Relion® 620 series

Advanced Recloser Protection and Control RER620

Application Manual

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ABB Inc.
Distribution Automation
4300 Coral Ridge Drive
Coral Springs, FL 33065, USA
Toll-free: 1 (800) 523-2620
Phone: +1 954-752-6700
Fax: +1 954 345-5329
http://www.abb.com/substationautomation

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

Table of Contents

Section 1 Introduction

1.1 This manual

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

1.2 Intended audience

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

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

1.3 Product documentation

1.3.1 Product documentation set

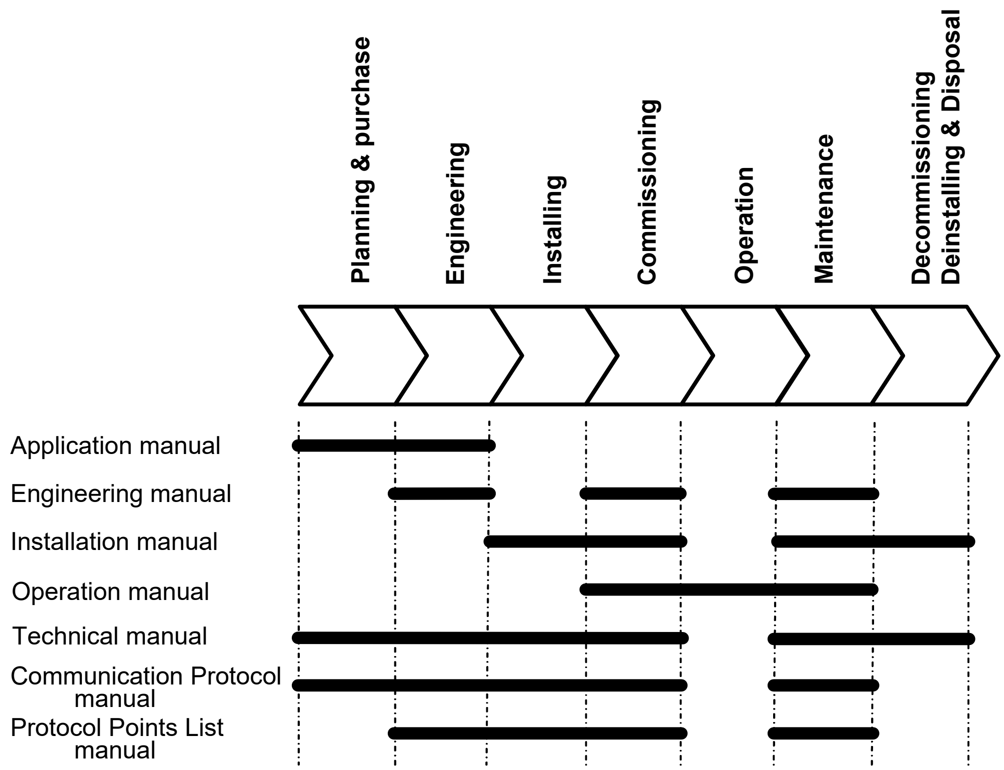


Figure 1: The intended use of manuals in different lifecycles

The engineering manual contains instructions on how to engineer the relays using the different tools in PCM600. The manual provides instructions on how to set up a PCM600 project and insert relays 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 DNP3.

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

The operation manual contains instructions on how to operate the relay once it has been commissioned. The manual provides instructions for monitoring, controlling and setting the relay. 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 relay. The manual concentrates on vendor-specific implementations. The point list manual describes the outlook and properties of the data points specific to the relay. 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/11/23/2010	1.0	First release
B/10/31/2011	1.1	Content updated to correspond to the product series version
C/08/14/2014	1.2	Content updated to correspond to the product series version
D/09/30/2015	1.2	Content updated
E/07/20/2017	1.3	Content updated

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

1.3.3 Related documentation

Name of the document	Document ID
Modbus Communication Protocol Manual	1MAC052634-MB
DNP3 Communication Protocol Manual	1MAC052460-MB
PG&E 2179 Communication Protocol Manual	1MAC396957-MB
IEC 61850 Engineering Guide	1MAC106231-MB
Installation Manual	1MAC051065-MB
Operation Manual	1MAC050592-MB
Technical Manual	1MAC050144-MB

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 relay 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.
- Push button navigation in the LHMI menu structure is presented by using the push button 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”.
- Relay 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.
- Analog inputs to protection functions are shown in the technical manual for clarity however these inputs and connections do not appear in the application logic. The connection of these analog signals is fixed internally to the corresponding function blocks and cannot be altered by users.

Function block

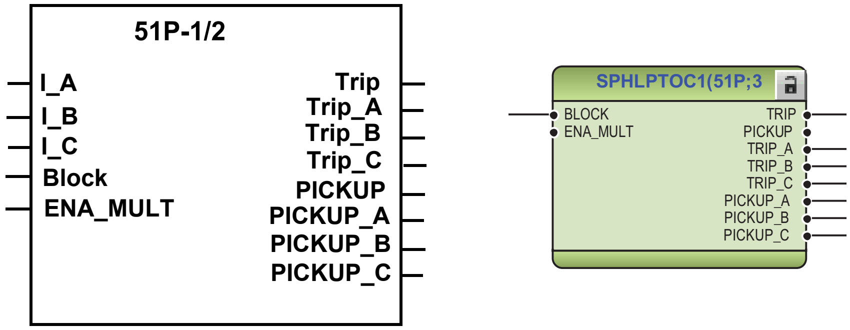


Figure 2: Function block as it appears in the manual (left) and in the ACT (right)

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: RER620 functions, codes and symbols

Function	IEC61850	IEC60617	ANSI/C37.2
Current Protection			
Single-phase non-directional time overcurrent protection with 1-ph trip option, low stage	SPHLPTOC1	3I>(1)	51P
Single-phase non-directional time overcurrent protection with 1-ph trip option, high stage 1	SPHLPTOC2	3I>(2)	50P-1
Single-phase non-directional time overcurrent protection with 1-ph trip option, high stage 2	SPHHPTOC1	3I>>(1)	50P-2
Single-phase non-directional instantaneous overcurrent protection with 1-ph trip option	SPHIPTOC1	3I>>>(1)	50P-3
Non-directional time overcurrent ground-fault protection, low stage	XEFLPTOC2	Io>(2)	51N
Non-directional time overcurrent ground-fault protection, high stage 1	XEFLPTOC3	Io>(3)	50N-1
Non-directional time overcurrent ground-fault protection, high stage 2	XEFHPTOC3	Io>>(3)	50N-2
Non-directional instantaneous time overcurrent ground-fault protection	XEFIPTOC2	Io>>>(2)	50N-3
Non-directional sensitive earth-fault	EFLPTOC3	Io>(3)	50SEF
Negative sequence non-directional time overcurrent protection 1	XNSPTOC1	I2 >(1)	46-1
Negative sequence non-directional time overcurrent protection 2	XNSPTOC2	I2 >(2)	46-2
Phase discontinuity protection	PDNSPTOC1	I2/I1>	46PD
Three-phase inrush detector	INPHAR	3I2f >	INR
Directional Protection			
Single-phase directional overcurrent protection, low stage 1	SDPHLPDOC1	3I >->(1)	67/51P-1
Single-phase directional overcurrent protection, low stage 2	SDPHLPDOC2	3I >->(2)	67/51P-2
Directional ground-fault protection, low stage 1	XDEFLPDEF1	Io>->(1)	67/51N-1
Directional ground-fault protection, low stage 2	XDEFLPDEF2	Io>->(2)	67/51N-2
Cold Load Timers			
Cold load timer 1 Phase A (in seconds)	TPSGAPC1	TPS(1)	62CLD-1

Function	IEC61850	IEC60617	ANSI/C37.2
Cold load timer 2 Phase A (in minutes)	TPMGAPC1	TPM(1)	62CLD-2
Cold load timer 1 Phase B (in seconds)	TPSGAPC2	TPS(2)	62CLD-3
Cold load timer 2 Phase B (in minutes)	TPMGAPC2	TPM(2)	62CLD-4
Cold load timer 1 Phase C (in seconds)	TPSGAPC3	TPS(3)	62CLD-5
Cold load timer 2 Phase C (in minutes)	TPMGAPC3	TPM(3)	62CLD-6
Voltage Protection			
Single-phase overvoltage 1, source 1 low stage	SPHPTOV1	3U >(1)	59-1
Single-phase overvoltage 2, source 1 high stage	SPHPTOV2	3U >(2)	59-2
Single-phase overvoltage 3, source 2 low stage	SPHPTOV3	3U >(3)	59-3
Single-phase undervoltage 1, source 1 low stage	SPHPTUV1	3U <(1)	27-1
Single-phase undervoltage 2, source 1 high stage	SPHPTUV2	3U <(2)	27-2
Single-phase undervoltage 3, source 2 low stage	SPHPTUV3	3U <(3)	27-3
Positive sequence overvoltage protection, source1	PSPTOV1	U1>(1)	59PS-1
Positive sequence overvoltage protection, source 2	PSPTOV2	U1>(2)	59PS-2
Negative sequence overvoltage protection, source1	NSPTOV1	U2>(1)	47
Negative sequence overvoltage protection, source 2	NSPTOV2	U2>(2)	47-2
Zero sequence overvoltage protection, source1	ROVPTOV1	Uo>(1)	59N-1
Zero sequence overvoltage protection, source 2	ROVPTOV2	Uo>(2)	59N-2
Frequency Protection			
Underfrequency, Overfrequency, Frequency rate of change, Source 1, Stage 1	FRPFRQ1	f</f>,df/dt(1)	81-1
Underfrequency, Overfrequency, Frequency rate of change, Source 1, Stage 2	FRPFRQ2	f</f>,df/dt(2)	81-2
Load Shed & Restoration, Source 1, Stage 1	LSHDPFRQ1	UFLS/R(1)	81S-1
Load Shed & Restoration, Source 1, Stage 2	LSHDPFRQ2	UFLS/R(2)	81S-2
Other Protection			
High Impedance Fault Detector	PHIZ1	PHIZ1	HIZ
Circuit breaker failure protection	SCCBRBRF1	3I>/Io>BF	50BFT
Circuit breaker close failure protection	SCCBRBCF1	SCCBRBCF1	50BFC
Directional positive sequence power protection	DPSRDIR1	P>->	32P
Directional negative/zero sequence power protection	DNZSRDIR1	Q>->	32N
Control			
Autoreclosing, 1ph and/or 3ph	SDARREC1	O -> I	79
Synch-check/voltage check (Source 1 is defined as bus, Source 2 as line)	SECRSYN1	SYNC	25
Circuit Breaker 1 (3 state inputs / 3 control outputs)	SCBXCBR1	I<->O CB	52
Loop control	DLCM	LCM	LCM
Supervision and Monitoring			
CB condition monitoring	SPSCBR1	CBCM	52CM
Fuse failure supervision, Source 1	SEQRFUF1	FUSEF	60
Measurement			
Three-phase current	CMMXU1	3I	IA,IB,IC
Demand metering, Max/Min metering	CMSTA1		
Sequence current	CSMSQI1	I1,I2,I0	I1, I2, I0

Function	IEC61850	IEC60617	ANSI/C37.2
Ground current	RESCMMXU1	Io	IG
Three-phase voltage, Source 1	VMMXU1	3U	VA,VB,VC
Three-phase voltage, Source 2	VMMXU2	3U(B)	VA,VB,VC(2)
Sequence voltages, Source 1	VSMSQI1	U1,U2,U0	V1,V2,V0
Sequence voltages, Source 2	VSMSQI2	U1,U2,U0(B)	V1,V2,V0(2)
Single and Three-phase power, Power factor and three phase energy, Source 1	APEMMXU1	P,SP,E	P,SP,E
Frequency, Source 1	FMMXU1	f	f
Recorders			
Digital fault recorder (DFR)	RDRE1	DR	DFR
Sequence of Events (SER)	SER	SER	SER
Fault Recorder	FLTMSTA	FLTMSTA	FLTMSTA
Fault Locator (FLOC)	DRFLO1	FLO	FLO
Other Functions			
Battery voltage, current. Test the battery	ZBAT1	UPS	UPS
Universal Power Drive	XGGIO115	X115(UPD)	X115(UPD)
Programmable buttons (16 buttons)	FKEYGGIO1	FKEYGGIO1	FKEYGGIO1
Move function block (8 outputs)	MVGAPC1	MVGAPC1	MVGAPC1
Move function block (8 outputs)	MVGAPC2	MVGAPC2	MVGAPC2
Pulse timer (8 timers)	PTGAPC1	PTGAPC1	PTGAPC1
Pulse timer (8 timers)	PTGAPC2	PTGAPC2	PTGAPC2
Generic control points (16 outputs)	SPCGGIO1	SPCGGIO1	SPCGGIO1
Generic control points (16 outputs)	SPCGGIO2	SPCGGIO2	SPCGGIO2
Set reset flip flops (8 outputs)	SRGAPC1	SRGAPC1	SRGAPC1
Set reset flip flops (8 outputs)	SRGAPC2	SRGAPC2	SRGAPC2
Time delay off timers (8 timers)	TOFGAPC1	TOFGAPC1	TOFGAPC1
Time delay off timers (8 timers)	TOFGAPC2	TOFGAPC2	TOFGAPC2
Time delay on timers (8 timers)	TONGAPC1	TONGAPC1	TONGAPC1
Time delay on timers (8 timers)	TONGAPC2	TONGAPC2	TONGAPC2
Multipurpose generic up-down counter	UDFCNT1	UDFCNT1	UDFCNT1
Multipurpose generic up-down counter	UDFCNT2	UDFCNT2	UDFCNT2
Multipurpose generic up-down counter	UDFCNT3	UDFCNT3	UDFCNT3
Multipurpose generic up-down counter	UDFCNT4	UDFCNT4	UDFCNT4
Multipurpose generic up-down counter	UDFCNT5	UDFCNT5	UDFCNT5
Multipurpose generic up-down counter	UDFCNT6	UDFCNT6	UDFCNT6
Multipurpose generic up-down counter	UDFCNT7	UDFCNT7	UDFCNT7
Multipurpose generic up-down counter	UDFCNT8	UDFCNT8	UDFCNT8
Multipurpose generic up-down counter	UDFCNT9	UDFCNT9	UDFCNT9
Multipurpose generic up-down counter	UDFCNT10	UDFCNT10	UDFCNT10
Multipurpose generic up-down counter	UDFCNT11	UDFCNT11	UDFCNT11
Multipurpose generic up-down counter	UDFCNT12	UDFCNT12	UDFCNT12

Section 2 RER620 overview

2.1 Overview

RER620 is a dedicated recloser relay designed for the protection, control, measurement and supervision of utility substations and industrial systems. RER620 is a member of ABB's Relion® product family and part of its 620 protection and control product series. The 620 series relays 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 relay provides main protection for overhead lines and cable feeders in distribution networks. The relay is also used as back-up protection in applications, where an independent and redundant protection system is required.

The 620 series relays support a range of communication protocols including IEC 61850 with GOOSE messaging, Modbus®, DNP3, PG&E 2179 and IEC 101/104.

2.1.1 Product version history

Product version	Product history
1.0	Product released
1.1	PG&E 2179 protocol, generic up/down counters, single phase power measurement etc. added
1.2	CVD Clamping Functionality, Modified Zero Clamping for Current Measurements, Cyber Security Enhancements, etc.
1.3	Added new configuration RA02

2.1.2 PCM600 and relay connectivity package version

- Protection and Control Relay Manager PCM600 Ver. 2.7 or later
- Relay Connectivity Package RER620 Ver. 1.3 or later
    - Parameter Setting
    - Firmware Update
    - Disturbance Handling
    - Signal Monitoring
    - Lifecycle Traceability
    - Signal Matrix
    - Communication Management
    - Configuration Wizard
    - Label Printing

- Relay User Management
- Relay Users
- Application Configuration
- IED Compare

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

2.2 Physical hardware

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

Table 2: Plug-in unit and case

Main unit	Slot ID	Module ID	Content options	
Plug-in unit	-	DISxxxx	HMI	128x128 LCD large display with text and graphics
	X100	PSMxxxx	Auxiliary power/BO module	24-60V DC 2 normally-open PO contacts 2 normally-closed SO contacts 2 double-pole PO contacts with TCS 1 dedicated internal fault output contact
	X105	BIOxxxx	BI/O Module	With configuration RA01, RA02 8 BIs 4 SO contacts
	X110	BIOxxxx	BI/O module	With configuration RA01, RA02 8 BIs 4 SO contacts
	X115	UPDxxxx	Actuator Drive	RS485 Communications to UPS 250V Boost voltage Three phase coil actuator drives 3 Pole Position switches 69 Switch
	X120	AIMxxxx	AI/BI module (current inputs)	With configuration RA01, RA02 3 phase current inputs (1/5A) 1 residual current input (1/5A or 0.2/1A) 4 BIs
Case	X130	SIMxxxx	AI module (voltage)	As default: CVD connections for primary input PT connections for secondary input. Both primary and secondary input can be set as either CVD or PT
	X000	COMxxxx	Communication module	See technical manual for detail about different type of communication modules. Communication protocols supported: IEC61850 DNP3 IEC 101/104 Modbus PG&E 2179

The rated input levels are selected in the relay software for phase current and ground current. Similarly, the rated input levels for CVD and PT voltages are selected through relay software. The binary input thresholds 18…176V DC are selected by adjusting the relay's parameter settings.

The optional BIO module can be added in the relay to all standard configurations.

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

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

Table 3: Number of physical connections in standard configuration

Conf.	Analog channels		Binary channels	
	CT	VT/CVD	BI	BO
RA01 and RA02	4	6	4	6
RA01 and RA02 with 1 BIO	4	6	12	10
RA01 and RA02 with 2 BIO	4	6	20	14

2.3 Local HMI

Figure 3: LHMI

The LHMI of the relay 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 4: Characters and rows on the view

Character size	Rows in view	Characters on row
Large, variable width (13x14 pixels)	4 rows 8 rows with large screen	min 8

The display view is divided into four basic areas.

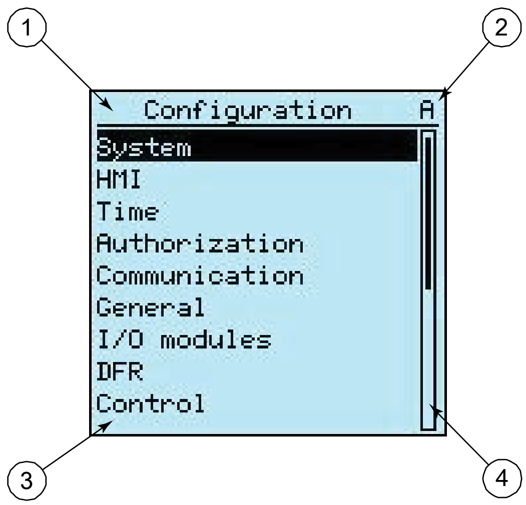


Figure 4: Display layout

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 Open and Close. 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.

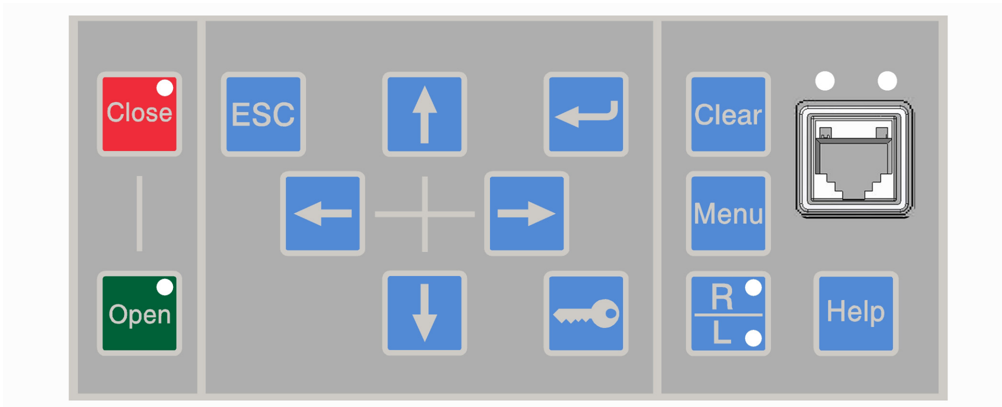


Figure 5: LHMI keypad with object control, navigation and command push-buttons and RJ-45 communication port

2.4 Web HMI

The WHMI enables the user to access the relay via a web browser. The supported web browser versions are Internet Explorer 9.0, 10.0 and 11.0.

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.

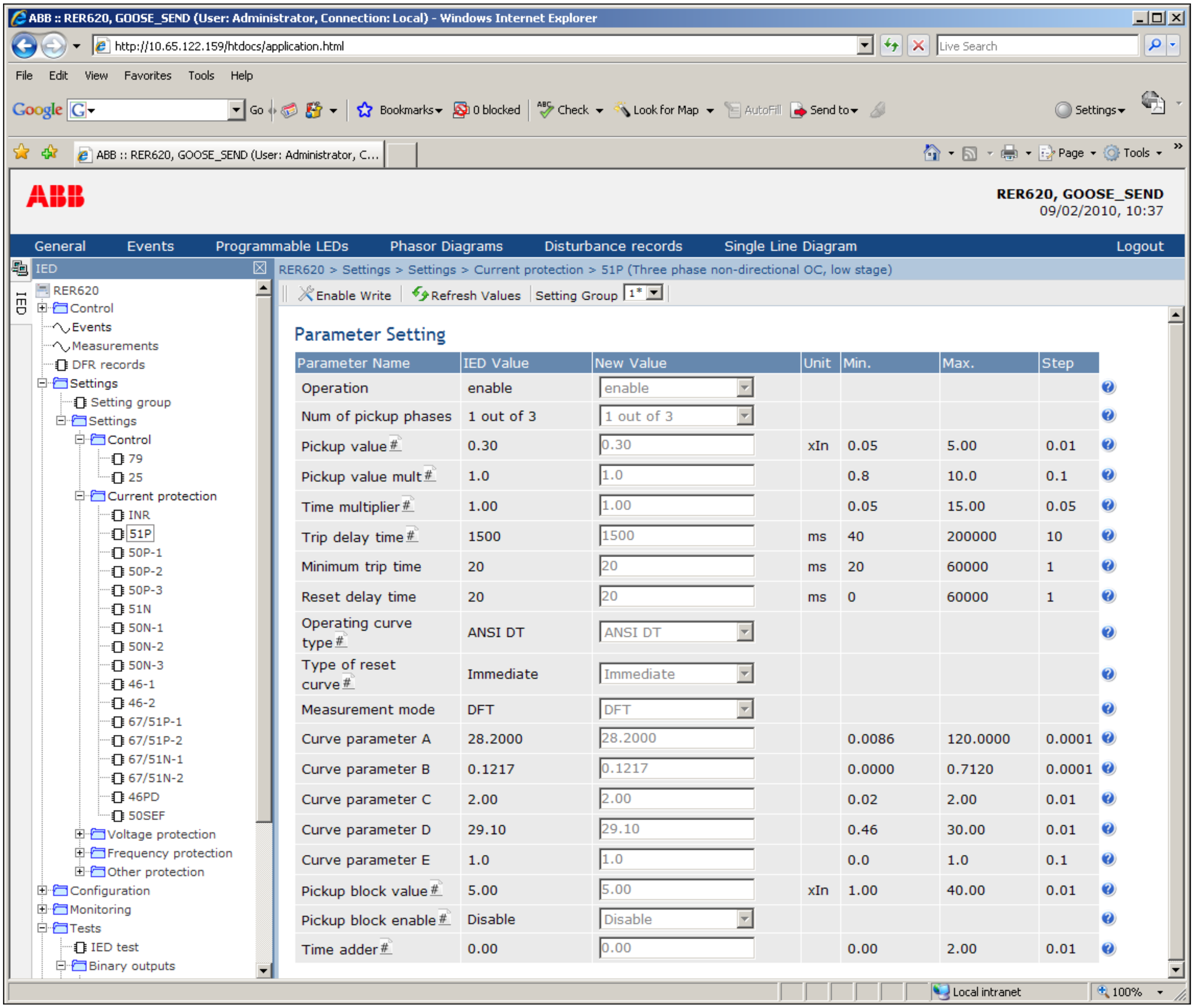


Figure 6: Example view of the WHMI

The WHMI can be accessed locally and remotely.

