SIEMENS

Reyrolle 7SR5 Overcurrent Protection 7SR51

V02.20

Device Manual

C53000-G7040-C014-1

NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

Disclaimer of Liability

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

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Revision Record

Version	Date	Modifications
2.20	2020/10	V2.20 firmware release: 5 CT models. 50GHS High Speed Earth Fault – Measured, 50GI Intermittent Earth Fault, 50HS High Speed Overcurrent – Phase, 67GI Directional Intermittent Earth Fault functions added. Modbus TCP, Syslog server support, SNMP V3 support, and independent binary input operate voltage settings added.
1.10	2020/02	V2.10 firmware release: 25 Synchrocheck – synchronizing function and 87NL Restricted earth fault protection – low-impedance added. Device language selection setting added. Security Log added. Two hardware ordering option variants added: 7SR5110-4 Overcurrent, 4 I, 23 BI, 12 BO, and 7SR5111-3 Directional Overcurrent, 4 I, 4 V, 19 BI, 12 BO.
1.00	2019/10	First issue

Preface

Purpose of the Manual

This manual provides an overview of the 7SR51 device family. It describes various functions (protection and supervision) used, device technical data, and device applications.

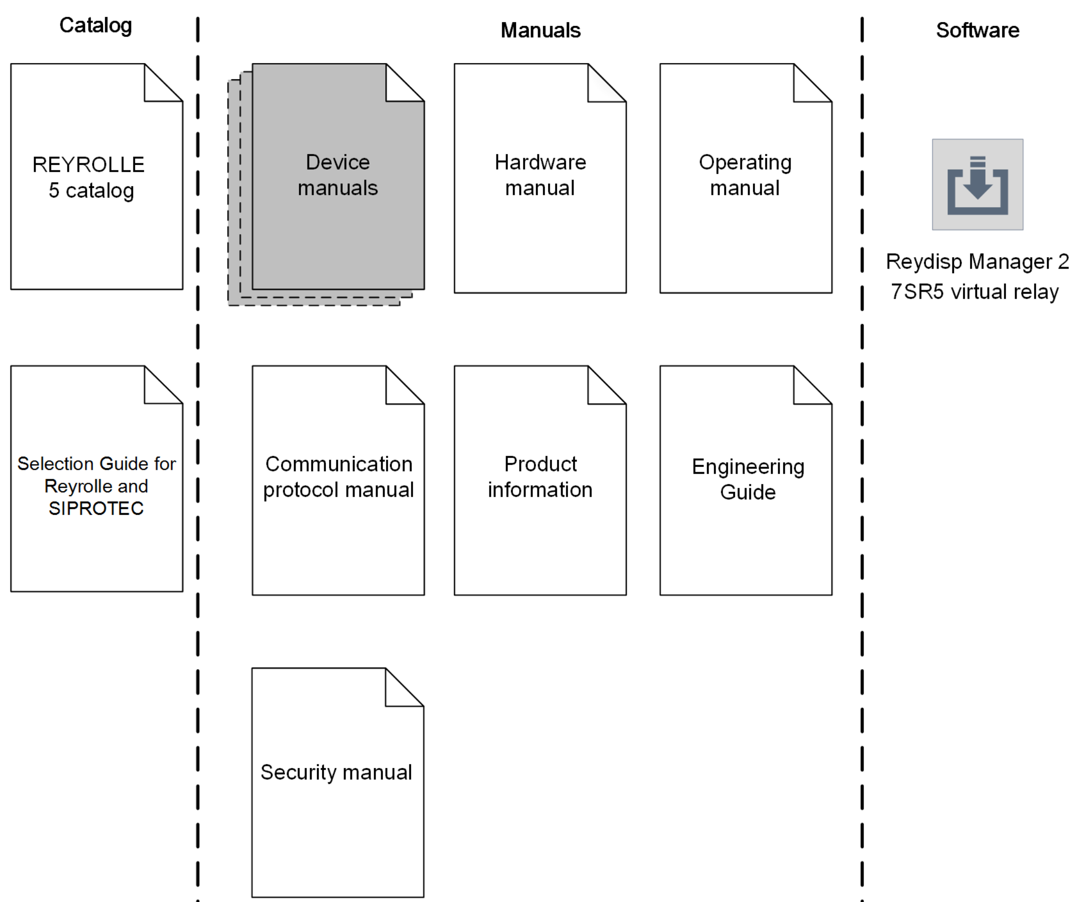
Target Audience

This manual is mainly intended for protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the Reyrolle 7SR51 device family.

Further Documentation



[dw_7SR5_furtherdocumentation_devicemanual, 3, en_US]

- Device manuals
  Each device manual describes the functions and applications of a specific Reyrolle 7SR51 device. The printed manual for the device has the same informational structure.
- Hardware manual
  The hardware manual describes the hardware building blocks and device combinations of the Reyrolle 7SR51 device family.
- Operating manual
  The operating manual describes the basic principles and procedures for operating and installing the devices of the Reyrolle 7SR51 range.
- Communication protocol manual
  The communication protocol manual contains a description of the protocols for communication within the Reyrolle 7SR51 device family and to higher-level network control centers.
- Security manual
  The Security manual describes the security features of the Reyrolle 5 devices and Reydisp Manager.
- Product information
  The product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each Reyrolle 7SR51 device.
- Engineering Guide
  The engineering guide describes the essential steps when engineering with Reydisp Manager 2. In addition, the engineering guide shows you how to load a planned configuration to a Reyrolle 7SR51 device and update the functionality of the Reyrolle 7SR51 device.
- Virtual Relay
  The virtual relay allows a user to view, control and manipulate a virtual 7SR51 device. The virtual relay is a tool that can facilitate training and understanding of the controls and functions on a Reyrolle 7SR51 device.
- Reyrolle 7SR51 catalog
  The Reyrolle 7SR51 catalog describes the system features and the devices of Reyrolle 7SR51.
- Selection guide for Reyrolle and SIPROTEC
  The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

Indication of Conformity

This product is CE-compliant to relevant EU directives.

Additional Support

For questions about the system, contact your Siemens sales partner.

Customer Support Center

Our Customer Support Center provides a 24-hour service.

Siemens AG
Smart Infrastructure – Digital Grid
Customer Support Center
Tel.: +49 911 2155 4466
E-Mail: *energy.automation@siemens.com*

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG
Siemens Power Academy TD
Humboldtstrasse 59
90459 Nuremberg
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Fax: +49 (911) 433-7929
E-mail: poweracademy@siemens.com
Internet: www.siemens.com/poweracademy

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:

DANGER

DANGER means that death or severe injury **will** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.

WARNING

WARNING means that death or severe injury **may** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.

CAUTION

CAUTION means that medium-severe or slight injuries **can** occur if the specified measures are not taken.

✧ Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage **can** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid property damage.

NOTE

Important information about the product, product handling or a certain section of the documentation which must be given attention.

Qualified Electrical Engineering Personnel

Only qualified electrical engineering personnel may commission and operate the equipment (module, device) described in this document. Qualified electrical engineering personnel in the sense of this document are people who can demonstrate technical qualifications as electrical technicians. These persons may commission, isolate, ground and label devices, systems and circuits according to the standards of safety engineering.

Proper Use

The equipment (device, module) may be used only for such applications as set out in the catalogs and the technical description, and only in combination with third-party equipment recommended and approved by Siemens.

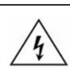
Problem-free and safe operation of the product depends on the following:

- Proper transport
- Proper storage, setup and installation
- Proper operation and maintenance

When electrical equipment is operated, hazardous voltages are inevitably present in certain parts. If proper action is not taken, death, severe injury or property damage can result:

- The equipment must be grounded at the grounding terminal before any connections are made.
- All circuit components connected to the power supply may be subject to dangerous voltage.
- Hazardous voltages may be present in equipment even after the supply voltage has been disconnected (capacitors can still be charged).
- Operation of equipment with exposed current-transformer circuits is prohibited. Before disconnecting the equipment, ensure that the current-transformer circuits are short-circuited.
- The limiting values stated in the document must not be exceeded. This must also be considered during testing and commissioning.
- Terminals are exposed when the device element is removed from the case.

Selection of Used Symbols on the Device

Nr.	Symbol	Description
1		Direct current, IEC 60417, 5031
2		Alternating current, IEC 60417, 5032
3		Direct and alternating current, IEC 60417, 5033
4		Earth (ground) terminal, IEC 60417, 5017
5		Protective conductor terminal, IEC 60417, 5019
6		Caution, risk of electric shock
7		Caution, risk of danger, ISO 7000, 0434
8		Guideline 2002/96/EC for electrical and electronic devices
9		Guideline for the Eurasian Market
10		AC 2 kV insulation test of reset coil, trip coil, and output contacts
11		5 kV impulse voltage test (type test) in compliance with Class III

Nr.	Symbol	Description
12		ESD-sensitive devices
13		Mandatory Conformity Mark for Electronics and Electrotechnical Products in Morocco
14		South Korea KC Certification for Electrical and Electronic Products

Open Source Software

The product contains, among other things, Open Source Software developed by third parties. The Open Source Software used in the product and the license agreements concerning this software can be found in the Readme_OSS. These Open Source Software files are protected by copyright. Your compliance with those license conditions will entitle you to use the Open Source Software as foreseen in the relevant license. In the event of conflicts between Siemens license conditions and the Open Source Software license conditions, the Open Source Software conditions shall prevail with respect to the Open Source Software portions of the software. The Open Source Software is licensed royalty-free. Insofar as the applicable Open Source Software License Conditions provide for it you can order the source code of the Open Source Software from your Siemens sales contact – against payment of the shipping and handling charges – for a period of at least 3 years after purchase of the product. We are liable for the product including the Open Source Software contained in it pursuant to the license conditions applicable to the product. Any liability for the Open Source Software beyond the program flow intended for the product is explicitly excluded. Furthermore, any liability for defects resulting from modifications to the Open Source Software by you or third parties is excluded. We do not provide any technical support for the product if it has been modified.

The ReadmeOSS documents for the product can be found here: *www.siemens.com/reyrolle*

Table of Contents

1 Introduction

7SR5 Devices

This manual is applicable to the following relays:

- 7SR5110 series
- 7SR5111 series
- 7SR5121 series

[sc_7SR5_size6_front angle, 1, --_--]

CAUTION

Current Transformer Circuits

✧ The secondary circuit of a live CT must not be open circuited. Non-observance of this precaution can result in injury to personnel or damage to equipment.

CAUTION

External Resistors

✧ Where external resistors are fitted to relays, these may present a danger of electric shock or burns, if touched.

CAUTION

Fibre Optic Communication

✧ Where fibre optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

CAUTION

Front Fascia

✧ For safety reasons the following symbols are displayed on the device.

✧ Dielectric Test Voltage 2 kV

✧ Impulse Test Above 5 kV

✧ Caution: Refer to Equipment Documentation

✧ Caution: Risk of Electric Shock

✧ Caution: Electrostatic Sensitive Devices

Modular Concept

The 7SR5 platform is common to a number of devices and so ensures the consistency and integrity of all functionalities across the device series:

- Modular system design in hardware, software, and communication
- Functional integration of various applications, such as protection, control, and fault recorder
- Consistent functionality across the entire family of devices
- Upgrade path using software libraries and updates

- Flexible hardware architecture
- Self-monitoring routines for device faults

General Properties

- Fully digital measured-value processing and control, from sampling and digitizing of measurands to closing and tripping decisions for the circuit-breaker.
- Complete galvanic and interference-free isolation of the internal processing circuits from the system measuring, control, and supply circuits through instrument transformers, binary inputs, binary outputs and DC/AC voltage converters.
- User friendly operation from the front fascia or from the Reydisp software tool via the data comms ports.
- Display of measured and metered values at the front.
- Storage of system demand data measured values.
- Storage of data relating to system faults with real-time tagging.
- Storage of instantaneous analogue values for fault records and analysis.
- Continuous monitoring of the measurands as well as the device hardware and software.
- Communication with central control and storage devices possible via the device interface.
- Synchronizable clock

The ordering structure for the devices is very straightforward as the devices have flexible interfaces and ordering options are minimized

Product Description	**Order No.**																	
	1	2	3	4	5	6	7		8	9	10	11	12		13	14	15	16
7SR51 Overcurrent Relay	7	S	R	5	1	n	n	-	n	A	A	n	n	-	0	A	A	0
							|	-	|			|	|					
Overcurrent: I/O Configurations						6	7	-	8			|	|					
4 I, 8 BI, 6 BO						1	0	-	1			|	1					
4 I, 13 BI, 8 BO						1	0	-	2			|	1					
4 I, 23 BI, 12 BO						1	0	-	4			|	6					
4 I, 38 BI, 18 BO						1	0	-	7			|	6					
						|	|	-	|			|	|					
Directional Overcurrent: I/O Configurations						|	|	-	|			|	|					
4 I, 4 V, 9 BI, 8 BO						1	1	-	1			|	1					
4 I, 4 V, 14 BI, 10 BO						1	1	-	2			|	6					
4 I, 4 V, 19 BI, 12 BO						1	1	-	3			|	6					
4 I, 4 V, 39 BI, 20 BO						1	1	-	7			|	6					
						|	|	-	|			|	|					
Special Applications Overcurrent: I/O Configurations						|	|	-	|			|	|					
5 I, 4 V, 17 BI, 10 BO						2	1	-	2			|	6					
5 I, 4 V, 37 BI, 18 BO						2	1	-	6			|	6					
												|	|					
CPU/Data Communication												11	|					
Standard: 1 x USB (front), RS485 (rear) ports												|	|					
2 x RJ45 ports												1	|					
2 x optical LC ports												2	|					
													|					
Case & Fascia													12					

Product Description	Order No.					
Housing width 3/8 x 19" (size 6), Housing height 4U	1					
Housing width 3/4 x 19" (size 12), Housing height 4U	6					

The multifunctional 7SR5 protection devices digitally process all tasks from acquisition of the measurands to controlling the circuit-breaker.

Front Fascia

The fascia Light Emitting Diodes (LEDs) and Liquid Crystal Display (LCD) provide information on the device function and report events, states, and measured values.

The fascia keypad enables on-site operation of the device without the need for the Reydisp software tool.

Device information such as setting parameters, operating and fault indications or measured values can be displayed, and setting parameters changed.

System equipment can be controlled from the front fascia when the 7SR5 is suitably configured.

Microcomputer System

All device functions are processed in the device CPU, these include, for example:

- Filtering and processing of the measurands
- Continuous monitoring of the measurands
- Monitoring of the pickup conditions for the individual protection functions
- Control of logic function signals
- Issue of trip and close commands
- Storage of events, indications, fault data and fault values
- Data communication
- Real time clock and time synchronization.

Power Supply

The 7SR5 is powered by an internal power supply. Brief interruptions in the supply voltage, which can occur during open circuits in the system auxiliary voltage supply are generally bridged by capacitor storage.

Analog Inputs

7SR5 devices have current transformer and, depending on the device type, voltage transformer inputs.

The 7SR5 analogue inputs transform the currents and voltages from the instrument transformers to the internal processing level of the device.

Current inputs are provided in groups of four CTs, these can be used to measure phase and earth currents. Where the application requires high current sensitivity a core balance current transformer can be used with the earth current input.

Voltage inputs are provided in groups of four VTs. The first 3 inputs (e.g. VT1/2/3) are grouped and are suitable for connection to all primary plant voltage transformer configurations, the fourth voltage input (e.g. VT4) is independent and can be connected as required by the application.

Binary Inputs and Outputs

7SR5 devices include a number of binary input functions, categorized as:

- Voltage operated binary inputs
- Virtual inputs/outputs (see also binary outputs in following list)
- Function key binary inputs
- General alarms

Binary output functions are categorized as :

- Binary output relays
- Virtual inputs/outputs (see also binary inputs in previous list)
- Fascia LEDs
- General pickup outputs
- Trip config outputs

Binary input and binary output functionality is fully programmable. These can be used for a number purposes.

Voltage operated binary inputs allow the device to receive external information from the system or from other devices.

The binary output relays are used to initiate primary plant switching and provide indications for remote signaling of important events and states.

Serial Interfaces

The USB interface on the relay fascia enables local communication with a personal computer when using the Reydisp operating program.

The IP address for all 7SR5 device front ports is 192.168.2.1.

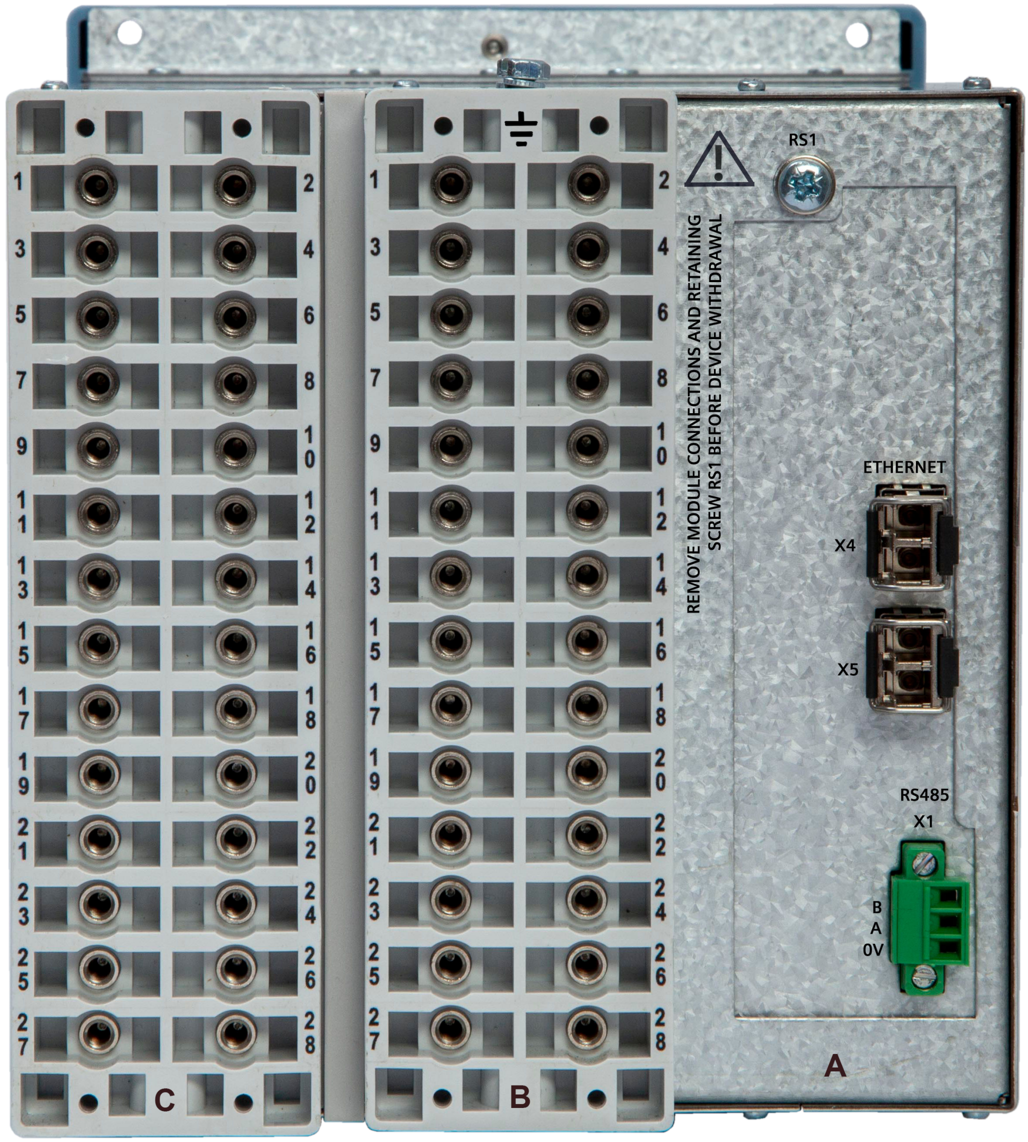
The USB drivers must be installed prior to connection.

A RS485 port on the rear of the device provides remote communications using user selectable protocols.

Ethernet Interfaces

Additional interfaces on the rear of the device provide remote communications using user selectable protocols.

- Redundant ethernet communication interfaces
- Redundant and independent protocols to control centers possible (such as IEC 61850)



[sc_7SR5_Size6_rear, 1, --_--]

2 Basic Structure of the Device Functionality

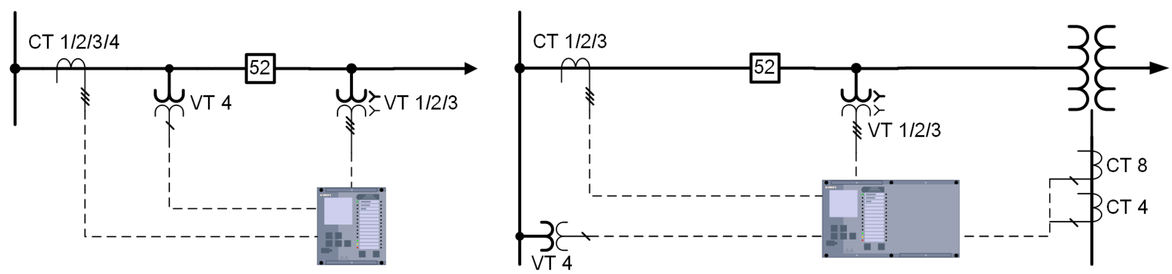
2.1 Analogue Inputs

The device functionality is dependent on the analogue input configuration.

Standard overcurrent devices have 4 CT inputs and directional overcurrent devices have both 4 CT inputs and 4 VT inputs. A special model is also available with 5 CT inputs and 4 VT inputs.

The measuring inputs (current and voltage inputs) for each function are parametrized in the **Device Configuration > CT/VT** settings menu, see *3.3 CT and VT Inputs* .

The analogue input connections for 7SR5 overcurrent and directional overcurrent devices is summarized in *Figure 2-1*.



[dw_7SR5_7SR51CTVTInputConnections, 2, en_US]

Figure 2-1 7SR51 Device Analogue Input Connections

The analogue input configuration for overcurrent devices is summarized in *Table 2-1*. Common configuration parameters are provided for the 3 phase inputs. Separate parameters are provided for the earth input and the second earth input provided only by 7SR512 devices.

Table 2-1 Device CT Input Configuration

Configuration > System Config		
Parameter	**Range**	**Default Setting**
CT1/2/3 Nominal	1 A/5 A	1 A
CT1/2/3 Ratio Prim	000000 to 999999	2000 A
CT1/2/3 Ratio Sec	0.2 to 7	1
CT4 Nominal	1 A/5 A	1 A
CT4 Ratio Prim	000000 to 999999	2000 A
CT4 Ratio Sec	0.2 to 7	1
CT8 Nominal	1 A/5 A	1 A
CT8 Ratio Prim	000000 to 999999	2000 A
CT8 Ratio Sec	0.2 to 7	1
Phase Rotation	ABC, ACB	ABC

The additional analogue input configuration (VT inputs) for directional overcurrent devices is summarized in *Table 2-2*.

Table 2-2 Device VT Input Configuration

Configuration > System Config		
Parameter	**Range**	**Default Setting**
VT1/2/3 Nominal	40 V to 160 V	63.5 V
VT1/2/3 Ratio Prim	000000 to 999999	132000 V
VT1/2/3 Ratio Sec	40 V to 160 V	110 V
VT1/2/3 Trim Magnitude	0 V to 20 V	0 V
VT1/2/3 Trim Angle	- 45° to + 45°	0°

Configuration > System Config		
Parameter	**Range**	**Default Setting**
VT1/2/3 Config	Va, Vb, Vc/Van, Vbn, Vcn/ Vab, Vbc, 3V0	Van, Vbn, Vcn
VT4 Nominal	40 V to 160 V	63.5 V
VT4 Ratio Prim	000000 to 999999	132000 V
VT4 Ratio Sec	40 V to 160 V	110 V
VT4 Trim Magnitude	0 V to 20 V	0 V
VT4 Trim Angle	- 45° to + 45°	0°

Interface Between Function Elements and Measuring Inputs

The functions receive the appropriate measuring inputs from the current and voltage transformers as summarized in *Table 2-1* and *Table 2-2*.

The measuring inputs (current and voltage inputs) are parametrized in the **Device Configuration > CT/VT** settings menu, see *3.3 CT and VT Inputs* .

2.2 Device Startup

7SR5 devices can be started in any 1 of 3 modes:

- Auxiliary Power On = Device is switched on by applying the auxiliary supply voltage.
- Expected = User initiated start e.g. after a change to the device user configuration or firmware upgrade.
- Unexpected = Caused by operation of the device self monitoring functions.

During the start up cycle the device should run the following process during normal behavior.

- The LCD backlight switches on, then off, and then returns to a backlit screen displaying the device type and startup logo.
- The LCD brightness can be adjusted by pressing the **Enter** (↲) and **Cancel** (X) pushbuttons together, then pressing the ► pushbutton. Using the ▲ or ▼ keys will then increase or decrease the brightness.
- The following messages are displayed on the bottom of the screen:
  - Starting File System
    Starting Software
    7SR5xx FW: Vxx.xx
        CFG: Vxx.xx

On the last display a progress bar is displayed to show the progress the sequence is running. On completion the device validates and runs the firmware, and completes the start up sequence. The device does this by displaying the default **Home Screen**, operating the healthy output contact and illuminating the **Healthy LED** green.

NOTE

The LCD contrast can be adjusted by pressing the **Enter** and **Cancel** pushbuttons together and then using the ▲ or ▼ keys to increase or decrease the contrast.

Events are generated to record the successful completion and cause of a device restart.

- Restart: This event is generated for device restarts. It is accompanied by another event which indicates the cause of the restart.
- Cold Start: This indicates that the device has been returned to factory condition, settings are defaulted and user configuration is removed. This event will be created during a restart following a device firmware update. The events are cleared when the device is updated following a configuration change so this event is rarely seen.
- Configuration Restart: This event indicates that the device was restarted to accept a configuration change which was required by the device software. It is also named SW forced Restart. [1]
- Power On: This event is created for normal restarts following power interruption or for voltage excursion outside of acceptable limits which has caused the device to restart.
- Unexpected Restart: This event is created during successful restart after the device self-monitoring has detected a condition that halts normal operation. Frequently repeated generation of this event can indicate a device defect or configuration problem. [2]
- Warm Start: If the device is unable to complete its startup procedure it will retry. If this repeats 10 times without successful startup completing, the stored Disturbance Records archive, Events Record archive, Fault Record archive, record of LED status prior to restart and non-volatile record of User Logic counters and latches are deleted in an attempt to clear data corruption which could be preventing restart. Device configuration and settings are not affected. This action is recorded as Warm Start.

---

1 Restart Counter: A resettable counter is provided which will be incremented for device restarts. This counter can be configured to include the different restart types and has a configurable target to provide an output alarm.

2 Unexpected Restart Blocking: Repeated restart of a defective device can be prevented by an additional counter. If a configurable number of unexpected restarts occur in a configurable time, the device will enter lock-up mode and will require repair.

The device also provides user alerts to provide indication of the devices configuration:

- The **Device Not Configured** message shall flash up on the LCD after a short duration if the user has not changed any parameter in the device. The message is removed by changing any parameter or loading a user configuration.

[sc_7SR5_DeviceNotConfigured, 1, --_--]

- The device provides indication that the IEC 61850 has been configured. The **IEC 61850 Configured Alert** parameter located in the **Configuration Device** menu can be **Enabled** to provide a screen alert message. The message should be **Disabled** for non IEC 61850 applications. The **IEC 61850 Not Configured** parameter is in the **Binary Output** matrix for mapping to a binary output, LED, and/or virtual signal.

NOTE

The **IEC 61850 Not Configured** alert will be displayed sequentially with any other configured alerts.

2.3 Real Time Clock

In order to allow the correct time recording of events synchronously, devices need a time synchronization.

The device clock function is used to time tag the stored data i.e. demand/data logs, waveform records, fault records and event records.

The internal device time is maintained in local time. All display time stamps and event logs are displayed in local time.

In order to maintain synchronizm within a substation, the clock can be synchronized with an external reference source.

The default date is set at `01/01/2000` deliberately to indicate the date has not yet been set, if the clock returns to default value the device will generate an event.

Time and date can be set either via the relay fascia in the **`Configuration > Device`** menu or via the data comms channel(s). When editing the time from the fascia, only the hours and minutes can be edited. When the user presses **`Enter`** after editing, the seconds are zeroed and the clock begins running.

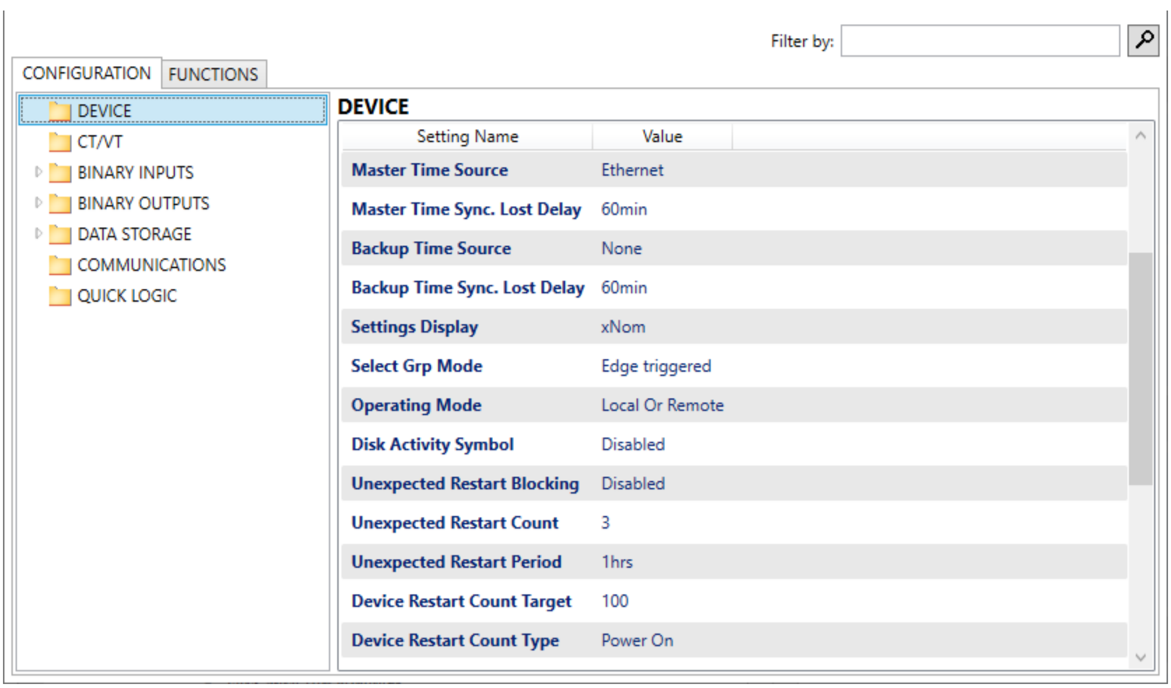
The time and date can also be set from Reydisp Manager 2 via the USB port or over an Ethernet connection using the **`Set Device Date & Time`** function.

In the event of loss of auxiliary power the real time clock is powered from a back up storage capacitor.

Setting the Time Source

Parameters for communication with **`Master`** and **`Backup`** clocks can be set in a device using the device settings.

If a communication protocol with time synchronization data can be used with the device then the time sources are configured as required.



[sc_7SR5_DeviceSettings, 2, --_--]

NOTE

The source for the master and back up clock must be set to be from different sources.

- Failure to receive a periodic time synch from the master clock will result in a master clock lost event/alarm. The period before raising the alarm is the user setting **Master Time Synch Lost Delay**.
- Failure to receive a periodic time synch from the master clock will result in a switch over to the backup clock (if configured). The period before switching over to the backup clock is the user setting **Master Time Synch Lost Delay**.
- Failure to receive a periodic time synch from the backup clock will result in a backup clock lost event/alarm (if configured). The period before raising the alarm is the user setting **Backup Time Sync Lost Delay**.
- Failure to receive a periodic time synch from the master and backup clock will result in a time synch not received event/alarm.

Master Clock	Backup Clock	Master Clock Lost Alarm	Backup Clock Lost Alarm	Time Synch Not Received Alarm
None	None	No	No	No
Yes	None	Yes	No	Yes – from master clock
Yes	Yes – same source as master clock	Yes	No	Yes – from master clock
Yes	Yes – different source as master clock	Yes	Yes	Yes – from backup clock

- At power-on the alarms **Master Clock Lost**, **Backup Clock Lost**, and **Time Sync Not Received** will be raised until the first valid time synch is received when the setting indicates the device is connected to a clock. Once the time synch is received these alarms will be cleared.
- An alarm will be provided to indicate if the clock has reset time to default time due to capacitor/battery backup discharge or failure.
- A binary input can be used for the master or back up time source. This will be done upon receiving a 0→1 transition on the user selectable **BI** (Binary Input Clock Synch). When the transition is detected the software clock will be synchronized to the nearest minute or hour as specified by the user parameter.
  - **Binary Input Seconds**
    When a pulse is received on the configured binary input **Clock Sync**. The milliseconds will be reset to 0 and the time is adjusted to the nearest second.
  - **Binary Input Minutes**
    When a pulse is received on the configured binary input **Clock Sync**. The millisecond and seconds will be reset to 0 and the time is adjusted to the nearest minute.

Time Server in the Network

For time synchronization via Ethernet according to Simple Network Time Protocol (SNTP), a time server must be present in the network. 1 or 2 time servers are supported. This time server must also be able to address the different time requirements of the devices as defined in SNTP. Time servers can be reached through an IP address.

The Simple Network Time Protocol is used to synchronize clocks via the Internet. With SNTP, client computers can synchronize their clocks with a time server via the Internet. SNTP enables a time resolution of 1 ms. When considering similar runtimes, SNTP can determine the average runtime of a synchronization telegram between the client and the server in the Ethernet network. This transmission time can be taken into account in the terminal device and improves synchronization of terminal devices.

SNTP is available for the integrated Ethernet interface.

Version SNTPv4 is supported.

A fault time indication is output when the clock server does not respond to inquiries from the device after the configured monitoring time expires. A time fault will be set in the time stamp of all indications.

The time fault indication does not appear when the SNTP server itself has no connection to the time source. However at device start up, as long as no connection has been established with the SNTP server or the time synchronization message indicates a Stratum greater than 3, the bit `ClockNotSynchronized` will be set in the time stamp.

The device supports 2 SNTP timer servers, the first, primary server remains the preferred server so that all devices, if possible, operate with the same master clock.

The 7SR5 ethernet module interrogates both NTP servers cyclically every minute. It normally synchronizes itself on the first parameterized primary NTP server. If the first NTP server doesn't respond to a query twice successively within the 1 minute polling interval, the time synchronization switchovers to the secondary, second server. Further switchover criteria are:

- The server shows alarm on the response telegram (variable leap = 3)
- The Stratum of the server is 0 (unknown) or greater than 5
- The current time is indicated with 0 (if no reception)
- The running time of the telegram in the net is greater than 5 ms

The switchover will be prevented if the second server delivers no considerably better time signal, i.e. if the server only was attainable last for less than 10 minutes, if it announces alarm or its Stratum is 0 or greater than 5, or it indicates the current time with 0 or the running time of the telegram in the net is greater than 5 ms. In all of these cases the device is then no longer synchronized. It runs with the internal ms time base and the last valid drift. After the parameterized time delay the device announces a time disturbance signal.

While the module is synchronizing on the second server, it also interrogates the first server. The switch back to the first server will only take place if it has performed an acceptable quality for 10 minutes as already mentioned. The switch back is delayed as long as all conditions are fulfilled.

At the startup of the module the first server will be interrogated, about 5 seconds later the second server, too. The time of the first server will also be taken if the Stratum is 0 or greater than 5 or the second server offers a better Stratum 5 seconds later.

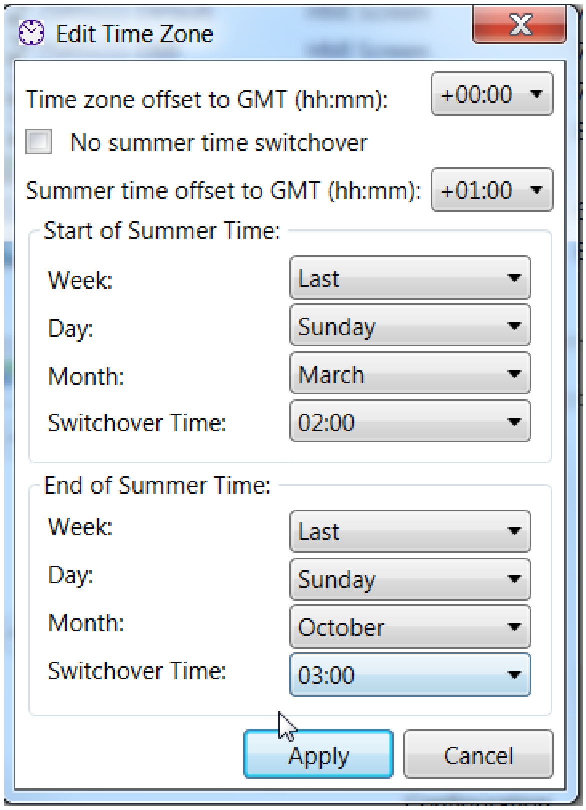
The announcement of a time disturbance signal works purely from the view of the device. I.e. it will only be announced if the device is no longer synchronized from the module.

For the redundant NTP client on the module this means that the announcement of the time disturbance signal will not be issued during a successful switchover on the second server. If the time delay of the indication is parameterized on the minimum value of 2 minutes in the device, which corresponds to a twice repeated failure, then the behavior isn't determined and the indication could possibly appear. So for a defined behavior the time delay for the time disturbance indication has to be parameterized up to at least 3 minutes. The time delay for the time disturbance indication is not available as a parameter on the module and therefore can neither be tested nor be used for an adapted switchover time (the above mentioned 10 min).

While switching back to the first NTP server no time disturbance indication will appear because the transition takes place without loss of synchronization.

Setting the Time Zone

The Ethernet interface uses the UTC time format and a parameter for configuring the applicable rules for the local time. Offset and daylight saving time are provided in Reydisp Manager.



[sc_7SR5_TimeZone, 1, --_--]

NOTE

The offset time zone for time synchronization is with reference to UTC and not the relays local time.

NOTE

If a time zone for time synchronization is already preset for the communication protocol, for example, DNP3 or IEC 60870-5-103, the time zone of the time source must be identical.

NOTE

If a time zone for time synchronization is from SNTP the time zone of the time source from the serial protocol must be identical as the offset and daylight saving rules will not be applied by the device.

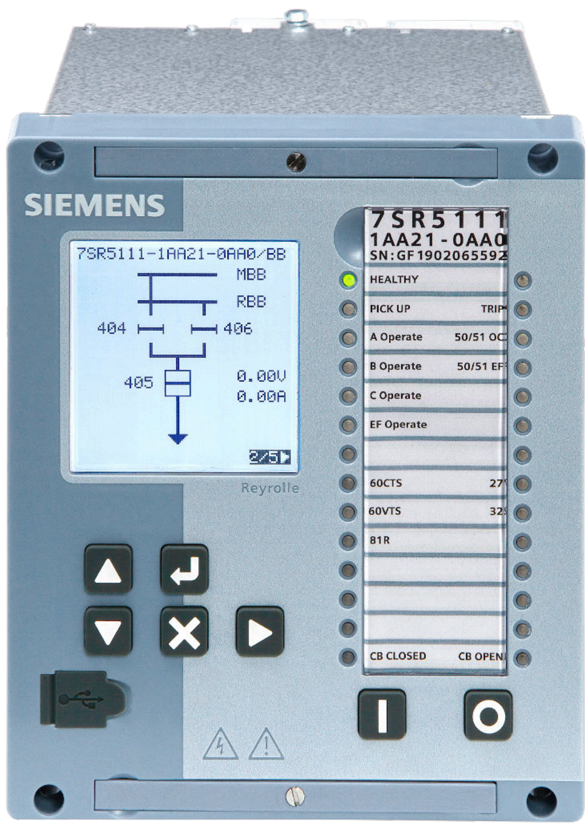
3 Device Functionality

3.1 Device Fascia

3.1.1 Overview of Functions

The fascia consists of:

- USB comms port for local access
- 28 user programmable LEDs (see *3.5 Binary Outputs*) and LED label insert.
- LCD for display of text and graphics
- 7 pushbuttons



[sc_7SR5_size6_FrontPhoto, 1, --_--]

Figure 3-1 Size 6 7SR5111 Device

Full device configuration and settings can be parameterized using the **Reydisp Manager** PC tool. Function setttings can also be entered from the relay fascia using the fascia navigation pushbuttons and viewed on the fascia LCD.

LCD

Device and system information is viewable on the 128 x 128 liquid crystal display (LCD).

The device **Home Screen** is the starting point from which the required menus are accessed using the fascia navigation keys. See the **Operations manual** for full details.

The user can return to the **Home Screen** by pressing the **Cancel** button several times from anywhere within the menu structure.

When the required device parameter is located within the menu structure it's setting can be edited or viewed as appropriate using the appropriate pushbuttons – see the **Operating manual**.

NOTE

The Setting ID or Control ID may need to be entered to change settings or carry out control commands from the device (see *3.2 Device Configuration*).

The LCD contrast can be adjusted by pressing the **Enter** and **Cancel** pushbuttons together and then using the ▲ or ▼ keys to increase or decrease the contrast.

The backlight brightness adjusted by pressing the **Enter** and **Cancel** pushbuttons together, then pressing the right arrow ► pushbutton to select brightness and then using the ▲ or ▼ keys to increase or decrease the level.

To conserve power the display backlighting is extinguished when no buttons are pressed for a user defined period. The **backlight timer** setting within the **Device Config** menu allows the timeout to be adjusted from 1 to 60 minutes and **Off** (backlight permanently on).

NOTE

The LCD display automatically switches off when no buttons are pressed for 60 minutes. Pressing any key will re-activate the display (see section *3.2 Device Configuration*).

The LCD is user configurable and can include graphics symbols to illustrate the associated primary plant. For further details refer to the Engineering Guide.

The device fascia display and navigation keys can be used to view and analyze the instruments and selected data. Stored data can be viewed and analyzed using RM2 (see *3.6 Data Storage*).

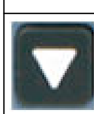
In service indications for the device and primary system are available from the device fascia, these include:

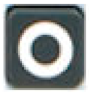
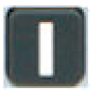
- Measured data – instruments and meters
- Device functions
- Device settings
- Device status
- Fault records

NOTE

No ID entry is necessary to read indications locally from the device LCD.

Table 3-1 Fascia Pushbuttons

	Menu navigation and settings increase
	Menu navigation and settings decrease
	**Enter** key, used to initiate and accept settings changes
	**Cancel** key, used to cancel settings changes and/or move up the menu structure by one level per press

	Menu navigation. Binary output reset from home screen (3 second delay)
	Binary input > Function key 0 (see *3.4 Binary Inputs*)
	Binary input > Function key 1 (see *3.4 Binary Inputs*)

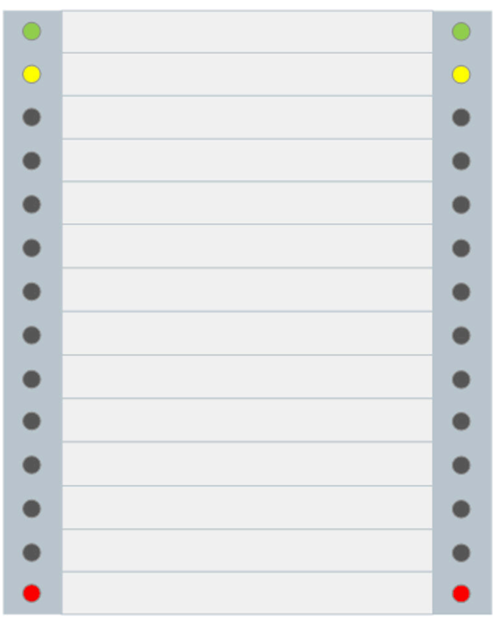
3.1.2 Indications and Instruments

LEDs

28 user programmable LEDs are provided on the device fascia in 2 columns.

A label is provided between the 2 columns of LEDs, this can be customized using the **Relay LED Label Template** utility.

LED operation is configured in the **Configuration > Binary Outputs > LED Config** menu (see *3.5 Binary Outputs*).



[sc_7SR5_LEDLabelTemplate, 1, --_--]

Figure 3-2 Example LED Template

NOTE

Hand reset LEDs can be reset by:

- Pressing the ► key for ≥ 3 seconds when the home screen is displayed and entering the **Control ID** if configured
- Energizing a suitably programmed binary input
- Sending an appropriate command over the data communications channel(s)

LCD

The structure of the device menu system is summarized in the following table. Note that the table shows typical information available but depends on device functionality:

Home screen	Mimic diagrams and device instruments can be configured in the Reydisp software tool and displayed on the home screen. See the **Operating manual** for full details.			
Settings	Configuration	Device (see *3.2 Device Configuration*)		
		CT/VT (see *3.3 CT and VT Inputs*)		
		Binary inputs (see *3.4 Binary Inputs*)		
		Binary outputs (see *3.5 Binary Outputs*)		
		Maintenance	Output matrix test	
		Data storage (see *3.6 Data Storage*)	Demand/data log	
			Waveform storage	
			Fault storage	
			Event storage	
			Energy	
			Fault locator	
		Communications (see *3.7 Data Communications*)		
		Quick logic (see *3.8 Quick Logic*)		
	Functions (Function Template) See *4.2 Function Groups and Function Elements*	Function config		
		Protection	<Fnct group>	Function element 1
				Function element n
			<Fnct group>	Function element 1
				Function element n
		Supervision	<Fnct group>	Function element 1
				Function element n
			<Fnct group>	Function element 1
				Function element n
		Control	<Fnct group>	Function element 1
				Function element n
			<Fnct group>	Function element 1
				Function element n

Instruments	Favourites			
	Current			
	Voltage			
	Frequency			
	Power			
	Energy			
	Synchrocheck			
	Thermal			
	Wattmetric			
	AFD meters			
	Vector shift			
	ROCOF			
	Maintenance			
	Auto reclose			
	Fault locator			
	Miscellaneous			
	General alarms			
	Demand			
	Binary inputs			
	Binary output			
	Virtual			
	Comms			
	Quick logic			
Control mode See *7 Control Functions*	CB: Open/Close			
	EF: In/Out			
	GS: In/Out			
	Operate Mode: Set Local/Remote/Out of Service/Test Mode			
	LED Test and Reset Hand Reset Binary Outputs			
	Trigger Waveform			
	Reset Waveforms			
	Reset Events			
	Reset Faults			
	Reset Data Log			
	Reset Demand			
	79: In/Out			
	Hotline Working: In/Out			
	Inst. Protections: In/Out			
	79: Trip & Reclose			
	79: Trip & Lockout			

Device information	Relay identifier			
	Circuit identifier			
	MLFB			
	Serial number			
	Firmware version			
	Comms FW version			
	Config version			
	Config capacity			

Home Screen(s)

Up to 5 home screens can be configured using the Reydisp software tool.

Settings

Parameter changes can be entered from the device fascia. These can be for the **Function Groups** (FG) or **Function Elements** (FE) i.e. the **Settings > Function** menus. 4 settings groups are provided for each function – Group number (Gn) 1 to 4.

NOTE

Where the **Setting Confirmation ID** has been enabled this must be entered to allow changes.

At any 1 time only 1 group of settings can be active – **Device Config > Active Group** setting, (see *3.2 Device Configuration*).

Settings data is stored in non-volatile memory in the device.

Instruments

The device instrumentation and metering provides real-time measured quantities and data, this is displayed on the relay fascia LCD (when in **Instruments Mode**) or via the data communications interface.

The primary values are calculated using the CT and VT parameters i.e. the values entered in the **Configuration > CT/VT** menu, (see *3.3 CT and VT Inputs*).

The user can add the meters that are most commonly viewed to a **Favorites** window by pressing the **Enter** key when viewing a meter. The relay will display the favorite meters after elapse of the **Configuration > Device > Favorite Meters Timer** setting. When more than 1 favorite meter is selected each selected meter is displayed on the LCD for 5 seconds.

The energy storage meters can be reset from a binary input and have a user selectable setting for their measurement in the **Configuration > Data Storage** menu, (see *3.6 Data Storage*).

Counter instruments can be reset by pressing the ► key when the instrument is displayed.

Communication Meters

The communications meters display the information and activity.

The information provided depends upon the module type and user configuration and is only available in English.

Control Mode Menu

This mode provides convenient access to commonly used relay control and test functions. When any of the items highlighted in the control menu are selected control is initiated by pressing the **Enter** key. The user is prompted to confirm the action, again by pressing the **Enter** key, before the command is executed.

NOTE

Control ID access code entry may be necessary to carry out control commands from the device, (see *3.2 Device Configuration*).

NOTE

A CB must be in a **Closed** state before an **Open** command will be accepted. And that a CB must be in an **Open** state before a **Close** command will be accepted. If not, the relay reports that the requested command is **Interlocked**.

NOTE

Switching a protection function **In/Out** via the **Control Mode** menu will not change that function group's **Enabled/Disabled** setting. The **Control Mode** menu selection will however over-ride the setting when disabling or switching the function out of service.

3.1.3 Reading Indications using Reydisp

Instruments and meters can be accessed locally from the front USB port.

See the **Engineering Guide** for full details.

3.2 Device Configuration

3.2.1 Overview of Functions

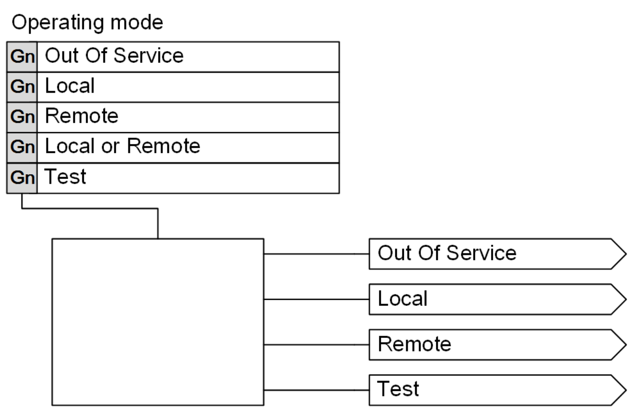
The device configuration parameters are used to parameterize selected basic operating functionality of the device.
The Reydisp Manager PC tool is used to configure the device.

3.2.2 Structure of the Function

The settings applied here are common to all function element settings groups i.e. settings group 1 (Gn1) to settings group 4 (Gn4).
The device configuration covers a number of operating modes including:

- Power system rated frequency
- Display operating modes including settings, meters, fault and alarm alerts
- Time setting and methods of time synchronizing
- Local, remote, test, and out of service operating modes
- User identification

3.2.3 Logic of the Function



[lo_7SR5_DeviceConfiguration_OperatingMode, 2, en_US]

Figure 3-3 Device Configuration > Operating Mode

3.2.4 Application and Setting Notes

Parameter: **`Language Setting`**

- Default Setting: **`English`**
  The language of the text displayed on the device LCD can be selected.

NOTE

The device will restart when the language setting is changed.

Parameter: **System Frequency**

- Default Setting: **50 Hz**
  This setting is selected to be equal to the power system rated frequency.

NOTE

Changing the parameter will cause the device to restart.

Parameter: **Active Group**

- Default Setting: **1 (Gn1)**
  The relay provides 4 groups of function settings – Group number (Gn) 1 to 4. At any 1 time only 1 group of settings can be active – **Device Config > Active Group** setting. An output is provided to indicate which setting group is active.
  It is possible to edit 1 group while the relay operates in accordance with settings from another active group using the **View/Edit Group** setting.
  Some settings are independent of the active group setting i.e. they apply to all settings groups. This is indicated on the top line of the relay LCD – where only the **Active Group No.** is identified. Where settings are group dependent this is indicated on the top line of the LCD by both the **Active Group No.** and the **View Group No.** being displayed.
  A change of settings group can be achieved either locally at the relay fascia, remotely over the data comms channel(s), or from a binary input. When using a binary input an alternative settings group is selected only whilst the input is energized (Select Grp Mode: Level triggered) or latches into the selected group after energization of the input (Select Grp Mode: Edge triggered).
  Different settings groups may be selected to provide more appropriate settings e.g. when the network is reconfigured, during periods temporary overload or during emergency operating conditions.
  Settings are stored in non-volatile memory.

Parameter: **View/Edit Group**

- Default Setting: **1 (Gn1)**
  Settings in the selected group (Gn) can be viewed and edited where required.

Parameter: **Setting Dependencies**

- Default Setting: **Enabled**
  When enabled the relay displays settings information for the enabled functions only.
  This reduces the amount of information in the settings screens as the functionality not being used is not shown. Using setting dependencies provides clearer information to the user as only available functionality is visible.

Parameter: **Favorite Meters Timer**

- Default Setting: **60 mins**
  The device displays the favorite meters selected by the user when the device has been inactive for a period in excess of the timer setting. Favorite meters are selected by viewing the relevant meter and pressing the **Enter** pushbutton. Favorite meter selection is cancelled by again selecting the meter and pressing the **Enter** pushbutton.
  When several meters are selected as favorites each selected screen is displayed for 5 seconds.

Parameter: **Backlight Timer**

- Default Setting: **5 mins**
  To conserve power the display backlighting is extinguished when no buttons are pressed for a user defined period. This setting is used to adjust the timeout from 1 to 60 minutes and **Off** (backlight permanently on).

NOTE

The LCD display automatically switches off when no buttons are pressed for 60 minutes.
Pressing any key will re-activate the display, (see *3.2 Device Configuration*).

Parameter: **Date**

- Default Setting:
  The current date is used to time tag device events and fault records.

NOTE

If a time and date has not been set and no time source is available, the time and date will default to **xx** at power on or restart. The display will show the current time based on this unconfigured data.

Parameter: **Time**

- Default Setting:
  The current time is used to time tag device events and fault records.
  If the auxiliary power supply is lost the real time clock is powered from a back up storage capacitor.

Parameter: **Master Time Source**

- Default Setting: **Ethernet**
  This setting is used to synchronize the real time clock to a reference source.

Parameter: **Master Time Sync. Lost Delay**

- Default Setting: **60 min**
  A binary output can be operated when loss of the time synchronizing signal has been detected for a period greater than the setting.

Parameter: **Backup Time Source**

- Default Setting: **<None>**

Parameter: **Backup Time Sync. Lost Delay**

- Default Setting: **60 min**
  A binary output can be operated when loss of the time synchronizing signal has been detected for a period greater than the setting.

Parameter: **Setting Display**

- Default Setting: · **Nom**
  The user can view current settings in the selected units.

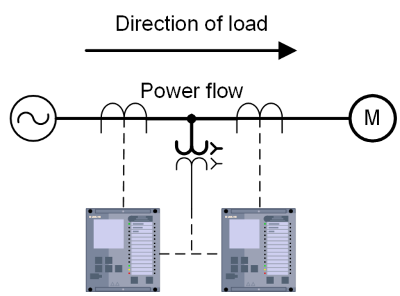
Parameter: **`Export Power/Lag VAr`**

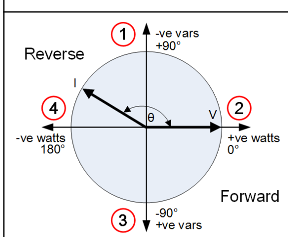
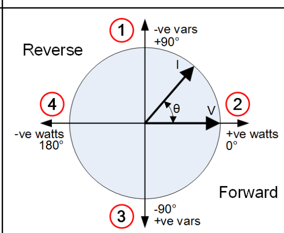
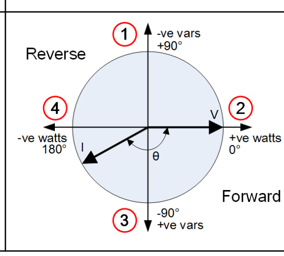
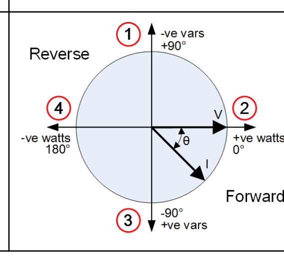
- Default Setting: **`+ve/+ve`**

  With both **`Export Power`** (W) and **`Lag VAr`** (VAr) set to be +ve, the direction of energy transfer will follow the IEC convention e.g. an induction motor consumes Watts and VArs, this is shown in *Table 3-2* as positive Watts and positive VArs.

  Setting either the **`Export Power`** (W) or **`Lag VAr`** (VAr) to be -ve, will reverse the direction of the energy transfer for these quantities. So forward VAr will then be reported as **`Imported Reactive Energy`**, and forward Watts will be reported as **`Exported Active Energy`**. See also **`Power Protection`** (32) and **`Power Factor`** (55) function elements.

Table 3-2 Energy Direction Convention



-ve/-ve P.F. Lagging Watts Import VArs Import	+ve/-ve P.F. Leading Watts Export VArs Import	-ve/+ve P.F. Leading Watts Import VArs Export	+ve/+ve P.F Lagging Watts Export VArs Export
Generator Circuit			Induction Motor Circuit
			
1) **Reactive Energy Import** (VArs reverse) IEC Convention: -ve vars			
2) **Active Energy Export** (Watts forward) IEC Convention: +ve watts			
3) **Reactive Energy Export** (VArs forward) IEC Convention: +ve vars			
4) **Active Energy Import** (Watts reverse) IEC Convention: -ve watts			

Parameter: **`IEC 61850 Check Bits`**

- Default Setting: **`Disabled`**

Parameter: **`Select Grp Mode`**

- Default Setting: **`Edge Triggered`**

  This setting is applicable when an assigned binary input is used to select a settings group. See **`Input Config > Input Matrix > Select Group n`**.

  When operated the active settings group can be set to 1 (Gn1), 2 (Gn2), 3 (Gn3) or 4 (Gn4). The select group mode is defined as follows:

  Level triggered: the selected settings group is operational only whilst the input is energized.

  Edge triggered: the selected settings group is enabled by the leading edge of the binary input operating pulse and remains latched in regardless of the status of the binary input.

NOTE

Only 1 group should be energized at any time. If a second group is selected simultaneously the second selection is ignored, even if the first subsequently resets. When a level triggered selection is reset, the relay will return to the previously active group.

Parameter: **`Operating Mode`**

- Default Setting: **`Local or Remote`**

Table 3-3 Operation Mode

Operation	Remote	Local	Out of Service	Test
Control				
Rear RS485 port (set as **`Remote`**)	Enabled	Disabled	Disabled	Disabled
Rear RS485 port (set as **`Local`**)	Disabled	Enabled	Disabled	Disabled
Rear ethernet ports (set as **`Remote`**)	Enabled	Disabled	Disabled	Disabled
Rear ethernet ports (set as **`Local`**)	Disabled	Enabled	Disabled	Disabled
Fascia (Control mode)	Disabled	Enabled	Disabled	Disabled
Front USB port (set as **`Remote`**)	Enabled	Disabled	Disabled	Disabled
Front USB port (set as **`Local`**)	Disabled	Enabled	Disabled	Disabled
Control and test reset– Fascia	Enabled	Disabled	Disabled	Disabled
Binary inputs (set as **`Enabled in Remote`**)	Enabled	Disabled	Disabled	Disabled
Binary inputs (set as **`Enabled in Local`**)	Disabled	Enabled	Disabled	Disabled
Binary inputs (set as **`Enabled in Out of Service`**)	Disabled	Disabled	Enabled	Disabled
Binary inputs (set as **`Enabled in Test Mode`**	Disabled	Disabled	Disabled	Enabled
Binary outputs	Disabled	Enabled	Disabled	Enabled
Mimic Screen Controls	Disabled	Enabled	Disabled	Disabled
Reporting				
Spontaneous				
IEC 60870-5-103	Enabled	Enabled	Disabled	Disabled
DNP3	Enabled	Enabled	Disabled	Disabled
General Interrogation				
IEC 60870-5-103	Enabled	Enabled	Disabled	Disabled
DNP3	Enabled	Enabled	Enabled	Enabled
MODBUS	Enabled	Enabled	Enabled	Enabled
Changing of settings				
Rear RS485 port (set as **`Remote`**)	Enabled	Disabled	Enabled	Disabled
Rear RS485 port (set as **`Local`**)	Disabled	Enabled	Enabled	Disabled
Rear ethernet ports (set as **`Remote`**)	Enabled	Disabled	Enabled	Disabled
Rear ethernet ports (set as **`Local`**)	Disabled	Enabled	Enabled	Disabled
Fascia	Enabled	Enabled	Enabled	Enabled
Front USB port (set as **`Remote`**)	Enabled	Disabled	Enabled	Disabled
Front USB port (set as **`Local`**)	Disabled	Enabled	Enabled	Disabled

Operation	Remote	Local	Out of Service	Test
Historical information				
Waveform records	Enabled	Enabled	Enabled	Enabled
Event records	Enabled	Enabled	Enabled	Enabled
Fault records	Enabled	Enabled	Enabled	Enabled
Setting information	Enabled	Enabled	Enabled	Enabled

Parameter: **Disk Activity Symbol**

- Default Setting: **Disabled**

  New Events, **Waveform Records** or **Fault Records** are held in volatile RAM. To increase the data storage capacity data is archived to non-volatile memory. Archiving is a secondary task so data transfer is initiated during quiescent operating periods of the device.

  Archiving may take several minutes, if power to the device is lost during this time some data will also be lost.

  The device can provide a visual indication at the top-right position of the LCD that data storage is taking place. A disc symbol is displayed showing that the copying of **Events**, **Waveform Records** or **Fault Records**, to non volatile disk storage is taking place. This symbol is displayed when this setting is enabled. Binary outputs can also be energized during periods of device or waveform archiving.

  The inverted A symbol at the top-right position of the LCD indicates that new **Events**, **Waveform Records** or **Fault Records** are currently being held in volatile RAM and have not yet been archived.

Parameter: **Unexpected Restart Blocking**

- Default Setting: **Disabled**

Parameter: **Unexpected Restart Count**

- Default Setting: **3**

Parameter: **Unexpected Restart Period**

- Default Setting: **1 hour**

  Restarting of the device is blocked if the number of unexpected starts exceeds the **Unexpected Restart Count** within the **Unexpected Restart Period**.

  Unexpected starts are initiated by the relay watchdog.

  The device will display an error message and enter **locked-up** mode. When locked-up, operation of all LED's and binary outputs, including **Device Healthy**, all pushbuttons and any data communications is disabled. Once the relay has switched to the **locked-up** mode, it is non-recoverable at site and must be returned for repair.

Parameter: **Device Restart Count Type**

- Default Setting: **Power On, Expected, Unexpected**

  Power On = Device is switched on by applying the auxiliary supply voltage.

  Expected = User initiated start e.g. after a change to the device congiguration.

  Unexpected = Caused by device failure detection such as watchdog

Parameter: **Device Restart Count Target**

- Default Setting: **100**
  The selected start types are monitored.
  Any combination of start type can be selected to increment the start count. The start types selected (ticked) will be added to the overall start-up count.
  When the **Count Target** is reached an output is raised, this output is available in the **Binary Output > Output Matrix**.

Parameter: **Trip Alert**

- Default Setting: **Enabled**
  When set to **Enabled** the fascia automatically displays the **Fault Records** screen after a binary output configured as a trip contact operates (see **Binary Outputs > Trip Config > Trip Contacts**).
  When set to **Disabled** the **Fault Records** screen is not automatically displayed on the LCD after operation of a trip contact. This setting is typically used during testing and commissioning to facilitate repetitive testing i.e. there is no requirement to repeatedly reset the LCD screen.

Parameter: **General Alarm Alert**

- Default Setting: **Enabled**
  When set to **Enabled** the fascia automatically displays the **General Alarm** screen after a binary output configured as a **General Alarm** operates (see **Binary Inputs > General Alarms**).
  When set to **Disabled** the **General Alarm** screen is not automatically displayed on the LCD after operation of a **General Alarm** binary input. This setting is typically used during testing and commissioning to facilitate repetitive testing i.e. there is no requirement to repeatedly reset the LCD screen.

Parameter: **IEC 61850 Configured Alert**

- Default Setting: **Disabled**
  This function provides indication that the IEC 61850 configuration has not been parameterized, it can be used to operate a binary output.

Parameter: **Relay Identifier**

- Default Setting: **7SR5**
  User defined text can be used to confirm the identify of the device e.g. when accessed remotely.
  This user defined text is displayed on the top 2 lines of the LCD display home screen.
  The **Relay Identifier** is used in communication with Reydisp to identify the relay.

Parameter: **Circuit Identifier**

- Default Setting: **<None>**
  User defined text can be used to identify the circuit monitored by the 7SR5 device.

Parameter: **Setting Confirmation ID**

- Default Setting: **Not Active**
  A user identifier code is required for settings changes at the device fascia. The **Setting ID** is set in Reydisp Manager (**Configuration > Device > Settings Confirmation ID > Set**).
  Settings changes can only be made at the device fascia after the **Setting ID** code is entered.
  The **Setting ID** will timeout 60 minutes after the last key press, or if the **Control ID** is entered.

Parameter: **Control Confirmation ID**

- Default Setting: **Not Active**
  A user identifier code is required to carry out control operations from the device fascia. The **Control ID** is set in Reydisp Manager (**Configuration > Device > Control Confirmation ID > Set**).
  Control actions can only be made at the device fascia after the **Control ID** code is entered.
  The **Control ID** will timeout 60 minutes after the last key press, or if the **Setting ID** is entered.

Parameter: **Security Log Confirmation ID**

- Default Setting: **Not Active**
  A user identifier code is required for settings changes at the device security log. The **Security Log Confirmation ID** is set in Reydisp Manager (**Configuration > Device > Security Log Confirmation ID > Set**).
  The security log can only be viewed at the device fascia after the **Security Log Confirmation ID** has been entered.

Parameter: **Reset Password**

- Default Setting: **No**
  This function is accessible at the device fascia only. The reset is applied to the connection password and the maintenance password. Completion of the reset requires the **Reset Confirmation ID**, **0000** to be entered.
  The maintenance and connection passwords can be set and modified only through the EN100 Web UI.
  The SNMPv3 password is set in the SNMP browser tool.
  The passwords can be reset from the fascia using the **Reset Password** feature.
  The following table shows the passwords used in device for security functions.

Password	Description
Maintenance	Password for: • EN100 firmware upgrade via Ethernet or USB • Firmware upgrade via Ethernet or USB • Resetting of the connection password • Security log access from web UI
Connection	Password for EN100 connection with Reydisp via Ethernet or USB
SNMP description	Default Auth Password: 12345678 Default Privacy Password: 12345678 The passwords can be changed in the SNMP browser tool in the **USM Users**.

The password must contain 8 to 24 ASCII-characters and must include at least:

- 1 capital letter (A-Z)
- 1 small letter (a-z)
- 1 digit (0-9)
- 1 special character from the set !"#$%&'()*+,-/:;<=>?@[\]^_{|}~

NOTE

The IP address 192.168.2.1 / home is used to access the EN100 web UI homepage. From the security menu of the homepage the user can set the maintenance password, set the connection password, and reset the connection password.

All passwords have no default value at device delivery and are recommended to be set by the user during commissioning.

The passwords protect against unauthenticated access.

Reset passwords for the device fascia have an Access ID of 0000.

Siemens recommends all passwords and User ID are configured.

NOTE

For further information on Real Time Clock see *2.3 Real Time Clock*.

3.2.5 Settings Menu

Configuration > Device Config		
Parameter	**Range**	**Default Setting**
Language setting	English, English US, Turkish, Spanish, Portuguese, German, French	English
System frequency	50 Hz/60 Hz	50 Hz
Active group	1, 2, 3, 4	1
View/edit group	1, 2, 3, 4	1
Setting dependencies	Enabled Disabled	Disabled
Favorite meters timer	Off, 1, 2, 5, 10, 15, 30, 60 min	60 min
Backlight timer	Off, 1, 2, 5, 10, 15, 30, 60 min	5 min
Date	DD/MM/YYYY	
Time	HH:MM:SS	
Master time source	None, ethernet, binary input seconds, binary input minutes, serial (COM1)	
Master time sync lost delay	1 to 90 min, Δ 1 min	60 min
Backup time source	None, ethernet, binary input seconds, binary input minutes, serial (COM1)	None
Backup time sync lost delay	1 to 90 min, Δ 1 min	60 min
Settings display	$\cdot I_{rated}$, primary, secondary	$\cdot I_{rated}$
CT 8 settings display	$\cdot I_{rated}$, primary, secondary	$\cdot I_{rated}$
Export power/Lag VAr	+ve/+ve, +ve/-ve, -ve/+ve, -ve/-ve	+ve/+ve
IEC 61850 Check Bits	Enabled Disabled	Disabled
Select group mode	Edge triggered, level triggered	Edge triggered
Operating mode	Out of service, local, remote, local or remote, test	Local or remote
Disk activity symbol	Enabled Disabled	Disabled

Configuration > Device Config		
Parameter	**Range**	**Default Setting**
Unexpected Restart blocking	Enabled Disabled	Disabled
Unexpected restart count	1 to 20	3
Unexpected restart period	1 hr to 100 hr	1 hr
Device restart count type	(111) Power on, expected, unexpected	111
Device restart count target	0 to 100000	100
Trip alert	Enabled Disabled	Enabled
General alarm alert	Enabled Disabled	Enabled
IEC 61850 Configured Alert	Enabled Disabled	Enabled
Relay identifier	<16 characters maximum>	7SR5
Circuit identifier	<16 characters maximum>	<None>
Setting Confirmation ID	<4 characters>	Not active
Control Confirmation ID	<4 characters>	Not active
Security Log Confirmation ID	<4 characters>	Not active
Reset passwords		No

3.2.6 IEC 61850 Functional Information Mapping

Every logical node has the below status behaviour based on the device operating mode. When the device is in either Test mode or Out of service mode the Test bit is set in the quality string.

***.Beh**

Information										
Local or Remote mode	0	0	0	0	0	0	1	0	0	1
Local mode	0	0	0	0	0	1	0	0	1	0
Remote mode	0	0	0	0	1	0	0	1	0	0
Out of Service mode	0	1	1	0	0	0	0	0	0	0
Test Mode	1	0	0	1	0	0	0	0	0	0
Any Inhibit	0	0	1	1	0	0	0	1	1	1
***.Beh.stVal**	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	OK: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

Protection LLN0 (PROT/LLN0)

LLN0.Mod

Information			
Device Ready	0	1	1
Out Of Service Mode	x	1	0
LLN0.Mod.stVal	**5**	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

LLN0.Health

Information		
Device Healthy	0	1
LLN0.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

LLN0.SGCB

Information	
Active SettingGroup	Group 1 to 4
LLN0.SGCB.ActSG	**Value**

Device (LPHD1)

LPHD1.Proxy

Information		
Reset Device	0	1
PTOC*.Health.stVal	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value DEVICE is not a PROXY: 0
DEVICE is a PROXY: 1

LPHD1.Health

Information		
Device Healthy	0	1
PTOC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

3.2.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Remote Mode			Output Control	Y	Y	Y
Local Mode			Output Control	Y	Y	Y
Out of Service Mode			Output Control	Y	Y	Y
Local & Remote			Output Control	Y	Y	Y
Setting Changed			Output	Y	Y	Y
Setting Group 1 Selected			Output Control	Y	Y	Y
Setting Group 2 Selected			Output Control	Y	Y	Y
Setting Group 3 Selected			Output Control	Y	Y	Y
Setting Group 4 Selected			Output Control	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

3.3 CT and VT Inputs

3.3.1 Overview of Functions

All device CT and VT inputs are configured in the **Configuration > CT/VT** menu.

The devices have a minimum of 4 current inputs arranged as 3 phase inputs CT 1, CT 2, CT 3, plus a single ground input CT 4. Where the device functionality requires further current inputs the hardware can provide these in groups of 4 i.e. as an addition 3 phase inputs CT 5, CT 6, CT 7, and an additional single ground input CT 8.

In the case of the 5 CT input device which utilises 3 phase inputs plus 2 ground inputs, the hardware inputs CT 5, CT 6, and CT7, are not supported by any software functionality such as current measurement, for metering or protection.

Where the device has voltage inputs then 4 VT inputs are provided.

Inputs from the primary system current and voltage transformers are converted to levels used by the protection and automation functions of the relay. The CT and VT input configuration settings ensure that the primary instrument and meter values are correctly displayed and logged.

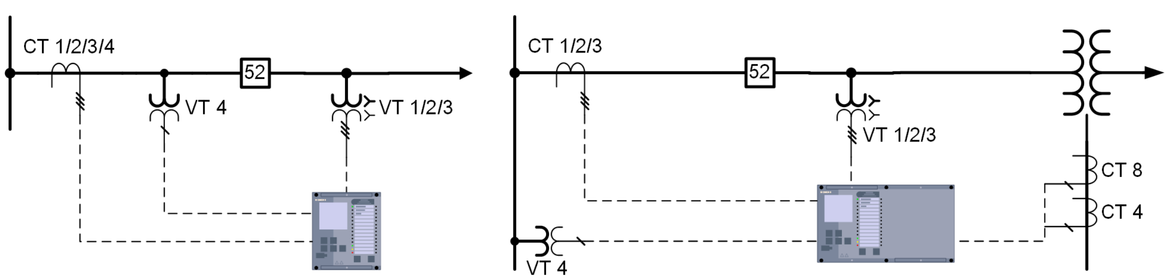
3.3.2 Structure of the Function

Analogue inputs for the CTs and VTs are supplied in groups of 4 CTs and 4 VTs inputs.

The first 3 numbered CT and VT inputs are grouped together and have the same group of configuration parameters e.g. CT 1/2/3 and VT 1/2/3. The fourth input has separate configuration parameters e.g. CT 4 and VT 4.

The optional fifth CT input, CT 8, also has separate configuration parameters.

Typical connections are shown in *Figure 3-4*.



[dw_7SR5_7SR51CTVTInputConnections, 2, en_US]

Figure 3-4 Typical CT and VT Input Connections For Standard Overcurrent Application

3.3.3 Application and Setting Notes

Parameter: **CT1/2/3 Nominal**

- Default setting: **2000**

  This setting is used to select the device CT input measuring range for the 3 line CT inputs. The setting value is used by the device instrumentation e.g. to display · I_{rated} values (nominal values).

Parameter: **CT1/2/3 Ratio Prim**

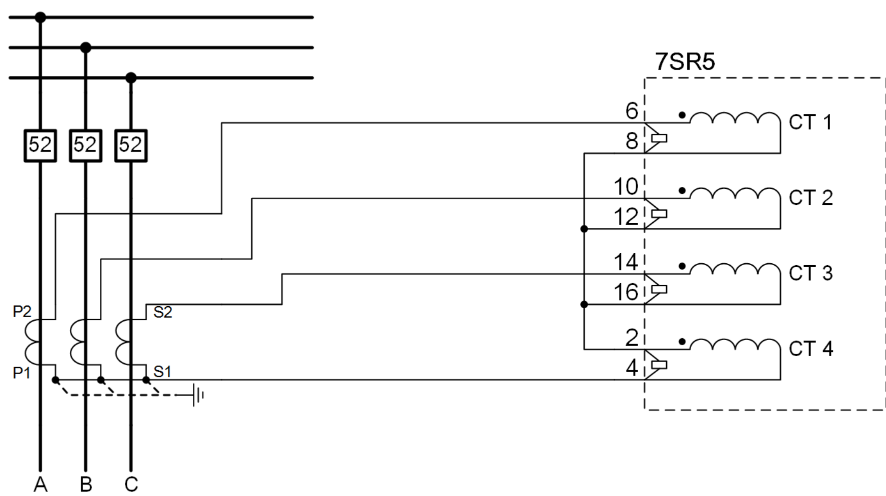
- Default setting: **1A**

  The setting value is used (in conjunction with **CT1/2/3 Ratio Sec** setting) by the device instrumentation e.g. to display primary current values.

Parameter: **`CT1/2/3 Ratio Sec`**

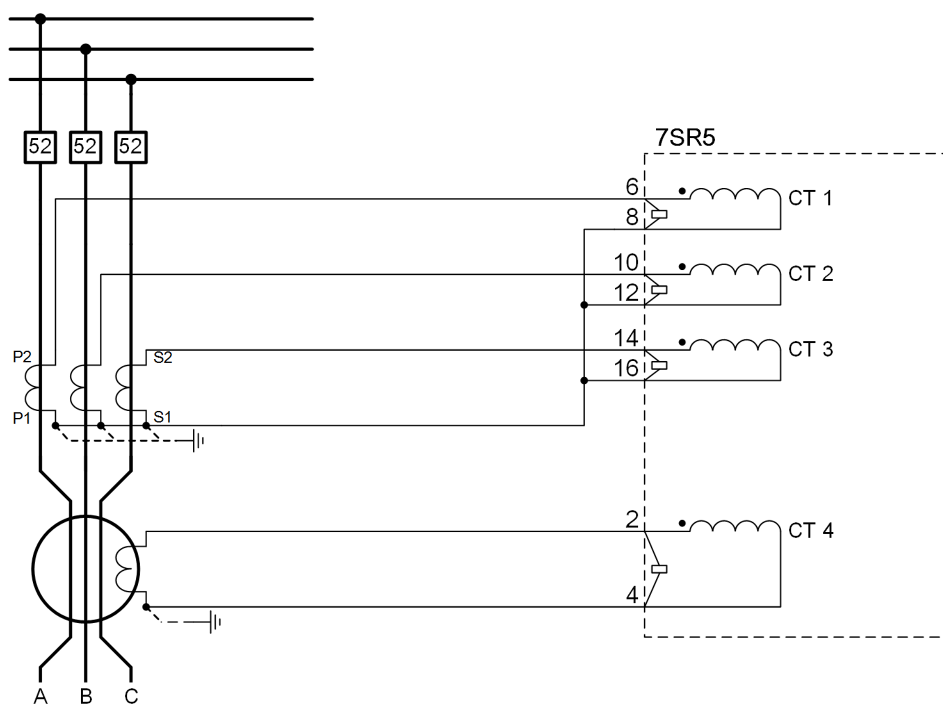
- Default setting: **`1`**

  The setting value is used (in conjunction with **`CT1/2/3 Ratio Prim`** setting) by the device instrumentation e.g. to display primary current values.



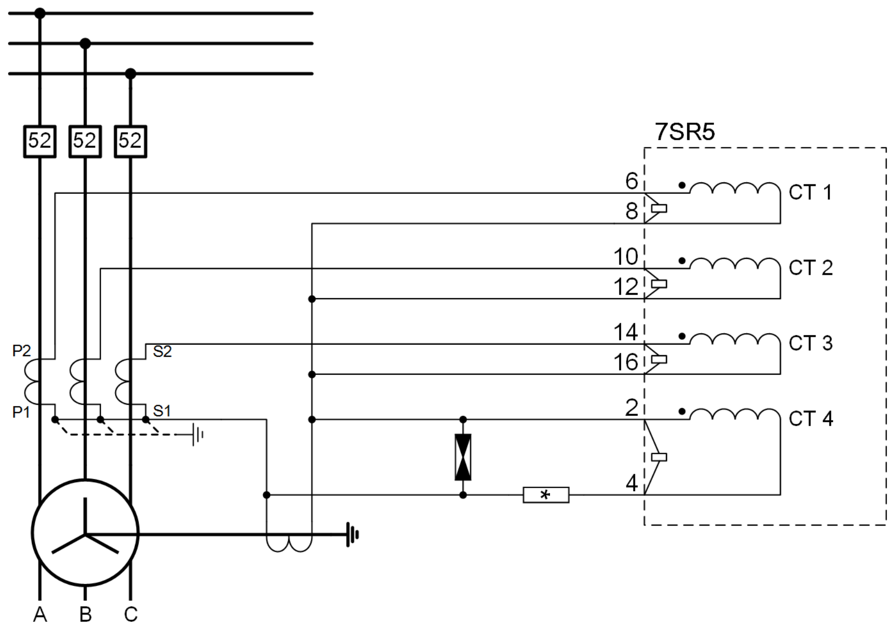
[dw_7SR5_ct-connection_diagram_01, 1, en_US]

Figure 3-5 3 Phase Overcurrent and Earth Fault using 3-Phase Line CTs (Holmgreen Connection)



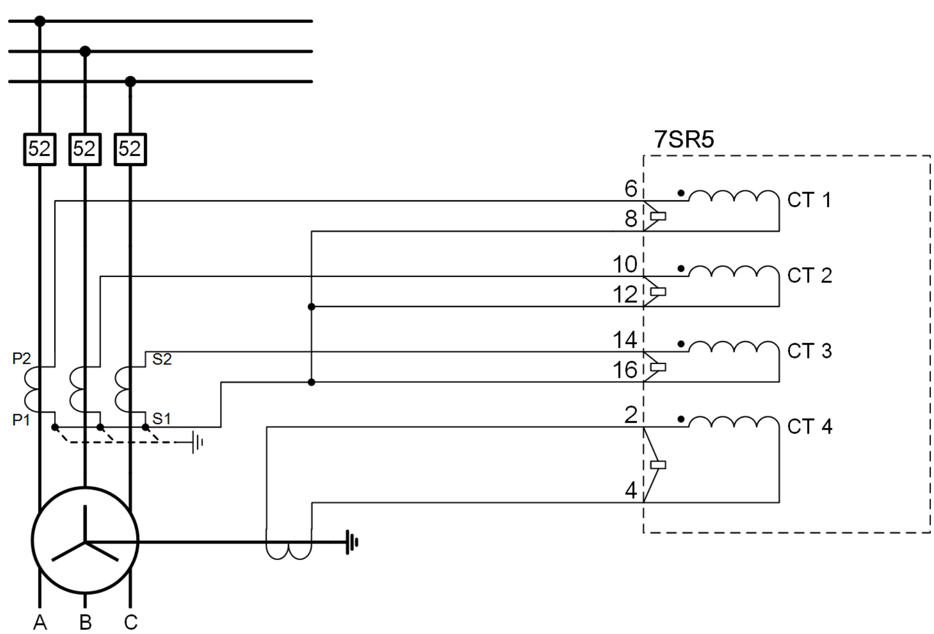
[dw_7SR5_ct-connection_diagram_02, 2, en_US]

Figure 3-6 3 Phase Overcurrent and Earth Fault Measured from Separate CT



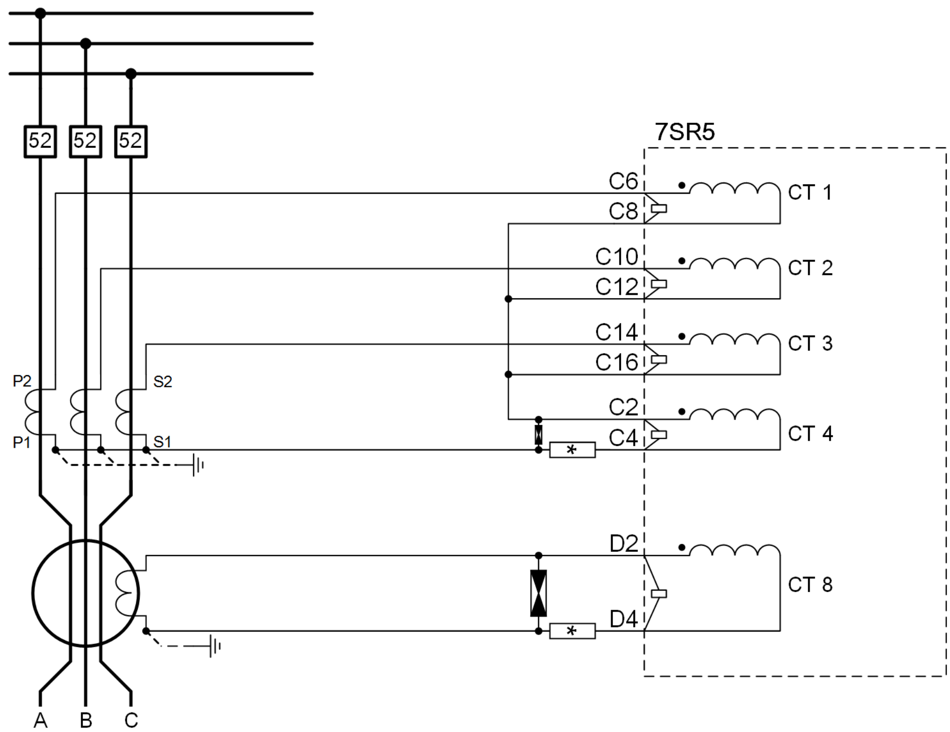
[dw_7SR5_ct-connection_diagram_03, 1, en_US]

Figure 3-7 3 Phase Overcurrent and High Impedance Restricted Earth Fault Protection



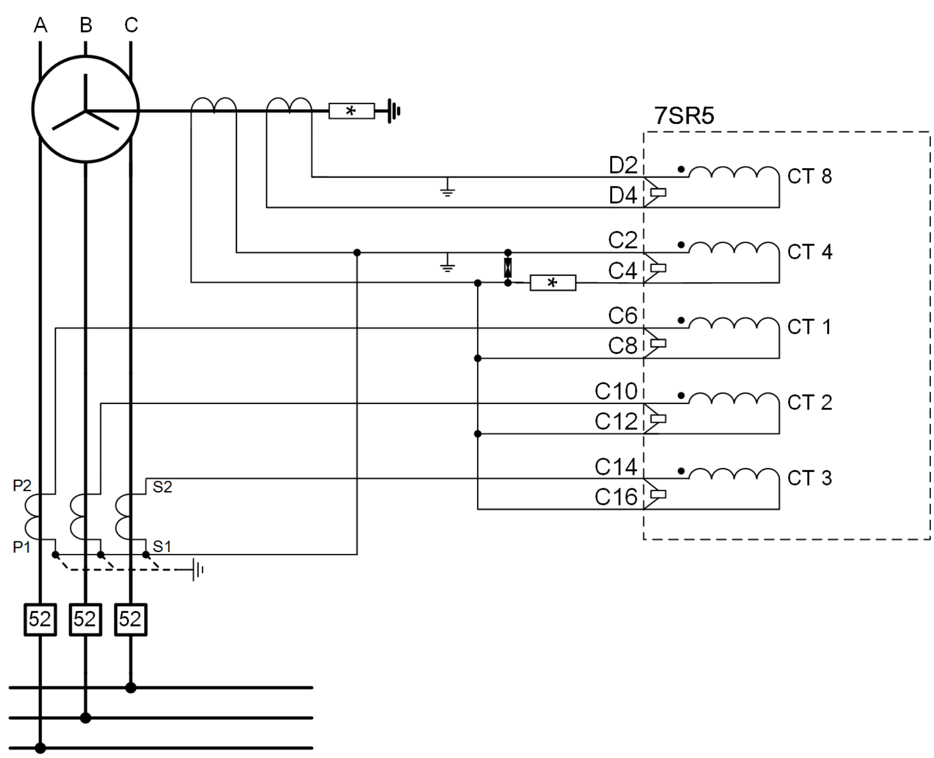
[dw_7SR5_ct-connectiondiagram_04, 2, en_US]

Figure 3-8 3 Phase Overcurrent and Low Impedance Restricted Earth Fault Protection



[dw_7SR5_ct-connectiondiagram_05, 1, en_US]

Figure 3-9 3 Phase Overcurrent, Measured Earth Fault and High Impedance Restricted Earth Fault Protection



[dw_7SR5_ct-connectiondiagram_06, 1, en_US]

Figure 3-10 3 Phase Overcurrent, Measured Earth Fault and High Impedance Restricted Earth Fault Protection and Long Time Inverse Standby Fault

Parameter: **CT4 Nominal**

- Default setting: **2000**
  This setting is used to select the device CT input measuring range for CT4 inputs. The setting value is used by the device instrumentation e.g. to display · I_{rated} values.

Parameter: **CT4 Ratio Prim**

- Default setting: **1A**
  The setting value is used (in conjunction with **CT4 Ratio Sec** setting) by the device instrumentation e.g. to display primary current values.

Parameter: **CT4 Ratio Sec**

- Default setting: **1**
  The setting value is used (in conjunction with **CT4 Ratio Prim** setting) by the device instrumentation e.g. to display primary current values.

Parameter: **CT8 Nominal**

- Default setting: **2000**
  This setting is used to select the device CT input measuring range for CT8 inputs. The setting value is used by the device instrumentation e.g. to display · I_{rated} values.

Parameter: **CT8 Ratio Prim**

- Default setting: **1A**
  The setting value is used (in conjunction with **CT8 Ratio Sec** setting) by the device instrumentation e.g. to display primary current values.

Parameter: **CT8 Ratio Sec**

- Default setting: **1**
  The setting value is used (in conjunction with **CT8 Ratio Prim** setting) by the device instrumentation e.g. to display primary current values.

Parameter: **VT1/2/3 Ratio Prim**

- Default setting: **132000 V**
  The setting value is used (in conjunction with **VT1/2/3 Ratio Sec** setting) by the device instrumentation e.g. to display primary voltage values.

Parameter: **VT1/2/3 Ratio Sec**

- Default setting: **110 V**
  The setting value is used (in conjunction with **VT1/2/3 Ratio Prim** setting) by the device instrumentation e.g. to display primary voltage values.

Parameter: **`VT1/2/3 Nominal`**

- Default setting: **`63.5 V`**
  This is set to the rated voltage applied to the VT input. The setting will be dependent on the **`VT Config`** setting e.g. phase-phase or phase-neutral Volts may be connected to the VT inputs.

Parameter: **`VT1/2/3 Trim Magnitude`**

- Default setting: **`0 V`**
  The setting value is used (in conjunction with **`VT1/2/3 Ratio Prim`** setting) by the device instrumentation e.g. to display primary voltage values.

Parameter: **`VT1/2/3 Trim Angle`**

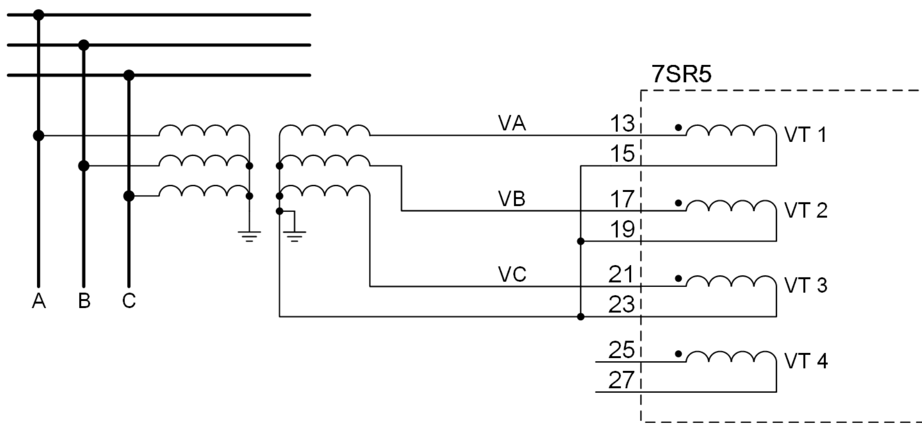
- Default setting: **`0°`**
  The setting value is used (in conjunction with **`VT1/2/3 Ratio Prim`** setting) by the device instrumentation e.g. to display primary voltage values.

Parameter: **`VT1/2/3 Config`**

- Default setting: **`Van, Vbn, Vcn`**

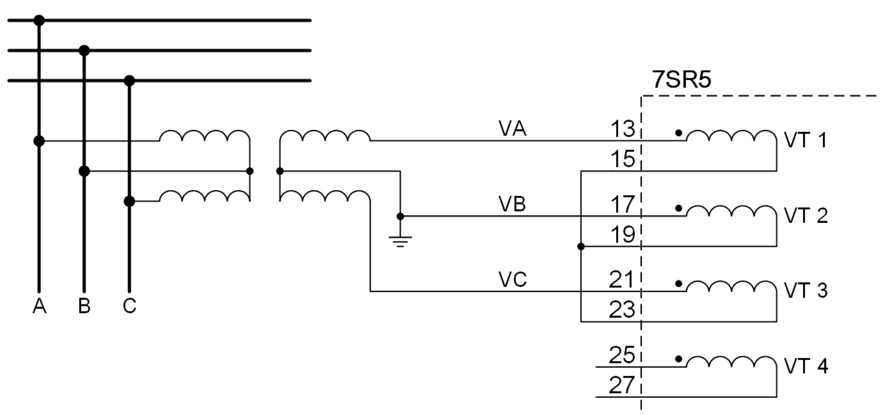
  This setting provides the device with the correct voltage inputs i.e. provides inputs configuration appropriate to the switchgear VT connections. The VT connections and required settings are illustrated in *Figure 3-11*, *Figure 3-12*, and *Figure 3-13*.

  Note that the switchgear VT connection may affect the functionality that can be used in the device on the system e.g. The VT1/2/3 configuration Va, Vb, Vc in *Figure 3-11*, *Figure 3-12*, and *Figure 3-13* does not allow zero sequence voltage V_0 to be measured and so functions requiring this quantity cannot be used when this VT configuration is selected.



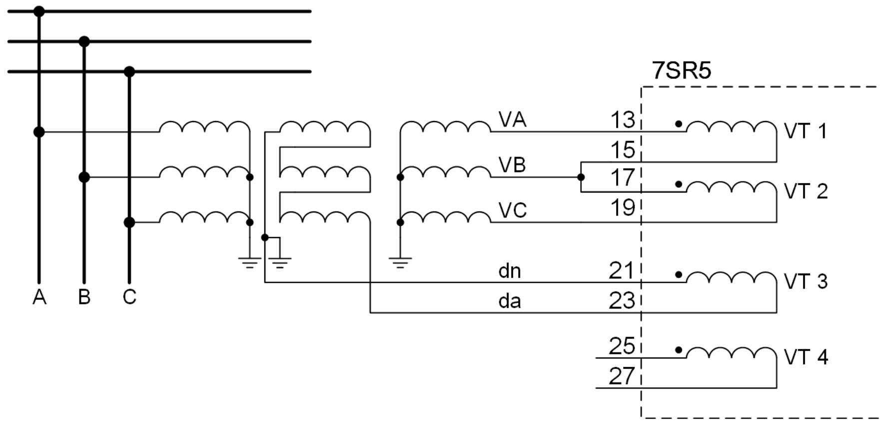
[dw_7SR5_vt-connection_diagram_01, 2, en_US]

Figure 3-11 Configuration CTs/VTs > VT 1/2/3 Config = Van, Vbn, Vcn



[dw_7SR5_vt-connection_diagram_02, 1, en_US]

Figure 3-12 Configuration CTs/VTs > VT 1/2/3 Config = Va, Vb, Vc



[dw_7SR5_vt-connection_diagram_03, 1, en_US]

Figure 3-13 Configuration CTs/VTs > VT 1/2/3 Config = Vab, Vbc, 3V0

Parameter: **`VT4 Nominal`**

- Default setting: **`63.5 V`**

  This is set to the rated voltage applied to the VT input. The setting will be dependent on the **`VT Config`** setting e.g. phase-phase or phase-neutral Volts may be connected to the VT inputs.

Parameter: **`VT4 Ratio Prim`**

- Default setting: **`132000 V`**

  The setting value is used (in conjunction with **`VT1/2/3 Ratio Sec`** setting) by the device instrumentation e.g. to display primary voltage values.

Parameter: **`VT4 Ratio Sec`**

- Default setting: **`110 V`**

  The setting value is used (in conjunction with **`VT1/2/3 Ratio Prim`** setting) by the device instrumentation e.g. to display primary voltage values.

Parameter: **`VT4 Trim Magnitude`**

- Default setting: **`0 V`**

  The setting value is used (in conjunction with **`VT1/2/3 Ratio Prim`** setting) by the device instrumentation e.g. to display primary voltage values.

Parameter: **`VT4 Trim Angle`**

- Default setting: **`0°`**

  The setting value is used (in conjunction with **`VT1/2/3 Ratio Prim`** setting) by the device instrumentation e.g. to display primary voltage values.

Parameter: **`Phase Rotation`**

- Default setting: **`ABC`**

  This setting can be used when the device is used with primary systems having reverse phase rotation. This allows the device functionality to operate correctly on these systems.

3.3.4 Settings Menu

Configuration > System Config		
Parameter	**Range**	**Default Setting**
CT1/2/3 Nominal	1 A/5 A	1 A
CT1/2/3 Ratio Prim	000000 to 999999	2000 A
CT1/2/3 Ratio Sec	0.2 to 7	1
CT4 Nominal	1 A/5 A	1 A
CT4 Ratio Prim	000000 to 999999	2000 A
CT4 Ratio Sec	0.2 to 7	1
CT8 Nominal	1 A/5 A	1 A
CT8 Ratio Prim	000000 to 999999	2000 A
CT8 Ratio Sec	0.2 to 7	1
VT1/2/3 Config	Va, Vb, Vc/Van, Vbn, Vcn/Vab, Vbc, 3V0	Van, Vbn, Vcn
VT1/2/3 Nominal	40 V to 160 V	63.5 V
VT1/2/3 Ratio Prim	000000 to 999999	132000 V
VT1/2/3 Ratio Sec	40 V to 160 V	110 V
VT1/2/3 Trim Magnitude	0 V to 20 V	0 V
VT1/2/3 Trim Angle	-45° to +45°	0°
VT4 Nominal	40 V to 160 V	63.5 V
VT4 Ratio Prim	000000 to 999999	132000 V
VT4 Ratio Sec	40 V to 160 V	110 V
VT4 Trim Magnitude	0 V to 20 V	0 V
VT4 Trim Angle	-45° to +45°	0°
Phase Rotation	ABC, ACB	ABC

3.4 Binary Inputs

3.4.1 Overview of Functions

7SR5 devices include a number of binary input functions:

- Binary inputs (number dependent on hardware configuration)
- Virtual inputs/outputs
- Function key binary inputs
- 20 General alarms

Binary inputs operate when the applied voltage exceeds the selected **Operate Voltage** setting. This setting applies to all binary inputs.

Binary inputs can be configured for inverted operation i.e. the input is energized when no supply is applied.

Virtual inputs/outputs are internal logic states.

Function keys (**I** and **O** pushbuttons) are located on the device fascia.

Functionality of each binary input is configured in the **Configuration > Binary Inputs** menu.

3.4.2 Structure of the Function

The operating parameters for each voltage operated binary input are defined in the **Binary Inputs > Binary Input Config** menu.

The operating voltage for all binary inputs is selected.

Each binary input can be individually configured to inverted operation and have operating pick up and drop off delays.

The function of each binary input or virtual input/output (when operated) is set in the **Binary Inputs > Input Matrix** menu. The input matrix defines the internal logic signals that are created by energization of selected binary inputs.

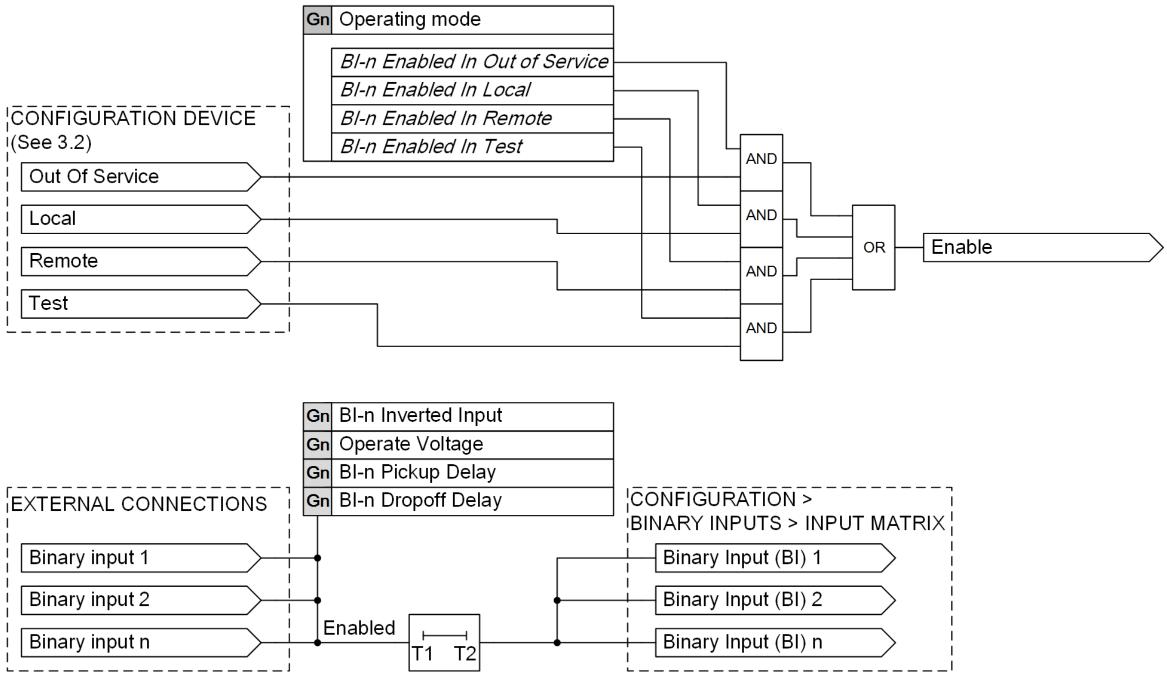
The operating parameters for each function key are defined in the **Binary Inputs > Function Key Config** menu.

The **General Alarms** menu allows the user to define the information displayed when a binary input is set as a **General Alarm**.

Binary inputs correspond to the logical node **CTRL BiGGIO** in IEC 61850.

Virtual inputs/outputs correspond to the logical node **CTRL VGGIO** in IEC 61850.

3.4.3 Logic of the Function



[lo_7SR5_BinaryInputConfiguration, 2, en_US]

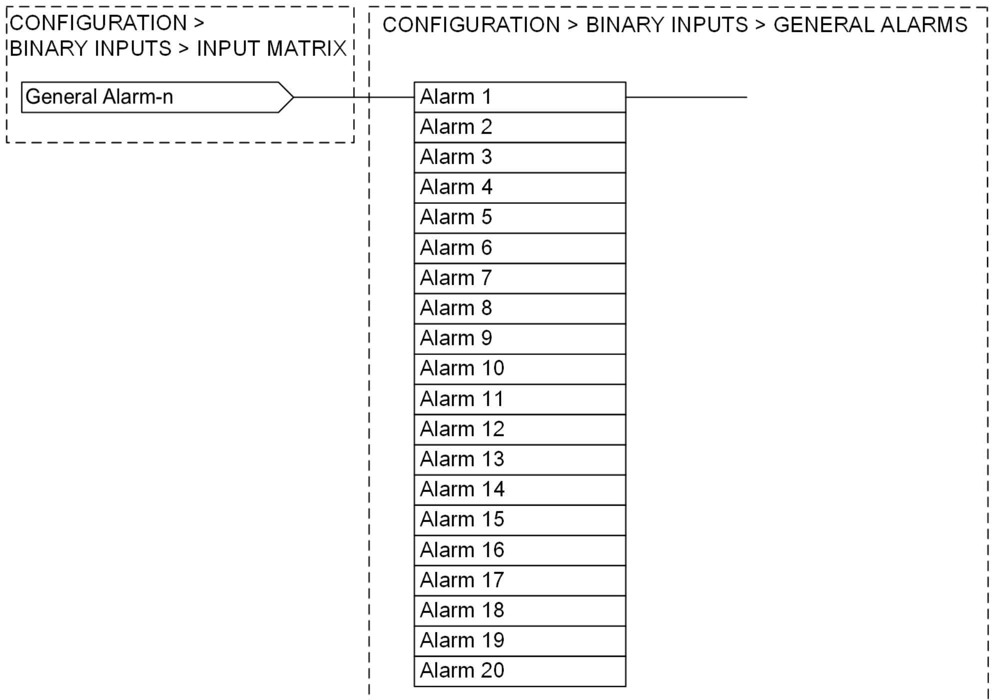
Figure 3-14 Logic Diagram:Voltage Operated Binary Input Configuration

Table 3-4 Binary Input Matrix

Setting Name
Reset Energy Meters
Inhibit 60VTS
Ext Trig 60VTS
Ext Reset 60VTS
Inhibit 60VTF-Bus
Reset 25 Sync
Ext Start 25 Sync
Start 25 System Sync
Inhibit 27-n
Inhibit 27Vx-n
Inhibit 32-n
Inhibit 37-n
Inhibit 37G-n
Inhibit 46DT-n
Inhibit 46IT-n
Inhibit 46BC-n
Inhibit 47-n
Inhibit 49-n
Reset 49-n
Reset Max Temp
Inhibit 81HB2
Inhibit 50-n

Setting Name
Inhibit 50HS-n
Inhibit 50G-n
Inhibit 50GHS-n
Inhibt Wattmetric
Inhibit 50GS-n
Inhibit 50N-n
Remote 50AFD
Reset AFD Counters
AFD Zone n Flash
AFD Zone n Ext Fail
50SOTF
Inhibit 50SOTF-n
Inhibit 50GSOTF-n
Reset 50GI-n
Inhibit 50GI-n
Inhibit 51CL
Inhibit 51-n
Inhibit 51G-n
Inhibit 51GS-n
Inhibit 51N-n
CB Closed
CB Open
Close CB
Block Close CB
Open CB
Block Open CB
Reset Freq Ops Count
Reset CB Count To 79 LO
Man Override Sync
79 Override Sync
Reset CB Total Trip
Reset CB Delta Trip
Reset CB Trip Time
Inhibit 50BF
50BF CB Faulty
50BF Mech Trip
50BF Ext Trip
Reset CB I^2t Wear
Trigger CB I^2t Wear
Inhibit 55-n
Inhibit 59-n
Inhibit 59Vx-n
Inhibit 59NDT-n
Inhibit 59NIT-n
Inhibit 60CTS-I
Inhibit 60CTS
74CCS-n

Setting Name
74TCS-n
Inhibit 78VS-n
79 Out
79 In
79 Trip & Reclose
79 Trip & Lockout
Lockout
79 Ext Trip
79 Ext Pickup
79 Block Reclose
Reset Lockout
79 SOTF
Inst Protection In
Inst Protection Out
Hot Line In
Hot Line Out
Inhibit 81-n
Inhibit 81R-n
Inhibit 87GH-n
Inhibit 87NL-n
Trig Trip Contacts
Inhibit Trip Contacts
Block Reset Trip Contacts
Trigger Fault Rec
Trigger Wave Rec
Select Group n
Clock Sync.
Reset LEDs & O/Ps
EF Out
EF In
GS Out
GS In
Set Out Of Service Mode
Set Local Mode
Set Remote Mode
Set Local Or Remote Mode
Set Test Mode
Reset Device Restart Count
General Alarm n
Reset Hrs In Service
Reset Demand
Inhibit Fault Loc



[lo_7SR5_BinaryInputGeneralAlarms, 2, en_US]

Figure 3-15 Logic Diagram: Binary General Alarms

3.4.4 Application and Setting Notes

Parameter: **Binary Inputs > Binary Input Config > Inverted Inputs**

- Default Setting: **<None>**

  When assigned as **inverted** the selected binary input picks up on loss of operate voltage and resets when the operate voltage is applied. Inversion occurs before the pickup and drop-off time delays are applied.

Parameter: **Binary Inputs > Binary Input Config > BI Operate Voltage**

- Default Setting: **Range 1: 24 V/48 V/60 V**

  This setting selects the binary input DC operate voltage. This is applied to all binary inputs. See performance specification/technical data for pickup voltage, drop-off voltage and voltage withstand levels.

Parameter: **Binary Inputs > Binary Input Config > BI Operate Voltage Selection**

- Default Setting: **Common**

  This setting allows the operate voltage to be specified separately for each binary input or all inputs to be set to a common range.

Parameter: **Binary Inputs > Binary Input Config > BI n Pickup Delay**

- Default Setting: **0.02 s**

  Each binary input can be independently set to operate after the operate voltage is applied plus a time delay. The inputs have a default pickup delay setting of 20 ms which provides security against operation in the presence of AC voltage across the input terminals e.g. induced AC voltage on cross site wiring connections. Where the application requires instantaneous operation the pickup delay can be set to 0.

Parameter: **Binary Inputs > Binary Input Config > BI n Drop off Delay**

- Default Setting: **0 s**
  Each binary input can be independently set to reset after the operate voltage is removed plus a time delay.

Parameter: **Binary Inputs > Binary Input Config > Enabled in Local**

- Default Setting: **<All>**
  Operation of the selected binary input is enabled when **Device Config > Operating Mode** is selected to **Local**, (see *3.2 Device Configuration*).

Parameter: **Binary Inputs > Binary Input Config > Enabled in Remote**

- Default Setting: **<All>**
  Operation of the selected binary input is enabled when **Device Config > Operating Mode** is selected to **Remote**, (see *3.2 Device Configuration*).

Parameter: **Binary Inputs > Binary Input Config > Enabled in Out of Service**

- Default Setting: **<All>**
  Operation of the selected binary input is enabled when **Device Config > Operating Mode** is selected to **Out of Service**, (see *3.2 Device Configuration*).

Parameter: **Inhibit <Function>**

- Default Setting: **<None>**
  When operated the binary input initiates the reset sequence of the relevant function element(s).

Parameter: **Ext Trig 60VTS**

- Default Setting: **<None>**
  Used to initiate the VT supervision function (60VTS) time delay element from a MCB connected in the VT secondary circuit, (see *6 Supervision Functions* , section 60VTS VT Supervision).

Parameter: **Ext Reset 60VTS**

- Default Setting:
  Used to reset the VT supervision function (60VTS) when a VT failure condition no longer exists, (see *6 Supervision Functions* , section 60VTS VT Supervision).

Parameter: **50BF-n CB Faulty**

- Default Setting: **<None>**
  This input is connected to the CB monitoring circuits. If this input is operated when a trip initiation is received an output will be given immediately (the timers are by passed), (see *6 Supervision Functions* , section 50BF Circuit-Breaker Failure Protection – 3 Pole).

Parameter: **50BF-n Mech Trip**

- Default Setting: **<None>**
  Used to trigger the circuit-breaker fail function. A binary input configured as **CB Closed** must also be energized to confirm CB failure, (see *6 Supervision Functions* , section 50BF Circuit-Breaker Failure Protection – 3 Pole).

Parameter: **50BF-n Ext Trip**

- Default Setting: **<None>**
  Used to trigger the circuit-breaker fail function. The measured current must be above the 50BF setting for the function to operate, (see *6 Supervision Functions* , section 50BF Circuit-Breaker Failure Protection – 3 Pole).

Parameter: **CB-n Open**

- Default Setting: **<None>**
  This input is used to monitor the CB status. It is operated when the associated CB is open e.g. it is connected to a CB auxiliary switch that is closed when the CB is open, (see *7 Control Functions*, section 52 Circuit-Breaker Control).

Parameter: **CB-n Closed**

- Default Setting: **<None>**
  This input is used to monitor the CB status. It is operated when the associated CB is closed e.g. it is connected to a CB auxiliary switch that is closed when the CB is closed, (see *7 Control Functions*, section 52 Circuit-Breaker Control).

Parameter: **Open CB-n**

- Default Setting: **<None>**
  Operation of the binary input is used to initiate a CB open command, (see *7 Control Functions*, section 52 Circuit-Breaker Control).

Parameter: **Close CB**

- Default Setting:
  Operation of the binary input is used to initiate a CB close command, (see *7 Control Functions*, section 52 Circuit-Breaker Control).

Parameter: **Inhibit CB-n Open**

- Default Setting: **<None>**
  This setting is used to block the opening of a CB e.g. due to low stored energy, (see *7 Control Functions*, section 52 Circuit-Breaker Control).

Parameter: **74TCS-n**

- Default Setting: **<None>**
  This setting is used when the binary input is connected in the CB trip circuit monitoring scheme wiring, (see *6 Supervision Functions* , section 74TC Trip-Circuit Supervision).

Parameter: **79 Trip & Reclose**

- Default Setting: **<None>**
  See *7 Control Functions*, section 79 Automatic Reclosing.

Parameter: **79 Trip & Lockout**

- Default Setting: **<None>**
  See *7 Control Functions*, section 79 Automatic Reclosing.

Parameter: **79 Ext Trip**

- Default Setting: **<None>**
  See *7 Control Functions*, section 79 Automatic Reclosing.

Parameter: **79 Ext Pickup**

- Default Setting: **<None>**
  See *7 Control Functions*, section 79 Automatic Reclosing.

Parameter: **79 Lockout**

- Default Setting: **<None>**
  This is used to prevent autoreclosing by cancelling the sequence or preventing starting. This could be used for unrecoverable conditions such as low gas (SF6) pressure etc, (see *7 Control Functions*, section 79 Automatic Reclosing.

Parameter: **79 Reset Lockout**

- Default Setting: **<None>**
  See *7 Control Functions*, section 79 Automatic Reclosing.

Parameter: **79 SOTF**

- Default Setting: **<None>**
  See *7 Control Functions*, section 79 Automatic Reclosing.

Parameter: **79 Block Reclose**

- Default Setting: **<None>**
  This is used to temporarily inhibit the CB close operation until conditions are correct. This is typically used with different circuit-breaker designs for signals such as **spring charging** or **low air pressure** which can be cleared during the sequence allowing the sequence to continue. The **Lockout** input is used for unrecoverable conditions such as low gas (SF6) pressure can be used to cancel an autoreclose sequence or prevent starting, (see *7 Control Functions*, section 79 Automatic Reclosing.

Parameter: **Reset 25 Sync**

- Default Setting: **<None>**
  See *7 Control Functions*, section 25 Synchrocheck – Synchronizing Function.

Parameter: **Ext Start 25 Sync**

- Default Setting: **<None>**
  See *7 Control Functions*, section 25 Synchrocheck – Synchronizing Function.

Parameter: **Start 25 System Sync**

- Default Setting: **<None>**
  See *7 Control Functions*, section 25 Synchrocheck – Synchronizing Function.

Parameter: **79 Override Sync**

- Default Setting: **<None>**
  See *7 Control Functions*, section 25 Synchrocheck – Synchronizing Function.

Parameter: **Man Override Sync**

- Default Setting: **<None>**
  See *7 Control Functions*, section 25 Synchrocheck – Synchronizing Function.

Parameter: **Trigger I^2t CB-n Wear**

- Default Setting: **<None>**
  The I^2t counter can be triggered from this input e.g. for a manually issued trip/open command, (see *7 Control Functions*, section 52 Circuit-Breaker Control).

Parameter: **Reset CB-n Trip Time**

- Default Setting: **<None>**
  This resets the CB trip time instrument i.e. the measured time between the trip being issued and detection of the CB open state, (see *7 Control Functions*, section 52 Circuit-Breaker Control).

Parameter: **General Alarm n**

- Default Setting: **Alarm n (n = 1 to 20)**
  In the **Binary Inputs > General Alarms** menu user defined text can be entered for alarm conditions e.g. **Buchholz Gas**. When a binary input programmed to **General Alarm n** is operated the user text is displayed on the fascia LCD.
  This display can be disabled, (see **Configuration > Device > General Alarm Alert**).

Parameter: **Trig Trip Contacts**

- Default Setting: **<None>**
  This setting is used to operate output relays assigned as **Binary Outputs > Trip Config > Trip Contacts**. This will also initiate operation of the functionality associated with trip contacts, (see *3.5 Binary Outputs*).

Parameter: **Block Reset Trip Contacts**

- Default Setting: **<None>**
  When energized any outputs configured as a **Trip Contact** will remain operated even when the initiating condition is removed, see *6.2 50BF Circuit-Breaker Failure Protection – 3 Pole*).

Parameter: **Trigger Fault Rec**

- Default Setting:
  This setting is used to trigger the fault recorder on demand.

Parameter: **Trigger Wave Rec**

- Default Setting: **<None>**
  This setting is used to trigger the waveform recorder on demand. Typically this is triggered on circuit switch using a binary input operated from a CB auxiliary switching or during periods of maintenance/monitoring testing.

Parameter: **Select Group n (n = 1 to 4)**

- Default Setting: **<None>**
  This setting switches the device settings to the nominated settings group number (Gn). The nominated settings group is active depending on the behavior of the **Select Group Mode** function, (see **Configuration > Device > Select Grp Mode**):
  Level triggered: the selected settings group is operational as long as the input is energized.
  Edge triggered: the selected settings group is enabled by the leading edge of the binary input operating pulse and remains latched in regardless of the status of the binary input.

Parameter: **Clock Sync**

- Default Setting: **<None>**
  The device real time clock is set to the nearest second when the binary input is operated i.e. on pickup.

Parameter: **Reset Start Count**

- Default Setting: **<None>**
  See *3.2 Device Configuration* .

Parameter: **Reset Hrs In Service**

- Default Setting: **<None>**
  See *3.2 Device Configuration* .

Parameter: **AFD Zone n Flash**

- Default Setting: **<None>**
  Binary inputs with this setting are intended for use with external arc sensors, they are operated by the detection of an arc caused by a system short circuit fault, (see *5 Protection and Automation Functions* , section 50AFD Arc Flash Detection).

Parameter: **Binary Inputs > Function Key Config > Function Key 0 Text**

- Default Setting:

Parameter: **Binary Inputs > Function Key Config > Function Key 1 Text**

- Default Setting:

Parameter: **Binary Inputs > Function Key Config > Close CB**

- Default Setting:

Parameter: **Binary Inputs > Function Key Config > Open CB**

- Default Setting:

3.4.5 Settings Menu

Binary Inputs > Input Matrix			
Parameter	**Range**	**Default Setting**	**Setting**
Reset Energy Meters	BI 1 to BI n		
Inhibit 60VTS	V1 to Vn		
Ext Trig 60VTS			
Ext Reset 60VTS			
Inhibit 60VTF-Bus			
Reset 25 Sync			
Ext Start 25 Sync			
Start 25 System Sync			
Inhibit 27-n			
Inhibit 27Vx-n			
Inhibit 32-n			
Inhibit 37-n			
Inhibit 37G-n			
Inhibit 46DT-n			
Inhibit 46IT-n			
Inhibit 46BC-n			
Inhibit 47-n			
Inhibit 49-n			
Reset 49-n			
Reset Max Temp			
Inhibit 81HB2			
Inhibit 50-n			
Inhibit 50HS-n			
Inhibit 50G-n			
Inhibit 50GHS-n			
Inhibt Wattmetric			
Inhibit 50GS-n			
Inhibit 50N-n			
Remote 50AFD			
Reset AFD Counters			
AFD Zone n Flash			
AFD Zone n Ext Fail			
50SOTF			
Inhibit 50SOTF-n			
Inhibit 50GSOTF-n			
Reset 50GI-n			
Inhibit 50GI-n			
Inhibit 51CL			
Inhibit 51-n			
Inhibit 51G-n			
Inhibit 51GS-n			
Inhibit 51N-n			
CB Closed			
CB Open			

Binary Inputs > Input Matrix			
Parameter	**Range**	**Default Setting**	**Setting**
Close CB			
Block Close CB			
Open CB			
Block Open CB			
Reset Freq Ops Count			
Reset CB Count To 79 LO			
Man Override Sync			
79 Override Sync			
Reset CB Total Trip			
Reset CB Delta Trip			
Reset CB Trip Time			
Inhibit 50BF			
50BF CB Faulty			
50BF Mech Trip			
50BF Ext Trip			
Reset CB I^2t Wear			
Trigger CB I^2t Wear			
Inhibit 55-n			
Inhibit 59-n			
Inhibit 59Vx-n			
Inhibit 59NDT-n			
Inhibit 59NIT-n			
Inhibit 60CTS-I			
Inhibit 60CTS			
74CCS-n			
74TCS-n			
Inhibit 78VS-n			
79 Out			
79 In			
79 Trip & Reclose			
79 Trip & Lockout			
Lockout			
79 Ext Trip			
79 Ext Pickup			
79 Block Reclose			
Reset Lockout			
79 SOTF			
Inst Protection In			
Inst Protection Out			
Hot Line In			
Hot Line Out			
Inhibit 81-n			
Inhibit 81R-n			
Inhibit 87GH-n			
Inhibit 87NL-n			
Trig Trip Contacts			

Binary Inputs > Input Matrix			
Parameter	**Range**	**Default Setting**	**Setting**
Inhibit Trip Contacts			
Block Reset Trip Contacts			
Trigger Fault Rec			
Trigger Wave Rec			
Select Group n			
Clock Sync.			
Reset LEDs & O/Ps			
EF Out			
EF In			
GS Out			
GS In			
Set Out Of Service Mode			
Set Local Mode			
Set Remote Mode			
Set Local Or Remote Mode			
Set Test Mode			
Reset Device Restart Count			
General Alarm n			
Reset Hrs In Service			
Reset Demand			
Inhibit Fault Loc			

Binary Inputs > Binary Input Config			
Parameter	**Range**	**Default Setting**	**Setting**
Inverted Inputs	BI1 to BIn	<none>	
BIn Operate Voltage	Range 1: 24 V/48 V/60 V Range2: 110 V/125 V Range 3: 220 V/250 V	Range 1: 24 V/48 V/60 V	
BI Operate Voltage Selection	Common Individual	Common	
BIn Pickup Delay	0 to 14400 s	0.02 s	
BIn Dropoff Delay	0 to 14400 s	0 s	
Enabled in Local	BI1 to BIn	<all>	
Enabled in Remote	BI1 to BIn	<all>	
Enabled in Out of Service	BI1 to BIn	<all>	
Enabled in Test Mode	BI1 to BIn	<all>	

Binary Inputs > Function Key Config			
Parameter	**Range**	**Default Setting**	**Setting**
Function Key 0 Text		OPEN CB	
Function Key 1 Text		CLOSE CB	
Enabled in Remote	F0, F1	<None>	

Binary Inputs > General Alarms			
Parameter	**Range**	**Default Setting**	**Setting**
General Alarm 1	<16 characters maximum>	ALARM 1	
General Alarm 2	<16 characters maximum>	ALARM 2	
General Alarm 3	<16 characters maximum>	ALARM 3	
General Alarm 4	<16 characters maximum>	ALARM 4	
General Alarm 5	<16 characters maximum>	ALARM 5	
General Alarm 6	<16 characters maximum>	ALARM 6	
General Alarm 7	<16 characters maximum>	ALARM 7	
General Alarm 8	<16 characters maximum>	ALARM 8	
General Alarm 9	<16 characters maximum>	ALARM 9	
General Alarm 10	<16 characters maximum>	ALARM 10	
General Alarm 11	<16 characters maximum>	ALARM 11	
General Alarm 12	<16 characters maximum>	ALARM 12	
General Alarm 13	<16 characters maximum>	ALARM 13	
General Alarm 14	<16 characters maximum>	ALARM 14	
General Alarm 15	<16 characters maximum>	ALARM 15	
General Alarm 16	<16 characters maximum>	ALARM 16	
General Alarm 17	<16 characters maximum>	ALARM 17	
General Alarm 18	<16 characters maximum>	ALARM 18	
General Alarm 19	<16 characters maximum>	ALARM 19	
General Alarm 20	<16 characters maximum>	ALARM 20	

3.4.6 IEC 61850 Functional Information Mapping

Voltage Operated Binary Inputs

BiGGIO1.Mod

Information	
Reset Device	x
BiGGIO1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

BiGGIO1.Health

Information		
Device Healthy	0	1
BiGGIO1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

BiGGIO1.Ind*

Information		
Binary I/P* Status	0	1
BiGGIO1.Ind*.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
* Values of 1 to max number of BI.
IEC 61850 Value ON: 1
OFF: 0

Virtual Inputs/Outputs

VGGIO1.Mod

Information	
Reset Device	x
VGGIO1.Mod.stVal	**1**

Device Annunciation	ON/TRUE: 1
	OFF/FALSE: 0
	Irrelevant: x
IEC 61850 Value	ON: 1
	BLOCKED: 2
	TEST: 3
	TEST/BLOCKED: 4
	OFF: 5

VGGIO1.Health

Information		
Device Healthy	0	1
VGGIO1.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1
	OFF/FALSE: 0
IEC 61850 Value	OK: 1
	WARNING: 2
	ALARM: 3

VGGIO1.Ind*

Information		
Virtual* Status	0	1
VGGIO1.Ind*.stVal	**0**	**1**

Device Annunciation	ON/TRUE: 1
	OFF/FALSE: 0
	* Values of 1 to 20.
IEC 61850 Value	ON: 1
	OFF: 0

3.4.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
General alarms			Input			
BI						
V						

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

3.5 Binary Outputs

3.5.1 Overview of Functions

7SR5 devices include a number of binary output functions:

- Binary outputs (number dependent on hardware configuration)
- Virtual inputs/outputs
- Fascia LEDs
- General pickup outputs
- Trip config outputs

Binary outputs consist of output relays (user specified number), 28 indication LEDs and 28 virtual input/outputs.

Any function element in the **`Output Matrix`** can be selected to operate any output relay, LED or virtual input/output.

Functions that initiate operation of each binary output are defined in the **`Configuration > Binary Outputs`** menu. All outputs are fully user configurable and can be programmed to operate from any or all of the available functions.

3.5.2 Structure of the Function

The operating parameters for each binary output are defined in the **`Binary Output Config`** menu.

This function corresponds to the logical node **`CTRL BoGGIO`** in IEC 61850

Each binary output relay can be user programmed to have hand or self-reset operation. Hand reset outputs can be reset either by:

- Pressing the fascia ► button for ≥ 3 seconds when the **`Home Screen`** is displayed
- Operating a suitably programmed binary input
- Sending an appropriate command over the data communication channel(s).

On loss of the auxiliary supply hand-reset output relays will reset. When the auxiliary supply is reconnected the output relays will remain in the reset state unless the initiating condition is still present.

The status of virtual inputs/outputs is volatile i.e. is not stored during power loss.

The operating parameters for each LED are defined in the **`LED Config`** menu.

This function corresponds to the logical node **`CTRL LGGIO`** in IEC 61850

Each LED can be programmed to be illuminated as either green, yellow or red. Where an LED is programmed to be lit both red and green it will illuminate yellow. The same LED can be assigned 2 different colors dependent upon whether a **`Pickup`** or **`Operate`** condition exists.

Each LED can be labeled by opening the LED label door and inserting the required label strip into the fascia recess. A template is available in the Reydisp software tool to allow users to create and print customized legends.

Each LED can be user programmed to have hand or self–reset operation. Hand reset LEDs can be reset either by:

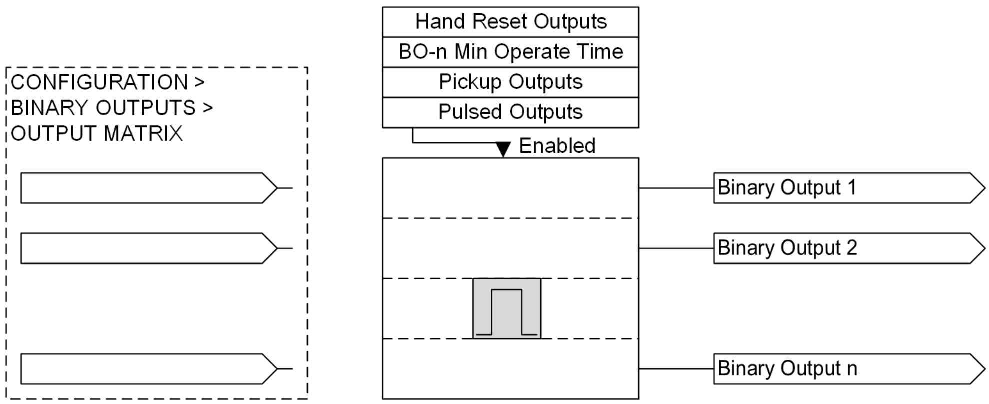
- Pressing the fascia ► button for ≥ 3 seconds when the **`Home Screen`** is displayed
- Operating a suitably programmed binary input
- Sending an appropriate command over the data communication channel(s).

The status of hand reset LEDs (non self-reset LEDs) is maintained by a back up storage capacitor in the event of an interruption to the auxiliary supply.

The **`General Pickup`** menu is used to select the relay functions that provide a pickup output e.g. to initiate a separate pickup LED.

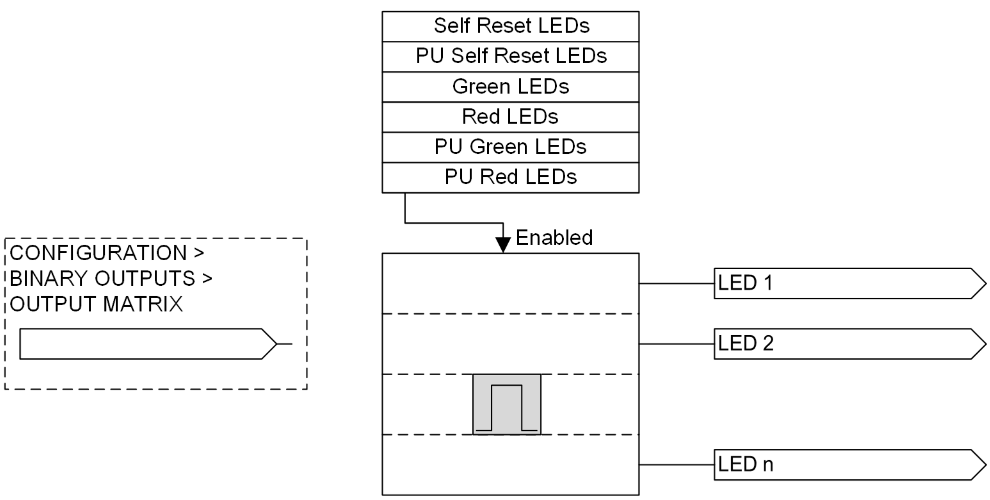
The **`Trip Config`** menu identifies which output relays are used as CB trip outputs.

3.5.3 Logic of the Function



[lo_7SR5_BinaryOutputConfiguration, 2, en_US]

Figure 3-16 Binary Output Configuration



[lo_7SR5_LEDConfiguration, 2, en_US]

Figure 3-17 LED Configuration

Table 3-5 Binary Output Matrix

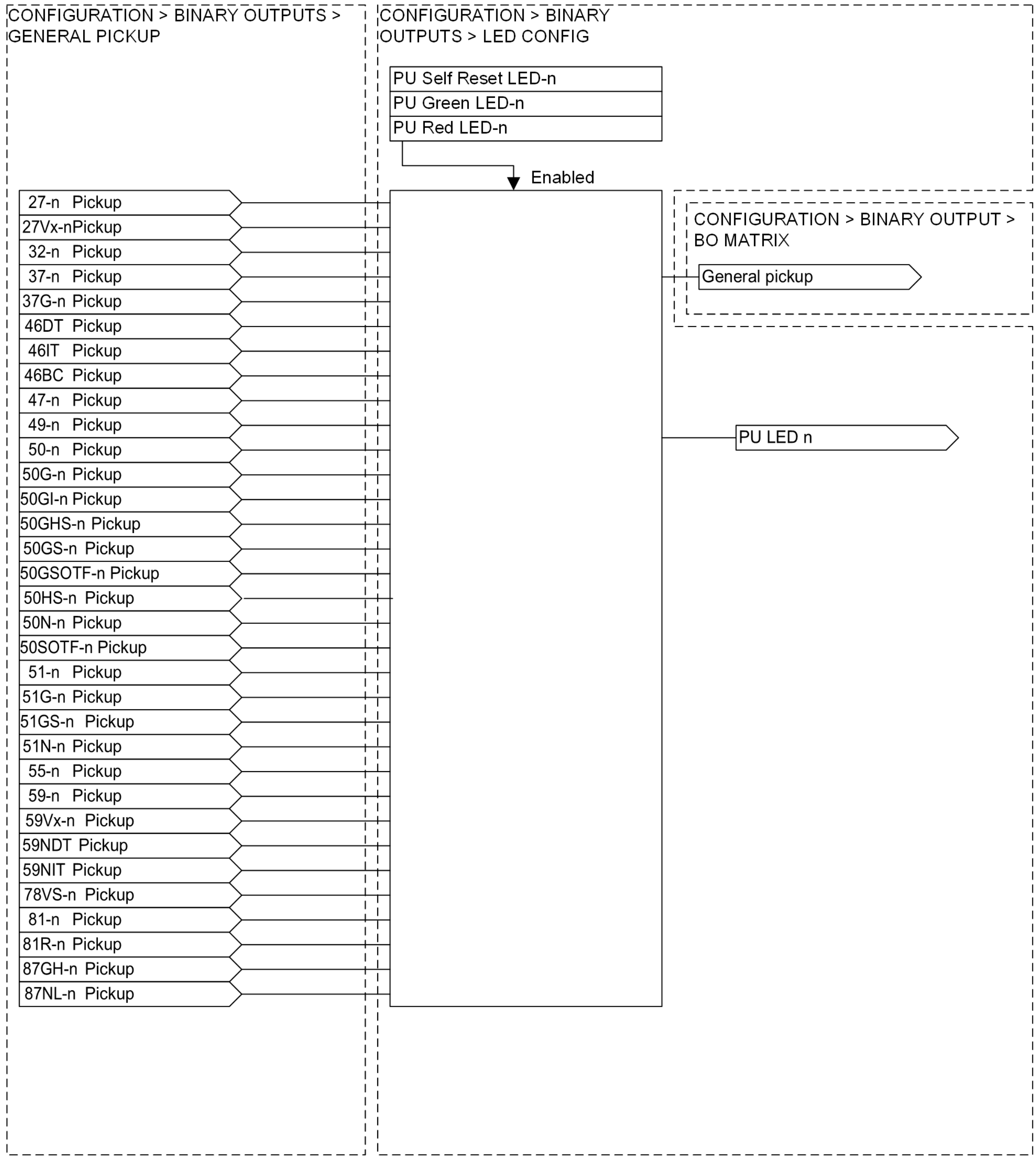
Setting Name
Device Healthy
Active Setting Grp n
+ve P (3P)
-ve P (3P)
+ve Q (3P)
-ve Q (3P)
Active Exp Pulse
Active Imp Pulse
Reactive Exp Pulse
Reactive Imp Pulse
21LB-3Ph Fwd
21LB-3Ph Rev

Setting Name
21LB-1Ph Fwd
21LB-1Ph Rev
60VTS
60VTF-Bus
25 Live Line
25 Live Bus
25 Dead Line
25 Dead Bus
25 Line UV
25 Bus UV
25 Diff Voltage
25 Voltage Check
25 In Sync
25 CS In Progress
25 SS In Progress
25 COZ In Progress
27-n
27 PhA
27 PhB
27 PhC
27Vx-n
32-n
37-n
37 PhA
37 PhB
37 PhC
37G-n
46DT-n
46IT-n
46BC-n
47-n
49-n Trip
49-n Alarm
49TS-n Trip
49TS-n Alarm
49TS-n Fail
Forward PF
Reverse PF
81HB2
50-n
50HS-n
Forward EF
Reverse EF
50G-n
50GHS-n
Wattmetric Po>
Forward GS

Setting Name
Reverse GS
50GS-n
50N-n
50AFD PhA
50AFD PhB
50AFD PhC
50GAFD
AFD Zone n Flash
AFD Zone n
AFD Zone n Fail
50SOTF-n
50GSOTF-n
Forward IEF
Reverse IEF
50GI-n
50GI-n IEF
50GI-n In Progress
51CL Active
51-n
51G-n
51N-n
CB Open Status
CB Closed Status
Manual Close CB Pulse
Successful Man Close
CB Fail to Close
Close CB Blocked
Open CB Pulse
CB Fail To Open
Open CB Blocked
CB Alarm
CB Freq Ops Count
CB Count to 79 LO
25 System Split LO
Man Override Sync
79 Override Sync
CB Total Trip Count
CB Delta Trip Count
CB Trip Time Alarm
50BF Delay n
50BF PhA
50BF PhB
50BF PhC
50BF EF
CB I^2t Wear
55-n
59-n

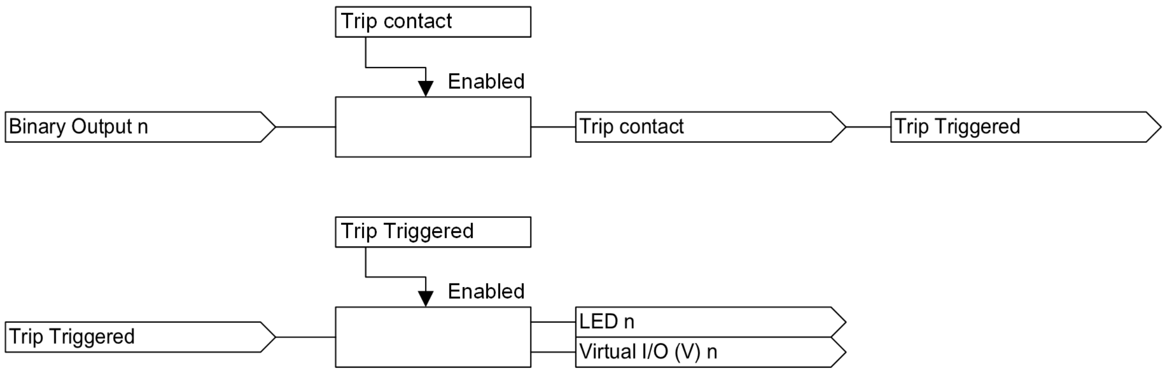
Setting Name
59 PhA
59 PhB
59 PhC
59Vx-n
59NDT-n
59NIT-n
60CTS-I
60CTS-I PhA
60CTS-I PhB
60CTS-I PhC
60CTS-V
74CCS-n
74TCS-n
78VS-n
79 Close CB Pulse
79 Trip & Reclose
79 Trip & Lockout
79 Out Of Service
79 In Service
79 In Progress
79 Block Extern
79 SOTF
79 Successful Reclose
Lockout
Inst Protection Out
79 Last Trip Lockout
Hot Line Working
81-n
81R-n
87GH-n
87NL-n
New Fault Stored
General Pickup
Waveform Archiving
Device Archiving
New Wave Stored
Master Clock Lost
Backup Clock Lost
Time Sync. Not Recieved
Clock Defaulted
BI n Operated
En
User Output n
Phase A Trip
Phase B Trip
Phase C Trip
Derived EF

Setting Name
Measured EF
Sensitive EF
EF Out
EF In
GS Out
GS In
Out Of Service Mode
Local Mode
Remote Mode
Local Or Remote Mode
Test Mode
Device Restart Count Alarm
Ethernet Life
Ethernet Error
IEC61850 Configured
IEC61850 TimeInvalid
Ethernet Chn Link Down



[lo_7SR5_GeneralPickup7SR51, 1, en_US]

Figure 3-18 General Pickup



[lo_7SR5_TripConfig, 2, en_US]

Figure 3-19 Trip Config

3.5.4 Application and Setting Notes

Parameter: **`Binary Output Config > Hand Reset Outputs`**

- Default Setting: **`<None>`**

  Unless programmed as above the output relays are self reset by default. These outputs will reset after removal of the operate condition or elapse of the **`Binary Output Config > Min. Operate Time`** setting, whichever is the longer.

  When set to **`Hand reset`** the output remains in the operate state until reset by:

  – pressing the ► button for 3 seconds, or

  – energizing a suitably programmed binary input, or

  – an appropriate command over the data communications channel(s).

