit-breaker position and the measured phase and calculated residual currents.

50BF-1 has two operating outputs: TRRET and TRBU. The TRBU output can be used to give a backup trip to the circuit breaker feeding upstream. In the configuration the TRBU output signal is connected to the output S01 (X100: 10-12) for CB1 and S02 (X100: 13-14) for CB2.

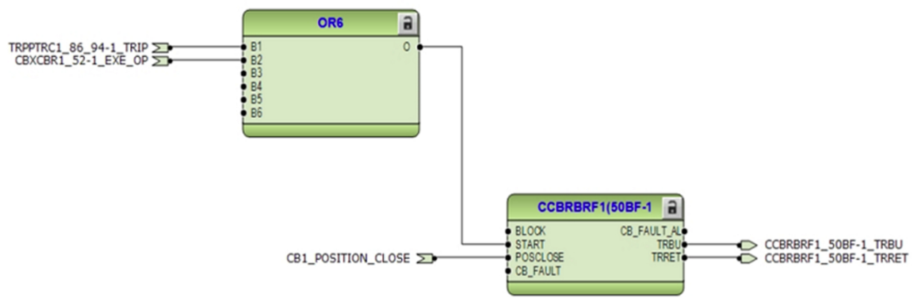


Figure 130: Circuit breaker-1 failure protection (Typical, similar scheme applicable for circuit breaker-2)

Three arc protection (AFD-1, AFD-2 and AFD-3) 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.

Trip signal from AFD-1 is connected to Master Trip 1 available at PO3(X100:15-19) and trip signal from AFD-2 is connected to Master Trip 2 available at PO4 (X100:20-24).

When HSO option is ordered, the Master Trips 1&2 are also arranged to trip HSO1 and HSO2 respectively at slot X110. AFD3 is also arranged to energize HSO3 at slot X110. This contact which may be wired to trip the bus and / or the incoming breaker as appropriate. The operation of these protection functions is connected to alarm LED 11.

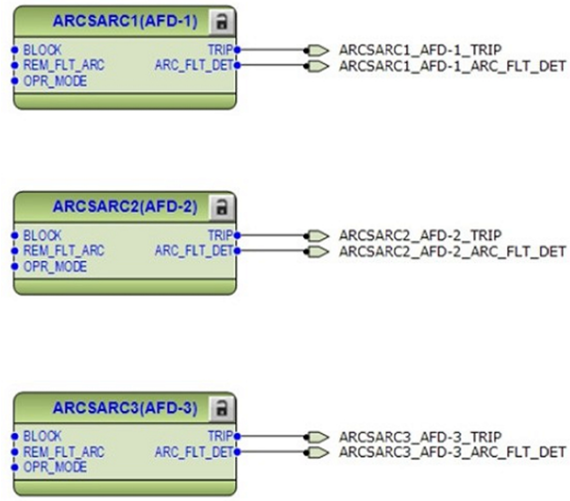


Figure 131: *Arc protection*

According to the order code the configuration includes high impedance fault protection function (HIZ). The function is available with functional application CB. The trip of the high impedance protection function is connected to the disturbance recorder and to the alarm LED 11.

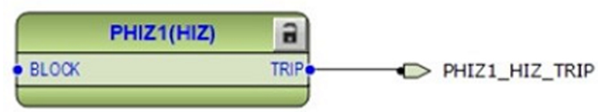


Figure 132: *High impedance fault protection*

The under frequency or over frequency protections (81-1 and 81-2) prevents damage to network components 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.

Two load shedding and restoration stages are offered in the standard configuration. The load shedding and restoration function (81LSH-1 and 81LSH-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.

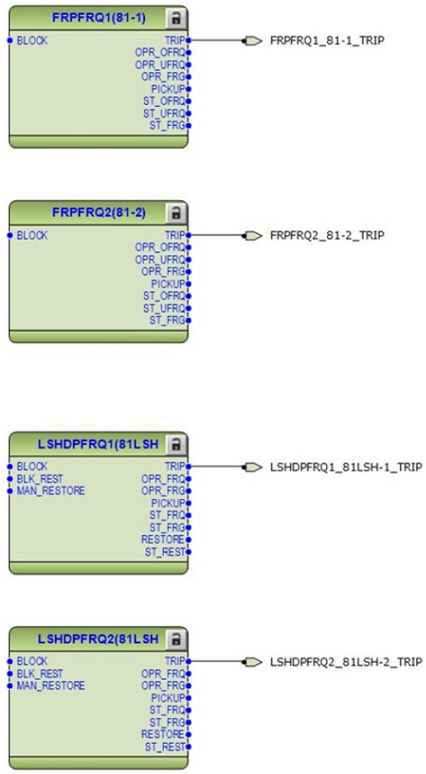


Figure 133: Frequency and Load shedding functions

A phase distance protection function (21P) is included as a standard function. It provides a fast and reliable protection for overhead lines and power cables. It is applied in distribution and sub-transmission networks where three-phase tripping is allowed for phase-to-phase / three-phase faults. Typically these networks are operated in ring or meshed type of configurations. It is also characteristic for these networks that the switching state is changed frequently due to daily operation and load flow considerations. The networks also include varying capacities of distributed generation. This makes it impossible to apply simple overcurrent based schemes. In these kinds of networks, 21P is used to provide a fast and selective protection for overhead lines and power cables. It can also be applied for radial feeders to increase the sensitivity of the protection, especially if the short circuit power of the source is low or it is changing due to network operation.

The protection has five distance phase elements Z1, Z2, Z3, Z4 and Z5 which may be set, depending on the application. When called in to protect a medium to long length feeders, the distance relay may be set to trip a feeder based on set impedance and time. Typically, Z1 may be set to protect 80% of the feeder, arranged to trip instantly. Zone 2 is set with a delay of about 500 mSec is set to trip faults upto 120% of the line. The Zone 3 may be set to provide backup protection for the protected feeder as well as adjoining components of the power system. If infeed from the remote end of the feeder is available, one of the zones Z5 can be set in reverse direction with adequate delay to provide backup protection for bus bar faults.

Very often, it is possible to utilize the instantaneous (Start / Pickup) output of one of the distance element to torque control one of the Overcurrent elements to grade with a downstream OC protection, typically on the LV side of a step down transformer at the tail of a transformer feeder protected by REF620.

From selectivity point of view, it is advantageous that in the protection chain all functions in different positions trip according to the same measuring principle. Therefore, 21P can also be applied for the backup protection of main transformers and buses. This way the selectivity with the distance protection of the outgoing lines is easier to achieve.

21P is suitable as a basic protection function against two and three phase faults in all kinds of networks, regardless of the treatment of the neutral point.

In the default configuration, the trip outputs of Z1 and Z2 are connected to trip the feeder through Master Trip logic. The Start/Pickup signals of the same elements are connected for fault record.

It is necessary to block the distance elements misoperating on loss of fuse. A signal from Fuse fail function is always wired to block the distance element. Since the bus voltage selection could be either from Bus1 or from Bus2, the appropriate bus voltage fuse failure blocking is directed to the distance element.