- Locally by connecting your laptop to the relay 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 5: Predefined user categories

Username	User rights
VIEWER	Read only access
OPERATOR	• Selecting remote or local state with (only locally) • Changing setting groups • Controlling • Clearing 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 relay to test mode • Selecting language
ADMINISTRATOR	• All listed above • Changing password • Factory default activation

For user authorization for PCM600, see PCM600 documentation.

2.6 Communication

The relay supports different communication protocols: IEC 61850, DNP3.0 Level 2, Modbus, IEC 104 – all using TCP/IP. DNP3, Modbus, IEC 101 also support serial communication, PG&E 2179 over serial. Operational information and control are available through these protocols. However, some communication functionality, for example, horizontal peer-to-peer communication between the relays and parameters setting, is only enable 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 relay can send and receive binary signals from other relays (so called horizontal communication) using the IEC61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. Further, the relay supports sending and receiving of analog values using GOOSE messaging. The relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. The relay 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 communication modules. The relay can be connected to Ethernet-based communication systems via the RJ-45 connector (100BASE-TX) or the fiber-optic LC connector (100BASE-FX). Also, a serial interface is available for RS-232/RS-485 communication.

Section 3 RER620 application

3.1 Applications

The protection and control relay RER620 is mainly intended for MV recloser applications. RER620 is available with a standard configuration, RA01, RA02 and is delivered from the factory with the default settings and parameters. The functional diagrams shown in this section describes the full functionality, flexibility and external connections of RER620 as delivered from the factory.

Table 6: Standard configurations

Description	Functional application configuration	Relay configuration
Single and Dual Source (6 VT inputs) - ABB	A	RA01
Single and Dual Source (6 VT inputs) - G&W / other	B	RA02

3.2 Functions

Table 7: Functions included in the RER620 standard configuration RA01, RA02

Function	IEC61850	IEC60617	ANSI/C37.2
Current Protection			
Single-phase non-directional time overcurrent protection with 1-ph trip option, low stage	SPHLPTOC1	3I>(1)	51P
Single-phase non-directional time overcurrent protection with 1-ph trip option, high stage 1	SPHLPTOC2	3I>(2)	50P-1
Single-phase non-directional time overcurrent protection with 1-ph trip option, high stage 2	SPHHPTOC1	3I>>(1)	50P-2
Single-phase non-directional instantaneous overcurrent protection with 1-ph trip option	SPHIPTOC1	3I>>>(1)	50P-3
Non-directional time overcurrent ground-fault protection, low stage	XEFLPTOC2	Io>(2)	51N
Non-directional time overcurrent ground-fault protection, high stage 1	XEFLPTOC3	Io>(3)	50N-1
Non-directional time overcurrent ground-fault protection, high stage 2	XEFHPTOC3	Io>>(3)	50N-2
Non-directional instantaneous time overcurrent ground-fault protection	XEFIPTOC2	Io>>>(2)	50N-3
Non-directional sensitive earth-fault	EFLPTOC3	Io>(3)	50SEF
Negative sequence non-directional time overcurrent protection 1	XNSPTOC1	I2 >(1)	46-1
Negative sequence non-directional time overcurrent protection 2	XNSPTOC2	I2 >(2)	46-2
Phase discontinuity protection	PDNSPTOC1	I2/I1>	46PD
Three-phase inrush detector	INPHAR	3I2f >	INR
Directional Protection			
Single-phase directional overcurrent protection, low stage 1	SDPHLPDOC1	3I >->(1)	67/51P-1
Single-phase directional overcurrent protection, low stage 2	SDPHLPDOC2	3I >->(2)	67/51P-2
Directional ground-fault protection, low stage 1	XDEFLPDEF1	Io>->(1)	67/51N-1
Directional ground-fault protection, low stage 2	XDEFLPDEF2	Io>->(2)	67/51N-2
Cold Load Timers			
Cold load timer 1 Phase A (in seconds)	TPSGAPC1	TPS(1)	62CLD-1
Cold load timer 2 Phase A (in minutes)	TPMGAPC1	TPM(1)	62CLD-2
Cold load timer 1 Phase B (in seconds)	TPSGAPC2	TPS(2)	62CLD-3
Cold load timer 2 Phase B (in minutes)	TPMGAPC2	TPM(2)	62CLD-4
Cold load timer 1 Phase C (in seconds)	TPSGAPC3	TPS(3)	62CLD-5
Cold load timer 2 Phase C (in minutes)	TPMGAPC3	TPM(3)	62CLD-6
Voltage Protection			
Single-phase overvoltage 1, source 1 low stage	SPHPTOV1	3U >(1)	59-1
Single-phase overvoltage 2, source 1 high stage	SPHPTOV2	3U >(2)	59-2
Single-phase overvoltage 3, source 2 low stage	SPHPTOV3	3U >(3)	59-3
Single-phase undervoltage 1, source 1 low stage	SPHPTUV1	3U <(1)	27-1
Single-phase undervoltage 2, source 1 high stage	SPHPTUV2	3U <(2)	27-2
Single-phase undervoltage 3, source 2 low stage	SPHPTUV3	3U <(3)	27-3
Positive sequence overvoltage protection, source1	PSPTOV1	U1>(1)	59PS-1
Positive sequence overvoltage protection, source 2	PSPTOV2	U1>(2)	59PS-2
Negative sequence overvoltage protection, source1	NSPTOV1	U2>(1)	47
Negative sequence overvoltage protection, source 2	NSPTOV2	U2>(2)	47-2

Function	IEC61850	IEC60617	ANSI/C37.2
Zero sequence overvoltage protection, source1	ROVPTOV1	Uo>(1)	59N-1
Zero sequence overvoltage protection, source 2	ROVPTOV2	Uo>(2)	59N-2
Frequency Protection			
Underfrequency, Overfrequency, Frequency rate of change, Source 1, Stage 1	FRPFRQ1	f</f>,df/dt(1)	81-1
Underfrequency, Overfrequency, Frequency rate of change, Source 1, Stage 2	FRPFRQ2	f</f>,df/dt(2)	81-2
Load Shed & Restoration, Source 1, Stage 1	LSHDPFRQ1	UFLS/R(1)	81S-1
Load Shed & Restoration, Source 1, Stage 2	LSHDPFRQ2	UFLS/R(2)	81S-2
Other Protection			
High Impedance Fault Detector	PHIZ1	PHIZ1	HIZ
Circuit breaker failure protection	SCCBRBRF1	3I>/Io>BF	50BFT
Circuit breaker close failure protection	SCCBRBCF1	SCCBRBCF1	50BFC
Directional positive sequence power protection	DPSRDIR1	P>->	32P
Directional negative/zero sequence power protection	DNZSRDIR1	Q>->	32N
Control			
Autoreclosing, 1ph and/or 3ph	SDARREC1	O -> I	79
Synch-check/voltage check (Source 1 is defined as bus, Source 2 as line)	SECRSYN1	SYNC	25
Circuit Breaker 1 (3 state inputs / 3 control outputs)	SCBXCBR1	I<->O CB	52
Loop control	DLCM	LCM	LCM
Supervision and Monitoring			
CB condition monitoring	SPSCBR1	CBCM	52CM
Fuse failure supervision, Source 1	SEQRFUF1	FUSEF	60
Measurement			
Three-phase current	CMMXU1	3I	IA,IB,IC
Demand metering, Max/Min metering	CMSTA1		
Sequence current	CSMSQI1	I1,I2,I0	I1, I2, I0
Ground current	RESCMMXU1	Io	IG
Three-phase voltage, Source 1	VMMXU1	3U	VA,VB,VC
Three-phase voltage, Source 2	VMMXU2	3U(B)	VA,VB,VC(2)
Sequence voltages, Source 1	VSMSQI1	U1,U2,U0	V1,V2,V0
Sequence voltages, Source 2	VSMSQI2	U1,U2,U0(B)	V1,V2,V0(2)
Single and Three-phase power, Power factor and three phase energy, Source 1	APEMMXU1	P,SP,E	P,SP,E
Frequency, Source 1	FMMXU1	f	f
Recorders			
Digital fault recorder (DFR)	RDRE1	DR	DFR
Sequence of Events (SER)	SER	SER	SER
Fault Recorder	FLTMSTA	FLTMSTA	FLTMSTA
Fault Locator (FLOC)	DRFLO1	FLO	FLO
Other Functions			
Battery voltage, current. Test the battery	ZBAT1	UPS	UPS
Universal Power Drive	XGGIO115	X115(UPD)	X115(UPD)
Programmable buttons (16 buttons)	FKEYGGIO1	FKEYGGIO1	FKEYGGIO1

Function	IEC61850	IEC60617	ANSI/C37.2
Move function block (8 outputs)	MVGAPC1	MVGAPC1	MVGAPC1
Move function block (8 outputs)	MVGAPC2	MVGAPC2	MVGAPC2
Pulse timer (8 timers)	PTGAPC1	PTGAPC1	PTGAPC1
Pulse timer (8 timers)	PTGAPC2	PTGAPC2	PTGAPC2
Generic control points (16 outputs)	SPCGGIO1	SPCGGIO1	SPCGGIO1
Generic control points (16 outputs)	SPCGGIO2	SPCGGIO2	SPCGGIO2
Set reset flip flops (8 outputs)	SRGAPC1	SRGAPC1	SRGAPC1
Set reset flip flops (8 outputs)	SRGAPC2	SRGAPC2	SRGAPC2
Time delay off timers (8 timers)	TOFGAPC1	TOFGAPC1	TOFGAPC1
Time delay off timers (8 timers)	TOFGAPC2	TOFGAPC2	TOFGAPC2
Time delay on timers (8 timers)	TONGAPC1	TONGAPC1	TONGAPC1
Time delay on timers (8 timers)	TONGAPC2	TONGAPC2	TONGAPC2
Multipurpose generic up-down counter	UDFCNT1	UDFCNT1	UDFCNT1
Multipurpose generic up-down counter	UDFCNT2	UDFCNT2	UDFCNT2
Multipurpose generic up-down counter	UDFCNT3	UDFCNT3	UDFCNT3
Multipurpose generic up-down counter	UDFCNT4	UDFCNT4	UDFCNT4
Multipurpose generic up-down counter	UDFCNT5	UDFCNT5	UDFCNT5
Multipurpose generic up-down counter	UDFCNT6	UDFCNT6	UDFCNT6
Multipurpose generic up-down counter	UDFCNT7	UDFCNT7	UDFCNT7
Multipurpose generic up-down counter	UDFCNT8	UDFCNT8	UDFCNT8
Multipurpose generic up-down counter	UDFCNT9	UDFCNT9	UDFCNT9
Multipurpose generic up-down counter	UDFCNT10	UDFCNT10	UDFCNT10
Multipurpose generic up-down counter	UDFCNT11	UDFCNT11	UDFCNT11
Multipurpose generic up-down counter	UDFCNT12	UDFCNT12	UDFCNT12

3.2.1 Default LED Connections

Table 7 (below) indicates the Label assignments for LEDs located to the right of the LCD HMI in the relay front panel.

Table 8: LED label assignments

LED	Label
LED 1	Phase A
LED 2	Phase B
LED 3	Phase C
LED 4	Ground
LED 5	Current
LED 6	Voltage
LED 7	Time
LED 8	Instantaneous
LED 9	79 Lockout
LED 10	Breaker Failure
LED 11	Loss of AC

3.2.2 One Touch Functions

For user ease, the RER 620 relay is designed with toggle buttons available in the relay front panel for quick selection. These buttons are programmed for pre-select options. The options include selecting settings groups 1 through 6, switching mode, hot line tag selection and so on. Tables 8 and 9 show the mapping between the toggle buttons available and option selected.

Table 9: Programmable buttons and functional selection 1...8 (left column in the relay Programmable buttons area)

Programmable Button	Functional Selection
Toggle Button 1	SG1 (Enabled/Disabled)
Toggle Button 2	SG2 (Enabled/Disabled)
Toggle Button 3	SG3 (Enabled/Disabled)
Toggle Button 4	SG4 (Enabled/Disabled)
Toggle Button 5	SG5 (Enabled/Disabled)
Toggle Button 6	SG6 (Enabled/Disabled)
Toggle Button 7	Switch Mode (Enabled/Disabled)
Toggle Button 8	Hot Line Tag (On/Off)

Table 10: Programmable buttons and functional selection 9…16 (right column in the relay Programmable buttons area)

Programmable Button	Functional Selection
Toggle Button 9	Ground Blocked (On/Off)
Toggle Button 10	Re-close Blocked (On/Off)
Toggle Button 11	Battery Test
Toggle Button 12	50SEF (Blocked)
Toggle Button 13	S1 (Enabled/Disabled)
Toggle Button 14	S2 (Enabled/Disabled)
Toggle Button 15	Loop Scheme Reset
Toggle Button 16	Emergency Open 3 phase

3.2.3 Connection Diagrams

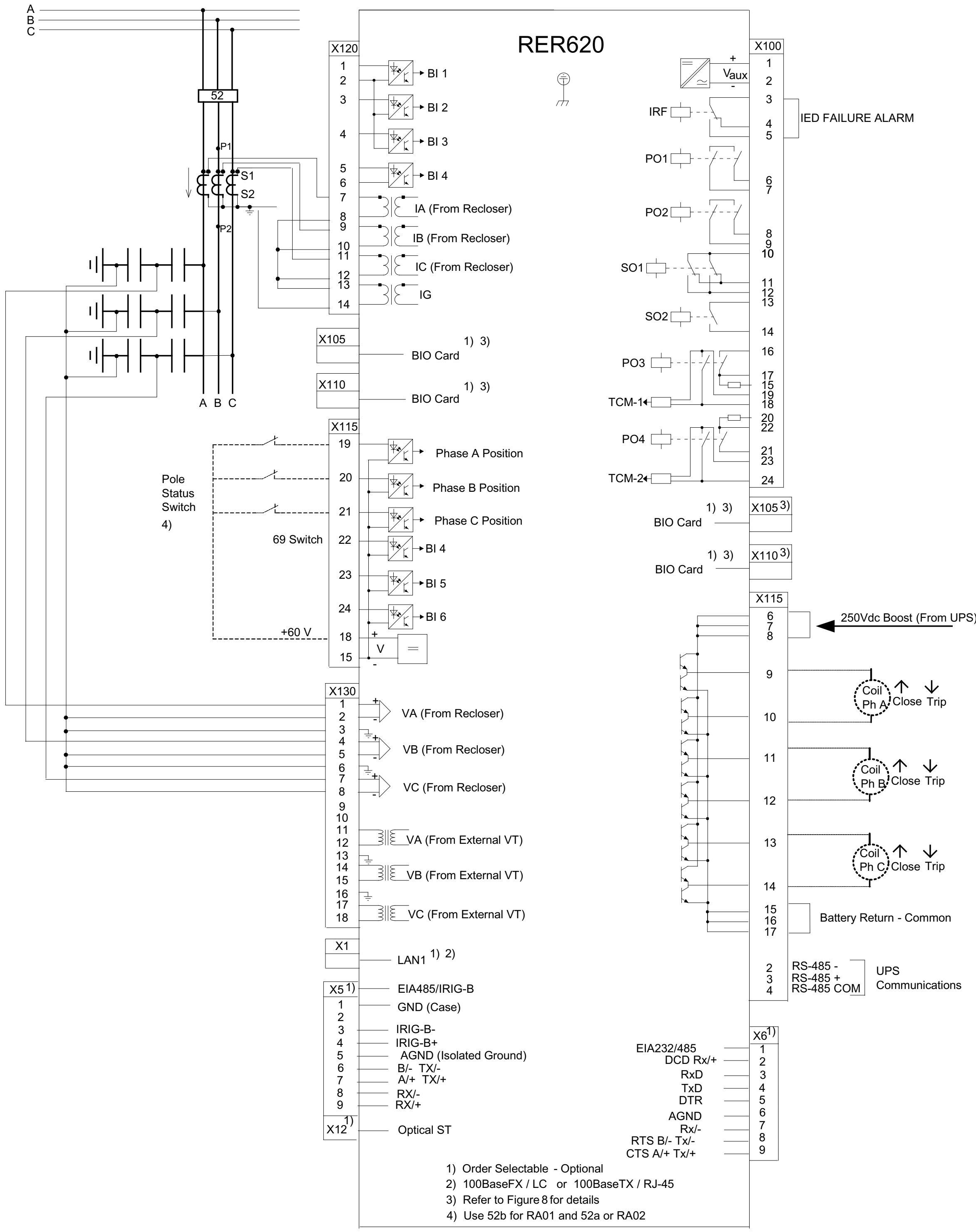


Figure 7: RER620 Connection diagram for standard modules

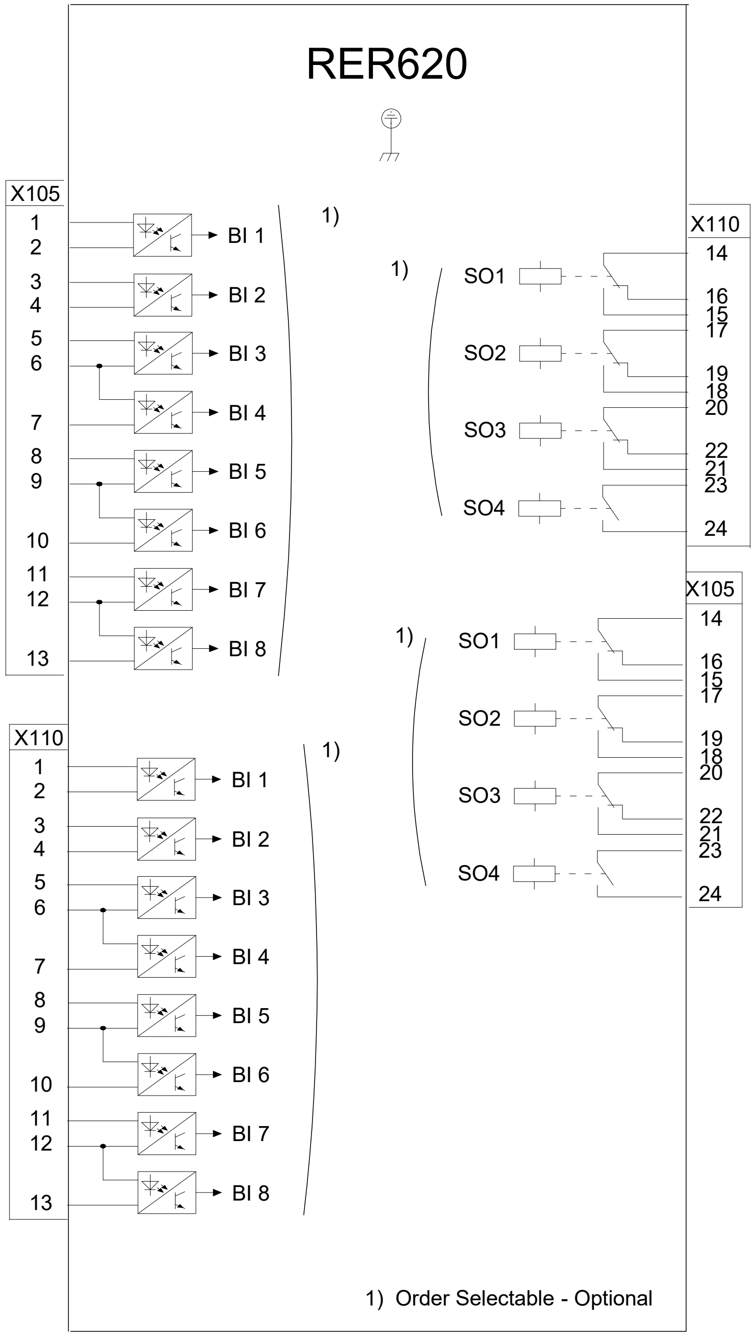


Figure 8: RER620 Connection diagram for optional BIO modules

3.3 Functional diagrams

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

The analog channels, measurements from CTs and CVTs/ PTs, have fixed connections to the different function blocks inside the relay's default configuration.

RER620 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. Figure 9 shows the default mapping for the available programmable buttons. Figure 10 shows the default mapping for the remote blocking features.