  On loss of the auxiliary supply hand-reset outputs will reset. When the auxiliary supply is re-established the binary output will remain in the reset state unless the initiating condition is still present.

WARNING

Self Reset Outputs.

✧ Any/all binary output relays can be used to operate the trip coils of the circuit-breaker directly where the trip coil current does not exceed the **`make and carry`** contact rating. Typically circuit-breaker auxiliary contacts or other auxiliary devices must be used to interrupt the trip coil current.

✧ With a failed breaker condition the relay may remain operated until current flow is interrupted by an up-stream device. The relay will then reset and attempt to interrupt trip coil current flowing through an output contact. Where this level is above the break rating of the output contact an auxiliary relay with heavy-duty contacts should be utilized in the primary system

---

Parameter: **`Binary Output Config > Min Operate Time`**

- Default Setting: **`0.1 s`**

  This time is initiated from the pickup of a **`self reset`** or **`pulsed`** output contact.

Parameter: **Binary Output Config > Pickup Outputs**

- Default Setting: **<None>**

  When assigned as a **Pickup** an output relay will operate for both the pickup and operate condition of the assigned function element(s). The pickup output of function elements is instantaneous i.e. without the time delay associated with the operate output.

Parameter: **Binary Output Config > Pulsed Outputs**

- Default Setting: **<None>**

  When operated, the output will reset after elapse of the **Min Operate Time** setting regardless of the initiating condition.

  As an example this feature can be used when a binary output is operated by a device counter reaching its target value. The operate condition (counter value) may be present for an indefinite period after operation of the output relay but continuous operation of the output relay is undesirable e.g. SCADA system interface.

Parameter: **Binary Outputs > LED Config > Self Reset LEDs**

- Default Setting: **L1 to L2 (Green), L2 to L28 (Red)**

  These LEDs are initiated by operation of the programmed function element.

  When the LED is operated for the function element operate state (after the pickup state plus time delay) it will be illuminated in the programmed color i.e. the chosen color is used in place of the pickup color. When selected to both green and red the LED will illuminate as yellow when operated.

  The LED resets when the initiating condition is removed.

  When not selected to self-reset the LEDs operate as hand reset outputs and must be manually reset when required, either by:

  - Pressing the fascia ► button for ≥ 3 seconds when the **Home Screen** is displayed
  - Operating a suitably programmed binary input
  - Sending an appropriate command over the data communication channel(s).

WARNING

LED Setting

✧ Where LEDs are set to neither green or red the LED will not illuminate when operated but it will still be recorded as an event or be shown as operated in the device instruments.

Parameter: **Binary Outputs > LED Config > PU Self Reset LEDs**

- Default Setting: **<None>**

  The selected LEDs will operate when the initiating pickup condition is present. The LED resets when the initiating condition is removed.

Parameter: **Binary Outputs > LED Config > PU Green LEDs/PU Red LEDs**

- Default Setting: **<All> (Green), <All> (Red)**

  The selected LEDs will operate when the initiating pickup condition is present. The LED resets when the initiating condition is removed.

  Whilst the LED is operated only for the pickup state (prior to the operate state) it will be illuminated in the programmed PU color. When selected to both green and red the LED will illuminate as yellow when operated.

  Example: The 51-1 element operation can be set to operate LED 4 from both its pickup and operate outputs. LED 4 mode of operation during 51-1 pickup and prior to 51-1 operation will be as determined by the settings **PU Self Reset LEDs**, **PU Green LEDs** and **PU Red LEDs**. After operation of 51-1 its operation will be determined by the settings **Self Reset LEDs**, **Green LEDs** and **Red LEDs**.

Parameter: **Binary Outputs > General Pickup**

- Default Setting: **<None>**

  Any combination of function element pickup outputs available in this menu can be selected to initiate **General Pickup** output. The function element pickup outputs are instantaneous output without any additional operate time delay.

  The **General Pickup** output can be mapped to operate any binary output, LED or virtual I/O.

  Typically this is used to indicate the initiating condition is above setting and can be used during commissioning or for system monitoring.

Parameter: **Binary Outputs > Trip Config > Trip Contacts**

- Default Setting: **<None>**

  Operation of the specified contacts are identified as those that are used to trip a circuit-breaker.

  Operation of any binary output assigned as a **Trip Contact** will trigger storage of a **Fault Data Record**, actuate the **Trip Alert** screen (when **System Config > Trip Alert = Enabled**) and initiate the **CB Fail** protection sequence (when enabled).

Parameter: **Binary Outputs > Trip Config > Trip Triggered**

- Default Setting: **<None>**

  Operation of the selected LEDs or virtual I/Os is initiated when a binary input configured as a **Trip Contact** operates. This provides a logic signal from the trip signal that can be used to provide indication that a trip has occured.

NOTE

Where the **Trip Triggered** is not configured then the **Trip Alert** and **Fault Records** will not be triggered.

3.5.5 Settings Menu

Binary Outputs > Output Matrix			
Parameter	**Range**	**Default Setting**	**Setting**
Device Healthy	BO 1 to BO n	BO 3, L1	
Active Setting Grp n	L1 to Ln	<none>	
+ve P (3P)	V1 to Vn		
-ve P (3P)			
+ve Q (3P)			
-ve Q (3P)			
Active Exp Pulse			
Active Imp Pulse			
Reactive Exp Pulse			
Reactive Imp Pulse			
21LB-3Ph Fwd			
21LB-3Ph Rev			
21LB-1Ph Fwd			
21LB-1Ph Rev			
60VTS			
60VTF-Bus			
25 Live Line			
25 Live Bus			
25 Dead Line			
25 Dead Bus			
25 Line UV			
25 Bus UV			
25 Diff Voltage			
25 Voltage Check			
25 In Sync			
25 CS In Progress			
25 SS In Progress			
25 COZ In Progress			
27-n			
27 PhA			
27 PhB			
27 PhC			
27Vx-n			
32-n			
37-n			
37 PhA			
37 PhB			
37 PhC			
37G-n			
46DT-n			
46IT-n			
46BC-n			
47-n			
49-n Trip			

Binary Outputs > Output Matrix			
Parameter	**Range**	**Default Setting**	**Setting**
49-n Alarm			
49TS-n Trip			
49TS-n Alarm			
49TS-n Fail			
Forward PF			
Reverse PF			
81HB2			
50-n			
50HS-n			
Forward EF			
Reverse EF			
50G-n			
50GHS-n			
Wattmetric Po>			
Forward GS			
Reverse GS			
50GS-n			
50N-n			
50AFD PhA			
50AFD PhB			
50AFD PhC			
50GAFD			
AFD Zone n Flash			
AFD Zone n			
AFD Zone n Fail			
50SOTF-n			
50GSOTF-n			
Forward IEF			
Reverse IEF			
50GI-n			
50GI-n IEF			
50GI-n In Progress			
51CL Active			
51-n			
51G-n			
51N-n			
CB Open Status			
CB Closed Status			
Manual Close CB Pulse			
Successful Man Close			
CB Fail to Close			
Close CB Blocked			
Open CB Pulse			
CB Fail To Open			
Open CB Blocked			
CB Alarm			

Binary Outputs > Output Matrix			
Parameter	**Range**	**Default Setting**	**Setting**
CB Freq Ops Count			
CB Count to 79 LO			
25 System Split LO			
Man Override Sync			
79 Override Sync			
CB Total Trip Count			
CB Delta Trip Count			
CB Trip Time Alarm			
50BF Delay n			
50BF PhA			
50BF PhB			
50BF PhC			
50BF EF			
CB I^2t Wear			
55-n			
59-n			
59 PhA			
59 PhB			
59 PhC			
59Vx-n			
59NDT-n			
59NIT-n			
60CTS-I			
60CTS-I PhA			
60CTS-I PhB			
60CTS-I PhC			
60CTS-V			
74CCS-n			
74TCS-n			
78VS-n			
79 Close CB Pulse			
79 Trip & Reclose			
79 Trip & Lockout			
79 Out Of Service			
79 In Service			
79 In Progress			
79 Block Extern			
79 SOTF			
79 Successful Reclose		L4	
Lockout		L5	
Inst Protection Out		L6	

Binary Outputs > Output Matrix			
Parameter	**Range**	**Default Setting**	**Setting**
79 Last Trip Lockout		<none>	
Hot Line Working			
81-n			
81R-n			
87GH-n			
87NL-n			
New Fault Stored			
General Pickup			
Waveform Archiving			
Device Archiving			
New Wave Stored			
Master Clock Lost			
Backup Clock Lost			
Time Sync. Not Recieved			
Clock Defaulted			
BI n Operated			
En			
User Output n			
Phase A Trip			
Phase B Trip			
Phase C Trip			
Derived EF			
Measured EF			
Sensitive EF			
EF Out			
EF In			
GS Out			
GS In			
Out Of Service Mode			
Local Mode			
Remote Mode			
Local Or Remote Mode			
Test Mode			
Device Restart Count Alarm			
Ethernet Life			
Ethernet Error			
IEC61850 Configured			
IEC61850 TimeInvalid			
Ethernet Chn Link Down			

Binary Outputs > Binary Outputs Config			
Parameter	**Range**	**Default Setting**	**Setting**
Hand Reset Outputs	BO 1 to BO n	<none>	
Min Operate Time n	0 to 2 s, Δ 0.01 s 2 to 20 s, Δ 0.1 s 20 to 60 s, Δ 1 s	0.1 s	
Pickup Outputs	BO 1 to BO n	<none>	
Pulsed Outputs	BO 1 to BO n	<none>	

Binary Outputs > LED Config			
Parameter	**Range**	**Default Setting**	**Setting**
Self Reset LEDs	L1 to Ln	L1, L2	
PU Self Reset LEDs	L1 to Ln	<all>	
Green LEDs	L1 to Ln	L1, L2	
Red LEDs	L1 to Ln	L2 to Ln	
PU Green LEDs	L1 to Ln	<all>	
PU Red LEDs	L1 to Ln	<all>	

Binary Outputs > General Pickup			
Parameter	**Range**	**Default Setting**	**Setting**
27 Pickups		<all>	
32 55 Pickups			
37 Pickups			
46 Pickups			
47 Pickups			
49 Pickups			
50 Pickups			
51 Pickups			
50G Pickups			
51G Pickups			
50N Pickups			
51N Pickups			
50GS Pickups			
51GS Pickups			
50SOTF Pickups			
59 Pickups			
78 Pickups			
81 Pickups			
87 Pickups			

Binary Outputs > Trip Config			
Parameter	**Range**	**Default Setting**	**Setting**
Trip Contacts	BO 1 to BO n	<none>	
Trip Triggered	L1 to Ln, V1 to Vn	<none>	

3.5.6 IEC 61850 Functional Information Mapping

Binary Output Relays

BoGGIO1.Mod

Information	
Reset Device	x
BoGGIO1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

BoGGIO1.Health

Information		
Device Healthy	0	1
BoGGIO1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

BoGGIO1.Ind*

Information		
Binary O/P* Status	0	1
BoGGIO1.Ind*.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
* Values of 1 to max number of available BO in the device.
IEC 61850 Value ON: 1
OFF: 0

LGGIO1.Mod

Information	
Reset Device	x
LGGIO1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

LGGIO1.Health

Information		
Device Healthy	0	1
LGGIO1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

LGGIO1.Ind*

Information		
LED* Status	0	1
LGGIO1.Ind*.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
* Values of 1 to 28.
IEC 61850 Value ON: 1
OFF: 0

PTRC1.Mod

Information		
Device Ready	0	1
PTRC1.Mod.stVal	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

PTRC1.Health

Information		
Device Ready	0	1
PTRC1.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

PTRC1.Op

Information		
Overcurrent protection element operated	0	1
50-1 Operated	0	1
50-2 Operated	0	1
50-3 Operated	0	1
50-4 Operated	0	1
50G-1 Operated	0	1
50G-2 Operated	0	1
50G-3 Operated	0	1
50G-4 Operated	0	1
50GHS-1 Operated	0	1
50GHS-2 Operated	0	1
50GI-1 Operated	0	1
50GI-2 Operated	0	1
50GS-1 Operated	0	1
50GS-2 Operated	0	1
50GS-3 Operated	0	1
50GS-4 Operated	0	1
50GSOTF-1 Operated	0	1
50GSOTF-2 Operated	0	1
50HS-1 Operated	0	1
50HS-2 Operated	0	1
50N-1 Operated	0	1
50N-2 Operated	0	1

Information		
50N-3 Operated	0	1
50N-4 Operated	0	1
50SOTF-1 Operated	0	1
50SOTF-2 Operated	0	1
51-1 Operated	0	1
51-2 Operated	0	1
51-3 Operated	0	1
51-4 Operated	0	1
51G-1 Operated	0	1
51G-2 Operated	0	1
51G-3 Operated	0	1
51G-4 Operated	0	1
51GS-1 Operated	0	1
51GS-2 Operated	0	1
51GS-3 Operated	0	1
51GS-4 Operated	0	1
51N-1 Operated	0	1
51N-2 Operated	0	1
51N-3 Operated	0	1
51N-4 Operated	0	1
87GH-1 Operated	0	1
87GH-2 Operated	0	1
87GH-3 Operated	0	1
87NL-1 Operated	0	1
PTRC1.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value FALSE: 0
TRUE: 1

NOTE

The information in the previous table is dependent on device configuration.

PTRC1.Str

Information		
General picked up (Elements as configured in general pickup menu)	0	1
PTRC1.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value FALSE: 0
TRUE: 1

PTRC1.Tr

Information		
Trip operated (as configured to trip contact)	0	1
PTRC1.Tr.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value FALSE: 0
TRUE: 1

PTRC1.OpCntRs

Information	
Resettable operations counter	Measured Value
PTRC1.OpCntRs.stVal	**Value**

Virtual Inputs/Outputs

VGGIO1.Mod

Information	
Reset Device	x
VGGIO1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

VGGIO1.Health

Information		
Device Healthy	0	1
VGGIO1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

VGGIO1.Ind*

Information		
Virtual* Status	0	1
VGGIO1.Ind*.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
* Values of 1 to 20.

IEC 61850 Value ON: 1
OFF: 0

3.5.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
BO		Binary output	Output Control			
LED		LED	Output			
LED PU			Output			
		Inhibit trip contacts	Input			
		Block reset trip contacts	Input			
LED reset			Output Control			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

3.6 Data Storage

Stored data can be viewed and analyzed from the device using the Reydisp PC tool.

Data storage is categorized as the types listed below:

- Demand/data logs
- Waveform records storage
- Fault records storage
- Event log
- Energy records
- Default Fault locator

All records are time stamped. When the maximum capacity of the data storage buffer is reached the oldest entries are deleted and replaced by the newest entries.

Indications can be output spontaneously via the communication interfaces of the device and when requested using the **General Interrogation** command. Reydisp can monitor device indications during online mode in a special indication window. Indications can be made accessible to higher-level control systems through mapping on various communication protocols.

Data records are backed up in non-volatile memory and are permanently stored even in the event of loss of auxiliary DC supply voltage.

The functionality is configured in the **Configuration > Data Storage** menu.

All power and energy measurements are calculated using the currents measured at the winding that the voltage inputs are associated with in the Function Configuration settings during device configuration in Reydisp Manager.

3.6.1 Demand Data Log

The data log monitors and records average, maximum and minimum demand levels.

The data log can measure and store up to 10,080 individual time stamped measurements, the time between each measured value (sampling rate) is defined by the user.

Maximum, minimum and mean values of measured current, voltage and power (where applicable) are recorded and can be viewed in the relay **Instruments** menu.

Complete demand log records can be viewed and analyzed using the Reydisp PC tool.

The functionality is configured in the **Configuration > Data Storage > Demand/Data Log** menu.

Demand Settings

Parameter: **Demand Data Log > Data Log Period**

- Default Setting: **5 min**
  This setting defines the time between each data sample.

Parameter: **Demand Data Log > Clear Data Log**

- Default Setting: **<None>**
  This setting deletes all contents of the data log.
  The data log can also be reset from a binary input or communication command.

Parameter: **Demand Data Log > Demand Window**

- Default Setting: **24 hrs**
  This setting defines the maximum time over which the demand values are measured. A new set of demand values are recorded after expiry of the **Demand Window Time**.

Parameter: **Demand Data Log > Demand Window Type**

- Default Setting: **Fixed**
  This selects how the **Demand Window** is defined:
  - **Fixed**: the maximum, minimum and mean values demand statistics are calculated over a fixed window duration. At the end of each window the internal statistics are reset and a new window is started. The first window is started when the setting is entered.
  - **Peak**: Records the maximum and minimum values since the **Demand Data Log** feature was last reset.
  - **Rolling**: the maximum, minimum and mean values demand statistics are calculated over a moving window duration. The internal statistics are updated when the window advances. The oldest stored values when new samples are recorded at the end of the **Demand Window**.

  Maximum and minimum values (and times) are stored for previous data log periods.

Parameter: **Demand Data Log > Demand Reset**

- Default Setting: **<None>**
  Demand data log statistics can be reset from the device fascia.
  The statistics can also be reset from a binary input or communication command. After reset the update period and window are immediately restarted.

Configuration > Data Storage > Demand Data Log		
Parameter	**Range**	**Default Setting**
Data log period	5 to 10 min, Δ 1 min 10 to 60 min, Δ 5 min	5 min
Clear data log		
Demand window	1 to 24 hr, Δ 1 hr	24 hr
Demand window type	Fixed, peak, rolling	Fixed
Demand reset		

The demand measurement function corresponds to the following logical nodes in IEC 61850:

Table 3-6 Demand Measurements

7SR5110 (Current only)	Ia (Ia =)	MEAS	MeanIMMXU1	A.phsA
	Ib (Ib =)	MEAS	MeanIMMXU1	A.phsB
	Ic (Ic =)	MEAS	MeanIMMXU1	A.phsC
	Ineut (Ig =)	MEAS	MeanIMMXU1	A.neut
	Ia (Ia =)	MEAS	MinIMMXU1	A.phsA
	Ib (Ib =)	MEAS	MinIMMXU1	A.phsB
	Ic (Ic =)	MEAS	MinIMMXU1	A.phsC
	Ineut (Ig =)	MEAS	MinIMMXU1	A.neut
	Ia (Ia =)	MEAS	MaxIMMXU1	A.phsA
	Ib (Ib =)	MEAS	MaxIMMXU1	A.phsB
	Ic (Ic =)	MEAS	MaxIMMXU1	A.phsC
	Ineut (Ig =)	MEAS	MaxIMMXU1	A.neut

7SR511 (Models with both Current & Voltage)	Ia (Ia =)	MEAS	MeanVIMMXU1	A.phsA
	Ib (Ib =)	MEAS	MeanVIMMXU1	A.phsB
	Ic (Ic =)	MEAS	MeanVIMMXU1	A.phsC
	Ineut (Ig =)	MEAS	MeanVIMMXU1	A.neut
	Frequency	MEAS	MeanVIMMXU1	Hz
	Power Factor (PF =)	MEAS	MeanVIMMXU1	PF.phsA
	Power Factor (PF =)	MEAS	MeanVIMMXU1	PF.phsB
	Power Factor (PF =)	MEAS	MeanVIMMXU1	PF.phsC
	Va (Va =)	MEAS	MeanVIMMXU1	PhV.phsA
	Vb (Vb =)	MEAS	MeanVIMMXU1	PhV.phsB
	Vc (Vc =)	MEAS	MeanVIMMXU1	PhV.phsC
	Va-b (Vab =)	MEAS	MeanVIMMXU1	PPV.phsAB
	Vb-c (Vbc =)	MEAS	MeanVIMMXU1	PPV.phsBC
	Vc-a (Vca =)	MEAS	MeanVIMMXU1	PPV.phsCA
	Power Factor (PF =)	MEAS	MeanVIMMXU1	TotPF
	Apparent Power (S =)	MEAS	MeanVIMMXU1	TotVA
	Reactive Power (Q =)	MEAS	MeanVIMMXU1	TotVAr
	Power (P =)	MEAS	MeanVIMMXU1	TotW
	Ia (Ia =)	MEAS	MinVIMMXU1	A.phsA
	Ib (Ib =)	MEAS	MinVIMMXU1	A.phsB
	Ic (Ic =)	MEAS	MinVIMMXU1	A.phsC
	Ineut (Ig =)	MEAS	MinVIMMXU1	A.neut
	Frequency	MEAS	MinVIMMXU1	Hz
	Power Factor (PF =)	MEAS	MinVIMMXU1	PF.phsA
	Power Factor (PF =)	MEAS	MinVIMMXU1	PF.phsB
	Power Factor (PF =)	MEAS	MinVIMMXU1	PF.phsC
	Va (Va =)	MEAS	MinVIMMXU1	PhV.phsA
	Vb (Vb =)	MEAS	MinVIMMXU1	PhV.phsB
	Vc (Vc =)	MEAS	MinVIMMXU1	PhV.phsC
	Va-b (Vab =)	MEAS	MinVIMMXU1	PPV.phsAB
	Vb-c (Vbc =)	MEAS	MinVIMMXU1	PPV.phsBC
	Vc-a (Vca =)	MEAS	MinVIMMXU1	PPV.phsCA
	Power Factor (PF =)	MEAS	MinVIMMXU1	TotPF
	Apparent Power (S =)	MEAS	MinVIMMXU1	TotVA
	Reactive Power (Q =)	MEAS	MinVIMMXU1	TotVAr
	Power (P =)	MEAS	MinVIMMXU1	TotW
	Ia (Ia =)	MEAS	MaxVIMMXU1	A.phsA
	Ib (Ib =)	MEAS	MaxVIMMXU1	A.phsB
	Ic (Ic =)	MEAS	MaxVIMMXU1	A.phsC
	Ineut (Ig =)	MEAS	MaxVIMMXU1	A.neut
	Frequency	MEAS	MaxVIMMXU1	Hz
	Power Factor (PF =)	MEAS	MaxVIMMXU1	PF.phsA
	Power Factor (PF =)	MEAS	MaxVIMMXU1	PF.phsB
	Power Factor (PF =)	MEAS	MaxVIMMXU1	PF.phsC
	Va (Va =)	MEAS	MaxVIMMXU1	PhV.phsA
	Vb (Vb =)	MEAS	MaxVIMMXU1	PhV.phsB

	Vc (Vc =)	MEAS	MaxVIMMXU1	PhV.phsC
	Va-b (Vab =)	MEAS	MaxVIMMXU1	PPV.phsAB
	Vb-c (Vbc =)	MEAS	MaxVIMMXU1	PPV.phsBC
	Vc-a (Vca =)	MEAS	MaxVIMMXU1	PPV.phsCA
	Power Factor (PF =)	MEAS	MaxVIMMXU1	TotPF
	Apparent Power (S =)	MEAS	MaxVIMMXU1	TotVA
	Reactive Power (Q =)	MEAS	MaxVIMMXU1	TotVAr
	Power (P =)	MEAS	MaxVIMMXU1	TotW

IEC 61850 Functional Information Mapping – Demand Measurement (MeanIMMXU*, MaxIMMXU*, MinIMMXU*)

MeanIMMXU*.Mod

Information	
Reset Device	x
MeanIMMXU*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

MeanIMMXU*.Health

Information		
Device Healthy	0	1
MeanIMMXU*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

MeanIMMXU*.A

Information	Value		
Ia (Ia =)	MeanIMMXU*.A.phsA.InstcVal.mag.f	Measured Value	Value
	MeanIMMXU*.A.phsA.cVal.mag.f	Measured Value	Value
	MeanIMMXU*.A.phsA.units.SIunit	5	A
	MeanIMMXU*.A.phsA.units.multiplier	0	1

Information	Value		
Ib (Ib =)	MeanIMMXU*.A.phsB.InstcVal.mag.f	Measured Value	Value
	MeanIMMXU*.A.phsB.cVal.mag.f	Measured Value	Value
	MeanIMMXU*.A.phsB.units.SIunit	5	A
	MeanIMMXU*.A.phsB.units.multiplier	0	1

Information	Value		
Ic (Ic =)	MeanIMMXU*.A.phsC.InstcVal.mag.f	Measured Value	Value
	MeanIMMXU*.A.phsC.cVal.mag.f	Measured Value	Value
	MeanIMMXU*.A.phsC.units.SIunit	5	A
	MeanIMMXU*.A.phsC.units.multiplier	0	1

Information	Value		
Ig (neut)	MeanIMMXU*.A.neut.InstcVal.mag.f	Measured Value	Value
	MeanIMMXU*.A.neut.cVal.mag.f	Measured Value	Value
	MeanIMMXU*.A.neut.units.SIunit	5	A
	MeanIMMXU*.A.neut.units.multiplier	0	1

MaxIMMXU*.Mod

Information	
Reset Device	x
MaxIMMXU*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

MaxIMMXU*.Health

Information		
Device Healthy	0	1
MaxIMMXU*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

MaxIMMXU*.A

Information	Value		
Ia (Ia =)	MaxIMMXU*.A.phsA.InstcVal.mag.f	Measured Value	Value
	MaxIMMXU*.A.phsA.cVal.mag.f	Measured Value	Value
	MaxIMMXU*.A.phsA.units.SIunit	5	A
	MaxIMMXU*.A.phsA.units.multiplier	0	1

Information	Value		
Ib (Ib =)	MaxIMMXU*.A.phsB.InstcVal.mag.f	Measured Value	Value
	MaxIMMXU*.A.phsB.cVal.mag.f	Measured Value	Value
	MaxIMMXU*.A.phsB.units.SIunit	5	A
	MaxIMMXU*.A.phsB.units.multiplier	0	1

Information	Value		
Ic (Ic =)	MaxIMMXU*.A.phsC.InstcVal.mag.f	Measured Value	Value
	MaxIMMXU*.A.phsC.cVal.mag.f	Measured Value	Value
	MaxIMMXU*.A.phsC.units.SIunit	5	A
	MaxIMMXU*.A.phsC.units.multiplier	0	1

Information	Value		
Ig (neut)	MaxIMMXU*.A.neut.InstcVal.mag.f	Measured Value	Value
	MaxIMMXU*.A.neut.cVal.mag.f	Measured Value	Value
	MaxIMMXU*.A.neut.units.SIunit	5	A
	MaxIMMXU*.A.neut.units.multiplier	0	1

MinIMMXU*.Mod

Information	
Reset Device	x
MinIMMXU*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

MinIMMXU*.Health

Information		
Device Healthy	0	1
MinIMMXU*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

MinIMMXU*.A

Information	Value		
Ia (Ia =)	MinIMMXU*.A.phsA.InstcVal.mag.f	Measured Value	Value
	MinIMMXU*.A.phsA.cVal.mag.f	Measured Value	Value
	MinIMMXU*.A.phsA.units.SIunit	5	A
	MinIMMXU*.A.phsA.units.multiplier	0	1

Information	Value		
Ib (Ib =)	MinIMMXU*.A.phsB.InstcVal.mag.f	Measured Value	Value
	MinIMMXU*.A.phsB.cVal.mag.f	Measured Value	Value
	MinIMMXU*.A.phsB.units.SIunit	5	A
	MinIMMXU*.A.phsB.units.multiplier	0	1

Information	Value		
Ic (Ic =)	MinIMMXU*.A.phsC.InstcVal.mag.f	Measured Value	Value
	MinIMMXU*.A.phsC.cVal.mag.f	Measured Value	Value
	MinIMMXU*.A.phsC.units.SIunit	5	A
	MinIMMXU*.A.phsC.units.multiplier	0	1

Information	Value		
Ig (neut)	MinIMMXU*.A.neut.InstcVal.mag.f	Measured Value	Value
	MinIMMXU*.A.neut.cVal.mag.f	Measured Value	Value
	MinIMMXU*.A.neut.units.SIunit	5	A
	MinIMMXU*.A.neut.units.multiplier	0	1

IEC 61850 Functional Information Mapping – (MeanVIMMXU*, MaxVIMMXU*, MinVIMMXU*)

MeanVIMMXU*.Mod

Information	
Reset Device	x
MeanVIMMXU*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

MeanVIMMXU*.Health

Information		
Device Healthy	0	1
MeanVIMMXU*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

MeanVIMMXU*.A

Information	Value		
Ia (Ia =)	MeanVIMMXU*.A.phsA.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.A.phsA.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.A.phsA.units.SIunit	5	A
	MeanVIMMXU*.A.phsA.units.multiplier	0	1

Information	Value		
Ib (Ib =)	MeanVIMMXU*.A.phsB.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.A.phsB.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.A.phsB.units.SIunit	5	A
	MeanVIMMXU*.A.phsB.units.multiplier	0	1

Information	Value		
Ic (Ic =)	MeanVIMMXU*.A.phsC.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.A.phsC.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.A.phsC.units.SIunit	5	A
	MeanVIMMXU*.A.phsC.units.multiplier	0	1

Information	Value		
Ig (neut)	MeanVIMMXU*.A.neut.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.A.neut.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.A.neut.units.SIunit	5	A
	MeanVIMMXU*.A.neut.units.multiplier	0	1

MeanVIMMXU*.Hz

Information	Value		
Frequency	MeanVIMMXU*.Hz.instmag.f	Measured Value	Value
	MeanVIMMXU*.Hz.mag.f	Measured Value	Value

MeanVIMMXU*.PF

Information	Value		
Power Factor (PF =)	MeanVIMMXU*.PF.phsA.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PF.phsA.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PF.phsA.units.SIunit	1	None
	MeanVIMMXU*.PF.phsA.units.multiplier	0	1

Information	Value		
Power Factor (PF =)	MeanVIMMXU*.PF.phsB.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PF.phsB.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PF.phsB.units.SIunit	1	None
	MeanVIMMXU*.PF.phsB.units.multiplier	0	1

Information	Value		
Power Factor (PF =)	MeanVIMMXU*.PF.phsC.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PF.phsC.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PF.phsC.units.SIunit	1	None
	MeanVIMMXU*.PF.phsC.units.multiplier	0	1

MeanVIMMXU*.PhV

Information	Value		
Va (Va =)	MeanVIMMXU*.PhV.phsA.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PhV.phsA.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PhV.phsA.units.SIunit	29	V
	MeanVIMMXU*.PhV.phsA.units.multiplier	0	1

Information	Value		
Vb (Vb =)	MeanVIMMXU*.PhV.phsB.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PhV.phsB.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PhV.phsB.units.SIunit	29	V
	MeanVIMMXU*.PhV.phsB.units.multiplier	0	1

Information	Value		
Vc (Vc =)	MeanVIMMXU*.PhV.phsC.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PhV.phsC.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PhV.phsC.units.SIunit	29	V
	MeanVIMMXU*.PhV.phsC.units.multiplier	0	1

MeanVIMMXU*.PPV

Information	Value		
Va-b (Vab =)	MeanVIMMXU*.PPV.phsAB.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PPV.phsAB.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PPV.phsAB.units.SIunit	29	V
	MeanVIMMXU*.PPV.phsAB.units.multiplier	0	1

Information	Value		
Vb-c (Vbc =)	MeanVIMMXU*.PPV.phsBC.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PPV.phsBC.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PPV.phsBC.units.SIunit	29	V
	MeanVIMMXU*.PPV.phsBC.units.multiplier	0	1

Information	Value		
Vc-a (Vca =)	MeanVIMMXU*.PPV.phsCA.InstcVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PPV.phsCA.cVal.mag.f	Measured Value	Value
	MeanVIMMXU*.PPV.phsCA.units.SIunit	29	V
	MeanVIMMXU*.PPV.phsCA.units.multiplier	0	1

MeanVIMMXU*.TotPF

Information	Value		
Total Power Factor (PF =)	MeanVIMMXU*.TotPF.instmag.f	Measured Value	Value
	MeanVIMMXU*.TotPF.mag.f	Measured Value	Value
	MeanVIMMXU*.TotPF.units.SIunit	1	None
	MeanVIMMXU*.TotPF.units.multiplier	0	1

MeanVIMMXU*.TotVA

Information	Value		
Apparent Power (S =)	MeanVIMMXU*.TotVA.instmag.f	Measured Value	Value
	MeanVIMMXU*.TotVA.mag.f	Measured Value	Value
	MeanVIMMXU*.TotVA.units.SIunit	61	VA
	MeanVIMMXU*.TotVA.units.multiplier	0	1

MeanVIMMXU*.TotVAr

Information	Value		
Reactive Power (Q =)	MeanVIMMXU*.TotVAr.instmag.f	Measured Value	Value
	MeanVIMMXU*.TotVAr.mag.f	Measured Value	Value
	MeanVIMMXU*.TotVAr.units.SIunit	63	VAr
	MeanVIMMXU*.TotVAr.units.multiplier	0	1

MeanVIMMXU*.TotW

Information	Value		
Active Power (P =)	MeanVIMMXU*.TotW.instmag.f	Measured Value	Value
	MeanVIMMXU*.TotW.mag.f	Measured Value	Value
	MeanVIMMXU*.TotW.units.SIunit	62	W (Watt)
	MeanVIMMXU*.TotW.units.multiplier	0	1

MaxVIMMXU*.Mod

Information	
Reset Device	x
MaxVIMMXU*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

MaxVIMMXU*.Health

Information		
Device Healthy	0	1
MaxVIMMXU*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

MaxVIMMXU*.A

Information	Value		
Ia (Ia =)	MaxVIMMXU*.A.phsA.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.A.phsA.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.A.phsA.units.SIunit	5	A
	MaxVIMMXU*.A.phsA.units.multiplier	0	1

Information	Value		
Ib (Ib =)	MaxVIMMXU*.A.phsB.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.A.phsB.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.A.phsB.units.SIunit	5	A
	MaxVIMMXU*.A.phsB.units.multiplier	0	1

Information	Value		
Ic (Ic =)	MaxVIMMXU*.A.phsC.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.A.phsC.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.A.phsC.units.SIunit	5	A
	MaxVIMMXU*.A.phsC.units.multiplier	0	1

Information	Value		
Ig (neut)	MaxVIMMXU*.A.neut.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.A.neut.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.A.neut.units.SIunit	5	A
	MaxVIMMXU*.A.neut.units.multiplier	0	1

MaxVIMMXU*.Hz

Information	Value		
Frequency	MaxVIMMXU*.Hz.instmag.f	Measured Value	Value
	MaxVIMMXU*.Hz.mag.f	Measured Value	Value

MaxVIMMXU*.PF

Information	Value		
Power Factor (PF =)	MaxVIMMXU*.PF.phsA.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PF.phsA.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PF.phsA.units.SIunit	1	None
	MaxVIMMXU*.PF.phsA.units.multiplier	0	1

Information	Value		
Power Factor (PF =)	MaxVIMMXU*.PF.phsB.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PF.phsB.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PF.phsB.units.SIunit	1	None
	MaxVIMMXU*.PF.phsB.units.multiplier	0	1

Information	Value		
Power Factor (PF =)	MaxVIMMXU*.PF.phsC.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PF.phsC.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PF.phsC.units.SIunit	1	None
	MaxVIMMXU*.PF.phsC.units.multiplier	0	1

MaxVIMMXU*.PhV

Information	Value		
Va (Va =)	MaxVIMMXU*.PhV.phsA.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PhV.phsA.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PhV.phsA.units.SIunit	29	V
	MaxVIMMXU*.PhV.phsA.units.multiplier	0	1

Information	Value		
Vb (Vb =)	MaxVIMMXU*.PhV.phsB.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PhV.phsB.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PhV.phsB.units.SIunit	29	V
	MaxVIMMXU*.PhV.phsB.units.multiplier	0	1

Information	Value		
Vc (Vc =)	MaxVIMMXU*.PhV.phsC.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PhV.phsC.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PhV.phsC.units.SIunit	29	V
	MaxVIMMXU*.PhV.phsC.units.multiplier	0	1

MaxVIMMXU*.PPV

Information	Value		
Va-b (Vab =)	MaxVIMMXU*.PPV.phsAB.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PPV.phsAB.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PPV.phsAB.units.SIunit	29	V
	MaxVIMMXU*.PPV.phsAB.units.multiplier	0	1

Information	Value		
Vb-c (Vbc =)	MaxVIMMXU*.PPV.phsBC.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PPV.phsBC.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PPV.phsBC.units.SIunit	29	V
	MaxVIMMXU*.PPV.phsBC.units.multiplier	0	1

Information	Value		
Vc-a (Vca =)	MaxVIMMXU*.PPV.phsCA.InstcVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PPV.phsCA.cVal.mag.f	Measured Value	Value
	MaxVIMMXU*.PPV.phsCA.units.SIunit	29	V
	MaxVIMMXU*.PPV.phsCA.units.multiplier	0	1

MaxVIMMXU*.TotPF

Information	Value		
Total Power Factor (PF =)	MaxVIMMXU*.TotPF.instmag.f	Measured Value	Value
	MaxVIMMXU*.TotPF.mag.f	Measured Value	Value
	MaxVIMMXU*.TotPF.units.SIunit	1	None
	MaxVIMMXU*.TotPF.units.multiplier	0	1

MaxVIMMXU*.TotVA

Information	Value		
Apparent Power (S =)	MaxVIMMXU*.TotVA.instmag.f	Measured Value	Value
	MaxVIMMXU*.TotVA.mag.f	Measured Value	Value
	MaxVIMMXU*.TotVA.units.SIunit	61	VA
	MaxVIMMXU*.TotVA.units.multiplier	0	1

MaxVIMMXU*.TotVAr

Information	Value		
Reactive Power (Q =)	MaxVIMMXU*.TotVAr.instmag.f	Measured Value	Value
	MaxVIMMXU*.TotVAr.mag.f	Measured Value	Value
	MaxVIMMXU*.TotVAr.units.SIunit	63	VAr
	MaxVIMMXU*.TotVAr.units.multiplier	0	1

MaxVIMMXU*.TotW

Information	Value		
Active Power (P =)	MaxVIMMXU*.TotW.instmag.f	Measured Value	Value
	MaxVIMMXU*.TotW.mag.f	Measured Value	Value
	MaxVIMMXU*.TotW.units.SIunit	62	W (Watt)
	MaxVIMMXU*.TotW.units.multiplier	0	1

MinMMXU*.Mod

Information	
Reset Device	x
MinMMXU*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

MinMMXU*.Health

Information		
Device Healthy	0	1
MinMMXU*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

MinVIMMXU*.A

Information	Value		
Ia (Ia =)	MinVIMMXU*.A.phsA.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.A.phsA.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.A.phsA.units.SIunit	5	A
	MinVIMMXU*.A.phsA.units.multiplier	0	1

Information	Value		
Ib (Ib =)	MinVIMMXU*.A.phsB.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.A.phsB.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.A.phsB.units.SIunit	5	A
	MinVIMMXU*.A.phsB.units.multiplier	0	1

Information	Value		
Ic (Ic =)	MinVIMMXU*.A.phsC.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.A.phsC.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.A.phsC.units.SIunit	5	A
	MinVIMMXU*.A.phsC.units.multiplier	0	1

Information	Value		
Ig (neut)	MinVIMMXU*.A.neut.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.A.neut.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.A.neut.units.SIunit	5	A
	MinVIMMXU*.A.neut.units.multiplier	0	1

MinVIMMXU*.Hz

Information	Value		
Frequency	MinVIMMXU*.Hz.instmag.f	Measured Value	Value
	MinVIMMXU*.Hz.mag.f	Measured Value	Value

MinVIMMXU*.PF

Information	Value		
Power Factor (PF =)	MinVIMMXU*.PF.phsA.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PF.phsA.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PF.phsA.units.SIunit	1	None
	MinVIMMXU*.PF.phsA.units.multiplier	0	1

Information	Value		
Power Factor (PF =)	MinVIMMXU*.PF.phsB.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PF.phsB.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PF.phsB.units.SIunit	1	None
	MinVIMMXU*.PF.phsB.units.multiplier	0	1

Information	Value		
Power Factor (PF =)	MinVIMMXU*.PF.phsC.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PF.phsC.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PF.phsC.units.SIunit	1	None
	MinVIMMXU*.PF.phsC.units.multiplier	0	1

MinVIMMXU*.PhV

Information	Value		
Va (Va =)	MinVIMMXU*.PhV.phsA.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PhV.phsA.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PhV.phsA.units.SIunit	29	V
	MinVIMMXU*.PhV.phsA.units.multiplier	0	1

Information	Value		
Vb (Vb =)	MinVIMMXU*.PhV.phsB.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PhV.phsB.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PhV.phsB.units.SIunit	29	V
	MinVIMMXU*.PhV.phsB.units.multiplier	0	1

Information	Value		
Vc (Vc =)	MinVIMMXU*.PhV.phsC.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PhV.phsC.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PhV.phsC.units.SIunit	29	V
	MinVIMMXU*.PhV.phsC.units.multiplier	0	1

MinVIMMXU*.PPV

Information	Value		
Va-b (Vab =)	MinVIMMXU*.PPV.phsAB.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PPV.phsAB.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PPV.phsAB.units.SIunit	29	V
	MinVIMMXU*.PPV.phsAB.units.multiplier	0	1

Information	Value		
Vb-c (Vbc =)	MinVIMMXU*.PPV.phsBC.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PPV.phsBC.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PPV.phsBC.units.SIunit	29	V
	MinVIMMXU*.PPV.phsBC.units.multiplier	0	1

Information	Value		
Vc-a (Vca =)	MinVIMMXU*.PPV.phsCA.InstcVal.mag.f	Measured Value	Value
	MinVIMMXU*.PPV.phsCA.cVal.mag.f	Measured Value	Value
	MinVIMMXU*.PPV.phsCA.units.SIunit	29	V
	MinVIMMXU*.PPV.phsCA.units.multiplier	0	1

MinVIMMXU*.TotPF

Information	Value		
Total Power Factor (PF =)	MinVIMMXU*.TotPF.instmag.f	Measured Value	Value
	MinVIMMXU*.TotPF.mag.f	Measured Value	Value
	MinVIMMXU*.TotPF.units.SIunit	1	None
	MinVIMMXU*.TotPF.units.multiplier	0	1

MinVIMMXU*.TotVA

Information	Value		
Apparent Power (S =)	MinVIMMXU*.TotVA.instmag.f	Measured Value	Value
	MinVIMMXU*.TotVA.mag.f	Measured Value	Value
	MinVIMMXU*.TotVA.units.SIunit	61	VA
	MinVIMMXU*.TotVA.units.multiplier	0	1

MinVIMMXU*.TotVAr

Information	Value		
Reactive Power (Q =)	MinVIMMXU*.TotVAr.instmag.f	Measured Value	Value
	MinVIMMXU*.TotVAr.mag.f	Measured Value	Value
	MinVIMMXU*.TotVAr.units.SIunit	63	VAr
	MinVIMMXU*.TotVAr.units.multiplier	0	1

MinVIMMXU*.TotW

Information	Value		
Active Power (P =)	MinVIMMXU*.TotW.instmag.f	Measured Value	Value
	MinVIMMXU*.TotW.mag.f	Measured Value	Value
	MinVIMMXU*.TotW.units.SIunit	62	W (Watt)
	MinVIMMXU*.TotW.units.multiplier	0	1

IEC 61850 Functional Information Mapping – Energy Measurement (MMTR*)

MMTR*.Mod

Information	
Reset Device	x
MMTR*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

MMTR*.Health

Information		
Device Healthy	0	1
MMTR*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

MMTR*.DmdVArh

Information	Value		
Reactive Energy Imp	MMTR*.DmdVArh.actVal	Measured Value	Value
	MMTR*.DmdVArh.units.SIUnit	73	VArh
	MMTR*.DmdVArh.units.multiplier	3	None
	MMTR*.DmdVArh.pulsQty	10 [3]	None

MMTR*.DmdWh

Information	Value		
Active Energy Imp	MMTR*.DmdWh.actVal	Measured Value	Value
	MMTR*.DmdWh.units.SIUnit	72	Wh
	MMTR*.DmdWh.units.multiplier	3	None
	MMTR*.DmdWh.pulsQty	10 [4]	None

MMTR*.SupVArh

Information	Value		
Reactive Energy Exp	MMTR*.SupVArh.actVal	Measured Value	Value
	MMTR*.SupVArh.units.SIUnit	72	VArh
	MMTR*.SupVArh.units.multiplier	3	None
	MMTR*.SupVArh.pulsQty	10 [5]	None

MMTR*.SupWh

Information	Value		
Active Energy Imp	MMTR*.SupWh.actVal	Measured Value	Value
	MMTR*.SupWh.units.SIUnit	72	Wh
	MMTR*.SupWh.units.multiplier	3	None
	MMTR*.SupWh.pulsQty	10 [6]	None

3 Dependant on the **Reactive Imp Energy Unit** setting. The unit of energy is calculated by combining the **multiplier** and the **pulsQty**. By default this is $10^3 \cdot 10$ = 10,000 or 10 kVArh.

4 Dependant on the **Active Imp Energy Unit** setting. The unit of energy is calculated by combining the **multiplier** and the **pulsQty**. By default this is $10^3 \cdot 10$ = 10,000 or 10 kVArh.

5 Dependant on the **Reactive Exp Energy Unit** setting. The unit of energy is calculated by combining the **multiplier** and the **pulsQty**. By default this is $10^3 \cdot 10$ = 10,000 or 10 kVArh.

6 Dependant on the **Active Exp Energy Unit** setting. The unit of energy is calculated by combining the **multiplier** and the **pulsQty**. By default this is $10^3 \cdot 10$ = 10,000 or 10 kVArh.

Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Demand metering reset			Output Control	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

3.6.2 Waveform Storage

Waveform records plot the instantaneous magnitude of each analogue input channel, the status of each binary input, binary output, virtual I/O and LED. The values are recorded at each sampling point used by the relay software.

Each recorded analogue waveform displays an input identifier and the instantaneous values at both cursor positions (user variable).

Each binary waveform displays the input/output number and the initiating condition(s) e.g. external input or protection element.

The latest 20 records can be stored, the most recent is waveform 1.

Waveform records are stored in real time into RAM memory and then archived to non-volatile memory as a background task during quiescent periods, (see *3.2 Device Configuration*). The RAM has a total capacity of 10 seconds of waveform data allocated to records of 10 s, 5 s, 2 s or 1 s. When the waveform archive buffer is full, the triggering of a new waveform record causes the oldest record to be overwritten.

NOTE

If a new record is triggered before the oldest record in RAM is archived, data can be lost. If records are expected in rapid succession, such as with short deadtime autoreclose, this setting should be selected to suit.

20 records are stored in the archive regardless of their duration.

Stored waveforms can be deleted from the relay fascia using the **`Control Mode`** menu or from Reydisp.

Relay waveform storage is triggered (initiated) by user selected relay operations, from the relay fascia (**`Control Mode`** menu), from a suitably programmed binary input or from the data comms channel(s). An output is provided to indicate when a new record has been stored.

The IEC 61850 implementation supports the file transfer model to transfer the waveform records in **`COMTRADE`** format with a MMS file directory name **`/COMTRADE/*`**.

Waveform Storage Settings

Parameter: **`Waveform Storage > Function Storage`**

- Default Setting:

  Waveform storage is triggered from operation of any of the selected protection or control elements.

  Waveform storage can also be triggered from the relay fascia, from a suitably programmed binary input or via the data comms channel(s).

Parameter: **`Waveform Storage > Pre-Trigger Storage`**

- Default Setting:
  The percentage of waveform storage prior to waveform triggering is user configurable e.g. for a 1 second waveform record the default setting displays 500 ms of pre-fault trigger waveforms and 500 ms of post-fault trigger waveforms.

Parameter: **`Waveform Storage > Record Duration`**

- Default Setting:
  The duration of each stored record is 1 s, 2 s, 5 s or 10 s.
  If records are expected in rapid succession, such as with short deadtime autoreclose, this setting should be selected to suit.

Configuration > Data Storage > Waveform Storage		
Parameter	**Range**	**Default Setting**
27 Storage	27-n, 27Vx-n	<None>
32 55 Storage	32-n, 55-n	<None>
37 Storage	37-n, 37G-n	<None>
46 Storage	46BC-n, 46DT-n	<All>
47 Storage	47-n	<None>
49 Storage	49-n	<None>
50 Storage	50-n, 50HS	<All>
50G Storage	50G-n, 50GHS-n, 50GI-n	<All>
50GS Storage	50GS-n	<All>
50N Storage	50N-n	<All>
51 Storage	51-n, 51G-n, 51N-n	<All>
51G Storage	51G-n	<All>
51GS Storage	51GS-n	<All>
51N Storage	51N-n	<All>
50SOTF Storage	50SOTF-n, 50GSOTF-n	<All>
59 Storage	59-n, 59Vx-n, 59NDT-n, 59NIT-n	<None>
78 Storage	78VS-n	<All>
81 Storage	81-n	<None>
87 Storage	87GH-n	<All>
Pre-Trigger storage	10 to 90 %, Δ 10 %	50 %
Record duration	1 s, 2 s, 5 s, 10 s	1 s
Trigger waveform	From: Device facia, binary input, comms	

IEC 61850 Functional Information Mapping

RDRE1.Mod

Information	
Device Ready	0
RDRE1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

RDRE1.Health

Information		
Device Healthy	0	1
RDRE1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

RDRE1.RcdMade

Information	
Fault Record ready for Download	0
RDRE1.RcdMade.StVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value FALSE: 0
TRUE: 1

RDRE1.FltNum

Information	
Fault Record Number	Integer
RDRE1.FltNum.StVal	**Value**

RDRE1.GriFltNum

Information	
Fault Record Number	Integer
RDRE1.GriFltNum.StVal	**Value**

Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Trigger storage			Output	Y	Y	Y
Clear waveform storage			Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

3.6.3 Fault Storage

Records are triggered from operation of an output relay programmed as a **`Trip Contact`**, (see *3.5 Binary Outputs*). The **`Trip Alert`** feature must also be enabled, (see *3.2 Device Configuration*).

Measured quantities for the last 100 relay trip fault records are stored with time and date of trip. Fault data records can be viewed on the HMI LCD. These include the LED status at the time of recording.

Fault records are stored in a rolling buffer. When the buffer is full the oldest faults are overwritten.

The functionality is configured in the **`Configuration > Data Storage > Fault Storage`** menu.

Fault data records can be cleared from the **Control Mode** menu using the **`Reset Faults`** command. The faults can also be deleted via a binary input or communication command.

Fault Storage Settings

Parameter: **`Fault Storage > Max Fault Rec Time`**

- Default Setting: **`2 s`**
  Sets the time period from fault trigger during which the operation of any LEDs is recorded.

NOTE

To achieve accurate instrumentation values for the fault records when testing, ensure a drop off delay is applied to the test set so that the injected quantities remain on for a short duration, typically 20 ms, after the relay has issued the trip output. This extended period of injection simulates the behavior of the power system where faulted conditions are present until CB operation.

IEC 61850 Functional Information Mapping – Last Trip Current & Voltage (VI_RFLT1)

VI_RFLT1.Mod

Information	
Reset Device	x
VI_RFLT1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

VI_RFLT.Health

Information		
Device Healthy	0	1
VI_RFLT1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

VI_RFLT1.PhV

Information	Value		
Va (Va =)	VI_RFLT1.PhV.phsA.cVal.mag.f	Measured Value	Value
	VI_RFLT1.PhV.phsA.units.SIunit	29	V
	VI_RFLT1.PhV.phsA.units.multiplier	0	1

Information	Value		
Vb (Vb =)	VI_RFLT1.PhV.phsB.cVal.mag.f	Measured Value	Value
	VI_RFLT1.PhV.phsB.units.SIunit	29	V
	VI_RFLT1.PhV.phsB.units.multiplier	0	1

Information	Value		
Vc (Vc =)	VI_RFLT1.PhV.phsC.cVal.mag.f	Measured Value	Value
	VI_RFLT1.PhV.phsC.units.SIunit	29	V
	VI_RFLT1.PhV.phsC.units.multiplier	0	1

VI_RFLT1.A

Information	Value		
Ia (Ia =)	VI_RFLT1.A.phsA.cVal.mag.f	Measured Value	Value
	VI_RFLT1.A.phsA.units.SIunit	5	A
	VI_RFLT1.A.phsA.units.multiplier	0	1

Information	Value		
Ib (Ib =)	VI_RFLT1.A.phsB.cVal.mag.f	Measured Value	Value
	VI_RFLT1.A.phsB.units.SIunit	5	A
	VI_RFLT1.A.phsB.units.multiplier	0	1

Information	Value		
Ic (Ic =)	VI_RFLT1.A.phsC.cVal.mag.f	Measured Value	Value
	VI_RFLT1.A.phsC.units.SIunit	5	A
	VI_RFLT1.A.phsC.units.multiplier	0	1

Information	Value		
Ineut (Ig =)	VI_RFLT1.A.neut.cVal.mag.f	Measured Value	Value
	VI_RFLT1.A.neut.units.SIunit	5	A
	VI_RFLT1.A.neut.units.multiplier	0	1

IEC 61850 Functional Information Mapping – Last Trip Current (I_RFLT)

I_RFLT.Mod

Information	
Reset Device	x
I_RFLT.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

I_RFLT.Health

Information		
Device Healthy	0	1
I_RFLT.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

I_RFLT.A

Information	**Value**		
Ia (Ia =)	I_RFLT.A.phsA.cVal.mag.f	Measured Value	Value
	I_RFLT.A.phsA.units.SIunit	5	A
	I_RFLT.A.phsA.units.multiplier	0	1

Information	**Value**		
Ib (Ib =)	I_RFLT.A.phsB.cVal.mag.f	Measured Value	Value
	I_RFLT.A.phsB.units.SIunit	5	A
	I_RFLT.A.phsB.units.multiplier	0	1

Information	**Value**		
Ic (Ic =)	I_RFLT.A.phsC.cVal.mag.f	Measured Value	Value
	I_RFLT.A.phsC.units.SIunit	5	A
	I_RFLT.A.phsC.units.multiplier	0	1

Information	**Value**		
Ineut (Ig =)	I_RFLT.A.neut.cVal.mag.f	Measured Value	Value
	I_RFLT.A.neut.units.SIunit	5	A
	I_RFLT.A.neut.units.multiplier	0	1

Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Clear fault records			Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

NOTE

For Last trip data in DNP3.0 and Modbus RTU please refer directly to the Communication Editor file in the Reydisp Manager configurator tool.

The following Disturbance Recorder channel numbers apply to this device depending on hardware model.

Protocol	FUN	ACC	Description
IEC 60870-5-103	182	1	V1
	182	2	V2
	182	3	V3
	182	4	Vx
	182	5	Ia
	182	6	Ib
	182	7	Ic
	182	8	Ig1
	182	9	Ig2

3.6.4 Energy Storage

The energy measurement storage function corresponds to the logical node **MMTR*** in IEC 61850.

The energy is displayed and reported as a count value **x** the **Energy Storage > Active/Reactive Exp/Imp Energy Unit** parameter.

The measured power is continuously integrated (over a 1-second window) to produce 4 energy quantities:

- Active Export Energy (W)
- Active Import Energy (W)
- Reactive Export Energy (VAr)
- Reactive Import Energy (VAr)

The direction of energy transfer is described in section *3.2 Device Configuration* .

Energy Storage Settings

Parameter: **Energy Storage > Active Exp Energy Unit**

- Default Setting: **10 kWh**

  The energy increments define the resolution of the stored energy values reported by instruments and communications protocols.

  When the accumulated energy quantities reach a set increment, the relay issues a pulse to the binary outputs i.e. **Active Exp Pulse**, (see *3.5 Binary Outputs*).

  The direction of energy transfer is described in section *3.2 Device Configuration* .

NOTE

Changing this parameter from the fascia will cause the device to restart to allow IEC 61850 to update.

Parameter: **Energy Storage > Active Imp Energy Unit**

- Default Setting: **10 kWh**

  The energy increments define the resolution of the stored energy values reported by instruments and communications protocols.

  When the accumulated energy quantities reach a set increment, the relay issues a pulse to the binary outputs i.e. **Active Imp Pulse**, (see *3.5 Binary Outputs*).

  The direction of energy transfer is described in section *3.2 Device Configuration* .

NOTE

Changing this parameter from the fascia will cause the device to restart to allow IEC 61850 to update.

Parameter: **Energy Storage > Reactive Exp Energy Unit**

- Default Setting: **10 kVArh**

  The energy increments define the resolution of the stored energy values reported by instruments and communications protocols.

  When the accumulated energy quantities reach a set increment, the relay issues a pulse to the binary outputs i.e. **Reactive Exp Pulse**, (see *3.5 Binary Outputs*).

  The direction of energy transfer is described in section *3.2 Device Configuration* .

NOTE

Changing this parameter from the fascia will cause the device to restart to allow IEC 61850 to update.

Parameter: **Energy Storage > Reactive Imp Energy Unit**

- Default Setting: **10 kVArh**

  The energy increments define the resolution of the stored energy values reported by instruments and communications protocols.

  When the accumulated energy quantities reach a set increment, the relay issues a pulse to the binary outputs i.e. **Reactive Imp Pulse**, (see *3.5 Binary Outputs*).

  The direction of energy transfer is described in section *3.2 Device Configuration* .

NOTE

Changing this parameter from the fascia will cause the device to restart to allow IEC 61850 to update.

Configuration > Data Storage > Energy Storage		
Parameter	**Range**	**Default Setting**
Active exp energy unit	1 kWh, 10 kWh, 100 kWh, 1 MWh, 10 MWh, 100 MWh	10 kWh
Active imp energy unit	1 kWh, 10 kWh, 100 kWh, 1 MWh, 10 MWh, 100 MWh	10 kWh

Configuration > Data Storage > Energy Storage		
Parameter	**Range**	**Default Setting**
Reactive exp energy unit	1 kVArh, 10 kVArh, 100 kVArh, 1 MVArh, 10 MVArh, 100 MVArh,	10 kVArh
Reactive imp energy unit	1 kVArh, 10 kVArh, 100 kVArh, 1 MVArh, 10 MVArh, 100 MVArh,	10 kVArh

NOTE

Changing this parameter from the fascia will cause the device to restart to allow IEC 61850 to update.

Table 3-7 Energy Measurements

Energy Measurements	Reactive Energy Imp	MEAS	MMTR1	DmdVArh
	Active Energy Imp	MEAS	MMTR1	DmdWh
	Reactive Energy Exp	MEAS	MMTR1	SupVArh
	Active Energy Exp	MEAS	MMTR1	SupWh

Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Clear event records		Reset Energy Meters	Output	Y	Y	Y
		Active Exp Pulse Operated	Input			
		Active Imp Pulse Operated	Input			
		Reactive Exp Pulse Operated	Input			
		Reactive Imp Pulse Operated	Input			
Active Exp Meter Reset			Output	Y		
Active Imp Meter Reset			Output	Y		
Reactive Exp Meter Reset			Output	Y		
Reactive Imp Meter Reset			Output	Y		

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

3.6.5 Event Log

The event recorder feature allows the time tagging of any change of state (Event) in the relay. As an event occurs, the actual event condition is logged as a record along with a time and date stamp to a resolution of 1 millisecond. There is capacity for a maximum of 5000 event records that can be stored in the relay and when the event buffer is full any new record will over-write the oldest.

The following events are logged:

- Change of state of binary outputs
- Change of state of binary inputs

- Change of settings and settings group
- Change of state of relay functions

The information available in the event log is defined in the Reydisp configuration tool. All logged data includes date, time and its state.

Events are available over data comms channels. Filtered events are available from the relay fascia.

Events record can be cleared via the **Control Mode** menu `Reset Events` command or `communications` command.

Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Clear event records			Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

3.6.6 Security Log

The 7SR5 device produces a log of events related to the access control of the device. These events are categorized as either warnings or alarms and provide information about the time and date, access point and a description of the action.

The following table lists the events provided:

Category	Description	Information
Warning	Log on and log off access session	Maximum of 5 users rear port and 1 user front port
Warning	Device configuration access	Download and upload of configuration file to and from the PC
Warning	Device configuration change	From Ethernet or USB
Warning	Firmware upload	From Ethernet or USB
Warning	Security logs accessed	From HMI or EN100 webpage
Warning	Time and date	Changed or time source changed.
Alarm	Password attempts	3 or more password login attempts. After a maximum of 5 failed attempts within a 5 minute period the connection is blocked until the block timeout of 30 minutes has elapsed. During the time that the connection action is blocked, each attempt to further connection will be logged. [7]
Warning	Password modified	Set or changed or reset
Alarm	Device restart	Reason for restart is given
Alarm	Firmware invalid	Attempt to download invalid firmware

The maximum security log capacity is 2048, after which it will overwrite the oldest event with the latest event. The security log can not be deleted or modified.

[7] Attempt number and timers are fixed

The security logs are listed in order of occurrence and can be viewed from the 7SR5 HMI or via the EN100 homepage.

To access the security log, select the **Security** tab and the **Security Log** access link is shown last on the list.

NOTE

If the maintenance password is not set it must be set before the security log can be accessed.

For information on viewing the Audit Logs please refer to the 7SR5 Security Manual.

3.6.7 Fault Locator

The single end type fault locator estimate the fault position using analogue information measured by the relay at 1 end of the protected circuit during the short duration of the fault.

Following relay operation due to a system fault, the fault waveform record is automatically evaluated to establish the fault type in terms of the phase(s) affected and the appropriate currents and voltages are used to calculate the fault impedance. The relay compares this information to a line model based on characteristic impedance parameters which are input to the relay as settings and provides an output estimate of the fault location.

Fault Location is reported for faults calculated in a zone which extends to 200 % of the forward line impedance and 10 % in the reverse direction. High resistance fault results where fault resistance is calculated as up to 20 times the line impedance are reported. For faults beyond these limits, the message **No Location** is reported.

Fault Location estimation is initiated by operation of a **Trip Contact**. Some protection elements may be configured to provide tripping for system conditions where fault location is not applicable. The initiation of the **Fault Locator** can be inhibited by binary input mapping or configuration of user logic.

The **Fault Locator** result data is available in the **Fault Data** records and can be viewed at the relay fascia and in the Reydisp PC tool.

The functionality is configured in the **Configuration > Data Storage > Fault Locator** menu.

Fault Locator Settings

Parameter: **Fault Locator > Line Angle**

- Default Setting: **75°**
  The line impedance angle when plotted in the R-X plane, this is used to enable the distance to fault to be calculated.

Parameter: **Fault Locator > EF Comp Z_0/Z_1 Ratio**

- Default Setting: **2.5**
  The earth fault return impedance ratio of zero to positive sequence impedance magnitudes.

Parameter: **Fault Locator > EF Comp Z_0 Angle**

- Default Setting: **75°**
  The earth fault return impedance characteristic phase angle of the zero sequence impedance. The characteristic angle of the zero sequence impedance is often significantly different to that of the positive sequence impedance.

Parameter: **Fault Locator > Z+ Impedance**

- Default Setting: **10 Ω**

  The protected line **Positive Sequence Impedance** is used to enable the distance to fault to be calculated.

Parameter: **Fault Locator > Secy Z+ Per Unit Distance**

- Default Setting: **0.5 Ω**

  The system positive sequence impedance per unit – see **Display Units**.

Parameter: **Fault Locator > Display Units**

- Default Setting: **Percent**

  The distance top fault is presented as a percentage of line length or a distance in miles or kilometers.

Parameter: **Fault Locator > System Earthing**

- Default Setting: **Normal**

  This is selected to **Normal** when the power system is not earthed through compensation (Peterson) coils.

  When the power system is earthed through compensation coils the setting is selected to **Compen-sated**.Earth fault currents are extremely low and are not proportional to fault location. Impedance based fault location cannot be used for earth faults. Phase to phase fault location can be estimated. On networks of this type it is possible to have 2 earth faults on the network simultaneously on different phases of the same circuit which will appear as a phase to phase fault (Cross Country fault). In these cases the measured impedance cannot give an accurate estimate of the fault condition. The device provides detection of this condition using the measured zero sequence voltage to positive sequence voltage ratio (U_0/U_1) to allow the possible cross country fault to be reported.

Parameter: **Fault Locator > U_0/U_1 Ratio**

- Default Setting: **0.1**

  The system zero sequence voltage to positive sequence voltage ratio.

Configuration > Data Storage > Fault Locator		
Parameter	**Range**	**Default Setting**
21FL Fault locator	Enabled Disabled	
Line angle	0 to 90°, Δ 1°	75°
EF comp Z_0/Z_1 ratio	0 to 10, Δ 0.01	2.5
EF comp Z_0 angle	0 to 359°, Δ 1°	75°
Z+ Impedance	0 to 100 Ω, Δ 0.1 Ω 101 to 250 Ω, Δ 1 Ω	10 Ω
Secy Z+ per unit distance	0.0005 to 5Ω, Δ 0.0005 Ω	0.5 Ω
Display units	Percent, Kilometers, Miles	Percent
System earthing	Normal, Compensated	Normal
V_0/V_1 Ratio	0 to 1, Δ 0.01	

IEC 61850 Functional Information Mapping

RFLO.Mod

Information			
Element Disabled	1	0	0
Element Inhibited	x	1	0
RFLO.Mod.stVal	**5**	**2**	**1**

Device Annunciation	ON/TRUE: 1
	OFF/FALSE: 0
	Irrelevant: x
IEC 61850 Value	ON: 1
	BLOCKED: 2
	TEST: 3
	TEST/BLOCKED: 4
	OFF: 5

RFLO.Health

Information		
Device Healthy	0	1
RFLO.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1
	OFF/FALSE: 0
IEC 61850 Value	OK: 1
	WARNING: 2
	ALARM: 3

RFLO.FltDiskm

Information	**Value**		
Distance To Fault (km)	RFLO.FltDiskm.mag.f	Measured Value	Value
	RFLO.FltDiskm units.SIunit	2	m
	RFLO.FltDiskm.units.multiplier	3	1000

RFLO.FltZ

Information	**Value**		
Fault Impedance (Ω)	RFLO.FltZ.mag.f	Measured Value	Value
	RFLO.FltZ.units.SIunit	30	Ω
	RFLO.FltZ.units.multiplier	0	1

Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Fault Impedance			Output	Y	Y	Y
Fault Forward/Line			Output	Y	Y	Y
Fault Reverse/Busbar			Output	Y	Y	Y
Distance to Fault			Meter	Y	Y	Y
Distance to Fault Percent			Meter	Y	Y	Y
Fault Reactance			Meter	Y	Y	Y
		Inhibit Fault Loc				

3.7 Data Communications

3.7.1 Overview of Functions

The relay data communication facility is compatible with control and automation systems and PCs running Reydisp suite of software. The relay can provide the following:

- Operational information
- Post-fault analysis
- Parameter interrogation
- Device configuration

The device provides 1 front USB communication interface (Com2) on the fascia and 1 RS485 (Com1) on the rear along with 2 Ethernet ports on the rear. The Ethernet ports can be ordered for connection with Electrical RJ45 or Optical LC access. The access to the communication settings for the USB port is available from the front menu structure via the keypad setting menu **`Communications`** or through the parameter configuration PC software.

Communication interface

- Com2-USB – The Com2-USB port is used for configuring the device with Reydisp software and allows the updating of firmware.

  The Com2-USB port has the IP address 192.168.2.1
- Com1-RS485 (Terminal Reference X1) – The Com1-RS485 port can be used for DNP3.0, IEC 60870-5-103 or Modbus RTU communications to a substation SCADA, integrated control system, or engineer remote access.

  The port can be independently mapped to the DNP3.0, IEC 60870-5-103 or Modbus RTU protocol or switched off in the device configuration.
- Com-Ethernet – 2 electrical (RJ45) ports (Channel 1/Terminal Reference X2 and Channel 2/Terminal Reference X3) or 2 optical (LC) ethernet ports (Channel 1/Terminal Reference X4 and Channel 2/Terminal Reference X5).

  The Ethernet ports can be used for IEC 61850 communications and Modbus TCP to a substation SCADA, integrated control system, or engineer remote access using Reydisp configuration software.

3.7.2 Structure of the Function

Communication is compatible with transmission and application standards for the serial port and IEC 61850 and Modbus TCP for Ethernet ports.

The 61850 comms can be user configured to provide HSR, PRP and RSTP operation.

For further details refer to the following IEC publications:

- MICS : Model Implementation Conformance Statement (automatically generated from the device configuration in RM2)
- PIXIT: Protocol Implementation Extra Information for Testing
- PICS: Protocol Implementation Conformance Statement
- TICS: Technical Issues Implementation Conformance Statement

3.7.3 Application and Setting Notes

Parameter: **`COM1-RS485 Protocol`**

- Default Setting: **`Off`**
  This setting is used to select the protocol used on the Com 1-RS485 interface port designated X1 on the rear of the device.

Parameter: **`COM1-RS485 Station Address`**

- Default Setting: **`0`**
  This setting is used to identify the device within the relevant range of the selected protocol.

Parameter: **`COM1-RS485 Baud Rate`**

- Default Setting: **`19200`**
  This setting is used to select the baud rate, rate at which the data is transferred via the RS485 serial connection.

Parameter: **`COM1-RS485 Parity`**

- Default Setting: **`EVEN`**
  This setting is used to select if a parity bit is added to the binary string to ensure the total number of bits is even or odd and is used for error detection.

Parameter: **`COM1-RS485 Mode`**

- Default Setting: **`Remote`**
  This setting is used to select the operating mode of the RS485 port and is used in conjunction with the device operating mode. Some actions are restricted on the port depending upon the ports mode and device operating mode.

Parameter: **`DNP3 Unsolicited Events`**

- Default Setting: **`Disabled`**
  This setting is used enable the support of unsolicited events in DNP3 protocol.

Parameter: **`DNP3 Destination Address`**

- Default Setting: **`0`**
  This setting is used to set the address of the master where the DNP3 unsolicited events are to be sent.

Parameter: **`DNP3 Application Timeout`**

- Default Setting: **`10`**
  This setting is used to configure the response time of the DNP3 application layer confirmation.

3.7.4 Settings Menu

Configuration > Data Storage		
Parameter	**Range**	**Default Setting**
COM1-RS485 Protocol	IEC 60870-5-103, MODBUS-RTU, DNP3, Off	Off
COM1-RS485 Station address	0 to 254 for IEC 60870-5-103 1 to 247 for Modbus RTU 0 to 65534 for DNP3	0
COM1-RS485 Baud rate	75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400	19200
COM1-RS485 Parity	NONE, ODD, EVEN	EVEN
COM1-RS485 Mode	Local, Remote, Local or Remote	Remote
USB Mode	Local, Remote, Local or Remote	Local
Ethernet Mode	Local, Remote, Local or Remote	Remote
DNP3 Unsolicited events	Disabled, Enabled	Disabled
DNP3 Destination address	0 to 65534	0
DNP3 Application timeout	5 to 300 s	10 s

Ethernet Parameters

The Ethernet interface parameters are configured in the Reydisp Manager pc software using the device **`Configure Interface`** tool and can not be configured from the fascia or device settings.

The devices support the Editions 1 and 2 of IEC 61850, and the selection is made in Reydisp Manager when creating the device. To provide complete compatibility with existing Edition 1 devices, you can use Reydisp Manager to switch the IEC 61850 server of the device to the Edition 1 mode. The IEC 61850 server then operates together with Edition 1 clients and exchanges GOOSE messages with Edition 1 devices.

[sc_7SR5_EthernetParameters, 1, --_--]

Parameter: **IP Address**

- Default Setting: **0.0.0.0**
  The IP address is also a unique identifier for a TCP/IP link. It is a 32-bit-wide number.
  The IP address is assigned during configuration of a network in a station. It can be set during device parameterization for a stand alone device and can also be set in the IEC 61850 **System Configurator** when the device is associated with a station. One exception to this is operation in a network with a DHCP server.

Parameter: **Subnet Mask**

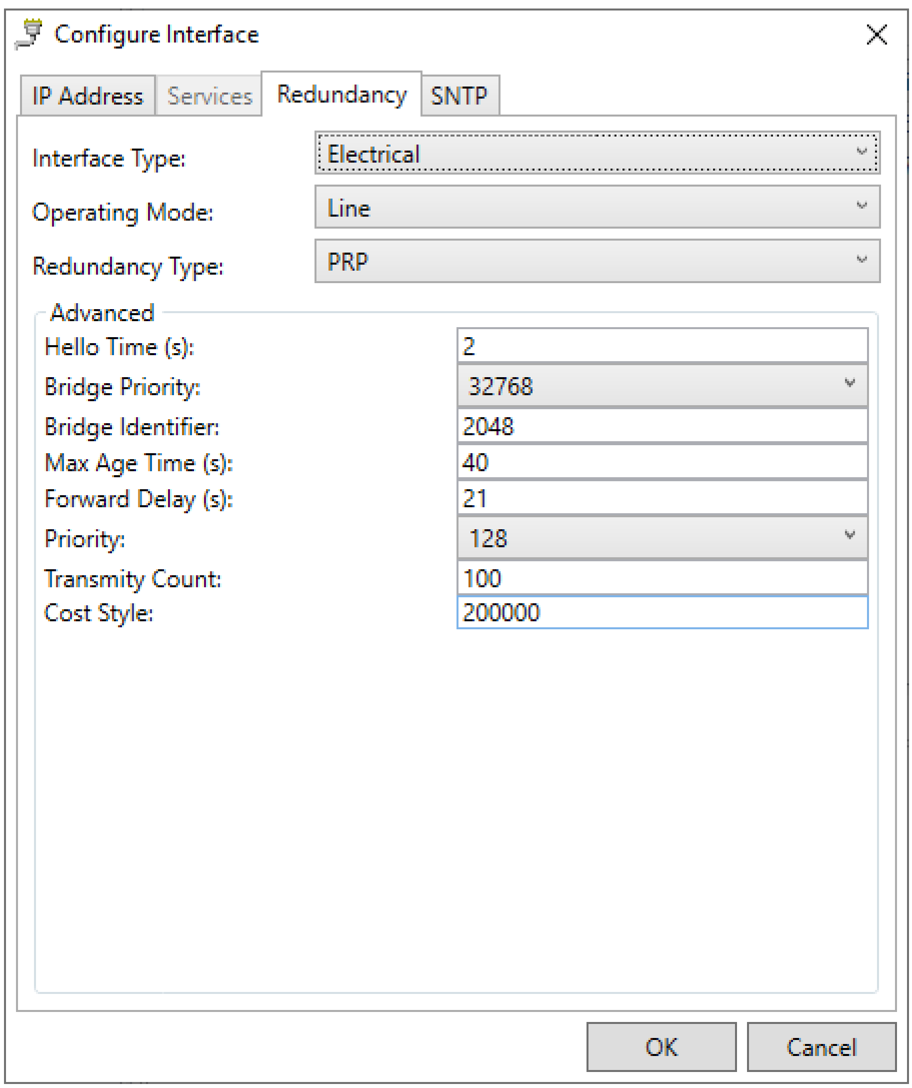
- Default Setting: **255.255.255.0**
  This mask must be set according to the addressing scheme of the network.

Parameter: **`Gateway Address`**

- Default Setting: **`0.0.0.0`**
  This is the IP address of the gateway. It is required whenever an address outside the LAN of the station is to be accessed. It can be set during device parameterization for a stand alone device and can also be set in the IEC 61850 **`System Configurator`** when the device is associated with a station.
  The Ethernet modules can be operated optionally with or without integrated switch function. This applies for the electrical as well as the optical module. This function can be selected via the parameterization. It is not necessary to make any indication in the order.

Parameter: **`Operating Mode`**

- Default Setting: **`Line`**
  The interfaces on the devices can be used in different operating modes. A distinction is drawn between the operating modes **`Line`** and **`Switch`**.



[sc_7SR5_EthernetParametersOperatingMode, 1, --_--]

Parameter: **`Redundancy Mode`**

- Default Setting: **`PRP`**

  When the **`Operating Mode`** is set to **`Switch`**, redundancy options are available to select.

Parameter	Description
RSTP	Rapid spanning tree protocol
OSM	Legacy Siemens redundancy protocol.
PRP	Parallel redundancy protocol
HSR	High-availability seamless redundancy

For detailed information on the parameterization of the **`Advanced`** setting please refer to the Communications manual.

3.7.5 Information List

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, Modbus TCP, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

3.8 Quick Logic

3.8.1 Overview of Functions

The **Quick Logic** feature allows the user to input up to 16 **Quick Logic** equations (E1 to E16) in text format. Equations can be entered using Reydisp or from the relay fascia.

Quick Logic allows the user to define basic logic schemes using the pushbuttons and LCD of the device fascia.

The logic is defined by an equation using standardized terms for binary inputs, binary outputs, LEDs, virtual I/O and logical functions.

Protection functions can be used in **Quick Logic** by mapping them to a **Virtual Input/Output**.

Graphical logic schemes are compiled using the Reydisp Manager **User Logic** tool.

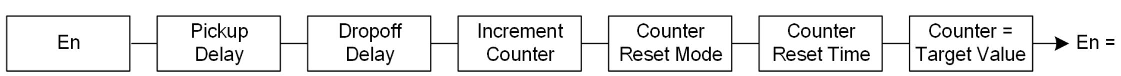
3.8.2 Structure of the Function

Up to 16 user definable logic equations can be configured in the device.

This function corresponds to the logical node **CTRL EGGIO** in IEC 61850.

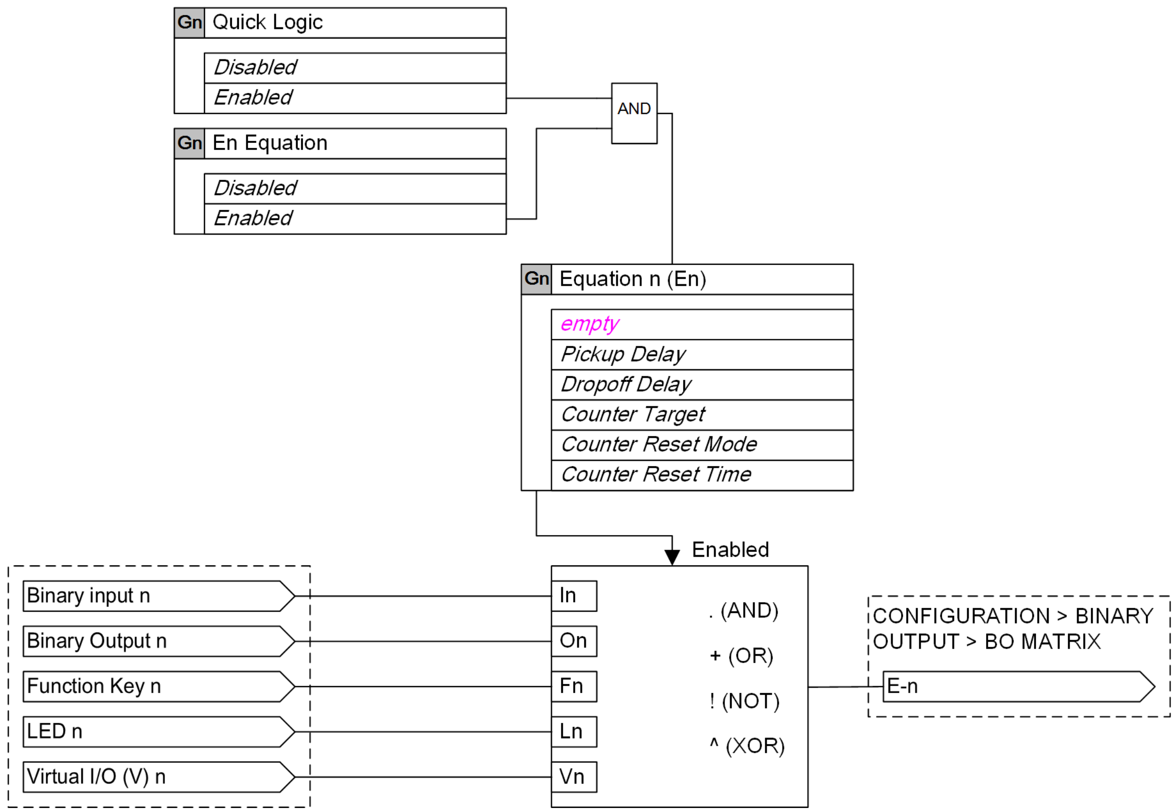
Equations are defined in the following stages:

- Define the logic equation
- Assign pickup delay
- Assign drop-off delay
- Assign an equation counter target
- Assign the counter reset mode
- Assign the counter reset time



[dw_7SR5_7SR5QuickLogicStructureOfTheFunction, 2, en_US]

3.8.3 Logic of the Function



[lo_7SR5_QuickLogic_LogicOfTheFunction, 2, en_US]

3.8.4 Application and Setting Notes

Parameter: **En =**

- Default Setting:
  Each logic equation is built up from text representing control characters. Each can be up to 20 characters long. Allowable characters are:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9	Digit
()	Parenthesis
!	**NOT** Function
.	**AND** Function
^	**EXCLUSIVE OR** Function
+	**OR** Function
En	Equation (number)
Fn	Function Key (number)
	‘1’ = Key pressed, ‘0’ = Key not pressed
In	Binary input (number)
	‘1’ = Input energized, ‘0’ = Input de-energized
Ln	LED (number)
	‘1’ = Input energized, ‘0’ = Input de-energized
On	Binary output (number)
	‘1’ = Output energized, ‘0’ = Output de-energized

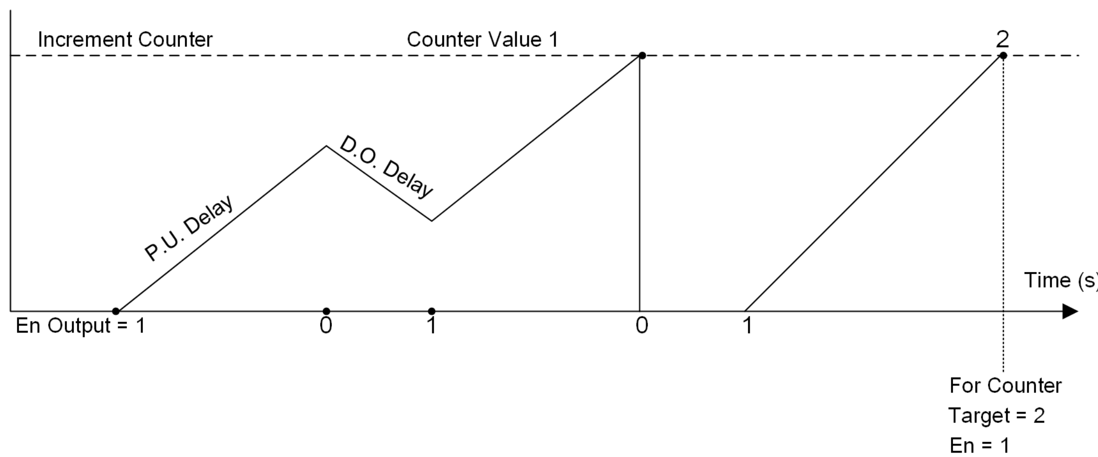
Vn	Virtual input/output (number) '1' = Virtual I/O energized, '0' = Virtual I/O de-energized

Parameter: **En Pickup Delay**

- Default Setting:
  When the equation is satisfied (=1) the pickup time delay is initiated (**En Pickup Delay**), when the equation is still set to true and the time delay has elapsed the counter value is increased by 1.

Parameter: **En Dropoff Delay**

- Default Setting:



[dw_7SR5_QuickLogicSequenceDiagram, 2, en_US]

Figure 3-20 Sequence Diagram: Quick Logic PU/DO Timers (Counter Reset Mode Off)

Parameter: **En Counter Target**

- Default Setting:
  An output is issued when the equation has been set to **true** (and the counter is incremented) for the number of times specified by the **Counter Target** setting.
  When the count value = **En Counter Target** the output of En is initiated and this value is held until the initiating conditions are removed when En is instantaneously reset.
  The output of En is assigned in the **Output Config > Output Matrix** menu where it can be programmed to any binary output (O), LED (L) or Virtual Input/Output (V) combination.

Parameter: **En Counter Reset Mode**

- Default Setting: **Off**
  Off: The counter will maintain its count value
  Single Shot: The counter will reset after the reset time delay. The **En Counter Reset Time** is started only when the counter is first incremented (i.e. counter value = 1) and not for subsequent counter operations.
  Multi Shot: The counter will reset after the reset time delay. The **En Counter Reset Time** is started each time the counter is incremented.

Parameter: **`En Counter Reset Time`**

- Default Setting:
  Where **`En Counter Reset Time`** elapses without further count increments the count value is reset to zero.

Settings Example

E1= I1.!I2: Equation 1 = Binary Input 1 AND NOT Binary Input 2 The output of E1 is set to **`true`** when the conditions of the equation are met.

3.8.5 Settings Menu

Configuration > Quicklogic		
Parameter	**Range**	**Default Setting**
Quick logic	Enabled Disabled	
En Equation	Enabled Disabled	
En =	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, (,), >, ^, !, ., In, Fn, Ln, On, Vn	
En Pickup delay	0 to 14400 s	0 s
En Dropoff delay		0 s
En Counter target	1 to 999	1
En Counter reset mode	Off, Single Shot, Multi Shot	Off
En Counter reset time	0 to 14400 s	0 s

3.8.6 IEC 61850 Functional Information Mapping

EGGIO1.Mod

Information	
Reset Device	x
EGGIO1.Mod.stVal	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

EGGIO1.Health

Information		
Device Healthy	0	1
EGGIO1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

EGGIO1.Ind*

Information		
Equation* Status	0	1
EGGIO1.Ind*.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
* Values of 1 to 16
IEC 61850 Value ON: 1
OFF: 0

3.8.7 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Quick Logic E1 to E16			Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

4 7SR51 Function Templates

4.1 Introduction

The device includes configuration protection, supervision, control, data communications and real time clock functions.

The protection, control and supervision functions that can be included in the device are dependent on the 7SR5 device type and it's hardware configuration.

The functionality available to a user is termed the **Function Template**.

Function templates comprise **Function Groups** (FG) and within each FG there may be a number of **Function Elements** (FE).

7SR511 overcurrent devices include a number of **Function Groups** each of which may contain one or more **Function Elements**. The maximum functionality is tabulated in *Table 4-1* (overcurrent) and *Table 4-2* (directional overcurrent).

Function groups and elements can be added or removed only by using the Reydisp software configurator tool.

Function groups and function elements that have been included can be **Enabled** or **Disabled** using Reydisp or from the device fascia:

- Protection and automation function elements, (see *5 Protection and Automation Functions*).
- Supervision function elements, (see *6 Supervision Functions*).
- Control function elements, (see *7 Control Functions*).

From the device fascia the protection, supervision and control function groups are enabled and disabled in the **Settings > Functions > Function Config** menu, (see *4.3 Function Configuration*).

NOTE

Modification of the Function Template will automatically update all associated files including the communication data points and IEC 61850 logical nodes.

4.2 Function Groups and Function Elements

The default overcurrent application template includes functions that are typically used in this type of device. The appropriate analogue inputs are provided in the 7SR5110 overcurrent/earth fault relay and 7SR5111 directional overcurrent/earth fault relays.

Table 4-1 and *Table 4-2* below provide a summary of the functions available using the analogue inputs.

Functions that do not use analogue input measurands are also provided, these include:

- 52 CB and plant control
- 74 Trip/close circuit supervision
- 79 Autoreclose functionality
- User logic schemes

Example – 7SR5110

The 7SR5110 overcurrent application templates are summarized in *Table 4-1*.

Table 4-1 Function Template for 7SR5110 Devices

Function Group (FG)	Maximum Number of Function Elements (FE)	Default Function Elements	Custom Function Elements	CT 1 CT 2 CT3	CT 4
37	2	1		Y	–
37G	2	1		–	Y
46BC	1	0		Y	–
46DT	1	1		Y	–
46IT	1	1		Y	–
49	1	1		Y	–
50	4	1		Y	–
50AFD	1	1		Y	–
50BF	1	1		Y	Y
50G	4	1		–	Y
50GAFD [8]	1	1		–	Y
50GI	1	1		–	–
50GHS	2	0		–	Y
50GS	4	1		–	Y
50GSOTF	2	1		–	Y
50HS	2	0		Y	–
50N	4	1		Y	–
50SOTF	2	1		Y	–
51	4	1		Y	–
51CL	See '51'			Y	–
51G	4	1		–	Y
51GS	4	1		–	Y
51N	4	1		Y	–
52	1	1		–	–
60CTS-I	1	1		Y	–

8

Function Group (FG)	Maximum Number of Function Elements (FE)	Default Function Elements	Custom Function Elements	CT 1 CT 2 CT3	CT 4
74CCS[9]	3	3		–	–
74TCS[9]	3	3		–	–
81HB2 [10]	1	1		Y	–
87GH	1	1		–	Y
87NL	1	0		–	–
79	1	0		–	–

Example – 7SR5111

The 7SR51x1 directional overcurrent application templates are summarized in *Table 4-2*.

Table 4-2 Function Templates for 7SR5111 Devices

Function Group (FG)	Maximum Number of Function Elements (FE)	Default Function Elements	Custom Function Elements	CT 1 CT 2 CT3	VT 1 VT 2 VT 3	VT 4	CT 4
21FL	1	1		Y	Y	–	–
21LB	1	1		Y	Y	–	–
25	1	1		–	Y	Y	–
27	4	1		–	Y	–	–
27Vx	2	1		–	–	Y	–
32	2	1		Y	Y	–	–
37	2	1		Y	–	–	–
37G	2	1		–	–	–	Y
46BC	1	1		Y	–	–	–
46DT	1	1		Y	–	–	–
46IT	1	0		Y	–	–	–
47	2	1		–	Y	–	–
49	1	1		Y	–	–	–
50	4	1		Y	–	–	–
50AFD	1	1		Y	–	–	–
50BF	1	1		Y	–	–	Y
50G	4	1		–	–	–	Y
50GAFD [11]	1	1		–	–	–	Y
50GHS	2	0		–	Y	Y	–
50GI	1	1		–	–	–	Y
50GS	4	1		–	–	–	Y
50HS	2	0		–	Y	Y	–
50N	4	1		Y	–	–	–
50GSOTF	2	1		–	–	–	Y
50SOTF	2	1		Y	–	–	–
51	4	1		Y	–	–	–

9 Always provided and not in the function config
10 This function cannot be added or removed in the device configuration manually. It is automatically removed when all of the associated functions are removed.
11 This is a sub menu of 50AFD and can not be added or removed in the device function config.

Function Group (FG)	Maximum Number of Function Elements (FE)	Default Function Elements	Custom Function Elements	CT 1 CT 2 CT3	VT 1 VT 2 VT 3	VT 4	CT 4
51CL	See '51'			Y	–	–	–
51G	4	1		–	–	–	Y
51GS	4	1		–	–	–	Y
51N	4	1		Y	–	–	–
51V	See '51'			Y	Y	–	–
52	1	1		–	–	–	–
55	2	1		Y	Y	–	–
59	4	1		–	Y	–	–
59N	1	1		–	Y	Y	–
59Vx	2	1		–	–	Y	–
60CTS-I	1	1		Y	–	–	–
60CTS-V	1	0		Y	Y	–	–
60VTS	1	1		Y	Y	–	–
67	1	1		Y	Y	–	–
67G	1	1		–	Y	–	Y
67GI	1	1		–	Y	–	Y
67GS	1	1		–	Y	–	Y
67N	1	1		Y	Y	–	–
74CCS[12]	3	3		–	–	–	–
74TCS[12]	3	3		–	–	–	–
78VS	2	1		–	Y	–	–
79	1	0		–	–	–	–
81	6	2		–	Y	–	–
81HB2 [13]	1	1		Y	–	–	–
81R	6	2		–	Y	–	–
87GH	1	1		–	–	–	Y
87NL	1	0		Y	–	–	Y

Default Function Template

The **Default Function Template** is the functionality included in the device when delivered from the factory.

The RM2 settings tool is used to add or remove **Function Groups** and **Function Elements** from the **Default Function** template. Customization of the **Default Template** is typically carried out during the engineering or installation phase of the project, prior to commissioning of the device.

The device has a capacity limit for the maximum number of functions that can be added into the device configuration. A capacity bar is visible in RM2 function configuration tool which will increase and decrease when functions are added and removed. The tools will indicate when the capacity is exceeded and prevent the user from saving. A meter is provided in the device information on the fascia to display the configuration capacity as a percentage of total user capacity.

Using the **RM2 > Tasks > Device Functionality** feature.

Default RM2 function templates are offered for selection automatically when a new device is created in RM2.

12

13

Custom Function Template

To ensure that the device functionality is viewed clearly and to facilitate parameterization it is recommended that the user compiles a customized function template (CFT) in the RM2 tool.

The CFT need only include the functionality that will be used by the application and typically includes only a part of the total functionality available in the device.

Optimization of the CFT will provide a clear minimized device/user interface.

All required function elements are selected from the Reydisp device **`Function Template`**.

When a function is initially installed the default settings of that function are applied.

4.3 Function Configuration

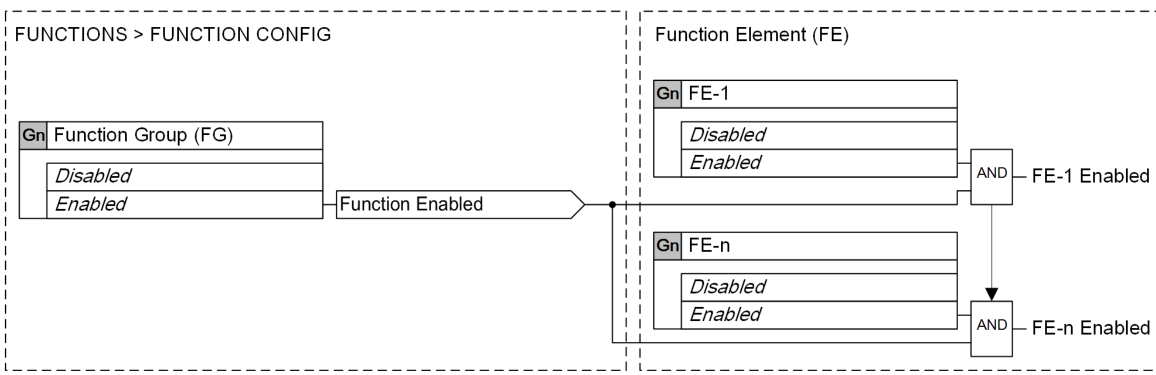
4.3.1 Overview of the Function

Each installed function group (FG) in the device can be enabled or disabled in this menu. All available function elements (FE) for the relevant FG can also be individually enabled or disabled from within the specific FE settings group.

4.3.2 Structure of the Function

The **`Function Config`** has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

4.3.3 Logic of the Function



[lo_7SR5_FunctionConfigurationlogicdiagram, 2, en_US]

Figure 4-1 Logic Diagram: Function Group and Function Element Enable/Disable

4.3.4 Application and Setting Notes

- Parameter: **`Function Enable/Disable`**
  Default setting: **`Disabled`**
  When set to disabled all instances of the relevent function element are disabled. When set to enabled the individual instances of the function elements can be enabled – see individual function described in sections 5, 6, and 7.

4.3.5 Settings Menu

Settings > Functions > Function Config						
Function Group	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
21LB Load blinder	Enabled Disabled	Disabled				
25 Check Sync	Enabled Disabled	Disabled				
27 Undervoltage	Enabled Disabled	Disabled				

Settings > Functions > Function Config						
Function Group	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
27Vx Undervoltage	Enabled Disabled	Disabled				
32 Power	Enabled Disabled	Disabled				
37 Undercurrent	Enabled Disabled	Disabled				
46 NPS overcurrent	Enabled Disabled	Disabled				
46BC Broken conductor	Enabled Disabled	Disabled				
47 Sequence voltage	Enabled Disabled	Disabled				
49 Thermal overload	Enabled Disabled	Disabled				
50 Overcurrent	Enabled Disabled	Disabled				
50AFD Arc flash	Enabled Disabled	Disabled				
50BF CB fail	Enabled Disabled	Disabled				
50G Earth fault	Enabled Disabled	Disabled				
50GI Intermittent earth fault	Enabled Disabled	Disabled				
50GS Sensitive EF	Enabled Disabled	Disabled				
50N Earth fault	Enabled Disabled	Disabled				
51 Overcurrent	Enabled Disabled	Disabled				
51CL Cold Load	Enabled Disabled	Disabled				
51G Earth fault	Enabled Disabled	Disabled				
51GS Sensitive EF	Enabled Disabled	Disabled				
51N Earth fault	Enabled Disabled	Disabled				
51V Voltage OC	Enabled Disabled	Disabled				
52 CB control	Enabled Disabled	Disabled				
55 Power factor	Enabled Disabled	Disabled				
59 Overvoltage	Enabled Disabled	Disabled				

Settings > Functions > Function Config						
Function Group	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
59N Overvoltage	Enabled Disabled	Disabled				
59Vx Overvoltage	Enabled Disabled	Disabled				
60CTS CT Supervision	Enabled Disabled	Disabled				
60CTS-V	Enabled Disabled	Disabled				
60VTS	Enabled Disabled	Disabled				
74CCS Close circuit	Enabled Disabled	Disabled				
74TCS Trip circuit	Enabled Disabled	Disabled				
78VS Vector shift	Enabled Disabled	Disabled				
79 Auto reclosing	Enabled Disabled	Disabled				
81 Frequency	Enabled Disabled	Disabled				
81HB2 Inrush	Enabled Disabled	Disabled				
81R Frequency df/dt	Enabled Disabled	Disabled				
87GH Restricted EF	Enabled Disabled	Disabled				
CB Counters	Enabled Disabled	Disabled				
I^2t CB Wear	Enabled Disabled	Disabled				

4.3.6 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 103	DNP3	MODBUS RTU

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the `Export Report` feature in the Reydisp Manager tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5 Protection and Automation Functions

5.1 21LB Load Blinder

5.1.1 Overview of Function

Load blinders are used with directional overcurrent protection elements to block tripping during sustained heavy reverse load current flow in distribution networks. The reverse current flow can be caused by the generation balance moving from the primary generating centers to distributed MV generation sources.

Distributed generation can cause power flow in reverse direction to normal system operation. Load impedance blinders are used to block overcurrent operation for reverse load current flow.

The load blinder is an impedance characteristic element with a minimum impedance level and operate angle limits and is conveniently illustrated using a R – X plane diagram.

5.1.2 Structure of the Function

The load blinder function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

The function monitors the primary system impedances using the 3 phase CT inputs e.g. CT1/2/3 and 3 phase VT inputs e.g. VT1/2/3. The function is parameterized to block operation of the overcurrent protection during reverse load current flow, but not to block the protection for fault currents in the operate direction.

The function has both single phase and 3 phase modes of operation.

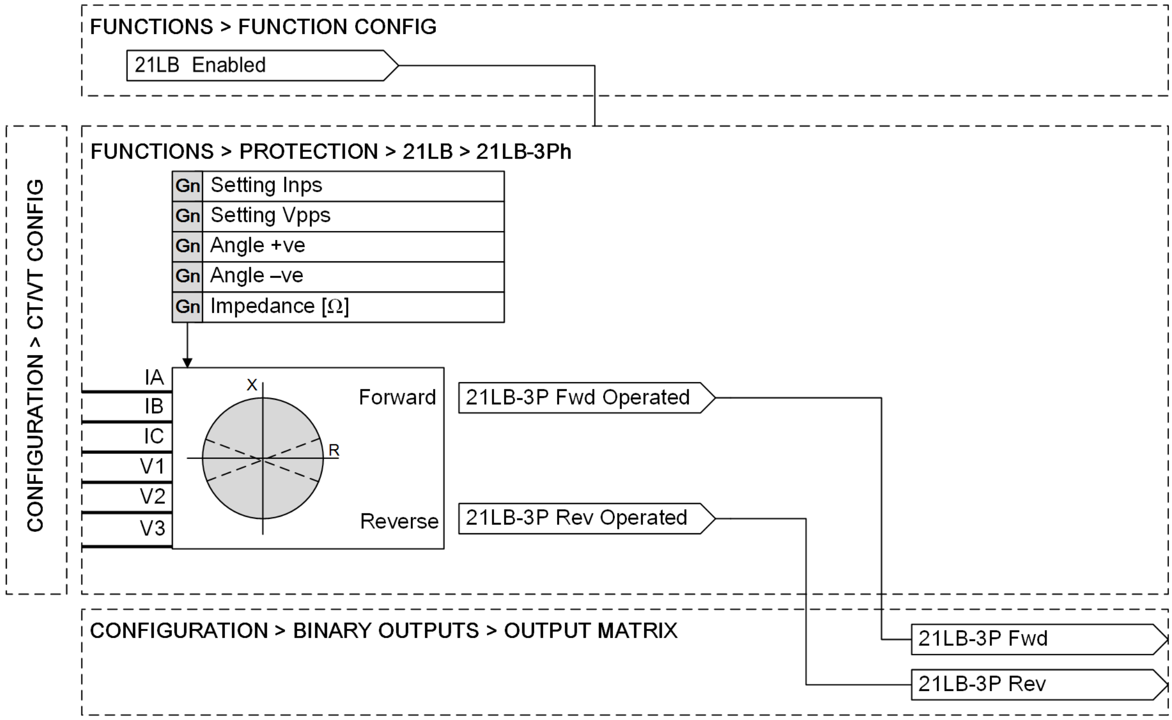
Operation of 3 phase mode can be selected to inhibit operation of the overcurrent function elements (50 and 51).

The single-phase mode is phase segregated and blocks the individual phases of the time delayed overcurrent function elements (51).

5.1.3 Logic of the Function

A 3-phase overcurrent blocking signal can only be issued when:

- Positive phase sequence voltage PPS (V_1) is above setting, and
- Negative phase sequence current NPS (I_2) is below setting, and
- Measured impedance (Z) is above setting,
- Measured impedance (Z) is within angular limits.

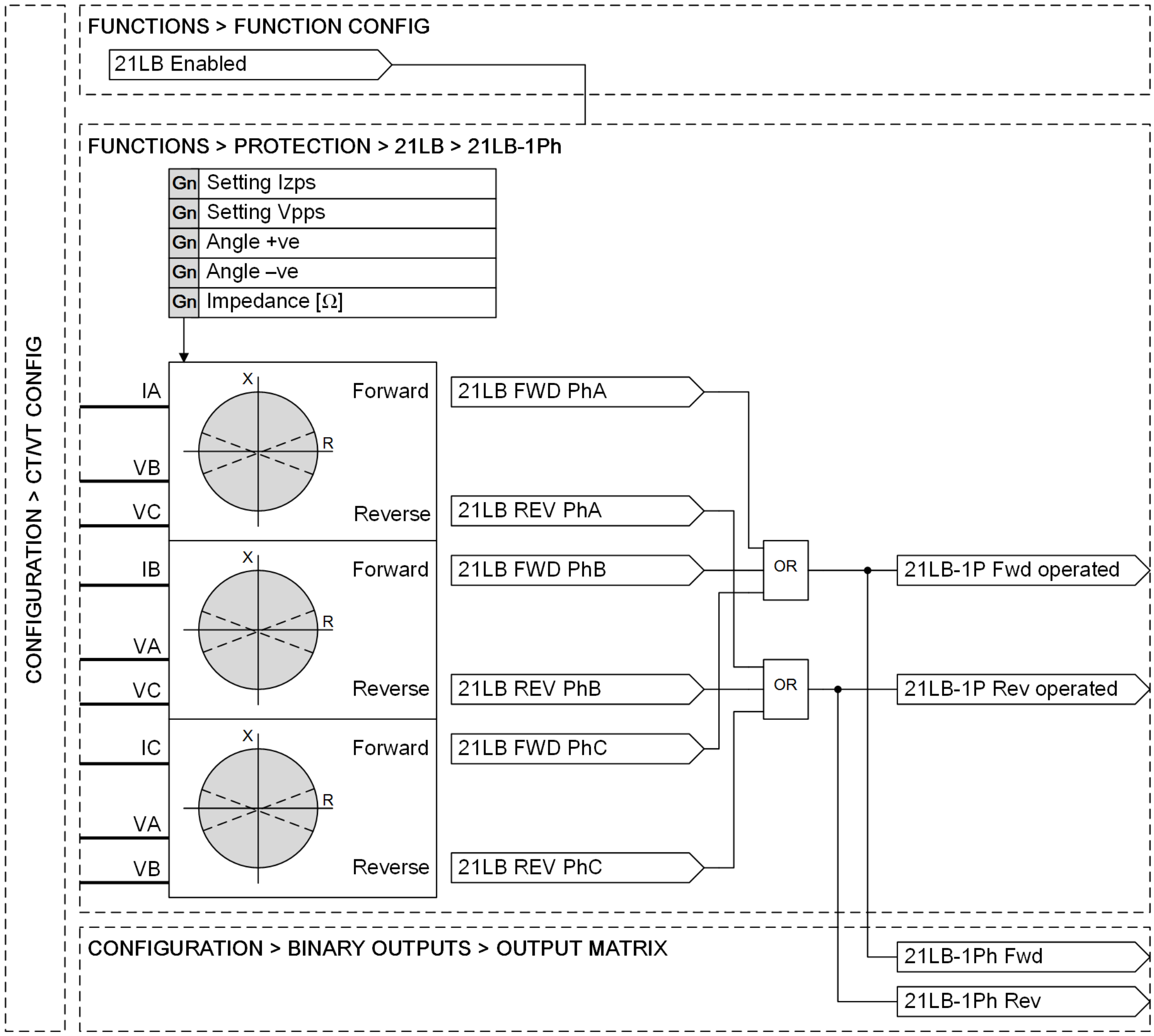


[lo_7SR5_21logicdiagramthreephase, 1, en_US]

Figure 5-1 Logic Diagram: 21LB Load Blinder 3-Phase

A single phase overcurrent blocking signal can only be issued when:

- Positive phase sequence voltage PPS (V_1) is above setting, and
- Zero phase sequence current ZPS (I_0) is below setting, and
- Measured impedance (Z) is above setting,
- Measured impedance (Z) is within angular limits.



[lo_7SR5_21logicdiagramsinglephase, 2, en_US]

Figure 5-2 Logic Diagram: 21LB Load Blinder Single Phase

5.1.4 Application and Setting Notes

Parameter: **1Ph > I_{zps} Setting**

- Default setting: **0.5 x I_n** (0.5 · I_{rated})

  This setting for the secondary zero phase sequence current determines whether the system current distributions are within normal operating limits e.g. flow of earth current is indicated by an increased zero phase sequence current (I_0). Operation of the 21LB function will be blocked for values of I_0 above this setting.

Parameter: **1Ph > V_{pps} Setting**

- Default setting: **50 V**

  This setting for the secondary positive phase sequence voltage determines whether the system voltage is within normal operating limits e.g. flow of fault current may be coincident with reduced positive phase sequence voltage (V_1) and increased negative phase sequence voltage (V_2). Operation of the 21LB function will be blocked for values of V_1 below this setting.

Parameter: **`1Ph > Angle +ve`**

- Default setting: **`20°`**
  Reverse load current flow will have a relatively high power factor in comparison to reverse fault current flow. This setting defines the positive pickup angle for the 21LB function i.e. the function will not operate for angular measurement above this setting.

Parameter: **`1Ph > Angle -ve`**

- Default setting: **`20°`**
  Reverse load current flow will have a relatively high power factor in comparison to reverse fault current flow. This setting defines the positive pickup angle for the 21LB function i.e. the function will not operate for angular measurement above this setting.

Parameter: **`1Ph > Impedance`**

- Default setting: **`10 Ω`**
  The secondary positive phase sequence impedance and defines the lowest level of 21LB pickup.

Parameter: **3Ph > I_{nps} Setting**

- Default setting: **0.5 x I_n** ($0.5 \cdot I_{rated}$)
  This setting for the secondary negative phase sequence current determines whether the system current distributions are within normal operating limits e.g. flow of unbalanced fault is indicated by an increased negative phase sequence current (I_2). Operation of the 21LB function will be blocked for values of I_2 above this setting.

Parameter: **3Ph > V_{pps} Setting**

- Default setting: **`50 V`**
  This setting for the secondary positive phase sequence voltage determines whether the system voltage is within normal operating limits e.g. flow of fault current may be coincident with reduced positive phase sequence voltage (V_1) and increased negative phase sequence voltage (V_2). Operation of the 21LB function will be blocked for values of V_1 below this setting.

Parameter: **`3Ph > Angle +ve`**

- Default setting: **`20°`**
  Reverse load current flow will have a relatively high power factor in comparison to reverse fault current flow, this setting defines the positive pickup angle for the 21LB function i.e. the function will not operate for angular measurement above this setting.

Parameter: **`3Ph > Angle -ve`**

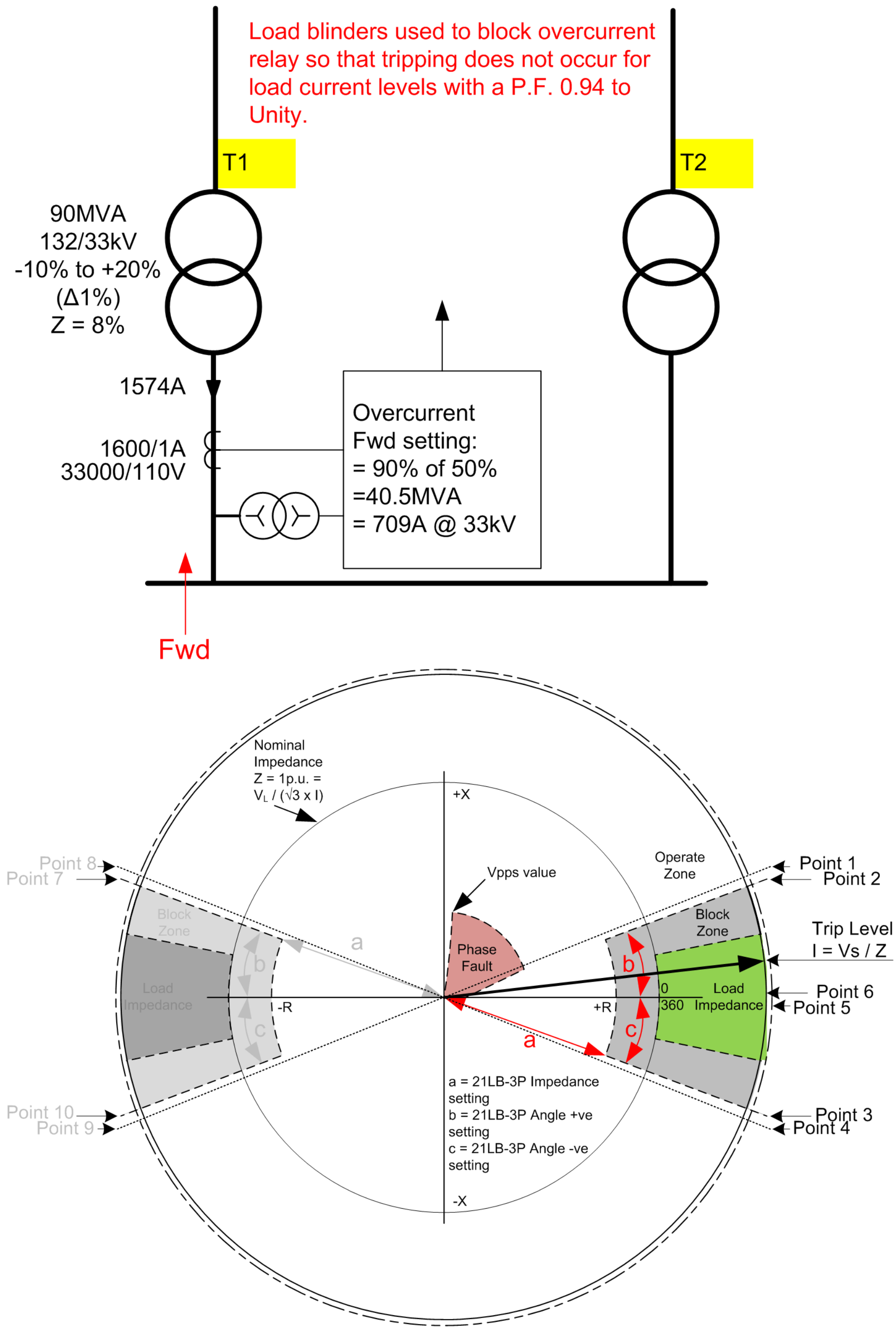
- Default setting: **`20°`**
  Reverse load current flow will have a relatively high power factor in comparison to reverse fault current flow. This setting defines the positive pickup angle for the 21LB function i.e. the function will not operate for angular measurement above this setting.

Parameter: **`3Ph > Impedance`**

- Default setting: **`10 Ω`**
  The secondary positive phase sequence impedance and defines the lowest level of 21LB pickup.

Settings Example

The 3-phase load blinders (21LB-3P) are required to block the directional overcurrent relay so that tripping is inhibited for reverse load current with a power factor greater than 0.94.



[dw_7SR5_function21LBsettingsexample, 1, en_US]

21LB-3P Impedance Setting ('a')

This is the minimum system impedance that allows operation of the load blinder; it is set in secondary Ω. To enable blocking of the overcurrent element for values of current up to say 1.5 times the nominal load current value (to allow for temporary reverse overload conditions) the setting is calculated from:

$$Z_{sec} = \frac{V_{rated,sec}}{\sqrt{3} \cdot I_{sec}} = \frac{110}{\sqrt{3} \cdot 1.5} = 42\ \Omega$$

[fo_function21LBimpedancesetting1, 1, en_US]

NOTE

The equivalent primary impedance to the above:

$$Z_{prim} = Z_{sec} \cdot \frac{I_{rated,sec}}{I_{rated,prim}} \cdot \frac{V_{rated,prim}}{V_{rated,sec}} = 42 \cdot \frac{1}{1600} \cdot \frac{33000}{110} = 7.88\ \Omega$$

Where:

$I_{rated,prim}$ = CT primary rating (A)

$I_{rated,sec}$ = CT secondary rating (A)

I_{sec} = Secondary current = 1.5 · $I_{rated,sec}$ (e.g. nominated max. reverse load current)

$V_{rated,prim}$ = VT primary rating (phase-phase V)

$V_{rated,sec}$ = VT secondary rating (phase-phase V)

Z_{prim} = Primary impedance

Z_{sec} = Secondary impedance

21LB-3P Angle (+ve and -ve) Setting ('b' and 'c')

A setting of 20 degrees will allow blocking of the overcurrent element for system load power factors between 0.94 and unity.

21LB-3P V_{pps} Setting

The blinder is only operational during normal load levels of reverse load flow. Where reverse current flow is caused by a system fault the positive sequence voltage will reduce significantly. To facilitate load blinder operation the system should be substantially balanced i.e. positive phase sequence voltage will be high. A setting of 0.95 V_{rated} is selected i.e. 21LB-V_1 setting = 0.95 · 63.5 = 60 V.

21LB-3P I_{nps} Setting

The blinder is only operational during normal load levels of reverse load flow. The system should be substantially balanced i.e negative phase sequence current will be low. A 21LB-3P I_2 setting = 0.05 I_{rated} is selected.

5.1.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
21LB Load Blinder	Enabled Disabled	Disabled				

Functions > Protection > 21LB > Gn 1Ph						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
I_{zps} Setting	0.05 to 1 · I_{rated}, Δ 0.05 1.5 to 5 · I_{rated}, Δ 0.5	0.5 · I_{rated}				
V_{pps} Setting	1 to 110 V, Δ 0.5 V	50.0 V				
Angle +ve	5 to 85°, Δ 1°	20°				
Angle -ve	5 to 85°, Δ 1°	20°				
Impedance	1 to 50 Ω, Δ 0.1 Ω	10 Ω				

Functions > Protection > 21LB > Gn 3Ph						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
I_{nps} Setting	0.05 to 1 · I_{rated}, Δ 0.05 1.5 to 5 · I_{rated}, Δ 0.5	0.5 · I_{rated}				
V_{pps} Setting	1 to 110 V, Δ 0.5 V	50.0 V				
Angle +ve	5 to 85°, Δ 1°	20°				
Angle -ve	5 to 85°, Δ 1°	20°				
Impedance	1 to 50 Ω, Δ 0.1 Ω	10 Ω				

5.1.6 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 103	DNP3	MODBUS RTU
21LB-3Ph Fwd		21LB-3Ph Fwd Operated	Output	✓	✓	✓
21LB-3Ph Rev		21LB-3Ph Rev Operated	Output	✓	✓	✓
21LB-1Ph Fwd		21LB-1Ph Fwd Operated	Output	✓	✓	✓
21LB-1Ph Rev		21LB-1Ph Rev Operated	Output	✓	✓	✓

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.2 27 Undervoltage Protection – 3-Phase

5.2.1 Overview of Function

3 phase undervoltage protection is used to:

- Monitor the permissible voltage range and provide alarms for values below normal limits.
- Decouple or reconfigure changeover systems when loss of supply is detected.
- To selectively disconnect loads (load shedding) to match generation capacity following a loss of generation which can be detected by undervoltage.

Undervoltages are typically caused by loss of generation, overload of lines or removal of lines from service, voltage controller failure at the transformer and error during control operations.

5.2.2 Structure of the Function

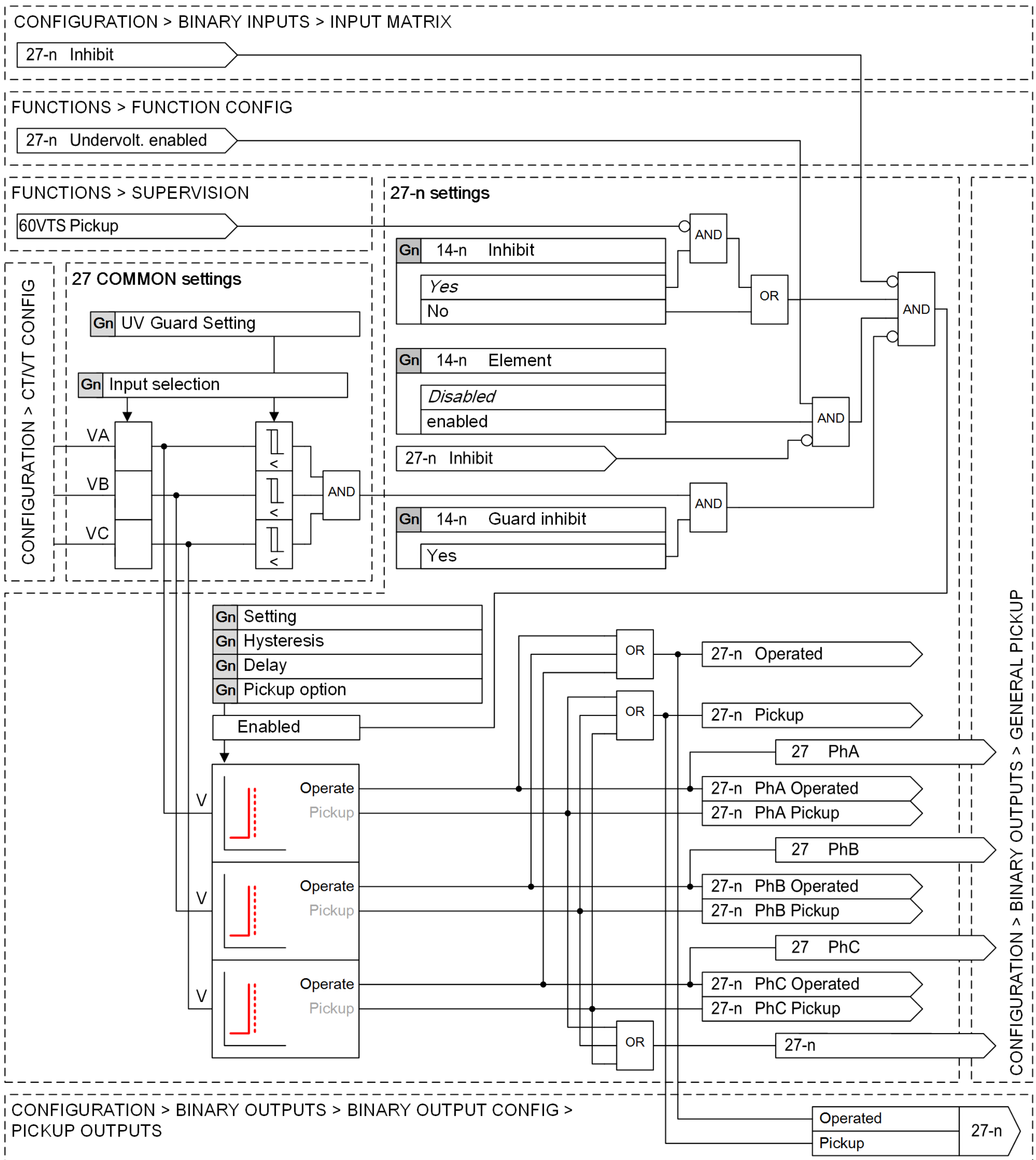
The 3 phase undervoltage function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A27PTUV*** in IEC 61850.

The function monitors the primary system using the 3 phase voltage inputs e.g. VT1/2/3. The fundamental frequency component is measured from processing of the measured voltage samples.

- A definite time delayed operate characteristic is used. Settings are provided for operate (pickup) threshold voltage, reset voltage level (hysteresis/drop-off) and time delay.
- Outputs are provided for pickup and operation.

5.2.3 Logic of the Function



[lo_7SR5_27logicdiagram, 2, en_US]

Figure 5-3 Logic Diagram: 27 Undervoltage Protection – 3 Phase

5.2.4 Application and Setting Notes

Parameter: **27 Common > Input Selection**

- Default setting: **ph-ph**

  This parameter defines whether the undervoltage protection function operates on phase-neutral voltages VA, VB, and VC or phase-phase voltages VAB, VBC, and VCA and is applied to all elements of this function type.

Parameter Value	Description
Ph-Ph	Where required to monitor the load under voltage conditions the phase to phase value is appropriate.
Ph-N	This setting may be considered where single phase loads are connected.

Parameter: **27 Common > UV Guard Setting**

- Default setting: **5 V**

  When the measured voltage of all inputs is below this setting operation of the 27 function elements can be blocked.

Parameter: **Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on or off if it is not required.

Parameter: **Pick-Up Option**

- Default setting: **Any**

  This setting defines whether the element picks up if the required voltage conditions are detected on any 1 phase **Any** or if they must be detected on all 3 phases **All**.

Parameter Value	Description
Any	This setting will allow detection during unbalanced voltage conditions and will operate for the worst phase. This is the appropriate setting for most applications.
All	This setting is commonly used when the element is used to detect loss of supply or for extra immunity from unbalance deviations.

Parameter: **Setting**

- Default setting: **80 V**

  This is the operating voltage threshold of the element, the element will pickup if the voltage falls below this value. This should be set to suit the individual application.

Parameter: **Hysteresis**

- Default setting: **3 %**

  This sets the drop-off threshold for the undervoltage element. The element will pickup if the voltage falls below the setting and will reset when the voltage recovers to the setting + hysteresis voltage. This setting is a percentage of the undervoltage setting.

  The default setting of 3 % is generally enough to avoid chatter of the element but care may be required for settings which are close to the nominal value otherwise the element may not reset when the voltage recovers to nominal value as the voltage is still in the hysteresis window.

Parameter: **Delay**

- Default setting: **0.1 s**

  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Parameter: **UV Guard Inhibit**

- Default setting: **Yes**

  This setting selects whether operation is blocked for measured voltages below setting. This is typically used to avoid nuisance operations whenever the circuit is de-energized. It is recommended that this setting is used unless the element is being applied as dead line or loss of supply detection.

Parameter: **VTS Inhibit**

- Default setting: **No**

  This setting defines the effect of a voltage transformer failure on the operation of each 27 element. If a VT failure is detected by the separate VTS element, the element will be automatically blocked if this setting is set to **Yes**. If this setting is set to **No**, the 27-n element will be unaffected by the VTS element operation and the 27-n element may operate on the erroneous voltage caused by the VT fuse failure which has been correctly identified by VTS. It is generally recommended that using the VTS Inhibit function is beneficial.

Settings Example

2-Stage Undervoltage Protection

This example shows settings that could be applied for a 2-stage undervoltage protection application.

Settings are applied to detect a condition of 10 % reduction in supply voltage compared to nominal as a standing level which may indicate a voltage control failure but also detects a 30 % reduction in voltage between any phases more quickly to allow remedial actions such as a supply changeover. The actions should not be initiated for a loss of supply which could result from a grid supply trip which is assumed to be handled separately. This example considers device settings for the 27 elements but does not cover I/O mappings and tripping logic.

- First stage

  To detect a -10 % deviation in the voltage compared to the expected 110 V phase to phase secondary nominal voltage allowing for a voltage controller which would be expected to correct this deviation in less than 2 seconds.

  Threshold = 110 · 0.9 = 99 V

  Time delay must be greater than 2 seconds. Choose 3 s.

  Choose a suitable element: 27-1

- Second stage

  To detect a -30 % deviation in the voltage compared to the expected 110 V phase to phase secondary nominal voltage allowing only for transient conditions and fault clearance and meeting the customers' expectations for supply changeover which will allow 1000 ms.

  Threshold = 110 · 0.7 = 77 V

  Time delay specified as 1000 ms.

  Choose a suitable element: 27-2

- Immunity to Loss of Supply

  Set UV guard to a low level that would not be expected unless the system is dead. Choose 5 V.

- Immunity to VT Fail

  Both of these elements will be affected by VT failure if these settings are applied but a 3 phase VT fail which would be required to affect the first stage may be less likely. In many cases it is preferable to inhibit the voltage protection.

- Any/All phases

  The voltage control will operate on all 3 phases and the failure will result in voltage reduction on all 3 phases. The first stage should be set to operate on **All** phases. The second stage must operate for undervoltage on **Any** phase.

Element	Setting Values	
27 Common	Input Selection	Ph-Ph
27 Common	UV Guard Setting	5 V
27-1	Element	Enabled
27-1	Setting	99 V
27-1	Hysteresis	3 %
27-1	Delay	3 s
27-1	U/V Guarded	Yes
27-1	VTS Inhibit	Yes
27-1	O/P Phases	All
27-2	Element	Enabled
27-2	Setting	77 V
27-2	Hysteresis	3 %
27-2	Delay	1 s
27-2	UV Guarded	Yes
27-2	VTS Inhibit	Yes
27-2	O/P Phases	All

5.2.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
27 Undervoltage	Enabled Disabled	Disabled				

Functions > Protection > 27 > Gn 27 Common						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Input Selection	Ph-Ph Ph-N	Ph-Ph				
UV Guard Setting	1 to 200 V, Δ 0.5 V	5 V				

Functions > Protection > 27 > Gn 27-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	5 to 200 V, Δ 0.5 V	80 V				
Hysteresis	0 to 80 %, Δ 0.1 %	3 %				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0.1 s				
VTS Inhibit	No Yes	No				

Functions > Protection > 27 > Gn 27-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
UV Guard Inhibit	No Yes	Yes				
Pickup Option	Any All	Any				

5.2.6 IEC 61850 Functional Information Mapping

A27PTUV*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A27PTUV*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A27PTUV*.Mod

Information					
27 Undervoltage Enabled (Function Config)	0	x	1	1	1
Element Inhibited	x	x	x	0	1
UV Guard Operated	x	x	1	0	x
27-n Element Disabled	x	1	0	0	0
A27PTUV*.Mod.stVal	**5**	**5**	**2**	**1**	**2**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A27PTUV*.Health

Information		
Device Healthy	0	1
A27PTUV*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A27PTUV*.Op

Information		
27-n Operated	0	1
A27PTUV*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A27PTUV*.Str

Information		
27-n Pickup	0	1
A27PTUV*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

5.2.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 27-n		Inhibit 27-n	Input			
27 PhA		27-n PhA Operated	Output	Y	Y	Y
27 PhB		27-n PhB Operated	Output	Y	Y	Y
27 PhC		27-n PhC Operated	Output	Y	Y	Y
27-n		27-n Operated	Output	Y	Y	Y
		27-n PhA Pickup	Output			
		27-n PhB Pickup	Output			
		27-n PhC Pickup	Output			
	27-n Pickup	27-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.3 27Vx Undervoltage Protection – Vx

5.3.1 Overview of Function

Single phase undervoltage protection is used to:

- Monitor the permissible voltage range and provide alarms for values outside of normal limits by monitoring any single phase connection point. This function is entirely independent from the 3 phase voltage inputs.
- Decouple or reconfigure changeover systems when loss of supply is detected.
- To selectively disconnect loads (load shedding) to match generation capacity following a loss of generation which can be detected by undervoltage.

Undervoltages are typically caused by loss of generation, overload of lines or removal of lines from service, voltage controller failure at the transformer and error during control operations.

5.3.2 Structure of the Function

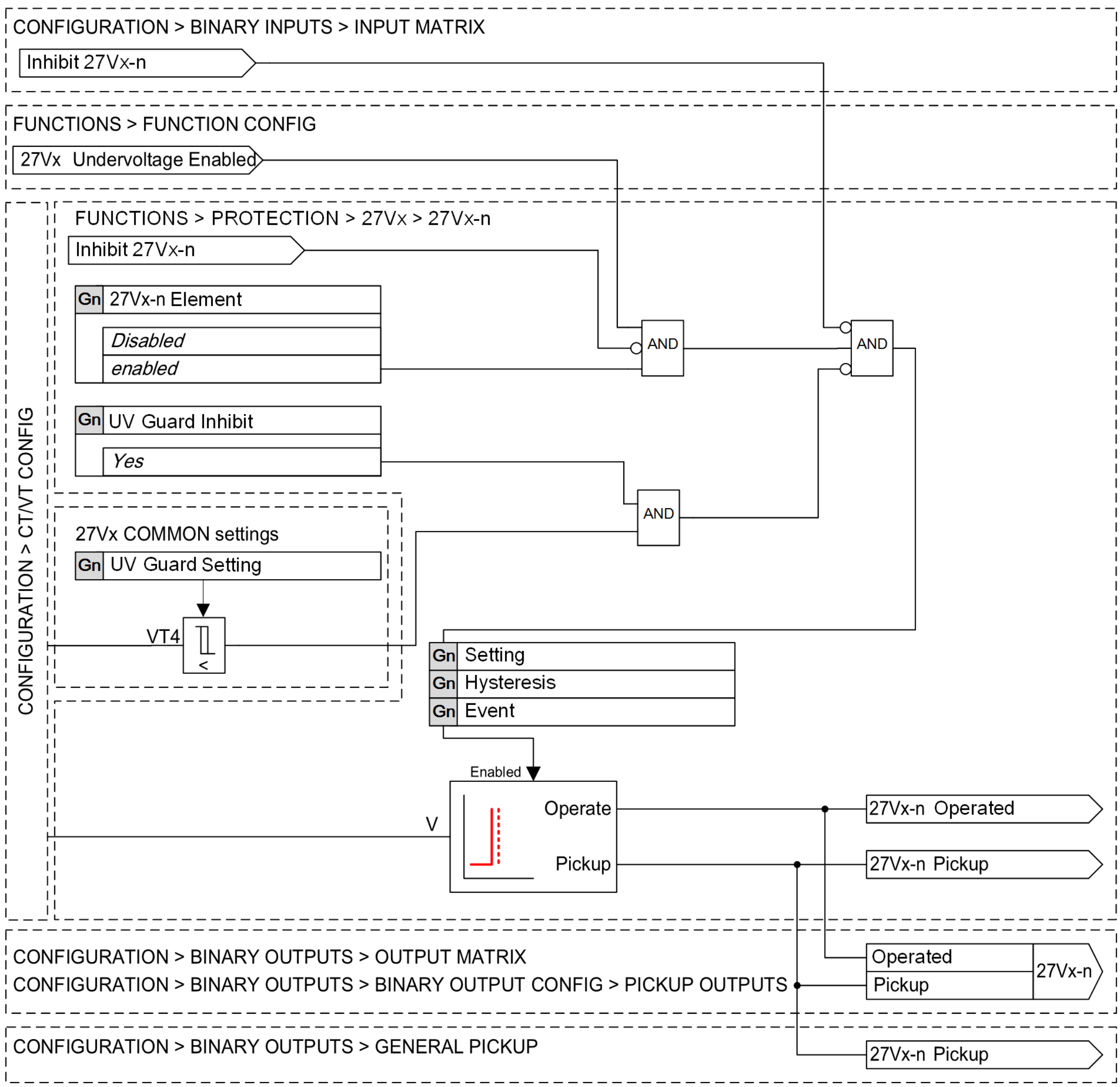
The single phase undervoltage function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **`A27VxPTUV*`** in IEC 61850.

The function monitors the primary system using the single phase VT input e.g. VT4. The fundamental frequency component is measured from processing of the measured voltage samples.

- A definite time delayed operate characteristic is used. Settings are provided for operate (pickup) threshold voltage, reset voltage level (hysteresis/drop-off) and time delay.
- Outputs are provided for pickup and operation.

5.3.3 Logic of the Function



[lo_7SR5_27Vxlogicdiagram, 2, en_US]

Figure 5-4 Logic Diagram: 27Vx Undervoltage Protection – Vx

5.3.4 Application and Setting Notes

Parameter: **27Vx Common > UV Guard Setting**

- Default setting: **5 V**
  When the measured voltage is below this setting operation of the 27Vx function elements can be blocked.

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These settings can be used to select the number of elements required.

Parameter: **Setting**

- Default setting: **80 V**
  This is the operating voltage threshold of the element. The element will pickup if the voltage falls below this value. This should be set to suit the individual application.

Parameter: **Hysteresis**

- Default setting: **3 %**
  This sets the drop-off threshold for the undervoltage element. The element will pickup if the voltage falls below the setting and will reset when the voltage recovers to the setting + hysteresis voltage. This setting is a percentage of the undervoltage setting.
  The default setting of 3 % is generally enough to avoid chatter of the element but care may be required for settings which are close to the nominal value otherwise the element may not reset when the voltage recovers to nominal value as the voltage is still in the hysteresis window.

Parameter: **Delay**

- Default setting: **0.1 s**
  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Parameter: **UV Guard Inhibit**

- Default setting: **Yes**
  This setting selects whether operation is blocked for measured voltages below setting.

Settings Example

2-stage undervoltage protection

This example shows settings that could be applied for a 2-stage undervoltage protection application.

This example applies settings to detect a condition of 10 % reduction in supply voltage compared to nominal as a standing level which may indicate a voltage control failure but also detects a 30 % reduction in voltage between any phases more quickly to allow remedial actions such as a supply changeover. The actions should not be initiated for a loss of supply which could result from a grid supply trip which is assumed to be handled separately. This example considers device settings for the 27Vx elements but does not cover I/O mappings and tripping logic.

- First stage
  To detect a -10 % deviation in the voltage compared to the expected 110 V phase to phase secondary nominal voltage allowing for a voltage controller which would be expected to correct this deviation in less than 2 seconds.
  Threshold = 110 · 0.9 = 99 V
  Time delay must be greater than 2 seconds. Choose 3 s.
  Choose a suitable element: 27Vx-1
- Second stage
  To detect a -30 % deviation in the voltage compared to the expected 110 V phase to phase secondary nominal voltage allowing only for transient conditions and fault clearance and meeting the customers' expectations for supply changeover which will allow 1000 ms.
  Threshold = 110 · 0.7 = 77 V
  Time delay specified as 1000 ms.
  Choose a suitable element: 27Vx-2
- Immunity to Loss of Supply
  Set UV guard to a low level that would not be expected unless the system is dead. Choose 5 V.

- Immunity to VT Fail

  Both of these elements will be affected by VT failure if these settings are applied but a 3 phase VT fail which would be required to affect the first stage may be less likely. In many cases it is preferable to inhibit the voltage protection.

- Any/All phases

  The voltage control will operate on all 3 phases and the failure will result in voltage reduction on all 3 phases. The first stage should be set to operate on `All` phases. The second stage must operate for undervoltage on `Any` phase.

Element	Setting Values	
27Vx Common	UV Guard Setting	5 V
27Vx-1	Element	Enabled
27Vx-1	Setting	99 V
27Vx-1	Hysteresis	3 %
27Vx-1	Delay	3 s
27Vx-1	UV Guarded	Yes
27Vx-2	Element	Enabled
27Vx-2	Setting	77 V
27Vx-2	Hysteresis	3 %
27Vx-2	Delay	1 s
27Vx-2	UV Guarded	Yes

5.3.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
27Vx Undervoltage	Enabled Disabled	Disabled				

Functions > Protection > 27Vx > Gn 27Vx Common						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
UV Guard Setting	1 to 200 V, Δ 0.5 V	5 V				

Functions > Protection > 27Vx > Gn 27Vx-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	5 to 200 V, Δ 0.5 V	80 V				
Hysteresis	0 to 80 %, Δ 0.1 %	3 %				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0.1 s				
UV Guard Inhibit	No Yes	Yes				

5.3.6 IEC 61850 Functional Information Mapping

A27VxPTUV*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A27VxPTUV*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A27VxPTUV*.Mod

Information				
27Vx Undervoltage Enabled (Function Config)	x	0	x	1
Element Disabled	1	0	0	0
Element Inhibited	x	x	1	0
A27VxPTUV*.Mod.stVal	**5**	**2**	**2**	

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A27VxPTUV*.Health

Information		
Device Healthy	0	1
A27VxPTUV*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A27VxPTUV*.Op

Information		
Element Operated	0	1
A27VxPTUV*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A27VxPTUV*.Str

Information		
Element picked up	0	1
A27VxPTUV*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.3.7 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Inhibit 27Vx-n		Inhibit 27Vx-n	Input			
27Vx-n		27Vx-n Operated	Output	Y	Y	Y
	27Vx-n Pickup	27Vx-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.4 32 Power Protection

5.4.1 Overview of Function

Power protection is used to:

- Detect whether the active, reactive or apparent power rises above or drops below a set threshold
- Monitor agreed power levels and limits and provide output status indications
- Detect both active and reactive power levels in the power systems or on electric machines
- Detect loss of motor load and initiate shutdown
- Detect low output or active power consumption from embedded generation and initiate disconnection from the power system. Generator no-load operation e.g. overspeed or plant operating characteristics must be considered

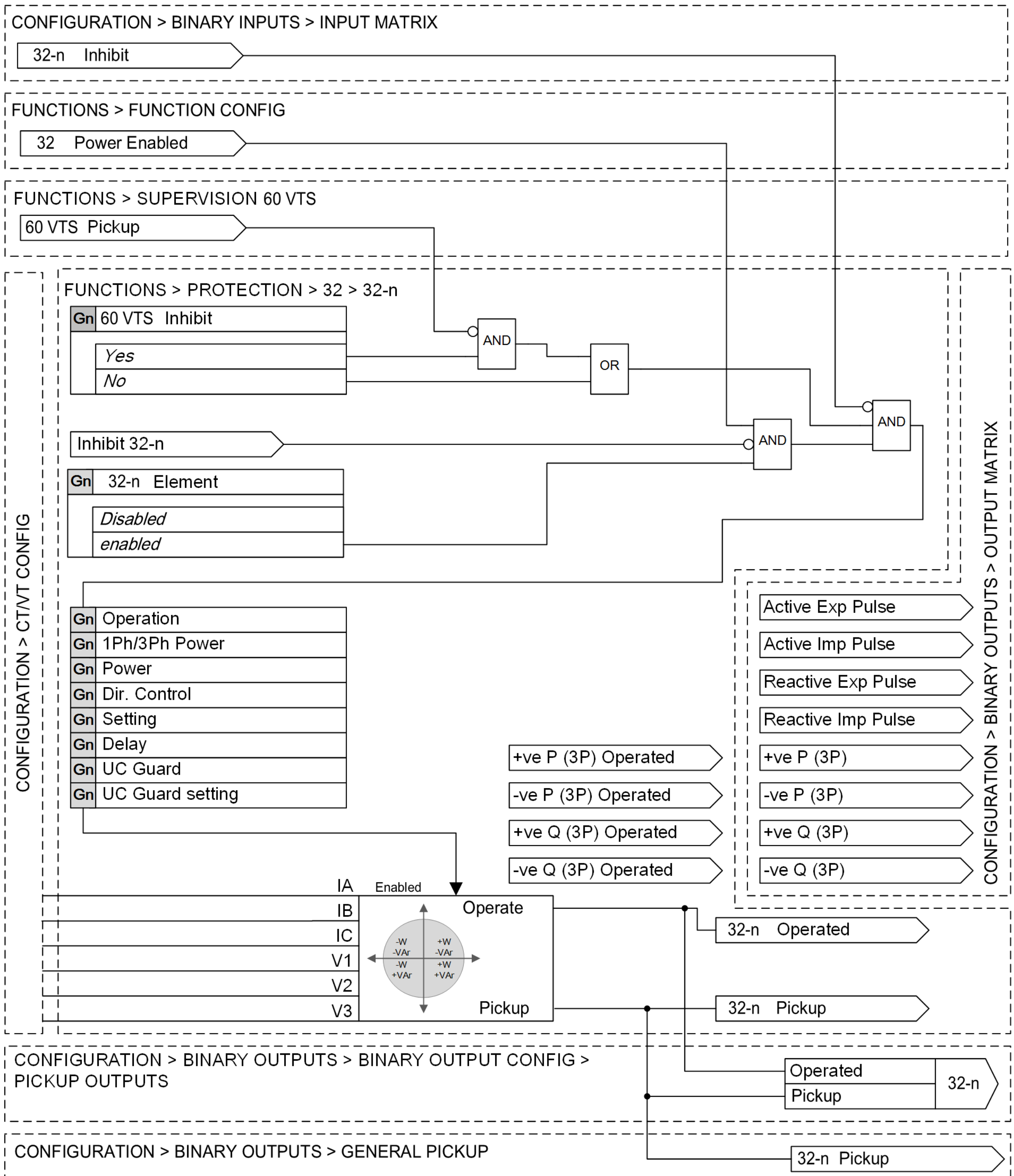
5.4.2 Structure of the Function

The power protection function elements have group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A32PDOP*** and **A32PDUP*** in IEC 61850.