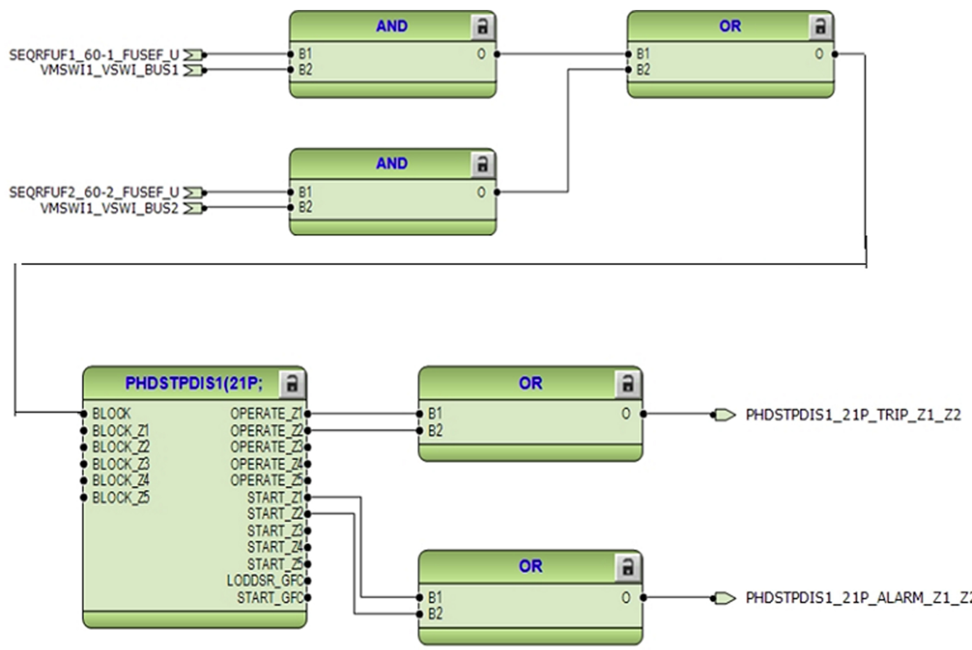


Figure 134: Distance Protection function

Fuse fail function is always wired to block the distance element. Since the bus voltage selection could be either from Bus1 or from Bus2, the appropriate bus voltage fuse failure blocking is directed to the distance element.

Care shall be taken while setting the distance element not to make the distance element so large as to make it operate for load flow condition. Provision is made in the function to discriminate load condition and avoid operation of the element for such conditions.

A forward direction full load power flow, with 65V VT seconday and 5A CT secondary would pose an apparent impedance to the relay of 13 Ohms, along the resistive direction.

Two Master Trip logics (86/94-1 and 86/94-2) are provided as a trip command collector. 86/94-1 collects the trip signals from 46, 46PD, 49F, 50P, 50N, 50G, 51LT, 51P, 51N, 51G, 67P, 67N, 81LSH-1, 87LOZREF, AFD-1 and SEF protection functions and is connected to trip output contact PO3 (X100:16-19) and also to high speed output HS01 (X110:15-16) for IEDs ordered with high speed binary output cards.

Open control commands to the circuit breaker from the local or remote is also connected directly to the output PO3 (X100:16-19) from circuit breaker control (52) function block.

86/94-2 collects the trip signals similar to Master Trip 1 except for AFD-1. Instead it collects input from AFD-2. It is connected to trip output contact PO4 (X100:20-24).

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

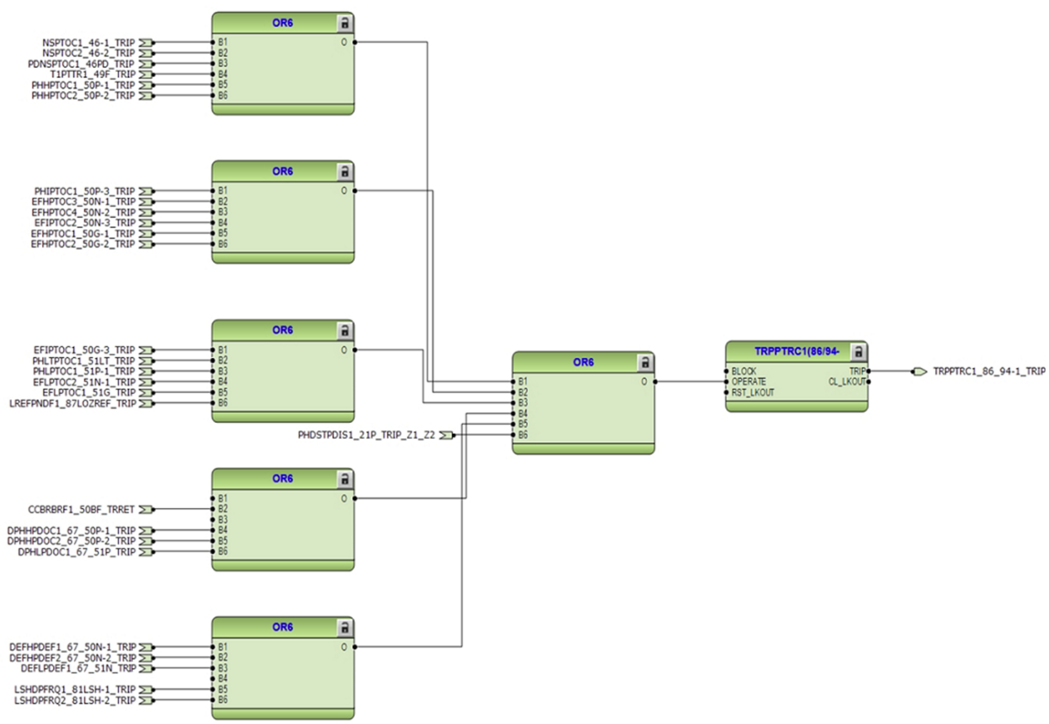


Figure 135: Master trip logic 1

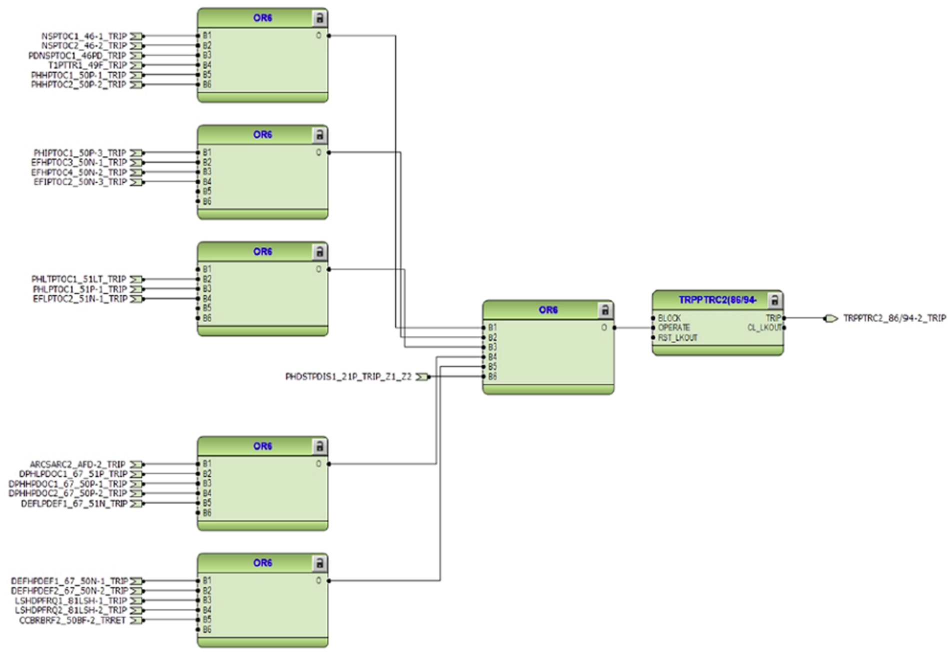


Figure 136: Master trip logic 2

3.5.8 Functional diagrams for control functions

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

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 of the interlocking conditions being active when the circuit breaker truck is closed in service position.

