



Reyrolle
Protection
Devices

7SR18 Solkor

Line Differential Relay

Energy Management

SIEMENS

Contents

Technical Manual Sections

1. Description of Operation
2. Configuration Guide
3. Installation Guide
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7SR18 Line Differential Protection

Description of Operation

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Symbols and Nomenclature

The following notational and formatting conventions are used within the remainder of this document:

Setting Menu Location

Setting:

Setting value:

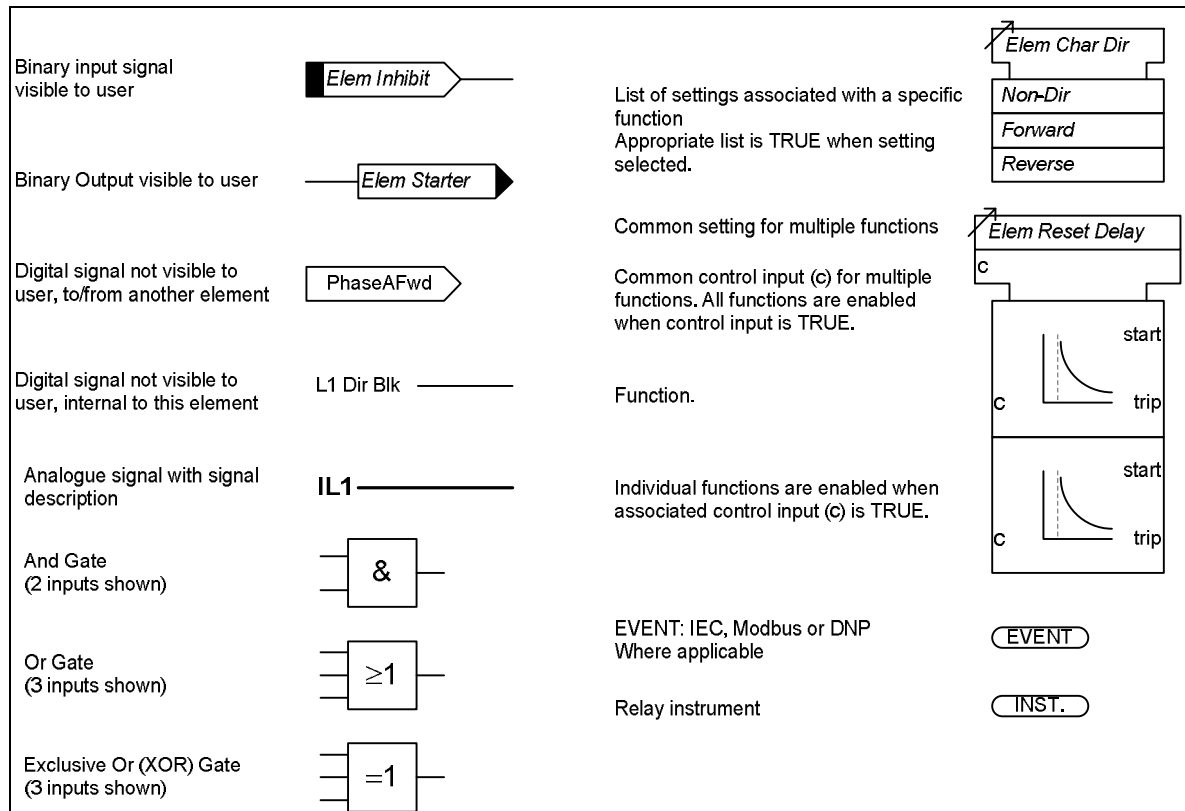
Alternatives:

MAIN MENU>SUB-MENU

Elem name -Setting

value

[1st] [2nd] [3rd]



Section 1: Introduction

This manual is applicable to the following relays: -

7SR18 Line Differential Relay

The 'Ordering Option' Tables summarise the features available in each model.

General Safety Precautions

It is the responsibility of the user to ensure that the equipment is installed, operated and used for its intended function in the manner specified by the manufacturer. If this is not the case, then any safety protection provided by the equipment may be impaired.

The equipment shall be isolated or disconnected from hazardous live voltage before accesses to potentially hazardous live parts is affected.



1.1 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.



1.2 EXTERNAL RESISTORS

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



1.3 FIBRE OPTIC COMMUNICATION

Where fibre optic communication ports are fitted, the lasers are Class 1 devices but recommend they should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.



1.4 FRONT COVER

The front cover provides additional securing of the relay element within the case. The relay cover should be in place during normal operating conditions.

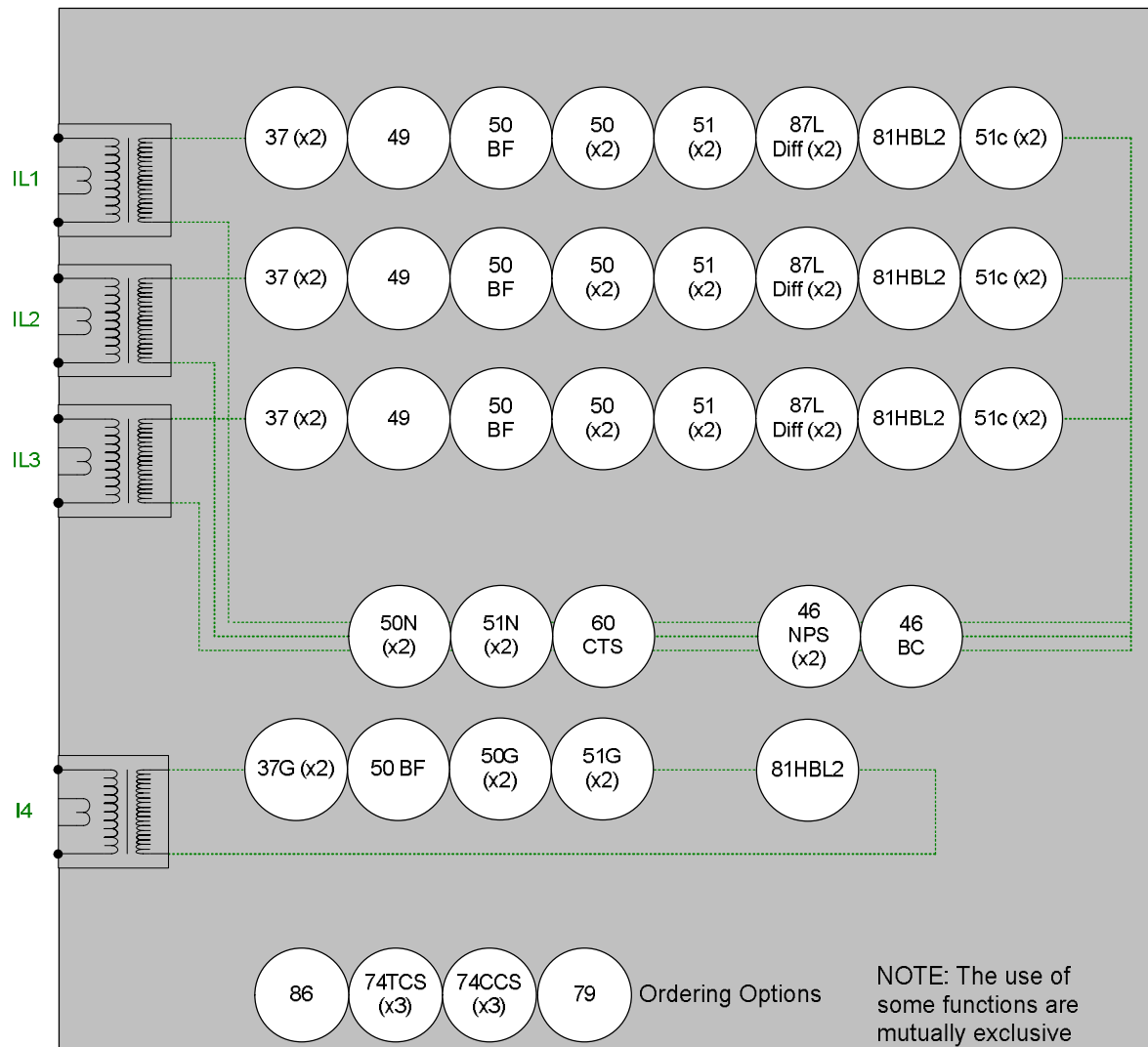


Figure 1.4-1 Functional Diagram of 7SR18 Non-Directional Three-Phase and Earth

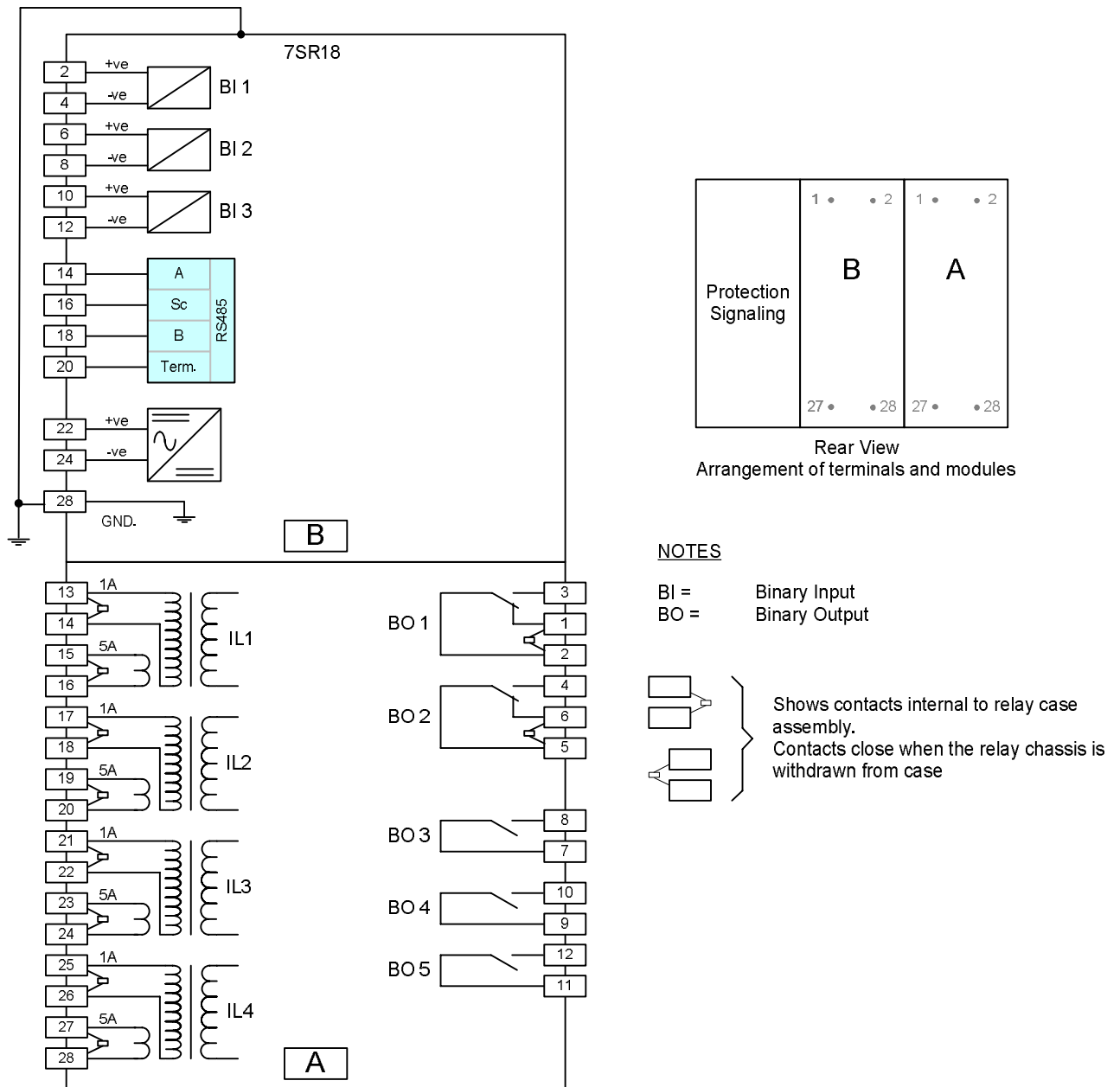


Figure 1.4-2 Connections Diagram for 7SR18 Non-Directional Relay (3BI and 5BO)

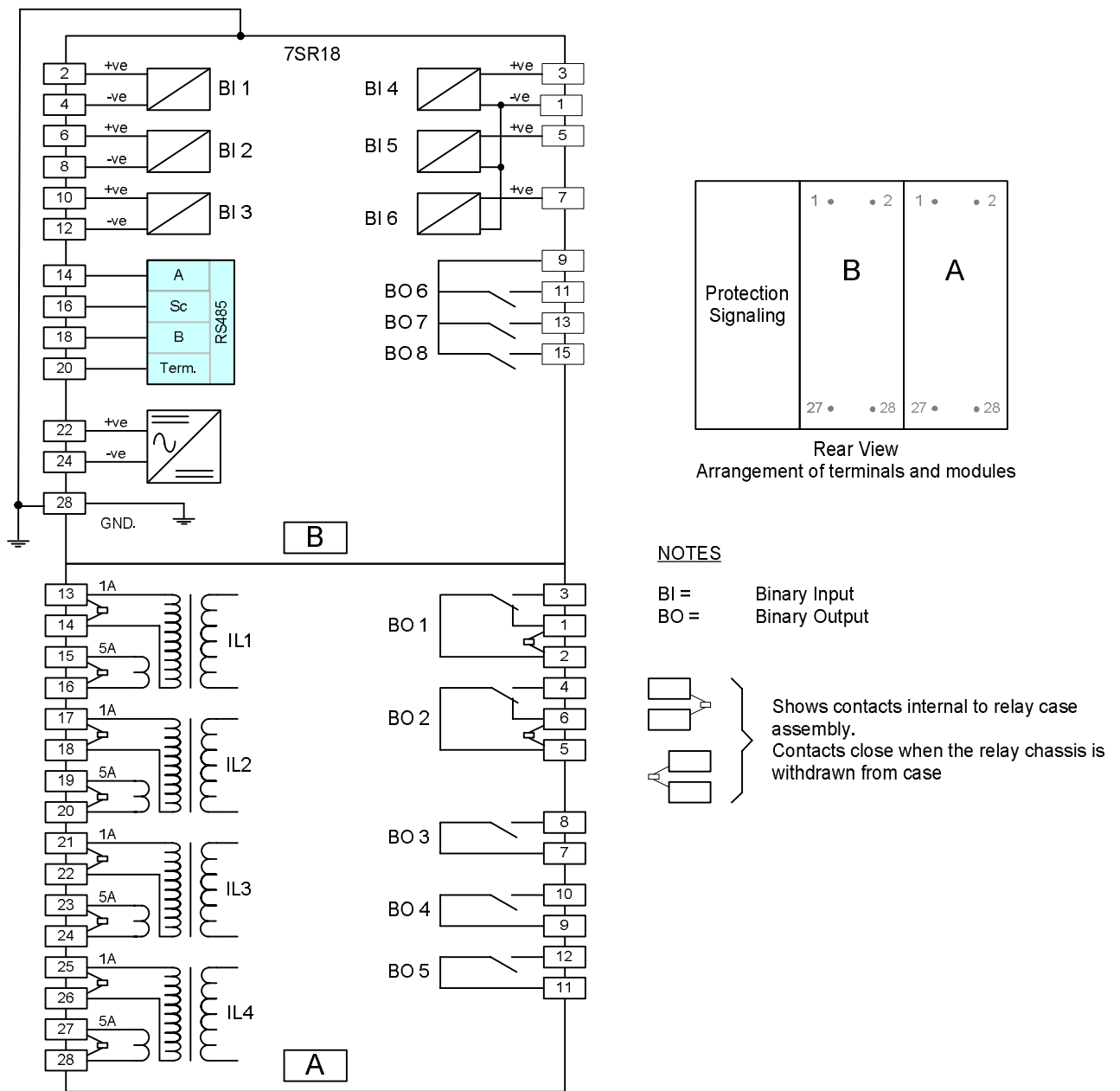


Figure 1.4-3 Connections Diagram for 7SR18 Non-Directional Relay (6BI and 8BO)

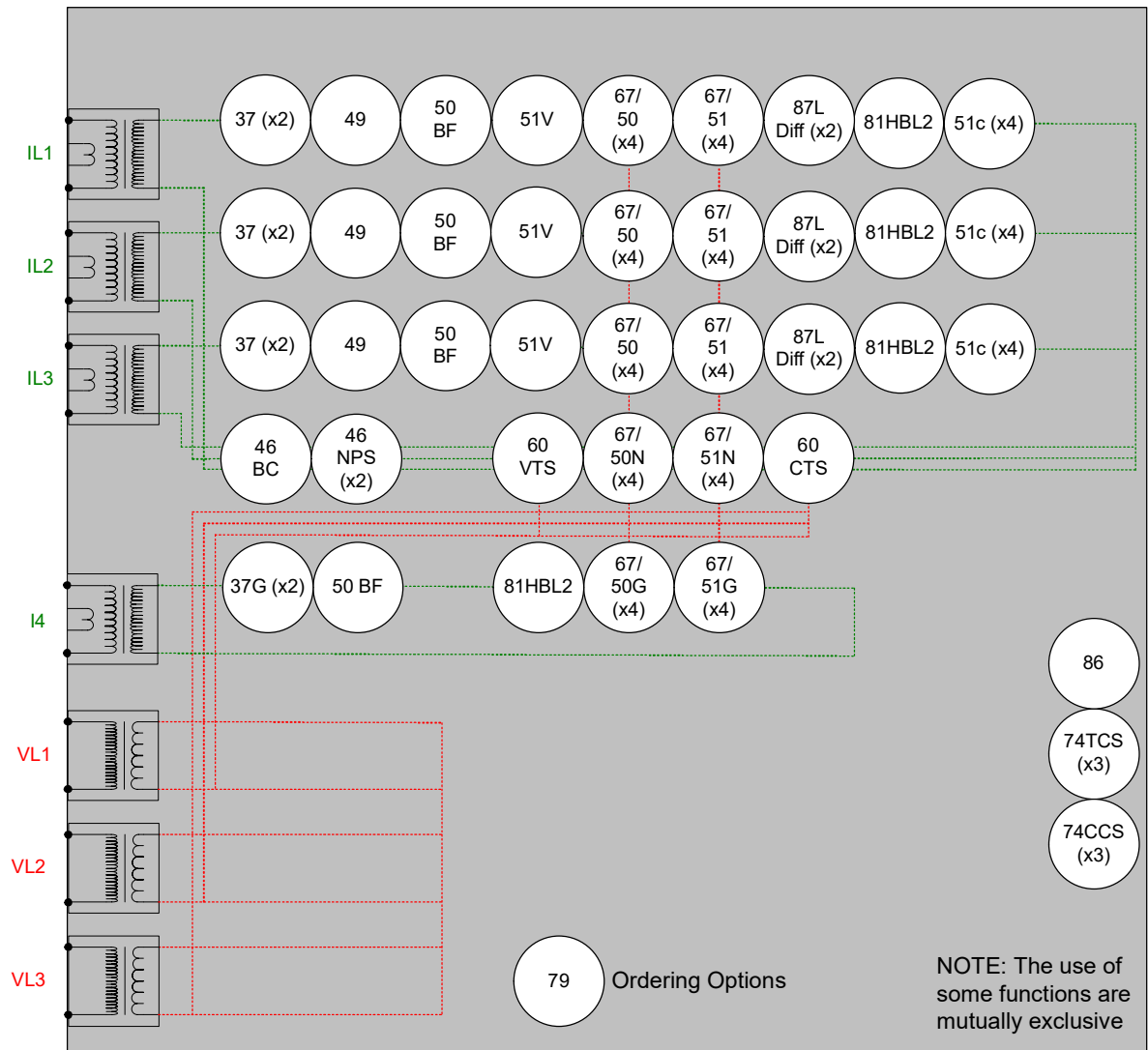


Figure 1.4-4 Functional Diagram of 7SR18 Directional Three-Phase and Earth

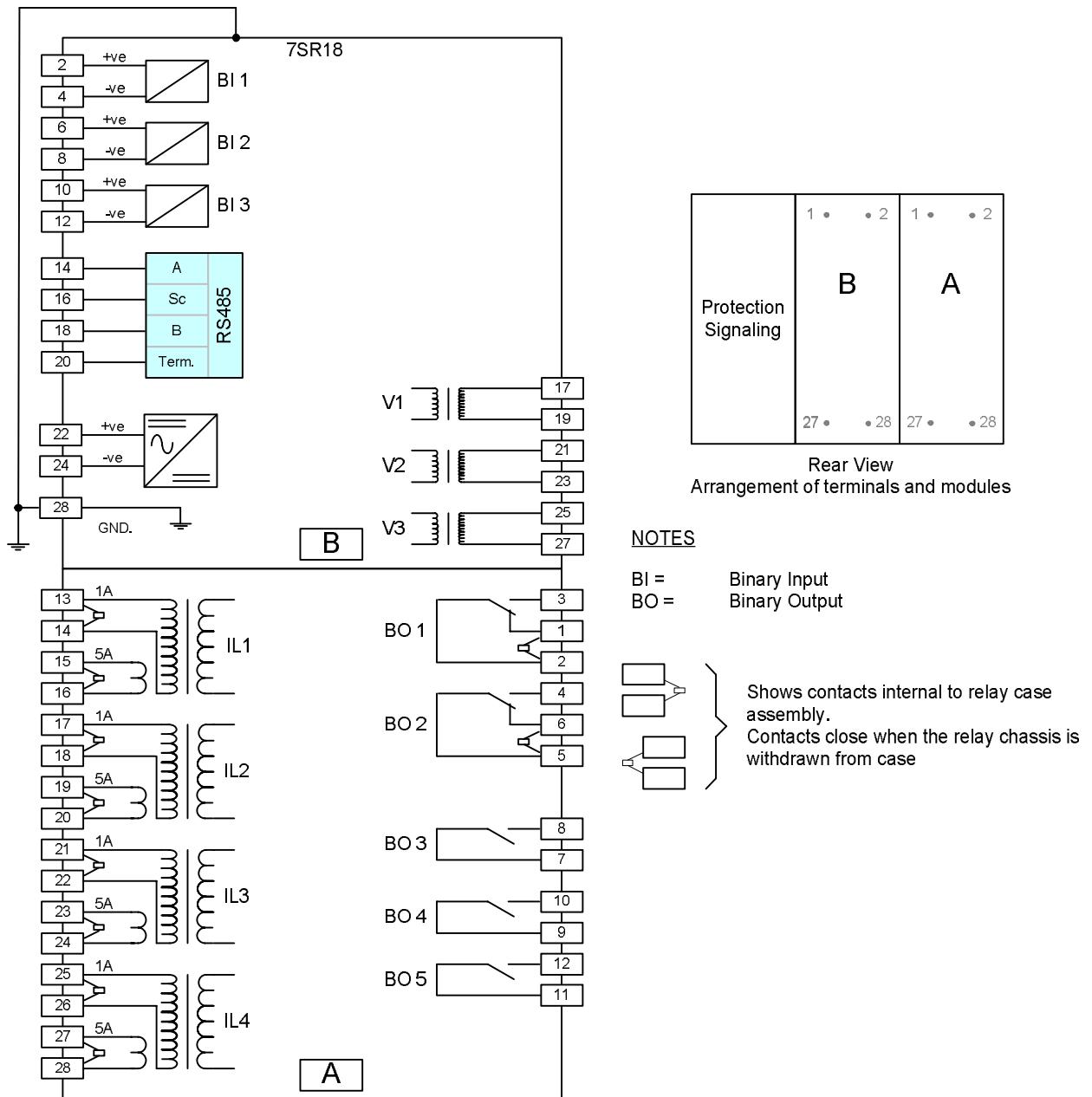


Figure 1.4-5 Connections Diagram for 7SR18 Directional Relay (3BI and 5BO)

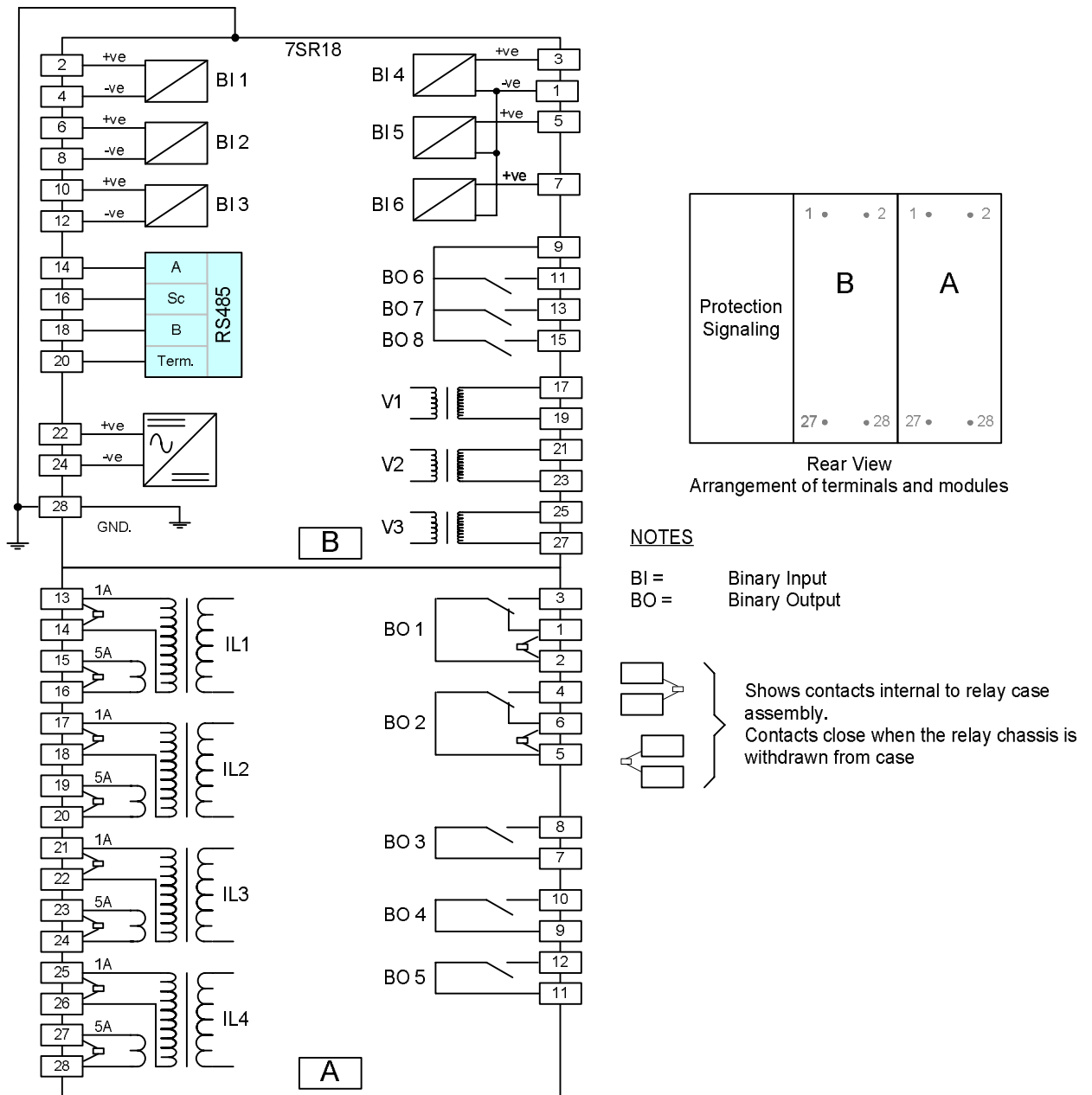


Figure 1.4-6 Connections Diagram for 7SR18 Directional Relay (6BI and 8BO)

Section 2: Hardware Description

2.1 General

The structure of the relays is based upon the Reyrolle Compact (RC) hardware platform. They are supplied in a size E6 case (where 1 x E = width of approx. 26 mm). The hardware design provides commonality between products and components across the Reyrolle Compact range of relays.

Table 2.1-1 Summary of 7SR18 Relay Configuration

Relay	Current Inputs	Voltage Inputs	Binary Inputs	Binary Outputs	LEDs (Individual)	Function Keys (each with LED)
7SR1811-1	4	-	3	5	18	0
7SR1812-1	4	-	3	5	10	6
7SR1813-1	4	-	6	8	18	0
7SR1814-1	4	-	6	8	10	6
7SR1811-2	4	3	3	5	18	0
7SR1812-2	4	3	3	5	10	6
7SR1813-2	4	3	6	8	18	0
7SR1814-2	4	3	6	8	10	6

Relays are assembled from the following PCBs:

1) Front Fascia (order option)

CPU

9 configurable LEDs + 1 Relay Healthy LED plus 8 configurable LEDs (Option)

9 configurable LEDs + 1 Relay Healthy LED plus 6 Function Keys each with LED (Option)

2) Current Analogue / Output module

4 x Current + 5 x Binary Output (BO)

3) Voltage Analogue / Input / output module

3 x Voltage Transformer (VT) (Option)

3 x Binary Input (BI) + 3 x Binary Output (BO) (Option)

3 x Voltage Transformer (VT) + 3 x Binary Input (BI) + 3 x Binary Output (BO) (Option)

4) Power Supply

3 x Binary Input (BI) + RS485

5) Protection Signalling module

6) Communications Module (2x Electrical Ethernet for IEC 61850) or (2x Optical Ethernet for IEC 61850) (Option)

2.2 Case

The relays are housed in cases designed to fit directly into standard panel racks. The case has a width of 156 mm and a height of 177 mm (4U). The required panel depth (with wiring clearance) is 287 mm.