The function monitors the primary system using the 3 phase current inputs e.g. CT1/2/3 and 3 phase VT inputs e.g. VT1/2/3. Function operation is selected to single phase or 3 phase power measurements.

5.4.3 Logic of the Function



[lo_7SR5_32logicdiagram, 2, en_US]

Figure 5-5 Logic Diagram: 32 Power Protection

5.4.4 Application and Setting Notes

Parameter: **`Operation`**

- Default setting: **`Over`**
  Each element can be individually set to operate when the power is above or below the setting.

Parameter: **1Ph/3Ph Power**

- Default setting: **3Ph**
  The setting can be applied as a single phase or 3 phase power level. The nameplate rating of 3 phase plant (e.g. motors and transformers) is usually the 3 phase rating.

Parameter: **Power (Measurement)**

- Default setting: **Real**
  This parameter is used to specify the measured power type real power (P), reactive power (Q) or apparent power (S).

Parameter: **Dir.Control**

- Default setting: **Non-Dir**
  When set to **Non-Dir** the scalar value of the measured power is compared to the setting value.
  Forward operation refers to positive measured value of:
  $V \cdot I \cdot \cos\theta$ (real power)
  $V \cdot I \cdot \sin\theta$ (reactive power)
  $V \cdot I$ (apparent power)
  Reverse operation refers to negative measured value of the above.

Parameter: **Setting**

- Default setting: **1 x S_n** ($1 \cdot S_{rated}$)
  The setting is input as a multiple of the rated/nominal secondary apparent power (S_{rated}) since all power measurements include the measurement of $V \cdot I$.
  rated (nominal) 3 phase power = $S_{\mathrm{rated}} = \sqrt{3} \cdot V_{\mathrm{L\ rated}} \cdot I_{\mathrm{rated}}$
  Rated/nominal current and voltage values are defined in the CT/VT config menu.

Parameter: **Delay**

- Default setting: **1 s**
  The function has a definite time delayed operate characteristic.

Parameter: **UC Guard**

- Default setting: **Off**

Parameter: **UC Guard Setting**

- Default setting: **0.2 x I_n** ($0.2 \cdot I_{rated}$)
  Power measuring elements can be blocked where all phase currents fall below this setting.

Parameter: **VTS Inhibit**

- Default setting: **No**

Settings Example

Directional power protection is often applied to motor or embedded generator applications to detect loss of load, loss of generation or back feeds. For these applications, Real power may be a more appropriate operating quantity.

Where the power phasor is within the power range (in tripping zone defined by **Power Type**, **Direction** and **Operate Mode**), an output is given.

The setting for all power types is in rated apparent power (S_{rated}), where:

rated (nominal) 3 phase power = $S_{rated} = \sqrt{3} \cdot V_{L\,rated} \cdot I_{rated}$

5.4.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
32 Power	Enabled Disabled	Disabled				

Functions > Protection > 32 > Gn 32-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Operation	Under Over	Over				
1Ph/3Ph Power	1Ph 3Ph	3Ph				
Power	Real (P) Reactive (Q) Apparent (S)	Real				
Dir.Control	Non-Dir Forward Reverse	Non-Dir				
Setting	0.05 to 2 · S_{rated}, Δ 0.01 S_{rated}	1 · S_{rated}				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	1 s				
VTS Inhibit	No Yes	No				
UC Guard	No Yes	No				
UC Guard Setting	0.05 to 1 · I_{rated}, Δ 0.05 I_{rated}	0.2 · I_{rated}				

5.4.6 IEC 61850 Functional Information Mapping

A32PDOP*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x

Information												
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A32PDOP*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A32PDOP*.Mod

Information				
32 Power Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A32PDOP*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A32PDOP*.Health

Information		
Device Healthy	0	1
A32PDOP*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A32PDOP*.Op

Information		
Element Operated	0	1
A32PDOP*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A32PDOP*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A32PDOP*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information												
Element Phase A picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element Phase A picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
Element Phase B picked up and Fwd Direction	x	x	x	0	0	0	0	1	0	1	0	0
Element Phase B picked up and Rev Direction	1	x	1	1	0	1	0	0	0	0	0	0
Element Phase C picked up and Fwd Direction	1	x	x	0	0	0	0	1	1	0	0	0
Element Phase C picked up and Rev Direction	x	1	x	1	1	0	0	0	0	0	0	0
A32PDOP*.Str.dirGeneral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element Phase A picked up	0	1
A32PDOP*.Str.phsA	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase A picked up and Fwd Direction	0	1	0
Element Phase A picked up and Rev Direction	1	0	0
A32PDOP*.Str.dirPhsA	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase B picked up	0	1
A32PDOP*.Str.phsB	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase B picked up and Fwd Direction	0	1	0
Element Phase B picked up and Rev Direction	1	0	0
A32PDOP*.Str.dirPhsB	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase C picked up	0	1
A32PDOP*.Str.phsC	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase C picked up and Fwd Direction	0	1	0
Element Phase C picked up and Rev Direction	1	0	0

Information			
A32PDOP*.Str.dirPhsC	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

A32PDUP*.Mod

Information				
32 Power Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A32PDUP*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A32PDUP*.Health

Information		
Device Healthy	0	1
A32PDUP*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A32PDUP*.Op

Information		
Element Operated	0	1
A32PDUP*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A32PDUP*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A32PDUP*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information												
Element Phase A picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element Phase A picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
Element Phase B picked up and Fwd Direction	x	x	x	0	0	0	0	1	0	1	0	0
Element Phase B picked up and Rev Direction	1	x	1	1	0	1	0	0	0	0	0	0
Element Phase C picked up and Fwd Direction	1	x	x	0	0	0	0	1	1	0	0	0
Element Phase C picked up and Rev Direction	x	1	x	1	1	0	0	0	0	0	0	0
A32PDUP*.Str.dirGen-eral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element Phase A picked up	0	1
A32PDUP*.Str.phsA	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase A picked up and Fwd Direction	0	1	0
Element Phase A picked up and Rev Direction	1	0	0
A32PDUP*.Str.dirPhsA	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase B picked up	0	1
A32PDUP*.Str.phsB	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase B picked up and Fwd Direction	0	1	0
Element Phase B picked up and Rev Direction	1	0	0
A32PDUP*.Str.dirPhsB	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase C picked up	0	1
A32PDUP*.Str.phsC	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase C picked up and Fwd Direction	0	1	0
Element Phase C picked up and Rev Direction	1	0	0
A32PDUP*.Str.dirPhsC	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.4.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 32-n		Inhibit 32-n	Input			
32-n			Output	Y	Y	Y
32-n Operated		32-n Operated	Output			
32-n Pickup	32-n Pickup	32-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.5 37 Undercurrent Protection – Phase

5.5.1 Overview of Functions

Phase undercurrent protection is used to :

- Detect loss of current flow after the primary circuit-breaking device is opened
- Detect the loss of loads e.g. this could indicate loss of cooling capacity
- Detect and protect pumps from running idle

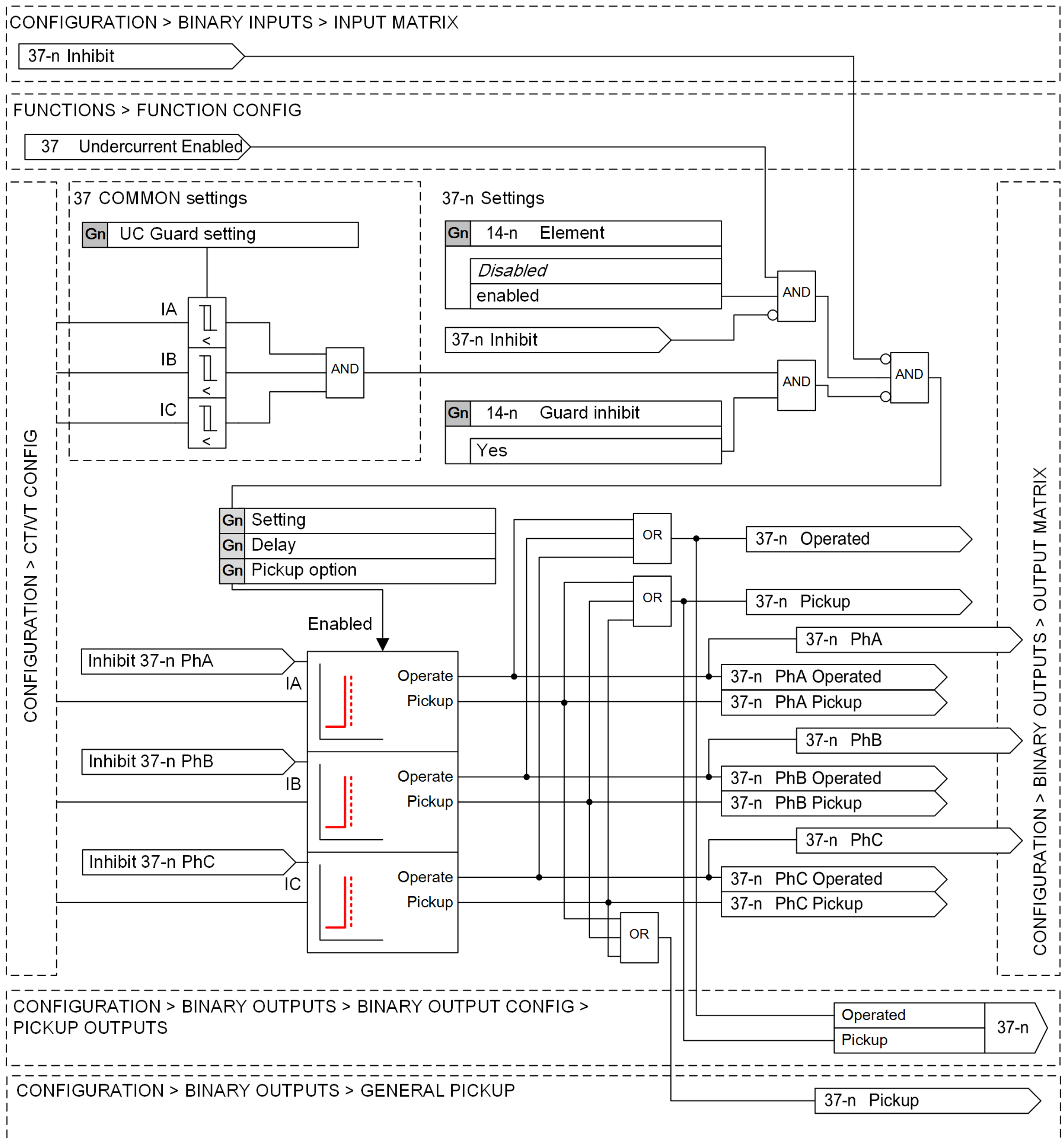
5.5.2 Structure of the Function

The undercurrent function elements have group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.
This function corresponds to the logical node **A37PTUC*** in IEC 61850.
The function monitors the primary system using the 3 phase current inputs e.g. CT1/2/3.
Function operation is selected to **Any** or **All** phases.

Blocking of the Stage

When a binary input configured as **Inhibit 37-n** is operated, the picked up relevent function element will reset.

5.5.3 Logic of the Function



[lo_7SR5_37logicdiagram, 2, en_US]

Figure 5-6 Logic Diagram: 37 Undercurrent Protection – Phase

5.5.4 Application and Setting Notes

Parameter: **`37 Common > UC Guard Setting`**

- Default setting: **0.1 x I_n** (0.1 · I_{rated})

  Current elements can be blocked if all phase currents fall below setting.

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. This setting can be used to select the number of elements required.

Parameter: **Pickup Option**

- Default setting: **All**
  This setting defines whether pickup is initiated when an undercurrent condition is detected on **Any** phase or is only initiated when an undercurrent is detected on **All** phases.

Parameter: **Setting**

- Default setting: **0.25 x I_n** (0.25 I_{rated})
  The setting to be appropriate to the respective application.
  A pickup value of 10 % is a practicable value for fault indications of electrical machines.

Parameter: **Delay**

- Default setting: **0 s**
  No specific recommendation is given: The setting to be appropriate to the respective application.

Parameter: **UC Guard Inhibit**

- Default setting: **Yes**
  Current elements can be blocked if all phase currents fall below setting.

5.5.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
37 Undercurrent	Enabled Disabled	Disabled				

Functions > Protection > 37 > Gn 37 Common						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
UC Guard Setting	0.05 to 5 I_{rated}, Δ 0.05 I_{rated}	0.1 · I_{rated}				

Functions > Protection > 37 > Gn 37-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.05 to 5 I_{rated}, Δ 0.05 I_{rated}	0.25 · I_{rated}				

Functions > Protection > 37 > Gn 37-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	1 s				
UC Guard Inhibit	Yes No	Yes				
Pickup Option	Any All	All				

5.5.6 IEC 61850 Functional Information Mapping

A37PTUC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A37PTUC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A37PTUC*.Mod

Information				
37 Undercurrent Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Undercurrent Guard Operated	x	x	x	0
Element Inhibited	x	x	1	0
A37PTUC*.Mod	**5**	**5**	**2**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A37PTUC*.Health

Information		
Device Healthy	0	1
A37PTUC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A37PTUC*.Op

Information		
Element Operated	0	1
A37PTUC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A37PTUC*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A37PTUC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information		
Element Phase A picked up	0	1
A37PTUC*.Str.phsA	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information		
Element Phase B picked up	0	1
A37PTUC*.Str.phsB	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information		
Element Phase C picked up	0	1
A37PTUC*.Str.phsC	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.5.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 37-n		Inhibit 37-n	Input			
		Inhibit 37-n PhA	Input			
		Inhibit 37-n PhB	Input			
		Inhibit 37-n PhC	Input			
37 PhA		37-n PhA Operated	Output	Y	Y	Y
37 PhB		37-n PhB Operated	Output	Y	Y	Y
37 PhC		37-n PhC Operated	Output	Y	Y	Y
37-n		37-n Operated	Output	Y	Y	Y
		37-n PhA Pickup	Output			
		37-n PhB Pickup	Output			
		37-n PhC Pickup	Output			
	37-n Pickup	37-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.6 37G Undercurrent Earth Fault – Measured

5.6.1 Overview of Functions

Earth undercurrent protection is used to detect negligible current flow in the system earth connection.

Negligible current flow in the system earth connection is the normal system operate state. This check of negligible current flow can be used in auto-isolation schemes.

5.6.2 Structure of the Function

The earth fault undercurrent function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

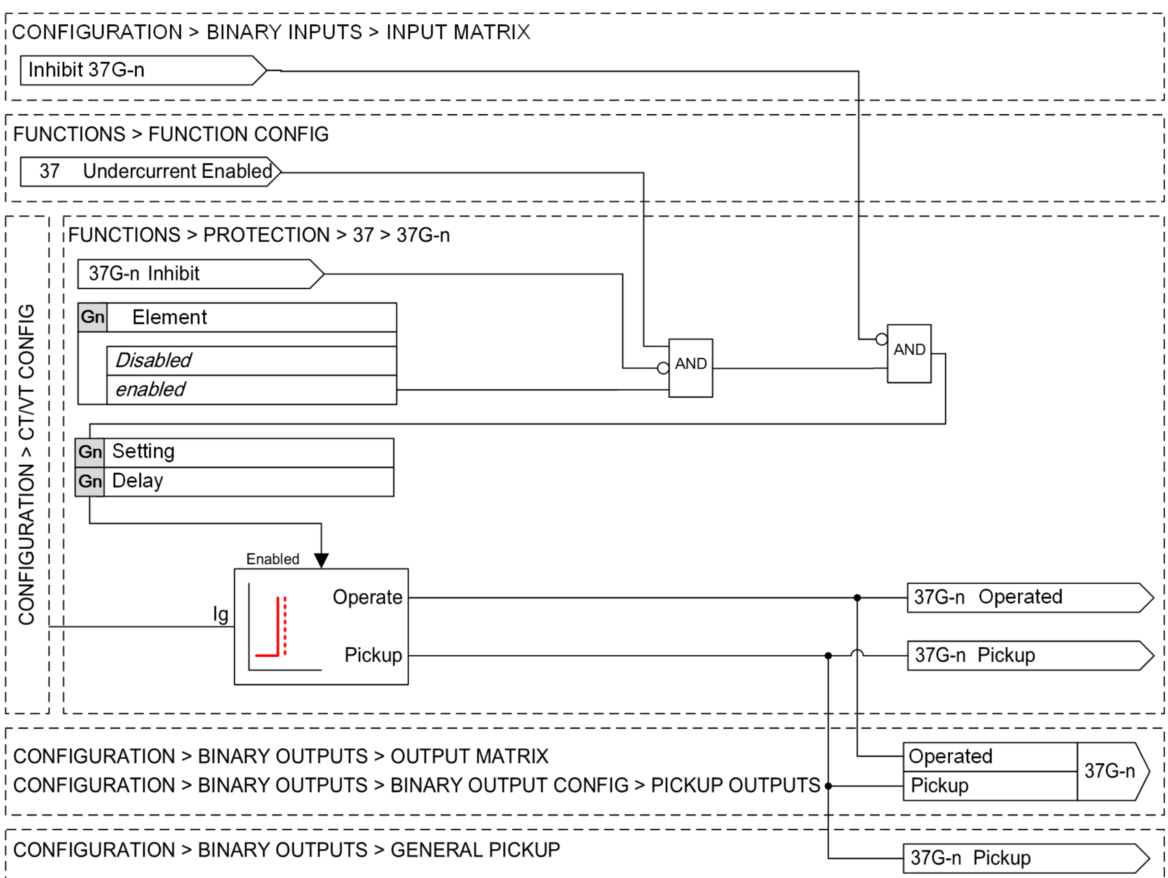
This function corresponds to the logical node **A37GPTUC*** in IEC 61850.

The function monitors the primary system using the single phase current input e.g. CT4.

Blocking of the Stage

When a binary input configured as **Inhibit 37G-n** is operated, the picked up relevent function element will reset.

5.6.3 Logic of the Function



[lo_7SR5_37Glogicdiagram, 2, en_US]

Figure 5-7 Logic Diagram: 37G Undercurrent Earth Fault – Measured

5.6.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. This setting can be used to select the number of elements required.

Parameter: **Setting**

- Default setting: **0.2 x I_n** (0.2 I_{rated})
  The setting to be appropriate to the respective application.
  A pickup value of 10 % is a practicable value for fault indications of electrical machines.

Parameter: **Delay**

- Default setting: **0 s**
  No specific recommendation is given: The setting to be appropriate to the respective application.

5.6.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
37 Undercurrent	Enabled Disabled	Disabled				

Functions > Protection > 37 > Gn 37G-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.005 to 5 I_{rated}, Δ 0.001 I_{rated}	0.2 · I_{rated}				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				

5.6.6 IEC 61850 Functional Information Mapping

A37GPTUC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x

Information												
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A37GPTUC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A37GPTUC*.Mod

Information				
37G Undercurrent Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A37GPTUC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A37GPTUC*.Health

Information		
Device Healthy	0	1
A37GPTUC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A37GPTUC*.Op

Information		
Element Operated	0	1
A37GPTUC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A37GPTUC*.Str

Information		
Element picked up	0	1
A37GPTUC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

5.6.7 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Inhibit 37G-n		Inhibit 37G-n	Input			
37G-n		37G-n Operated	Output	Y	Y	Y
	37G-n Pickup	37G-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.7 46 Negative-Sequence Overcurrent Protection

5.7.1 Overview of Functions

Negative sequence overcurrent protection is used to:

- Detect 1-phase or 2-phase short circuits in the electrical power system
- Protect electric machines during excessive unbalanced load
- Alarm for unbalanced system load conditions

5.7.2 Structure of the Function

The negative phase sequence overcurrent protection function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A46DTPTOC*** and **A46ITPTOC*** in IEC 61850.

The function monitors the primary system using the 3 phase current inputs e.g. CT1/2/3. The negative sequence phase (NPS) component of current (I_2) is derived from the 3 phase currents.

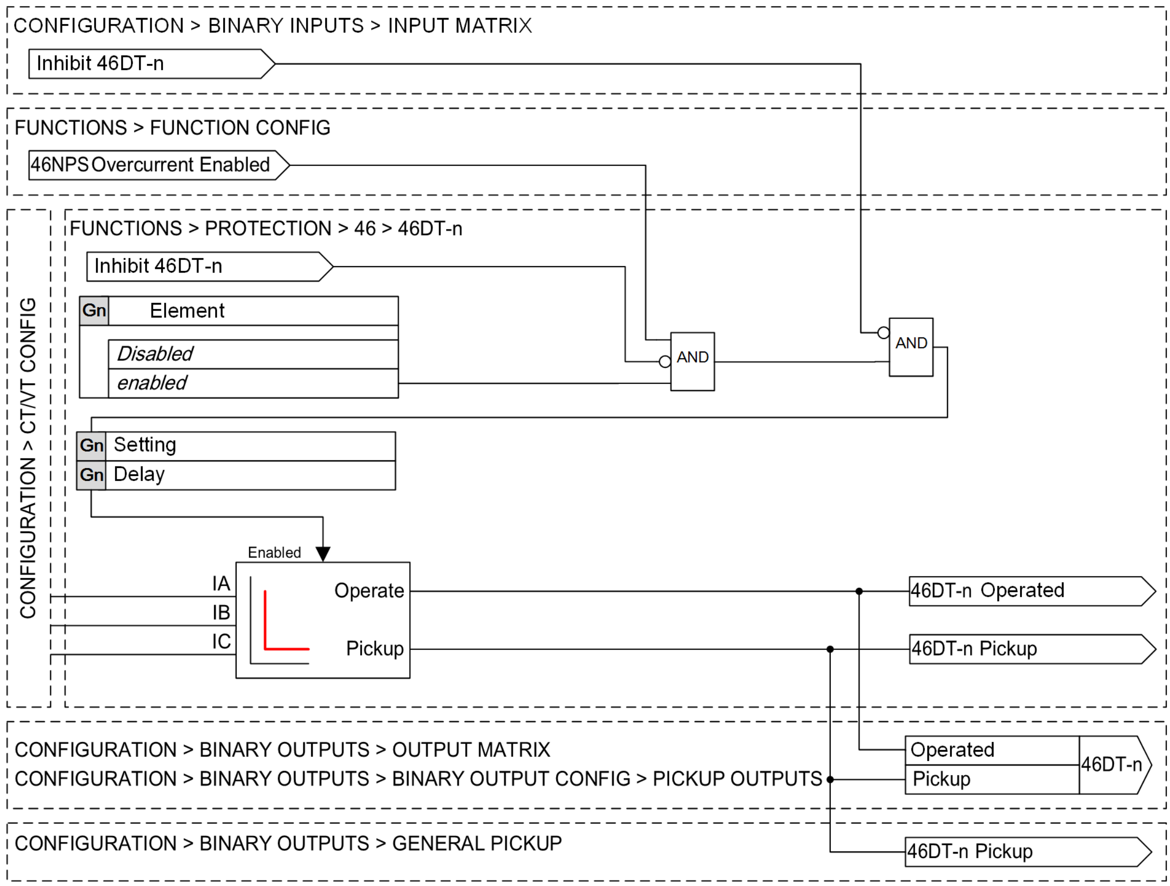
The function has 2 element types:

- Definite-time negative-sequence protection (46DT)
- Inverse-time negative-sequence protection (46IT)

Blocking of the Stage

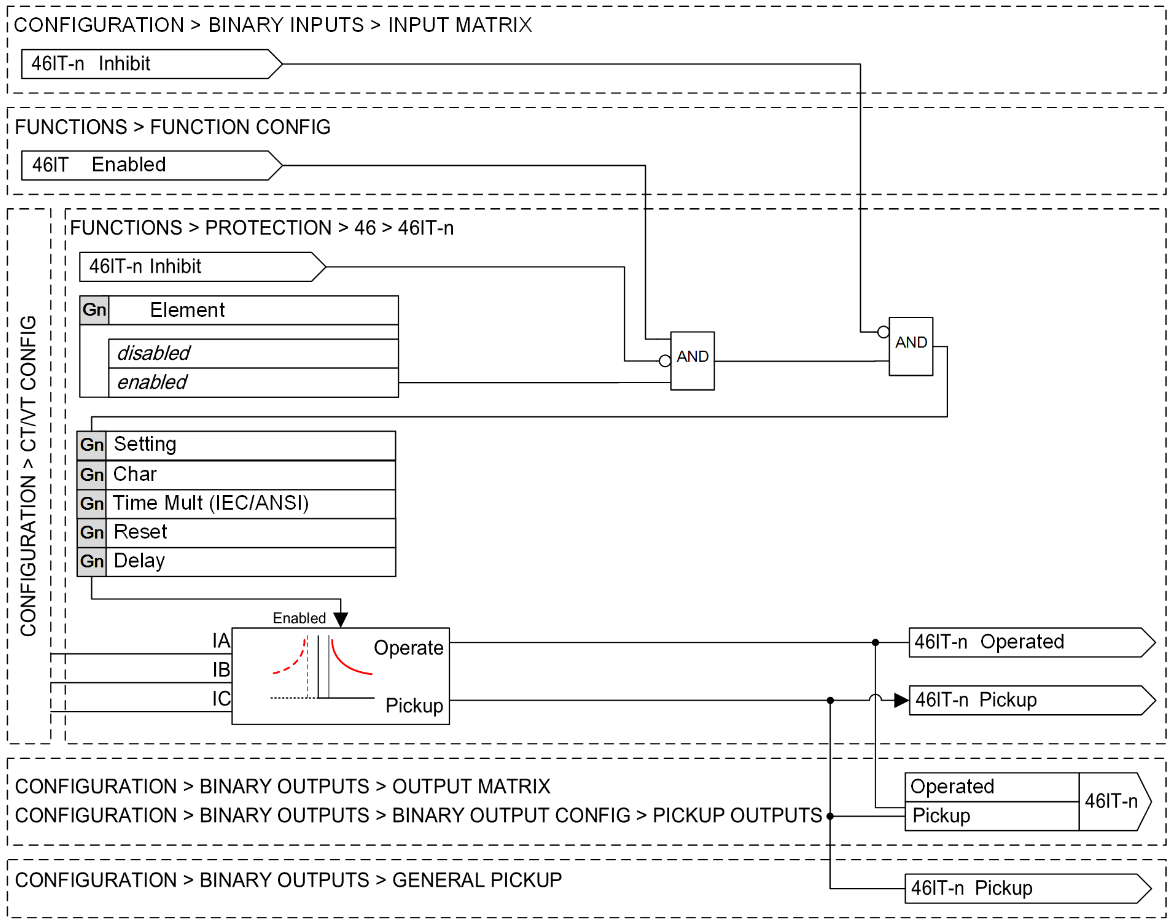
When a binary input configured as **Inhibit 46DT-n** or **Inhibit 46IT-n** is operated, the associated function element will reset.

5.7.3 Logic of the Function



[lo_7SR5_46logicdiagram, 2, en_US]

Figure 5-8 Logic Diagram: 46DT Negative Phase Sequence Overcurrent



[lo_7SR5_46ITlogicdiagram, 1, en_US]

Figure 5-9 Logic Diagram: 46IT Negative Phase Sequence Overcurrent

5.7.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. This setting can be used to select the number of elements required.

Parameter: **46DT-n Setting**

- Default setting: **0.1 x I$_n$** (0.1 I_{rated})
  The operate level depends on the respective application. A threshold value of 10 % is a practicable value for fault indications of electrical machines.

Parameter: **46DT-n Delay (DTL)**

- Default setting: **0.02 s**
  The setting of the operate delay depends on the application. Grading with other devices in the power-system must be considered.
  For motors, the time depends on the permissible withstand time for the set unbalanced load.

Parameter: **46IT-n Setting**

- Default setting: **0.25 x I_n** (0.25 I_{rated})

  The operate level depends on the respective application. A threshold value of 10 % is a practicable value for fault detection for different applications.

Parameter: **46-IT-n Char**

- Default setting: **IEC-NI**

  Selects the operating characteristic curve required for the specific application.

Parameter: **Time Mult (IEC/ANSI)**

- Default setting: **1**

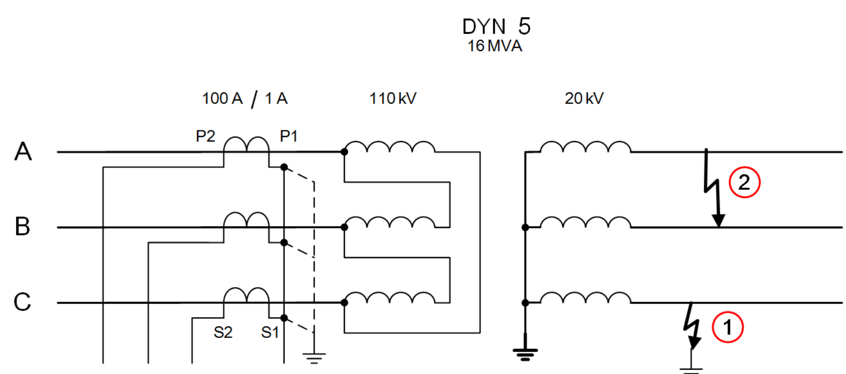
  The set value for the time multiplier is derived from the time-grading study of the electrical network or protected plant.

Settings Example

Backup Protection with a 3-Winding Transformer

The function Negative Sequence Overcurrent Protection can be used to provide a transformer sensitive backup protection on the supply side as it will detect low 1-phase and 2-phase short circuit currents. Also on the low-voltage side, 1-phase short circuits can be used, which do not create a zero-sequence system in the current on the upper-voltage side (for example in vector group Dyn).

The following example explains the achieved sensitivity.



[dw_7SR5_Function46SettingsExample, 1, en_US]

Figure 5-10 1-Phase and 2-Phase Short Circuit on Transformer

(1) 1-phase earth fault

(2) 2-phase short circuit

The standardization is based on the transformer rated object current (Reference value = rated current).

If the pickup value on the HV side is 12 % (46-n Setting = 0.12) of the transformer rated current, this corresponds to 0.1 A on the secondary side. With this the following currents and sensitivities are reached.

1-phase short circuit

$$I_{F;ph-gnd} = 3 \cdot \frac{V_{US}}{V_{LS}} \cdot \frac{I_{CT,prim}}{I_{CT,S}} \cdot I_2 = 3 \cdot \frac{110\ \text{kV}}{20\ \text{kV}} \cdot \frac{100\ \text{A}}{1\ \text{A}} \cdot 0.1\ \text{A} = 165\ \text{A}$$

[fo_function46ShortCircuit1-phase, 1, en_US]

Sensitivity

$$\frac{I_{F,ph-gnd}}{I_{rated,transf.-LS}}[\%] = \frac{I_{F,ph-gnd}}{\frac{S_{rated,transf.}}{\sqrt{3}\cdot V_{LS}}} \cdot 100\ \% = \frac{165\ A}{\frac{16\ MVA}{\sqrt{3}\cdot 20\ kV}} \cdot 100\ \% = 36\ \%$$

[fo_function46ShortCircuit1-phaseSensitivity, 1, en_US]

2-phase short circuit

$$I_{F;ph-ph} = \sqrt{3} \cdot \frac{V_{HS}}{V_{LS}} \cdot \frac{I_{P,CT}}{I_{S,CT}} \cdot I_2 = \sqrt{3} \cdot \frac{110\ kV}{20\ kV} \cdot \frac{100\ A}{1\ A} \cdot 0.1\ A = 95\ A$$

[fo_function46ShortCircuit2-phase, 1, en_US]

Sensitivity

$$\frac{I_{F,ph-ph}}{I_{rated,transf.-LS}}[\%] = \frac{I_{F,ph-ph}}{\frac{S_{rated,transf.}}{\sqrt{3}\cdot V_{LS}}} \cdot 100\ \% = \frac{95\ A}{\frac{16\ MVA}{\sqrt{3}\cdot 20\ kV}} \cdot 100\ \% = 21\ \%$$

[fo_function46ShortCircuit2-phaseSensitivity, 1, en_US]

Since this is the short circuit on the low-voltage side, the time delay must be coordinated with the times of subordinate protection devices.

Line or Cable Networks

In line or cable networks, the function Negative-sequence protection is used to detect weak current caused by unbalanced faults. In the unbalanced fault, the pickup values of the overcurrent protection is not reached.

The current is based on the rated object current (Reference value = rated current).

Therefore:

The 2-phase short circuit with the current I leads to a negative-sequence current:

$$I_2 = \frac{1}{\sqrt{3}} \cdot I = 0.58 \cdot I$$

[fo_function46ShortCircuit-2phaseLineNetwork, 1, en_US]

The 1-phase short circuit with the current I leads to a negative-sequence current:

$$I_2 = \frac{1}{3} \cdot I = 0.33 \cdot I$$

[fo_function46ShortCircuit-1phaseLineNetwork, 1, en_US]

If the protection works exclusively with short circuits, the protection must be set via the value for 2-phase operation. Then a 2-phase short circuit can be assumed with more than 60 % of the rated object current. Set the standardization on the rated object current. To avoid over-function with overload, Siemens recommends a pickup value of approximately 65 %. Coordinate the time delays with the network grading for phase short circuits.

Break in Primary System

To record breaks in the primary system, set standardization on I_2/I_1 (Reference value = pos. seq. current) to achieve a higher sensitivity (independence of load current). For a 1-phase break, the ratio of the negative-sequence current and the positive-sequence current can be described according to the following equation with the negative-system and zero-sequence impedance (Z_2, Z_0).

$$\frac{I_2}{I_1} = \frac{1}{1+\frac{\sum Z_2}{\sum Z_0}}$$

[fo_function46BreakinPrimarySystem, 1, en_US]

In the isolated system or with 1-sided ground, the zero-sequence impedance is infinity and thus the ratio is always 1. Observe a 2-sided grounded network and set the zero-system impedance equal to the negative-system impedance, then the ratio is 0.5. If a wire break occurs in the secondary circuit, a value of 1 or 0.5 is also possible.

For a 2-phase break, current can only flow with a 2-sided grounded network. In this case, the ratio I_2/I_1 = 1. If a partial 1-phase load is expected, the ratio is also set. The setting value is dependent on the maximum 1-phase load. For a setting value of 10 %, the phase current can be 30 %.

If you want to prevent an indication with short circuits, activate the current limiting to, for example, 1.2 $I_{rated,obj}$ (Current limitation I_{max} = yes; Maximum phase current = 1.2 A at 1 A transformer and ideal adaptation to the protected object). Here calculate the current with the current transformer ratio to the secondary circuit.

The setting of the protection stage is aligned to the network type. A setting value of 25 % **`Threshold = 25 %`** offers a sufficiently high sensitivity. If errors occur in the current transformer circuit, there can, however, also be a tripping. To prevent overfunctions during the AREC cycles, the time delay for the tripping must be set long. A time of 60 s **`Operate delay = 60.00 s`** offers sufficient reliability.

5.7.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
46 Negative Sequence Over-current	Enabled Disabled	Disabled				

Functions > Protection > 46 > 46DT-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.05 to 4 I_{rated}, Δ 0.01 I_{rated}	0.1 · I_{rated}				
Delay	0 to 14400 s	0.02 s				

Functions > Protection > 46 > 46IT-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.05 to 2.5 I_{rated}, Δ 0.01 I_{rated}	0.25 · I_{rated}				
Char	DTL IEC-NI, IEC-VI IEC-EI, IEC-LTI ANSI-EI, ANSI-MI ANSI-VI	IEC-NI				
TMS (IEC/ANSI)	0.025 to 1.6, Δ 0.01 1.6 to 5, Δ 0.1 5 to 100, Δ 1	1				
Delay (DTL)	0 to 20 s Δ 0.01 s	5 s				
Reset	IEC/ANSI Decaying 0 to 60 s Δ 1 s	0 s				

5.7.6 IEC 61850 Functional Information Mapping

A46DTPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A46DTPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A46DTPTOC*.Mod

Information				
46 NPS Overcurrent Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A46DTPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A46DTPTOC*.Health

Information		
Device Healthy	0	1
A46DTPTOC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A46DTPTOC*.Op

Information		
Element Operated	0	1
A46DTPTOC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A46DTPTOC*.Str

Information		
Element picked up	0	1
A46DTPTOC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A46ITPTOC*.Mod

Information				
46 NPS Overcurrent Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A46ITPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A46ITPTOC*.Health

Information		
Device Healthy	0	1
A46ITPTOC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A46ITPTOC*.Op

Information		
Element Operated	0	1
A46ITPTOC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A46ITPTOC*.Str

Information		
Element picked up	0	1
A46ITPTOC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.7.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 46DT-n		Inhibit 46DT-n	Input			
46DT-n			Output	Y	Y	Y
46DT-n Operated		46DT-n Operated	Output			
	46DT-n Pickup		Output			
Inhibit 46IT-n		Inhibit 46IT-n	Input			
46IT-n			Output	Y	Y	Y
46IT-n Operated		46IT-n Operated	Output			
	46IT-n Pickup		Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.8 46BC Broken Conductor Detection

5.8.1 Overview of Functions

The Broken Conductor Detection function is used to:

- Detect open circuit primary conductors on 1 or 2 phases
- Provide an alarm for indication purposes

5.8.2 Structure of the Function

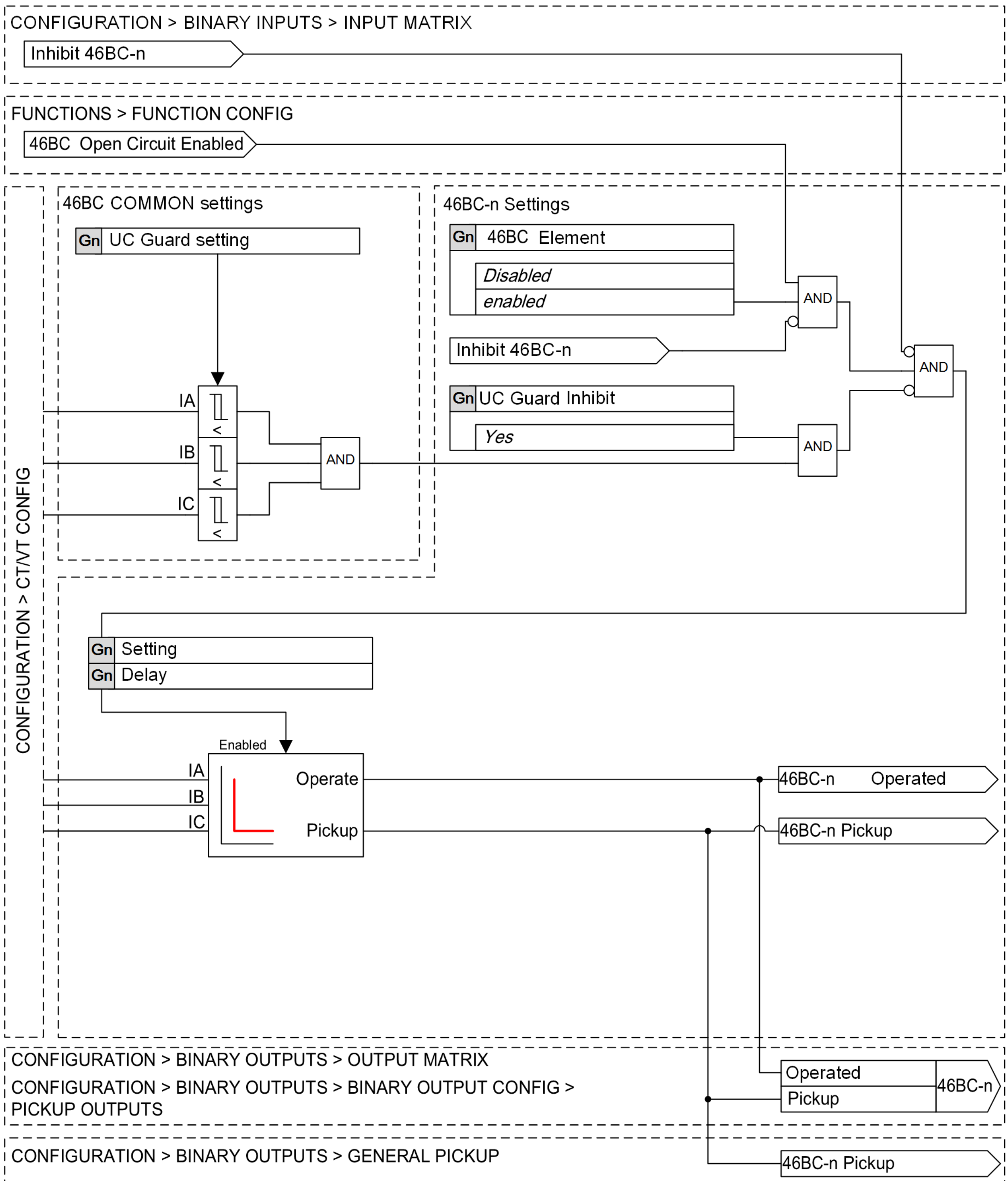
The broken conductor detection function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A46BCPTOC*** in IEC 61850.

The function monitors the primary system using the 3 phase current inputs e.g. CT1/2/3. The fundamental frequency component is measured from processing of the measured current samples.

The broken conductor in a 3 phase system is detected by a high the ratio of the negative phase sequence (NPS) current level to positive phase sequence (PPS) current level

5.8.3 Logic of the Function



[lo_7SR5_46BClogicdiagram, 2, en_US]

Figure 5-11 Logic Diagram: 46BC Broken Conductor Detection

5.8.4 Application and Setting Notes

Parameter: **`46BC Common > UC Guard Setting`**

- Default setting: **0.1 x I_n** (0.1 · I_{rated})
  If the negative

Parameter: **`46BC-n Element`**

- Default setting: **`Disabled`**
  This setting is used to allow the element to be switched on or off if it is not required.

Parameter: **`46BC-n Setting`**

- Default setting: **`20 %`**
  If the negative phase sequence current is above this percentage of the positive sequence current the 46BC-n element will pickup.

Parameter: **`46BC-n Delay`**

- Default setting: **`20 s`**
  This is the delay applied to the 46BC-n operated output. This delay is used to prevent nuisance indications which would otherwise occur during switching operations and system faults.

Settings Example

Where very low phase currents are measured, correct operation of the broken conductor function may be unreliable e.g. it may operate for unbalanced loads. The operation of the broken conductor function can be blocked during periods of low system loading by using the undercurrent guard feature.

5.8.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
46BC Open Circuit	Enabled Disabled	Disabled				

Functions > Protection > 46BC >Gn 46BC Common						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
UC Guard Setting	0.05 to 5 · I_{rated} Δ 0.05 · I_{rated}	0.1 · I_{rated}				

Functions > Protection > 46BC > 46BC-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	20 to 100 %, Δ 1 %	20 %				

Functions > Protection > 46BC > 46BC-n						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Delay	0.03 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	20 s				
UC Guard Inhibit	Yes No	No				

5.8.6 IEC 61850 Functional Information Mapping

A46BCPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A46BCPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A46BCPTOC*.Mod

Information				
46BC Open Circuit Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Undercurrent Guard	x	x	x	0
Element Inhibited	x	x	1	0
A46BCPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A46BCPTOC*.Health

Information		
Device Healthy	0	1
A46BCPTOC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A46BCPTOC*.Op

Information		
Element Operated	0	1
A46BCPTOC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A46BCPTOC*.Str

Information		
Element picked up	0	1
A46BCPTOC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.8.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 46BC-n		Inhibit 46BC-n	Input			
46BC-n		46BC-n Operated	Output	Y	Y	Y
	46BC-n Pickup	46BC-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.9 47 Sequence Overvoltage Protection

5.9.1 Overview of Function

Sequence overvoltage protection is used to:

- Monitor symmetrical positive sequence voltage content which is not affected by unbalance in the 3 phase voltages
- Monitor unbalance voltage and provide tripping or alarms for values outside of normal limits
- Protect equipment (for example, plant components, machines, etc.) against damages caused by unbalance
- Detect overvoltage, system faults, fuse failure, and broken conductors

5.9.2 Structure of the Function

The Sequence Overvoltage Protection function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A47PTOV*** in IEC 61850.

The function monitors the primary system using the 3 phase VT inputs e.g. VT1, VT2 and VT3. The fundamental frequency component is measured from processing of the measured voltage samples. Operation can be based on the user selection of the positive phase sequence voltage, negative phase sequence voltage or zero phase sequence voltage.

NOTE

Where VT1/2/3 configuration is selected to **Va,Vb,Vc** then zero phase sequence overvoltage cannot be measured.

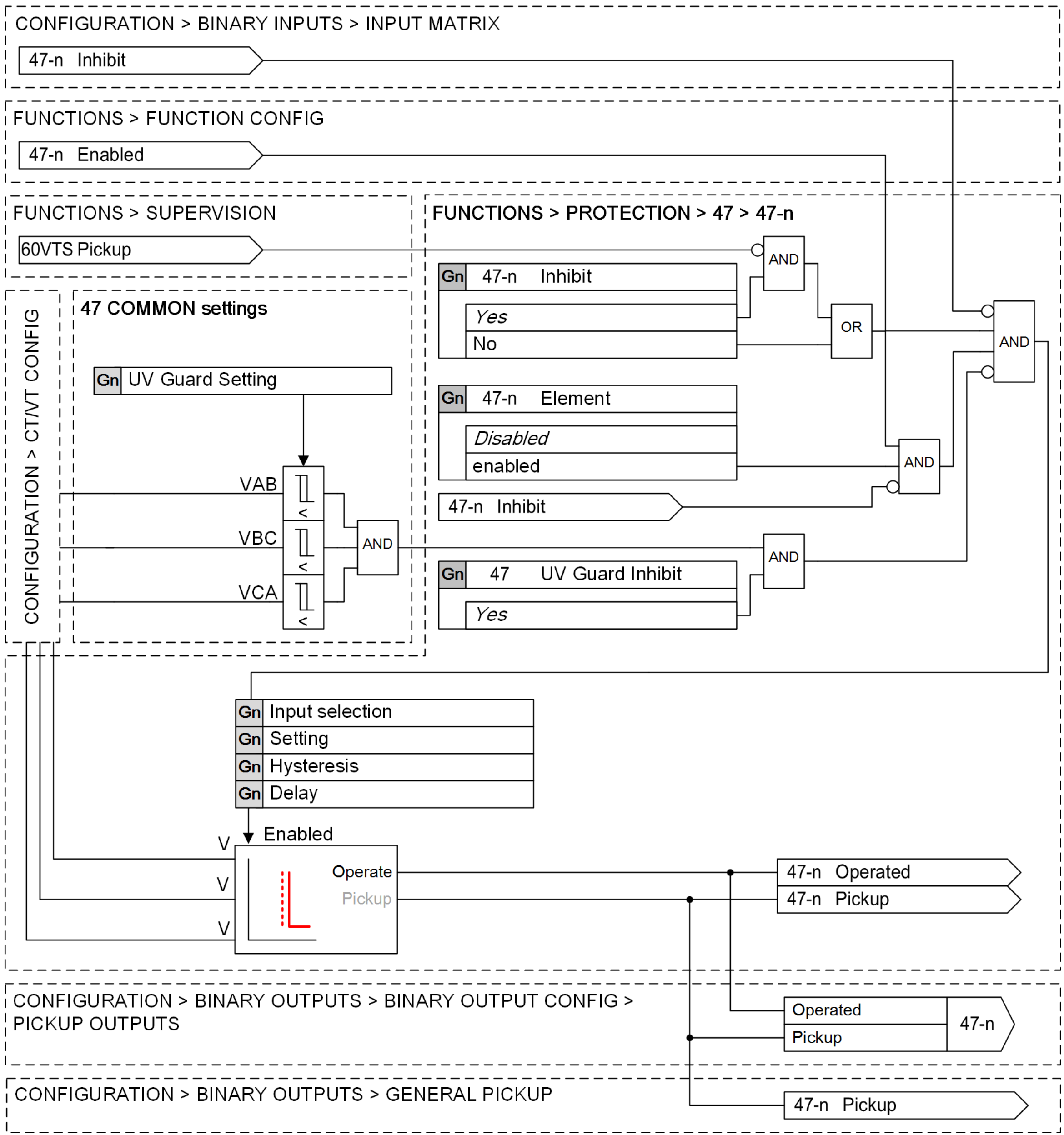
A definite time delayed operate characteristic is used. Settings are provided for operate (pickup) threshold voltage, reset voltage level (hysteresis/drop-off) and time delay.

Outputs are provided for pickup and operation.

Correct operation is dependent on valid information being received from the VT inputs, incorrect measurement and operation may result if a VT fuse fails. When a fuse failure is detected, 60VTS function, the 47 function can be inhibited.

When a function inhibit is applied from a binary input, logic signal, VTS, or undervoltage guard, an element that is picked up will be reset. Reset of the inhibit will allow restart of the operating delay.

5.9.3 Logic of the Function



[lo_7SR5_function47logicdiagram, 2, en_US]

Figure 5-12 Logic Diagram: 47 Sequence Overvoltage Protection

5.9.4 Application and Setting Notes

Parameter: **`47 Common > UV Guard Setting`**

- Default setting: **`5 V`**

  Voltage elements can be blocked if all phase voltages fall below the setting.

Parameter: **`Element`**

- Default setting: **`Disabled`**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These settings can be used to select the number of elements required.

Parameter: **`47-n Input Selection`**

- Default setting: **NPS** (V_2)

Parameter Value	Description
PPS (V_1)	Positive sequence can be used to detect underlying overvoltage on the system. This measurement is immune to distortion of voltage values due to imbalance.
NPS (V_2)	Negative sequence can be used to detect unbalance between phases. Unbalanced voltage gives rise to unbalanced current flows.
ZPS (V_0)	Zero sequence is a measurement of residual voltage. This drives current in through the neutral or system earth connections.

Parameter: **`Setting`**

- Default setting: **`20 V`**
  This is the pickup threshold of the element and is compared against the respective sequence voltage. For PPS (V_1) this would usually set at a level higher than rated system voltage or lower if the overvoltage element is to be used in logic to provide positive sequence undervoltage monitoring. For negative or zero phase sequence voltages this is usually set at a lower level because there voltages are negligible during normal system running conditions. For earth fault or residual voltage detection the setting is in zero phase sequence (ZPS) volts and therefore 1/3 of the residual voltage ($3V_0$). The elements should be set to suit the individual application.

Parameter: **`Hysteresis`**

- Default setting: **`3 %`**
  The element will reset when the voltage recovers to the 47-n setting minus the 47-n hysteresis setting. The default setting of 3 % is generally enough to avoid chatter of the element but care may be required for settings which are close to the nominal value when set to PPS (V_1) otherwise the element may not reset when the voltage recovers to nominal value as the voltage is still in the hysteresis window.

Parameter: **`Delay`**

- Default setting: **`1 s`**
  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Parameter: **`VTS Inhibit`**

- Default setting: **`No`**
  This setting defines the effect of a voltage transformer failure on the operation of each 47-n function element. If a VT failure is detected by the separate VTS element, operation of the 47-n element will be blocked if this setting is set to **`Yes`**. If this setting is set to **`No`**, the 47-n element is unaffected by the VTS element operation and the 47-n element may operate on the erroneous voltage caused by the VT fuse failure. It is generally recommended that a setting of **`Yes`** is beneficial if the input selection is set to **`NPS`** or **`ZPS`**.

Parameter: **`UV Guard Inhibit`**

- Default setting: **`Yes`**
  Function elements can be blocked if all phase voltages fall below setting.

Settings Example

Negative Phase Sequence (NPS) protection detects phase unbalances and is widely used in protecting rotating plant such as motors and generators. However such protection is almost universally based on detecting NPS current rather than voltage. This is because the NPS impedance of motors etc. is significantly less than the Positive Phase Sequence (PPS) impedance and therefore the ratio of NPS to PPS current is much higher than the equivalent NPS:PPS voltage ratio.

NPS voltage is used for monitoring busbar supply quality rather than detecting system faults. The presence of NPS voltage is due to unbalanced load on a system. Any system voltage abnormality is important since it will affect every motor connected to the source of supply and can result in mass failures in an industrial plant. NPS voltage function elements can be used as alarms to indicate that the level of NPS has reached abnormal levels. Remedial action can then be taken, such as introducing a balancer network of capacitors and inductors. Very high levels of NPS voltage indicate incorrect phase sequence due to an incorrect connection.

5.9.5 Settings Menu

Configuration > Function Config						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
47 Sequence Voltage	Disabled Enabled	Disabled				

Functions > Protection > 47 > Gn 47 Common						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
UV Guard Setting	1 to 200 V, Δ 0.5 V	5 V				

Functions > Protection > 47 > Gn 47-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Disabled Enabled	Disabled				
Measurement	NPS (V2) PPS (V1) ZPS (V0)	NPS				
Setting	1 to 200 V, Δ 0.5 V	20 V				
Hysteresis	0 to 80 %, Δ 1 %	3 %				
Delay	0 to 20 s Δ 0.01 s, 20 to 100 s Δ 0.1 s, 100 to 1000 s Δ 1 s, 1000 to 10000 s Δ 10 s, 10000 to 14400 s Δ 100 s	1 s				
VTS Inhibit	No Yes	No				
UV Guard Inhibit	No Yes	Yes				

5.9.6 IEC 61850 Functional Information Mapping

Functional Description	Logical Device LD	Logical Node LN	Instantiated Data Object DOI
47-(Gn)	PROT	A47PTOV(Gn)	Mod Beh Health NamPlt Str Op

A47PTOV*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A47PTOV*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	OK: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A47PTOV*.Mod

Information				
47 Sequence Voltage Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
UV Guard	x	x	x	0
Element Inhibited	x	x	1	0
A47PTOV*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A47PTOV*.Health

Information		
Device Healthy	0	1
A47PTOV*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A47PTOV*.Op

Information		
Element Operated	0	1
A47PTOV*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A47PTOV*.Str

Information		
Element picked up	0	1
A47PTOV*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.9.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 47-n		Inhibit 47-n	Input			
47-n Operated		47-n Operated	Output	Y	Y	Y
	47-n Pickup	47-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.10 49 Thermal Overload Protection

5.10.1 Overview of Function

Thermal overload protection is used to estimate the real-time thermal state (θ) of static plant e.g. cables or transformers.

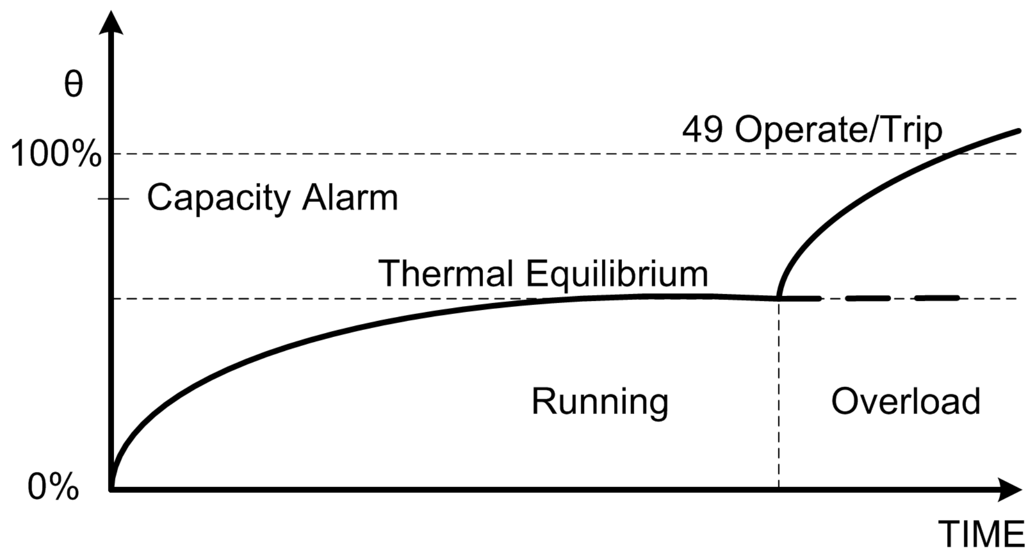
5.10.2 Structure of the Function

The thermal overload function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A49PTTR*** in IEC 61850.

The function monitors the primary system current using the 3 phase CT inputs e.g. CT1/2/3. The RMS current is measured from processing of the current samples. An output is given for any phase operation.

A calculation of the Thermal State (θ) from the measured currents is based on both past and present current levels. θ = 0 % for unheated equipment, and θ = 100 % for maximum thermal withstand of equipment or the trip threshold.



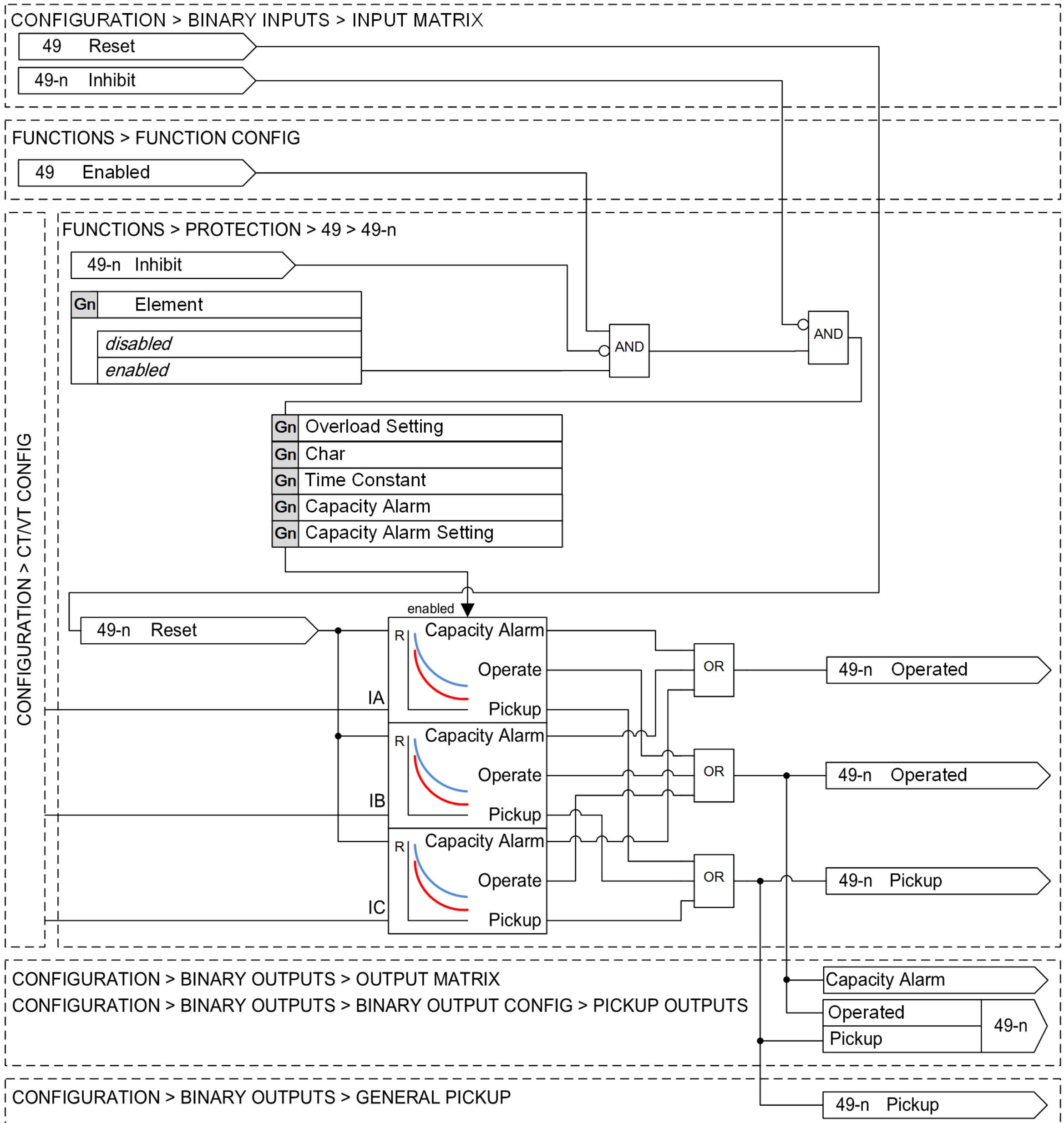
[dw_7SR5_ThermalOverloadHeatingandCoolingCharacteristic, 1, en_US]

Figure 5-13 Thermal Overload Heating and Cooling Characteristic

For given current level, the Thermal State will ramp up over time until Thermal Equilibrium is reached when Heating Effects of Current = Thermal Losses. The heating/cooling curve characteristic is dependent upon the Thermal Time Constant, this must be representative of the thermal characteristics for the protected plant. Similarly the overload setting $I_θ$ is related to the thermal withstand of the plant.

An alarm is provided for θ at or above a set % of capacity to indicate that a potential trip condition exists and that the system should be scrutinized for abnormalities.

5.10.3 Logic of the Function



[lo_7SR5_49logicdiagram, 2, en_US]

Figure 5-14 Logic Diagram: 49 Thermal Overload Protection

5.10.4 Application and Setting Notes

The thermal state is calculated using the measured True RMS current.

Operate Time (T):

$$T = \tau \cdot \ln\left[\frac{I^2 - I_p^2}{I^2 - I_\theta^2}\right]$$

[fo_7SR5_thermal equation, 1, en_US]

T = Operate time in minutes
τ = Time constant (minutes)
ln = Log natural
I = Measured current
I_p = Pre-load
I_θ = Overload setting

For the heating curve:

$$\theta = \frac{I^2}{I_\theta^2} \cdot \left(1 - e^{-t/\tau}\right) \cdot 100\ \%$$

[fo_7SR5_heatingCurve, 1, en_US]

θ = Thermal state at time t
I = Measured thermal current
I_θ = 49 Overload setting (or $k.I_B$)

The final steady state thermal condition can be predicted for any steady state value of input current where t >τ,

$$\theta_F = \frac{I^2}{I_\theta^2} \cdot 100\ \%$$

[fo_7SR5_thermalSteadyState, 1, en_US]

θ_F = Final thermal state before disconnection of device

The thermal state may be reset from the fascia, a user logic reset or externally via a binary input.

Parameter: **Overload Setting**

- Default setting: **1.05 x I_n** (1.05 · I_{rated})
  The pickup level, equivalent to the factor $k.I_B$ as defined in the IEC 60255-8 thermal operating characteristics. It is the value of current above which 100 % of thermal capacity will be reached after a period of time and it is therefore normally set slightly above the full load current of the protected plant.

Parameter: **Char**

- Default setting: **IEC**
  The operate characteristic can be based on the IEC thermal curve or a user thermal curve can be used.

Parameter: **Time Constant**

- Default setting: **10 min**
  This setting is chosen to match the thermal characteristic of the protected plant.

Parameter: **Capacity Alarm Setting**

- Default setting: **50 %**
  An alarm can be given if the thermal state of the system exceeds a specified percentage of the protected equipment’s thermal capacity.

5.10.5 Settings Menu

Configuration > Function Config						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
49 Thermal Overload	Disabled Enabled	Disabled				

Functions > Protection > 49 > Gn 49-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Disabled Enabled	Disabled				
Overload Setting	0.1 to 3 · I_{rated}, Δ 0.01 I_{rated}	1.05 · I_{rated}				
Char	IEC User	IEC				
Time Constant	1 to 1000 min, Δ 0.5 min	10 min				
Capacity Alarm	Disabled Enabled	Disabled				
Capacity Alarm Setting	50 to 100 %, Δ 1 %	50 %				

5.10.6 IEC 61850 Functional Information Mapping

A49PTTR*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A49PTTR*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A49PTTR*.Mod

Information				
49 Thermal Overload Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A49PTTR*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A49PTTR*.Health

Information		
Device Healthy	0	1
A49PTTR*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A49PTTR*.Op

Information		
Element Operated	0	1
A49PTTR*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A49PTTR*.Str

Information		
Element picked up	0	1
A49PTTR*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A49PTTR*.AlmThm

Information		
Element Alarm	0	1
A49PTTR*.AlmThm.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

5.10.7 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Inhibit 49-n		Inhibit 49-n	Input			
Reset 49-n		Reset 49-n	Input			
49-n Trip		49-n Trip Operated	Output	Y	Y	Y
49-n Alarm		49-n Alarm Operated	Output	Y	Y	Y
	49-n Pickup	49-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.11 50 Instantaneous Overcurrent – Phase

5.11.1 Overview of Functions

Time overcurrent protection is used to provide:

- Short circuit detection in electrical equipment
- High speed highset overcurrent protection of plant where appropriate
- Coordinated operation with other devices using current and time graded settings

5.11.2 Structure of the Function

The instantaneous overcurrent function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A50PTOC*** in IEC 61850.

The function monitors the primary system current using the 3 phase CT inputs e.g. CT1/2/3.

The basic time overcurrent protection function (50) is summarized below:

- Current measurement is based on either fundamental or RMS current
- Operation with a definite time delayed (DTL) characteristic
- Outputs are provided for each phase

The basic function is non-directional but can be directionalized. This requires 3 phase VT inputs e.g. VT1/2/3.

Each 50 function element can be set to operate for forward current, reverse current or independently of current direction. Directionalized functionality is controlled by the outputs of the 67 function element.

- Provides information regarding flow direction of phase current for selective application of overcurrent protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

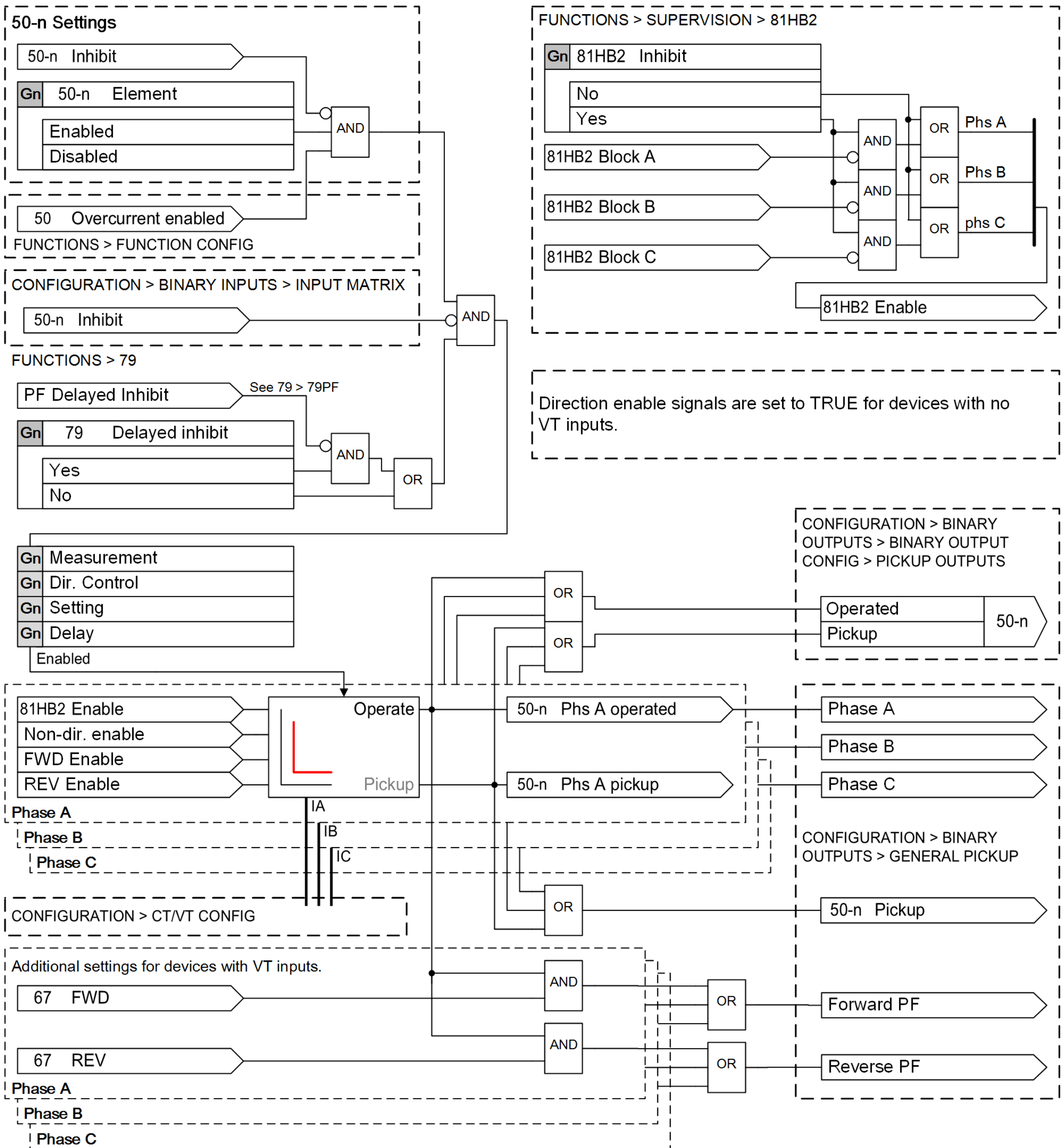
Where directionalized overcurrent protection is used, correct operation is dependent on valid information being received from the VT inputs, operation of each directionalized element will be affected if a VT fuse fails. When a fuse failure is detected, 60VTS function, each element can be selected to either ignore the VT failure, switch to non-directionalized operation (which does not require VT inputs) or be inhibited.

When installed in power transformer circuits increased currents may be measured by the overcurrent function during switch in of the transformer. Each element can be set to be inhibited when inrush current is detected, (see *6 Supervision Functions* , section 81HB2 Inrush Current Detection).

Elements can be mapped to start **79 Automatic Reclosing** by selection of the element as a **79 PF Trigger** within the 79 function element menus. For advanced autoreclose applications each element can be selected to be inhibited during delayed autoreclose shots of a multi-shot sequence.

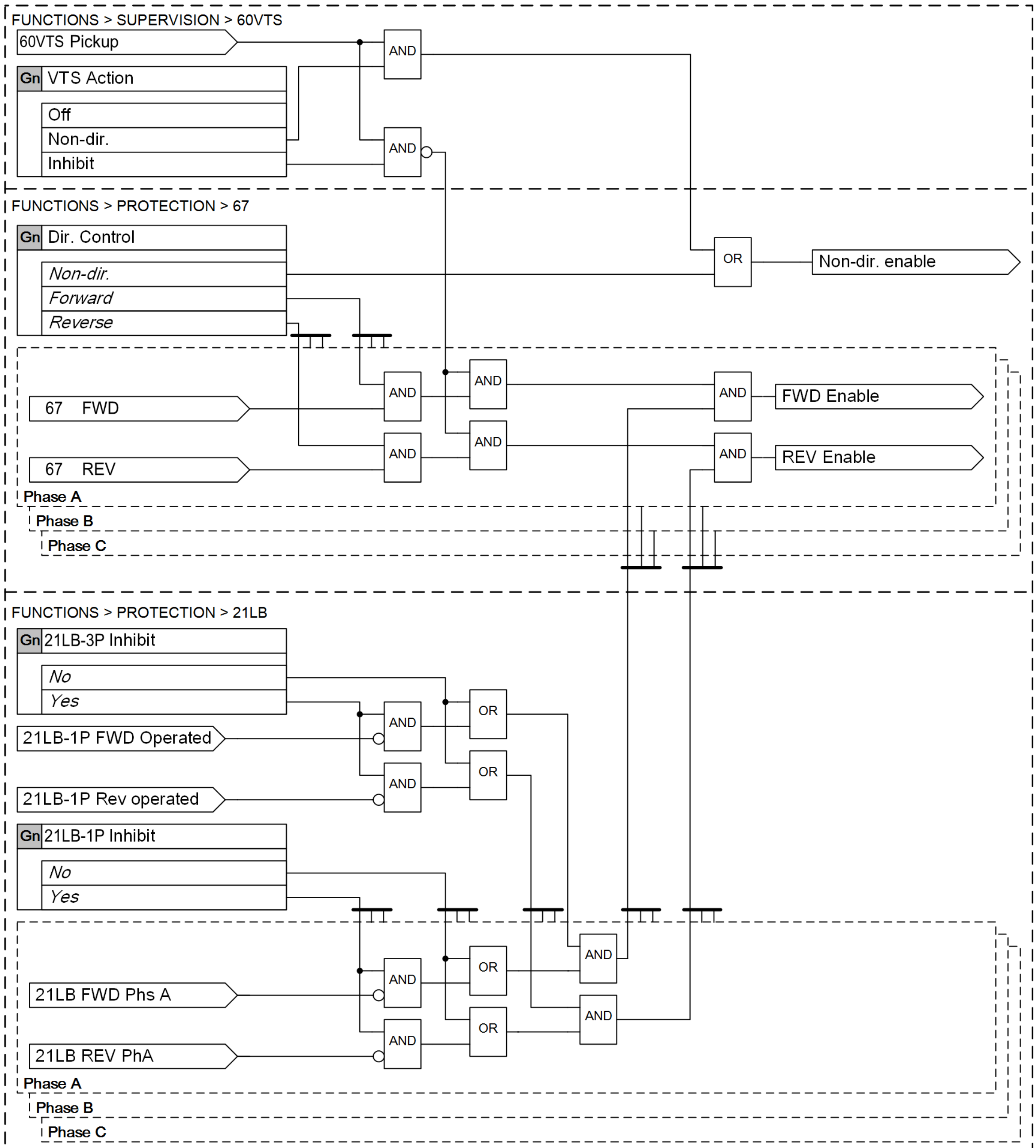
Where significant distributed generation is installed in the power system network, load current may flow in the reverse direction to normal operation, this is not fault current but may be in excess of low directionalized overcurrent settings. Each element can be set to be inhibited during periods of low reverse load current flow, (see *5 Protection and Automation Functions* , section 21LB Load Blinder).

5.11.3 Logic of the Function



[lo_7SR5_50logicdiagram_part-1, 2, en_US]

Figure 5-15 Logic Diagram: 50 Instantaneous Overcurrent – Phase



[lo_7SR5_50logicdiagram_part-2, 1, en_US]

Figure 5-16 Logic Diagram: 50 Instantaneous Overcurrent – Phase (Additional Settings Using VT Inputs)

5.11.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Measurement`**

- Default setting: **`RMS`**

  Selects whether fundamental frequency RMS or the True RMS value of the measured currents is used.

Parameter Value	Description
RMS	Select this if it is required to consider the effects of harmonic currents. This method may be required if there are significant harmonic content such as at capacitor banks or filter networks. This method is required for correct grading with fuses or electromechanical overcurrent relays.
Fundamental	This method is used: • When harmonic components are not to be considered in the current evaluation. • For current/time grading with devices which also measure fundamental current. • For unbalance type protection where the unbalance applies at fundamental frequency and the risk of errors in transient response measurement can be avoided.

Parameter: **`Dir. Control`**

- Default setting: **`Non-Dir`**

  This setting is used to define whether the element will operate for overcurrent detection in the **`Forward`** or **`Reverse`** direction based on the 67 directional element decision or for any overcurrent regardless of the 67 direction. This allows the overcurrent protection to have different current and time settings for forward and reverse faults by using 2 elements. Additional non-directional elements can be used for backup or high set and will still be active if the main directional elements are inhibited by VTS etc.

  This parameter is not provided in devices that do not have voltage inputs or for current inputs that are not polarized by the voltage inputs.

Parameter Value	Description
Non-Dir	The element operates regardless of the current direction or presence of voltage.
Forward	The element will operate only for current in a forward direction.
Reverse	The element will operate only for current in a reverse direction.

Parameter: **`Setting`**

- Default setting: **1 x I_n** ($1 \cdot I_{rated}$)

  This setting defines the operating current threshold of the element.

  This setting should be chosen to suit the individual application.

Parameter: **Delay**

- Default setting: **0 s**
  This time delay should be set to suit the individual application.

Parameter: **VTS Action**

- Default setting: **Off**
  Voltage transformer failure can affect the directional decision and introduce an error. This setting selects if operation of the **60VTS Voltage Transformer Supervision** element automatically affects the operation of the element.

Parameter Value	Description
OFF	The function element operates with no consideration of the 60VTS element output status.
Inhibit	When a VT failure is determined by the 60VTS function operation of the function element is inhibited. Clearance of a system fault will then rely on other elements or devices.
Non-Dir	When a VT failure is determined by the 60VTS function the 50 element is switched to non-directional operation – this does not require VT inputs. The element will operate for overcurrent regardless of current direction.

NOTE

During a VT failure the device may assess the direction incorrectly and the element may operate for faults in the non-operate direction or not operate for faults in the operate direction.

Parameter: **81HB2 Inhibit**

- Default setting: **No**
  High levels of inrush currents into reactive components such as transformers when they are switched in can result in operation of overcurrent elements. The inrush current can be detected by the 81HB2 element. This can be configured to inhibit the overcurrent element automatically.

Parameter Value	Description
No	The element is not inhibited by operation of the 81HB2 element.
Yes	The overcurrent element is inhibited by operation of the 81HB2 element and automatically released when the 81HB2 element resets.

Parameter: **79 Delayed Inhibit**

- Default setting: **No**
  The autoreclose scheme can be designed such that only instantaneous elements are used for the first trip(s) of the sequence before reverting to time graded protection. This setting allows the delayed element to be inhibited during the delayed autoreclose shots and should be left at the default setting of **No** unless this is required.

NOTE

Function elements are assigned as **Delayed Trips** in the 79 > 79PF menu.

Parameter Value	Description
No	The element is not inhibited by the autoreclose sequence design.
Yes	The element will be inhibited during any autoreclose shot which is designated as **`Delayed`**. Incorrect configuration can result in no protection being enabled.

Parameter: **`21LB-3P Inhibit`**

- Default setting: **`No`**

  Where the reverse load flow current may cause incorrect operation of directional overcurrent protection this function is used to inhibit the 50 element when the measured power factor is within defined limits.

Parameter: **`21LB-1P Inhibit`**

- Default setting: **`No`**

  Where the reverse load flow current may cause incorrect operation of directional overcurrent protection this function is used to inhibit the 50 element when the measured power factor is within defined limits.

Settings Example

Each instantaneous element has an independent setting for pickup current and a follower definite time lag (DTL) which can be used to provide time grading margins, sequence co-ordination grading or scheme logic. The "instantaneous" description relates to the pickup of the element rather than its operation.

Instantaneous elements can be used in current graded schemes where there is a significant difference between the fault current levels at different relay points.

The instantaneous element is set to pickup at a current above the maximum fault current at the next downstream relay location, and below its own minimum fault current level. The protection is set to operate instantaneously and is often termed **`Highset Overcurrent`**. A typical application is the protection of transformer HV connections – the impedance of the transformer ensuring that the LV side has a much lower level of fault current.

The 50-n function elements have a very low transient overreach i.e. their accuracy is not appreciably affected by DC offset transients associated with fault inception.

5.11.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
50 Overcurrent	Enabled Disabled	Disabled				

Functions > Protection > 50 > Gn 50-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Measurement	RMS Fundemental	RMS				

Functions > Protection > 50 > Gn 50-n						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Dir. Control [14]	Non-Dir forward reverse	Non-Dir				
Setting	0.05 to 2.5 I_{rated}, Δ 0.01 I_{rated} 2.55 to 25 I_{rated}, Δ 0.05 I_{rated} 25.5 to 50 I_{rated}, Δ 0.5 I_{rated}	$1 \cdot I_{rated}$				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				
VTS Action [14]	Off Inhibit Non-Dir	Off				
81HB2 Inhibit	No Yes	No				
79 Delayed Inhibit	No Yes	No				
21LB-3P Inhibit [14]	No Yes	No				
21LB-1P Inhibit [14]	No Yes	No				

5.11.6 IEC 61850 Functional Information Mapping

A50PTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A50PTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

14 Applies only to devices with VT inputs

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50PTOC*.Mod

Information				
50 Overcurrent Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A50PTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50PTOC*.Health

Information		
Device Healthy	0	1
A50PTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50PTOC*.Op

Information		
Element Operated	0	1
A50PTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A50PTOC*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A50PTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information												
Element Phase A picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element Phase A picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
Element Phase B picked up and Fwd Direction	x	x	x	0	0	0	0	1	0	1	0	0
Element Phase B picked up and Rev Direction	1	x	1	1	0	1	0	0	0	0	0	0
Element Phase C picked up and Fwd Direction	1	x	x	0	0	0	0	1	1	0	0	0
Element Phase C picked up and Rev Direction	x	1	x	1	1	0	0	0	0	0	0	0
A50PTOC*.Str.dirGeneral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element Phase A picked up	0	1
A50PTOC*.Str.phsA	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase A picked up and Fwd Direction	0	1	0
Element Phase A picked up and Rev Direction	1	0	0
A50PTOC*.Str.dirPhsA	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase B picked up	0	1
A50PTOC*.Str.phsB	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase B picked up and Fwd Direction	0	1	0
Element Phase B picked up and Rev Direction	1	0	0
A50PTOC*.Str.dirPhsB	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase C picked up	0	1
A50PTOC*.Str.phsC	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase C picked up and Fwd Direction	0	1	0
Element Phase C picked up and Rev Direction	1	0	0
A50PTOC*.Str.dirPhsC	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.11.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 50-n		Inhibit 50-n	Input			
		50-n PhA Pickup	Output			
		50-n PhB Pickup	Output			
		50-n PhC Pickup	Output			
		50-n PhA Operated	Output			
		50-n PhB Operated	Output			
		50-n PhC Operated	Output			
	50-n Pickup	50-n Pickup	Output			
50-n		50-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.12 50AFD Arc Flash Detection

5.12.1 Overview of Functions

Arc detector inputs and instantaneous overcurrent/earth fault protection elements are used to provide:

- Detection of fault arcs in electrical switchgear
- Arc detector optical to electrical interface is connected between the arc flash detector and binary input
- Optional check of fault using high speed overcurrent and/or earth fault elements
- Discriminative tripping and isolation of switchgear zones
- Up to 6 zones of monitoring

5.12.2 Structure of the Function

The arc flash detection function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A50AFDSARC***, **A50AFDPTOC**, and **A50GAFDPTOC** in IEC 61850.

The light from arcs is detected using the 7XG31xx series of equipment being connected to the binary inputs – see separate 7XG31 publications:

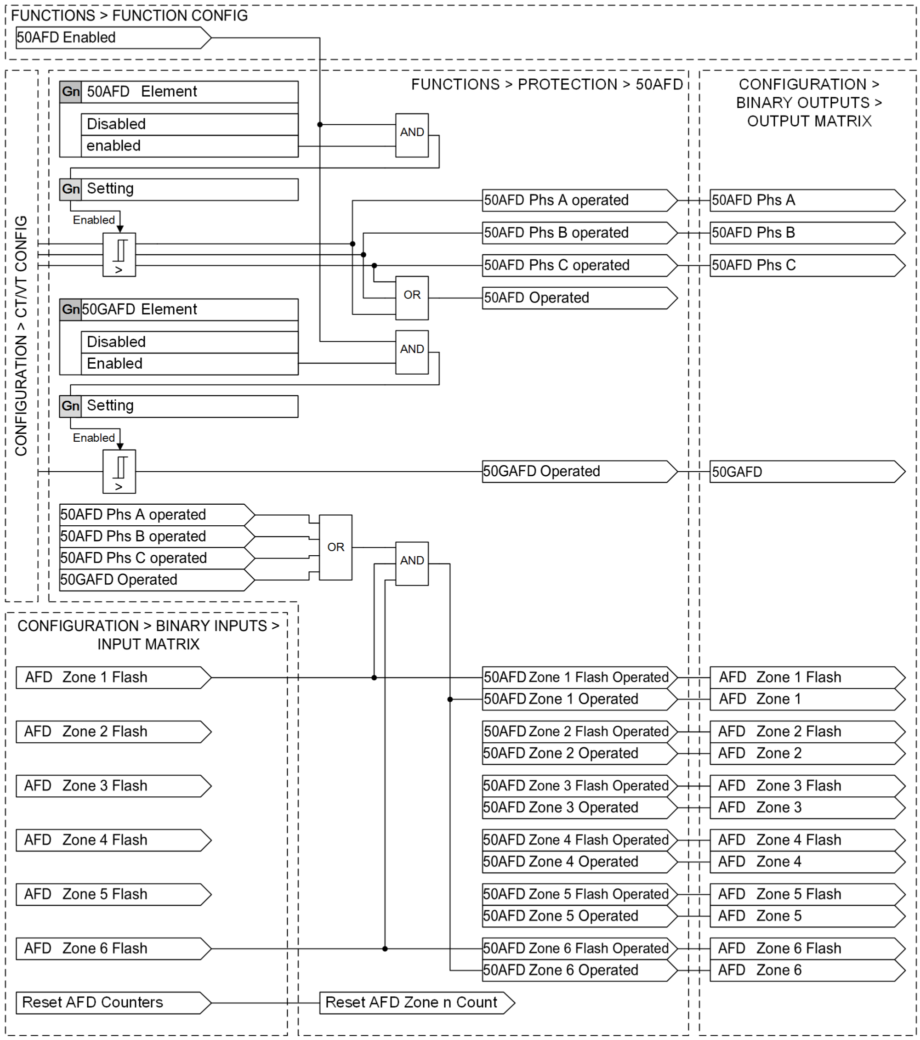
- 7XG3120 Arc fault monitor relay
- 7XG3123 Arc fault interface module
- 7XG3124 Arc fault monitor
- 7XG3130 Arc sensor

Overcurrent check detectors are provided that are high speed and specific to the 50AFD function.

Outputs are available from the 50AFD current check elements.

Outputs are available from Zone 'n' flash inputs and current check detector elements (n = 1 to 6).

5.12.3 Logic of the Function



[lo_7SR5_50AFDlogicdiagram, 2, en_US]

Figure 5-17 Logic Diagram: 50AFD/50GAFD Arc Flash Detection

5.12.4 Application and Setting Notes

Parameter: **`50AFD-n > Setting`**

- Default setting: **2 x I_n** (2 · I_{rated})

  This setting defines the operating current threshold of the element. The applied phase current must exceed this setting.

  This setting is used to verify that the arc detection is also accompanied by an overcurrent and so provides a check and increases operational security. This setting should be above load current levels.

Parameter: **`50GAFD-n > Setting`**

- Default setting: **2 x I_n** (2 · I_{rated})

  This setting defines the operating current threshold of the element. The applied phase current must exceed this setting.

  This setting is used to verify that the arc detection is also accompanied by earth fault current and so provides a check and increases operational security.

Settings Example

There should be little or no current flowing to earth in a healthy system so earth fault relays can be given far lower pickup levels than relays which detect excess current above load current in each phase conductor. Earth fault relays are important where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance as any earth fault current that flows in the phase conductors will be limited.

5.12.5 Settings Menu

Functions > Function Config							
Parameter	**Range**	**Settings**					
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**	
50AFD Arc Flash	Enabled Disabled	Disabled					

Functions > Protection > 50AFD > Gn 50AFD-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.5 to 20 I_{rated}, Δ 0.1 I_{rated}	2x				

Functions > Protection > 50AFD > Gn 50GAFD-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.05 to 8 I_{rated}, Δ 0.01 I_{rated}	2x				

5.12.6 IEC 61850 Functional Information Mapping

A50AFDPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A50AFDPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50AFDPTOC*.Mod

Information				
50AFD Enabled (Function Config)	x	0	x	1
50AFD Element Disabled	1	x	0	0
50AFD Element Inhibited	x	x	1	0
A50AFDPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50AFDPTOC*.Health

Information		
Device Healthy	0	1
A50AFDPTOC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A50AFDPTOC*.Op

Information		
Element Operated	0	1
A50AFDPTOC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A50AFDPTOC*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A50AFDPTOC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information		
Element Phase A picked up	0	1
A50AFDPTOC*.Str.phsA	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information		
Element Phase B picked up	0	1
A50AFDPTOC*.Str.phsB	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information		
Element Phase C picked up	0	1
A50AFDPTOC*.Str.phsC	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A50GAFDPTOC*.Mod

Information				
50AFD Enabled (Function Config)	x	0	x	1
50GAFD Element Disabled	1	x	0	0
50GAFD Element Inhibited	x	x	1	0
A50GAFDPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GAFDPTOC*.Health

Information		
Device Healthy	0	1
A50GAFDPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50GAFDPTOC*.Op

Information		
Element Operated	0	1
A50GAFDPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A50GAFDPTOC*.Str

Information		
Element picked up	0	1
A50GAFDPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A50AFDSARC*.Mod

Information	
Reset Device	x
A50AFDSARC*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50AFDSARC*.Health

Information		
Device Healthy	0	1
A50AFDSARC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50AFDSARC*.FACntRs

Information	Measurand	Value
AFD Operate Count	A50AFDSARC*.FACntRs.stVal	0 to 10000

Information	
AFD Operate Count	Value (0 to 10000)
A50AFDSARC*.FACntRs.ctlVal	**Value (0 to 10000)**

A50AFDSARC*.FADet

Information		
AFD Operated	0	1
A50AFDSARC*.FADet.stVal	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.12.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Reset AFD Counters			Input			
		Reset AFD Zone n Count	Input			
AFD Zone n Flash		AFD Zone n Flash	Input			
50AFD PhA		50AFD PhA Operated	Output			
50AFD PhB		50AFD PhB Operated	Output			
50AFD PhC		50AFD PhC Operated	Output			
50GAFD		50GAFD Operated	Output			
		50AFD Operated	Output			
AFD Zone 1 Flash		AFD Zone 1 Flash Operated	Output			
AFD Zone 1 Count		AFD Zone 1 Count Operated	Meter			
AFD Zone 1		AFD Zone 1 Operated	Output			
AFD Zone 2 Flash		AFD Zone 2 Flash Operated	Output			
AFD Zone 2 Count		AFD Zone 2 Count Operated	Meter			
AFD Zone 2		AFD Zone 2 Operated	Output			
AFD Zone 3 Flash		AFD Zone 3 Flash Operated	Output			
AFD Zone 3 Count		AFD Zone 3 Count Operated	Meter			
AFD Zone 3		AFD Zone 3 Operated	Output			
AFD Zone 4 Flash		AFD Zone 4 Flash Operated	Output			
AFD Zone 4 Count		AFD Zone 4 Count Operated	Meter			
AFD Zone 4		AFD Zone 4 Operated	Output			
AFD Zone 5 Flash		AFD Zone 5 Flash Operated	Output			
AFD Zone 5 Count		AFD Zone 5 Count Operated	Meter			
AFD Zone 5		AFD Zone 5 Operated	Output			
AFD Zone 6 Flash		AFD Zone 6 Flash Operated	Output			
AFD Zone 6 Count		AFD Zone 6 Count Operated	Meter			
AFD Zone 6		AFD Zone 6 Operated	Output			
		Remote 50 AFD	Input			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.13 50G Instantaneous Earth Fault – Measured

5.13.1 Overview of Functions

Instantaneous/time delayed earth fault protection is used to provide:

- Short circuit detection in electrical equipment.
- High speed protection where appropriate to its location in the power system network and/or network impedances.
- Backup or emergency protection in addition to other protection functions or devices.
- Coordinated operation with other devices using time graded settings.

5.13.2 Structure of the Function

The measured instantaneous earth fault function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A50GPTOC*** in IEC 61850.

The function monitors the primary system current using the earth fault CT input e.g. CT4.

The basic instantaneous/time delayed measured earth fault function (50G) is summarized below:

- Measurement is based on either fundamental frequency or RMS current.
- Elements operate with a definite time delayed (DTL) characteristic.
- Outputs are provided for general pickup and trip.

The basic function is non-directional but can be directionalized when the device is fitted with VT inputs.

Each 50G element can be set to operate for forward current, reverse current or independently of current direction. Directionalized functionality uses the decision of the 67G element.

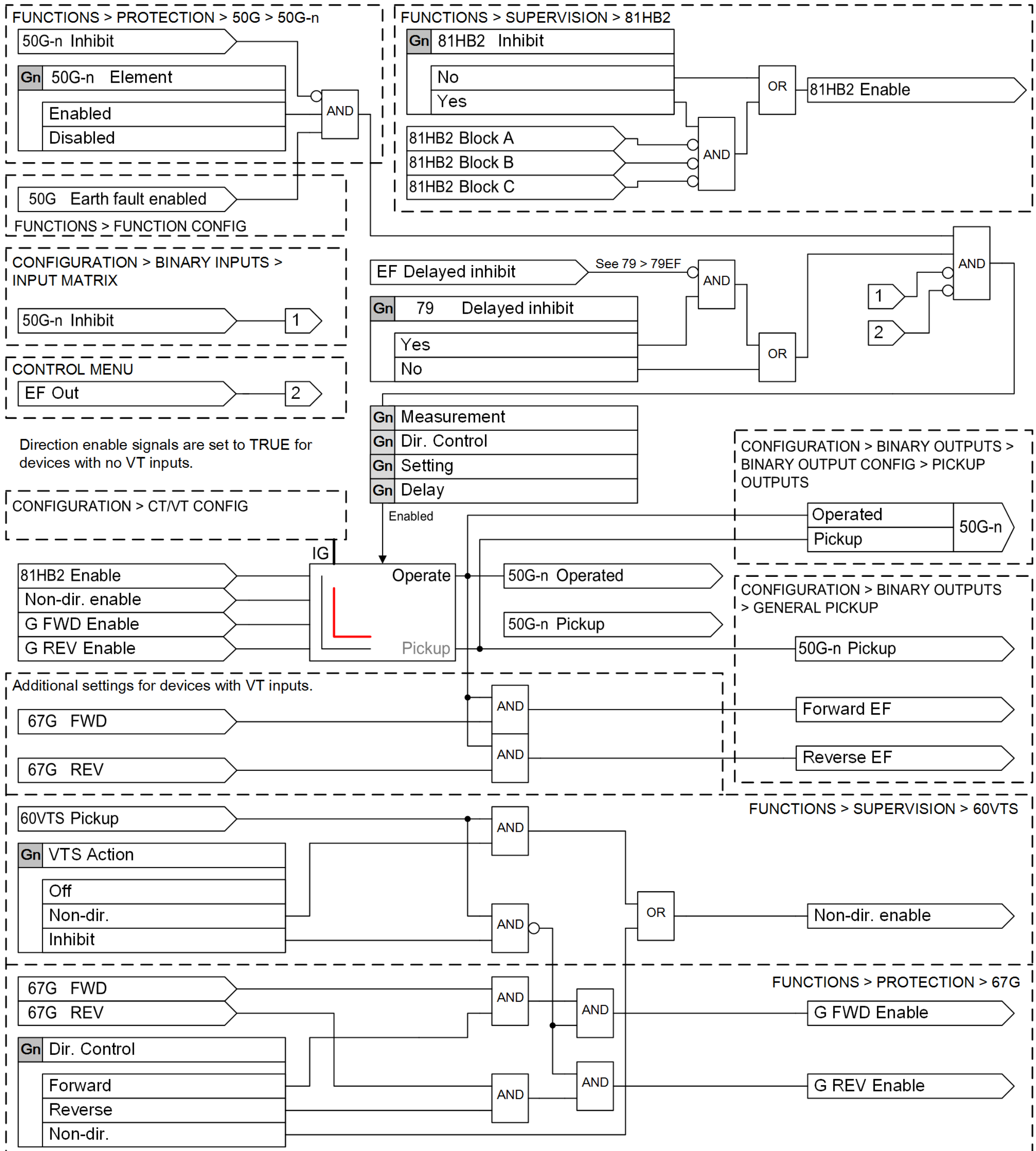
- Provides information regarding flow direction of earth current for selective application of earth fault protection.
- Ensures selective fault detection for parallel lines or transformers with infeed at one end.
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies.

Where earth fault protection is directionalized correct operation is dependent on valid information being received from the VT inputs, operation of each directionalized element will be affected if a VT fuse fails. When a fuse failure is detected, 60VTS function, each element can be selected to either ignore the VT failure, switch to non-directionalized operation (which does not require VT inputs) or be inhibited.

When installed in power transformer circuits earth currents may be measured by the function during switch in of the transformer. Each element can be set to be inhibited when inrush current is detected, (see *6 Supervision Functions* , section 81HB2 Inrush Current Detection).

Elements can be mapped to start **79 Automatic Reclosing** by selection of the element as a **79 PF Trigger** within the 79 function element menus. For autoreclose sequences that require operation of instantaneous or time delayed protections to be inhibited this can be selected in settings menu.

5.13.3 Logic of the Function



[lo_7SR5_50Glogicdiagram, 2, en_US]

Figure 5-18 Logic Diagram: 50G Instantaneous Earth Fault – Measured

5.13.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These settings can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Measurement`**

- Default setting: **`RMS`**

  Selects whether fundamental frequency RMS or the True RMS value of the measured currents used.

Parameter Value	Description
RMS	Select this method of measurement if it is required to consider the effects of harmonic currents. This method may be required if there are significant harmonic content such as at capacitor banks or filter networks. This method is required for correct grading with fuses or electromechanical overcurrent relays.
Fundamental	This method is used if harmonic components are not to be considered in the current evaluation. This method may be required for correct grading with devices which do not provide true RMS measurement. This method may be preferred for unbalance type protection where the unbalance applies at fundamental frequency and the risk of errors in transient response measurement can be avoided.

Parameter: **`Dir. Control`**

- Default setting: **`Non-Dir`**

  This setting is used to define whether the element will operate for earth faults detected in the **`Forward`** or **`Reverse`** direction based on the 67G directional element decision or for any earth fault regardless of the 67G direction. This allows the earth fault protection to have different current and time settings for forward, reverse and non-directional faults by using three 67G function elements.

  This parameter is not provided in devices that do not have voltage inputs or for current inputs that are not polarized by the voltage inputs.

Parameter Value	Description
Non-Dir	Select this setting if the element is to operate regardless of the current direction or presence of voltage.
Forward	Select this setting if the element is to operate only in a forward direction.
Reverse	Select this setting if the element is to operate only in a reverse direction.

Parameter: **`Setting`**

- Default setting: **0.5 x I_n** ($0.5 \cdot I_{rated}$)

  This setting defines the operating current threshold of the element. The operation timing will then be dependent on the selected delay setting.

  This setting should be set to suit the individual application.

Parameter: **Delay**

- Default setting: **0 s**
  This time delay setting should be set to suit the individual application.

Parameter: **VTS Action**

- Default setting: **Off**
  Voltage transformer failure can affect the directional decision and introduce an error. This setting selects if operation of the 60VTS Voltage Transformer Supervision element automatically affects the operation of the element.

Parameter Value	Description
Off	60VTS operation does not affect the element and the forward/reverse directional decision assessed from the applied voltage is applied regardless of the 60VTS state. During a VT failure the device may assess the direction incorrectly and the element may operate for faults in the non-operate direction or not operate for faults in the operate direction.
Inhibit	When 60VTS detects a VT failure the element is immediately inhibited automatically and will not operate. Tripping of a system fault will then rely on other elements or devices.
Non-Dir	When 60VTS detects a VT failure the element will become non-directional and ignore the directional decision. The element will operate for overcurrent regardless of which direction the fault current is in.

Parameter: **81HB2 Inhibit**

- Default setting: **No**
  High levels of inrush currents into reactive components such as transformers when they are switched can result in operation of overcurrent elements. The inrush current can be detected by a high percentage of second harmonic current content by the 81HB2 element. This can be configured to inhibit the overcurrent element automatically by configuration of this setting.

Parameter Value	Description
No	The earth fault element is not affected by operation of the 81HB2 element.
Yes	The earth fault element is inhibited by when the 81HB2 element is operated.

Parameter: **79 Delayed Inhibit**

- Default setting: **No**
  The autoreclose scheme sequence may require that some selected protection elements are only used for the first trip(s) of the sequence, typically instantaneous ungraded protection elements, before reverting to graded protection.
  This setting is used to inhibit 50G operation when it is parameterized as instantaneous and only delayed tripping is required. This should be selected to the default setting **Off** unless required by the autoreclose sequence.

Parameter Value	Description
No	The earth fault element is normally active and is not blocked by autoreclose sequence requirements.
Yes	The 50G element will be inhibited from the autoreclose logic as required by the applied sequence. Incorrect configuration can result in no protection being enabled.

Settings Example

There should be little or no current flowing to earth in a healthy system so earth fault relays can be given far lower pickup levels than relays which detect current above load current in each phase conductor. Earth fault relays are important where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance as any earth fault current that flows in the phase conductors will be limited.

5.13.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
50G Earth Fault	Enabled Disabled	Disabled				

Functions > Protection > 50G > Gn 50G-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Measurement	RMS Fundamental	RMS				
Dir. Control	Non-Dir Forward Reverse	Non-Dir				
Setting	0.005 to 2.5 I_{rated}, Δ 0.005 I_{rated} 2.55 to 25 I_{rated}, Δ 0.05 I_{rated}	0.5 · I_{rated}				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				
VTS Action	Off Inhibit Non-Dir	Off				
81HB2 Inhibit	No Yes	No				
79 Delayed Inhibit	No Yes	No				

5.13.6 IEC 61850 Functional Information Mapping

A50GPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A50GPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GPTOC*.Mod

Information				
50G Earth Fault Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A50GPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GPTOC*.Health

Information		
Device Healthy	0	1
A50GPTOC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A50GPTOC*.Op

Information		
Element Operated	0	1
A50GPTOC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A50GPTOC*.Str

Information		
Element picked up	0	1
A50GPTOC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.13.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 50G-n		Inhibit 50G-n	Input			
E/F off/on			Control	Y	Y	Y
	50G-n Pickup	50G-n Pickup	Output			
50G-n		50G-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.14 50GHS High Speed Earth Fault – Measured

5.14.1 Overview

High speed earth fault protection is used to provide:

- Very high speed operating protection for fast clearance of high current earth faults

5.14.2 Structure of the Function

The element is not installed in the default device configuration and must be added via the Reydisp Manager tool if required. It is located in the 50G element group alongside the standard 50G elements. In general, the standard 50G elements are easily fast enough for most applications and provide additional functionality for greater flexibility.

50HS High speed phase overcurrent is also available for fast clearance of phase faults.

The high speed earth fault function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A50GHSPTOC*** in IEC 61850.

The function monitors measured earth current at CT4, or alternatively can be configured for CT8 for 7SR512 devices.

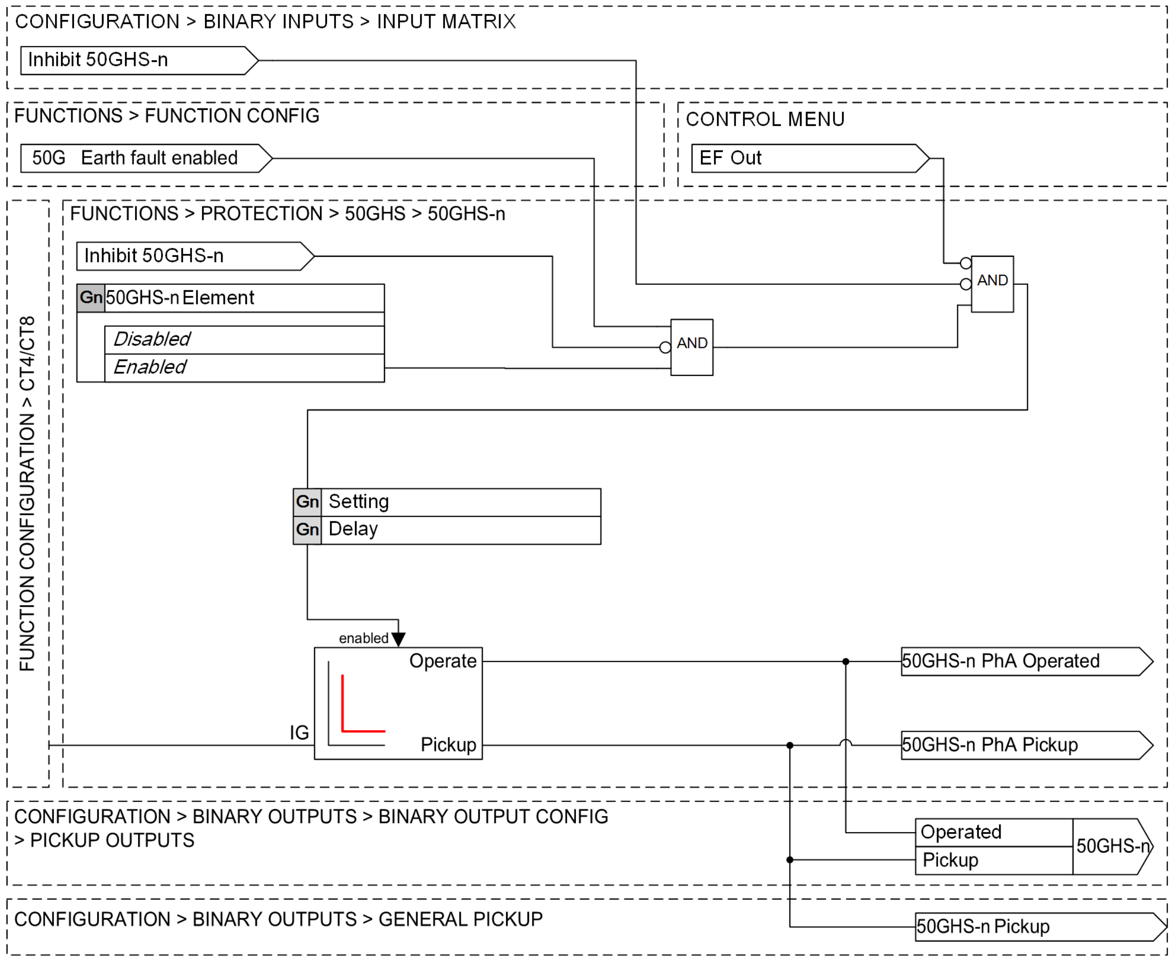
The high speed measured earth fault function (50GHS) is summarized in the following list:

- Operation time of less than 1 cycle can be achieved for high multiples of current setting
- Elements can be set to operate with a definite time delayed (DTL) characteristic but are usually set to 0 ms delay for fastest possible ungraded operation
- Outputs are provided for general pickup and trip

The function is non-directional, does not filter fundamental frequency for operation, it uses measured current only and cannot be inhibited by second harmonic content as these additions would introduce delay to element operation.

It is usually not appropriate to start **79 Automatic Reclosing** for the high current faults typically associated with this function and therefore these elements are not included in the standard mapping for autoreclose start. This can be easily configured as an external start via relay settings and user logic if required.

5.14.3 Logic of the Function



[lo_7SR5_50GHSlogicdiagram, 1, en_US]

Figure 5-19 Logic Diagram: 50GHS High Speed Earth Fault – Measured

5.14.4 Application and Setting Notes

Parameter: **`Element`**

- Default setting: **`Disabled`**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. This setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Setting`**

- Default setting: **`0.5 x In`** ($0.5 \cdot I_{rated}$)
  This setting defines the operating current threshold of the element.
  This setting should be set to suit the individual application. Fast operation will be achieved for > 200 % of this setting.

Settings Example

There should be little or no current flowing to earth in a healthy system so earth fault relays can be given lower pickup levels than relays which detect excess current above load current in each phase conductor. Higher settings are generally recommended for fast elements to avoid operation for pole scatter during circuit breaker operations and other such transient conditions. High speed earth fault function are not usually applied where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance as any earth fault current will be limited.

5.14.5 Settings Menu

Configuration > Function Config						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
50G Earth Fault[15]	Enabled Disabled	Disabled				

Functions > Protection > 50G > Gn 50GHS-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.5 to 2.5 · I_{rated}, Δ 0.01 I_{rated} 2.55 to 25 · I_{rated}, Δ 0.05 I_{rated}	0.5 · I_{rated}				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				

5.14.6 IEC 61850 Functional Mapping

A50GHSPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A50GHSPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

15 This setting is also used by the standard 50G elements

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GHSPTOC*.Mod

Information				
Measured E/F Enabled (Function Config)	x	0	x	1
Element Disabled	1	0	0	0
Element Inhibited	x	x	1	0
A50GHSPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GHSPTOC*.Health

Information		
Protection Healthy	0	1
A50GHSPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50GHSPTOC*.Op

Information		
Element Operated	0	1
A50GHSPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A50GHSPTOC*.Str

Information		
Element picked up	0	1
A50GHSPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value TRUE: 1
FALSE: 0

5.14.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 50GHS-n		Inhibit 50GHS-n	Input			
E/F off/on			Control	Y	Y	Y
	50GHS-n Pickup	50GHS-n Pickup	Output			
50GHS-n		50GHS-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.15 50GI Intermittent Earth Fault

5.15.1 Overview

The function **Intermittent Earth Fault Protection** (ANSI 50GI) is used to:

- Detect intermittent earth faults in grounded, compensated, or isolated cable systems selectively
- Can be operated in 2 different modes:
  - Operate only by counting repeated earth-current pulses without expiry of the rest time between pulses
  - Operate by integration of the fault current duration in combination with counting earth-current pulses without expiry of the rest time between pulses
- Can be with a directional criterion if voltage inputs are available

The intermittent earth faults in cable systems are frequently caused by weak insulation or water ingress in cable joints. The earth faults are characterized by the following properties:

- Intermittent earth faults can show very short high earth-current pulses (up to several hundred amperes) with an often short duration of several milliseconds or even less
- Intermittent earth faults are self-extinguishing and will reignite after a short time, this time may be as short as one half period or up to several periods, depending on the power-system conditions and the fault type
- Intermittent earth faults can persist over longer periods (several seconds to minutes) before developing into static persistent earth faults

5.15.2 Structure of the Function

Up to 2 independent Intermittent Earth Fault protection elements can be defined.

The 2 elements have an identical structure.

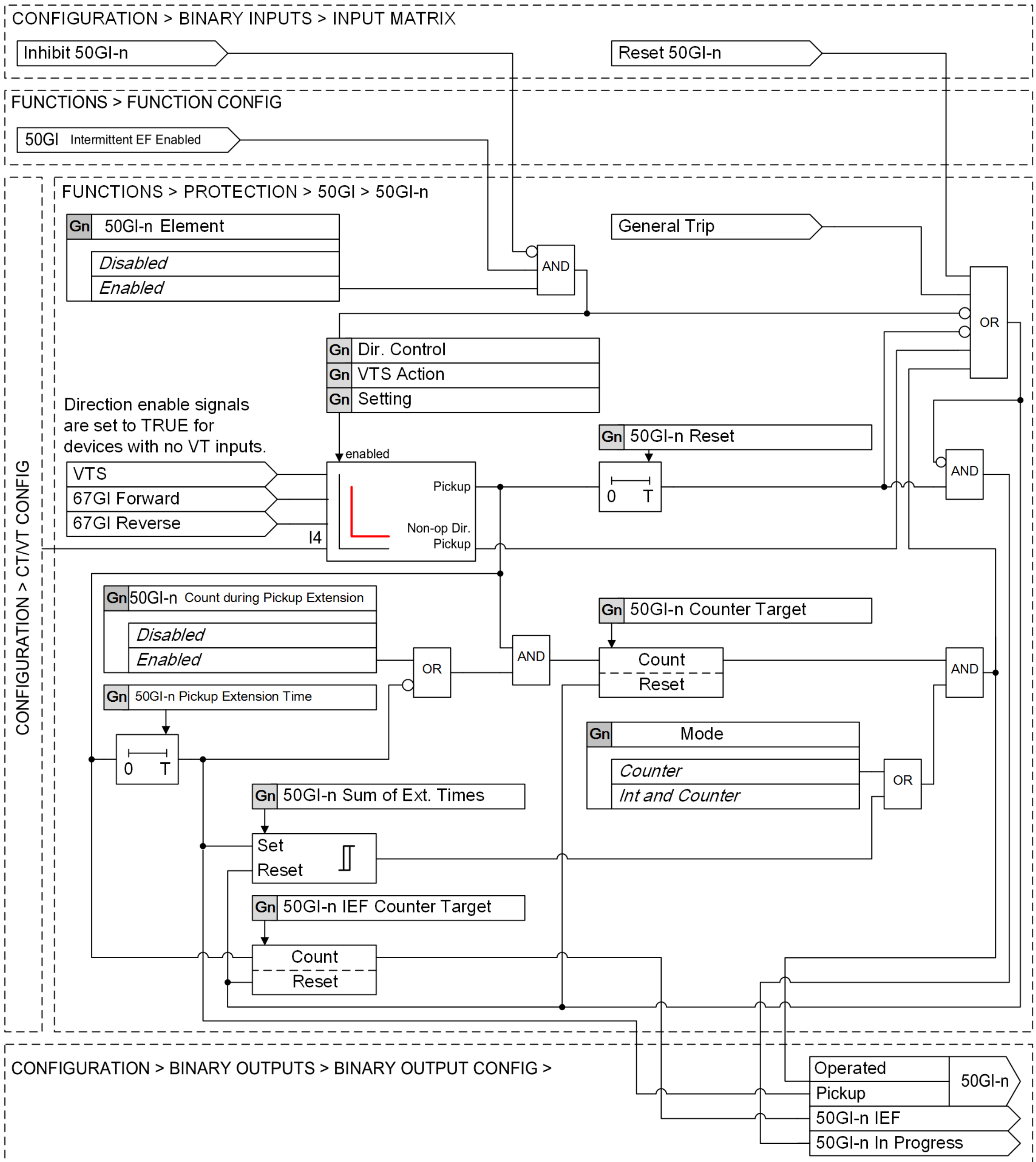
The elements can be set to be dependent on current direction in 7SR51 devices with voltage measurement if required or non-directional. Elements are supplied in 7SR51 devices without voltage measurement without the directional option.

The elements can be set to operate based on a counter target for the instances of current pulses or to apply an additional integration of the time duration of the pulses.

Directional elements can be set to operate for current in the forward or reverse direction. Pulses of earth fault current above **50GI-n Setting** in the non-operating direction will cause immediate reset of the 50GI-n element, **50GI-n In Progress** and the **50GI-n Reset time** will start again after the next operate direction pickup.

This protection function calculates the rms magnitude of the residual current from processing of the earth current samples on the measured earth channel.

5.15.3 Logic of the Function



[lo_7SR5_50GIlogicdiagram, 1, en_US]

Figure 5-20 Logic Diagram: 50GI Intermittent Earth Fauult

Direction Determination and Pulse Counting

When the RMS value of earth current is above the **50GI Setting** and in the operating direction, if applicable, the element will pickup and the first Intermittent Earth Fault pulse will be counted. When the current falls below setting the pickup resets, the reset time starts and the counter waits for the next pulse. If the current rises above setting again and is in the operating direction before the reset time expires, the pulse count is incremented to 2 and continues for subsequent pulses. Whenever the current falls below setting between pulses the reset time starts again. If the reset time expires without a further pickup pulse, the counter is reset and waits for the next first pulse to start again. If a current pickup is detected in the non-operate direction at any time, the pickup and the counter are immediately reset. The operation of the 50GI-n element can be set to be non-directional. Directional settings for the 50GI element are defined in the 67GI element. An output signal is provided for **50GI-n In Progress** which can be used to indicate that the counter and duration integration are active and therefore the reset time is running. This signal has a separate count setting which can be set to greater than 1 to avoid nuisance indications. Operation of this signal raises a separate **50GI-n IEF** output and operates General Pickup and communications protocol pickup events including the IEC 61850 **50GIPTOC*.Str** data attribute. An additional **50GI-n Pickup** output is provided in the device logic template for testing purposes and custom configuration if required.

Operating Mode

In addition to the fault pulse counter the device can be set to integrate the duration of each successive current pulse and compare to a total operate time. The element can be set to operate for achieving the counter target only or for **Int and counter**.

Operation **Counter**: The multiple earth-current pulses of intermittent earth faults can result in a damage of the protected object. A high count value can be applied to avoid nuisance operations due to switching transients. In this mode, the criterion for operate is only the number of directional current pulses.

Operation **Int and counter**: An intermittent earth fault can result in thermal stress on the protected object. Both the magnitude and the duration of the earth-current pulses are responsible for the level of thermal stress. In order to replicate the thermal stress, the stage sums up the duration of the pickups with an integrator. In addition to the integration the counter is also applied. The counter logic provides the required directional determination of the current pulses. Additional **50GI-n Integrator** and **50GI-n Count** outputs are provided in the device logic template for testing purposes and custom configuration if required. These signals can be used to provide separate outputs for Integrator timing reached independent of the count target and Count Target reached, independent of the Integrator. An additional parameter is provided to configure whether the count is incremented during the pickup extension time or only a single increment is applied for additional current pulses.

Element Inhibits

An inhibit input is provided to allow the 50GI-n element to be blocked.

A reset input is also provided to allow the 50GI-n element to be reset.

In the event of an inhibit being applied by a binary input, logic signal or VTS, an element that is picked up will be reset. Subsequent reset of the inhibit will allow restart of the operating delay.

5.15.4 Application and Setting Notes

Measurement Value for Pickup and Integration

The element is operated from the RMS value of the measured earth current to take into account the harmonic components as these components contribute to the thermal load. The short duration of some fault current pulses can lead to attenuation of measurement but this is generally not significant since the fault current magnitude is several times that of the protection threshold.

Pickup, Limited Pickup, and Stabilized Pickup

Whenever current exceeds the **50GI Setting** threshold, the element identifies the pickup. The pickup indication is prolonged by a user settable time **Pickup extension Time**.

This stabilization is especially important for the coordination with the existing static or electromechanical overcurrent protection or other external equipment and will also prevent an excessive burst of repeated events on the system interface or fault recording.

Intermittent Earth-Fault Indication

The element counts the earth current pulses. If the number of pulse counts in the operating direction is equal to or greater than **50GI-n IEF Counter Target**, the signal **50GI-n IEF** is raised.

If the signal **50GI-n IEF** is raised, this can be used to inhibit the operation of other protection elements such as typically the 59N Neutral Overvoltage backup protection.

Operate

The conditions for issuing the signal Operate depend on the operating mode.

Operation	Conditions for Issuing the Operate Signal
Counter	• The current-pulse counter reached the **50GI-n Counter Target**, which is signaled via the 50GI-n Count logic point • The pickup is active, which is signaled via the Pickup indication
Int and Counter	• The 3I0 current integration value reaches the predefined **Sum of Pickup Extension Times**, which is signaled via the **50GI-n Integrator** logic point • The current-pulse counter reached the **50GI-n Counter Target**, which is signaled via the 50GI-n Count indication • The pickup is active, which is signaled via the Pickup indication

When a current pulse in the opposite direction to the setting **Dir. Control** is detected, the Integrator and the Counter are reset.

Reset Time for the Definition of the Interval between Independent Earth Faults

If there is a large interval between independent earth faults or if the earth fault extinguishes and does not restrike again within a larger time, the stressed equipment can cool down. In this case, no operate is necessary. If a subsequent pulse is detected that is considered as a new incident. The reset timer monitors the separation of the current pulses and is reset at the end of each pulse in anticipation of the next. The integration of the pulse duration is reset only if the Reset time expires without a further pulse.

Reset Conditions

The element Reset timer is restarted when the earth fault current falls below setting. The integrator is reset when the Reset timer expires or if the element operates. It is also reset by operation of General Trip.

Parameter: **Pickup Extension Time**

- Default setting: **0.10 s**

  The parameter **Pickup Extension Time** is used to extend the pickup time to create a stabilized pickup signal which may be particularly important for the coordination with existing static or electromechanical equipment. This time is also integrated in the Int and Counter mode such that it constitutes a minimum time that is added as an extension to model the additional thermal effect of very short duration current pulses.

Parameter: **No. of pulses for operate**

- Default setting: Counter Target = **5**

  The pulses in the operating direction, if applicable, are counted. If the pulse counter reaches the set value of the parameter **Counter Target** the directional counter criterion is fulfilled. The setting of parameter **Counter Target** depends on the **Operation**.

Operation Mode	Application and Setting Notes
Counter	The number of directional pulses is the determining operate criterion. Thus do not set the value for parameter **Counter Target** too small. Consider that a permanent intermittent earth fault will cause many current pulses. If no time-grading considerations are required, Siemens recommends using a value in the range of 10 to 20.
Integrator and counter	The integrator and the counter are the determining operate criteria while the counter criterion is only used for the direction determination. The value for parameter **Counter Target** to fulfill the directional criterion can be set to a rather small value in the range of 3 to 5.

Parameter: **Sum Of Pickup Extension Time**

- Default setting: **1 s**

  This parameter is only available in the operating mode **Int and counter**.

  With the parameter **Sum Of Pickup Extension Time**, you set the threshold value for the integrator. If the integration reaches **Sum Of Pickup Extension Time**, the stage operates if the Pulse no. reached signal and the pickup state is present.

  The parameter **Sum Of Pickup Extension Time** represents one of the 5 selectivity criteria (**Dir. Control**, **Setting**, **Pickup Extension Time**, **Reset**, and **Sum Of Pickup Extension Time**) for coordination of the relays on subordinate graded devices. It is comparable to the time grading of the overcurrent protection. The **Sum Of Pickup Extension Time** has the shortest summation time in the radial system for the device that is closest to the intermittent earth fault and that picks up.

Parameter: **Count During Pickup Extension**

- Default setting: **Disabled**

  If this setting is **Enabled**, additional current pulses during the **Pickup Extension Time** will increment the Counter, if **Disabled**, the counter is incremented only once.

Parameter: **Reset**

- Default setting: **300 s**

  With the parameter **Reset** you can define the maximum interval between 2 adjacent earth faults. If the interval is larger than the **Reset** time the counter and integrator are reset when the reset time is reached. The **Reset** time parameter is typically much higher than the operate value of the **Sum Of Pickup Extension Time**.

Tripping Function

These elements can be used an alarm or monitoring function. If the element is a tripping function it must be configured to a designated **Trip Contact** to trigger a **Fault Record**. Triggering of waveform storage is separate and should be configured if required

5.15.5 Settings Menu

Configuration > Function Config						
Parameter	Setting Options	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
50GI Intermittent EF	Enabled Disabled	Disabled				

Functions > Protection > 50G > Gn 50GI-n						
Parameter	Setting Options	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Element	Enabled Disabled	Disabled				
Dir.Control	Forward Reverse Non-Dir	Non-Dir				
Operation	Counter Int and Counter	Int and Counter				
Setting	0.05 to 0.1 · I_{rated}, Δ 0.001 I_{rated} 0.1 to 2 · I_{rated}, Δ 0.005 I_{rated}	0.02 · I_{rated}				
Pickup Extension Time	0 to 10 s Δ 0.005 s	0.10 s				
Count During Pickup Extension	Enabled Disabled	Disabled				
IEF Counter Target	2 to 100	3				
Counter Target	2 to 10	5				
Reset	1 to 600 s Δ 1 s	300 s				
Sum of Ext Time	0.01 to 60 s Δ 0.01 s	0.5 s				

5.15.6 IEC 61850 Functional Mapping

A50GI|PTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A50GIPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GIPTOC*.Mod

Information				
Intermittent E/F Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A50GIPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GIPTOC*.Health

Information		
Device Healthy	0	1
A50GIPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50GIPTOC*.Op

Information		
Element Operated	0	1
A50GIPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value TRUE: 1
FALSE: 0

A50GIPTOC*.Str

Information		
Element in progress	0	1
A50GIPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information		
Element in progress	1	0
A50GIPTOC*.Str.dirGeneral	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value False: 0
Forward: 1

5.15.7 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Forward IEF		67GI in forward direction	Output	Y	Y	Y
Reverse IEF		67GI in reverse direction	Output	Y	Y	Y
50GI-n Reset		Reset 50GI-n	Input	Y	Y	Y
50GI-n Inhibit		Inhibit 50GI-n	Input	Y	Y	Y
50GI-n		Element Operated	Output	Y	Y	Y
50GI-n IEF		50GI-n IEF Counter Target exceeded	Output	Y	Y	Y
50GI-n In Progress		50GI-n counter running following a pickup	Output	Y	Y	Y
50GI-n Pickup		50GI-n pickup, (current above setting)	Output	Logic only	Logic only	Logic only
50GI-n Integrator		50GI-n Sum of Pickup Extension Times exceeded	Output	Logic only	Logic only	Logic only
50GI-n Count		50GI-n Counter exceeded	Output	Logic only	Logic only	Logic only

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.16 50GS Instantaneous Sensitive Earth Fault – Measured

5.16.1 Overview of Function

Instantaneous sensitive earth fault protection is used to provide:

- Detection of low level earth current in electrical equipment
- Earth fault protection for compensated or isolated networks. This requires directional current detection, (see *5 Protection and Automation Functions* , section 67 Directional Overcurrent/Earth Fault).
- Backup or emergency protection in addition to other protection functions or devices
- Coordinated operation with other devices using time graded settings

5.16.2 Structure of the Function

The measured instantaneous earth fault element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A50GSPTOC*** in IEC 61850.

The function monitors the primary system current using the earth fault CT input e.g. CT4.

The basic instantaneous measured earth fault function (50GS) is summarized below:

- Measurement is based on fundamental frequency current
- Elements operate with a definite time-delayed (DTL) characteristic
- Outputs are provided for general pickup and trip

The basic function is non-directional, it can be directionalized when the device is fitted with VT inputs.

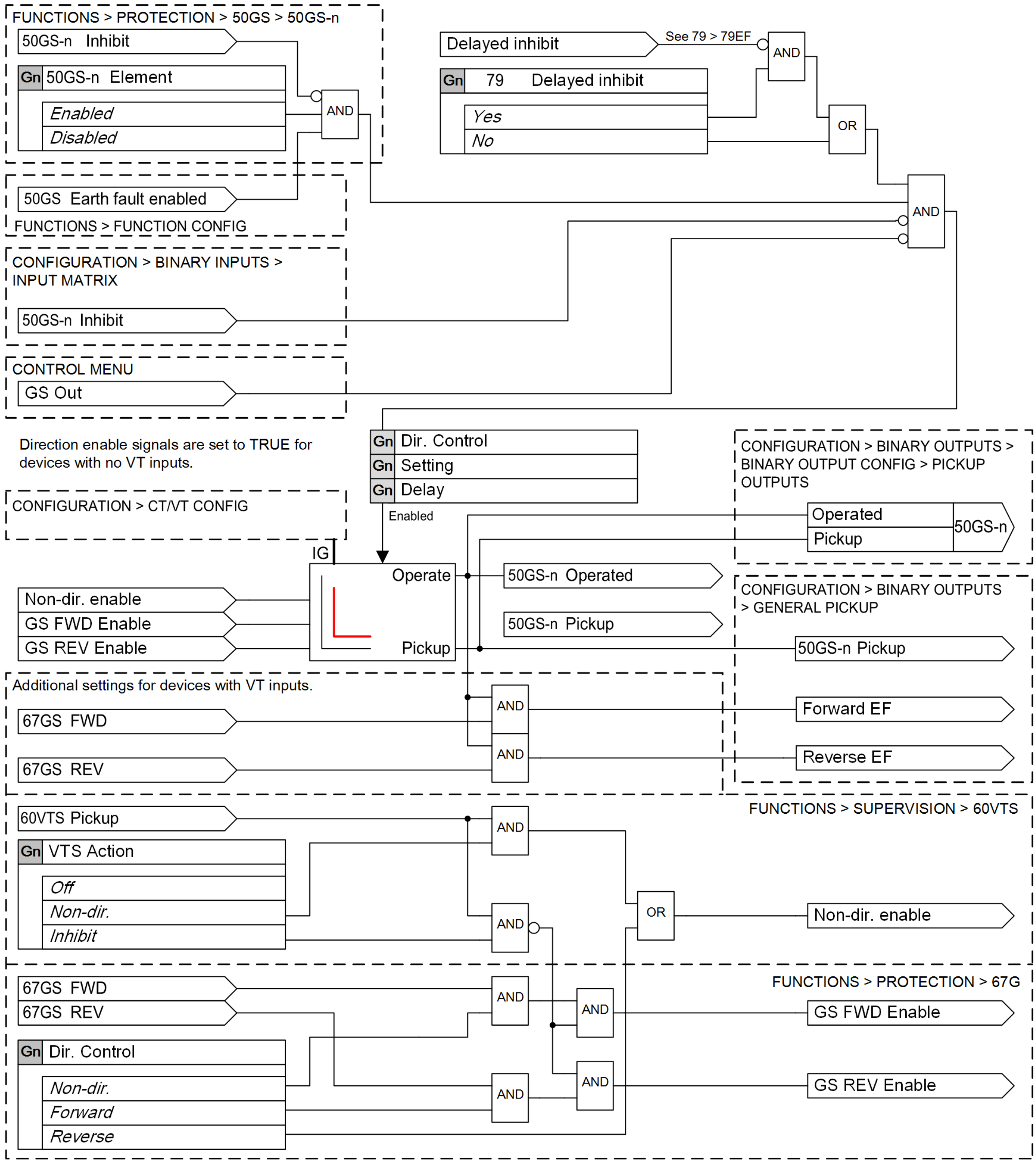
Each 50GS element can be set to operate for forward current, reverse current or independently of current direction. Directionalized functionality uses the decision of the 67GS element.

- Provides information regarding flow direction of earth current for selective application of earth fault protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies
- Can provide earth fault protection for compensated or isolated networks, (see *5 Protection and Automation Functions* , section 67 Directional Overcurrent/Earth Fault).

Where earth fault protection is directionalized correct operation is dependent on valid information being received from the VT inputs, operation of each directionalized element will be affected if a VT fuse fails. When a fuse failure is detected, 60VTS function, each element can be selected to either ignore the VT failure, switch to non-directionalized operation (which does not require VT inputs) or be inhibited.

Elements can be mapped to start **79 Automatic Recloser** by selection of the element as a **79 GS Trigger** within the 79 function element menus. For autoreclose sequences that require operation of instantaneous or protections to be inhibited this can be selected in settings menu.

5.16.3 Logic of the Function



[lo_7SR5_50GSlogicdiagram, 2, en_US]

Figure 5-21 Logic Diagram: 50GS Instantaneous Sensitive Earth Fault – Measured

5.16.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **Dir. Control**

- Default setting: **Non-Dir**

  This setting is used to define whether the element will operate for earth faults detected in the **Forward** or **Reverse** direction based on the 67GS directional element decision or for any earth fault regardless of the 67GS direction. This allows the earth fault protection to have different current and time settings for forward, reverse and non-directional faults by using three 67GS function elements.

  This parameter is not provided in devices that do not have voltage inputs or for current inputs that are not polarized by the voltage inputs.

Parameter Value	Description
Non-Dir	Select this setting if the element is to operate regardless of the current direction or presence of voltage.
Forward	Select this setting if the element is to operate only in a forward direction.
Reverse	Select this setting if the element is to operate only in a reverse direction.

Parameter: **Setting**

- Default setting: **0.5 x I_n** ($0.5 \cdot I_{rated}$)

  This setting defines the operating current threshold of the element. The operation timing will then be dependent on the selected delay setting.

  This setting should be set to suit the individual application.

Parameter: **Delay**

- Default setting: **0 s**

  This time delay setting should be set to suit the individual application.

Parameter: **VTS Action**

- Default setting: **Off**

  Voltage transformer failure can affect the directional decision and introduce an error. This setting selects if operation of the **60VTS Voltage Transformer Supervision** element automatically affects the operation of the element.

Parameter Value	Description
Off	60VTS operation does not affect the element and the forward/reverse directional decision assessed from the applied voltage is applied regardless of the 60VTS state. During a VT failure the device may assess the direction incorrectly and the element may operate for faults in the non-operate direction or not operate for faults in the operate direction.
Inhibit	When 60VTS detects a VT failure the element is immediately inhibited automatically and will not operate. Tripping of a system fault will then rely on other elements or devices.
Non-Dir	When 60VTS detects a VT failure the element will become non-directional and ignore the directional decision. The element will operate for overcurrent regardless of which direction the fault current is in.

Parameter: **79 Delayed Inhibit**

- Default setting: **No**

  The autoreclose scheme can be designed such that only instantaneous elements are used for the first trip(s) of the sequence before reverting to time graded protection. This setting allows the delayed element to be inhibited during the delayed autoreclose shots and should be left at the default setting of **Off** unless this is required.

  Note that function elements are assigned as **Delayed Trips** in the **79 > 79GS** menu.

Parameter Value	Description
No	The element is not inhibited by the autoreclose sequence design.
Yes	The element will be inhibited during any autoreclose shot which is designated as delayed. Incorrect configuration can result in no protection being enabled.

Settings Example

There should be little or no current flowing to earth in a healthy system so earth fault relays can be given far lower pickup levels than relays which detect excess current above load current in each phase conductor. Earth fault relays are important where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance as any earth fault current that flows in the phase conductors will be limited.

5.16.5 Settings Menu

Configuration > Function Config						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
50GS Sensitive Earth Fault	Enabled Disabled	Disabled				

Functions > Protection > 50GS > Gn 50GS-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Dir.Control [16]	Non-Dir Forward Reverse	Non-Dir				
Setting	0.005 to 0.1 · I_{rated}, Δ 0.001 I_{rated} 0.105 to 1 · I_{rated}, Δ 0.005 I_{rated}	0.5 · I_{rated}				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				

16 Applies only to devices with VT inputs.

Functions > Protection > 50GS > Gn 50GS-n						
Parameter	Setting Options	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
VTS Action [16]	Off Inhibit Non-Dir	Off				
79 Delayed Inhibit	No Yes	No				

5.16.6 IEC 61850 Functional Information Mapping

A50GSPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A50GSPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GSPTOC*.Mod

Information				
50GS Sensitive EF Enabled (Function Config)	x	0	x	1
Element Disabled	1	0	0	0
Element Inhibited	x	x	1	0
A50GSPTOC*.Mod.stVal	**5**	**2**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50GSPTOC*.Health

Information		
Device Healthy	0	1
A50GSPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50GSPTOC*.Op

Information		
Element Operated	0	1
A50GSPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A50GSPTOC*.Str

Information		
Element Picked Up	0	1
A50GSPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element picked up and Fwd Direction	0	1	0
Element picked up and Rev Direction	1	0	0
A50GSPTOC*.Str.dirGeneral	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.16.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 50GS-n		Inhibit 50GS-n	Input			
E/F off/on			Control	Y	Y	Y
	50GS-n Pickup	50GS-n Pickup	Output			
50GS-n		50GS-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.17 50HS High Speed Overcurrent – Phase

5.17.1 Overview

High speed earth fault protection is used to provide:

- Very high speed operating protection for fast clearance of high current phase faults

5.17.2 Structure of the Function

The element is not installed in the default device configuration and must be added via the Reydisp Manager tool if required. It is located in the 50 Overcurrent element group alongside the standard 50 elements. In general, the standard 50 elements are easily fast enough for most applications and provide additional functionality for greater flexibility.

50GHS High speed earth fault is also available for fast clearance of earth faults.

The high speed overcurrent function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A50HSPTOC*** in IEC 61850.

The function monitors phase current at CT1, CT2 and CT3.