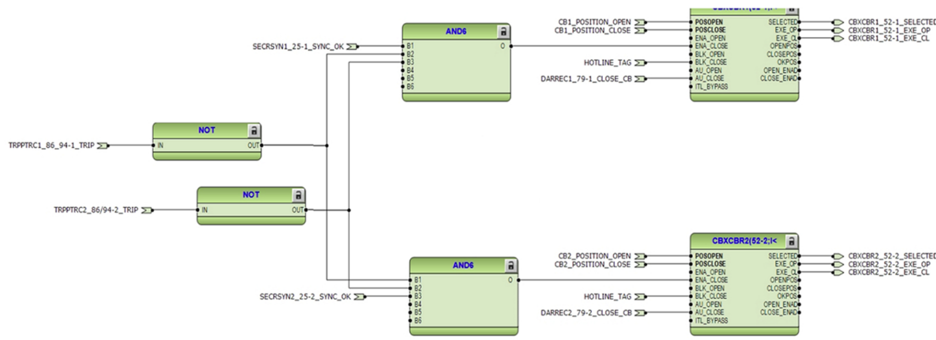


Figure 137: Circuit breaker control

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.

The autorecloser functionality (79) is configured to be initiated by operate signals from a number of protection stages through the INIT1...5 inputs. It is possible to create individual autoreclose sequences for each input.

The autoreclose function can be blocked with the INHIBIT_RECL input. By default, the operation of selected protection functions is connected to this input. A control command to the circuit breaker, either local or remote, also blocks the autoreclose function via the CBXCBR-selected signal. The circuit breaker availability for the autoreclosure sequence is expressed with the CB_READY input in DARREC1.

The autoreclose locked status is connected to the alarm LED 7. The unsuccessful autoreclosing UNSUC_RECL is connected to the disturbance recorder.

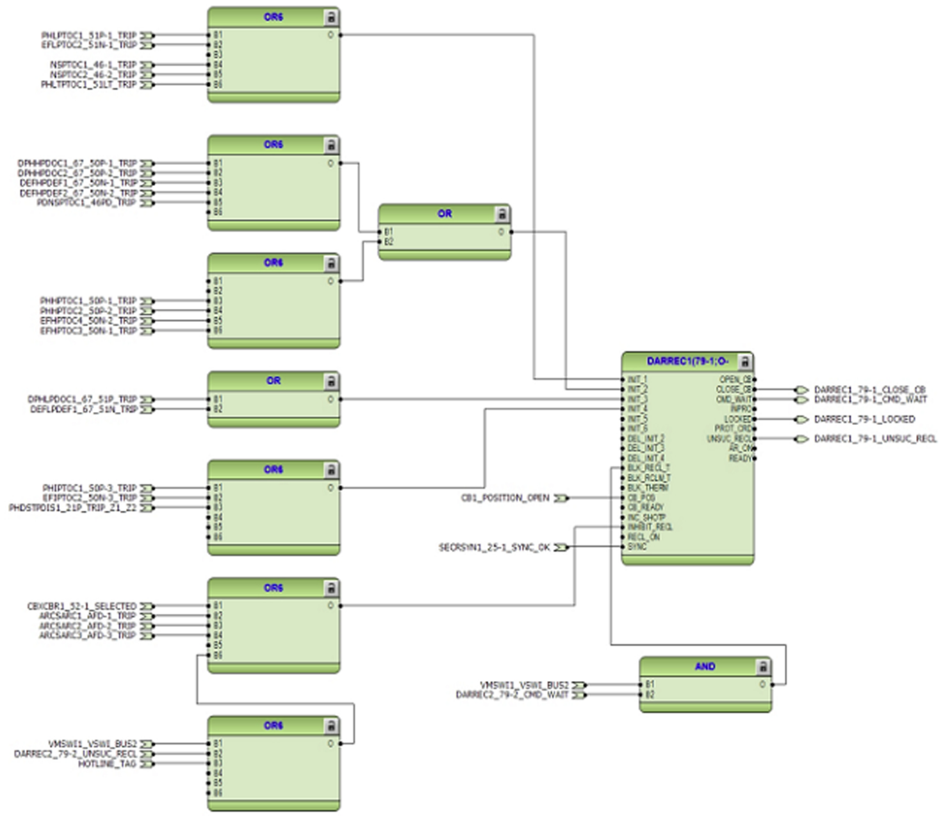


Figure 138: *Autoreclosing, Breaker 52-1*

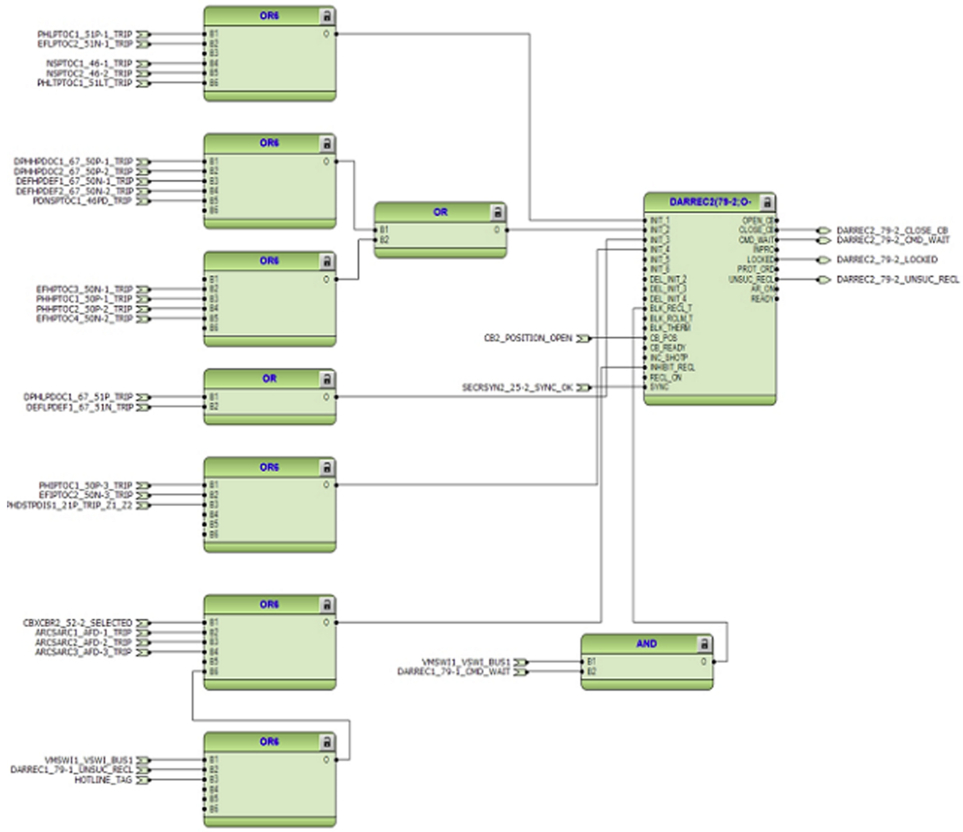


Figure 139: Autoreclosing, Breaker 52-2

3.5.9 Functional diagrams for condition monitoring

Two trip circuit monitoring (TCM-1 and TCM-2) stages are provided to supervise the trip circuit of the circuit breakers connected at PO3 (X100:15-19) and PO4 (X100:20-24).