The complete relay assembly is withdrawable from the front of the case. Contacts in the case ensure that the CT circuits and normally closed contacts remain short-circuited when the relay is removed. To withdraw the relay, remove the plastic fascia cover by rotating the two securing pins and withdraw using the plastic handles. The relay should not be carried using these handles. The relay should only be held by the top and bottom plates and the user should not touch the exposed PCB's. The exposed relay should be treated as an electronic device and should not be handled roughly or exposed to contamination and should be protected from damage. The relay should be re-inserted into the case and without the use of excessive force.



Figure 2.2-1 Front View of Relay

The rear terminal blocks comprise M4 female terminals for wire connections. Each terminal can accept two 4 mm crimps.



Figure 2.2-2 Rear view of Relay

Located at the top rear of the case is a screw clamp earthing point, this must be connected to terminal B28 and directly to the main panel earth. This connection point is indicated by the following symbol.

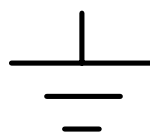


Figure 2.2-3 Earth connection Symbol

2.3 Front Cover

As standard the relay is supplied with a transparent front cover. The front cover is used to secure the relay assembly in the case.



Figure 2.3-1 Relay with transparent cover

2.4 Power Supply Unit (PSU)

Several variants of the relay PSU can be ordered: -

Ordering Option	Auxiliary Voltage	Binary Input Threshold
M	24 V DC to 250 V DC, 100 V AC to 230 V AC	19 V DC
N	24 V DC to 250 V DC, 100 V AC to 230 V AC	88 V DC

Table 2.4-1 Power Supply Unit (PSU) options

The rated auxiliary supply voltage is clearly stated on the relay fascia rating label, see Figure 2.5-2 below.

All binary inputs are polarity conscious and will not operate if the DC supply polarity is reversed. For consistency and safety it is advised that AC connections for auxiliary supply and binary inputs are made with the Live connection to the +ve terminal and Neutral connection to –ve.

If the auxiliary supply voltage falls below the relay minimum operate level, the PSU will automatically switch itself off and latch out, which prevents any PSU overload conditions occurring. The PSU is reset by switching the auxiliary supply off and on.

The relay has a non-serviceable internal 2 A 300 V T rated fuse, soldered to the PSU PCB.

2.5 Operator Interface/ Fascia

The operator interface is designed to provide a user-friendly method of controlling, entering settings and retrieving data from the relay.



Figure 2.5-1 Relay with Transparent cover removed

The fascia is an integral part of the relay. Handles are located at each side of the relay which allow it to be withdrawn from the relay case. The relay should not be carried by these handles.

Relay Information

Above the LCD labels provide the following information: -

- 1) Product Information & Rating Label, containing: -
MLFB ordering code, (with hardware version suffix).
Product name (e.g. Solkor)
Nominal current rating (In)
Rated frequency (fn)
Auxiliary supply rating (Vx)
Binary input supply rating (BI)
Serial number (F.No)
- 2) Blank label for user defined information.

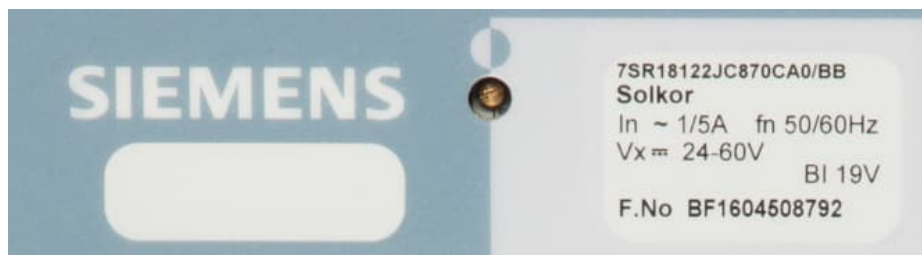


Figure 2.5-2 Close up of Typical Relay Label

A 'template' is available in 'Reydisp Evolution/Help/Open Relay LED Template' to allow users to create and print customised labels.

For information and safety reasons the following symbols are displayed on the fascia panel: -



Caution: Refer to Equipment Documentation



Caution: Risk of Electric Shock

Liquid Crystal Display (LCD)

A 4-line by 20-character alpha-numeric liquid crystal display indicates settings, instrumentation, fault data and control commands.

To conserve power the display backlighting is extinguished when no buttons are pressed for a user defined period. The 'backlight timer' setting within the "SYSTEM CONFIG" menu allows the timeout to be adjusted from 1 minute to 60 minutes and "Off" (backlight permanently on). Pressing any key will re-activate the display.

The LCD contrast can be adjusted using a flat blade screwdriver to turn the screw located below the contrast symbol . Turning the screw clockwise increases the contrast, anti-clockwise reduces the contrast.

User defined identifying text can be programmed into the relay using the **System config/Relay Identifier and System config/Circuit Identifier** setting. The 'Identifier' texts are displayed on the LCD display, over two lines, at the top level of the menu structure. The 'Relay Identifier' is used in communication with Reydisp to identify the relay. Pressing the Cancel button several times will always return the user to this screen.



Figure 2.5-3 Typical Relay Identifier LCD Text

LCD Indication

General Alarms are user defined text messages displayed on the LCD when mapped to binary or virtual inputs. Up to six general alarms of 16 characters can be programmed, each triggered from one or more input. Each general alarm will also generate an event.

If multiple alarms are activated simultaneously the messages are displayed on a separate page in a rolling display on the LCD. The System Config>**General Alarm Alert** setting **Enabled/Disabled** allows the user to select if the alarms are to be displayed on the LCD when active.

All general alarms raised when a fault trigger is generated will be logged into the Fault Data record.

Standard Keys

The relay is supplied as standard with five pushbuttons. The buttons are used to navigate the menu structure and control relay functions. They are labelled: -

▲	Increases a setting or moves up menu.
▼	Decreases a setting or moves down menu.
TEST/RESET▶	Moves right, can be used to reset selected functionality and for LED test (at relay identifier screen).
ENTER	Used to initiate and accept settings changes.
CANCEL	Used to cancel settings changes and/or move up the menu structure by one level per press.

NOTE: All settings and configuration of LEDs, BI and BO can be accessed and set by the user using these keys. Alternatively configuration/settings files can be loaded into the relay using 'Reydisp'. When the System Config>**Setting Dependencies** is ENABLED, only the functions that are enabled will appear in the menu structure.

'PROTECTION HEALTHY' LED

This green LED is steadily illuminated to indicate that DC voltage has been applied to the relay power supply and that the relay is operating correctly. If the internal relay watchdog detects an internal fault then this LED will continuously flash.

Indication LEDs

Relays have 9 or 17 user programmable LED indicators. Each LED can be programmed to be illuminated as green, yellow or red in colour. Where an LED is programmed to be lit both red and green it will illuminate yellow. The same LED can be assigned two different colours dependent upon whether a Start/Pickup or Operate condition exists. LED's can be assigned to the pick-up condition and colour selected in the OUTPUT CONFIG>LED CONFIG menu.

Functions are assigned to the LEDs in the OUTPUT CONFIG>OUTPUT MATRIX menu.

Each LED can be labelled by withdrawing the relay and inserting a label strip into the pocket behind the front fascia. A 'template' is available in the Reydisp software tool to allow users to create and print customised legends.

Each LED can be user programmed as hand or self-resetting. Hand reset LEDs can be reset by either pressing the TEST/RESET► button, energising a suitably programmed binary input, or, by sending an appropriate command over the data communications channel(s).

The status of hand reset LEDs is maintained by a back-up storage capacitor in the event of an interruption to the d.c. supply voltage.

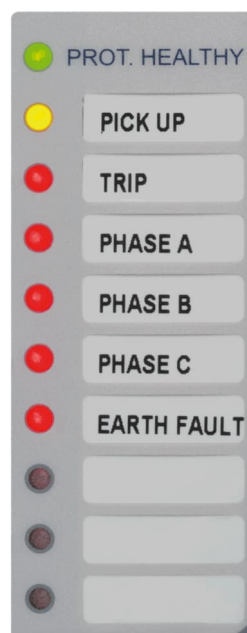


Figure 2.5-4 LED Indication Label

2.6 Current Inputs

Four current inputs are provided on the Analogue Input module. Terminals are available for both 1 A and 5 A inputs.

The relay can be used for line differential, phase-fault and earth-fault protection.

Current is sampled at 1600 Hz for both 50 Hz and 60 Hz system frequencies. Protection and monitoring functions of the relay use either the Fundamental Frequency RMS or the True RMS value of current appropriate to the individual function.

The waveform recorder samples and displays current input waveforms at 1600 Hz.

The primary CT ratio used for the relay instruments can be set in the CT configuration menu.

The CT direction can be changed by Enabling the Phase Reversal setting which is provided on a per phase basis.

2.7 Voltage Inputs

Three voltage inputs are provided on the Analogue Input module on the 7SR181 Directional variant of the relay.

Voltage is sampled at 1600Hz for both 50Hz and 60Hz system frequencies. Monitoring functions of the relay use fundamental frequency voltage measurement.

The primary VT ratio used for the relay instruments can be set in the CT/VT configuration menu.

2.8 Binary Inputs

The binary inputs (BI) are opto-couplers operated from a suitably rated power supply.

Relays are fitted with 3 binary inputs or 6 binary inputs depending on the variant. The user can assign any binary input to any of the available functions (INPUT CONFIG > INPUT MATRIX).

Pick-up (PU) and drop-off (DO) time delays are associated with each binary input. Where no pick-up time delay has been applied the input may pick up due to induced ac voltage on the wiring connections (e.g. cross site wiring). The default pick-up time of 20 ms provides ac immunity. Each input can be programmed independently.

Each input may be logically inverted to facilitate integration of the relay within the user scheme. When inverted the relay indicates that the BI is energised when no voltage is applied. Inversion occurs before the PU & DO time delay, see Figure 2.8-1.

Binary inputs can be configured for intentional operation from a 110/115 V rms a.c. power supply by setting of 0 ms PU and 25 ms DO timers. If additional pickup or drop-off time delays are required by the scheme logic, this functionality can be achieved by programmable logic within the device. For AC operation, live and neutral wiring should be routed as a pair in close proximity and limited to a length of less than 10 m.

Each input may be mapped to any front Fascia indication LED and/or to any Binary output contact and can also be used with the internal user programmable logic. This allows the relay to provide panel indications and alarms.

Each binary input is set by default to be read when the relay is in both the local or remote condition. A setting is provided to allow the user to select if each individual input shall be read when the relay is in the local or remote condition in the INPUT CONFIG > BINARY INPUT CONFIG menu.

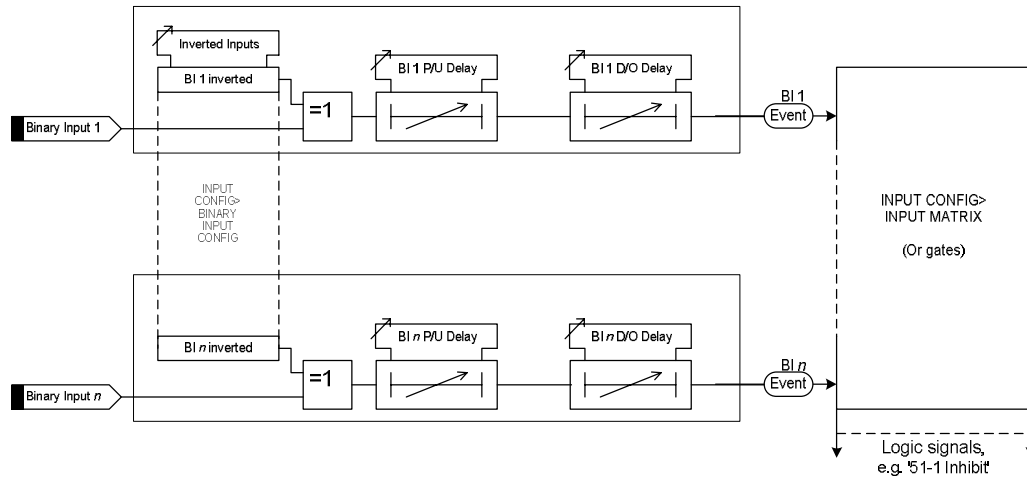


Figure 2.8-1 Binary Input Logic

2.9 Binary Outputs (Output Contacts)

Relays are fitted with 5 binary output (BO) contacts or 8 binary output contacts depending upon variant. All outputs are fully user configurable and can be programmed to operate from any or all of the available functions.

In the default mode of operation binary outputs are self reset and remain energised for a user configurable minimum time of up to 60 seconds. If required, outputs can be programmed to operate as 'hand reset' or 'pulsed'. If the output is programmed to be 'hand reset' and 'pulsed' then the output will be 'hand reset' only.

Operating a binary output as 'hand reset' fulfils the requirements of ANSI function 86 (Lockout).

The binary outputs 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. The circuit breaker auxiliary contacts or other in-series auxiliary device must be used to break the trip coil current.

Any BO can be assigned as a 'Trip Contact' in the OUTPUT CONFIG>TRIP CONFIG menu. Operation of a 'Trip Contact' will operate any LED or virtual assigned from the 'Trip Triggered' feature in the same menu and will initiate the fault record storage, actuate the 'Trip Alert' screen where enabled and CB Fail protection when enabled.

Where a protection function is mapped to an output contact, the output contact can be configured to trigger when the protection function picks-up rather than when it operates. Such output contacts are configured via the OUTPUT CONFIG>BINARY OUTPUT CONFIG>*Pickup Outputs* setting.

Notes on Pulsed Outputs

When operated, the output will reset after a user configurable time of up to 60 seconds regardless of the initiating condition.

Notes on Self Reset Outputs

Self reset operation has a minimum reset time of 100 ms

With a failed breaker condition the relay may remain operated until current flow is interrupted by an upstream device. When the current is removed the relay will then reset and attempt to interrupt trip coil current flowing via its output contact. Where this current level is above the break rating of the output contact an auxiliary relay with heavy-duty contacts should be utilised in the primary system to avoid damage to the relay.

Notes on Hand Reset Outputs – 86 Lockout

Any binary output can be programmed to provide an 86 lockout function by selecting it to be hand reset. Hand reset outputs can be reset by either pressing the **TEST/RESET** button, by energising a suitably programmed binary input, or, by sending 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.

Notes on General Pickup

An output, General Pickup, is available to indicate that the pickup level has been exceeded for one or more protection functions. Any protection function can be mapped to trigger this output in the **OUTPUT CONFIG>PICKUP CONFIG** menu.

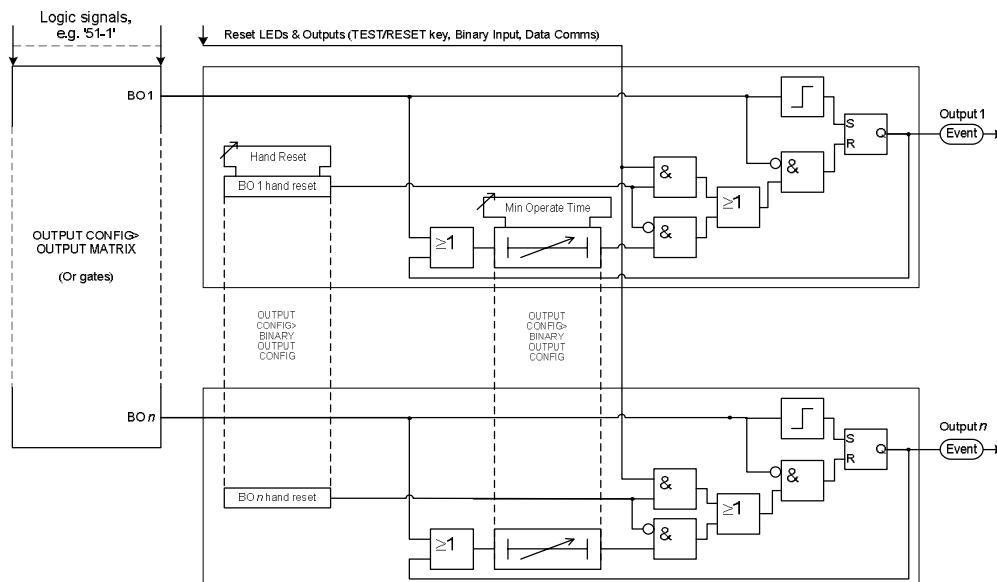


Figure 2.9-1 Binary Output Logic

2.10 Virtual Input/Output Connections

The relays have 8 virtual input/output connections, these are internal binary stores. By assigning the status of data items like starters, alarms, equations etc. to a virtual input/output, the status of these items can be used to fulfil higher levels of functionality.

The status of various data items can be assigned to virtual inputs/outputs using the **INPUT CONFIG > OUTPUT MATRIX** menu.

These virtual input/outputs can be used as inputs to various functions - including blocks, inhibits, triggers, alarms etc. - using the **INPUT CONFIG > INPUT MATRIX** menu.

Virtual input/outputs can also be used as data items in equations.

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

2.11 Self Monitoring

The relay incorporates several self-monitoring features. Each of these features can initiate a controlled reset recovery sequence.

Supervision includes a power supply watchdog, code execution watchdog, memory checks by checksum and processor/ADC health checks. When all checks indicate the relay is operating correctly the 'Protection Healthy' LED is illuminated on the fascia.

If an internal failure is detected, a message will be displayed. The relay will reset in an attempt to rectify the failure. This will result in de-energisation of any binary output mapped to 'protection healthy' and flashing of the protection healthy LED. If a successful reset is achieved by the relay the LED and output contact will revert back to normal operational mode, and the relay will restart, therefore ensuring the circuit is protected for the maximum time.

A Start-up Counter Meter is provided to display the number of start-ups the relay has performed. Once the number of start-ups has exceeded a set number, an Alarm output can be given.



Figure 2.11-1 Start-up Counter Meter

Reset of the counter can be done from the meter or via a binary input or a command.

Various types of start-up are monitored by the relay:

1. **power-on starts** (auxiliary supply initiation)
2. **expected starts** (user initiated via comms, language changes, custom protection curve etc.)
3. **unexpected starts** (caused by the relay watchdog)

Any combination of these can be selected for the start-up count. This is done in the MAINTENANCE MENU>START COUNT menu using the **Start Up Types** setting. All the start-up types selected (ticked) will be added to the overall start-up count.

The number of restarts before the alarm output is raised is set in the MAINTENANCE MENU>START COUNT menu using the **Start Up Count Target** setting.

When the number of relay start-ups reaches the target value an output is raised, OUTPUT MATRIX>**Start Up Count Alarm**, which can be programmed to any combination of binary outputs, LED's or virtual outputs.

The following screen-shot shows the events, which are generated when the relay re-starts. The highlighted events show the cause of the re-start. The event which comes next shows the type of restart followed by the relay: Warm, Cold or Re-Start.

As a further safeguard, if the Relay performs a number of unexpected starts **SYSTEM CONFIG>Unexpected Restart Count** in a given time **SYSTEM CONFIG>Unexpected Restart Period**, it can be configured using the **SYSTEM CONFIG>Unexpected Restart Blocking** setting to remove itself from service. In this case the Relay will display a typical error message such as: -



Figure 2.11-2 Unexpected Restarts Lockout Text

The relay will enter a locked-out mode, while in this mode it will disable operation of all LED's, Binary Outputs, including Protection Healthy, pushbuttons and any data communications activity. Once the Relay has failed in this manner, it is non-recoverable at site and must be returned to the manufacturer for repair.

A meter, Miscellaneous Meters>Unexpected Restarts, is provided to show how many Unexpected Restarts have occurred during the previous Unexpected Restart Period. This is resettable from the front fascia.

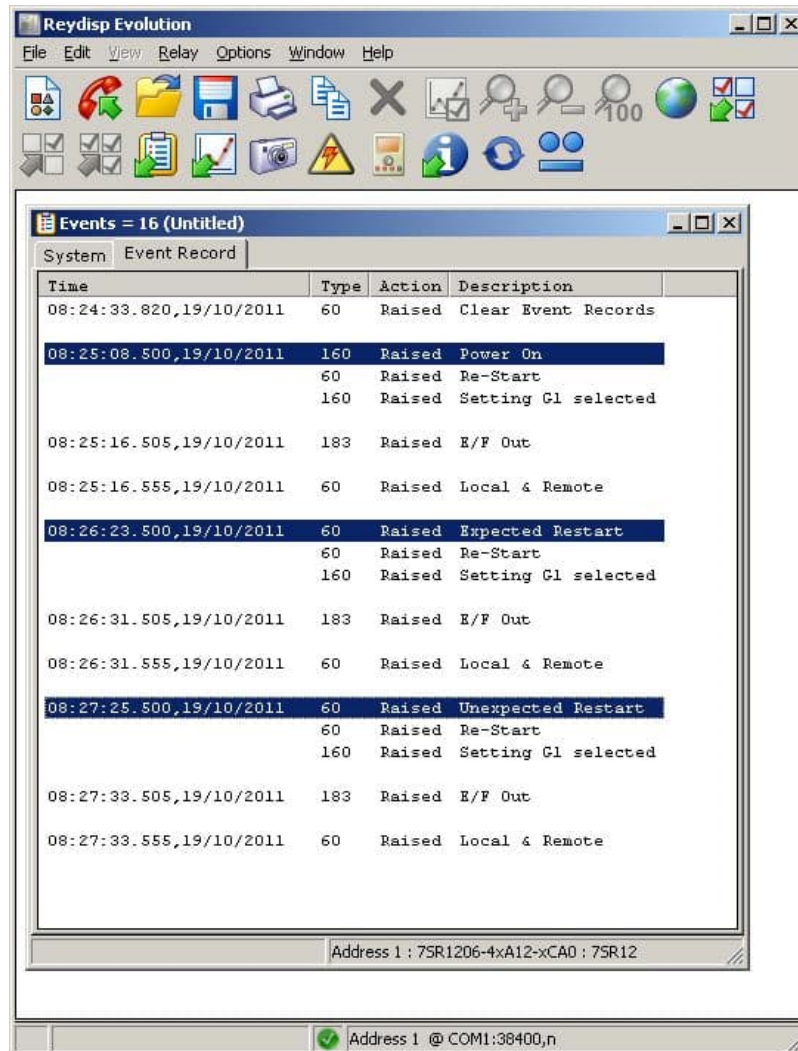


Figure 2.11-3 Typical Start-up Events Text

2.11.1 Protection Healthy/Defective

When the relay has an auxiliary DC supply and it has successfully passed its self-checking procedure then the front fascia Protection Healthy LED is turned on.

A changeover or open contact can be mapped via the binary output matrix to provide an external protection healthy signal.

A changeover or closed contact can be mapped via the binary output matrix to provide an external protection defective signal. With the 'Protection Healthy' this contact is open. When the auxiliary DC supply is not applied to the relay or a problem is detected within the relay then this output contact closes to provide external indication.

If the relay is withdrawn from the case, the case shorting contact will make across the normally closed contacts to provide an external alarm.

Section 3: Protection Functions

3.1 Differential Protection

There are two biased differential elements **87L-1** & **87L-2**.

The fundamental frequency current is measured with the line CT inputs. These line currents are both multiplied and corrected before being applied to the current differential elements.

3.1.1 Overall Biased Differential (87L-n)

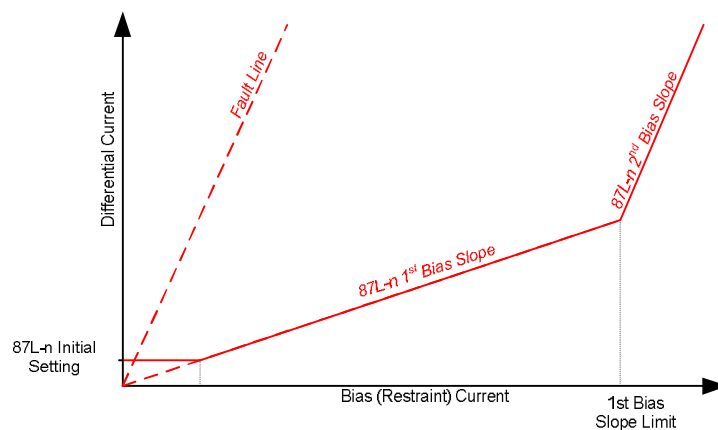


Figure 3.1.1-1 Biased Differential Characteristic (Offset Disabled)

Figure 3.1.1-1 illustrates the biased differential characteristic. The biased differential elements calculate the operate current for each phase from the vector sum of local and remote currents i.e. $I_{\text{operate}} = I_L + I_R$.

The bias (or restraint) current is calculated from the total current of I_L and I_R currents i.e. $I_{\text{restrain}} = \frac{I_L + I_R}{2}$.

Within the relay the fundamental frequency RMS line currents are modified by the **CT Multiplier** settings before being applied to the biased differential elements. The **CT Multiplier** setting is applied to the line currents – the CT secondary currents. The multiplier is used to correct any CT ratio mismatch so that ideally nominal current is applied to the biased differential algorithm.

The **87L Initial** setting defines the minimum differential current required to operate the relay.

The **87L 1st Bias Slope** setting is used to ensure protection stability in the presence of steady state errors e.g. the effects of cable capacitive current etc.

The **87L 1st Bias Slope Limit** setting defines the border between the 1st and 2nd bias slopes.

The **87L 2nd Bias Slope** setting is used to modify the sensitivity of the differential algorithm at higher current levels.

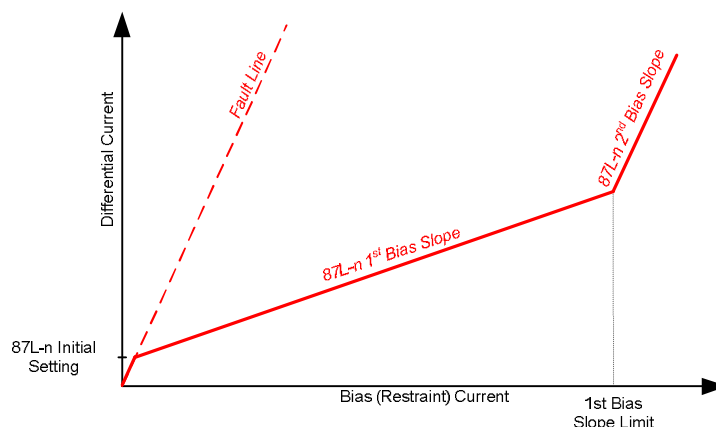


Figure 3.1.1-2 Biased Differential Characteristic (Offset Enabled - Default)

The **87L-1 Offset** setting can be Enabled and is a historical Reyrolle method used to introduce more stability.

Operation of the biased differential elements can be inhibited from:

Inhibit 87L-n

A binary or virtual input.

User Inhibit

Reylogic (graphical logic).

The phase independent reversal feature **Gn Phase-n Reversal** in the **CT/VT Config Menu** is defaulted to Disabled and is intended for use where CTs have been connected incorrectly.

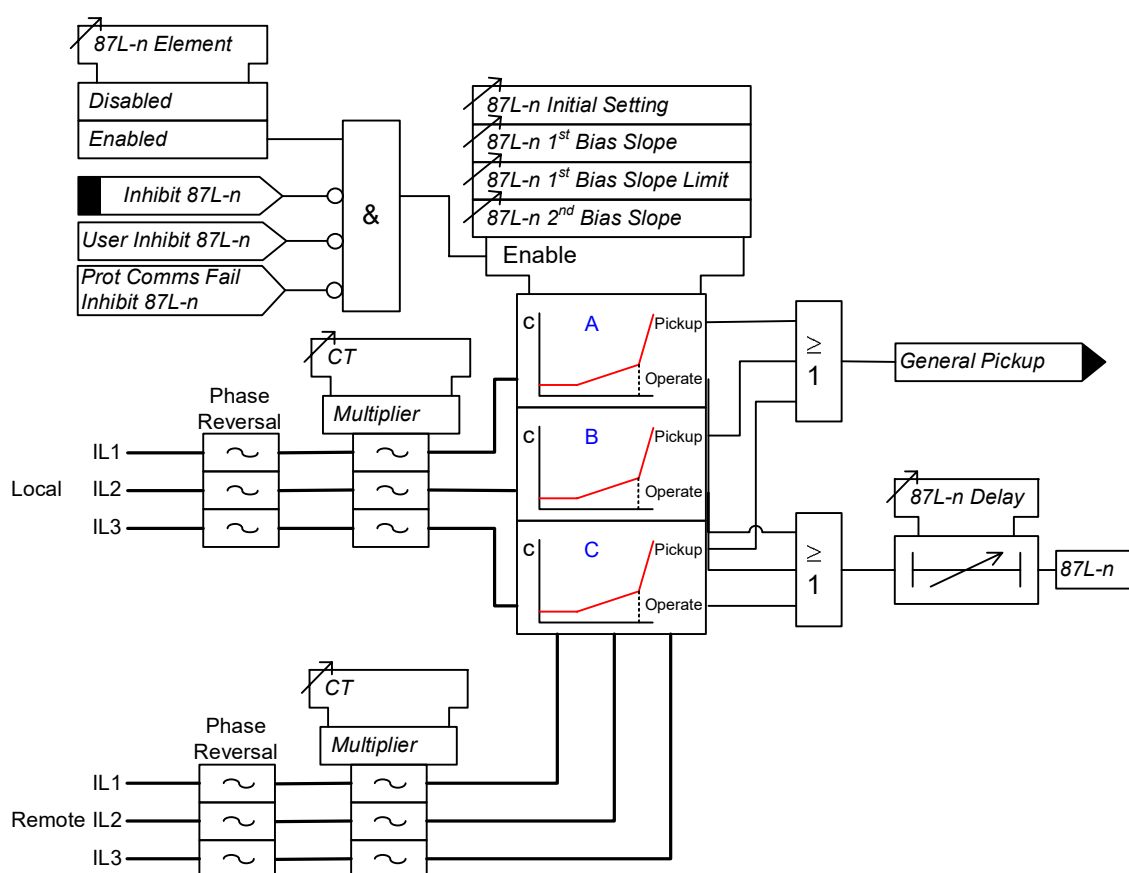


Figure 3.1.1-3 Logic Diagram: Biased Current Differential Protection

3.1.2 Differential Highset (87HS-n)

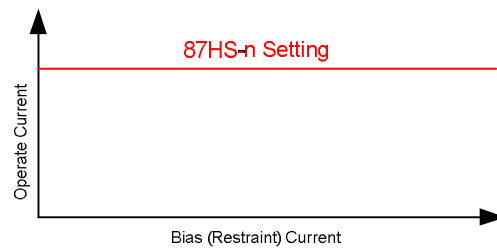


Figure 3.1.2-1 Differential Highset Characteristic

The differential protection elements **87L-1** & **87L-2** each have an associated High Set element i.e. **87HS-1** & **87HS-2**.