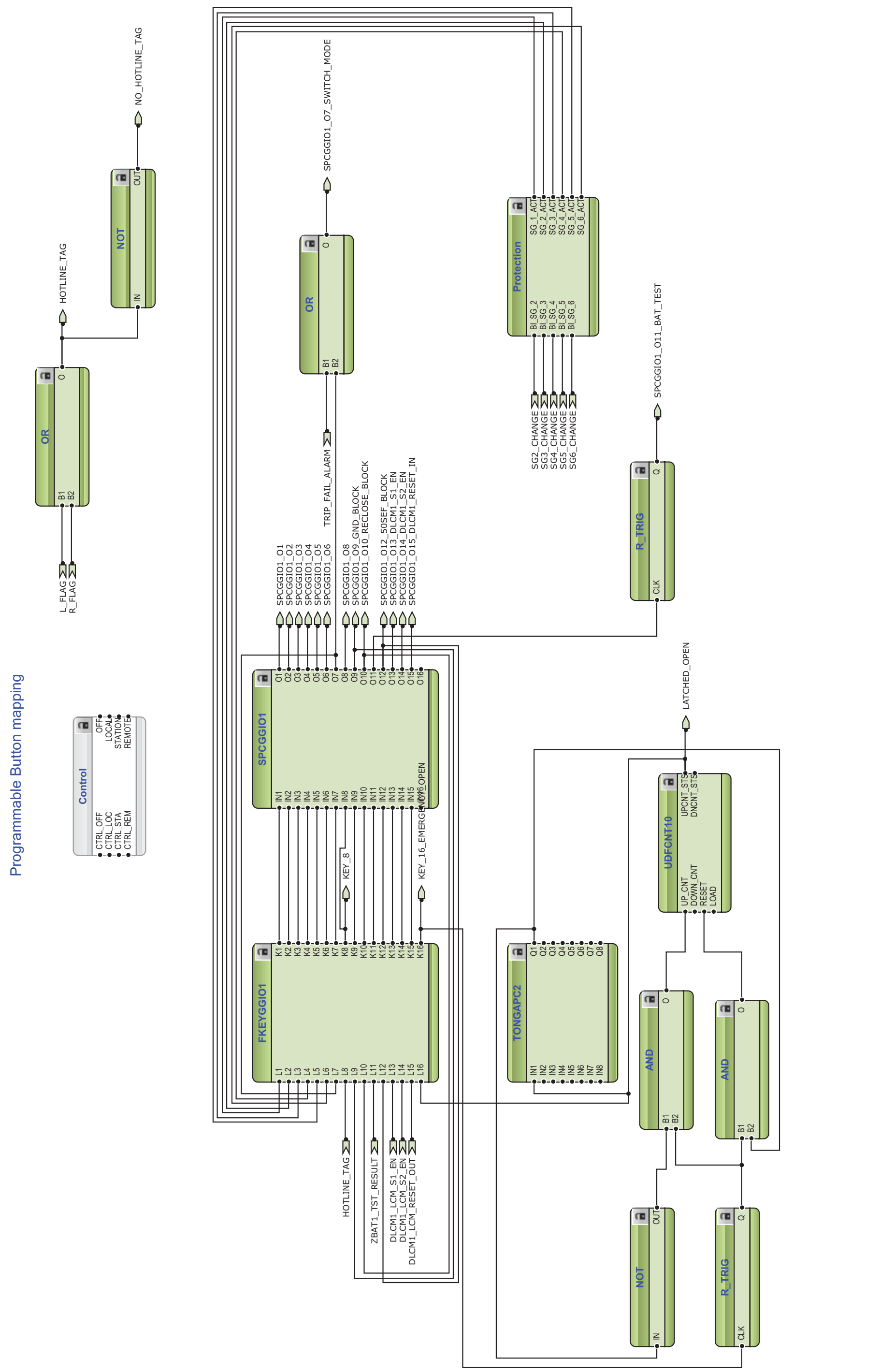


Figure 9: *Programmable button default mapping*

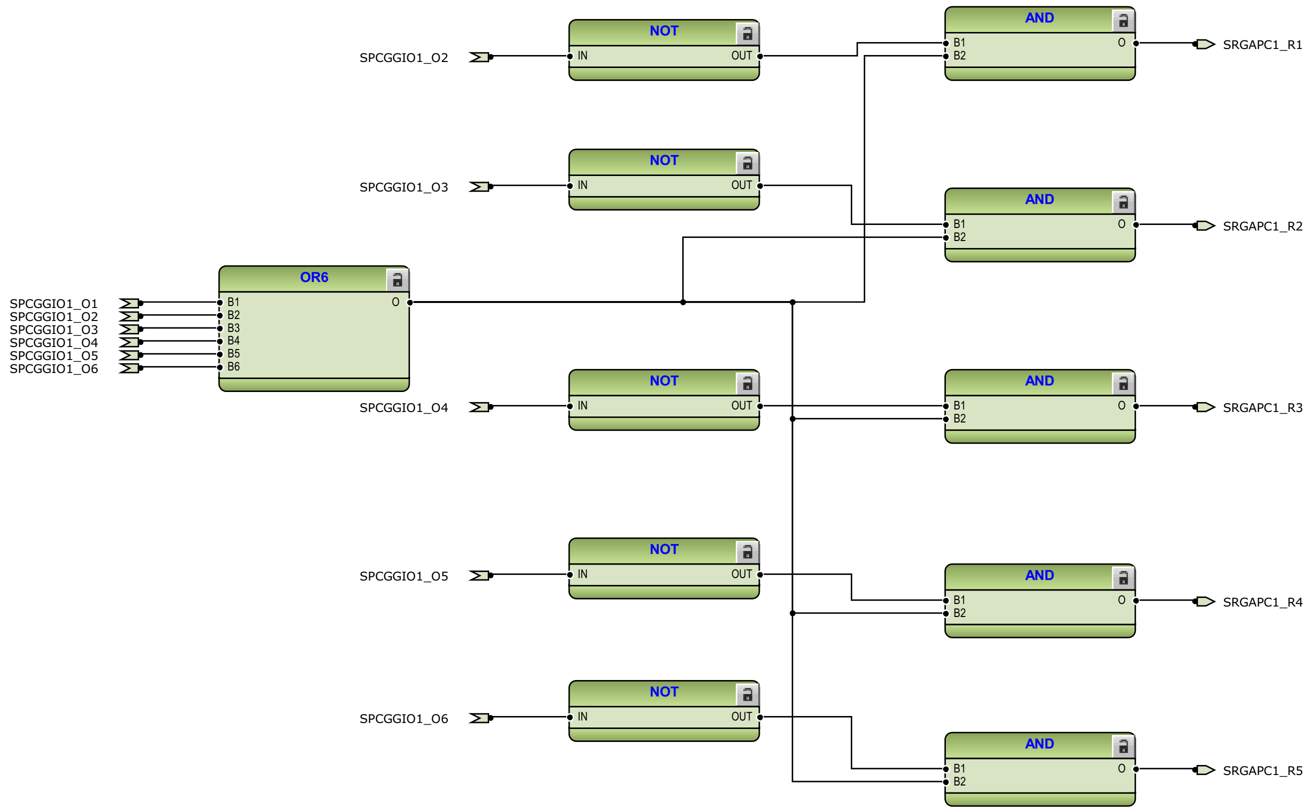


Figure 10: Programmable button mapping for remote blocking

3.3.1 Functional diagrams for protection

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

The phase overcurrent protection provided by RER620 is available with single phase trip option. In this case, the relay trips only the phase in where the fault is detected, without disturbing the other two phases if single phase trip option is selected. Otherwise, all three phases are tripped and the related outputs Trip (Operate) and pickup (Start) are activated.

The overcurrent protection function picks up when the phase current exceeds the set limit. The trip time characteristics for low stage 51P and high stage 50P-1/2 can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The instantaneous stage 50P-3 always trips with the DT characteristic.

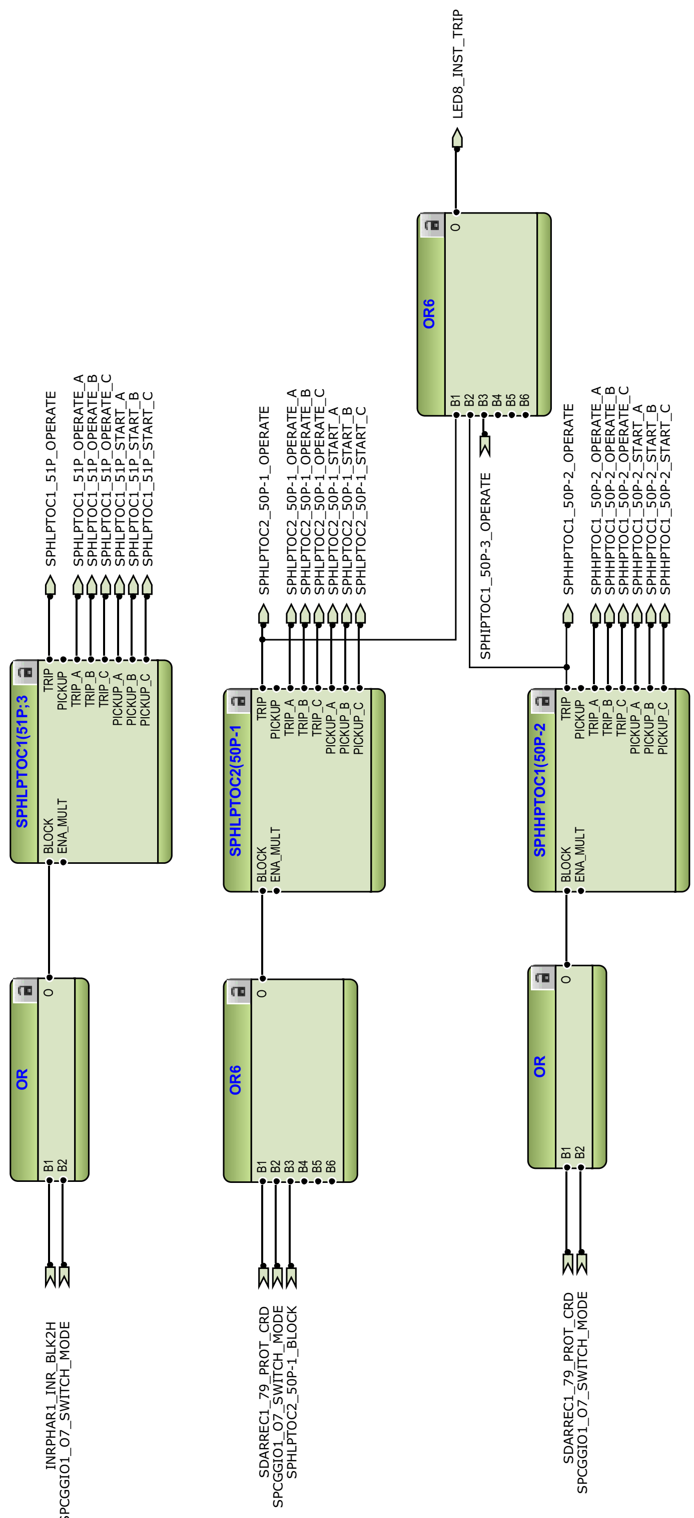


Figure 11: Phase time overcurrent protection

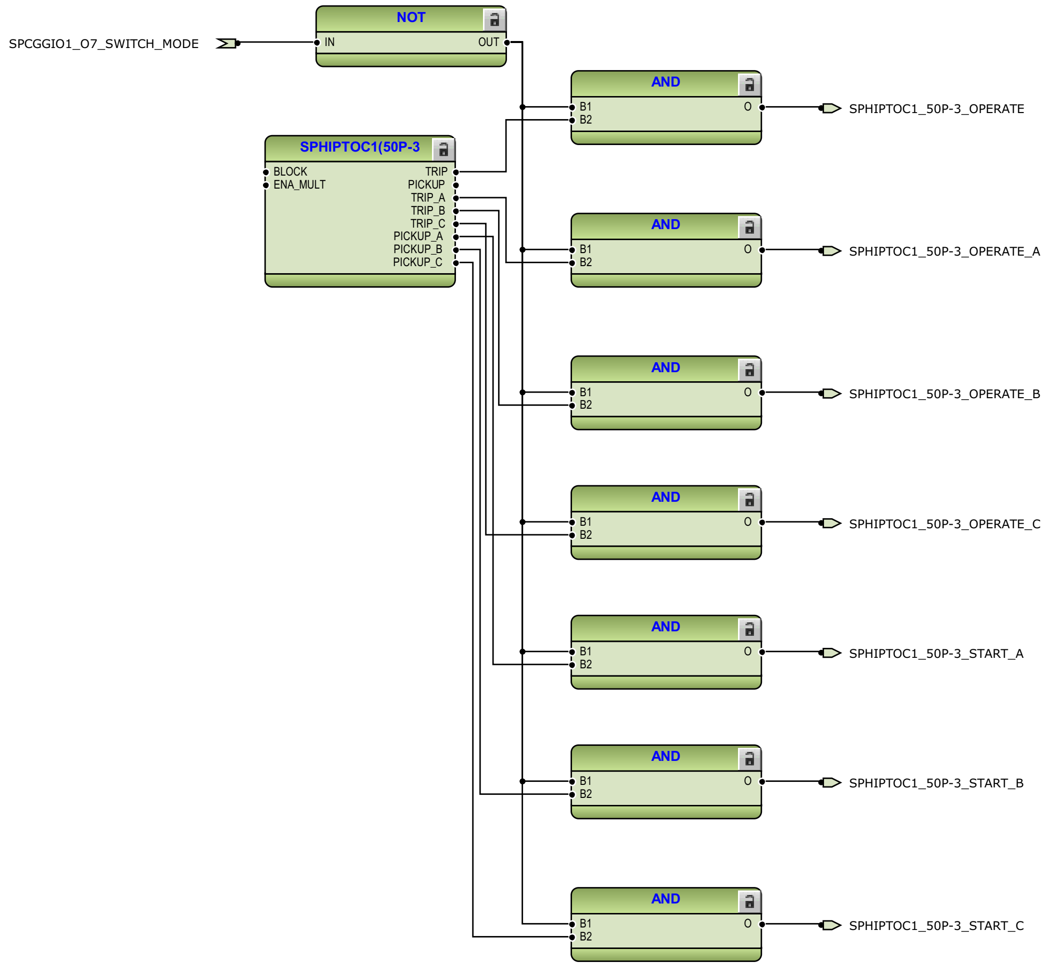


Figure 12: Instantaneous phase overcurrent protection

The ground-fault function 51N/50N is used as non-directional ground-fault protection for feeders. The function picks up and trips when the measured (IG) or calculated (IN) ground current exceeds the set limit. The trip time characteristic for low stage 51N and high stage 50N-1/2 can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The instantaneous stage 50N/G-3 always trips with the DT characteristic.

The negative phase-sequence current protection 46 can be used for high sensitivity to unbalance situations such as single phase, phase-to-phase fault, etc. The phase discontinuity protection (46PD) provides protection for interruptions in the normal three-phase load supply like in downed conductor situations.

The sensitive earth-fault protection (50SEF) and high impedance fault detection (HIZ) provide protection against high impedance faults. If the load unbalance is high, 50SEF needs to be set high to avoid misoperations which render 50SEF ineffective for such applications. In those cases, HIZ can provide detection which would otherwise be undetected.