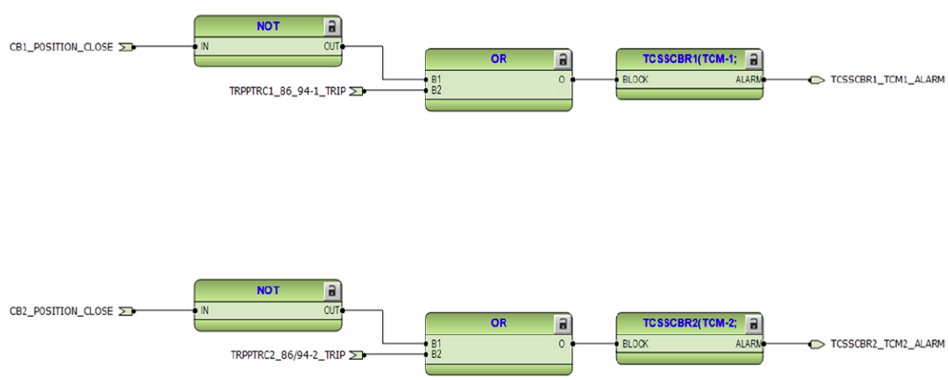


Figure 140: Trip circuit monitoring

The TCM-1 and TCM-2 functions are blocked by 86/94-1, 86/94-2 and when the circuit-breaker is not in closed position

.

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 (CCM). When a failure is detected, function activates and can be used to block protection functions which operates using calculated sequence component currents for example 46, thus avoiding mal-operation.

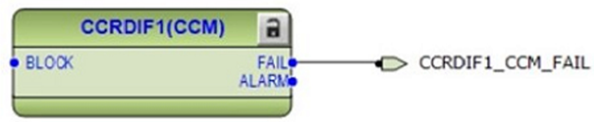


Figure 141: *Current circuit supervision*

By default the FAIL output from CCM function is only connected to disturbance recorder.

The fuse failure supervision SEQRFUF1 and SEQRFUF2 detect failures in voltage measurement circuits in respective buses Bus1 and Bus2 VT inputs. 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.

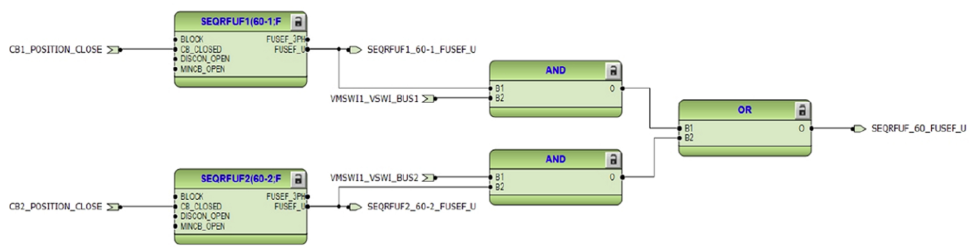


Figure 142: *Fuse failure monitoring*

The circuit breaker condition monitoring functions (52CM-1 and 52CM-2) supervise the circuit breakers' status based on the binary input information connected and measured current levels. The function introduces various supervision alarms.

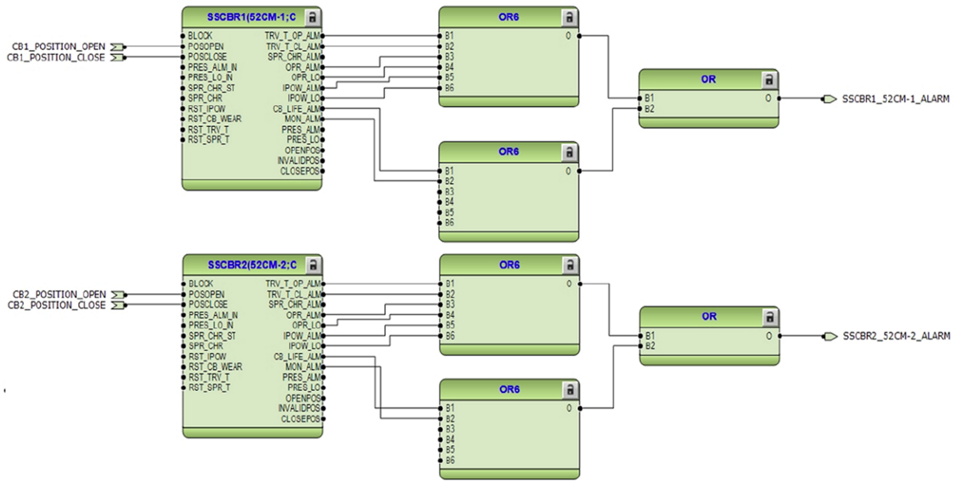


Figure 143: Circuit breaker condition monitoring

Cable fault detector (CFD) is offered for detecting self clearing in the feeder.

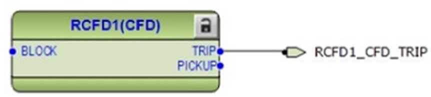


Figure 144: Cable fault detector

By default the TRIP output from CFD function is only connected to disturbance recorder.

3.5.10 Functional diagrams for measurements

The phase current inputs to the IED are measured by three-phase current measurement (IA, IB, IC) function block. The ground current input to the IED is measured by single phase current measurement (IG) function block. The current input is connected to the X120 card in the back panel. Similarly the sequence and residual currents are measured by sequence current measurement (I1, I2, I0).

Both the buses' phase voltage inputs are connected to the X130 card in the back panel. The voltages are measured by (VA,VB,VC), (VA,VB,VC(2)) function blocks. Similarly the sequence voltages are measured by sequence voltage measurement (V1, V2, V0) and (V1,V2,V0(2)) function blocks respectively.

The measurements can be seen from the LHMI and is available using the measurement option in the menu selection. Based on the settings, function blocks can generate low alarm/warning, high alarm/warning signals for the measured current values.

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

The power quality function (PQI-1) is used to measure the harmonic contents of the phase current. This functionality is included according to ordercode selection.

The power quality function (PQVPH-1) is used to measure the harmonic contents of the phase voltages. This functionality is included according to ordercode selection.

The power quality function (PQSS-1) is used to measure the voltage variation i.e. sags and swells. This functionality is included according to ordercode selection.

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

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 corresponding feeder.

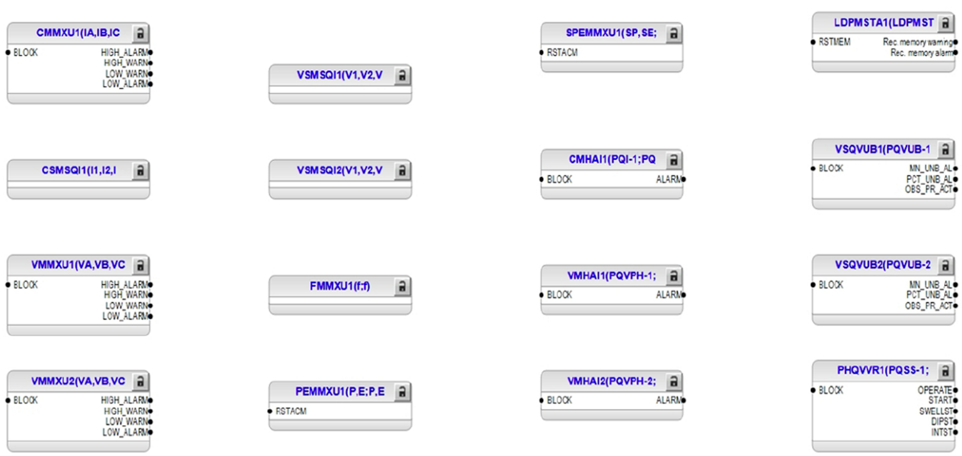


Figure 145: Current, voltage, power and energy measurements and load profile function

3.5.11 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 off TOF-1, TOF-2, TOF-3 and TOF-4,
- Four instance of Time delay on TON-1, TON-2, TON3 and TON-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.