Figure 3.1.2-1 illustrates the differential highset characteristic. The differential highset elements calculate the operate current for each phase from the vector sum of local relay and remote relay currents i.e. $I_{\text{OPERATE}} = I_L + I_R$.

87HS Setting defines the differential current required to operate the element. The output of **87HS Delay** can be mapped to relay outputs.

Operation of the highset differential elements can be inhibited from: -

Inhibit 87HS

A binary or virtual input.

User Inhibit

Reylogic (graphical logic).

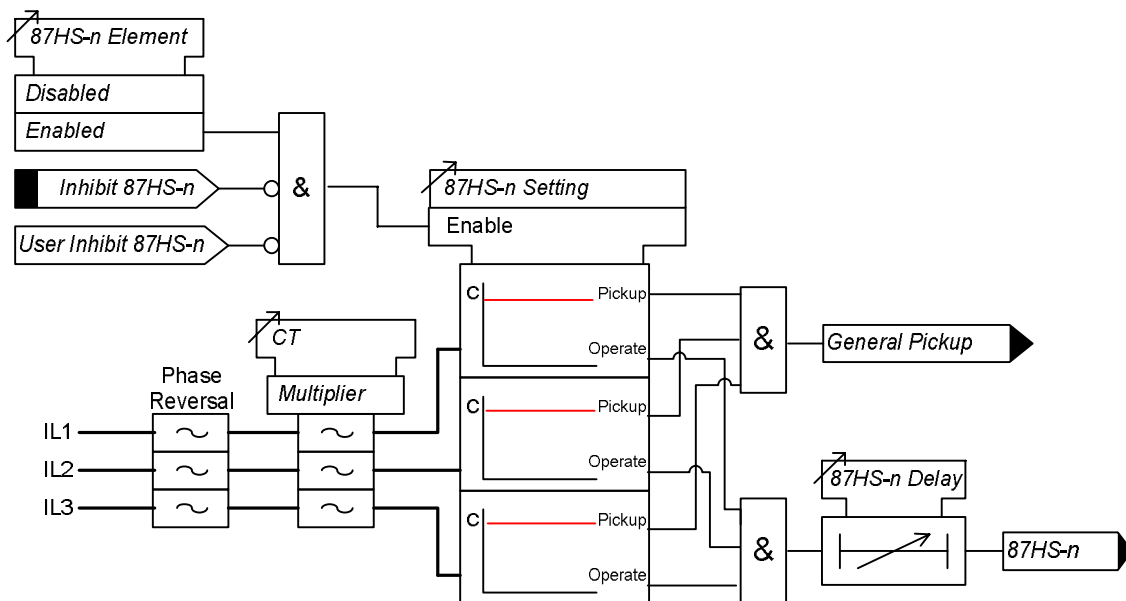


Figure 3.1.2-2 Logic Diagram: Differential High Set Current Protection

3.2 Protection Communications

The protection communications interface can be disabled in the 'Function Config' settings menu. This setting must be set to 'Enabled' for the device to provide differential protection, 87 Intertrip or 85 Intertrip signals between two connected devices.

3.2.1 Protection Communications Address

The device address for the protection communications connection is defined by the 'Prot'n Comms Address' user setting. The two connected devices must be addressed as a complimentary pair for communication to be established. This ensures that if a connection is made to a device on another primary circuit in error during installation or maintenance operations, the mistake is immediately identified.

Device address 1 will only communicate with device address 254, device 2 only with 253 and so on.

3.2.2 Protection Communication Signalling Supervision

The 'Prot'n Comms Disturb' output is raised for any protection communication signalling disturbance detected. This can be for a CRC error on the frame, a missed frame, a frame out of sequence, etc. This output is fleeting and will be cleared when authentic communication has been re-established. The 'Prot'n Comms Alarm' is more of a persistent output. If there is a prolonged disturbance detected the alarm output will be raised after the 'Prot'n Comms Alarm Delay'. Differential protection is inhibited during periods of disturbance or when the relays are not synchronised.

'Prot'n Comms In Sync' is raised when there are no communication disturbances and both devices are now synchronised.

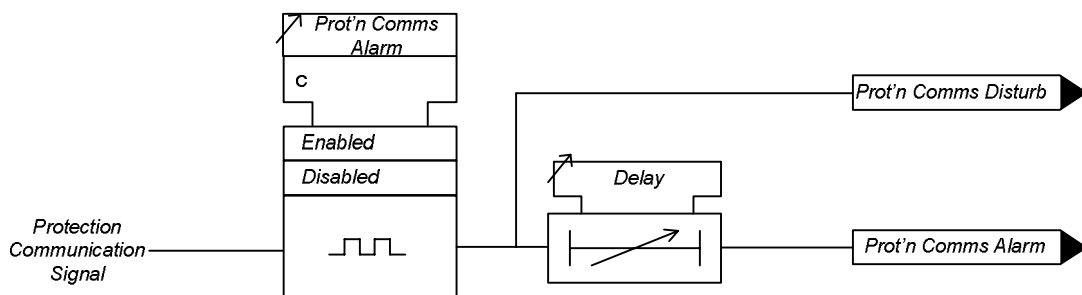


Figure 3.2.2-1 Logic Diagram: Protection Communications Signalling Supervision

3.2.3 Protection Test Mode

The device provides test modes that can be useful during commissioning. The 'Prot'n Test Mode' setting must be returned to the 'Disabled' value after testing for differential protection to be active. Loop test mode can be used to test a single device in isolation. If this mode is selected and a suitable fibre loop is used to directly connect the Transmitter and Receiver ports of the protection communications interface, the device will assume a healthy communications connection without the need for a second device. Differential protection will be active for testing purposes and will measure locally measured current with zero current assumed at the remote end.

Line test mode can be selected with a remote device connected. The differential protection elements and intertrips will be inhibited at the remote relay but healthy connection and correct device addressing is required for local differential protection to be active for testing purposes. Differential protection will be active and will measure locally measured current with zero current assumed at the remote end. The communications quality metering is still active in this mode and can be used to show line losses and data corruption.

3.3 Inter-Trip Elements

There are several types of Inter-Trip elements, internal and external.

3.3.1 Internal Inter-Trip Elements (87R-*n*)

The line differential elements **87L-1** and **87L-2** each have their associated inter-trip element e.g. **87R-1** & **87R-2**. These are used to ensure both ends of a feeder are cleared when internal fault differential protection has operated. When an internal fault occurs, even if it is fed largely from one end, the differential comparators at both ends operate identically and trip their respective circuit-breakers. To ensure tripping at both ends, an inter-trip, using the above elements, is sent between the local and remote relays.

3.3.2 External Inter-Trip Elements (85S-*n*, 85R-*n*)

Six external inter-trip channels are provided designated **85S-*n*** sending & **85R-*n*** receiving. These are of the Direct Inter-trip type and are independent of the differential protection. They are driven from mapped binary inputs or internal user programmable logic. At the receiving end the inter-trip follows the status of the sending end binary input or programmable logic. They can be used as direct control or permissive control via programmable logic to control features or operate any user selected contact. Inter-trip channels are especially useful to apply Start, Inhibit, Lockout logic to a Feeder Autoreclose scheme to allow sequenced closing of the circuit-breakers.

3.4 Current Protection: Phase Overcurrent (67, 50, 51)

All phase overcurrent elements have a common setting for the 50 elements and 51 elements to measure either fundamental frequency RMS or True RMS current: -

True RMS current: **50 Measurement = RMS, 51 Measurement = RMS**

Fundamental Frequency RMS current: **50 Measurement = Fundamental, 51 Measurement = Fundamental**

3.4.1 Directional Control of Overcurrent Protection (67)

The directional element produces forward and reverse outputs for use with overcurrent elements. These outputs can then be mapped as controls to each shaped and instantaneous over-current element.

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.

The Characteristic angle is the phase angle by which the polarising voltage must be adjusted such that the directional detector gives maximum sensitivity in the forward operate zone when the current is in phase with it. The reverse operate zone is the mirror image of the forward zone.

Voltage polarisation is achieved for the phase-fault elements using the quadrature voltage i.e. at unity power factor I leads V by 90° . Each phase current is compared to the voltage between the other two phases i.e. for normal phase sequence 1-2-3:

$$I_{L1} \sim V_{23} \quad I_{L2} \sim V_{31} \quad I_{L3} \sim V_{12}$$

When the device is applied to reverse sequence networks, i.e. 1-3-2, the polarizing is corrected internally by the *Gn Phase Rotation* setting in the *CT/VT Config menu*.

The characteristic angle can be user programmed to any angle between -95° and $+95^\circ$ using the **67 Char Angle** setting. The voltage is the reference phasor (V_{ref}) and the **67 Char Angle** setting is added to this to adjust the forward and reverse zones.

The centre of the forward zone is set by (V_{ref} Angle + **67 Char Angle**) and should be set to correspond with I_{fault} Angle for maximum sensitivity i.e.

For fault current of -60° (I lagging V by 60°) a **67 Char Angle** of **$+30^\circ$** is required for maximum sensitivity (i.e. due to quadrature connection $90^\circ - 60^\circ = 30^\circ$).

OR

For fault current of -45° (I lagging V by 45°) a **67 Char Angle** of **$+45^\circ$** is required for maximum sensitivity (i.e. due to quadrature connection $90^\circ - 45^\circ = 45^\circ$).

Two-out-of-three Gate

When the **67 2-Out-Of-3 Logic** setting is set to **Enabled**, the directional elements will only operate for the majority direction, e.g. if I_{L1} and I_{L3} are detected as forward flowing currents and I_{L2} is detected as reverse current flow, phases L_1 and L_3 will operate forwards, while phase L_2 will be inhibited.

Minimum Polarising Voltage

The **67 Minimum Voltage** setting defines the minimum polarising voltage level. Where the measured polarising voltage is below this level 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.

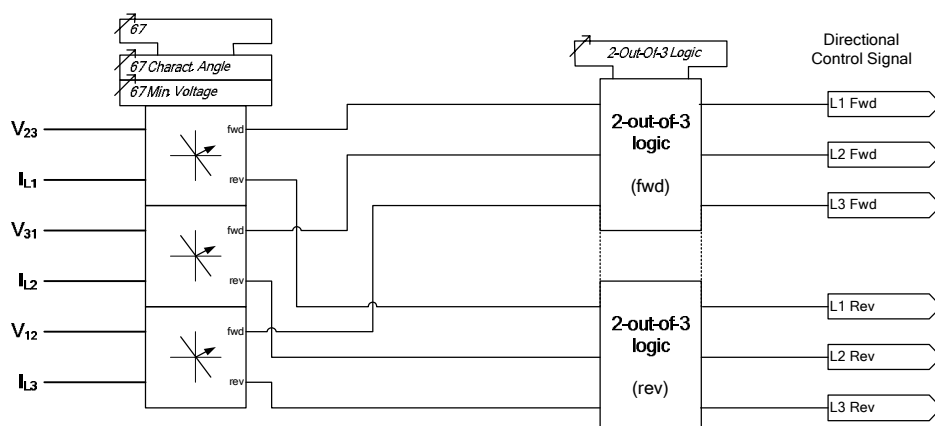


Figure 3.4.1-1 Logic Diagram: Directional Overcurrent Element (67)

3.4.2 Instantaneous Overcurrent Protection (50)

Up to four Instantaneous overcurrent elements are provided (depending upon variant): -

50-1, 50-2, 50-3 & 50-4

Each instantaneous element (50-n) has independent settings. **50-n Setting** for pick-up current and **50-n Delay** follower time delay. The instantaneous elements have transient free operation.

Where directional elements are present the direction of operation can be set using **50-n Dir. Control** setting. Directional logic is provided independently for each 50-n element, e.g. giving the option of using two elements set to forward and two to reverse.

Operation of the instantaneous overcurrent elements can be inhibited from:

Inhibit 50-n

A binary or virtual input.

79 P/F Inst Trips: 50-n

When 'delayed' trips only are allowed in the auto-reclose sequence (**79 P/F Prot'n Trip n = Delayed**).

50-n Inrush Action: Block

Operation of the inrush current detector function.

50-n VTS Action: Inhibit

Operation of the VT Supervision function.

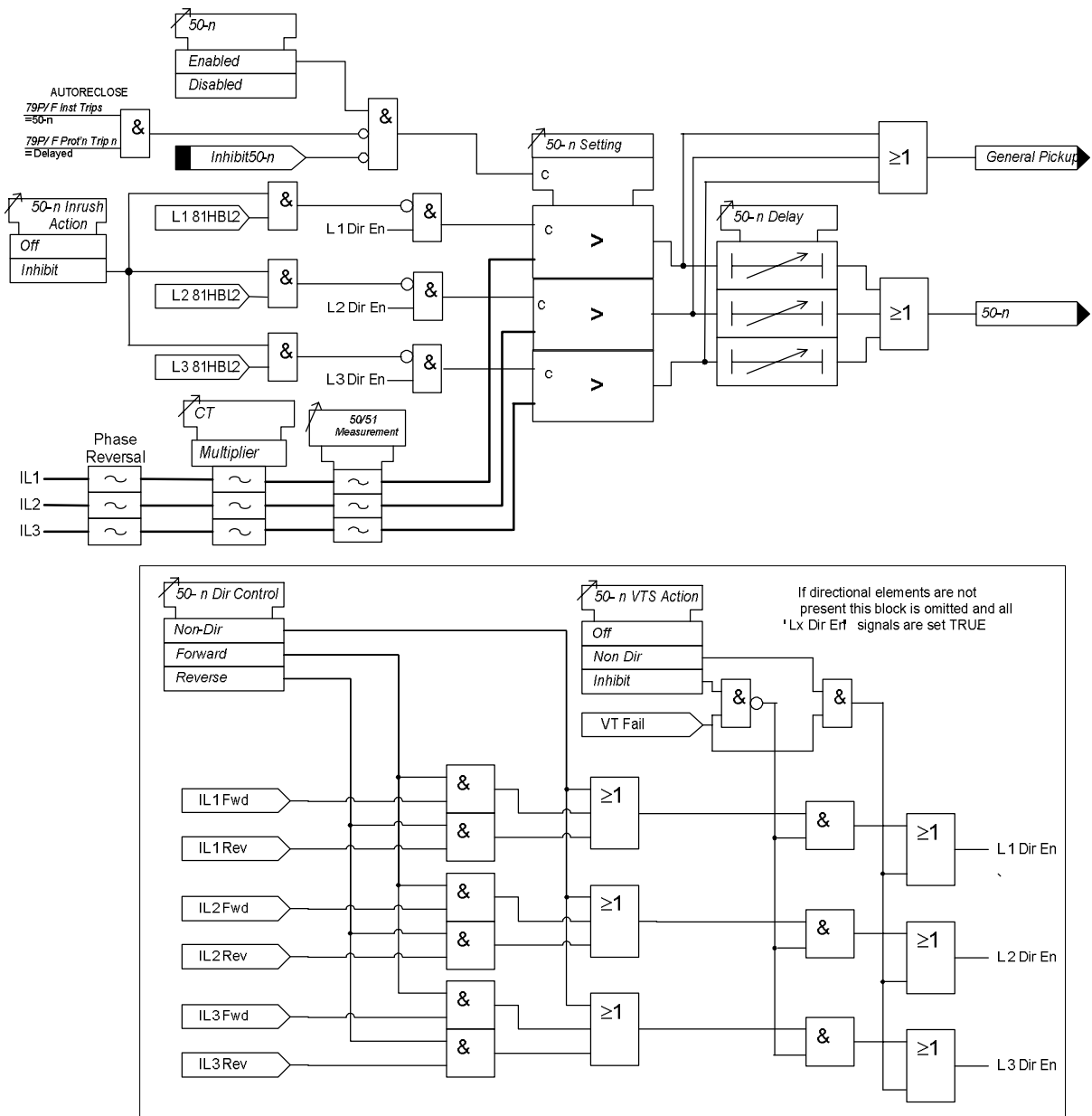


Figure 3.4.2-1 Logic Diagram: Instantaneous Over-current Element

3.4.3 Time Delayed Overcurrent Protection (51)

Up to four time-delayed overcurrent elements are provided in the relay (depending upon variant): -

51-1, 51-2, 51-3 & 51-4

51-n Setting sets the pick-up current level. A number of shaped characteristics are provided. An inverse definite minimum time (IDMT) characteristic is selected from IEC, ANSI or user specific curves using **51-n Char**. A time multiplier is applied to the characteristic curves using the **51-n Time Mult** setting. Alternatively, a definite time lag delay (DTL) can be chosen using **51-n Char**. When Definite Time Lag (DTL) is selected the time multiplier is not applied and the **51-n Delay (DTL)** setting is used instead. The full list of operating curves is given in 'Settings and Instruments Guide'. Operating curve characteristics are illustrated in 'Performance Specification'.

The **51-n Reset** setting can apply a **definite time delayed** reset, or when the operation is configured as an IEC or ANSI or user characteristic if the reset is selected as **(IEC/ANSI) DECAYING** reset the associated reset curve will be used. The reset mode is significant where the characteristic has reset before issuing a trip output – see 'Applications Guide'

A minimum operate time for the characteristic can be set using **51-n Min. Operate Time** setting.

A fixed additional operate time can be added to the characteristic using **51-n Follower DTL** setting.

Where directional elements are present the direction of operation can be set using **51-n Dir. Control** setting. Directional logic is provided independently for each 51-n element

Operation of the time delayed overcurrent elements can be inhibited from e.g. giving the option of using two elements set to forward and two to reverse.

Inhibit 51-n	A binary or virtual input.
79 P/F Inst Trips: 51-n	When 'delayed' trips only are allowed in the auto-reclose sequence (79 P/F Prot'n Trip n = Delayed).
51c	Activation of the cold load settings.
50-n Inrush Action: Block	Operation of the inrush current detector function.
51-n VTSAction: Inhibit	Operation of the VT Supervision function.

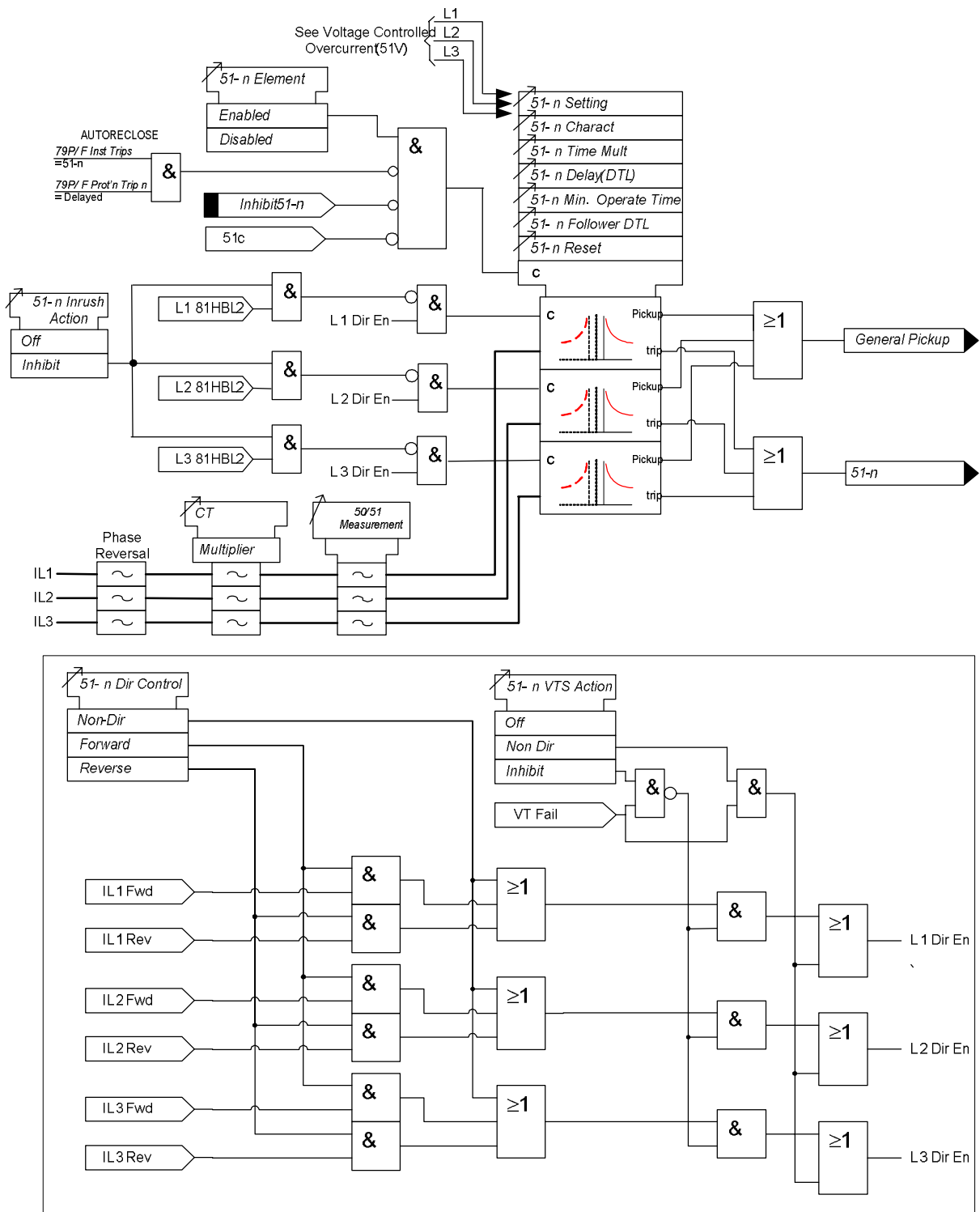


Figure 3.4.3-1 Logic Diagram: Time Delayed Overcurrent Element

3.4.4 Voltage Controlled Overcurrent (51V)

Voltage controlled overcurrent is only available in relays with four current inputs.

Each shaped overcurrent element **51-n Setting** can be independently controlled by the level of measured (control) input voltage.

For applied voltages above **VCO Setting** the 51-n element operates in accordance with its normal current setting (see 3.1.3). For input Ph-Ph control voltages below **VCO Setting** a multiplier (**51-n Multiplier**) is applied to reduce the 51-n pickup current setting.

51-n Multiplier is applied to each phase independently when its control phase-phase voltage falls below **VCO Setting**. The voltage levels used for each phase over-current element are shown in the table below. Relays with a Ph-N connection automatically calculate the correct Ph-Ph control voltage.

Current Element	Control Voltage
I_{L1}	V_{12}
I_{L2}	V_{23}
I_{L3}	V_{31}

The Voltage Controlled Overcurrent function (51V) can be inhibited from:

VCO VTSAction: Inhibit

Operation of the VT Supervision function.

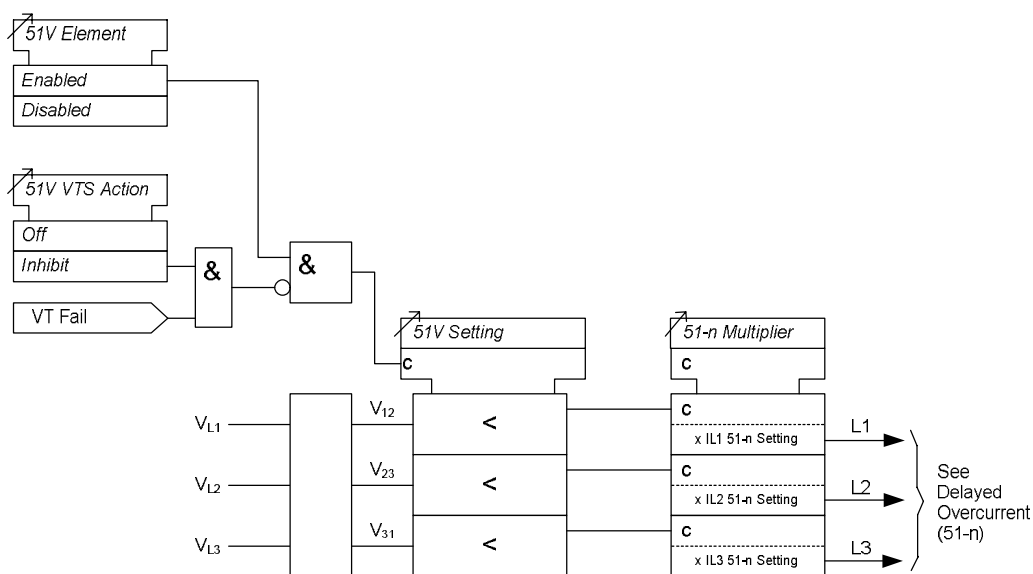


Figure 3.4.4-1 Logic Diagram: Voltage Controlled Overcurrent Element

3.5 Current Protection: Derived Earth Fault (67N, 51N, 50N)

The earth current is derived by calculating the sum of the measured line currents. The elements measure the fundamental frequency RMS current.

3.5.1 Directional Control of Derived Earth Fault Protection (67N)

The directional element produces forward and reverse outputs for use with derived earth fault elements. These outputs can be mapped as controls to each shaped and instantaneous element.

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.

The Characteristic angle is the phase angle by which the polarising voltage must be adjusted such that the directional detector gives maximum sensitivity in the forward operate zone when the current is in phase with it. The reverse operate zone is the mirror image of the forward zone.

The derived directional earth fault elements can use either zero phase sequence (ZPS) or negative phase sequence (NPS) polarising. This is selected using the **67N Polarising Quantity** setting. Whenever a zero-sequence voltage is available (a five-limb VT that can provide a zero sequence path or an open-delta VT connection) the earth-fault element can use zero-sequence voltage and current for polarisation. If zero-sequence polarising voltage is not available e.g. when a two phase (phase to phase) connected VT is installed, then negative-sequence voltage and negative-sequence currents must be used. The type of VT connection is specified by **Voltage Config** (CT/VT CONFIG menu). Settings advice is given in the Applications Guide.

Voltage polarisation is achieved for the earth-fault elements by comparison of the appropriate current with its equivalent voltage:

67N Polarising Quantity: ZPS $I_0 \sim V_0$

67N Polarising Quantity: NPS $I_2 \sim V_2$

The characteristic angle can be user programmed to any angle between -95° and $+95^\circ$ using the **67N Char Angle** setting. The voltage is the reference phasor (V_{ref}) and the **67N Char Angle** setting is added to this to adjust the forward and reverse zones.

The centre of the forward zone is set by (V_{ref} Angle + **67N Char Angle**) and should be set to correspond with I_{fault} Angle for maximum sensitivity e.g.

For fault current of -15° (I lagging V by 15°) a **67N Char Angle** of -15° is required for maximum sensitivity.

OR

For fault current of -45° (I lagging V by 45°) a **67 Char Angle** of -45° is required for maximum sensitivity.

Minimum Polarising Voltage

The **67N Minimum Voltage** setting defines the minimum polarising voltage level. Where the measured polarising voltage is below this level 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.

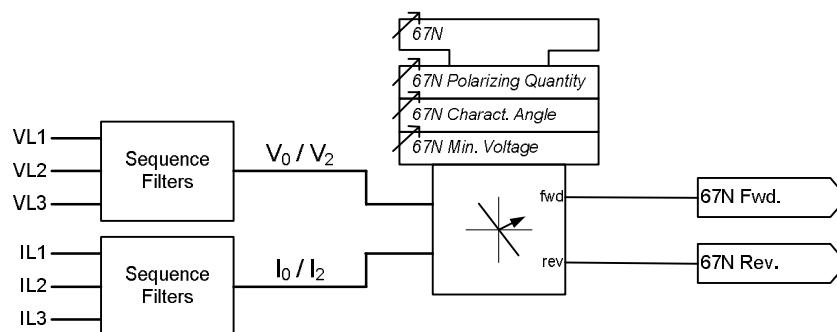


Figure 3.5.1-1 Logic Diagram: Derived Directional Earth Fault Protection

3.5.2 Instantaneous Derived Earth Fault Protection (50N)

Up to four instantaneous derived earth fault elements are provided in the relay (depending upon variant): -

50N-1, 50N-2, 50N-3 & 50N-4

Each instantaneous element has independent settings for pick-up current **50N-n Setting** and a follower time delay **50N-n Delay**. The instantaneous elements have transient free operation.

Where directional elements are present the direction of operation can be set using **50N-n Dir. Control** setting. Directional logic is provided independently for each 50-n element.

Operation of the instantaneous earth fault elements can be inhibited from:

Inhibit 50N-n

A binary or virtual input.

79 E/F Inst Trips: 50N-n

When 'delayed' trips only are allowed in the auto-reclose sequence (**79 E/F Prot'n Trip n = Delayed**).

50-n Inrush Action: Block

Operation of the inrush current detector function.