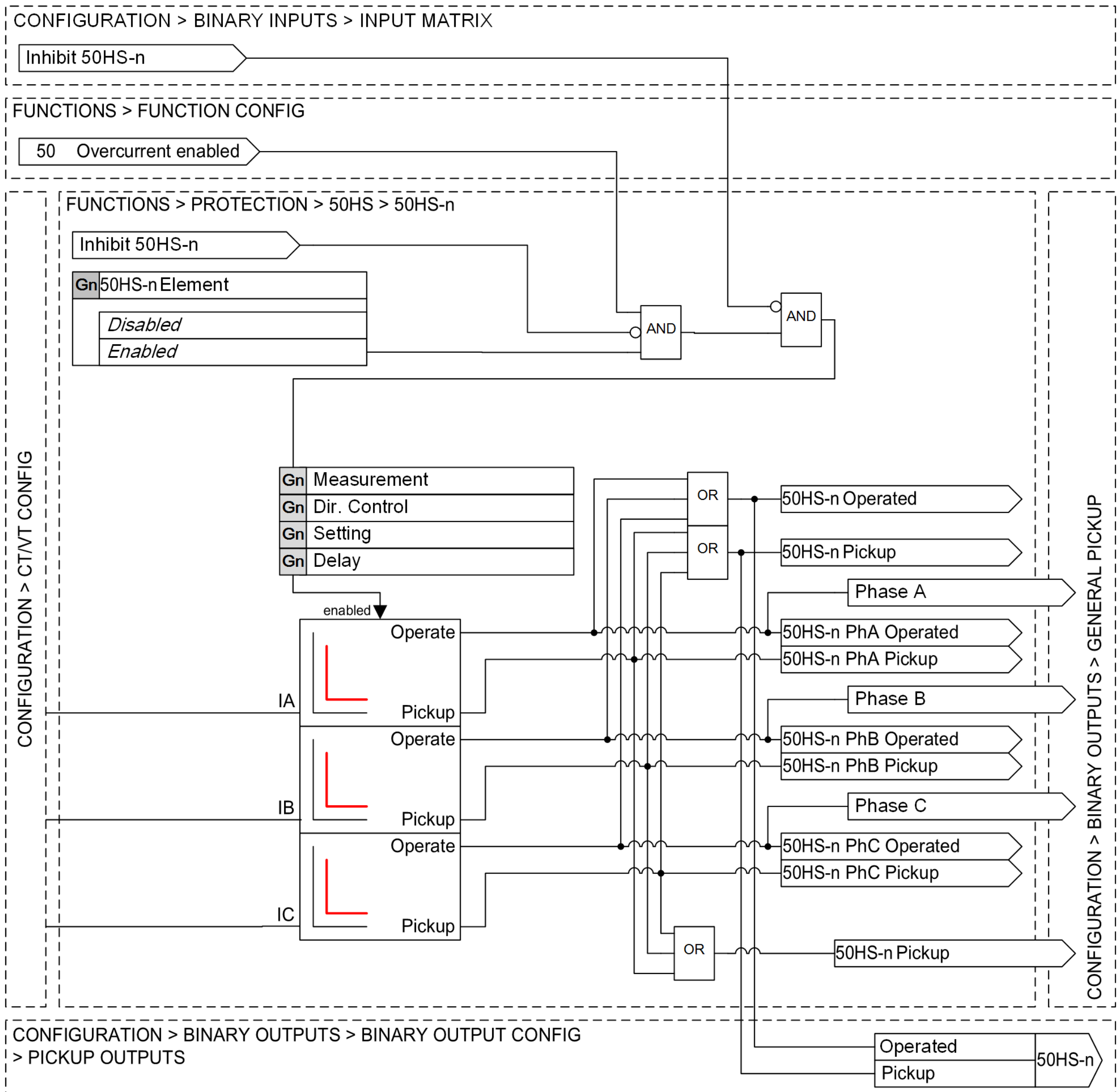
The high speed overcurrent function (50HS) is summarized in the following list:

- Operation time of less than 1 cycle can be achieved for high multiples of current setting
- Elements can be set to operate with a definite time delayed (DTL) characteristic but are usually set to 0 ms delay for fastest possible ungraded operation
- Outputs are provided for general pickup and trip

The function is non-directional, does not filter fundamental frequency for operation and cannot be inhibited by second harmonic content as these additions would introduce delay to element operation.

It is usually not appropriate to start **79 Automatic Reclosing** for the high current faults typically associated with this function and therefore these elements are not included in the standard mapping for autoreclose start. This can be easily configured as an external start via relay settings and user logic if required.

5.17.3 Logic of the Function



[lo_7SR5_50HSlogicdiagram, 1, en_US]

Figure 5-22 Logic Diagram: 50HS High Speed Overcurrent – Phase

5.17.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. This setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Setting`**

- Default setting: **`2 x In`** (2 · I_{rated})

  This setting defines the operating current threshold of the element.

  This setting should be set to suit the individual application. Fast operation will be achieved for > 200 % of this setting.

Settings Example

Setting current threshold should be selected above load current and above other transient current levels such as magnetizing inrush current associated with transformers.

5.17.5 Settings Menu

Configuration > Function Config						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
50 Overcurrent[17]	Enabled Disabled	Disabled				

Functions > Protection > 50 > Gn 50HS-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.5 to 2.5 · I_{rated}, Δ 0.01 I_{rated} 2.55 to 25 · I_{rated}, Δ 0.05 I_{rated} 25.5 to 50 · I_{rated}, Δ 0.5 I_{rated}	1 · I_{rated}				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				

5.17.6 IEC 61850 Functional Mapping

A50HSPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x

17 This setting is also used by the standard 50 elements

Information												
A50HSPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50HSPTOC*.Mod

Information				
50 Overcurrent Enabled (Function Config)	x	0	x	1
Element Disabled	1	0	0	0
Element Inhibited	x	x	1	0
A50HSPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50HSPTOC*.Health

Information		
Protection Healthy	0	1
A50HSPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50HSPTOC*.Str

Information		
Element picked up	0	1
A50HSPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

5.17.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 50HS-n		Inhibit 50HS-n	Input			
		50HS-n PhA Pickup	Output			
		50HS-n PhB Pickup	Output			
		50HS-n PhC Pickup	Output			
		50HS-n PhA Operated	Output			
		50HS-n PhB Operated	Output			
		50HS-n PhC Operated	Output			
	50HS-n Pickup	50HS-n Pickup	Output			
50HS-n		50HS-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.18 50N Instantaneous Earth Fault – Calculated

5.18.1 Overview of Functions

Instantaneous/time delayed earth fault protection is used to provide:

- Short circuit detection in electrical equipment
- High speed protection where appropriate to its location in the power system network and/or network impedances
- Backup or emergency protection in addition to other protection functions or devices
- Coordinated operation with other devices using time graded settings

5.18.2 Structure of the Function

The calculated instantaneous earth fault function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A50NPTOC*** in IEC 61850.

The function monitors the primary system earth current by calculating the sum of the 3 phase CT inputs e.g. CT1/2/3.

The basic instantaneous/time delayed measured earth fault function (50N) is summarized below:

- Measurement is based on fundamental frequency current
- Elements operate with a definite time delayed (DTL) characteristic
- Outputs are provided for general pickup and trip

The basic function is non-directional but can be directionalized. This requires 3 phase VT inputs e.g. VT1/2/3.

Each 50N element can be set to operate for forward current, reverse current or independently of current direction. Directionalized functionality uses the decision of the 67N element.

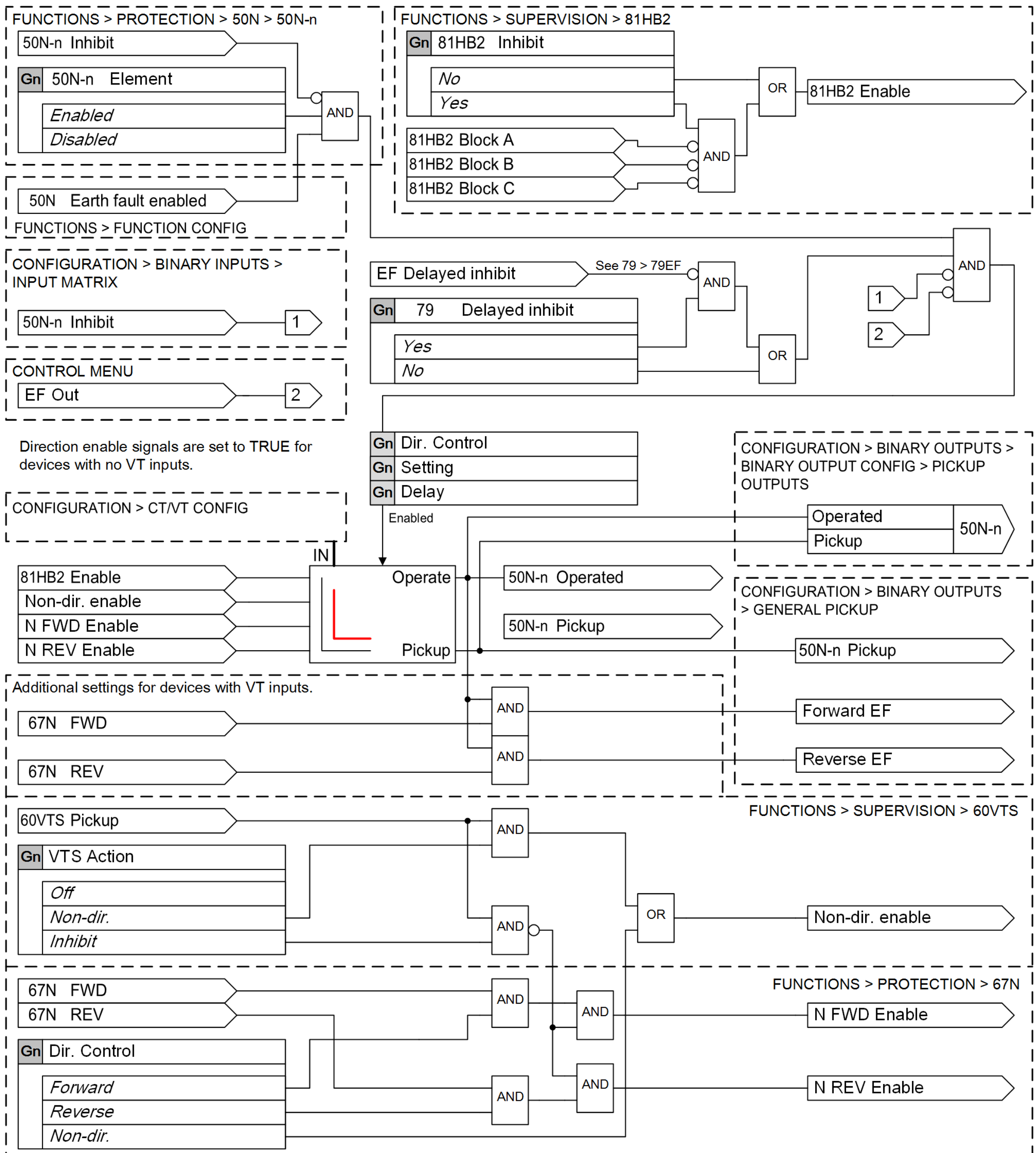
- Provides information regarding flow direction of earth current for selective application of earth fault protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

Where earth fault protection is directionalized correct operation is dependent on valid information being received from the VT inputs, operation of each directionalized element will be affected if a VT fuse fails. When a fuse failure is detected, 60VTS function, each element can be selected to either ignore the VT failure, switch to non-directionalized operation (which does not require VT inputs) or be inhibited.

When installed in power transformer circuits earth currents may be measured by the function during switch in of the transformer. Each element can be set to be inhibited when inrush current is detected, (see *6 Supervision Functions* , section 81HB2 Inrush Current Detection).

Elements can be mapped to start **79 Automatic Reclosing** by selection of the element as a **79 EF Trigger** within the 79 function element menus. For autoreclose sequences that require operation of instantaneous or time delayed protections to be inhibited this can be selected in settings menu.

5.18.3 Logic of the Function



[lo_7SR5_50Nlogicdiagram, 2, en_US]

Figure 5-23 Logic Diagram: 50N Instantaneous Earth Fault – Calculated

5.18.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. This setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Dir. Control`**

- Default setting: **`Non-Dir`**

  This setting is used to define whether the element will operate for earth faults detected in the **`Forward`** or **`Reverse`** direction based on the 67N directional element decision or for any earth fault regardless of the 67N direction. This allows the earth fault protection to have different current and time settings for forward, reverse and non-directional faults by using three 67N function elements.

  This parameter is not provided in devices that do not have voltage inputs or for current inputs that are not polarized by the voltage inputs.

Parameter Value	Description
Non-Dir	Select this setting if the element is to operate regardless of the current direction or presence of voltage.
Forward	Select this setting if the element is to operate only in a forward direction.
Reverse	Select this setting if the element is to operate only in a reverse direction.

Parameter: **`Setting`**

- Default setting: **0.5 x I_n** (0.5 · I_{rated})

  This setting defines the operating current threshold of the element. The operation timing will then be dependent on the selected delay setting.

  This setting should be set to suit the individual application.

Parameter: **`Delay`**

- Default setting: **`0 s`**

  This time delay setting should be set to suit the individual application.

Parameter: **`VTS Action`**

- Default setting: **`Off`**

  Voltage transformer failure can affect the directional decision and introduce an error. This setting selects if operation of the **`60VTS Voltage Transformer Supervision`** element automatically affects the operation of the element.

Parameter Value	Description
Off	60VTS operation does not affect the element and the forward/reverse directional decision assessed from the applied voltage is applied regardless of the 60VTS state. During a VT failure the device may assess the direction incorrectly and the element may operate for faults in the non-operate direction or not operate for faults in the operate direction.
Inhibit	When 60VTS detects a VT failure the element is immediately inhibited automatically and will not operate. Tripping of a system fault will then rely on other elements or devices.
Non-Dir	When 60VTS detects a VT failure the element will become non-directional and ignore the directional decision. The element will operate for overcurrent regardless of which direction the fault current is in.

Parameter: **`81HB2 Inhibit`**

- Default setting: **`No`**

  High levels of inrush currents into reactive components such as transformers when they are switched can result in operation of overcurrent elements. The inrush current can be detected by a high percentage of second harmonic current content by the 81HB2 element. This can be configured to inhibit the overcurrent element automatically by configuration of this setting.

Parameter Value	Description
No	The earth fault element is not affected by operation of the 81HB2 element.
Yes	The earth fault element is inhibited by when the 81HB2 element is operated.

Parameter: **`79 Delayed Inhibit`**

- Default setting: **`No`**

  The autoreclose scheme sequence may require that some selected protection elements are only used for the first trip(s) of the sequence, typically instantaneous ungraded protection elements, before reverting to graded protection.

  This setting is used to inhibit 50N operation when it is parameterized as instantaneous and only delayed tripping is required. This should be selected to the default setting **`Off`** unless required by the autoreclose sequence.

Parameter Value	Description
No	The earth fault element is normally active and is not blocked by autoreclose sequence requirements.
Yes	The 50N element will be inhibited from the autoreclose logic as required by the applied sequence. Incorrect configuration can result in no protection being enabled.

Settings Example

There should be little or no current flowing to earth in a healthy system so earth fault relays can be given far lower pickup levels than relays which detect excess current above load current in each phase conductor. Earth fault relays are important where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance as any earth fault current that flows in the phase conductors will be limited.

5.18.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
50N Earth Fault	Enabled Disabled	Disabled				

Functions > Protection > 50N > Gn 50N-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Measurement	RMS Fundemental	RMS				
Dir. Control	Non-Dir forward reverse	Non-Dir				
Setting	0.05 to 2.5 I_{rated}, Δ 0.01 I_{rated} 2.55 to 50 I_{rated}, Δ 0.5 I_{rated}	0.5 · I_{rated}				
Delay (DTL)	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				
VTS Action	Off Inhibit Non-Dir	Off				
81HB2 Inhibit	No Yes	No				
79 Delayed Inhibit	No Yes	No				

5.18.6 IEC 61850 Functional Information Mapping

A50NPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A50NPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50NPTOC*.Mod

Information				
50N Earth Fault Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A50NPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50NPTOC*.Health

Information		
Device Healthy	0	1
A50NPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50NPTOC*.Op

Information		
Element Operated	0	1
A50NPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value TRUE: 1
FALSE: 0

A50NPTOC*.Str

Information		
Element picked up	0	1
A50NPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element picked up and Fwd Direction	0	1	0
Element picked up and Rev Direction	1	0	0
A50NPTOC*.Str.dirGeneral	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.18.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 50N-n		Inhibit 50N-n	Input			
	50N-n Pickup	50N-n Pickup	Output			
50N-n		50N-n Operated	Output			
E/F off/on			Control	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.19 50SOTF Switch onto Fault

5.19.1 Overview of Functions

The 50SOTF and 50GSOTF protection is used to provide:

- Detect phase and earth faults in the electrical power system immediately after energization
- Provides additional overcurrent and earth fault protection at the time of circuit-breaker close operation
- Reports that a fault was present during a close operation
- Can be used to prevent repeatedly closing a circuit-breaker onto a faulted system
- Can ensure that faults are cleared from the circuit-breaker being closed rather than from a remote location

5.19.2 Structure of the Function

The switch onto fault function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **SOTFPTOC*** and **SOTFGPTOC*** in IEC 61850.

The 50SOTF function monitors the primary system phase currents using the line CT inputs e.g. CT1/2/3.

The 50GSOTF function monitors the primary system earth current using the earth fault CT input e.g. CT4.

The switch onto fault elements are automatically enabled during the **Manual Close Pulse** and the **Manual Close Reclaim** time and disabled at any other time unless the **Line Check** input is energized. The **Line Check** input provides an additional alternative method to apply the switch onto fault function. The 50SOTF elements provide additional 3 phase overcurrent and measured earth fault elements that can be set to suit fault detection during energization of a circuit. Typically these elements are set faster than graded overcurrent and earth fault protection to clear faults when the circuit-breaker is closed onto a faulted system.

Each element can be selected to operate using RMS or fundamental frequency measurement.

Blocking of the Stage

The 50SOTF function can be disabled if it is not required.

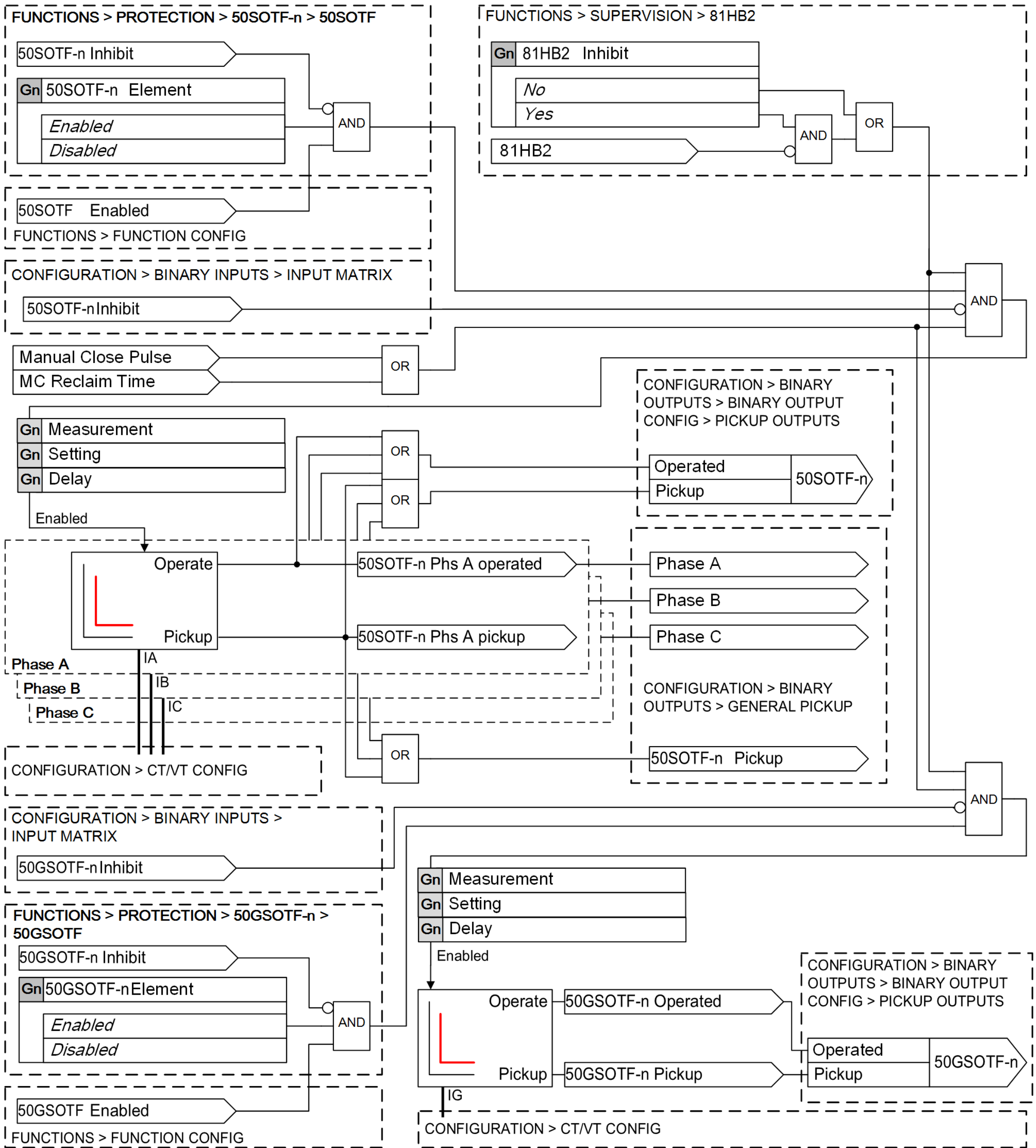
Each element can be individually enabled.

Each element has an inhibit input that can be operated by binary input, comms protocols or user logic. When an element inhibit is applied, a picked-up protection element will reset.

If an element is picked up or even operated at the end of the **Manual Close Reclaim** time the element will be reset and disabled.

Each element can be set to be inhibited by inrush current detected by the 81HB2 element. Phase overcurrent elements are inhibited by 2^{nd} harmonic content on the affected phase. Earth fault elements are inhibited by 2^{nd} harmonic content on any phase.

5.19.3 Logic of the Function



[lo_7SR5_50SOTFlogicdiagram, 2, en_US]

Figure 5-24 Logic Diagram: 50SOTF Switch Onto Fault

5.19.4 Application and Setting Notes

Parameter: **Gn Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is off and is not available.
Enabled	The element is available for use and can be parame-terize.

Parameter: **`Gn Measurement`**

- Default setting: **`RMS`**
  Selects whether fundamental frequency RMS or the true RMS value of the measured currents used.

Parameter: **`Gn 50SOTF-n Setting`**

- Default setting: **1 x I_n** (1 · I_{rated})
  The setting of the parameter threshold depends on the respective application e.g. setting above load curent and below fault current levels.

Parameter: **`Gn 50GSOTF-n Setting`**

- Default setting: **0.5 x I_n** (0.5 · I_{rated})
  The setting of the parameter threshold depends on the respective application e.g. setting below minimum fault current levels.

Parameter: **`Gn Delay`**

- Default setting: **`0 ms`**
  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Parameter: **`Gn 81HB2 Inhibit`**

- Default setting: **`No`**
  High levels of inrush currents into reactive components such as transformers when they are switched can result in operation of overcurrent elements. The inrush current can be detected by a high percentage of second harmonic current content by the 81HBL2 element. This can be configured to inhibit the overcur-rent element automatically by configuration of this setting.

Parameter Value	Description
No	The element is not affected by operation of the 81HBL2 element.
Yes	The element is inhibited by operation of the 81HBL2 element and automatically released when the 81HBL2 element resets.

5.19.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
50SOTF	Enabled Disabled	Disabled				

Functions > Protection > 50SOTF-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Measurement	RMS Fundamental	RMS				
Setting	0.05 to 2.5 I_{rated}, Δ 0.01 I_{rated} 2.55 to 50 I_{rated}, Δ 0.5 I_{rated}	1 · I_{rated}				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				
81HB2 Inhibit	No Yes	No				

Functions > Protection > 50GSOTF-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Measurement	RMS Fundemental	RMS				
Setting	0.05 to 2.5 I_{rated}, Δ 0.01 I_{rated} 2.55 to 25 I_{rated}, Δ 0.05 I_{rated}	0.5 · I_{rated}				
Delay (DTL)	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				
81HB2 Inhibit	No Yes	No				

5.19.6 IEC 61850 Functional Information Mapping

SOTFPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x

Information												
SOTFPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

SOTFPTOC*.Mod

Information				
50SOTF Enabled (Function Config)	x	0	x	1
Element Disabled	1	0	0	0
Element Inhibited	x	x	1	0
SOTFPTOC*.Mod.stVal	**5**	**2**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

SOTFPTOC*.Health

Information		
Device Healthy	0	1
SOTFPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

SOTFPTOC*.Op

Information		
Element Operated	0	1
SOTFPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

SOTFPTOC*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
SOTFPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information												
Element Phase A picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element Phase A picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
Element Phase B picked up and Fwd Direction	x	x	x	0	0	0	0	1	0	1	0	0
Element Phase B picked up and Rev Direction	1	x	1	1	0	1	0	0	0	0	0	0
Element Phase C picked up and Fwd Direction	1	x	x	0	0	0	0	1	1	0	0	0
Element Phase C picked up and Rev Direction	x	1	x	1	1	0	0	0	0	0	0	0
SOTFPTOC*.Str.dirGeneral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element Phase A picked up	0	1
SOTFPTOC*.Str.phsA	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase A picked up and Fwd Direction	0	1	0
Element Phase A picked up and Rev Direction	1	0	0
SOTFPTOC*.Str.dirPhsA	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase B picked up	0	1
SOTFPTOC*.Str.phsB	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase B picked up and Fwd Direction	0	1	0
Element Phase B picked up and Rev Direction	1	0	0
SOTFPTOC*.Str.dirPhsB	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase C picked up	0	1
SOTFPTOC*.Str.phsC	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase C picked up and Fwd Direction	0	1	0
Element Phase C picked up and Rev Direction	1	0	0
SOTFPTOC*.Str.dirPhsC	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

SOTFGPTOC*.Mod

Information				
50SOTFG Enabled (Function Config)	x	0	x	1
Element Disabled	1	0	0	0
Element Inhibited	x	x	1	0
SOTFGPTOC*.Mod.stVal	**5**	**2**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

SOTFGPTOC*.Health

Information		
Device Healthy	0	1
SOTFGPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

SOTFGPTOC*.Op

Information		
Element Operated	0	1
SOTFGPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

SOTFGPTOC*.Str

Information		
Element picked up	0	1
SOTFGPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element picked up and Fwd Direction	0	1	0
Element picked up and Rev Direction	1	0	0
SOTFGPTOC*.Str.dirGeneral	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.19.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 50SOTF-n		Inhibit 50SOTF-n	Input			
Inhibit 50GSOTF-n		Inhibit 50GSOTF-n	Input			
50SOTF-n		50SOTF-n Operated	Output			
50GSOTF-n		50SOTFG-n Operated	Output			
		50SOTF-n PhA Pickup	Output			
		50SOTF-n PhB Pickup	Output			
		50SOTF-n PhC Pickup	Output			
		50SOTF-n PhA Operated	Output			
		50SOTF-n PhB Operated	Output			
		50SOTF-n PhC Operated	Output			
	50SOTF-n Pickup	50SOTF-n Pickup	Output			
	50GSOTF-n Pickup	50GSOTF-n Pickup				

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.20 51 Time-Delayed Overcurrent – Phase

5.20.1 Overview of Function

Time overcurrent protection is used to provide:

- Short circuit detection in electrical equipment
- Backup or emergency overcurrent protection in addition to other protection functions or devices
- Coordinated operation with other devices using current and time graded setting

5.20.2 Structure of the Function

The time delayed overcurrent function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **`A51PTOC*`** in IEC 61850.

The function monitors the primary system current using the 3 phase CT inputs e.g. CT1/2/3.

The basic time overcurrent protection function (51) is summarized below:

- Current measurement is based on either fundamental or RMS current
- A number of time versus current operate curves are selectable based on IEC and ANSI standards
- Alternatively the 51 elements can operate with a definite time delayed (DTL) characteristic
- Outputs are provided for each phase. A general pickup and general 51 output are also provided
- Phase indications are provided

The basic function is non-directional, it can be directionalized this requires 3 phase VT inputs e.g. VT1/2/3.

Each 51 element can be set to operate for forward current, reverse current or independently of current direction. Directionalized functionality uses the decision of the 67 element.

- Provides information regarding flow direction of phase current for selective application of overcurrent protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

Where directionalized overcurrent protection is used correct operation is dependent on valid information being received from the VT inputs. Operation of each directionalized element will be affected if a VT fuse fails. When a fuse failure is detected, 60VTS function, each element can be selected to either ignore the VT failure, switch to non-directionalized operation (which does not require VT inputs) or be inhibited.

When installed in power transformer circuits increased currents may be measured by the overcurrent function during switch in of the transformer. Each element can be set to be inhibited when inrush current is detected, (see *6 Supervision Functions* , section 81HB2 Inrush Current Detection).

Elements can be mapped to start **`79 Automatic Reclosing`** by selection of the element as a **`79 PF Trigger`** within the 79 function element menus. For advanced autoreclose applications each element can be selected to be inhibited during delayed autoreclose shots of a multi-shot sequence.

Where significant distributed generation is installed in the power system network, load current may flow in the reverse direction to normal operation. This is not fault current but may be in excess of low directionalized overcurrent settings. Each element can be set to be inhibited during periods of low reverse load current flow, (see *5 Protection and Automation Functions* , section 21LB Load Blinder).

Voltage Controlled Overcurrent

Reduced fault current may flow where the driving fault voltage is reduced e.g. due to system impedances. The overcurrent setting can be automatically reduced by the **`51V Multiplier`** when low voltage is measured at the VT inputs.

Cold Load Protection

51 elements are affected by the setting of the **51CL Cold Load** function.

51CL can be configured for any **51 Time-Delayed Overcurrent** element to automatically apply modified settings following a CB close after an extended open state to pick up **Cold Load** at an elevated level which could exceed the normal protection tripping level and then revert to normal settings after a configurable period of time or if the load current reduces to below a set level.

The setting of each shaped overcurrent element (51-n) can be inhibited and alternative **Cold Load** settings can be applied for a period following circuit switch in.

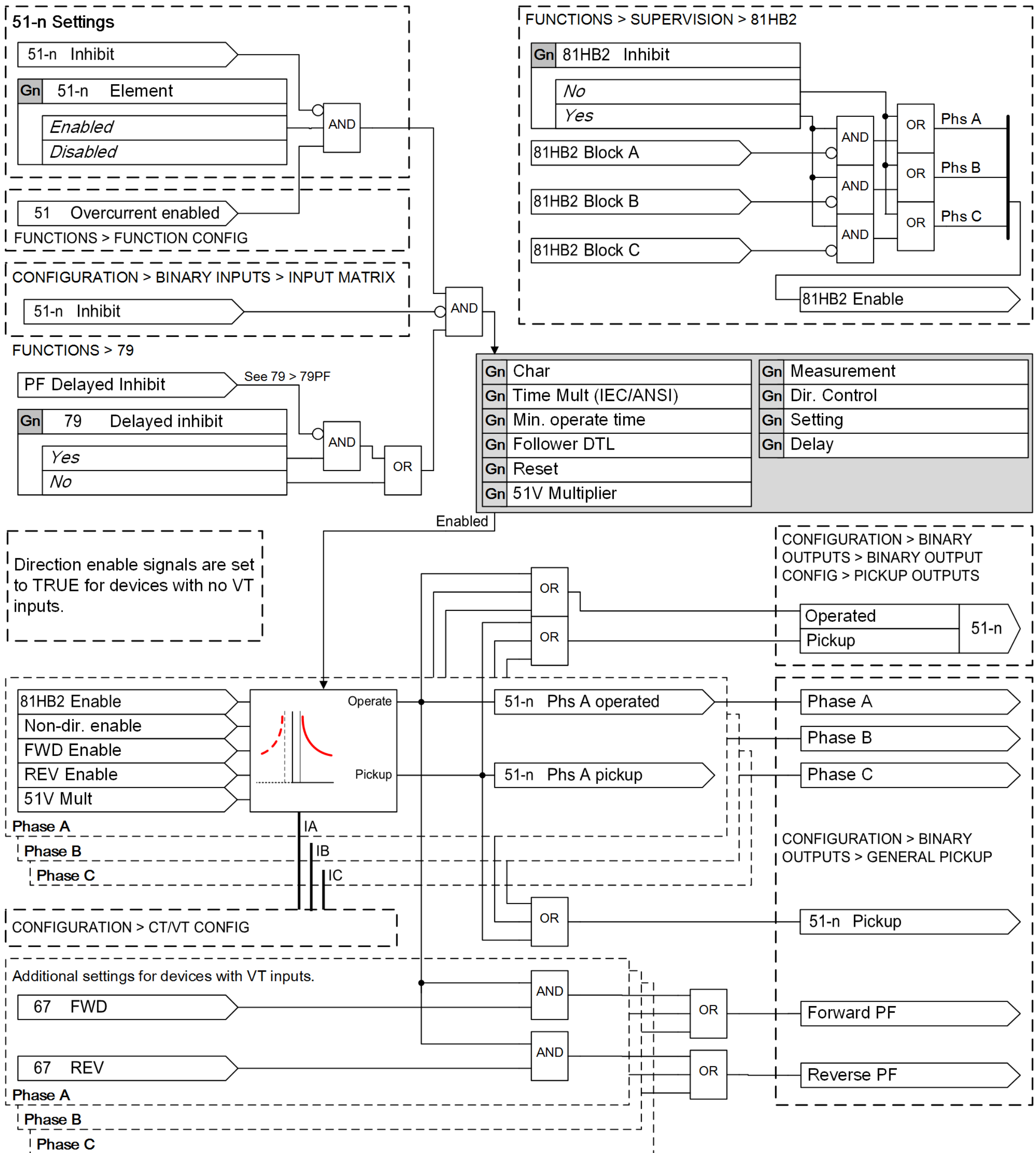
During **Cold Load** settings conditions any directional settings applied in the phase overcurrent menu are still applicable.

A CB **Don't Believe It** (DBI) condition is not acted on, causing the element to remain operating in accordance with the relevant 51-n settings. Where the **Reduced Current** setting is disabled, reversion to 51-n settings will only occur at the end of the **Drop-off** time. If any element is picked up on expiry of **Drop-off** time, the relay will issue a trip and lockout.

If the circuit-breaker is re-opened before expiry of the **Drop-off** time, the drop-off timer is held but not reset. Resetting the timer for each trip could result in damaging levels of current flowing for a prolonged period during a rapid sequence of trips/closes.

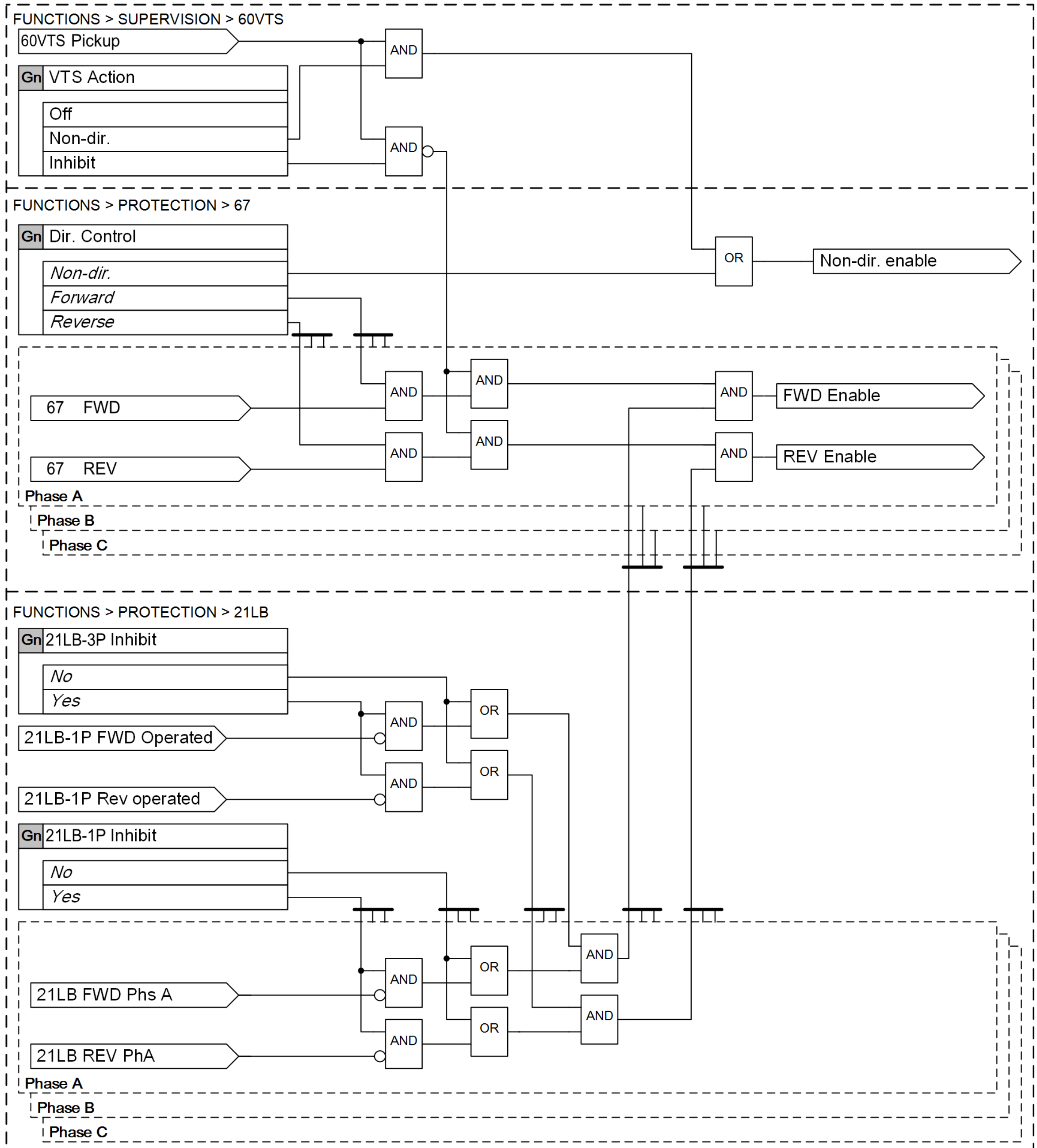
Cold load trips use the same binary output(s) as the associated 51-n element.

5.20.3 Logic of the Function



[lo_7SR5_51logicdiagram, 2, en_US]

Figure 5-25 Logic Diagram: 51 Time Delayed Overcurrent – Phase



[lo_7SR5_50logicdiagram_part-2, 1, en_US]

Figure 5-26 Logic Diagram: 51 Time Delayed Overcurrent – Phase (Additional Settings Using VT Inputs)

5.20.4 Application and Setting Notes

Parameter: **51V Element (Ph-Ph)**

- Default setting: **Disabled**
  This setting switches the element on or off dependent on the requirements of the application.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **51V Setting**

- Default setting: **30 V**

  This setting defines the operating voltage threshold of the element. When the phase to phase control voltage is below this voltage setting the phase current settings of the 51-n elements on the affected phase will be modified by the **51V Multiplier**. The phase allocation of control voltages is as shown below:

Current Element	Control Voltage
I_A	V_{AB}
I_B	V_{BC}
I_C	V_{CA}

If the voltage falls below setting when the 51-n element is picked up, the element does not reset and will continue to time out towards operation at the 51V rate.

The voltage setting should be set to suit the individual application.

Parameter: **51V VTS Inhibit**

- Default setting: **No**

  This setting defines the operating voltage threshold of the element. When the applied voltage is below this setting the element will pickup.

  The voltage setting should be set to suit the individual application.

Parameter: **51-n Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element.

  These settings can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **51-n Measurement**

- Default setting: **RMS**

  Selects whether fundamental frequency RMS or the true RMS value of the measured currents used.

Parameter Value	Description
RMS	Select this method of measurement if it is required to consider the effects of harmonic currents. This method may be required if there is significant harmonic content such as at capacitor banks or filter networks. This method is required for correct grading with fuses or electromechanical overcurrent relays.
Fundamental	This method is used: • When harmonic components are not to be considered in the current evaluation • For current/time grading with devices which also measure fundamental current • For unbalance type protection where the unbalance applies at fundamental frequency and the risk of errors in transient response measurement can be avoided

Parameter: **51-n Dir.Control**

- Default setting: **Non-Dir**

  This setting is used to define whether the element will operate for overcurrent detection in the **Forward** or **Reverse** direction based on the 67 directional element decision or for any overcurrent regardless of the 67 direction. This allows the overcurrent protection to have different current and time settings for forward and reverse faults by using 2 elements. Additional non-directional elements can be used for backup or high set and will still be active if the main directional elements are inhibited by VTS etc.

  This parameter is not provided in devices that do not have voltage inputs or for current inputs that are not polarized by the voltage inputs.

  If a protection element is set as non-directional then it will operate independently of the output of the directional detector. However, if a protection element is programmed for forward directional mode then operation will occur only for a fault lying within the forward operate zone. Conversely, if a protection element is programmed for reverse directional mode then operation will occur only for a fault lying within the reverse operate zone. Typically the forward direction is defined as being “away” from the busbar or “towards” the protected zone.

Parameter Value	Description
Non-Dir	Select this setting if the element is to operate regardless of the current direction or presence of voltage.
Forward	Select this setting if the element is to operate only in a forward direction.
Reverse	Select this setting if the element is to operate only in a reverse direction.

Parameter: **51-n Setting**

- Default setting: **1 x I_n** ($1 \cdot I_{rated}$)

  This setting defines the operating current threshold of the element. The applied phase current must exceed this setting by a factor of 1.05 for pickup of the element. The operation timing will then be dependent on the selected characteristic for the element setting. The element pickup will reset when the current is reduced by a factor of 0.97, the setting and the reset characteristic will be applied. This factor is always applied for 51 elements including when the **Char** is selected as DTL.

  This setting should be set to suit the individual application.

Parameter: **Char**

- Default setting: **IEC NI** (IEC normal inverse)

  This setting defines the characteristic of the inverse curve. Standard ANSI and IEC curves are provided as standard. The characteristic curves and associated formulas are shown in *10 Technical Data*.

  Custom (user defined) curves can be configured in Reydisp Manager and added to the device configuration. The custom curve will appear as an additional option in the **Char** setting list using the name that is entered in Reydisp Manager for all elements for which the curve is applicable.

  The characteristic can also be set as DTL, see **51-n Delay**.

  The characteristic should be set to suit the individual application.

Parameter: **Time Mult (IEC/ANSI)**

- Default setting: **1**

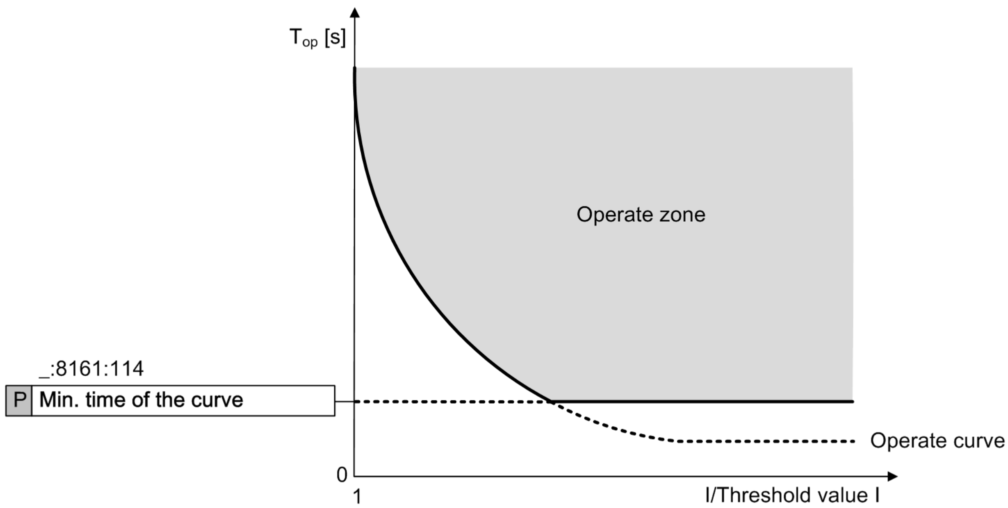
  This setting defines the time multiplier that is applied to the selected current curve. For IEC curves this value is traditionally in the range 0 to 1.6 and for ANSI curves a value of 0 to 15 is typically applied.

Parameter: **51-n Delay (DTL)**

- Default setting: **5 s**
  This is the time delay setting for the element when the **Char** is selected as DTL. This should be set to suit the individual application. This setting is not used if any other characteristic curve is selected.

Parameter: **Min Operate Time**

- Default setting: **0 s**
  With the parameter a minimum operate delay time can be selected. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwDocp01_040715-01.vsd, 1, en_US]

Figure 5-27 Minimum Operating Time of the Curve

This is traditionally used with recloser systems only and otherwise is recommended to be left at the default setting of 0 s.

Parameter: **Follower DTL**

- Default setting: **0 s**
  This setting allows an additional time to be added to that achieved by the selected characteristic curve. It is applied as a DTL time after the operate state from the curve is achieved. With this setting, the whole curve is shifted linearly on the time axis by this additional definite time.
  This is traditionally used with recloser systems only and otherwise is recommended to be left at the default setting of 0 s.

Parameter: **Reset**

- Default setting: **0 s**
  The reset parameter is used to define whether the element pickup resets to 0 instantaneously when the current falls below setting or a reset curve characteristic or fixed DTL is applied. This operation is significant during intermittent faults where an induction disc device would be partially rotated when the fault current is reapplied.

Parameter Value	Description
IEC/ANSI Decaying	This selection applies a resetting curve to the element pickup to provide emulation of an induction disc device. The standard IEC curve is applied if the operating **Char** is an IEC Characteristic and the ANSI reset curve is applied for an ANSI operating **Char**. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a disc emulation reset.
0 s	Use this setting for instantaneous reset of the element. When the current falls below setting the pickup will instantaneously reset completely and subsequent increase in current above setting will restart the operation delay from 0.
1 s to 60 s	The percentage operated state is retained when the current falls below setting for a period of the set delay. Subsequent increase in current to above setting within the set delay will allow operation to resume from the partially operated state instead of 0.

Parameter: **VTS Action**

- Default setting: **Off**

  Voltage transformer failure can affect the directional decision and introduce an error. This setting selects if operation of the **60VTS Voltage Transformer Supervision** element automatically affects the operation of the element.

Parameter Value	Description
Off	The function element operates with no consideration of the 60VTS element output status.
Inhibit	When a VT failure is determined by the 60VTS function operation of the function element is inhibited. Clearance of a system fault will then rely on other elements or devices.
Non-Dir	When a VT failure is determined by the 60VTS function the 51 element is switched to non-directional operation – this does not require VT inputs. The element will operate for overcurrent regardless of current direction.

NOTE

During a VT failure the device may assess the direction incorrectly and the element may operate for faults in the non-operate direction or not operate for faults in the operate direction.

Parameter: **81HB2 Inhibit**

- Default setting: **No**

  High levels of inrush currents into reactive components such as transformers when they are switched in can result in operation of overcurrent elements. The inrush current can be detected by the 81HB2 element. This can be configured to inhibit the overcurrent element automatically.

Parameter Value	Description
No	The element is not inhibited by operation of the 81HB2 element.
Yes	The overcurrent element is inhibited by operation of the 81HB2 element and automatically released when the 81HB2 element resets.

Parameter: **79 Delayed Inhibit**

- Default setting: **No**
  The autoreclose scheme can be designed such that only instantaneous elements are used for the first trip(s) of the sequence before reverting to time graded protection. This setting allows the delayed element to be inhibited during the delayed autoreclose shots and should be left at the default setting of **Off** unless this is required.
  Note that function elements are assigned as **Delayed Trips** in the **79 > 79PF** menu.

Parameter Value	Description
No	The element is not inhibited by the autoreclose sequence design.
Yes	The element will be inhibited during any autoreclose shot which is designated as **Delayed**. Incorrect configuration can result in no protection being enabled.

Parameter: **21LB-3P Inhibit**

- Default setting: **No**
  Where the reverse load flow current may cause incorrect operation of directional overcurrent protection this function is used to inhibit the 51 function when the measured power factor is within defined limits.

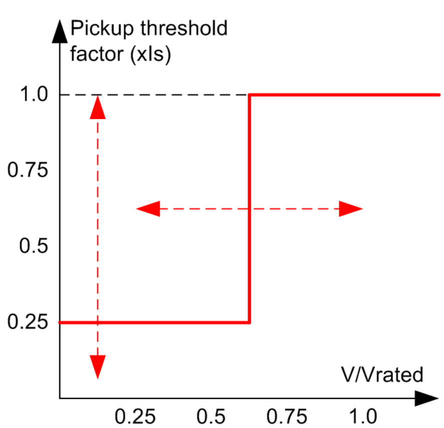
Parameter: **21LB-1P Inhibit**

- Default setting: **No**
  Where the reverse load flow current may cause incorrect operation of directional overcurrent protection this function is used to inhibit the 51 function when the measured power factor is within defined limits.

Parameter: **51V Multiplier**

- Default setting: 0.5
  For applied voltages above the 51V setting each 51-n phase element operates at its normal current setting. When the phase control voltage drops below the 51V setting then a current multiplier setting is applied to that phase.
  The **51V Multiplier** will reduce the 51-n pickup current setting for that phase as the multiplier will have a setting value < 1.

51-n Phase Current	Control Voltage
IA	Vab
IB	Vbc
IC	Vca



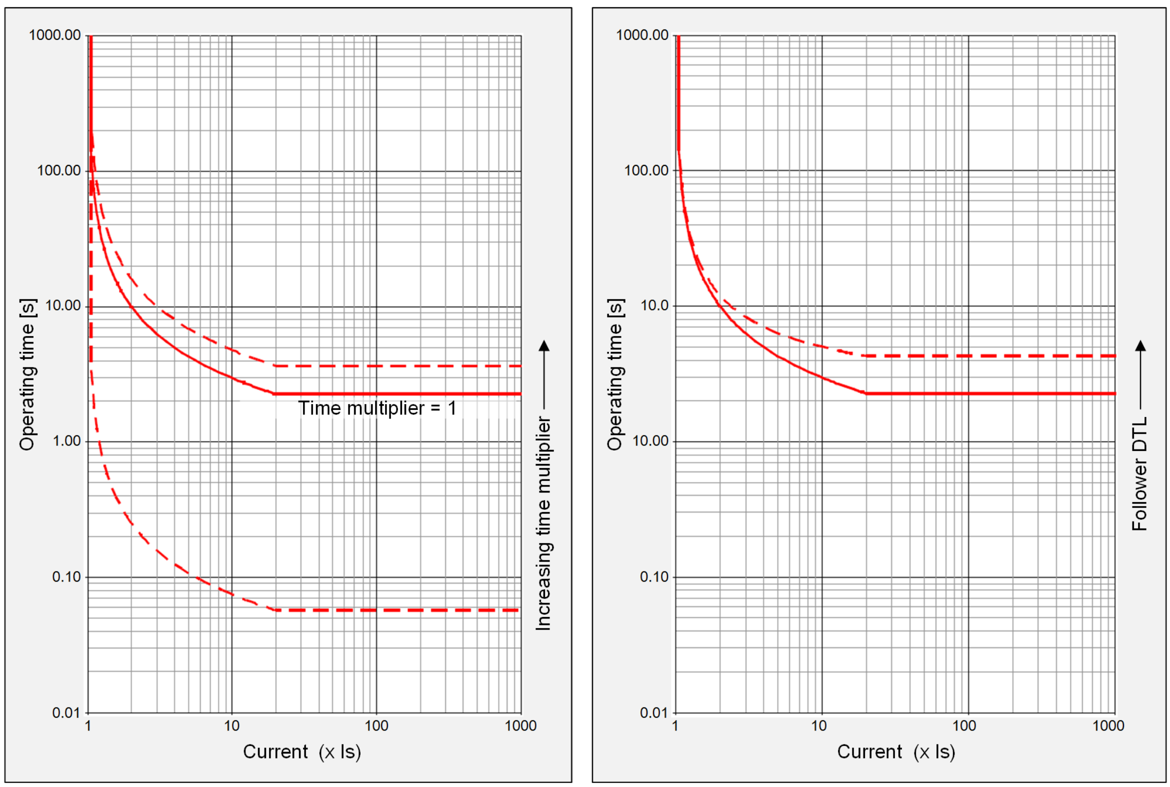
[dw_7SR5_function51ApplicationAndSettingNotes, 1, en_US]

Settings Example

The 51-n characteristic element provides a number of time/current operate characteristics. The element can be defined as either an **Inverse Definite Minimum Time Lag** (IDMTL) or **Definite Time Lag** (DTL) characteristic. If an IDMTL characteristic is required, then IEC, ANSI/IEEE and a number of manufacturer specific curves are supported.

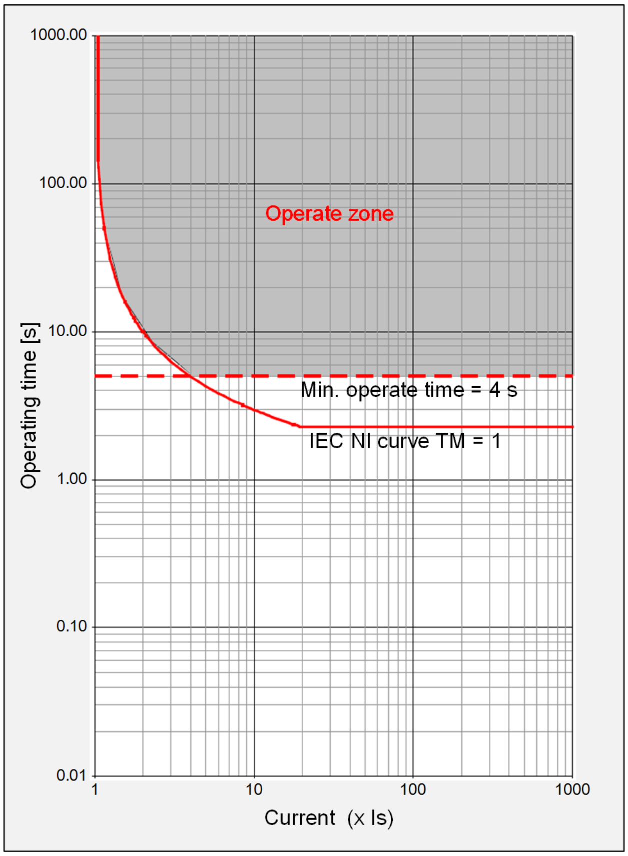
IDMTL characteristics are defined as **Inverse** because their tripping times are inversely proportional to the fault current being measured. This makes them particularly suitable to grading studies where it is important that only the relay(s) closest to the fault operate. Discrimination can be achieved with minimized operating times.

To optimize the grading capability of the relay additional time multiplier, **Follower DTL** or **Minimum Operate Time** settings can be applied.



[dw_IEC-NI-curve_with_time-muliplier_followe-DTL, 1, en_US]

Figure 5-28 IEC NI Curve with Time Multiplier and Follower DTL Applied



[dw_IEC-NI-curve_with_min-op-time-setting-appl, 1, en_US]

Figure 5-29 IEC NI Curve with Minimum Operate Time Setting Applied

To increase sensitivity, dedicated earth fault elements are used. There should be little or no current flowing to earth in a healthy system so such relays can be given lower pickup levels than relays which detect current above load current in each phase conductor. Such dedicated earth fault relays are important where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance and the fault current detected in the phase conductors will be limited.

Selection of Overcurrent Characteristics

Each pole has 2 independent overcurrent characteristics. Where required the 2 curves can be used:

- To produce a composite curve
- To provide a 2 stage tripping scheme
- Where one curve is to be directionalized in the forward direction the other in the reverse direction

The characteristic curve shape is selected to be the same type as the other relays on the same circuit or to grade with items of plant e.g. fuses or earthing resistors.
The application of IDMTL characteristic is summarized in the following table:

Table 5-1 Application of IDMTL Characteristics

OC/EF Curve Characteristic	Application
IEC Normal Inverse (NI) ANSI Moderately Inverse (MI)	Generally applied
IEC Very Inverse (VI) ANSI Very Inverse (VI)	Used with high-impedance paths where there is a significant difference between fault levels at protection points.

OC/EF Curve Characteristic	Application
IEC Extreme Inversely (EI) ANSI Extremely Inverse (EI)	Grading with fuses
IEC Long Time Inverse (LTI)	Used to protect transformer earthing resistors having long withstand times.
Recloser Specific	Use when grading with specific recloser.

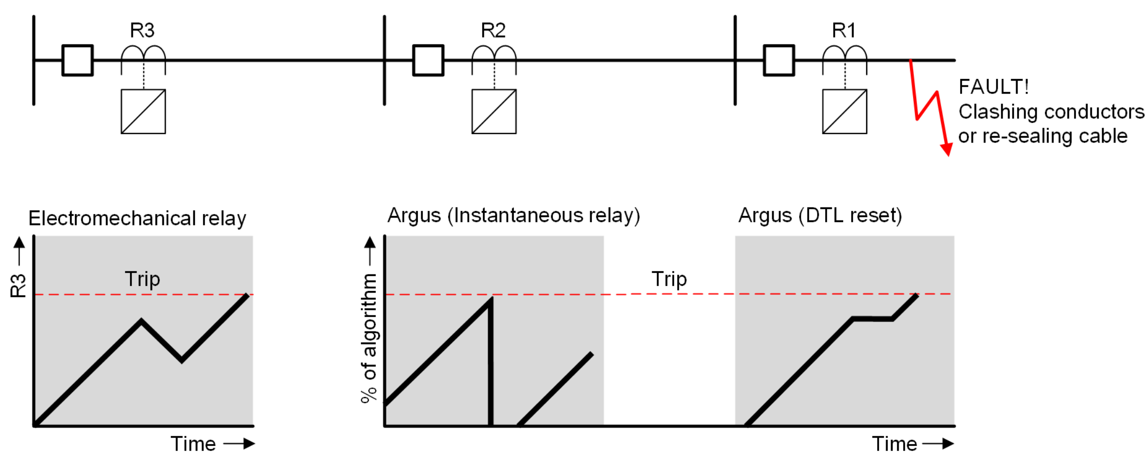
Reset Delay

The increasing use of plastic insulated cables, both conventionally buried and aerial bundled conductors, have given rise to the number of flashing intermittent faults on distribution systems. At the fault position, the plastic melts and temporarily reseals the faulty cable for a short time after which the insulation fails again. The same phenomenon has occurred in compound-filled joint boxes or on "clashing" overhead line conductors. The repeating process of the fault can cause electromechanical disc relays to "ratchet" up and eventually trip the faulty circuit if the reset time of the relay is longer than the time between successive faults.

To mimic an electromechanical relay the relay can be user programmed for an **ANSI Decaying** characteristic when an **ANSI Operate** characteristic is applied. Alternatively a DTL reset (0 to 60 seconds) can be used with other operate characteristics.

For protection of cable feeders, it is recommended that a 60 second DTL reset be used.

On overhead line networks, particularly where reclosers are incorporated in the protected system, instantaneous resetting is desirable to ensure that, on multiple shot reclosing schemes, correct grading between the source relays and the relays associated with the reclosers is maintained.



[dw_7SR5_function51drawing, 3, en_US]

Figure 5-30 Reset Delay

5.20.5 Settings Menu

Configuration > Function Config						
Parameter	Setting Options	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
51 Overcurrent	Enabled Disabled	Disabled				

Functions > Protection > 51 > Gn 51V Common						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	5 to 200 V, Δ 0.5 V	30 V				
VTS Inhibit	No Yes	No				

Functions > Protection > 51 > Gn 51CL Common						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Pickup Time	1 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	600 s				
Drop-off Time	1 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	600 s				
Reduced Current	Enabled Disabled	Disabled				
Reduced Current Level	0.05 to 2.5 I_{rated}V, Δ 0.05 I_{rated}	0.25 · I_{rated}				
Reduced Current Time	1 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	600 s				

Functions > Protection > 51 > Gn 51-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Measurement	RMS Fundamental	RMS				
Dir. Control [18]	Non-Dir Forward Reverse	Non-Dir				
Setting	0.05 to 2.5 · I_{rated}, Δ 0.01 I_{rated}	1 · I_{rated}				

18 Applies only to devices with VT inputs.

Functions > Protection > 51 > Gn 51-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Char	DTL IEC-NI IEC-VI IEC-EI IEC-LTI ANSI-EI ANSI-MI ANSI-VI	IEC-NI				
Time Mult (IEC/ANSI)	0.01 to 1.6, Δ 0.01 1.6 to 5, Δ 0.1 5 to 100, Δ 1	1				
Delay (DTL)	0 to 20 s Δ 0.01 s	5 s				
Min Operate Time	0 to 20 s Δ 0.01 s	0 s				
Follower DTL	0 to 20 s Δ 0.01 s	0 s				
Reset	IEC/ANSI Decaying 0 to 60 s Δ 1 s	0 s				
VTS Action [18]	Off Inhibit Non-Dir	Off				
81HB2 Inhibit	No Yes	No				
79 Delayed Inhibit	No Yes	No				
21LB-3P Inhibit [18]	No Yes	No				
21LB-1P Inhibit [18]	No Yes	No				
51V Multiplier [18]	0.25 to 1 Δ 0.05	0.5				

Functions > Protection > 51 > Gn 51CL-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.05 to 2.5 · I_{rated}, Δ 0.01 I_{rated}	1 · I_{rated}				
Char	DTL IEC-NI IEC-VI IEC-EI IEC-LTI ANSI-EI ANSI-MI ANSI-VI	IEC-NI				

Functions > Protection > 51 > Gn 51CL-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Time Mult (IEC/ANSI)	0.01 to 1.6, Δ 0.01 1.6 to 5, Δ 0.1 5 to 100, Δ 1	1				
Delay (DTL)	0 to 20 s Δ 0.01 s	5 s				
Min Operate Time	0 to 20 s Δ 0.01 s	0 s				
Follower DTL	0 to 20 s Δ 0.01 s	0 s				
Reset	IEC/ANSI Decaying 0 to 60 s Δ 1 s	0 s				

5.20.6 IEC 61850 Functional Information Mapping

A51PTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A51PTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	OK: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A51PTOC*.Mod

Information				
51 Overcurrent Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A51PTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A51PTOC*.Health

Information		
Device Healthy	0	1
A51PTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A51PTOC*.Op

Information		
Element Operated	0	1
A51PTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A51PTOC*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A51PTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information												
Element Phase A picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element Phase A picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
Element Phase B picked up and Fwd Direction	x	x	x	0	0	0	0	1	0	1	0	0

Information												
Element Phase B picked up and Rev Direction	1	x	1	1	0	1	0	0	0	0	0	0
Element Phase C picked up and Fwd Direction	1	x	x	0	0	0	0	1	1	0	0	0
Element Phase C picked up and Rev Direction	x	1	x	1	1	0	0	0	0	0	0	0
A50PTOC*.Str.dirGen-eral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element Phase A picked up	0	1
A51PTOC*.Str.phsA	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase A picked up and Fwd Direction	0	1	0
Element Phase A picked up and Rev Direction	1	0	0
A51PTOC*.Str.dirPhsA	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase B picked up	0	1
A51PTOC*.Str.phsB	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase B picked up and Fwd Direction	0	1	0
Element Phase B picked up and Rev Direction	1	0	0

Information			
A51PTOC*.Str.dirPhsB	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase C picked up	0	1
A51PTOC*.Str.phsC	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase C picked up and Fwd Direction	0	1	0
Element Phase C picked up and Rev Direction	1	0	0
A51PTOC*.Str.dirPhsC	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.20.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 51CL		Inhibit Cold Load	Input			
		51CL Active Operated	Output			
Inhibit 51-n		Inhibit 51-n	Input			
		51-n PhA Pickup	Output			
		51-n PhB Pickup	Output			
		51-n PhC Pickup	Output			
		51-n PhA Operated	Output			
		51-n PhB Operated	Output			
		51-n PhC Operated	Output			
	51-n Pickup	51-n Pickup	Output			
51-n		51-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.21 51G Time-Delayed Earth Fault – Measured

5.21.1 Overview of Functions

Time-delayed earth fault protection is used to provide:

- Detection of earth current in electrical equipment
- Backup or emergency protection in addition to other protection functions or devices
- Coordinated operation with other devices using time graded settings

5.21.2 Structure of the Function

The measured time-delayed earth fault function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A51GPTOC*** in IEC 61850.

The function monitors the primary system current using the earth fault CT input e.g. CT4.

The basic time-delayed measured earth fault function (51G) is summarized below:

- Measurement is based on either fundamental frequency or RMS current
- A number of time vs current operate curves are selectable based on IEC and ANSI standards
- Alternatively the 51G elements can operate with a definite time-delayed (DTL) characteristic
- Outputs are provided for general pickup and trip

The basic function is non-directional but can be directionalized when the device is fitted with VT inputs.

Each 51G element can be set to operate for forward current, reverse current or independently of current direction. Directionalized functionality uses the decision of the 67G element.

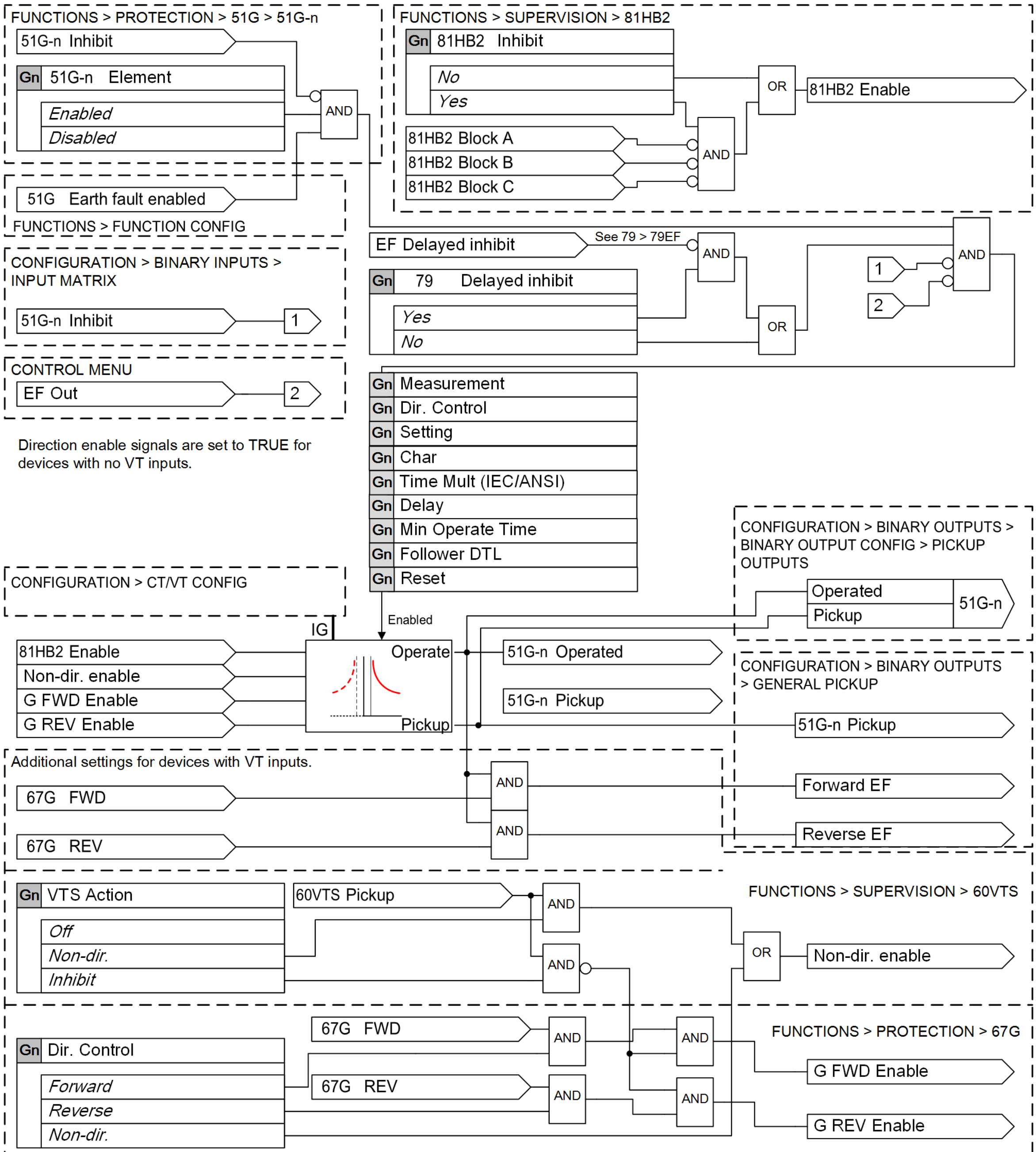
- Provides information regarding flow direction of earth current for selective application of earth fault protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

Where earth fault protection is directionalized correct operation is dependent on valid information being received from the VT inputs, operation of each directionalized element will be affected if a VT fuse fails. When a fuse failure is detected, 60VTS function, each element can be selected to either ignore the VT failure, switch to non-directionalized operation (which does not require VT inputs) or be inhibited.

When installed in power transformer circuits earth currents may be measured by the function during switch in of the transformer. Each element can be set to be inhibited when inrush current is detected, (see *6 Supervision Functions* , section 81HB2 Inrush Current Detection).

Elements can be mapped to start **79 Automatic Recloser** by selection of the element as a **79 PF Trigger** within the 79 function element menus. For advanced autoreclose applications each element can be selected to be inhibited during delayed autoreclose shots of a multi-shot sequence.

5.21.3 Logic of the Function



[lo_7SR5_51Glogicdiagram, 2, en_US]

Figure 5-31 Logic Diagram: 51G Time-Delayed Earth Fault – Measured

5.21.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Measurement`**

- Default setting: **`RMS`**

  Selects whether fundamental frequency RMS or the true RMS value of the measured currents used.

Parameter Value	Description
RMS	Select this method of measurement if it is required to consider the effects of harmonic currents. This method may be required if there are significant harmonic content such as at capacitor banks or filter networks. This method is required for correct grading with fuses or electromechanical overcurrent relays.
Fundamental	This method is used if harmonic components are not to be considered in the current evaluation. This method may be required for correct grading with devices which do not provide true RMS measurement. This method may be preferred for unbalance type protection where the unbalance applies at fundamental frequency and the risk of errors in transient response measurement can be avoided.

Parameter: **`Dir. Control`**

- Default setting: **`Non-Dir`**

  This setting is used to define whether the element will operate for earth faults detected in the **`Forward`** or **`Reverse`** direction based on the 67G directional element decision or for any earth fault regardless of the 67G direction. This allows the earth fault protection to have different current and time settings for forward, reverse and non-directional faults by using three 67G function elements.

  This parameter is not provided in devices that do not have voltage inputs or for current inputs that are not polarized by the voltage inputs.

Parameter Value	Description
Non-Dir	Select this setting if the element is to operate regardless of the current direction or presence of voltage.
Forward	Select this setting if the element is to operate only in a forward direction
Reverse	Select this setting if the element is to operate only in a reverse direction

Parameter: **`Setting`**

- Default setting: **1 x I_n** (1 · I_{rated})

  This setting defines the operating current threshold of the element. The measured earth current must exceed this setting by a factor of 1.05 for pickup of the element. The operation timing will then be dependent on the selected characteristic for the element setting. The element pickup will reset when the current is reduced by 0.97 the setting and the reset characteristic will be applied. This factor is always applied for 51 elements including when the **`Char`** is selected as DTL.

  This setting should be set to suit the individual application.

Parameter: **Char**

- Default setting: **IEC NI – IEC normal inverse**

  This setting defines the characteristic of the inverse curve. Standard ANSI and IEC curves are provided as standard. The characteristic curves and associated formulas are shown in *10 Technical Data*.

  Custom (user defined) curves can be configured in Reydisp Manager and added to the device configuration. The custom curve will appear as an additional option in the **Char** setting list using the name that is entered in Reydisp Manager for all elements for which the curve is applicable.

  The characteristic can also be set as DTL, see **51G-n Delay**,

  The characteristic should be set to suit the individual application.

Parameter: **Time Mult** (IEC/ANSI)

- Default setting: **1**

  This setting defines the time multiplier that is applied to the selected current curve. For IEC curves this value is traditionally in the range 0 to 1.6 and for ANSI curves a value of 0 to 15 is typically applied.

Parameter: **Delay** (DTL)

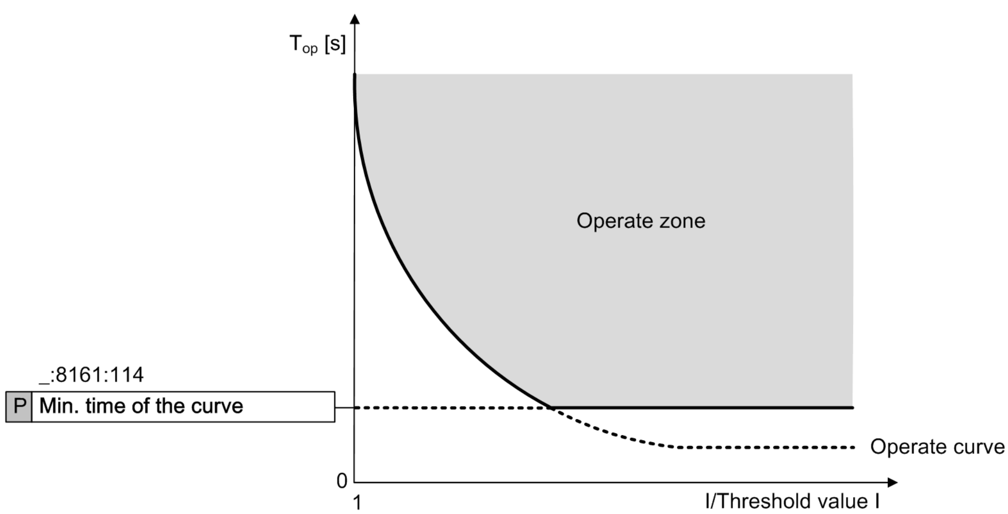
- Default setting: **0.1 s**

  This is the time delay setting for the element when the **Char** is selected as DTL. This should be set to suit the individual application. This setting is not used if any other characteristic curve is selected.

Parameter: **Min Operate Time**

- Default setting: **0 s**

  With the parameter a minimum operate delay time can be selected. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwDocp01_040715-01.vsd, 1, en_US]

Figure 5-32 Minimum Operating Time of the Curve

This is traditionally used with recloser systems only and otherwise is recommended to be left at the default setting of 0 s.

Parameter: **Follower DTL**

- Default setting: **0 s**

  This setting allows an additional time to be added to that achieved by the selected characteristic curve. It is applied as a DTL time after the operate state from the curve is achieved. With this setting, the whole curve is shifted linearly on the time axis by this additional definite time.

  This is traditionally used with recloser systems only and otherwise is recommended to be left at the default setting of 0 s.

Parameter: **Reset**

- Default setting: **0 s**

  The **Reset** parameter is used to define whether the element pickup resets to 0 instantaneously when the current falls below setting or a reset curve characteristic or fixed DTL is applied. This operation is significant during intermittent faults where an induction disc device would be partially rotated when the fault current is reapplied.

Parameter Value	Description
IEC/ANSI Decaying	This selection applies a resetting curve to the element pickup to provide emulation of an induction disc device. The standard IEC curve is applied if the operating **Char** is an IEC characteristic and the ANSI reset curve is applied for an ANSI operating **Char**. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a disc emulation reset.
0 s	Use this setting for instantaneous reset of the element. When the current falls below setting the pickup will instantaneously reset completely and subsequent increase in current above setting will restart the operation delay from 0.
1 s to 60 s	The percentage operated state is retained when the current falls below setting for a period of the set delay. Subsequent increase in current to above setting within the set delay will allow operation to resume from the partially operated state instead of 0.

Parameter: **VTS Action**

- Default setting: **Off**

  Voltage transformer failure can affect the directional decision and introduce an error. This setting selects if operation of the **60VTS Voltage Transformer Supervision** element automatically affects the operation of the element.

Parameter Value	Description
Off	The function element operates with no consideration of the 60VTS element output status.
Inhibit	When a VT failure is determined by the 60VTS function operation of the function element is inhibited. Clearance of a system fault will then rely on other elements or devices.
Non-Dir	When a VT failure is determined by the 60VTS function the 51 element is switched to non-directional operation. This does not require VT inputs. The element will operate for overcurrent regardless of current direction.

NOTE

During a VT failure the device may assess the direction incorrectly and the element may operate for faults in the non-operate direction or not operate for faults in the operate direction.

Parameter: **81HB2 Inhibit**

- Default setting: **No**

  High levels of inrush currents into reactive components such as transformers when they are switched can result in operation of overcurrent elements. The inrush current can be detected by a high percentage of second harmonic current content by the 81HB2 element. This can be configured to inhibit the overcurrent element automatically by configuration of this setting.

Parameter Value	Description
No	The element is not inhibited by operation of the 81HB2 element
Yes	The overcurrent element is inhibited by operation of the 81HB2 element and automatically released when the 81HB2 element resets.

Parameter: **79 Delayed Inhibit**

- Default setting: **No**

  The autoreclose scheme sequence may require that some selected protection elements are only used for the first trip(s) of the sequence, typically instantaneous ungraded protection elements, before reverting to graded protection.

  This setting allows the delayed element to be inhibited during the delayed autoreclose shots and should be left at the default setting of **Off** unless this is required.

  Note that function elements are assigned as **Delayed Trips** in the **79 > 79PF** menu.

Parameter Value	Description
No	The element is not inhibited by the autoreclose sequence design.
Yes	The element will be inhibited during any autoreclose shot which is designated as **Delayed**. Incorrect configuration can result in no protection being enabled.

Settings Example

There should be little or no current flowing to earth in a healthy system so earth fault relays can be given far lower pickup levels than relays which detect excess current above load current in each phase conductor. Earth fault relays are important where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance as any earth fault current that flows in the phase conductors will be limited.

5.21.5 Settings Menu

Functions > Function Config							
Parameter	Range	Settings					
		Default	Gn1	Gn2	Gn3	Gn4	
51G Earth Fault	Enabled Disabled	Disabled					

Functions > Protection > 51G > Gn 51G-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Measurement	RMS Fundamental	RMS				
Dir.Control [19]	Non-Dir Forward Reverse	Non-Dir				
Setting	0.005 to 0.1 · I_{rated}, Δ 0.001 I_{rated} 0.105 to 1 · I_{rated}, Δ 0.005 I_{rated}	0.5 · I_{rated}				
Char	DTL IEC-NI IEC-VI IEC-EI IEC-LTI ANSI-EI ANSI-MI ANSI-VI	IEC-NI				
Time Mult (IEC/ANSI)	0.01 to 1.6, Δ 0.01 1.6 to 5, Δ 0.1 5 to 100, Δ 1	1				
Delay (DTL)	0 to 20 s Δ 0.01 s	5 s				
Min Operate Time	0 to 20 s Δ 0.01 s	0 s				
Follower DTL	0 to 20 s Δ 0.01 s	0 s				
Reset	IEC/ANSI Decaying 0 to 60 s Δ 1 s	0 s				
VTS Action [19]	Off Inhibit Non-Dir	Off				
81HB2 Inhibit	No Yes	No				
79 Delayed Inhibit	No Yes	No				

5.21.6 IEC 61850 Functional Information Mapping

A51GPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x

19 Applies only to devices with VT inputs.

Information												
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A51GPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A51GPTOC*.Mod

Information				
51G Earth Fault Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A51GPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A51GPTOC*.Health

Information		
Device Healthy	0	1
A51GPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A51GPTOC*.Op

Information		
Element Operated	0	1
A51GPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A51GPTOC*.Str

Information		
Element picked up	0	1
A51GPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element picked up and Fwd Direction	0	1	0
Element picked up and Rev Direction	1	0	0
A51GPTOC*.Str.dirGeneral	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.21.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 51G-n		Inhibit 51G-n	Input			
E/F off/on			Control	Y	Y	Y
	51G-n Pickup	51G-n Pickup	Output			
51G-n		51G-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.22 51GS Time-Delayed Sensitive Earth Fault – Measured

5.22.1 Overview of Function

Time-delayed sensitive earth fault protection is used to provide:

- Detection of low level earth current in electrical equipment
- Backup or emergency protection in addition to other protection functions or devices
- Coordinated operation with other devices using time graded settings

5.22.2 Structure of the Function

The measured time-delayed earth fault element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A51GSPTOC*** in IEC 61850.

The function monitors the primary system current using the earth fault CT input e.g. CT4.

The basic time-delayed measured earth fault function (51GS) is summarized below:

- Measurement is based on fundamental frequency current
- A number of time versus current operate curves are selectable based on IEC and ANSI standards
- Alternatively the 51GS elements can operate with a definite time-delayed (DTL) characteristic
- Outputs are provided for general pickup and trip

The basic function is non-directional, it can be directionalized this requires 3 phase VT inputs e.g. VT1/2/3.

Each 51GS element can be set to operate for forward current, reverse current or independently of current direction. Directionalized functionality uses the decision of the 67GS element.

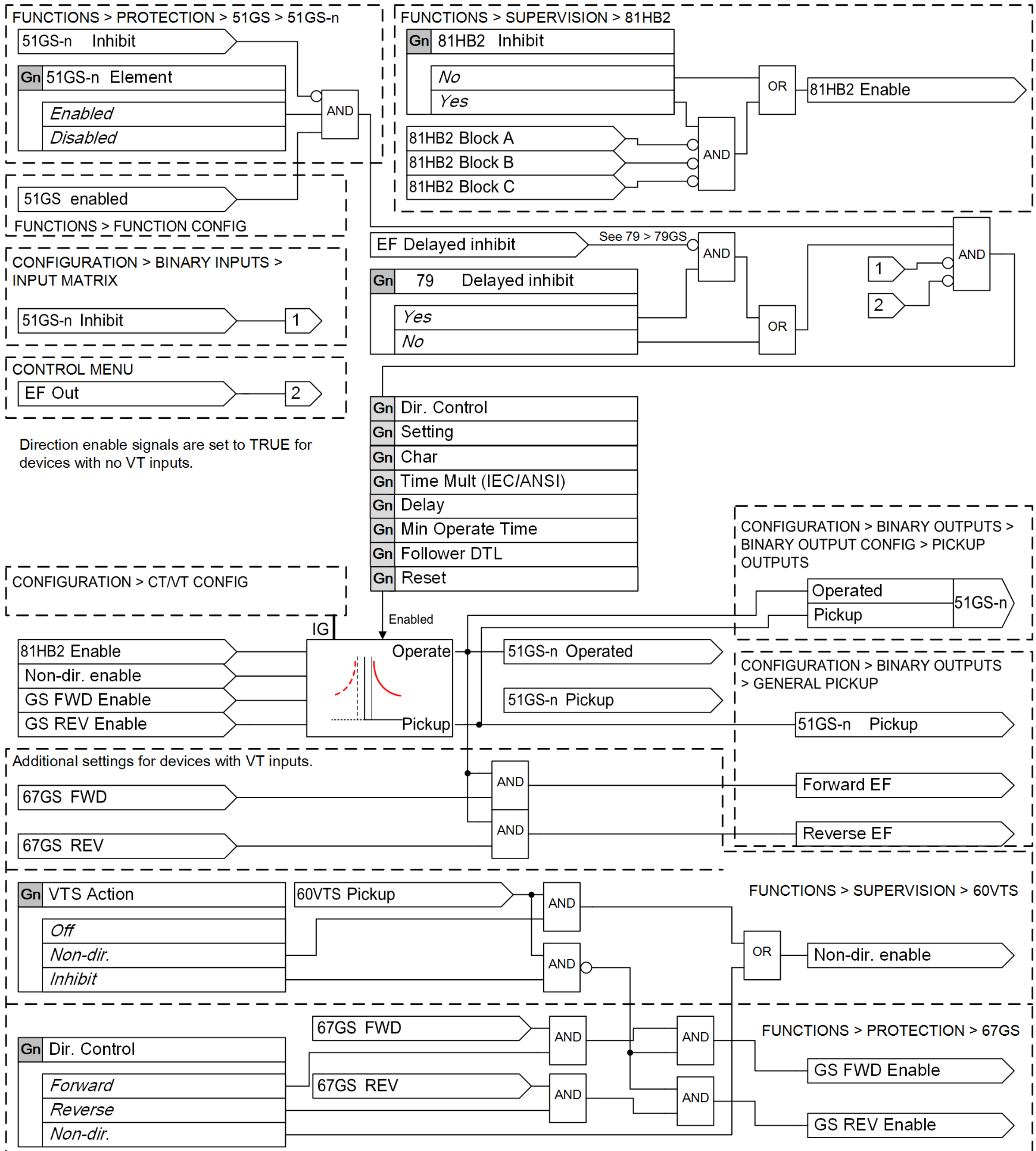
- Provides information regarding flow direction of earth current for selective application of earth fault protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

Where earth fault protection is directionalized correct operation is dependent on valid information being received from the VT inputs, operation of each directionalized element will be affected if a VT fuse fails. When a fuse failure is detected, 60VTS function, each element can be selected to either ignore the VT failure, switch to non-directionalized operation (which does not require VT inputs) or be inhibited.

When installed in power transformer circuits earth currents may be measured by the function during switch in of the transformer. Each element can be set to be inhibited when inrush current is detected, (see *6 Supervision Functions* , section 81HB2 Inrush Current Detection).

Elements can be mapped to start **79 Automatic Recloser** by selection of the element as a **79 GS Trigger** within the 79 function element menus. For advanced autoreclose applications each element can be selected to be inhibited during delayed autoreclose shots of a multi-shot sequence.

5.22.3 Logic of the Function



[lo_7SR5_51GSlogicdiagram, 2, en_US]

Figure 5-33 Logic Diagram: 51GS Time-Delayed Sensitive Earth Fault – Measured

5.22.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Dir.Control`**

- Default setting: **`Non-Dir`**

  This setting is used to define whether the element will operate for earth faults detected in the **`Forward`** or **`Reverse`** direction based on the 67GS directional element decision or for any earth fault regardless of the 67GS direction. This allows the earth fault protection to have different current and time settings for forward, reverse and non-directional faults by using three 67GS function elements.

  This parameter is not provided in devices that do not have voltage inputs or for current inputs that are not polarized by the voltage inputs.

Parameter Value	Description
Non-Dir	Select this setting if the element is to operate regardless of the current direction or presence of voltage.
Forward	Select this setting if the element is to operate only in a forward direction.
Reverse	Select this setting if the element is to operate only in a reverse direction.

Parameter: **`Setting`**

- Default setting: **0.5 x I_n** ($0.5 \cdot I_{rated}$)

  This setting defines the operating current threshold of the element. The measured earth current must exceed this setting by a factor of 1.05 for pickup of the element. The operation timing will then be dependent on the selected characteristic for the element setting. The element pickup will reset when the current is reduced by a factor of 0.97 the setting, and the reset characteristic will be applied. This factor is always applied for 51N elements including when the **`Char`** is selected as DTL.

  This setting should be set to suit the individual application.

Parameter: **`Char`**

- Default setting: **`IEC NI`** (IEC normal inverse)

  This setting defines the characteristic of the inverse curve. Standard ANSI and IEC curves are provided as standard. The characteristic curves and associated formulas are shown in *10 Technical Data*.

  Custom (user defined) curves can be configured in Reydisp Manager and added to the device configuration. The custom curve will appear as an additional option in the **`Char`** setting list using the name that is entered in Reydisp Manager for all elements for which the curve is applicable.

  The characteristic can also be set as DTL, see **`Delay`**,

  The characteristic should be set to suit the individual application.

Parameter: **`Time Mult (IEC/ANSI)`**

- Default setting: **`1`**

  This setting defines the time multiplier that is applied to the selected current curve. For IEC curves this value is traditionally in the range 0 to 1.6 and for ANSI curves a value of 0 to 15 is typically applied.

Parameter: **`Delay (DTL)`**

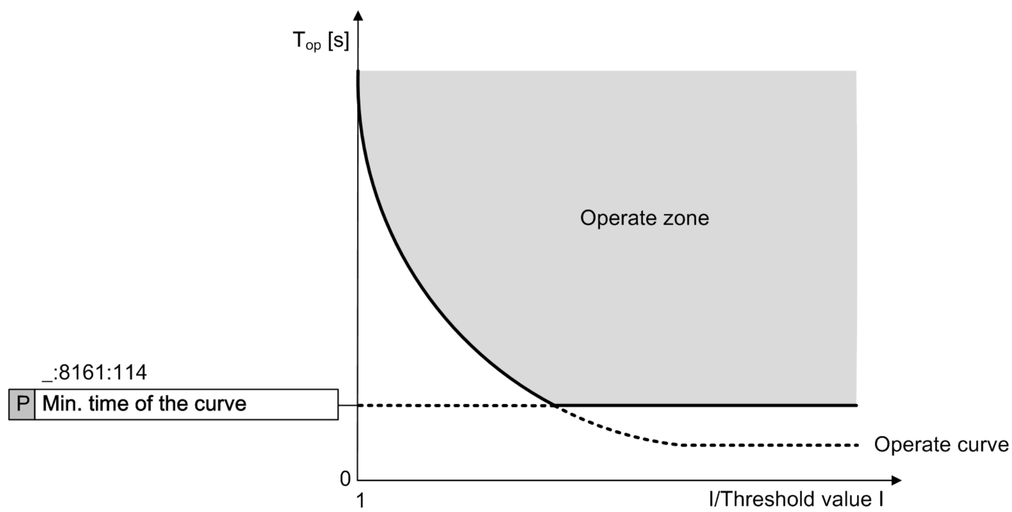
- Default setting: **`5 s`**

  This is the time delay setting for the element when the **`Char`** is selected as DTL. This should be set to suit the individual application. This setting is not used if any other characteristic curve is selected.

Parameter: **`Min Operate Time`**

- Default setting: **`0 s`**

  With the parameter a minimum operate delay time can be selected. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwDocp01_040715-01.vsd, 1, en_US]

Figure 5-34 Minimum Operating Time of the Curve

This is traditionally used with recloser systems only and otherwise is recommended to be left at the default setting of 0 s.

Parameter: **`Follower DTL`**

- Default setting: **`0 s`**

  This setting allows an additional time to be added to that achieved by the selected characteristic curve. It is applied as a DTL time after the operate state from the curve is achieved. With this setting, the whole curve is shifted linearly on the time axis by this additional definite time.

  This is traditionally used with recloser systems only and otherwise is recommended to be left at the default setting of 0 s.

Parameter: **`Reset`**

- Default setting: **`0 s`**

  The **`Reset`** parameter is used to define whether the element pickup resets to 0 instantaneously when the current falls below setting or a reset curve characteristic or fixed DTL is applied. This operation is significant during intermittent faults where an induction disc device would be partially rotated when the fault current is reapplied.

Parameter Value	Description
IEC/ANSI Decaying	This selection applies a resetting curve to the element pickup to provide emulation of an induction disc device. The standard IEC curve is applied if the operating **Char** is an IEC characteristic and the ANSI reset curve is applied for an ANSI operating **Char**. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a disc emulation reset.
0 s	Use this setting for instantaneous reset of the element. When the current falls below setting the pickup will instantaneously reset completely and subsequent increase in current above setting will restart the operation delay from 0.
1 s to 60 s	The percentage operated state is retained when the current falls below setting for a period of the set delay. Subsequent increase in current to above setting within the set delay will allow operation to resume from the partially operated state instead of 0.

Parameter: **VTS Action**

- Default setting: **Off**

  Voltage transformer failure can affect the directional decision and introduce an error. This setting selects if operation of the **60VTS Voltage Transformer Supervision** element automatically affects the operation of the element.

Parameter Value	Description
Off	The function element operates with no consideration of the 60VTS element output status.
Inhibit	When a VT failure is determined by the 60VTS function operation of the function element is inhibited. Clearance of a system fault will then rely on other elements or devices.
Non-Dir	When a VT failure is determined by the 60VTS function the 51 element is switched to non-directional operation – this does not require VT inputs. The element will operate for overcurrent regardless of current direction.

NOTE

During a VT failure the device may assess the direction incorrectly and the element may operate for faults in the non-operate direction or not operate for faults in the operate direction.

Parameter: **79 Delayed Inhibit**

- Default setting: **No**

  The autoreclose scheme can be designed such that only instantaneous elements are used for the first trip(s) of the sequence before reverting to time graded protection. This setting allows the delayed element to be inhibited during the delayed autoreclose shots and should be left at the default setting of **Off** unless this is required.

  Note that function elements are assigned as **Delayed Trips** in the **79 > 79PF** menu.

Parameter Value	Description
No	The element is not inhibited by the autoreclose sequence design.
Yes	The element will be inhibited during any autoreclose shot which is designated as delayed. Incorrect configuration can result in no protection being enabled.

Settings Example

There should be little or no current flowing to earth in a healthy system so earth fault relays can be given far lower pickup levels than relays which detect excess current above load current in each phase conductor. Earth fault relays are important where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance as any earth fault current that flows in the phase conductors will be limited.

5.22.5 Settings Menu

Configuration > Function Config						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
51GS Sensitive Earth Fault	Enabled Disabled	Disabled				

Functions > Protection > 51GS > Gn 51GS-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Dir. Control [20]	Non-Dir Forward Reverse	Non-Dir				
Setting	0.005 to 0.1 · I_{rated}, Δ 0.001 I_{rated} 0.105 to 1 · I_{rated}, Δ 0.0051 I_{rated}	0.5 · I_{rated}				
Char	DTL IEC-NI IEC-VI IEC-EI IEC-LTI ANSI-EI ANSI-MI ANSI-VI	IEC-NI				
Time Mult (IEC/ANSI)	0.01 to 1.6, Δ 0.01 1.6 to 5, Δ 0.1 5 to 100, Δ 1	1				
Delay (DTL)	0 to 20 s Δ 0.01 s	5 s				
Min Operate Time	0 to 20 s Δ 0.01 s	0 s				
Follower DTL	0 to 20 s Δ 0.01 s	0 s				
Reset	IEC/ANSI Decaying 0 to 60 s Δ 1 s	0 s				
VTS Action [20]	Off Inhibit Non-Dir	Off				
79 Delayed Inhibit	No Yes	No				

20 Applies only to devices with VT inputs.

5.22.6 IEC 61850 Functional Information Mapping

A51GSPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A51GSPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A51GSPTOC*.Mod

Information				
51GS Sensitive EF Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A51GSPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A51GSPTOC*.Health

Information		
Device Healthy	0	1
A51GSPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A51GSPTOC*.Op

Information		
Element Operated	0	1
A51GSPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A51GSPTOC*.Str

Information		
Element picked up	0	1
A51GSPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information												
Element picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
A51GSPTOC*.Str.dirGeneral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element picked up	0	1
A51GSPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element picked up and Fwd Direction	0	1	0
Element picked up and Rev Direction	1	0	0
A51GSPTOC*.Str.dirGeneral	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.22.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 51GS-n		Inhibit 51GS-n	Input			
GS off/on			Control	Y	Y	Y
	51GS-n Pickup	51GS-n Pickup	Output			
51GS-n		51GS-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.23 51N Time-Delayed Earth Fault – Calculated

5.23.1 Overview of Function

Time-delayed earth fault protection is used to provide:

- Detection of earth current in electrical equipment
- Backup or emergency protection in addition to other protection functions or devices
- Coordinated operation with other devices using time graded settings

5.23.2 Structure of the Function

The calculated time-delayed earth fault element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A51NPTOC*** in IEC 61850.

The function monitors the primary system earth current by calculating the sum of the 3 phase CT inputs e.g. CT1/2/3.

The basic instantaneous/time-delayed calculated earth fault function (51N) is summarized below:

- Measurement is based on either fundamental or RMS current
- A number of time versus current operate curves are selectable based on IEC and ANSI standards
- Alternatively the 51N elements can operate with a definite time-delayed (DTL) characteristic
- Outputs are provided for general pickup and trip

The basic function is non-directional, it can be directionalized this requires 3 phase VT inputs e.g. VT1/2/3.

Each 51N element can be set to operate for forward current, reverse current or independently of current direction. Directionalized functionality uses the decision of the 67N element.

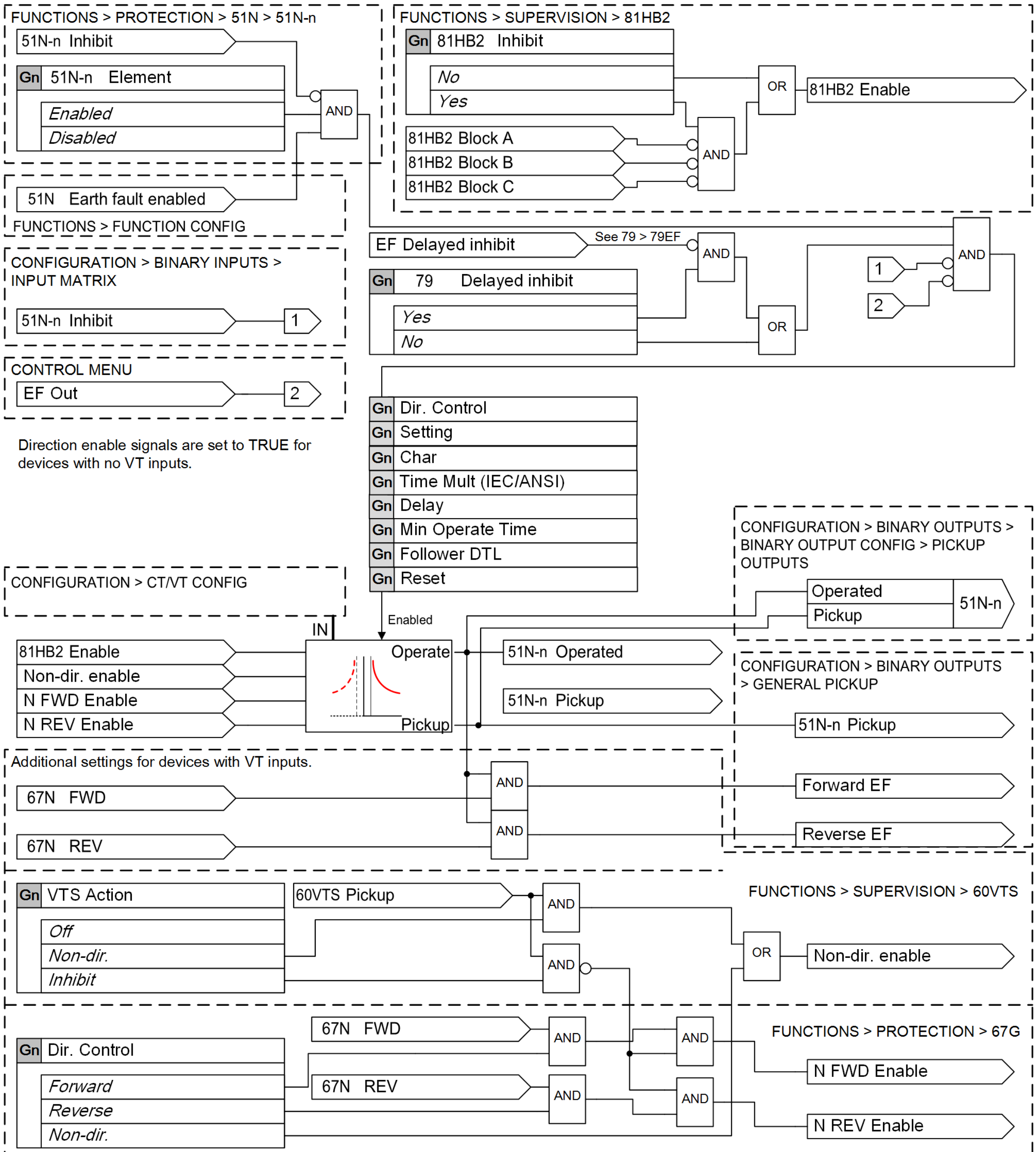
- Provides information regarding flow direction of earth current for selective application of earth fault protection
- Ensures selective fault detection for parallel lines or transformers with infeed at one end
- Ensures selective fault detection in cable runs with infeed at both ends or in lines connected to form ring topologies

Where earth fault protection is directionalized correct operation is dependent on valid information being received from the VT inputs, operation of each directionalized element will be affected if a VT fuse fails. When a fuse failure is detected, 60VTS function, each element can be selected to either ignore the VT failure, switch to non-directionalized operation (which does not require VT inputs) or be inhibited.

When installed in power transformer circuits earth currents may be measured by the function during switch in of the transformer. Each element can be set to be inhibited when inrush current is detected, (see *6 Supervision Functions* , section 81HB2 Inrush Current Detection).

Elements can be mapped to start **79 Automatic Recloser** by selection of the element as a **79 EF Trigger** within the 79 function element menus. For advanced autoreclose applications each element can be selected to be inhibited during delayed autoreclose shots of a multi-shot sequence.

5.23.3 Logic of the Function



[lo_7SR5_51Nlogicdiagram, 2, en_US]

Figure 5-35 Logic Diagram: 51N Time-Delayed Earth Fault – Calculated

5.23.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Dir. Control`**

- Default setting: **`Non-Dir`**

  This setting is used to define whether the element will operate for earth faults detected in the **`Forward`** or **`Reverse`** direction based on the 67N directional element decision or for any earth fault regardless of the 67N direction. This allows the earth fault protection to have different current and time settings for forward, reverse and non-directional faults by using three 67N function elements.

  This parameter is not provided in devices that do not have voltage inputs or for current inputs that are not polarized by the voltage inputs.

Parameter Value	Description
Non-Dir	Select this setting if the element is to operate regardless of the current direction or presence of voltage.
Forward	Select this setting if the element is to operate only in a forward direction.
Reverse	Select this setting if the element is to operate only in a reverse direction.

Parameter: **`Setting`**

- Default setting: **0.5 x I_n** ($0.5 \cdot I_{rated}$)

  This setting defines the operating current threshold of the element. The calculated earth current must exceed this setting by a factor of 1.05 for pickup of the element. The operation timing will then be dependent on the selected characteristic for the element setting. The element pickup will reset when the current is reduced by a factor of 0.97 the setting, and the reset characteristic will be applied. This factor is always applied for 51N elements including when the **`Char`** is selected as DTL.

  This setting should be set to suit the individual application.

Parameter: **`Char`**

- Default setting: **`IEC NI`** (IEC normal inverse)

  This setting defines the characteristic of the inverse curve. Standard ANSI and IEC curves are provided as standard. The characteristic curves and associated formulas are shown in *10 Technical Data*.

  Custom (user defined) curves can be configured in Reydisp Manager and added to the device configuration. The custom curve will appear as an additional option in the **`Char`** setting list using the name that is entered in Reydisp Manager for all elements for which the curve is applicable.

  The characteristic can also be set as DTL, see **`Delay`**,

  The characteristic should be set to suit the individual application.

Parameter: **`Time Mult (IEC/ANSI)`**

- Default setting: **`1`**

  This setting defines the time multiplier that is applied to the selected current curve. For IEC curves this value is traditionally in the range 0 to 1.6 and for ANSI curves a value of 0 to 15 is typically applied.

Parameter: **`Delay (DTL)`**

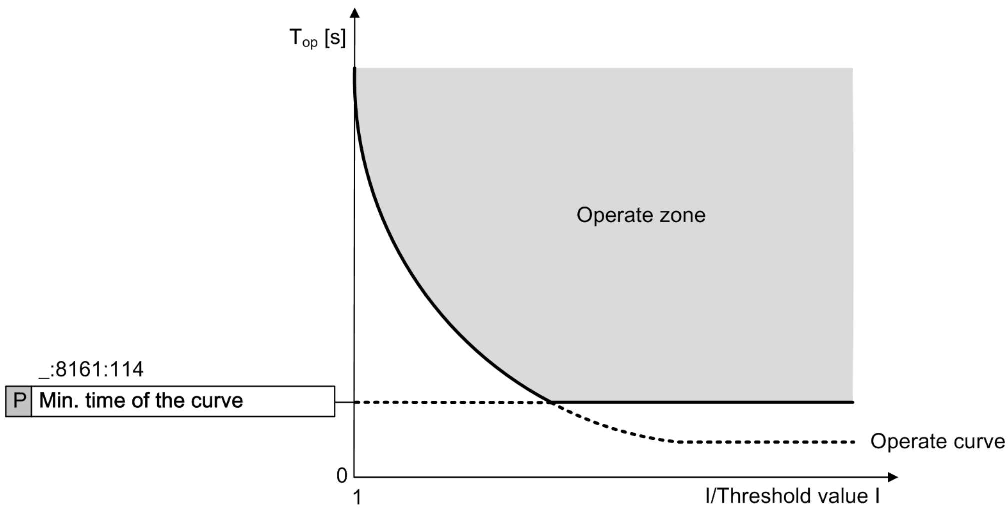
- Default setting: **`5 s`**

  This is the time delay setting for the element when the **`Char`** is selected as DTL. This should be set to suit the individual application. This setting is not used if any other characteristic curve is selected.

Parameter: **51N-n Min Operate Time**

- Default setting: **0 s**

  With the parameter a minimum operate delay time can be selected. The operate delay time of inverse-time characteristic curve never falls below the minimum operate delay time.



[DwDocp01_040715-01.vsd, 1, en_US]

Figure 5-36 Minimum Operating Time of the Curve

This is traditionally used with recloser systems only and otherwise is recommended to be left at the default setting of 0 s.

Parameter: **Follower DTL**

- Default setting: **0 s**

  This setting allows an additional time to be added to that achieved by the selected characteristic curve. It is applied as a DTL time after the operate state from the curve is achieved. With this setting, the whole curve is shifted linearly on the time axis by this additional definite time.

  This is traditionally used with recloser systems only and otherwise is recommended to be left at the default setting of 0 s.

Parameter: **Reset**

- Default setting: **0 s**

  The **Reset** parameter is used to define whether the element pickup resets to 0 instantaneously when the current falls below setting or a reset curve characteristic or fixed DTL is applied. This operation is significant during intermittent faults where an induction disc device would be partially rotated when the fault current is reapplied.

Parameter Value	Description
IEC/ANSI Decaying	This selection applies a resetting curve to the element pickup to provide emulation of an induction disc device. The standard IEC curve is applied if the operating **Char** is an IEC characteristic and the ANSI reset curve is applied for an ANSI operating **Char**. Select this setting if the device is coordinated with electromechanical devices or other devices which perform a disc emulation reset.
0 s	Use this setting for instantaneous reset of the element. When the current falls below setting the pickup will instantaneously reset completely and subsequent increase in current above setting will restart the operation delay from 0.
1 s to 60 s	The percentage operated state is retained when the current falls below setting for a period of the set delay. Subsequent increase in current to above setting within the set delay will allow operation to resume from the partially operated state instead of 0.

Parameter: **VTS Action**

- Default setting: **Off**

  Voltage transformer failure can affect the directional decision and introduce an error. This setting selects if operation of the **60VTS Voltage Transformer Supervision** element automatically affects the operation of the element.

Parameter Value	Description
Off	The function element operates with no consideration of the 60VTS element output status.
Inhibit	When a VT failure is determined by the 60VTS function operation of the function element is inhibited. Clearance of a system fault will then rely on other elements or devices.
Non-Dir	When a VT failure is determined by the 60VTS function the 51 element is switched to non-directional operation – this does not require VT inputs. The element will operate for overcurrent regardless of current direction.

NOTE

During a VT failure the device may assess the direction incorrectly and the element may operate for faults in the non-operate direction or not operate for faults in the operate direction.

Parameter: **81HB2 Inhibit**

- Default setting: **No**

  High levels of inrush currents into reactive components such as transformers when they are switched in can result in operation of overcurrent elements. The inrush current can be detected by the 81HB2 element. This can be configured to inhibit the overcurrent element automatically.

Parameter Value	Description
No	The element is not inhibited by operation of the 81HB2 element.
Yes	The overcurrent element is inhibited by operation of the 81HB2 element and automatically released when the 81HB2 element resets.

Parameter: **79 Delayed Inhibit**

- Default setting: **No**

  The autoreclose scheme can be designed such that only instantaneous elements are used for the first trip(s) of the sequence before reverting to time graded protection. This setting allows the delayed element to be inhibited during the delayed autoreclose shots and should be left at the default setting of **Off** unless this is required.

  Note that function elements are assigned as **Delayed Trips** in the **79 > 79PF** menu.

Parameter Value	Description
No	The element is not inhibited by the autoreclose sequence design.
Yes	The element will be inhibited during any autoreclose shot which is designated as delayed. Incorrect configuration can result in no protection being enabled.

Settings Example

There should be little or no current flowing to earth in a healthy system so earth fault relays can be given far lower pickup levels than relays which detect excess current above load current in each phase conductor. Earth fault relays are important where the fault path to earth is a high-resistance one (such as in highly arid areas) or where the system uses high values of earthing resistor/reactance as any earth fault current that flows in the phase conductors will be limited.

5.23.5 Settings Menu

Configuration > Function Config						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
51N Earth Fault	Enabled Disabled	Disabled				

Functions > Protection > 51N > Gn 51N-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Dir. Control [21]	Non-Dir Forward Reverse	Non-Dir				
Setting	0.05 to 2.5 · I_{rated}, Δ 0.05 I_{rated}	0.5 · I_{rated}				
Char	DTL IEC-NI IEC-VI IEC-EI IEC-LTI ANSI-EI ANSI-MI ANSI-VI	IEC-NI				
Time Mult (IEC/ANSI)	0.01 to 1.6, Δ 0.01 1.6 to 5, Δ 0.1 5 to 100, Δ 1	1				

21 Applies only to devices with VT inputs.

Functions > Protection > 51N > Gn 51N-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Delay (DTL)	0 to 20 s Δ 0.01 s	5 s				
Min Operate Time	0 to 20 s Δ 0.01 s	0 s				
Follower DTL	0 to 20 s Δ 0.01 s	0 s				
Reset	IEC/ANSI Decaying 0 to 60 s Δ 1 s	0 s				
VTS Action [21]	Off Inhibit Non-Dir	Off				
81HB2 Inhibit	No Yes	No				
79 Delayed Inhibit	No Yes	No				

5.23.6 IEC 61850 Functional Information Mapping

A51NPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A51NPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A51NPTOC*.Mod

Information				
51N Earth Fault Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A51NPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A51NPTOC*.Health

Information		
Device Healthy	0	1
A51NPTOC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A51NPTOC*.Op

Information		
Element Operated	0	1
A51NPTOC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value TRUE: 1
FALSE: 0

A51NPTOC*.Str

Information		
Element picked up	0	1
A51NPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value TRUE: 1
FALSE: 0

Information												
Element picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
A51NPTOC*.Str.dirGeneral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element picked up	0	1
A51NPTOC*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element picked up and Fwd Direction	0	1	0
Element picked up and Rev Direction	1	0	0
A51NPTOC*.Str.dirGeneral	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.23.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 51N-n		Inhibit 51N-n	Input			
E/F off/on			Control	Y	Y	Y
	51N-n Pickup	51N-n Pickup	Output			
51N-n		51N-n Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.24 55 Power Factor

5.24.1 Overview of Functions

The power factor protection function is used to:

- Detect when the power factor of the load deviates outside of normal limits, above or below a set threshold to identify connection of abnormal loading
- Monitor agreed power factor levels and limits and provide output status indications
- Detect starting/running transition in motor applications and can be used to inhibit stall protection
- Detect motor underload conditions

Power factor is the ratio of real power to apparent power. Power factor can be leading or lagging depending on the phase relationship of voltage and current.

The real and reactive power polarities can be independently inverted to suit customer preference and convention using the **`Configuration > Device > Export Power/ Lag Var`** setting.

5.24.2 Structure of the Function

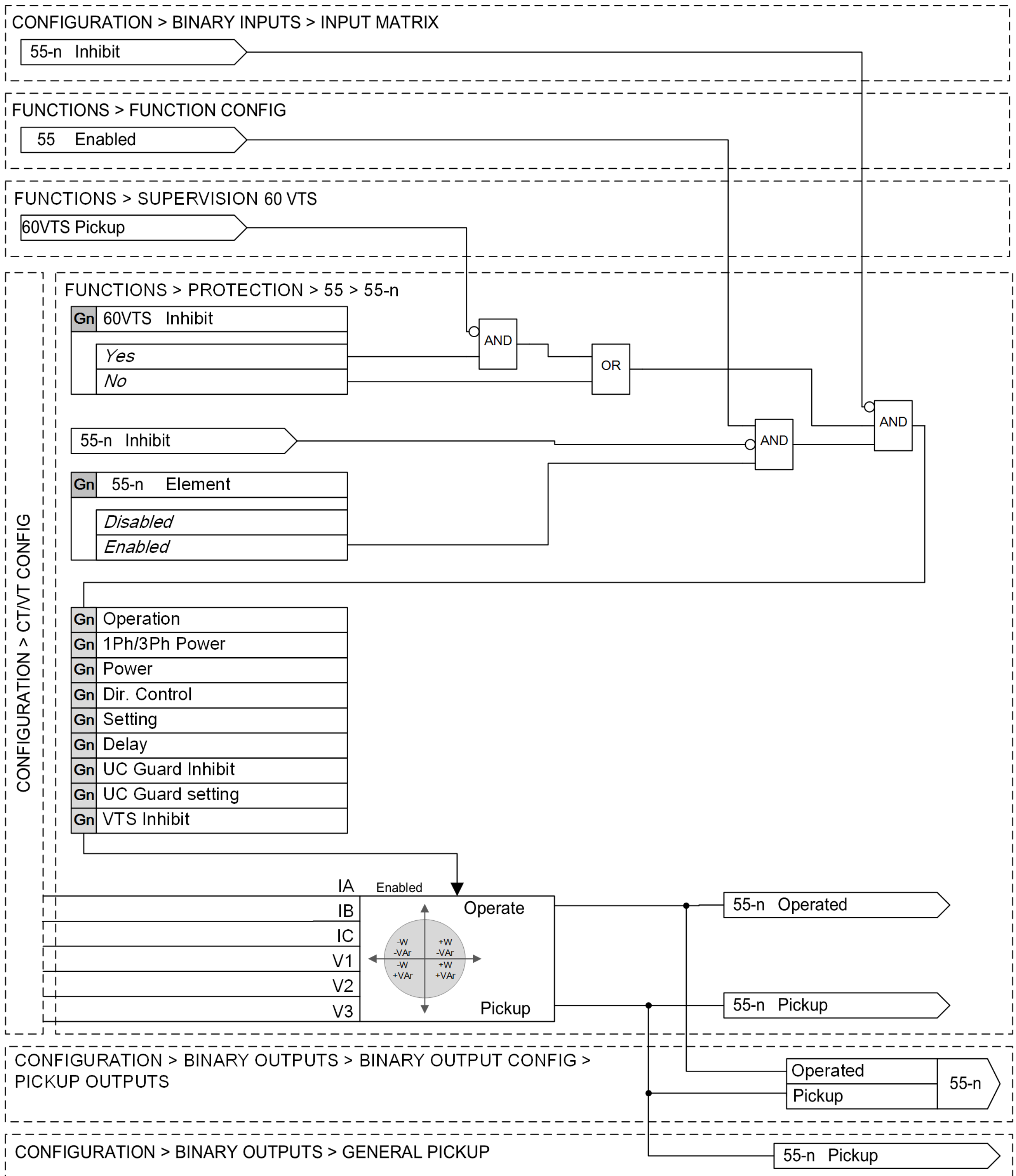
The power factor function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **`A55PDOP*`** and **`A55PDUP*`** in IEC 61850.

The function monitors the primary system using the 3 phase CT inputs e.g. CT1/2/3 and 3 phase VT inputs e.g. VT1/2/3. The fundamental frequency component is measured from processing of the measured current samples.

Each element can be set to operate for power factor over or under a settable threshold. Operation is based on any phase being above the setting or all 3 phases.

5.24.3 Logic of the Function



[lo_7SR5_55logicdiagram, 3, en_US]

Figure 5-37 Logic Diagram: 55 Power Factor

5.24.4 Application and Setting Notes

Parameter: **Operation**

- Default setting: **Under**

  Each element can be individually set to indicate operation when the power factor is above or below the set threshold. Normal system operating conditions generally have a power factor approaching unity and an **Under-PF** element will operate to indicate unwanted conditions. An **Over-PF** element is useful to provide an operated indication during normal healthy conditions.

Parameter: **1Ph/3Ph Power**

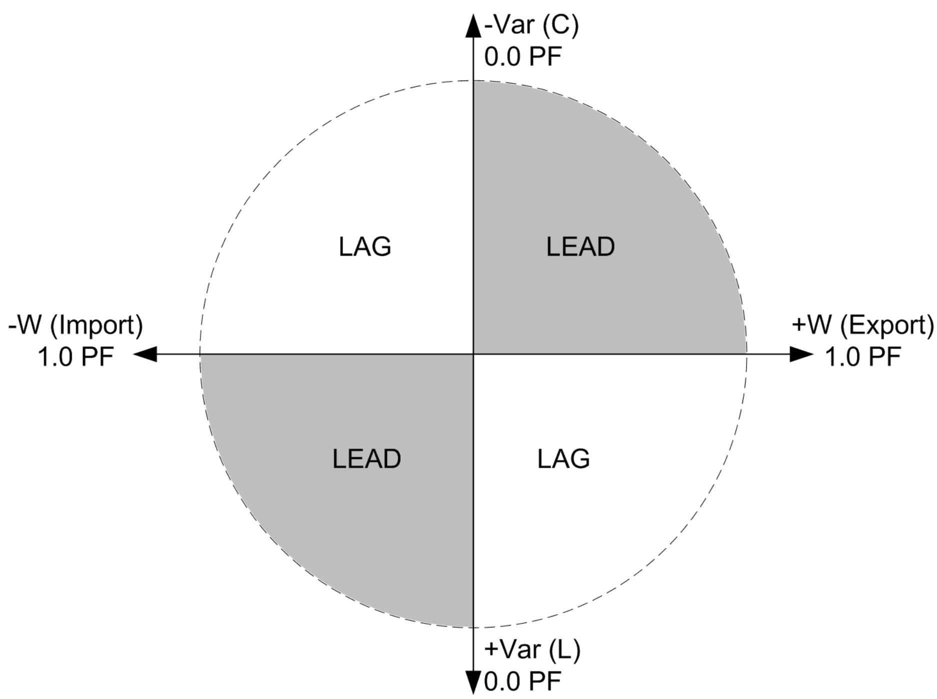
- Default setting: **3Ph**

  The relay measures the power components on each phase individually and provides the 3 phase sum values. This setting is used to define whether the 55-n protection element operates from the 3 phase value of power factor or from any of the individual phases. If it is required to provide a signal for all phases beyond a threshold, the element should be set to 1 phase operation but the **Under/Over Operation** should be reversed to suit with an inversion applied to the output signal in suitable logic.

Parameter: **Dir. Control**

- Default setting: **Non-Dir**

  The operating threshold can be applied as magnitude value only when set as **Non-Dir** or can be applied to only leading or lagging power factor e.g. when set as **Lagging** the element will not operate during leading power factor conditions. The element operates for both forward and reverse power flow.



[dw_7SR5_function55ApplicationAndSettingNotes, 1, en_US]

Parameter: **Setting**

- Default setting: **0.85**

  This sets the operating threshold as a power factor magnitude value.

Parameter: **Delay**

- Default setting: **1 s**
  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Parameter: **55-n UC Guard**

- Default setting: **Enabled**
  This can be used to block element operation if the current is below the setting in all 3 phases (?). This is used to avoid nuisance operations at very low levels of current.

Parameter: **UC Guard Setting**

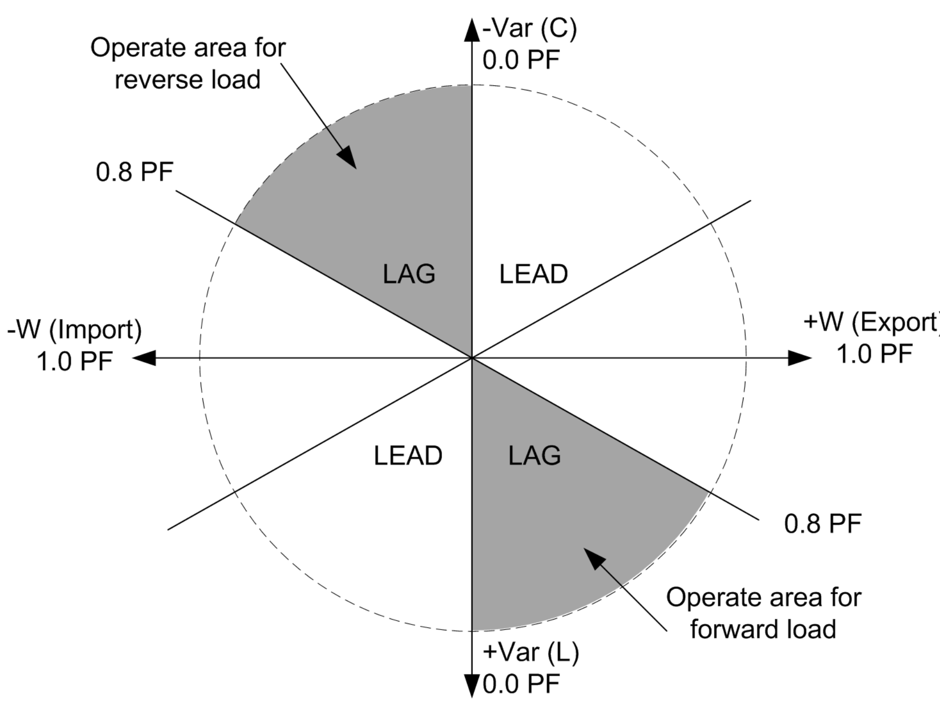
- Default setting: **0.2 x I_n** ($0.2 \cdot I_{rated}$)
  This defines the minimum current required for the element to operate. This should be set to a level below which the power factor should not be considered as significant or cannot be measured accurately.

Parameter: **VTS Inhibit**

- Default setting: **No**
  The 55-n element can be set to be automatically inhibited when a voltage has been identified as invalid by the VTS element.

Settings Example

An output is required when any phase load has a power factor below 0.8 lagging for more than 10 seconds.



[dw_7SR5_function55SettingsExample, 1, en_US]

Functions > Protection > 55	
Element	Enabled
Operation	Under
1Ph/3Ph Power	1Ph
Dir. Control	Lag

Functions > Protection > 55	
Setting	0.8
Delay	10 s
UC Guard	Enabled
UC Guard Setting	$0.1 \cdot I_{rated}$
VTS Inhibit	Enabled

The output for the 55-1 element pickups and operation should then be mapped to the output matrix, user logic, and communications.

5.24.5 Settings Menu

Functions > Function config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
55 Power Factor	Enabled Disabled	Disabled				

Functions > Protection > 55 > Gn 55-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Operation	Under Over					
1Ph/3Ph Power	1Ph 3Ph					
Dir. Control	Non-Dir Lead Lag					
Setting	0.05 to 0.99, Δ 0.01					
Delay (DTL)	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	1 s				
UC Guard	No Yes					
UC Guard Setting	0.05 to $1 \cdot I_{rated}$, Δ $0.05\ I_{rated}$					
VTS Inhibit	No Yes	Yes				

5.24.6 IEC 61850 Functional Information Mapping

A55PDOP*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A55PDOP*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A55PDOP*.Mod

Information				
55 Power Factor Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
UC Guard operated	x	x	x	0
Element Inhibited	x	x	1	0
A55PDOP*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A55PDOP*.Health

Information		
Device Healthy	0	1
A55PDOP*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A55PDOP*.Op

Information		
Element Operated	0	1
A55PDOP*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A55PDOP*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A55PDOP*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information												
Element Phase A picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element Phase A picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
Element Phase B picked up and Fwd Direction	x	x	x	0	0	0	0	1	0	1	0	0
Element Phase B picked up and Rev Direction	1	x	1	1	0	1	0	0	0	0	0	0
Element Phase C picked up and Fwd Direction	1	x	x	0	0	0	0	1	1	0	0	0
Element Phase C picked up and Rev Direction	x	1	x	1	1	0	0	0	0	0	0	0
A55PDOP*.Str.dirGeneral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element Phase A picked up	0	1
A55PDOP*.Str.phsA	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase A picked up and Fwd Direction	0	1	0
Element Phase A picked up and Rev Direction	1	0	0
A55PDOP*.Str.dirPhsA	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase B picked up	0	1
A55PDOP*.Str.phsB	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase B picked up and Fwd Direction	0	1	0
Element Phase B picked up and Rev Direction	1	0	0
A55PDOP*.Str.dirPhsB	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

Information		
Element Phase C picked up	0	1
A55PDOP*.Str.phsC	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information			
Element Phase C picked up and Fwd Direction	0	1	0
Element Phase C picked up and Rev Direction	1	0	0
A55PDOP*.Str.dirPhsC	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

A55PDUP*.Mod

Information				
55 Power Factor Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A55PDUP*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A55PDUP*.Health

Information		
Device Healthy	0	1
A55PDUP*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A55PDUP*.Op

Information		
Element Operated	0	1
A55PDUP*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A55PDUP*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A55PDUP*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information												
Element Phase A picked up and Fwd Direction	x	1	1	0	0	0	0	1	0	0	1	0
Element Phase A picked up and Rev Direction	x	x	x	1	0	0	1	0	0	0	0	0
Element Phase B picked up and Fwd Direction	x	x	x	0	0	0	0	1	0	1	0	0
Element Phase B picked up and Rev Direction	1	x	1	1	0	1	0	0	0	0	0	0
Element Phase C picked up and Fwd Direction	1	x	x	0	0	0	0	1	1	0	0	0
Element Phase C picked up and Rev Direction	x	1	x	1	1	0	0	0	0	0	0	0
A55PDUP*.Str.dirGeneral	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2
FWD and REV: 3

Information		
Element Phase A picked up	0	1
A55PDUP*.Str.phsA	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information			
Element Phase A picked up and Fwd Direction	0	1	0
Element Phase A picked up and Rev Direction	1	0	0
A55PDUP*.Str.dirPhsA	**2**	**1**	**0**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	No-Dir: 0 FWD: 1 REV: 2

Information		
Element Phase B picked up	0	1
A55PDUP*.Str.phsB	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information			
Element Phase B picked up and Fwd Direction	0	1	0
Element Phase B picked up and Rev Direction	1	0	0
A55PDUP*.Str.dirPhsB	**2**	**1**	**0**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	No-Dir: 0 FWD: 1 REV: 2

Information		
Element Phase C picked up	0	1
A55PDUP*.Str.phsC	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Information			
Element Phase C picked up and Fwd Direction	0	1	0
Element Phase C picked up and Rev Direction	1	0	0

Information			
A55PDUP*.Str.dirPhsC	**2**	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value No-Dir: 0
FWD: 1
REV: 2

5.24.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 55-n		Inhibit 55-n	Input			
55-n		55-n Operated	Output	Y	Y	Y
	55-n Pickup	55-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.25 59 Overvoltage Protection – 3 Phase

5.25.1 Overview of Functions

3 phase overvoltage protection is used to:

- Monitor the primary system voltage and provide alarms for values outside of normal limits by monitoring the 3 phase voltage inputs
- Protect equipment (for example, plant components, machines, etc.) against insulation failure due to overvoltage
- Decouple or reconfigure changeover systems due to overvoltage (for example, wind power supply or parallel sources)

Overvoltages are typically caused by loss of connection to load or sudden reduction in load, voltage controller failure at the transformer and error during control operations.

Abnormally high voltages in power systems are typically caused by:

- Transformer or generator voltage controller malfunction or
- Incorrect switching or control operations on long lines under low-load conditions or
- Following load shedding or
- Due to islanded operation or disconnected generators

Overvoltages can be caused by resonances between capacitor banks and line or transformer inductances.

5.25.2 Structure of the Function

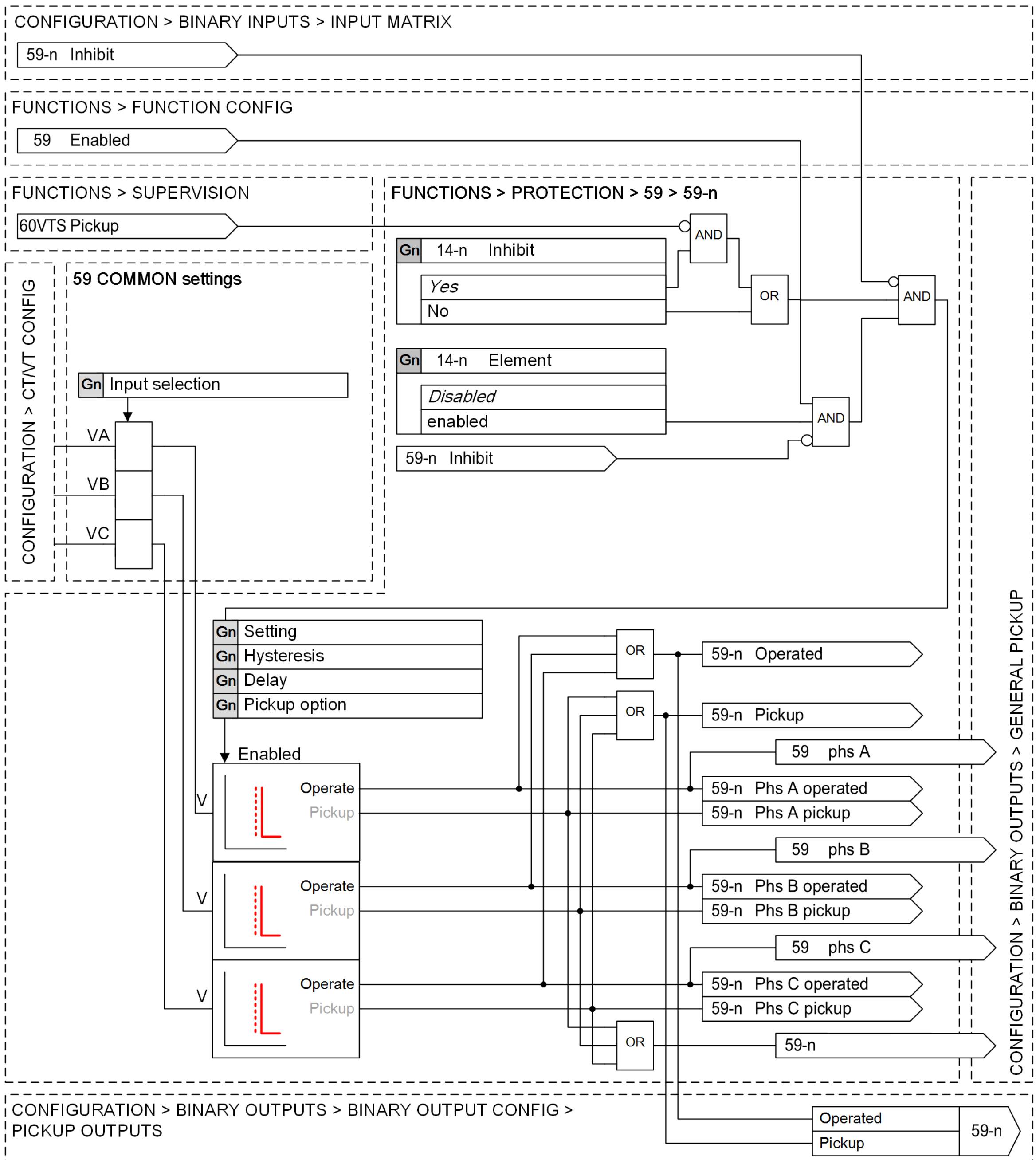
The 3 phase overvoltage function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical nodes **A59PTOV*** in IEC 61850.

The function requires VT inputs, it monitors the primary system using the 3 phase voltage inputs e.g. VT1/2/3. The fundamental frequency component is measured from processing of the measured voltage samples.

- A definite time delayed operate characteristic is used. Settings are provided for operate (pickup) threshold voltage, reset voltage level (hysteresis/drop-off) and time delay
- Outputs are provided for pickup and operation

5.25.3 Logic of the Function



[lo_7SR5_59logicdiagram, 2, en_US]

Figure 5-38 Logic Diagram: 59 Overvoltage Protection – 3 Phase

5.25.4 Application and Setting Notes

Parameter: **Input Selection**

- Default setting: **ph-ph**

  This parameter defines whether the undervoltage protection function operates on phase-neutral voltages V_A, V_B, and V_C or phase-phase voltages V_{AB}, V_{BC}, and V_{CA} and is applied to all elements of this function type.

Parameter Value	Description
ph-ph	Select this setting to monitor the load voltage conditions. For this setting the function will not pick up on earth faults.
ph-N	Select the phase to neutral setting where it is required detect voltage unbalances and overvoltage conditions caused by earth faults.

Parameter: **Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. This setting can be used to select the number of elements required.

Parameter: **Pickup Option**

- Default setting: **Any**

  This setting defines whether the element picks up if the required voltage conditions are detected on one phase **Any** or if they must be detected on all 3 phases **All**.

Parameter Value	Description
Any	This setting will allow detection during unbalanced voltage conditions and will operate for the worst phase. This is the appropriate setting for most applications
All	This setting is commonly used when the element is used to detect loss of supply or for extra immunity from unbalance deviations.

Parameter: **Setting**

- Default setting: **80 V**

  This is the operating voltage threshold of the element. The element will pickup if the voltage rises above this value. This should be set to suit the individual application.

Parameter: **Hysteresis**

- Default setting: **3 %**

  This sets the drop-off threshold. The element will pickup if the voltage rises above the **59-n Setting** and will reset when the voltage reduces to **59V-n Setting** minus the **59-n Hysteresis**.

  The default setting of 3 % is generally enough to avoid chatter of the element but care may be required for settings which result in a reset voltage close to the rated voltage as the element may not reset when the primary system recovers voltage within the acceptable operating tolerance as the voltage is still inside of the hysteresis window.

Parameter: **Delay**

- Default setting: **0.1 s**

  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Parameter: **VTS Inhibit**

- Default setting: **No**
  This setting defines the effect of a **Voltage Transformer Failure** on the operation of each 27/59 element. If a VT failure is detected by the separate VTS element, the 27/59 element will be automatically blocked if this setting is set to **Inhibit**. If this setting is set to **Off**, the 27-59-n element will be unaffected by the VTS element operation and the 27/59-n element may operate on the erroneous voltage caused by the VT fuse failure which has been correctly identified by VTS. It is generally recommended that setting to **Inhibit** is beneficial.

Settings Example

2-Stage Overvoltage Protection

This example considers a 2-stage overvoltage protection application. Settings are applied to detect a condition of 5 % increase in voltage compared to nominal, this condition may indicate a voltage control failure. A 20 % increase in voltage is detected more quickly to allow remedial actions such as a network reconfiguration or trip.

- First stage
  To detect a +5 % deviation in the voltage compared to the expected 63.5 V phase to neutral secondary nominal voltage connected to the V4 input allowing for a voltage controller which would be expected to correct this deviation in less than 2 seconds.
  Threshold = 63.5 · 1.05 = 66.675 V
  Time delay must be greater than 2 seconds. Choose 3 s.
  Choose a suitable element: 59Vx-1
- Second stage
  To detect a +20 % deviation in the voltage compared to the expected 63.5 V phase to neutral secondary nominal voltage connected to the voltage inputs allowing only for transient conditions and fault clearance and meeting the customers' expectations for disconnection which will allow 1000 ms.
  Threshold = 63.5 · 1.2 = 76.2 V
  Time delay specified as 1000 ms.
  Choose a suitable element: 59Vx-2

Element	Setting Values	
59-1	59-1 Element	Enabled
59-1	59-1 Setting	67 V
59-1	59-1 Hysteresis	3 %
59-1	59-1 Delay	3 s
59-2	59-2 Element	Enabled
59-2	59-2 Setting	76.5 V
59-2	59-2 Hysteresis	3 %
59-2	59-2 Delay	1 s

5.25.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
59 Overvoltage	Enabled Disabled	Disabled				

Functions > Protection > 59 > Gn 59 Common						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Input Selection	Ph-Ph Ph-N	Ph-Ph				

Functions > Protection > 59 > Gn 59-n						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Element	Enabled Disabled	Disabled				
Pickup Option	Any All	Any				
Setting	1 to 200 V, Δ 0.5 V	80 V				
Hysteresis	0 to 80 %, Δ 1 %	3 %				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0.1 s				
VTS Inhibit	No Yes	No				

5.25.6 IEC 61850 Functional Information Mapping

A59PTOV*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A59PTOV*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A59PTOV*.Mod

Information				
59 Overvoltage Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A59PTOV*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A59PTOV*.Health

Information		
Device Healthy	0	1
A59PTOV*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A59PTOV*.Op

Information		
Element Operated	0	1
A59PTOV*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A59PTOV*.Str

Information		
Element Phase A picked up or	0	1
Element Phase B picked up or	0	1
Element Phase C picked up	0	1
A59PTOV*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information		
Element Phase A picked up	0	1
A59PTOV*.Str.phsA	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information		
Element Phase B picked up	0	1
A59PTOV*.Str.phsB	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information		
Element Phase C picked up	0	1
A59PTOV*.Str.phsC	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

5.25.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 59-n		Inhibit 59-n	Input			
59-n		59-n Operated	Output	Y	Y	Y
59 PhA		59-n PhA Operated	Output	Y	Y	Y
59 PhB		59-n PhB Operated	Output	Y	Y	Y
59 PhC		59-n PhC Operated	Output	Y	Y	Y
	59-n Pickup	59-n Pickup	Output			
		59-n PhA Pickup	Output			
		59-n PhB Pickup	Output			
		59-n PhC Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.26 59N Neutral Voltage Displacement

5.26.1 Overview of Functions

The function **Neutral Voltage Displacement** protection is used to:

- Monitor for voltage displacement of the neutral point which should not normally be present in a balanced 3 phase system. The neutral voltage is calculated from the 3 phase voltage inputs
- Monitor for unbalance in the phase supply voltages of a 3 phase system
- Identify abnormal system conditions which result in voltage unbalance in a 3 phase system
- Monitor single phase voltage applied to the separate 4^{th} voltage input by alternative configuration of settings

5.26.2 Structure of the Function

The neutral voltage displacement function elements have group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical nodes **A59NITPTOV*** and **A59NDTPTOV*** in IEC 61850.

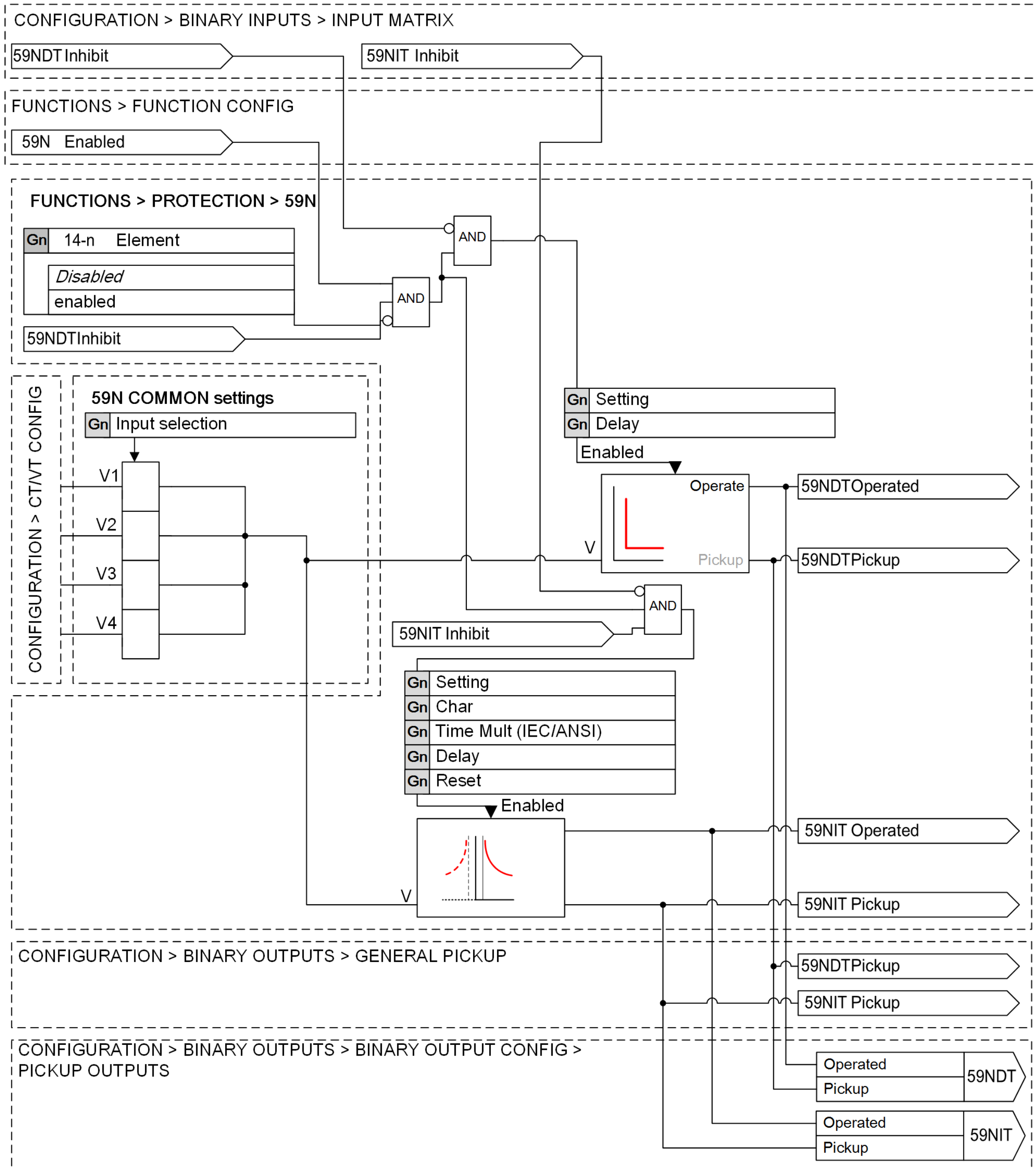
The neutral voltage displacement protection function is used in devices with VT inputs voltage measurement and is applied to the calculated sum of the VT1/2/3 inputs. Alternatively the function can be configured to operate from the 4^{th} voltage input measured voltage.