3.5.12 Function diagrams for logging functions

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

Table 30: List of analog channels connected to DFR (REF620 Config C)

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

A few channels of the binary channel are connected to trigger the digital fault recorder as shown in Figure 146. More connection can be made as per individual need. Also when disturbance recorder is triggered the analog values available at the analog inputs are recorded by fault recorder FR

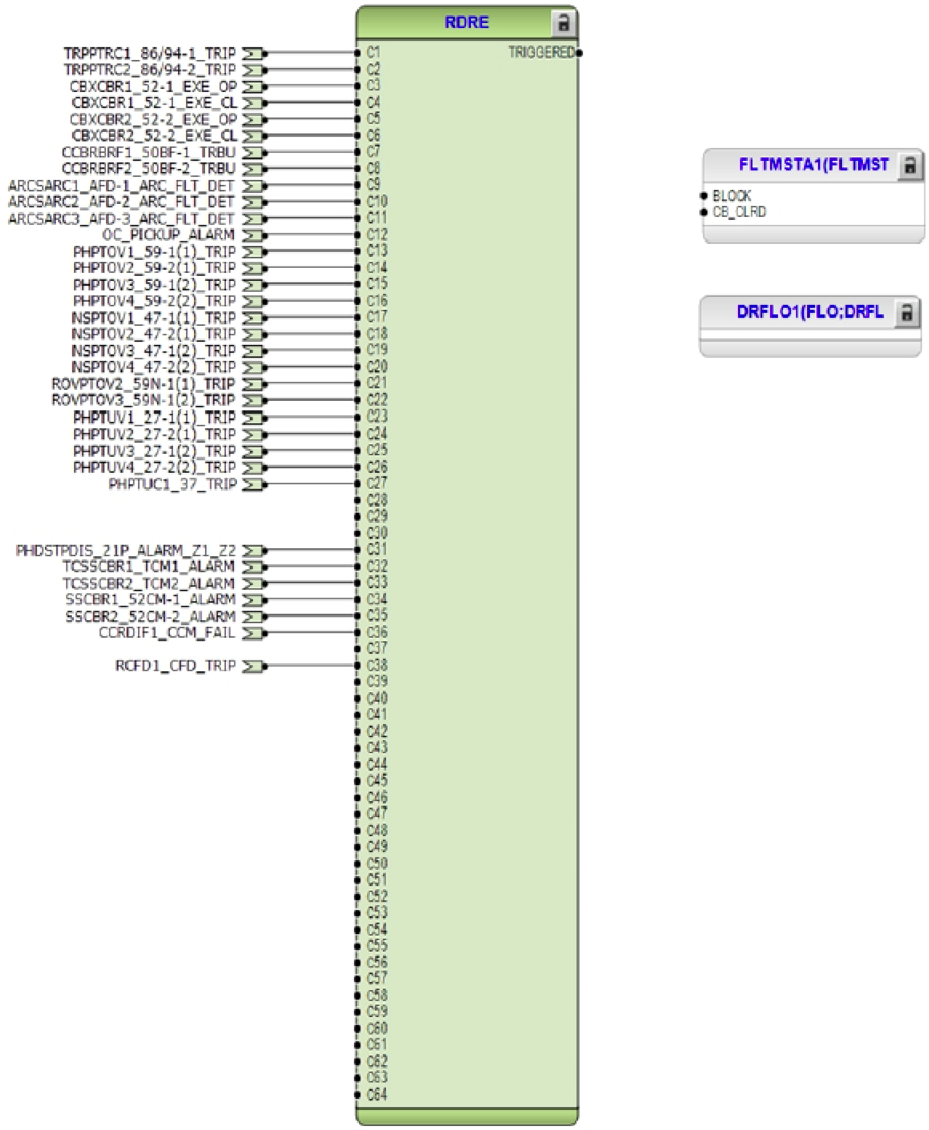


Figure 146: 64 channel Disturbance fault recorder and locator

3.5.13 Functional diagrams for I/O and Alarm LEDs

The default binary I/O connected in the configuration and Alarm LEDs are indicated in Figure 147 to Figure 151.