50N-n VTSAction: Inhibit

Operation of the VT Supervision function

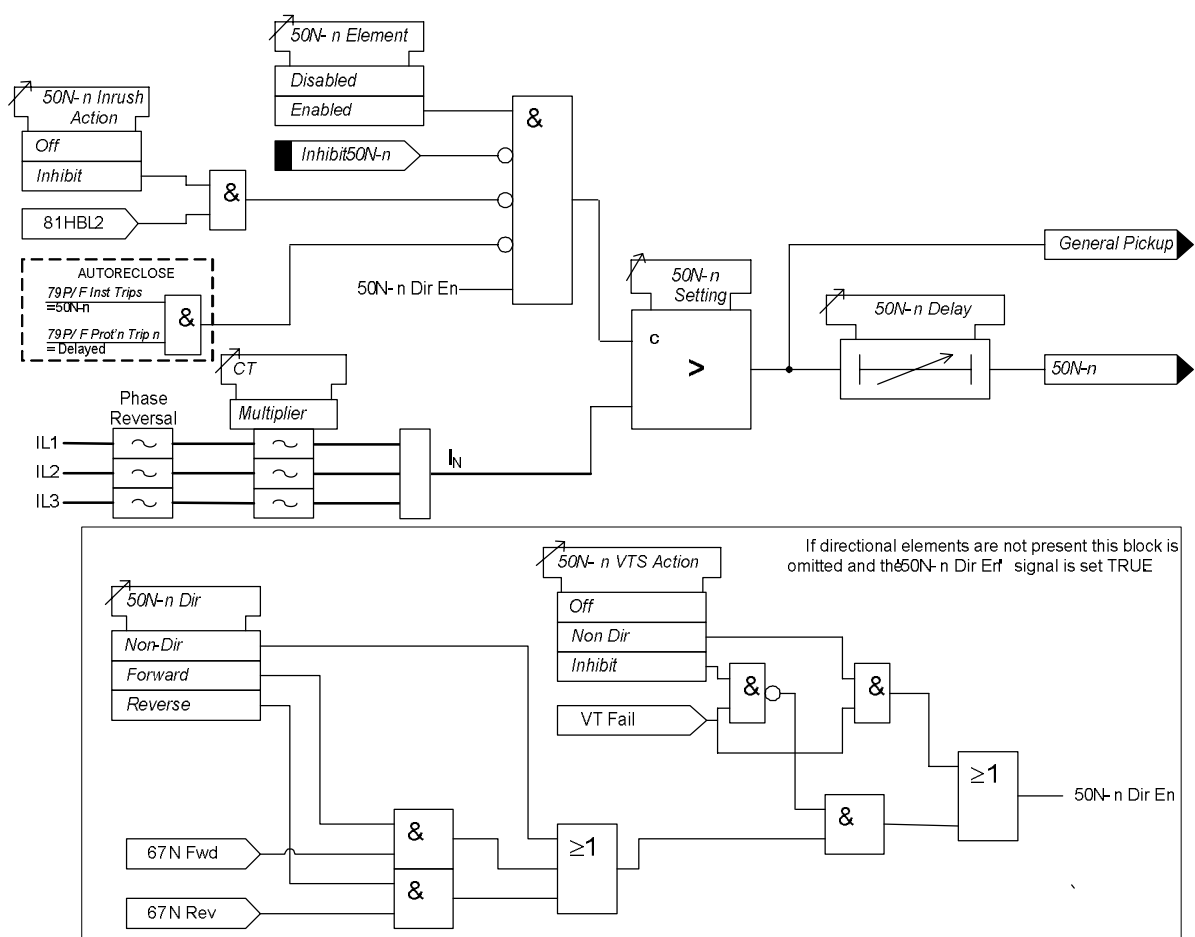


Figure 3.5.2-1 Logic Diagram: Derived Instantaneous Earth Fault Element

3.6 Current Protection: Measured Earth Fault (67G, 51G, 50G)

The earth current is measured directly via a dedicated current analogue input, IL4.

All measured earth fault elements have a common setting to measure either fundamental frequency RMS or True RMS current:

True RMS current: **50 Measurement = RMS, 51 Measurement = RMS**

Fundamental Frequency RMS current: **50 Measurement = Fundamental, 51 Measurement = Fundamental**

3.6.1 Directional Control of Measured Earth Fault Protection (67G)

The directional element produces forward and reverse outputs for use with measured earth fault elements. These outputs can be mapped as controls to each shaped and instantaneous element.

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.

The Characteristic angle is the phase angle by which the polarising voltage must be adjusted such that the directional detector gives maximum sensitivity in the forward operate zone when the current is in phase with it. The reverse operate zone is the mirror image of the forward zone.

The measured directional earth fault elements use zero phase sequence (ZPS) polarising.

Voltage polarisation is achieved for the earth-fault elements by comparison of the appropriate current with its equivalent voltage:

$$I_0 \sim V_0$$

The characteristic angle can be user programmed to any angle between -95° and $+95^\circ$ using the **67G Char Angle** setting. The voltage is the reference phasor (V_{ref}) and the **67G Char Angle** setting is added to this to adjust the forward and reverse zones.

The centre of the forward zone is set by (V_{ref} Angle + **67G Char Angle**) and should be set to correspond with I_{fault} Angle for maximum sensitivity e.g.

For fault current of -15° (I lagging V by 15°) a **67G Char Angle** of -15° is required for maximum sensitivity, OR

For fault current of -45° (I lagging V by 45°) a **67G Char Angle** of -45° is required for maximum sensitivity.

Minimum Polarising Voltage

The **67G Minimum Voltage** setting defines the minimum polarising voltage level. Where the measured polarising voltage is below this level 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.

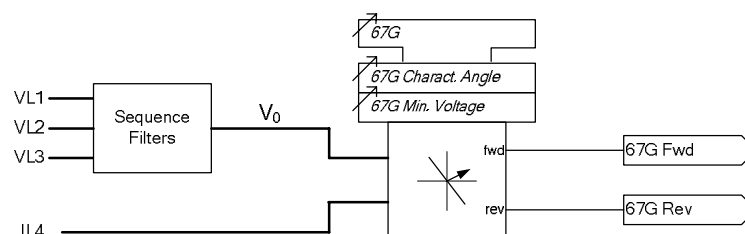


Figure 3.6.1-1 Logic Diagram: Measured Earth Fault Protection

50G-1, 50G-2, 50G-3 & 50G-4

Operation of the instantaneous measured earth fault elements can be inhibited from:

Inhibit 50G-n	A binary or virtual input.
79 E/F Inst Trips: 51N-n	When 'delayed' trips only are allowed in the auto-reclose sequence (79 E/F Prot'n Trip n = Delayed).
50-n Inrush Action: Block	Operation of the inrush current detector function.
50G-n VTSAction: Inhibit	Operation of the VT Supervision function

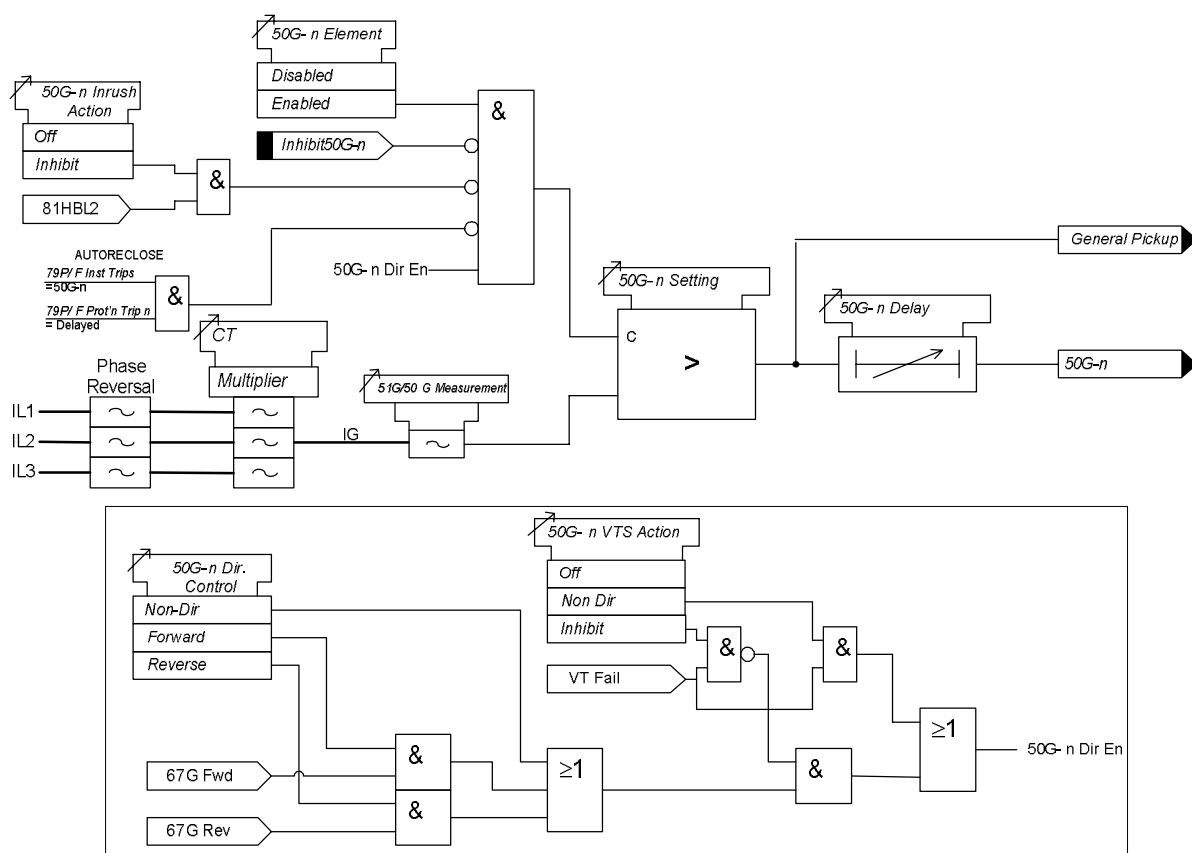


Figure 3.6.2-1 Logic Diagram: Measured Instantaneous Earth-fault Element

3.6.3 Time Delayed Measured Earth Fault Protection (51G)

Up to four time-delayed derived earth fault elements are provided in the relay (depending upon variant): -

51G-1, 51G-2, 51G-3 & 51G-4

51G-n Setting sets the pick-up current level.

A number of shaped characteristics are provided. An inverse definite minimum time (IDMT) characteristic is selected from IEC and ANSI curves using **51G-n Char**. A time multiplier is applied to the characteristic curves using the **51G-n Time Mult** setting. Alternatively, a definite time lag (DTL) can be chosen using **51G-n Char**. When DTL is selected the time multiplier is not applied and the **51G-n Delay (DTL)** setting is used instead.

The **51-n Reset** setting can apply a **definite time delayed** reset, or when the operation is configured as an IEC or ANSI or user characteristic if the reset is selected as **IEC/ANSI (DECAYING)** reset the associated reset curve will be used. The reset mode is significant where the characteristic has reset before issuing a trip output – see ‘Applications Guide’

A minimum operate time for the characteristic can be set using **51G-n Min. Operate Time** setting.

A fixed additional operate time can be added to the characteristic using **51G-n Follower DTL** setting.

Where directional elements are present the direction of operation can be set using **51G-n Dir. Control** setting. Directional logic is provided independently for each 51G-n element e.g. giving the option of using two elements set to forward and two to reverse.

Operation of the time delayed measured earth fault elements can be inhibited from: -

Inhibit 51G-n

A binary or virtual input.

79 E/F Inst Trips: 51G-n

When 'delayed' trips only are allowed in the auto-reclose sequence (**79 E/F Prot'n Trip n = Delayed**).

50-n Inrush Action: Block

Operation of the inrush current detector function.

50N-n VTSAction: Inhibit

Operation of the VT Supervision function

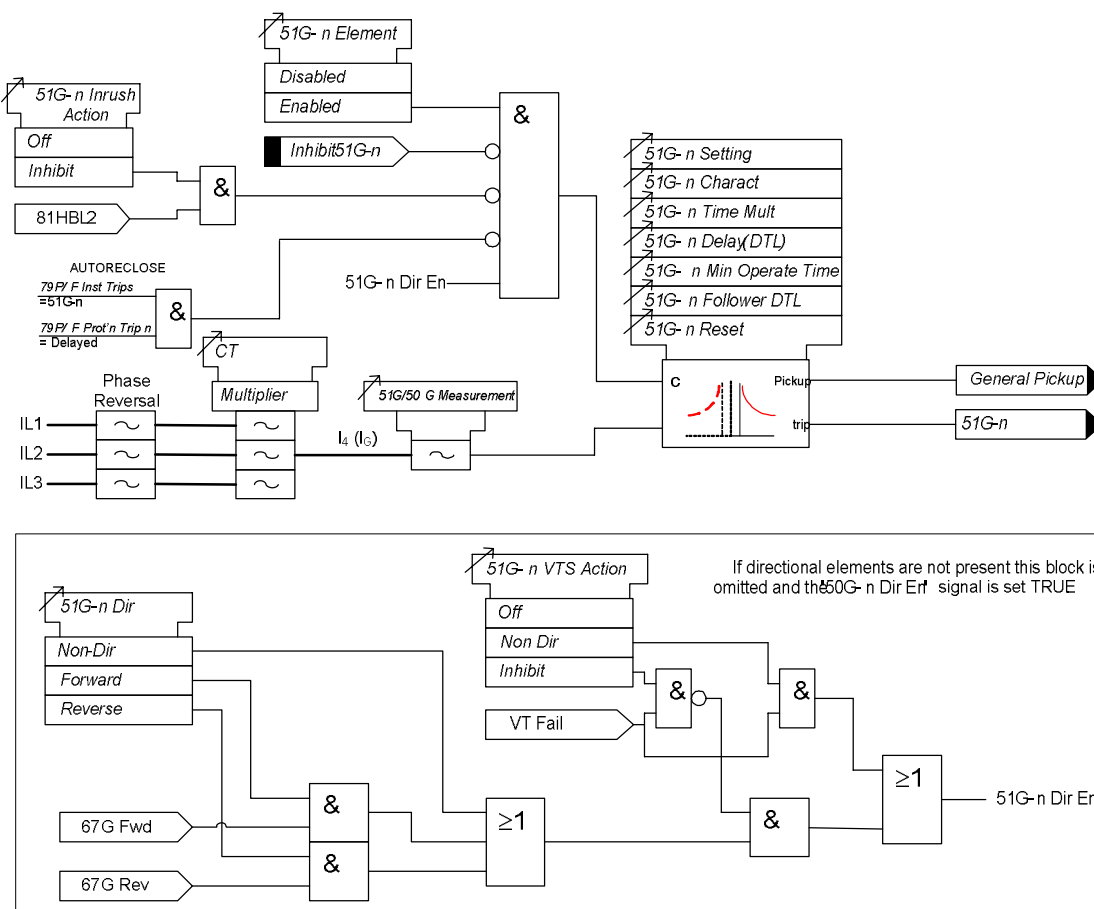


Figure 3.6.3-1 Logic Diagram: Measured Time Delayed Earth Fault Element (51G)

3.7 Current Protection: Cold Load (51c)

The setting of each shaped overcurrent element (51-n) can be inhibited and alternative 'cold load' settings (51c-n) can be applied for a period following circuit switch in.

The Cold Load settings are applied after the circuit breaker has been open for longer than the **Pick-Up Time** setting.

Following circuit breaker closure the 'cold load' overcurrent settings will revert to those defined in the Phase Overcurrent menu (51-n) after either elapse of the **Drop-Off Time** setting or when the measured current falls below the **Reduced Current Level** setting for a time in excess of **Reduced Current Time** setting.

During cold load settings conditions any directional settings applied in the Phase Overcurrent menu are still applicable.

A CB 'Don't Believe It' (DBI) alarm condition, see Section 4.3, is not acted on, causing the element to remain operating in accordance with the relevant 51-n settings. Where the **Reduced Current** setting is set to **OFF** 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 a recloser is present).

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.

Operation of the cold load element can be inhibited from:

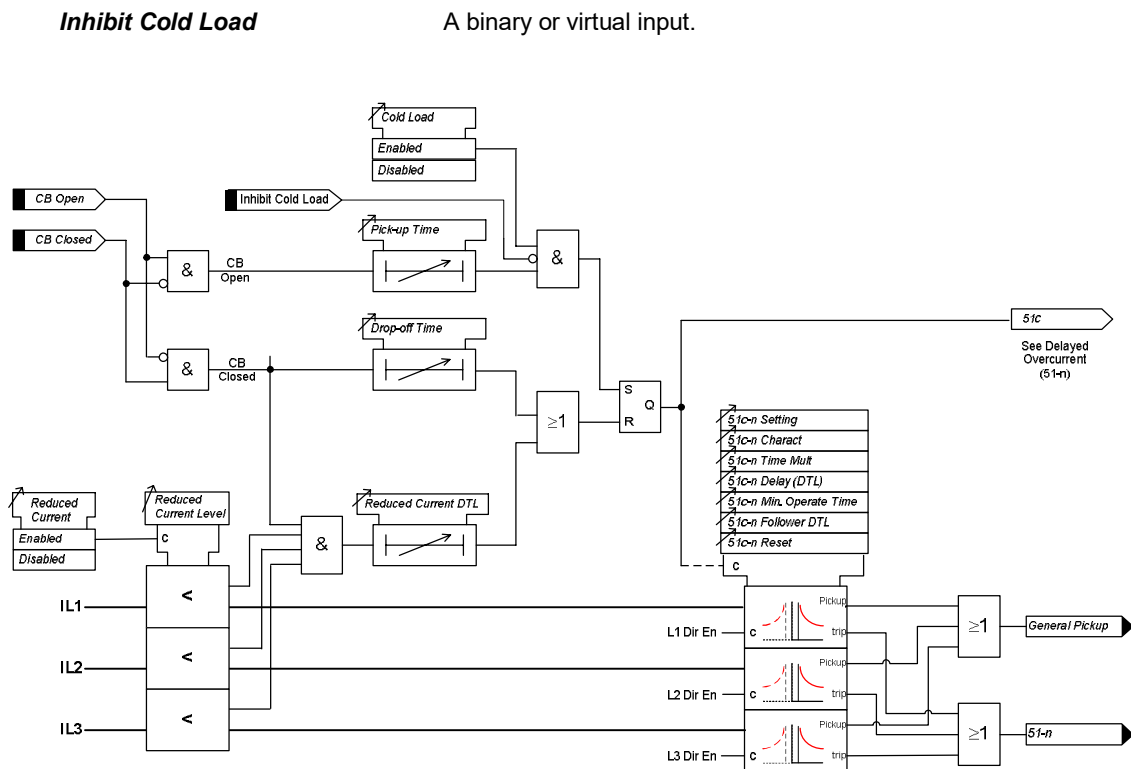


Figure 3.7-1 Logic Diagram: Cold Load Settings (51c)

3.8 Current Protection: Negative Phase Sequence Overcurrent - (46NPS)

The negative sequence phase (NPS) component of current (I_2) is derived from the three phase currents. It is a measure of the quantity of unbalanced current in the system.

Two NPS current elements are provided – **46IT** and **46DT**.

The 46IT element can be configured to be either definite time lag (DTL) or inverse definite minimum time (IDMT),

46IT Setting sets the pick-up current level for the element.

A number of shaped characteristics are provided. An inverse definite minimum time (IDMT) characteristic is selected from IEC and ANSI curves using **46IT Char**. A time multiplier is applied to the characteristic curves using the **46IT Time Mult** setting. Alternatively, a definite time lag delay (DTL) can be chosen using **46IT Char**. When Definite Time Lag (DTL) is selected the time multiplier is not applied and the **46IT Delay (DTL)** setting is used instead.

The **46IT Reset** setting can apply a **definite time delayed** or **ANSI (DECAYING)** reset.

The 46DT element has a DTL characteristic. **46DT Setting** sets the pick-up current and **46DT Delay** the follower time delay.

Operation of the negative phase sequence overcurrent elements can be inhibited from:

- Inhibit 46IT** A binary or virtual input.
- Inhibit 46DT** A binary or virtual input.

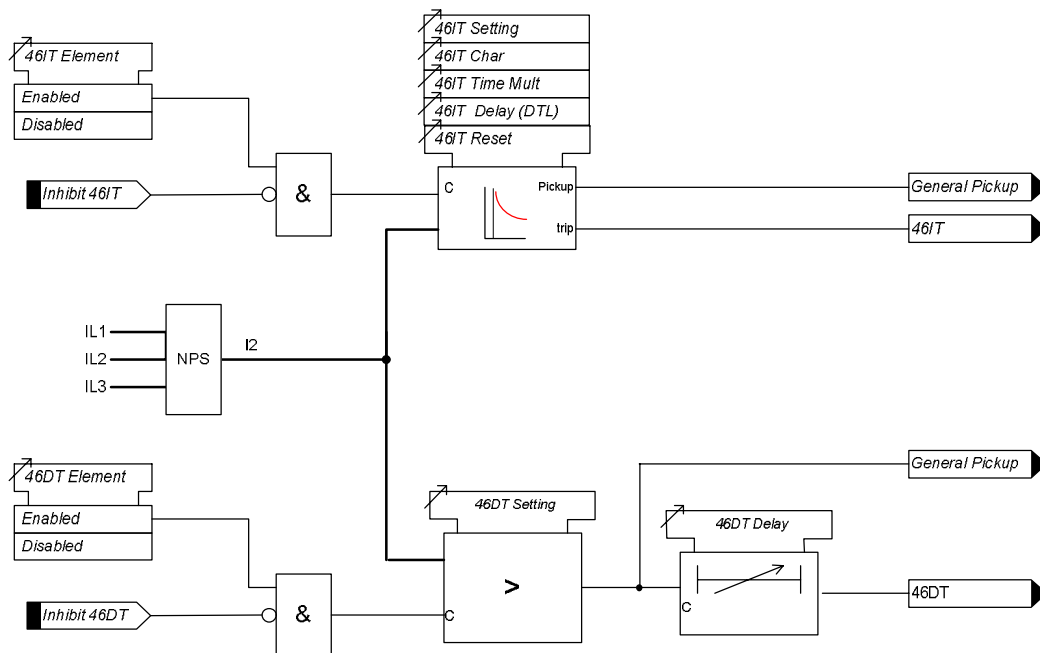


Figure 3.8-1 Logic Diagram: Negative Phase Sequence Overcurrent (46NPS)

3.9 Current Protection: Under-Current (37 & 37G)

Two under-current elements are provided **37-1 & 37-2** for phase currents and two are provided **37G-1 & 37G-2** for the earth fault.

Each phase has an independent level detector and current-timing element. **37-n Setting** sets the pick-up current. An output is given after elapse of the **37-n Delay** setting, when either any or all phases have operated depending upon setting.

An output is also given to indicate the operated phase.

All under-current elements work with True RMS currents.

Operation of the under-current elements can be inhibited from:

Inhibit 37-n	A binary or virtual input.
37UI Guard Setting	0.05, 0.1..5xIn

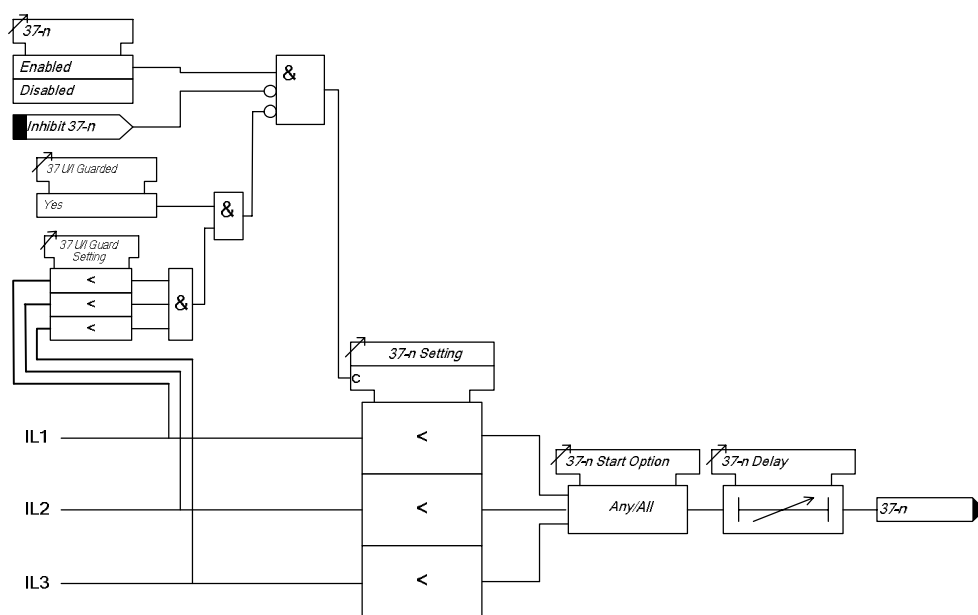


Figure 3.9-1 Logic Diagram: Phase Current Inputs Undercurrent Detector (37)

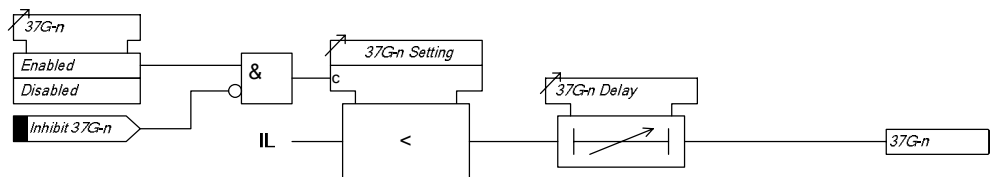


Figure 3.9-2 Logic Diagram: Earth Current Inputs Undercurrent Detector (37G)

3.10 Current Protection: Thermal Overload (49)

The relay provides a thermal overload suitable for the protection of static plant. Phase segregated elements are provided. The temperature of the protected equipment is not measured directly. Instead, thermal overload conditions are calculated using the measure True RMS current.

Should the current rise above the **49 Overload Setting** for a defined time an output signal will be initiated. The operating time is a function of thermal time constant **49 Time Constant** and previous current levels.

Operate Time (t):-

$$t = \tau \times \ln \left\{ \frac{I^2 - I_P^2}{I^2 - (k \times I_B)^2} \right\}$$

Where t = Time in minutes

τ = **49 Time Constant** setting (minutes)

$\ln$ = Log Natural

I = measured current

I_P = Previous steady state current level

k = Constant

I_B = Basic current, typically the same as I_n

$k \cdot I_B$ = **49 Overload Setting** (I_0)

Additionally, an alarm can be given if the thermal state of the system exceeds a specified percentage of the protected equipment's thermal capacity **49 Capacity Alarm** setting.

For the heating curve:

$$\theta = \frac{I^2}{I_0^2} \cdot (1 - e^{-t/\tau}) \times 100\%$$

Where:

θ = thermal state at time t

I = measured thermal current

I_0 = **49 Overload** setting (or $k \cdot I_B$)

The final steady state thermal condition can be predicted for any steady state value of input current where $t > \tau$,

$$\theta_F = \frac{I^2}{I_0^2} \times 100\%$$

Where:

θ_F = final thermal state before disconnection of device

49 Overload Setting I_0 is expressed as a multiple of the relay nominal current and is equivalent to the factor $k \cdot I_B$ as defined in the IEC60255-8 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 device.

The thermal state may be reset from the fascia or externally via a binary input.

Thermal overload protection can be inhibited from:

Inhibit 49 A binary or virtual input.

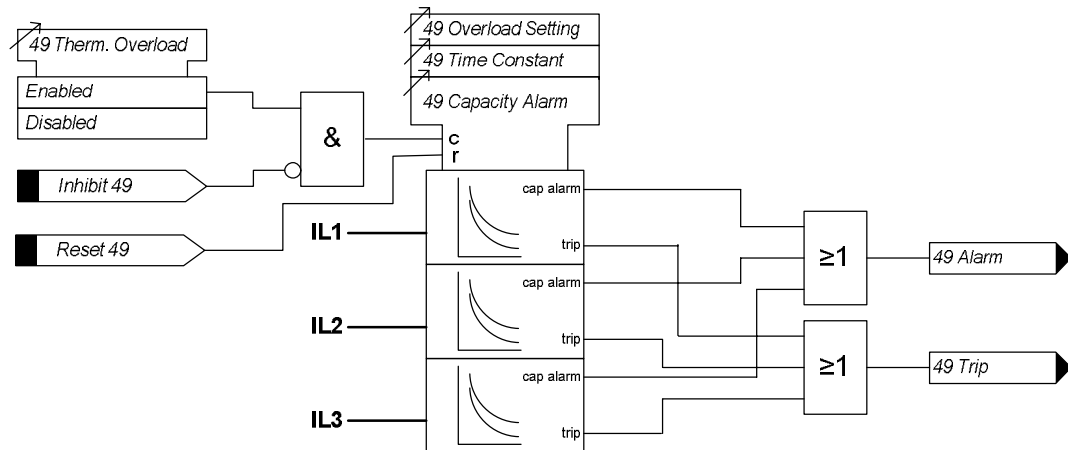


Figure 3.10-1 Logic Diagram: Thermal Overload Protection (49)

3.11 Current Protection: Line Check 50LC, 50G LC

This feature prevents a CB being repeatedly manually closed onto a faulted line. It is enabled upon the **Manual CB Close** output being issued. If a fault is detected following closure, the Relay will trip for **Line Check**. A fault is detected if the measured current is above the **LC-n Setting** level for a period greater than the **LC-n Delay**.

Two line check elements are provided, **LC-1 and LC-2**, for each fault type - phase and earth – in the CURRENT PROT'N > LINE CHECK menu.

The feature will remain enabled until the CB has been closed for a duration equal to the **Close CB Pulse + Reclaim Timer** (AR option) settings in the CIRCUIT BREAKER MENU. Alternatively, the element will remain enabled as long as the **Line Check** binary input is energised.