There is 1 definite-time overvoltage protection element and 1 inverse-time overvoltage protection element.

The inverse-time element can be selected to a definite-time characteristic to provide a total of 2 DTL voltage elements or a user definable inverse characteristic.

This protection function operates on the fundamental frequency component evaluated from processing of the measured voltage samples.

5.26.3 Logic of the Function



[lo_7SR5_59Nlogicdiagram, 2, en_US]

Figure 5-39 Logic Diagram: 59N Neutral Voltage Displacement

5.26.4 Application and Setting Notes

Parameter: **Function Config > 59N Overvoltage**

- Default setting: **Disabled**

  This setting is located in the **Function Config** menu and is used to allow the 59N function to be switched on and off if it is not required. If this setting is set to **Disabled**, the 59DT and 59IT elements are not available for configuration. A separate setting is also provided for each element for use when 59N is set to **Enabled**.

Parameter: **59N Common > Input Selection**

- Default setting: **Vn**

  This setting is common to the 59NDT and 59NIT elements and is used to allow the elements to operate from either Vn, the calculated neutral voltage derived from the sum of the 3 phase voltages, or Vx, the voltage measured directly using the V4 voltage input.

Parameter: **59NDT-n Element**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These settings can be used to select the number of elements required.

Parameter: **59NDT-n Setting**

- Default setting: **5 V**

  This is the operating voltage threshold of the element. The element will pickup if the voltage rises above this value. This should be set to suit the individual application.

Parameter: **59NDT-n Delay**

- Default setting: **0.1 s**

  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Parameter: **59NIT-n Setting**

- Default setting: **Disabled**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These settings can be used to select the number of elements required.

Parameter: **59NIT-n Setting**

- Default setting: **5 V**

  This is the operating voltage threshold of the element. The element will pickup if the voltage rises above this value. This should be set to suit the individual application.

Parameter: **59NIT-n Char**

- Default setting: **DTL**

  This setting defines the characteristic of the inverse curve. Any custom voltage curve that has been configured can be selected from the list. The characteristic can also be set as DTL so that 2 DTL elements are available (59NDT and 59NIT).

Parameter: **59NIT-n Time Mult**

- Default setting: **1**
  This setting defines the time multiplier that is applied to the selected inverse voltage curve. If a DTL characteristic is selected, this setting is not used.

Parameter: **59NIT-n Delay (DTL)**

- Default setting: **0.1 s**
  This is the time delay setting for the element when the DTL characteristic is selected. This should be set to suit the individual application. When a curve characteristic is selected, this setting is not used.

Parameter: **59NIT-n Reset**

- Default setting: **0 s**
  The reset parameter is used to define whether the element pickup resets to zero instantaneously when the operating voltage falls below setting or a reset curve characteristic or fixed DTL is applied. This operation is significant during intermittent faults or fluctuating voltage levels.
- Tripping Function
  These elements can be used as an alarm or monitoring function. Triggering of waveform storage must be configured if required. If the element is a tripping function it must be configured to a designated **Trip Contact** to trigger a **Fault Record**.

5.26.5 Settings Menu

Functions > Protection > 59N > Gn 59N Common						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Input Selection	Vn V4	Ph-Ph				

Functions > Protection > 59N > Gn 59NDT-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	1 to 200 V, Δ 0.5 V	80 V				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0.1 s				

Functions > Protection > 59N > Gn 59NIT-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	1 to 200 V, Δ 0.5 V					
Char	DTL					
Time Mult (IEC ANSI)	0.1 to 10, Δ 0.1 10.5 to 140, Δ 0.5	1				

Functions > Protection > 59N > Gn 59NIT-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Delay	0 to 20 s Δ 0.01 s	5 s				
Reset	IEC/ANSI Decaying 0 to 60 s Δ 1 s					

5.26.6 IEC 61850 Functional Information Mapping

A59NITPTOV*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A59NITPTOV*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A59NITPTOV*.Mod

Information				
59N Overvoltage Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A59NITPTOV*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A59NITPTOV*.Health

Information		
Device Healthy	0	1
A59NITPTOV*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A59NITPTOV*.Op

Information		
Element Operated	0	1
A59NITPTOV*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A59NITPTOV*.Str

Information		
Element Phase picked up	0	1
A59NITPTOV*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A59NDTPTOV*.Mod

Information				
59N Overvoltage Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A59NDTPTOV*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A59NDTPTOV*.Health

Information		
Device Healthy	0	1
A59NDTPTOV*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A59NDTPTOV*.Str

Information		
Element Phase picked up	0	1
A59NDTPTOV*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A59NDTPTOV*.Op

Information		
Element Operated	0	1
A59NDTPTOV*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

5.26.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 59NDT		Inhibit 59NDT	Input			
59NDT		59NDT Operated	Output			
	59NDT Pickup	59NDT Pickup	Output			
Inhibit 59NIT		Inhibit 59NIT	Input			
59NIT		59NIT Operated	Output			
	59NIT Pickup	59NIT Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.27 59Vx Overvoltage Protection – Vx

5.27.1 Overview of Function

Single phase overvoltage protection is used to:

- Monitor the primary system voltage and provide alarms for values outside of normal limits by monitoring the single phase voltage inputs
- Protect equipment (for example, plant components, machines, etc.) against insulation failure due to overvoltage
- Decouple or reconfigure changeover systems due to overvoltage (for example, wind power supply or parallel sources)

Overvoltages are typically caused by loss of connection to load or sudden reduction in load, voltage controller failure at the transformer and error during control operations.
Abnormally high voltages in power systems are typically caused by:

- Transformer or generator voltage controller malfunction or
- Incorrect switching or control operations on long lines under low-load conditions or
- Following load shedding or
- Islanded operation or disconnected generators

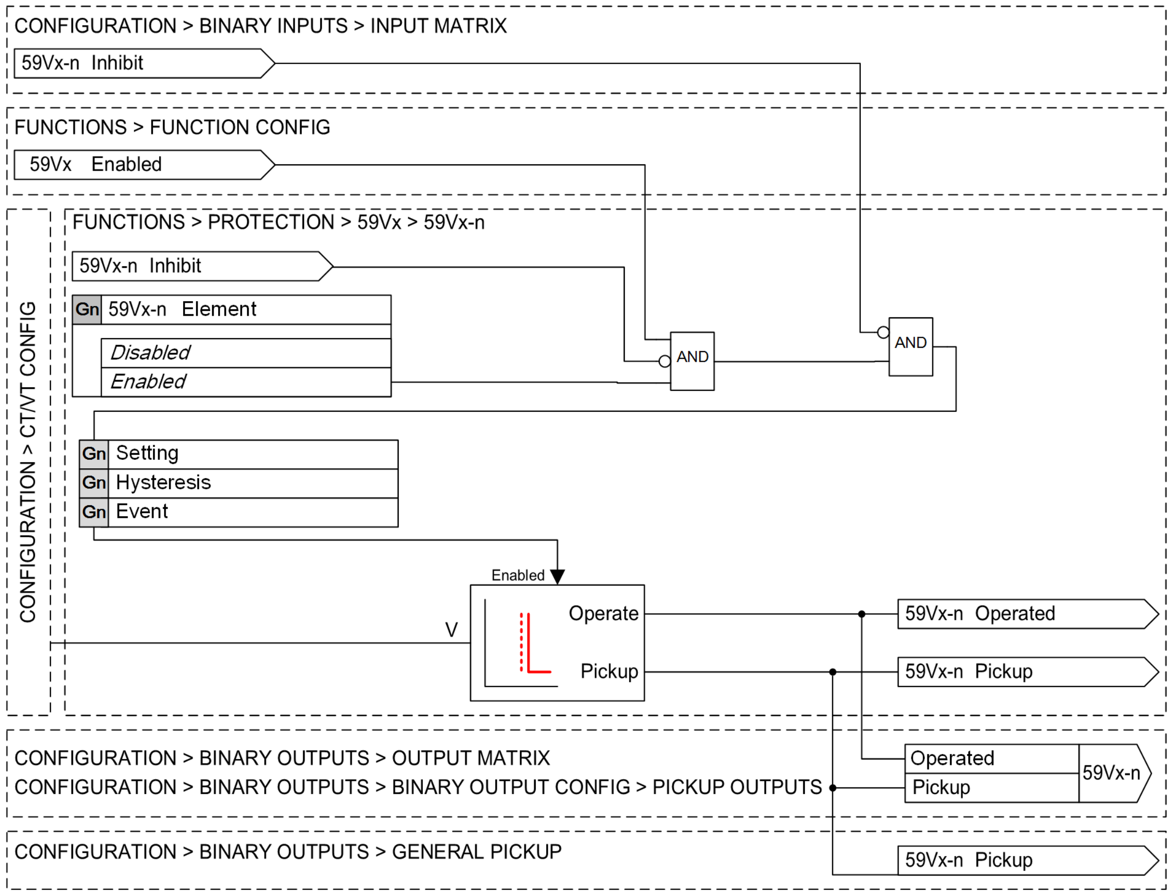
Overvoltages can be caused by resonances between capacitor banks and line or transformer inductances.

5.27.2 Structure of the Function

The single phase undervoltage function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.
This function corresponds to the logical node **`A59VxPTOV*`** in IEC 61850.
The function monitors the primary system using the single phase VT input e.g. VT4. The fundamental frequency component is measured from processing of the measured voltage samples.

- A definite time delayed operate characteristic is used. Settings are provided for operate (pickup) threshold voltage, reset voltage level (hysteresis/drop-off) and time delay.
- Outputs are provided for pickup and operation.

5.27.3 Logic of the Function



[lo_7SR5_59Vxlogicdiagram, 2, en_US]

Figure 5-40 Logic Diagram: 59Vx Overvoltage Protection – Vx

5.27.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These settings can be used to select the number of elements required.

Parameter: **Setting**

- Default setting: **80 V**
  This is the operating voltage threshold of the element. The element will pickup if the voltage falls below this value. This should be set to suit the individual application.

Parameter: **Hysteresis**

- Default setting: **3 %**
  This sets the drop-off threshold for the undervoltage element. The element will pickup if the voltage falls below the setting and will reset when the voltage recovers to the setting + hysteresis voltage. This setting is a percentage of the undervoltage setting.
  The default setting of 3 % is generally enough to avoid chatter of the element but care may be required for settings which are close to the nominal value otherwise the element may not reset when the voltage recovers to nominal value as the voltage is still in the hysteresis window.

Parameter: **Delay**

- Default setting: **0.1 s**
  This is the time delay setting for the DTL element. This should be set to suit the individual application.

5.27.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
59Vx Overvoltage	Enabled Disabled	Disabled				

Functions > Protection > 59Vx > Gn 59Vx-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	5 to 200 V, Δ 0.5 V	80 V				
Hysteresis	0 to 80 %, Δ 0.1 %	3 %				
Delay	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0.1 s				

5.27.6 IEC 61850 Functional Information Mapping

A59VxPTOV*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x

Information												
A59VxPTOV*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A59VxPTOV*.Mod

Information				
59Vx Overvoltage Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A59VxPTOV*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A59VxPTOV*.Health

Information		
Device Healthy	0	1
A59VxPTOV*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A59VxPTOV*.Op

Information		
Element Operated	0	1
A59VxPTOV*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A59VxPTOV*.Str

Information		
Element picked up	0	1
A59VxPTOV*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value TRUE: 1
FALSE: 0

5.27.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 59Vx-n		Inhibit 59Vx-n	Input			
59Vx-n		59Vx-n Operated	Output	Y	Y	Y
	59Vx-n Pickup	59Vx-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.28 67 Directional Overcurrent/Earth Fault

5.28.1 Overview of Functions

Directional overcurrent and earth fault protection is used to provide discriminative graded protection where the fault current can flow in either direction.

5.28.2 Structure of the Function

The directional overcurrent protection function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

The 67 function monitors the primary system current direction using the 3 phase CT inputs e.g. CT1/2/3 and 3 phase VT inputs e.g. VT1/2/3.

The 67N function uses the 3V0 voltage, measured or calculated from VT1/2/3 depending on the **Voltage Config** setting to determine the direction of current calculated from the sum of the 3 phase CT inputs i.e. I_N, which is used by the 50N and 51N elements. Similarly 67G uses 3V0 to determine the direction for 50G and 51G elements, 67GS uses 3V0 to determine the direction for 50GS and 51GS elements and 67GI uses 3V0 to determine the direction for 50GI elements. The current used for G, GS and GI elements in standard 4 CT devices is the CT4 current. In the special 5 CT devices the operating current for these measured earth fault elements can be selected in the **Function Configuration** in Reydisp Manager as CT4 or CT8. The current source for the 67G, 67GS and 67GI directional measurement is selected similarly in the **Function Configuration** in Reydisp Manager. If a 50G or 51G element is applied to the same current input as the 67G, that earth fault element will support the directional options. If the 50G or 51G element is applied to the opposite earth fault current input to 67G, the element will be non-directional. 67GS and 67GI are similar, although separate.

The function elements determine the direction of current flow by measuring the phase angle of the current, **operate quantity**, against the appropriate voltage, **reference quantity**.

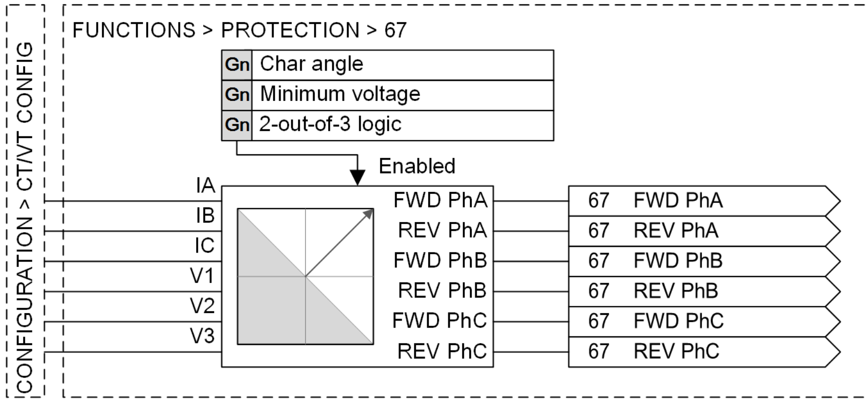
If a protection element is set as non-directional then it will operate independently of the output of the directional detector. However, if a protection element is programmed for forward directional mode then operation will occur only for a fault lying within the forward operate zone. Conversely, if a protection element is programmed for reverse directional mode then operation will occur only for a fault lying within the reverse operate zone.

Typically, to achieve consistent settings, the forward direction refers to current flow from the busbar or towards the protected zone. The reverse current direction refers to power flowing into the busbar.

The function has 5 function element types:

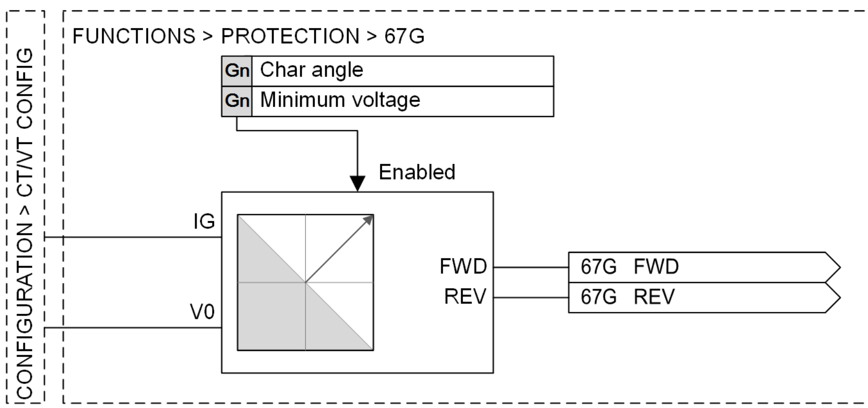
- Directional control of overcurrent elements (67)
- Directional control of measured earth fault elements (67G)
- Directional control of sensitive earth fault elements (67GS)
- Directional control of intermittent earth fault elements (67GI)
- Directional control of calculated earth fault elements (67N)

5.28.3 Logic of the Function



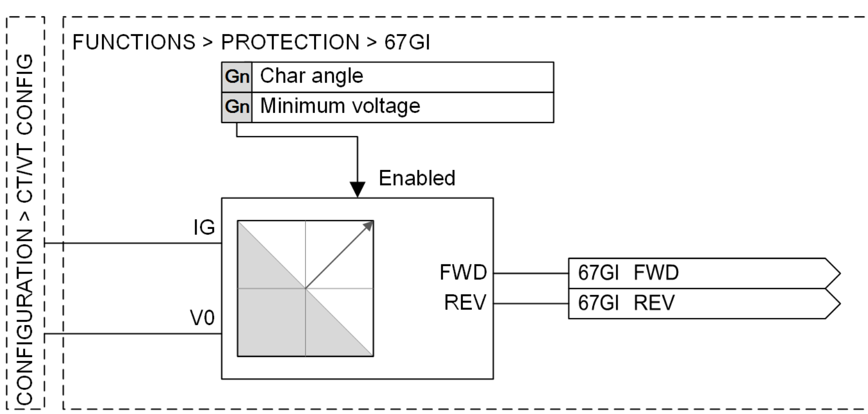
[lo_7SR5_67logicdiagram, 2, en_US]

Figure 5-41 Logic Diagram: 67 Directional Overcurrent – Phase



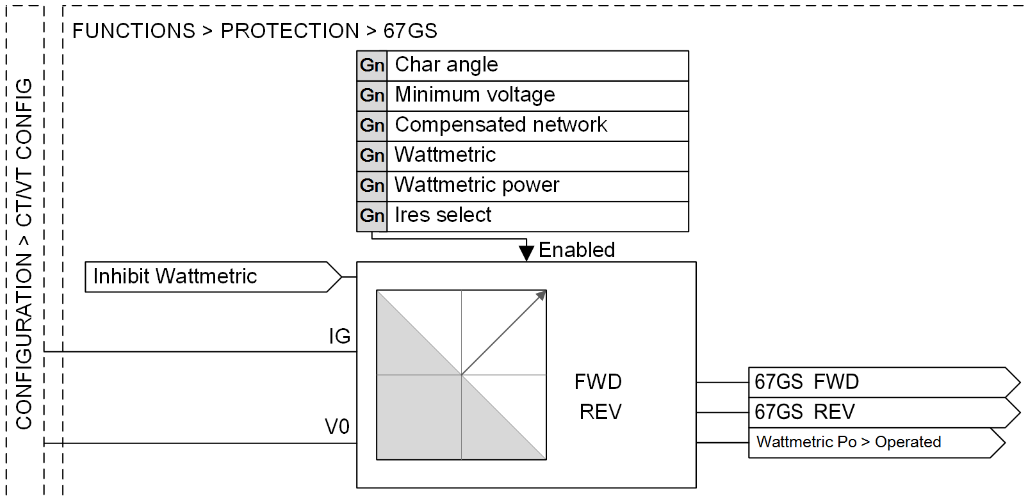
[lo_7SR5_67Glogicdiagram, 1, en_US]

Logic Diagram: 67G Directional Earth Fault – Measured



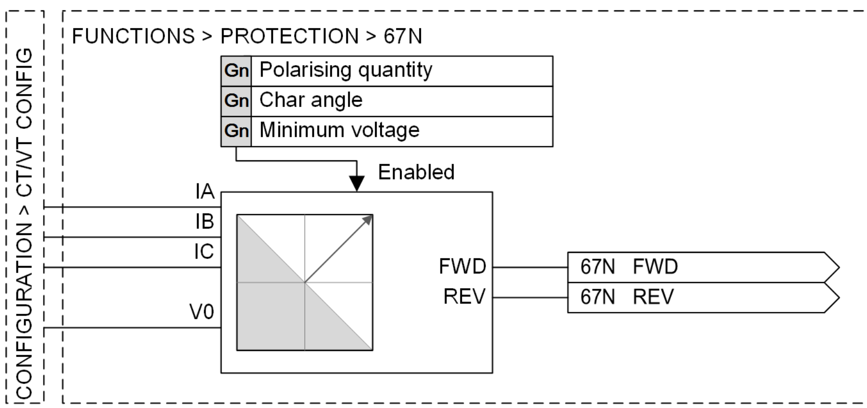
[lo_7SR5_67GIlogicdiagram, 1, en_US]

Figure 5-42 Logic Diagram: 67GI Directional Intermittent Earth Fault



[lo_7SR5_67GSlogicdiagram, 1, en_US]

Figure 5-43 Logic Diagram: 67GS Directional Sensitive Earth Fault – Measured



[lo_7SR5_67Nlogicdiagram, 1, en_US]

Figure 5-44 Logic Diagram: 67N Directional Earth Fault – Calculated

5.28.4 Application and Setting Notes

Parameter: **67 > Char Angle**

- Default setting: **45°**

  The directional overcurrent element provides forward and reverse outputs that can be used to control each overcurrent element.

  The directional overcurrent function elements use a 90° quadrature connection. The phase angle of each operate current element is compared to the phase angle of the voltage from the other 2 phases for normal phase sequence A-B-C. This connection introduces a 90° phase shift (Current Leading Voltage) between reference and operate quantities which must be allowed for in the **Characteristic Angle** setting.

  The voltage phasor is the reference quantity (Vref) and the current phasor is the operate quantity.

I (Operate)	V (Reference)
I_a	V_{bc}
I_b	V_{ca}
I_c	V_{ab}

NOTE

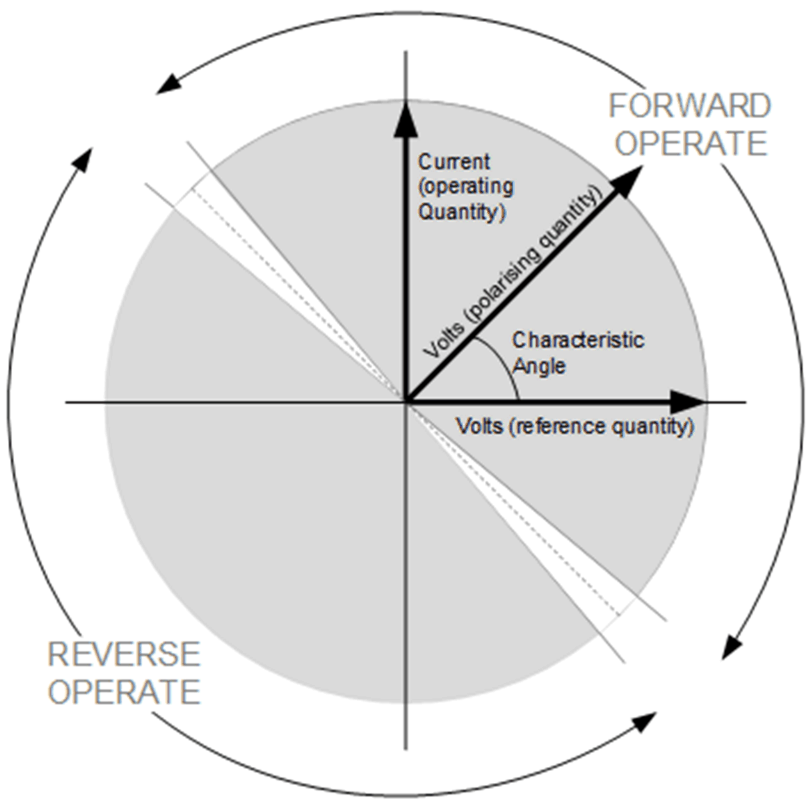
When the device is applied to reverse sequence networks, i.e. A-C-B, the polarizing is corrected using the **Configuration > CT/VT > Phase Rotation** setting.

The characteristic angle is the phase angle by which the reference voltage must be adjusted such that the directional detector gives maximum sensitivity in the forward operate zone i.e. when the operate current is in phase with the polarizing voltage. A fault is determined to be in the selected direction if it lies within +/- 85° of the **Characteristic Angle** setting.

For fault current of -60° (I lagging V by 60°) a setting of +30° is required for maximum sensitivity (due to quadrature connection 90° - 60° = 30°). OR

For fault current of -45° (I lagging V by 45°) a setting of +45° is required for maximum sensitivity (due to quadrature connection 90° - 45° = 45°).

The reverse operate zone is the mirror image of the forward zone.



[dw_7SR5_function67ApplicationAndSettingNotes1, 1, en_US]

Figure 5-45 Phase Fault Directional Characteristic

Parameter: **67 > Minimum Voltage**

- Default setting: **1 V**

  Where the measured polarizing voltage is below this setting no directional control signal is given and operation of protection elements set as directional will be inhibited. This prevents mal-operation under fuse failure/MCB tripped conditions where noise voltages can be present.

Parameter: **67 > 2-out-of-3 Logic**

- Default setting: **Disabled**
  When set to **Enabled**, the directional elements will only operate for the majority direction, e.g. if I_a and I_c are detected as forward flowing currents and I_b is detected as reverse current flow, then directional enable signals **67 FWD PhA** and **67 FWD PhC** will operate while phase the phase B directional enable signal will be inhibited.

Parameter: **67G > Char Angle**

- Default setting: **-15°**
  The 67G directional element provides forward and reverse outputs that can be used to control each measured earth fault element.
  The measured directional earth fault elements use the zero phase sequence (V_0) voltage as the reference quantity and the measured (I_G) current phasor is the operate quantity.

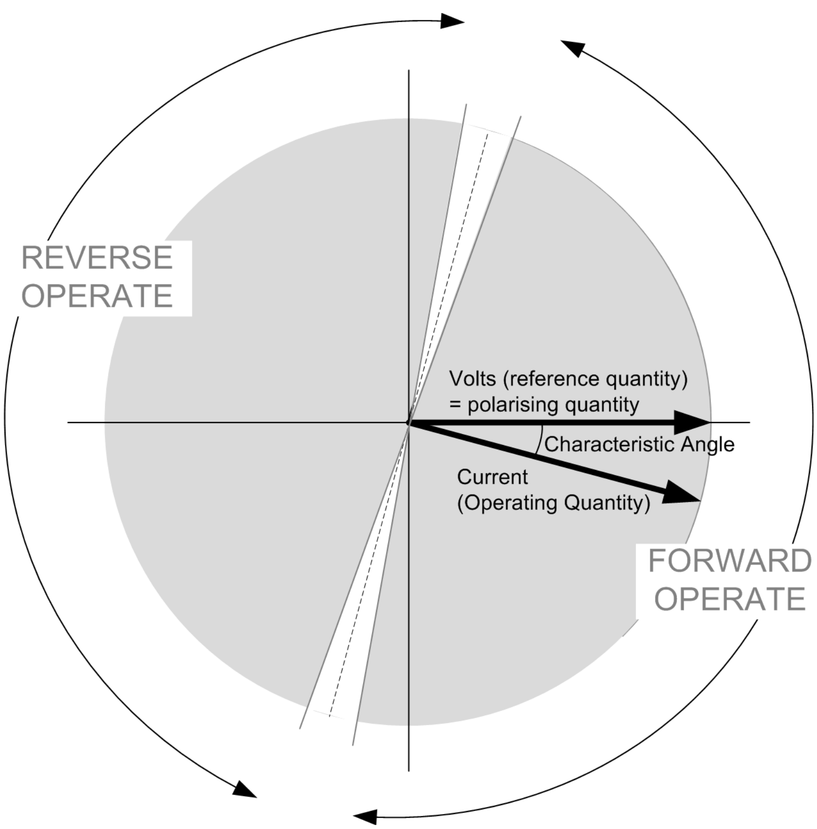
I (Operate)	V (Reference)
I_G	V_0

The characteristic angle is the phase angle by which the reference voltage must be adjusted such that the directional detector gives maximum sensitivity in the forward operate zone i.e. when the operate current is in phase with the polarizing voltage. A fault is determined to be in the selected direction if lies within +/- 85° of the **Characteristic Angle** setting.

For fault current of -15° (I lagging V by 15°) a setting of -15° is required for maximum sensitivity OR

For fault current of -45° (I lagging V by 45°) a setting of -45° is required for maximum sensitivity.

The reverse operate zone is the mirror image of the forward zone.



[dw_7SR5_function67ApplicationAndSettingNotes2, 1, en_US]

Figure 5-46 Earth Fault Directional Characteristic

Parameter: **67G > Minimum Voltage**

- Default setting: **0.33 V**
  This setting defines the minimum polarizing voltage level. Where the measured voltage is below this level no directional output is given and protection elements set as directional will not operate. This prevents mal-operation under fuse failure/MCB tripped conditions where noise voltages can be present.

Parameter: **67GI > Char Angle**

- Default setting: **-15°**
  The 67GI directional element provides forward and reverse outputs that can be used to control each intermittent earth fault element.
  The intermittent directional earth fault elements use the zero phase sequence (V_0) voltage as the reference quantity and the measured intermittent earth fault current is the operate quantity.

I (Operate)	V (Reference)
Measured I_{GI}	V_0

The characteristic angle is the phase angle by which the reference voltage must be adjusted such that the directional detector gives maximum sensitivity in the forward operate zone i.e. when the operate current is in phase with the polarizing voltage. A fault is determined to be in the selected direction if lies within +/- 85° of the **Characteristic Angle** setting.

For fault current of -15° (I lagging V by 15°) a setting of -15° is required for maximum sensitivity OR

For fault current of -45° (I lagging V by 45°) a setting of -45° is required for maximum sensitivity.

The reverse operate zone is the mirror image of the forward zone.

Parameter: **67GI > Minimum Voltage**

- Default setting: **0.33 V**
  This setting defines the minimum polarizing voltage level. Where the measured voltage is below this level no directional output is given and protection elements set as directional will not operate. This prevents mal-operation under fuse failure/MCB tripped conditions where noise voltages can be present.

Parameter: **67GS > Char Angle**

- Default setting: **-15°**
  The 67GS directional element provides forward and reverse outputs that can be used to control each sensitive earth fault element.
  The sensitive directional earth fault elements use the zero phase sequence (V_0) voltage as the reference quantity and the measured (I_{GS}) current phasor is the operate quantity.

I (Operate)	V (Reference)
Measured I_{GS}	V_0

The characteristic angle is the phase angle by which the reference voltage must be adjusted such that the directional detector gives maximum sensitivity in the forward operate zone i.e. when the operate current is in phase with the polarizing voltage. A fault is determined to be in the selected direction if lies within +/- 85° of the **Characteristic Angle** setting.

For fault current of -15° (I lagging V by 15°) a setting of -15° is required for maximum sensitivity OR

For fault current of -45° (I lagging V by 45°) a setting of -45° is required for maximum sensitivity.

The reverse operate zone is the mirror image of the forward zone.

Parameter: **67GS > Minimum Voltage**

- Default setting: **0.33 V**
  This setting defines the minimum polarizing voltage level. Where the measured voltage is below this level no directional output is given and protection elements set as directional will not operate. This prevents mal-operation under fuse failure/MCB tripped conditions where noise voltages can be present.

Parameter: **67GS > Compensated Network**

- Default setting: **Disabled**
  For resonant grounded systems where compensation (Petersen) coils are fitted, earth fault current is deliberately reduced to zero and therefore is difficult to measure for protection purposes. However, the wattmetric component in the capacitive charging currents, which are close to the directional zone boundary, can be used to indicate fault location. It is advantageous to increase the directional limits towards ± 90° so that the directional boundary can be used to discriminate between faulted and healthy circuits. This feature must be enabled for use with compensated networks only.

Parameter: **67GS > Wattmetric**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element.

Parameter: **67GS > Wattmetric Power**

- Default setting: **0.10 x I_n x W** (0.10 · I_{rated} · W)

Parameter: **67GS > Ires Select**

- Default setting: **Ires**
  Use of only the sine (reactive) component of the residual current is achieved by setting **Ires Select** to **Ires Real**.
  Where it is required to select the operating current to I_{RES}Cos(θ - ∅) the characteristic angle is set to ∅ to +90°.
  See *Figure 5-54*.

Parameter: **67N > Polarizing Quantity**

- Default setting: **ZPS**
  The 67N directional element provides forward and reverse outputs that can be used to control each calculated earth fault element. The directional calculated earth fault elements use zero or negative phase sequence polarizing.

Polarizing Quantity	I (Operate)	V (Reference)
ZPS	I_0	V_0
NPS	I_2	V_2

Negative sequence polarizing is used when a zero-sequence polarizing voltage is not available e.g. when a phase to phase VT is installed, see Voltage Config (CT/VT CONFIG menu).

Parameter: **67N > Char Angle**

- Default setting: **-15°**

  The characteristic angle is the phase angle by which the reference voltage must be adjusted such that the directional detector gives maximum sensitivity in the forward operate zone i.e. when the operate current is in phase with the polarizing voltage. A fault is determined to be in the selected direction if lies within +/- 85° of the **Characteristic Angle** setting.

  For fault current of -15° (I lagging V by 15°) a setting of -15° is required for maximum sensitivity OR

  For fault current of -45° (I lagging V by 45°) a setting of -45° is required for maximum sensitivity.

  The reverse operate zone is the mirror image of the forward zone.

Parameter: **67N > Minimum Voltage**

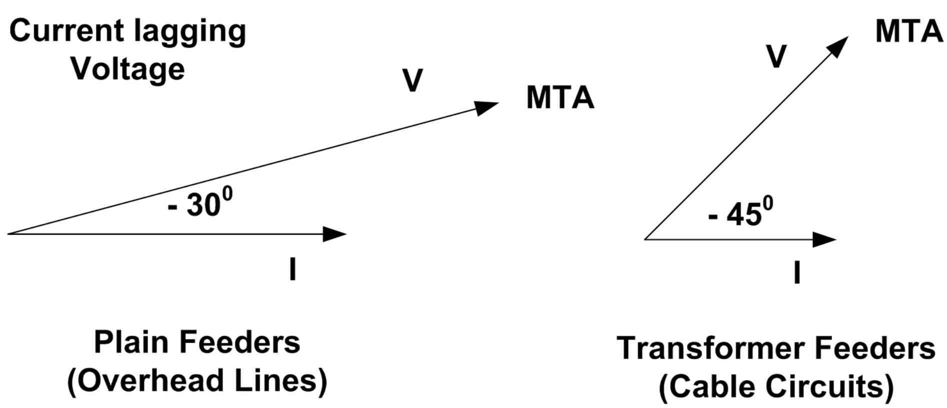
- Default setting: **0.33 V**

  Where the measured polarizing voltage is below this setting no directional output is given and operation of protection elements set as directional will be inhibited. This prevents mal-operation under fuse failure/MCB tripped conditions where noise voltages can be present.

Settings Example

Directional Protection

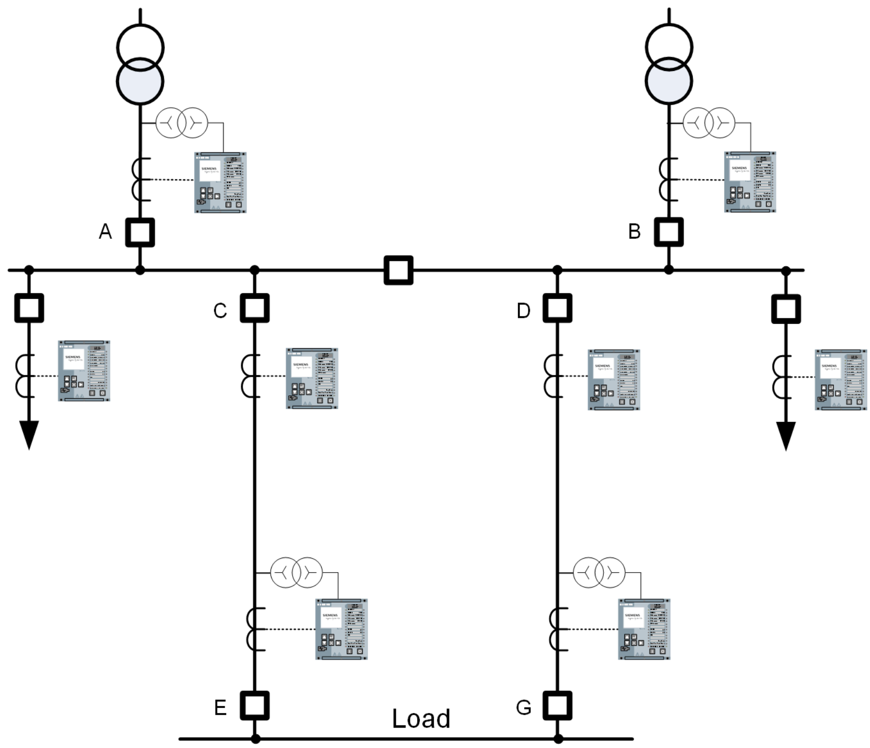
A number of studies have been made to determine the optimum MTA settings e.g. W.K Sonnemann’s paper “A Study of Directional Element Connections for Phase Relays”. The following figure shows the most likely fault angle for phase faults on overhead line and cable circuits.



[dw_7SR5_function67SettingExample1, 1, en_US]

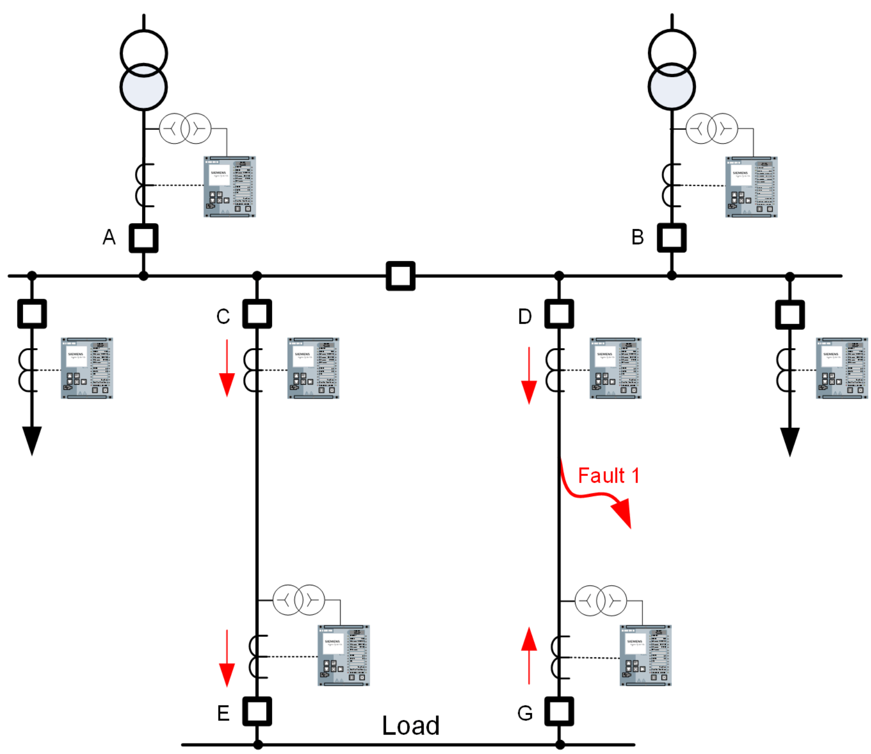
Figure 5-47 Phase Fault Angles

Directional overcurrent elements allow greater fault selectivity than non-directional elements for interconnected systems where fault current can flow in both directions through the relaying point. Consider the network shown above. The circuit breakers at A, B, E and G have directional overcurrent relays fitted since fault current can flow in both directions at these points. The forward direction is defined as being away from the busbar and against the direction of normal load current flow. These forward looking IDMTL elements can have sensitive settings applied i.e. low current and time multiplier settings.



[dw_7SR5_function67SettingExample2, 1, en_US]

Figure 5-48 Application of Directional Overcurrent Protection



[dw_7SR5_function67SettingExample3, 1, en_US]

Figure 5-49 Feeder Fault on Interconnected Network

Considering the D-G feeder fault shown in *Figure 5-49*: the current magnitude through breakers C and D will be similar and their associated relays will have similar prospective operate times. To ensure that only the faulted feeder is isolated **G FWD** must be set to be faster than C. Relay G will thus trip first on **FWD** settings, leaving D to operate to clear the fault. The un-faulted feeder C-E maintains power to the load.

Relays on circuits C and D at the main substation need not be directional to provide the above protection scheme. However additional directional elements could be mapped to facilitate a blocked overcurrent scheme of busbar protection.

At A and B, forward looking directional elements enable sensitive settings to be applied to detect transformer faults whilst reverse elements can be used to provide back-up protection for the relays at C and D.

By using different settings for forward and reverse directions, closed ring circuits can be set to grade correctly whether fault current flows in a clockwise or counter clockwise direction i.e. it may be practical to use only 1 relay to provide dual directional protection.

2 Out of 3 Logic

Sensitive settings can be used with directional overcurrent relays since they are directionalized in a way which opposes the flow of normal load current i.e. on the substation incomers as shown on fig. 2.6-4? However on occurrence of transformer HV or feeder incomer phase-phase faults an unbalanced load current may still flow as an unbalanced driving voltage is present. This unbalanced load current during a fault may be significant where sensitive overcurrent settings are applied – the load current in 1 phase may be in the operate direction and above the relay setting.

Where this current distribution may occur then the relay is set to **Current Protection > Phase Overcurrent > 67 2-out-of-3 Logic = Enabled**

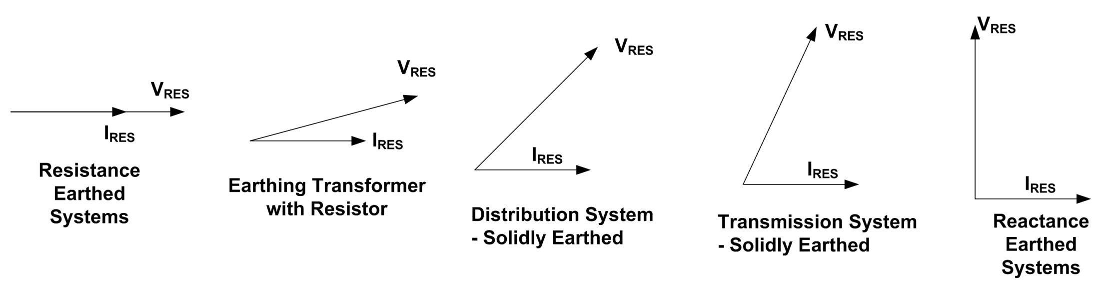
Enabling 2-out-of-3 logic will prevent operation of the directional phase fault protection for a single phase to earth fault. Dedicated earth fault protection should therefore be used if required.

Directional Earth Fault

The directional earth fault elements, either measured directly or derived from the 3 line currents the zero sequence current (operate quantity) and compare this against the derived zero phase sequence voltage (polarizing quantity). The required setting is entered directly as dictated by the system impedances.

Example: Expected fault angle is -45° (i.e. residual current lagging residual voltage) therefore 67G char angle = -45° derived directional earth elements, 50N and 51N, can be selectable to use either ZPS or NPS Polarizing. This is to allow for the situation where ZPS voltage is not available; perhaps because a 3-limb VT is being used. NPS polarizing uses the phase of the NPS voltage and NPS current for directional polarizing but the ZPS derived earth fault current is still the operating quantity. Care must be taken as the **Characteristic Angle** may require adjustment if NPS polarizing is used. Once again the fault angle is completely predictable, though this is a little more complicated as the method of earthing must be considered.

MTA (I wrt V)				
O^0	-15^0	-45^0	-65^0	-90^0
← Resistive Neutral			Reactive Neutral →	



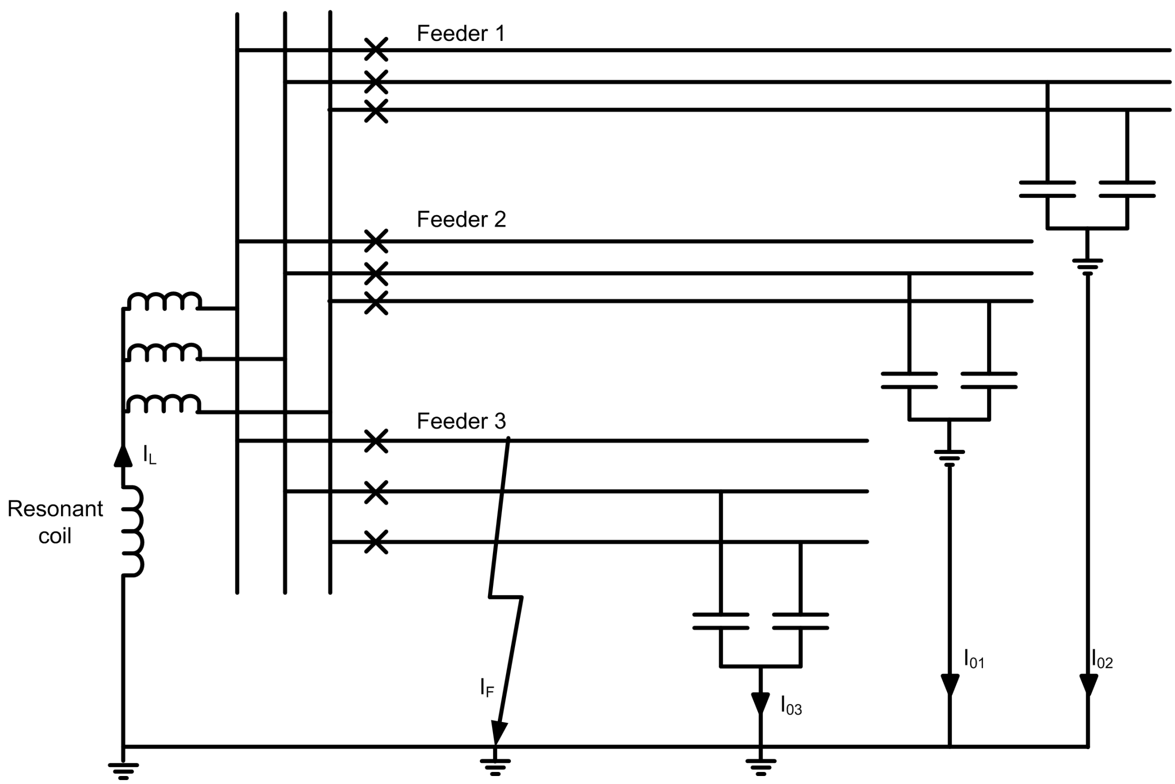
[dw_7SR5_function67SettingExample4, 1, en_US]

Figure 5-50 Earth Fault Angles

Compensated Coil Earthing Netorks

In compensated networks the resonant coil (Petersen coil) is tuned to match the capacitive charging currents such that when an earth fault occurs, negligible fault current will flow. However, resistive losses in the primary conductors and the earthing coil will lead to resistive (wattmetric) components which can be measured by the 50/51GS elements and used to indicate fault position.

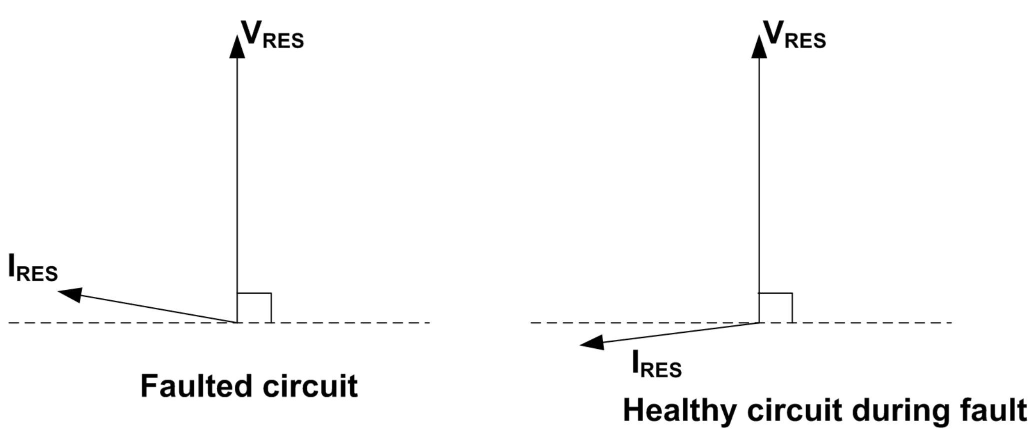
Core balance CTs are recommended for this application to achieve the necessary accuracy of residual current measurement.



[dw_7SR5_function67SettingExample5, 1, en_US]

Figure 5-51 Earth Fault Current Distribution In Compensated Network

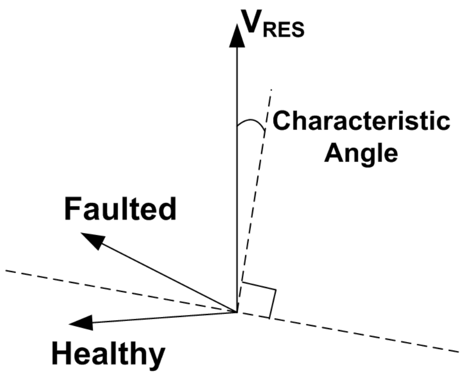
3 methods are commonly employed to detect the wattmetric current – 7SR5 devices can be configured to provide each of these methods.



[dw_7SR5_function67SettingExample6, 1, en_US]

Figure 5-52 Earth Fault Current Direction In Compensated Netowrk

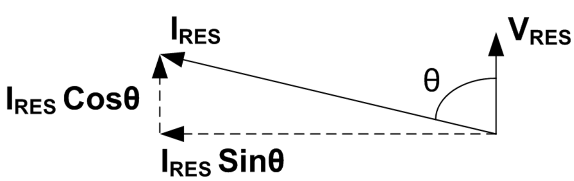
The directional boundary can be used to discriminate between healthy and faulted feeders. The characteristic angle is set to approximately 0° and the boundary at +90° used to detect the direction of the resistive component within the residual current. Setting of the boundary is critical to discriminate between faulted and unfaulted circuits. Setting **67GS Compensated Network** to **Enabled** will set the directional boundaries to ± 87° around the characteristic angle, fine adjustment of the boundary may be necessary using the **Characteristic Angle** setting.



[dw_7SR5_function67SettingExample7, 1, en_US]

Figure 5-53 Adjustment Of Characteristic Angle

The element measuring circuit can be subjected to only the cosine component of residual current i.e. to directly measure the real (wattmetric) current due to losses. The current $I_{RES}Cos(\theta - \varnothing)$ is calculated where θ is the measured phase angle between residual current and voltage and ∅ is the characteristic angle. This option is selected by setting **Ires Select** to **Ires Real**. The characteristic angle should be set to 0°.



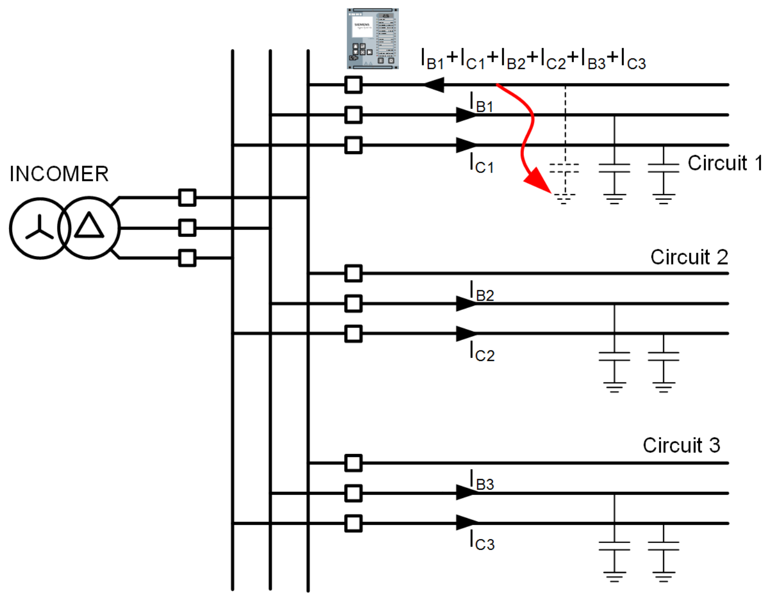
[dw_7SR5_function67SettingExample8, 1, en_US]

Figure 5-54 Cosine Component Of Current

Application of a wattmetric power characteristic. The directional 50/51GS function element operation is subject to an additional sensitive residual power element which operates only on the real (wattmetric) component of residual power.

Isolated Networks

During earth faults on isolated distribution networks there is no fault current path to the source and subsequently no fault current will flow. However, the phase-neutral capacitive charging currents on the 3 phases will become unbalanced and the healthy phase currents will create an unbalance current which flows to earth. Unbalanced charging current for the whole connected network will return to the source through the fault path. This will produce a current at the relay which can be used to detect the presence of the fault. On each healthy circuit the unbalanced capacitive currents appear as a residual current which lags the residual voltage by 90°. On the faulted circuit the charging current creates no residual but the return of the charging current on the other circuits appears as a residual current which leads the residual voltage by 90°. The characteristic angle should be set to +90°.



[dw_7SR5_function67SettingExample9, 1, en_US]

Figure 5-55 Earth Fault Current In Isolated Network

Some customers prefer to use only the sine (reactive) component of the residual current ($I_{Sin\theta)}$ which can be easily achieved by setting **Ires Select** to **Ires Real** to select the operating current to $I_{RES}Cos(\theta - \varnothing)$ and setting the characteristic angle ∅ to +90°.

Minimum Polarizing Voltage

The correct residual voltage direction must be measured to allow a forward/reverse decision to be made. Minimum polarizing voltage setting can be used to prevent tripping when fault conditions are such that significant residual voltage is not generated and the directional decision would be unreliable. The setting must allow for error in voltage measurement due to VT inaccuracy and connection. It can be used to improve stability under non-fault conditions during unbalanced load, when earth fault elements with very sensitive current settings are applied. This is ensured by selecting a setting which is near to the minimum expected residual voltage during fault conditions.

High impedance earthing methods, including compensated and isolated systems, will result in high levels of residual voltage, up to 3 times normal phase to neutral voltage, during earth faults. The minimum polarizing voltage can therefore be increased to allow very low residual current settings to be applied without risk of operation during unbalanced load conditions.

5.28.5 Settings Menu

Functions > Protection > 67 > Gn 67						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Char Angle	-95° to +95°, Δ 1°	45°				
Minimum Voltage	1 V to 20 V, Δ 0.5 V	1 V				
2-out-of-3 Logic	Enabled Disabled	Disabled				

Functions > Protection > 67 > Gn 67G						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Char Angle	-95° to +95°, Δ 1°	-15°				
Minimum Voltage	0.33 V to 67 V, Δ 0.5 V	0.33 V				

Functions > Protection > 67 > Gn 67GI						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Char Angle	-95° to +95°, Δ 1°	-15°				
Minimum Voltage	0.33 V to 67 V, Δ 0.5 V	0.33 V				

Functions > Protection > 67 > Gn 67GS						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Char Angle	-95° to +95°, Δ 1°	-15°				
Minimum Voltage	0.33 V to 67 V, Δ 0.5 V	0.33 V				
Compensated Network	Enabled Disabled	Disabled				
Wattmetric	Enabled Disabled	Disabled				
Wattmetric Power	0.05 to 20 · I_{rated} · W, Δ 0.05 · I_{rated} · W	0.1 · I_{rated} · W				
Ires Select	Ires Ires Real	Ires				

Functions > Protection > 67 > Gn 67N						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Polarizing Quantity	NPS ZPS	ZPS				
Char Angle	-95° to +95°, Δ 1°	-15°				
Minimum Voltage	0.33 V to 3 V, Δ 0.5 V	0.33 V				

5.28.6 Information List

Input/Output Matrix	General Pickup	User Logic	Type
		67 FWD PhA	Output
		67 REV PhA	Output
		67 FWD PhB	Output
		67 REV PhB	Output
		67 FWD PhC	Output
		67 REV PhC	Output
		67G FWD	Output
		67G REV	Output
		Inhibit Wattmetric	Input
		67GI FWD	Output
		67GI REV	Output
		67GS FWD	Output

Input/Output Matrix	General Pickup	User Logic	Type
		67GS REV	Output
		Wattmetric Po> Operated	Output
		67N FWD	Output
		67N REV	Output

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.29 78VS Voltage Vector Shift

5.29.1 Overview of Functions

The function **Voltage Vector Shift** is used to detect “islanding” or loss of connection between a generator and the main utility supply. If the detected vector shift is greater than setting on all 3 measured voltages an output is issued. Operation of the element is instantaneous. The vector shift occurs once and then the voltage stabilizes so a delayed operation is not applicable. Phase detection by means of zero-crossing measurement is used to maximize speed of operation.

5.29.2 Structure of the Function

The **Voltage Vector Shift** function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

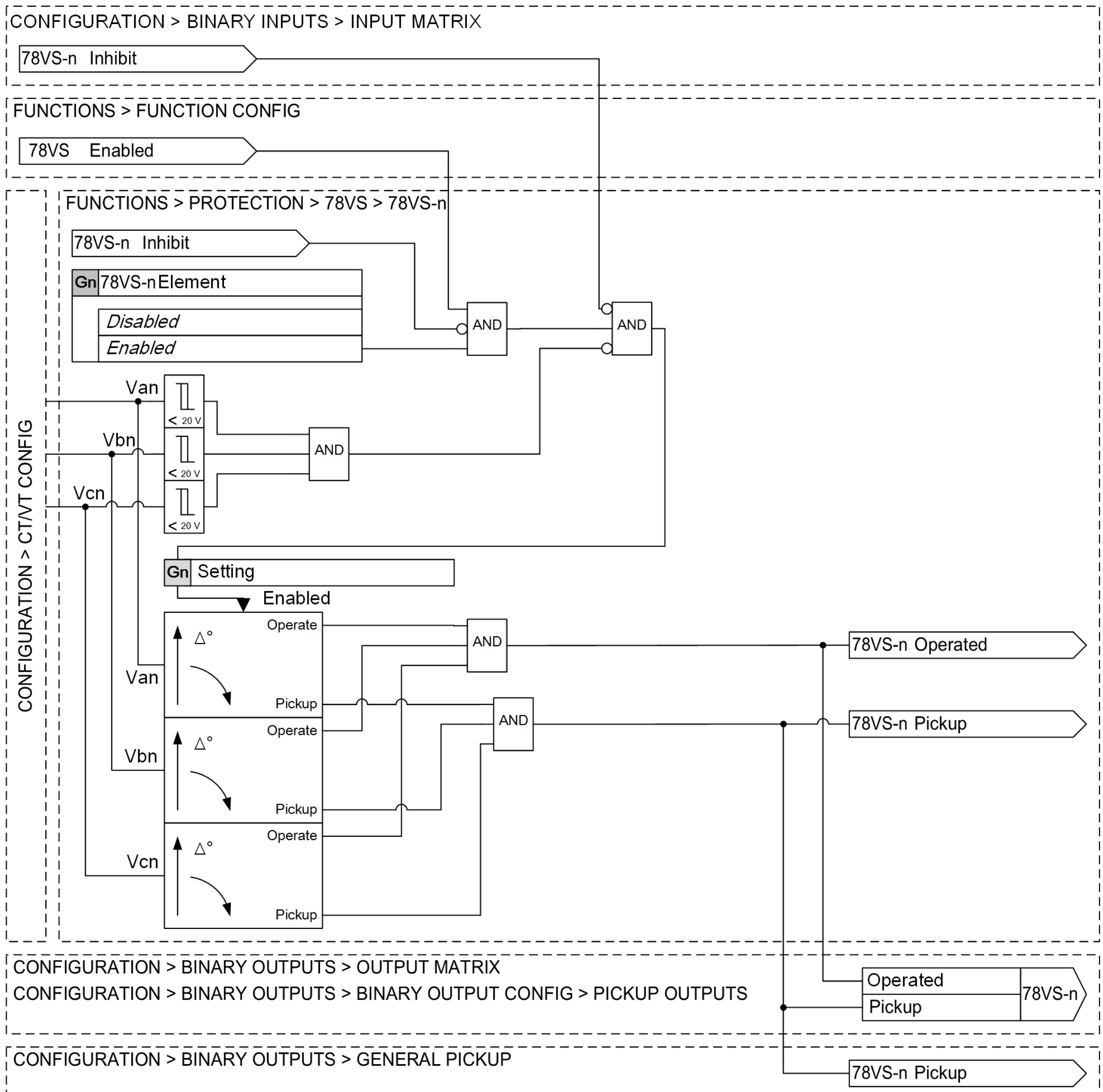
This function corresponds to the logical node **A78VSPPAM*** in IEC 61850.

The function requires VT inputs, it monitors the primary system using the 3 phase voltage inputs e.g. VT1/2/3.

NOTE

Each element measures the voltage vector position of Van, Vbn and Vcn. As the phase-neutral voltage is monitored. This feature can only be used when the **CT/VT Config > Phase Voltage Config** setting is selected to **Van,Vbn,Vcn** or **Vab,Vbc,3V0**.

5.29.3 Logic of the Function



[lo_7SR5_78VSlogicdiagram, 2, en_US]

Figure 5-56 Logic Diagram: 78VS Voltage Vector Shift

5.29.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**
  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter: **Setting**

- Default setting: **10°**

  This is the operating threshold of the element. The measured voltage vector phase shift in all 3 phases must be above setting for operation. This should be set to suit the individual application. There is an absolute cut-off of vector shift measurement at 30°.

Element Inhibits

In the event of an inhibit being applied by a binary input or logic signal, an element that is picked up will be reset. Reset of the inhibit will allow restart of the operating delay.

Voltage vector measurement is blocked when all phase-neutral voltages fall below 20 V. To allow the voltage to stabilize this under voltage inhibit will reset 300 ms after all phase voltages recover to levels above 20 V.

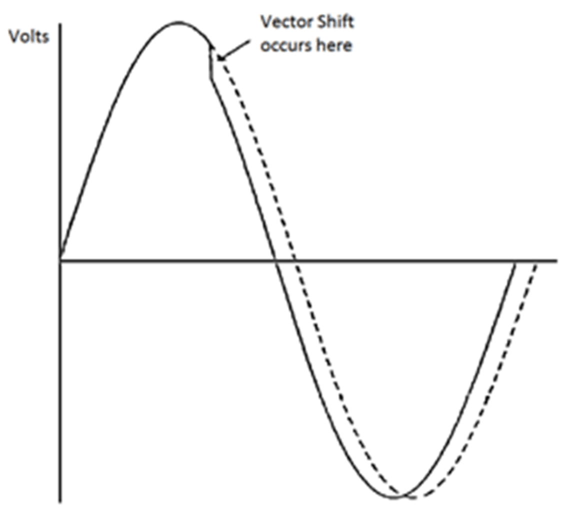
Tripping Function

These elements can be used to trip the circuit-breaker and isolate the local network from the grid.

Triggering of waveform storage must be configured if required. If the element is a tripping function it must be configured to a designated trip contact to trigger a fault record.

Settings Example

When a generator is connected to an electricity supply system, the generator will respond to any transitory changes in load to keep both voltage and frequency levels as close to constant as possible. When a LoM event occurs, however, the generator is unable to respond instantaneously to the sudden, large-scale change in load and an instantaneous shift in the phase of the generator voltage can result (Voltage Vector Shift). The sudden change in load causes a sudden change in cycle length. The cycle length becomes shorter or longer depending on whether the newly formed island has a surplus or shortage of generation.



[dw_7SR5_function78SettingsExample, 1, en_US]

Figure 5-57 Vector Shift

This vector shift can be in either direction depending on whether load increases or decreases. Where the DG capacity is insufficient to supply the local load and power is supplemented from the mains then a LoM event will cause the DG load to increase.

With an increase in load, the voltage would tend to “jump back” as shown in *Figure 5-57*. This would occur when a trip on the mains network has left the distributed generation to try and supply the whole of the down-stream load. This would be the usual condition leading to a LOM tripping.

Alternatively, if the local generation is supplying both a local load and the mains network, as happens with some industrial systems, disconnection from the mains network would create an islanding condition in which there may be an excess of electrical supply and the voltage would tend to “jump forward”.

There is an obvious link between the 78 element and the 81R (Rate-of-Change-of-Frequency) element. However the equivalent vector shift seen for expected ROCOF levels should not result in operation of the 78 element.

The highest 81R pickup setting is 10 Hz/s.

This equates to a ROCOF of 0.1 Hz over the 10 ms measuring interval.

Giving an equivalent vector shift of (360°/50 Hz) · 0.1 Hz = 0.72°.

At 60 Hz system frequency, the equivalent is 0.5° vector shift at maximum ROCOF setting.

Attempting to differentiate between the 2 elements at inordinately high levels of ROCOF would impose a delay on the operation of the 78 element and so this is considered acceptable. Momentary changes in phase can occur due to load switching operations. These can be as great as 5° and must be allowed for in the setting of the 78 pickup setting. A setting of 6° is recommended by the G.59 standard for connection of distributed generation to an electricity supply system, and settings of 8° to 12° are typical.

When the exported power to the mains network is very low, there is a risk that the drop in load will be insufficient to cause a vector shift, or will cause a vector shift of limited extent. Generally it is required that exported power will be of the order of 10 % to 20 % of total power generated before a LOM will always be detected.

5.29.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
78VS Vector Shift	Enabled Disabled	Disabled				

Functions > Protection > 78VS > Gn 78VS-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	2° to 30°, Δ 0.5°	10°				

5.29.6 IEC 61850 Functional Information Mapping

A78VSPPAM*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A78VSPPAM*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	OK: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A78VSPPAM*.Mod

Information				
78VS Vector Shift Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A7VS8PPAM*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A78VSPPAM *.Health

Information		
Device Healthy	0	1
A78VSPPAM*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A78VSPPAM *.Op

Information		
Element Operated	0	1
A78VSPPAM*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.29.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 78VS-n		Inhibit 78VS-n	Input			
78VS-n		78VS-n Operated	Output	Y	Y	Y
	78VS-n Pickup	78VS-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.30 81 Frequency Protection – "f>" or "f<"

5.30.1 Overview of Functions

Frequency protection is used to:

- Initiate load shedding – selective disconnection of load to match system capacity due to loss of generation or under/overvoltage (for example, wind power supply, system faults or plant failure)
- Monitor the permissible frequency range and provide alarms for values outside of normal limits
- Protect equipment (for example, plant components, machines, etc.) against damages caused by overload due to underfrequency or overfrequency

Abnormally low frequency in power systems are typically caused by mismatch between generating capacity or transmission capacity and connected load due to disconnection of generation or transmission circuits due to faults or error. The balance can be restored by automated disconnection of less critical loads to allow the system to stabilize with critical load connection maintained.

Abnormally high frequency can be caused by problems with generation regulation control systems in combination with tripping of load or due to islanding of a local generation system which is disconnected from the main grid and its normal load due to system faults.

5.30.2 Structure of the Function

The **Frequency Protection** function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A81PTUF*** and **A81PTOF*** in IEC 61850.

Each element can be individually selected to measure frequency from the 3 phase voltage inputs e.g. VT1/2/3.or the 4th voltage input e.g. VT4.

Each threshold frequency protection element can be set to operate as either an underfrequency or an overfrequency element.

Each element has a settable hysteresis band to avoid intermittent operation for frequency near to setting.

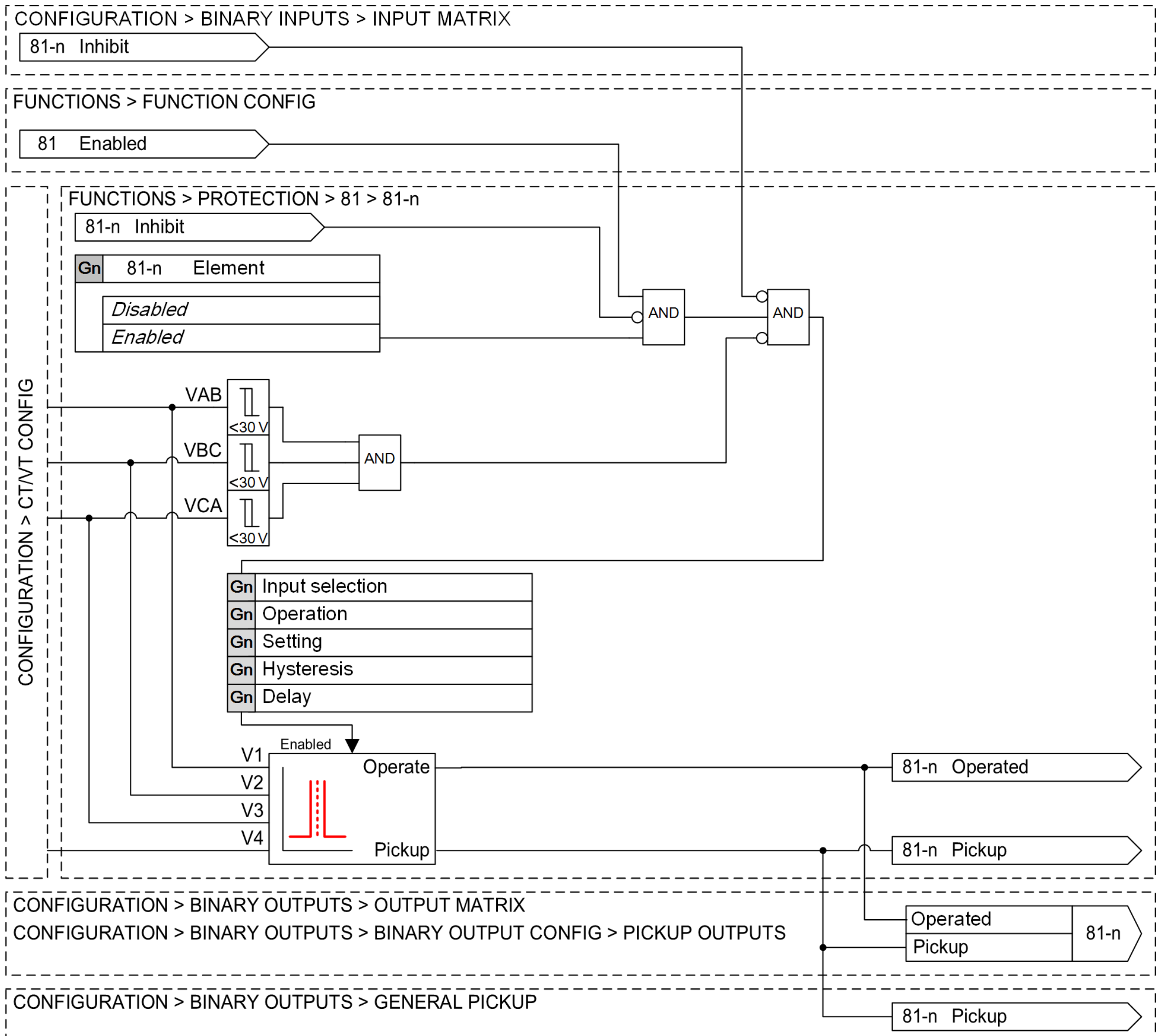
If 3 phase voltage is selected the phase to neutral voltage is used to measure frequency.

The voltage selection algorithm uses VT1 input when it is within voltage limits. When VT1 input falls out of limits the device checks VT2 and VT3 inputs and uses one of them if it is within limits. The frequency measurement is blocked if the applied fundamental frequency voltage at the relay terminals is less than the minimum voltage threshold.

Voltage Selection

When the **81 Input Selection** is set to VT1/2/3 the largest magnitude phase to neutral voltage is selected as the source for frequency measurement based on fundamental frequency DFT measurement. When a phase is selected it will continue to be used unless the voltage falls below the minimum threshold of 30 Vrms using fundamental frequency DFT. If the selected voltage falls below the minimum threshold, the source will change to the highest phase to neutral voltage from the other 2 phase to neutral values. The frequency measurement will be continuous and any element that is picked up will be unaffected.

5.30.3 Logic of the Function



[lo_7SR5_81logicdiagram, 2, en_US]

Figure 5-58 Logic Diagram: 81 Frequency Protection – "f>" or "f<"

5.30.4 Application and Setting Notes

Parameter: **`Element`**

- Default setting: **`Disabled`**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter: **`Input Selection`**

- Default setting: **`VT1/2/3`**

  Each 81 element can be individually set to measure frequency from the 3 phase VT inputs or single phase VT input.

Parameter: **Operation**

- Default setting: **Under**
  Each 81 element can be individually set to be either an underfrequency or overfrequency element.

Parameter: **Setting**

- Default setting: **49.5 Hz**
  This is the operating frequency threshold of the element. If the element is underfrequency, the element will pickup if the frequency falls below this value. If the element is overfrequency, the element will pickup if the frequency rises above this value. This should be set to suit the individual application.

Parameter: **Hysteresis**

- Default setting: **0.1 %**
  This is used to set the drop-off threshold for an 81 element. If the element is underfrequency, the element will pickup if the frequency falls below the 81-n setting and will reset when the frequency recovers to the 81-n setting plus the 81-n hysteresis frequency. If the element is overfrequency, the element will pickup if the frequency rises above the 81-n setting and will reset when the frequency recovers to the 81-n setting minus the 81-n hysteresis frequency. This setting is set as a percentage of the 81-n setting. The default setting of 0.1 % (approximately 0.05 Hz for setting around 50 Hz) is generally enough to avoid chatter of the element but consideration may be required for settings which are close to the nominal value otherwise the element may not reset when the frequency recovers to nominal value as the frequency is still in the hysteresis window.

Parameter: **Delay**

- Default setting: **1 s**
  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Element Inhibits

In the event of an inhibit being applied by a binary input or logic signal, an element that is picked up will be reset. Reset of the inhibit will allow restart of the operating delay.

Frequency measurement is blocked when all phase-phase (line) voltages fall below 30 V. To allow the voltage to stabilize this under voltage inhibit will reset 300 ms after all line voltages recover to levels above 30 V.

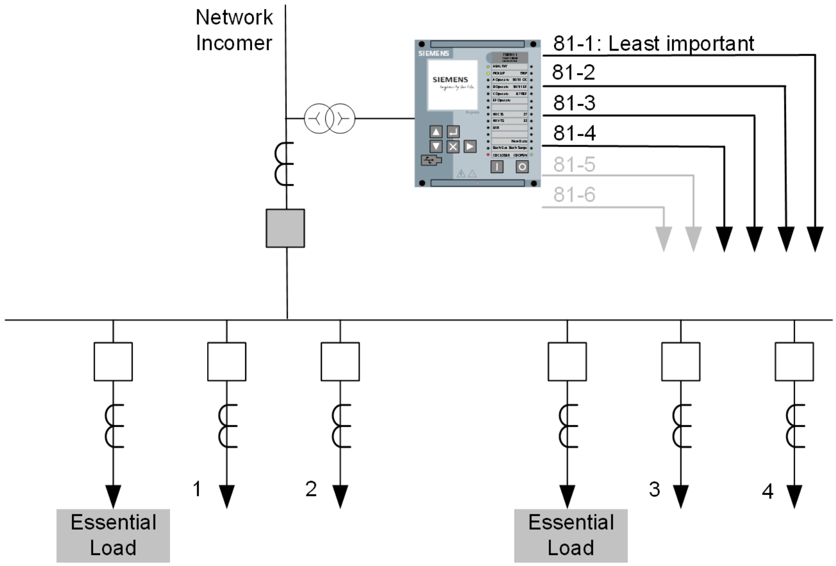
Frequency measurement is blocked for changes in frequency above 15 Hz/s. Very high rates of frequency change may be indicative of a system short circuit fault that causes a sudden in the voltage vector positions.

Tripping Function

These elements can be used an alarm or monitoring function. Triggering of waveform storage must be configured if required. If the element is a tripping function it must be configured to a designated trip contact to trigger a fault record.

Settings Example

This example shows setting that could be applied for a 4-stage underfrequency application. This example applies settings to provide automatic disconnection of load in stages depending on measurement of underfrequency. This could occur due to a loss of generating capacity in a network which results in an overload condition which can be managed by disconnection of the least critical loads in stages to maintain the supply of the most critical loads whenever possible. The elements would be configured to operate 4 independent output contacts or IEC 61850 goose which would be connected to separate circuit-breaker tripping circuits. This example considers device settings for the 81 elements but does not cover I/O mappings and tripping logic.



[dw_7SR5_function81SettingExample, 1, en_US]

- First stage
  Least important load such as domestic customers.
- Second stage
  Separate stage load such as further domestic load and infrastructure supply.
- Third stage
  Light industrial customer load.
- Fourth stage
  Higher importance light industrial load.
- Unaffected loads
  Critical load which should be maintained whenever possible.

Settings for timings should be assessed depending on network requirements and customer practices.

Frequency setting should avoid expected network variations. Timing should allow for system fault detection and clearance. Timing between stages should allow for CB operation and system recovery following shedding of previous stage.

Element	Setting Values	
81-1	81-1 Element	Enabled
81-1	81-1 Operation	Under
81-1	81-1 Setting	49.5 Hz
81-1	81-1 Hysteresis	0.1 %
81-1	81-1 Delay	3 s
81-1	81-1 Input Selection	VT1/2/3
81-2	81-2 Element	Enabled
81-2	81-2 Operation	Under
81-2	81-2 Setting	49.5 Hz
81-2	81-2 Hysteresis	0.1 %
81-2	81-2 Delay	5 s
81-2	81-2 Input Selection	VT1/2/3
81-3	81-3 Element	Enabled
81-3	81-3 Operation	Under
81-3	81-3 Setting	49.2 Hz

Element	Setting Values	
81-3	81-3 Hysteresis	0.1 %
81-3	81-3 Delay	5 s
81-3	81-3 Input Selection	VT1/2/3
81-4	81-4 Element	Enabled
81-4	81-4 Operation	Under
81-4	81-4 Setting	49 Hz
81-4	81-4 Hysteresis	0.1 %
81-4	81-4 Delay	5 s
81-4	81-4 Input Selection	VT1/2/3

5.30.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
81 Frequency	Enabled Disabled	Disabled				

Functions > Protection > 81 > Gn 81-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Input Selection	VT1/2/3 VT4	VT1/2/3				
Operation	Under Over	Under				
Setting	40 to 70 Hz, Δ 0.01 Hz	49.5 Hz				
Hysteresis	0 to 2 %, Δ 0.1 %	0.1 %				
Delay (DTL)	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	1 s				

5.30.6 IEC 61850 Functional Information Mapping

A81PTUF*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x

Information												
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A81PTUF*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A81PTUF*.Mod

Information				
81 Frequency Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
Element Operation: Under	x	x	1	1
A81PTUF*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A81PTUF*.Health

Information		
Device Healthy	0	1
A81PTUF*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A81PTUF*.Op

Information		
Element Operated	0	1
A81PTUF*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A81PTUF*.Str

Information		
Element picked up	0	1
A81PTUF*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A81PTOF*.Mod

Information				
81 Frequency Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
Element Operation: Over	x	x	1	1
A81PTOF*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A81PTOF*.Health

Information		
Device Healthy	0	1
A81PTOF*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A81PTOF*.Op

Information		
Element Operated	0	1
A81PTOF*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A81PTOF*.Str

Information		
Element picked up	0	1
A81PTOF*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.30.7 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Inhibit 81-n		Inhibit 81-n	Input			
81-n		81-n Operated	Output	Y	Y	Y
	81-n Pickup	81-n Pickup	Output			

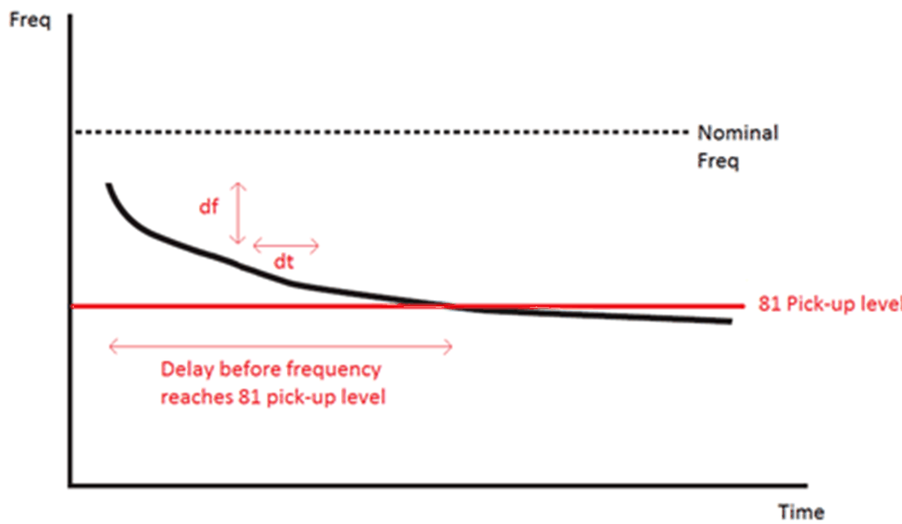
The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.31 81R Frequency Protection – "df/dt"

5.31.1 Overview of Functions

Frequency df/dt protection (also known as "rate of change of frequency protection") can be used in place of 81 (Under/Overfrequency) elements when they can take an unacceptably long time. e.g. where the frequency changes gradually and so takes time to reach the Under or Overfrequency pickup level; after which the element delay to trip will then begin. For such applications it may be more desirable to use an 81R df/dt function element.



[dw_7SR5_function81ROverview, 1, en_US]

Figure 5-59 Use of ROCOF Elements

ROCOF is applied to both load shedding and loss-of-mains (LOM) detection. In both instances, it may be necessary to have fast tripping times. For load shedding it may be necessary to restore voltage and frequency levels to regulated levels within a specific timeframe. For LOM, it may be necessary to disconnect a source of generation before the mains network is restored e.g. by auto-reclosure thereby avoiding synchronizing problems.

Where load has reduced, creating an excess of generated power, frequency will rise and a positive df/dt curve will result. This would be the case where a local load has become "islanded" and the local generation is higher than that required to supply it. Reductions in "downstream" load levels, caused by switching or tripping events, should not be sufficient to cause the 81R elements to operate since the connection to the mains supply will ensure voltage and frequency regulation and the effect on the local generation should not be great.

The 81R function is more sensitive than the vector shift (78R) function to system frequency/voltage vector movements. The minimum 81R setting = 0.05 Hz/s. This corresponds to a vector shift of 0.007°. The maximum 81R setting = 10 Hz/s corresponding to a vector shift of 1.44° at 50 Hz (minimum 78R setting = 2°).

5.31.2 Structure of the Function

The frequency df/dt protection function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A81RPFRC*** in IEC 61850.

The function requires VT inputs, it monitors the primary system using the 3 phase voltage inputs e.g. VT1/2/3.

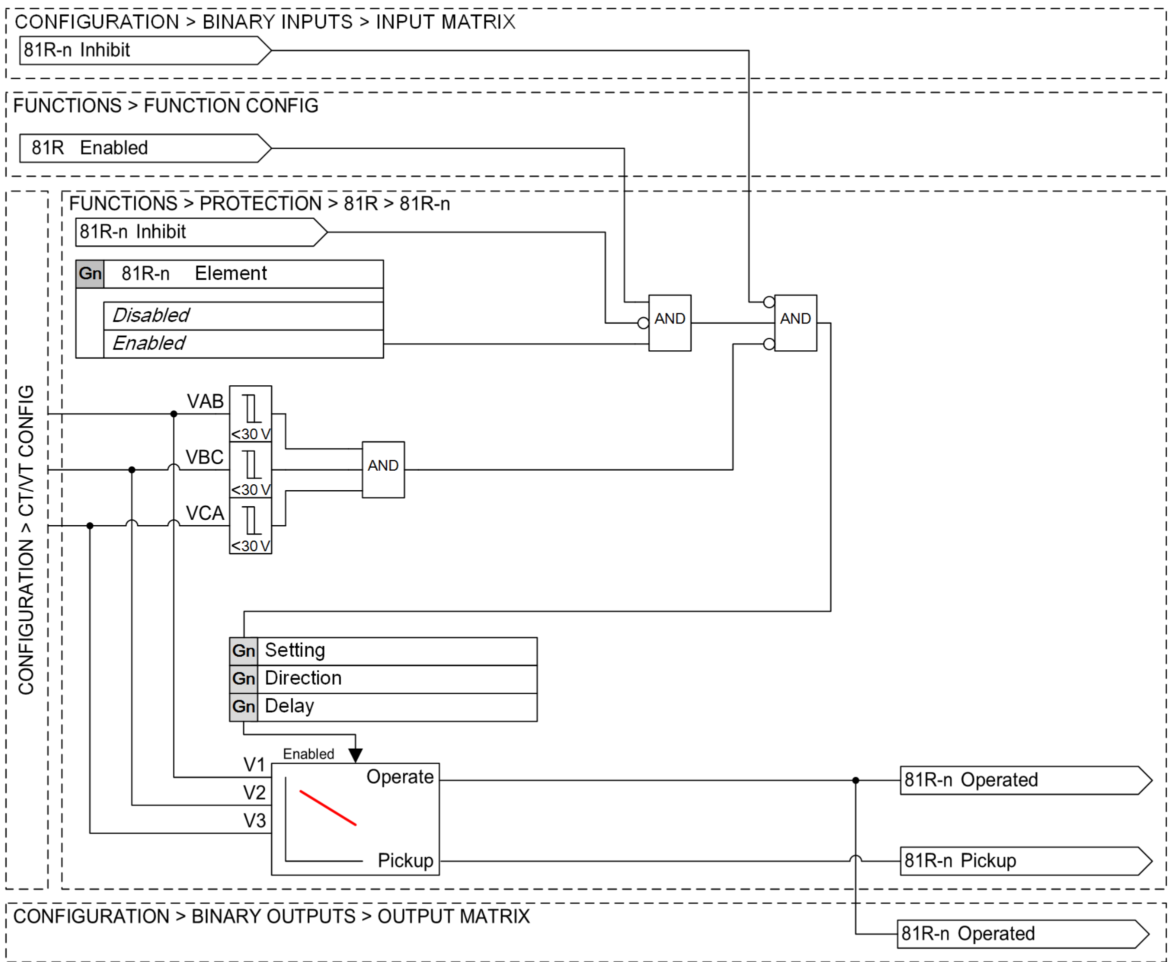
The df/dt protection can be set to operate on positive frequency change rate, negative frequency change rate or frequency change rate independent of direction.

Voltage Selection

The largest magnitude phase to neutral voltage is selected as the source for df/dt measurement based on fundamental frequency DFT measurement.

When a phase is selected it will continue to be used unless the voltage falls below the minimum threshold of 30 V rms using fundamental frequency DFT. If the selected voltage falls below the minimum threshold, the source will change to the highest phase to neutral voltage from the other 2 phase to neutral values. The frequency measurement will be continuous and any element that is picked up will be unaffected.

5.31.3 Logic of the Function



[lo_7SR5_81Rlogicdiagram, 2, en_US]

Figure 5-60 Logic Diagram: 81R Frequency Protection – "df/dt"

5.31.4 Application and Setting Notes

Parameter: **`Element`**

- Default setting: **`Disabled`**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter: **Setting**

- Default setting: **0.1 Hz/s**
  This is the operating frequency threshold of the element. If the element is underfrequency, the element will pickup if the frequency falls below this value. If the element is overfrequency, the element will pickup if the frequency rises above this value. This should be set to suit the individual application.

Parameter: **Direction**

- Default setting: **Both**
  Each 81R function element can be individually set to operate on positive frequency change rate, negative frequency change rate or frequency change rate independent of direction.

Parameter: **Delay**

- Default setting: **0 s**
  This is the time delay setting for the DTL element. This should be set to suit the individual application.

Element Inhibits

In the event of an inhibit being applied by a binary input or logic signal, an element that is picked up will be reset. Reset of the inhibit will allow restart of the operating delay.

Frequency df/dt measurement is blocked when all phase-phase voltages fall below 30 V. To allow the voltage to stabilize this under voltage inhibit will reset 300 ms after all line voltages recover to levels above 30 V.

The 81R function is blocked for voltage vector shifts > 3°. To ensure against operation at lower values of vector shift (i.e. an equivalent ROCOF of 20.8 Hz/s) a time delay of 300 ms can be applied to the 81R element (i.e. this is in excess of the 81R operate time).

Settings Example

Loss of Mains (LOM)

ROCOF's of up to 0.1 Hz/s can be expected on power networks due to normal system operations. The G.59 standard, defining the requirements for connecting significant distributed generation to a mains supply, therefore recommends an 81R pickup setting of 0.125 Hz/s. However frequency does not decay in a linear manner and for this reason it is inadvisable to set the 81R element to be too fast. A short period of rapid decay may be uncharacteristic of the system condition but sufficient to trip off the element. Not allowing for this complex decay characteristic is one of the main reasons that 81R protection has gained a reputation for being unstable. At such a low level of 81R pickup as 0.125 Hz/s, a delay in the order of 300 ms is recommended.

The second 81R element can be set to a higher pickup level, but with a corresponding reduction in operate time.

Load Shedding

Frequency broadly decays in an exponential curve during a load shedding situation, eventually stabilizing at a reduced level. However predicting the rate of decay is a complex issue. The most significant factors being the scale of the overload and the amount of inertia (resistance to change) in the network. A number of operational conditions will have an effect and these will rarely be constant over a number of load shedding events. For this reason a detailed knowledge of the system is essential for arriving at suitable settings.

Where other protection elements are used as part of the load shedding scheme, such as 27 undervoltage or 81 underfrequency, it is advisable that the 81R elements are set so that they contribute to the overall scheme coverage. Operate times should be long enough so that any previous loading shedding event has had an opportunity to take effect. There will be a delay between a load shedding command being sent and the resulting reduction in load during which frequency may continue to fall. A delay of 300 ms to 400 ms will be sufficient to allow for all cases.

In particular it must be remembered that automatic load shedding represents a highly unusual system condition and can be viewed as an emergency, last-ditch measure. For this reason it should never be set too sensitively or too fast-acting, inadvertent loss of load having a potentially catastrophic effect on the power network.

The provision of programmable logic in the relays means that protection features can be easily configured to provide quite complex control functionality. For example, following a load shedding event, an 81 Under/Over-frequency element can be configured to provide load restoration once the frequency has recovered for a minimum duration. With the order of load restoration being defined in sequential logic.

Alternatively, to improve stability, an 81 element can be used as a starter for the 81R elements. In this case the 81R elements could be inhibited until the frequency varies by an abnormal amount; as indicated by the picking-up of the 81 element.

Where a high rate of frequency change has been detected, indicating a large generated power to load imbalance, it may be preferable to shed 2 or more load groups at the same time without waiting for the relative underfrequency levels to be reached.

5.31.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
81R Frequency RoCof	Enabled Disabled	Disabled				

Functions > Protection > 81R > Gn 81R-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.05 to 10 Hz/s, Δ 0.05 Hz	0.1 Hz/s				
Direction	Both Positive Negative	Both				
Delay (DTL)	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s	0 s				

5.31.6 IEC 61850 Functional Information Mapping

A81RPFRC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A81RPFRC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	OK: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A81RPFRC*.Mod

Information				
81R Frequency Rocof Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A81RPFRC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A81rPFRC *.Health

Information		
Device Healthy	0	1
A81RPFRC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A81RPFRC *.Str

Information		
Element picked up	0	1
A81RPFRC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A81RPFRC *.Op

Information		
Element Operated	0	1
A81RPFRC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.31.7 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Inhibit 81R-n		Inhibit 81R-n	Input			
81R-n		81R-n Operated	Output	Y	Y	Y
	81R-n Pickup	81R-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.32 87GH Restricted Earth-Fault Protection – High-Impedance

5.32.1 Overview of Functions

High impedance restricted earth fault protection:

- Detects earth faults in transformers, shunt reactors, neutral reactors or rotating machinery
- Has high sensitivity to earth faults and so can detect faults near the neutral point
- Can be part of an integrated overall differential protection
- Detects earth faults in the protected zone
- Is stable during external faults

5.32.2 Structure of the Function

The **Restricted Earth Fault Protection – High-Impedance** function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A87GHPTOC*** in IEC 61850.

The function monitors the primary system differential current using the earth fault CT input e.g. CT4.

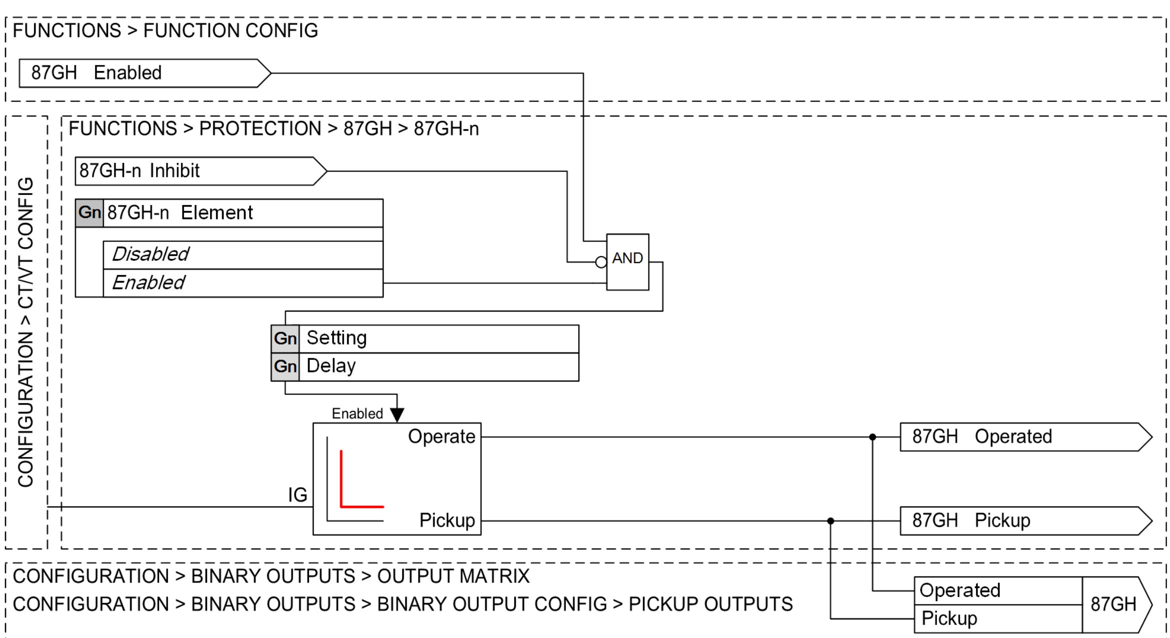
The zone of REF protection is defined by the position of the CTs and the transformer winding. REF protection provides a low operate current (fault setting) for in zone earth faults and stability during external faults.

To achieve stability of the high impedance REF elements and limit overvoltages a series stabilizing resistor and a non-linear resistor are wired into the scheme.

The operating voltage of the relay/stabilizing resistor combination is calculated taking into account the r.m.s. value of the symmetrical component of the transformer through fault current.

The relay current setting is calculated taking into account the required operate level for in-zone earth faults (fault setting).

5.32.3 Logic of the Function



[lo_7SR5_87GHlogicdiagram, 2, en_US]

Figure 5-61 Logic Diagram: 87GH Restricted Earth Fault Protection – High-Impedance

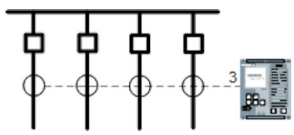
5.32.4 Application and Setting Notes

A high-impedance current differential scheme provides protection stability (does not operate) during through faults with or without coincident saturated CT conditions. The scheme allows the user to select a suitable operate current to detect all internal fault conditions.

Basic Principles of Operation

The CT locations define the limits of the protected zone. CT secondary windings are connected in parallel with the relay so that all currents are summated and only unbalance current flows through the protection relay.

Typically 1 protection relay is provided per protected zone. On important circuits relays may be duplicated i.e. 2 relays are wired in parallel.



[sc_7SR5_BalancedCirculatingCurrentProtectionSystem, 1, --_--]

Figure 5-62 Balanced Circulating Current Protection System

The relay measures the difference in current "entering" the protected zone with that "leaving" the protected zone. Where no internal fault occurs and the CTs transform perfectly the differential current is zero.

High-impedance differential protection must:

- Guarantee stability for all load and through fault conditions. Note that due to transient CT errors (e.g. CT saturation) the CTs may not transform perfectly
- Guarantee operation for all internal fault conditions

Stability Requirement

The use of class PX CTs (IEC 61869-2) ensures steady state CT errors are minimized. Transient CT errors are caused by CT saturation e.g. due to high currents flowing at times of through faults. Where CT saturation conditions are different in each CT this will cause differential current to flow in the CT secondary circuit wiring. The highest level of differential current will flow when one set of CTs is fully saturated, providing zero output and all other CTs transform normally.

When fully saturated the CT secondary provides no current and it behaves as a resistance in the secondary circuit. Differential current in the secondary circuit will flow either through this resistance or through the relay. A stabilizing resistance is added in series with the relay input to ensured that the operate voltage at the current setting is greater than the maximum voltage which can appear across the element/stabilizing resistor during the maximum assigned through fault conditions. It is assumed that any earthing resistor can become short-circuit.

This maximum voltage that can appear across the relay circuit can be determined by a simple calculation which makes the following assumptions:

- One current transformer is fully saturated making its excitation current negligible
- The remaining current transformers maintain their ratio

The resistance of the secondary winding of the saturated CT together with the leads connecting it to the relay circuit terminals constitute the only burden in parallel with the relay.

The minimum required relay operate voltage setting (V_{set}) is given by:

$$V_S \geq I_F (R_{CT} + R_L) \cdot T$$

[fo_function87GHApplication&SettingsFunction1, 1, en_US]

To ensure high speed relay operation the relay circuit operating voltage should be selected in accordance with the stability requirement above, also, the operate voltage should not exceed 0.5 · CT knee point voltage (Vk).

$$V_S \leq \frac{V_K}{2}$$

[fo_function87GHApplication&SettingsFunction2, 1, en_US]

Operation Requirement

For internal faults the relay will operate at the calculated voltage setting (V_{set}). This operating voltage will also be applied across the CT secondary windings of all the CT secondaries connected in parallel with the relay. This voltage will drive a magnetizing current in each of the CT secondary windings and this must be added to the relay operate current when calculating the operate current of the high-impedance protection scheme.

$$P.O.C. = (I_S + I_{NLR} + \sum I_{MAG})/T$$

[fo_function87GHApplication&SettingsFunction3, 1, en_US]

Consideration of Component Thermal Ratings

When the relay circuit operates for an internal fault the circuit-breakers are opened and the flow of fault current ceases.

Where a CB fails to trip then fault current will flow in the high-impedance circuit until the fault is cleared by the operation of CB failure or back-up protection. The thermal rating of the relay circuit components should then be considered.

Alternatively the high-impedance circuit can be arranged to short circuit the external components after operation.

Establishing the Required Stabilizing Resistor Value

The relay burden need not be considered as it is effectively negligible relative to the burden of the stabilizing resistor. The setting (operate) voltage (V_{set}) across the relay and stabilizing resistor at the relay operating current (I_{set}).

$$R_{STAB} = \frac{V_S}{I_S}$$

[fo_function87GHApplication&SettingsFunction4, 1, en_US]

Stabilizing resistor power rating must be sufficient for continuous operation at the circuit operate voltage (V_{set}).

$$P_{CONT} \geq (I_S)^2 \cdot R_{STAB}$$

[fo_function87GHApplication&SettingsFunction5, 1, en_US]

Short time rated to withstand I_{Fint} for the maximum fault clearance time. For a failed circuit-breaker condition the back up protection clearance time is considered, typically a 1 second rating is sufficient.

$$P_{1SEC} \geq \frac{V_{Fint}{}^{2}}{R_{STAB}}$$

[fo_function87GHApplication&SettingsFunction6, 1, en_US]

Where:

$$V_{Fint} \geq \sqrt[4]{(V_K{}^3 \cdot R_{STAB} \cdot I_{Fint})} \cdot 1.3$$

[fo_function87GHApplication&SettingsFunction7, 1, en_US]

Where I_{Fint} is not known, the breaking capacity current of the circuit-breaker can be used.

Limiting Circuit Over-Voltages (Metrosils)

Non-linear resistors are connected in parallel with the relay circuit to limit the peak voltage developed across the high-impedance components during internal faults to a safe level below 3 kV peak. Where a Metrosil is not connected in circuit the peak voltage can be calculated from:

$$V_{PK} = 2 \cdot \sqrt{2 \cdot V_K \cdot ((I_{Fint} \cdot R_{STAB}) - V_K)}$$

[fo_function87GHApplication&SettingsFunction8, 1, en_US]

Notwithstanding the above calculation SPDL recommend that a Metrosil is always fitted in the high-impedance relay circuit.

The use of non-linear resistors manufactured by Metrosil is recommended. The operate characteristic is defined by:

Voltage characteristic:

$$V = C.I^{\beta}$$

[fo_function87GHApplication&SettingsFunction9, 1, en_US]

For DC or instantaneous values.

$$Irms = 0.52 \left(\frac{Vrms \;\; \sqrt{2}}{C}\right)^{\frac{1}{\beta}}$$

[fo_function87GHApplication&SettingsFunction10, 1, en_US]

For applied sinusoidal voltages.

$$Vpeak = 1.09C\ (Irms)^{\beta}$$

[fo_function87GHApplication&SettingsFunction11, 1, en_US]

For applied sinusoidal currents.

Where: C and β are Metrosil constants.

When supplied as discrete components 7XG14 Metrosils can be specified as single or 3 phase, with a diameter of 75 mm or 150 mm and have constant C values of 450, 900 or 1000.

Metrosils of diameter 75 mm have a thermal rating of up to 8 kJ. Where a higher thermal rating is required Metrosils of 150 mm diameter should be used.

The optional component box includes both 3 phase resistors and 3 phase Metrosils. Metrosils in the component box have a C value of 1000.

The chosen Metrosil C value must:

- Ensure negligible current flows through the Metrosil at relay operate voltage (V_{set}), and,
- Limit overvoltages for operational and safety reasons i.e. 1.09C (I_{Fint}β) < 3 kV

A C value of 450 is generally acceptable where the relay operate voltage is less than 100 V, a C value of 1000 is recommended for settings above 100 V.

Metrosil short time power rating must:

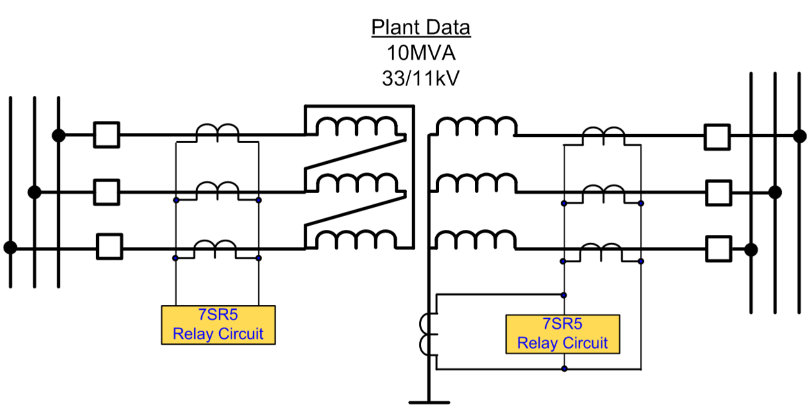
Be sufficient to dissipate the heat created by the flow of maximum secondary internal fault current. The Metrosil is chosen so that it can withstand I_{Fint} for the maximum fault clearance time. For a failed circuit-breaker condition the back up protection clearance time must be considered, typically a 1 second rating is sufficient.

$$P_{1SEC} \geq \frac{4}{\pi} \cdot I_F \cdot T \cdot V_K$$

[fo_function87GHApplication&SettingsFunction12, 1, en_US]

- Parameter: **`87GH-n Setting`**
  Default setting: **0.02 x I_n** ($0.02 \cdot I_{rated}$)
  The current setting is dependent on a number of factors including the external component values relay settings and values of circuit components can be calculated in the following order:
  - Establish System Parameters
    Circuit connections
    Switchgear rating
    System fault level (I_F)
    Required fault setting/Primary operate current (P.O.C)
  - CT and Connection Details
    CT turns ratio (T)
    CT knee point voltage (Vk)
    CT magnetizing current (Imag)
    CT secondary resistance (R_{CT})
    CT lead resistance (R_L)
  - Calculate required Stability Voltage Setting limits
    Establish provisional minimum and maximum operate voltages
  - Calculate Primary Operate Current (P.O.C) limits
    Establish required fault setting current
  - Establish Series Stabilizing Resistor Value
    Finalize relay setting current, operate voltage, and fault setting
  - Calculate required thermal rating of Stabilizing Resistor
  - Metrosil: Establish constants and required thermal rating

Settings Example



[dw_7SR5_function87GHApplicationAndSettingNotes3, 1, en_US]

Figure 5-63 Example System – Restricted Earth Fault

Plant Data

See *Figure 5-63*

Settings Requirements

$$\text{Rated Current} = \frac{10 \cdot 106}{\sqrt{3} \cdot 11000} = 525 \text{ A}$$

[fo_function87TExample7, 1, en_US]

Assigned through fault current (rated stability limit) = 16 · load current = 8.4 kA, or, as specified by the user
Required Fault Setting (Primary Operate Current)
10 to 25 % of protected winding rated current, or as specified by the user
Required P.O.C. = 53 - 131 A. Say 60 A.

Line CT (LCT) and Connection Details

Turns ratio (T)	1 to 600
Voltage knee point (V_K)	350 V
Magnetising current (Imag) @ V_K	40 mA
CT secondary resistance (R_{CT})	7.5 Ω
CT lead loop resistance (R_L)	0.15 Ω max.

Neutral CT (NCT) and Connection Details

Turns ratio (T)	1 to 600
Voltage knee point (V_K)	350 V
Magnetising current (Imag) @ V_K	50 mA
CT secondary resistance (R_{CT})	6 Ω
CT lead loop resistance (R_L)	0.15 Ω max.

Calculation of Required Stability Voltage Limits

The assigned through fault current is 31.5 kA.

$$V_S \geq \frac{8400}{600} \cdot (7.5 + 0.15) = 107.1 \text{ V}$$

[fo_function87GHApplication&SettingsFunction13, 1, en_US]

$$V_S \geq \frac{8400}{600} \cdot (6 + 0.15) = 86.1 \text{ V}$$

[fo_function87GHApplication&SettingsFunction14, 1, en_US]

$$V_S \leq \frac{V_K}{2} = \frac{300}{2} = 150 \text{ V}$$

[fo_function87GHApplication&SettingsFunction15, 1, en_US]

Calculation of Stabilizing Resistor Value

The required relay setting I_{set} can be calculated from:

$$\text{POC} = \frac{(3(I_{MAGLCT}) + I_{MAGNCT} + \text{Irelay})}{T}$$

[fo_function87GHApplication&SettingsFunction21, 1, en_US]

$$\text{Irelay} = \text{POC} \cdot T - (3(I_{MAGLCT}) + I_{MAGNCT}) = \frac{60}{600} - \text{Imag total}$$

[fo_function87GHApplication&SettingsFunction22, 1, en_US]

$$= 0.1 - (3(I_{MAGLCT}) + I_{MAGNCT})$$

[fo_function87GHApplication&SettingsFunction23, 1, en_US]

The magnetizing current is dependent on the relay operate voltage (V_{set}). This is not finalized yet so a provisional value is chosen from the above i.e. 107.1 < V_{set} < 150

Say $V_{setprov}$ = 120 V. From CT magnetizing curve: At 120 V I_{MAGLCT} = 9 mA and I_{MAGNCT} = 12 mA

$$\text{Irelay} = 0.1 - (3(0.009) + 0.012) = 0.06\ \text{A}$$

[fo_function87GHApplication&SettingsFunction24, 1, en_US]

$$\text{Rstab} = \frac{120}{0.061} = 1967\ \Omega\ (\text{Say } 2000\ \Omega \text{ giving } V_{set} = 2000 \cdot 0.06 = 120\ \text{V})$$

[fo_function87GHApplication&SettingsFunction25, 1, en_US]

Metrosil Specification

C Value

V_{set} = 120 V (i.e. > 100 V) so a C value of 1000 is chosen

Short Time Power Rating

Using the empirical formula

$$P_{1SEC} \geq \frac{4}{\pi} \cdot I_F \cdot T \cdot V_K$$

[fo_function87GHApplication&SettingsFunction12, 1, en_US]

$$P_{1SEC} \geq \frac{4}{\pi} \cdot 8400 \cdot \frac{1}{600} \cdot 350 = 6.24\ \text{kW}$$

[fo_function87GHApplication&SettingsFunction16, 1, en_US]

For values < 8 kW/s a 75 mm Metrosil is used.

Stabilizing Resistor Specification

Continuous Power Rating

$$P_{CONT} \geq I_S^2 \cdot R_{STAB}$$

[fo_function87GHApplication&SettingsFunction17, 1, en_US]

$$I_{Fint} = \frac{8400}{600} = 14\ \text{A}$$

[fo_function87GHApplication&SettingsFunction18, 1, en_US]

$$V_{FINT} \geq \sqrt[4]{350^3 \cdot 2000 \cdot 14} \cdot 1.3 = 1361\ \text{V}$$

[fo_function87GHApplication&SettingsFunction19, 1, en_US]

Short Time Power Rating

$$P_{1SEC} \geq \frac{V_{Fint}\ 2}{R_{STAB}}$$

[fo_function87GHApplication&SettingsFunction6, 1, en_US]

Where:

$$I_{Fint} = \frac{8400}{600} = 14\ A$$

[fo_function87GHApplication&SettingsFunction18, 1, en_US]

$$V_{Fint} \geq \sqrt[4]{(V_{K^3} \cdot R_{STAB} \cdot I_{Fint})} \cdot 1.3$$

[fo_function87GHApplication&SettingsFunction7, 1, en_US]

$$V_{FINT} \geq \sqrt[4]{350^3 \cdot 2000 \cdot 14} \cdot 1.3 = 1361\ V$$

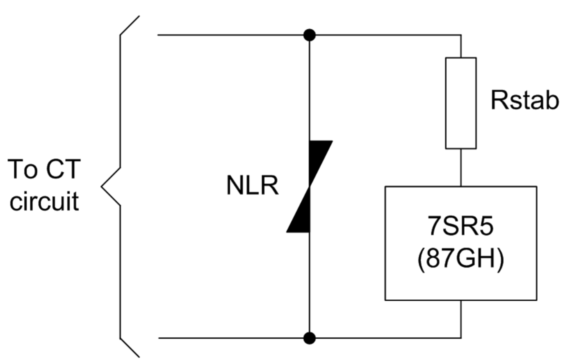
[fo_function87GHApplication&SettingsFunction19, 1, en_US]

$$P_{1SEC} \geq \frac{1361^2}{2000} = 926\ W$$

[fo_function87GHApplication&SettingsFunction20, 1, en_US]

Summary of Relay Settings and Components

87GH-1 Element = Enabled
87GH-1 Setting = 0.06 A
87GH-1 Delay = 0 s
Rstab = 2000 Ω, 40 W continuous (typical manufacturers data)
Metrosil diameter = 75 mm
Metrosil C value = 1000



[dw_7SR5_function87GHApplicationAndSettingNotes4, 1, en_US]

Figure 5-64 REF Relay Circuit

5.32.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
87GH Restricted EF	Enabled Disabled	Disabled				

Functions > Protection > 87 > Gn 87GH-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.02 to 0.95, Δ 0.005 I_{rated}	0.2 I_{rated}				
Delay (DTL)	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	0 s				

5.32.6 IEC 61850 Functional Information Mapping

A87GHPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A87GHPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A87GHPTOC*.Mod

Information				
87GH Restricted EF Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A87GHPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0 Irrelevant: x
IEC 61850 Value	ON: 1 BLOCKED: 2 TEST: 3 TEST/BLOCKED: 4 OFF: 5

A87GHPTOC*.Health

Information		
Device Healthy	0	1
A87GHPTOC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A87GHPTOC*.Str

Information		
Element picked up	0	1
A87GHPTOC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A87GHPTOC*.Op

Information		
Element Operated	0	1
A87GHPTOC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.32.7 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Inhibit 87GH-n		Inhibit 87GH-n	Input			
87GH-n		87GH-n Operated	Output	Y	Y	Y
	87GH-n Pickup	87GH-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

5.33 87NL Restricted Earth-Fault Protection – Low-Impedance

5.33.1 Overview of Functions

Low impedance restricted earth fault protection:

- Detects earth faults in the protected zone
- Has high sensitivity to earth faults and so can detect faults near the neutral point
- Can be part of an integrated overall differential protection
- Is stable during external faults

5.33.2 Structure of the Function

The **Restricted Earth Fault Protection – Low-Impedance** function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A87NLPTOC*** in IEC 61850.

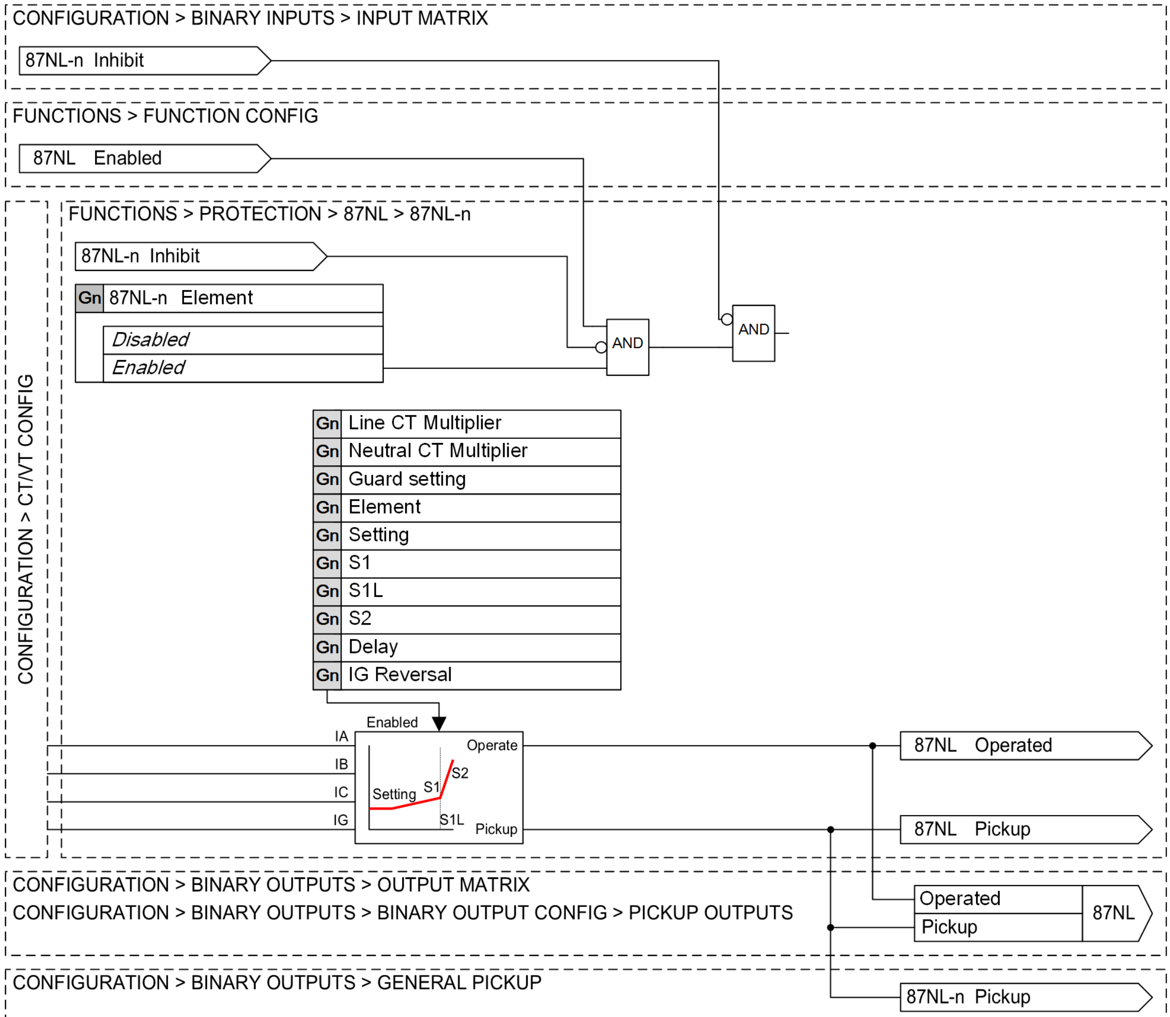
The function monitors the primary system differential current using the 3 phase current inputs e.g. CT1/2/3 and the earth fault CT input e.g. CT4.

The zone of REF protection is defined by the position of the CTs and the transformer winding. REF protection provides a low operate current (fault setting) for in zone earth faults and stability during external faults.

The 87NL function element operates when both the measured earth current (Ig) exceeds the **Guard setting** and the differential operate current exceeds the operate value.

To achieve stability, biasing is used. This measures the earth current flowing in the calculated and measured earth current inputs and varies the operate current acordingly.

5.33.3 Logic of the Function



[lo_7SR5_87NLlogicdiagram, 2, en_US]

Figure 5-65 Logic Diagram: 87NL Restricted Earth Fault Protection – Low-Impedance

5.33.4 Application and Setting Notes

- Parameter: **`Line CT Multiplier`**

  Default setting: **1x**

  The line current transformer primary ratings may not be matched exactly to the rated currents of the protected object so internal ratio correction current multiplying factors are applied to the CT secondary currents.

  For through fault conditions the outputs of the **`Line CT Multiplier`** and the **`Neutral CT Multiplier`** must be equal.

- Parameter: **`Neutral CT Multiplier`**

  Default setting: **1x**

  The neutral CT may be used with other earth fault protections and may have a lower ratio than the line CTs e.g. to provide increased protection sensitivity.

  The **`Neutral CT Multiplier`** setting is used to match the neutral CT ratio to the line CT ratio.

- Parameter: **`Guard Setting`**
  Default setting: **0.05 x In** ($0.05 \cdot I_{rated}$)
  The measured earth current, e.g. CT4 current, must be above the **`Guard Setting`** for the element to pickup. See also parameter **`Setting`**.

- Parameter: **`Element`**
  Default setting: **Disabled**

- Parameter: **`Setting`**
  Default setting: **0.3 x In** ($0.3 \cdot I_{rated}$)
  The minimum level of differential operate current must be above this setting for the element to pickup. See also parameter **`Guard Setting`**.

- Parameter: **`S1`**
  Default setting: **0.3x**
  This setting is used to compensate for any differential current present under steady state conditions due to CT mismatch.

- Parameter: **`Gn S1L`**
  Default setting: **1 x In** ($1 \cdot I_{rated}$)
  This is normally set to the rated current of the protected object e.g. transformer.

- Parameter: **`S2`**
  Default setting: **2x**
  The bias slope is applied above S1L to provide additional restraint for through faults.

- Parameter: **`Ig Reversal`**
  Default setting: **Disabled**
  The Ig current input to the 87NL function can be reversed if necessary e.g. to maintain consistency with the overall protection scheme wiring.

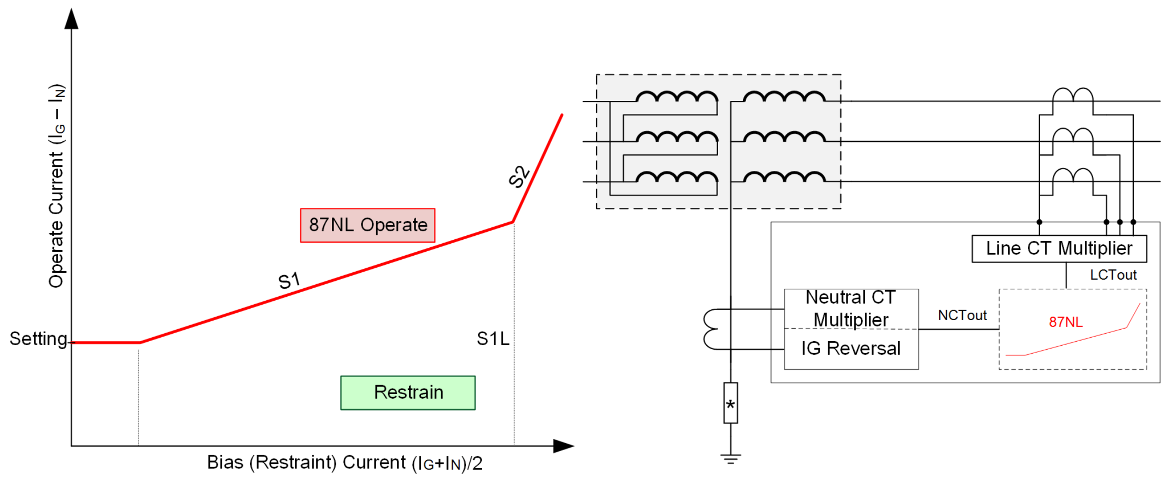
Settings Example

ICT Settings for Current Magnitude Balance

Internal current multipliers are used to equalize the outputs from the line and neutral CTs when the same current flows through both e.g. during a through earth fault.
Where possible the output of each ICT Multiplier (ICT_{OUT}) is set to 1x the CT secondary current at the rated current of the protected plant, the 87NL function then operates at the primary levels indicated by its settings with respect to the primary plant rating. Where balance at $ICT_{OUT} = 1$ is not possible the resultant primary operate currents must be considered: when $ICT_{OUT} < 1$ the function is less sensitive than its differential settings, when $ICT_{OUT} > 1$ the 87NL element is more sensitive than its setting indicates. To compensate for the resultant ICT_{OUT} value the settings must be multiplied by ICT_{OUT}.
See following examples.

87NL Settings

The 87NL element provides unit protection for earth faults. Magnitude restraint bias is used to ensure the relay is stable when load current or external (out of zone) fault current flows through the associated power transformer. As the bias current increases the differential current required for operation increases.

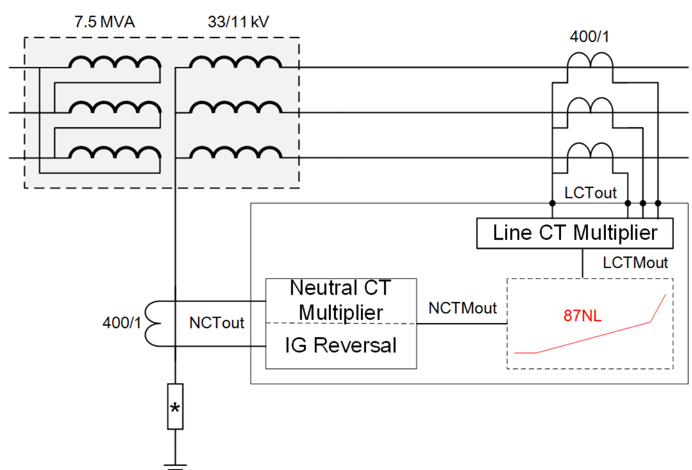


[dw_7SR5_87NLCharacteristic, 1, en_US]

Figure 5-66 87NL Characteristic

Selection of CT Multiplier Settings

The line and neutral CT Multipliers are set to provide the same outputs for system healthy conditions. Where possible the outputs will be equal to the CT 1/2/3 (line) and CT4 (neutral) nominal ratings at rated plant current.



[dw_7SR5_87NLICTSettingsExample1, 1, en_US]

Figure 5-67 ICT Settings – Example 1

The line and neutral CTs have 1 A rated secondary current (ISR = 1 A).

CONFIGURATION > CT/VT > CT1/2/3 Nominal = 1 A.

CONFIGURATION > CT/VT > CT4 Nominal = 1 A.

The rated current of the protected plant = $$\frac{\frac{7.5 \cdot 106}{\sqrt{3}}}{11000} = 394 \text{ A } (I_{rated})$$

Line CT = $$\frac{400(I_{PR})}{1(I_{SR})}$$

At plant rating Line CT output (LCTout) = $$\frac{I_{rated} \cdot I_{SR}}{I_{PR}} = \frac{394 \cdot 1}{400} = 0.985 \text{ A}$$

Select Line CT Multiplier setting (Line CT Multiplier) = $\frac{I_{SR}}{LCTout} = \frac{1}{0.985} = 1.02$ x

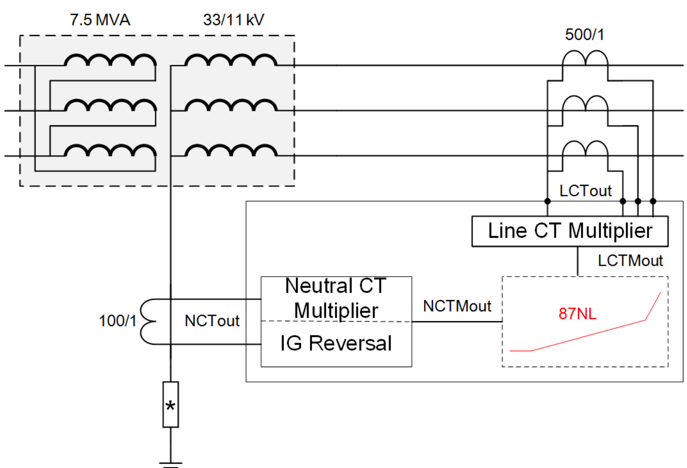
At plant rating Line CT Multiplier output (LCTMout) = $\text{LCTout} \cdot \text{Line CT Multiplier} = 0.985 \cdot 1.02 = 1$

Neutral CT = $\frac{400(I_{PR})}{1(I_{SR})}$

At plant rating Neutral CT output (NCTout) = $\frac{I_{rated} \cdot I_{SR}}{I_{PR}} = \frac{394 \cdot 1}{400} = 0.985$ A

Select Neutral CT Multiplier setting (Neutral CT Multiplier) = $\frac{I_{SR}}{NCTout} = \frac{1}{0.985} = 1.02$ x

At plant rating Neutral CT Multiplier output (NCTMout) =
$\text{NCTout} \cdot \text{Neutral CT Multiplier} = 0.985 \cdot 1.02 = 1$



[dw_7SR5_87NLICTSettingsExample2, 1, en_US]

Figure 5-68 ICT Settings – Example 2

The line and neutral CTs have 1 A rated secondary current (ISR = 1 A).

CONFIGURATION > CT/VT > CT1/2/3 Nominal = 1 A.

CONFIGURATION > CT/VT > CT4 Nominal = 1 A.

The rated current of the protected plant = $\frac{7.5 \cdot 106}{\frac{\sqrt{3}}{11000}} = 394$ A (I_{rated})

Line CT = $\frac{500(I_{PR})}{1(I_{SR})}$

At plant rating Line CT output (LCTout) = $\frac{I_{rated} \cdot I_{SR}}{I_{PR}} = \frac{394 \cdot 1}{500} = 0.788$ A

Select Line CT Multiplier setting (Line CT Multiplier) = $\frac{I_{SR}}{LCTout} = \frac{1}{0.788} = 1.27$ x

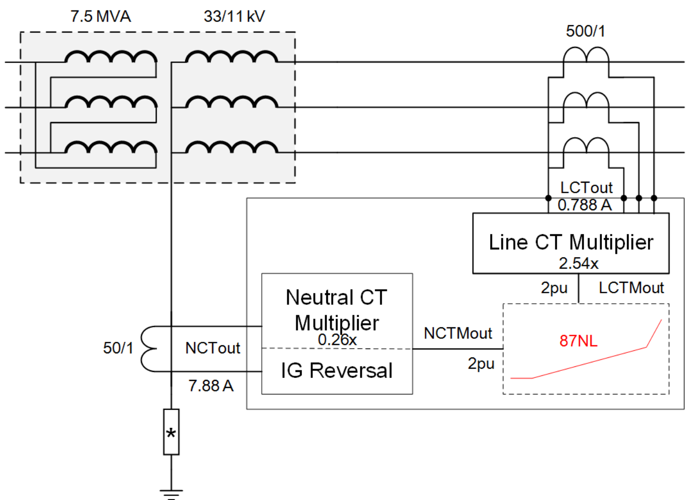
At plant rating Line CT Multiplier output (LCTMout) = $\text{LCTout} \cdot \text{Line CT Multiplier} = 0.788 \cdot 1.27 = 1$

Neutral CT = $\frac{100(I_{PR})}{1(I_{SR})}$

At plant rating Neutral CT output (NCTout) = $\frac{I_{rated} \cdot I_{SR}}{I_{PR}} = \frac{394 \cdot 1}{100} = 3.94$ A

Select Neutral CT Multiplier setting (Neutral CT Multiplier) = $\frac{I_{SR}}{NCTout} = \frac{1}{3.94} = 0.26$ x

At plant rating Neutral CT Multiplier output (NCTMout) = $\text{NCTout} \cdot \text{Neutral CT Multiplier} = 3.94 \cdot 0.26 = 1$



[dw_7SR5_87NLICTSettingsExample3, 1, en_US]

Figure 5-69 ICT Settings – Example 3

The line and neutral CTs have 1 A rated secondary current (ISR = 1 A).

CONFIGURATION > CT/VT > CT1/2/3 Nominal = 1 A.

CONFIGURATION > CT/VT > CT4 Nominal = 1 A.

The rated current of the protected plant = $\frac{\frac{7.5 \cdot 106}{\sqrt{3}}}{11000} = 394 \text{ A } (I_{rated})$

Line CT = $\frac{500\,(I_{PR})}{1\,(I_{SR})}$

At plant rating Line CT output (LCTout) = $\frac{I_{rated} \cdot I_{SR}}{I_{PR}} = \frac{394 \cdot 1}{500} = 0.788 \text{ A}$

Select Line CT Multiplier setting (Line CT Multiplier) = $\frac{I_{SR}}{LCTout} = \frac{1}{0.788} = 1.27$ x

At plant rating Line CT Multiplier output (LCTMout) = $\text{LCTout} \cdot \text{Line CT Multiplier} = 0.788 \cdot 1.27 = 1$

Neutral CT = $\frac{50\,(I_{PR})}{1\,(I_{SR})}$

At plant rating Neutral CT output (NCTout) = $\frac{I_{rated} \cdot I_{SR}}{I_{PR}} = \frac{394 \cdot 1}{50} = 7.88 \text{ A}$

Select Neutral CT Multiplier setting (Neutral CT Multiplier) = $\frac{I_{SR}}{NCTout} = \frac{1}{7.88} = 0.13$ x

At plant rating Neutral CT Multiplier output (NCTMout) = $\text{NCTout} \cdot \text{Neutral CT Multiplier} = 7.88 \cdot 0.13 = 1$

NOTE

In this example the calculated **`Neutral CT Multiplier`** setting is below the minimum available setting (0.25x). Both the **`Line CT Multiplier`** and **`Neutral CT Multiplier`** settings can be multiplied by 2 i.e. **`Line CT Multiplier`** = 2.54x and **`Neutral CT Multiplier`** = 0.26x. At plant rating **`Line CT Multiplier`** output (LCTMout) = LCTout · **`Line CT Multiplier`** = 0.788 · 2.54 = 2. At plant rating **`Neutral CT Multiplier`** output (NCTMout) = NCTout · **`Neutral CT Multiplier`** = 7.88 · 0.26 = 2.

The **`Line CT Multiplier`** and **`Neutral CT Multiplier`** settings produce outputs of 2p.u. at plant rating so the differential settings applied will be 2 x the indicated values (see following).

Summary of Required Settings

Configuration CT/VT >	
CT1/2/3 Nominal	1 A
CT1/2/3 Ratio Prim	400
CT1/2/3 Ratio Sec	1
CT4 Nominal	1 A
CT4 Ratio Prim	400
CT4 Ratio Sec	1

Functions > Function Config >	
Gn 87NL Low Impedance	Enabled

Functions > 87NL > 87NLn	
Gn Line CT Multiplier	1.02 (Settings produces LICTout = 1.00)
Gn Neutral CT Multiplier	1.06 (Settings produces NICTout = 1.00)
Gn Guard Setting	0.05 · I_{rated}
Gn Element	Enabled
Gn Setting	0.3 · I_{rated} (0.3 · ICTout)
Gn S1	0.3x
Gn S1L	1 · I_{rated} ($\frac{1}{0.14} \cdot 0.5 = 3.6 \cdot \text{ICTout}$)
Gn S2	2x (Default value)
Gn Delay	0 s
Gn Ig Reversal	Disabled

Output Config > Output Matrix	
87NL	BOn, Ln

87BD Initial Setting (0.1 to 2.0 · I_{rated})

This setting is selected to ensure stability in the presence of CT and relay errors when low levels of bias current are present i.e. low load levels.

This is the minimum level of differential current at which the relay will operate. Typically this setting is chosen to be above any steady state CT errors, where class 5P CTs are used a setting of 0.2 · I_{rated} ensures protection stability.

87NL S1 Setting (0.0 to 0.7)

Steady state unbalance current will appear in the differential (operate) circuit of the relay due to CT measurement errors and relay tolerances. The differential current will increase with increasing load or through fault current, to ensure stability, the differential current required for operation increases with increasing bias current. The bias characteristic increases the operate current as the bias (restraint) current increases.

Typically this setting is chosen to be above any steady state CT errors, where class 5P CTs are used a setting of 0.2 · I_{rated} ensures protection stability.

87BD 1st Bias Slope Limit Setting (1 to 20 · I_{rated})

Above this setting the ratio of differential current to bias current required for operation is increased.

When a through fault occurs, saturation of one or more CTs may cause a transient differential current to be detected by the relay. The bias slope limit is chosen to ensure the biased differential function is stable for high through fault currents coincident with CT saturation. This setting defines the upper limit of S1 bias slope and is expressed in multiples of nominal rated current i.e. the lower the setting the more stable the protection.

The default setting is 1.0x.

87NL S2 (1.0 to 2.0)

These settings are chosen to ensure the biased differential function is stable for high through fault currents coincident with CT saturation.

The default setting is 1.0x.

87BD Time Delay Setting

The default setting is 0 ms, a 5 ms setting can be considered where the circuit is cabled to ensure stability during resonant conditions.

5.33.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
87NL Low Impedance	Enabled Disabled	Disabled				

Functions > Protection > 87 > Gn 87NL-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Line CT Multiplier	0.25x to 3x, Δ 0.01	1x				
Neutral CT Multiplier	0.25x to 3x, Δ 0.01	1x				
Guard Setting	0.05 to 5 · I_{rated}, Δ 0.05	0.05 · I_{rated}				
Element	Enabled Disabled	Disabled				
Setting	0.05 to 2 I_{rated}, Δ 0.05 I_{rated}	0.3 I_{rated}				
S1	0.1x to 0.2x, Δ 0.05	0.3x				
S1L	1 to 2x, Δ 0.1 I_{rated}	1 · I_{rated}				
S2	1 to 2x, Δ 0.05x	2x				
Delay	0 to 1 s Δ 0.005 s	0 s				
Ig Reversal	Enabled Disabled	Disabled				

5.33.6 IEC 61850 Functional Information Mapping

A87NLPTOC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A87NLPTOC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A87NLPTOC*.Mod

Information				
87NL Restricted EF Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A87NLPTOC*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A87NLPTOC*.Health

Information		
Device Healthy	0	1
A87NLPTOC*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A87NLPTOC*.Str

Information		
Element picked up	0	1
A87NLPTOC*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A87NLPTOC*.Op

Information		
Element Operated	0	1
A87NLPTOC*.Op.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

5.33.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 87NL-n		Inhibit 87NL-n	Input			
87NL-n		87NL-n Operated	Output	Y	Y	Y
	87NL-n Pickup	87NL-n Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

6 Supervision Functions

6.1 49TS Temperature Sensor Supervision

6.1.1 Overview of Function

Temperature Monitoring Interface

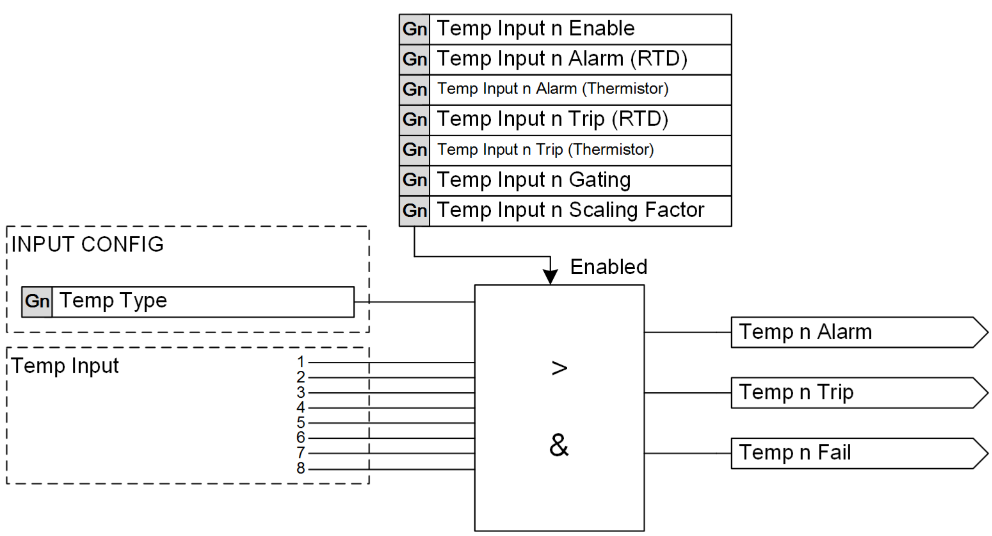
Where the optional integral temperature sensor inputs are not fitted, up to twelve Pt100 RTD temperature sensors can be monitored via the external (optional) 7XV5662-6AD10 and 7XV5662-7AD10 temperature monitoring interface (TMI). The TMI is connected to the relay COM1-RS485 comms port. The comms port is selected to **Communications > COM1-RS485 > Modbus-Client**. This prevents the use of other relay data communications on this port. The relay and TMI are selected to the same baud rate and parity.

The 7SR57 continuously polls the TMI. Each monitored input can be independently programmed to provide alarm and trip thresholds giving instantaneous outputs. Outputs can be assigned to each of the temperature inputs. The value returned by each temperature input can be displayed.

Temp Input Fail Protection setting: Each active temperature input can be monitored for short circuit and open circuit failure. A temperature input fail alarm output is generated by a failure condition and the failed input is identified in the **Instruments** menu. No trip or alarm output is given by a failed input. This feature can be disabled.