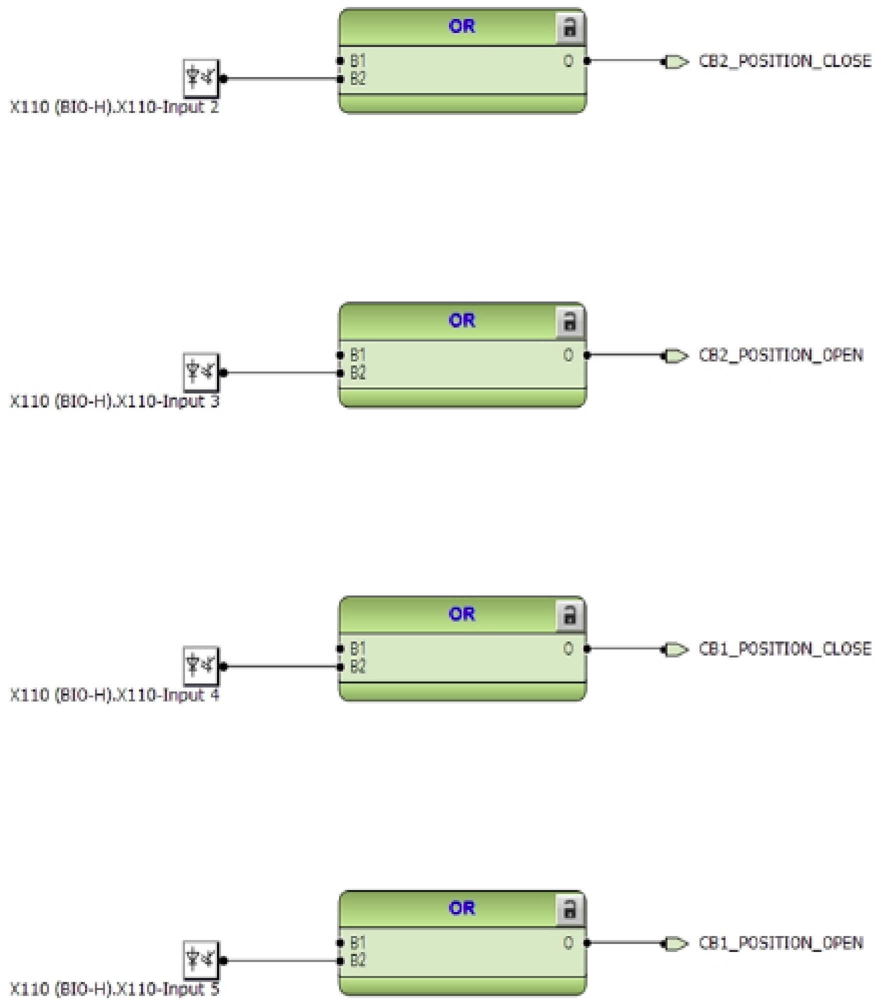


Figure 147: Binary inputs

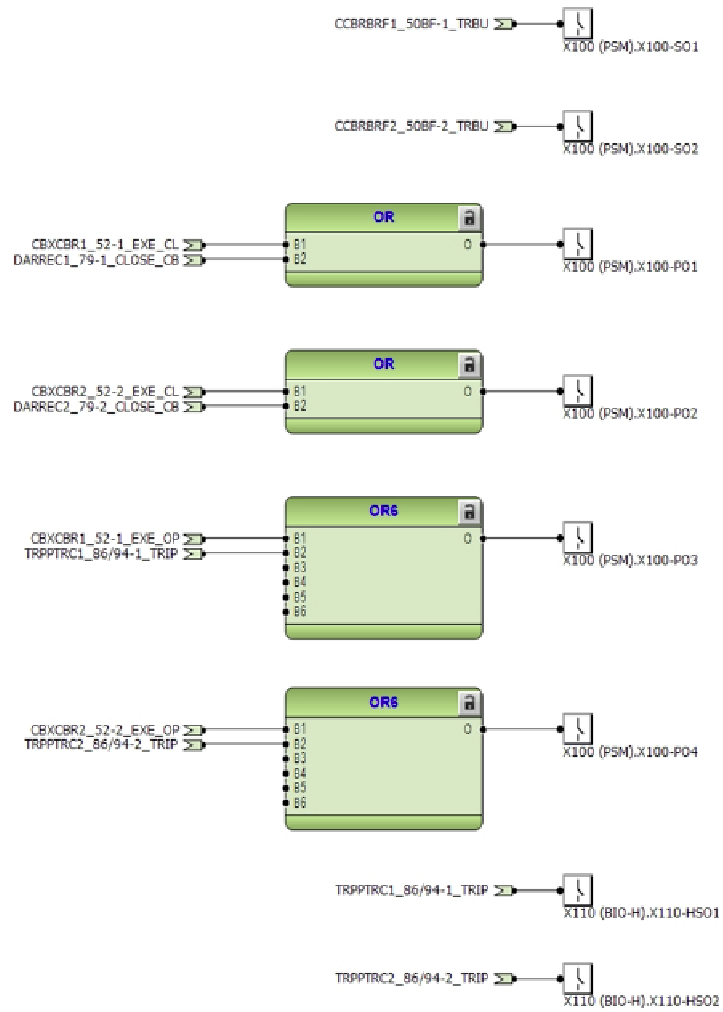


Figure 148: Binary outputs

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

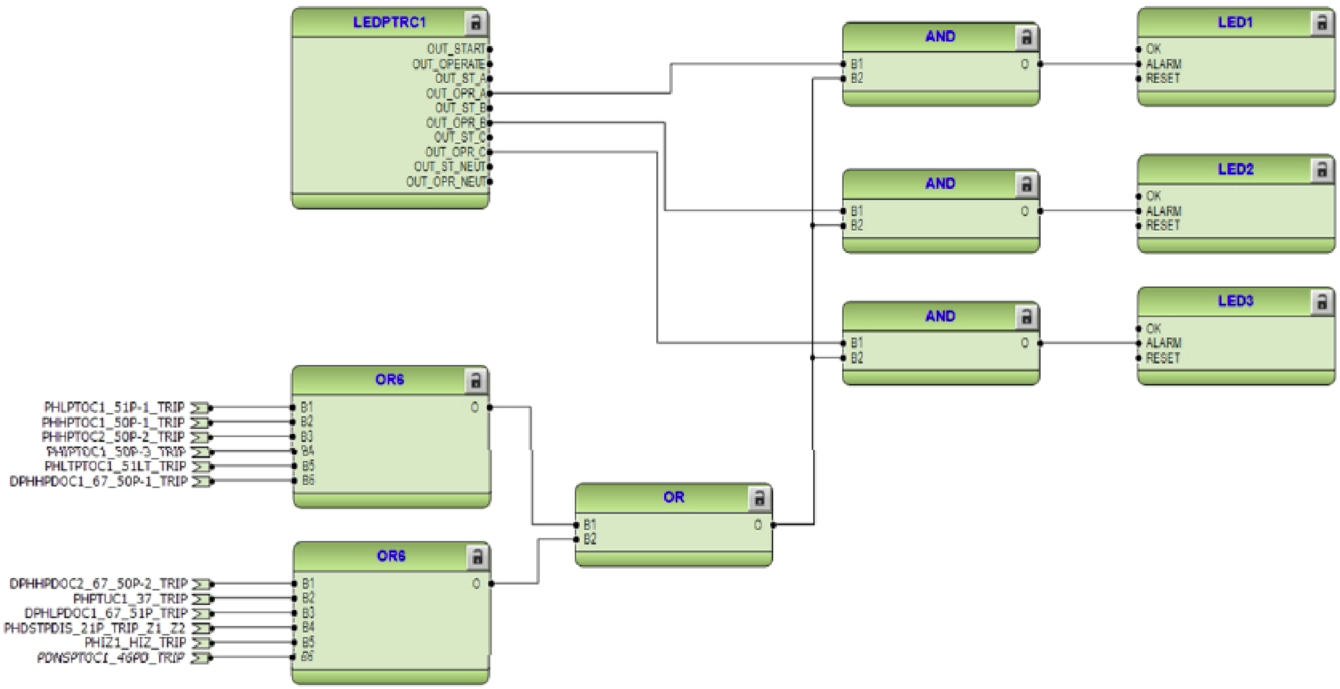


Figure 149: *Alarm LEDs 1 – 3*

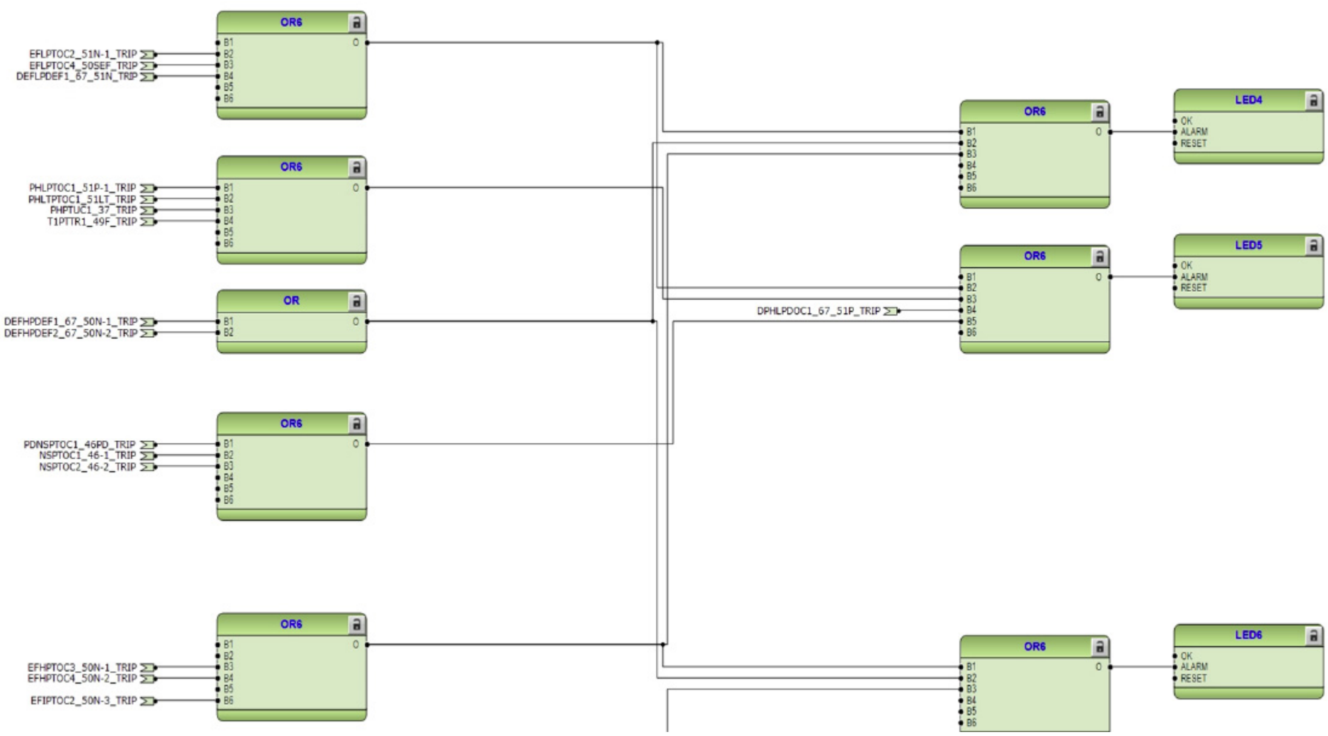


Figure 150: *Alarm LEDs 4 – 6*

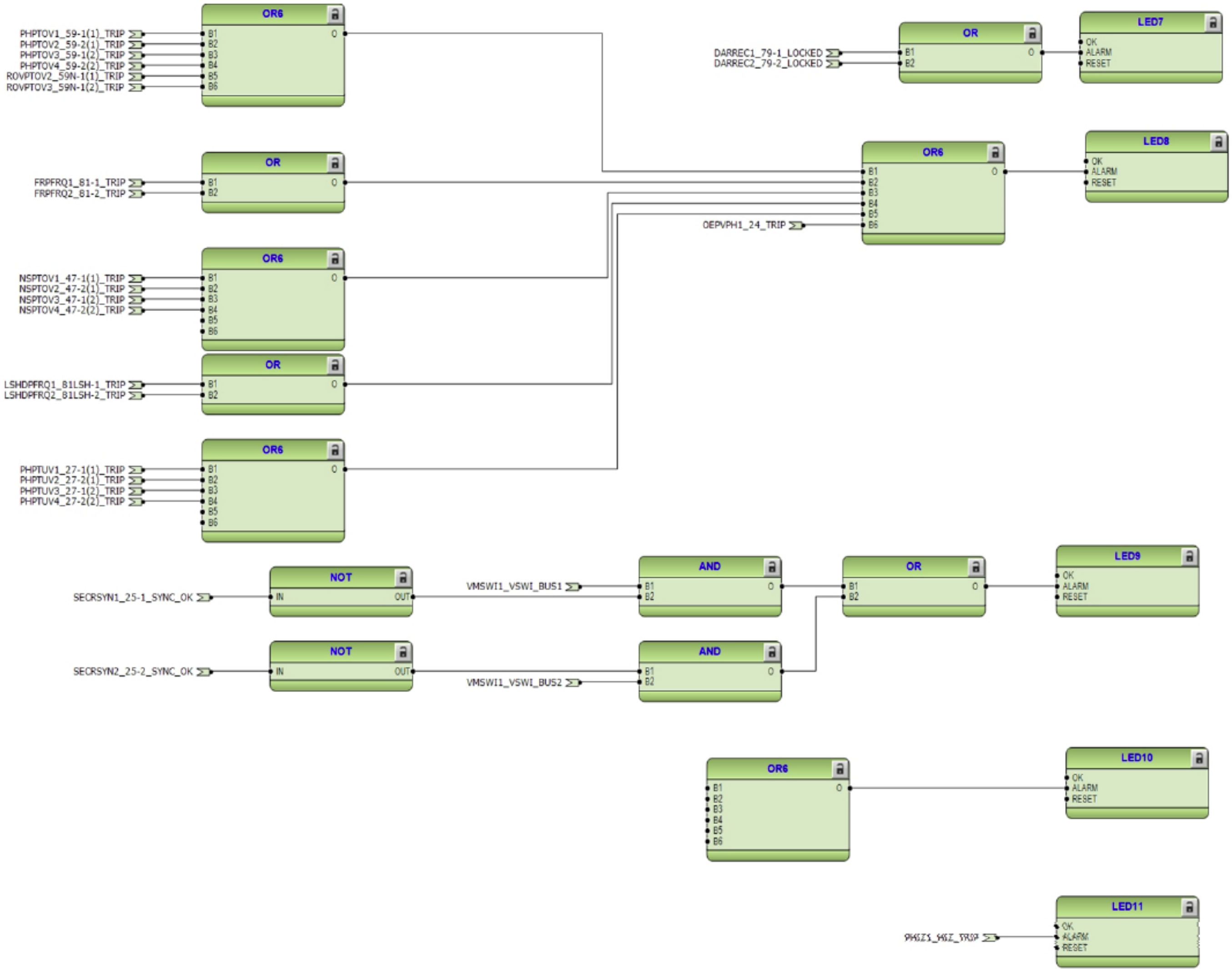


Figure 151: *Alarm LEDs 7 – 11*

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 152) that operation of most of the protections become impossible.

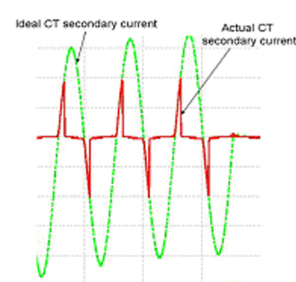


Figure 152: CT secondary waveform when severe AC saturation occurs