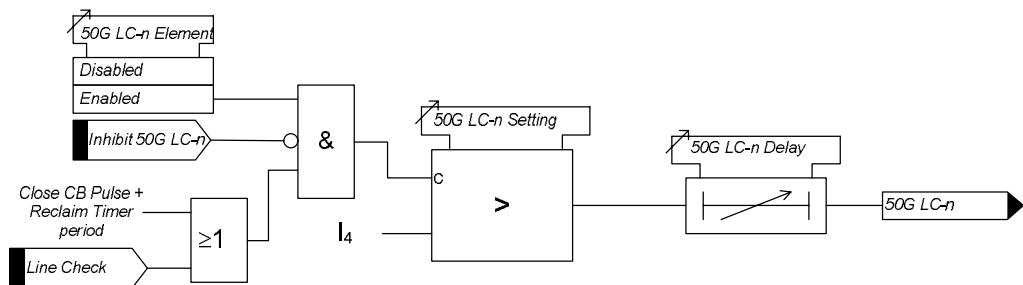


Figure 3.11-1 Logic Diagram: 50G Line Check Elements (50G LC)

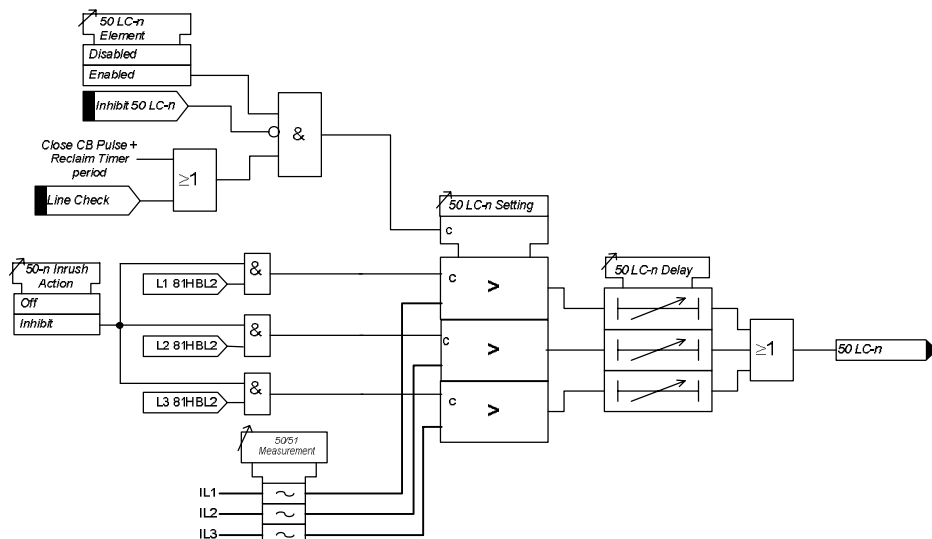


Figure 3.11-2 Logic Diagram: 50 Line Check Elements (50LC)

Section 4: Control & Logic Functions

4.1 Auto-Reclose (79)

4.1.1 Overview

A high proportion of faults on an Overhead Line (OHL) network are transient. These faults can be cleared and the network restored quickly by using Instantaneous (Fast) Protection trips followed by an automated sequence of Circuit Breaker (CB) re-closures after the line has been dead for a short time. This 'deadtime' allows the fault current arc to fully extinguish.

The addition of Autoreclose to the Differential protection allows time sequenced closing to be applied. The schemes can be configured from simple time delayed CB1 followed by CB2: to more complex full 4-shot instantaneous and delayed systems.

Typically this auto reclose (AR) sequence of Instantaneous Trip(s) and Reclose Delays (Dead times) 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 Network in-service as possible.

The AR function, therefore, has to: -

- Control the type of Protection trip applied at each stage of a sequence

- Control the Auto Reclose of the Circuit Breaker to provide the necessary network Dead times, to allow time for Arc extinction

- Co-ordinate its Protection and Auto Reclose sequence with other fault clearing devices.

A typical sequence would be – 2 INST+1Delayed+HighSet Trips with 1 sec & 10 sec dead times.

The Auto Reclose feature may be switched in and out of service by a number of methods, these are:

- 79 Autoreclose ENABLE/DISABLE** (AUTORECLOSE CONFIG menu)

- A keypad change from the CONTROL MODE

- Via the data communications channel(s),

- From a **79 OUT** binary input. Note the **79 OUT** binary input has priority over the **79 IN** binary input - if both are raised the auto-reclose will be Out of Service.

Knowledge of the CB position status is integral to the auto-reclose functionality. CB auxiliary switches must be connected to **CB Closed** and **CB Open** binary inputs. A circuit breaker's service status is determined by its position i.e. from the binary inputs programmed **CB Open** and **CB Closed**. The circuit breaker is defined as being in service when it is closed. The circuit memory functionality prevents autoreclosing when the line is de-energised, or normally open.

AR is started by a valid protection operation that is internally mapped to trip in the 79 Autoreclose protection menu or an external trip received via a binary input **79 Ext Trip**, while the associated circuit breaker is in service.

The transition from AR started to deadtime initiation takes place when the CB has opened and the protection pickups have reset and the trip relay has reset. If any of these do not occur within the **79 Sequence Fail Timer** setting the relay will Lockout. This prevents the AR being primed indefinitely. **79 Sequence Fail Timer** can be switched to **0** (= OFF).

Once an AR sequence has been initiated, up to 4 reclose operations can be attempted before the AR is locked-out. The relay is programmed to initiate a number of AR attempts, the number is determined by **79 Num Shots**. Each reclosure (shot) is preceded by a time delay - **79 Elem Deadtime n** - giving transient faults time to clear. Separate dead-time settings are provided for each of the 4 recloses and for each of the fault types – P/F, E/F, and External.

Once a CB has reclosed and remained closed for a specified time period (the Reclaim time), the AR sequence is re-initialised and a Successful Close output issued. A single, common Reclaim time is used (**Reclaim Timer**). When an auto-reclose sequence does not result in a successful reclosure the relay goes to the lockout state.

Indications

The Instruments Menu includes the following meters relevant to the status of the Auto-Reclose and Manual Closing of the circuit breaker: -

- Autoreclose Status
- Out of Service
- Close Shot.
- CB Open Countdown Timer
- CB Close Countdown Timer

Inputs

External inputs to the recloser functionality need to be wired to the binary inputs. Functions which can be mapped to these binary inputs include: -

- 79 Out (edge triggered)
- 79 In (edge triggered)
- CB Closed
- CB Open
- 79 Ext Trip
- 79 Ext Pickup
- 79 Block Reclose
- Block Close CB
- Close CB
- 79 Trip & Reclose
- 79 Trip & Lockout
- 79 Line Check
- Hot Line In
- Hot Line Out

Outputs

Outputs are fully programmable to either binary outputs or LEDs. Programmable outputs include: -

- 79 Out Of Service
- 79 In Service
- 79 In Progress
- 79 AR Close CB
- 79 Successful AR
- 79 Lockout
- 79 Close Onto Fault
- 79 CB Fail to Close
- 79 Trip _Reclose
- 79 Trip _Lockout
- 79 Block Extern

4.1.2 Auto Reclose sequences

The CONTROL & LOGIC>AUTO RECLOSE PROT'N and CONTROL & LOGIC>AUTORECLOSE CONFIG' menus, allow the user to set independent Protection and Auto Reclose sequences for each type of fault i.e. Phase Fault (P/F), Derived/Measured Earth Fault (E/F) or External Protections (EXTERN). Each Auto Reclose sequence can be user set to up to four-shots i.e. five trips + four reclose sequence, with independently configurable type 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 Auto Reclose Sequences up to the maximum shot count i.e.:-

- Inst or Delayed Trip 1 + (DeadTime 1: 0.1s-14400s)**
- +** **Inst or Delayed Trip 2 + (DeadTime 2: 0.1s-14400s)**
- +** **Inst or Delayed Trip 3 + (DeadTime 3: 0.1s-14400s)**
- +** **Inst or Delayed Trip 4 + (DeadTime 4: 0.1s-14400s)**
- +** **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 two **Inst** trips followed by at least one **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, i.e. that as much of the system as possible is live after the fault is cleared.

A **HS trips to lockout** setting is provided such that when the number of operations of elements assigned as HS trips reach the setting the relay will go to lockout.

The number of Shots (Closes) is user programmable, note: - only one Shot Counter is used to advance the sequence, the Controller selects the next Protection characteristic/Dead time according to the type of the last Trip in the sequence e.g. PF, EF or EXTERNAL.

Reclose Dead Time

User programmable dead times are available for each protection trip operation.

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 energised after the dead time has elapsed.

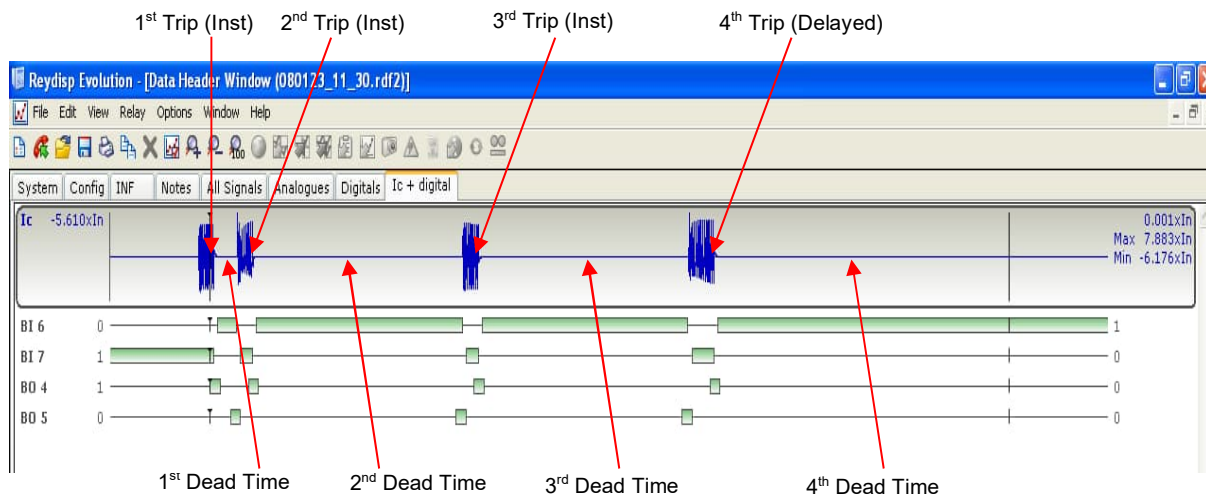


Figure 4.1.2-1 Typical Sequence with 3 Instantaneous and 1 Delayed trip

4.2 Autoreclose Prot'n Menu

This menu presents the Overcurrent Protection elements available for each type of Fault i.e. P/F or E/F 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 Auto Reclose Relay. The resultant configuration enables the Auto Reclose function to correctly apply the required Protection for each shot in a sequence.

4.3 Autoreclose Config Menu

This menu allows the following settings to be made:-

79 Autoreclose Enabled turns ON all AutoReclose Functions.

79 Num Shots Sets the allowed number of AutoReclose attempts in a sequence.

79 Retry Enable **Enabled** configures the relay to 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.

79 Retry Attempts Sets the maximum number of retry attempts.

79 Retry Interval Sets the time delay between retry attempts.

79 Reclose Blocked Delay 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 **79 Reclose Blocked Delay** sets the time **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. $\text{Dead Time} + \text{Reclose Blocked Delay} = \text{Lockout}$.

79 Sequence Fail Timer Sets the time that AutoReclose start can be primed. Where this time expires before all the DAR start signals are not received i.e. the CB has opened, protection pickups have reset and the trip relay has reset, the Relay goes to Lockout.

Minimum LO Delay Sets the time that the Relay's Lockout condition is maintained. After the last allowed Trip operation in a specific sequence the Circuit-Breaker will be left locked-out in the open position and can only be closed by manual or remote SCADA operation. The **Minimum Lockout Delay** timer can be set to delay a too-fast manual close after lockout, this prevents an operator from manually closing onto the same fault too quickly and thus performing multiple sequences and possibly burning-out Plant.

Reset LO by Timer Set to **Enabled** this ensures that the Lockout condition is reset when the timer expires, Lockout indication will be cleared; otherwise, set to Disabled, the Lockout condition will be maintained until the CB is Closed by a Close command.

79 Sequence Co-Ord 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 followed by current switch-off. It then increments its Shot count and advances to the next stage of the auto-reclose 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.

79 Cold Load Action Selects whether whilst Cold Load is active the relay will perform only Delayed Trips. When set to Off, both Inst and Delayed elements will be active. This setting does not block Autoreclose for Cold Load trips.

Notes on the 'Lockout' State

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.

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 time of 2s. The Lockout condition cannot be reset if there is an active lockout input.

Note: If the 'CB Total Trip Count' or the 'CB Frequent Ops Count' target is reached the relay will do one delayed tip and lockout.

4.4 P/F Shots Sub-Menu

This menu allows the Phase fault trip/reclose sequence to be parameterized:-

- | | |
|--|---|
| 79 P/F Prot'n Trip1 | The first protection Trip in the P/F sequence can be set to either Inst or Delayed . |
| 79 P/F Deadtime 1 | Sets the first Reclose Delay (Dead time) in the P/F sequence. |
| 79 P/F Prot'n Trip2 | The second protection Trip in the P/F sequence can be set to either Inst or Delayed . |
| 79 P/F Deadtime 2 | Sets the second Reclose Delay (Dead time) in the P/F sequence. |
| 79 P/F Prot'n Trip3 | The third protection Trip in the P/F sequence can be set to either Inst or Delayed . |
| 79 P/F Deadtime 3 | Sets the third Reclose Delay (Dead time) in the P/F sequence. |
| 79 P/F Prot'n Trip 4 | The fourth protection Trip in the P/F sequence can be set to either Inst or Delayed . |
| 79 P/F Deadtime 4 | Sets the fourth Reclose Delay (Dead time) in the P/F sequence. |
| 79 P/F Prot'n Trip5 | The fifth and last protection Trip in the P/F sequence can be set to either Inst or Delayed . |
| 79 P/F HighSet Trips to Lockout | 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. |
| 79 P/F Delayed Trips to Lockout | Sets the number of allowed Delayed trips, 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. |

4.5 E/F Shots Sub-Menu

This menu allows the Earth Fault trip/reclose sequence to be parameterized:-

As above but E/F settings.

4.6 Extern Shots Sub-Menu

This menu allows the External Protection auto-reclose sequence to be parameterized:-

79 P/F Prot'n Trip1	Not Blocked/Blocked - Blocked raises an output which can be mapped to a Binary output to Block an External Protection's Trip Output.
79 P/F Deadtime 1	Sets the first Reclose Delay (Deadtime) for the External sequence.
79 P/F Prot'n Trip2	Not Blocked/Blocked - Blocked raises an output which can be mapped to a Binary Output to Block an External Protection's second Trip output.
79 P/F Deadtime 2	Sets the second Reclose Delay (Deadtime) in the External sequence.
79 P/F Prot'n Trip3	Not Blocked/Blocked - Blocked raises an output which can be mapped to a Binary output to Block an External Protection's third Trip Output.
79 P/F Deadtime 3	Sets the third Reclose Delay (Deadtime) in the External sequence.
79 P/F Prot'n Trip4	Not Blocked/Blocked - Blocked raises an output which can be mapped to a Binary output to Block an External Protection's fourth Trip Output.
79 P/F Deadtime 4	Sets the fourth Reclose Delay (Deadtime) in the External sequence.
79 P/F Prot'n Trip5	Not Blocked/Blocked - Blocked raises an output which can be mapped to a Binary output to Block an External Protection's fifth Trip Output.
79 P/F Extern Trips to Lockout	Sets the number of allowed External protection' trips, Relay will go to Lockout on the last Trip.

These settings allow the user to set-up a separate AutoReclose sequence for external protection(s) having a different sequence to P/F or E/F protections. The '**Blocked**' setting allows the Autoreclose sequence to raise an output at any point in the sequence to Block further Trips by the External Protection thus allowing the Overcurrent P/F or Earth Fault elements to apply Overcurrent Grading to clear the fault.

Other Protection Elements in the Relay can also be the cause of trips and it may be that AutoReclose is required; the External AutoReclose sequence can be applied for this purpose. By setting-up internal Quick Logic equation(s) the user can define and set what should occur when any one of these other elements operates.

Figure 4.6-1 Basic Auto-Reclose Sequence Diagram

4.7 Manual CB Control

A Manual Close Command can be initiated in one of three ways: via a **Close CB** binary input, via the data communication Channel(s) or from the relay CONTROL MODE menu. It causes an instantaneous operation via **Manual Close CB** binary output.

Repeated Manual Closes are avoided by checking for Positive edge triggers. Even if the Manual Close input is constantly energised the relay will only attempt one close.

A Manual Close will initiate Line Check if **Line Check Trip** is enabled. If a fault appears on the line during the Close Pulse with Line Check enabled, the relay will initiate a Trip and Lockout. 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.

Close CB 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.

Blocked Close Delay

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.

Open CB Delay

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.

It should be noted that a CB trip initiated by an **Open CB** command 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, I²t measurement and operation counter.

CB Controls Latched

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.

4.8 Circuit Breaker

This menu includes relay settings applicable to manual close (MC) functionality.

'CB Failed To Open' and 'CB Failed to Close' features are used to confirm that a CB has not responded correctly to each Trip and Close Command.

Close CB Pulse

The duration of the **Close CB Pulse** is settable to allow a range of CBs to be used. The **Close CB Pulse** must be long enough for the CB to physically close.

The Close pulse will be terminated if any protection pick-up operates or a trip occurs. This is to prevent Close and Trip Command pulses existing simultaneously. A **79 Close Onto Fault** (auto-reclose option) output is given if a pick-up or trip operates during the Close Pulse. This can be independently wired to Lockout.

The output **CB Fail to Close** is issued if the CB is not closed at the end of the close pulse, **Close CB Pulse**.

CB Control Trip Time

When this is set to **Enabled**, the relay will measure the CB trip time following operation of either a CB control open output or a CB Trip output. The trip time is displayed by the MAINTENANCE METERS > CB Trip Time meter.

When this is set to Disabled, the relay will measure the trip time following operation of a CB Trip output only. Operation of a CB control open output will then not cause the trip time to be measured.

Open CB Pulse

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.

CB Travel Alarm

The **CB Open** and **CB Closed** binary inputs are continually monitored to track the CB Status.

The CB should only ever be in one of three states: -

CB Status	CB Open binary input	CB Closed binary input
CB is Open	1	0
CB is Closed	0	1
CB is Travelling between the above 2 states	0	0

The Relay goes to Lockout and the **CB Alarm** output is given where the Travelling 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.

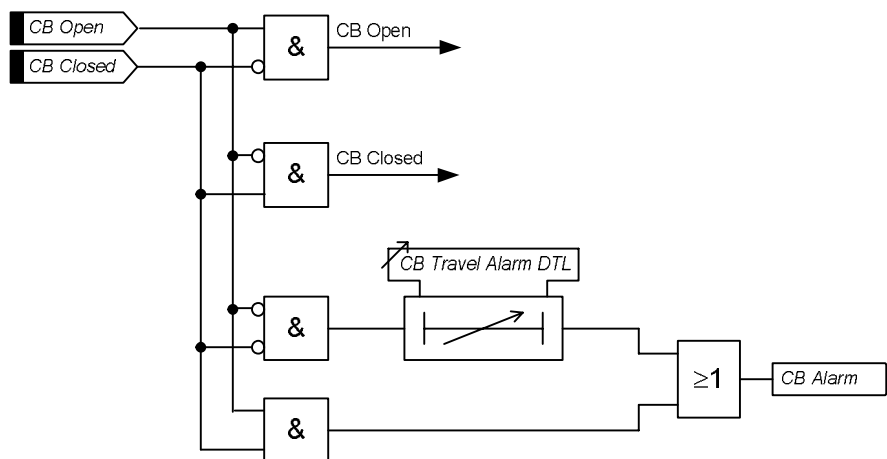


Figure 4.8-1 Logic Diagram: Circuit Breaker Status

Trip Time Alarm

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.

Trip Time Adjust

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.

4.9 Quick Logic

The 'Quick Logic' feature allows the user to input up to 4 logic equations (E1 to E4) in text format. Equations can be entered using Reydisp or at the relay fascia.

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)
In	Binary Input (number)
	'1' = Input energised, '0' = Input de-energised
Ln	LED (number)
	'1' = LED energised, '0' = LED de-energised
On	Binary output (number)
	'1' = Output energised, '0' = Output de-energised
Vn	Virtual Input/Output (number)
	'1' = Virtual I/O energised, '0' = Virtual I/O de-energised

Example Showing Use of Nomenclature

E1= ((I1^V1).!O2)+L1

Equation 1 = ((Binary Input 1 XOR Virtual I/O 1) AND NOT Binary Output 2) OR LED 1

When the equation is satisfied (=1) it is routed through a pick-up timer (**En Pickup Delay**), a drop-off timer (**En Dropoff Delay**), and a counter which instantaneously picks up and increments towards its target (**En Counter Target**).

The counter will either maintain its count value **En Counter Reset Mode = OFF**, or reset after a time delay:

En Counter Reset Mode = Single Shot: 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. Where **En Counter Reset Time** elapses and the count value has not reached its target the count value is reset to zero.

En Counter Reset Mode = Multi Shot: The **En Counter Reset Time** is started each time the counter is incremented. Where **En Counter Reset Time** elapses without further count increments the count value is reset to zero.

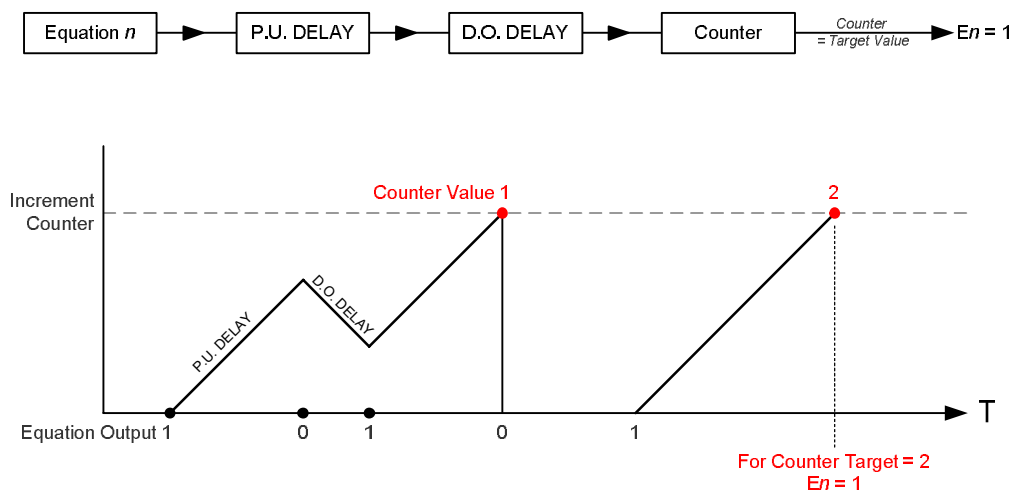


Figure 4.9-1 Sequence Diagram: Quick Logic PU/DO Timers (Counter Reset Mode Off)

When the count value = **En Counter Target** the output of the counter (E_n) = 1 and this value is held until the initiating conditions are removed when E_n is instantaneously reset.

The output of E_n 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.

Protection functions can be used in Quick Logic by mapping them to a Virtual Input / Output.

Section 5: Supervision Functions

5.1 Circuit Breaker Failure (50BF)

The circuit breaker fail function has two time delayed outputs that can be used for combinations of re-tripping or back-tripping. CB Fail outputs are given after elapse of the **50BF-1 Delay** or **50BF-2 Delay** settings. The two timers run concurrently.

The circuit breaker fail protection time delays are initiated either from:

An output **Trip Contact** of the relay (MENU: OUTPUT CONFIG\TRIP CONFIG\Trip Contacts), or

A binary or virtual input assigned to **50BF Ext Trig** (MENU: INPUT CONFIG\INPUT MATRIX\50BF Ext Trig).

A binary or virtual input assigned to **50BF Mech Trip** (MENU: INPUT CONFIG\INPUT MATRIX\ 50BF Mech Trip).

CB Fail outputs will be issued providing any of the 3 phase currents are above the **50BF Setting** or the current in the fourth CT is above **50BF-I4** 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.

Both **50BF-1** and **50BF-2** can be mapped to any output contact or LED.

An output is also given to indicate the faulted phase, **50BF PhA**, **50BF PhB**, **50BF PhC** and **50BF EF**

If the **CB Faulty** input (MENU: INPUT CONFIG\INPUT MATRIX\CB Faulty) is energised when a CB trip is given the time delays **50BF-n Delay** will be by-passed and the output given immediately.

Operation of the CB Fail elements can be inhibited from:

Inhibit 50BF

A binary or virtual input.

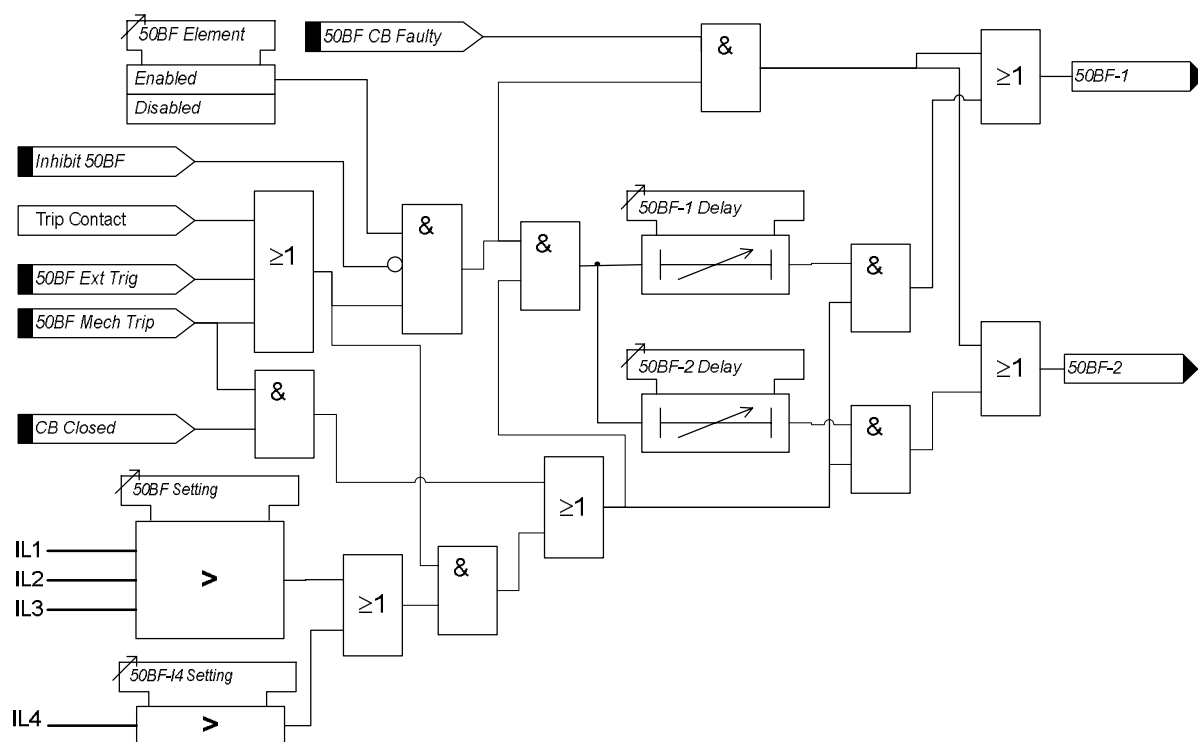


Figure 5.1-1 Logic Diagram: Circuit Breaker Fail Protection (50BF)

5.2 VT Supervision (60VTS)

1 or 2 Phase Failure Detection

Normally the presence of negative phase sequence (NPS) or zero phase sequence (ZPS) voltage in a power system is accompanied by NPS or ZPS current. The presence of either of these sequence voltages without the equivalent level of the appropriate sequence current is used to indicate a failure of one or two VT phases.

The **60VTS Component** setting 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 relay utilises fundamental voltage measurement values for this function.

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** for a time greater than **60VTS Delay**.

3 Phase Failure Detection

Under normal load conditions rated PPS voltage would be expected along with a PPS load current within the circuit rating. Where PPS load current is detected without corresponding PPS voltage this could indicate a three 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 element has a **60VTS VPPS** setting, an **60VTS IPPS Load** setting and a setting for **60VTS IPPS Fault**. A VT is considered to have failed where positive sequence voltage is below **60VTS VPPS** while positive sequence current is above **IPPS Load** and below **IPPS Fault** level for more than **60VTS Delay**.

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 **VPPS** setting while NPS voltage is below **VNPS** 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.