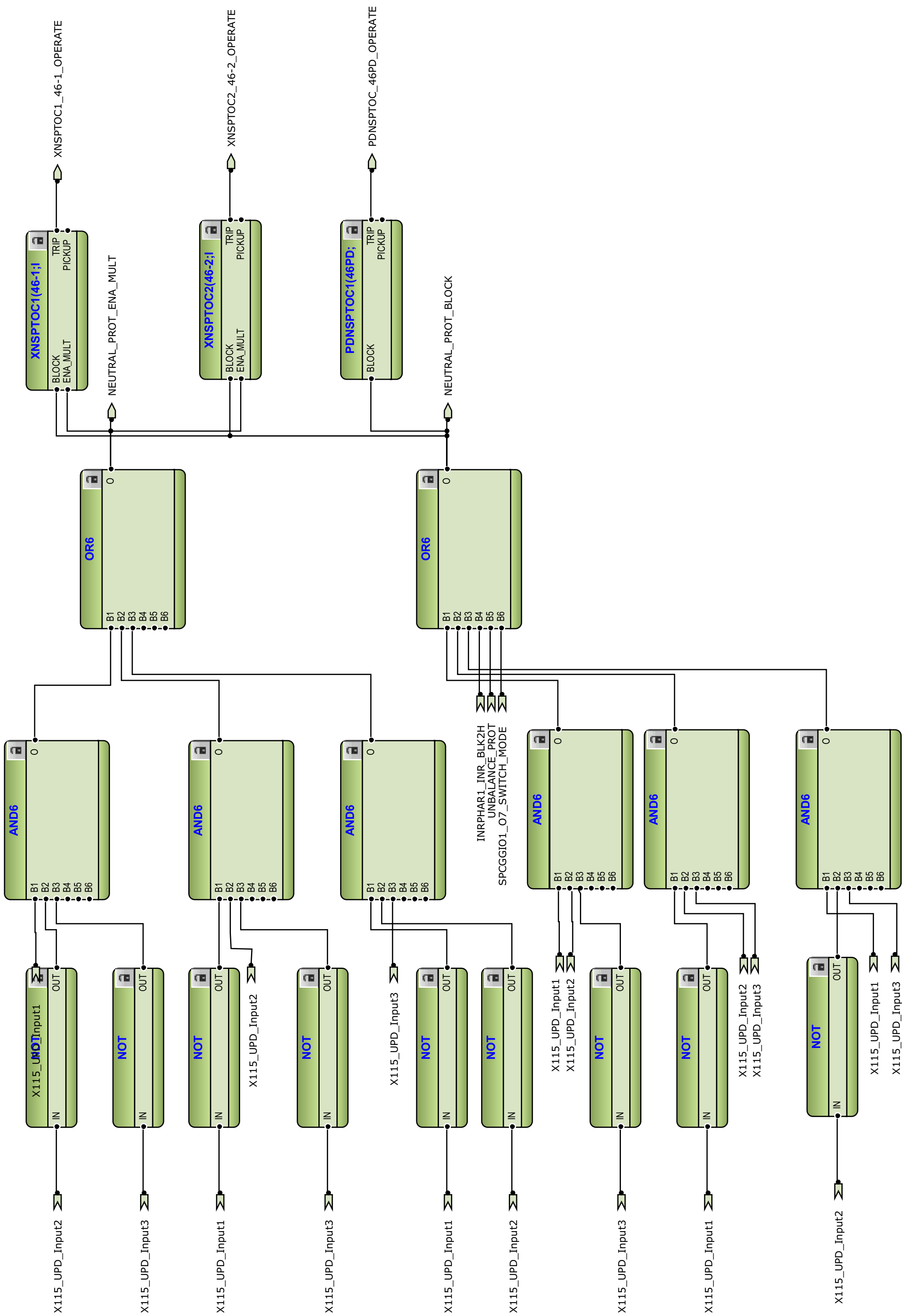


Figure 13: Neutral and negative sequence protection blocking

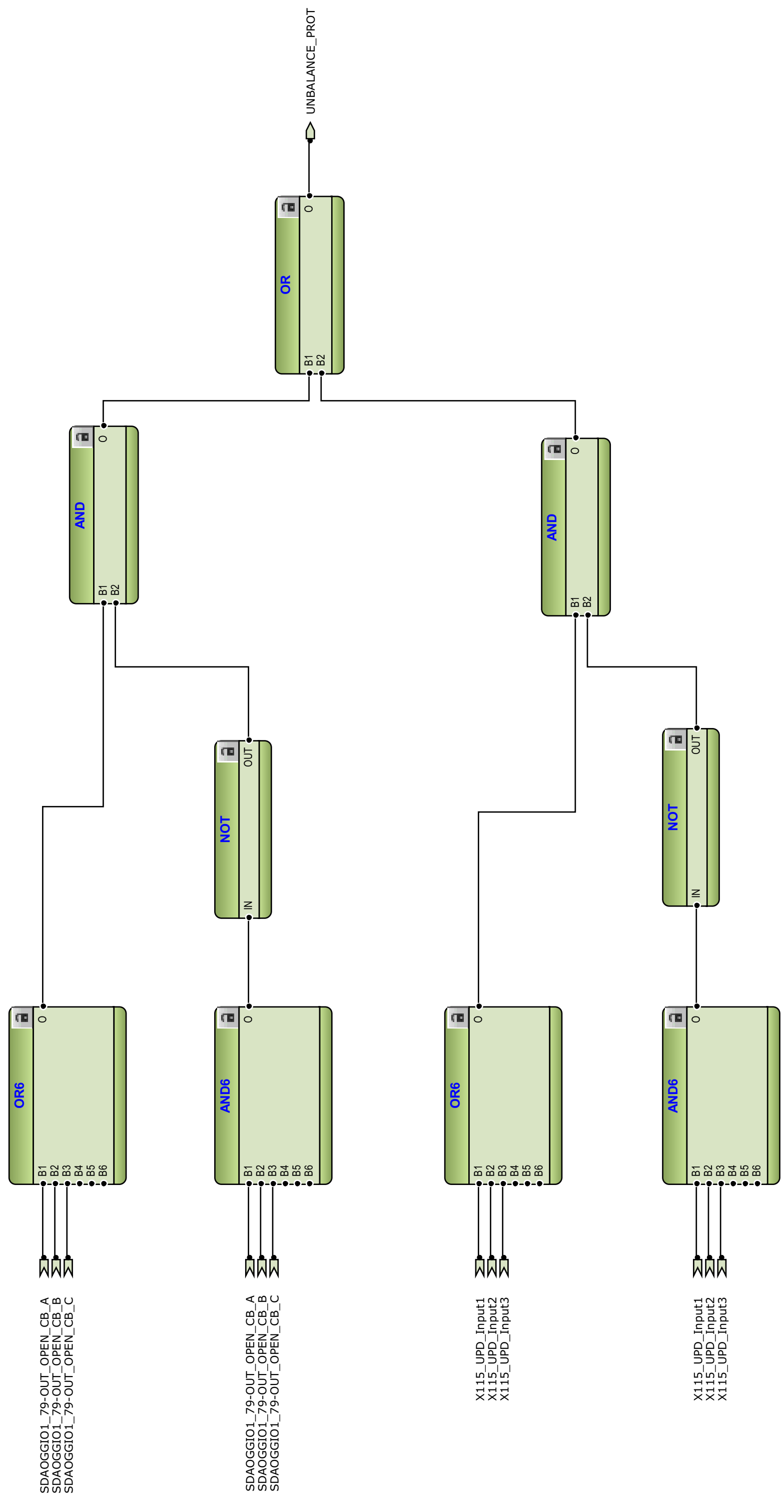


Figure 14: Unbalance mode protection

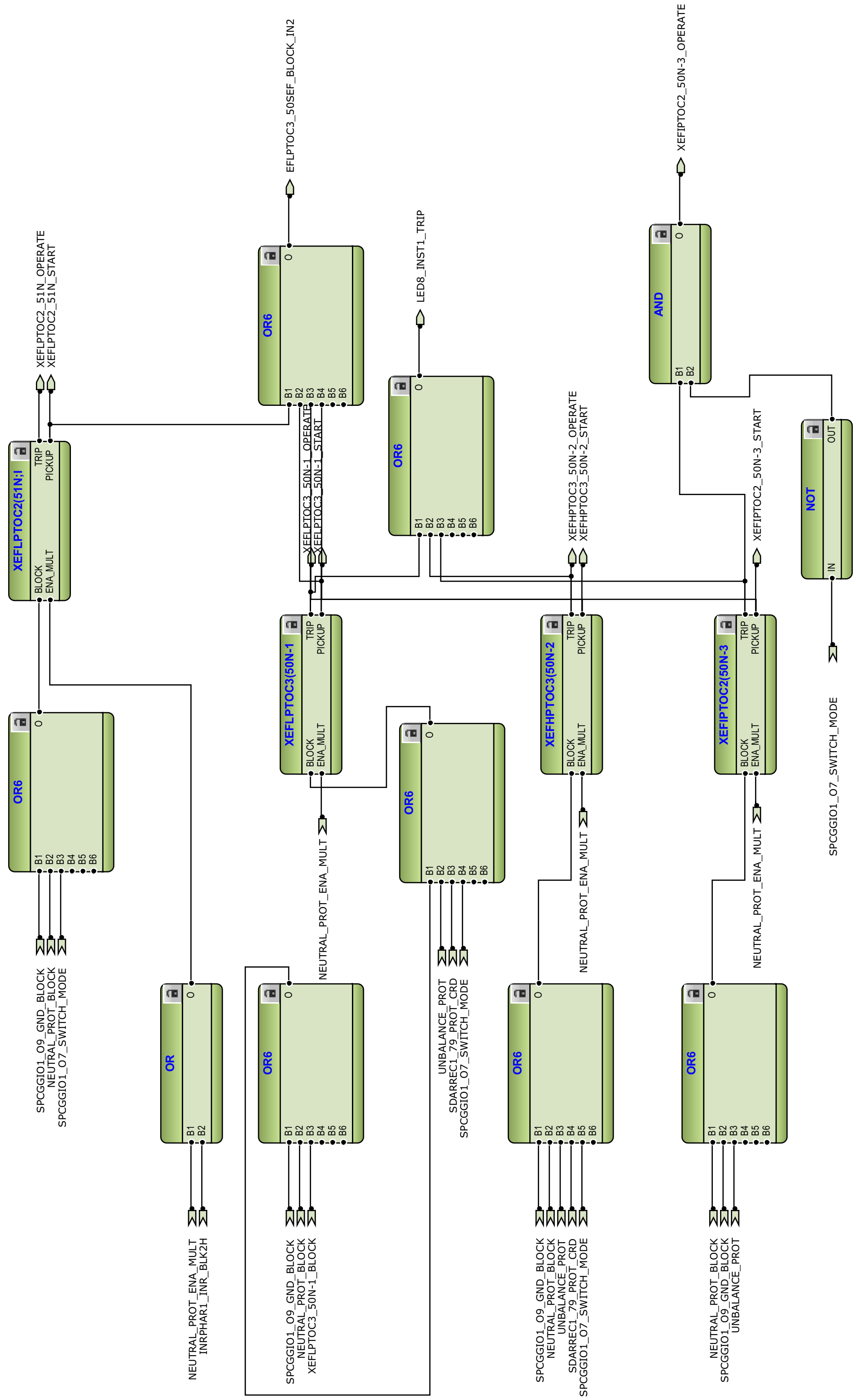


Figure 15: Ground overcurrent protection

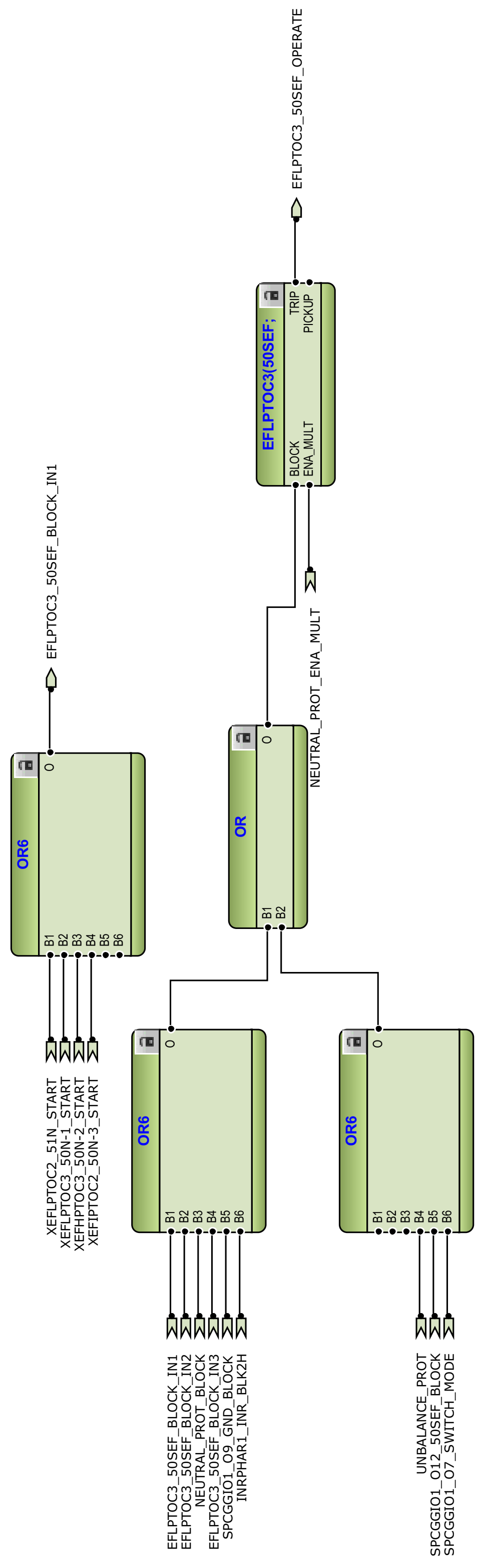


Figure 16: Sensitive earth fault protection

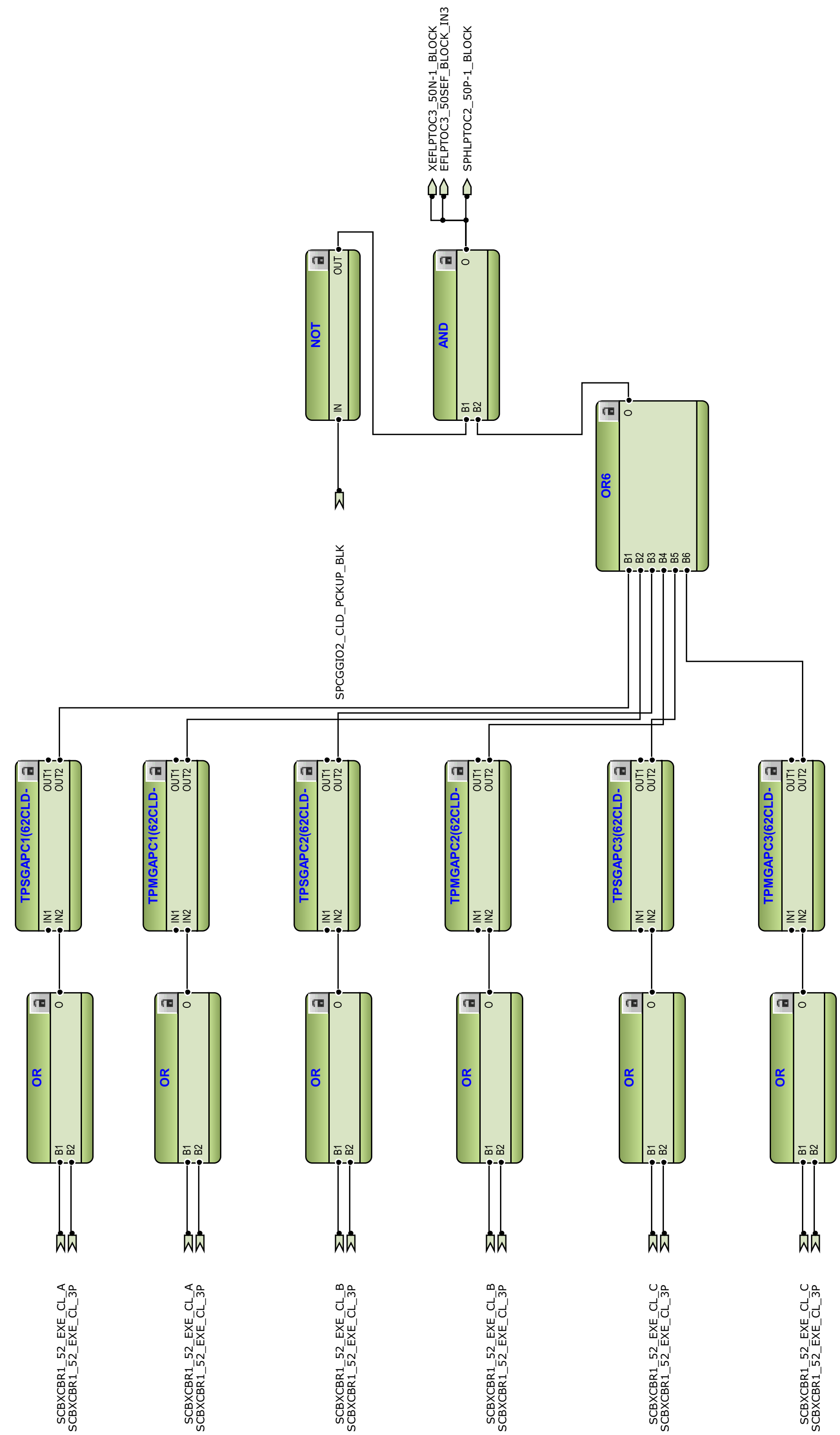


Figure 17: Cold Load Timers

The RER620 relay provides cold load timers in minutes or seconds resolution for various application needs. In total, six Cold load timers are available to provide utmost flexibility in cold-load inrush detection. The timer function blocks can be used for single phase or three phase blocking. Any functions can be selected to be blocked during the cold load timers pickup duration using the ACT/SMT.

The directional phase or ground over current protection provides a high level of selective fault detection. The directional over current function can be used in closed ring networks or in radial networks with generation connected remote in the system, thus giving fault current infeed in “reverse” direction.