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

$$V_X > I_f (R_{CT}+R_L+R_B)$$ 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.

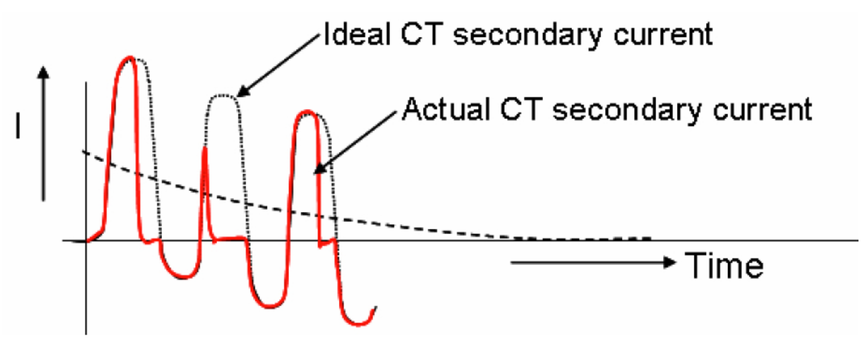


Figure 153: CT waveform when saturation occurs due to DC transients

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.

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

where,

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

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 $\mathbf{R_{CT}}$ 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%, $\psi = 0.25$. 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 154 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.