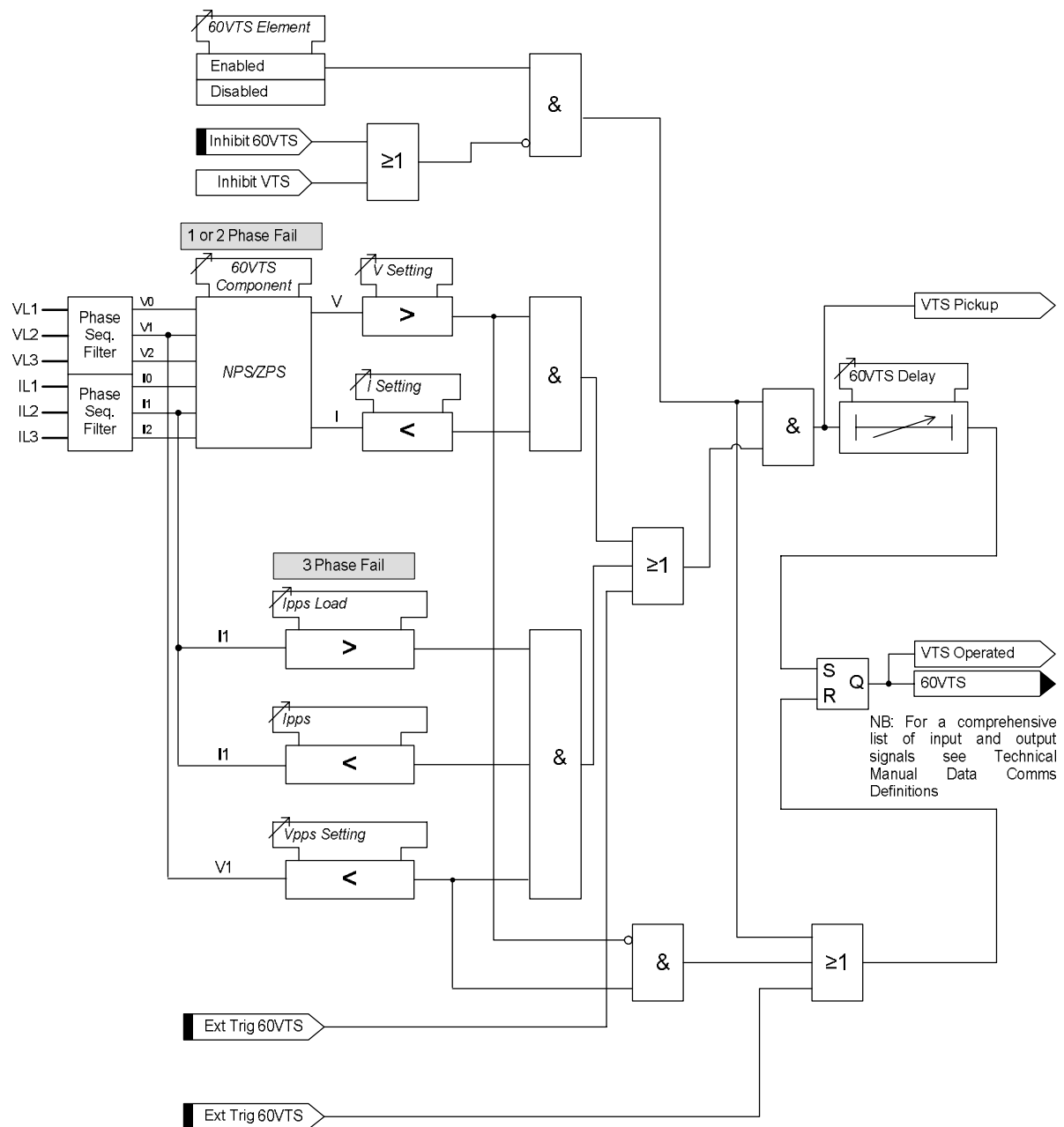


Figure 5.2-1 Logic Diagram: Circuit Breaker Fail Protection (50BF)

5.3 CT Supervision (60CTS-I & CTS)

The relay has two methods of detecting a CT failure, depending on the relay model. CT Supervision is only available in relays with four current inputs.

5.3.1 60CTS-I

The current from each of the Phase Current Transformers is monitored. If one or two of the three input currents falls below the CT supervision current setting **CTS-I** for more than **60CTS-I Delay** then a CT failure output (**60CTS Operated**) is given. If all three input currents fall below the setting, CT failure is not raised.

An output is also given to indicate the faulted phase, **60CTS-I PhA**, **60CTS-I PhB**, and **60CTS-I PhC**

Operation of the CT supervision elements can be inhibited from:

Inhibit 60CTS-I

A binary or virtual input.

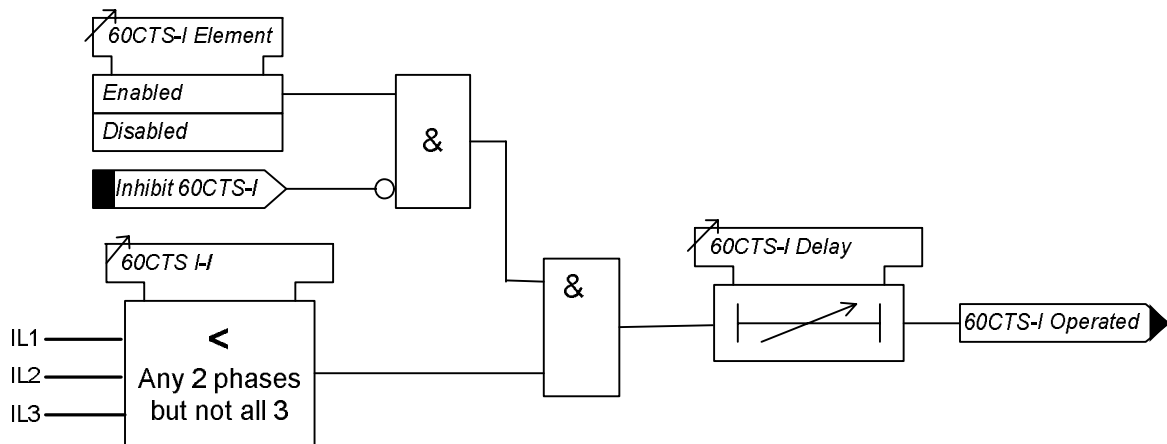


Figure 5.3.1-1 Logic Diagram: CT Supervision Function (60CTS-I)

5.3.2 60CTS

Normally the presence of negative phase sequence (NPS) current in a power system is accompanied by NPS voltage. The presence of NPS current without NPS voltage is used to indicate a current transformer failure.

The element has a setting for NPS current level **60CTS Inps** and a setting for NPS voltage level **60CTS Vnps**. If the negative sequence current exceeds its setting while the negative sequence voltage is below its setting for more than **60CTS Delay** then a CT failure output (**60CTS Operated**) is given.

Operation of the CT supervision elements can be inhibited from:

Inhibit 60CTS

A binary or virtual input.

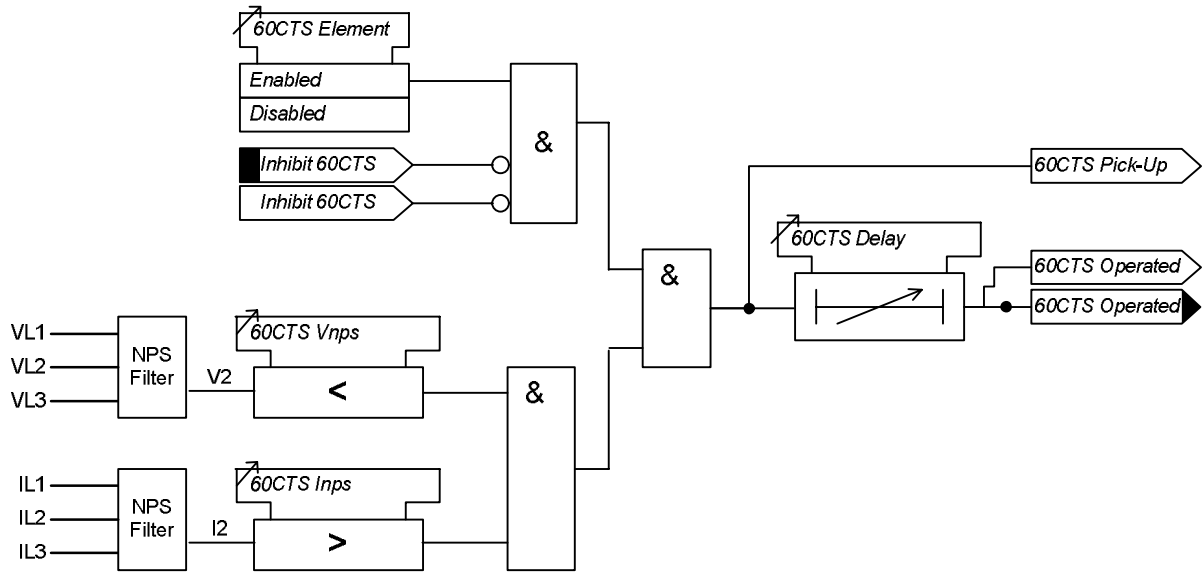


Figure 5.3.2-1 Logic Diagram: CT Supervision Function (60CTS)

5.4 Broken Conductor (46BC)

The element calculates the ratio of NPS to PPS currents. Where the NPS:PPS current ratio is above **46BC Setting** an output is given after the **46BC Delay**.

The Broken Conductor function can be inhibited from

Inhibit 46BC A binary or virtual input.

46BC U/C Guard A minimum load current.

46BC U/C Guard Setting (0.05, 0.1... 5x In)

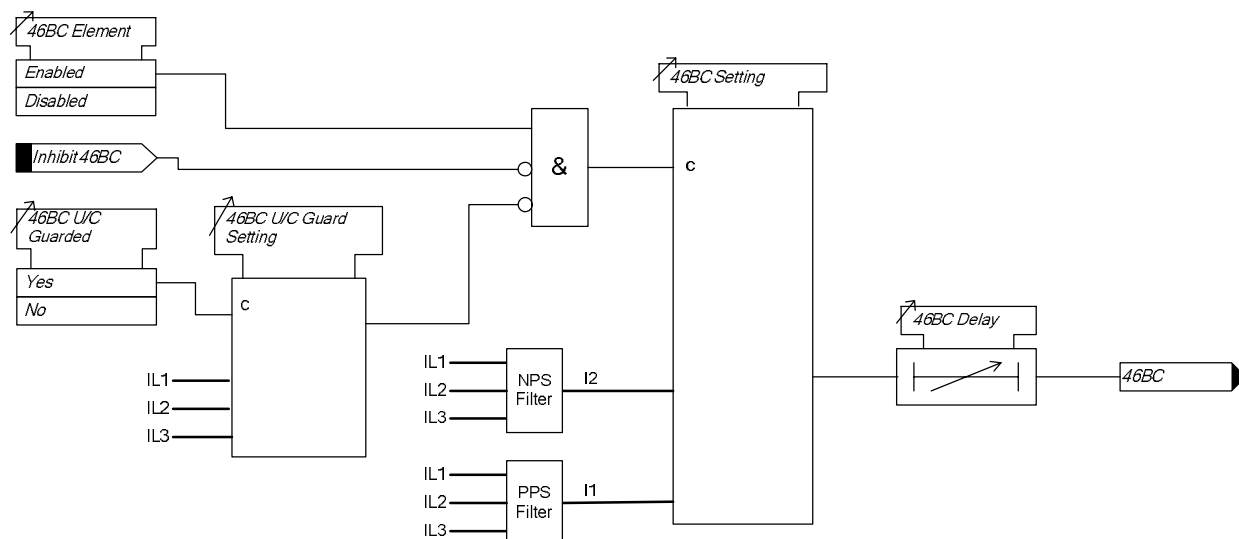


Figure 5.4-1 Logic Diagram: Broken Conductor Function (46BC)

5.5 Trip / Close Circuit Supervision (74TCS & 74CCS)

The relay provides three trip circuit supervision elements and three close circuit supervision elements. All elements are identical in operation and independent from each other allowing 3 trip and 3 close circuits to be monitored.

One or more binary inputs can be mapped to **74TCS-n**. The inputs are connected into the trip circuit such that at least one input is energised when the trip circuit wiring is intact. If all mapped inputs become de-energised, due to a break in the trip circuit wiring or loss of supply an output is given.

The **74TCS-n Delay** setting prevents failure being incorrectly indicated during circuit breaker operation. This delay should be greater than the operating time of the circuit breaker.

The use of one or two binary inputs mapped to the same Trip Circuit Supervision element (e.g. 74TCS-n) allows the user to realise several alternative monitoring schemes.

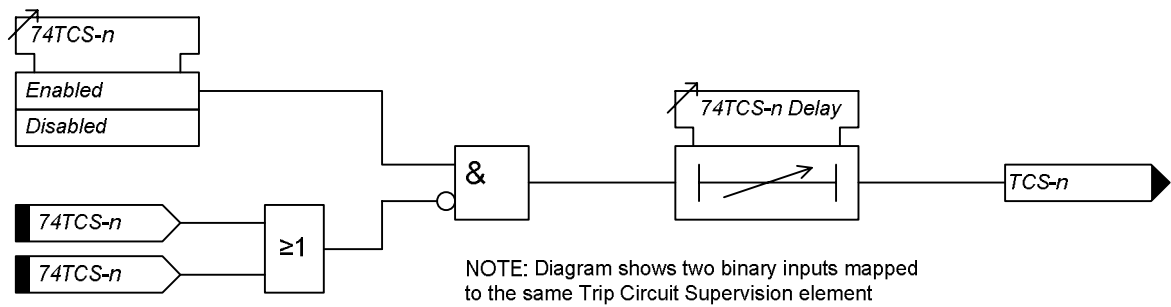


Figure 5.5-1 Logic Diagram: Trip Circuit Supervision Feature (74TCS)

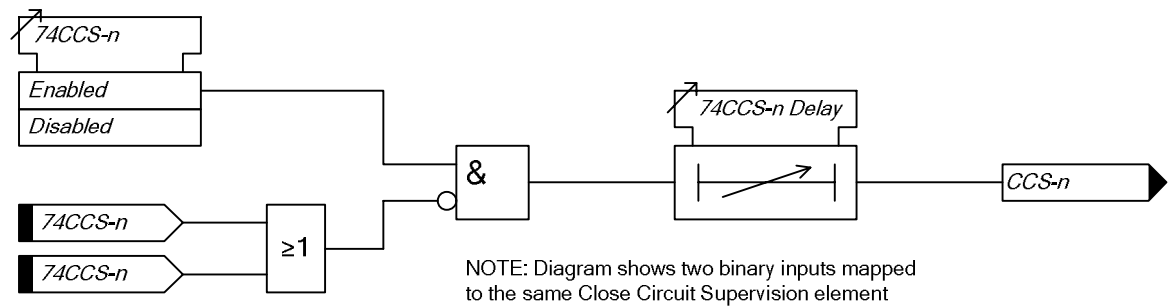


Figure 5.5-2 Logic Diagram: Close Circuit Supervision Feature (74CCS)

5.6 2nd Harmonic Block/Inrush Restraint (81HBL2) phase elements only

Inrush restraint detector elements are provided, these monitor the line currents.

The inrush restraint detector can be used to block the operation of selected elements during transformer magnetising inrush conditions.

The **81HBL2 Bias** setting allows the user to select between **Phase**, **Sum** and **Cross** methods of measurement:

Phase Each phase is inhibited separately.

Sum With this method the square root of the sum of the squares of the second harmonic in each phase is compared to each operate current individually.

Cross All phases are inhibited when any phase detects an inrush condition.

An output is given where the measured value of the second harmonic component is above the **81HBL2** setting.

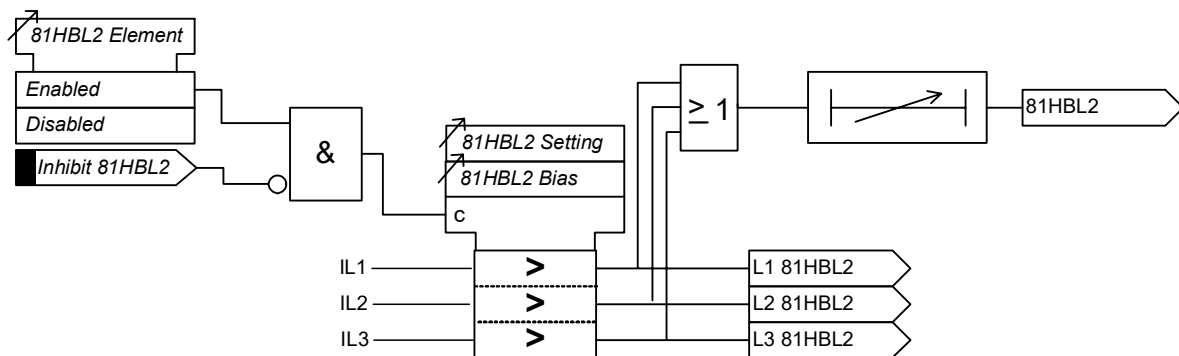


Figure 5.6-1 Functional Diagram for Harmonic Block Feature (81HBL2)

Section 6: Other Features

6.1 Data Communications

Two communication ports are provided designated COM1 and COM2. COM1 is a RS485 connection available on the terminal blocks at the rear of the relay. COM2 is a USB port provided at the front of the relay for local access using a PC.

Optionally, additional IEC61850 communication ports are available: -

2x Electrical Ethernet with RJ45 connectors IEC 61850 - (COM 3),

2x Optical Ethernet with Duplex LC 100BaseF connectors IEC 61850 - (COM 3)

The COM1 port can be selected to operate as a local or a remote port operation.

Communication is compatible with Modbus-RTU, IEC60870-5-103 FT 1.2 and DNP 3.0 transmission and application standards.

For communication with the relay via a personal computer (PC) a user-friendly software package, Reydisp Evolution or Reydisp Manager, is available to allow transfer of relay settings, waveform records, event records, fault data records, Instruments / meters and control functions. Reydisp is compatible with IEC60870-5-103.

6.2 IEC 61850 Communications

The relay can optionally be provided with IEC61850 comms.

IEC61850 is provided with an added EN100 communication module.

The following EN100 output alarms are provided:

EN100 Life:	When the relay is powered up, the EN100 Module initializes with the relay. When initialization is successful this point becomes true.
EN100 Error:	During relay operation, if an error occurs with the data communication between the EN100 module and the relay, this point becomes true. - This does not specify if there is an error with one of the communication channels (Link 1/2)
IEC61850 Configured:	This point will become true when an IEC 61850 station/network has been configured and the all 61850 associated data has been synchronized to the relay
EN100 Ch1 Link Down:	When communication is lost on the Channel 1 Ethernet port this point becomes true.
EN100 CH2 Link Down:	When communication is lost on the Channel 2 Ethernet port this point becomes true.

For further details refer to the following publications:

Model Implementation Conformance Statement (MICS)

Protocol Implementation Conformance Statement (PICS)

Protocol Implementation Extra Information for Testing (PIXIT)

6.3 Maintenance

6.3.1 Output Matrix Test

This feature is only visible from the Relay fascia and allows the user to operate the relays functions. The test of the function will automatically operate any Binary Inputs or LED's already assigned to that function.

Any protection function which is enabled in the setting menu will appear in the Output Matrix Test.

6.3.2 CB Counters

The following CB maintenance counters are provided:

CB Total Trip Count:	Increments on each trip command issued.
CB Delta Trip Count:	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.
CB Frequent Ops Count	Logs the number of trip operations in a rolling window period of one hour. An output is available to reset this counter.

Binary outputs can be mapped to each of the above counters, these outputs are energised when the user defined **Count Target** or **Alarm Limit** is reached.

6.3.3 I²t CB Wear

An I²t counter is also included; this 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 I²t value at the time of trip is added to the previously stored value and an alarm is given when any one of the three 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 I²t value can also triggered and reset from a binary input or command.

6.3.4 Start Count

Refer to 2.11 Self Monitoring.

6.4 Data Storage

6.4.1 General

The relay stores three types of data: relay event records, analogue/digital waveform records and fault records. Data records are backed up in non-volatile memory and are permanently stored even in the event of loss of auxiliary supply voltage. The data storage menu contains the settings for the Demand, Waveform and Fault storage features.

6.4.2 Demand

Maximum, minimum and mean values are available as instruments which can be read in the relay INSTRUMENTS MENU or via Reydisp.

The **Gn Demand Window** setting defines the maximum period of time over which the demand values are valid. A new set of demand values is established after expiry of the set time.

The **Gn Demand Window Type** can be set to **FIXED** or **PEAK** or **ROLLING**.

When set to **FIXED** the maximum, minimum and mean values demand statistics are calculated over fixed Window duration. At the end of each window the internal statistics are reset and a new window is started.

When set to **PEAK** the maximum and minimum values since the feature was reset are recorded.

When set to **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 every **Updated Period**.

The statistics can be reset from a binary input or communication command, after a reset the update period and window are immediately restarted.

6.4.3 Event Records

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 1000 event records that can be stored in the relay and when the event buffer is full any new record will over-write the oldest. Stored events can be erased using the DATA STORAGE>**Clear Events** setting or from Reydisp Evolution.

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 any of the control functions of the relay.
- Protection element operation.

All events can be uploaded over the data communications channel(s) and can be displayed in the 'Reydisp' package in chronological order, allowing the sequence of events to be viewed. Events can be selected to be made available spontaneously to an IEC 60870-5-103, Modbus RTU or DNP 3.0 compliant control system. The function number and event number can also be changed. The events are selected and edited using the Reydisp software tool.

6.4.4 Waveform Records.

Waveform records indicate the instantaneous magnitude of each analogue input channel and the status of each binary channel i.e. binary input, binary output, virtual I/O and LED. The values are recorded at each sampling point and are sampled at a rate of 1600 Hz.

Each recorded analogue waveform displays an input identifier, minimum value, maximum value 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.

Triggering of waveform storage is configured from the 'Settings > DATA STORAGE > WAVEFORM STORAGE' menu. Triggering is initiated 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).

The latest 8 records are stored for easy retrieval; the most recent is waveform 1. Records are archived by the relay during quiescent periods. The duration of each stored record is either: 1 s, 2 s, 4 s or 8 s depending on selection. The user can also specify the percentage of waveform storage prior to waveform triggering. When the waveform archive buffer is full (i.e. 8 records are stored) the triggering of a new waveform record causes the oldest record - waveform 8 – to be overwritten.

Stored waveforms can be deleted using the DATA STORAGE > *Clear Waveforms* setting.

6.4.5 Fault Records

Fault records are stored and can be displayed on the Fascia LCD. They can be triggered by user selected relay operations or via a suitably programmed binary input. An output is provided to indicate when a new record has been stored.

Fault records provide a summary of the relay status at the time of trip, i.e. the element that issued the trip, any elements that were picked up, the fault type, LED indications, date and time. The **Max Fault Rec. Time** setting sets the time period from fault trigger during which the operation of any LEDs is recorded.

The relay can be set to automatically display the fault record on the LCD when a fault occurs by enabling the SYSTEM CONFIG> **Trip Alert** setting. When the trip alert is enabled the fault record will be displayed until the fault is removed.

With the **Trip Alert** setting enabled the user will have to press the **TEST/RESET▶** button three times in order to return to the home screen after a trip has occurred. The user will then have to press the **TEST/RESET▶** button a further time (four in total) to reset the relay.

1. After a trip occurs the **Trip Alert** displays the time and date of the trip. The user then presses the **TEST/RESET▶** button.
2. The fault type is then displayed with the date the fault occurred. The fascia prompts the user to press the **TEST/RESET▶** button to view the details of this fault.
3. The information regarding the fault is then displayed. The user then presses the **TEST/RESET▶** button to return to the home screen.
4. Pressing the **TEST/RESET▶** button one further time will reset the relay.

With the **Trip Alert** setting disabled the user only has to press the trip reset button once to reset the relay.

When examined together the event records and the fault records will detail the full sequence of events leading to a trip.

Fault records are stored in a rolling buffer, with the oldest faults overwritten. The fault storage can be cleared with the DATA STORAGE/Fault Storage>**Clear Faults** setting or from Reydisp.

6.4.6 Disk Activity Warning

The Data Storage facilities offered by the Relay involve archiving a huge amount of data to non-volatile memory. Since such functionality is always secondary to the Protection functionality offered by the Relay, this means that data transfers can take significant amounts of time; perhaps several minutes. If the Relay is power-cycled during a storage cycle, some of the data will be lost. For this reason, the Relay can provide a visual warning (at the top-right position of the LCD) that data storage is taking place:

The 'ø' disk symbol shows that the copying of Events, Waveform Records or Fault Records, to non volatile disk storage, is currently in progress.

Whether this symbol is displayed or not is set by the SYS CONFIG > **Disk Activity Symbol** setting.

To avoid such data archiving causing a sluggish response of the HMI during Testing or Commissioning – when a considerable number of new Data records are likely to be created – it is possible to temporarily suspend it. The duration of this block is set by the SYS CONFIG > **Archiver Blocking Time** setting. Once this Time has elapsed, the block is removed and all stored data will be archived as usual.

The '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 the archiving, to non-volatile flash disk storage, is being temporarily blocked.

6.4.7 Energy Storage

The measured Power is continuously integrated (over a one-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 set by: SYSTEM CONFIG> **Export Power/Lag VAr**. With both **Export Power** (W) and **Lag VAr** (VAr) set to be **+ve**, the Direction of Energy transfer will follow the IEC convention, as shown in the figure.

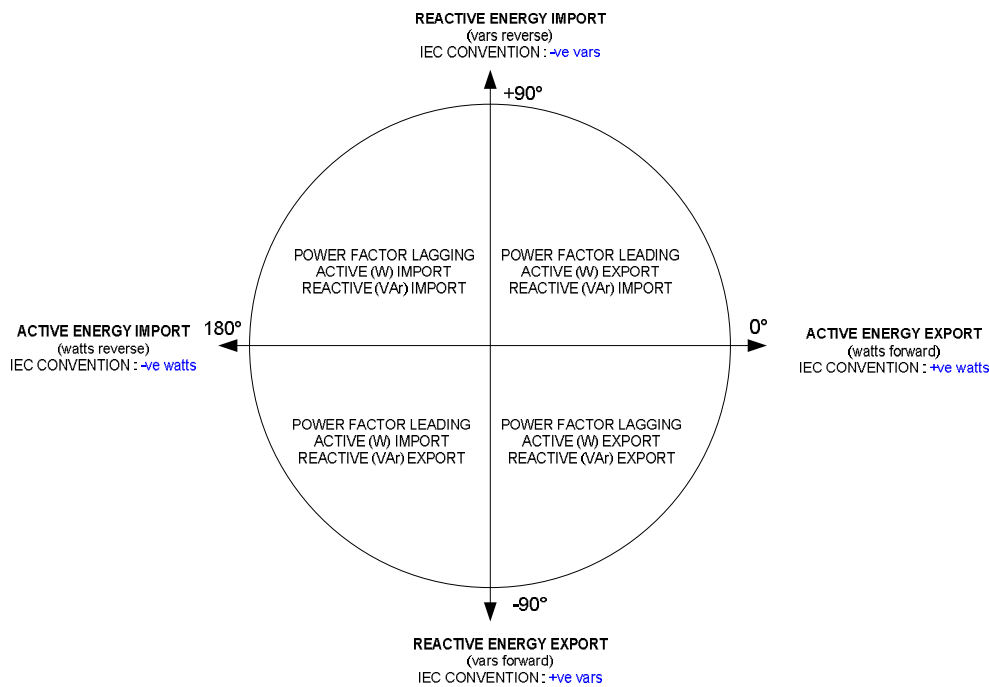


Figure 6.4.7-1 Energy Direction Convention

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.

When the accumulated Energy quantities reach a set increment, the Relay issues a pulse to the binary outputs: OUTPUT CONFIG/OUTPUT MATRIX> **Active Exp Pulse**, **Active Imp Pulse**, **Reactive Exp Pulse** and **Reactive Imp Pulse**.

The Energy increments are set by the settings: DATA STORAGE/ENERGY STORAGE> **Active Exp Energy Unit**, **Active Imp Energy Unit**, **Reactive Exp Energy Unit** and **Reactive Imp Energy Unit**. These setting also define the resolution of the stored energy values reported by instruments and communications protocols. The value is stored in the range 0-999999 which continues from zero automatically when 999999 is reached.

6.5 Metering

The metering feature provides real-time data available from the relay fascia in the 'Instruments Mode' or via the data communications interface.

The Primary values are calculated using the CT ratios set in the **CT/VT Config** menu.

The text displayed in the relays 'Instruments Mode' associated with each value can be changed from the default text using the Reydisp software tool.

The user can add the meters that are most commonly viewed to a 'Favourites' window by pressing 'ENTER' key when viewing a meter. The relay will scroll through these meters at an interval set in the **System Config/Favourite Meters Timer** menu.

The energy storage meters can be reset from a binary input and have a user selectable setting for their measurement in the **Data Storage/Energy storage menu**.

6.6 Operating Mode

The relay has three operating modes, Local, Remote and Out of Service. The following table identifies the functions operation in each mode.

The modes can be selected by the following methods: -

SYSTEM CONFIG>**OPERATING MODE** setting, a Binary Input or Command

Table 6.6-1 Operating Mode

OPERATION	REMOTE MODE	LOCAL MODE	SERVICE MODE
Control			
Rear Ports	Enabled	Disabled	Disabled
Fascia (Control Mode)	Disabled	Enabled	Disabled
USB	Disabled	Enabled	Disabled
Binary Inputs	Setting Option	Setting Option	Enabled
Binary Outputs	Enabled	Enabled	Disabled
Reporting			
Spontaneous			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
General Interrogation			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
MODBUS	Enabled	Enabled	Disabled
Changing of Settings			
Rear Ports	Enabled	Disabled	Enabled
Fascia	Enabled	Enabled	Enabled
USB	Disabled	Enabled	Enabled
Historical Information			
Waveform Records	Enabled	Enabled	Enabled
Event Records	Enabled	Enabled	Enabled
Fault Information	Enabled	Enabled	Enabled
Setting Information	Enabled	Enabled	Enabled

6.7 Control Mode

This mode provides convenient access to commonly used relay control and test functions. When any of the items listed 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 that 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 also that switching a protection function IN / OUT via the Control Menu will not change that function's ENABLED / DISABLED setting. The Control Menu selection will over-ride the setting, however.

Control Mode commands are password protected using the Control Password function – see Section 6.10.

6.8 Real Time Clock

Time and date can be set either via the relay fascia using appropriate commands in the System Config menu or via the data comms channel(s). Time and date are maintained while the relay is de-energised by a back up storage capacitor. The length of time for which this data will be maintained will depend on such things as temperature, length of time in service, etc. However the data will be maintained for a minimum of 1.8 days.