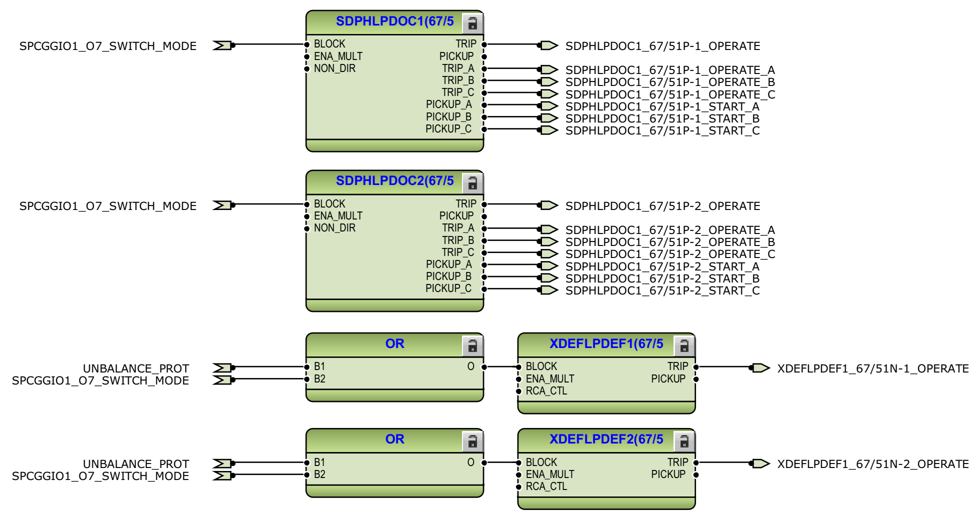


Figure 18: Directional phase and ground overcurrent protection

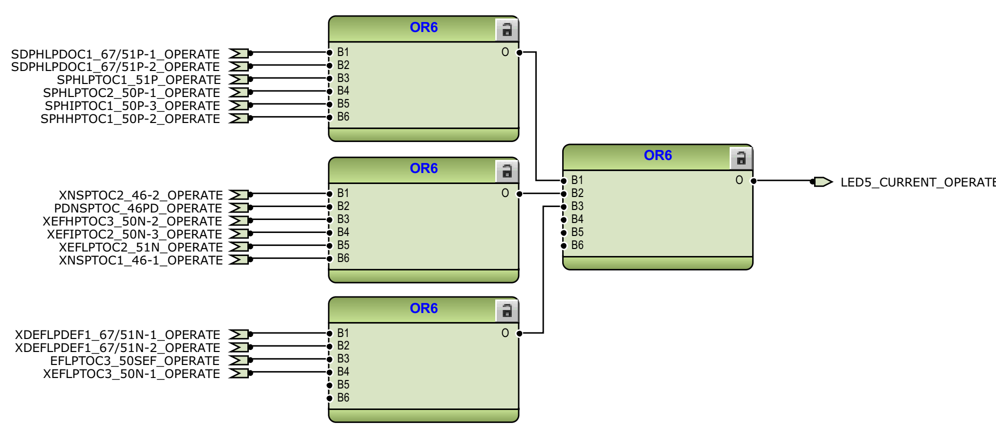


Figure 19: Overcurrent protection LED indication

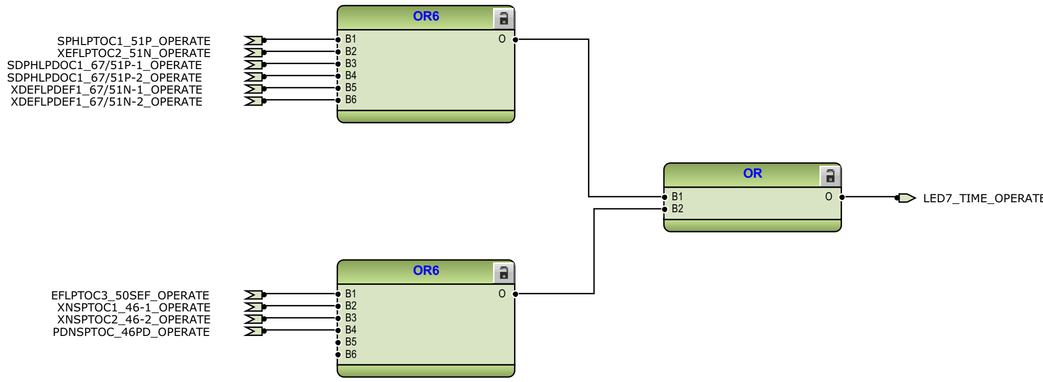


Figure 20: Time overcurrent protection LED indication

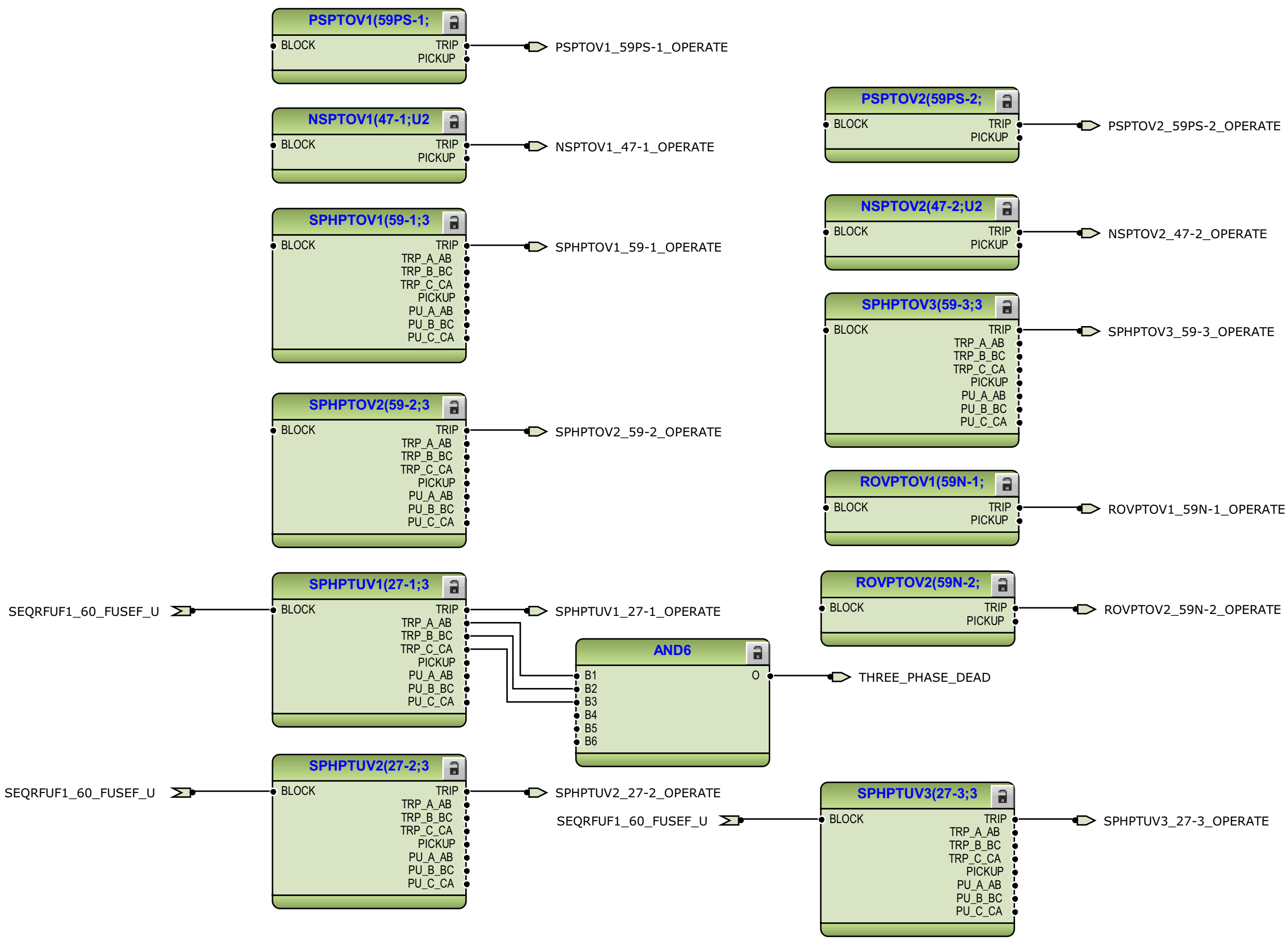


Figure 21: Voltage protection

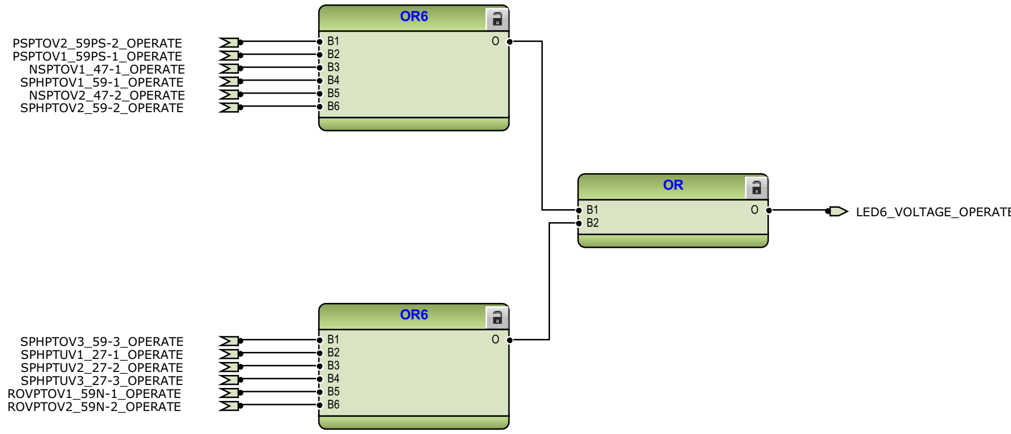


Figure 22: Voltage protection LED indication

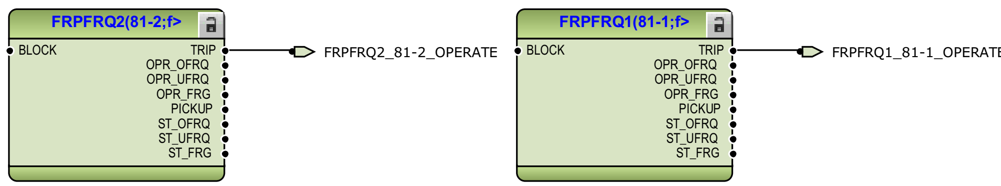


Figure 23: Frequency protection

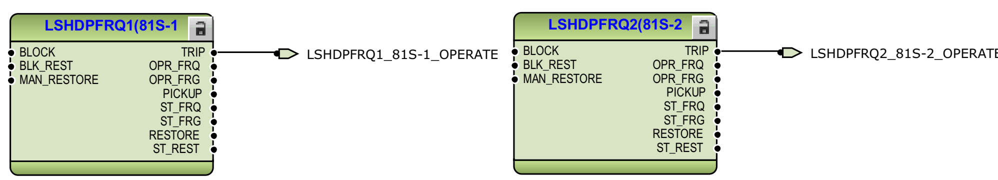


Figure 24: Load shed and restoration functions

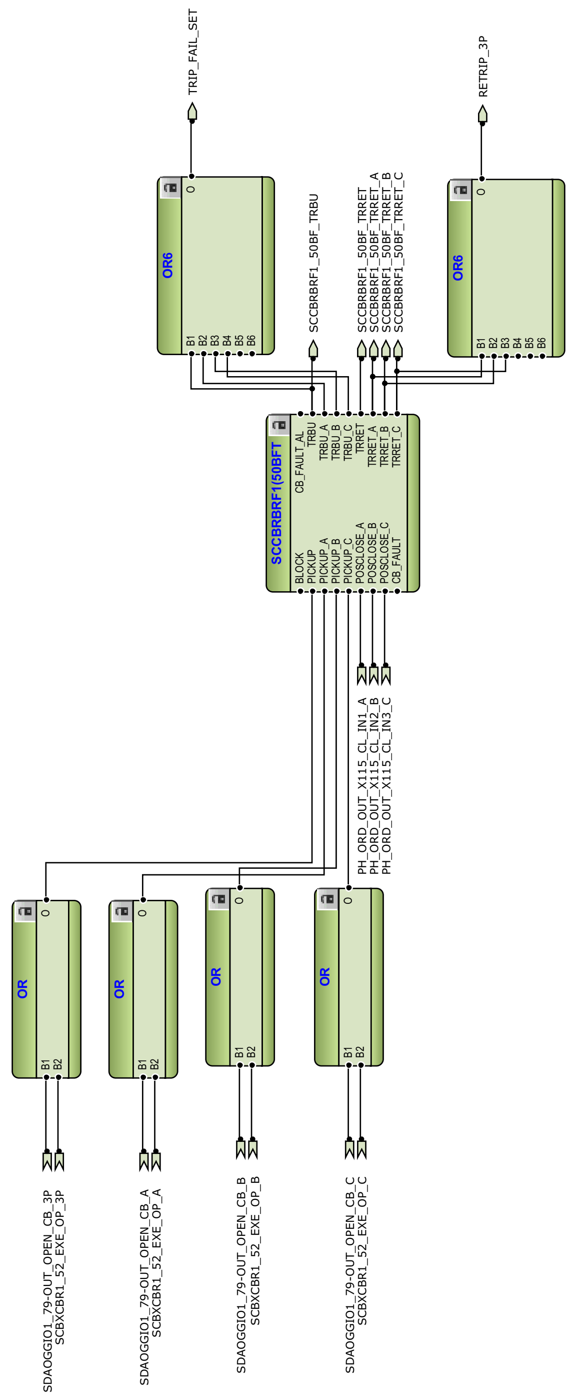


Figure 25: Breaker (trip) failure protection

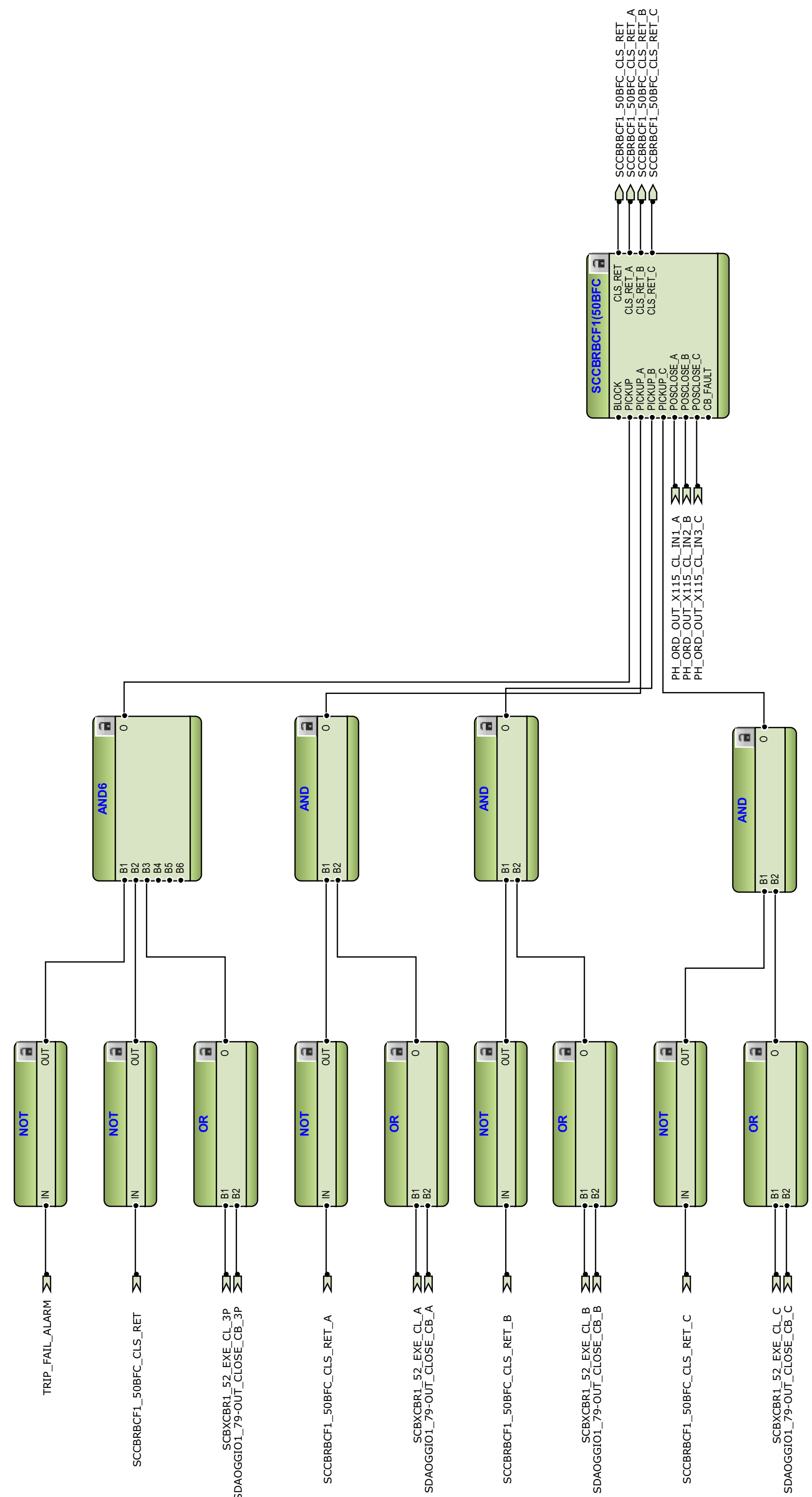


Figure 26: Breaker close failure protection

3.3.2 Functional diagrams for control and autoreclosing

The loop control module (LCM) enables the RER620 to perform automatic loop restoration functions, commonly accepted as a means to significantly improve circuit reliability and to provide more effective system operation. The LCM is designed to implement a loop control scheme by providing switching operations of the recloser to sectionalize or remove the faulted section from the distribution system. The LCM enables a recloser to monitor up to two banks of three-phase voltages and to consider them in controlling breaker operations.

A recloser loop control scheme typically utilizes a predetermined number of RER620 controlled reclosers installed in series between two substation feeder circuits. This provides isolation of any faulted section within a given distribution circuit while simultaneously re-establishing service to all customers unaffected by the faulted section within a relatively short period. Loop control schemes are typically located at or near key customers at various locations throughout the distribution system, or where reliability on particular circuits is particularly poor.

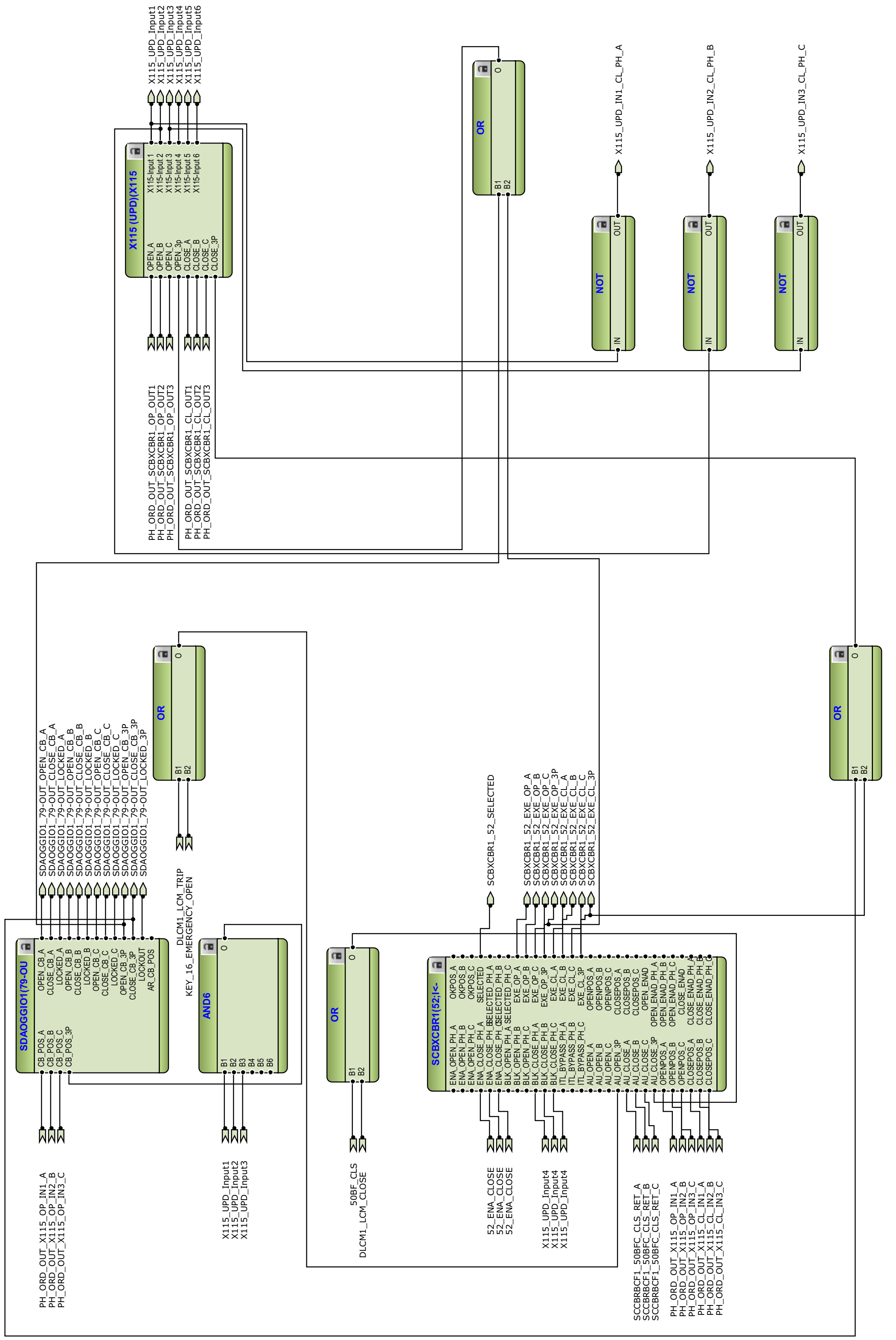


Figure 27: *Breaker control for RA01*

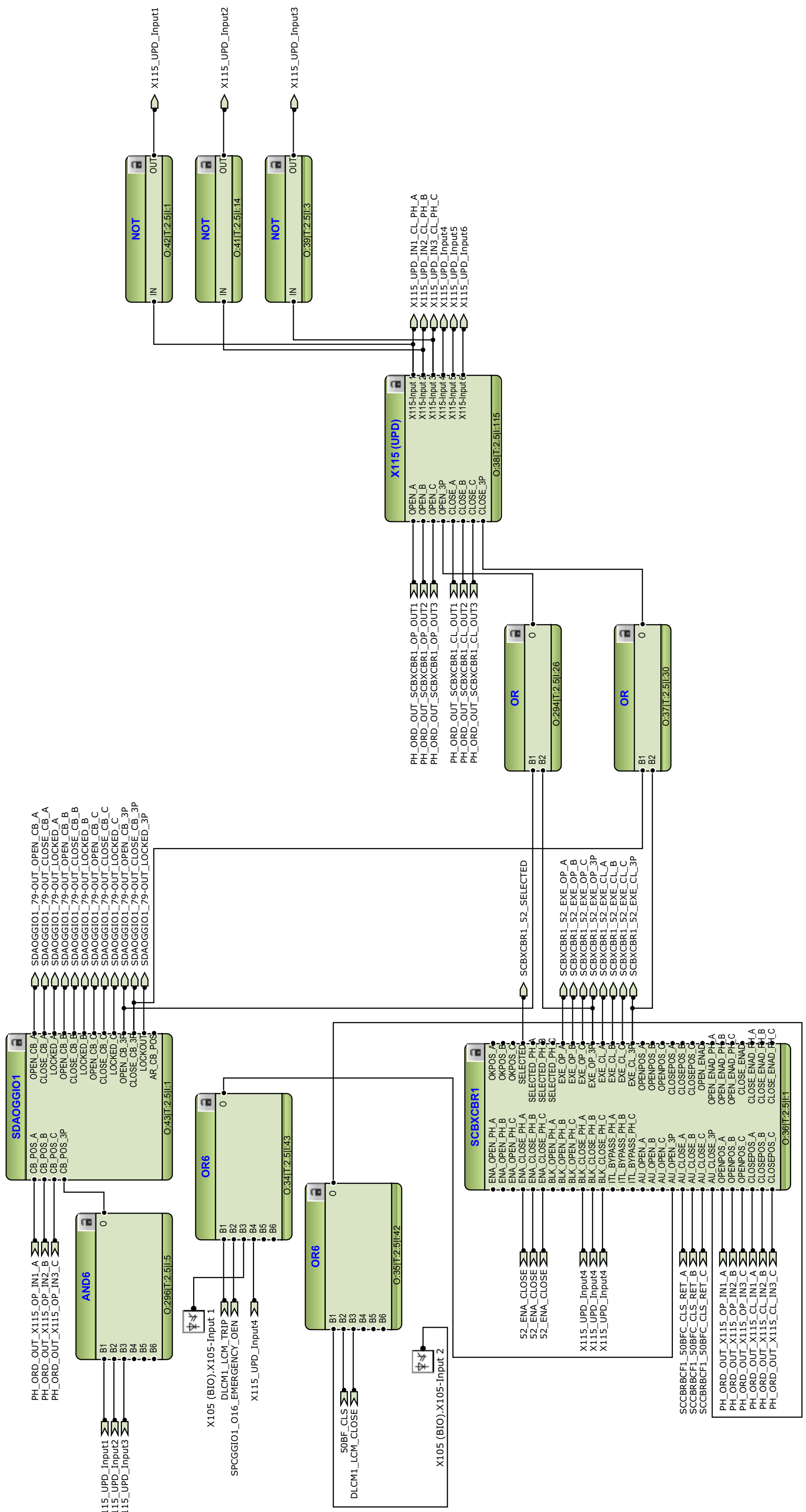
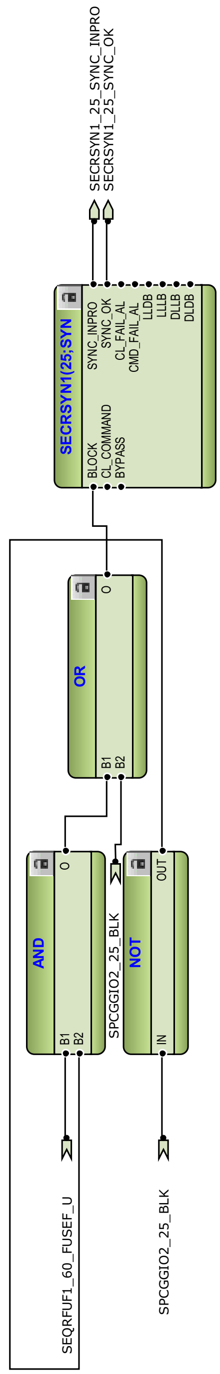


Figure 28: Breaker control for RA02



Note:

In synch-check function the two voltage inputs are referred to as **Bus** and **Line** while RER620 the inputs are referred to as **Source-1** and **Source-2**.

Unless otherwise indicated, consider Source-1 as Bus and Source-2 as Line side. For example if Source 2 voltage goes below the 'dead' threshold setting, the same will be considered as Line Dead as TRUE by synchro check function. If Source 2 voltage goes above 'live' threshold, the Live Line will be TRUE.

Figure 29: Synch-check function

RER620 "Latched Open" logic scheme:

The RER620 has a user settable "Latched Open" logic scheme as a part of default configuration. This logic scheme will use one local HMI push button which will immediately open all breaker poles (see Figure 9 and Figure 27) and set the

'Latched_Open' channel (see Figure 9). LHMI close, Remote/SCADA Close and Reclosing (79) re-close commands are not allowed while in the Latched Open state.

"Latched Open" can be activated through push button 16 [Key 16], circled in the figure below, which is labeled as "Emergency Open 3 Ph". A corresponding Pushbutton LED will be activated to indicate a Latched Open state which can be used as a visual reference.

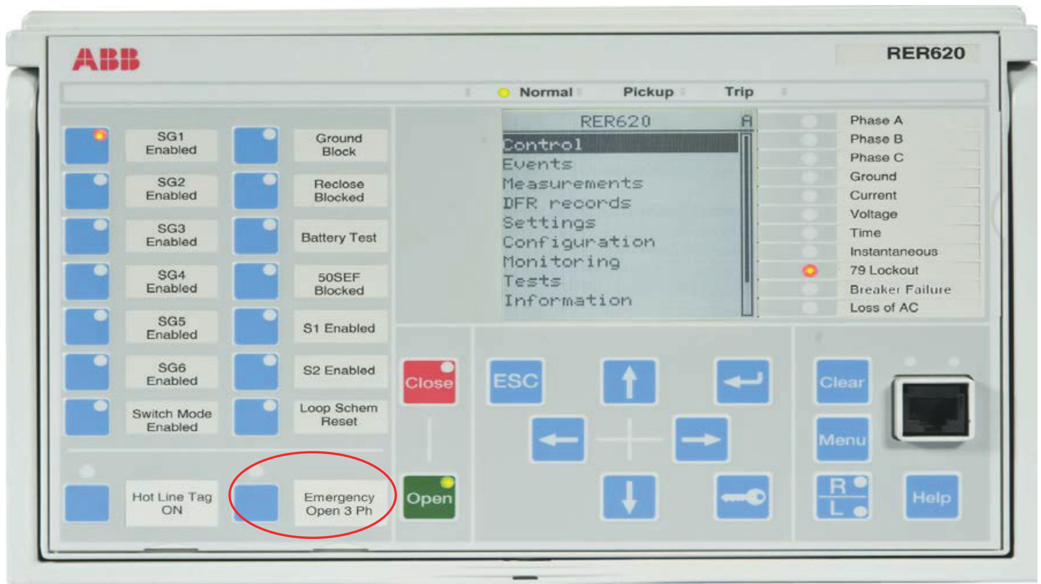


Figure 30: "LACHED_OPEN" channel connected to Auto Recloser function

Once 'Latched Open' state is activated, unless it is de-activated, a Close operation will no longer be possible. The 'Latched Open' state can be de-activated by the same push-button, after a minimal interval of 5 seconds.

The "Figure 31" shows the Auto reclose function with "Latched Open" as one of the input channel connected. Here when "Latched Open" input activated, it inhibits recloser function.

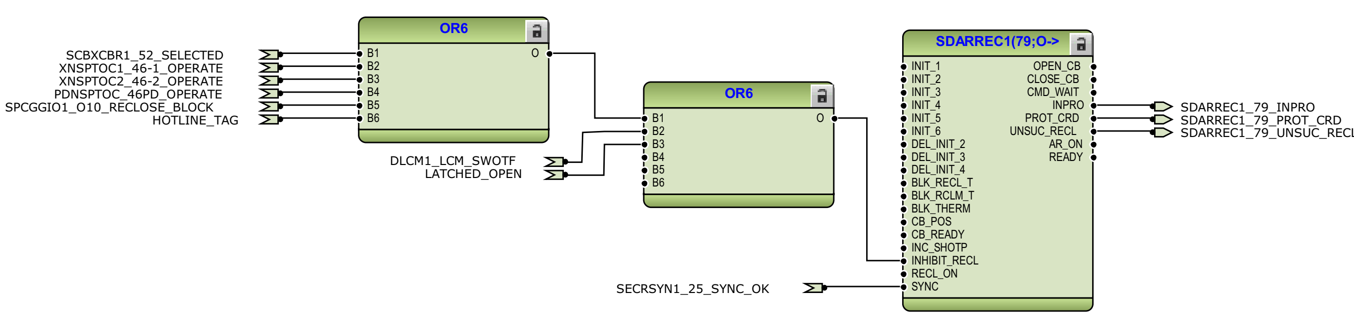


Figure 31: Auto reclose function

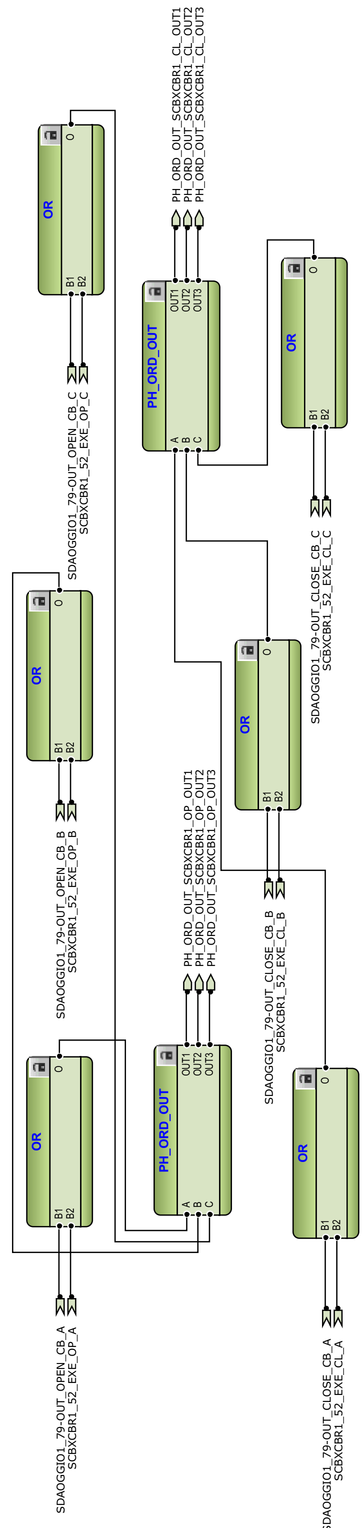


Figure 32: Auto reclose output function (Also refer to figure for Breaker Control)