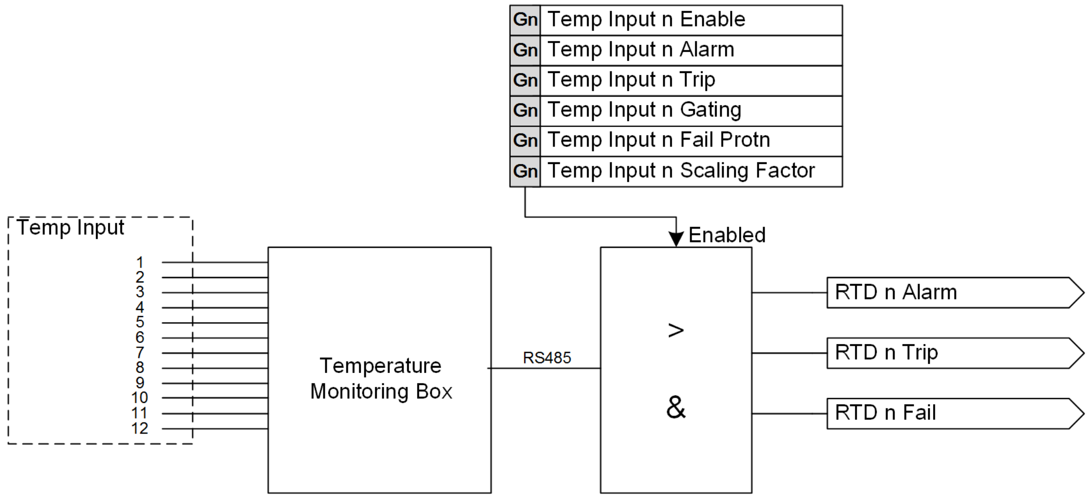
6.1.2 Structure of the Function

6.1.3 Logic of the Function



[lo_7SR5_49TSlogicdiagram1, 1, en_US]

Figure 6-1 Logic Diagram: 49TS Temperature Sensor Monitoring



[lo_7SR5_49TSlogicdiagram2, 1, en_US]

Figure 6-2 Logic Diagram: 49TS Temperature Sensor Monitoring using External Temperature Monitoring Interface

6.1.4 Application and Setting Notes

Parameter: **Temp Input n Enable**

- Default setting: **Disabled**

Parameter: **Temp Input n Alarm (RTD)**

- Default setting: **70 °C**

  Temp Input n Alarm setting: An alarm output is available where the measured temperature exceeds the alarm setting.

Parameter: **Temp Input n Alarm (Thermistor)**

- Default setting: **1000 ohms** (1000 Ω)

  Temp Input n Alarm setting: An alarm output is available where the measured resistance is above setting (PTC thermistor) or the measured resistance is below setting (NTC thermistor).

Parameter: **Temp Input n Trip (RTD)**

- Default setting: **80 °C**

  Temp Input n Trip setting: A trip output is available where the measured temperature exceeds the alarm setting.

Parameter: **Temp Input n Trip (Thermistor)**

- Default setting: **1000 ohms** (1000 Ω)

  Temp Input n Trip setting: A trip output is available where the measured resistance is above setting (PTC thermistor) or the measured resistance is below setting (NTC thermistor).

Parameter: **Temp Input n Gating**

- Default setting: **None**

  Temp Input n Gating setting: Further trip security is provided by allowing each temperature input to be AND gated with other input(s). If this feature is selected then no trip will be issued unless all gated inputs are operated simultaneously. Temperature input alarm outputs are not gated.

  Each active temperature input is monitored for short circuit and open circuit failure. A temperature input fail alarm output is generated by a failure condition and the failed input is identified in the **Instruments** menu. No trip or alarm output is given by a failed input.

  The value returned by each temperature input can be displayed in the relay instruments menu.

Parameter: **Scaling Factor**

- Default setting: **1 x** (1 ·)

  The default value for the temperature scaling factors is **1 x**.

  Where required the temperature **Scaling Factor** is applied in the temperature input values and the temperature **Trip & Alarm** functions will operate on the basis of scaled input. For scaling factors less than **1 x** the maximum trip and alarm settings will be reduced. E.g. for scaling factor 0.5x applied to 260° setting the maximum **Trip & Alarm** settings will be 0.5 · 260° = 130°.

Settings Example

6.1.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
49TS Temperature Sensor Supervision	Enabled Disabled	Disabled				

Functions > Protection > 49TS > Gn 49TS						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Enable	Enabled Disabled	Disabled				
Alarm (RTD)	0 to 250	70 °C				
Alarm (Thermistor)	100 to 30000	1000 Ω				
Trip (RTD)	0 to 250	80 °C				
Trip (Thermistor)	100 to 30000	1000 Ω				
Gating	8 Bit Binary	None				
Scaling Factor	0.5 to 1.5	1 ·				

6.1.6 IEC 61850 Functional Information Mapping

STMP*.Beh

Information						
Element Enabled (Function Config)	1	1	1	1	1	0
Element Disabled	0	0	0	0	0	x
Local or Remote mode	0	0	0	0	1	x
Local mode	0	0	0	1	0	x
Remote mode	0	0	1	0	0	x
Out of Service mode	0	1	0	0	0	x
Test Mode	1	0	0	0	0	x
STMP*.Beh.stVal	**3**	**3**	**1**	**1**	**1**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
TEST: 3
OFF: 5

STMP *.Mod

Information		
49TS Temperature Sensor Supervision Enabled (Function Config)	0	1
STMP*.Mod.stVal	**5**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

STMP*.Health

Information		
Device Healthy	0	1
STMP*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

STMP*.Alm

Information		
Element Alarm Level	0	1
STMP*.Alm.stval	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

STMP*.Trip

Information		
Element Trip	0	1
STMP*.Trip.stval	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

6.1.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 103	DNP3	MODBUS RTU
49Ts-n Trip		49Ts-n Trip	Input Output	Y	Y	Y
49TS-n Alarm		49TS-n Alarm	Input Output	Y	Y	Y
49TS-n Fail		49TS-n Fail	Input Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

6.2 50BF Circuit-Breaker Failure Protection – 3 Pole

6.2.1 Overview of Functions

Where a circuit-breaker (CB) fails to operate, the power system will remain in a hazardous state until current flow is interrupted by remote or back-up protections. To minimize any delay, CB failure protection monitors the status and tripping of the associated CB and issues a back-up trip signal if the CB fails.

6.2.2 Structure of the Function

The circuit-breaker fail function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **A50BFRBRF*** in IEC 61850.

The function monitors the primary system using the 4 current inputs e.g. CT1/2/3/4. The fundamental frequency component is measured from processing of the measured current samples.

The function is initiated by the operation of output relays assigned as trip contacts or from a binary input. Current flow is monitored after a tripping signal has been issued. If any of the 50BF current check elements have not reset before the timers have expired an output is given. For CB trips where the fault is not current related an additional input is provided, **50BF Mech Trip**, which monitors the CB closed input and provides an output if the circuit-breaker has not opened before the timers expire.

Outputs are also given to indicate the faulted phase, 50BF PhA , 50BF PhB, 50BF PhC and 50BF EF.

The circuit-breaker fail function has 2 time delayed outputs. For some systems, only the first will be used and the CB failure output will be used to back-trip the adjacent CB(s). On other systems, however, this output will be used to re-trip the local CB to minimize potential disruption to the system, if possible via a secondary trip coil and wiring. The second CB failure stage will then be used to back-trip the adjacent CB(s). The 2 time delays run concurrently.

The circuit-breaker fail protection time delays are initiated either from:

- An output trip contact of the relay (**Configuration > Binary Outputs > Trip Config > Trip Contacts**), or
- A binary or virtual input assigned to **50BF Ext Trip** (**Configuration > Binary Inputs > Input Matrix > 50BF Ext Trip**), or
- A binary or virtual input assigned to **50BF Mech Trip** (**Configuration > Binary Inputs > Input Matrix > 50BF Mech Trip**).

50BF Ext Trip

Any binary input can be mapped to this input to trigger the circuit-breaker fail function. Current must be above setting for the function to operate. This function is used with an external protection device.

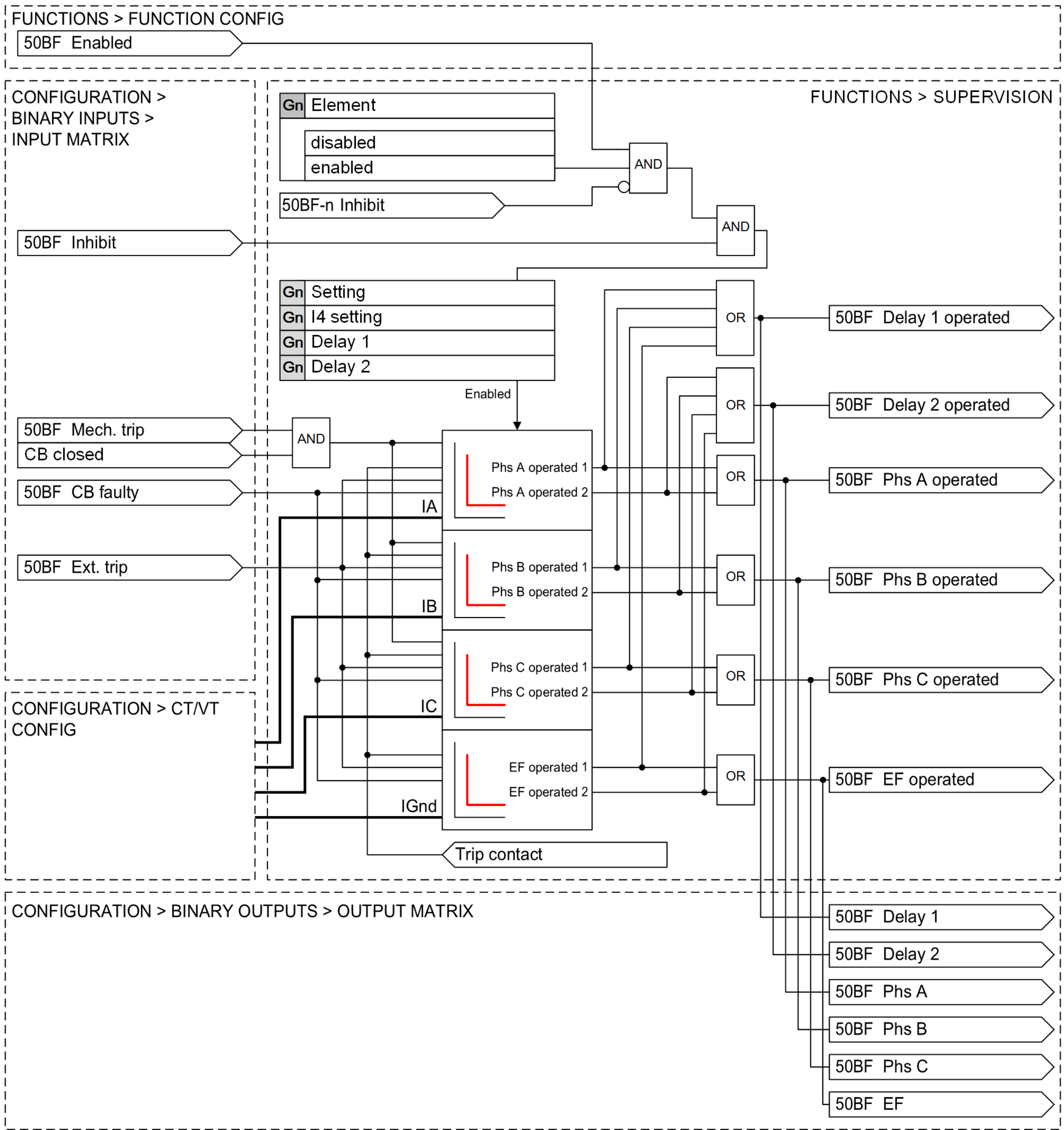
50BF Mech Trip

Any binary input can be mapped to this input to trigger the circuit-breaker fail function. For the function to operate the circuit-breaker closed input is used to detect a failure, not the current. This can be used where the current flow may be absent or too low for tripping e.g. with a transformer Buchholz protection.

50BF CB Faulty

Any binary input can be mapped to this input, if it is energized when a trip initiation is received then 50BF outputs will be given immediately (the timers are by passed).

6.2.3 Logic of the Function



[lo_7SR5_50BFlogicdiagram, 2, en_US]

Figure 6-3 Logic Diagram: 50BF Circuit-Breaker Failure Protection – 3 Pole

6.2.4 Application and Setting Notes

Parameter: **Setting**

- Default setting: **0.2 x I_n** (0.2 · I_{rated})

  When any phase current is measured above this setting the CB is determined as being in the closed position i.e. current is still flowing.

  The phase current setting must be set below the minimum phase protection setting current.

Parameter: **`Ig Setting`**

- Default setting: **0.05 x I_n** (0.05 · I_{rated})
  When earth current is measured above this setting the CB is determined as being in the closed position i.e. current is still flowing.
  The earth fault current setting must be set below the minimum earth fault protection setting current.

Parameter: **`Delay 1`**

- Default setting: **`60 ms`**
  See *Settings Example, Page 447*.

Parameter: **`Delay 2`**

- Default setting: **`120 ms`**
  See *Settings Example, Page 447*.

Settings Example

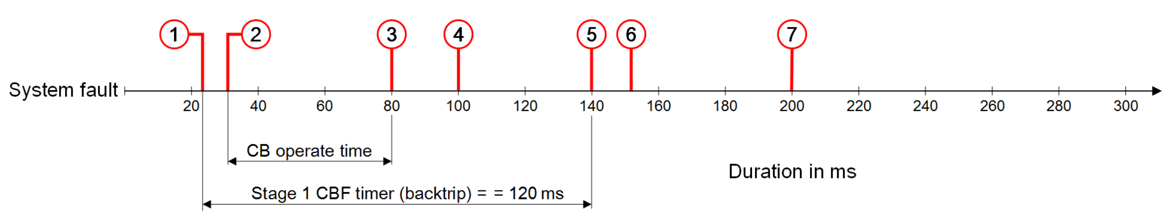
50BF DTL1/50BF DTL2

The time delays run concurrently within the relay. The time delay applied to the CB fail protection must be in excess of the longest CB operate time + relay reset time + a safety margin.

First Stage (Retrip)	
Trip relay operate time	10 ms
Reset time	20 ms
CB tripping time	50 ms
Safety margin	40 ms
Overall first stage CBF time delay	120 ms

Second Stage (Back Trip)	
First CBF time delay	120 ms
Trip relay operate time	10 ms
CB tripping time	50 ms
Reset time of measuring element	20 ms
Margin	60 ms
Overall second stage CBF time delay	260 ms

The safety margin is extended by 1 cycle for the second CBF stage as this will usually involve a back-trip of a busbar tripping scheme.

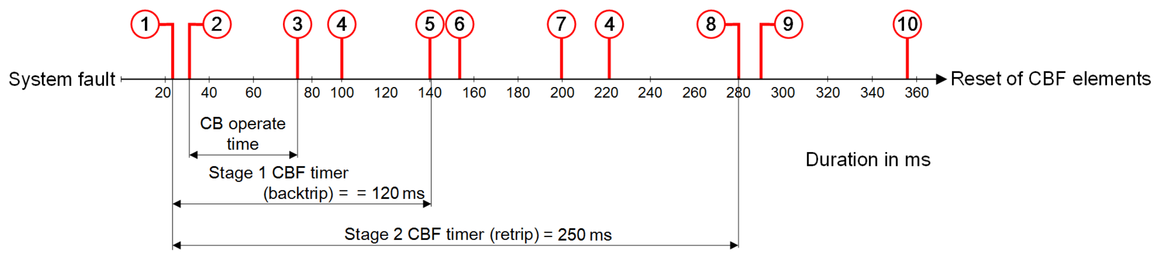


[dw_7SR5_function50BFSettingExample1, 2, en_US]

Figure 6-4 Single Stage Circuit-Breaker Fail Timing

(1) Relay operation and CBF timer started
(2) Main trip relay operation
(3) Failure of CB to trip
(4) Reset of CBF elements does not occur

(5) Backtrip operation
(6) Backtrip trip relay
(7) CB backtrip successful



[dw_7SR5_function50BFSettingExample2, 2, en_US]

Figure 6-5 2 Stage Circuit-Breaker Fail Timing

(1) Relay operation and CBF timer started
(2) Main trip relay operation
(3) Failure of CB to trip
(4) Reset of CBF elements does not occur
(5) CBF retrip operation
(6) CBF retrip trip relay
(7) Failed CB retrip operation
(8) Backtrip operation
(9) Backtrip trip relay
(10) Operation of all BB CB's

6.2.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
50BF CB Fail	Enabled Disabled	Disabled				

Functions > Protection > 50BF > Gn 50BF-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.05 to 2 · I_{rated}, Δ 0.05 I_{rated}	0.2 · I_{rated}				
I4 Setting	0.05 to 2 · I_{rated}, Δ 0.05 I_{rated}	0.05 · I_{rated}				
Delay 1	0.02 to 60 s, Δ 0.005 s	60 ms				
Delay 2	0.02 to 60 s, Δ 0.005 s	120 ms				

CB Fail outputs will be issued providing any of the 3 phase currents are above the setting or the current in the fourth CT is above **I4** setting for longer than the **50BF-n Delay** setting, or for a mechanical protection trip the circuit-breaker is still closed when the **50BF-n Delay** setting has expired, indicating that the fault has not been cleared.

If the **50BF CB Faulty** input **Input Config > Input Matrix > 50BF CB Faulty** is energized when a CB trip is given then **Delay 1** and **Delay 2** will be by-passed and the output given immediately.

6.2.6 IEC 61850 Functional Information Mapping

A50BFRBRF*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A50BFRBRF*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50BFRBRF*.Mod

Information				
50BF CB Fail Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A50BFRBRF*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A50BFRBRF*.Health

Information		
Device Healthy	0	1
A50BFRBRF*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A50BFRBRF*.OpEx

Information		
External trip raised	0	1
A50BFRBRF*.OpEx.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A50BFRBRF*.OpIn

Information		
Internal trip raised	0	1
A50BFRBRF*.OpIn.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A50BFRBRF*.Str

Information		
Element picked up	0	1
A50BFRBRF*.Str.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

6.2.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 50BF-1		Inhibit 50BF	Input			
50BF Delay 1		50BF Delay 1 Operated	Output			
50BF CB Faulty			Input			
50BF Mech Trip			Input			
50BF Ext Trip			Input			
50BF Delay 2		50BF Delay 2 Operated	Output			
50BF PhA		50BF PhA Operated	Output	Y	Y	Y

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
50BF PhB		50BF PhB Operated	Output	Y	Y	Y
50BF PhC		50BF PhC Operated	Output	Y	Y	Y
50BF EF		50BF EF Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

6.3 60CTS CT Supervision

6.3.1 Overview of Functions

The **60CTS Current Transformer Supervision** function is used to:

- Detect open circuit current transformer connections on 1 or 2 phases
- Provide an alarm for indication purposes

6.3.2 Structure of the Function

The CT supervision function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

The function monitors the primary system current using the 3 phase CT inputs e.g. CT1/2/3. The fundamental frequency component is measured from processing of the measured current samples.

The 60CTS-V function also monitors the voltage inputs e.g. VT1/2/3.

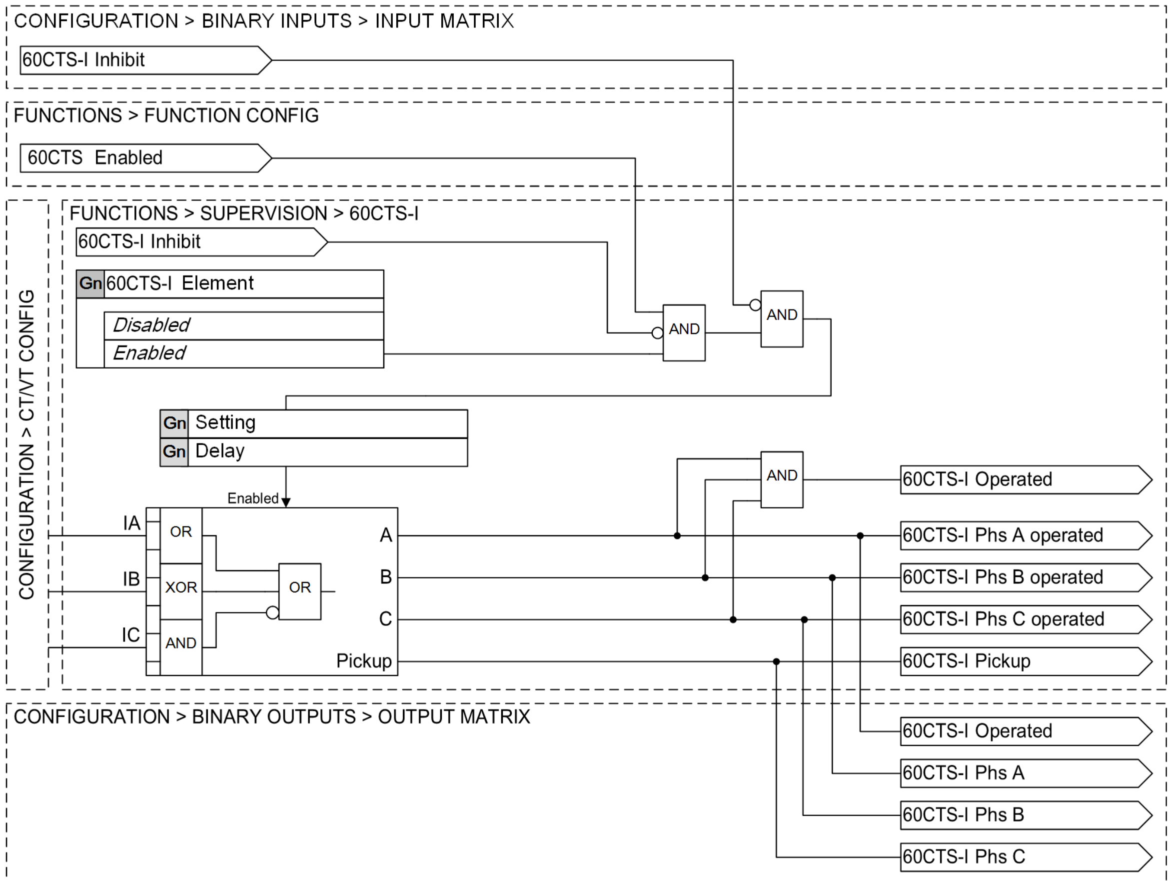
NOTE

If all 3 input currents fall below the setting, CT failure is not raised.

The function has 2 element types:

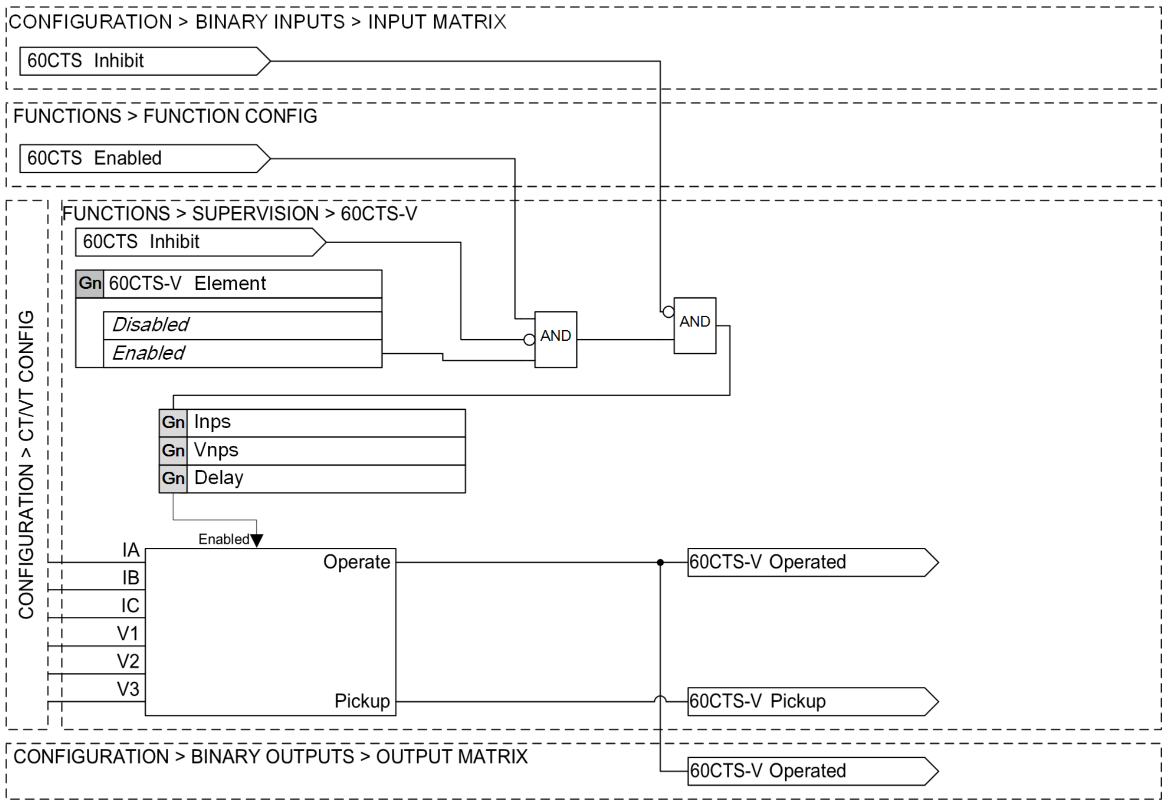
- 60CTS-I: CT supervision – current reference
  CT and CT wiring connection faults are detected when 1 or 2 of the 3 input currents falls below the CT supervision current setting for a time in excess of the delay setting.
  Outputs are available to indicate the faulted phase.
- 60CTS-V: CT supervision – voltage reference
  The presence of negative phase sequence (NPS) current in a power system is normally accompanied by NPS voltage. The presence NPS current without the corresponding level of NPS voltage a CT or CT wiring fault.
  The 60CTS-V function element operates when the measured negative phase sequence current (I_2) is above setting and the measured negative phase sequence voltage (V_2) is below setting.

6.3.3 Logic of the Function



[lo_7SR5_60CTS-Ilogicdiagram, 2, en_US]

Figure 6-6 Logic Diagram: 60CTS-I CT Supervision – Current Reference



[lo_7SR5_60CTS-Vlogicdiagram, 2, en_US]

Figure 6-7 Logic Diagram: 60CTS-V CT Supervision – Voltage Reference

6.3.4 Application and Setting Notes

Parameter: **`Gn 60CTS-I Element`**

- Default setting: **`Disabled`**

  This setting is used to allow the element to be switched on and off if it is not required.

Parameter Value	Description
Disabled	This element is off and is not available
Enabled	The element is available for use and can be parameterized

Parameter: **`Gn 60CTS-I Setting`**

- Default setting: **0.05 x I_n** (0.05 · I_{rated})

  The current from each phase is monitored. If 1 or 2 of the 3 input currents falls below this setting the **`60CTS Delay`** is initiated.

  If all 3 input currents fall below the setting, CT failure is not raised.

Parameter: **`Gn 60CTS-I Delay`**

- Default setting: **`10 s`**

  This is the delay applied to the 60CTS-I alarm output. This delay is used to prevent nuisance indications which would otherwise occur during switching operations and system faults.

Parameter: **`Gn 60CTS-V Element`**

- Default setting: **`Disabled`**
  This setting is used to allow the element to be switched on and off if it is not required.

Parameter Value	Description
Disabled	This element is off and is not available
Enabled	The element is available for use and can be parameterized

Parameter: **`Gn 60CTS-V Inps`**

- Default setting: **0.1 x I_n** (0.1 · I_{rated})
  If the measured negative phase sequence current is above this threshold without corresponding NPS voltage it could indicate that a CT failure has occurred. The 60CTS-V element will not operate unless this threshold is exceeded.

Parameter: **`Gn 60CTS-V Vnps`**

- Default setting: **`10 V`**
  If the negative phase sequence voltage is above this threshold this indicates a system fault and operation of the 60CTS-V element is inhibited.

Parameter: **`Gn 60CTS-V Delay`**

- Default setting: **`10 s`**
  This is the delay applied to the 60CTS-V alarm output. This delay is used to prevent nuisance indications which would otherwise occur during switching operations and system faults.

Settings Example

When a CT fails, the current levels seen by the protection become unbalanced, however this condition would also occur during a system fault.

Following a CT failure, if 1 or 2 of the 3 phases falls below the CT supervision setting the element will operate subject to a time delay to prevent operation for transitory effects.

Operation of other protection function elements can be inhibited using output logic signals, however operation of the 60CTS-I function may not inhibit high speed protection functionality. User settings are to be considered.

A 3-phase CT failure is considered so unlikely (these being independent units) that this condition is not tested for.

6.3.5 Settings Menu

Functions > Function Config						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
60CTS CT Supervision	Enabled Disabled	Disabled				

Functions > Supervision > 60CTS > 60CTS-I						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Setting	0.05 to 2 · I_{rated}, Δ 0.05 · I_{rated}	0.05 · I_{rated}				
Delay (DTL)	0.03 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	10 s				

Functions > Supervision > 60CTS > 60CTS-I						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Inps	0.05 to 1 · I_{rated}, Δ 0.05 · I_{rated}	0.1 · I_{rated}				
Vnps	7 to 110 V, Δ 1 V	10 V				
Delay (DTL)	0.03 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	10 s				

6.3.6 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Inhibit 60CTS-I		Inhibit 60CTS-I	Input			
		60CTS-I Pickup	Output			
60CTS-I		60CTS-I Operated	Output	Y	Y	Y
60CTS-I PhA		60CTS-I PhA Operated	Output	Y	Y	Y
60CTS-I PhB		60CTS-I PhB Operated	Output	Y	Y	Y
60CTS-I PhC		60CTS-I PhC Operated	Output	Y	Y	Y
Inhibit 60CTS		Inhibit 60CTS				
		60CTS-V Pickup	Output			
60CTS-V		60CTS-V Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

6.4 60VTS VT Supervision

6.4.1 Overview of Functions

The **60VTS Voltage Transformer Supervision** function is used to:

- Detect the loss of voltage supply due to VT fuse operation on 1, 2 or 3 phases
- Provide a delayed alarm for indication purposes
- Can be used to automatically inhibit protection elements that could be adversely affected by the resulting erroneous voltage
- Can be used to automatically switch directional protection elements to be non-directional during failed fuse conditions

6.4.2 Structure of the Function

The VT supervision function has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

The function monitors the VT using the 3 phase VT inputs e.g. VT1/2/3 and 3 phase CT inputs e.g. CT1/2/3. The fundamental frequency component are measured from processing of the measured samples.

The pickup output from the 60VTS function element is used internally to block selected protection elements.

1 or 2 Phase Failure Detection

The presence of negative phase sequence (NPS) or zero phase sequence (ZPS) voltage in a power system is normally accompanied by NPS or ZPS current. The presence NPS or ZPS voltages without the corresponding level of NPS or ZPS current can indicate a failure of 1 or 2 VT phases.

3 Phase Failure Detection

During normal load conditions PPS voltage and PPS load currents are measured within operating limits. Measurement of PPS load without corresponding PPS voltage can indicate 3 phase VT failure. To ensure these conditions are not caused by a 3 phase fault the PPS current must also be below the fault level.

The VT is considered to have failed where positive sequence voltage is below 60VTS V_1 while positive sequence current is above I_1 load and below I_1 fault level.

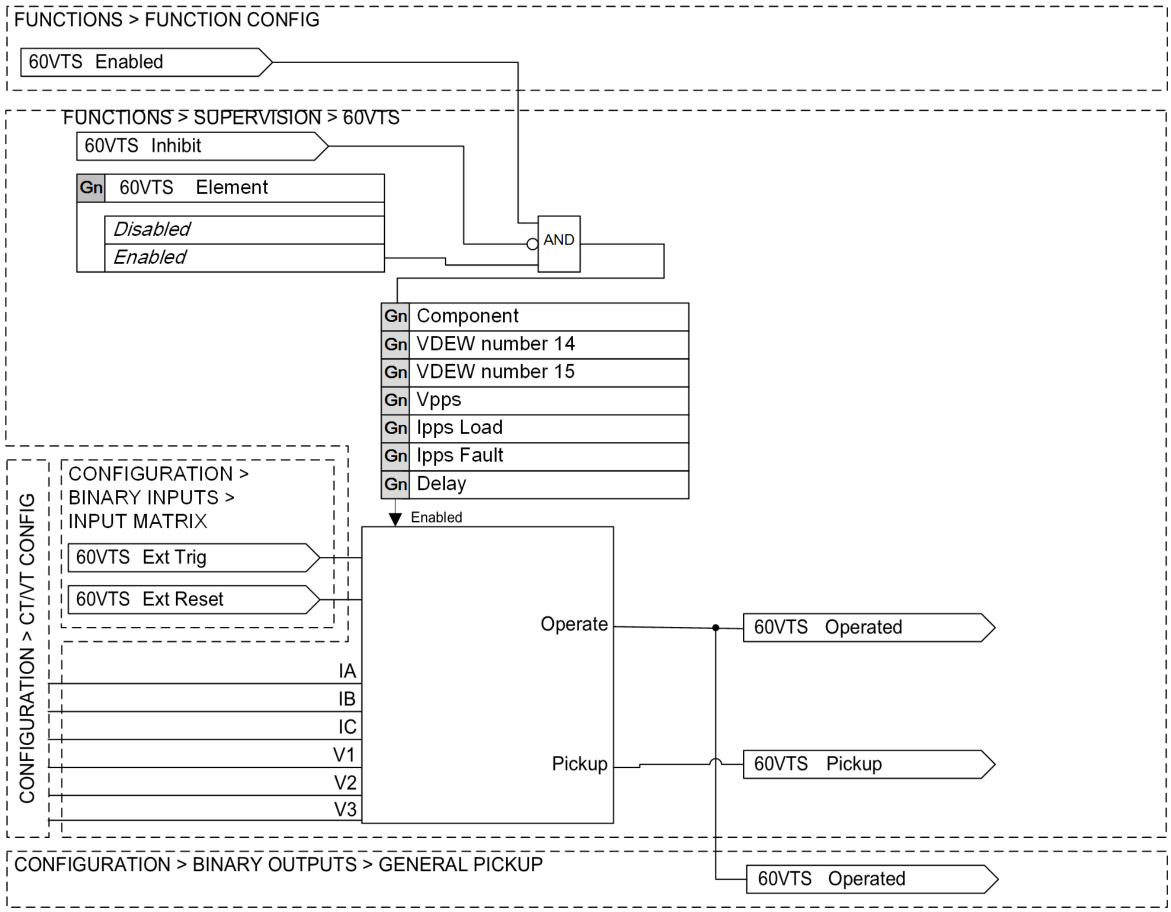
External MCB

A binary input can be set as **Ext Trig 60VTS** to allow the **60VTS Delay** element to be started from an external MCB operating.

Once a VT failure condition has occurred the output is latched on and is reset by any of the following:

- Voltage is restored to a healthy state i.e. above V_1 setting while NPS or ZPS voltage is below V setting
- **Ext Reset 60VTS** – A binary or virtual input, or function key and a VT failure condition no longer exists
- **Inhibit 60VTS** – A binary or virtual input

6.4.3 Logic of the Function



[lo_7SR5_60VTSlogicdiagram, 2, en_US]

Figure 6-8 Logic Diagram: 60VTS VT Supervision

6.4.4 Application and Setting Notes

Parameter: **`Gn 60VTS Element`**

- Default setting: **`Disabled`**
  This setting is used to allow the element to be switched on and off if it is not required. If the element is disabled, the validity of the voltage supply will not be assessed and voltage dependent elements will operate based on the measured voltage.

Parameter Value	Description
Disabled	This element is off and is not available.
Enabled	The element is available for use and can be parameterized.

Parameter: **`Gn 60VTS Component`**

- Default setting: **`NPS`**

  Selects the method used for the detection of loss of 1 or 2 VT phases i.e. ZPS or NPS components. The sequence component voltage is derived from the line voltages; suitable VT connections must be available.

  The element has user settings 60VTS V and 60VTS I. A VT is considered to have failed where the voltage exceeds 60VTS V while the current is below 60VTS I.

Parameter Value	Description
NPS	This method should be used for most applications.
ZPS	This method can be used to suit older customer specifications which specify this method but NPS is preferred.

Parameter: **`Gn 60VTS V`**

- Default setting: **`7 V`**

  This setting is the threshold for negative or zero sequence unbalance voltage that is used to detect that a voltage supply is not present.

Parameter: **`Gn 60VTS I`**

- Default setting: **0.1 x I_n** ($0.1 \cdot I_{rated}$)

  This setting is the threshold for negative or zero sequence unbalance current that is used to detect that a system fault may be present and therefore the presence of sequence voltage may not indicate a fuse failure.

Parameter: **Gn 60VTS V_{PPS}**

- Default setting: **`15 V`**

  If the balanced positive phase sequence voltage is below this threshold the 60VTS element can detect a 3 phase voltage failure depending on assessment of current level. If the balanced positive phase sequence voltage is above this threshold, 60VTS will reset for 1, 2 or 3 phase operation.

Parameter: **Gn 60VTS I_{PPS} Load**

- Default setting: **0.1 x I_n** ($0.1 \cdot I_{rated}$)

  If the balanced positive phase sequence current is below this threshold the 60VTS element will not detect a 3 phase VF failure.

Parameter: **Gn 60VTS I_{PPS} Fault**

- Default setting: **10 x I_n** ($10 \cdot I_{rated}$)

  If the balanced positive phase sequence current is above this threshold it is assumed that a fault is present and the 60VTS element will not detect a 3 phase VF failure.

Parameter: **`Gn 60VTS Delay`**

- Default setting: **`10 s`**

  This is the delay applied to the 60VTS operate output. Protection element blocking for VT failure is instantaneous but a delay is applied to the 60VTS indication output to prevent nuisance indications.

  If the conditions persist for a time greater than **`60VTS Delay`** an alarm output signal is raised for use as indication. If normal current levels resume before the time delay expires the VTS condition is reset but if the time delay has elapsed with VTS conditions met, the alarm output is raised and the VTS status is latched and will not reset for reset of current conditions. Reset of voltage conditions at any time will reset the VTS function element.

6.4.5 Settings Menu

Functions > Protection > 60VTS						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Component	NPS ZPS	NPS				
V	7 to 110 V, Δ 1 V	7 V				
I	0.05 to 1 · I_{rated}, Δ 0.05 · I_{rated}	0.1 · I_{rated}				
V_{PPS}	15 to 110 V, Δ 1 V	15 V				
I_{PPS} Load	0.05 to1 · I_{rated}, Δ 0.05 · I_{rated}	0.1 · I_{rated}				
I_{PPS} Fault	0.05 to 20 · I_{rated}, Δ 0.05 · I_{rated}	10 · I_{rated}				
Delay (DTL)	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	10 s				

6.4.6 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Inhibit 60VTS		Inhibit 60VTS	Input			
60VTS		60VTS Operated	Output	Y	Y	Y
		60VTS Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

6.5 60VTF Bus Voltage Supervision

6.5.1 Overview of Functions

The 60 VTF function monitors the bus voltage to detect failure of the voltage supply.

6.5.2 Structure of the Function

When the 25 Synchronizing function is installed in the device an additional supervision element is added. 60VTF can provide an alarm to indicate failure of the bus VT if the line voltage is live but the bus voltage is dead when the circuit breaker is in the closed condition. A setting is provided to delay the operation of the 60VTF output for this condition to avoid operation during transient conditions.

The function has 2 element types:

6.5.3 Settings Menu

Functions > Supervision > 60VTF						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element	Enabled Disabled	Disabled				
Delay (DTL)	0.03 to 100 s Δ 0.01 s	2 s				

6.5.4 Information List

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
60VTF-Bus		VTF-Bus Operated	Output	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

6.6 74CC Close-Circuit Supervision

6.6.1 Overview of Functions

The **`Close-Circuit Supervision`** function monitors the integrity of the wiring connections between the protection device and the circuit-breaker close coil.

An alarm is issued if the circuit is not complete i.e. an open circuit is detected.

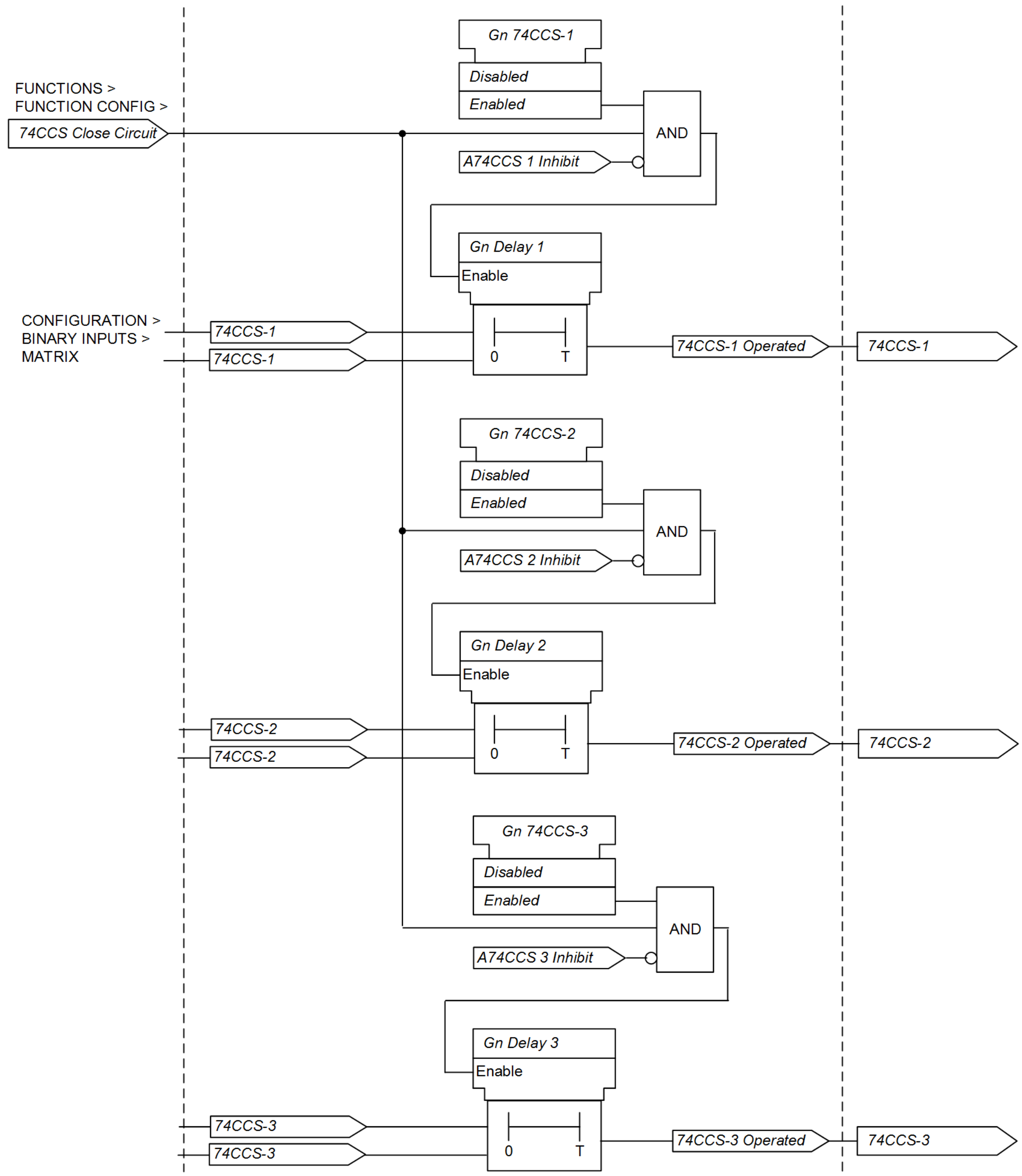
6.6.2 Structure of the Function

The device provides 3 close-circuit supervision function elements. All elements are identical in operation and independent from each other allowing 3 close-circuits to be monitored. This allows close-circuit monitoring of both circuit-breakers with phase segregated close coils or circuit-breakers with a single common close coil.

1 or more binary inputs can be mapped to 74CCS-n. The inputs are connected into the close-circuit such that at least 1 input is energized when the close-circuit wiring is intact. If all mapped inputs become de-energized due to a break in the close-circuit wiring or loss of CB close supply an output is given after a time delay.

The use of 1 or 2 binary inputs mapped to the same close-circuit supervision element (e.g. 74CCS-n) allows the user to realize several alternative monitoring schemes.

6.6.3 Logic of the Function



[lo_7SR5_74CClogicdiagram, 2, en_US]

Figure 6-9 Logic Diagram: 74CC Close-Circuit Supervision

6.6.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**

  A separate setting is provided for each element. These settings can be used to select the number of elements required e.g. for circuit-breakers with phase segregated or 1 common close coil.

Parameter: **`Delay`**

- Default setting: **`0.4 s`**
  Time delayed operation prevents failure being incorrectly indicated during circuit-breaker operation. This delay should be greater than the operating time of the circuit-breaker.

Settings Example

Binary inputs may be used to monitor the integrity of the CB trip and close circuit wiring. A small current flows through the BI and the circuit. This current operates the BI confirming the integrity of the auxiliary supply, CB coil, auxiliary switch, C.B. secondary isolating contacts and associated wiring. If monitoring current flow ceases, the BI drops off and if it is user programmed to operate 1 of the output relays, this can provide a remote alarm. In addition, an LED on the relay can be programmed to operate. A user text label can be used to define the operated LED e.g. **`Trip CCT Close`**.

The relevant binary input is mapped to 74TCS-n or 74CCS in the **`Input Config > Input Matrix`** menu. To avoid giving spurious alarm messages while the circuit-breaker is operating the input is given a 0.4 s drop-off delay in the **`Input Config > Binary Input Config`** menu.

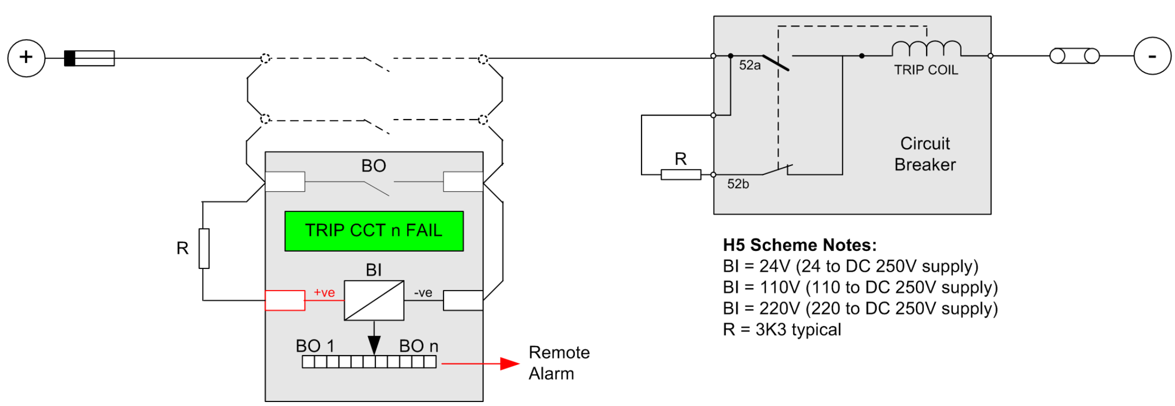
To provide an alarm output a normally open binary output is mapped to 74TCS-n or 74CCS-n.

The following circuits are derived from UK ENA S15 standard schemes H5, H6 and H7.

For compliance with this standard:

- Where more than 1 device is used to close the CB then connections should be looped between the closing contacts. To ensure that all wiring is monitored the binary input must be at the end of the looped wiring.
- Resistors must be continuously rated and where possible should be of wire-wound construction.

Scheme 1 (Basic)

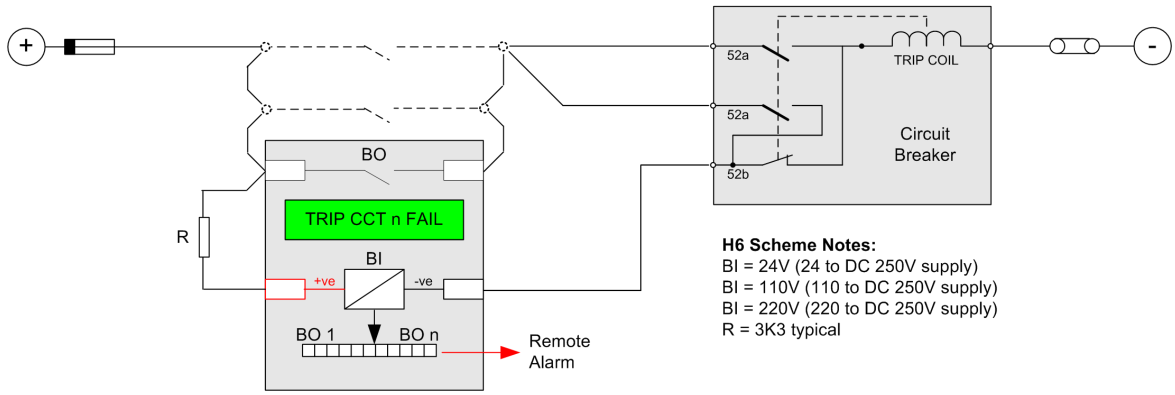


[dw_7SR5_function74TCSettingExample1, 1, en_US]

Figure 6-10 Trip-Circuit Supervision Scheme 1 (H5)

Scheme 1 provides full trip supervision with the circuit-breaker **`Open`** or **`Closed`**. Where a **`Hand Reset Trip Contact`** is used, measures must be taken to inhibit alarm indications after a CB trip.

Scheme 2 (Intermediate)

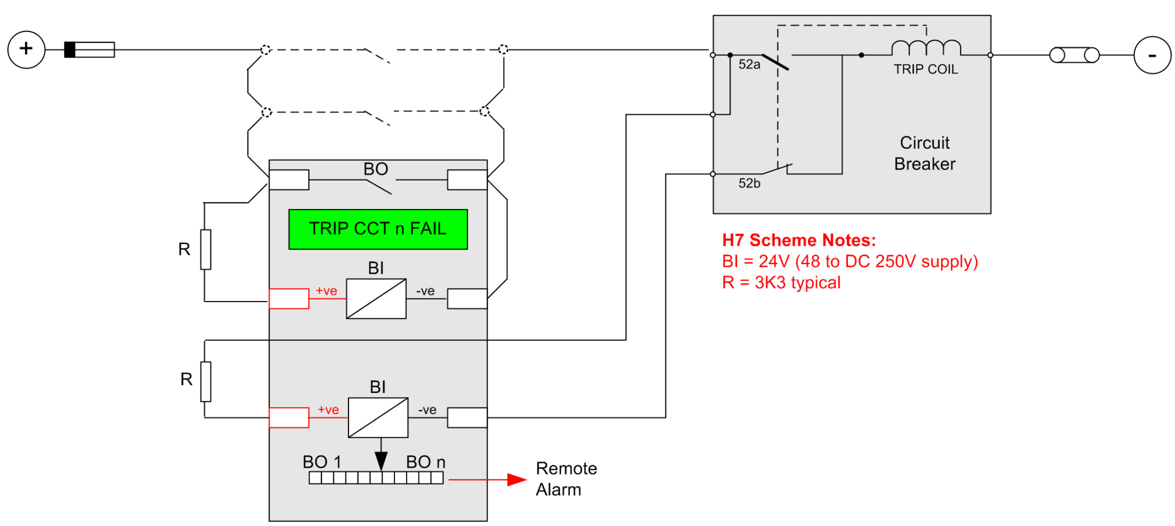


[dw_7SR5_function74TCSettingExample2, 1, en_US]

Figure 6-11 Trip-Circuit Supervision Scheme 2 (H6)

Scheme 2 provides continuous trip-circuit supervision of the trip coil with the circuit-breaker `Open` or `Closed`. It does not provide pre-closing supervision of the connections and links between the tripping contacts and the circuit-breaker and may not therefore be suitable for some circuits which include an isolating link.

Scheme 3 (Comprehensive)



[dw_7SR5_function74TCSettingExample3, 1, en_US]

Figure 6-12 Trip-Circuit Supervision Scheme 3 (H7)

Scheme 3 provides full trip supervision with the circuit-breaker `Open` or `Closed`.

6.6.5 Settings Menu

Functions > Function Config						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
74CC Close-Circuit	Enabled Disabled	Disabled				

Functions > Protection > 74 > Gn 74-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element 1	Enabled Disabled	Disabled				
Delay 1	0 to 60 s, Δ 0.02 s	0.4 s				
Element 2	Enabled Disabled	Disabled				
Delay 2	0 to 60 s, Δ 0.02 s	0.4 s				
Element 3	Enabled Disabled	Disabled				
Delay 3	0 to 60 s, Δ 0.02 s	0.4 s				

6.6.6 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
74CC-1			Input			
74CC-2			Input			
74CC-3			Input			
		A74CC-1 Inhibit	Input			
		A74CC-2 Inhibit	Input			
		A74CC-3 Inhibit	Input			
74CC-1		74CC-1 Operated	Output			
74CC-2		74CC-2 Operated	Output			
74CC-3		74CC-3 Operated	Output			
		Close Circuit Fail Operated	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

6.7 74TC Trip-Circuit Supervision

6.7.1 Overview of Functions

The **`Trip-Circuit Supervision`** function monitors the integrity of the wiring connections between the protection device and the circuit-breaker trip coil.

An alarm is issued if the circuit is not complete i.e. an open circuit is detected.

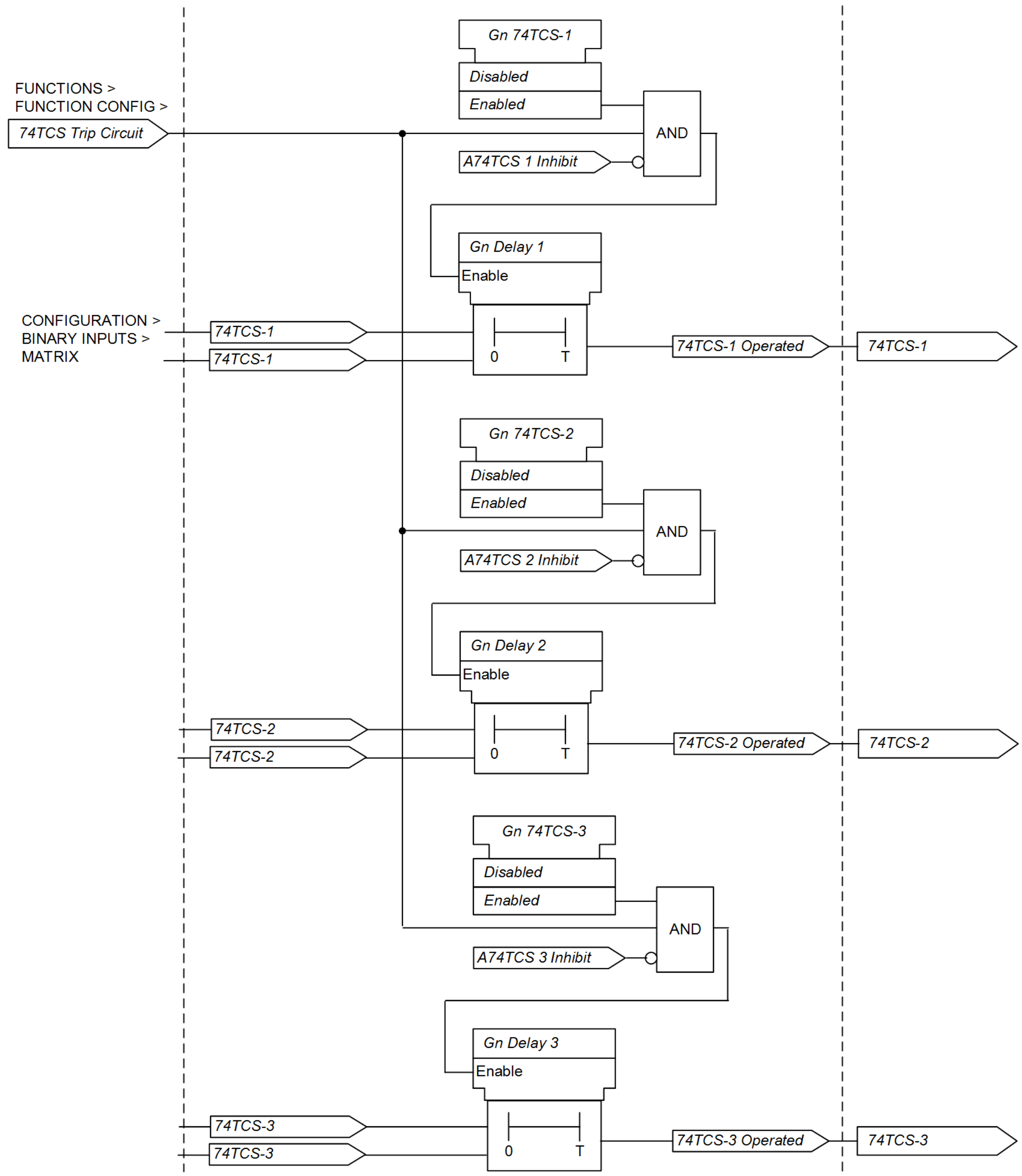
6.7.2 Structure of the Function

The device provides 3 trip-Circuit supervision function elements. All elements are identical in operation and independent from each other allowing 3 trip-circuits to be monitored. This allows trip-circuit monitoring of both circuit-breakers with phase segregated trip coils or circuit-breakers with a single common trip coil.

1 or more binary inputs can be mapped to 74TCS-n. The inputs are connected into the trip-circuit such that at least 1 input is energized when the trip-circuit wiring is intact. If all mapped inputs become de-energized due to a break in the trip-circuit wiring or loss of CB trip supply an output is given after a time delay.

The use of 1 or 2 binary inputs mapped to the same trip-circuit supervision element (e.g. 74TCS-n) allows the user to realize several alternative monitoring schemes.

6.7.3 Logic of the Function



[lo_7SR5_74TClogicdiagram, 2, en_US]

Figure 6-13 Logic Diagram: 74TC Trip-Circuit Supervision

6.7.4 Application and Setting Notes

Parameter: **Element**

- Default setting: **Disabled**

  A separate setting is provided for each element. These settings can be used to select the number of elements required e.g. for circuit-breakers with phase segregated or 1 common trip coil.

Parameter: **Delay**

- Default setting: **0.4 s**
  Time delayed operation prevents failure being incorrectly indicated during circuit-breaker operation. This delay should be greater than the operating time of the circuit-breaker.

Settings Example

Binary inputs may be used to monitor the integrity of the CB trip and close circuit wiring. A small current flows through the BI and the circuit. This current operates the BI confirming the integrity of the auxiliary supply, CB coil, auxiliary switch, C.B. secondary isolating contacts and associated wiring. If monitoring current flow ceases, the BI drops off and if it is user programmed to operate 1 of the output relays, this can provide a remote alarm. In addition, an LED on the relay can be programmed to operate. A user text label can be used to define the operated LED e.g. **Trip CCT Fail**.

The relevant binary input is mapped to 74TCS-n or 74CCS in the **Input Config > Input Matrix** menu. To avoid giving spurious alarm messages while the circuit-breaker is operating the input is given a 0.4 s drop-off delay in the **Input Config > Binary Input Config** menu.

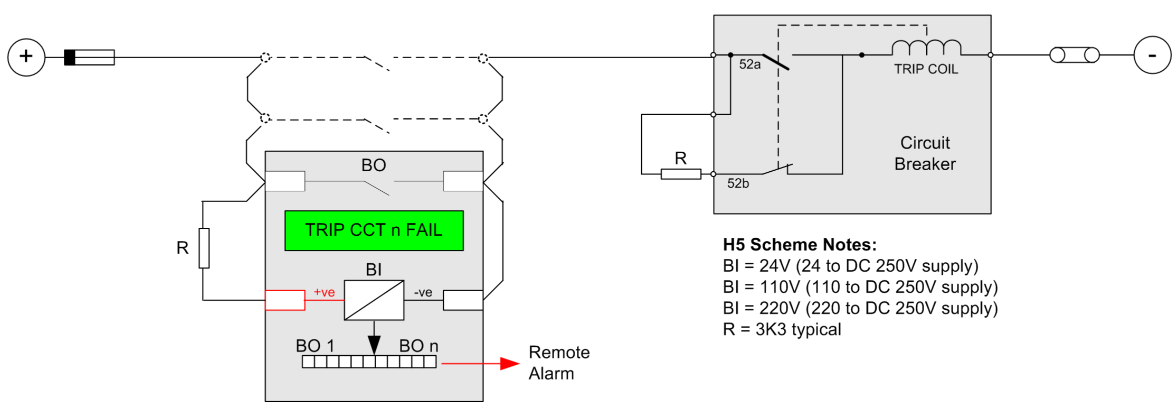
To provide an alarm output a normally open binary output is mapped to 74TCS-n or 74CCS-n.

The following circuits are derived from UK ENA S15 standard schemes H5, H6 and H7.

For compliance with this standard:

- Where more than 1 device is used to trip the CB then connections should be looped between the tripping contacts. To ensure that all wiring is monitored the binary input must be at the end of the looped wiring.
- Resistors must be continuously rated and where possible should be of wire-wound construction.

Scheme 1 (Basic)

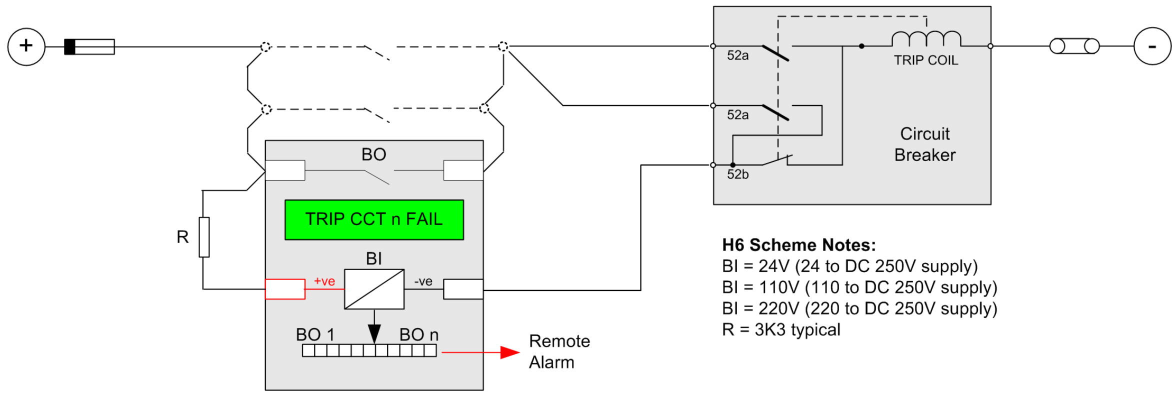


[dw_7SR5_function74TCSettingExample1, 1, en_US]

Figure 6-14 Trip-Circuit Supervision Scheme 1 (H5)

Scheme 1 provides full trip supervision with the circuit-breaker **Open** or **Closed**. Where a **Hand Reset Trip Contact** is used, measures must be taken to inhibit alarm indications after a CB trip.

Scheme 2 (Intermediate)

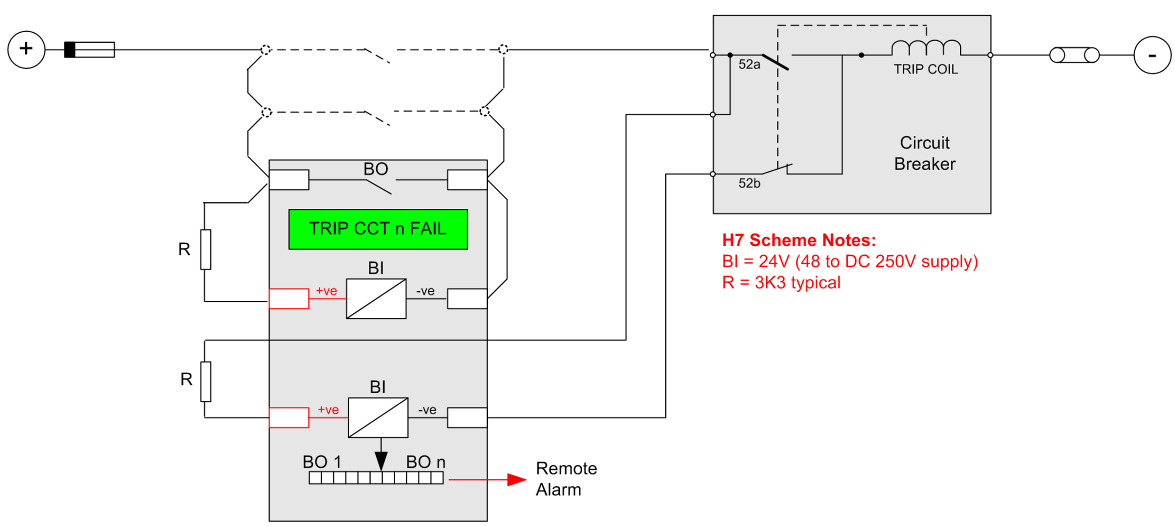


[dw_7SR5_function74TCSettingExample2, 1, en_US]

Figure 6-15 Trip-Circuit Supervision Scheme 2 (H6)

Scheme 2 provides continuous trip-circuit supervision of the trip coil with the circuit-breaker **Open** or **Closed**. It does not provide pre-closing supervision of the connections and links between the tripping contacts and the circuit-breaker and may not therefore be suitable for some circuits which include an isolating link.

Scheme 3 (Comprehensive)



[dw_7SR5_function74TCSettingExample3, 1, en_US]

Figure 6-16 Trip-Circuit Supervision Scheme 3 (H7)

Scheme 3 provides full trip supervision with the circuit-breaker **Open** or **Closed**.

6.7.5 Settings Menu

Functions > Function Config							
Parameter	**Range**	**Settings**					
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
74TC Trip-Circuit	Enabled Disabled	Disabled				

Functions > Protection > 74 > Gn 74-n						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Element 1	Enabled Disabled	Disabled				
Delay 1	0 to 60 s, Δ 0.02 s	0.4 s				
Element 2	Enabled Disabled	Disabled				
Delay 2	0 to 60 s, Δ 0.02 s	0.4 s				
Element 3	Enabled Disabled	Disabled				
Delay 3	0 to 60 s, Δ 0.02 s	0.4 s				

6.7.6 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
74TC-1			Input			
74TC-2			Input			
74TC-3			Input			
		A74TC-1 Inhibit	Input			
		A74TC-2 Inhibit	Input			
		A74TC-3 Inhibit	Input			
74TC-1		74TC-1 Operated	Output			
74TC-2		74TC-2 Operated	Output			
74TC-3		74TC-3 Operated	Output			
		Trip Circuit Fail Operated	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

6.8 81HB2 Inrush Current Detection

6.8.1 Overview of Functions

The elements can be used to block operation of selected functions where these are liable to mal-operate during transformer switch in conditions.

6.8.2 Structure of the Function

The inrush detector function has group dependent settings. These settings can be different in each set-tings group – group numbers (Gn) 1 to 4.

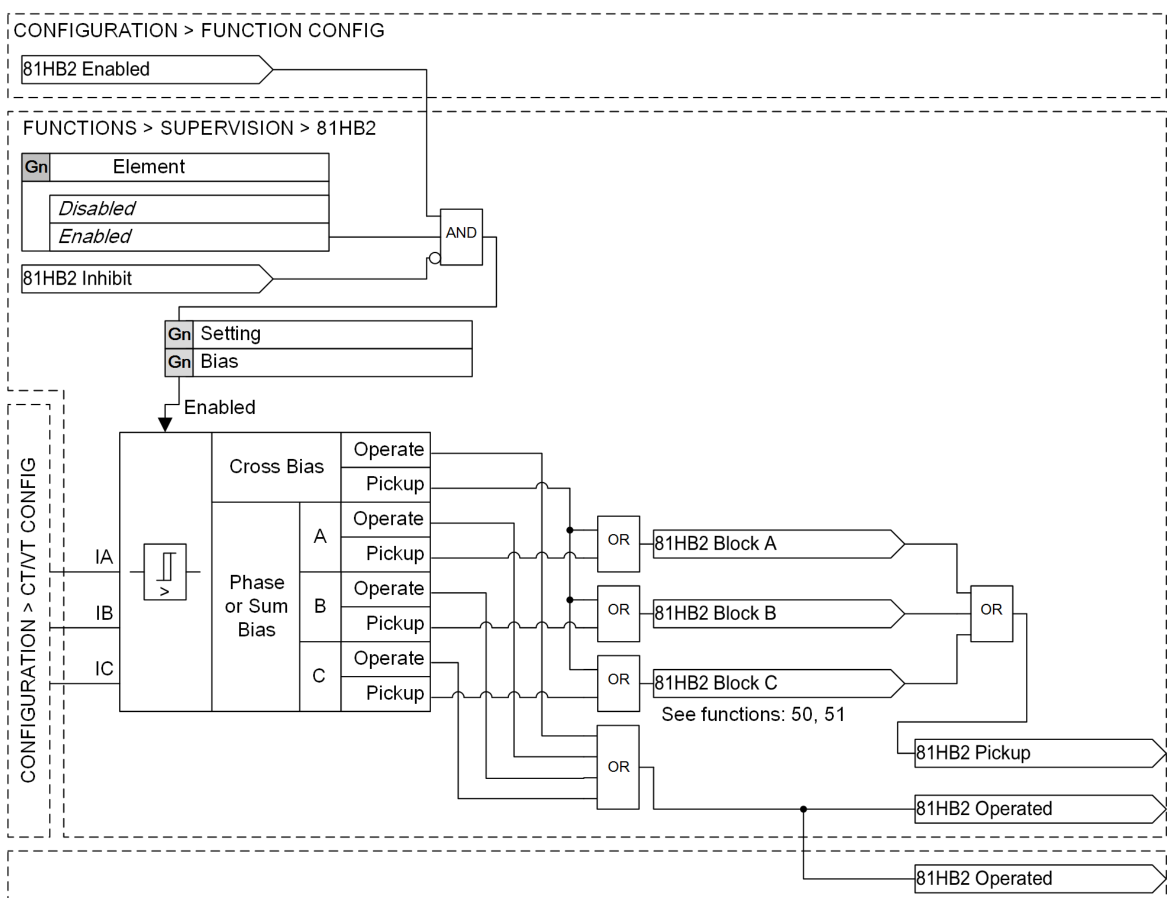
This function corresponds to the logical nodes **A81HB2PHAR*** in IEC 61850.

The function monitors the primary system using the 3 phase current inputs e.g. CT1/2/3.

The inrush detector function (81HB2) is summarized below:

- High speed (instantaneous) operate characteristic
- Logic outputs are provided to block selected device functionality and for external indications

6.8.3 Logic of the Function



[lo_7SR5_81HB2logicdiagram, 2, en_US]

Figure 6-17 Logic Diagram: 81HB2 Inrush Current Detection

6.8.4 Application and Setting Notes

Parameter: **`81HB2 Element`**

- Default setting: **`Disabled`**

  This setting is used to allow the element to be switched on and off if it is not required. A separate setting is provided for each element. These setting can be used to select the number of elements required.

Parameter Value	Description
Disabled	This element is switched out and is not available
Enabled	The element is available for use and can be parameterized

Parameter: **`81HB2 Setting`**

- Default setting: **`0.2.I`**

  This setting defines the operating threshold of the element. The ratio of the second harmonic component of current compared to the fundamental component of current is exceeded.

  This setting should be set to the default value unless in-service experience produces incorrect operation.

Parameter: **`81HB2 Bias`**

- Default setting: **`Cross`**

  Selects whether fundamental frequency RMS or the true RMS value of the measured currents used.

Parameter Value	Description
Cross	The ratio of second harmonic component to fundamental frequency component for each phase is monitored independently. $A_{2nd} : A_{Fund}$ $B_{2nd} : B_{Fund}$ $C_{2nd} : C_{Fund}$ All phases are inhibited when the ratio of second harmonic component to fundamental frequency component in any phase exceeds setting.
Phase	The ratio of second harmonic component to fundamental frequency component for each phase is monitored independently. $A_{2nd} : A_{Fund}$ $B_{2nd} : B_{Fund}$ $C_{2nd} : C_{Fund}$ Individual phase outputs are given when the ratio exceeds setting on the relevant phase.
Sum	The ratio of the 'square root of the sum of the squares of all second harmonics' is compared to each fundamental frequency component individually. $\sqrt{A_{2nd}^2 + B_{2nd}^2 + C_{2nd}^2} : A_{Fund}$ $\sqrt{A_{2nd}^2 + B_{2nd}^2 + C_{2nd}^2} : B_{Fund}$ $\sqrt{A_{2nd}^2 + B_{2nd}^2 + C_{2nd}^2} : C_{Fund}$ Individual phase outputs are given when the ratio exceeds setting on the relevant phase.

6.8.5 Settings Menu

Functions > Function Config						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
81HB2 2nd Harmonic	Enabled Disabled	Disabled				

Functions > Protection > 81HB2 > Gn 81HB2-n						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Element	Enabled Disabled	Disabled				
Setting	0.1 to 0.5 · I, Δ 0.01 · I	0.2 · I				
Bias	Cross Phase Sum	Cross				

6.8.6 IEC 61850 Functional Information Mapping

A81HB2PHAR*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A81HB2PHAR*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A81HB2PHAR*.Mod

Information				
81HB2 2nd Harmonic Enabled (Function Config)	x	0	1	1
Element Disabled	1	x	0	0
Element Inhibited	x	x	1	0
A81HB2PHAR*.Mod.stVal	**5**	**5**	**2**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A81HB2PHAR*.Health

Information		
Device Healthy	0	1
A81HB2PHAR*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

A81HB2PHAR*.Str

Information		
Element picked up	0	1
A81HB2PHAR*.Str.general	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

Inrush Detector	81HB2	MEAS	A81Hb2MMXU1	A.phsA
	81HB2	MEAS	A81Hb2MMXU1	A.phsB
	81HB2	MEAS	A81Hb2MMXU1	A.phsC

6.8.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Inhibit 81HB2		Inhibit 81HB2	Input			
81HB2		81HB2 Operated	Output			
		81HB2 Pickup	Output			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

7 Control Functions

7.1 Device Control Functions

7.1.1 Overview of Functions

7SR5 devices include several types of control functionality.

7.1.2 Structure of the Function

7SR5 devices include several types of control functionality. Control is divided into the following categories:

- Device fascia LCD mimic diagram(s)/fascia function keys
- Control Mode menu/fascia function keys
- **Settings > Configuration > Device menu**
- Binary inputs
- Reset of binary outputs
- Control of data storage functions
- Single point data points
- Double point data points
- **Settings > Functions > Control menu**

Control from Device Fascia LCD Mimic Diagram(s)/Fascia Function Keys

Device Fascia LCD Mimic Diagram

Controllable plant items that have been included by the user in the configurable fascia LCD, (see *3.1 Device Fascia*).

The device is supplied with a default **Home Screen** displaying the basic metered values. Up to 5 screens, including the default, can be configured in the Reydisp PC tool and sent to the device. The screens support user configurations for meters, mimic indications and controllable items.

All controllable mimic items are select before execute from the fascia.

From the selected screen the **Enter** key should be used to access the controllable item. If no controllable items are configured the device will display a message to advise the user.

NOTE

During device configuration plant items may be configured to display position only or as controllable items.

The display will flash the first controllable item on the chosen screen. Using the arrow keys the user must navigate to select the correct item. Once selected the item will flash. The item can then be controlled using the **I** and **O** keys to select the correct operation. The **Enter** key is used to confirm the action and generates the control command.

NOTE

The controlling action may be restricted by the devices operating mode which is managed in junction with the device operating mode parameters, (see *3.2 Device Configuration*).

User Controls

To support the control of additional user configured items the device provides a number of control elements that can be used in the user logic, mimic diagram and communication interface configuration.

The IEC 61850 can be selected with the appropriate control model. IEC 61850 also supports SP & DP.

3 different control model types are available:

- Direct without feedback monitoring (direct normal security)
- Direct with feedback monitoring (direct with enhanced security)
- With SBO with feedback monitoring (SBO with enhanced security)

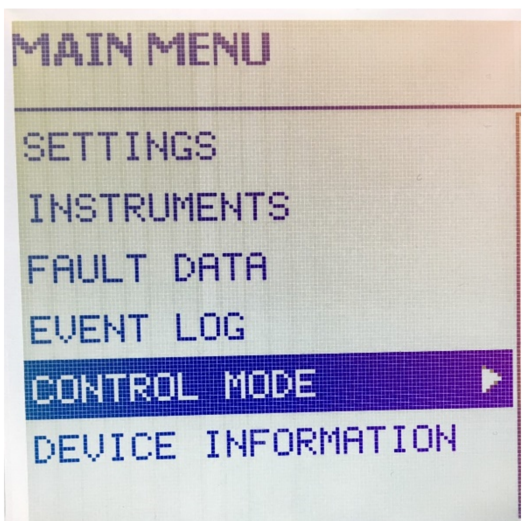
NOTE

SBO without feedback monitoring is not supported.

The **Control Confirmation ID**, when active, must be entered to proceed with the control action. If any logic interlocking has been created within the Reylogic the item may not change state and the operation blocked.

Control from Control Mode Menu/Fascia Function Keys

The device provides a number of preconfigured control items from the fascia menus. From the **Home Screen** the **Down** arrow can be pressed to access the **Main Menu**. The user can then, using the arrows, scroll to the **Control Mode** menu. The **Right** arrow is used to enter the **Control Mode** menu.



[sc_7SR5_ControlModeMenu, 1, --_--]

Figure 7-1 Control Mode Menu

The following items are available as preconfigured controllable items located in the **Control Mode** menu:

- CB Open/Close
- EF In/Out
- GS In/Out
- Operate Mode:
  - Set Local or Remote mode
  - Set Local mode
  - Set Remote mode
  - Set Out of Service
  - Set Test Mode
- 79 Out of Service/In Service
- Hotline Working In/Out

- Inst Prot'n In/Out
- 79 Trip and Reclose Confirm Action
- 79 Trip & Lockout Confirm Action
- LED Test and Reset Hand Reset Binary Outputs
- Trigger Waveforms
- Reset Waveforms
- Reset Events
- Reset Faults
- Reset Data Log
- Reset Demand
- Reset Thermal

NOTE

If the function is disabled the control operation will be blocked or removed from the options.

See *3.1 Device Fascia* .
These items can also be reset over the communications protocol.
These items can also be reset from a binary input or by creating a reset logic in the Reylogic tool.

NOTE

The controlling action may be restricted by the devices operating mode which is managed in conjunction with the device operating mode parameters, (see *3.2 Device Configuration*).

See *3.6 Data Storage* .

Settings > Configuration > Device Menu

The following are controllable items in the **`Device`** menu:

- Active group
- Time source
- Operating mode
- Setting ID
- Control ID
- Passwords reset

See *3.2 Device Configuration* .

Control from Binary Inputs

When energized the binary inputs can be used for selected control functionality:

- Select device local/remote/out of service operating modes
- Inhibit operation of function elements
- Reset counters and meters
- Initiate operation of associated circuit-breaker open/close
- Trigger data storage functions
- Initiate **`Control Mode`** menu functions

See *3.4 Binary Inputs* .

Control of Binary Outputs

To clear any latched LED's or binary output relays the **Right** arrow must be held for 3 seconds when the **Home Screen** is visible.

NOTE

This can be carried out without entering a **User ID**.

The LED and binary outputs can also be reset via the communications or a binary input.

See *3.5 Binary Outputs* .

7.1.3 IEC 61850 Functional Information Mapping

LLNO*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
LLNO*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation	ON/TRUE: 1
	OFF/FALSE: 0
	Irrelevant: x
IEC 61850 Value	OK: 1
	BLOCKED: 2
	TEST: 3
	TEST/BLOCKED: 4
	OFF: 5

Control LLN0 (CTRL/LLN0)

LLN0.Mod

Information			
Device Ready	0	1	1
Out Of Service Mode	x	1	0
LLN0.Mod.stVal	**5**	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

LLN0.Health

Information		
Device Healthy	0	1
LLN0.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

LLN0.Loc

Information		
Not Remote Mode	0	1
LLN0.Loc.stVal	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

LLN0.LEDRs

Information		
Reset LEDs	1	-
LLN0.LEDRs.ctlVal	**1**	**0**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Interlocking

Q0CILO1.Mod

Information	
Reset Device	x
Q0CILO1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

Q0CILO1.Health

Information		
Device Healthy	0	1
Q0CILO1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Q0CILO1.EnaCls

Information		
NOT Block Close CB	0	1
Q0CILO1.EnaCls.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Q0CILO1.EnaOpn

Information		
NOT Block Open CB	0	1
Q0CILO1.EnaOpn.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

User Single Point GGIO Control Elements (Normal Security) (SPDONSGGIO1, SPDONSGGIO2, SPDONSGGIO3, SPDONSGGIO4)

SPDONSGGIO*.Mod

Information	
Reset Device	x
SPDONSGGIO*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

SPDONSGGIO*.Health

Information		
Device Healthy	0	1
SPDONSGGIO*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

SPDONSGGIO*.SPCSO

Information		
SPDONS (Off/Open)	1	-
SPDONS (On/Close)	-	1
SPDONSGGIO*.SPCSO.ctlVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value ON: 1
OFF: 0

Information		
SPDONS Status (On/Closed)	0	1
SPDONSGGIO*.SPCSO.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value ON: 1
OFF: 0

User Single Point GGIO Control Elements (Enhanced Security) (SPDOESGGIO1, SPDOESGGIO2, SPDOESGGIO3, SPDOESGGIO4)

SPDOESGGIO*.Mod

Information	
Reset Device	x
SPDOESGGIO*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

SPDOESGGIO*.Health

Information		
Device Healthy	0	1
SPDOESGGIO*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

SPDOESGGIO*.SPCSO

Information		
SPDOES (Off/Open)	1	-
SPDOES (On/Close)	-	1
SPDOESGGIO*.SPCSO.ctlVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value ON: 1
OFF: 0

Information		
SPDOES Status (On/Closed)	0	1
SPDOESGGIO*.SPCSO.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value ON: 1
OFF: 0

User Double Point GGIO Control Elements (Normal Security) (DPDOnsGGIO1, DPDOnsGGIO2, DPDOnsGGIO3, DPDOnsGGIO4)

DPDONSGGIO*.Mod

Information	
Reset Device	x
DPDONSGGIO*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

DPDONSGGIO*.Health

Information		
Device Healthy	0	1
DPDONSGGIO*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

DPDONSGGIO*.DPCSO

Information		
DPDONS (Off/Open)	1	-
DPDONS (On/Close)	-	1
DPDONSGGIO*.DPCSO.ctlVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value ON: 1
OFF: 0

Information				
DPDONS Status (Off/Open)	0	1	0	1
DPDONS Status (On/Closed)	0	0	1	1
DPDONSGGIO*.DPCSO.stVal	**00**	**01**	**10**	**11**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value ON: 1
OFF: 0

User Double Point GGIO Control Elements (Enhanced Security) (DPDOesGGIO1, DPDOesGGIO2, DPDOesGGIO3, DPDOesGGIO4)

DPDOESGGIO*.Mod

Information	
Reset Device	x
DPDOESGGIO*.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

DPDOESGGIO*.Health

Information		
Device Healthy	0	1
DPDOESGGIO*.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

DPDOESGGIO*.DPCSO

Information		
DPDOES (Off/Open)	1	-
DPDOES (On/Close)	-	1
DPDOESGGIO*.DPCSO.ctlVal	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	ON: 1 OFF: 0

Information				
DPDOES Status (Off/Open)	0	1	0	1
DPDOES Status (On/Closed)	0	0	1	1
DPDOESGGIO*.DPCSO.stVal	**00**	**01**	**10**	**11**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	ON: 1 OFF: 0

7.1.4 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
		User mimic status 1 (to 10)				
		User mimic control 1 (to 10)				
		Function key 0				
		Function key 1				
		User SP serial command 1 (to 8) (On/Close)		Y	Y	Y
		User DP serial command 1 (to 8) (On/Close)		Y	Y	Y
		User DP serial command 1 (to 8) (Off/Open)		Y	Y	Y

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
		Control recieved				
		Command recieved				

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

7.2 25 Synchrocheck – Synchronizing Function

7.2.1 Overview of Function

The synchronizing function is available in the Directional Overcurrent 7SR51 devices.

The synchronizing function is used to check that the voltage conditions indicate that it is safe to close an open circuit-breaker without risk of damage to the circuit-breaker or excessive disturbance to the system. This requires that voltage transformers are available to measure the voltages directly on both sides of the circuit-breaker.

7.2.2 Structure of the Function

The synchronizing function includes all voltage checks applied during manual closing and autoreclosing operations and can be disabled if voltage checks are not required. Options are provided within the **25 Synchrocheck** function to control operations for live or dead conditions on each side as well as live both sides where matching limits are applied.

This function corresponds to the logical node **A25RSYN1** in IEC 61850.

The **25 Synchrocheck** function can be used to provide simple voltage checks, apply basic voltage thresholds or apply more complex phase angle and slip frequency matching.

Voltages are checked to allow closing to proceed only if the voltages meet requirements specified in settings. Check synchronizing settings for magnitude, phase and frequency difference apply only when the open circuit-breaker is live on both sides. Additionally, settings can be configured to allow closing to proceed when one side, the other side or both sides are dead. The voltage levels, time delays and window of time in which voltage conditions must be met are adjustable by user settings.

The timing of closure, for charging lines which are dead following fault clearance, is controlled to co-ordinate with other devices. Closure can be delayed to allow a sequenced restoration i.e for an interconnected system, one end of a feeder will charge the dead line then the second end will close using check synchronizing.

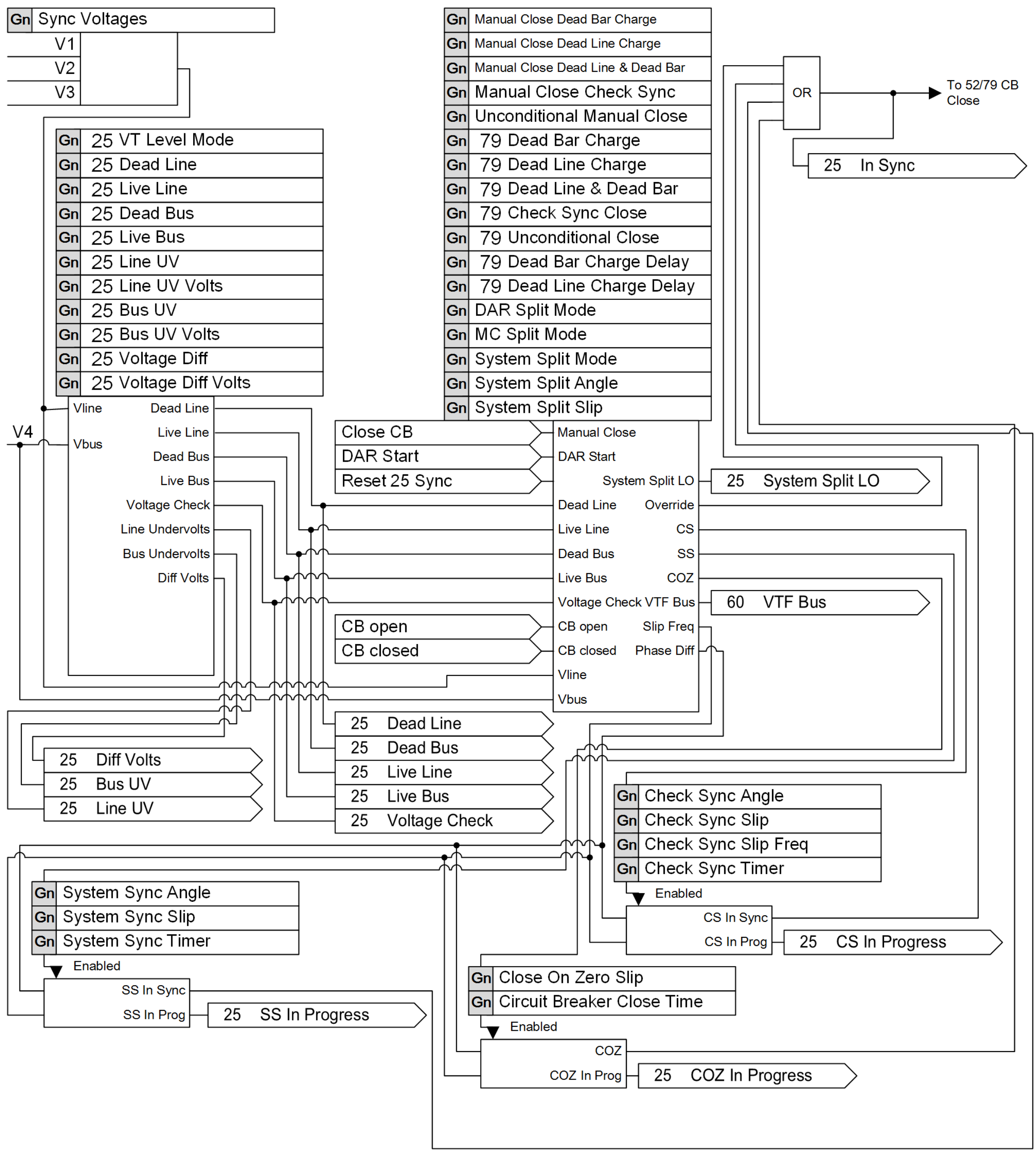
Settings allow different closure options to be configured for manual close operations and autoreclose.

Check synchronizing settings are initially used to evaluate if the circuit-breaker close command should be issued when requested if it is live on both sides. If a split system is detected during this evaluation, the **System Split** output signal is raised and the synchronizing parameters required for circuit-breaker close may be affected. Separate settings are provided to define the action for **Manual Close** and **Autoreclose** if a **System Split** is detected. The relay can contintinue to apply **Check Synchronizing** settings or can change to alternative **System Synchronizing** parameters for phase difference and slip or can use the **Close on Zero** method. System synchronizing settings typically apply a smaller phase angle window and allow for the expected slip frequency. System synchronizing only allows closure when the phase difference is reducing. The **Close on Zero** method will issue a close pulse on a slipping system such that the circuit-breaker closes with no phase difference in voltages on either side.

A split system can be detected by an abnormal phase difference between voltages or by a slipping phase difference.

When the 25 Synchronizing function is installed in the device an additional supervision element is added. 60VTF can provide an alarm to indicate failure of the bus VT if the line voltage is live but the bus voltage is dead when the circuit breaker is in the closed condition. See *6.5 60VTF Bus Voltage Supervision*.

7.2.3 Logic of the Function



[lo_7SR5_25logicdiagram, 2, en_US]

Figure 7-2 Logic Diagram: 25 Synchrocheck – Synchronizing Function

7.2.4 Application and Setting Notes

Parameter: **Gn Sync Voltages**

- Default setting: **Vbn**

  The single phase voltage source used for synchronizing can be selected as any phase to phase or phase to earth voltage for flexibility. The voltage is compared to the corresponding voltage from the 3 phase arrangement on the other side of the circuit-breaker. Voltage settings are selected as a percentage of the nominal voltage specified in the **CT/VT Config** menu. The phase selection is made by changing the **Sync Voltages** in the 25 menu.

Voltage monitoring elements

Parameter: **Gn Dead Line**

- Default setting: **20 %**

Parameter: **Gn Live Line**

- Default setting: **90 %**

Parameter: **Gn Dead Bus**

- Default setting: **20 %**

Parameter: **Gn Live Bus**

- Default setting: **90 %**

Voltage detectors determine the status of the line or bus. If the voltages on either the line or bus are below a set threshold level they can be considered to be **Dead**. If the voltages are within a setting band around the nominal voltage they are classed as **Live**. Independent voltage detectors are provided for both line and bus. In addition to the live and dead status, closing can be blocked for undervoltage level on either side of the circuit-breaker for excessive differential voltage when both sides are in the **Live** state.

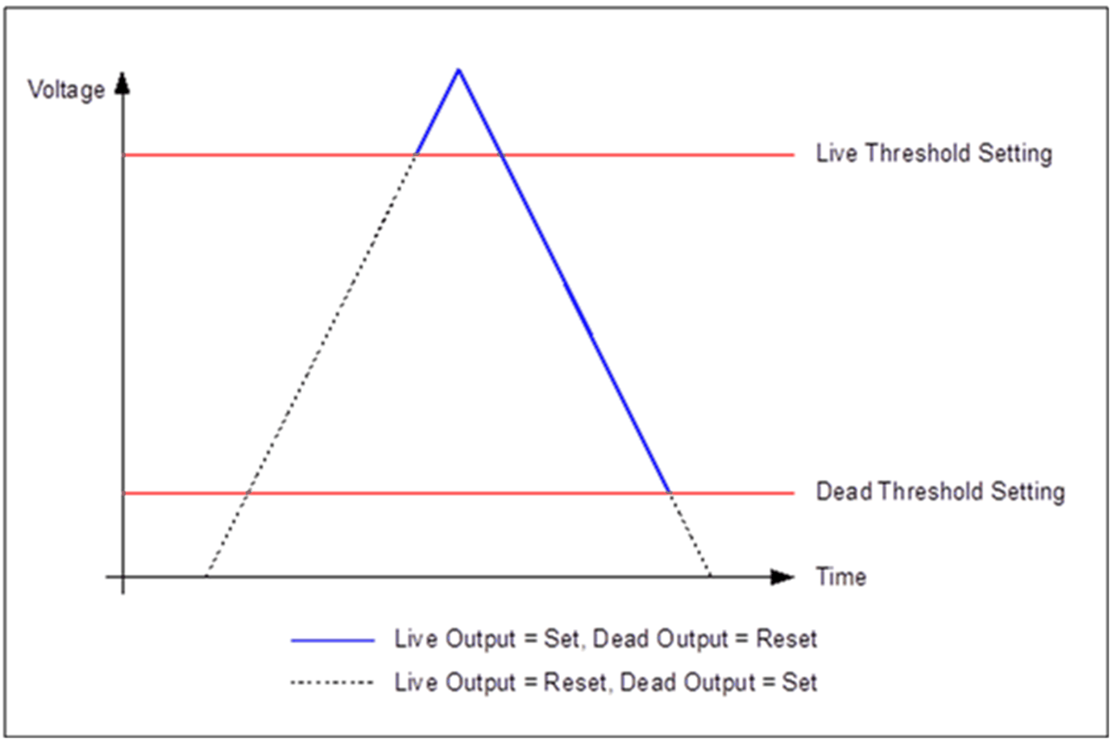
2 options are provided for determining the live or dead status of the line and bus voltages and the options can behave differently when the voltages are at an intermediate voltage level. The selection is made by changing the **VT Level Mode** in the **Voltage Setting** menu. The 2 options are as follows:

Parameter: **`Gn VT Level Mode`**

- Default setting: **`2 State`**

  VT Level Mode: 2 State

  In this mode, if a voltage is initially at or below the **`Dead`** setting then it will be classed as dead until it has increased and reached the **`Live`** setting and then continues to be live until it has decreased and reached the **`Dead`** setting. This effectively allows for variable amounts of hysteresis to be set. The voltages are always considered to be either live or dead. When voltage is initially applied to the relay it will ramp up and always pass through the dead state first. The user should ensure that the live and dead states do not overlap.



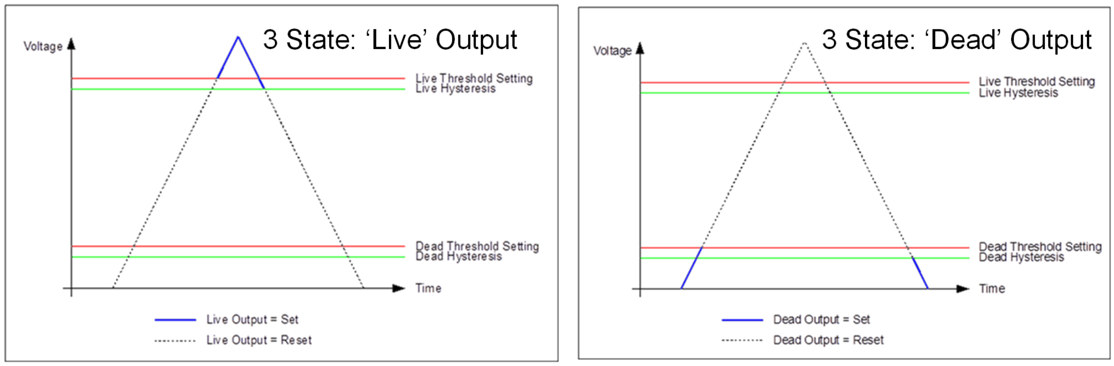
[dw_7SR5_function25ApplicationAndSettingNotes, 1, en_US]

Figure 7-3 VT Level Mode: 2 State

VT Level Mode: 3 State

The line or bus voltages are only classed as live when above the live threshold. When the voltage falls below the live threshold, the live output is reset but the dead output does not set until the voltage falls below the dead threshold. For the indeterminate state, where both live and dead outputs have the same value; both are reset.

In this mode a 3% fixed hysteresis on the element drop-off, minimises ‘chattering’ during voltage fluctua-tions near to the thresholds.



[dw_7SR5_function25ApplicationAndSettingNotes1, 1, en_US]

Figure 7-4 VT Level Mode: 3 State

Parameter: **Gn Line UV**

- Default setting: **Disabled**

Parameter: **Gn Line UV Volts**

- Default setting: **90 %**

Parameter: **Gn Bus UV**

- Default setting: **Disabled**

Parameter: **Gn Bus UV Volts**

- Default setting: **90 %**
  The undervoltage detectors, if enabled by the **Line UV** and **Bus UV** settings, will block a close output command from **Manual Close** control or **autoreclose**. If either the line voltage is below the **Line UV Volts** setting value or the bus voltage is below the **Bus UV Volts** setting value, closing will be blocked. Both line and bus have their own independent settings and are applied to the selected single phase voltage inputs.

Parameter: **Gn Voltage Diff**

- Default setting: **Disabled**

Parameter: **Gn Voltage Diff Volts**

- Default setting: **10 %**
  The differential voltage detector, if enabled by the **Voltage Diff** setting, can block a close output command from **Manual Close** control or **autoreclose** if the difference between the line and bus voltages is greater than the **Voltage Diff Volts** setting value when both sides are live.

Reclosure modes

The synchronizing element can be set to allow manual close operations and autoreclose sequences to proceed for various system voltage conditions. The voltage conditions are checked at the **Close Inhbit** state which follows the **Autoreclose Deadtime**.

The voltage conditions selected must be met within the **Check Sync Timeout Window** time if this is enabled. This time is settable and starts at the receipt of a **Close CB** command for **Manual Close**.

The voltage applied to the V4 input is considered to be the busbar voltage and the single phase voltage selected from voltages applied to inputs V1,V2 & V3 are the line voltage.

Synchronizing Check settings apply only if both line and bus are live. Reclosure modes provide additional close options for when one or both sides are dead. Separate settings are provided for **Manual Close** and **Autoreclose** options.

NOTE

All modes are set to **Disabled** by default for safety and any mode required must be enabled in settings therefore the close command will not be issued with device default setting configuration.

Parameter: **Gn Manual Close Dead Bar Charge**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Manual Close** to proceed when the line voltage is live and the busbar is dead.

Parameter: **Gn Manual Close Dead Line Charge**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Manual Close** to proceed when the busbar voltage is live and the line is dead.

Parameter: **Gn Manual Close Dead Line & Dead Bar**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Manual Close** to proceed when the line voltage and the busbar voltage are dead.

Parameter: **Gn Manual Close Check Sync**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Manual Close** to proceed when both the line and busbar are considered live and other synchronizing requirements are met.

Parameter: **Gn Unconditional Manual Close**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Manual Close** to proceed regardless of the voltage condition of the bus or Lline. This option will override other **Manual Close** options.

Parameter: **Gn 79 Dead Bar Charge**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Autoreclose** to proceed when the line voltage is live and the busbar is dead.

Parameter: **Gn 79 Dead Line Charge**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Autoreclose** to proceed when the busbar voltage is live and the line is dead.

Parameter: **Gn 79 Dead Line & Dead Bar Close**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Autoreclose** to proceed when the line voltage and the busbar voltage are dead.

Parameter: **Gn 79 Check Sync Close**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Autoreclose** to proceed when both the line and busbar are considered live and other synchronizing requirements are met.

Parameter: **Gn 79 Unconditional Close**

- Default setting: **Disabled**
  When set to **Enabled**, allows **Autoreclose** to proceed regardless of the voltage condition of the bus or line. This option will override other **Autoreclose** options.

Parameter: **Gn 79 DLC Delay**

- Default setting: **0 s**

Parameter: **Gn 79 DBC Delay**

- Default setting: **0 s**
  Separate autoreclose delay settings are provided for **Dead Line Charge** and **Dead Bus Charge** closure by the **79 DLC Delay** and **79 DBC Delay** settings. These are applied after the autoreclose dead time when voltage conditions are checked and met, at the **Close Inhibit** stage of the sequence. This feature effectively allows the dead time to be set differently for faults on each side of the circuit-breaker to allow correct sequence closing to be applied.

Parameter: **Gn Check Sync during Dead Time**

- Default setting: **Disabled**
  This feature allows the dead time to be truncated if the voltage is restored before the dead time has expired. This option can be used to detect that the remote circuit-breaker has successfully closed DLC and restored voltage to the line before the dead time has expired and the autoreclose sequence can proceed after checking that synchronizing conditions are met.

Synchronizing override

The **Man Override Sync** input is provided to bypass the voltage and synchronizing checks to provide an emergency close function. Similarly, check synchronizing can be overridden by the **79 Override Sync** input during autoreclose. Override can be set by binary inputs, control commands and the function keys.

Check synchronizing mode

For the relay to issue a **Check Sync Close** a CB close must be initiated by a **Manual CB Close** command or an autoreclose sequence in progress and the following conditions which are configured by settings have to be met:

Parameter: **Gn Check Sync**

- Default setting: **Enabled**
  This setting must be set to **Enabled** for the device to issue a **Check Sync Close**.

Parameter: **Gn Check Sync Timer**

- Default setting: **2 s**

  The synchronizing conditions must be met for the duration of this time i.e. the phase angle and voltage blocking features have to be within their parameters for the length of the slip timer setting. If either the phase angle, the slip or the voltage elements fall outside of their limits the timer is immediately reset and must begin again if they subsequently come back inside of all limits. (This ensures that a close output will not be given if there is a transient disturbance on the system due to e.g. some remote switching operations). The line and bus voltages must both be considered live. This timer can be set to zero.

Parameter: **Gn Check Sync Angle**

- Default setting: **20°**

  The phase difference between the line and bus voltages has to be less than the phase angle setting value. Whilst within the limits the phase angle can be increasing or decreasing and the element will still issue a valid close signal. This condition parameter cannot be disabled but can be set to a value of up to 90° which will always be met except in the case of seriously abnormal network conditions.

Parameter: **Gn Check Sync Slip**

- Default setting: **Enabled**

  This setting can be disabled so that the frequency is ignored and only phase angle is considered as a parameter for **Synchronizing Check**.

Parameter: **Gn Check Sync Slip Freq**

- Default setting: **0.050 Hz**

  The frequency difference between line and bus has to be less than the slip frequency setting value.

Parameter: **Gn Line Undervolts**

- Default setting: **Disabled**

  If this setting is enabled the line voltage must be above the setting as well as being considered live for **Synchronizing Check** to proceed.

Parameter: **Gn Line Undervolts Volts**

- Default setting: **90 %**

  The line voltage has to be above the line undervoltage setting value and also above 5 V for an output to be given if **25 Line Undervolts** is enabled.

Parameter: **Gn Bus Undervolts**

- Default setting: **Disabled**

  If this setting is enabled the bus voltage must be above the setting as well as being considered live for **Synchronizing Check** to proceed.

Parameter: **Gn Bus Undervolts Volts**

- Default setting: **90 %**

  The bus voltage has to be above the bus undervoltage setting value and also above 5 V for an output to be given if **25 Bus Undervolts** is enabled.

Parameter: **Gn Volts Diff**

- Default setting: **Disabled**
  If this setting is enabled the difference between the line voltage and bus voltage must be less than the setting as well as being considered live on both sides for **Synchronizing Check** to proceed.

Parameter: **Gn Volts Diff Volts**

- Default setting: **10 %**
  The difference between the line and bus voltages has to be less than the differential voltage detector setting value for an output to be given if **25 Volts Diff** is enabled.

When **Close Inhibit** state is reached or a **Manual Close** is initiated with both voltages live, the synchronizing is started in the **Check Synchronizing** mode of operation. The **CS in Progress** output is raised and the **Check Synchronizing** limits are applied. To change to **System Synchronization** a system split must be detected.

System split detector

A system split occurs where part of the system becomes islanded and operates separately. Under these conditions the frequencies of the voltages either side of the breaker are asynchronous and therefore high phase angle differences will occur as the voltage phasors slip past each other.

The decision to change synchronizing settings when a system split is detected during autoreclose and manual closing is set separately for **Manual Close** and **autoreclose**.

When a system split has been detected the settings can be changed to system split settings which can be different to **Check Synchronising** parameters. Apply the **Close on Zero** function, stop the closing sequence and raise **Lockout** or ignore the split and continue to operate with **Check Synch** settings after raising the system split output.

The system split condition is detected when either the measured phase difference angle exceeds the preset **25 System Split Angle** value or if the slip frequency exceeds a preset **25 System Split Slip** rate based on the selection of **25 System Split Mode** setting.

NOTE

The system split setting is an absolute value and a split will occur regardless of the direction of the slip e.g. if an angle of 170° is selected, then starting from 0°, a split will occur at +170° or -170° i.e.+190°. This will generally be achieved quickly during the first slip revolution during a split condition. If a system split occurs during an autoreclose **Check Sync** operation, with **25 System Sync** set to **Enabled**, the following events occur:

A **System Split** event is recorded.

- If the **25 DAR Split Mode** is set to **Check Sync**, check synchronizing will continue.
- If the **25 DAR Split Mode** setting has been set to **System Sync**, the system sync function is started.

Parameter: **Gn MC Split Mode**

- Default setting: **Check Sync**

  This setting specifies the synchronizing check parameters to use when a system split is detected during a **Manual Close** operation. If a system split occurs during a **Manual Close Check Sync** operation, with **25 System Sync** set to **Enabled**, the following events occur:

  A System Split event is recorded.

  – If the **25 MC Split Mode** is set to **Check Sync**, check synchronizing will continue using existing settings.

  – If the **25 MC Split Mode** setting has been set to **System Sync**, the **System Sync** function is started. The **25 SS In Progress** can be mapped to an output relay or LED for alarm indication.

  – If the **25 MC Split Mode** setting has been set to **Close On Zero**, the **Close On Zero** function is started. The **25 COZ In Progress** can be mapped to an output relay or LED for alarm indication.

Parameter: **Gn DAR Split Mode**

- Default setting: **Check Sync**

  This setting specifies the synchronizing check parameters to use when a system split is detected. If the **25 DAR Split Mode** setting has been set to **System Sync**, the **System Sync** function is started. The **25 SS In Progress** can be mapped to an output relay or LED for monitoring during testing or for alarm indication.

  If the **25 DAR Split Mode** setting has been set to **Close On Zero**, the **Close On Zero** function is started. The **25 COZ In Progress** can be mapped to an output relay or LED for alarm indication. If the **25 DAR Split Mode** has been set to **Lockout**, then, a **25 System Split LO** output is given which can be mapped to an output relay or LED for alarm indication. The relay will stay in the lockout state until reset. during an autoreclose operation. The **Check Sync** option will allow the limits to continue unchanged.

System synchronizing mode

For the relay to issue a **System Sync Close** both the bus and line voltages must be considered live by the voltage monitoring elements and the differential voltage must be below setting. The **System Synchronizing** operation of the relay will only be started after a **System Split** is detected as described previously during an autoreclose or manual close sequence. The operation is controlled by the following parameters.

Parameter: **Gn System Sync**

- Default setting: **Enabled**

  This setting allows the **System Syncronizing** function to execute. This setting must be enabled if the **System Sync** function is required for **Manual Close** or **autoreclose** operations.

Parameter: **Gn System Sync Angle**

- Default setting: **10°**

  The phase difference between the line and bus voltages has to be less than the phase angle setting value and the phase angle has to be decreasing before the element will issue a valid close signal or raise the **In Synch** signal.

Parameter: **Gn System Sync Slip**

- Default setting: **Enabled**

Parameter: **Gn System Sync Slip Freq**

- Default setting: **0.125 Hz**
  The frequency difference between line and bus has to be less than the slip frequency setting value. Slip frequency must be above the **25 Split Slip** setting to avoid reversion to check synchronizing conditions. The settings for **25 System Sync Slip** and **25 Split Slip** must differ by at least 20 mHz.

Parameter: **Gn System Sync Slip Timer**

- Default setting: **0.2 s**
  The phase angle and voltage blocking features have to be within their parameters for the length of the slip timer setting. If either the phase angle or the voltage elements fall outside of their limits the slip timer is reset. If they subsequently come back in then the slip timer has to time out before an output is given. (This ensures that a close output will not be given if there is a transient disturbance on the system due to e.g. some remote switching operations).

Close on zero mode

If the **25 DAR Split Mode** or **25 MC Split Mode** is set to **Close On Zero** the relay will apply a **Close On Zero** to the respective closing operation if the synchronizing mode changes due to a detection of system split. The measured slip frequency and the measured phase difference are used to provide a **Close Pulse** which will close the CB when the phase difference is reducing and timed with the setting **25 CB Close Time** such that the instant of closure is when the phase difference is zero. The slip frequency must be less than the **25 COZ Slip Freq** but greater than the **25 Split Slip** setting to avoid reversion to check synchronizing conditions.

Since this feature is part of the system synchronizing function, **25 System Sync** must also be set to **Enabled**.

Parameter: **GnClose On Zero**

- Default setting: **Enabled**

Parameter: **GnClose On Zero Slip**

- Default setting: **0.125 Hz**
  The frequency difference between line and bus has to be less than the slip frequency setting value. Slip frequency must be above the **25 Split Slip** setting to avoid reversion to check synchronizing conditions. The settings for **25 Close On Zero Slip** and **25 Split Slip** must differ by at least 20 mHz.

Parameter: **Gn Circuit Breaker Close Time**

- Default setting: **60 ms**
  This is the time that is applied as compensation to ensure that the closure of the circuit-breaker contacts occurs at the point of zero phase difference.

System sync reset

If the close conditions of **System Sync** are not met and a zero slip condition is subsequently detected, by the slip falling below the **25 Split Slip** setting, the relay will exit from system sync mode and revert to check synchronizing mode. The reversion allows the device to use the **Check Sync** parameters which are typically wider, to allow a close following the restoration of normal operation when the islanded network has been reconnected to the main network by successful reclosure of a parallel connection.

Settings Example

The check synch function can be used to apply voltage checks even if differential voltage, phase angle and slip frequency check parameters are not required for the application. This can achieve a controlled sequence of closing for systems that can be supplied from both ends such as parallel feeders, ring networks or networks which can be backfed.

Settings can be selected to allow autoreclose operations to proceed only under certain combinations of voltage conditions, live on one side, the other side, both sides or neither. These options are set separately for autoreclose and **`Manual Close`** conditions which are typically set to be less restrictive. Manual close is typically allowed under all conditions as it is the responsibility of the operator. Check synch parameters are then applied if both sides are live as a safety check that the system is in a normal condition. Autoreclose options are selected to suit network arrangements to provide the desired sequence of restoration if more than one circuit-breaker trips for a fault in an interconnected network.

Settings can be selected such that following the autoreclose deadtime(s) after a trip at both ends of a faulted circuit, autoreclose will proceed from one end first as a **`Dead Line Charge`** followed by a check sync close at the other end when voltage is restored to the line. In addition, delays can be applied to **`Dead Line Charge`** and **`Dead Bar Charge`** to effectively provide extended deadtimes for different conditions or provide a reversion to **`Dead Line Charge`** at the second end if the first end fails to close.

If specific limits for phase angle difference are not required, a large value of 90° can be selected which will not affect operation as this condition will always be met.

`Check Sync Timer` is the minimum time for which check sync conditions must be met before a close is issued when both sides are live. This was traditionally used to check for slip frequency conditions but can also be used to allow for transient conditions following a remote **`Dead Line Charge`**, including allowing for protection operation at the remote end. If closing is required during slip conditions, setting of this timer must consider that the voltages must remain inside of the check sync angle window with the maximum required slip frequency applied.

System sync is used to check conditions are within limits for an islanded system condition and are not generally used for standard distribution applications, particularly for autoreclose.

Close on zero can be a preferred method for connecting islanded generation but is not required for standard distribution applications.

7.2.5 Settings Menu

Functions > Control > 25						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Sync Voltages	Van, Vbn, Vcn, Vab, Vbc, Vca	Van				
VT Level Mode	2 State, 3 State	2 State				
Dead Line	0 to 150 %, Δ 1 %	20 %				
Live Line	0 to 150 %, Δ 1 %	90 %				
Dead Bus	0 to 150 %, Δ 1 %	20 %				
Live Bus	0 to 150 %, Δ 1 %	90 %				
Line UV	Enabled Disabled	Enabled				
Line UV Volts	0 to 150 %, Δ 1 %	90 %				
Bus UV	Enabled Disabled	Enabled				
Bus UV Volts	0 to 150 %, Δ 1 %	90 %				
Voltage Diff	Enabled Disabled	Enabled				
Volt Diff Volts	0 to 100 %, Δ 1 %	10 %				
Check Sync	Enabled Disabled	Enabled				
Check Sync Angle	0 to 90°, Δ 1 %	20°				

Functions > Control > 25						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Check Sync Slip	Enabled Disabled	Enabled				
Check Sync Slip Freq	0 to 2 Hz, Δ 0.01 Hz	0.05 Hz				
Check Sync Timer	0 to 100 s, Δ 0.01 s	2 s				
System Split Mode	Phase, Slip	Phase				
System Split Angle	0 to 180°, Δ 1°	175°				
System Split Slip Freq	0 to 2 Hz, Δ 0.01 Hz	0.02 Hz				
System Sync	Enabled Disabled	Enabled				
System Sync Angle	1 to 90°, Δ 1°	10°				
System Sync Slip Freq	0 to 2 Hz, Δ 0.005 Hz	0.125 Hz				
System Sync Timer	0 to 100 s, Δ 0.01 s	0.2 s				
Close On Zero	Enabled Disabled	Enabled				
Close On Zero Slip Freq	0 to 2 Hz, Δ 0.005 Hz	0.125 Hz				
Circuit Breaker Close Time	0 to 900 ms, Δ 1 ms	60 ms				
DAR Split Mode	Check Sync, System Sync, Close On Zero, Lockout	CS				
MC Split Mode	Check Sync, System Sync, Close On Zero	CS				
Sync Close Timeout	Enabled Disabled	Enabled				
Sync Close Timeout Window	0 to 1200 s, Δ 1 s	60 s				

Functions > Control > 52 > CB-1						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Manual Close Dead Bar Charge	Enabled Disabled	Disabled				
Manual Close Dead Line Charge	Enabled Disabled	Disabled				
Manual Close Dead Line & Dead Bar	Enabled Disabled	Disabled				
Manual Close Check Sync	Enabled Disabled	Disabled				
Unconditional Manual Close	Enabled Disabled	Disabled				

Functions > Control > 79 > 79 Common						
Parameter	Range	Settings				
		Default	Gn1	Gn2	Gn3	Gn4
Dead Bar Charge	Enabled Disabled	Disabled				
Dead Line Charge	Enabled Disabled	Disabled				

Functions > Control > 79 > 79 Common						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Dead Line & Dead Bar Close	Enabled Disabled	Disabled				
Check Sync Close	Enabled Disabled	Disabled				
Unconditional Close	Enabled Disabled	Disabled				
Dead Line Charge Delay	0 to 60	0 s				
Dead Bar Charge Delay	0 to 60	0 s				
Live Line Check	Enabled Disabled	Disabled				
Check Sync During Dead-time	Enabled Disabled	Disabled				

7.2.6 IEC 61850 Functional Information Mapping

A25SYN1*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A25SYN1*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A25SYN1

A25RSYN1.Mod

Information	
Reset Device	x
A25RSYN1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A25RSYN1.Health

Information		
Protection Healthy	0	1
A25RSYN1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A25RSYN1.Rel

Information		
In Sync	0	1
A25RSYN1.Rel.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A25RSYN1.VInd

A25RSYN1.AngInd

Information		
Voltage Diff exceded	0	1
A25RSYN1.VInd.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Information		
Phase Diff exceded	0	1
A25RSYN1.AngInd.stVal	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A25RSYN1.HzInd

Information		
Slip Frequency exceded	0	1
A25RSYN1.HzInd.stVal	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A25RSYN1.SynPrg

Information		
Sync In Progress	0	1
A25RSYN1.SynPrg.stVal	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	TRUE: 1 FALSE: 0

A25RSYN1.DifVClc

Information	**Value**		
Voltage Difference	A25RSYN1.DifVClc.mag.f	Measured Value	Value
	A25RSYN1.DifVClc.units.SI unit	1	x Nominal
	A25RSYN1.DifVClc.units. multiplier	0	

A25RSYN1.DifAngClc

Information	Value		
Angle Difference	A25RSYN1.DifAngClc.mag.f	Measured Value	Value
	A25RSYN1.DifAngClc.units.SIunit	9	deg
	A25RSYN1.DifAngClc.units.multiplier	0	

A25RSYN1.DifHzClc

Information	Value		
Frequency Difference	A25RSYN1.DifHzClc.mag.f	Measured Value	Value
	A25RSYN1.DifHzClc.units.SIunit	33	Hz
	A25RSYN1.DifHzClc.units.multiplier	0	

7.2.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
79 Override Sync		79 Override Sync	Input	Y	Y	Y
Ext Start 25 Sync		Ext Start 25 Sync	Input	Y	Y	Y
Reset 25 Sync		Reset 25 Sync	Input	Y	Y	Y
Start 25 System Sync		Start 25 System Sync	Input	Y	Y	Y
25 Live Line		25 Live Line	Output	Y	Y	Y
25 Live Bus		25 Live Bus	Output	Y	Y	Y
25 Line U/V		25 Line U/V		Y	Y	Y
25 Bus U/V		25 Bus U/V		Y	Y	Y
25 Voltage Dif >		25 Voltage Dif >		Y	Y	Y
25 CS Slip Freq >		25 CS Slip Freq >		Y	Y	Y
25 System Split		25 System Split		Y	Y	Y
25 SS Slip Freq >		25 SS Slip Freq >		Y	Y	Y
25 COZ Slip Freq >		25 COZ Slip Freq >		Y	Y	Y
25 In Sync		25 In Sync	Output	Y	Y	Y
25 CS In Progress		25 CS In Progress	Output	Y	Y	Y
25 SS In Progress		25 SS In Progress	Output	Y	Y	Y
25 COZ In Progress		25 COZ In Progress	Output	Y	Y	Y
25 System Split LO		25 System Split LO	Output	Y	Y	Y
25 Check Sync		25 Check Sync		Y	Y	Y
25 System Sync		25 System Sync		Y	Y	Y
25 Close On Zero		25 Close On Zero		Y	Y	Y
25 Dead Line		25 Dead Line	Output	Y	Y	Y
25 Dead Bus		25 Dead Bus	Output	Y	Y	Y
Man Override Sync		Man Override Sync	Input	Y	Y	Y
Dead Bus Close		Dead Bus Close		Y	Y	Y

Input/Output Matrix	**General Pickup**	**User Logic**	**Type**	**IEC 60870-5-103**	**DNP3**	**MODBUS RTU**
Dead Line Close		Dead Line Close		Y	Y	Y
		25 Check Sync Operated	Output	Y	Y	Y
		25 System Sync Operated	Output	Y	Y	Y
		25 Close on Zero Operated	Output	Y	Y	Y
		Dead Line Close Operated	Output	Y	Y	Y
		Dead Bus Close Operated	Output	Y	Y	Y
79 Override Sync		79 Override Sync	Output	Y	Y	Y
25 Phase Diff		25 Phase Diff	Value	Y	Y	Y
25 Slip Freq		25 Slip Freq	Value	Y	Y	Y
25 Voltage Diff		25 Voltage Diff	Value	Y	Y	Y

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

7.3 52 Circuit-Breaker Control

7.3.1 Overview of Function

The CB control function is used to configure:

- CB open/close control and monitoring of the CB open/close status
- CB operations (maintenance) counters and alarm targets
- CB wear (I^2t) counters and alarm targets

7.3.2 Structure of the Function

The CB control function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

This function corresponds to the logical node **Q0XCBR*** in IEC 61850.

The CB control uses select before operate with enhanced security.

The CB control and monitoring function is configured in 3 stages:

- The CB control and status monitoring parameters are defined
- CB operations counters and counter target settings are entered
- Parameters to define the CB wear (I^2t) monitoring are entered

A **Manual Close** command can be initiated in one of 3 ways:

- Via a Close CB binary input
- Via the data communication channel(s)
- From the relay **Control Mode** menu

It causes an instantaneous operation via **Manual Close** CB binary output.

If 25 Synchrocheck is installed, options for **Manual Close** voltage checks are automatically introduced into the 52 function. See *7.2 25 Synchrocheck – Synchronizing Function*.

Options must be configured within the 52 function to allow manual close to proceed depending on different voltage conditions of dead on both sides and live on one or both sides. An **Uncondional Manual Close** setting is available that will override the 25 function voltage checks.

Repeated manual closes are avoided by checking for positive edge triggers. Even if the **Manual Close** input is constantly energized the relay will only attempt 1 close.

A **Manual Close** will initiate switch-onto-fault protection if 50SOTF is enabled. If a fault appears on the line during the **Close Pulse** or during the **Reclaim Time** with **Line Check** enabled, the relay will initiate a trip and **Lock-out**. This prevents a CB being repeatedly closed onto a faulted line. Where **Line Check Trip = Delayed** then instantaneous protection is inhibited until the reclaim time has elapsed.

Manual Close resets **Lockout**, if the conditions that caused **Lockout** have reset, i.e. there is no trip or **Lockout** input present.

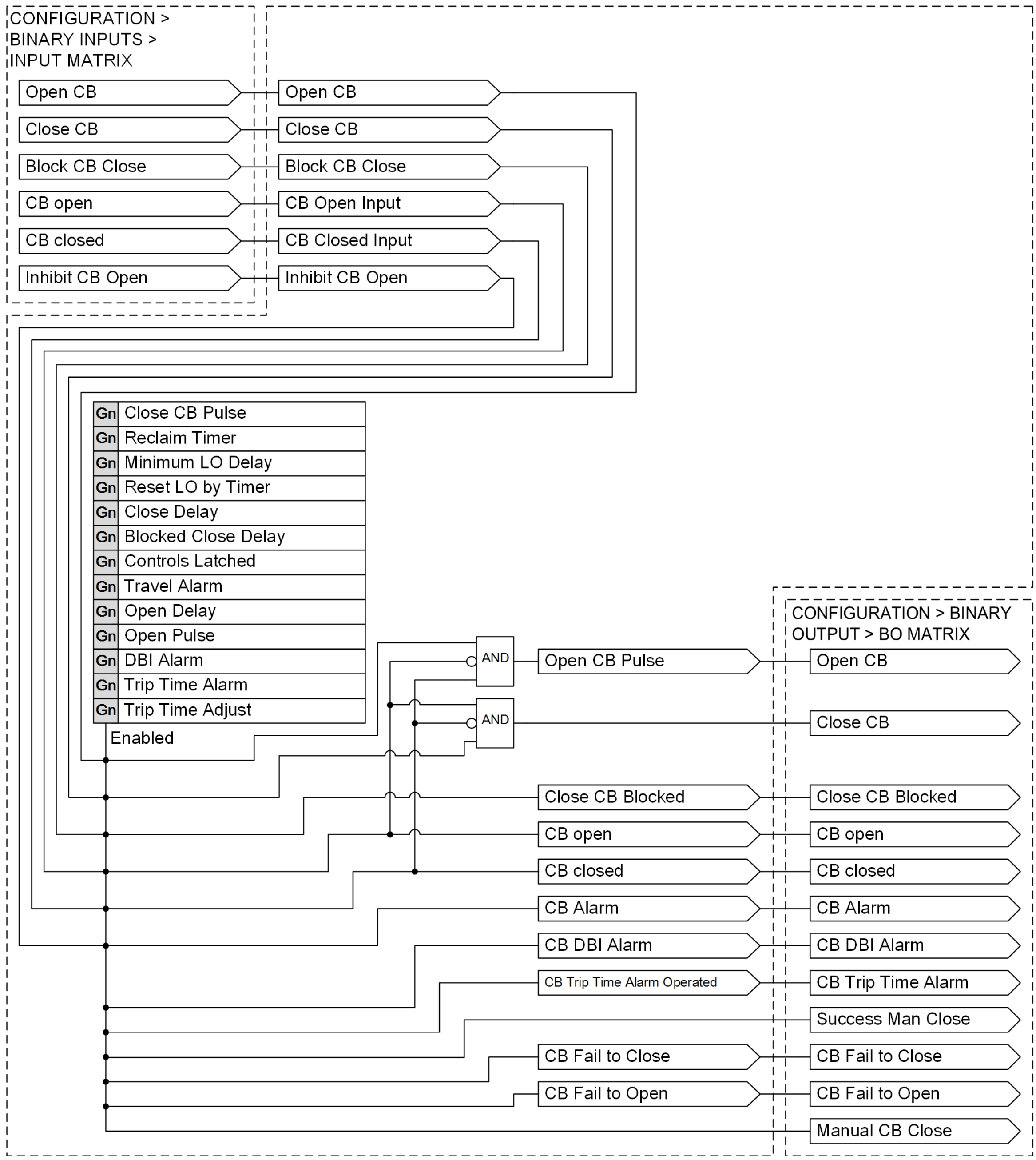
Manual Close cannot proceed if there is a **Lockout** input present.

With the autoreclose function set to **Disabled** the **Manual Close** control is still active.

The I^2t counter can provide an estimation of contact wear and maintenance requirements. The algorithm works on a per phase basis, measuring the arcing current during faults. The I^2t value at the time of trip is added to the previously stored value and an alarm is given when any 1 of the 3 phase running counts exceeds the set alarm limit . The t value is the time between CB contacts separation when an arc is formed, **Separation Time**, and the **CB Clearance** time.

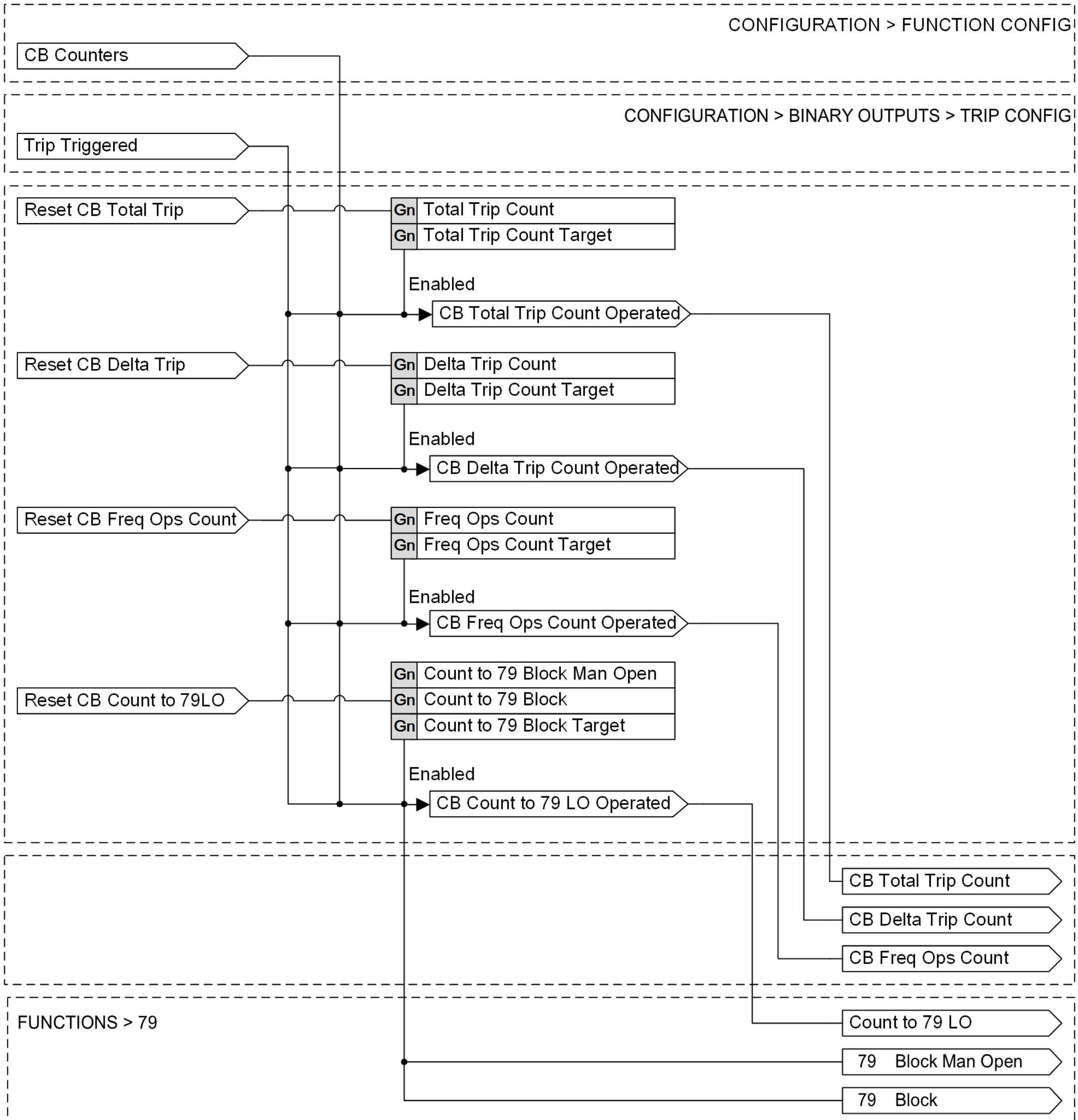
The I^2t value can also triggered and reset from a binary input or command.

7.3.3 Logic of the Function



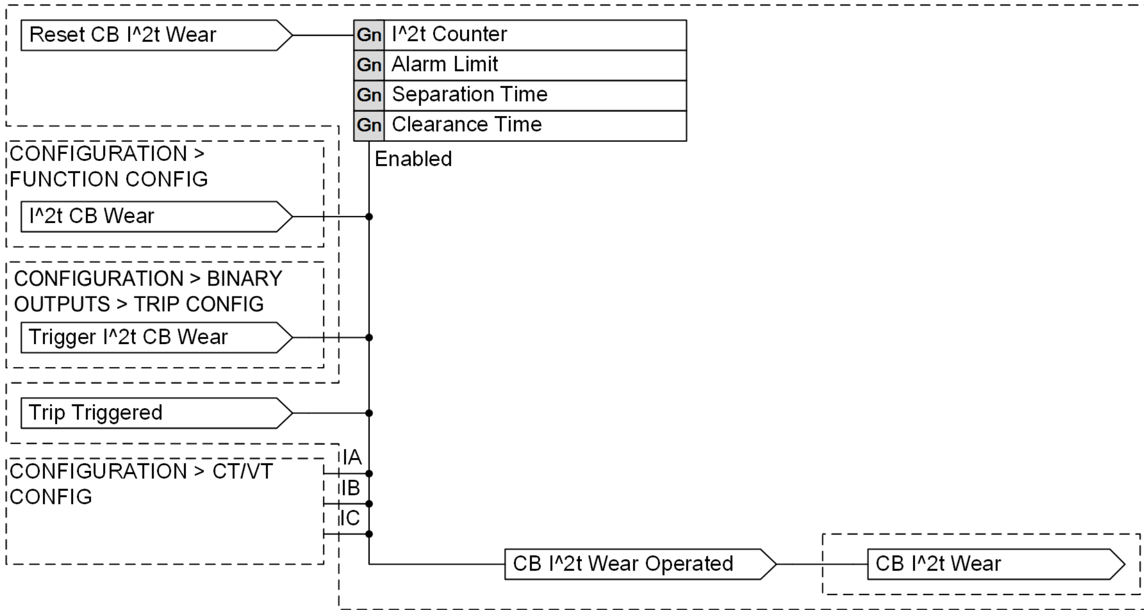
[lo_7SR5_52CBStatuslogicdiagram, 2, en_US]

Figure 7-5 Logic Diagram: 52 Circuit-Breaker Control Status



[lo_7SR5_52CBCounterslogicdiagram, 2, en_US]

Figure 7-6 Logic Diagram: 52 Circuit-Breaker Control Counters



[lo_7SR5_52I2tlogicdiagram, 2, en_US]

Figure 7-7 Logic Diagram: 52 Circuit-Breaker Control I^2t Counters

7.3.4 Application and Setting Notes

Parameter: **CB-n > Close CB Pulse**

- Default setting: **2 s**

Parameter: **CB-n > Reclaim Timer**

- Default setting: **2 s**

  Following CB close the reclaim time is started. If a trip occurs during this time the autoreclose will increment the shot number, return to sequence in progress or lockout if it is the final shot of the sequence. If the reclaim timer expires without a protection trip the relay will raise **79 Successful AR** and return to **In Service**. If a further trip occurs after completion of the reclaim, it is considered to be a new sequence which is started from the beginning.

Parameter: **CB-n > Minimum LO Delay**

- Default setting: **2 s**

Parameter: **CB-n > Reset LO by Timer**

- Default setting: **Enabled**

Parameter: **CB-n > Close Delay**

- Default setting: **10 s**

  The close output is raised after the control command has been raised and after elapse of this time delay. The **Close CB Delay** is applicable to manual CB close commands received through a **Close CB** binary input or via the **Control** menu. Operation of the **Manual Close** CB binary output is delayed by the **Close CB Delay** setting. The status of this delay is displayed on the relay fascia as it decrements towards zero. Only when the delay reaches zero will the close command be issued and related functionality initiated.

Parameter: **CB-n > Blocked Close Delay**

- Default setting: **5 s**

  The close command may be delayed by a **Block Close** CB signal applied to a binary input. This causes the feature to pause before it issues the CB close command and can be used, for example, to delay CB closure until the CB energy has reached an acceptable level. If the block signal has not been removed before the end of the defined time, **Blocked Close Delay**, the relay will go to the lockout state. The output **Close CB Blocked** indicates this condition.

Parameter: **CB-n > Controls Latched**

- Default setting: **Latch**

  CB controls for manually closing and tripping can be latched for extra security.

  With reset operation, the control resets when the binary input drops off. This can lead to multiple control restarts due to bounce on the binary input signal.

  With latch operation, the close or trip sequence always continues to completion (or sequence failure) and bounce on the binary input is ignored.

  Reset operation can be useful, however, as it allows a close or trip sequence to be aborted by dropping off the binary input signal.

Parameter: **CB-n > Travel Alarm**

- Default setting: **1 s**

  The **CB Open** and **CB Closed** binary inputs are continually monitored to track the **CB Status**.

  The CB should only ever be in 3 states:

CB Status	CB Open Binary Input	CB Closed Binary Input
CB is Open	1	0
CB is Closed	0	1
CB is traveling between the above 2 states	0	0

The relay goes to **Lockout** and the **CB Alarm** output is given where the traveling condition exists for longer than the **CB Travel Alarm** setting.

An instantaneous **CB Alarm** is given for a 1/1 state, i.e. where the CB indicates it is both open and closed at the same time.

Parameter: **CB-n > Open Delay**

- Default setting: **10 s**

  The **Open CB Delay** setting is applicable to CB trip commands received through an **Open CB** binary input or via the **Control** menu. Operation of the **Open CB** binary output is delayed by the **Open CB Delay** setting. The status of this delay is displayed on the relay fascia as it decrements towards zero. Only when the delay reaches zero will the trip command be issued and related functionality initiated.

  Note that a CB trip initiated by an **Open CB** control is fundamentally different from a CB trip initiated by a protection function. A CB trip caused by a **CB Open** command will not initiate functionality such as circuit-breaker fail, fault data storage, I^2t measurement and operation counter.

Parameter: **CB-n > Open Pulse**

- Default setting: **1 s**

  The duration of the CB open pulse is user settable to allow a range of CBs to be used.

  The CB open pulse must be long enough for the CB to physically open.

Parameter: **CB-n > DBI Alarm**

- Default setting: **0 s**

  The **CB Open** and **CB Closed** binary inputs are continually monitored to track the **CB Status**.

  A "Don't Believe it" (DBI) condition exists for a 1/1 state, i.e. where the CB indicates it is both open and closed at the same time.

  The relay goes to **Lockout** and the **CB Alarm** output is given where the DBI condition exists for longer than the **CB DBI Delay** setting.

Parameter: **CB-n > Trip Time Alarm**

- Default setting: **0.2 s**

  The **CB Trip Time** meter displays the measured time between the trip being issued and the CB auxiliary contacts changing state. If this measured time exceeds the **Trip Time Alarm** time, a **Trip Time Alarm** output is issued.

Parameter: **CB-n > Trip Time Adjust**

- Default setting: **0.015 s**

  This allows for the internal delays caused by the relay, especially the delay before a binary input operates, to be subtracted from the measured CB trip time. This gives a more accurate measurement of the time it took for the CB to actually trip.

Parameter: **CB-1 > Unconditional Manual Close**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed. When Enabled this allows Manual Close to proceed for any voltage conditions of Live and Dead and overrides the options below.

Parameter: **CB-1 > Manual Close Dead Bar Charge**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed. When Enabled this allows Manual Close to proceed when the Line side is live and the busbar side is dead. Parameters for the Live/Dead assessment are specified within the 25 function.

Parameter: **CB-1 > Manual Close Dead Line Charge**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed. When Enabled this allows Manual Close to proceed when the Line side is dead and the busbar side is live. Parameters for the Live/Dead assessment are specified within the 25 function.

Parameter: **CB-1 > Manual Close Dead Line and Dead Bar**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed. When Enabled this allows Manual Close to proceed when the both Line and Busbar are dead. Parameters for the Live/Dead assessment are specified within the 25 function.

Parameter: **CB-1 > Manual Close Check Sync**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed. When Enabled the 25 Sychronising settings must be met to allow Manual Close to proceed when both sides are live. Parameters for the Live/ Dead assessment are specified within the 25 function.

Parameter: **CB-n Counters > Total Trip Count Target**

- Default setting: **100**

  Increments on each trip command issued.

Parameter: **CB-n Counters > Delta Trip Count Target**

- Default setting: **100**

  Additional counter which can be reset independently of the **Total Trip Counter**. This can be used, for example, for recording trip operations between visits to a substation.

Parameter: **CB-n Counters > Frequent Ops Count Target**

- Default setting: **10**

  Logs the number of trip operations in a rolling window period of 1 hour. An input is available to reset this counter.