In order to maintain synchronism within a substation, the relay can be synchronised to the nearest second or minute using the communications interface, or a binary input.

The default date is set at 01/01/2000 deliberately to indicate the date has not yet been set. When editing the **Time**, only the hours and minutes can be edited. When the user presses **ENTER** after editing the seconds are zeroed and the clock begins running.

6.8.1 Time Synchronisation – Data Communication Interface

Where the data comms channel(s) is connected the relay can be directly time synchronised using the global time synchronisation. This can be from a dedicated substation automation system or from 'Reydisp Evolution' communications support software.

6.8.2 Time Synchronisation – Binary Input

A binary input can be mapped **Clock Sync from BI**. The seconds or minutes will be rounded up or down to the nearest value when the BI is energised. This input is leading edge triggered.

6.9 Settings Groups

The relay provides four groups of settings – Group number (Gn) 1 to 4. At any one time only one group of settings can be 'active' – SYSTEM CONFIG>**Active Group** setting. An output is provided to indicate which setting group is active.

It is possible to edit one 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 via a binary input. When using a binary input an alternative settings group is selected only whilst the input is energised (**Select Grp Mode: Level triggered**) or latches into the selected group after energisation of the input (**Select Grp Mode: Edge triggered**).

Settings are stored in non-volatile memory.

6.10 Password Feature

The relay incorporates two levels of password protection – one for settings, the other for control functions.

The programmable password feature enables the user to enter a 4 character alpha numeric code to secure access to the relay functions. A Password of **NONE** indicates that a Password has not been set and that the Password feature is disabled. Where a Relay is delivered with the Password already set, this will be "AAAA".

The password must be entered twice as a security measure against accidental changes. Once a password has been entered then it will be required thereafter to change settings or initiate control commands. Passwords can be de-activated by using the password to gain access and by entering the password **NONE**. Again this must be entered twice to de-activate the security system.

As soon as the user attempts to change a setting or initiate control the password is requested before any changes are allowed. Once the password has been validated, the user is 'logged on' and any further changes can be made without re-entering the password. If no more changes are made within 1 hour then the user will automatically be 'logged off', re-enabling the password feature.

The Settings Password prevents unauthorised changes to settings from the front fascia or over the data comms channel(s). The Control Password prevents unauthorised operation of controls in the relay Control Menu from the front fascia.

The password validation screen also displays a numerical code. If the password is lost or forgotten, this code should be communicated to Siemens Protection Devices Ltd. and the password can be retrieved.

7SR18 Line Differential Protection Configuration Guide

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2017/11	Typographical revisions, drawing amendments
2018/07	Amended connection diagrams, additional disposal information
2022/05	Typographical revisions to page footer, no changes to content

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2016/11	2436H80016R4d-1b	First Release
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Section 1: Introduction

1.1 Relay Menus And Display

All relay fascias contain the same access keys although the fascias may differ in appearance from model to model. The basic menu structure is also the same in all products and consists of four main menus, these being,

Settings Mode - allows the user to view and (if allowed via the settings mode password) change settings in the relay.

Instruments Mode - allows the user to view the relay meters e.g. current, etc.

Fault Data Mode - allows the user to view the type and data of any fault that the relay has detected.

Control Mode - allows the user to control external plant under the relays control for example the CB (if allowed via the control mode password)

The menus can be viewed via the LCD by pressing the access keys as below,

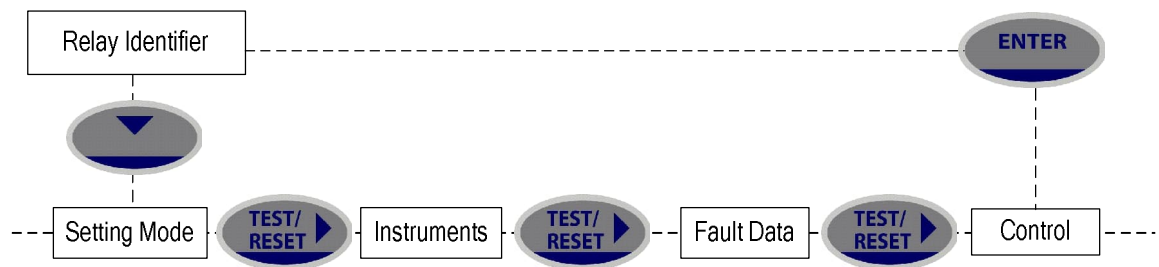


Figure 1.1-1 Menu Navigation

Pressing CANCEL returns to the Identifier screen.

LCD Contrast

To change the contrast on the LCD insert a flat nosed screwdriver into the screwhead below the contrast symbol, turning the screwhead left or right decreases and increases the contrast of the LCD.



Figure 1.1-2 Contrast symbol



Figure 1.1-3 Relay Fascia (Please note fascia may differ from illustration)

Section 2: Operation Guide

2.1 User Interface Operation

The basic menu structure flow diagram is shown in Figure 2.1-2. This diagram shows the main modes of display: Settings Mode, Instrument Mode, Fault Data Mode and Control Mode. When the relay leaves the factory all data storage areas are cleared and the settings set to default as specified in settings document.

When the relay is first energised the user is presented with the following message: -



Figure 2.1-1 Relay Identifier Screen

On the factory default setup the relay LCD should display the relay identifier, on each subsequent power-on the screen that was showing before the last power-off will be displayed. The push-buttons on the fascia are used to display and edit the relay settings via the LCD, to display and activate the control segment of the relay, to display the relays instrumentation and Fault data and to reset the output relays and LED's. The five push-buttons have the following functions: -



READ DOWN



READ UP

Used to navigate the menu structure.



ENTER

The ENTER push-button is used to initiate and accept setting changes.

When a setting is displayed pressing the ENTER key will enter the edit mode, the setting will flash and can now be changed using the ▲ or ▼ buttons. When the required value is displayed the ENTER button is pressed again to accept the change. When an instrument is displayed pressing ENTER will toggle the instruments favourite screen status.



CANCEL

This push-button is used to return the relay display to its initial status or one level up in the menu structure. Pressed repeatedly will return to the Relay Identifier screen. It is also used to reject any alterations to a setting while in the edit mode.



TEST/RESET

This push-button is used to reset the fault indication on the fascia. When on the Relay Identifier screen it also acts as a lamp test button, when pressed all LEDs will momentarily light up to indicate their correct operation. It is also moves the cursor right ► when navigating through menus and settings.

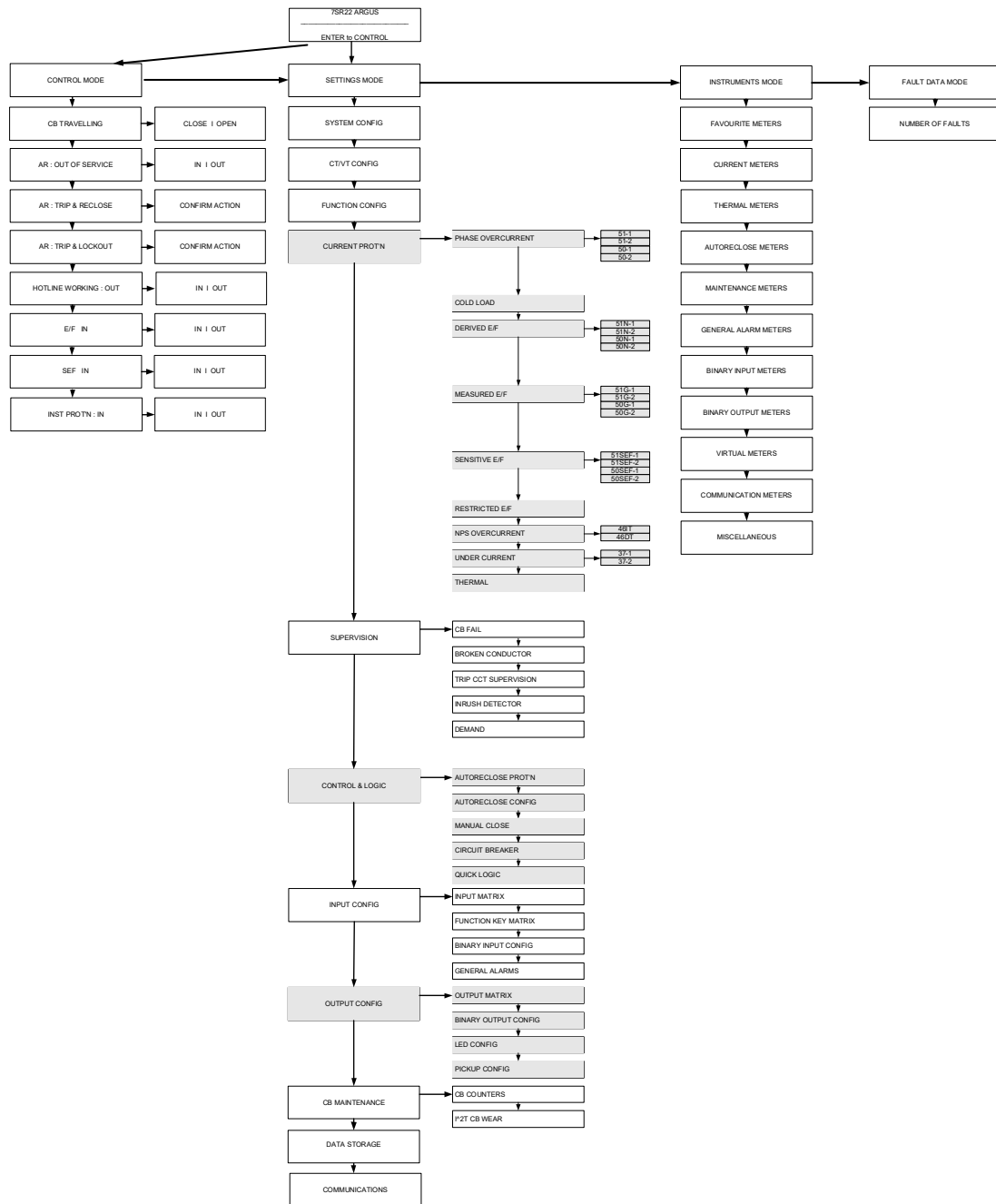


Figure 2.1-2 Typical Menu Structure

Section 3: Configuring the Relay Using Reydisp Evolution

To set the relay using the communication port the user will need the following:-

PC with Reydisp Evolution Installed. (This can be download from our website www.energy.siemens.com and found under the submenu 'Software'). This software requires windows 2000-service pack 4 or above, or windows XP with service pack 2 or above.

3.1 Physical Connection

The relay can be connected to Reydisp Evolution via any of the communication ports on the relay. Suitable communication Interface cable and converters are required depending which port is being used.

3.1.1 Front USB connection

To connect your pc locally via the front USB port.

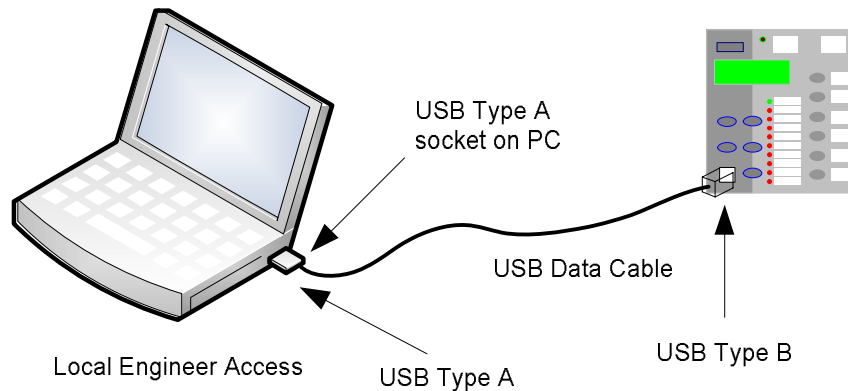


Figure 3.1.1-1 USB connection to a PC

3.1.2 Standard rear RS485 connection

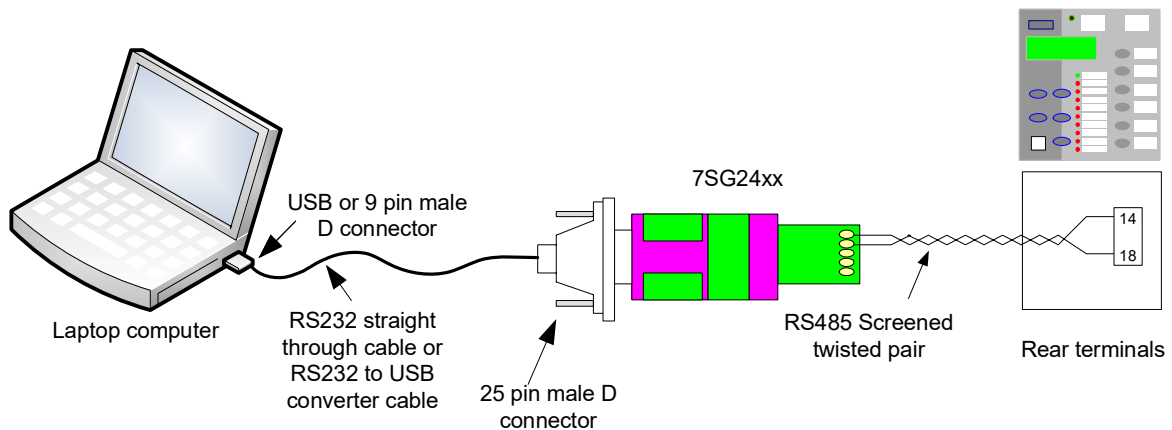
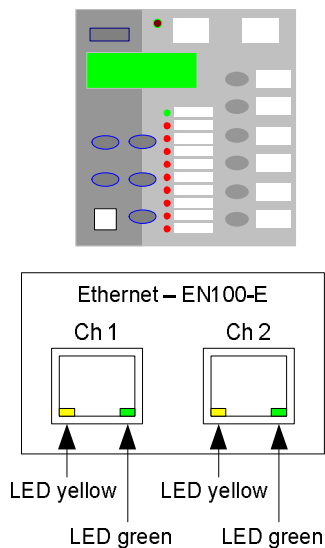


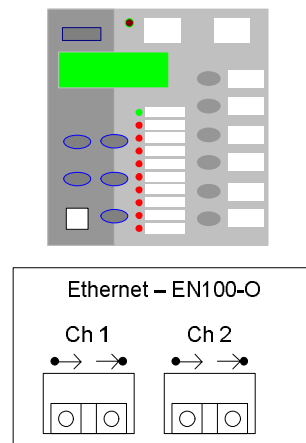
Figure 3.1.2-1 Standard rear RS485 connection to a PC

3.1.3 Optional Rear EN100 Ethernet Module

Connections are made on the rear underside of the relay either RJ45 sockets (electrical) or Duplex LC (fibre optic) connectors depending on the option ordered.



EN100 Module – RJ45 Interface



EN100 Module – Duplex-LC Interface

Green LED (Physical Link)

Off – No link

On – Link present

Yellow LED (Activity)

Off – No traffic

On/flashing – Traffic

Figure 3.1.3-1 EN100 Ethernet Module

3.1.4 Configuring Relay Data Communication

Using the keys on the relay fascia scroll down the settings menu's into the 'communications' menu and change the settings for the communication port used on the relay. All of the below settings may not be available in all relay types. Reydisp Evolution software uses IEC60870-5-103 protocol to communicate.

COM1 – Standard RS485 Rear Port

COM2 - USB Port

LAN – Optional Ethernet Ports

Setting name	Range	Default	Notes
Station Address	1 – 254 for IEC60870-5-103 0 – 247 for Modbus RTU 0 – 65520 for DNP3.0	0	Address given to relay to identify that relay from others which may be using the same path for communication as other relays for example in a fibre optic hub
COM1-RS485 Protocol	OFF, IEC60870-5-103, MODBUS-RTU, DNP3.0	IEC60870-5-103	COM1 is the rear mounted RS485 port
COM1-RS485 Baud Rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400	19200	
COM1-RS485 Parity	NONE, ODD, EVEN	EVEN	
COM2-USB Protocol	OFF, IEC60870-5-103, DNP3.0, MODBUS-RTU, ASCII	IEC60870-5-103	COM2 is the front USB port
COM2-USB Baud Rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400 57600 115200 230400 460800 921600	Auto detects	Auto detects baud rate via Connection Manager Setting
COM2-USB Parity	NONE, ODD, EVEN	EVEN	

3.1.5 Configuring Relay Protection Communication Address.

Using the keys on the relay fascia scroll down the 'Settings' menu into the 'Prot'n Comms' menu and 'Protection Comms' sub-menu to change the 'Prot'n Address'. The sum of the addresses of both relays must add to 255. This number must be divided between the relays typically as e.g. 1 & 254 or 2 & 253 or 3 & 252... etc.

Setting name	Range	Default	Notes
Protection Address	1 – 254	0	Different address could signify Local or Remote relay designation.

3.1.6 Optional Rear EN100 Ethernet Module (COM3)

The optional ethernet interface is primarily provided for support of IEC 61850 protocol. Support for IEC 870-5-103 is also provided over this interface to allow connection with Reydisp Evolution and Reydisp Manager software for interrogation, editing and download of relay settings and other data. Ordering options are available with two RJ45 electrical connectors or with two duplex LC fibre optic connectors.

Setting name	Range	Default	Setting	Notes
LAN Protocol	OFF, IEC60870-5-103	IEC60870-5-103		

If this setting is set to Off, access to relay data using Reydisp Evolution and Reydisp Manager software via the Ethernet interface is not available.

3.1.7 Connecting to the Relay via Reydisp Evolution

When Reydisp Evolution software is running all available communication ports of the PC will automatically be detected.

On the start page tool bar open up the sub-menu File > Connect.

The 'Communication Manager' window will display all available communication ports. With the preferred port highlighted, select the 'Properties' option and ensure the baud rate and parity match that selected in the relay Data Comms settings. Select 'Connect' to initiate the relay-PC connection.

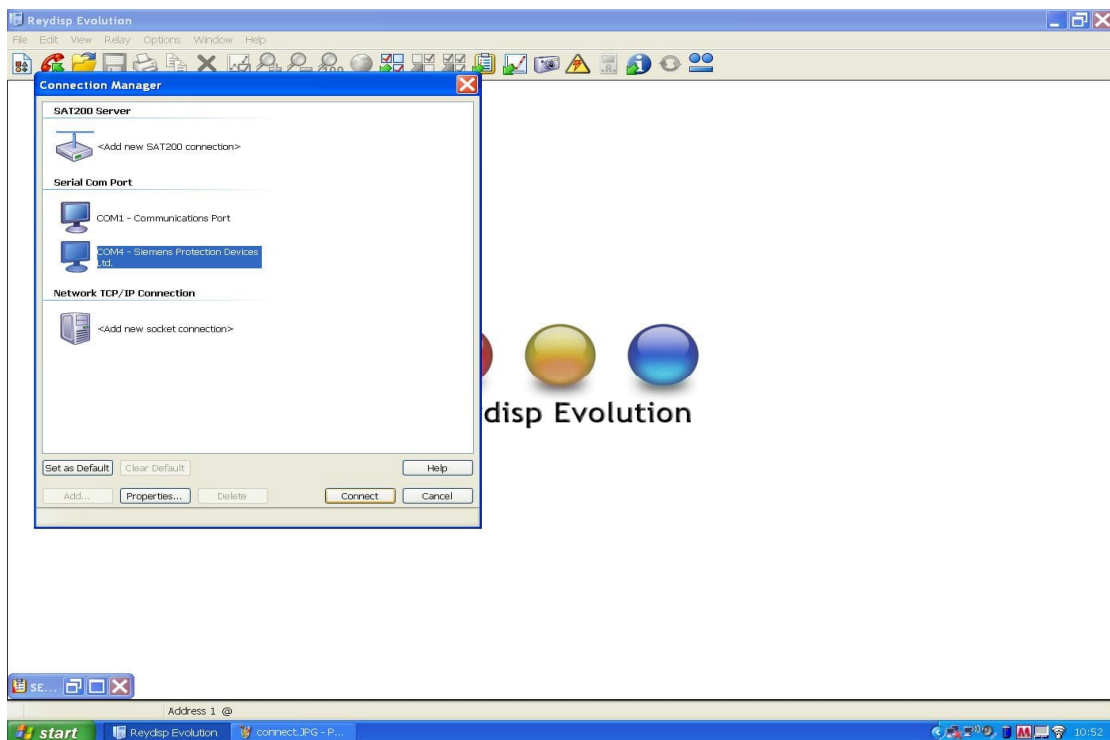


Figure 3.1.7-1 PC Comm Port Selection

Via the Relay > Set Address > Address set the relay address (1-254) or alternatively search for connected devices using the Relay > Set Address > Device Map. The relay can now be configured using the Reydisp Evolution software. Please refer to the Reydisp Evolution Manual for further guidance.

7SR18 Line Differential Protection Installation Guide

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Document Release History

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2016/11	First issue
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2023/02	Symbols list added page 5. Table 1 corrected.

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Section 1: Introduction

1.1 Packaging

Relays are supplied in packaging designed to mechanically protect them while in both transit and storage.

This packaging should be recycled where systems exist, or disposed of in a manner which does not provide a threat to health or the environment. All laws and regulations specific to the country of disposal should be adhered to.

1.2 Unpacking, Storage and Handling

On receipt remove the relay from the container in which it was received and inspect it for obvious damage. It is recommended that the relay not be removed from its case. If damage has been sustained a claim should be immediately be made against the carrier, also inform Siemens Protection Devices Limited, and the nearest Siemens agent. When not required for immediate use, Relays should be stored in their original packaging. The place of storage should be dry and free from dust. It should also not exceed the storage temperature and humidity limits of the Relay; given in the Performance Specification of this manual. The relay contains static sensitive devices, which are susceptible to damage due to static discharge. The relay's electronic circuits are protected from damage by static discharge when the relay is housed in its case. The relay element should not be withdrawn or reinserted into the relay case while auxiliary voltage is present.

If the relay element is withdrawn from its case it should be treated as an electronic device and should not be handled roughly or exposed to contamination and should be protected from damage. The relay element should be re-inserted into the case with care and without the use of excessive force. If the relay element is not to be immediately replaced the cover should be refitted to the case to prevent contamination.

To withdraw the relay element, remove the plastic front cover by rotating the two securing pins and withdraw using the plastic handles. The relay should not be carried using these handles. The relay should only be held by the top and bottom plates and the user should not touch the exposed PCB's.

The device should be isolated from the auxiliary power supply and the circuit breaker tripping and other control circuits before the relay element is withdrawn or reinserted into the relay case.

There can be no requirement to disassemble any relay, since there are no user serviceable parts in the relay. If any modules have been tampered with, then the guarantee will be invalidated. Siemens Protection Devices Limited reserves the right to charge for any subsequent repairs.

1.3 Selection of Used Symbols on the Device

No.	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
12		ESD-sensitive devices
13		CE marking
14		Mandatory conformity mark for electronics and electrotechnical products in Morocco
15		South Korea KC certification for electrical and electronic products
16		United Kingdom (UK) conformity-assessed marking
17		TSI chassis earth (ground) symbol, IEC 60417, 5020

1.4 Recommended Mounting Position

The relay uses a liquid crystal display (LCD) for programming and operation. The LCD has a vertical viewing angle of $\pm 30^\circ$ and is back-lit. However, the best viewing position is at eye level, and this is particularly important given its control features.

The relay should be mounted on the circuit-breaker (or protection panel) to allow the operator the best access to the relay features.

1.5 Wiring

The product should be wired according to the scheme requirements, with reference to the appropriate wiring diagram. Wire specification and size should be selected to suit the application.

The device does not contain any internal fuse or other user serviceable protection components. Typically the PSU is connected to the auxiliary supply via an external HRC fuse rated at 6 A (BS88/IEC60269 or suitably rated miniature circuit-breaker may be installed. Isolation links may also be installed in accordance with user requirements.

The equipment shall be isolated or disconnected from hazardous live voltage before access to potentially hazardous live parts is affected.

Note that when the Relay is powered-up for the first time, it is good practice to do so with the trip and control links removed. This limits potential damage caused by incorrect scheme wiring.

1.6 Earthing

Terminal 28 of the PSU (Power Supply Unit) should be solidly earthed by a direct connection to the panel earth. The Relay case earth stud connection should be connected to terminal 28 of the PSU. A minimum wire size of 2.5 mm² is recommended. Before any subsequent maintenance or other interaction with the device, the integrity of this protective conductor connection shall be checked before carrying out any other actions.

It is normal practice to additionally 'daisy chain' together the case (safety) earths of all the Relays installed in a panel to prevent earth current loops posing a risk to personnel.

1.7 Ancillary Equipment

The relay can be interrogated locally or remotely. For local interrogation a portable PC with suitable version of MS Windows (2000 SP4 or XP SP2) and Reydisp Evolution™ s/w (Latest Version available 32 bit) using USB port situated on front of the relay.

1.8 Disposal

The Relay should be disposed of in a manner which does not provide a threat to health or the environment. All laws and regulations specific to the country of disposal should be adhered to.

1.8.1 Environmental Protection Hints

Disposal of Old Equipment and Batteries (Applicable only for European Union and Countries with a Recycling System)

The disposal of our products and possible recycling of their components after decommissioning has to be carried out by an accredited recycling company, or the products/components must be taken to applicable collection points. Such disposal activities must comply with all local laws, guidelines and environmental specifications of the country in which the disposal is done. For the European Union the sustainable disposal of electronic scrap is defined in the respective regulation for "waste electrical and electronic equipment" (WEEE).



The crossed-out wheellie bin on the products, packaging and/or accompanying documents means that used electrical and electronic products and batteries must not be mixed with normal household waste.

According to national legislation, penalties may be charged for incorrect disposal of such waste.

By disposing of these products correctly you will help to save valuable resources and prevent any potential negative effects on human health and the environment.

NOTE: Our products and batteries must not be disposed of as household waste. For disposing batteries it is necessary to observe the local national/international directives.

Disposal of Mobile Storage Devices (e.g. USB Sticks and Memory Cards)

When disposing of/transferring mobile storage devices, using the **format** or **delete** functions only changes the file management information and does not completely delete the data from your mobile storage device. When disposing of or transferring a mobile storage device, Siemens strongly recommends physically destroying it or completely deleting data from the mobile storage device by using a commercially available computer data erasing software.

REACH/RoHS Declaration

You can find our current **REACH/RoHS** declarations at:

<https://www.siemens.com/global/en/home/products/energy/ecotransparency/ecotransparency-downloads.html>

NOTE: You can find more information about activities and programs to protect the climate at the EcoTransparency website:

<https://www.siemens.com/global/en/home/products/energy/ecotransparency.html>

Section 2: Equipment Operating Conditions

2.1 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.

2.2 External Resistors



Where external resistors are connected to the relay circuitry, these may present a danger of electric shock or burns, if touched.

2.3 Fibre Optic Communication



Where fibre optic communication ports are fitted, the lasers are Class 1 devices but recommend they should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

2.4 Front Cover



The front cover provides additional securing of the relay element within the case. The relay cover should be in place during normal operating conditions.

Section 3: Dimensions and Panel Fixings

3.1 Relay Dimensions and Weight

Relays are supplied in the modular size E6.

The following drawing which is available from the website gives panel cut-out and mounting details.

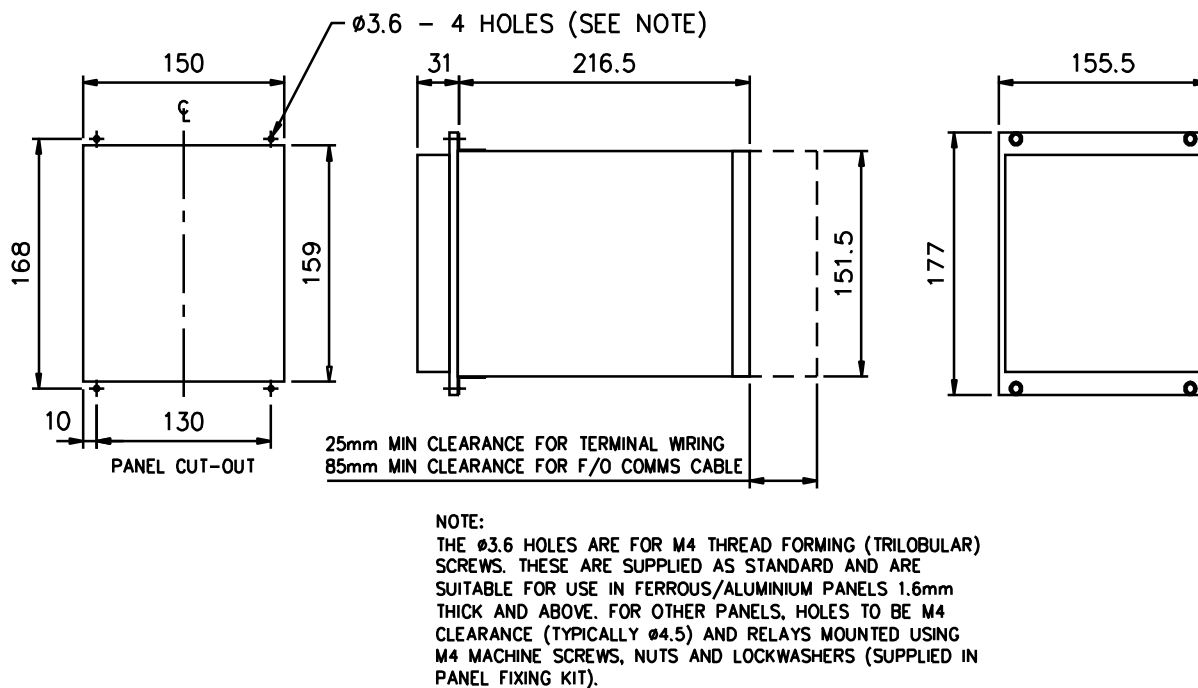


Figure 3.1-1 Overall Dimensions and Panel Drilling for Size E6 Epsilon Case

Hardware Model	Net Weight Kg
7SR1811	4.26 kg
7SR1812	4.26 kg
7SR1813	4.26 kg
7SR1814	4.26 kg

3.2 Fixings

3.2.1 Crimps

Ring crimp terminal with 90° bend are recommended.