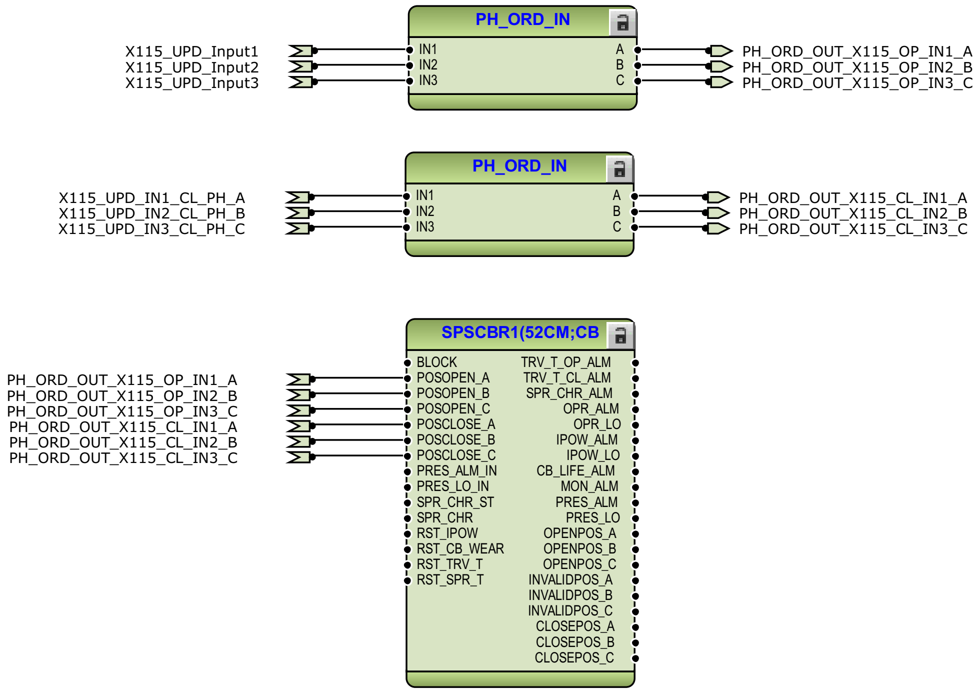


Figure 33: Breaker condition monitoring

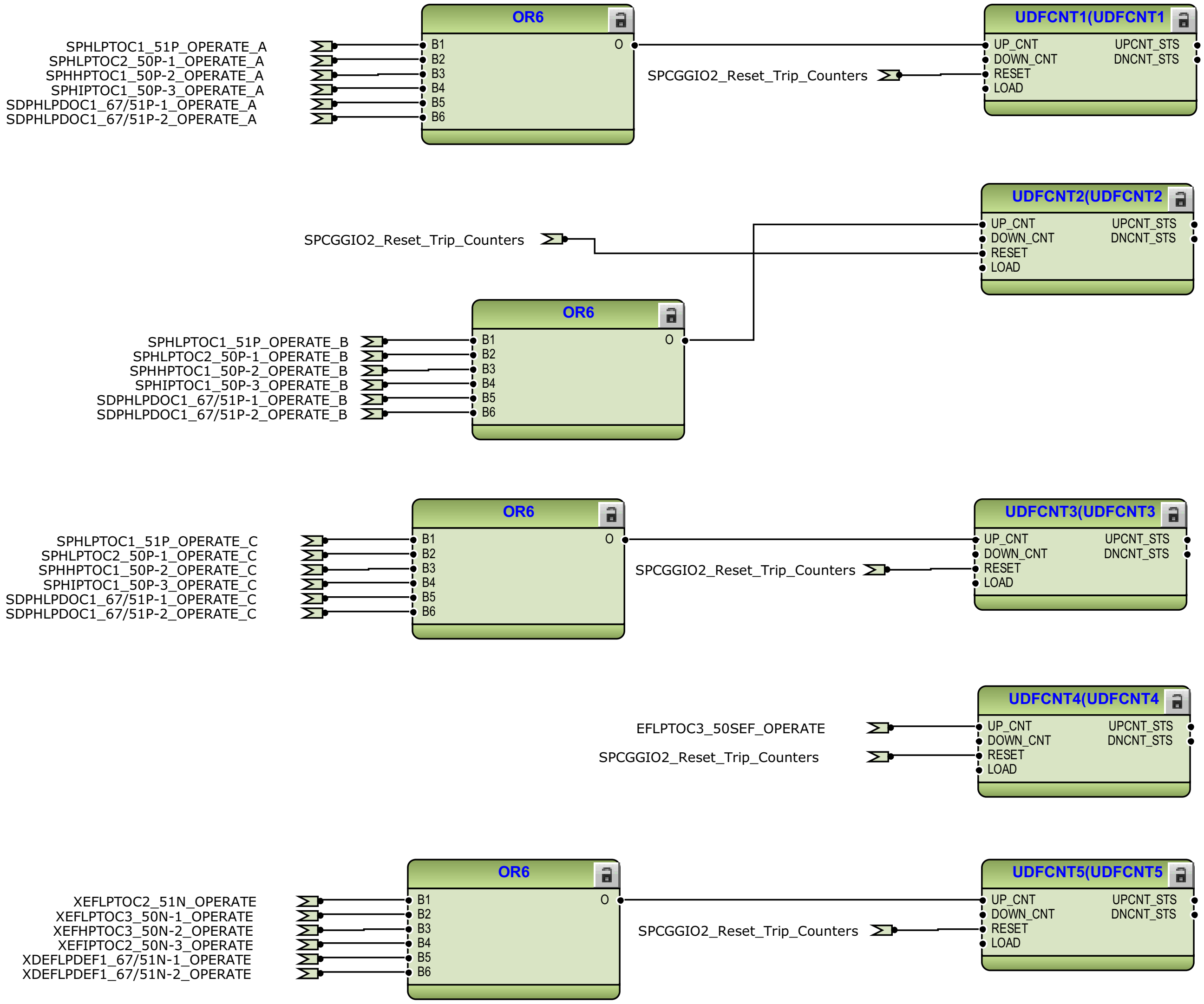


Figure 34: *Generic Up-Down counters*

RER620 “Blocking Close while on Standing Trip Condition” Scheme:

This application logic is for preventing rare possibility of damage to relay, by blocking the Close command, when there is a trip signal existing (‘standing trip’), a scenario that is possible with an improper secondary test method. For e.g., if the tripping current is not removed after the recloser opens, and a user or communications issues a CLOSE command, the standing TRIP from the secondary injection has the potential to overlap with the CLOSE command and result in damage to the relay. Note that closing into a fault, is not the same as a standing trip. Closing into a fault will provide sufficient time between the CLOSE and TRIP commands, even if the relay trip is set to trip instantaneously or the shortest TRIP time possible.

The “Figure 35” shows logic scheme which disables “52_ENABLE_CLOSE” output channel in an active TRIP (or ‘standing trip’) condition. This output channel is in-turn connected to “ENA_CLOSE_PH_x” inputs of all phases for SCBXCBR function in Figure 27.

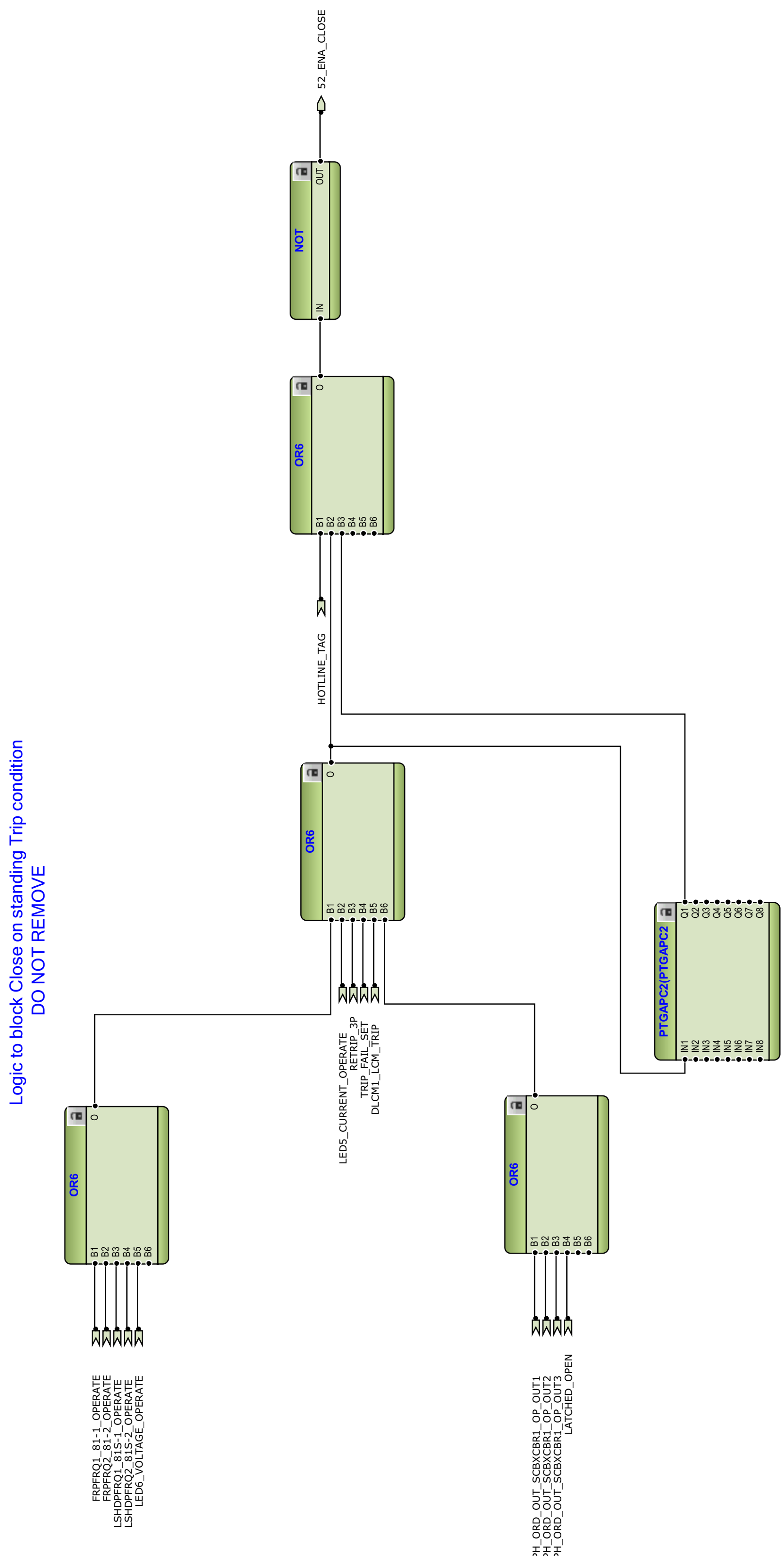


Figure 35: Logic to block Close on standing Trip condition

3.3.3 Functional diagrams for measurements

The current input to the RER620 is measured by the CMMXU1 (three-phase current measurement) function block. The current input is connected to the X12O card in the back plane. The CSMSQI (sequence current measurement) function block measures the sequence currents. The measurements can be seen from the LHMI and is available using the Measurement option in the menu selection. The ground current is measured by the RESCMMXU (residual current measurement). Based on the settings, these blocks can generate low alarm/warning, high alarm/warning signals for the measured current values.

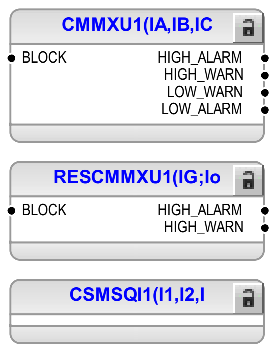


Figure 36: Current measurements

The voltage inputs to the RER620 connected through the X130 card are measured using the VMMXU function block. There are two blocks available to measure the voltage inputs from two sources. The two sources can be from the recloser and the external voltage transformer. This block also generates the high alarm/warning and low alarm/warning signal based on the preset levels.

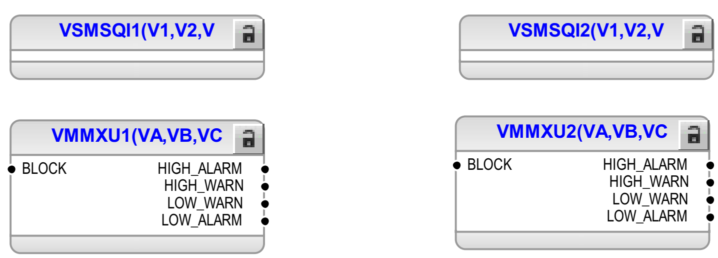


Figure 37: Voltage measurements

The power measurement in RER620 is handled by the APEMMXU block. The APEMMXU block calculates the single and three phase active power, reactive power, apparent power, power factor and three phase energy quantities based on the analog inputs. The output values of this block can be seen in the LHMI menu or available to the external world through communications. Please refer the RER620 technical manual for additional details about the function block. Also, refer the RER620 Modbus point list manual, RER620 DNP Point list manual and PG&E 2179 Point list manual for available data through communications.

Figure 38: Power measurement

The FMMXU block measures the frequency of the analog inputs to the RER620. The value measured is displayed in Hertz.

Figure 39: Frequency measurement

3.3.4 Functional diagram for digital fault recorder

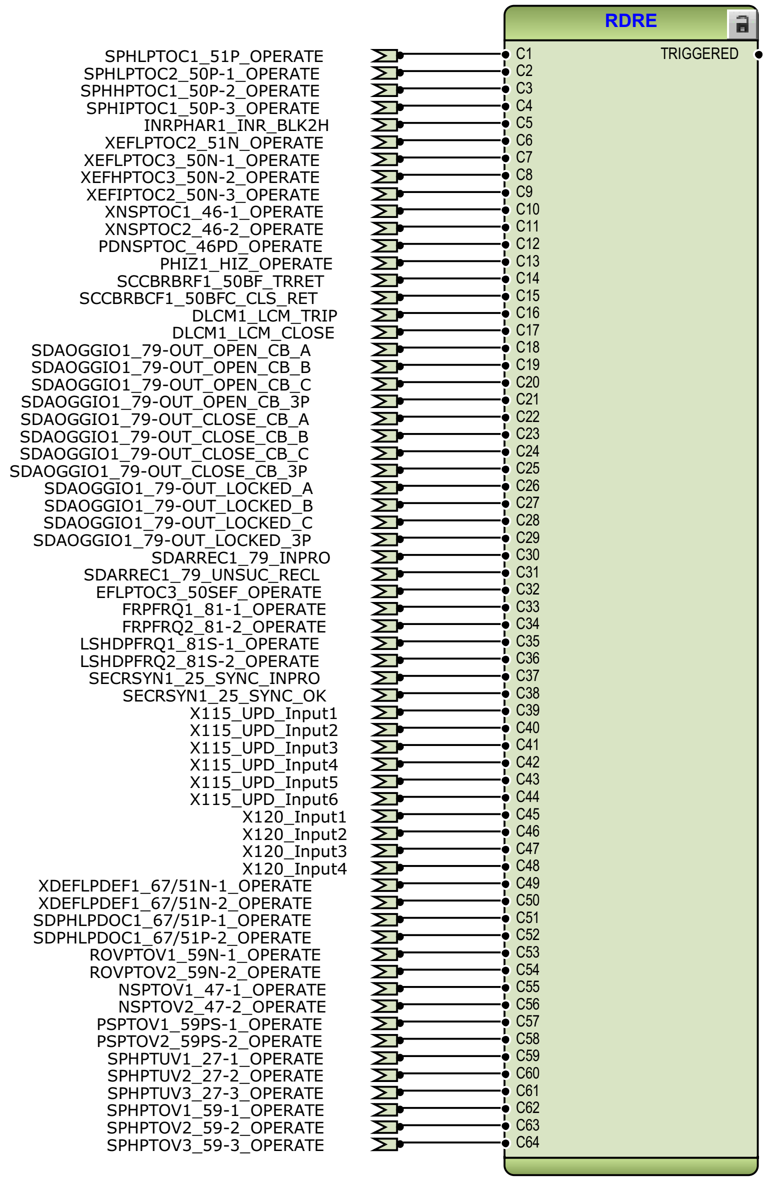


Figure 40: Digital fault recorder digital inputs

3.3.5 Output LEDs

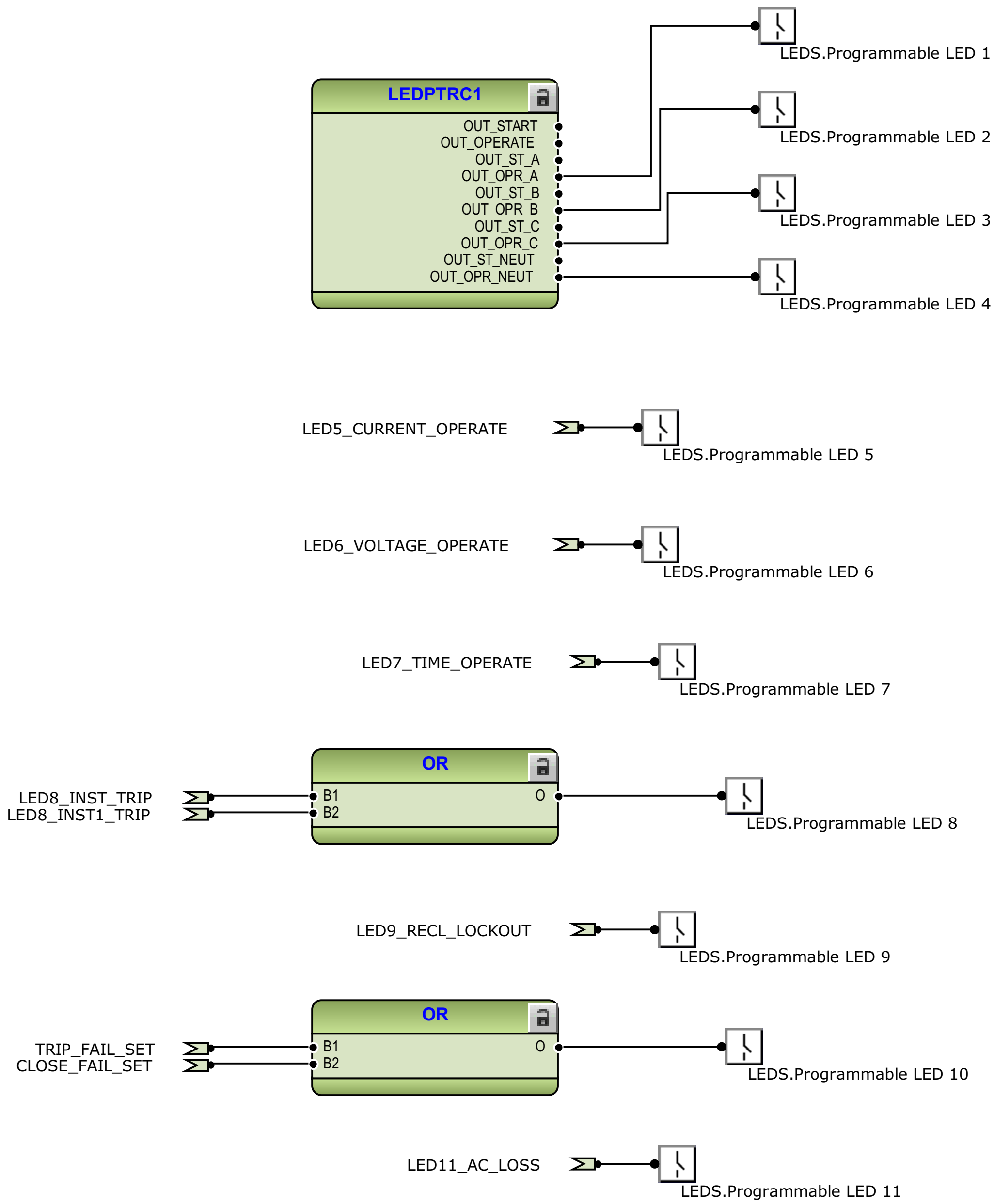


Figure 41: Default LED outputs

3.4 Auto reclose

The RER620 single-phase tripping and reclosing option is advantageous for use on many electric utility distribution systems, including rural, residential and some commercial loads. It provides a control capability function of the recloser to trip and/or lockout whenever there is a fault on one-phase, two-phases or three-phases. This feature allows an electric utility to prevent unnecessary three-phase interruptions and outages of their distribution network where a majority of outages can be attributed to single-phase transient type faults thereby improving the overall power system reliability and quantity of power delivered to customers on the distribution feeder.

3.4.1 Overview of the features in single-phase tripping

As an example of single-phase operation of an RER620 with a recloser, imagine that the recloser is protecting a rural three-phase line. Suppose that a fault occurs on A-phase, where the fault is permanent and there is no fuse between the recloser and the fault. A conventional three-phase recloser will trip for two instantaneous operations followed by two time-delayed operations. The single-phase fault on A-phase will cause all customers downstream to experience three interruptions of power and an outage until the fault is repaired, cleared and the recloser restored to normal operation. The RER620 with single-phase tripping can operate the recloser for the same single-phase fault on A-phase as a single-pole trip, reclose and lockout. This provides a significant advantage to 67% of the customers downstream of the fault since their power is not interrupted. The operation of single-phase operation will trip for two instantaneous operations, two time-delayed operation and lockout on the A-phase pole. Since the fault is a permanent single-phase-to-ground fault, (e.g. A-N), the load connected to A-phase will experience an outage but the other two phases (e.g. B-phase and C-phase) will not experience any interruption of power and will stay energized.

The single phase tripping option is designed to be extremely flexible in order to meet the most demanding requirements. Listed below are brief descriptions of the features for single-phase and three-phase tripping operation:

RER620s supplied with the single phase tripping option consist of the same hardware (front panel and modules) as the standard three phase units. Settings for single phase tripping RER620s, however, vary from the three phase units. With this option, you must select whether you want to use the single phase tripping option or not in SDARREC Settings. In three-phase tripping mode, the RER620 operates in the same manner as a unit without the single-phase tripping option. Single-phase tripping is disabled. Three-phase tripping is enabled.

In single-phase tripping mode, the phase that detects fault current (e.g., current above the pickup threshold level) will initiate the recloser respective pole to trip open. In this mode, for each protection group, the user may choose one of three modes of operation for single-phase tripping: APAT (All Poles All the Time), OPUP (Only Picked Up Phases) and OOAP (One Or All Phases).

3.4.1.1 Conditions on Single Phase Tripping

- When there is a single-phase fault and there is another phase that becomes involved, the additional phase will immediately time out and trip on the curve associated with the step that the other phase has tripped on last. However, all tripped phases will reclose in tandem.

- When a single phase has locked out, the reset timer will count down from its set value in the recloser settings. If another phase becomes involved before the reset time expires, that phase will operate one shot to lockout. If, alternatively, the reset timer has expired, the additional involved phase will go through the full sequence of programmed operations.
- In single-phase tripping, the phase fault current must be greater than the phase element pickup for the single-phase trip to occur. If the fault current is above the neutral setting, but below the phase setting, a three-phase trip will occur. o In the case where both the phase and ground element pick up (all phases must be closed for neutral pickup), the trip time for the involved phases will be based on the faster of the phase trip or the ground setting.
- After a single phase trip or lockout operation, all ground tripping is de-energized. This prevents nuisance tripping of adjacent phases afterwards, due to load imbalance.

3.4.1.2 OPUP Mode - Only Picked Up Phases

If OPUP is selected, any respective phase that detects fault current by the RER620 is actuated to open the respective pole of the recloser. The option for OPUP also allows each pole on the recloser to open independently if the RER620 detects fault current on any of the other two phases.

For example, suppose that a fault is detected on phase B. The RER620 will sense this pickup and initiate a binary output signal from the RER620 to the recloser, the recloser will trip open phase B and await timing from the RER620 for subsequent reclose or lockout. Now suppose that during the pickup and subsequent trip of phase B, the RER620 senses another fault on phase A. The RER620 will detect that fault and initiate a binary output signal from the RER620 to the recloser for pole A, the recloser will trip open phase A and then await timing from the RER620 for reclose or lockout. Comparable sequences may occur and operation of the RER620 will continue to operate for phase C or any combination of phase(s) caused by excessive load or fault current.

3.4.1.3 OOAP Mode - One Or All Phases

In this mode, if a single-phase fault is detected or picked up on one pole, a single-phase trip will occur as in the case of OPUP mode. However, if a combination of two or three phases pickup or detect a fault, then the RER620 will initiate a binary trip output to the recloser for all three poles to trip.

For example, consider a situation where the distribution load has motors connected onto the distribution line. If a single-phase fault occurred on any phase of the line, the RER620 should initiate a trip of all three phases, OOAP, to prevent the three-phase motors from single phasing. A three-phase motor may continue to run with the loss of a single-phase, but it will overheat. In addition, a stopped three-phase motor that is attempting to start with the loss of a single-phase will cause overheating in the motor. For this application, a distribution line with three-phase motors should implement OOAP on single-phase faults.