Parameter: **CB-n Counters > CB Count to 79 Block Man Open**

- Default setting: **Disabled**

  Selects whether the **CB Count** to **AR Block** is incremented for **Manual Open** operations. If disabled, the **CB Count** to **AR Block** will only increment for protection trip commands.

Parameter: **CB-n Counters > CB Count to 79 Block Target**

- Default setting: **100**

  Displays the number of CB trips experienced by the CB before the AR is blocked. When the target is reached the relay will only do 1 **Delayed Trip** to **Lockout**. An output is available to reset this value.

Parameter: **CB-n I^2T Wear > Alarm Limit**

- Default setting: **10 MA^2 s**

  The I^2t counter provides an estimate of the CB contact wear, from this planned maintenance of the CB can be scheduled. The setting is in primary current so the effect of the CT ratios must be considered.

  The algorithm works on a per phase basis, measuring the CB contact arcing current measured during CB opening to clear the fault. Arcing current flows from the point of contact separation until the fault is cleared. The I^2t value at the time of trip is added to the previously stored value and an alarm is given when any one of the 3 phase running counts exceeds the **Alarm Limit** setting. The value for t is calculated from:

  t = Clearance Time - (Contact) separation time

  See below for the user set values of separation time and clearance time.

  The I^2t value can also triggered and reset from a binary input or command.

Parameter: **CB-n I^2T Wear > Separation Time**

- Default setting: **`0.02 s`**
  The user set value for the (contact) separation time is the time between issue of the trip command and separation of the CB contacts separation. This can be obtained from CB test records.

Parameter: **CB-n I^2T Wear > Clearance Time**

- Default setting: **`0.04 s`**
  The user set value for the clearance time is the time between issue of the trip command and interruption (clearance) of the fault current. This can be obtained from CB test and operational records.

7.3.5 Settings Menu

Configuration > Function config						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
CB Counters	Enabled Disabled	Disabled				
I^2t CB Wear	Enabled Disabled	Disabled				

Functions > Control > 52 > CB-n						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Close CB Pulse		2 s				
Reclaim Timer		2 s				
Minimum LO Delay		2 s				
Reset LO by Timer	Enabled Disabled	Enabled				
Close Delay		10 s				
Blocked Close Delay		5 s				
Controls Latched		Latch				
Travel Alarm		1 s				
Open Delay		10 s				
Open Pulse		1 s				
DBI Alarm		0 s				
Trip Time Alarm		0.2 s				
Trip Time Adjust		0.015 s				

Additional Settings when 25 Synchrocheck is Installed						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Unconditional Manual Close	Enabled Disabled	Disabled				
Manual Close Dead Bar Charge	Enabled Disabled	Disabled				
Manual Close Dead Line Charge	Enabled Disabled	Disabled				

Additional Settings when 25 Synchrocheck is Installed						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Manual Close Dead Line and Dead Bar	Enabled Disabled	Disabled				
Manual Close Check Sync	Enabled Disabled	Disabled				

Functions > Control > 52 > CB-n Counters						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Total Trip Count	Enabled Disabled	Disabled				
Total Trip Count Target		100				
Delta Trip Count	Enabled Disabled	Disabled				
Delta Trip Count Target						
CB Frequent Ops Count	Enabled Disabled	Disabled				
CB Freq Ops Count Target						
CB Count to 79 Block Man Open	Enabled Disabled	Disabled				
CB Count to 79 Block	Enabled Disabled	Disabled				
CB Count to 79 Block Target						

Functions > Control > 52 > CB-n I^2t Wear						
Parameter	**Setting Options**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
I^2t CB Wear	Enabled Disabled	Disabled				
Alarm Limit		10 MA^2 s				
Separation Time						
Clearance Time						

7.3.6 IEC 61850 Functional Information Mapping

Q0XCBR1.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x

Information												
Q0XCBR1.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

Q0XCBR1.Mod

Information	
Reset Device	x
Q0XCBR1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Q0XCBR1.Health

Information		
Device Healthy	0	1
Q0XCBR1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Q0XCBR1.BlkCls

Information		
CB Control Close Block	0	1
Q0XCBR1.BlkCls.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value TRUE: 1
FALSE: 0

Q0XCBR1.BlkOpn

Information		
CB Control Open Block	0	1
Q0XCBR1.BlkOpn.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

Q0XCBR1.BlkOpCnt

Information	Measurand	Value
CB Operations Counter	Q0XCBR1.OpCnt.stVal	0 to 10000

Q0XCBR1.Pos

Information				
CB Status Open	0	1	0	1
CB Status Closed	0	0	1	1
Q0XCBR1.Pos.stVal	**00**	**01**	**10**	**11**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value INTERMEDIATE STATE: 00
OFF: 01
ON: 10
INVALID STATE: 11

Q0XCBR1.SumSwARs1

Information	Measurand	Value
CB Wear PhA	Q0XCBR1. SumSwARs1.stVal	0 to 10000

Q0XCBR1.SumSwARs2

Information	Measurand	Value
CB Wear PhB	Q0XCBR1. SumSwARs2.stVal	0 to 10000

Q0XCBR1.SumSwARs3

Information	Measurand	Value
CB Wear PhC	Q0XCBR1. SumSwARs3.stVal	0 to 10000

Q0CSWI1.Mod

Information	
Reset Device	x
Q0CSWI1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

Q0CSWI1.Health

Information		
Device Healthy	0	1
Q0CSWI1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Q0CSWI1.Pos

Information				
CB Open Status	0	1	0	1
CB Closed Status	0	0	1	1
Q0CSWI1.Pos.stVal	**00**	**01**	**10**	**11**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value INTERMEDIATE STATE: 00
OFF: 01
ON: 10
INVALID STATE: 11

CNTDELGGIO1.Mod

Information	
Reset Device	x
CNTDELGGIO1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

CNTDELGGIO1.Health

Information		
Device Healthy	0	1
CNTDELGGIO1.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1
	OFF/FALSE: 0
IEC 61850 Value	OK: 1
	WARNING: 2
	ALARM: 3

CNTDELGGIO1.ISCSO1

Information	Measurand	Value
CB Delta Trip Count	CNTDELGGIO1.ISCSO1.stVal	0 to 10000

Information	
CB Delta Trip Count	Value (0 to 10000)
CNTDELGGIO1.ISCSO1.Oper.ctlVal	**Value (0 to 10000)**

CNTDELGGIO1.ISCSO2

Information	Measurand	Value
CB Delta Trip Count Target	CNTDELGGIO1.ISCSO2.stVal	0 to 10000

Information	
CB Delta Trip Count Target	Value (0 to 10000)
CNTDELGGIO1.ISCSO2.Oper.ctlVal	**Value (0 to 10000)**

CNTDELGGIO1.SPCSO

Information		
CB Delta Trip Count Target Reached	0	1
CNTDELGGIO1.SPCSO	**0**	**1**

Device Annunciation	ON/TRUE: 1
	OFF/FALSE: 0
IEC 61850 Value	FALSE: 0
	TRUE: 1

Q0CILO1.Mod

Information	
Reset Device	x
Q0CILO1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

Q0CILO1.Health

Information		
Protection Healthy	0	1
Q0CILO1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Q0CILO1.EnaCls

Information		
NOT CB Control Close Block	0	1
Q0CILO1.EnaCls.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Q0CILO1.EnaOpn

Information		
NOT CB Control Close Block	0	1
Q0CILO1.EnaOpn.stVal	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Q0CSWI1.Mod

Information	
Reset Device	x
Q0CSWI1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x

IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

Q0CSWI1.Health

Information		
Protection Healthy	0	1
Q0CSWI1.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Q0CSWI1.Pos

Information				
CB Open	0	1	0	1
CB Close	0	0	1	1
Q0CSWI1.Pos.stVal	**00**	**01**	**10**	**11**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0

IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

Circuit Breaker Counters	CB Delta Trip Count	CTRL	SeCntDelGGIO1	ISCSO1
	CB Delta Trip Count Target	CTRL	CntDelGGIO1	ISCSO2
	CB Delta Trip Count Target Reached	CTRL	CntDelGGIO1	SPCSO
	CB Ph A Trip Count	CTRL	CntPhAGGIO1	ISCSO1
	CB Ph A Trip Count Target	CTRL	CntPhAGGIO1	ISCSO2
	CB Ph A Trip Count Target Reached	CTRL	CntPhAGGIO1	SPCSO
	CB Ph B Trip Count	CTRL	CntPhBGGIO1	ISCSO1
	CB Ph B Trip Count Target	CTRL	CntPhBGGIO1	ISCSO2
	CB Ph B Trip Count Target Reached	CTRL	CntPhBGGIO1	SPCSO
	CB Ph C Trip Count	CTRL	CntPhCGGIO1	ISCSO1
	CB Ph C Trip Count Target	CTRL	CntPhCGGIO1	ISCSO2
	CB Ph C Trip Count Target Reached	CTRL	CntPhCGGIO1	SPCSO
	CB E/F Trip Count	CTRL	CntEFGGIO1	ISCSO1
	CB E/F Trip Count Target	CTRL	CntEFGGIO1	ISCSO2
	CB E/F Trip Count Target Reached	CTRL	CntEFGGIO1	SPCSO
	CB Count To AR Block	CTRL	CntLOGGIO1	ISCSO1
	CB Count To AR Block Target	CTRL	CntLOGGIO1	ISCSO2
	CB Count To AR Block Target Reached	CTRL	CntLOGGIO1	SPCSO

Circuit Breaker	CB Control Close Block	CTRL	Q0XCBR1	BlkCls
	CB Control Open Block	CTRL	Q0XCBR1	BlkOpn
	CB Status Open	CTRL	Q0XCBR1	Pos
	CB Status Closed	CTRL	Q0XCBR1	Pos
	CB Operations Counter	CTRL	Q0XCBR1	OpCnt
	CB Wear PhA	CTRL	Q0XCBR1	SumSwARs1
	CB Wear PhB	CTRL	Q0XCBR1	SumSwARs2
	CB Wear PhC	CTRL	Q0XCBR1	SumSwARs3

7.3.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Close CB		Close CB	Input			
Block CB Close		Block CB Close	Input			
CB Closed		CB Closed Input	Input			
CB Open		CB Open Input	Input			
Open CB		Open CB	Input			
Inhibit CB Open		Inhibit CB Open	Input			
CB Fail to Close		CB Fail to Close	Output			
CB DBI Alarm		CB DBI Alarm	Output			
CB Open		CB Open	Output			
Open CB		Open CB Pulse	Output			
CB Closed		CB Closed	Output	Y	Y	Y
Close CB Blocked		Close CB Blocked	Output			
CB Fail to Open		CB Fail to Open	Output			
CB Alarm		CB Alarm	Output			
CB Trip Time Alarm		CB Trip Time Alarm Operated	Output			
Reset CB Total Trip		Reset CB Total Trip	Control			
Reset CB Delta Trip		Reset CB Delta Trip	Control			
Reset Freq Ops Count		Reset Freq Ops Count	Control			
Reset CB Count to 79 LO		Reset CB Count to 79 LO	Control			
CB Phase A Trip Count		CB Phase A Trip Count	Meter			
CB Phase B Trip Count		CB Phase B Trip Count	Meter			
CB Phase C Trip Count		CB Phase C Trip Count	Meter			
CB E/F Trip Count		CB E/F Trip Count	Meter			
CB Delta Trip Count		CB Delta Trip Count Operated	Meter			
CB Freq Ops Count		CB Freq Ops Count Operated	Meter			
Count to 79 LO		CB Count to 79 LO Operated	Meter			
Reset CB I^2t Wear		Reset CB I^2t Wear	Control			
CB I^2t Wear		CB I^2t Wear Operated	Output			
CB Wear CBA		CB Wear CBA	Meter			
CB Wear CBB		CB Wear CBB	Meter			
CB Wear CBC		CB Wear CBC	Meter			
CB Wear CBA Remain		CB Wear CBA Remain	Meter			
CB Wear CBB Remain		CB Wear CBB Remain	Meter			
CB Wear CBC Remain		CB Wear CBC Remain	Meter			

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

7.4 79 Automatic Reclosing

7.4.1 Overview of Functions

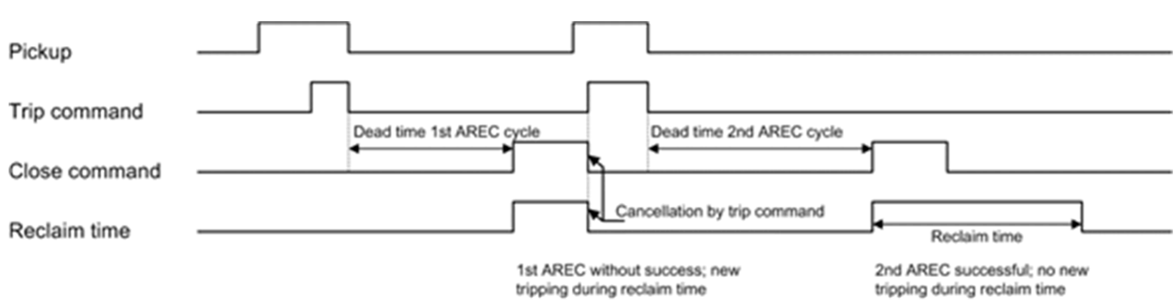
The cause of a high proportion of faults on an overhead line (OHL) network is transient in nature. The arc is then sustained by energy supplied from an otherwise healthy power network. These faults can be cleared by any circuit-breaker trip and the network restored by reclose of the circuit-breaker after the line has been dead for a short time to allow the fault current arc to fully extinguish.

In distribution systems, additional high speed – low setting protection elements can be configured specifically for this purpose which will clear these transient faults without the requirement to grade with other protection devices. Delayed protection can then be applied which will provide correct grading with other devices and slower protection trip time as well as greater energy which can burn-off some semi-permanent faults before further re-close(s). Typically this autoreclose (AR) sequence of Instantaneous (Inst) trip(s) and reclose delay (Deadtime) followed by delayed trip(s) provide the automatic optimum method of clearing all types of fault i.e. both transient and permanent, as quickly as possible and achieving the desired outcome of keeping as much of the net-work in-service as possible

The **Automatic Reclosing** function:

- Automatically reconnects circuits following clearance of transient faults on overhead line networks where such faults are possible
- Can be used to save downstream fuses for transient faults
- Can interface with external protection devices as well as internal elements
- Integrates with circuit-breaker control logic, monitoring and settings and provides event recording of the sequence and instrumentation for use during testing
- Can incorporate synchronizing check to ensure safe and stable restoration
- Can be used to control the application of protection elements to provide initial fast fault clearance for transient faults but revert to time graded protection following a pickup on reclose
- Can apply repeated reclose shots up to 4 times (5 trips) with increasing dead times between attempts
- Can apply different deadtimes for different fault types and also different deadtimes for each autoreclose shot
- Can be switched in and out of service locally and remotely

Figure 7-8 shows an example for a typical sequence with 2 automatic reclose attempts where the fault is still present at the first reclose but the second attempt is successful.



[dw_7SR5_function79Overview, 1, en_US]

Figure 7-8 Sequence Diagram of a 2-Shot Autoreclose (2nd Reclosing Successful)

7.4.2 Structure of the Function

The **Automatic Reclosing** function element has group dependent settings. These settings can be different in each settings group – group numbers (Gn) 1 to 4.

Settings for the circuit-breaker are used by autoreclose and shared with **Manual Close** control.

Voltage settings for **Synchrocheck** are shared with **Manual Close** control but separate configuration settings are provided to allow closing to proceed for different live and dead voltage conditions for Autoreclose and Manual Close.

The autoreclose function can provide a number of reclosing attempts (shots). The function has a number of configuration settings which are used for all fault types.

The autoreclose sequence is defined by settings for the number of shots and deadtimes for different fault types: phase fault (50, 51), earth fault (50G, 50N, 51G, 51N) or sensitive earth fault (50GS, 51GS) and external fault (via binary input configured as **79 Ext Trip**).

An autoreclose shot is initiated from operation of a protection trip that has been configured as an autoreclose trigger for one of the fault types for a circuit-breaker that is in service. If a circuit-breaker is already in the open position before the trip occurs, autoreclose will not be started. Any of the protection elements can be configured as a trigger for its respective type or can be configured to trigger as an external trip by configuration of suitable user logic. A protection operation which is not configured as an autoreclose trigger can still be configured to trip the circuit-breaker but will not initiate autoreclose. A protection operation can be mapped to lockout the autoreclose if required. This will ensure that autoreclose is not started following that element operation to prevent simultaneous operation of other elements from starting autoreclose.

The autoreclose operates as a sequence of states where the state is changed when actions occur and a typical sequence is as follows:

- In service (wait for trip)
- Trip CB from a protection that is configured as a **79 Trigger**
- Sequence in progress (wait for trip reset and **CB Open**)
- Deadtime (timeout dependent on initiating trip type)
- Close inhibit (check voltage levels, synchronizing requirements and for any block signals)
- Close pulse (send close command and check for trip)
- Reclaim (wait for trip, increment shot number and return to **Sequence In Progress** or timeout, raise **Successful Autoreclose** and return to **In Service**.

A sequence can be stopped due to some actions or errors which result in:

- • Lockout (alarm and wait for manual reset or reset automatically by timer)

After the first reclose (shot) the reclaim time starts. If another trip occurs within the reclaim time, the shot number is incremented and the deadtime is selected depending on the trip type for that shot. This is handled as the next shot in the same sequence. A common shot counter is used which is applied regardless of the element type which causes the trip. The maximum number of shots is configured by setting and the sequence can be shortened for particular fault types by additionally configuring the maximum number of **HS Trips**, **Delayed Trips** and **Extern Trips** to **Lockout**. If a trip does not occur during the reclaim time, **Successful Autoreclose** is reported and the autoreclose resets to shot 1 and waits for a trip to start a new sequence.

The **79 Lockout** input can be used to cancel an autoreclose sequence or prevent starting. The **79 Block Reclose** input is used to temporarily inhibit the close operation until conditions are correct. This is typically used with different circuit-breaker designs for signals such as “spring charging” or ”low air pressure” which can be cleared during the sequence allowing the sequence to continue whereas the **Lockout** input is used for unrecoverable conditions such as low gas (SF6) pressure.

The **Hot Line** function is provided to improve safety when personel are working near to live primary equipment. The feature is manually switched in during these conditions and will initiate instantaneous CB tripping and **Lockout** for the pickup of any overcurrent (50, 51), earth fault (50G, 50N, 51G, 51N) or sensitive earth fault (50GS, 51GS) protection element that is configured to operate **General Pickup**. In addition, manual closing of the circuit-breaker is blocked when **Hot Line** is active. This can help to prevent unintended energization of a dead circuit whilst personnel are working nearby. **Hot Line** must be switched off before the circuit-breaker can be closed. **Hot Line** can be configured to be switched in or out by binary inputs, function keys or by commands via the communications protocols. There are no other configurable options for **Hot Line**. **Lockout** will prevent autoreclose.

NOTE

Autoreclose cannot be triggered by pickup or operation of other protection elements such as under/over-voltage, frequency, thermal or negative sequence overcurrent.

The menus, allow the user to set independent protection and autoreclose sequences for each type of fault i.e. phase fault (P/F), calculated/measured earth fault, sensitive earth fault or external protections.

Each autoreclose sequence can be user set to up to 4-shots i.e.5 trips + 4 reclose sequence, with independently configurable types of **`Protection Trip`**. Overcurrent and earth fault elements can be assigned to any combination of fast (Inst), delayed or highset (HS) trips. **`Deadtime Delay`** time settings are independent for each AR shot. The user has programming options for autoreclose sequences up to the maximum shot count i.e.

- Inst or Delayed Trip 1 + (DeadTime 1: 0.1 s to 14400 s)
- + Inst or Delayed Trip 2 + (DeadTime 2: 0.1 s to 14400 s)
- + Inst or Delayed Trip 3 + (DeadTime 3: 0.1 s to 14400 s)
- + Inst or Delayed Trip 4 + (DeadTime 4: 0.1 s to 14400 s)
- + Inst or Delayed Trip 5 – Lockout.

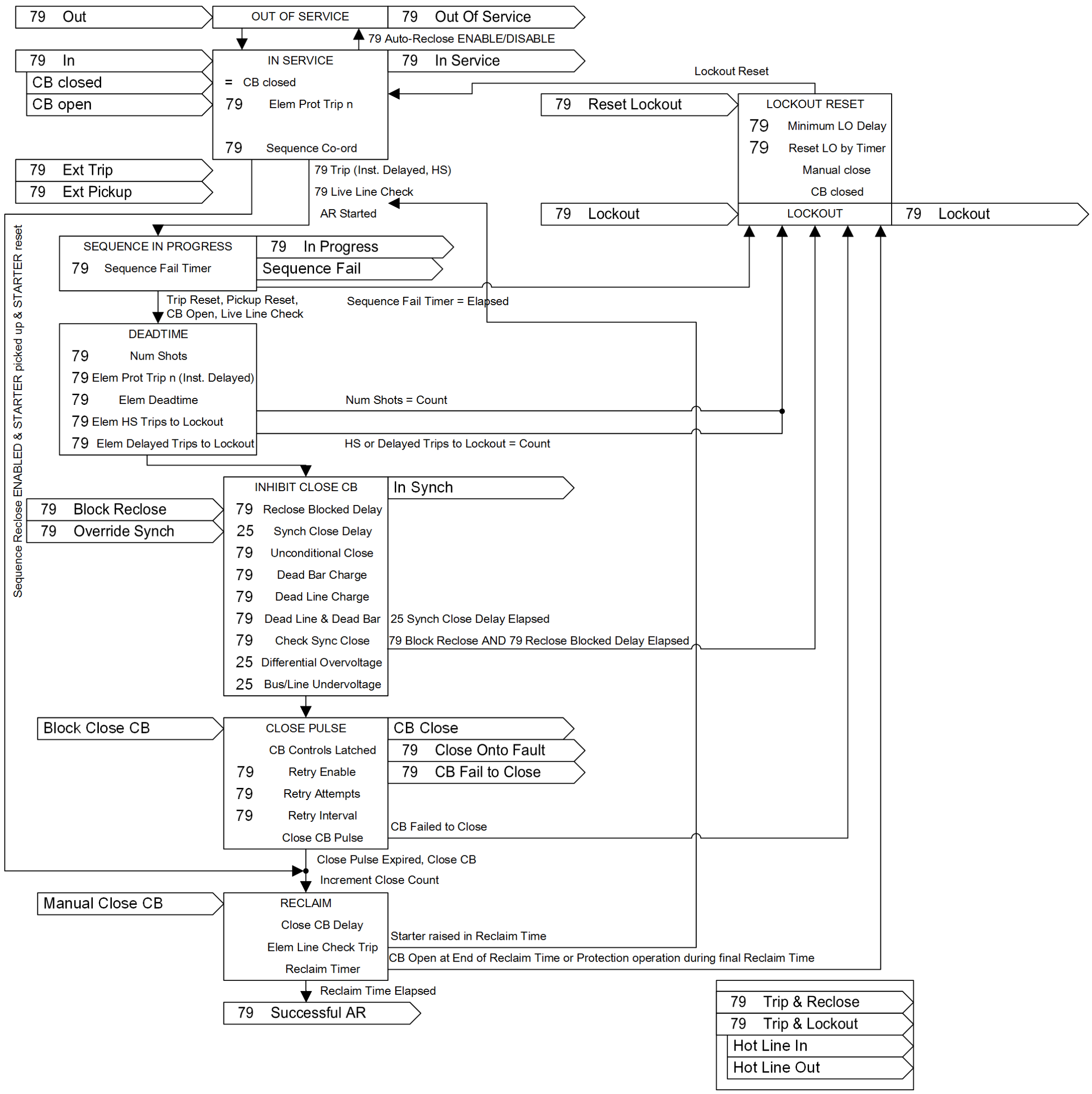
The AR function recognizes developing faults and, as the shot count advances, automatically applies the correct type of protection and associated dead time for that fault type at that point in the sequence.

A typical sequence would consist of 2 inst trips followed by at least 1 delayed trip. This sequence enables transient faults to be cleared quickly by the inst trip(s) and permanent fault to be cleared by the combined delayed trip. The delayed trip must be graded with other recloser/CB's to ensure system discrimination is maintained, ie. that as much of the system as possible is live after the fault is cleared.

This menu presents the overcurrent protection elements available for each type of fault i.e. P/F, E/F (N/G) or SEF and allows the user to select those that are to be applied as inst trips, those that are to be applied as delayed trips, and those that are to be applied as HS trips (HighSet), as required by the selected sequence.

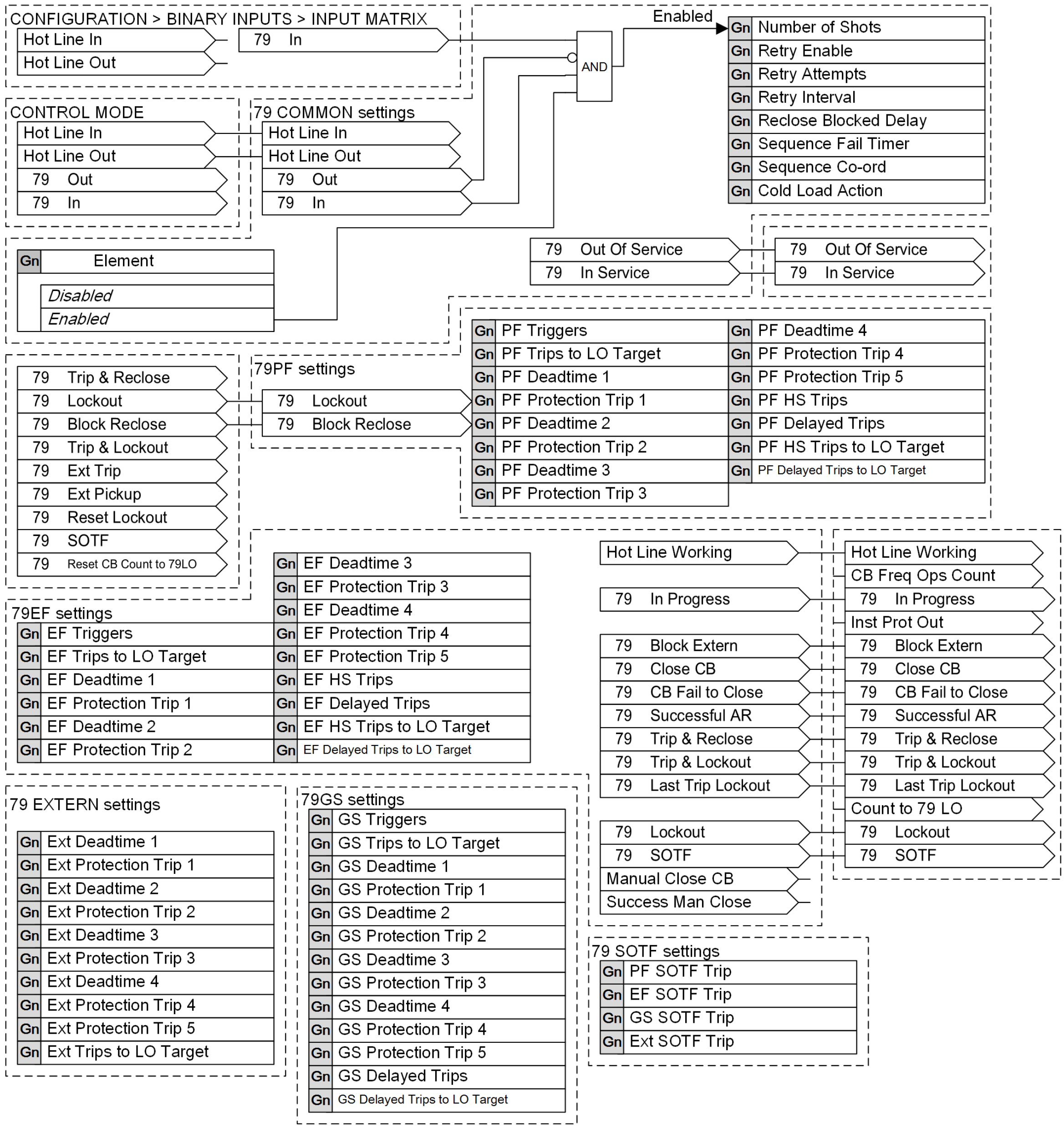
There is no corresponding setting for external as the external protection type is not normally controlled by the autoreclose relay. The resultant configuration enables the **`Automatic Reclosing`** function to correctly apply the required protection for each shot in a sequence.

7.4.3 Logic of the Function



[lo_7SR5_79logicdiagram, 2, en_US]

Figure 7-9 Logic Diagram: 79 Automatic Reclosing



[lo_7SR5_79logicdiagramAdditionalSettings, 2, en_US]

Figure 7-10 Logic Diagram: 79 Automatic Reclosing Configuration Parameters

7.4.4 Application and Setting Notes

Parameter: **`79 Common > Autoreclose`**

- Default setting: **`Disabled`**

  The autoreclose feature can be switched in and out of service.

  This can also be achieved by mapping of binary input or user logic or as a control function from the fascia menu or communications protocols.

Parameter: **79 Common > Number of Shots**

- Default setting: **1**

  The number of shots (Closes) is user programmable. The controller selects the next protection characteristic/dead time according to the type of the last trip in the sequence e.g. PF, EF, SEF or external.

NOTE

Only one shot counter is used to advance the sequence.

Parameter: **79 Common > Retry Enable**

- Default setting: **Disabled**

  When enabled the relay will perform further attempts to automatically close the circuit-breaker where the CB has initially failed to close in response to a close command.

  If the first attempt fails the relay will wait for the **79 Retry Interval** to expire then attempt to close the CB again.

Parameter: **79 Common > Retry Attempts**

- Default setting: **1**

  When enabled the relay will perform further attempts to automatically close the circuit-breaker where the CB has initially failed to close in response to a close command.

  If the first attempt fails the relay will wait for the **79 Retry Interval** to expire then attempt to close the CB again.

Parameter: **79 Common > Retry Interval**

- Default setting: **60 s**

  When enabled the relay will perform further attempts to automatically close the circuit-breaker where the CB has initially failed to close in response to a close command.

  If the first attempt fails the relay will wait for the **79 Retry Interval** to expire then attempt to close the CB again.

Parameter: **79 Common > Reclose Blocked Delay**

- Default setting: **60 s**

  If the CB is not ready to receive a close command or if system conditions are such that the CB should not be closed immediately e.g. a close-spring is not charged, then a binary input mapped to **Reclose Block** can be raised and the close pulse will not be issued but will be held-back. The **Reclose Blocked Delay** sets the time that the **Reclose Block** is allowed to be raised, if this time delay expires the relay will go to **Lockout**. If **Reclose Block** is cleared, before this time expires, then the CB close pulse will be issued at that point in time. Dead time + **Reclose Blocked Delay** = **Lockout**.

Parameter: **79 Common > Sequence Fail Timer**

- Default setting: **60 s**

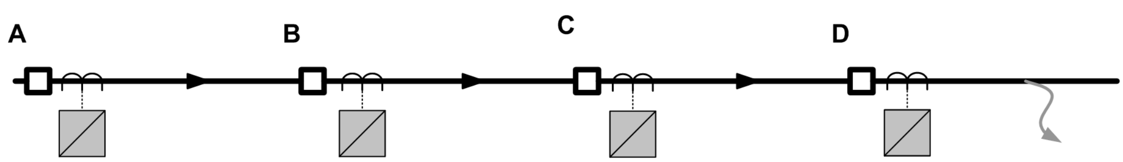
  An autoreclose sequence will start if the circuit-breaker was closed, a trip has occurred and the protection element is configured as an autoreclose trigger. The autoreclose will remain in the **Sequence in Progress** state until the circuit-breaker is open and the protection pickup has reset. It will then progress to the dead time state. If this does not occur within the **79 Sequence Fail Timer** the autoreclose will go to the **Lockout** state. This prevents autoreclose being primed indefinitely.

Parameter: **79 Common > Sequence Co-ord**

- Default setting: **Enabled**

  When set to **Enabled** the relay will co-ordinate its sequence and shot count such that it automatically keeps in step with downstream devices as they advance through their sequence. The relay detects that a pickup has operated but has dropped-off before its associated time delay has expired. It then increments its shot count and advances to the next stage of the autoreclose sequence without issuing a trip. This is repeated as long as the fault is being cleared by the downstream device such that the relay moves through the sequence bypassing the inst trips and moving on to the delayed trip to maintain grading margins.

  When the advanced instantaneous and delayed protection sequence is applied with more than one device installed in series on a network it is important that all devices co-ordinate the advance through their own ARC sequences even though the protection does not operate. The operation of a downstream protection can be detected by the upstream device by an element pickup even though this does not result in a trip or reclose. This is termed **Sequence Co-ordination** and prevents an excessive number of recloses as each successive relay attempts to clear the fault in isolation. For this reason each relay in an ARC scheme must be set with identical instantaneous and delayed sequence of trips.



[dw_7SR5_function79ApplicationAndSettingNotes1, 1, en_US]

Figure 7-11 Sequence Co-ordination

The relay closest to the fault (D) would step through its instantaneous trips in an attempt to clear the fault. If unsuccessful, the relay would move to a delayed trip sequence.

The other relays in the network (A, B and C) would recognize the sequence of pickup followed by current switch-off as ARC sequences. They would therefore also step to their delayed trip to retain co-ordination with the respective downstream devices. The next trip would be subject to current grading and **Lockout** the ARC sequence such that the fault is cleared by the correct CB.

When set to **Enabled** the relay will co-ordinate its sequence and shot count such that it automatically keeps in step with downstream devices as they advance through their sequence. The relay detects that a pickup has operated but has dropped-off before its associated time delay has expired. This indicates that a downstream protection device has operated to clear the fault. The relay increments its shot count and advances to the next stage of the autoreclose sequence without a trip being issued so that its shot number is kept in alignment with that of the downstream device. This is repeated as long as the fault is being cleared by the downstream device such that the relay moves through the sequence bypassing the inst trips and moving on to the delayed trip at the same time as the downstream device to maintain grading margins when the delayed protection is applied.

The **Sequence Co-ordination** feature should generally be considered when more than 1 device with autoreclose are connected in series with overlapping protection.

Parameter: **79 Common > Cold Load Action**

- Default setting: **Off**

Parameter: **79 Common > Dead Bar Charge**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When Enabled this allows Auroreclose to proceed when the Line side is live and the busbar side is dead. Parameters for the Live/Dead assessment are specified within the 25 function.

Parameter: **79 Common > Dead Line Charge**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When Enabled this allows Auroreclose to proceed when the Line side is dead and the busbar side is live. Parameters for the Live/Dead assessment are specified within the 25 function.

Parameter: **79 Common > Dead Line & Dead Bar**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When Enabled this allows Auroreclose to proceed when the both Line and Busbar are dead. Parameters for the Live/Dead assessment are specified within the 25 function.

Parameter: **79 Common > Check Sync Close**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When Enabled the 25 Sychronising settings must be met to allow Auroreclose to proceed when both sides are live. Parameters for the Live/Dead assessment are specified within the 25 function.

Parameter: **79 Common > Unconditional Close**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When Enabled this allows Autoreclose to proceed for any voltage conditions of Live and Dead and overrides the options below.

Parameter: **79 Common > Dead Line Charge Delay**

- Default setting: **0 s**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. This setting is used to apply an additional delay following the deadtime only when the Bar is Live and the Line is Dead. This allows the deadtime to be extended for these conditions for co-ordination with remote end reclosing.

Parameter: **79 Common > Dead Bar Charge Delay**

- Default setting: **0 s**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. This setting is used to apply an additional delay following the deadtime only when the Line is Live and the Bar is Dead. This allows the deadtime to be extended for these conditions for co-ordination with remote end reclosing.

Parameter: **79 Common > Check Sync During Deadtime**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When this setting is Enabled, the deadtime will be truncated and Close Inhibit Check Synch will start if the voltage is restored such that both sides become Live during the deadtime. This can be applied to shorten the reclose sequence after the remote end has closed.

Parameter: **79 Common > LO Line VT Fail**

- Default setting: **Disabled**

  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When this setting is Enabled, the Autoreclose will Lockout if a Line VT Fail is identified by 60 VTS.

Parameter: **79 Common > LO Bus VT Fail**

- Default setting: **Disabled**
  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When this setting is Enabled, the Autoreclose will Lockout if a Bus VT Fail is identified by the 25 Synchrocheck voltage checks.

Parameter: **79 Common > Live Line Check**

- Default setting: **Disabled**
  This setting appears when function 25 Synchrocheck is installed with Autoreclose. When this setting is Enabled, the Autoreclose will not start unless the Line was Live before the trip occurred and will wait for one side voltage to be dead before the deadtime will start.

Parameter: **79 PF > PF Triggers**

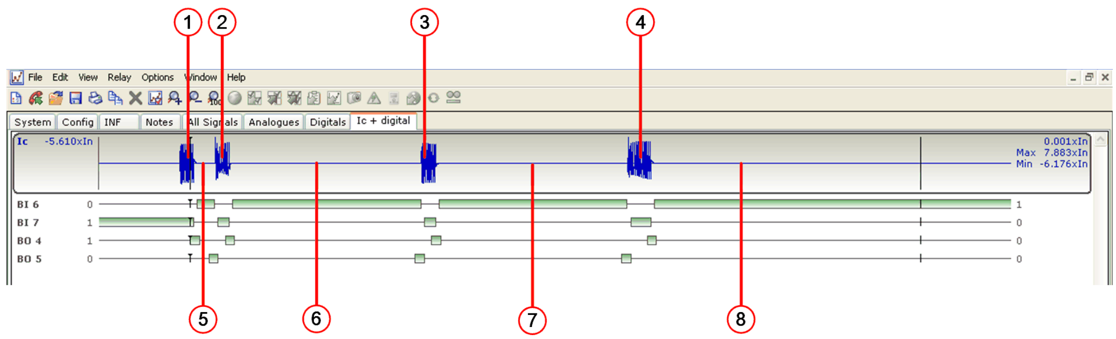
- Default setting: **<all>**

Parameter: **79 PF > PF Trips to LO Target**

- Default setting: **5**

Parameter: **79 PF > PF Deadtime 1**

- Default setting: **5 s**
  Sets the first reclose delay (Dead time) in the P/F sequence.
  The autoreclose will remain in this state for the appropriate deadtime setting time. The setting applied depends on the fault type defined by the autoreclose trigger mapping for the protection element that tripped and the current autoreclose shot number. If a further protection trip occurs during the deadtime the autoreclose will increment the shot number then return to **Sequence in Progress**, wait for the trip to reset before starting the next dead time. When the dead time time setting expires, the autoreclose progresses to **Close Inhibit**. The dead time is initiated when the trip output contact reset, the pickup is reset and the CB is open. The CB close output relay is energized after the dead time has elapsed.



[dw_7SR5_function79SettingExample, 2, en_US]

Figure 7-12 Typical AR Sequence with 3 Inst and 1 Delayed trip

(1) 1st trip (Inst)
(2) 2nd trip (Inst)
(3) 3rd trip (Inst)
(4) 4th trip (Delayed)
(5) 1st dead time
(6) 2nd dead time
(7) 3rd dead time
(8) 4th dead time

Parameter: **79 PF > PF Protection Trip 1**

- Default setting: **Inst**
  Each autoreclose attempt (autoreclose shot) is defined as being either a delayed trip or an inst trip. These settings types are used in advanced schemes.

Parameter: **79 PF > PF HS Trips**

- Default setting: **<none>**

Parameter: **79 PF > PF Delayed Trips**

- Default setting: **<none>**

Parameter: **79 PF > HS Trips to LO Target**

- Default setting: **5**

  Sets the number of allowed **HighSet** trips. The relay will go to **Lockout** on the last **HighSet** trip. This function can be used to limit the duration and number of high current trips that the circuit-breaker is required to perform. If the fault is permanent and close to the circuit-breaker then there is no point in forcing a number of delayed Trips before the relay goes to **Lockout**, that sequence will be truncated.

Parameter: **79 PF > Delayed Trips to LO Target**

- Default setting: **5**

  Sets the number of allowed delayed trips, the relay will go to **Lockout** on the last delayed trip. This function limits the number of delayed trips that the relay can perform when the instantaneous protection elements are externally inhibited for system operating reasons, sequences are truncated.

Parameter: **79 PF > PF SOTF Trip**

- Default setting: **Inst**

Settings Example

- Out of Service

  Autoreclose is switched out and will not start if a trip occurs. This state will remain until autoreclose is switched in.

- In Service

  Autoreclose is in service and is in an idle state and ready for a trip to occur.

- Sequence in progress

  An autoreclose sequence will start if the circuit-breaker was closed, a trip has occurred and the protection element is configured as an autoreclose trigger. Additionally, the line voltage must be live and the line or bus voltage must go dead if **Live Line Check** is **Enabled** in devices with **Check Synchronizing**. The autoreclose shot number will be incremented from 0 to 1. The autoreclose will remain in the **Sequence in Progress** state until the circuit-breaker is open and the protection pickup has reset. It will then progress to the **Deadtime** state. If this does not occur within the **79 Sequence Fail Timer** the autoreclose will go to the **Lockout** state. This prevents autoreclose being primed indefinitely. **79 Sequence Fail Timer** can be switched to 0 (= Off).

- Deadtime

  The autoreclose will remain in this state for the appropriate deadtime setting time. The setting applied depends on the fault type defined by the autoreclose trigger mapping for the protection element that tripped and the current autoreclose shot number. The deadtime will not start until either the bus or line goes dead if **Live Line Check** is **Enabled**. If a further protection trip occurs during the deadtime the autoreclose will increment the shot number then return to **Sequence in Progress**, wait for the trip to reset before starting the next deadtime. When the deadtime time setting expires, the autoreclose progresses to **Close Inhibit**. In devices with **Check Synchronizing**, if **Check Sync during Deadtime** is **Enabled** and the line becomes live during the deadtime and check synchronizing settings are met before the deadtime expires, the autoreclose truncates the deadtime and progresses to **Close Inhibit**.

- Close Inhibit

  At the end of the deadtime the autoreclose progresses to **Close Inhibit**. The line and bus voltage levels are checked for close conditions in devices with check syncronizing. DLC/DBC time delays and check sync parameters are applied depending on voltage level and phase and the applicable **Check Sync**, **System Sync** or **Close on Zero** settings. The state of **79 Block Reclose** and **Block Close** inputs are also checked. When all conditions are met the **Close Pulse** is issued.

- Close Pulse

  The **CB Close** signal is operated. The duration of the signal is defined by the **79 Close CB Pulse** setting. If a protection trip operates during the close pulse, the output **79 Close Onto Fault** is raised, the close pulse output is truncated and the shot number incremented. The autoreclose will return to **Sequence in Progress** for the next shot or **Lockout** if it is the final shot of the sequence. If no protection operation occurs the autoreclose sequence will progress to the **Reclaim** state.

- Reclaim

  Following CB close the reclaim time is started (**Functions > Control > 52 > CB-n > Reclaim Timer**). If a trip occurs during this time the autoreclose will increment the shot number, return to **Sequence in Progress** or **Lockout** if it is the final shot of the sequence. If the reclaim timer expires without a protection trip the relay will raise **79 Successful AR** and return to **In Service**. If a further trip occurs after completion of the reclaim, it is considered to be a new sequence which is started from the beginning.

- Lockout

  This state can be reached following a complete autoreclose sequence where the fault has persisted to the final shot. Typically this is because the protection has operated during the final reclaim time or the circuit-breaker is open at the end of the final reclaim time. In these cases the output **79 Last Trip Lockout** is raised as well as **79 Lockout**. Lockout can also be reached by operation of the **79 Lockout** input at any time or invalid circuit-breaker status from the binary inputs. Lockout is also reached from within an autoreclose sequence if a failure occurs such as CB fail to close, expiry of the **79 Sequence Fail Timer**, **79 Reclose Blecked Delay** or check synchronizing conditions are not met at **Close Inhibit** or the **79 HS Trips to Lockout** or **79 Delayed Trips to Lockout** is reached. The **Lockout** state can be configured with a minimum time for which the state is held to allow other systems to react and can be set to automatically reset at the end of this time or to be retained until manually reset. A CB **Manual Close** operation will reset the **79 Lockout** alarm and the autoreclose will return to the **In Service** state unless the **79 Lockout** input is permanently raised or CB status is invalid. The **Lockout** condition can not be reset if there is an active lockout input.

  The **Lockout** state can be reached for a number of reasons. Lockout will occur for the following:

  – At the end of the **79 Sequence Fail Timer**

  – At the end of the reclaim timer if the CB is in the open position

  – A protection operates during the final reclaim time

  – If a close pulse is given and the CB fails to close

  – The **79 Lockout** binary input is active

  – At the end of the **79 Reclose Blocked Delay** due to presence of a persistent block signal

  – When the **79 Elem HS Trips to Lockout** count is reached

  – When the **79 Elem Delayed Trips to Lockout** count is reached

  An alarm output is provided to indicate last trip to lockout.

  Once lockout has occurred, an alarm (**79 Lockout**) is issued and all further close commands, except **Manual Close**, are inhibited.

  If the **Lockout** command is received while a **Manual Close** operation is in progress, the feature is immediately locked-out.

  Once the **Lockout** condition has been reached, it will be maintained until reset. The following will reset lockout:

  – By a **Manual Close** command, from fascia, comms or close CB binary input

  – By a **79 Reset Lockout** binary input, provided there is no signal present that will cause lockout

  – At the end of the **79 Minimum LO Delay** time setting if **79 Reset LO by Timer** is selected to **Enabled**, provided there is no signal present which will cause lockout

  – Where lockout was entered by an **A/R Out** signal during an autoreclose sequence then a **79 In** signal must be received before lockout can reset

  – By the CB closed binary input, provided there is no signal present which will cause lockout

  The lockout condition has a delayed drop-off of 2 s. The lockout condition can not be reset if there is an active lockout input.

Interaction of Automatic Reclosing Function and Protection Functions

Autoreclose is started by operation of a protection element which is mapped as a **79 Trigger**. These are selected by settings that are found in the menus for each fault type within the 79 settings:

- 79 PF Triggers allows 50 and 51 overcurrent elements to be selected as autoreclose triggers
- 79 EF Triggers allows 50N, 50G, 51N and 51G earth fault elements to be selected as autoreclose triggers

- 79 GS Triggers allows 50Gs and 51Gs sensitive earth fault elements to be selected as autoreclose triggers
- 79 Extern Triggers allows trip signals from external protection relays to be connected to binary inputs to start autoreclose. Similarly other internal protection elements to be selected as autoreclose triggers by mapping to the **79 ExtTrip** input via user logic.

In the 79 settings, each autoreclose attempt (autoreclose shot) is defined as being either a normal delayed trip or an inst trip. This setting controls the ungraded instantaneous protection elements which are used in advanced schemes.

The **79 Delayed Inhibit** setting within each overcurrent and earth fault element is then used to define whether each element is in service or automatically disabled during a sequence. During a delayed shot, all protection elements that are designated as inst are inhibited. During an inst shot, all elements are active and no inhibits are applied. For simple autoreclose sequences this advanced functionality is not required and all shots should be set to inst and or all elements should be set to delayed. Care should be taken if any elements are set to both inst and delayed as incorrect setting can result in no protection being in service. Inst protection elements are not automatically inhibited when autoreclose is switched out, if this common arrangement is required it must be configured in user logic. Inst elements are not automatically inhibited when autoreclose is disabled. If autoreclose is disabled, elements should not be configured as type inst.

Interfacing Automatic Reclosing Function with External Protection Devices

Autoreclose can be initiated from another protection device via a binary input connection or other input such as IEC 61850 goose. Logic can also be configured to use the **79 Extern** autoreclose sequence for internal protection functions which are not included in the standard autoreclose fault types such as voltage, frequency and un-balance protections. The 79 element provides a blocking signal which can be configured for each shot in the sequence such as **79 Extern Prot'n Trip 1** which can be used to inhibit the external device tripping such as if it is an instantaneous type device which should not operate when the sequence has reached a delayed shot. In addition, the sequence will not start or continue if the **Extern Trigger** input is raised on a shot where the **Extern Block** is raised. The maximum number of shots is controlled by the **79 Num Shots** setting but can also be limited by the **79 Extern Trips to LO** setting.

7.4.5 Settings Menu

Functions > Control > 79 > 79 Common						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
Autoreclose	Enabled Disabled	Disabled				
Number of Shots	1 to 4	1				
Retry Enable	Enabled Disabled	Disabled				
Retry Attempts	1 to 10	1				
Retry Interval	0 to 600 s Δ 1 s	60 s				
Reclose Blocked Delay	0 to 600 s Δ 1 s	60 s				
Sequence Fail Timer	0 to 600 s Δ 1 s	60 s				
Sequence Co-ord	Enabled Disabled					
Cold Load Action	Off Delayed					

Functions > Control > 79 > 79PF						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
PF Triggers	<all> 50-n 51-n	<all>				
PF Trips to LO Target	1 to 5	5				
PF Deadtime 1	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
PF Deadtime 2	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
PF Deadtime 3	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s Delayed	5 s				
PF Deadtime 4	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
PF Protection Trip 1	Inst Delayed	Inst				
PF Protection Trip 2	Inst Delayed	Inst				
PF Protection Trip 3	Inst Delayed	Delayed				
PF Protection Trip 4	Inst Delayed	Delayed				
PF Protection Trip 5	Inst Delayed	Delayed				
PF HS Trips	<none> 50-n 51-n	<none>				
PF Delayed Trips	<none> 50-n 51-n	<none>				
PF HS Trips to LO Target	1 to 5	5				
PF Delayed Trips to LO Target	1 to 5	5				

Functions > Control > 79 > 79EF						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
EF Triggers	50-n 51-n	<all>				
EF Trips to LO Target	1 to 5	5				
EF Deadtime 1	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
EF Deadtime 2	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
EF Deadtime 3	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s Delayed	5 s				
EF Deadtime 4	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
EF Protection Trip 1	Inst Delayed	Inst				
EF Protection Trip 2	Inst Delayed	Inst				
EF Protection Trip 3	Inst Delayed	Delayed				
EF Protection Trip 4	Inst Delayed	Delayed				
EF Protection Trip 5	Inst Delayed	Delayed				
EF HS Trips	<none> 50G-n 50N-n 51G-n 51N-n	<none>				
EF Delayed Trips	<none> 50G-n 50N-n 51G-n 51N-n	<none>				

Functions > Control > 79 > 79EF						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
EF HS Trips to LO Target						
EF Delayed Trips to LO Target						

Functions > Control > 79 > 79GS						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
GS Triggers	50GS-n 51GS-n	<all>				
GS Trips to LO Target		5				
GS Deadtime 1	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
GS Deadtime 2	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
GS Deadtime 3	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s Delayed	5 s				
GS Deadtime 4	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
GS Protection Trip 1	Inst Delayed	Inst				
GS Protection Trip 2	Inst Delayed	Inst				
GS Protection Trip 3	Inst Delayed	Delayed				
GS Protection Trip 4	Inst Delayed	Delayed				
GS Protection Trip 5	Inst Delayed	Delayed				
GS Delayed Trips	<none> 50GS-n 51GS-n					
GS Delayed Trips to LO Target						

Functions > Control > 79 > 79Extern						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
PF Deadtime 1	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
PF Deadtime 2	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
PF Deadtime 3	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s Delayed	5 s				
PF Deadtime 4	0 to 20 s Δ 0.01 s 20 to 100 s Δ 0.1 s 100 to 1000 s Δ 1 s 1000 to 10000 s Δ 10 s 10000 to 14400 s Δ 100 s	5 s				
PF Protection Trip 1	Inst Delayed	Inst				
PF Protection Trip 2	Inst Delayed	Inst				
PF Protection Trip 3	Inst Delayed	Delayed				
PF Protection Trip 4	Inst Delayed	Delayed				
PF Protection Trip 5	Inst Delayed	Delayed				
Extern Trips to LO Target	1 to 5	5				

Functions > Control > 79 > 79 SOTF						
Parameter	**Range**	**Settings**				
		Default	**Gn1**	**Gn2**	**Gn3**	**Gn4**
PF SOTF Trip	Inst Delayed	Inst				
EF SOTF Trip	Inst Delayed	Inst				
GS SOTF Trip	Inst Delayed	Inst				
Extern SOTF Trip	Not Blocked Blocked	Not Blocked				

7.4.6 IEC 61850 Functional Information Mapping

A79RREC*.Beh

Information												
Element Enabled (Function Config)	1	1	1	1	1	1	1	1	1	1	x	0
Element Disabled	0	0	0	0	0	0	0	0	0	0	1	x
Any Inhibit	0	0	1	1	0	0	0	1	1	1	x	x
Local or Remote mode	0	0	0	0	0	0	1	0	0	1	x	x
Local mode	0	0	0	0	0	1	0	0	1	0	x	x
Remote mode	0	0	0	0	1	0	0	1	0	0	x	x
Out of Service mode	0	1	0	1	0	0	0	0	0	0	x	x
Test Mode	1	0	1	0	0	0	0	0	0	0	x	x
A79RREC*.Beh.stVal	**3**	**3**	**4**	**4**	**1**	**1**	**1**	**2**	**2**	**2**	**5**	**5**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value OK: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A79RREC*.Mod

Information					
Reset Device	x	x	x	x	x
79 Disabled	x	1	0	0	0
Autoreclose In	x	x	1	1	0
Autoreclose Out	1	x	0	0	1
Autoreclose Blocked	x	x	1	0	0
A79RREC*.Mod.stVal	**5**	**5**	**2**	**1**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

A79RREC*.Health

Information		
Device Healthy	0	1
A79RREC*.Health.stVal	**3**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value OK: 1
WARNING: 2
ALARM: 3

A79RREC*.Op

Information		
Autoreclose Operated	0	1
A79RREC*.Op.general	**0**	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value TRUE: 1
FALSE: 0

A79RREC*.AutoRecSt

Information			
79 In Progress	0	1	0
79 Successful AR	0	0	1
A79RREC*.AutoRecSt.stVal	**1**	**2**	**3**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
IEC 61850 Value READY: 1
IN PROGRESS: 2
SUCCESSFUL: 3

CNTLOGGIO1.Mod

Information	
Reset Device	x
CNTLOGGIO1.Mod.stVal	**1**

Device Annunciation ON/TRUE: 1
OFF/FALSE: 0
Irrelevant: x
IEC 61850 Value ON: 1
BLOCKED: 2
TEST: 3
TEST/BLOCKED: 4
OFF: 5

CNTLOGGIO1.Health

Information		
Device Healthy	0	1
CNTLOGGIO1.Health.stVal	**3**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	OK: 1 WARNING: 2 ALARM: 3

CNTLOGGIO1.ISCSO1

Information	Measurand	Value
CB Count To AR Block	CntLOGGIO1.ISCSO1.stVal	0 to 10000

Information	
CB Count To AR Block	Value (0 to 10000)
CntLOGGIO1.ISCSO1.Oper.ctlVal	**Value (0 to 10000)**

CNTLOGGIO1.ISCSO2

Information	Measurand	Value
CB Count To AR Block Target	CntLOGGIO1.ISCSO2.stVal	0 to 10000

Information	
CB Count To AR Block Target	Value (0 to 10000)
CntLOGGIO1.ISCSO2.Oper.ctlVal	**Value (0 to 10000)**

CNTLOGGIO1.SPCSO

Information		
CB Count To AR Block Target Reached	0	1
CNTLOGGIO1.SPCSO	**0**	**1**

Device Annunciation	ON/TRUE: 1 OFF/FALSE: 0
IEC 61850 Value	FALSE: 0 TRUE: 1

7.4.7 Information List

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
		79 Out	Input			
		79 In	Input			
		Autoreclose on/off	Control		Y	Y
		79 Lockout	Input			
		79 Block Reclose	Input			
		Hot Line In	Input			
		Hot Line Out	Input			
		Hot line working on/off	Control			Y
		Auto-reclose active	Output	Y		
		Reclose blocked	Output	Y		

Input/Output Matrix	General Pickup	User Logic	Type	IEC 60870-5-103	DNP3	MODBUS RTU
Manual CB Close		Manual Close CB	Output			
Success Man Close		Successful Man Close	Output	Y		
79 Close CB		79 Close CB	Output			
79 Trip & Reclose		79 Trip & Reclose	Output			
79 Trip & Lockout		79 Trip & Lockout	Output			
79 Lockout		79 Lockout	Output			
79 Out of Service		79 Out of Service	Output			
79 In Service		79 In Service	Output			
79 In Progress		79 In Progress	Output			
79 Block Extern		79 Block Extern	Output			
79 SOTF		79 SOTF	Output			
79 Successful AR		79 Successful AR	Output			
79 CB Fail to Close		79 CB Fail to Close	Output			
79 Last Trip Lockout		79 Last Trip Lockout	Output	Y		
Hot Line Working		Hot Line Working	Output	Y		

The complete serial protocol information list containing the DNP3, IEC 60870-5-103, and Modbus RTU data information for the configured device can be generated using the Export Report feature in the Reydisp Manager 2 tool, Serial Comms & Events.

For the complete list of Modbus TCP information refer to the Reydisp Manager Modbus TCP Mapping file.

8 Instruments and Meters

8.1 Introduction

The measurands are recorded from the analogue inputs.

Further measurands are calculated from these measured values where the instrument or meter requires measurands from more than 1 input. For example, the electric power is calculated from the voltage and current measurands.

For the display, the measured values of a device are summed up in the following groups:

- Operational measured values
- Fundamental and symmetrical components
- Function-specific measured values
- Minimum values, maximum values, average values
- Energy metered values

The device instrumentation and metering provides real-time measured quantities and data, this is displayed on the relay fascia LCD (when in **Instruments Mode**) or via the data communications interface.

The primary values are calculated using the CT and VT parameters i.e. the values entered in the **Configuration > CT/VT** menu – see section *3.3 CT and VT Inputs* .

The user can add the meters that are most commonly viewed to a **Favorites** window by pressing the **Enter** key when viewing a meter. The relay will display the favorite meters after elapse of the **Configuration > Device > Favorite Meters Timer** setting. When more than 1 favorite meter is selected each selected meter is displayed on the LCD for 5 seconds.

The energy storage meters can be reset from a binary input and have a user selectable setting for their measurement in the **Configuration > Data Storage** menu. See section *3.6 Data Storage* .

Counter instruments can be rest by pressing the ► key when the instrument is displayed.

8.2 Instruments

The device functionality is dependent on the analogue input configuration.

The structure of the device menu system is summarized in the following table.

Favorites	The home screen mimic is added to the favorites. The favorites will be displayed only when a meter has been added and the **`Favorite Meters Timer`** has elapsed. See *3.2 Device Configuration*	
Current (See *3.3 CT and VT Inputs*)	Primary: IA, IB, IC	A
	Secondary: Ia, Ib, Ic	A
	Nominal: Ia, Ib, Ic	$\cdot I_{rated}$
	Sequence: I_1, I_2, I_0	$\cdot I_{rated}$
	Calculated Earth: Pri, Sec, Nom	A
	Last Trip Current: IA, IB, IC	A
	Measured Earth (IG): Pri, Sec, Nom	A, $\cdot I_{rated}$
	Measured Earth (IG2): Pri, Sec, Nom	A, $\cdot I_{rated}$
Voltage (See *3.3 CT and VT Inputs*)	Prim Ph-Ph Voltage: VAB, VBC, VCA	V
	Sec Ph-Ph Voltage: Vab, Vbc, Vca	V
	Nom Ph-Ph Voltage: Vab, Vbc, Vca	$\cdot V_{rated}$
	Prim Ph-N Voltage: VA, VB, VC	V
	Sec Ph-N Voltage: Va, Vb, Vc	V
	Nom Ph-N Voltage: Va, Vb, Vc	$\cdot V_{rated}$
	Sequence: V_1, V_2, V_0	V
	Calculated Earth: Pri, Sec	V
	Last Trip Voltage: VA, VB, VC	V
	Voltage (V4): Pri, Sec, Nom	V, $\cdot V_{rated}$
Frequency	Frequency V4 Frequency	Hz
Power [22][23]	P Phase: A, B, C P (3P)	W
	Q Phase: A, B, C Q (3P)	Var
	S Phase: A, B, C S (3P)	VA
	PF Phase: A, B, C PF (3P)	p.u.
	P Phase: A, B, C P (3P)	$\cdot S_{rated}$
	Q Phase: A, B, C Q (3P)	$\cdot S_{rated}$
	S Phase: A, B, C S (3P)	$\cdot S_{rated}$

22 3 phase real, reactive and apparent power are the sum of the 3 phase values.

23 3 phase power factor is the average of the 3 phase values.

Energy (See *3.6 Data Storage*)[24]	Active Energy Export Active Energy Import	X10kWh
	Reactive Energy Export Reactive Energy Import	X10kWh
Sync	Line Volts Bus Volts Line Freq Bus Freq Phase Diff Slip Freq Voltage Diff	V V Hz Hz Degrees Hz %
Thermal (See *5.10 49 Thermal Overload Protection*)	Thermal Status Phase: A, B, C	%
Wattmetric [25] Ires R: The real component of the measured residual current.	Ires R Pres Ires R Angle I_0 to V_0 Angle	A W Degrees Degrees
Directional (See *5.28 67 Directional Overcurrent/Earth Fault*)	67 67G 67GI 67GS 67N	
AFD Meters		
Vector Shift	VA, VB, VC	Degrees
ROCOF	Fine Coarse Direction	Hz/s Hz/s None/FWD/REV
	Last Trip Fine Last Trip Coarse	Hz/s Hz/s
Maintenance (See *7.3 52 Circuit-Breaker Control*)	CB Manual Close Last Close CB Manual Open Last Open	ms
	CB Trip Time	ms
	CB Total Trips Count CB Total Trips Target	n n
	CB Delta Trips Count CB Delta Trips Target	n n
	CB Wear Phase: A, B, C	MA^2 s
	CB Wear Remaining Phase: A, B, C	%
Auto Reclose	Autoreclose State Autoreclose Close Shot	n
Fault Locator	Distance Impedance Reactance	%, km, Miles. (see *3.6 Data Storage*)

24 The displayed value is dependent on the Export PowerLag Var setting.

25

Miscellaneous	Device Restart Alarm Count Device Restart Alarm Target	n n
	Hrs In Service Time	Hrs
	Date Time Waveform Recs Fault Recs	dd/mm/yyyy hh:mm:ss n n
	Event Recs Data Log Recs Setting Group	n n n
General Alarms	General Alarm n	16 x alpha-numeric characters. Configuration > Binary Inputs > General Alarms
Demand (See *3.6 Data Storage*)	IA Demand: Max, Min, Mean	A
	IB Demand: Max, Min, Mean	A
	IC Demand: Max, Min, Mean	A
	IG Demand: Max, Min, Mean	A
	IG2 Demand: Max, Min, Mean	A
	VA Demand: Max, Min, Mean	V
	VB Demand: Max, Min, Mean	V
	VC Demand: Max, Min, Mean	V
	VAB Demand: Max, Min, Mean	V
	VBC Demand: Max, Min, Mean	V
	VCA Demand: Max, Min, Mean	V
	Frequency Demand: Max, Min, Mean	Hz
	P 3P Demand: Max, Min, Mean	W
	Q 3P Demand: Max, Min, Mean	Var
	S 3P Demand: Max, Min, Mean	VA
	PF 3P Demand: Max, Min, Mean	p.u.
Binary Inputs (See *3.4 Binary Inputs*)	BI1 to BIn	0/1
Binary Outputs (See *3.5 Binary Outputs*)	BO1 to BOn	0/1
Virtual	V_1 to V_n (total number of virtuals)	0/1

Communica-tion[26][27][28]	COM1 Traffic	Activity on the rear RS485 port
	Tx1	Transmitted Data
	Rx1	Received Data
	Ethernet Information	
	Version	Firmware Version of EN100
	Part#	
	Ethernet Meter 1	Network Config
	Ethernet Meter 2	MAC Address: EN100 Mac Address
	Ethernet Meter 3	IP Address: IPAddress
	Ethernet Meter 4	NM Address: Subnet Mask Address
	Ethernet Meter 5	GW Address: Gateway Address
	Ethernet Meter 6 3 Functions	NT1 Address NTP Server Address. The contents of this line toggle in intervals of approx. 10 s between the server address and the time elapsed since the last synchronization. If the server address is displayed the star (*) symbolizes an active SNTP server. The time is displayed for up to 999 s (i.e. approx. 16 min). A display of 999 right after startup of the device signals that there is no synchronization via SNTP. This line also signals the existence of corrupt parameters. This is the case when the parameter settings of the module do not match the parameter settings of the device. The third function deals with the signalization of a double IP address. When a device starts up in the network, the existence of the IP address is checked. If the address already exists in the network, a static information to that effect is displayed in line 6: **6 !!MAC!!0007E908FCC8** In that case, the device will not be connected to the network. The double IP address can be identified from the MAC address displayed. which is part of the existing IP address.
	Ethernet Meter 7	`Chan 1/2 = Up/Up` Shows that both channels are active. This information is only displayed if the internal switch is active. If 1 of the 2 channels is down, the ring is broken.
	Ethernet Meter 8	`Rx/TxCnt=` Shows the number of telegrams received and transmitted. This counter is not reset and signals that the interface is working correctly.

26 The communications meters display the information and activity. The screen itself depends on the module type and is available only in English.

27 Ethernet meters 15 to 26 are not available for Line, PRP and HSR.

28 The Ethernet meters are only available in English.

Ethernet Meter 9	**Rx/TxErr=** The telegram errors found are counted.
Ethernet Meter 10	**Rx/Tx10s=** Shows a 10 s mean value of the telegrams received and transmitted.
Ethernet Meter 11	**CPU load=** Information on the processor load of the communication module.
Ethernet Meter 12	**LRx1/LTx1=** Information on the status of the optical interface. The first value in the line is determined from the receive output at the port; it shows **norm** for an output up to -28 dBm, **weak** up to -30 dBm. If the receive output is less1, only bars will be displayed. This does not necessarily mean a broken connection; a broken connection will be shown in meter 7. The status **weak** should normally not occur if the optical budget is kept within permissible limits. If it is displayed, the connections need to be checked. The second value is the transmit output. The display **norm** shows a transmit output of -16 dBm, which is the normal state. Lower outputs are indicated by bars. This does not indicate that the transmitter will fail straight away but that the driver, due to aging, is no longer able to deliver a transmit output of -16 dBm2. Whether the connection as a whole is able to function depends also on the condition of the cables and the receiver. Precise information is provided by the symbol error rate in the FEC statistics on the module home page (see ????).
Ethernet Meter 13	**LRx2/LTx2=** As above Meter 12
Ethernet Meter 14	**Switch RSTP** Redundancy mode RSTP set in the switch.
Ethernet Meter 15	**Priority =** Displayed as set in Reydisp Manager.
Ethernet Meter 16	**Bridge Id =** Displayed as set in Reydisp Manager.
Ethernet Meter 17	**Hello Time =** Displayed as set in Reydisp Manager.
Ethernet Meter 18	**Max Age Tm =** Displayed as set in Reydisp Manager.
Ethernet Meter 19	**Forward Del =** Displayed as set in Reydisp Manager.
Ethernet Meter 20	**Max TransmCnt =** Displayed as set in Reydisp Manager.
Ethernet	**R/RS1=A/DR/RS2=R/F**

		Meter 21	Interface status in the RSTP ring. The role and the status (R/Sx=) are displayed for both channels (ports).
			
			Roles of the ports
			
			The following roles are defined for the ports:
			
			• Root port role (R): A root port is connected with the root switch, i.e. it has a logical connection with it. With internal switches, 1 of the 2 ports always has the role of a root port.
			• Designated port role (D): A designated port can also establish a connection with the root switch, but in a different way. 1 of the 2 ports of the internal switch normally has the designated port role.
			• Alternate port role (A): An alternate port can establish a connection in case of a failure. In stable operation, there must be exactly 1 alternate port in 1 device per ring. In the absence of a port with this role in a ring, the redundancy is not ensured. The ring is open.
			  – According to IEEE 802.3 the receive output window is -14 dBm to -31 dBm.
			  – According to IEEE 802 the output window of the transmitter is between -14 dBm and -20 dBm.
			
			Port states
			
			In addition to the role played by them, ports have states assigned to them. The following states are defined:
			
			• Forwarding state (F): This is in normal operation the state of the ports which play the root or designated role, i.e. payload telegrams are always transmitted.
			• Discarding state (D): Discarding state means that telegrams are discarded and not forwarded. In normal operation, only the port with the alternate role has this status.
			• Learning state (L): This state is not available in the internal switches. The switch structure is such that the port does not require a learning phase.
			
			Normal status

		In our example, port 1 shows the role **alternate** and the status **designated**, which means that this port does neither accept nor transmit telegrams from and to the device. Port 2 has role **root** and status **forwarding**, which means that telegrams are transmitted and received through this port. We can conclude from the information displayed that this device is the logical separating point in the optical ring.
	Ethernet Meter 22 to 26	Internal data
Quick Logic	V_1 to V_{rated}	0/1
Current Measurements	Ia	
	Ib	
	Ic	
	In	
	Ig/Isef	

Table 8-1 Measurements

Current Measurements	Ia	MEAS	VI_MMXU1	A.phsA
	Ib	MEAS	VI_MMXU1	A.phsB
	Ic	MEAS	VI_MMXU1	A.phsC
	In	MEAS	VI_MMXU1	A.neut
	Ig/Isef	MEAS	VI_MMXU1	A.res
Current Sequence Components Measurements	Current	MEAS	I_MSQI1	SeqA.C1
	Current	MEAS	I_MSQI1	SeqA.C2
	Current	MEAS	I_MSQI1	SeqA.C3
Voltage Measurements	Vab	MEAS	VI_MMXU1	PPV.phsAB
	Vbc	MEAS	VI_MMXU1	PPV.phsBC
	Vca	MEAS	VI_MMXU1	PPV.phsCA
	Va	MEAS	VI_MMXU1	PhV.phsA
	Vb	MEAS	VI_MMXU1	PhV.phsB
	Vc	MEAS	VI_MMXU1	PhV.phsC
	Vn	MEAS	VI_MMXU1	PhV.neut
	Vx	MEAS	VI_MMXU1	PhV.res
Voltage Sequence Components Measurements	Voltage	MEAS	V_MSQI1	SeqV
Frequency Measurement	Frequency	MEAS	VI_MMXU1	Hz

Power Measurements	W phs A (P)	MEAS	VI_MMXU1	W
	W phs B (P)	MEAS	VI_MMXU1	W
	W phs C (P)	MEAS	VI_MMXU1	W
	Total W (P)	MEAS	VI_MMXU1	TotW
	VAr phs A (Q)	MEAS	VI_MMXU1	Var.phsA
	VAr phs B (Q)	MEAS	VI_MMXU1	Var.phsB
	VAr phs C (Q)	MEAS	VI_MMXU1	Var.phsC
	Total VAr (Q)	MEAS	VI_MMXU1	TotVAr
	VA phs A (S)	MEAS	VI_MMXU1	VA.phsA
	VA phs B (S)	MEAS	VI_MMXU1	VA.phsB
	VA phs C (S)	MEAS	VI_MMXU1	VA.phsC
	Total VA (S)	MEAS	VI_MMXU1	TotVA
	Power Factor phs A	MEAS	VI_MMXU1	PF.phsA
	Power Factor phs B	MEAS	VI_MMXU1	PF.phsB
	Power Factor phs C	MEAS	VI_MMXU1	PF.phsC
	Total Power Factor	MEAS	VI_MMXU1	TotPF

Information List

The following meters are available, depending upon hardware configuration and can not be edited.

Protocol IEC 60870-5-103	Description	ASDU	Cause of Transmission
Function 183 Information 148	IL1, 2, 3, VL1, 2, 3, P, Q, F, VL1-2, L2-3, L3-1 IL1 (2.4x) (Window 1 %) IL2 (2.4x) (Window 1 %) IL3 (2.4x) (Window 1 %) VL1 (1.2x) (Window 1 %) VL2 (1.2x) (Window 1 %) VL3 (1.2x) (Window 1 %) P (2.4x) (Window 1 %) Q (2.4x) (Window 1 %) F (1.2x) (Window 0.1 %) VL1-2 (1.2x) (Window 1 %) VL2-3 (1.2x) (Window 1 %) VL3-1 (1.2x) (Window 1 %)	9	Cyclic: Refresh rate 5 s 9 or value change greater than Window x %.
Function 183 Information 149	Power $W_{1, 2, 3}$, Power $VAr_{1, 2, 3}$, Power $Factor_{1, 2, 3}$ W1 (2.4x) (Window 1 %) W2 (2.4x) (Window 1 %) W3 (2.4x) (Window 1 %) VAr1 (2.4x) (Window 1 %) VAr2 (2.4x) (Window 1 %) VAr3 (2.4x) (Window 1 %) PF1 (1.2x) (Window 1 %) PF2 (1.2x) (Window 1 %) PF3 (1.2x) (Window 1 %)	9	Cyclic: Refresh rate 5 s 9 or value change greater than Window x %.

Protocol IEC 60870-5-103	Description	ASDU	Cause of Transmission
Function 183 Information 216	Vx, Bus Freq, Phase Diff, Diff Volts and Slip Freq Vx (1.2x) (Window 0 %) Bus Freq (1.2x) (Window 0 %) Phase Diff (1.2x) (Window 0 %) [29] Diff Volts (1.2x) (Window 0 %) Slip Freq (1.2x) (Window 0 %)	9	Cyclic: Refresh rate 5 s 9 or value change greater than Window x %.
Function 183 Information 236	Max Ia, b, c, Van, bn, cn, P, Q, Vab, bc, ca Ia Max (2.4x) (Window 1 %) Ib Max (2.4x) (Window 1 %) Ic Max (2.4x) (Window 1 %) Van Max1 (1.2x) (Window 1 %) Vbn Max2 (1.2x) (Window 1 %) Vcn Max3 (1.2x) (Window 1 %) P Max (2.4x) (Window 1 %) Q Max (2.4x) (Window 1 %) Vab Max (1.2x) (Window 1 %) Vbc Max (1.2x) (Window 1 %) Vca Max (1.2x) (Window 1 %)	9	Cyclic: Refresh rate 5 s 9 or value change greater than Window x %.

For metered information in DNP3 and Modbus RTU please refer directly to the Communication editor file in the Reydisp Manager configurator tool.

[29] Phase difference is stored as -1 to +1 as a multiple of 180° nominal.

9 Functional Tests

9.1 General Notes

Various tests have to be performed for commissioning to warrant the correct function of the device. The commissioning and maintenance of this equipment should only be carried out by skilled personnel trained in protective relay maintenance and capable of observing all the safety precautions and regulations appropriate to this type of equipment, the test equipment and also the associated primary equipment.

Inspection

Check that the device is not physically damaged.

The equipment ratings, operating instructions, and installing structions shall be checked before comissioning or maintenance actions.

The integrity of any protective earth conductor connection shall be checked before carrying out any other actions.

Ensure that all connections are tight and correct to the relay wiring diagram and the scheme diagram. Check that the relay is the correct model and version and is correctly configured. Check that it is fully inserted into the case.

Settings and Configuration

Select the required relay configuration and settings for the application. If more than 1 settings group is to be used for the application, it may be necessary to test both groups and also to test operation of the change mechanism. When using settings groups it is important to remember that the relay need not necessarily be operating according to the settings that are currently being displayed on the device screen. There is an **Active Settings Group** on which the relay operates and an **Edit/View Settings Group** which is visible on the display and which can be changed from the fascia keys. This allows the settings in 1 group to be altered from the relay fascia while the protection continues to operate on a different unaffected group. The **Active Settings Group** and the **Edit Settings Group** are selected in the **Configuration Device** menu. The currently **Active Group** and the group currently **Viewed** are shown at the top of the display in the **Settings** display screen. If the **View Group** is not shown at the top of the display, this indicates that the setting is common to all groups. CT/VT ratio, I/O mapping and other settings which are directly related to hardware are common to all groups. If the relay is allowed to trip during testing then the instruments display will be interrupted and replaced by the **Trip Alert** screen which displays fault data information. If this normal operation interferes with testing then this function can be temporarily disabled for the duration of testing by use of the **Trip Alert** enabled/disabled setting in the **Configuration Device** menu.

Hardware Tests

Operation of all inputs and outputs is tested in the factory. Tests can be repeated to check the device operation in its intended application or by simple direct operation tests as described below.

AC measuring accuracy is calibrated and tested in the factory but can be easily tested by checking values displayed by the relay instruments during secondary injection as described below.

Secondary Injection Tests

Secondary tests can never replace primary tests because they cannot include connection faults. They provide a theoretical check of the setting values only.

For tests using secondary test equipment, make sure that all necessary input signals are simulated and output circuits are interrupted, particularly trip and close commands to the circuit-breakers and other plant unless that functionality is included in the test.

Isolate the auxiliary DC supplies for alarm and tripping from the relay and remove the trip and intertrip links. Ensure that any essential services that share supplies are not interrupted.

Disconnect communications ports or configure control systems to prepare for the tests.

Carry out injection tests for each relay function as required as described in this document.

> **NOTE**
>
> For all high current tests it must be ensured that the test equipment has the required rating and stability and that the relay is not stressed beyond its thermal limit. The maximum duration of the current injection should be limited in case an error is present such that the expected relay operation does not stop the test.

Primary Injection Tests

Primary tests may be done only by qualified personnel who are familiar with the commissioning of protection systems, with the operation of the system, and with safety regulations and provisions (switching, earthing, etc.).

Primary injection tests are essential to check the ratio and polarity of the transformers as well as the secondary wiring.

Switching operations also have to be performed for complete commissioning of the protection system.

> **NOTE**
>
> If the current transformers associated with the protection are located in power transformer bushings it may not be possible to apply test connections between the current transformer and the power transformer windings. Primary injection is needed, however, to verify the polarity of the CTs. In these circumstances primary current must be injected through the associated power transformer winding. It may be necessary to short circuit another winding in order to allow current to flow. During these primary injection tests the injected current is likely to be small due to the impedance of the transformer and limitations of test equipment.

Putting into Service

After tests have been performed satisfactorily the relay should be put back into service as follows:

- Remove all test connections.
- Replace all secondary circuit fuses and links, or close miniature circuit-breakers.
- Ensure the **Protection Healthy** LED is on and steady if configured, and that all LED indications are correct. If necessary press the **x** key until the **Relay Identifier** screen is displayed, then press ► to reset the indication LEDs.
- The relay meters should be checked in **Instruments Mode** with the relay on load.
- The relay settings should be downloaded to a computer and a copy stored for record of the settings produced. The installed settings should then be compared against the required settings supplied before testing began. Automated setting comparison can be carried out by Reydisp using the check operation of Reydisp Manager. Settings can be downloaded from the device, and compared, using Reydisp Manager.

The described tests are for guidance for experienced personnel that can ensure that these are performed safely.

Routine Maintenance

The device does not require scheduled preventative maintenance although some users apply periodic checking schedules to all protection devices. Operational checking can be limited to periodic visual checks of measured analogue values at the device instruments or the data provided over the communications channels to supplement the continuous self-checking features of the device.

Repair

The device is designed with no user serviceable parts and if a device reports a failure it can be returned to Siemens for investigation and repair. Contact and return details will be provided by the local Siemens office. Necessary precautions such as isolating the equipment, power supply and connections should be applied before investigating further, particularly with respect to safety earthing.

9.2 Hardware Measurement Tests

Binary Inputs

The operation of the binary input(s) can be monitored on the **Binary Input Meters** display shown in **Instruments Mode**. Apply the required supply voltage onto each binary input in turn and check for correct operation. Depending on the application, each binary input may be programmed to perform a specific function; each binary should be checked to prove that its mapping and functionality is set as part of the Scheme Operation tests.

Where the pick-up timers associated with a binary input are set these delays can be checked either as part of the scheme logic or individually. To check a binary pick-up time delay, the binary input can be temporarily mapped to an output relay that has a normally open contact. This can be achieved in the **Output Matrix** submenu by utilizing the **BI n Operated** settings. Use an external timer to measure the interval between binary input energization and closure of the output contacts. Similarly, to measure the drop-off delay, map the binary input to an output relay that has a normally closed contact, time the interval between binary input de-energization and closure of the output contacts.

NOTE

The time measured will include an additional delay, typically less than 20 ms, due to the response time of the binary input hardware, software processing time and the operate time of the output relay.

BI	Tested	DO Delay Setting	Measured	PU Delay Setting	Measured	Notes (method of initiation)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

Binary Outputs

A minimum of 8 output relays are provided. 2 of these have change over contacts, BO1 and BO2. BO3 provides a normally closed contact, typically used to indicate device health. The remainder have normally open contacts.

Care should be observed with regard to connected devices when forcing contacts to operate for test purposes. Short duration energization can cause contact failure due to exceeding the break capacity when connected to inductive load such as electrically reset trip relays.

Contacts can be operated from Reydisp Manager for testing purposes. Relay – Control - Close output relay. This function will energize the output for its minimum operate time. This time is specified in the **Configuration > Binary Outputs > Binary Output Config** menu for each output relay and may be too short to measure manually with a continuity tester.

An alternative method of energizing an output permanently so that wiring can be checked is to temporarily map the relay being tested to the **Protection Healthy** signal in the **Output Matrix**, as this signal is permanently energized the mapped relay will be held energized, normally open contacts will be closed and normally closed contacts will be opened.

BO	Checked	Notes (method of test)
1NO		
1NC		
2NO		
2NC		
3NC		
4		
5		
6		
7		
8		

Relay Case Shorting Contacts

CT input terminals and the terminals of normally closed contacts of binary outputs 1, 2, and 3 are fitted with case mounted shorting contacts which provide a closed contact when the relay is withdrawn from the case. The operation of these contacts should be checked if they are essential for scheme connections.

CT Shorting contacts checked	
Binary Output 1 terminals B2 and B4 Alarm Checked	
Binary Output 2 terminals B10 and B12 Alarm Checked	
Binary Output 3 terminals B14 and B16 Alarm Checked	

AC Analogue Energizing Quantities

Voltage Trim

The voltage inputs of the 7SR5 are provided with a **Voltage Trim** feature that can be used to compensate for voltage drop and phase shift introduced by the secondary wiring to the device. The applied voltage is scaled internally to allow for the actual effects of long secondary wiring runs which case significant voltage attenua-tion.

The site specific settings required to suit the installed equipment should be verified by primary application and modified at the commissioning stage. Voltage and current instruments should be used to ensure that the measurements align with the applied primary quantities. If this feature is used it will cause modified voltage magnitude and phase to be measured when secondary voltages are directly applied to the device during secondary testing. The test injection voltages must be adjusted to suit the trim settings or the trim set to zero for the duration of the applicable tests.

Voltage and current measurement for each input channel is displayed in the **Instrumentation Mode** sub-menus, each input should be checked for correct connection and measurement accuracy by single phase secondary injection at nominal levels. Ensure that the correct instrument displays the applied signal within limits of the `Technical Data`.

	Applied Current.......................						**Applied Voltage............**			
	CT1 I_A	CT2 I_B	CT3 I_C	CT4 $I_{G/GS}$	CT8 I_{G2}	Toler-ance	VT1 V_A/V_{AB}	VT2 V_B/V_{BC}	VT3 V_C/V_{CA}	Tolerance
Secondary										
Primary										

9.3 Functional Test for the Phase-Rotation Direction

NOTE

Check that the configuration of phase sequence (direction of rotating field) of the device is correct for the system connections. This can be changed if necessary by the setting of the **Phase Rotation** parameter in the **CT/VT** menu.

The phase sequence can be determined via the **Sequence Components** measured values instruments. If normal balanced load analogue signals are applied to the device the value of applied current and voltage should be shown as positive sequence values with negligible negative sequence components. If the value is displayed as negative-sequence values with negligible positive sequence values, the setting parameter **Phase Rotation** does not correspond to the supplied signals and connections.

If this parameter is incorrect this will invert the forward and reverse directions of directional protection as well as affecting any function that utilizes sequence component values.

	ZPS	**NPS**
Voltage		
Current		

9.4 Direction Test of the Phase Quantities (Current and Voltage Connection)

The proper connection of the current and voltage transformer is checked with load current flowing over the line to be protected. For this, the line must be switched on. A load current of at least 0.1 of rated current has to flow over the line; it should be resistive or resistive-inductive and the actual direction of the load current has to be known. In case of doubt, meshed and ring systems should be opened or reconfigured. The line remains switched on the for the duration of the measurements.

The direction determination in the device is derived directly from the measurement of applied currents and voltages and is displayed in the device instruments. First make sure that the power measured values correspond to the power direction. Conventionally, the forward direction (measuring direction) is considered to be from the busbar toward the line but particularly for incoming circuits the network operator may prefer the opposite direction to be used.

Using the power measured values displayed in the instruments at the device, make sure that it corresponds to the expected power direction:

- P is positive if the active (real) power flows into the line or protected object.
- P is negative if the active (real) power flows to the busbar or out of the protected object.
- Q is positive if the inductive reactive power flows into the line or protected object.
- Q is negative if the inductive reactive power flows to the busbar or out of the protected object.

If the power measured values have a different sign than expected, then the power flow is opposite the current direction convention that is defined by the applied settings. This can be the case, for example, at the opposite end to the line where it may be considered as an incoming circuit.

If the values are not as expected, it may be due to the current transformer star point direction error or a polarity reversal at the voltage connection. The convention direction can be reversed by configuration of device settings but this setting should not be used to disguise a wiring error.

9.5 Direction Test of the Earth Quantities for Directional Earth-Fault Functions

Overview

If only calculated earth fault protection is used in the device and only calculated residual voltage 3V0, testing as above for direction test of the phase quantities (Current and Voltage Connection) is sufficient to ensure that the direction is correct, no additional directional test is required.

If earth current is measured such as for measured earth fault protection elements, or the residual voltage is directly measured such as with a 3V0 voltage configuration, the correct polarity of the earth current and the earth voltage path must be checked in addition to the phase checks.

⚠ **DANGER**

Live system parts! Capacitive coupled voltages on dead parts!

Noncompliance with the following measures can lead to death, serious physical injury, or considerable material damage.

✧ Primary measures may be performed only on dead and earthed system parts.

Directional Testing for Solid or Resistive-Earthed Systems

Primary Test

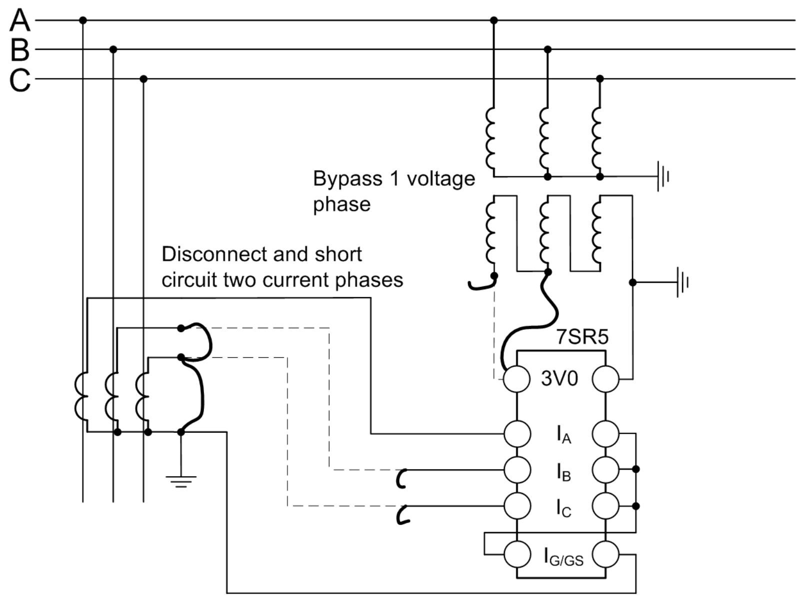
The primary test is used for the evaluation of the correct polarity of the transformer connections for the definitive determination of the earth fault direction.

To generate a zero-sequence voltage V_0, the e-n winding of 1 phase in the voltage-transformer set (for example, phase A) is bypassed, see *Figure 9-1*. If no connection on the e–n windings of the voltage transformer is provided, the corresponding phase is disconnected on the secondary side, see *Figure 9-2*. Only the current of the transformer in the phase of which the voltage is missing is transferred via the current circuit. If the line carries resistive-inductive load, the protection is subject to the same conditions as those existing during a earth fault in line direction.

For directional testing, the relay instruments show the direction of the applied current for the measured earth input as well as the calculated earth current. This should be used to check current polarity. The forward/reverse boundary of current direction for the instruments is defined by the parameters for 67N, 67G and 67GS protection elements.

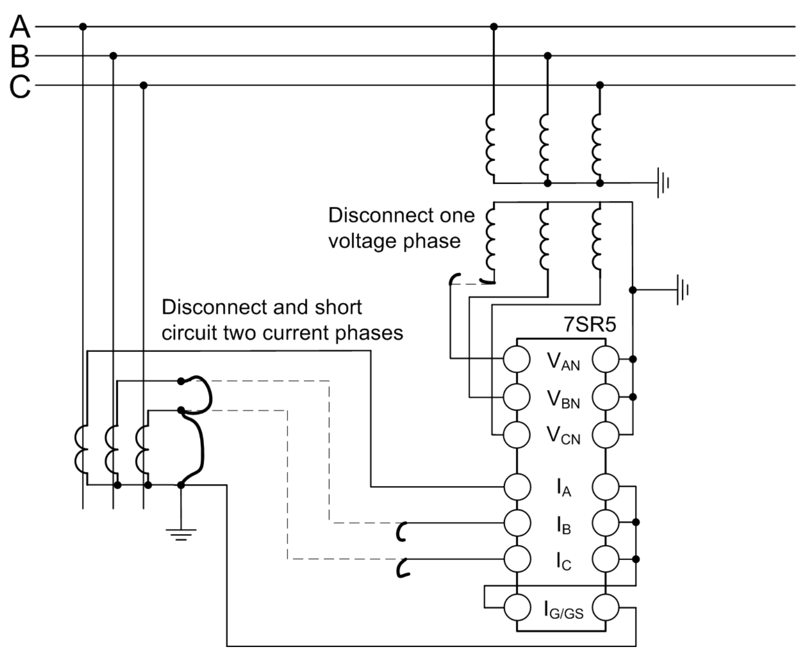
If a wrong direction is logged, 1 of the following conditions may have occurred:

- The direction of the load flow is from the line towards the busbar.
- The ground-current connection is incorrect.
- The voltage connection is incorrect.
- The device directional settings are incorrect.



[lo_7SR5_FunctionalTestsLogicDiagram1, 1, en_US]

Figure 9-1 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Broken-Delta Connection



[lo_7SR5_FunctionalTestsLogicDiagram2, 1, en_US]

Figure 9-2 Polarity Testing, Example with Current Transformers Configured in a Holmgreen-Connection and VTs with Star Connection

Directional Testing for Isolated or Resonant-Earthed Systems

Primary Test

The most reliable test is by application of a primary earth fault. This is usually practical on these types of networks due to the low fault currents involved. The primary test is used to provide a definitive evaluation of the correct polarity of the transformer connections for the determination of the earth fault direction.

At least one 50GS element should be **Enabled** and configured as **Forward** or **Reverse**. This would typically be configured to trip the circuit-breaker. The 67GS directional element must be correctly configured to suit the network.

Typically the test procedure is as follows:

- Isolate the circuit and apply safety earths at both ends.
- Apply a single phase to earth short circuit at any convenient location on the circuit.
- Remove safety earths
- Close the circuit-breaker to energize the system with the primary short circuit applied.
- Isolate the circuit at by opening the circuit-breaker if it is not tripped already.
- Check operation of the 50GS element and particularly 67GS **Forward** direction indication. If **Reverse** direction is indicated as the fault direction this indicates that there is a wiring polarity problem that requires investigation and correction.
- Apply safety earths
- Remove the test short circuit.
- Remove the safety earths.

9.6 Circuit-Breaker Test

NOTE

Siemens recommends isolating the circuit-breaker of the tested feeder at both ends before starting the tests. Line disconnector switches and busbar disconnector switches must be open so that the circuit-breaker can be operated without risk.

The circuit-breaker tripping operation should be tested from a protection trip to ensure that all connections are made and function completely.

Manual circuit-breaker open and close operations should also be tested. The correct operation of status signals from circuit-breaker auxiliary contacts should be checked during these tests.

Autoreclose configuration should be tested to confirm timing, sequences and other settings.

Correct operation of auxiliary contact signals may be required for correct operation of the relay.

Correct voltage levels and synchronizing conditions may be required for correct closing sequence operations. Operating modes of the relay and interlocking logic can block plant operating commands. This should be investigated if undesirable behavior occurs but the correct operation of such signals should also be checked. Circuit-breaker status is displayed in the **Control Mode** menu and can be configured on a mimic diagram. Binary input state and autoreclose sequence state is displayed in the device instruments.

Trip and Lockout and **Trip and Reclose** input points are provided for circuit-breaker testing purposes. Circuit-breaker operation time is displayed in the maintenance meter instruments and should be checked during testing.

9.7 Primary and Secondary Tests of the Circuit-Breaker Failure Protection

Integration of the Protection Function into the Station

The integration of the protection function into the station must be tested for the individual application. Because of the multitude of possible applications and possible system configurations, the required tests cannot be described here in detail.

NOTE

If circuit-breaker fail is provided precautions must be taken to ensure that this system is not triggered during testing of the protection device.

CAUTION

Tests on the local circuit-breaker of the feeder cause a trip command to the output to the adjacent (busbar) circuit-breakers.

Noncompliance with the following measure can result in minor personal injury or physical damage.

✧ In a first step, interrupt the trip commands to the adjacent (busbar) circuit-breakers, for example, by disconnection of the corresponding supply voltages.

Incorrect installation or configuration of circuit-breaker fail protection can cause significant system disturbance and therefore may warrant special attention. For testing the circuit-breaker failure protection, it must be ensured that the protection (external protection device or device-internal protection functions) cannot operate the circuit-breaker. The corresponding trip command must be interrupted.

Although the following list does not claim to be complete, it can also contain points which are not applicable for all applications.

Circuit-Breaker Auxiliary Contacts

Correct configuration, connection and operation of circuit-breaker auxiliary contacts is essential for the correct operation of circuit-breaker failure functionality.

- Make sure that the correct assignment has been checked and operation tested.

Internal CB Fail Starting Conditions (Trip Command from Internal Protection Function)

The internal start can be tested by means of tripping a protection function, for example, the main protection function of the device.

- Check the settings for circuit-breaker failure initiation by protection elements.
- For the circuit-breaker failure protection to be able to pick up, a phase current (see current-flow criterion) must be present. This can be generated by secondary test current injection.
- Generate the trip for the protection function. This can be generated within the device by a test sequence (see description in the Operating manual) or by creating corresponding secondary test values.
- The trip command(s) and their time delay compared to the pickup, depending on the parameterization.

Completion of Testing

- All temporary measures taken for testing must be undone, such as special switch positions, interrupted trip commands, changes to setting values, or individually switched off protection functions.

9.8 Testing of the Synchrocheck Function

The synchrocheck function is used to prevent unsafe manual closing and autoreclosing operations for the circuit-breaker. Correct configuration, connection and operation is essential for safe operation and this warrants special attention during commissioning.

Testing should at least be applied to check that closing operations do not occur when unmatched voltages are applied and for correct operation when the system voltage is dead on one or both sides. Confirmation of correct settings can be provisionally checked by application of secondary voltages supplied from suitable test equipment but as a minimum, checking for the expected voltage alignment at the relay metering under normal healthy system conditions should be confirmed before closing for the first time with an energized system. Errors such as incorrect phase selection must be identified and eliminated for safe operation.

Measuring the Circuit-Breaker Closing Time

The closing time of the circuit-breaker must be configured as a device setting if **`Close on Zero`** is used. This can be measured from a waveform record following a close operation if the record is configured to be triggered from the CB close pulse.

Firstly, a condition in which the circuit-breaker can be closed without hazard should be identified, typically with one side dead.

The relay should be configured to be triggered from the CB close pulse.

Apply a **`Manual CB Close`** operation with live primary voltage.

Retrieve the waveform record from the device using Reydisp for examination.

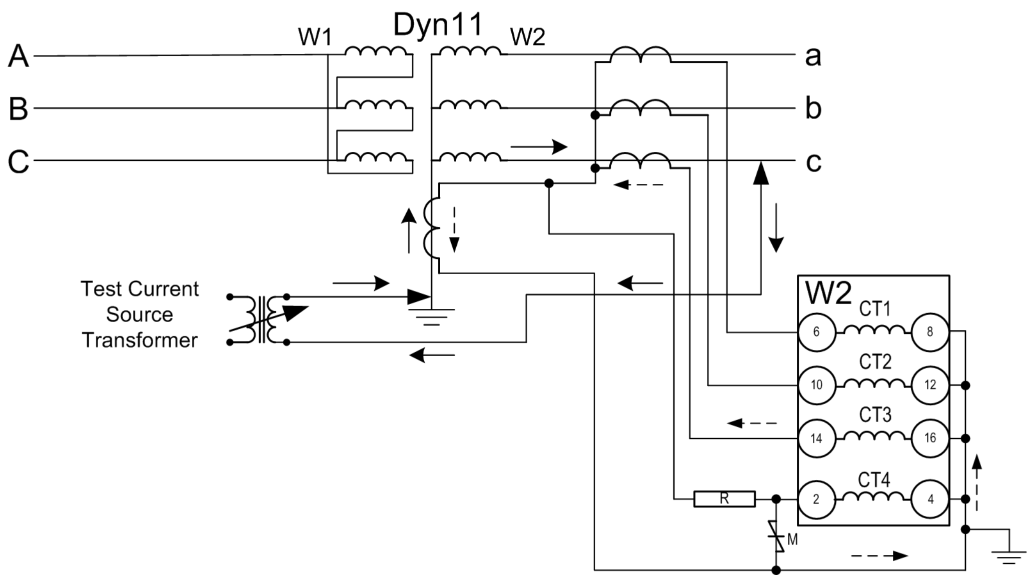
The time should be measured using the cursors from the start of the close pulse to the point at which the primary voltage starts to appear on the dead side.

The time determined here is the real closing time and not the mechanical operating time of the circuit-breaker.

9.9 Restricted Earth Fault Protection – High-Impedance

In addition to the protection setting and the correct routing of the signals, the polarity connection of current transformers is important and must be tested for proper system integration.

A single phase primary injection test is the preferred method to prove that the earth point current transformer is polarity connection is correct. Inspection of connection markings is possible but may not be totally conclusive. The high impedance resistor should be short circuited to reduce the driving voltage requirements of the test equipment. The REF spill current should be measured at the relay and should be an order of magnitude less than the relay setting.



[lo_7SR5_FunctionalTestsLogicDiagram9, 1, en_US]

Figure 9-3 Test with High-Current Test Equipment

9.10 Protection Functional Tests

Protection Functional Tests

This section details the procedures for testing each protection function of the 7SR5 relays. These tests are typically carried out by secondary injection to verify the correct operation of the associated input and output functionality, and communications protocol information for protection operations and logic and can be used to confirm that the pick-ups levels and time delays are as expected for the applied settings if this is required for scheme approval testing.

Guidance for calculating test input quantities is given in the relevant test description where required. In many cases it may be necessary to inhibit some functions during the testing of others, this prevents any ambiguity caused by the operation of multiple functions from the same of input quantities. The **Function Config** menu provides a convenient high level point at which all elements of a particular function can be **Enabled/ Disabled** to suit testing. The **Config** tab in Reydisp Evolution can be used to **Enable/Disable** individual elements. Note that this screen disables functions by applying setting changes to the relay and that any changes must be sent to the relay to take effect and settings must be returned to their correct value after testing.

Any LED can be assigned to be a **General Pickup** LED in the **Output Matrix** menu and used to assess operation of functions during testing if other functions are disabled or if the setting allocating **General Pickup** is temporarily modified.

Voltage inputs may not be required for testing of non-directional overcurrent elements but it may be advantageous to apply balanced 3 phase nominal rated voltage to the VT inputs during testing to avoid inadvertent operation of other functions. Particular care should be taken when testing overcurrent functions that the thermal rating of the current inputs is not exceeded.

It should be considered that where several overlapping elements are used simultaneously, the overall protection operate time may be dependent on the operation of different individual elements at the various levels of applied current or voltage. The resulting composite characteristic may be tested by enabling all of the relevant applicable elements or the element operations can be separated or disabled and tested individually.

All relay settings should be checked before testing begins. It is recommended that the relay settings are extracted from the relay using Reydisp Evolution software and a copy of these settings is stored for reference during and after testing. It may be necessary to disable some protection functions during the testing of other functions to allow unambiguous results to be obtained.

Care must be taken to reset or re-enable any settings that have been temporarily altered during the testing before the relay can be put into service. At the end of testing the relay settings should be compared to the file extracted at the start to ensure that errors have not been introduced.

9.10.1 21LB Load Blinder

Load blinders are designed to block overcurrent elements from tripping in heavy load conditions. User settings 21LB 3Ph Angle +ve, 21LB 3Ph Angle -ve, and 21LB 3Ph impedance allow users to define the blinder region depending on the networks or line’s loading and fault limits. The 3Ph impedance is the positive sequence impedance which is specified in secondary Ω and can be calculated by the phase to neutral voltage divided by the phase current

Determining Load Blinder Regions (21LB)

Apply balanced 3 phase rated voltage and balanced current in phase with the phase to neutral voltages. Current level should be selected such that the impedance calculated from Van/Ia is greater than the 21LB 3Ph impedance setting. Typically $0.5 \cdot I_{rated}$. The **Load Blinder FWD** signal should be active.

Increase the angle of the 3 phase currents in a leading (positive) direction. This will approach the **Forward**(+) boundary defined by the Angle +ve setting. The **Load Blinder FWD** signal will reset when the angle is above the setting plus 3° hysteresis and will pickup again if the angle is reduced to below the Angle +ve setting.

Increase the angle of the 3 phase currents in a lagging (negative) direction. This will approach the **Forward**(-) boundary defined by the Angle -ve setting. The **Load Blinder FWD** signal will reset when the angle is above the setting plus 3° hysteresis and will pickup again when the angle is reduced to below the Angle -ve setting.

This can be repeated for the reverse load settings for clarity if required. Increasing the 3 phase current angle in the leading (positive) direction from forwards towards anti-phase (180 degrees) with respect to the 3 phase voltage will pick up the **Load Blinder REV** signal when the angle from 180° equals the Angle +ve setting. Increasing still further in the anticlockwise direction will approach the **Reverse**(-) boundary. The **Load Blinder REV** signal will reset when the angle is above the Angle -ve setting plus 180° plus 3° hysteresis and will pickup again when the angle is reduced to below 180° plus Angle -ve angle setting.

Table 9-1 Angle boundary

Load Blinder region	Forward (+) Boundary		Forward (-) Boundary	
	Angle = (Default=20°)		Angle = (Default=20°)	
	PU (Raised)	DO (Reset)	PU (Raised)	DO (Reset)
Angle				

V_1 Setting

V_1 Setting can be checked by reducing balanced 3 phase voltage to below the setting with the low level current as above, applied at zero degrees.

Table 9-2 V_1 Setting

Parameters	Setting	Operation
V_1 Setting	42 V	

Determining Impedance Sensitivity

The impedance can be calculated directly from phase-neutral voltage divided by phase current.

Apply balanced 3 phase rated voltage and balanced 3 phase rated current. Calculate the current required to achieve the relay impedance setting with nominal voltage. If this is possible without exceeding relay thermal rating it can be injected manually. Increase the current until the **Load Blinder FWD** resets. If the current required will exceed the continuous rating, short duration tests will be required at 90 % of impedance setting. Alternatively, voltage can be reduced to allow lower current to be applied to achieve the required impedance but the V_1 Setting must always be exceeded as this will otherwise block the operation.

Table 9-3 Trip Level

Parameters	Setting	DO	PU
Impedance Ω			
Voltage V	63.5		

9.10.2 27 Undervoltage Protection – 3 Phase

Where more than 1 undervoltage (27) elements are being used with different settings, it is convenient to test the elements with the lowest settings first. The elements with higher settings can then be tested without disabling the lower settings.

Note that if the voltage is reduced below the 27UVG setting, the function may be blocked. VTS operation may also block the 27 undervoltage function. Current inputs are not required to stabilize the relay during voltage element testing.

The 27 undervoltage can be set to operate from phase to phase or phase to neutral voltage. Test voltage should be connected to suit.

If the **Pickup Option** is set to **All**, the voltage on all phases must be reduced simultaneously. Otherwise the 3 phases should be tested individually. Balanced nominal rated voltage should be connected to the 3 phases. If the DTL is short, starting from nominal voltage, slowly decrease the applied 3P or appropriate single phase test voltage until the **Pickup** LED (temporarily mapped) is on. Record the operate voltage. The LED should light at setting Volts +/-5 %. Slowly increase the input voltage until the LED extinguishes. Record the reset voltage to check the **Hysteresis** setting. If the DTL is long, the operate level should be checked by applying a voltage of 90 % of setting voltage. Check hysteresis by resetting element to the operate level setting plus the **Hysteresis** setting.

Connect the relevant output contact(s) to stop the test set. Step the applied voltage to a level below the setting. The test set should be stopped at the operate time setting +/-5 %.

Test the other 2 phases by repeating the above if necessary.

When testing is complete reinstate any of the disabled functions.

Phase	Setting (Volts)	DTL (sec)	Hyst.	D.O. (calcu-lated)	P.U. Volts	D.O Volts	Op. Time @ 0.5 · V_{set} (UV)	UV Guard	Toler-ance
V_{AB}/ V_A									
V_{BC}/ V_A									
V_{CA}/ V_C									

Element Blocking

The undervoltage elements can be blocked by **Binary Input Inhibit** and **VT Supervision**. This functionality should be checked.

Element	BI Inhibits	VT Supervision
27-1		
27-2		
27-3		
27-4		

Check correct indication, trip output, alarm contacts, waveform record.

When testing is complete reinstate any of the disabled functions.

Undervoltage Guard

If any 27 undervoltage element is set to be inhibited by the **UV Guard** element, this function should be tested.

Connect the test voltage inputs to suit the installation wiring diagram utilizing any test socket facilities available. It may be useful to temporarily map an LED as **General Pickup** to assist during testing. **UV Guard** operation will reset the **General Pickup** if no other element is operated. This LED should not be set as **Hand Reset** in the output matrix.

Starting from nominal voltage, apply a step decrease to the applied voltage to a level below the 27 undervoltage setting but above the 27UVG setting such that an undervoltage element operation occurs. Slowly reduce the applied voltage until the 27 undervoltage element resets, this can be detected by the **General Pickup** LED reset if no other element is operated (this includes any undervoltage element which is not **UV Guarded**).

Phase	Setting (Volts)	Tolerance	V Element Used for Test	Blocked Volts	Notes
UVG					

9.10.3 27Vx Undervoltage Protection – Vx

27Vx elements operate similarly to the 27 elements but are applied to the fourth voltage input Vx.

Where more than one 27Vx undervoltage elements are being used with different settings, it is convenient to test the elements with the lowest settings first. The elements with higher settings can then be tested without disabling the lower settings.

Note that if the voltage is reduced below the **UV Guard** setting threshold, the function may be blocked. Current inputs are not required to stabilize the relay during voltage element testing.

Single phase voltage should be connected to the Vx input directly. If the DTL is short, starting from nominal voltage, slowly decrease the applied test voltage until the **Pickup** LED (temporarily mapped) is on. Record the operate voltage. The LED should light at setting Volts ± 5 %. Slowly increase the input voltage until the LED extinguishes. Record the reset voltage to check the **Hysteresis** setting. If the DTL is long, the operate level should be checked by applying a voltage of 90 % of setting voltage. Check hysteresis by resetting element to the operate level setting plus the **Hysteresis** setting.

Connect the relevant output contact(s) to stop the test set. Step the applied voltage to a level below the setting. The test set should be stopped at the operate time setting ± 5 %.

When testing is complete reinstate any of the disabled functions.

Setting (Volts)	DTL (sec)	Hyst.	D.O. (calcu-lated)	P.U. Volts	D.O Volts	Op. Time @ 0.5 · V_{set} (UV)	UV Guard	Tolerance

Element Blocking

The Vx Under Voltage elements can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
27-1	
27-2	

Check correct indication, trip output, alarm contacts, waveform record.

When testing is complete reinstate any of the disabled functions.

Undervoltage Guard

If any Vx undervoltage element is set to be inhibited by the **UV Guard** element, this function should be tested.

Connect the test voltage inputs to suit the installation wiring diagram utilizing any test socket facilities available. It may be useful to temporarily map an LED as **General Pickup** to assist during testing. **UV Guard** operation will reset the **General Pickup** if no other element is operated. This LED should not be set as **Hand Reset** in the output matrix.

Starting from nominal voltage, apply a step decrease to the applied voltage to a level below the 27Vx undervoltage setting but above the 27Vx **UV Guard** setting such that an undervoltage element operation occurs. Slowly reduce the applied voltage until the 27Vx undervoltage element resets, this can be detected by the **General Pickup** LED reset if no other element is operated (this includes any undervoltage element which is not UV guarded).

Phase	Setting (Volts)	Tolerance	V Element Used for Test	Blocked Volts	Notes
Vx UVG					

9.10.4 32 Power Protection

This function can be tested by application 3P current and voltage. For over-power, the elements with the highest setting should be tested first and for under-power the elements with the lowest settings should be tested first. The elements with other settings can then be tested without need to disable the elements already tested.

From the nominal power setting S_{rated} gradually increase/decrease applied voltage or current until 32-n operation occurs. In general it is most convenient to apply balanced rated voltage and increase or decrease current on 1 or 3 phases. The thermal withstand limitations of the current inputs and overvoltage limitations of voltage inputs, stated in the **Technical Data** should always be observed throughout testing. This will avoid trigger of VTS which may be configured to block 32 power elements, usually only underpower.

The **Forward/Reverse** direction of power is defined by the **Export Power/Lag Var** convention setting in the **Configuration Device** menu. For real power, set phase current in phase with phase-neutral voltage on all phases for forward direction and to 180° for reverse for a +ve convention setting. For reactive power, set phase current to lag phase-neutral voltage by 90° for forward direction and current to lead voltage by 90° for reverse direction for a +ve convention setting. Non-directional real or reactive power elements will operate for both forward and reverse direction. Apparent power elements will operate for power which is independent of the phase angle between voltage and current. If the **32-n Delay** setting is long it will be advantageous to map the function to temporarily drive the relevant pickup output in the **Pickup Config** sub-menu in the **Output Config** menu as this will allow the **Pickup** led to operate for the function. If the delay setting is short the operation of the element can be easily checked directly.

The current or voltage should then be decreased/increased until the element resets.

If the element is set to have a **UC Guard** applied, the applied current must be above the **32-n UC Guard Setting**. Apply setting power +10 % for over-power or -10 % for under-power and record operating time.

	Power (· S_{rated})	U/O	DTL (sec)	P.U. Power (· S_{rated})	D.O. Power (· S_{rated})	Op. Time ± 0.5 Hz	UC Guard	Notes
32-1								
32-2								

If the element is set with **UC Guard**, the setting can be tested by applying the test current at a level below the **32-n UC Guard Setting** at a power in the operate range. Increase the current until the relay operates.

UCG	UCG Setting (· I_{rated})	Power Element Used for Test	Blocked Current (D.O.)	Unblocked Current (P.U.)	Notes
U/O Power					

Element Blocking

The U/O power elements can be blocked by **Binary Input Inhibit** or operation of VTS. This functionality should be checked.

Element	BI Inhibits	VTS Inhibit
32-1		
32-2		

Check correct indication, trip output, alarm contacts, waveform record.

When testing is complete reinstate any of the disabled functions.

9.10.5 37 Undercurrent Protection – Phase

If 2 undercurrent 37 elements are used with different settings, it is convenient to test the element with the lowest setting first. The higher setting element can then be tested without interference from the other element.

Apply 3 phase balanced current at a level above the undercurrent 37-n setting until the element resets. Reduce single phase current to below setting to prove the operation of the **Pickup Option Any/All** setting.

If DTL setting is small, gradually reduce single phase current or 3 phase currents until element operates.

If DTL is large apply 1.1 times setting, check for no operation, apply 0.9 times setting, check operation.

Testing of this element phase by phase may cause inadvertent operation of the 46 NPS overcurrent elements. Apply 0.5 times setting current and record operating time.

Phase	I_{set} (Amps)	DTL (sec)	P.U. Current Amps	Tolerence	Op. Time 0.5 · I_{set}	Tolerance
CT1(I_A)						
CT2(I_B)						
CT3(I_C)						

Element Blocking

The undercurrent elements can be blocked by **`Binary Input Inhibit`**. This functionality should be checked.

Element	BI Inhibits
37-1	
37-2	

Element Blocking from Current Guard

The elements can be blocked by the undercurrent guard function. This functionality should be checked.

Element	Guard Setting	Blocked
37-1		
37-2		

Check correct phase indication, trip output, alarm contacts, waveform record.

9.10.6 37G Undercurrent Earth Fault – Measured

If 2 undercurrent 37G elements are used with different settings, it is convenient to test the element with the lowest setting first. The higher setting element can then be tested without interference from the other element.

Apply current to the single phase input at a level above the undercurrent 37G-n setting until the element resets.

If DTL setting is small, gradually reduce current until element operates.

If DTL is large apply 1.1 times setting, check for no operation, apply 0.9 times setting, check operation.

Apply 0.5 times setting current and record operating time.

Phase	I_{set} (Amps)	DTL (sec)	P.U. Current Amps	Tolerence	Op. Time 0.5 · I_{set}	Tolerance
CT4(I_G)						

Element Blocking

The undercurrent elements can be blocked by **`Binary Input Inhibit`**. This functionality should be checked.

Element	BI Inhibits
37G-1	
37G-2	

Element Blocking from Current Guard

The elements can be blocked by the undercurrent guard function. This functionality should be checked.

Element	Guard Setting	Blocked
37G-1		
37G-2		

Check correct phase indication, trip output, alarm contacts, waveform record.

9.10.7 46 Negative Sequence Overcurrent Protection

Where 2 NPS elements are being used with different settings, it is convenient to test the elements with the highest settings first. The elements with lower settings can then be tested without disabling the lower settings. The thermal withstand limitations of the current inputs, stated in the `Technical Data` should always be observed during testing.

NPS overcurrent can be tested using a normal 3P balanced source. 2 phase current connections should be reversed so that the applied balanced 3P current is negative phase sequence.

If `Phase Rotation ACB` is selected in the CT/VT menu, the expected PPS and NPS are exchanged and the output from a standard positive sequence test set will be considered as NPS.

Definite Time NPS Overcurrent (46DT)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9 times setting, check for no operation, apply 1.1 times setting, check operation.

Apply 2 times setting current if possible and record operating time.

Phase	I_{set} (Amps)	DTL (sec)	P.U. Current Amps	Tolerance	Operate Time $2 \cdot I_{set}$	Tolerance
NPS						

Check correct indication, trip output, alarm contacts, waveform record.

Inverse Time NPS Overcurrent (46IT)

It will be advantageous to map the function being tested to temporarily drive the relevant pickup output in the `Pickup Config` sub-menu in the `Output Config` menu as this will allow the `Pickup` led to operate for the function.

Gradually increase current until `Pickup` LED operates.

Apply 2 times setting current and record operating time.

Apply 5 times setting current and record operating time.

Compare to calculated values for operating times.

P.U. D.O. & Timing Tests	Ph.	Dir	Char. (NI EI VI LTI, DTL)	I_{set} (A)	Tm	Operate Current			Operate Time		
						P.U. (Amps)	D.O. (Amps)	Tol	$2 \cdot I_{set}$ (sec)	$5 \cdot I_{set}$ (sec)	Tol
	NPS										

Calculated timing values in seconds for Tm = 1.0

Curve	$2 \cdot I_{set}$	$5 \cdot I_{set}$
IEC-NI	10.03	4.28
IEC-VI	13.50	3.38
IEC-EI	26.67	3.33
IEC-LTI	120.00	30.00
ANSI-MI	3.80	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.30

Note that the operate time may be subject to the `Minimum Op Time` setting for the element and/or may have a `Follower DTL` applied.

ANSI Reset

If the element is configured as an ANSI characteristic, it may have an ANSI decaying reset delay applied. ANSI reset times from operated condition to fully reset are as follows for zero applied current and Tm = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 s
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calcu-lated)	50 % Operate Time (meas-ured)
		First test (c)			Second test (c)

Element Blocking

The NPS overcurrent elements can be blocked by **`Binary Input Inhibit`**. This functionality should be checked.

Element	BI Inhibits
46IT	
46DT	

Check correct indication, trip output, alarm contacts, waveform record.

When testing is complete reinstate any of the disabled functions.

9.10.8 46BC Broken Conductor Detection

Broken conductor uses the ratio of NPS current to PPS current to detect an open circuit conductor . These quantities can be produced directly from many advanced test sets but with limited equipment the following approach can be applied.

Apply 3P balanced current with normal phase rotation direction. This current will consist of PPS alone, no NPS or ZPS. Increase 1 phase current magnitude in isolation to produce NPS. The single phase unbalance current will contain equal quantities of ZPS, NPS and PPS. The NPS component will be 1/3 of the unbalance current and the total PPS component will be value of the original balanced 3P current plus 1/3 of the additional unbalance current. i.e. as the single phase unbalance current increases, the ratio of NPS to PPS will also increase. The levels of each sequence component current can be monitored in the **`Current Meters`** in **`Instruments`** mode.

Inject 1 A of balanced current. Gradually increase imbalance current, operating level should be as follows:

46BC Setting	1P Unbalance Current (% of 3P current)
20 %	75 %
25 %	100 %
30 %	129 %
35 %	161 %
40 %	200 %

46BC-1 Setting	3P Balanced Current (A)	1P Unbalance Current (A)	Measured Unbalance Current

Apply 1 A 1P unbalance current without 3P balanced current. Measure 46BC-1 operating time.

46BC-1 Delay Setting	Measured

Element Blocking

The **Broken Conductor** element can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
46BC-1	

Element Blocking from Current Guard

The elements can be blocked by undercurrent guard function. This functionality should be checked.

Element	Guard Setting	Blocked
46BC-1		

9.10.9 47 Sequence Overvoltage Protection

Where 2 NPS voltage elements are being used with different settings, it is convenient to test the elements with the highest settings first. The elements with lower settings can then be tested without disabling the lower settings.

NPS overvoltage can be tested using a normal 3P balanced source. 2 phase voltage connections should be reversed so that the applied balanced 3P voltage is negative phase sequence.

If the 47-n delay is small, gradually increased the applied balanced 3P voltage until element operates.

If DTL is large apply 0.9 times setting, check for no operation, apply 1.1 times setting, check operation.

Apply 2 times setting current if possible and record operating time.

	Setting (Volts)	Delay (sec)	Hyst.	P.U. (Volts)	D.O. (Volts)	Op. Time @ $2 \cdot V_{set}$	U/V Guard	Tolerance
NPS								

Element Blocking

The NPS overvoltage element can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
47-1	
47-2	

Check correct indication, trip output, alarm contacts, waveform record.

Undervoltage Guard (47 U/V Guard)

If any 47 NPS overvoltage element is set to be inhibited by the 47 undervoltage guard element, this function should be tested.

Connect the test voltage inputs to suit the installation wiring diagram utilizing any test socket facilities available. It may be useful to temporarily map an LED as **General Pickup** to assist during testing. 47UVG operation will reset the **General Pickup** if no other element is operated. This LED should not be set as **Hand Reset** in the output matrix.

Starting from nominal voltage, apply a step decrease to the applied voltage to a level below the 47 NPS voltage setting but above the 47UVG setting such that an NPS overvoltage element operation occurs. Slowly reduce the applied voltage until the 47 NPS voltage element resets, this can be detected by the **General Pickup** LED reset if no other element is operated (this includes any undervoltage element which is not UV guarded).

Phase	Setting (Volts)	Tolerence	V Element Used for Test	Blocked Volts	Notes
UVG					

9.10.10 49 Thermal Overload Protection

The current can be applied from a 3P balanced supply or phase by phase from a 1P supply. Alternatively the 3 phase current inputs can be connected in series and injected simultaneously from a single 1P source.

The **Thermal Overload** setting and **Time Constant** setting can be considered together to calculate the operating time for a particular applied current.

The following table lists operate times for a range of **Time Constant** settings for an applied current of 2 times the **Thermal Overload** setting. Ensure that the thermal rating of the relay is not exceeded during this test.

Time Constant (min)	Operate Time (s)
1	17.3
2	34.5
3	51.8
4	69
5	86.3
10	173
15	259
20	345
25	432
30	51.8
50	863
100	1726

The **Thermal State** must be in the fully reset condition in order to measure the operate time correctly. This can be achieved by setting change in the **Thermal Protection** settings menu or by pressing the **Test/ Reset** button when the **Thermal Meter** is shown in the **Instruments** mode.

Reset the thermal state then apply 2 times the **Overload** setting current.

Calculated Operate Time (s)	Measured Operate Time (s)

If the **Thermal Overload Capacity Alarm** is used, this can be tested by monitoring the **Thermal Capacity** in the instruments menu. If the **Thermal Time Constant** is longer than a few minutes, this can be assessed during the timing test above. If the **Time Constant** is less than a few minutes, a lower multiple of current will be required such that the rate of capacity increase is slowed to allow monitoring of the instrument to be accurate.

Capacity Alarm Setting	Measured

Element Blocking

The thermal element can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
49	

9.10.11 50/51 Phase Overcurrent

Some other current protection functions may overlap with these functions during testing, it may be useful to disable some functions to avoid ambiguity. It should be particularly noted that if the function is enabled, the 51C **Cold Load** settings may modify the normal 50-n and 51-n settings if the CB is open during testing.

Voltage inputs may not be required for this function if the **Phase Overcurrent** functions are not directional but it may be advantageous to apply balanced 3 phase nominal rated voltage to the VT inputs during testing to avoid inadvertent operation of other functions. Particular care should be taken when testing overcurrent functions that the thermal rating of the current inputs is not exceeded.

Instantaneous Overcurrent – Phase (50)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9 times setting, check for no operation, apply 1.1 times setting, check operation.

Apply 2 times setting current if possible and record operating time.

Phase	Dir.	I_{set} (Amps)	DTL (sec)	P.U. Current Amps	Tolerence	Op. Time 2 · I_{set}	Tolerance
CT1(I_A)							
CT2(I_B)							
CT3(I_C)							

Check correct indication, trip output, alarm contacts, waveform record.

Time Delayed Overcurrent – Phase (51)

It will be advantageous to map the function being tested to temporarily drive the relevant pickup output in the **Pickup Config** sub-menu in the **Output Config** menu as this will allow the **Pickup** LED to operate for the function.

Gradually increase current until **Pickup** LED operates.

Apply 2 times setting current and record operating time.

Apply 5 times setting current and record operating time.

Compare to calculated values for operating times.

Gradually reduce current until the element drops off and record the level.

Table 9-4 P.U. D.O. & Timing Tests

Phase	Dir	Char. Curve	I_{set} (Amps)	Tm	Operate Current			Operate Time		
					P.U. (Amps)	D.O. (Amps)	Tol	2 · I_{set} (sec)	5 · I_{set} (sec)	Tol
CT1(I_A)										
CT2(I_B)										
CT3(I_C)										

Calculated timing values in seconds for Tm = 1.0

Curve	2 · I_{set}	5 · I_{set}
IEC-NI	10.03	4.28
IEC-VI	13.5	3.38
IEC-EI	26.67	3.33

Curve	$2 \cdot I_{set}$	$5 \cdot I_{set}$
IEC-LTI	120	30
ANSI-MI	3.8	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.3

Note that the operate time may be subject to the **`Minimum Op Time`** setting for the element and/or may have a **`Follower DTL`** applied.

Element Blocking

The phase overcurrent elements can be blocked by **`Binary Input Inhibit`**, **`VT Supervision`** and **`Inrush Detector`** operation, as well as 79 **`Delayed Inhibit`** setting. 79 inst elements are often configured to be blocked by the autoreclose **`Out`** state using logic. If applicable this functionality should be checked. The characteristic can be modified by **`Cold Load`** (51-n only) and **`Voltage Controlled Overcurrent`** and can be made non-directional by **`VT Supervision`**. This functionality should be checked.

Element	BI Inhibits	VTS Action	81HBL2 Inhibit	79 Delayed Inhibit
51-1				
51-2				
51-3				
51-4				
50-1				
50-2				
50-3				
50-4				

ANSI Reset

If the element is configured as an ANSI characteristic, it may have an ANSI decaying reset delay applied.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and Time multiplier (Tm) = 1.0. The reset curve characteristic type and TM is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calculated)	50 % Operate Time (measured)
		First test (c)			Second Test (c)

Check correct indication, trip output, alarm contacts, waveform record.

IEC Reset

If the element is configured as an IEC characteristic, it may have an IEC decaying reset delay applied.

IEC reset times from operated condition to fully reset are as follows for zero applied current and Time multiplier (Tm) = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Check correct indication, trip output, alarm contacts, waveform record.

9.10.12 50AFD Arc Flash Detection

The overcurrent level can be tested without an arc flash by separately energizing or inverting the arc detector binary input continuously for the duration of the test for the zone being tested.

50AFD current threshold can be tested by single phase current injection on any of the 3 phase inputs. 50GAFD current threshold can be tested by single phase current injection on the CT4 current input.

If the current setting is low, gradually increase current until element operates.

If the current level required is greater than the thermal limit of the relay, apply 0.9 times setting, check for no operation, apply 1.1 times setting, check operation.

Optical sensors such as 7XG31 can be tested by application of a suitable light source. Relay instrumentation can be used to indicate binary input pickup or by the 50AFD **Zone-n Flash** outputs.

The 7XG31 devices will typically require 10000 lx light level for 1.25 ms to trigger. A high powered photographic flash is the most convenient means of initiating positive sensor operation.

Note that mobile phone or small compact camera flashes may not have sufficient power to cause sensor operation but may be suitable if held directly against the sensor.

Check correct indication, trip output, alarm contacts, waveform record.

9.10.13 50G/51G Measured Earth Fault

Other protection functions may overlap with these functions during testing, it may be useful to disable some functions to avoid ambiguity. **Calculated EF**, **Measured EF**, **Sensitive EF** & **Restricted EF** protections can be **Enabled/Disabled** individually or as groups in the **Function Config** menu.

Measured EF elements can be separated from **Calculated EF** and **Sensitive EF** by secondary injection of current through the CT4 input circuit only.

If any of these elements are defined as directional the correct voltage phase direction will be required to produce an operation of those elements.

Directional Polarity (67G)

See *10 Technical Data* for testing details.

MTA	Forward				Reverse			
	Lag (point C)		Lead (point A)		Lead (point B)		Lag (point D)	
	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off
	MTA -85		MTA +85		MTA -85		MTA -85	
Measured EF								

Definite Time Overcurrent (50G)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9 times setting, check for no operation, apply 1.1 times setting, check operation.

Apply 2 times setting current if possible and record operating time.

Check correct indication, trip output, alarm contacts, waveform record.

Note that these elements can be set to directional.

Phase	Dir.	I_{set} (Amps)	DTL (sec)	P.U. Current Amps	Op. Time 2 · I_{set}	Notes
CT4						

If VTS action is set to **Block**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element does not operate.

If VTS action is set to **Non-Directional**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element operates at its normal setting. Reverse the voltage phase direction whilst checking that the element does not reset.

Inverse Time Overcurrent (51G)

It will be advantageous to map the function being tested to temporarily drive the relevant pickup output in the **Pickup Config** sub-menu in the **Output Config** menu as this will allow the **Pickup** LED to operate for the function.

Gradually increase current until **Pickup** LED operates.

Apply 2 times setting current and record operating time.

Apply 5 times setting current and record operating time.

Compare to calculated values for operating times.

Table 9-5 P.U. D.O. & Timing Tests

Ph.	Dir	Char. (NI EI VI LTI, DTL)	I_{set} (A)	Tm	Operate Current			Operate Time		
					P.U. (Amps)	D.O. (Amps)	Tol	2 · I_{set} (sec)	5 · I_{set} (sec)	Tol
CT4										

Calculated timing values in seconds for Tm = 1.0

Curve	2 · I_{set}	5 · I_{set}
IEC-NI	10.03	4.28
IEC-VI	13.5	3.38
IEC-EI	26.67	3.33
IEC-LTI	120	30
ANSI-MI	3.8	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.3

Note that the operate time may be subject to the **Minimum Op Time** setting for the element and/or may have a follower DTL applied.

If VTS action is set to **Block**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element does not operate.

If VTS action is set to Non-Directional, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element operates at its normal setting. Reverse the voltage phase direction whilst checking that the element does not reset.

Element Blocking

The **Measured Earth Fault** elements can be blocked by **Binary Input Inhibit**, **VT Supervision** and **Inrush Detector** operation. The characteristic can be made non-directional by **VT Supervision**. This functionality should be checked.

Element	BI Inhibits	VTS Action	81HBL2 Inhibit
51G-1			
51G-2			
51G-3			
51G-4			
50G-1			
50G-2			
50G-3			
50G-4			

ANSI Reset

If the element is configured as an ANSI characteristic, it may have an ANSI decaying reset delay applied.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and Tm = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calculated)	50 % Operate Time (measured)
		First test (c)			Second Test (c)

Check correct indication, trip output, alarm contacts, waveform record.

IEC Reset

If the element is configured as an IEC characteristic, it may have an IEC (decaying) reset delay applied.

IEC reset times from operated condition to fully reset are as follows for zero applied current and Time multiplier (Tm) = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level. Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calcu-lated)	50 % Operate Time (meas-ured)
		First test (c)			Second Test (c)

9.10.14 50GHS High Speed Earth Fault – Measured

Some other current protection functions may overlap with these elements during testing, it may be useful to disable some functions to avoid ambiguity. Element current setting can be tested by monitoring of the pickup signal in the same way as any standard 50 earth fault element setting. Time delay is generally not applied to these elements and therefore does not require testing. The high speed performance can be checked by applying high multiples of current. Precautions should be included in the test application to ensure that the duration of the current is limited, including in the case where the test is not stopped by the relay operation.

Setting	Measured

Special consideration is required to achieve the fastest operate times during testing. Applying fault current at 0° point on wave will result in slower operating times as even high peak currents will start from low values for several milliseconds. For earth fault testing current should be applied with zero pre-fault current. Switching at 45° provides a reasonable compromise between zero and maximum transient and will demonstrate high speed.

9.10.15 50GI Intermittent Earth Fault

Other protection functions may overlap with these functions during testing, it may be useful to disable some functions to avoid ambiguity. **`Measured EF`** and **`Sensitive EF`** protections can be **`Enabled`**/**`Disabled`** individually or as groups in the **Function Config** menu.

`Intermittent EF` elements can be separated from **`Calculated EF`** by secondary injection of current through the CT4 input circuit only.

If any of the intermittent earth fault elements are defined as directional the correct voltage phase direction will be required to produce an operation of those elements.

Directional Polarity 67GI

See *9.10.27 67G/67GI/67GS/67N Directional Earth Fault* for testing details.

Direction can be monitored at the 67GI directional meter or using the 50GI-n pickup signal but control of the **`50GI-n Reset`** signal may be required to reset the pickup before applying successive tests.

MTA	Forward				Reverse			
	Lag (point C)		Lead (point A)		Lead (point B)		Lag (point D)	
	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off
	MTA -85		MTA +85		MTA -85		MTA -85	
Intermit-tent EF								

Pickup current threshold can be tested by ramping current upwards from zero until the 50GI-n pickup signal is raised. **50GI-n Reset** can be used to reset the pickup and **In Progress** signals.

Counter Mode

Apply repeated forward (or reverse) current pulses to check the setting of the IEF and element operation counters. The setting of the Reset time can be checked by variation in time between successive application of the current pulses.

Int and Counter Mode

Apply repeated forward current pulses in the operate direction to check settings for the **Sum of Pickup Extension Times**, **Pickup Extension Time**, **Reset** time, and Count settings for IEF indication and element operation. Reset of the element for detection of a non-operate direction pulse can be demonstrated by insertion of an opposing direction pulse in the test sequence.

9.10.16 50GS/51GS Sensitive Earth Fault

Other protection functions may overlap with these functions during testing, it may be useful to disable some functions to avoid ambiguity. **Calculated EF**, **Measured EF**, **Sensitive EF** & **Restricted EF** protections can be **Enabled/Disabled** individually or as groups in the **Function Config** menu.

Sensitive EF (GS) elements can be separated from **Calculated EF** by secondary injection of current through the CT4 input circuit only.

If any of these elements are defined as directional the correct residual voltage phase direction will be required to produce correct operation of the 67GS element for an operation of those elements.

The 67GS elements will normally operate on the residual current through the CT4 input but can be set to operate on only the real (wattmetric) component of this current by setting 67GS **I_{res} Select** to **I_{res} Real**. If this option is selected, the residual current and voltage should be set in anti-phase during testing to so that the applied current is purely real and can be measured directly.

If 67GS **Wattmetric** is set to **Enabled**, the residual real power must also exceed the 67GS **Wattmetric Power** setting to permit any directional 50GS element operation

Directional Polarity

See *10 Technical Data* for testing details.

If 67GS **Wattmetric** is set to **Enabled**, the residual real power must also exceed the 67GS **Wattmetric Power** setting to permit GS operation. As the directional boundary is approached, the wattmetric current, will by definition reduce towards zero. It is therefore necessary to increase the residual current or to temporarily disable the **Wattmetric** function to allow the directional boundary to be tested.

If the 67GS **Compensated Network** setting is set to **Enabled**, the directional boundaries will be extended to MTA + 87° and MTA - 87°.

MTA	Forward				Reverse			
	Lag (point C)		Lead (point A)		Lead (point B)		Lag (point D)	
	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off
	MTA -85		MTA +85		MTA -85		MTA -85	
GS								

Definite Time Overcurrent (50GS)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9 times setting, check for no operation, apply 1.1 times setting, check operation.

Apply 2 times setting current if possible and record operating time.

Check correct indication, trip output, alarm contacts, waveform record.

Note that these elements can be set to directional.

Table 9-6 P.U. D.O. & Timing Tests

Ph.	Dir	Char. (NI EI VI LTI, DTL)	I_{set} (A)	Tm	Operate Current			Operate Time		
					P.U. (Amps)	D.O. (Amps)	Tol	$2 \cdot I_{set}$ (sec)	$5 \cdot I_{set}$ (sec)	Tol
CT4										

Check correct indication, trip output, alarm contacts, waveform record.

Note that these elements can be set to directional.

If VTS action is set to **`Block`**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element does not operate.

If VTS action is set to **`Non-Directional`**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element operates at its normal setting. Reverse the voltage phase direction whilst checking that the element does not reset.

Wattmetric Protection

The **`Wattmetric Earth Fault`** protection requires that the GS current setting is exceeded, the residual power setting is exceeded and the directional element operated, simultaneously.

During testing of the 67GS **`Wattmetric Power`** setting it is essential that the current setting is also exceeded. This can usually be achieved by applying current which is above setting to the GS input whilst applying single phase voltage, in anti-phase with the current, to any 1 phase to neutral voltage input. In this way, the wattmetric power is equal to the product of the applied current and applied voltage and can be adjusted by adjustment of the voltage magnitude.

Wattmetric Power Setting	Current Applied I_{op}	Dir	Operate Voltage V_{op}	Calculated P_{op} $I_{op} \cdot V_{op}$

During testing of the 67GS **I_{res} Select** residual current setting it is essential that the **`Wattmetric Power`** setting is also exceeded. This can usually be achieved by applying the test current to the GS input whilst applying a nominal single phase voltage, in anti-phase with the current, to all 3 phase to neutral voltage inputs. In this way, the wattmetric power is equal to the product of 3 times the applied voltage and the applied current and this should always be greater than the **`Wattmetric Power`** setting.

Inverse Time Overcurrent (51GS)

It will be advantageous to map the function being tested to temporarily drive the relevant pickup output in the **`Pickup Config`** sub-menu in the Outp**`ut Config`** menu as this will allow the **`Pickup`** LED to operate for the function.

Gradually increase current until **`Pickup`** LED operates.

Apply 2 times setting current and record operating time.

Apply 5 times setting current and record operating time.

Compare to calculated values for operating times.

Table 9-7 P.U. D.O. & Timing Tests

Ph.	Dir	Char. (NI EI VI LTI, DTL)	I_{set} (A)	Tm	Operate Current			Operate Time		
					P.U. (Amps)	D.O. (Amps)	Tol	$2 \cdot I_{set}$ (sec)	$5 \cdot I_{set}$ (sec)	Tol
CT4										

Calculated timing values in seconds for Tm = 1.0

Curve	$2 \cdot I_{set}$	$5 \cdot I_{set}$
IEC-NI	10.03	4.28
IEC-VI	13.5	3.38
IEC-EI	26.67	3.33
IEC-LTI	120	30
ANSI-MI	3.8	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.3

Note that the operate time may be subject to the **`Minimum Op Time`** setting for the element and/or may have a follower DTL applied.

If VTS action is set to **`Block`**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element does not operate.

If VTS action is set to **`Non-Directional`**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element operates at its normal setting. Reverse the voltage phase direction whilst checking that the element does not reset.

Element Blocking

The **`Sensitive Earth Fault`** elements can be blocked by Binary Input Inhibit, VT Supervision and Wattmetric protection. The characteristic can be made non-directional by VT Supervision. This functionality should be checked.

Element	BI Inhibits	VTS Action
51GS-1		
51GS-2		
51GS-3		
51GS-4		
50GS-1		
50GS-2		
50GS-3		
50GS-4		

ANSI Reset

If the element is configured as an ANSI characteristic, it may have an ANSI decaying reset delay applied.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and Tm = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calculated)	50 % Operate Time (measured)
		First test (c)			Second Test (c)

Check correct indication, trip output, alarm contacts, waveform record.

IEC Reset

If the element is configured as an IEC characteristic, it may have an IEC (decaying) reset delay applied.