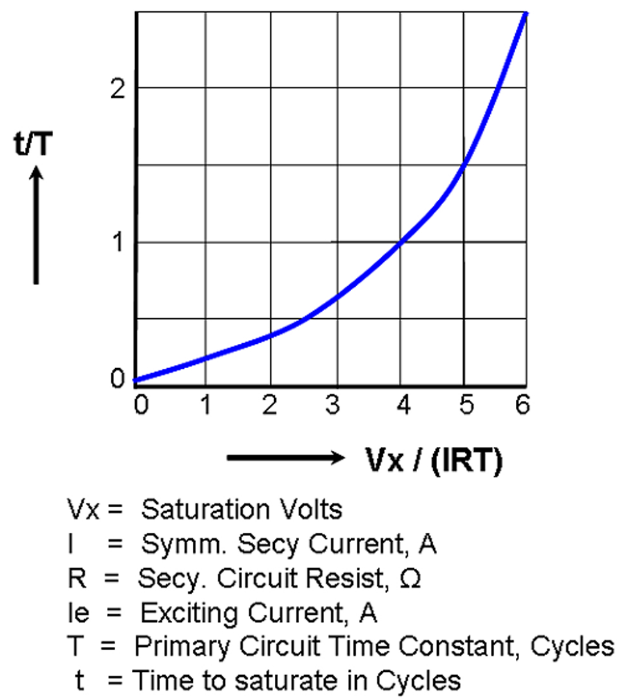


Figure 154: Time to saturate as a function of the saturation voltage and secondary circuit resistance

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

5.1.1 Auxiliary supply voltage input

Table 31: Auxiliary voltage supply

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

5.1.2 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 typically as part of Analog Input Modules (AIM) located in Slot ID X120 or X130, in configuration A. They are always available in all configurations as part of Binary Input and Output Modules (BIO)s located in Slot IDs X105, X110 and X115 based on ordering code.

The following tables give terminal numbers of Binary Inputs available depending on the type of AIM or BIO module. A prefix as to the slot ID has to be attached based on the ordering code.

Table 32: Binary input terminals, part of AIM0016, in position X120, only Config A

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

Table 33: Binary input terminals, part of AIM 0006, in Slot X130, only Config A

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

Table 34: Binary input terminals in BIO (8BI+4BO) in slots X105, X110 or X115
Note: Xnnn in the following table with appropriate Slot ID X105, X110 or X115 as applicable.

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

Table 35: Binary input terminals in BIO (8BI+3HSO) in slots X110 or X115
Note: Xnnn in the following table with appropriate Slot ID X110 or X115 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, -

5.1.3 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.

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 36: 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 are heavy-duty trip contacts capable of controlling most circuit breakers. On delivery from the factory, the trip signals from all the protection stages are routed to PO3 and PO4.

Table 37: 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

The IED can be ordered with BIO cards with High Speed Power Outputs in designated slots. When Arc protection is ordered with HSO outputs, that protection is configured to energize one or more of those outputs by default.

Table 38: Binary High Speed Output terminals in BIO (8BI+3HSO) in slots X110 or X115 as alternative option

Note: Substitute Xnnn in the following table with appropriate Slot ID X110 or X115 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 (in slots X115 and X105 optional) can be used for signaling on pickup and tripping of the IED. On delivery from the factory, a few of the protection stages are routed to signaling outputs, for onward alarm / external trip multiplications.

Table 39: 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 40: Binary signal output terminals in BIO (8BI+4BO) in slots X105, X110 or X115

Note: Substitute Xnnn in the following table with appropriate Slot ID X105, X110 or X115 as applicable.

Terminal	Description
Xnnn-14 Xnnn-15 Xnnn -16	SO1, common SO1, NO SO1, NC

Terminal	Description
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

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 41: 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 band 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-TXA	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
HW	Hardware
HSO	High-speed Output is a hybrid discrete/electromechanical output that is rated as a power output.
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

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
WAN	Wide area network
WCT	Window Type CT (Also refer to CBCT)
WHMI	Web human machine interface

Legend

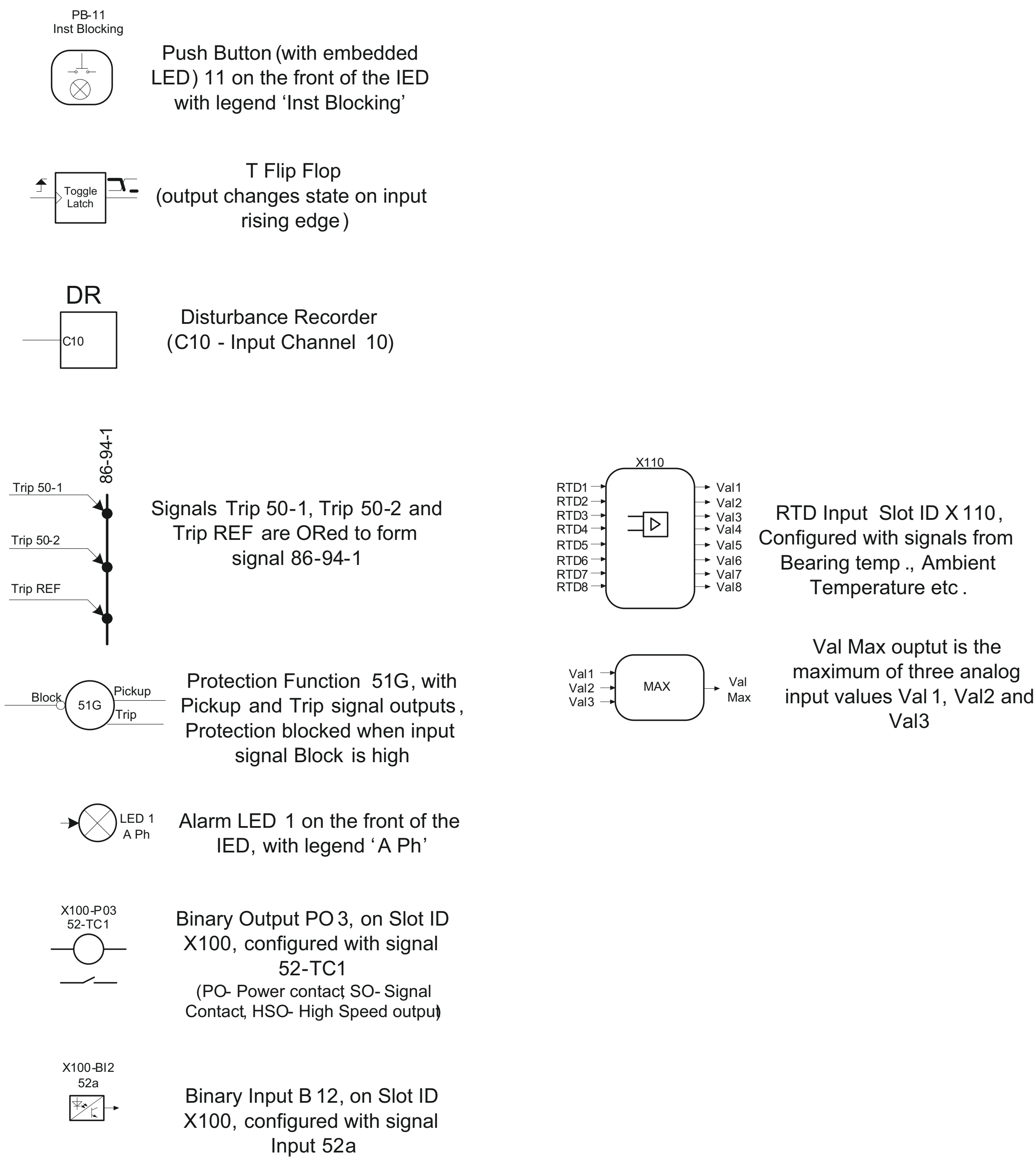


Figure 155: Legend

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