Some common examples:

- The recloser is set to trip on a single-phase fault in single-phase fashion, but lockout in three-phase fashion (OOAP). A fault is detected and the recloser trips open on one phase and will lockout on all three phases if the fault detected is a permanent fault.
- The recloser is set to trip on a single-phase fault (OOAP). A two-phase fault is detected and the recloser trips open on all three-phases and will lockout on all three phases if the fault detected is a permanent fault.

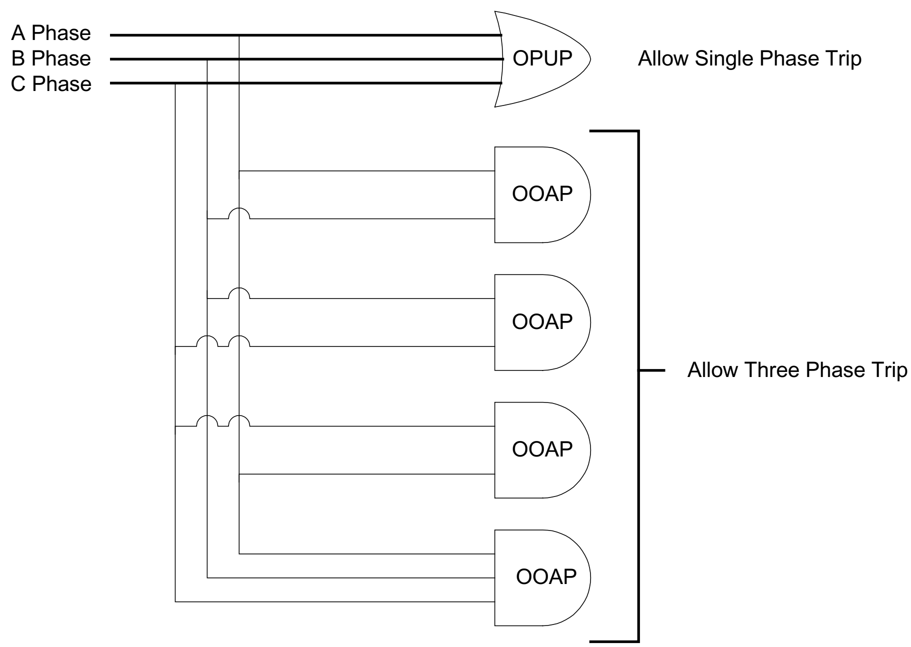


Figure 42: OPUP - OOAP logic

3.4.1.4 APAT: (All Poles All the Time)

- In this case, the single phase function is disabled. The recloser operates as a three phase recloser. However, we still have three actuators and three position sensors for the three poles, so the controls must operate independently. However, for any fault, the trip, reclose, lockout signals are issued to all three phases.

3.4.2 Autorecloser logic

A full Autorecloser functionality consists of 3 sections or parts having 6 SDAIGGIO supporting input function blocks, 1 main SDARREC function block and 1 SDAOGGIO supporting output function block.

The first part of the function called active phase detection which determines which phase(s), if any, are to be tripped from the connected inputs to the consist of per phase trip / pickup signals from various protection functions, and the states of all poles, if any of them is / are open . This determination is based on the condition of each phase (whether tripped, only picked up or already open).

The second part of the function invokes the basic autorecloser function, which determines whether / when to reclose / lockout etc.

The third part of the function distributes the autorecloser outputs to the phases currently active, as determined by the first part of the function. Outputs from the function consist of per phase breaker open / close commands, and lockout signals.

3.4.3 Input function blocks (SDAIGGIOs)

The input section, consists of six modular supporting functional blocks called SDAIGGIOs, collates various signal phase trip / pickup signals from different single phase protection functions. It uses the logic described below to determine which phases are to be activated for this reclose cycle, and tailors its outputs to be fed to the autorecloser / output functions.

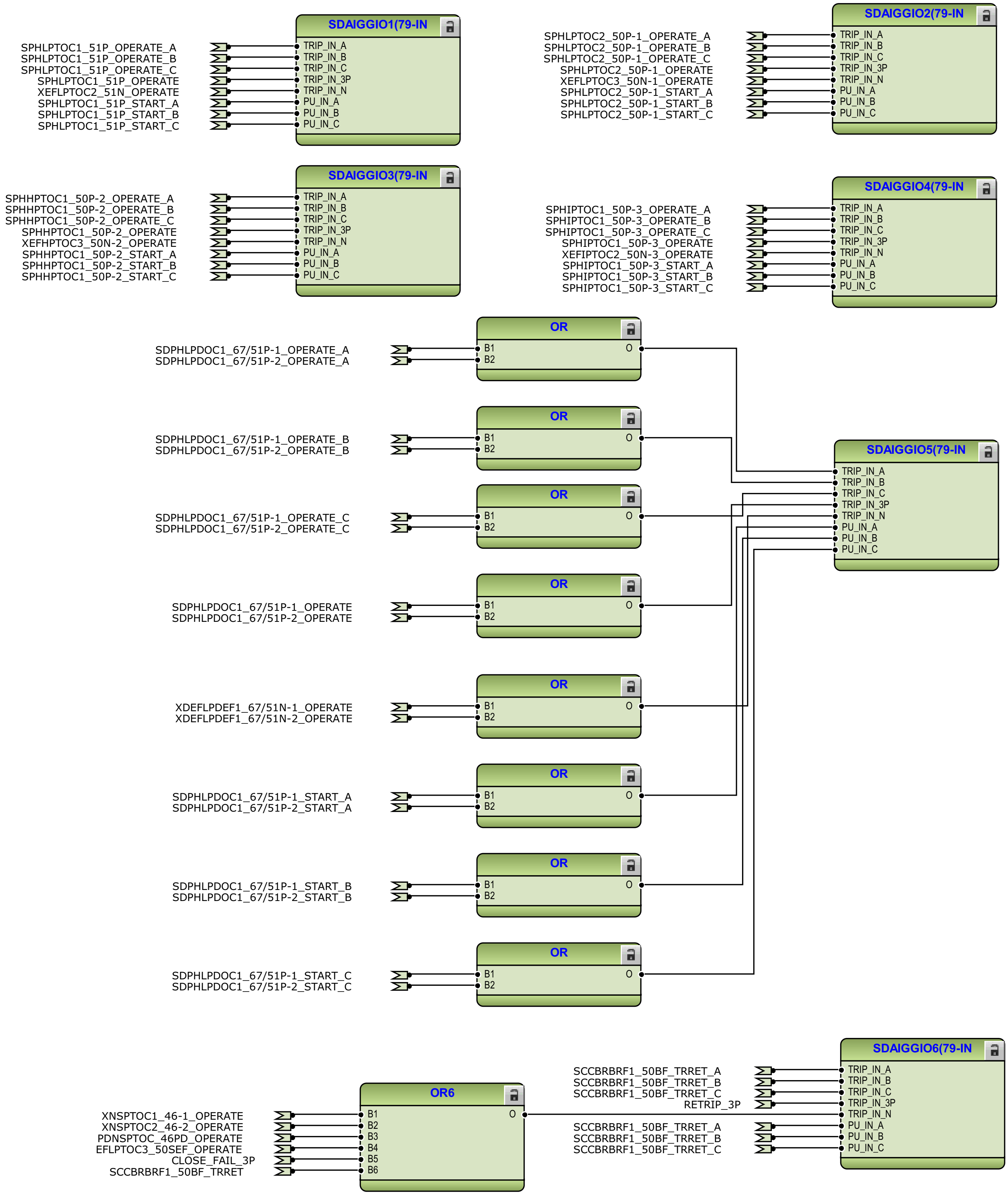


Figure 43: Input function logic

They are not independent function blocks and they are instantiated as part of overall autoreclosing functionality. These SDAIGGIO blocks accepts trip / pickup signals from a protection function and determines (based on settings) which phases are to be tripped. It then generates one TRIP output, along with which phases are active.

3.4.4 Auto Recloser Block (SDARREC)

The autorecloser function accepts "TRIP" signals from the SDAIGGIO functions internally, and generates the appropriate reclose / open / lockout signals, for use by the output function. The logics are built which are visible in the application configuration for inhibiting the reclose function from the outputs of HLT, LATCHED, DLCM functionalities which can be connected to the INHIBIT_RECL input channel of the SDARREC function block in order to block the reclosing functionality on specific scenarios.

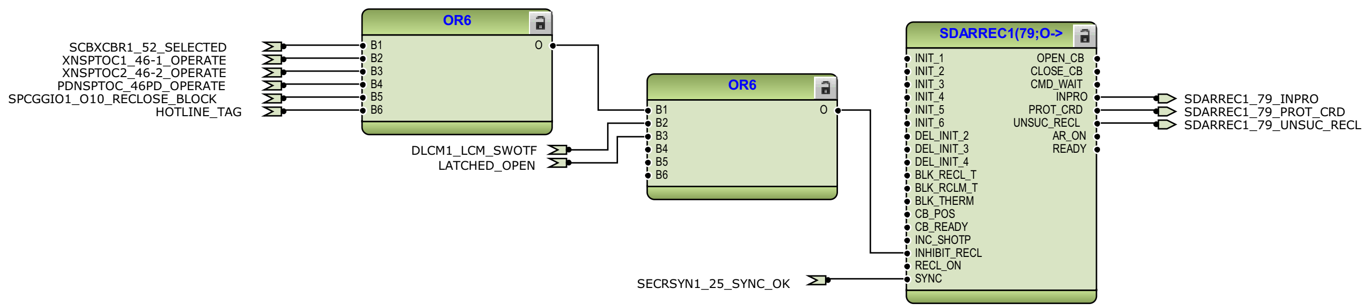


Figure 44: Autorecloser function logic

3.4.5 Output Interface Block (SDAOGGIO)

Output interface block (SDAOGGIO) combines the outputs from the Autorecloser function and the "Active Phase Detect" function internally to route the TRIP / RECLOSE / LOCKOUT signals to the phases that are active for the reclose cycle in progress currently. Also actual breaker status of individual pole are connected as input channels for SDAOGGIO function block in the application configuration.

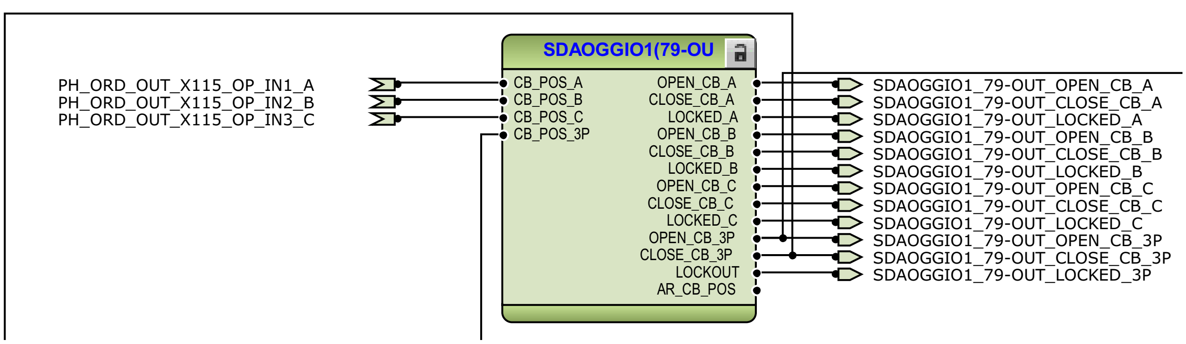


Figure 45: Output Interface function logic

3.5 Loop Control Module

The loop control module (LCM) enables the RER620 to perform automatic loop restoration functions, commonly accepted as a means to significantly improve circuit reliability and to provide more effective system operation. The LCM is designed to implement a loop control scheme by providing switching operations of the recloser to sectionalize or remove the faulted section from the distribution system. The LCM enables a recloser to monitor up to two banks of three-phase voltages (6 potential transformers total) and to consider them in controlling breaker operations.

A recloser loop control scheme typically utilizes a predetermined number of RER620 controlled reclosers installed in series between two substation feeder circuits. This provides isolation of any faulted section within a given distribution circuit while simultaneously re-establishing service to all customers unaffected by the faulted section within a relatively short period. Loop control scheme are typically located at or near key customers at various locations throughout the distribution system, or where reliability on particular circuits is particularly poor.

A typical full implementation of a loop system consists of 3 type of reclosers:

- Sectionalizing reclosers
- Midpoint reclosers
- TiePoint recloser

An explanation of the function of each of these reclosers types is given in the section below.

3.5.1 Sectionalizing Recloser

The Sectionalizing recloser is a normally closed recloser that opens in response to a downstream fault condition or to a loss of phase voltage from an upstream circuit. The sectionalizer is typically the first protective device on the distribution line outside the substation. Various settings determine the Sectionalizing recloser's sensitivity to both current and voltage conditions. By design, for permanent faults between the substation and the Sectionalizing recloser, the Sectionalizing recloser will open after a program delay to set up for the back feeding from the alternate source. This timer is set to expire prior to the Midpoint and Tiepoint timers.

3.5.2 Midpoint Recloser

The Midpoint recloser also is normally closed. Unlike the Sectionalizing recloser, however, it does not open in response to phase voltage loss. Instead, it supports loop control by automatically altering the RER620 settings in accordance with changing voltage conditions. Specifically, upon the expiration of it's under voltage timer, it will switch to a new setting group to prepare for a back feed condition and for a period will go into non-reclose mode. The reason for the nonreclose is that in the event the fault is between the Sectionalizing unit and the Midpoint, it would be undesirable to have the recloser sequence through multiple operations. Though the reclose blocked condition will change to normal after a programmed amount of time, the control will stay in New Settings Group until the loop scheme is reset.

3.5.3 Tiepoint Recloser

The Tiepoint recloser, unlike the Sectionalizing and Midpoint recloser is normally open. It closes in response to a loss of all phase voltages from one source if the other source phase voltages are live. Once closed, the Tiepoint breaker will trip automatically if a downstream overcurrent condition exists and is not isolated by the midpoint recloser first. The Tiepoint recloser can be set to employ different fault thresholds depending on which side of the loop it is supplying, i.e., which side is downstream. After the close operation, it also is set to go into non-reclose mode for a period of time in the event the fault is between the Midpoint and Tiepoint. If the control changed to New Settings Group for the close operation, it will remain in that setting group until the Recloser is opened and the loop scheme is reset.

3.5.4 DLCM Function Block

The Loop Control Module (DLCM) function is configured in RER620 as a part of its default configuration as shown in Figure 46.

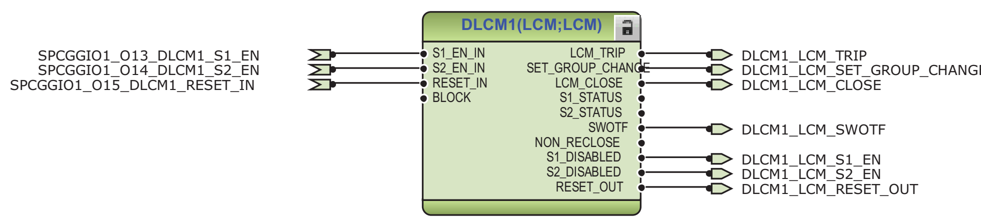


Figure 46: DLCM Function in ACT configuration

3.5.5 Phase Selection

The identification of source and phases for which, phase status has to be determined is done in the phase selection.

The loop control is operated in 4 modes as "Sectionalize", "Mid-point", "Tie-point" or "Disabled" in LCM Mode setting.

The Line side src setting can be selected as "S1" or "S2" to select the respective source as line side source. If the power is flowing from S1 to S2 then the Line side src is selected as "S1" and vice versa.

The condition for any source to be enabled in sectionalizer or midpoint modes is that, the respective source should be selected as Line side source and Vt line enable should be "TRUE" and the corresponding source enable input should be activated through push buttons 13 & 14 [Key 13 & Key 14] in LHMI ,circled in the Figure 47.

Figure 47: LHMI - captioned LCM Source "S1 & S2 Enable" and "Loop Scheme Reset" buttons

The condition for any source to be enabled in tie-point mode is to set the settings Vt line enable and Vt load enable as TRUE and the respective source enable push buttons need to be activated as explained above. The configuration logic for source selection is shown in Figure 48.

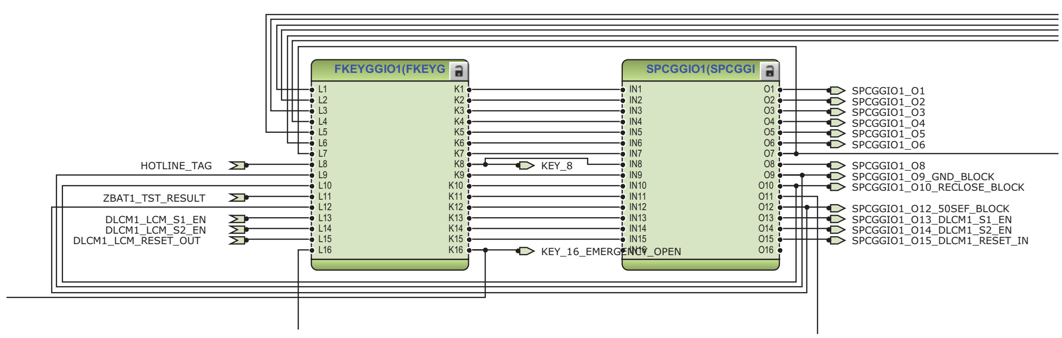


Figure 48: Logic for DLCM "S1 & S2 Enable" and "Loop Scheme Reset

Once the line side source is selected the phases of the respective source is identified by giving the number of voltage transformers connected to the respective source.

In case of sectionalizer mode, the Vt config line setting is selected with number of voltage transformers connected. If the Vt config line is "1" or "2",the Vt line phase setting is selected as the phase to which the voltage transformers is connected. The Vt line enable should be TRUE to consider the settings Vt config line and Vt line phase.

In case of mid-point mode, the numbers of voltage transformers connected can be either 1 or 3. So the Vt config line can be either "1" or "3". The phase selection is similar as in sectionalizer mode but Vt config line cannot be "2".

In case of tie-point mode the 3 phases of both sources are considered. Hence in tie-point mode the Vt config line and Vt config load settings should be selected as "3" and Vt line enable and Vt load enable should be selected as 'TRUE". That is tie-point recloser should always have 3 voltage transformers connected to each source.

3.5.6 Phase Status Determination

Phase status determination module determines the status of phases selected. The status of phase can be live or dead or neither live nor dead based on the level of the respective phase voltages.

In midpoint mode, the SET_GROUP_CHANGE is activated and SWOTF output is activated for a time of SWOTF time setting if the status of the phases selected is dead and if En set grp chg setting is TRUE.

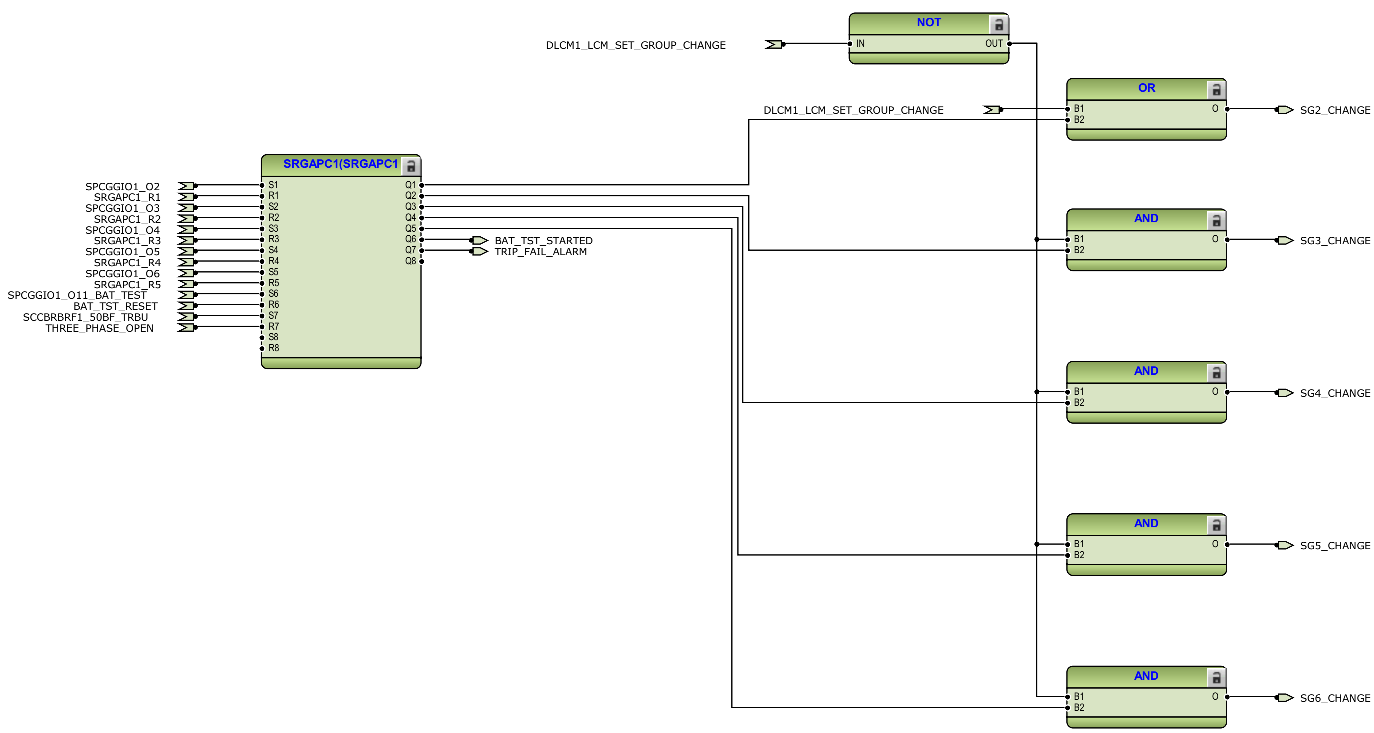


Figure 49: Group change initiation through LCM

In tie point mode, the LCM_CLOSE is activated and also the SWOTF output is activated for a time of SWOTF time setting, if the status of the 3 phases of one source is live and the status of 3 phases of the other source is dead. And also the SET_GROUP_CHANGE is activated, if source selected as line side is dead and if En set grp chg setting is TRUE.

Figure 49 shows logic related to group change initiation through DLCM function. The SWOTF output of DLCM function is one of the input to "INHIBIT_RECL" input channel in 79 (SDARREC) function which inhibits the reclosing function.