IEC reset times from operated condition to fully reset are as follows for zero applied current and Time multiplier (Tm) = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level. Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calculated)	50 % Operate Time (measured)
		First test (c)			Second Test (c)

9.10.17 50HS High Speed Overcurrent – Phase

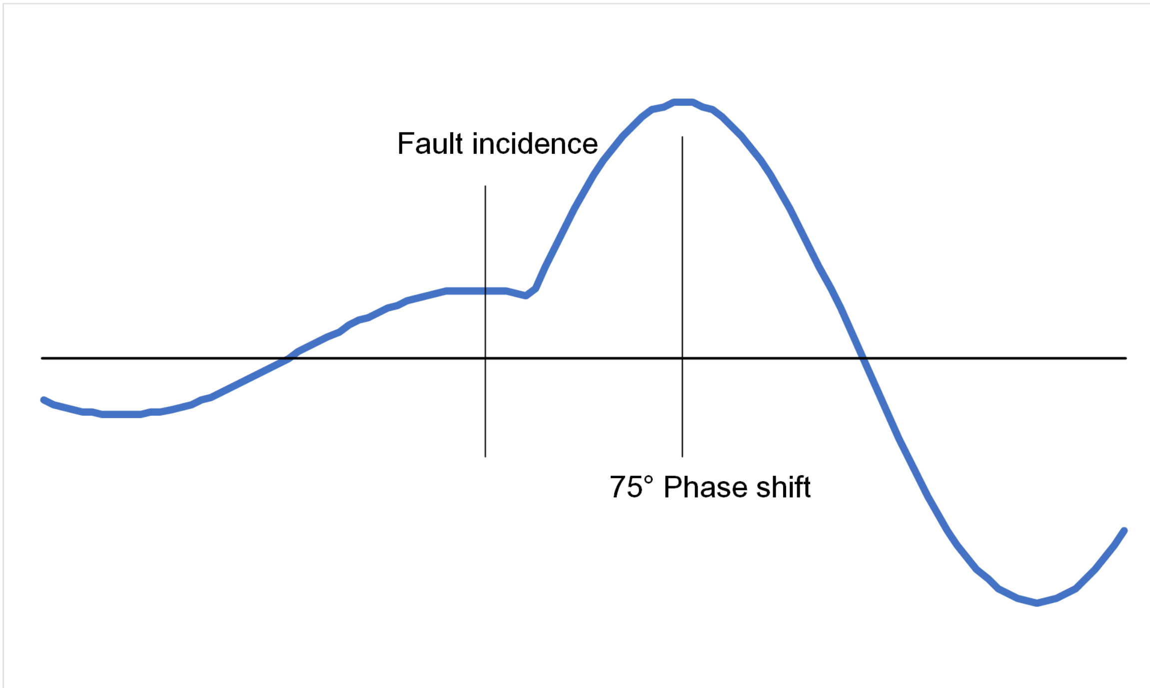
Some other current protection functions may overlap with these elements during testing, it may be useful to disable some functions to avoid ambiguity. Element current setting can be tested by monitoring of the pickup signal in the same way as any standard phase overcurrent setting. Time delay is generally not applied to these elements and therefore does not require testing. The high speed performance can be checked by applying high multiples of current. Precautions should be included in the test application to ensure that the duration of the current is limited, including in the case where the test is not stopped by the relay operation.

Phase	Setting	Measured
A		
B		
C		

Special consideration is required to achieve the fastest operate times during testing. Applying overcurrent at 0° point on wave will result in slower operating times as even high peak currents will start from low values for several milliseconds. Operating speed can be improved if pre-fault load is applied but switching transients and phase shift can affect timing.

Example:

For a typical overhead distribution line with characteristic angle 75° lagging and unity power factor load, apply 50 % of setting as pre-fault load until just after a peak, i.e. (N · 20 ms) + 6 ms, for 50 Hz, step current to 5x setting starting from a phase of 33°. This simulates a typical overhead line fault without introducing a transient which could be affected by test equipment capabilities. This should reliably indicate the high speed operating time.



[dw_7SR5_FaultIncidence, 1, en_US]

Figure 9-4 Fault Incidence

For testing without pre-fault load, a fault incidence of 0° will result in a slower time. Switching at 45° provides a reasonable compromise between zero and maximum transient and will demonstrate high speed. This test is also applicable for 50GHS testing where pre-fault earth fault current does not apply.

9.10.18 50N/51N Calculated Earth Fault

Other protection functions may overlap with these functions during testing, it may be useful to disable some functions for simplicity. **Calculated EF**, **Measured EF**, **Sensitive EF** & **Restricted EF** protections can be **Enabled/Disabled** individually or as groups in the **Function Config** menu.

Calculated EF elements can be separated from **Measured/Sensitive EF** by arrangement of the secondary injection circuit by shorting/disconnecting CT4 Input.

If any of these elements are defined as directional the correct voltage phase direction will be required to produce an operation of those elements.

Directional Polarity (67N)

See *10 Technical Data* for testing details.

MTA	Forward				Reverse			
	Lag (point C)		Lead (point A)		Lead (point B)		Lag (point D)	
	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off
	MTA -85		MTA +85		MTA -85		MTA -85	
Calculated EF								

Definite Time Overcurrent (50N)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9 times setting, check for no operation, apply 1.1 times setting, check operation.

Apply 2 times setting current if possible and record operating time.

Check correct indication, trip output, alarm contacts, waveform record.

Note that these elements can be set to directional.

Phase	Dir.	I_{set} (Amps)	DTL (sec)	P.U. Current Amps	Op. Time 2 · I_{set}	Notes
N						

If VTS action is set to **`Block`**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase 3P current and check that the element does not operate.

If VTS action is set to **`Non-Directional`**, this option should be tested. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase a-phase current and check that the element operates at its normal setting. Reverse the voltage phase direction whilst checking that the element does not reset.

Inverse Time Overcurrent (51N)

It will be advantageous to map the function being tested to temporarily drive the relevant pickup output in the **`Pickup Config`** sub-menu in the **`Output Config`** menu as this will allow the **`Pickup`** LED to operate for the function.

Gradually increase current until **`Pickup`** LED operates.

Apply 2 times setting current and record operating time.

Apply 5 times setting current and record operating time.

Compare to calculated values for operating times.

Table 9-8 P.U. D.O. & Timing Tests

Ph.	Dir	Char. (NI EI VI LTI, DTL)	I_{set} (A)	Tm	Operate Current			Operate Time		
					P.U. (Amps)	D.O. (Amps)	Tol	2 · I_{set} (sec)	5 · I_{set} (sec)	Tol
N										

Calculated timing values in seconds for Tm = 1.0

Curve	2 · I_{set}	5 · I_{set}
IEC-NI	10.03	4.28
IEC-VI	13.5	3.38
IEC-EI	26.67	3.33
IEC-LTI	120	30
ANSI-MI	3.8	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.3

Note that the operate time may be subject to the **`Minimum Op Time`** setting for the element and/or may have a follower DTL applied.

Element Blocking

The **`Calculated Earth Fault`** elements can be blocked by **`Binary Input Inhibit`**, **`VT Supervision`** and **`Inrush Detector`** operation. The characteristic can be made non-directional by **`VT Supervision`**. This functionality should be checked.

Element	BI Inhibits	VTS Action	81HBL2 Inhibit
51N-1			
51N-2			
51N-3			
51N-4			
50N-1			
50N-2			
50N-3			
50N-4			

ANSI Reset

If the element is configured as an ANSI characteristic, it may have an ANSI decaying reset delay applied.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and Tm = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calculated)	50 % Operate Time (measured)
		First test (c)			Second Test (c)

Check correct indication, trip output, alarm contacts, waveform record.

IEC Reset

If the element is configured as an IEC characteristic, it may have an IEC (decaying) reset delay applied.

IEC reset times from operated condition to fully reset are as follows for zero applied current and Time multiplier (Tm) = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level. Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calcu-lated)	50 % Operate Time (meas-ured)
		First test (c)			Second Test (c)

9.10.19 50SOTF Switch Onto Fault

Switch Onto Fault elements are only active for the duration of the circuit-breaker close pulse and reclaim time following **Manual Close** of the circuit-breaker. For testing purposes it is necessary to initiate a **Manual Close** operation with the circuit-breaker in an open state. It is not necessary for the **CB Close** to actually complete so the close signal can be blocked externally for testing purposes. **CB Fail** to **Close** will raise **Lockout** which will need to be reset between tests.

Definite Time Overcurrent (50SOTF)

Initiate a **Manual Close** operation with the CB in an open state.

Apply 0.9 times setting, check for no operation.

Reset the resulting **Lockout** state.

Repeat with apply 1.1 times setting, check operation.

Repeat with 2 times setting current if possible and record operating time.

Definite Time Measured Earth Fault (50GSOTF)

Initiate a **Manual Close** operation with the CB in an open state.

Apply 0.9 times setting, check for no operation.

Reset the resulting Lockout state.

Repeat with apply 1.1 times setting, check operation.

Repeat with 2 times setting current if possible and record operating time.

Phase	I_{set} (Amps)	DTL (sec)	P.U. Current Amps	Tolerence	Op. Time 2 · I_{set}	Tolerance
CT1(I_A)						
CT2(I_B)						
CT3(I_C)						
CT4						

Check correct indication, trip output, alarm contacts, waveform record.

9.10.20 51CL Cold Load Overcurrent – Phase

The CB must be open for more than the **Cold Load Pick-up Time** to allow testing of this function. It may be convenient to reduce this setting to suit the test procedure. If the CB is open throughout the tests, the **Cold Load** protection settings can be tested provided that the current is not allowed to fall below the level of the **Reduced Current Level** for more than the **Reduced Current Time** during testing. It may be convenient to set the **Reduced Current** setting to **Disabled** for the duration of the test. The **Cold Load Active** output is provided and can be used as an indication during testing.

Ensure that the **Cold Load** active is not raised. This can be reset by **CB Closed** for more than the **Cold Load Drop-off Time** or current less than the **Reduced Current Level** for greater than the **Reduced Current Time**. Check the **Cold Load Pick-up Delay** by applying or simulating **CB Open**. Measure the time delay before **Cold Load Active** is raised. Apply current above the **Reduced Current Level** if this functionality is **Enabled** before applying **CB Closed**. Measure the time for **Cold Load Active** to reset.

It will be advantageous to map the function being tested to temporarily drive the relevant pickup output in the **`Pickup Config`** sub-menu in the **`Output Config`** menu as this will allow the **`Pickup`** LED to operate for the function.

Gradually increase current until **`Pickup`** LED operates.

Apply 2 times setting current and record operating time.

Apply 5 times setting current and record operating time.

Compare to calculated values for operating times.

Table 9-9 P.U. D.O. & Timing Tests

Ph.	Dir	Char. (NI EI VI LTI, DTL)	I_{set} (A)	Tm	Operate Current			Operate Time		
					P.U. (Amps)	D.O. (Amps)	Tol	$2 \cdot I_{set}$ (sec)	$5 \cdot I_{set}$ (sec)	Tol
CT1(I_A)										
CT2(I_B)										
CT3(I_C)										

Calculated timing values in seconds for Tm = 1.0

Curve	$2 \cdot I_{set}$	$5 \cdot I_{set}$
IEC-NI	10.03	4.28
IEC-VI	13.5	3.38
IEC-EI	26.67	3.33
IEC-LTI	120	30
ANSI-MI	3.8	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.3

Note that the operate time may be subject to the **`Minimum Op Time`** setting for the element and/or may have a **`Follower DTL`** applied.

ANSI Reset

If the element is configured as an ANSI characteristic, it may have an ANSI reset delay applied.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and Tm = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level. Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calculated)	50 % Operate Time (measured)
		First test (c)			Second Test (c)

Check correct indication, trip output, alarm contacts, waveform record.

IEC Reset

If the element is configured as an IEC characteristic, it may have an IEC (decaying) reset delay applied.

IEC reset times from operated condition to fully reset are as follows for zero applied current and Time multiplier (Tm) = 1.0. The reset curve characteristic type and Tm is defined by the operating characteristic.

Curve	Fully Operated to Reset with Zero Current Applied & Tm = 1 (s)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2 times setting for a time to ensure element operation, b) Zero current for the reset time above (xTm), c) 2 times setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level. Repeat the test with the reset time (b) reduced to 50 % of the previous value. Ensure that the second operate time (c) is 50 % of the first (a) operate time.

Operate Time (expected)	Reset Time (calculated)	Operate Time (measured)	50 % Reset Time (calculated)	50 % Operate Time (calculated)	50 % Operate Time (measured)
		First test (c)			Second Test (c)

Element Blocking

The 51CL overcurrent elements can be blocked by **`Binary Input Inhibit`**. This functionality should be checked.

Element	BI Inhibits
51CL	

9.10.21 51V Voltage Dependent Overcurrent – Phase

OC Phase	Control Voltage
CT1(I_A)	V_{12}(V_{AB})
CT2(I_B)	V_{23}(V_{BC})
CT3(I_C)	V_{31}(V_{CA})

`IDMT Phase Overcurren`t elements 51-n should be tested for pick-up and timing before this function is tested. The **`General Pickup`** LED can be used to assess operation of this function if other functions are disabled or if the setting allocating **`General Pickup`** is temporarily modified.

Apply nominal 3 phase balanced voltage. Apply 3 phase balanced current at a level below the normal 51-n setting but above the effective 51V-n setting. Ensure that the thermal rating of the relay is not exceeded. Gradually reduce the voltage until the a-b voltage is less than the **`Voltage`** setting. **`Pickup`** LED operation can be used to confirm the **`Voltage`** setting. If the 51V-n current setting is above the continuous rating of the relay an alternative procedure should be used, apply test current in short duration shots with applied voltage being gradually reduced for each subsequent shot.

Apply nominal 3 phase balanced voltage. Increase the voltage such that the a-b voltage is 110 % of the **`Voltage`** setting. Test current can be applied as 3 phase balanced current or as a single phase a-b current via CT1 and returning through CT2. Gradually increase the a-b phase current or balanced 3P current until **`Pickup`** LED operates. Confirm result of phase O/C test above.

Reduce the applied voltage to a level such that VAB phase-phase voltage is less than 90 % of the setting. The element threshold is operated by phase to phase voltage but the most common connection of the 3 phase voltage inputs is phase to neutral.

Gradually increase the CT1 phase-phase current until **`Pickup`** LED operates.

Note that these elements may be set as directional. If this is the case, the phase angle of the current must be set with respect to the voltage to produce operation of the elements.

Voltage Setting (V, p-p)	Measured (V, p-p)

	I Setting	Multiplier	Calculated PU	Measured	Tolerance
51-1 Pickup					
51-2 Pickup					
51-3 Pickup					
51-4 Pickup					

Element Blocking

The `Voltage Controlled Overcurrent` function can be set to Inhibit for `VT Supervision` operation. This functionality should be checked. Apply balanced voltage and current. Reduce a-phase voltage to cause a VTS condition. Increase 3P current until the element operates at its full setting, i.e. 51V settings are not used.

Element	VTS Action
51-1	
51-2	
51-3	
51-4	

Check correct indication, trip output, alarm contacts.

9.10.22 55 Power Factor

Apply balanced 3 phase rated voltage and current. Increase current phase angle until the LED assigned to ’55-n’ is on. Record this angle in the table below. Decrease the angle until the LED resets. Record the angle.

	55 Setting	Angle	Pick-Up	Drop-Off
55-1				
55-2				

If the element is set with `55-n UC Guard Enabled`, the setting can be tested by applying the test current at a level below the `55-n U/C Guard Setting` at a power in the operate range. Increase the current until the relay operates.

UCG	UCG Setting (· I_{rated})	Power Element Used for Test	Blocked Current (D.O.)	Unblocked Current (P.U.)	Notes
Power Factor					

Element Blocking

The `Power Factor` elements can be blocked by `Binary Input Inhibit`. This functionality should be checked.

Element	BI Inhibits	
55-1		
55-2		

Check correct indication, trip output, alarm contacts, waveform record.

When testing is complete reinstate any of the disabled functions.

9.10.23 59 Overvoltage Protection – 3 Phase

Where more than 1 overvoltage (59) elements are being used with different settings, it is convenient to test the elements with the highest settings first. The elements with lower settings can then be tested without disabling the higher settings.

If the **O/P Phases** is set to **All**, the voltage on all phases must be increased simultaneously. Otherwise the 3 phases can be tested individually. There is a common setting for to select the voltage to be measured as phase-phase or phase-neutral. If the DTL setting is short, starting from nominal voltage, slowly increase the applied 3P or VL1 test voltage until the **Pickup** LED (temporarily mapped) is on. The LED should light at setting **Volts** ±5 % decrease the input voltage to nominal **Volts** and the LED will extinguish. Record the reset voltage to check the **Hysteresis** setting. If the DTL setting is long, the operate level can be checked by applying 100 % of setting to cause operation followed by setting minus the **Hysteresis** setting to cause reset.

Connect the relevant output contact(s) to stop the test set. Step the applied voltage to a level above the setting. The test set should be stopped at the **Operate Time** setting ±5 % test the other phases by repeating the above if necessary.

Phase	Setting (Volts)	U/O	DTL (sec)	Hyst.	D.O. (calculated)	P.U. Volts	D.O Volts	Op. Time @ 1.2 · V_{set} (OV) @ 0.5 · V_{set} (UV)	UV Guard	Tolerance
$V_A(V_{AB})$										
$V_B(V_{BC})$										
$V_C(V_{CA})$										

Element Blocking

The **Under/Over Voltage** elements can be blocked by **Binary Input Inhibit** and **VT Supervision**. This functionality should be checked.

Element	BI Inhibits	VT Supervision
59-1		
59-2		
59-3		
59-4		

When testing is complete reinstate any of the disabled functions.

9.10.24 59N Neutral Voltage Displacement

The normal voltage source for the **Neutral Overvoltage** 59N function is V_{rated}, calculated from the applied 3 phase voltage inputs but it can be configured to operate from the single phase V4 input. To test, apply test voltage to 1 phase input.

Definite Time (59NDT)

If DTL setting is small, gradually increase single phase voltage until element operates.

If DTL is large apply 0.9 times setting, check for no operation, apply 1.1 times setting, check operation.

Apply 2 times setting voltage if possible and record operating time.

Phase	Setting (Volts)	Delay (sec)	P.U. Current (Volts)	Op. Time @ 2 · V_{set}	Tolerance
E					

Check correct indication, trip output, alarm contacts, waveform record.

Inverse Time (59NIT)

It will be advantageous to map the function being tested to temporarily drive the relevant pickup output in the **Pickup Config** sub-menu in the **Output Config** menu as this will allow the **Pickup** LED to operate for the function.

Gradually increase voltage until **Pickup** LED operates.

Apply 2 times setting voltage and record operating time.

Apply a higher multiple of setting voltage and record operating time.

Compare to calculated values for operating times from:

$$t_{op}(s) = Tm\left[\frac{1}{\left[\frac{V_{rated}}{V_{set}}\right] - 1}\right]$$

[fo_function59N, 1, en_US]

Where Tm = Time multiplier and V_{rated}/V_{set} = multiple of setting.

Phase	Setting (Volts)	Tm	Operate Voltage			Operate Time		
			P.U. (Volts)	D.O. (Volts)	Tolerance	@ 2 · V_{set} (s)	@ - · V_{set} (s)	Tolerance
E								

Element Blocking

The **Neutral Overvoltage** elements can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
59NIT-1	
59NDT-1	

Check correct indication, trip output, alarm contacts, waveform record.

When testing is complete reinstate any of the disabled functions.

9.10.25 59Vx Overvoltage Protection – Vx

59Vx elements operate similarly to the 59 elements above but are applied to the fourth voltage input Vx.

Where more than one 59Vx undervoltage elements are being used with different settings, it is convenient to test the elements with the highest settings first. The elements with lower settings can then be tested without disabling the lower settings.

Single phase voltage should be connected to the Vx input directly. If the DTL is short, starting from nominal voltage, slowly increase the applied test voltage until the **Pickup** LED (temporarily mapped) is on. Record the operate voltage. The LED should light at setting **Volts** ±5 %. Slowly decrease the input voltage until the LED extinguishes. Record the reset voltage to check the **Hysteresis** setting. If the DTL is long, the operate level should be checked by applying a voltage of 110 % of setting voltage. Check hysteresis by resetting element to the operate level setting minus the **Hysteresis** setting. Connect the relevant output contact(s) to stop the test set. Step the applied voltage to a level above the setting. The test set should be stopped at the operate time setting ±5 %.

When testing is complete reinstate any of the disabled functions.

Setting (Volts)	DTL (sec)	Hyst.	D.O. (calculated)	P.U. Volts	D.O Volts	Op. Time @ 1.2 · V_{set} (OV)	Tolerance

Check correct indication, trip output, alarm contacts, waveform record.

Element Blocking

The Vx overvoltage elements can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
59Vx-1	
59Vx-2	

Check correct indication, trip output, alarm contacts, waveform record.

When testing is complete reinstate any of the disabled functions.

9.10.26 67 Directional Overcurrent – Phase

If the relay has **Directional Overcurrent** elements, the common direction polarizing can be checked independently from the individual overcurrent elements and their settings. If **Phase Rotation ACB** is selected in the CT/VT menu, this corresponds to negative phase sequence and the **Forward** and **Reverse** will be automatically exchanged by internal relay configuration. The tests below describe normal ABC rotation and the forward/reverse direction reversal will be experienced for ACB settings unless single phase voltages are inverted. Directions for 3 phase testing will also be reversed unless the 3 phase supply rotation is reversed. This can be achieved by swapping any 2 phase wires, for both current and voltage with a standard ABC test supply. **Direction Earth Fault** direction is not affected by the **Phase Rotation** direction.

In the **Instruments** mode display, indication is provided in the **Directional Meters** menu which displays current direction under P/F Dir as forward or reverse based on the output states of the directional elements, i.e. whether they see forward current, reverse current or neither for each pole with respect to the 67 **Char Angle** setting in the **Phase Overcurrent** menu. This display and the equivalent **Measured** and **Calculated Earth Fault** direction meters can be used as an aid to commissioning testing.

1. Check the direction of each pole in turn by connecting to the appropriate terminals. The following table shows the polarizing quantity for each pole.

Table 9-10 Connections for Directional Polarity

Overcurrent Pole	Polarizing Voltage
Phase A	V_{BC}
Phase B	V_{CA}
Phase C	V_{AB}

2. Inject single phase rated current and apply single phase-phase rated voltage at the **Char Angle** (MTA) phase angle setting, to each phase in turn. For each pole, monitor the directional display in the instrument menu and check that indication of forward current (FWD) is displayed. To achieve the required forward characteristic angle, the phase angle of the current should be greater than that of the polarizing voltage by the angle setting.

3. Repeat all of the above with the current connections reversed. Indication should now be given of reverse (REV) current flow.

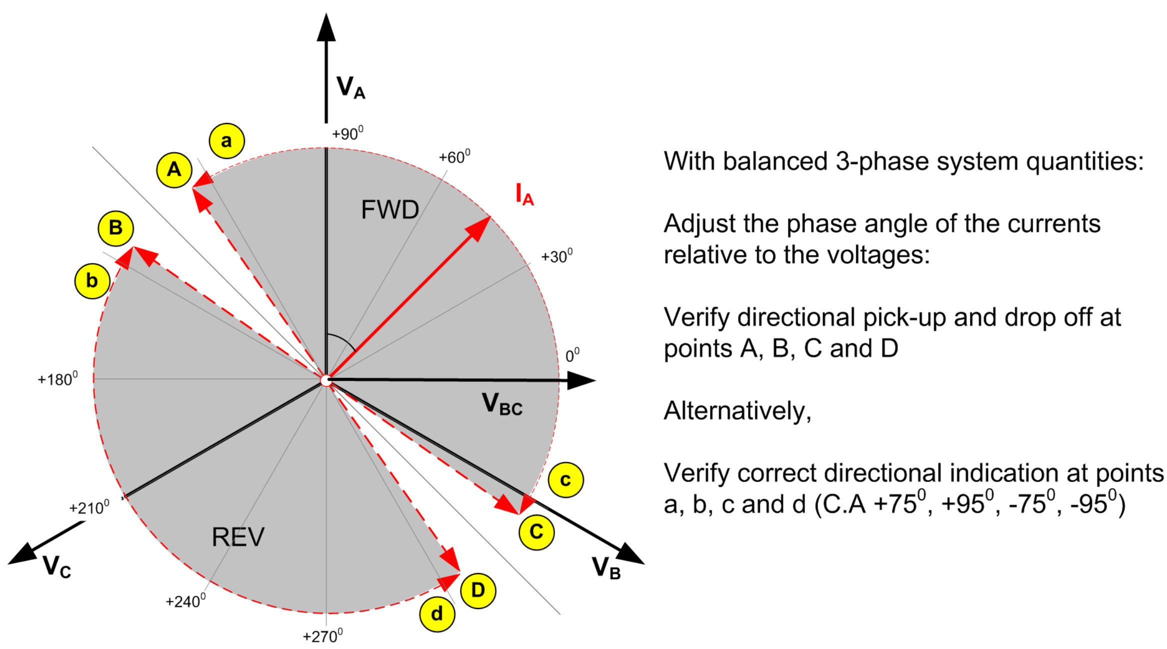
Phase	A	B	C
Forward	FWD	FWD	FWD
Reverse	REV	REV	REV

4. Apply balanced 3 phase rated voltage and current with V_{BC} voltage as a 0° reference and I_a at the characteristic angle. Increase current phase angle until the **Fwd** indication is extinguished. Record this angle in the table below (Forward lead DO). Continue to increase/decrease the angle until the instrument reads **Rev**. Record the angle (Reverse lead PU). Reduce the current angle until the **Rev** extinguishes (Reverse lead DO). and the **Fwd** subsequently returns (Forward lead PU), recording the angles. Repeat the above tests, starting from the **Characteristic Angle**, but reducing the current phase angle to record the directional boundaries in the opposite (lag) direction. The recorded angle should be the angle at which the phase current leads the phase-

phase polarizing voltage. This measurement is greatly simplified if the polarizing reference voltage is set to 0° and the current phase angle is measured with respect to this reference.

Alternatively, the instrument can be checked at the 4 points marked a, b, c & d on *Figure 9-5* only.

	Forward				Reverse			
	Lag (point C)		Lead (point A)		Lead (point B)		Lag (point D)	
	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off	Pick-up	Drop-off
MTA	MTA -85		MTA +85		MTA -85		MTA -85	
Phase A								
Phase B								
Phase C								



[dw_7SR5_function67FunctionalTests, 1, en_US]

Figure 9-5 Directional Phase Fault Boundary System Angles

5. With the instrument reading **Fwd** or **Rev**, reduce the voltage until the element resets. Record the minimum phase-phase operate voltage.

Minimum Voltage Setting	Measured

2 Out Of 3 Logic

Ensure that at least 1 **Phase Overcurrent** element is set to **Directional**. Apply balanced nominal voltage. Apply current at a level above the 50/51 setting on phase A only at the characteristic angle for forward operation, normally 45° lagging. Ensure no **Directional Phase Overcurrent** element operation occurs. Note that non-directional **Phase Overcurrent** and non-direction **Earth Fault** elements may operate unless disabled.

Repeat the test with phase A current as above but also with equal current in the B phase at 180° to that in the A phase.

1 Phase Current		2 Phase Current	
No 50/51-n Operation		50/51-n Operation	

9.10.27 67G/67GI/67GS/67N Directional Earth Fault

`Calculated Earth Fault`, **`Measured Earth Fault`**, **`Intermittent Earth Fault`**, and **`Sensitive Earth Fault`** elements can be set as directional. These are polarized from residual voltage, calculated from the 3 phase voltage inputs or the 3V0 input depending on the VT1/2/3 **`Config`** setting in the CT/VT menu.

The relay **`Char Angle`** setting is the characteristic phase angle of the fault impedance i.e. the phase angle of the fault current with respect to the voltage driving the current. The earth fault functions are polarized from the residual voltage which is in anti-phase with the fault voltage for a single-phase to earth fault. Care is required when testing by secondary injection with regard to current and voltage polarity.

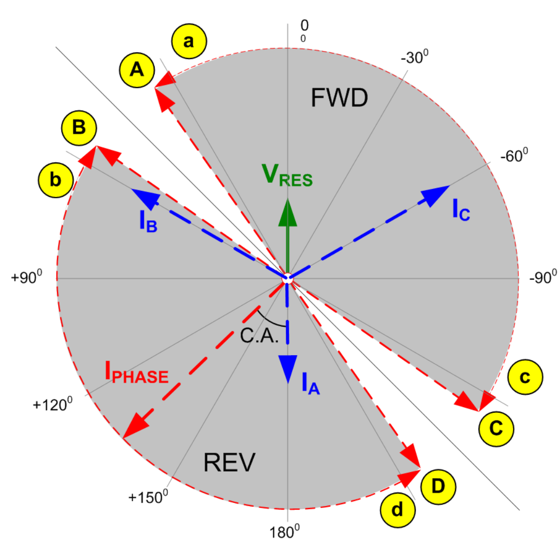
To simulate an earth fault on a relay with 3 phase-phase or 3 phase-neutral connected voltage inputs, defined by the VT1/2/3 **`Config`** setting of Van,Vbn,Vcn or Va,Vb,Vc, proceed as follows. Balanced 3P voltage should first be applied, then the phase-neutral voltage magnitude on the faulted phase should be reduced in magnitude with no change in phase angle to produce V_{res} and simulate the fault. The fault current, on the faulted phase only, should be set at the MTA with respect to the phase-neutral voltage on the faulted phase, e.g. for a relay setting of -15°, set the phase current to lag the ph-n voltage by 15°.

Alternatively, a single phase voltage source can be used in the above test. The polarity of this voltage, applied to the faulted phase-neutral alone, must be reversed to produce the same residual voltage (V_{res}) phase direction as that produced by the 3P voltage simulation described above.

For the **`Phase Voltage Config`** of Vab, Vbc, Vo, the single phase voltage applied to the Vo input is used as the polarizing quantity. The inversion is once again required since this input is designed to measure the residual voltage directly, as produced by an 'open delta VT' arrangement. The current must be set at the MTA with respect to the inversion of this voltage. e.g. for a relay setting of -15°, the phase current must lag the (Vo + 180°) voltage by 15°, i.e. if Vo is set at 180°, set I_{ph} at -15°.

If the pickup of one directional **`Earth Fault`** element is mapped to an LED, this can be used to check directional boundaries for pickup and drop-off as the current phase angle is increased and decreased. Note that the **`Calculated Earth Fault`**, **`Measured Earth Fault`**, and **`Sensitive Earth Fault`** have separate directional settings and must be tested individually.

`Intermittent Earth Fault` pickup will start the **`In Progress`** signal which drives the pickup indication. The **`50GI-n Reset`** signal can be used to force a reset of the pickup for testing purposes.



The diagram opposite shows a Phase A – Earth fault.

Apply residual voltage either directly to input or by reducing voltage of faulted phase.

Adjust the phase angle of the phase current relative to the voltage:

Verify directional pick-up and drop off at points A, B, C and D

Alternatively,

Verify correct directional indication at points a, b, c and d (C.A +75°, +95°, -75°, -95°)

[dw_7SR5_function67G/67GS/67NFunctionalTests, 1, en_US]

Figure 9-6 Directional Earth Fault Boundary System Angles

9.10.28 78VS Voltage Vector Shift

Vector shift is a 3 phase protection and therefore test voltages must be applied to all 3 VT inputs. Elements with the highest pick-up setting should be tested first. The elements with lower pick-up settings can then be tested without the need to disable the elements already tested.

To test operation of the 78 elements, it is necessary to apply a step change to the phase angle i.e. a 'jump' in the voltage waveform. The size of the jump is increased with each test step until the element operates. Being instantaneous, there is no difference between the element picking-up and operating. Therefore the 78-n output contact can be used for both pick-up and timing measurements.

Voltage Vector Shift (°)	P.U. Phase Step (°)	Operate Time (s)	UV Guard	Notes

The applied voltage must be above the 78 **`UV Guard`** (Ph-N) setting in the **`Vector Shift`** menu for the element to operate. This setting can be tested by applying the test voltage at a level below the 78 U/V **`Guard`** setting at a vector shift in the operate range. Increase the voltage until the relay operates.

UVG Setting (Volts)	Vector Shift Element Used for Test	Blocked Vector Shift (D.O.)	Unblocked Vector Shift (P.U.)	Notes

Check correct indication, trip output, alarm contacts, waveform record.

Element Blocking

The vector shift elements can be blocked by **`Binary Input Inhibit`**. This functionality should be checked.

Element	BI Inhibits
78-1	
78-2	

When testing is complete reinstate any of the disabled functions.

9.10.29 81 Frequency Protection – "f>" or "f<"

Elements can be mapped to operate for frequency measurement on the 3 phase voltage inputs or the single phase input V4. The 3 phase function can be tested by application of 1P or 3P voltage. For over-frequency, the elements with the highest setting should be tested first and for under-frequency the elements with the lowest settings should be tested first. The elements with other settings can then be tested without need to disable the elements already tested. Note that the relay is designed to track the gradual changes in power system frequency and that sudden step changes in frequency during testing do not reflect normal system operation. Normal, instantaneous, operation of the frequency element is 140 ms to 175 ms in line with the **`Technical Data`**. Application of sudden step changes to frequency can add additional delay which can produce misleading test results.

Gradually increase/decrease applied voltage frequency until 81-n operation occurs. Elements set for more extreme frequency fluctuation should be tested first with lesser elements disabled.

If the 81-n **`Delay`** setting is long it will be advantageous to map the function to temporarily drive the relevant pickup output in the **`Pickup Config`** sub-menu in the **`Output Config`** menu as this will allow the **`Pickup`** LED to operate for the function. If the delay setting is short the operation of the element can be easily checked directly.

The frequency should then be gradually decreased/increased until the element resets. The reset frequency can be used to check the **`Hysteresis`** setting.

Apply setting frequency +0.5 Hz for over-frequency or -0.5 Hz for under-frequency and record operating time.

Starting with the element in the operated condition, gradually increase or decrease the applied voltage until the element resets. Measure the reset voltage level to check the 81 **`Hysteresis`** setting.

Freq (Hertz)	U/O	Delay (sec)	Hyst.	D.O. (calc.)	P.U. Freq (Hz)	D.O. Freq. (Hz)	Operate Time @ ± 0.5 Hz	UV Guard	Notes

Element Blocking

The U/O frequency elements can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
81-1	
81-2	
81-3	
81-4	
81-5	
81-6	

Check correct indication, trip output, alarm contacts, waveform record.

When testing is complete reinstate any of the disabled functions.

9.10.30 81R Frequency Protection – "df/dt"

This function is applied to the 3 phase voltages but can be tested by application of only 1P or all 3P voltages. Check **Phase Voltage Config** setting to identify correct voltage inputs for test voltage application. Elements with the highest **ROCOF** pickup setting should be tested first. The elements with lower pickup settings can then be tested without need to disable the elements already tested. The applied phase voltage must be above 19 V for the element to operate. Tests should be applied at rated voltage.

Gradually increase/decrease applied voltage frequency gradient until 81R-n operation occurs. If the 81R-n **Delay** setting is long it will be advantageous to map the function to temporarily drive the relevant pickup output in the **Pickup Config** sub-menu in the **Output Config** menu as this will allow the **Pickup** LED to operate for the function. If the delay setting is short the operation of the element can be easily checked directly.

The frequency gradient should then be gradually decreased/increased until the element resets.

Apply voltage frequency gradient at twice setting level and record operating time.

ROCOF (Hz/s)	Dir	Delay (sec)	P.U. ROCOF (Hz/s)	D.O. ROCOF (Hz/s)	Operate Time @ 2 · setting	Notes

Check correct indication, trip output, alarm contacts, waveform record.

Element Blocking

The **ROCOF** elements can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
81R-1	
81R-2	
81R-3	
81R-4	
81R-5	
81R-6	

When testing is complete reinstate any of the disabled functions.

9.10.31 87GH Restricted Earth Fault Protection – High-Impedance

The setting resistance should be measured and the value compared to that specified in the settings data. Both values should be recorded.

Settings Data Resistor Value	Measured

The high value of setting resistance **R** will often prevent secondary current injection when using a digital test set. It is normal practice in these cases to short out the series resistor to allow testing, the shorting link should be removed after testing.

Since the **DTL** setting is generally small the pick-up setting can be tested by gradually increasing current until element operates. The relay should be disconnected from the current transformers for this test.

Apply 2 times setting current if possible and record operating time.

Phase	I_{set} (Amps)	DTL (sec)	P.U. Current Amps	Tolerance	Operate Time $2 \cdot I_{set}$	Tolerance

It is also desirable to check the operating voltage achieved with the setting resistor and all parallel CTs connected but de-energized. A higher capacity test set will be required for this test. Adequate current must be supplied to provide the magnetizing current of all connected CTs. Precautions should be taken to ensure that no personnel are at risk of contact with any of the energized secondary wiring during the test.

Settings Data Voltage Setting	Measured

To complete testing of the **REF** requires primary injection through the phase and residual **REF** CT in series to simulate an out of zone fault and ensure stability of the relay. The test can then be repeated with the **REF** CT secondary connections reversed to prove operation.

Element Blocking

The **Restricted Earth Fault** element can be blocked by **Binary Input Inhibit**. This functionality should be checked.

Element	BI Inhibits
87GH	

Check correct indication, trip output, alarm contacts, waveform record.

Check that any shorting links are removed after testing.

9.10.32 87NL Restricted Earth Fault Protection – Low-Impedance

87NL Restricted Earth Fault Protection – Low-Impedance

The polarity of the 4^{th} CT connection is critical for correct operation of the 87NL function and should be checked by primary injection through the phase and residual (REF) CT in series to simulate an out of zone fault and ensure stability of the relay. The HV terminals of the transformer will need a short circuit applied so it is convenient to apply this test at the same time as testing of the differential protection.

Test current may be limited by transformer impedance and test equipment capacity.

The device has instruments which display measured values for the currents in the **Low Impedance Meters** menu and these can be used for testing purposes.

Check that the **operate** current is approximately zero for primary injection with current flowing through one phase and the transformer ground connection point to simulate an **external** fault condition. If the **operate** current is approximately double that of the injected current, shown as **restrain** current, this indicates the I_g current transformer polarity is incorrect and the 87NL function will not operate correctly.

	Test Applied	Measured
Current injected	$\cdot I_{rated}$	
Phase difference	0°	
Relay I_n	$\cdot I_{rated}$	
Relay I_g	$\cdot I_{rated}$	
Line I_n	$\cdot I_{rated}$	
Line I_g	$\cdot I_{rated}$	
87NL Restrain	$\cdot I_{rated}$	
87NL Operate	$\cdot I_{rated}$	

In addition, the I_n and I_g Relay currents should have similar magnitude but line currents may be different if dissimilar phase and ground CT ratios are installed.

Settings can be checked by secondary injection if required.

Basic operation of the element is easily checked by secondary injection of the I_g current alone. The element will operate at the **87NL Setting**.

This test can also be used to measure a DTL time delay applied as **87NL Delay**.

Accuracy of the biased characteristic can also be tested by secondary injection if required to confirm settings of the slope and limit settings. Single phase current injection can be applied to I_A to generate an I_n current directly to create bias current. Tests must include the CT multiplier settings if different phase and I_g CT ratios are used. The I_g current must be greater than the **Guard Setting** for operation. For simplicity, I_g and $I_n(I_A)$ currents should be applied with zero phase difference. For simplicity, differential test points can be created at $I_n = I_{restrain} + \left(\frac{I_{op}}{2}\right)$ and $I_g = I_{restrain} - \left(\frac{I_{op}}{2}\right)$. Always ensure that thermal ratings are not exceeded when differential tests are applied. Current injection with opposing phase angle can be used to reduce test currents.

$$I_{op} = \text{Setting, for } I_{restrain} \le \text{Setting}$$

[fo_function87NLApplication&SettingsFunction3, 1, en_US]

$$I_{op} = \frac{\left(\left|I_g\right| + \left|I_n\right|\right)}{2} \cdot S1, \text{for Setting} < I_{restrain} < S1L$$

[fo_function87NLApplication&SettingsFunction4, 1, en_US]

$$I_{op} = \{S1 \cdot S1L\} + \left\{\left[\left(\frac{\left(\left|I_g\right| + \left|I_n\right|\right)}{2}\right) - S1L\right] \cdot S2\right\} \text{ for } I_{restrain} > S1L$$

[fo_function87NLApplication&SettingsFunction5, 1, en_US]

$I_{restrain}$	$I_n = I_{restrain} + \left(\frac{I_{op}}{2}\right)$	$I_g = I_{restrain} - \left(\frac{I_{op}}{2}\right)$	I_{pickup}

Element Blocking

The low impedance restricted earth fault element can be blocked by **`Binary Input Inhibit`**. This functionality should be checked.

Element	BI Inhibits
87NL-1	
87NL-2	

Check correct indication, trip output, alarm contacts and waveform record.

9.11 Supervision Functions

9.11.1 49TS Temperature Sensor Supervision

9.11.2 50BF Circuit-Breaker Failure Protection – 3 Pole

The circuit-breaker fail protection time delays are initiated either from:

- A binary output mapped as **Trip Contact** in the **Configuration > Binary Inputs > Input Matrix** menu, or
- A binary input mapped as 50BF **Ext Trip** in the **Configuration > Binary Inputs > Input Matrix** menu. Or
- A binary input mapped as 50BF **Mech Trip** in the **Configuration > Binary Inputs > Input Matrix** menu.

Apply a trip condition by injection of current to cause operation of a suitable protection element. Allow current to continue after the trip at a level of 110 % of the 50BF **Setting** current level on any phase. Measure the time for operation of 50BF-1 **Delay** and 50BF-2 **Delay**. Repeat the sequence with the 50BF CB **Faulty** input energized and ensure the 50BF-1 and 50BF-2 outputs operate without delay, by-passing the timer delay settings.

Repeat the sequence with current at 90 % of the 50BF **Setting** current level after the element trip and check for no **CB Fail** operation.

Repeat the sequence by injecting the current to CT4 and using the 50BF-I4 **Setting**.

50BF Setting (· I_{rated})	Test Current	50BF-1 Delay	50BF-2 Delay
	(110 %)		
	(90 %)	No Operation	No Operation
	50BF CB Faulty	Operation No Delay	Operation No Delay

50BF-I4 Setting (· I_{rated})	Test Current	50BF-1 Delay	50BF-2 Delay
	(110 %)		
	(90 %)	No Operation	No Operation
	50BF CB Faulty	Operation No Delay	Operation No Delay

If the circuit-breaker can also receive a trip signal from a protection function where there is no increase in current, this trip input should be mapped to 50BF **Mech Trip** in the **Configuration > Binary Inputs > Input Matrix** menu.

Initiate this binary input and simulate the circuit-breaker remaining closed by ensuring the **CB Closed** binary input is energized and ensure operation of the 50BF-1 and 50BF-2 outputs after their programmed delays.

50BF Mech Trip		50BF-1 Delay	50BF-2 Delay
	CB Closed		
	CB Open	No Operation	No Operation

Element Blocking

The **CB Fail** function can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
50BF	

9.11.3 60CTS CT Supervision

60CTS-I CT Supervision – Current Reference

Apply 3 Phase balanced current to the relay, reduce the current in any 1 or 2 phases to a level below 60CTS-I setting. Measure the delay to operation.

Gradually reduce the 3 Phase current until the element resets.

Setting	Measured
60CTS-I Delay	
60CTS-I I_2 Setting	

60CTS-V CT Supervision – Voltage Reference

The presence of NPS current without NPS voltage is used to indicate a current transformer failure.

Apply normal 3P balanced current with a crossover of any 2 phases at a level above 60CTS-V I_2 setting.

Measure the delay to operation.

Apply 3P balanced voltage with a similar phase crossover to the current. Increase the applied 3P voltage until the CTS-V element resets.

Reduce the 3P voltage to cause CTS-V operation again. Gradually reduce the 3P current until the element resets.

Setting	Measured
60CTS-V Delay	
60CTS-V I_2	
60CTS-V V_2	

Element Blocking

The **`CT Supervision`** function can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
60CTS	

9.11.4 60VTS VT Supervision

1 or 2 Phase VT Fail

Apply 3P balanced nominal current and voltage. Reduce 1 phase voltage until VTS operates, record voltage reduction level.

60VTS V Setting	Setting · 3	Measured Voltage Reduction

Increase the voltage until VTS resets. Increase current on 1 phase by 110 % of 3 times the **`60VTS I`** setting. Reduce voltage as above and check for no operation. Return voltage to nominal. Increase current on 1 phase by 90 % of 3 times the **`60VTS I`** setting. Reduce voltage as above and check for VTS operation.

60VTS I Setting	Setting · 3	110 % of Setting · 3	90 % of Setting · 3

3 Phase VT Fail

Apply 3P balanced nominal voltage and 3P balanced current at a level between the **60VTS I_1 Load** setting and the **60VTS I_1 Fault** setting. Reduce the balanced voltage on all 3 phases until the VTS operates at the **60VTS V_1** setting. Return the voltage to nominal and ensure that VTS resets.

Reduce the 3P balanced current to a level below the **60VTS I_1 Load** setting. Reduce the 3P balanced voltage to a level below the operate level above. Gradually increase the 3P balanced current until the VTS operates.

Check that the thermal rating of the relay current inputs is not exceeded during the following test. Increase the 3P balanced current to a level above the **60VTS I_1 Fault** setting. Reduce the 3P balanced voltage to a level below the operate level above. Gradually reduce the 3P balanced current until the VTS operates.

	Setting	Measured
60VTS V_1		
60VTS I_1 Load		
60VTS I_1 Fault		

If the VTS can be started from a status input fed from an external source, this functionality should be tested.

Ext_Trig 60VTS Operation	Not Applicable

Element Blocking

The **`VT Supervision`** can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
60VTS	

9.11.5 74CC/74TC Close/Trip Circuit Supervision

The T/CCS-n **`Delay`** can be initiated by applying an inversion to the relevant status input and measured by monitoring of the alarm output. Operation of the alarm output should be checked.

TCS-n Delay Setting	Measured

CCS-n Delay Setting	Measured

Check that the switching threshold of the binary inputs is configured to be below half the rated value of the control voltage if the advanced arrangement is installed where 2 inputs are energized in series in the CB open condition.

Check that the binary inputs used are correctly isolated from other input circuits, particularly for the advance 2 input schemes.

If resistors are installed in the scheme, check that they are present, the correct value and connected correctly. Resistors are not necessary for scheme operation but can be specified to provide additional security if component failure results in a short circuit.

9.11.6 81HB2 Inrush Current Detection

Logical operation of the harmonic blocking can be tested by current injection at 100 Hz for 50 Hz devices or 120 Hz for 60 Hz devices to cause operation of the blocking signals. No fundamental frequency is required.

To test the pickup setting of the 81HB2 element it is necessary to inject both fundamental frequency and second harmonic current into the same phase input by parallel sources or more advanced test equipment that supports that functionality.

Current setting is defined as a percentage of the total current and therefore for a setting of 0.20 · I the threshold will be found at 0.25 · rated current 2nd harmonic if 1.0 · rated current fundamental is injected i.e.

$$\frac{0.25}{(0.25+1)} = 0.2$$

[fo_function81HB2FunctionalTests, 1, en_US]

Current	Expected	Measured
I_f	$1 \cdot I_{rated}$	
I_{2f}		

9.12 Control and Logic Functions

9.12.1 25 Synchrocheck - Synchronizing Function

Instruments on the device fascia can be used to measure synchronizing voltages.

Checking of connection of the correct voltage selection by secondary injection is not enough to prove correct configuration. The phase difference should also be checked at the sync meters with live primary connections to ensure correctness.

Increase and decrease the line and bus voltages in turn to measure the pickup and reset of the live and dead state detection. Check that the required 2 or 3 state operation is selected. Check the operation of the bus and line undervoltage detectors, if enabled, also check the operation of the differential voltage. Individual output signals are provided for testing as well as a combined **25 Voltage Check** output signal. This signal is not affected by phase difference or slip frequency.

Operation of the check sync thresholds can be checked by monitoring the **25 In Synch** output signal. This signal is only active when a CB closing action is requested. This can be achieved by applying a continuous signal to the **Ext Start 25 Sync** input which will activate the signal but will not generate CB close operations. Check sync settings, system split operation and system sync settings can be tested by adjustment of phase angles and frequency of applied voltages.

If system sync settings are applied following a system split, care should be taken when testing phase angle and slip frequency that a system split is not inadvertently triggered.

9.12.2 79 Automatic Reclosing

Autoreclose sequences can be specified differently for Phase, Earth, Externally Initiated and GS Sensitive Earth faults. Sequences should be simulated for each applicable different fault type with the actual relay settings required for service installed in the relay.

The relay requires that the correct indications are received at the CB auxiliary contact inputs and that the injected current and voltage used to generate protection operations are timed to the autoreclose sequence to provide a realistic simulation of the actual system conditions.

The **Instruments** menu contains **Autoreclose Meters** for the **Autoreclose State** and the **Shot No**. which are useful during sequence testing.

When autoreclose is in service and waiting for a trip to initiate a sequence the instrument should display **In Service**. When a trip occurs the instrument should display **Sequence in Progress**. If it does not it indicates that the protection trip is not configured to start autoreclose.

When the CB is **Open**, the protection trip is reset and the voltage conditions are correct the instrument should indicate that the **First Deadtime** is in progress. If the instrument continues to display **Sequence in Progress** and then switches to **Lockout** when the **Sequence Fail Timer** expires, this indicates that those conditions have not been met.

At the end of the expected deatime, the instrument will display **Close Inhibit** until voltage conditions are met. This may be instantaneous depending on settings and applied signals or may time out to **Lockout** is conditions are not met. In this case the voltages, connections and settings likely require investigation.

The instrument should then display **Close Pulse** and then **Reclaim**. **Lockout** or failure usually indicates a circuit-breaker problem or close onto fault resulting in termination of the sequence for the applied settings.

If a further trip does occur during the **Close Pulse** or **Reclaim** time then the instrument will return to **Sequence in Progress** and proceed with the next shot.

The time stamped **Events** listing can be downloaded from the relay to a pc to allow diagnosis of the sequence including measurements of sequence **Dead Times** and other timing without the use of external measuring equipment or complex connections.

9.12.3 Quick Logic

If this functionality is used, the logic equations may interfere with testing of other protection functions in the relay. The function of the `Quick Logic` equations should be tested conjunctively with connected plant or by simulation to assess suitability and check for correct operation on an individual basis with tests specifically devised to suit the particular application.

10 Technical Data

10.1 General Device Data

10.1.1 Instrumentation

	Instrument Value	Reference	Typical Accuracy
I	Current	10 % to 200 % I_{rated}	± 1 % or ± 1 % I_{rated}
V	Voltage	10 % to 200 % V_{rated}	± 1 % or ± 1 % V_{rated}
W	Power (P)	$V = V_{rated}$ I = 10 % to 200 % I_{rated} PF ≥ 0.8	± 3 % S_{rated} where $S_{rated} = V_{rated} \cdot I_{rated}$
VA_r	Reactive power (Q)		
VA	Apparent power (S)		
PF	Power factor	$V = V_{rated}$, 10 % to 200 % I_{rated}, PF ≥ 0.8	± 0.05
f	Frequency	47.5 to 52.5 Hz @ 50 Hz 57 to 63 Hz @ 60 Hz	± 10 mHz

10.2 21LB Load Blinder

10.2.1 3 Phase Load Blinder (21LB-3P)

Reference

	Parameter	Value
$I_{2\ set}$	I_2 level setting	$0.05 \cdot I_{rated}$ to $5 \cdot I_{rated}$
$V_{2\ set}$	V_2 level setting	1 V to 110 V
φ+ set	Angle +ve setting	5° to 85°
φ- set	Angle –ve setting	5° to 85°
Z_{set}	Impedance setting	1 Ω to 100 Ω

Operate and Reset Level

	Attribute	Value
V_{op}	V_1 operate level	V_{set}: ± 2 % or ± 0.5 V
	V_1 reset level	110 % $V_{1\ op}$: ± 5 % V_{rated}
I_{op}	I_2 operate level	I_{set}: ± 5 % or ± 1 % I_{rated}
	Impedance	Z_{set}: ± 5 % or ± 0.1 Ω
	Repeatability	± 1 %

Operate Angle

	Attribute		Value
φ_{op}	Operating angle	Forward	φ+ set ± 5° to φ- set ± 5°
		Reverse	(180° - φ+ set) ± 5° to (180° + φ- set) ± 5°

10.2.2 Single Phase Load Blinder (21LB-1P)

Reference

	Parameter	Value
$I_{0\ set}$	I_0 level setting	$0.05 \cdot I_{rated}$ to $5 \cdot I_{rated}$
$V_{1\ set}$	V_1 level setting	1 V to 110 V
φ+ set	Angle +ve setting	5° to 85°
φ- set	Angle –ve setting	5° to 85°
Z_{set}	Impedance setting	1 Ω to 100 Ω

Operate and Reset Level

	Attribute	Value
V_{op}	V_1 operate level	V_{set}: ± 2 % or ± 0.5 V
	V_1 reset level	110 % $V_{1\ op}$: ± 5 % V_{rated}
I_{op}	I_0 operate level	I_{set}: ± 5 % or ± 1 % I_{rated}
	Impedance	Z_{set}: ± 5 % or ± 0.1 Ω
	Repeatability	± 1 %

	Attribute		Value
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate Angle

	Attribute		Value
φ_{op}	Operating angle	Forward	φ + set ± 5° to φ - set ± 5°
		Reverse	(180° - φ + set) ± 5° to (180° + φ - set) ± 5°

10.3 25 Synchrocheck – Synchronizing Function

Reference

	Parameter	Value
$V_{\text{dl set}}$	Dead Line	0 to 150 %, Δ 1 %
$V_{\text{ll set}}$	Live Line	0 to 150 %, Δ 1 %
$V_{\text{db set}}$	Dead Bus	0 to 150 %, Δ 1 %
$V_{\text{lb set}}$	Live Bus	0 to 150 %, Δ 1 %
$V_{\text{luv set}}$	Line UV Volts	0 to 150 %, Δ 1 %
$V_{\text{buv set}}$	Bus UV Volts	0 to 150 %, Δ 1 %
$V_{\text{diff set}}$	Volt Diff Volts	0 to 100 %, Δ 1 %
$\phi_{\text{cs set}}$	Check Sync Angle	0 to 90°, Δ 1°
$f_{\text{cs set}}$	Check Sync Slip Freq	0 to 2 Hz, Δ 0.01 Hz
$t_{\text{cs set}}$	Check Sync Timer	0 to 100 s, Δ 0.01 s
$\phi_{\text{sps set}}$	System Split Angle	0 to 180°, Δ 1°
$f_{\text{sps set}}$	System Split Slip Freq	0 to 2 Hz, Δ 0.01 Hz
$\phi_{\text{ss set}}$	System Sync Angle	1 to 90°, Δ 1°
$f_{\text{ss set}}$	System Sync Slip Freq	0 to 2 Hz, Δ 0.005 Hz
$t_{\text{ss set}}$	System Sync Timer	0 to 100 s, Δ 0.01 s
$f_{\text{coz set}}$	Close On Zero Slip Freq	0 to 2 Hz, Δ 0.005 Hz
$t_{\text{dlc set}}$	Dead Line Charge Delay (79 Common)	0 to 60 s
$t_{\text{dbc set}}$	Dead Bus Charge Delay (79 Common)	0 to 60 s

Operate and Reset Level

		Attribute	Value
V_{dl}	2 State	Dead Line operate level / Live Line reset level	$V_{\text{dl set}}$, ± 1 % V_n
V_{ll}		Live Line operate level / Dead Line reset level	$V_{\text{ll set}}$, ± 1 % V_n
V_{db}		Dead Bus operate level / Live Bus reset level	$V_{\text{db set}}$, ± 1 % V_n
V_{lb}		Live Bus operate level / Dead Bus reset level	$V_{\text{lb set}}$, ± 1 % V_n
V_{dl}	3 State	Dead Line operate level	$V_{\text{dl set}}$, ± 1 % V_n
		Dead Line reset level	V_{dl} - 4 %, ± 1 % V_n
V_{ll}		Live Line operate level	$V_{\text{ll set}}$, ± 1 % V_n
		Live Line reset level	V_{ll} - 4 %, ± 1 % V_n
V_{db}		Dead Bus operate level	$V_{\text{db set}}$, ± 1 % V_n
		Dead Bus reset level	V_{db} - 4 %, ± 1 % V_n
V_{lb}		Live Bus operate level	$V_{\text{lb set}}$, ± 1 % V_n
		Live Bus reset level	V_{lb} - 4 %, ± 1 % V_n
V_{luv}	Line undervoltage	Operate level	$V_{\text{luv set}}$ ± 1 % V_{rated}
		Reset level	≤ V_{luv} + 4 %
V_{buv}	Bus undervoltage	Operate level	$V_{\text{buv set}}$ ± 1 % V_{rated}
		Reset level	≤ V_{buv} + 4 %

		Attribute		Value
V_{diff}	Voltage difference	Operate level		$V_{diff\ set}$ ± 1 % V_{rated}
		Reset level		≤ V_{diff} - 4 %
$\phi_{cs\ op}$	Check sync	Operate angle Reset angle Repeatability		ϕ_{set}, ± 1° ϕ_{op}, ± 1° ± 1 %
$\phi_{sps\ op}$	System split			
$\phi_{ss\ op}$	System sync			
$f_{cs\ op}$	Check sync slip freq	Operate frequency Reset frequency Repeatability		f_{set}, ± 10 mHz f_{op}, - 10 mHz ± 10 mHz
$f_{sps\ op}$	System split slip freq			
$f_{ss\ op}$	System sync slip freq			
$f_{coz\ op}$	Close on zero slip freq			
		Repeatability		± 1 %
		Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
			f_{rated} ± 5 %	≤ 1 %

Operate and Reset Time

	Attribute		Value
$t_{cs\ op}$	Check sync	Operate time	t_{set} ± 20 ms[30]
$t_{ss\ op}$	System sync		
$t_{dlc\ op}$	Dead line charge delay	Element basic operate time Operate time Repeatability	20 ms ± 20 ms t_{set} + t_{basic} ± 1 % ± 20 ms
$t_{dbc\ op}$	Dead bus charge delay		

30 Minimum synchronizing time following restoration of voltage from a dead condition is 430 ms.

10.4 27 Undervoltage Protection – 3-Phase

10.4.1 Common Settings

Reference

	Parameter	Value
V_{set}	UV guard setting	1 to 200 V, Δ 0.5 V
V	Applied voltage (for operate time)	1.1 to 0.5 · V_{set} (switched)

Operate and Reset Level

	Attribute	Value
V_{op}	Operate level	V_{set}: ± 2 % or ± 0.5 V (ph-ph V)
	Reset level	V_{op} + hysteresis, ± 2 % or 0.5 V

10.4.2 Undervoltage Protection

Reference

	Parameter	Value
V_{set}	Setting	5 to 200 V, Δ 0.5 V
V	Applied voltage (for operate time)	1.1 to 0.5 · V_{set} (switched)
Hysteresis	Hysteresis	0 to 80 %, Δ 0.1 %
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		V_{set}: ± 2 % or ± 0.5 V
	Reset level		(100 % - hysteresis) · V_{op} ± 1 % or ± 0.25 V
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0.5 · V_{set}: 63 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	
	Disengaging time	< 80 ms

10.5 27Vx Undervoltage Protection – Vx

10.5.1 Common Settings

Reference

	Parameter	Value
V_{set}	UV guard setting	1 to 200 V, Δ 0.5 V
V	Applied voltage (for operate time)	1.1 to 0.5 · V_{set} (switched)

Operate and Reset Level

	Attribute	Value
V_{op}	Operate level	V_{set}: ± 2 % or ± 0.5 V (ph-ph V)
	Reset level	V_{op} + hysteresis, ± 2 % or 0.5 V

10.5.2 Undervoltage Protection

Reference

	Parameter	Value
V_{set}	Setting	5 to 200 V, Δ 0.5 V
V	Applied voltage (for operate time)	1.1 to 0.5 · V_{set} (switched)
Hysteresis	Hysteresis	0 to 80 %, Δ 0.1 %
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		V_{set}: ± 2 % or ± 0.5 V
	Reset level		(100 % - hysteresis) · V_{op} ± 1 % or ± 0.25 V
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0.5 · V_{set}: 63 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	
	Disengaging time	< 80 ms

10.6 32 Power Protection

Reference

	Parameter		Value
S_{set}	Setting		0.05 to 2.0 · S_{rated}, Δ 0.05
S	Applied power (for operate time)	Over-power	0 to 1.1 · S_{set} (switched): V_{rated}, 1.1 · I, PF = 1 0 to 2 · S_{set} (switched): V_{rated}, 2 · I, PF = 1
		Under-power	1.1 to 0.5 · S_{set} (switched)
t_{delay}	Delay setting		0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
S_{op}	Operate level		S_{set}: ± 5 % or ± 2 % S_{rated}
	Reset level	Overpower	≥ 95 % S_{op}
		Underpower	≤ 105 % S_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time	Overpower	1.1 · S_{set}: 60 ms ± 10 ms
			2 · S_{set}: 45 ms ± 10 ms
		Underpower	0.5 · S_{set}: 40 ms ± 10 ms
t_{op}	Operate time following delay		t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability		± 1 % or ± 10 ms
	Disengaging time		< 40 ms

10.7 37 Undercurrent Protection – Phase

10.7.1 Common Settings

Reference

	Parameter	Value
I_{set}	UC guard setting	0.05 to 5 · I_{rated}, Δ 0.05
I	Applied current (for operate time)	1.1 to 0.5 · I_{set} (switched)

Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level	≤ 105 % I_{op} ± 1 %
t_{op}	Operate time	0.5 · I_{set}: 35 ms, ± 10 ms
	Reset time	

10.7.2 Undercurrent Protection

Reference

	Parameter	Value
I_{set}	Setting	0.05 to 5 · I_{rated},Δ 0.05
I	Applied current (for operate time)	1.1 to 0.5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≤ 105 % I_{op} or I_{op} ± 1 % I_{rated}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0.5 · I_{set}: 40 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 60 ms

10.8 37G Undercurrent Earth Fault – Measured

Reference

	Parameter	Value
I_{set}	Setting	0.005 to 5 · I_{rated}
I	Applied current (for operate time)	1.1 to 0.5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≤ 105 % I_{op} ± 1 %
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0.5 · I_{set}: 40 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 60 ms

10.9 46 Negative-Sequence Overcurrent Protection

10.9.1 Definite Time Element (46DT)

Reference

	Parameter	Value
I_{set}	Setting	0.05 to 4 · I_{rated}
I	Applied current (for operate time)	0 to 2 · I_{set} (switched) 0 to 5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	2 · I_{set}: 40 ms ± 10 ms 5 · I_{set}: 30 ms ± 10 ms
t_{delay}	char = DTL	t_{delay} ± 1 % or ± 30 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 90 ms

10.9.2 Inverse Time Element (46IT)

Reference

	Parameter	Value
char	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time multiplier setting	0.025 to 1.6
I_{set}	Setting	0.05 to 2.5 · I_{rated}
I	Applied current (for operate time) IDMTL	0 to 2 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s
t_{reset}	Reset setting	ANSI Decaying, 0 to 60 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I_{set}: ± 4 % or ± 1 % I_{rated}
	Reset level		> 95 % I_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute		Value
	Starter operate time (≥ 2 · I_{set})		35 ms ± 10 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \left[\frac{K}{\left(\frac{I}{I_s}\right)^{\alpha} - 1}\right] \cdot Tm$ ± 5 % or ± 50 ms IEC-NI: K = 0.14, α = 0.02 IEC-VI: K = 13.5, α = 1 IEC-EI: K = 80, α = 2 IEC-LTI: K = 120, α = 1
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left(\frac{I}{I_s}\right)^{P} - 1} + B\right] \cdot Tm$ ± 5 % or ± 50 ms ANSI-MI: A = 0.0515, B = 0.114, P = 0.02 ANSI-VI: A = 19.61, B = 0.491, P = 2 ANSI-EI: A = 28.2, B = 0.1217, P = 2
		char = DTL	t_{delay} ± 1 % or ± 20 ms
	Reset time	ANSI Decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$ ± 5 % or ± 50 ms ANSI-MI: R = 4.85 ANSI-VI: R = 21.6 ANSI-EI: R = 29.1
		t_{reset}	t_{reset} ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 60 ms

10.10 46BC Broken Conductor Detection

10.10.1 Common Settings

Reference

	Parameter	Value
I_{set}	UC guard setting	0.05 to 5 · I_{rated}, Δ 0.05
I	Applied current (for operate time)	1.1 to 0.5 · I_{set} (switched)

Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level	90 % I_{op} ± 5 %
t_{op}	Operate time	0.5 · I_{set}: 35 ms ± 10 ms
	Reset time	

10.10.2 Broken Conductor Detection

Reference

	Parameter	Value
I_{set}	Setting (I2/I1)	20 % to 100 %, Δ 1 %
I	Applied current (for operate time)	
t_{delay}	Delay setting	0.03 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 %
	Reset level		90 % I_{op} ± 5 %
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	40 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms
	Disengaging time	< 80 ms

10.11 47 Sequence Overvoltage Protection

10.11.1 Common Settings

Reference

	Parameter	Value
V_{set}	UV guard setting	1 to 200 V, Δ 0.5 V
V	Applied voltage (for operate time)	0 V to 2 · V_{set} (switched) 0 V to 10 · V_{set} (switched)

Operate Level

	Attribute	Value
V_{op}	Operate level	V_{set}: ± 2 % or ± 0.5 V (ph-ph V)
t_{op}	Operate time	0 V to 1.5 · V_{set}: 80 ms ± 20 ms 0 V to 10 · V_{set}: 55 ms ± 20 ms

10.11.2 Overvoltage Protection

Reference

	Parameter	Value
	Measurement	V_1, V_2, V_0
V_{set}	Setting	1 to 115 V, Δ 0.5 V
V	Applied voltage (for operate time)	0 to 1.5 · V_{set} (switched) 0 to 10 · V_{set} (switched)
Hysteresis	Hysteresis	0 to 80 %, Δ 0.1 %
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		V_{set}: ± 2 % or ± 0.5 V
	Reset level		(100 % - hysteresis) · V_{op} ± 2 % or ± 0.5 V
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.5 · V_{set}: 80 ms ± 20 ms
		10 · V_{set}: 55 ms ± 20 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 2 % or ± 20 ms

	Attribute	Value
	Repeatability	± 1 % or ± 20 ms
	Overshoot time	< 40 ms
	Disengaging time	< 90 ms

10.12 49 Thermal Overload Protection

Reference

	Parameter	Value
I_{set}	Overload setting	0.1 to 3 · I_{rated}, Δ 0.01 I_{rated}
T_{th}	Time constant setting	0.5 to 1000 min, Δ 0.5 min

Operate and Reset Level

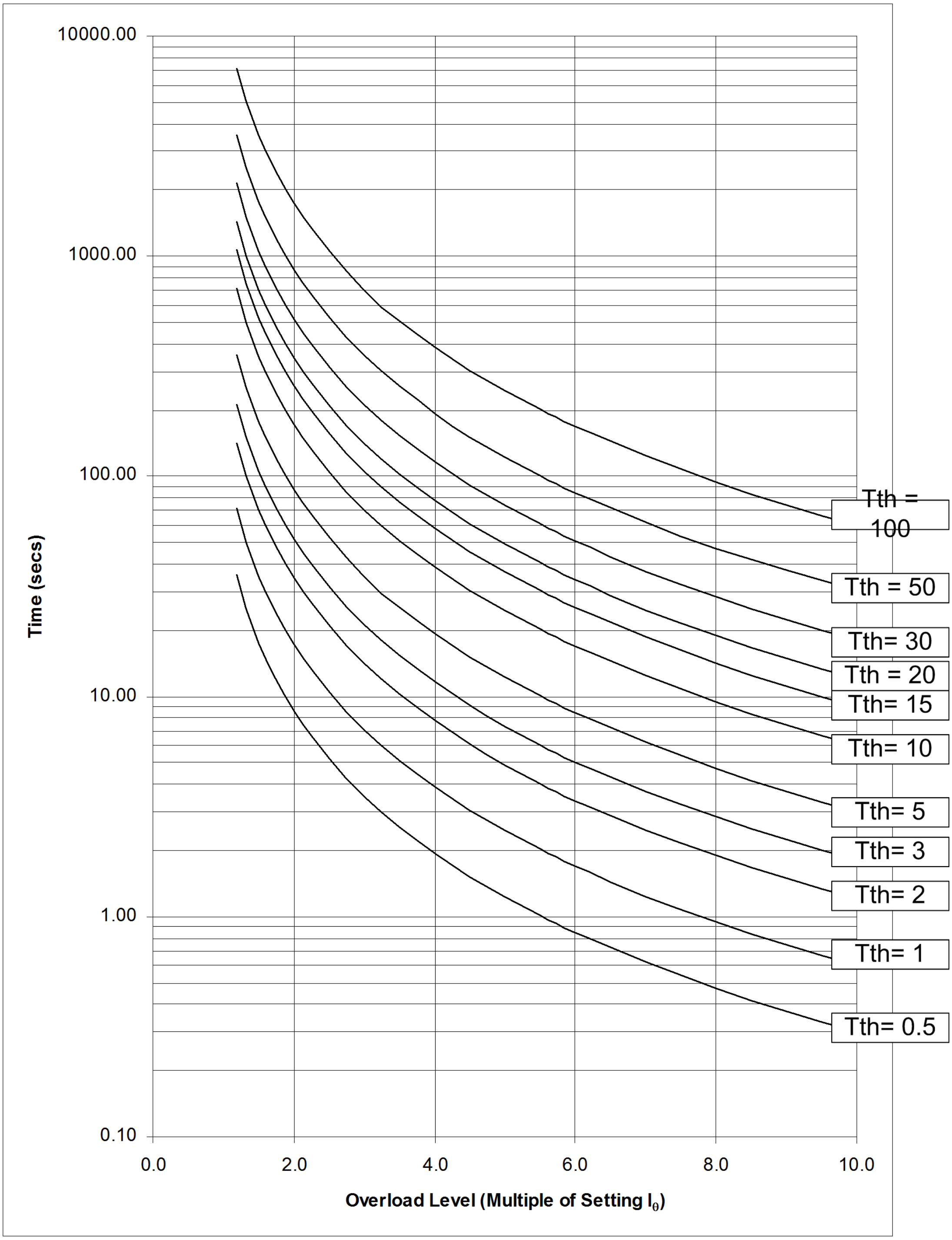
	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≤ 95 % I_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value	
t_{op}	Overload trip operate time (min)	$t = \tau \cdot \ln \left\{ \frac{I^2 - I^2_{prior}}{I^2 - I^2_{set}} \right\}$	± 5 % or ± 100 ms, (I_{set}: 0.3 to 3 · I_{rated}) I = Average rms current I_p = Pre-load current I_θ = Thermal overload setting current τ = Thermal heating time constant (minutes) ln = Natural logarithm t = Operate time (minutes)
	Repeatability	± 100 ms	

Current (multiples of setting)	Operate time t for various time constraints (s)										
	0.5 min	1 min	2 min	3 min	5 min	10 min	15 min	20 min	30 min	50 min	100 min
1.2	35.57	71.14	142.27	213.41	355.69	711.37	1067.06	1422.75	2134.12	3556.87	7113.74
1.5	17.63	35.27	70.53	105.8	176.34	352.67	529.01	705.34	1058.02	176..36	3526.72
2	8.63	17.26	34.52	51.78	86.3	172.61	258.91	345.22	517.83	863.05	1726.09
2.5	5.23	10.46	20.92	31.38	52.31	104.61	156.92	209.22	313.84	523.06	1046.12
3	3.53	7.07	14.13	21.2	35.33	70.67	106	141.34	212.01	353.35	706.7
3.5	2.55	5.11	10.22	15.33	25.55	51.09	76.64	102.19	153.28	255.47	510.95
4	1.94	3.87	7.74	11.62	19.36	38.72	58.08	77.45	116.17	193.62	387.23
4.5	1.52	3.04	6.08	9.12	15.19	30.39	45.58	60.77	91.16	151.93	303.86
5	1.22	2.45	4.9	7.35	12.25	24.49	36.74	48.99	73.48	122.47	244.93
5.5	1.01	2.02	4.03	6.05	10.08	20.17	30.25	40.34	60.51	100.85	201.7

Current (multi-ples of setting)	Operate time t for various time constraints (s)										
	0.5 min	**1 min**	**2 min**	**3 min**	**5 min**	**10 min**	**15 min**	**20 min**	**30 min**	**50 min**	**100 min**
6	0.85	1.69	3.38	5.07	8.45	16.9	25.35	33.81	50.71	84.51	169.03
7	0.62	1.24	2.47	3.71	6.19	12.37	18.56	24.74	37.11	67.86	123.72
8	0.47	0.94	1.89	2.83	4.72	9.45	14.17	18.90	28.35	47.25	94.49
9	0.37	0.75	1.49	2.24	3.73	7.45	11.18	14.91	22.36	37.27	74.54
10	0.30	0.60	1.21	1.81	3.02	6.03	9.05	12.06	18.09	30.15	60.3



[dw_7SR5_thermaloverloadgraph, 1, en_US]

Figure 10-1 Thermal Overload Protection Curves

10.13 50 Instantaneous Overcurrent – Phase

Reference

	Parameter	Value
	Measurement	RMS, fundamental
	Directional control	Non-directional, forward, reverse
I_{set}	Setting	0.05 to 2.5 · I_{rated}, Δ 0.01 2.55 to 25 · I_{rated}, Δ 0.05 25.5 to 50 · I_{rated}, Δ 0.5
I	Applied current (for operate time)	0 to 2 · I_{set} (switched) 0 to 5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	2 · I_{set}: 35 ms ± 10 ms
		5 · I_{set}: 25 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

10.14 50AFD Arc Flash Detection

Reference (50AFD)

	Parameter	Value
I_{set}	Setting	0.5 to 20 · I_{rated}, Δ 0.05
I	Applied current (for operate time)	0 to 2 · I_{set} (switched)

Operate and Reset Level (50AFD)

	Attribute		Value
I_{op}	Operate level (no DC transient)		I_{set}: ± 10 %
	Transient overreach (X/R ≤ 100)		≤ -30 %
	Reset level		≥ 95 % I_{op}
	Repeatability		± 5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time (50AFD)

	Attribute	Value
t_{basic}	Element basic operate time	2 · I_{set}: < 20 ms
t_{op}	AFD zone operate time (Arc and 50AFD)	2 · I_{set}: 15 ms - 25 ms
	Repeatability	± 10 ms
	Disengaging time	< 50 ms

10.14.1 50GAFD Earth Arc Flash Detection

Reference (50GAFD)

	Parameter	Value
I_{set}	Setting	0.5 to 8 · I_{rated}, Δ 0.05
I	Applied current (for operate time)	0 to 2 · I_{set} (switched)

Operate and Reset Level (50GAFD)

	Attribute		Value
I_{op}	Operate level (no DC transient)		I_{set}: ± 10 %
	Transient overreach (X/R ≤ 100)		≤ -30 %
	Reset level		≥ 95 % I_{op}
	Repeatability		± 5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time (50GAFD)

	Attribute	Value
t_{basic}	Element basic operate time	2 · I_{set}: < 20 ms
t_{op}	AFD zone operate time (Flash and 50AFD)	2 · I_{set}: 15 ms - 25 ms

	Attribute	Value
	Repeatability	± 10 ms
	Disengaging time	< 50 ms

10.15 50BF Circuit-Breaker Failure Protection – 3 Pole

10.15.1 50BF Circuit-Breaker Failure Protection – 3 Pole

Reference

	Parameter	Value
I_{set}	Setting	0.050 to $2 \cdot I_{rated}$
t_{delay1}	Stage 1 delay setting	20 to 60000 ms
t_{delay2}	Stage 2 delay setting	20 to 60000 ms

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}, ± 5 % or ± 1 % I_{rated}
I_{reset}	Reset level		< 100 % I_{op} ± 5 % or ± 1 % I_{rated}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	< 20 ms
t_{op}	Stage 1	t_{delay1}, ± 1 % or ± 20 ms
	Stage 2	t_{delay2}, ± 1 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms
	Overshoot	< 20 ms ($2 \cdot I_{set}$)
	Disengaging time	< 30 ms

Circuit-Breaker Supervision

Position supervision via circuit-breaker auxiliary contacts	
For 3 pole CB tripping	1 input each for make contact and break contact

NOTE

The circuit-breaker failure protection can also work without the circuit-breaker auxiliary contacts stated. Auxiliary contacts are required for circuit-breaker failure protection in cases where the current flow may be absent or too low for tripping (for example with a transformer Buchholz protection).

10.15.2 50BF-I4 Circuit-Breaker Failure Protection – 3 Pole

Reference

	Parameter	Value
I_{set}	Setting	0.005 to $2 \cdot I_{rated}$
t_{delay1}	Stage 1 delay setting	20 to 60000 ms
t_{delay2}	Stage 2 delay setting	20 to 60000 ms

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}, ± 5 % or ± 1 % I_{rated}
I_{reset}	Reset level		< 100 % I_{op} ± 5 % or ± 1 % I_{rated}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	< 20 ms
t_{op}	Stage 1	t_{delay1}, ± 1 % or ± 20 ms
	Stage 2	t_{delay2}, ± 1 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms
	Overshoot	< 20 ms (2 · I_{set})
	Disengaging time	< 30 ms

Circuit-Breaker Supervision

Position supervision via circuit-breaker auxiliary contacts	
For 3 pole CB tripping	1 input each for make contact and break contact

NOTE

The circuit-breaker failure protection can also work without the circuit-breaker auxiliary contacts stated.

Auxiliary contacts are required for circuit-breaker failure protection in cases where the current flow may be absent or too low for tripping (for example with a transformer Buchholz protection).

10.16 50G Instantaneous Earth Fault – Measured

Reference

	Parameter	Value
	Measurement	RMS, fundamental
	Directional control [31]	Non-Dir, forward, reverse
I_{set}	Setting	0.005 to 0.1 · I_{rated}, Δ 0.001 0.105 to 2.5 · I_{rated}, Δ 0.005 2.55 to 25 · I_{rated}, Δ 0.05
I	Applied current (for operate time)	0 to 2 · I_{set} (switched) 0 to 5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	2 · I_{set}: 35 ms ± 10 ms
		5 · I_{set}: 25 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

31 Requires VT inputs

10.17 50GHS High Speed Earth Fault – Measured

Reference

	Parameter	Value
	Directional control [32]	Non-Dir, forward, reverse
I_{set}	Setting	0.5 to 2.5 · I_{rated}, Δ 0.01 2.55 to 25 · I_{rated}, Δ 0.05
I	Applied current (for operate time)	0 to 2 · I_{set} (switched) 0 to 5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 · I_{set}: 18 ms to 24 ms
		0 to 5 · I_{set}: 10 ms to 16 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

32 Requires VT inputs

10.18 50GI Intermittent Earth Fault

Reference

	Parameter	Value
	Directional control [33]	Non-Dir, forward, reverse
	Op mode	Counter, int and counter
I_{set}	Setting	0.005 to 0.1 · I_{rated}, Δ 0.001 0.1 to 2 · I_{rated}, Δ 0.005
I	Applied multiple of setting for timing	0 to 4 · I_{set} (switched)
	Applied current pulse duration (for operate time)	> 5 ms
	Minimum time between applied pulses	40 ms
t_{delay}	Delay setting	0.01 to 60 s, Δ 0.01 s
t_{ext}	Pickup extension time	0 to 10 s, Δ 0.005 s
t_{reset}	Reset	1 to 600 s, Δ 1 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	4 · I_{set}: 20 ms ± 5 ms
		5 · I_{set}: 25 ms ± 10 ms
	Repeatability	± 5 ms
t_{delay}	Overall operate time (Σ t_{basic} + t_{ext})	± 1 % or ± 10 ms for each pulse
t_{reset}	Reset time	± 1 % or ± 10 ms

33 Requires VT inputs

10.19 50GS Instantaneous Sensitive Earth Fault – Measured

Reference

	Parameter	Value
	Directional control [34]	Non-Dir, forward, reverse
I_{set}	Setting	0.005 to $0.1 \cdot I_{rated}$, Δ 0.001 0.105 to $1 \cdot I_{rated}$, Δ 0.005
I	Applied current (for operate time)	0 to $2 \cdot I_{set}$ (switched) 0 to $5 \cdot I_{set}$ (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	$2 \cdot I_{set}$: 35 ms ± 10 ms
		$5 \cdot I_{set}$: 25 ms ± 10 ms
t_{op}	Operate time following delay	$t_{basic} + t_{delay}$ ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

34 Requires VT inputs

10.20 50HS High Speed Overcurrent – Phase

Reference

	Parameter	Value
	Directional control [35]	Non-Dir, forward, reverse
I_{set}	Setting	0.5 to 2.5 · I_{rated}, Δ 0.01 2.55 to 25 · I_{rated}, Δ 0.05 25 to 50 · I_{rated}, Δ 0.5
I	Applied current (for operate time)	0 to 2 · I_{set} (switched) 0 to 5 · I_{set} (switched) 0.5 to 2 · I_{set} (switched) 0.5 to 5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 · I_{set}: 18 ms to 24 ms
		0 to 5 · I_{set}: 10 ms to 16 ms
		0.5 to 2 · I_{set}: 16 ms to 22 ms
		0.5 to 5 · I_{set}: 10 ms to 16 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

35 Requires VT inputs

10.21 50N Instantaneous Earth Fault – Calculated

Reference

	Parameter	Value
	Directional control [36]	Non-Dir, forward, reverse
I_{set}	Setting	0.05 to 2.5 · I_{rated}, Δ 0.01 2.55 to 25 · I_{rated}, Δ 0.05 25.5 to 50 · I_{rated}, Δ 0.5
I	Applied current (for operate time)	0 to 2 · I_{set} (switched) 0 to 5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	2 · I_{set}: 40 ms ± 10 ms
		5 · I_{set}: 30 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

[36] Requires VT inputs

10.22 51 Time-Delayed Overcurrent – Phase

Reference

	Parameter		Value
	51V setting $51V_{set}$ [37]		5 V to 200 V
	51V operate level		V_{set} ± 5 % or ± 1 % V_{rated}
	51CL reduced current level		0.05 to 2.5 · I_{rated}
	Measurement		RMS, fundamental
	Directional control [37]		Non-Dir, forward, reverse
I_{set}	Setting		0.05 to 2.5 · I_{rated}, Δ 0.01
I	Applied current (for operate time)	IDMTL	0 to 2 · I_{set} (switched) 0 to 20 · I_{set} (switched)
		DTL	0 to 5 · I_{set} (switched)
char	Characteristic		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time multiplier (IEC/ANSI)		0.025 to 1.6, Δ 0.025 1.6 to 5, Δ 0.1 5 to 100, Δ 1
t_{delay}	Delay setting		0 to 20 s, Δ 0.01 s
	Minimum operate time		0 to 20 s, Δ 0.01 s
	Follower DTL		0 to 20 s, Δ 0.01 s
t_{reset}	Reset setting		ANSI decaying IEC decaying DTL: 0 to 60 s
	51V multiplier		0.25 to 1, Δ 0.05

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I_{set}: ± 4% or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

[37] Requires VT inputs

Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		20 ms ± 20 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \left[\frac{K}{\left(\frac{I}{I_s}\right)^{\alpha} - 1}\right] \cdot Tm$, ± 5 % or ± 30 ms For char = IEC-NI: K = 0.14, α = 0.02 IEC-VI: K = 13.5, α = 1 IEC-EI: K = 80, α = 2 IEC-LTI: K = 120, α = 1
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left(\frac{I}{I_s}\right)^{P} - 1} + B\right] \cdot Tm$, ± 5 % or ± 30 ms For char = ANSI-MI: A = 0.0515, B = 0.114, P = 0.02 ANSI-VI: A = 19.61, B = 0.491, P = 2 ANSI-EI: A = 28.2, B = 0.1217, P = 2
		char = DTL	t_{delay}, ± 1 % or ± 20 ms
	Reset time	ANSI decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$, ± 5 % or ± 30 ms For char = ANSI-MI: R = 4.85 ANSI-VI: R = 21.6 ANSI-EI: R = 29.1
		IEC decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$, ± 5 % or ± 50 ms For char = IEC-NI: R = 9.7 IEC-VI: R = 43.2 IEC-EI: R = 58.2 IEC-LTI: R = 80
		t_{reset}	t_{reset}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

10.23 51G Time-Delayed Earth Fault – Measured

Reference

	Parameter		**Value**
I_{set}	Setting		0.005 to 1, Δ 0.005
I	Applied current (for operate time)	IDMTL	0 to 2 · I_{set} (switched) 0 to 20 · I_{set} (switched)
		DTL	0 to 5 · I_{set} (switched)
char	Characteristic		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time multiplier (IEC/ANSI)		0.025 to 1.6, Δ 0.025 1.6 to 5, Δ 0.1 5 to 100, Δ 1
t_{delay}	Delay setting		0 to 20 s, Δ 0.01 s
	Minimum operate time		0 to 20 s, Δ 0.01 s
	Follower DTL		0 to 20 s, Δ 0.01 s
t_{reset}	Reset setting		ANSI decaying IEC decaying DTL: 0 to 60 s

Operate and Reset Level

	Attribute		**Value**
I_{op}	Operate level		105 % I_{set}: ± 4% or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		20 ms ± 20 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \left[\frac{K}{\left(\frac{I}{I_s}\right)^{\alpha} - 1}\right] \cdot Tm$, ± 5 % or ± 30 ms For char = IEC-NI: K = 0.14, α = 0.02 IEC-VI: K = 13.5, α = 1 IEC-EI: K = 80, α = 2 IEC-LTI: K = 120, α = 1
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left(\frac{I}{I_s}\right)^{P} - 1} + B\right] \cdot Tm$, ± 5 % or ± 30 ms For char = ANSI-MI: A = 0.0515, B = 0.114, P = 0.02 ANSI-VI: A = 19.61, B = 0.491, P = 2 ANSI-EI: A = 28.2, B = 0.1217, P = 2
		char = DTL	t_{delay}, ± 1 % or ± 20 ms
	Reset time	ANSI decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$, ± 5 % or ± 30 ms For char = ANSI-MI: R = 4.85 ANSI-VI: R = 21.6 ANSI-EI: R = 29.1
		IEC decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$, ± 5 % or ± 50 ms For char = IEC-NI: R = 9.7 IEC-VI: R = 43.2 IEC-EI: R = 58.2 IEC-LTI: R = 80
		t_{reset}	t_{reset}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

10.24 51GS Time-Delayed Sensitive Earth Fault – Measured

Reference

	Parameter		Value
I_{set}	Setting		0.005 to 1, Δ 0.005
I	Applied current (for operate time)	IDMTL	0 to 2 · I_{set} (switched) 0 to 20 · I_{set} (switched)
		DTL	0 to 5 · I_{set} (switched)
char	Characteristic		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time multiplier (IEC/ANSI)		0.025 to 1.6, Δ 0.025 1.6 to 5, Δ 0.1 5 to 100, Δ 1
t_{delay}	Delay setting		0 to 20 s, Δ 0.01 s
	Minimum operate time		0 to 20 s, Δ 0.01 s
	Follower DTL		0 to 20 s, Δ 0.01 s
t_{reset}	Reset setting		ANSI decaying IEC decaying DTL: 0 to 60 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I_{set}: ± 4% or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		20 ms ± 20 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \left[\frac{K}{\left(\frac{I}{I_s}\right)^{\alpha} - 1}\right] \cdot Tm$, ± 5 % or ± 30 ms For char = IEC-NI: K = 0.14, α = 0.02 IEC-VI: K = 13.5, α = 1 IEC-EI: K = 80, α = 2 IEC-LTI: K = 120, α = 1
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left(\frac{I}{I_s}\right)^{P} - 1} + B\right] \cdot Tm$, ± 5 % or ± 30 ms For char = ANSI-MI: A = 0.0515, B = 0.114, P = 0.02 ANSI-VI: A = 19.61, B = 0.491, P = 2 ANSI-EI: A = 28.2, B = 0.1217, P = 2
		char = DTL	t_{delay}, ± 1 % or ± 20 ms
	Reset time	ANSI decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$, ± 5 % or ± 30 ms For char = ANSI-MI: R = 4.85 ANSI-VI: R = 21.6 ANSI-EI: R = 29.1
		IEC decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$, ± 5 % or ± 50 ms For char = IEC-NI: R = 9.7 IEC-VI: R = 43.2 IEC-EI: R = 58.2 IEC-LTI: R = 80
		t_{reset}	t_{reset}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

10.25 51N Time-Delayed Earth Fault – Calculated

Reference

	Parameter		Value
I_{set}	Setting		0.05 to 2.5 · I_{rated}, Δ 0.01
I	Applied current (for operate time)	IDMTL	0 to 2 · I_{set} (switched) 0 to 20 · I_{set} (switched)
		DTL	0 to 5 · I_{set} (switched)
char	Characteristic		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time multiplier (IEC/ANSI)		0.025 to 1.6, Δ 0.025 1.6 to 5, Δ 0.1 5 to 100, Δ 1
t_{delay}	Delay setting		0 to 20 s, Δ 0.01 s
	Minimum operate time		0 to 20 s, Δ 0.01 s
	Follower DTL		0 to 20 s, Δ 0.01 s
t_{reset}	Reset setting		ANSI decaying IEC decaying DTL: 0 to 60 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I_{set}: ± 4% or ± 1 % I_{rated}
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		20 ms ± 20 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \left[\frac{K}{\left(\frac{I}{I_s}\right)^{\alpha} - 1}\right] \cdot Tm$, ± 5 % or ± 30 ms For char = IEC-NI: K = 0.14, α = 0.02 IEC-VI: K = 13.5, α = 1 IEC-EI: K = 80, α = 2 IEC-LTI: K = 120, α = 1
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left(\frac{I}{I_s}\right)^{P} - 1} + B\right] \cdot Tm$, ± 5 % or ± 30 ms For char = ANSI-MI: A = 0.0515, B = 0.114, P = 0.02 ANSI-VI: A = 19.61, B = 0.491, P = 2 ANSI-EI: A = 28.2, B = 0.1217, P = 2
		char = DTL	t_{delay}, ± 1 % or ± 20 ms
	Reset time	ANSI decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$, ± 5 % or ± 30 ms For char = ANSI-MI: R = 4.85 ANSI-VI: R = 21.6 ANSI-EI: R = 29.1
		IEC decaying	$t_{reset} = \frac{R}{\left[\frac{I}{I_{set}}\right]^2} \cdot Tm$, ± 5 % or ± 50 ms For char = IEC-NI: R = 9.7 IEC-VI: R = 43.2 IEC-EI: R = 58.2 IEC-LTI: R = 80
		t_{reset}	t_{reset}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

10.26 55 Power Factor

10.26.1 Common Settings

Reference

	Parameter	Value
I_{set}	UC guard setting	0.05 to 1 · I_{rated}
I	Applied current (for operate time)	1.1 to 0.5 · I_{set} (switched)

10.26.2 Power Factor

Reference

	Parameter		Value
	Directional control		Non-directional, lead, lag
PF_{set}	Power factor setting		0.05, 0.99, Δ 0.05
PF	Applied power factor (for operate time)	Lead	1 to 0.5 · PF_{set} (switched). V = V_{rated}, I = I_{rated}
		Lag	
t_{delay}	Delay setting		0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
PF_{op}	Operate level		PF_{set}: ± 0.05
	Reset level	Lead	± 0.01 PF_{op}
		Lag	≤ 105 % PF_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate Time

	Attribute		Value
t_{basic}	Element basic operate time	Lead/Lag	≤ 70 ms
t_{op}	Operate time following delay		t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability		± 1 % or ± 10 ms

10.27 59 Overvoltage Protection – 3 Phase

Reference

	Parameter	Value
V_{set}	Setting	5 to 199.5, 200 V
V	Applied voltage (for operate time)	0 to 1.1 · V_{set} (switched) 0 to 2 · V_{set} (switched)
Hysteresis	Hysteresis	0 to 80 %
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		V_{set}: ± 2 % or ± 0.5 V
	Reset level		V_{op} - hysteresis ± 2 % or 0.5 V
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.1 · V_{set}: 73 ms ± 10 ms
		2 · V_{set}: 63 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	
	Disengaging time	< 80 ms

10.28 59N Neutral Voltage Displacement

10.28.1 Common Settings

Reference

	Parameter	Value
	Input selection	VN, VT4

10.28.2 Definite Time Element (59NDT)

Reference

	Parameter	Value
V_{set}	Setting	1 to 100 V
V	Applied voltage (for operate time)	0 to 2 · V_{set} (switched) 0 to 10 · V_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		V_{set}: ± 2 % or ± 0.5 V
	Reset level		≥ 95 % V_{op} or ± 0.5 V
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.5 · V_{set}: 76 ms ± 20 ms
		10 · V_{set}: 63 ms ± 20 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms
	Overshoot time	< 80 ms
	Disengaging time	< 100 ms

10.28.3 Inverse Time Element (59NIT)

Reference

	Parameter	Value
Tm	Time multiplier setting	0.1 to 140
V_{set}	Setting	1 to 100 V

	Parameter	Value
$3 \cdot V_0$	Applied voltage (for operate time) IDMTL	0 to $2 \cdot V_{set}$ (switched)
t_{delay}	Delay setting	0 to 20 s
t_{reset}	Reset setting	0 to 60 s

Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		V_{set}: ± 2 % or ± 0.5 V
	Reset level		≥ 95 % V_{op} or ± 0.5 V
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		$2 \cdot V_{set}$: 65 ms ± 20 ms
t_{op}	Operate time following delay	char = IDMTL	$t_{op} = \frac{Tm}{\left[\frac{3 \cdot V_0}{V_{set}}\right] - 1}$ ± 5 % or ± 65 ms
		char = DTL	For DTL < starter operate time = t_{basic}For DTL > starter operate time: t_{delay} ± 1 % or ± 40 ms
	Reset time	char = IDMTL	t_{reset} ± 5 % or ± 65 ms
		char = DTL	t_{reset} ± 1 % or ± 40 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 70 ms
	Disengaging time		< 100 ms

10.29 59Vx Overvoltage Protection – Vx

Reference

	Parameter	Value
V_{set}	Setting	5 to 199.5, 200 V
V	Applied voltage (for operate time)	0 to 1.1 · V_{set} (switched) 0 to 2 · V_{set} (switched)
Hysteresis	Hysteresis	0 to 80 %
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		V_{set}: ± 2 % or ± 0.5 V
	Reset level		V_{op} - hysteresis ± 2 % or 0.5 V
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.1 · V_{set}: 73 ms ± 10 ms
		2 · V_{set}: 63 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	
	Disengaging time	< 80 ms

10.30 60CTS-I CT Supervision – Current Reference

Reference

	Parameter	Value
I_{set}	Current threshold setting	0.05 to 2 · I_{rated}
t_{delay}	Delay setting	0.03 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Current Threshold

	Attribute		Value
I_{op}	CT failed current level		I_{set}: ± 5 % or ± 1 % I_{rated}
	Reset level		90 % I_{op}: ± 5 % or ± 1 % I_{rated}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	30 ms ± 20 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms

10.31 60CTS-V CT Supervision – Voltage Reference

Reference

	Parameter	Value
I_{set}	I2 setting	0.05 to 1, Δ 0.05
V_{set}	V2 setting	7 to 110 V, Δ 1 V
t_{delay}	Delay setting	0.03 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	30 ms ± 20 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms

10.32 60VTS VT Supervision

Reference

	Parameter	Value
Component	V	V_2, V_0
V_{set}	Sequence voltage	7 to 110 V, Δ 1 V
I_{set}		0.05 to 1 · I_{rated}, Δ 0.05
V_1 setting		1 to 110 V
I_1 load	I_1 load	0.05 to 1 · I_{rated}, Δ 0.05
I_1 fault	I_1 fault	0.05 to 20, I_{rated}
t_{delay}	Delay setting	0.03 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		V_{set}: ± 5 % V_{rated}
	Reset level		90 % V_{2op}: ± 5 % V_{rated}
I_{set}	Operate level		I_2: ± 5 % · I_{rated}
	Reset level		90 % I_{2op}: ± 5 % · I_{rated}
I_1 fault	Operate level		I_1F: ± 5 % · I_{rated}
	Reset level		90 % I_{1op}: ± 5 % · I_{rated}
I_1 load	Operate level		I_1: ± 5 % · I_{rated}
	Reset level		90 % I_{1load}: ± 5 % · I_{rated}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time	0 V to 2 · V_{set}	32 ms ± 10 ms
	Operate time		t_{basic} ± 1 % or ± 10 ms
	Repeatability		± 1 % or ± 10 ms

10.33 67 Directional Overcurrent – Phase

Reference

	Parameter	Value
θ_{set}	Characteristic angle setting	-95° to +95°
$Vmin_{set}$	Minimum voltage setting	1 V to 20 V
$2/3_{set}$	2 out of 3 logic	Disabled / enabled
I	Applied current (for operate time)	$0.1 \cdot I_{rated}$ $1 \cdot I_{rated}$
V	Applied voltage	$0.1 \cdot V_{rated}$ $1 \cdot V_{rated}$

Operate Angle

	Attribute		Value
θ_{op}	Characteristic angle (I with respect to V)		θ_{set}, ± 5°
	Operating angle	Forward	θ_{set} - 85° ± 5° to θ_{set} + 85° ± 5°
		Reverse	(θ_{set} - 180°) - 85° ± 5° to (θ_{set} - 180°) + 85 ° ± 5°
	Variation in characteristic angle	-10 °C to +55 °C	± 5 °
		f_{rated} ± 5 %	± 5 °

Operate Threshold

	Attribute	Value
	Minimum operating voltage	> 1 V ± 0.25 V

Operate and Reset Time

	Attribute	Value
t_{op}	Operate time	Typically 32 ms < 40 ms at characteristic angle + 50/51 element operate time
t_{reset}	Reset time	Typically < 65 ms at characteristic angle

10.34 67G Directional Earth Fault – Measured

Reference

	Parameter	Value
θ_{set}	Characteristic angle setting	-95° to +95°
$Vmin_{set}$	Minimum voltage setting	0.33 to 3 V, Δ 0.5 V
CT/VT config	Van, Vbn, Vcn	Van, Vbn, Vcn
I	Applied current (for operate time)	$0.1 \cdot I_{rated}$ $1 \cdot I_{rated}$
V	Applied voltage	$0.1 \cdot V_{rated}$ $1 \cdot V_{rated}$

Operate Angle

	Attribute		Value
θ_{op}	Characteristic angle (I with respect to V)		θ_{set}, ± 5°
	Operating angle	Forward	θ_{set} - 85° ± 5° to θ_{set} + 85° ± 5°
		Reverse	(θ_{set} - 180°) - 85° ± 5° to (θ_{set} - 180°) + 85 ° ± 5°
	Variation in charac-teristic angle	-10 °C to +55 °C	± 5 °
		f_{rated} ± 5 %	± 5 °

Operate Threshold

	Attribute	Value
	Minimum operating voltage	> 0.33 V ± 0.25 V

Operate and Reset Time

	Attribute	Value
t_{op}	Operate time	Typically 32 ms < 40 ms at characteristic angle + 50/51 element operate time
t_{reset}	Reset time	Typically < 65 ms at characteristic angle

10.35 67GI Directional Intermittent Earth Fault

Reference

	Parameter	Value
θ_{set}	Characteristic angle setting	-95° to +95°
$Vmin_{set}$	Minimum voltage setting	0.33 to 3 V, Δ 0.5 V
CT/VT config	Van, Vbn, Vcn	Van, Vbn, Vcn
I	Applied current (for operate time)	$> 0.1 \cdot I_{rated}$
V	Applied voltage	$0.1 \cdot V_{rated}$ to $3 \cdot V_{rated}$

Operate Angle

	Attribute		Value
θ_{op}	Characteristic angle (I with respect to V)		θ_{set}, ± 5°
	Operating angle	Forward	θ_{set} - 85° ± 5° to θ_{set} + 85° ± 5°
		Reverse	(θ_{set} - 180°) - 85° ± 5° to (θ_{set} - 180°) + 85 ° ± 5°
	Variation in characteristic angle	-10 °C to +55 °C	± 5 °
		f_{rated} ± 5 %	± 5 °

Operate Threshold

	Attribute	Value
	Minimum operating voltage	> 0.33 V ± 0.25 V

Operate and Reset Time

	Attribute	Value
t_{op}	Operate time	Typically < 25 ms at characteristic angle
t_{reset}	Reset time	Typically < 25 ms at characteristic angle

10.36 67GS Directional Sensitive Earth Fault – Measured

Reference

	Parameter	Value
θ_{set}	Characteristic angle setting	-95° to +95°
$Vmin_{set}$	Minimum voltage setting	0.33 to 67 V, Δ 0.5 V
I	Applied current (for operate time)	$0.1 \cdot I_{rated}$ $1 \cdot I_{rated}$
V	Applied voltage (for operate time)	$0.1 \cdot V_{rated}$ $1 \cdot V_{rated}$
	Compensated network	Enabled / disabled
	Wattmetric	Enabled / disabled
	Wattmetric power	0.05 to 20 · I_{rated} · W, Δ 0.05
	I_{res} select	I_{res}, I_{res} real

Operate Angle

	Attribute		Value
θ_{op}	Characteristic angle (I with respect to V)		θ_{set}, ± 5°
	Operating angle	Forward	θ_{set} - 85° ± 5° to θ_{set} + 85° ± 5°
		Reverse	(θ_{set} - 180°) - 85° ± 5° to (θ_{set} - 180°) + 85 ° ± 5°
	Variation in characteristic angle	-10 °C to +55 °C	± 5 °C
		f_{rated} ± 5 %	± 5 °C

Operate Threshold

	Attribute	Value
	Minimum operating voltage	0.33 V ± 0.25 V

Operate and Reset Time

	Attribute	Value
t_{op}	Operate time	Typically 32 ms < 40 ms at characteristic angle + 50/51 element operate time
t_{reset}	Reset time	Typically < 65 ms at characteristic angle

10.37 67N Directional Earth Fault – Calculated

Reference

	Parameter	Value
	Polarizing quantity	V2, V0
θ_{set}	Characteristic angle setting	-95° to +95°
$Vmins_{et}$	Minimum voltage setting	0.33 to 3 V, Δ 0.5 V
I	Applied current (for operate time)	$0.1 \cdot I_{rated}$ $1 \cdot I_{rated}$
V	Applied voltage	$0.1 \cdot V_{rated}$ $1 \cdot V_{rated}$

Operate Angle

	Attribute		Value
θ_{op}	Characteristic angle (I with respect to V)		θ_{set}, ± 5°
	Operating angle	Forward	θ_{set} - 85° ± 5° to θ_{set} + 85° ± 5°
		Reverse	(θ_{set} - 180°) - 85° ± 5° to (θ_{set} - 180°) + 85 ° ± 5°
	Variation in characteristic angle	-10 °C to +55 °C	± 5 °
		f_{rated} ± 5 %	± 5 °

Operate Threshold

	Attribute	Value
	Minimum operating voltage	> 0.33 V

Operate and Reset Time

	Attribute	Value
t_{op}	Operate time	Typically 32 ms < 40 ms at characteristic angle + 50/51 element operate time
t_{reset}	Reset time	Typically < 65 ms at characteristic angle

10.38 78VS Voltage Vector Shift

Reference

	Parameter	Value
θ_{set}	Vector shift setting	2° to 30°, Δ 0.5°

Operate Level

	Attribute		Value
θ_{op}	Operate level		θ_{set} ± 2°
	Variation IEC 60255-1	-10 °C to +55 °C	
		f_{rated} ± 5 %	

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	≤ 40 ms

10.39 81 Frequency Protection – "f>" or "f<"

Reference

	Parameter	Value
f_{set}	Setting	43 to 68 Hz, Δ 0.01 Hz
f	Applied frequency (for operate time)	
Hysteresis	Hysteresis	0 to 2 %, Δ 0.1 %
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 100 s, Δ 0.1 s 100 to 1000 s, Δ 1 s 1000 to 10000 s, Δ 10 s 1000 to 14400 s, Δ 100 s

Operate and Reset Level

	Attribute		Value
f_{op}	Operate level		f_{set}: ± 10 MHz
	Reset level	Over frequency	(100 % - hysteresis) · f_{op} ± 10 mHz
		Under frequency	(100 % + hysteresis) · f_{op} ± 10 mHz
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time (for ROCOF between 0.1 and 5 Hz/s)	Over frequency	Typically < 110 ms
			Maximum < 150 ms
		Under frequency	Typically < 110 ms
			Maximum < 150 ms
t_{op}	Operate time following delay		t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability		± 1 % or ± 10 ms
	Disengaging time		< 100 ms

10.40 81HB2 Inrush Current Detection

Reference

	Parameter	Value
	Bias	Cross, Phase, Sum
I_{set}	2nd harmonic current content setting	0.1 to 0.5 · I, Δ 0.01
I	Applied current (for operate time)	0 to 2 · I_{set} (switched)

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set} ± 5 %
	Reset level		< 95 % I_{op}
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

10.41 81R Frequency Protection – "df/dt"

Reference

	Parameter	Value
df/dt_{set}	df/dt setting	0.050 to 10 Hz/s
	Direction	Both, positive, negative
df/dt	Applied rate of frequency (for operate time)	0 to 1.3 · df/dt_{set} (switched) 0 to 2 · df/dt_{set} (switched)
t_{delay}	Delay setting	0 to 20 s, Δ 0.01 s 20 to 200 s, Δ 0.1 s

Operate and Reset Level

	Attribute		Value
df/dt_{op}	Operate level		df/dt_{set} ± 50 MHz/s (f_{rated} ± 3 Hz
	Repeatability		± 1 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time (for ROCOF > 1.3x setting)	Typically < 215 ms
		Maximum < 300 ms
	Element basic operate time (for ROCOF > 2x setting)	Typically < 185 ms
		Maximum < 200 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms

10.42 87GH Restricted Earth-Fault Protection – High-Impedance

Reference

	Parameter	Value
I_{set}	Setting	0.005 to 0.95 · I_{rated}, Δ 0.005
I	Applied current (for operate time)	0 to 2 · I_{set} (switched) 0 to 5 · I_{set} (switched)
t_{delay}	Delay setting	0 to 14400 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		I_{set}: ± 5 % or ± 1 % · I_{rated}
	Reset level		95 % I_{op}: ± 5 % or ± 0.1 % · I_{rated}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation IEC 60255-1	-10 °C to +55 °C	≤ 5 %
		f_{rated} ± 5 %	≤ 5 %

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	2 · I_{set}: 45 ms ± 10 ms
		5 · I_{set}: 35 ms ± 10 ms
t_{op}	Operate time following delay	t_{basic} + t_{delay} ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

10.43 87NL Restricted Earth-Fault Protection – Low-Impedance

Reference

	Parameter	Value
ICT	Gn Line CT multiplier	0.25 to 3 x, Δ 0.01
	Gn Neutral CT multiplier	0.25 to 3 x, Δ 0.01
	Gn Guard setting	0.05 to 5 · I_{rated}, Δ 0.05 · I_{rated}
I_{init}	Gn setting	0.1 to 2 p.u., Δ 0.05 p.u.
S1	Gn S1	0.1 to 0.7, Δ 0.05
S1L	Gn S1L	1 to 2 · I_{rated}, Δ 0.1 · I_{rated}
S2	Gn S2	1 to 2 x, Δ 0.05 x
I	Applied current (for operate time)	0 to 3 · I_{op} (switched)
DTL	Gn Delay	0 to 1 s, Δ 0.005 s

Operate and Reset Level

	Attribute		Value
I_{op}	Operate level $I_{op} = \lvert I_G - I_N \rvert$ $I_{BIAS} = \frac{\lvert I_g \rvert + \lvert I_n \rvert}{2}$		I_{BIAS} 0 to 1 p.u.: $I_{op} > I_{init}$ I_{BIAS} 1 p.u. to S1L: $I_{op} > S1(I_{BIAS} - 1) + I_{init}$ $I_{BIAS} >$ S1L: $I_{op} > S2(I_{BIAS} - S1L) + S1(S1L - 1) + I_{init}$ Where S1 = 1st Bias slope S1L = 1st Bias slope limit S2 = 2nd Bias slope
	Operate level		± 10 % of I_{op} or ± 0.1 p.u.
	Reset level		≥ 90 % of I_{op}
	Repeatability		± 2 %
	Transient overreach		≤ 5 %
	Variation IEC 60255-1	-10 °C to +55 °C	
		f_{rated} ± 5 %	

Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	3 · I_{op}, < 30 ms
t_{op}	Operate time following delay	t_{basic} + DTL, ± 1 % or ± 10 ms

A Appendix

A.1 Ordering Information

Ordering Information – 7SR51 Overcurrent Protection Relay

<table>
<tr><th>Product Description</th><th colspan="18">Order No.</th></tr>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td></td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td></td><td>13</td><td>14</td><td>15</td><td>16</td></tr>
<tr><td>**7SR51 Overcurrent Relay**</td><td>7</td><td>S</td><td>R</td><td>5</td><td>1</td><td>n</td><td>n</td><td>-</td><td>n</td><td>A</td><td>A</td><td>n</td><td>n</td><td>-</td><td>0</td><td>A</td><td>A</td><td>0</td></tr>
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<tr><td>Overcurrent: I/O Configurations</td><td></td><td></td><td></td><td></td><td></td><td>6</td><td>7</td><td>-</td><td>8</td><td></td><td></td><td>|</td><td>|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4 I, 8 BI, 6 BO</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>0</td><td>-</td><td>1</td><td></td><td></td><td>|</td><td>1</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4 I, 13 BI, 8 BO</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>0</td><td>-</td><td>2</td><td></td><td></td><td>|</td><td>1</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4 I, 23 BI, 12 BO</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>0</td><td>-</td><td>4</td><td></td><td></td><td>|</td><td>6</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4 I, 38 BI, 18 BO</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>0</td><td>-</td><td>7</td><td></td><td></td><td>|</td><td>6</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Directional Overcurrent: I/O Configurations</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td>|</td><td>-</td><td>|</td><td></td><td></td><td>|</td><td>|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4 I, 4 V, 9 BI, 8 BO</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>-</td><td>1</td><td></td><td></td><td>|</td><td>1</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4 I, 4 V, 14 BI, 10 BO</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>-</td><td>2</td><td></td><td></td><td>|</td><td>6</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4 I, 4 V, 19 BI, 12 BO</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>-</td><td>3</td><td></td><td></td><td>|</td><td>6</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4 I, 4 V, 39 BI, 20 BO</td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>1</td><td>-</td><td>7</td><td></td><td></td><td>|</td><td>6</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Special Applications Overcurrent: I/O Configurations</td><td></td><td></td><td></td><td></td><td></td><td>|</td><td>|</td><td>-</td><td>|</td><td></td><td></td><td>|</td><td>|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5 I, 4 V, 17 BI, 10 BO</td><td></td><td></td><td></td><td></td><td></td><td>2</td><td>1</td><td>-</td><td>2</td><td></td><td></td><td>|</td><td>6</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5 I, 4 V, 37 BI, 18 BO</td><td></td><td></td><td></td><td></td><td></td><td>2</td><td>1</td><td>-</td><td>6</td><td></td><td></td><td>|</td><td>6</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>CPU/Data Communication</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>11</td><td>|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Standard: 1 x USB (front), RS485 (rear) ports</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>|</td><td>|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2 x RJ45 ports</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>|</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2 x optical LC ports</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>2</td><td>|</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Case & Fascia</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>12</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Housing width 3/8 x 19" (size 6), Housing height 4U</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Housing width 3/4 x 19" (size 12), Housing height 4U</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>6</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

NOTE

CT inputs: 1 A/5 A, 50 Hz/60 Hz

VT inputs: 40 V to 160 V, 50 Hz/60 Hz

PSU: DC 24 V to DC 250 V, AC 100 V to AC 230 V

PSU: AC = 50 Hz/60 Hz

BI: DC 24 V/DC 110 V/DC 220 V

IEC 61850 Ethernet editions 1 and 2

Modbus TCP

Modbus RTU, IEC 60870-5-103, DNP3 Serial

SNMP

Syslog

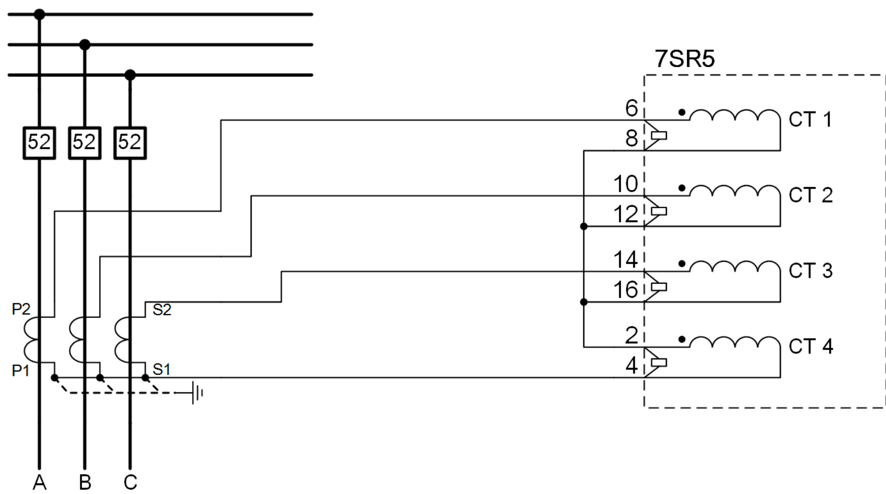
SNTP

User selectable languages: English, French, German, Portugese, Spanish, Turkish

Ordering Information – 7SR5 Spares and Accessories

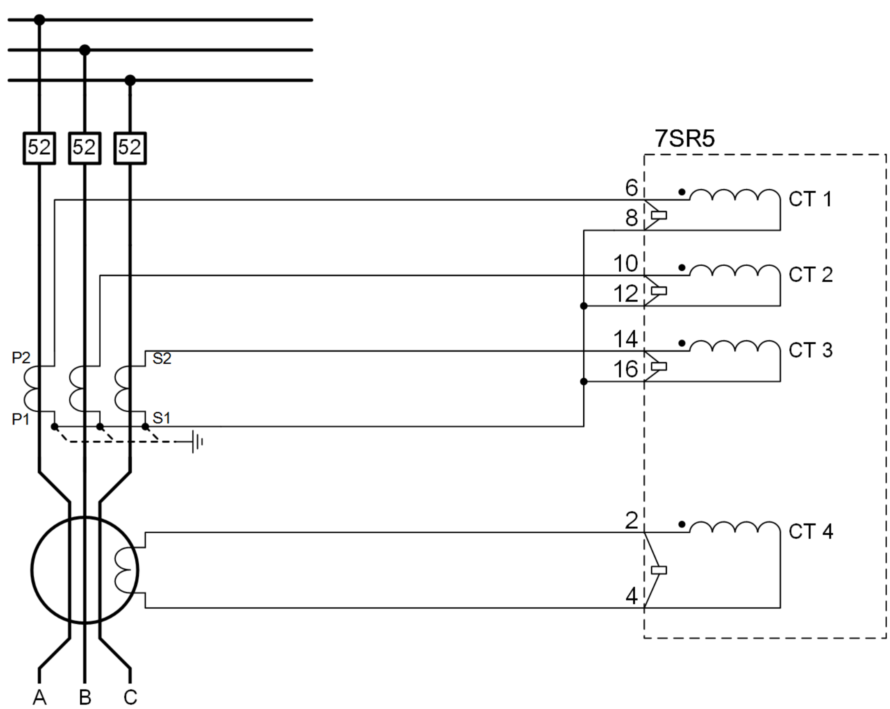
Product Description	**Order No.**																	
	1	2	3	4	5	6	7		8	9	10	11	12		13	14	15	16
7SR5 Spares and Accessories	7	X	G	1	n	n	1	-	0	A	A	0	0	-	0	A	A	0
					|	|												
Fiber optic data communication port inserts (7SR5)					1	1												
Terminal plug for RS485 wiring (3-way)					1	3												
Captive screws for fascia levers (7SR5)					6	1												
Hinged cover for fascia LED label (7SR5)					6	2												

A.2 Current Transformer Connections



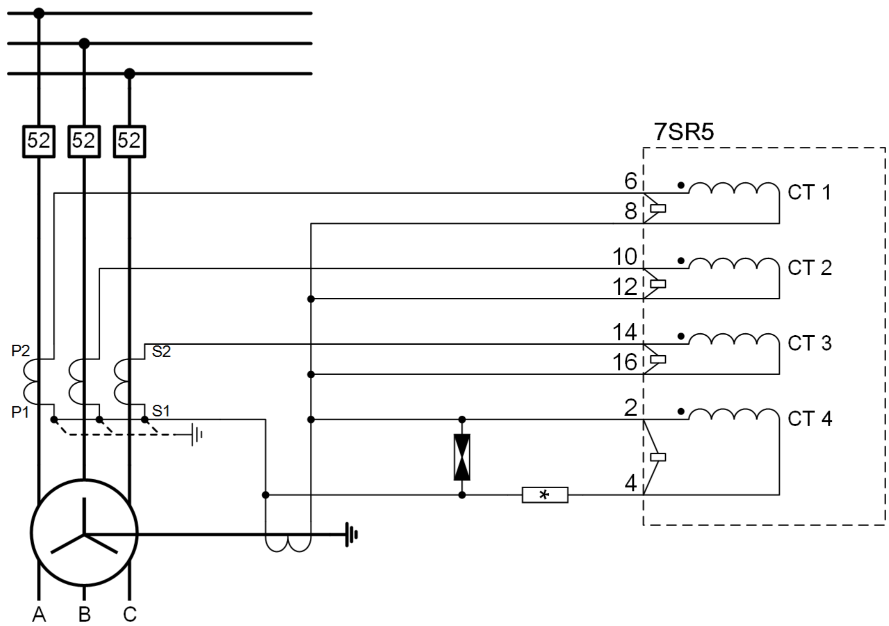
[dw_7SR5_ct-connection_diagram_01, 1, en_US]

Figure A-1 3 Phase Overcurrent and Earth Fault using 3-Phase Line CTs (Holmgreen Connection)



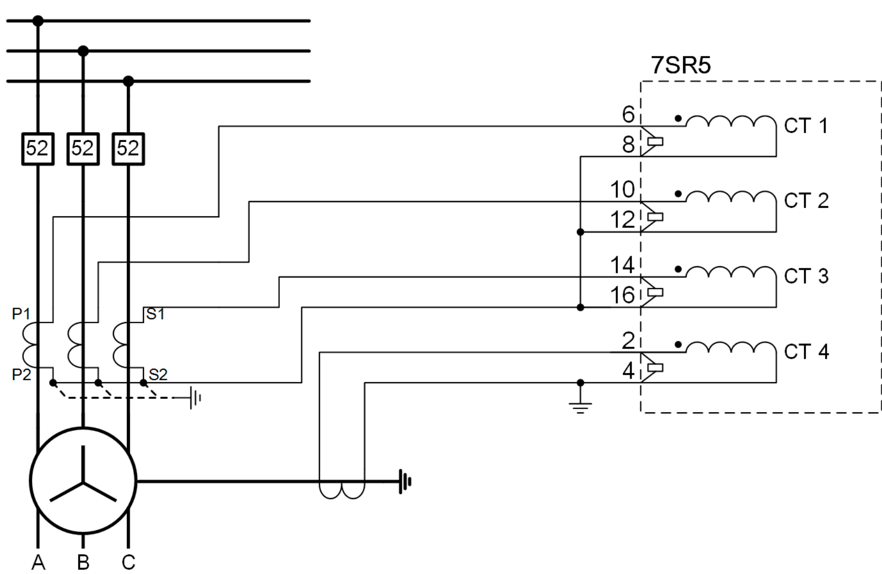
[dw_7SR5_ct-connection_diagram_02, 1, en_US]

Figure A-2 3 Phase Overcurrent and Earth Fault Measured from Separate CT



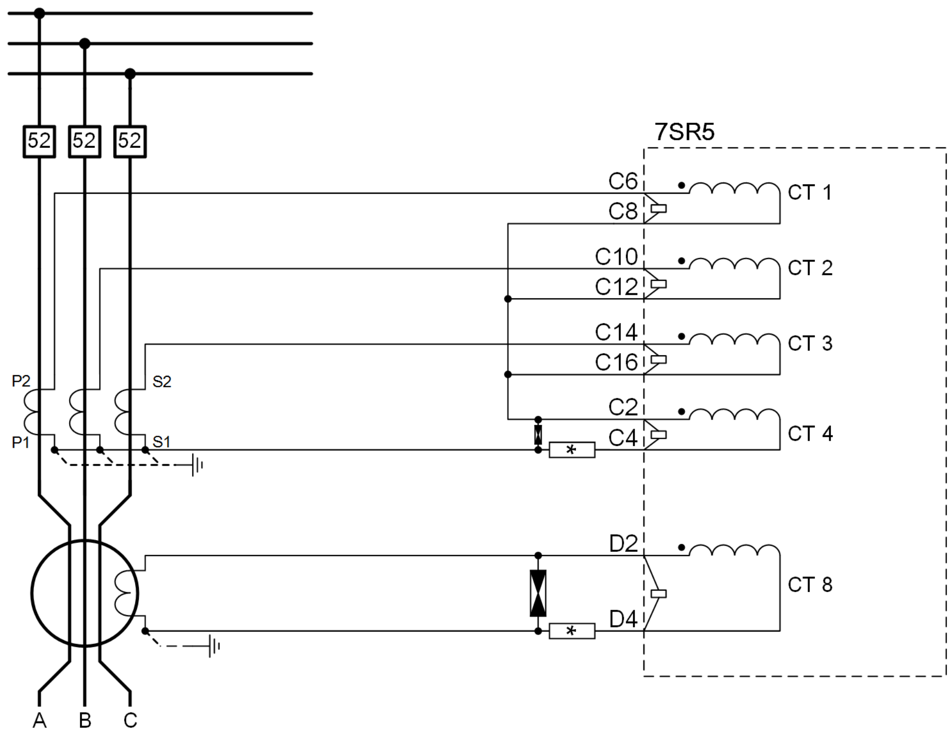
[dw_7SR5_ct-connection_diagram_03, 1, en_US]

Figure A-3 3 Phase Overcurrent and High Impedance Restricted Earth Fault Protection



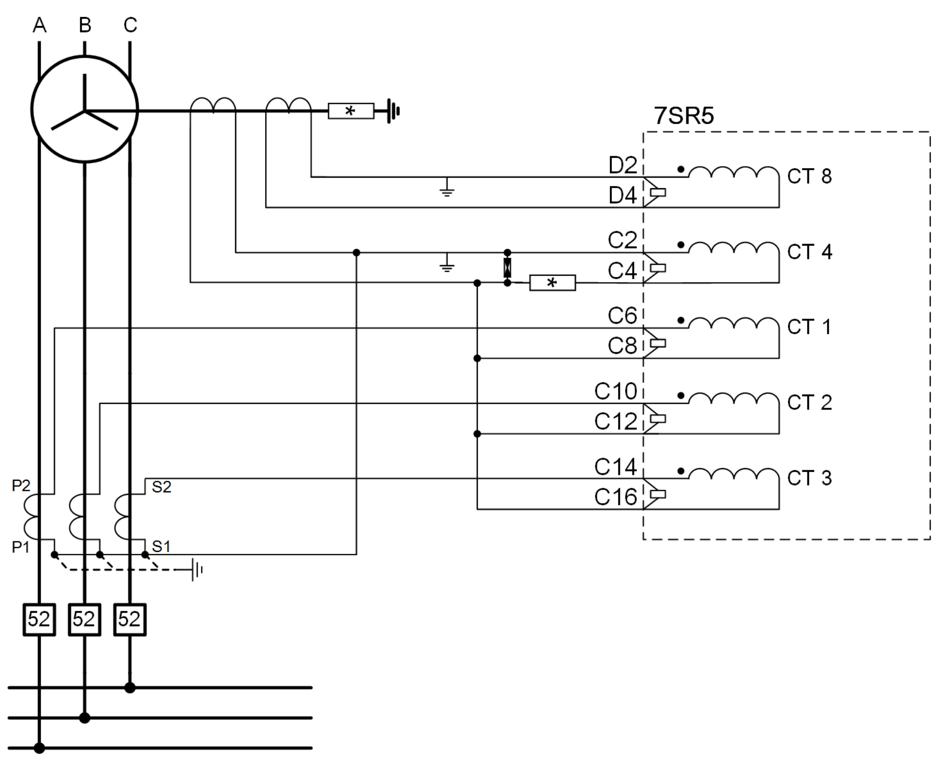
[dw_7SR5_ct-connectiondiagram_04, 1, en_US]

Figure A-4 3 Phase Overcurrent and Low Impedance Restricted Earth Fault Protection



[dw_7SR5_ct-connectiondiagram_05, 1, en_US]

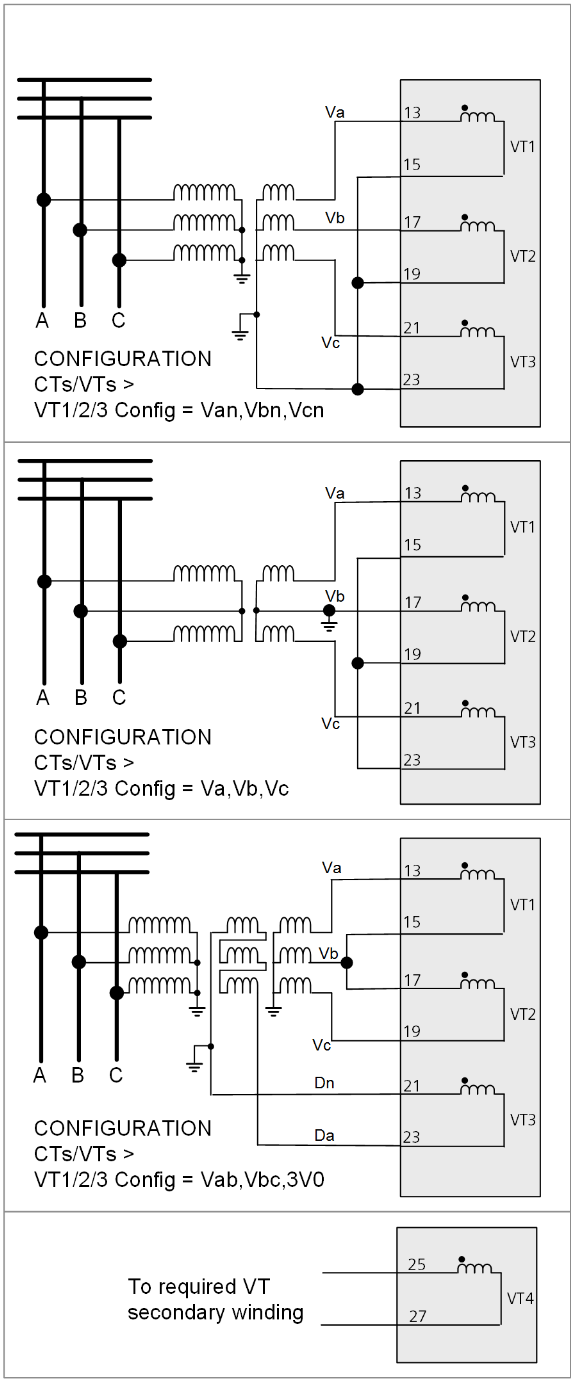
Figure A-5 3 Phase Overcurrent, Measured Earth Fault and High Impedance Restricted Earth Fault Protection



[dw_7SR5_ct-connectiondiagram_06, 1, en_US]

Figure A-6 3 Phase Overcurrent, Measured Earth Fault and High Impedance Restricted Earth Fault Protection and Long Time Inverse Standby Fault

A.3 Voltage Transformer Connections

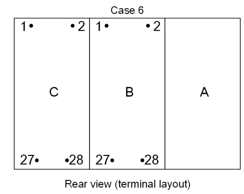


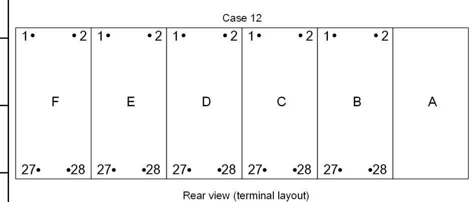
[lo_7SR5_VTConnections, 1, en_US]

Figure A-7 Illustration of VT Configuration Settings and VT Connections (Typical)

A.4 7SR51 Overcurrent Device Terminal Diagrams

Variant	Hardware Type	Module Design	Rear Terminal Diagram
7SR5110-1	4 I, 8 BI, 6 BO, Case 6	AB1 – C1	
7SR5110-2	4 I, 13 BI, 8 BO, Case 6	AB1 – C2	
7SR5110-4	4 I, 23 BI, 12 BO, Case 12	AB1 – C2 – D1	
7SR5110-7	4 I, 38 BI, 18 BO, Case 12	AB1 – C2 – D1 – E1 – F1	
7SR5111-1	4 I, 4 V, 9 BI, 8 BO, Case 6	AB2 – C3	
7SR5111-2	4 I, 4 V, 14 BI, 10 BO, Case 12	AB2 – C3 – D2	
7SR5111-3	4 I, 4 V, 19 BI, 12 BO, Case 12	AB2 – C3 – D3	
7SR5111-7	4 I, 4 V, 39 BI, 20 BO, Case 12	AB2 – C3 – D3 – E2 – F2	
7SR5121-2	5 I, 4 V, 17 BI, 10 BO, Case 12	AB2 – C3 – D4	
7SR5121-6	5 I, 4 V, 37 BI, 18 BO, Case 12	AB2 – C3 – D4 – E3 – F3	





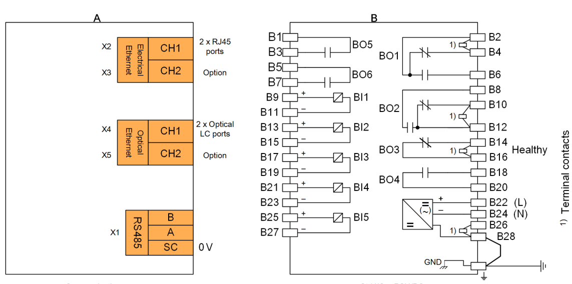


Figure A-8 AB1 Terminal Diagram

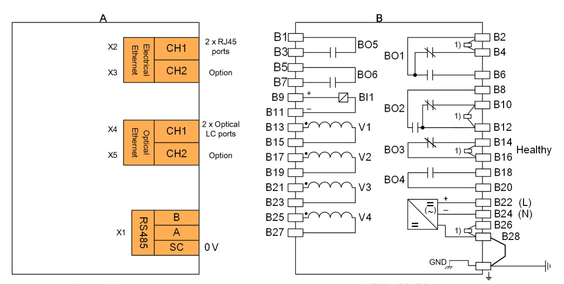


Figure A-9 AB2 Terminal Diagram

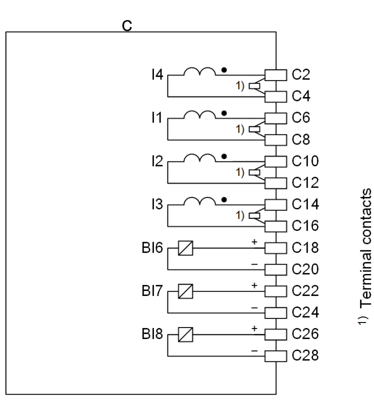


Figure A-10 C1 Terminal Diagram

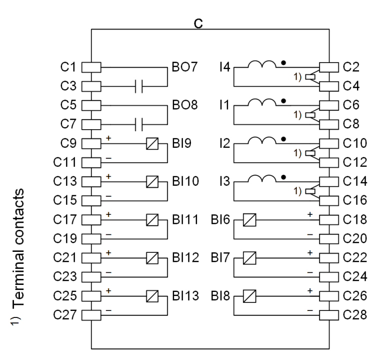


Figure A-11 C2 Terminal Diagram

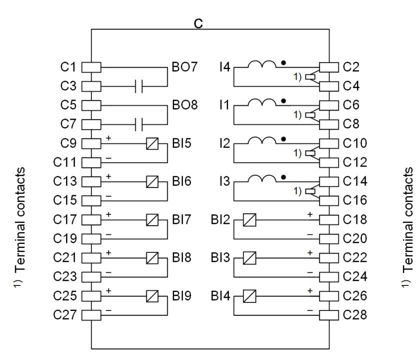


Figure A-12 C3 Terminal Diagram

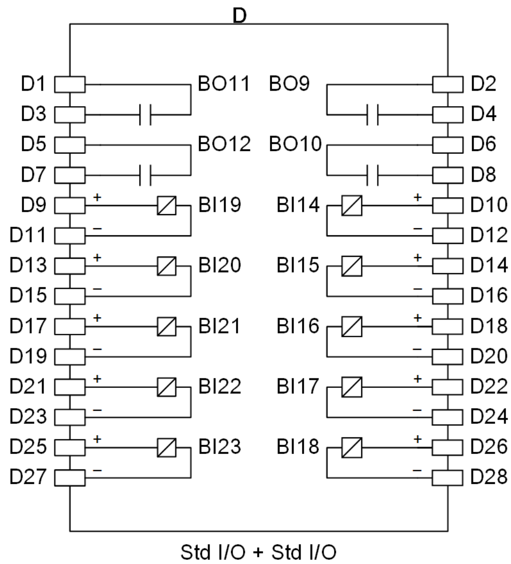


Figure A-13 D1 Terminal Diagram

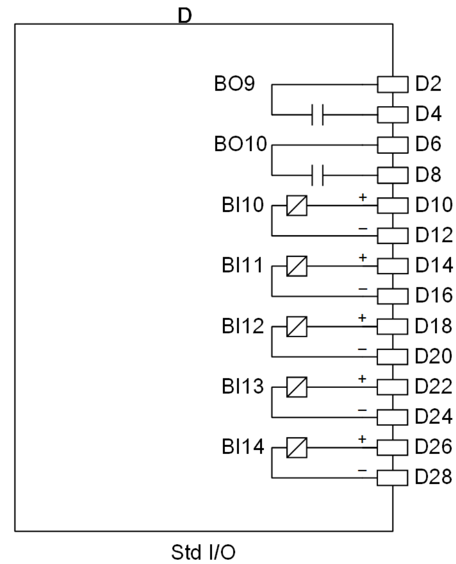


Figure A-14 D2 Terminal Diagram

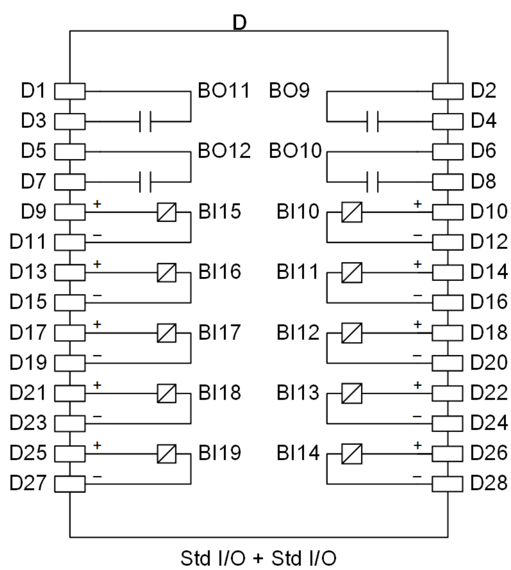


Figure A-15 D3 Terminal Diagram

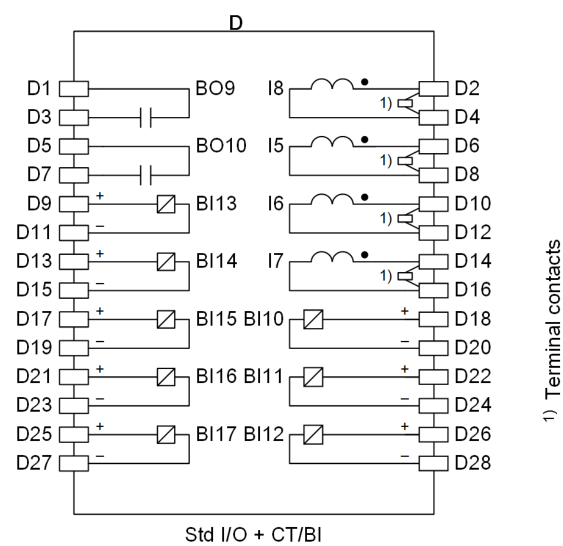


Figure A-16 D4 Terminal Diagram

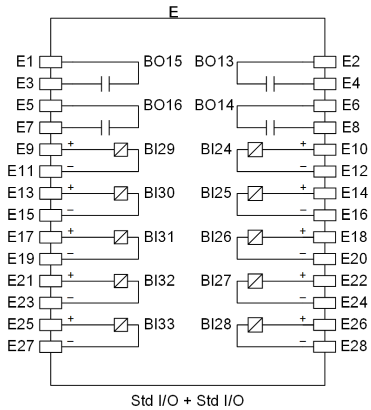


Figure A-17 E1 Terminal Diagram

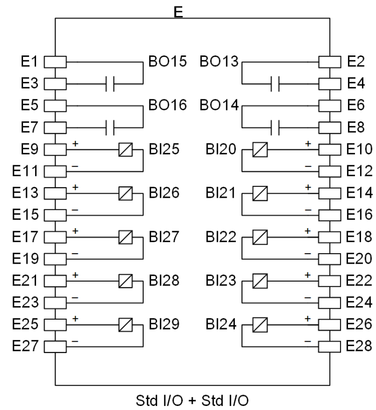


Figure A-18 E2 Terminal Diagram

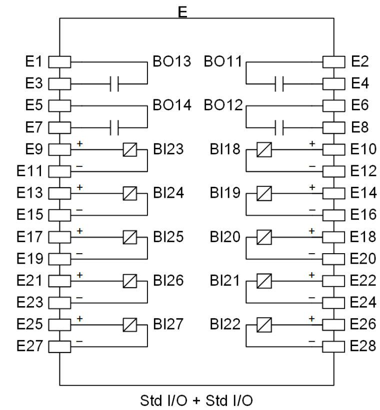


Figure A-19 E3 Terminal Diagram

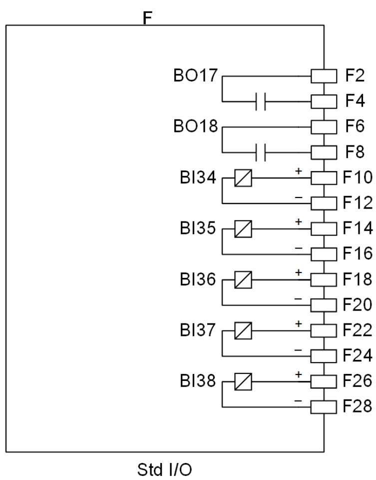


Figure A-20 F1 Terminal Diagram

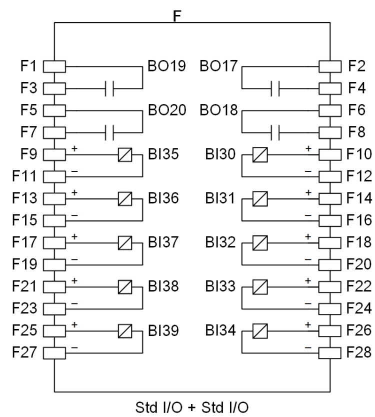


Figure A-21 F2 Terminal Diagram

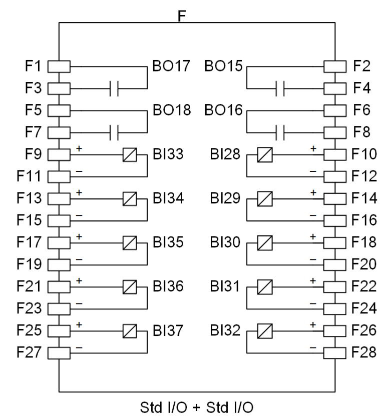


Figure A-22 F3 Terminal Diagram