3.5.7 Resetting DLCM Function

In the sectionalizer and midpoint mode, if the setting "Reset on power up" setting is set as "TRUE", then after any re-initialization activity in the relay like power off-and-on, software reset, committing to a setting change etc., the loop control will be in reset or active state and RESET_OUT output will FALSE.

If the setting "Reset on power up" is set as "FALSE", then after any re-initialization activity in the relay, the loop control will be in non-reset or in-active state and RESET_OUT output will TRUE. In that case, after restoring the line the DLCM function is reset through push button 15 [Key 15: Loop Scheme Reset] circled in the Figure 47.

In the tie-point mode, after the power on and power off of the relay, the loop control will always go into non-reset mode due to safety reasons. The loop control function can be moved to active or reset state only through push button 15 [Key 15: Loop Scheme Reset] after restoring the line.

The configuration logic for LCM Reset is shown in Figure 48. All the restoration steps should be performed before in full compliance with all applicable safety procedures before resetting the DLCM functionality in RER620 relay.

3.6 Hot Line Tag Functionality

The RER620 has a user settable ‘Hot Line Tag’ (HLT) function as a part of default configuration. When this function is enabled, automatic reclosing and manual closing of breaker is inhibited.

The HLT function can be enabled and disabled locally (i.e. when R/L is set to L), by the dedicated push-button on LHMI of the relay. The push-button toggles the status of the function. When the HLT function is enabled locally, it can only be disabled locally i.e., it cannot be disabled remotely. The HLT function can also be enabled and disabled remotely by SCADA, i.e. when R/L button is set to R. When the HLT function is enabled remotely, it can only be disabled remotely i.e., it cannot be disabled locally. If the HLT function is already enabled locally, it cannot be enabled again remotely and vice versa.

When the HLT function is enabled, the reclosing sequence is inhibited i.e., in the event of a Trip, automatic Close is no longer possible and Lockout takes place. When in single phase mode, if an overcurrent trip occurs only the faulted phase is opened and lockout occurs. Also, when the HLT function is enabled, a manual Close attempt, either from the LHMI or by SCADA is blocked.

A LED on the LHMI of the relay, identified by label ‘Hot Line Tag ON’ indicates the status of the HLT function – Enable = Illuminated / Disable = not Illuminated. The LED follows the status of the function, irrespective of, from where it is enabled or disabled i.e. Local/Remote.

The status of the HLT function is stored in non-volatile memory i.e. the status is maintained even when the relay power is cycled.

Figure 50: LHMI - captioned HLT and R/L push-buttons and LEDs

The HLT function does not automatically initiate changes to settings. If any such changes are desired, for e.g., sensitive protection settings, it is up to the user to do such changes.

The HLT function is configured in RER620 as a part of its default configuration and is implemented using function blocks and logic gates. The application configuration/logic scheme is shown in figure below.

L_Flag or R_Flag represents the HLT function status, which can be activated and deactivated locally through pushbutton 8 (Key 8, Figure 50) or remotely through SPCGGIO1_8 (Figure 50) respectively. The logic as designed accounts for the end user to accurately activate or deactivate the Logic based on the customer's implementation procedure. For example, If SCADA or HMI system activates the logic then, the RER620 will not allow for the local deactivation of the logic.

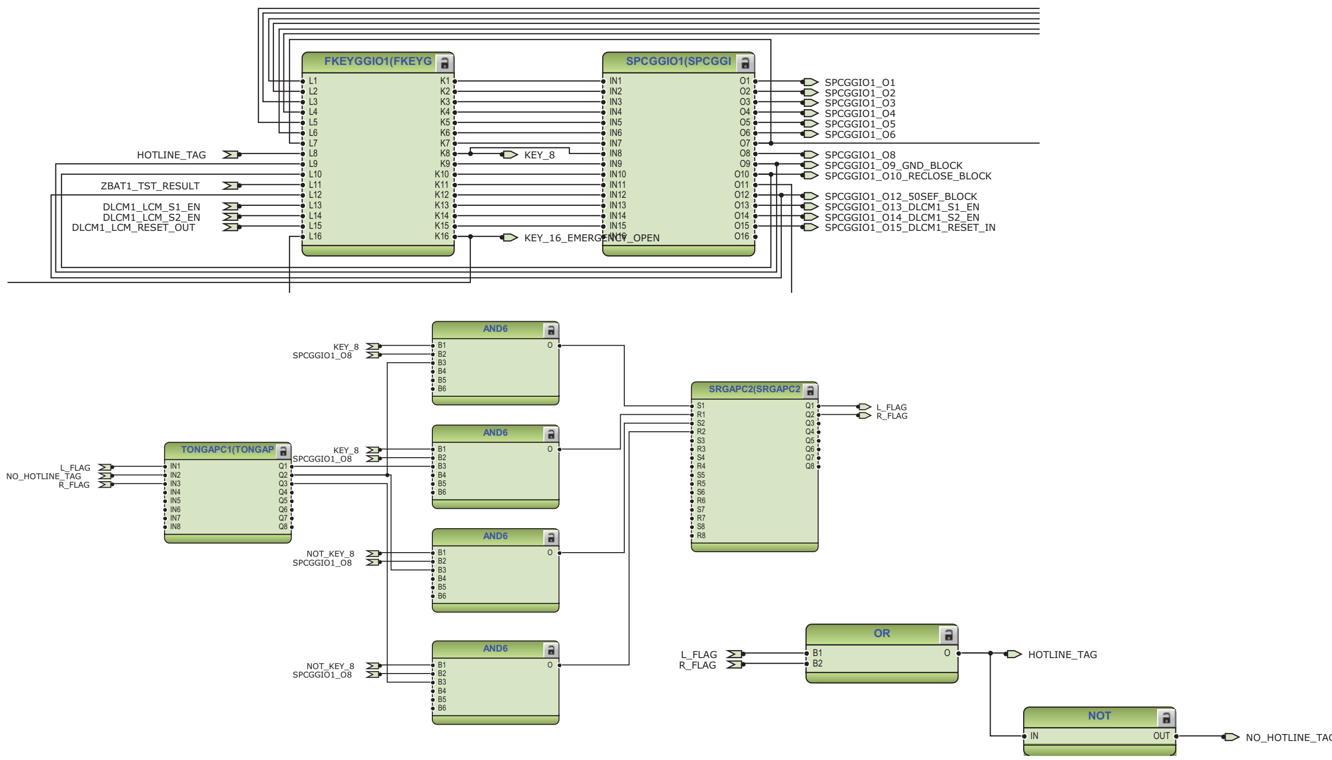


Figure 51: *HLT function Logic Scheme*

The application of Hot-Line functionality is as shown in the figure below. These logic schemes are located in the Control Tab. The Auto reclose SDARREC1 (79) function has HOTLINE_TAG as one of the channels connected to the INHIBIT_RECL input. When HLT function is activated, it inhibits recloser function and also it negates the ENA_CLOSE inputs for the SCBXCBR1 (52) function block, thus blocks closing.

This signal can be bypassed by ITL_BYPASS (interlocking bypass, Figure 52) signal, however the default logic does not use the ITL_BYPASS signal. If the ITL_BYPASS signal were to be used, it is recommended to connect the HOTLINE_TAG signal to the BLK_CLOSE inputs (Figure 52) which cannot be bypassed by ITL_BYPASS.

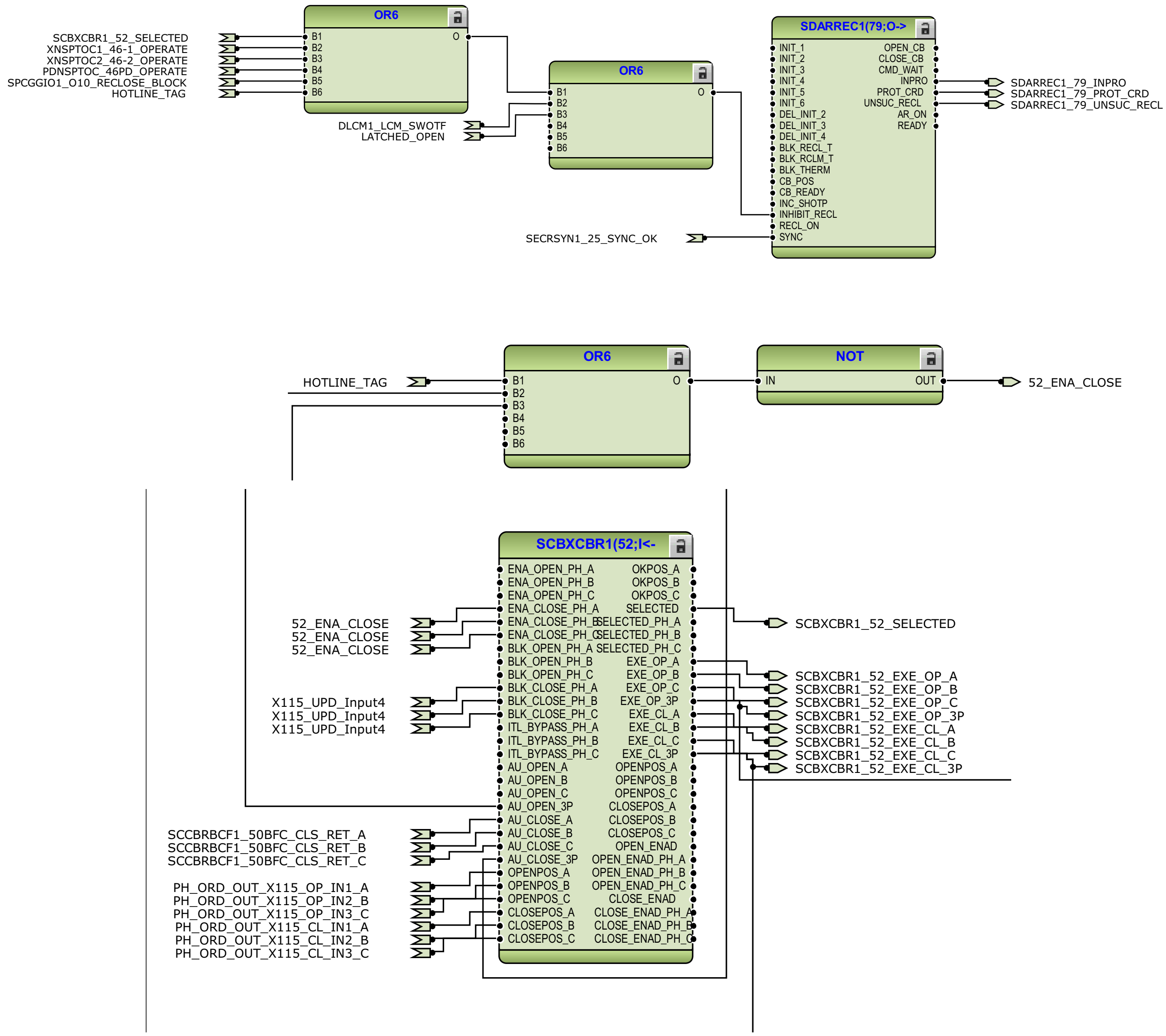


Figure 52: Application of Hot Line Logic

Section 4 Requirements for measurement transformers

4.1 Current transformers

4.1.1 Current transformer requirements for non-directional overcurrent protection

For reliable and correct operation of the overcurrent 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 short circuit 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 relay 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. If other accuracy class CTs are used then refer the following discussions.

4.1.1.1 Current transformer accuracy class and accuracy limit factor

The rated accuracy limit factor (F_n) is the ratio of the rated accuracy limit primary current to the rated primary current. For example, a protective current transformer of type 5P10 has the accuracy class 5P and the accuracy limit factor 10. For protective current transformers, the accuracy class is designed by the highest permissible percentage composite error at the rated accuracy limit primary current prescribed for the accuracy class concerned, followed by the letter “P” (meaning protection).

Table 11: Limits of errors according to IEC 60044-1 for protective current transformers

Accuracy class	Current error at rated primary current (%)	Phase displacement at rated primary current		Composite error at rated accuracy limit primary current (%)
		minutes	centiradians	
5P	±1	±60	±1.8	5
10P	±3	-	-	10

The accuracy classes 5P and 10P are both suitable for non-directional overcurrent protection. The 5P class provides a better accuracy. This should be noted also if there are accuracy requirements for the metering functions (current metering, power metering, and so on) of the relay.

The CT accuracy primary limit current describes the highest fault current magnitude at which the CT fulfils the specified accuracy. Beyond this level, the secondary current of the CT is distorted and it might have severe effects on the performance of the protection relay.

In practice, the actual accuracy limit factor (F_a) differs from the rated accuracy limit factor (F_n) and is proportional to the ratio of the rated CT burden and the actual CT burden.

The actual accuracy limit factor is calculated using the formula:

$$F_a \approx F_n \times \frac{|S_{in} + S_n|}{|S_{in} + S|}$$

F_n the accuracy limit factor with the nominal external burden S_n

S_{in} the internal secondary burden of the CT

S the actual external burden

4.1.1.2 Non-directional overcurrent protection

The current transformer selection

Non-directional overcurrent protection does not set high requirements on the accuracy class or on the actual accuracy limit factor (F_a) of the CTs. It is, however, recommended to select a CT with F_a of at least 20.

The nominal primary current I_{1n} should be chosen in such a way that the thermal and dynamic strength of the current measuring input of the relay is not exceeded. This is always fulfilled when

$I_{1n} > I_{kmax} / 100$,

I_{kmax} is the highest fault current.

The saturation of the CT protects the measuring circuit and the current input of the relay. For that reason, in practice, even a few times smaller nominal primary current can be used than given by the formula.

Recommended pickup current settings

If I_{kmin} is the lowest primary current at which the highest set overcurrent stage is to trip, the pickup current should be set using the formula:

Current pickup value < 0.7 x (I_{kmin} / I_{1n})

I_{1n} is the nominal primary current of the CT.

The factor 0.7 takes into account the protection relay inaccuracy, current transformer errors, and imperfections of the short circuit calculations.

The adequate performance of the CT should be checked when the setting of the high set stage overcurrent protection is defined. The trip time delay caused by the CT saturation is typically small enough when the overcurrent setting is noticeably lower than F_a.

When defining the setting values for the low set stages, the saturation of the CT does not need to be taken into account and the pickup current setting is simply according to the formula.

Delay in operation caused by saturation of current transformers

The saturation of the CT may cause a delayed relay operation. To ensure the time selectivity, the delay must be taken into account when setting the trip times of successive relays.

With definite time mode of operation, the saturation of CT may cause a delay that is as long as the time the constant of the DC component of the fault current, when the current is only slightly higher than the pickup current. This depends on the accuracy limit factor of the CT, on the remanence flux of the core of the CT, and on the trip time setting.

With inverse time mode of operation, the delay should always be considered as being as long as the time constant of the DC component.

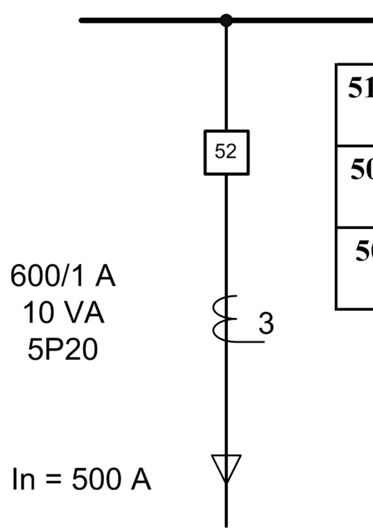
With inverse time mode of operation and when the high-set stages are not used, the AC component of the fault current should not saturate the CT less than 20 times the pickup current. Otherwise, the inverse operation time can be further prolonged. Therefore, the accuracy limit factor F_a should be chosen using the formula:

F_a > 20*Current pickup value / I_{1n}

The Current pickup value is the primary pickup current setting of the relay.

4.1.1.3 Example for non-directional overcurrent protection

The following figure describes a typical medium voltage feeder. The protection is implemented as three-stage definite time non-directional overcurrent protection.



51P	**1200 A** **0.75 s**	**2.00 x I_{2n}** **0.75 s**
50P-1/2	**1800A** **0.50 s**	**3.00 x I_{2n}** **0.50 s**
50P-3	**3500 A** **0.20 s**	**5.83 x I_{2n}** **0.20 s**

Figure 53: Example of three-stage overcurrent protection

The maximum three-phase fault current is 41.7 kA and the minimum three-phase short circuit current is 22.8 kA. The actual accuracy limit factor of the CT is calculated to be 59.

The pickup current setting for low-set stage (51P) is selected to be about twice the nominal current of the cable. The trip time is selected so that it is selective with the next relay (not visible in the figure above). The settings for the high-set stage and instantaneous stage are defined also so that grading is ensured with the downstream protection. In addition, the pickup current settings have to be defined so that the relay operates with the minimum fault current and it does not trip with the maximum load current. The settings for all three stages are as in the figure above.

For the application point of view, the suitable setting for instantaneous stage (50P-3) in this example is 3 500 A (5.83 x I_{2n}). For the CT characteristics point of view, the criteria given by the current transformer selection formula is fulfilled and also the relay setting is considerably below the F_a. In this application, the CT rated burden could have been selected much lower than 10 VA for economical reasons.

Section 5 Relay physical connections

5.1 Inputs

5.1.1 Phase currents

Table 12: Inputs for phase currents

Terminal	Description
X120-7, 8	Ia
X120-9, 10	Ib
X120-11, 12	Ic

5.1.2 Ground current

Table 13: Inputs for ground current

Terminal	Description
X120-13, 14	Ig

5.1.3 Phase voltages

Table 14: Phase voltage inputs

Terminal	Description
X130- 1,2	Va, From recloser
X130- 4,5	Vb, From recloser
X130- 7,8	Vc, From recloser
X130- 11,12	Va, From external VT
X130- 14,15	Vb, From external VT
X130- 17,18	Vc, From external VT

5.1.4 Auxiliary supply voltage input

The auxiliary voltage of the relay is connected to terminals X100/1-2. At DC supply, the positive lead is connected to terminal X100-1. The permitted auxiliary voltage range is 24-60 VDC.

Table 15: Auxiliary voltage supply

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

5.1.5 Binary inputs

The binary inputs can be used, for example, to generate a blocking signal, to unlatch output contacts, to trigger the fault recorder or for remote control of relay settings.

There are four binary input terminals available with X120 fault by default. In addition to that, two additional BIO modules can be included in slots 105 and 110. Each BIO module includes eight input terminals.

Table 16: Input terminals for BIO module in X105/X110 slot, 1…13

Terminal	Description
X105/X110-1 X105/X110-2	BI1, + BI1, -
X105/X110-3 X105/X110-4	BI2, + BI2, -
X105/X110-5 X105/X110-6	BI3, + BI3, -
X105/X110-6 X105/X110-7	BI4, - BI4, +
X105/X110-8 X105/X110-9	BI5, + BI5, -
X105/X110-9 X105/X110-10	BI6, - BI6, +
X105/X110-11 X105/X110-12	BI7, + BI7, -
X105/X110-12 X105/X110-13	BI8, - BI8, +

Table 17: Binary Input terminals X120-1…6

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, -

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. They can be used for any such application. However, recloser closing and opening signals are issued from UPD module as described in section 5.2.4.

Table 18: Output contacts

Terminal	Description
X100-6	PO1, NO
X100-7	PO1, NO
X100-8	PO2, NO
X100-9	PO2, NO
X100-15	PO3, NO (TCS resistor)
X100-16	PO3, NO
X100-17	PO3, NO
X100-18	PO3 (TCS1 input), NO
X100-19	PO3 (TCS1 input), NO
X100-20	PO4, NO (TCS resistor)
X100-21	PO4, NO
X100-22	PO4, NO
X100-23	PO4 (TCS1 input), NO
X100-24	PO4 (TCS1 input), NO

5.2.2 Outputs for signaling

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

Table 19: Output contacts X100-10…14

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

Table 20: Output contacts X110-14…24

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

5.2.3 IRF

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

Table 21: IRF contact

Terminal	Description
X100-3	IRF, common
X100-4	Closed; IRF or Vaux disconnected
X100-5	Closed; no IRF, and Vaux connected

5.2.4 UPD

Output contacts Pole A, Pole B and Pole C are used for controlling the recloser. Recloser status is monitored using Pole positions inputs. Also position of 69 switch is monitored through pin 22. All these I/Os are pre-wired at delivery from the factory.

Table 22: UPD terminals

Conn.	Pin no.	Pin name Modules: BIO0003	Description
X115	1	Not connected	+3.3V DC
X115	2	RS-485 -	From UPS
X115	3	RS-485 +	From UPS
X115	4	RS-485 Common	+15V DC
X115	5	Not connected	+15V DC
X115	6	250V DC	Boost, from UPS
X115	7	250V DC	Boost, to Cap
X115	8	250V DC	Boost, to Cap
X115	9	Drive A +	Pole A
X115	10	Drive A -	Pole A
X115	11	Drive B +	Pole B
X115	12	Drive B -	Pole B
X115	13	Drive C+	Pole C
X115	14	Drive C -	Pole C
X115	15	COM	Common, to Cap
X115	16	COM	Common, to Cap
X115	17	COM	Common, from UPS
X115	18	+60V DC	From UPS
X115	19	DI1 +	Pole A position
X115	20	DI2 +	Pole B position
X115	21	DI3 +	Pole C position
X115	22	DI4 +	69 Switch
X115	23	DI5 +	Spare
X115	24	DI6 +	Spare

Section 6 Glossary

615/620 series	Series of numerical relays for basic, inexpensive and simple protection and supervision applications of utility substations, and industrial switchgear and equipment
100BASE-FX	A physical media defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses fibre-optic cabling
100BASE-TX	A physical media defined in the IEEE 802.3 Ethernet standard for local area networks (LANs) that uses twisted-pair cabling category 5 or higher with RJ-45 connectors
ACT	Application configuration tool
AIM	Analog input module
ANSI	American National Standards Institute
BI	Binary input
BI/O	Binary input/output
BO	Binary output
CB	Circuit breaker
CT	Current transformer
CVD	Capacitive voltage divider
DFR	Digital fault recorder
DIS	Display module
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
IEC 61850	International standard for substation communication and modelling
Relay	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 Relay Manager
PO	Power output
PT	Potential transformer
RJ-45	Galvanic connector type
RS-232	Serial interface standard
RS-485	Serial link according to EIA standard RS485
SIM	Sensor input module
SMT	Signal monitoring tool
SO	Signal output
TCP/IP	Transmission Control Protocol/Internet Protocol
TCS	Trip-circuit supervision
UPD	Universal power driver
WAN	Wide area network
WHMI	Web human-machine interface

Contact us

ABB Inc.
Distribution Automation
4300 Coral Ridge Drive
Coral Springs, FL 33065, USA
Phone:+1 (800) 523-2620
Phone:+1 954-752-6700
Fax:+1 954 345-5329
www.abb.com/substationautomation