3.2.2 Panel Fixings

Typical mounting screw kit per Relay consists of the following: -

- 4 off M4x10 mm Screws

- 4 off M4 Nuts

- 4 off M4 Lock Washer

Typical rear terminal block fixing kit (1kit per terminal block fitted to relay) consists of the following: -

- 28 off M4, 8 mm Screws

- 28 off M4 Lock Washer

Relay rear retaining screw: -

- 1 off M3x8 mm Screw

Section 4: Rear Terminal Drawings

4.1 E6 Case



Figure 4.1-1 E6 Case viewed from rear (Typical)

Notes

- 1) Recommended terminations are pre-insulated and must be crimped using approved tooling.
- 2) RS485 (Block "B" Terms 14, 16, 18, 20) connection to this communication facility is by screened, twisted pair cable. On site when wiring other facilities ensure that these terminals are not obscured by other wiring runs. Cable should be RS485 compliant.

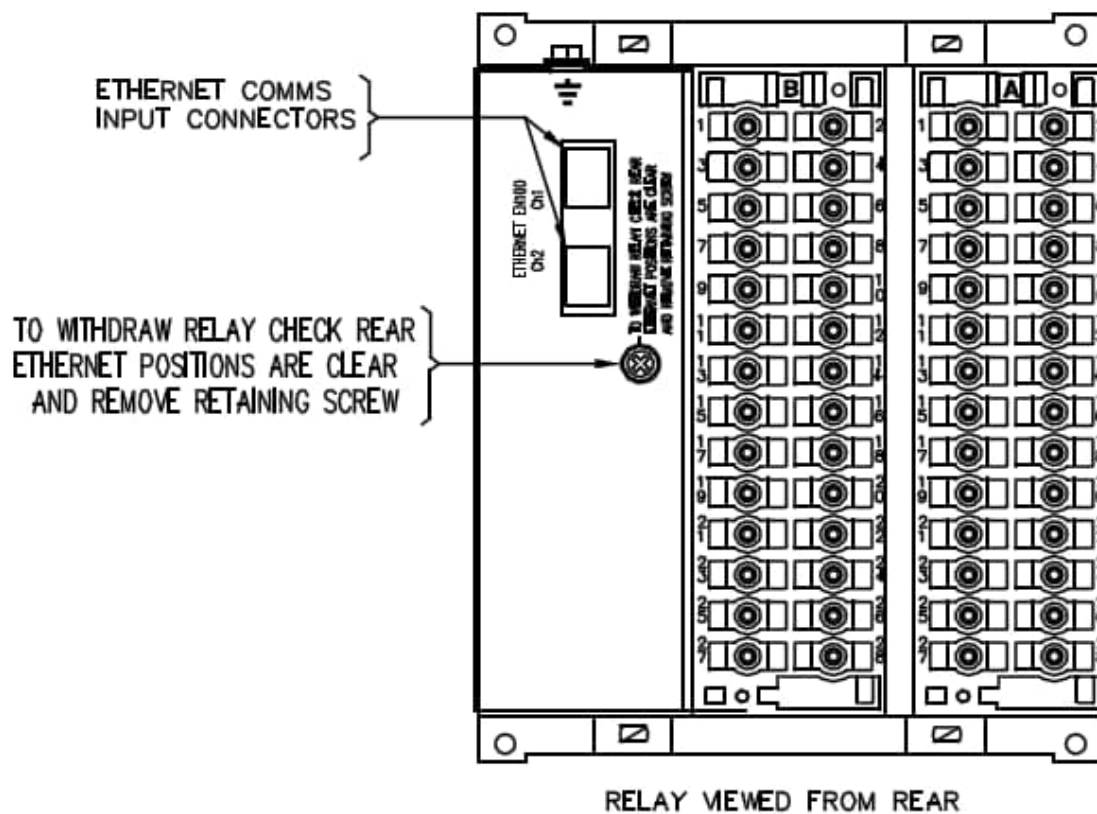


Figure 4.1-2 E6 Case Terminal Arrangement viewed from rear (Typical)

Section 5: Connection/Wiring/Diagrams

5.1 Wiring Diagram: 7SR18 Relay with 3BI & 5BO

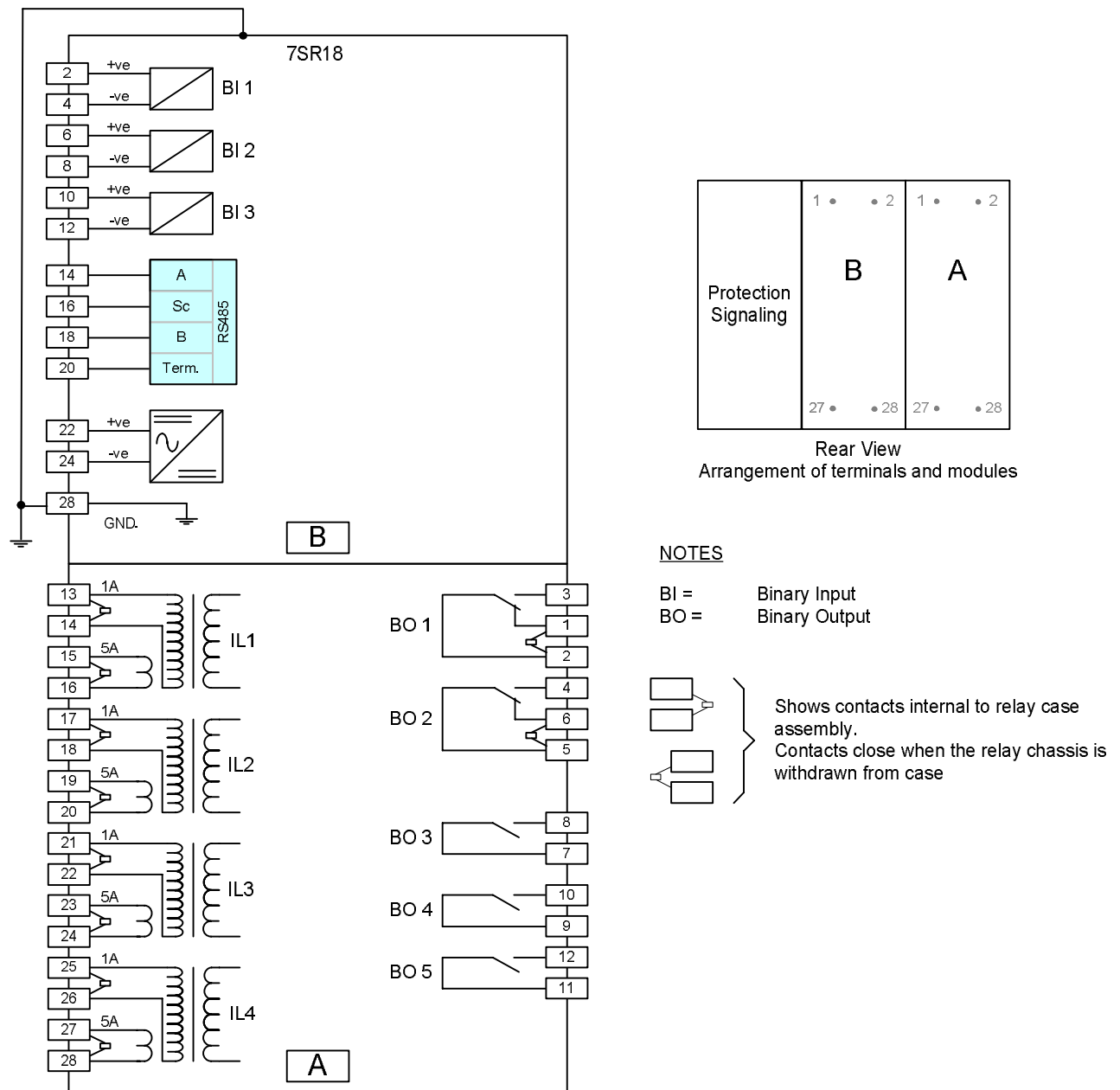


Figure 5.1-1 Connection Diagram for Non-Directional Relay (3BI 5BO)

5.2 Wiring Diagram: 7SR18 Relay with 6BI & 8BO

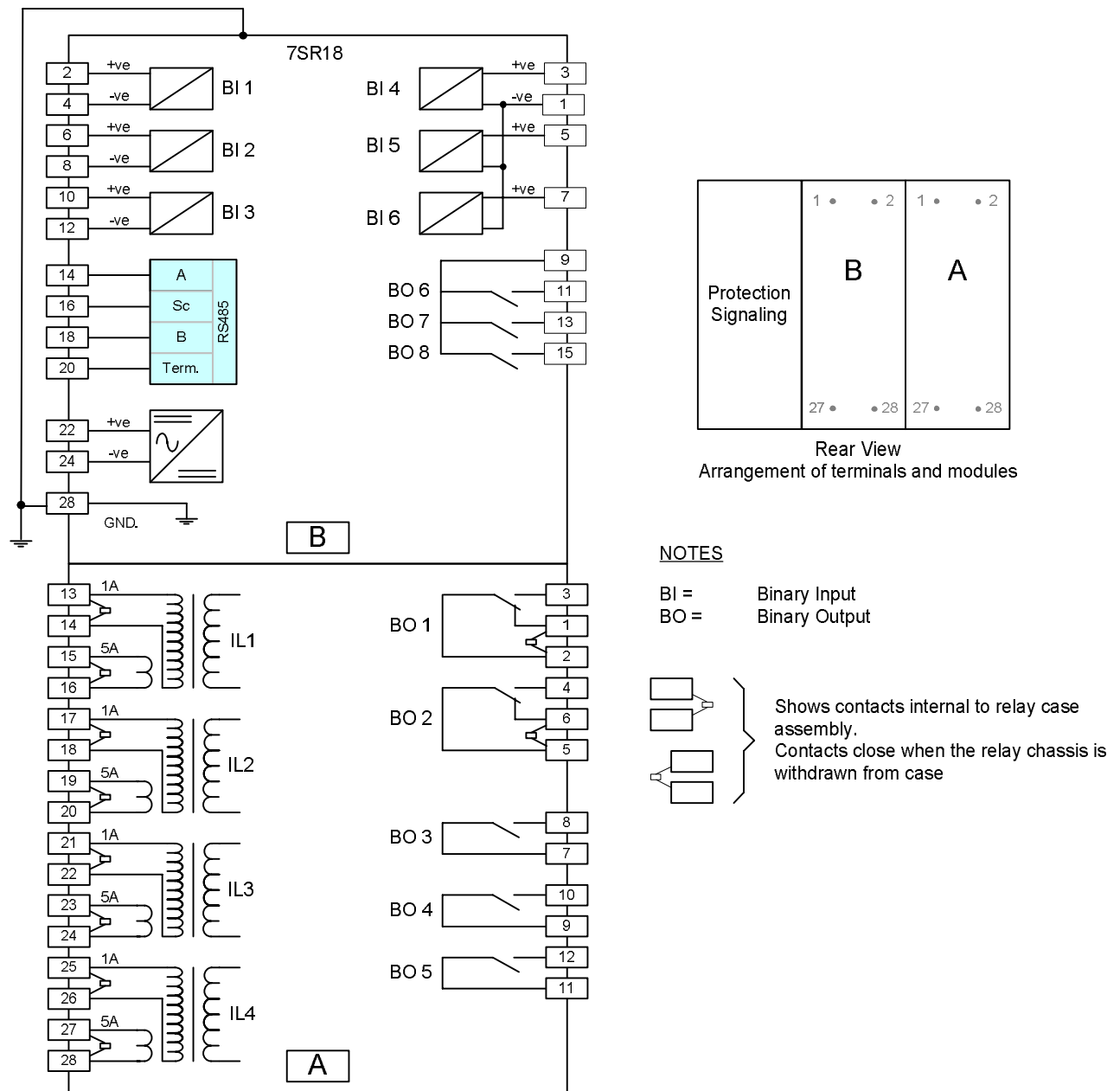


Figure 5.2-1 Connection Diagram for Non-Directional Relay (6BI 8BO)

5.3 Wiring Diagram: 7SR18 Relay with 3BI & 5BO

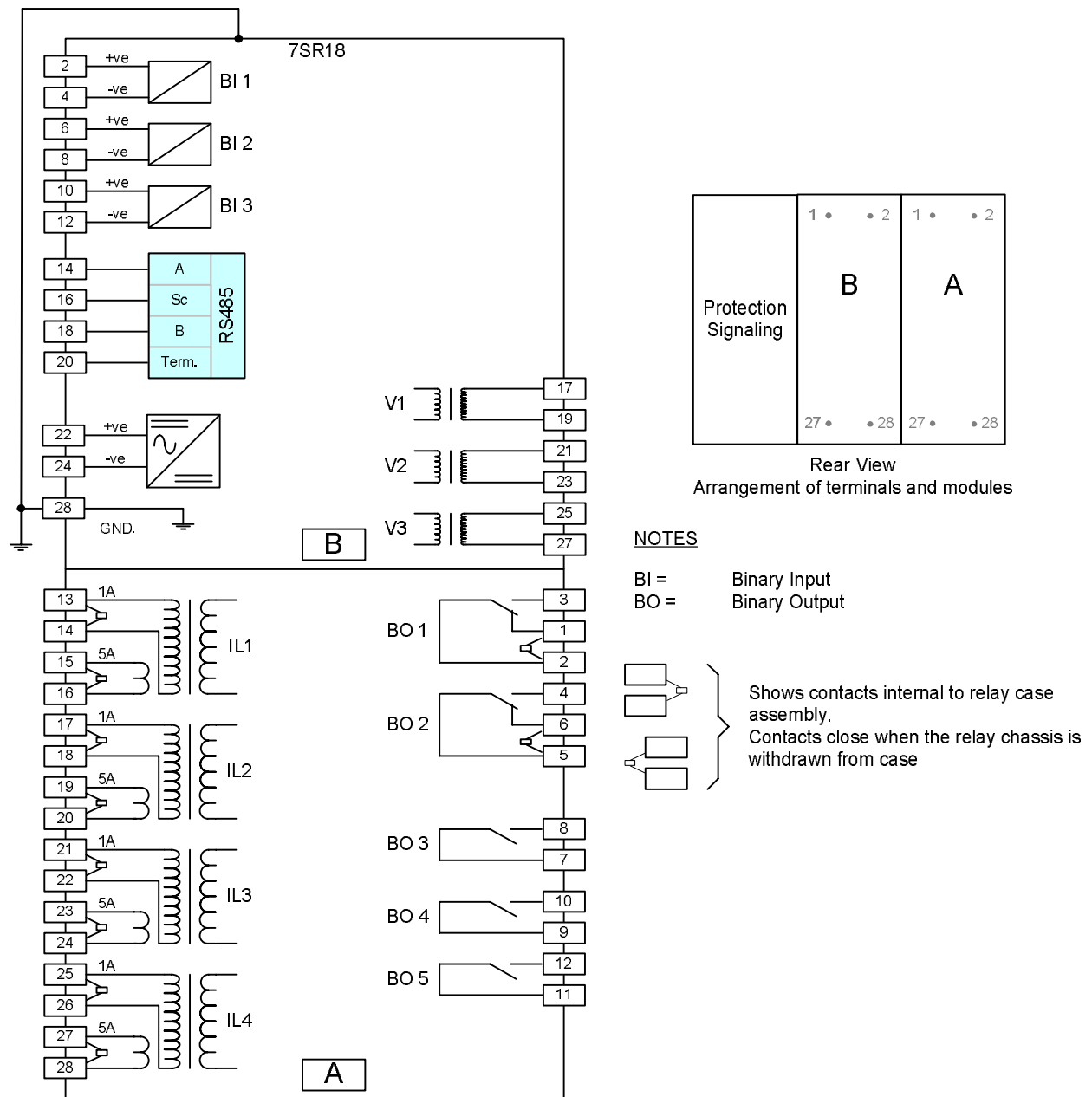


Figure 5.3-1 Connection Diagram for Directional Relay (3BI 5BO)

5.4 Wiring Diagram: 7SR18 Relay with 6BI & 8BOz

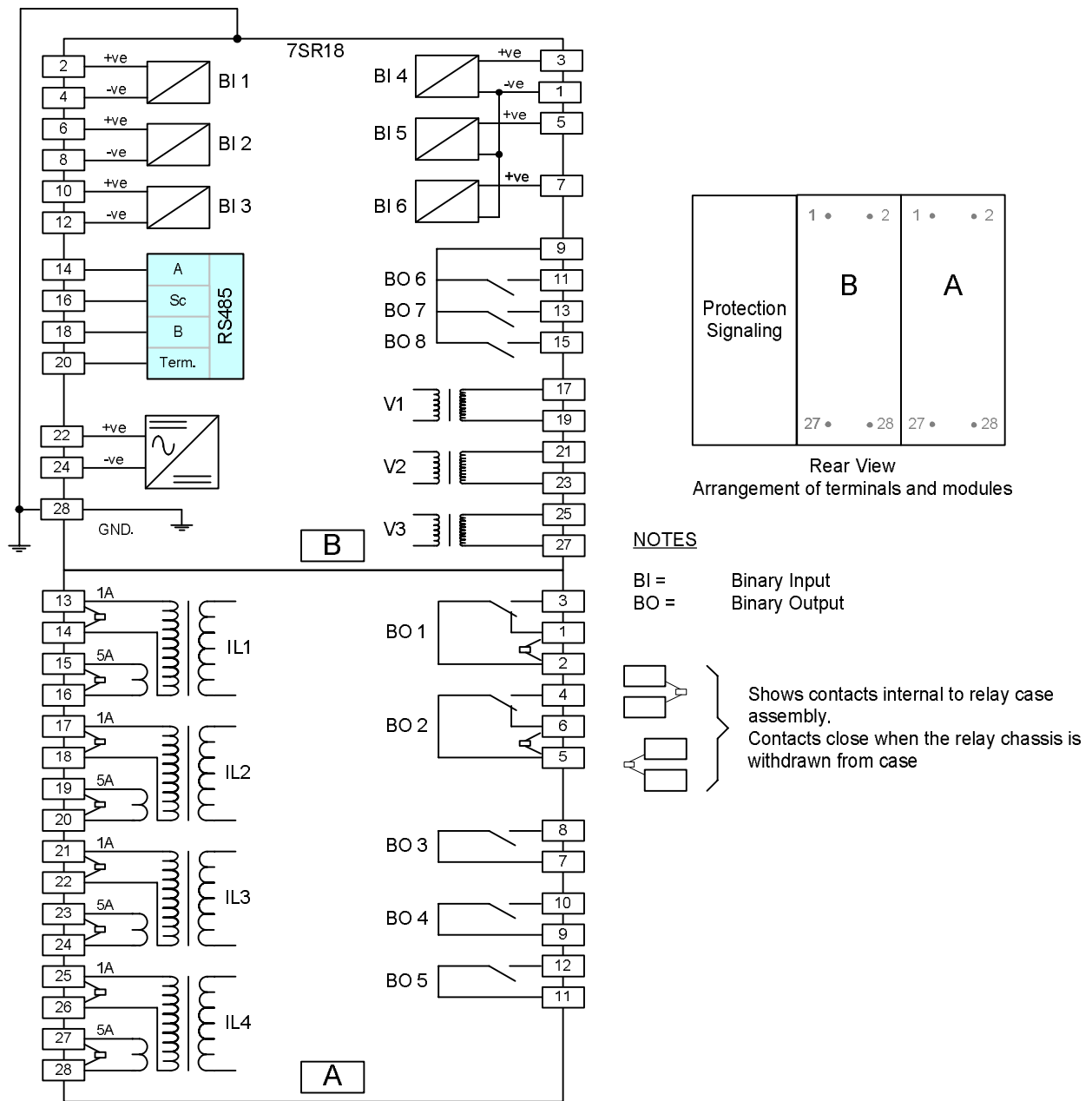
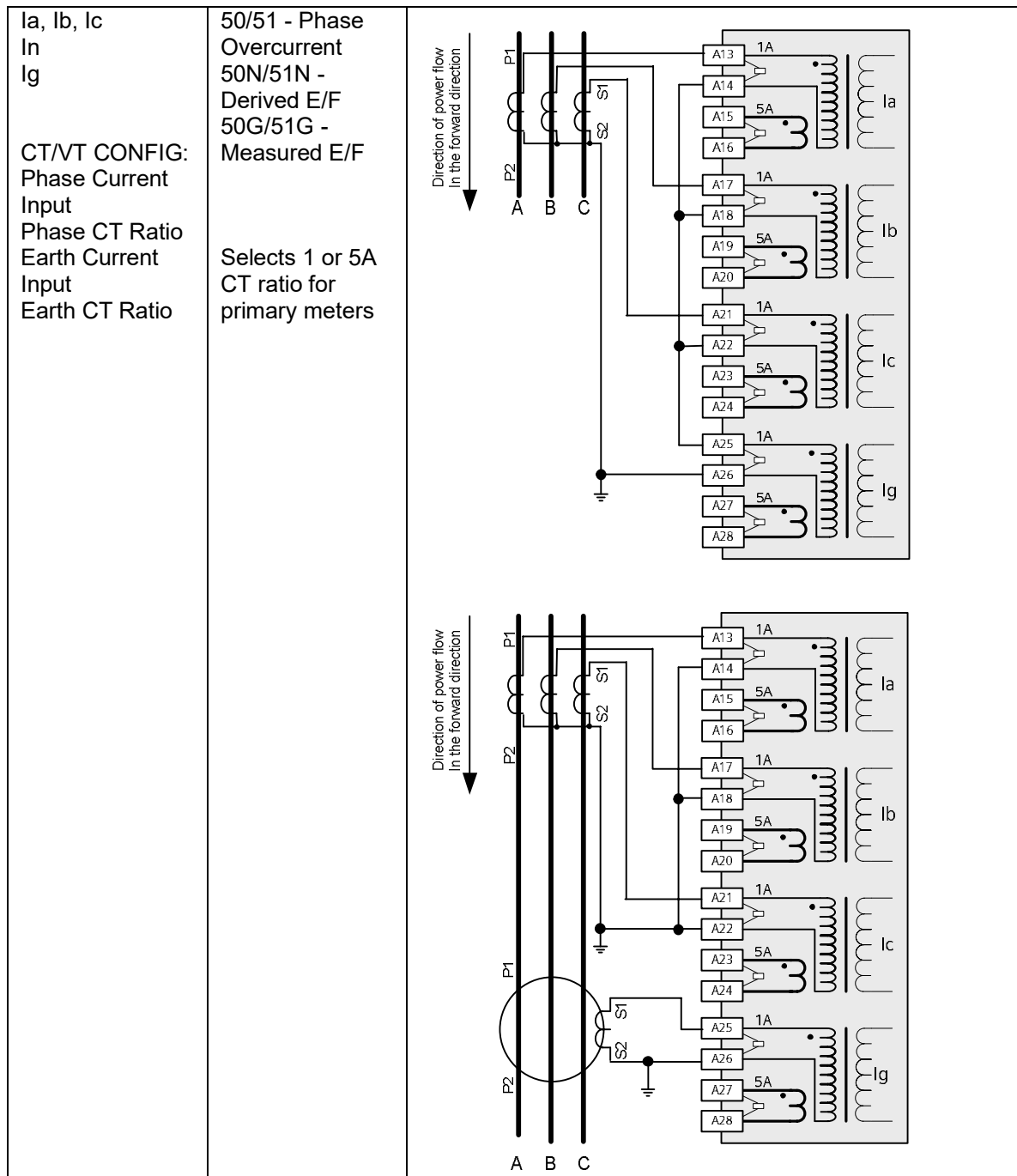
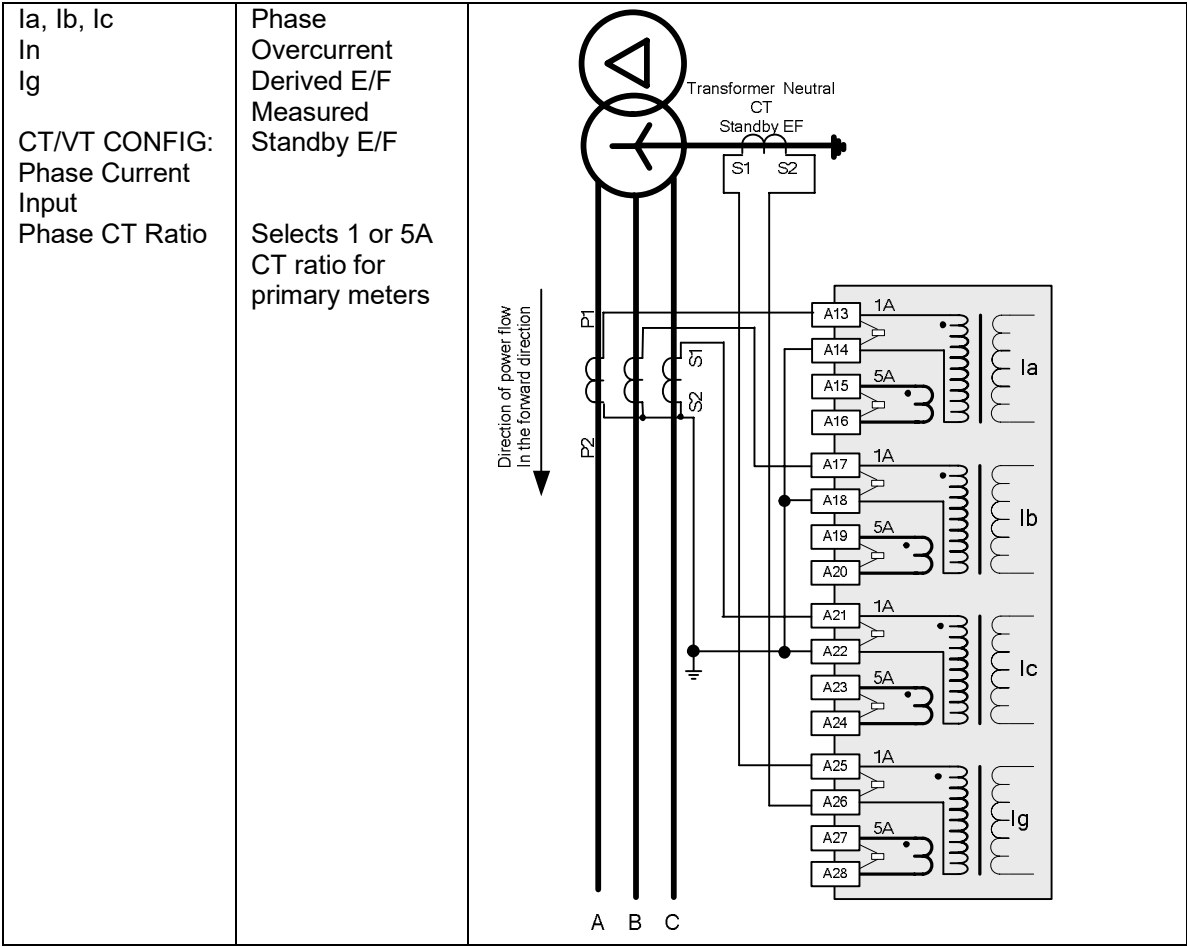


Figure 5.4-1 Connection Diagram for Directional Relay (6BI 8BO)

5.5 Typical Current Transformer Configurations

Relay Current Configuration Setting	Description	Connection
In	50G/51G - Measured E/F	
IREF	64H – Measured Restricted E/F	
Ia, Ib, Ic In CT/VT CONFIG: Phase Current Input Phase CT Ratio	50/51 - Phase Overcurrent 50N/51N - Derived E/F Selects 1 or 5A CT ratio for primary meters	





5.6 Voltage Transformer Configurations

Relay Voltage Configuration Setting	Description	Connection
Van, Vbn, Vcn	67 & 67N & 67G 47, 59N, 27/59 & 81 Phase – Neutral Phase – Phase Calculated NPS ZPS	
Va, Vb, Vc	67 & 67N & 67G 47, 27/59 & 81 Phase – Neutral Phase – Phase Calculated NPS No ZPS available	
Vab, Vbc, 3Vo	67 & 67N & 67G 47, 59N, 27/59 & 81 Phase – Neutral Calculated Phase – Phase Phase Vca Calculated NPS ZPS	

Section 6: Data Comms Connections

6.1 RS485 Connection

The RS485 communication port is located on the rear of the relay and can be connected using a suitable RS485 120Ω screened twisted pair cable.

The RS485 electrical connection can be used in a single or multi-drop configuration. The RS485 master must support and use the Auto Device Enable (ADE) feature.

The last device in the connection must be terminated correctly in accordance with the master driving the connection. A terminating resistor is fitted in each relay, when required this is connected in circuit using an external wire loop between terminals 18 and 20 of the power supply module.

The polarity of the signal terminals is marked as A and B in line with the RS485 standard. The polarity is that when the bus is in the quiescent state and no communication is taking place, the B terminal is more positive than A. This can be used to identify the polarity of any equipment to be connected, typically measured at each terminal in turn to ground. Connection of the device to a termination network at the end of the bus will also be to suit the quiescent state as shown below.

The polarity marking is often found to be reversed or marked as +/- on other equipment so care is required. If the devices are connected in reverse, communication to all devices will be disturbed but no damage will occur. If problems are experienced during commissioning, the connections should be tried in reverse.

Up to 64 relays can be connected to the RS485 bus.

The RS485 data communications link with a particular relay will be broken if the relay element is withdrawn from the case, all other relays will still communicate.

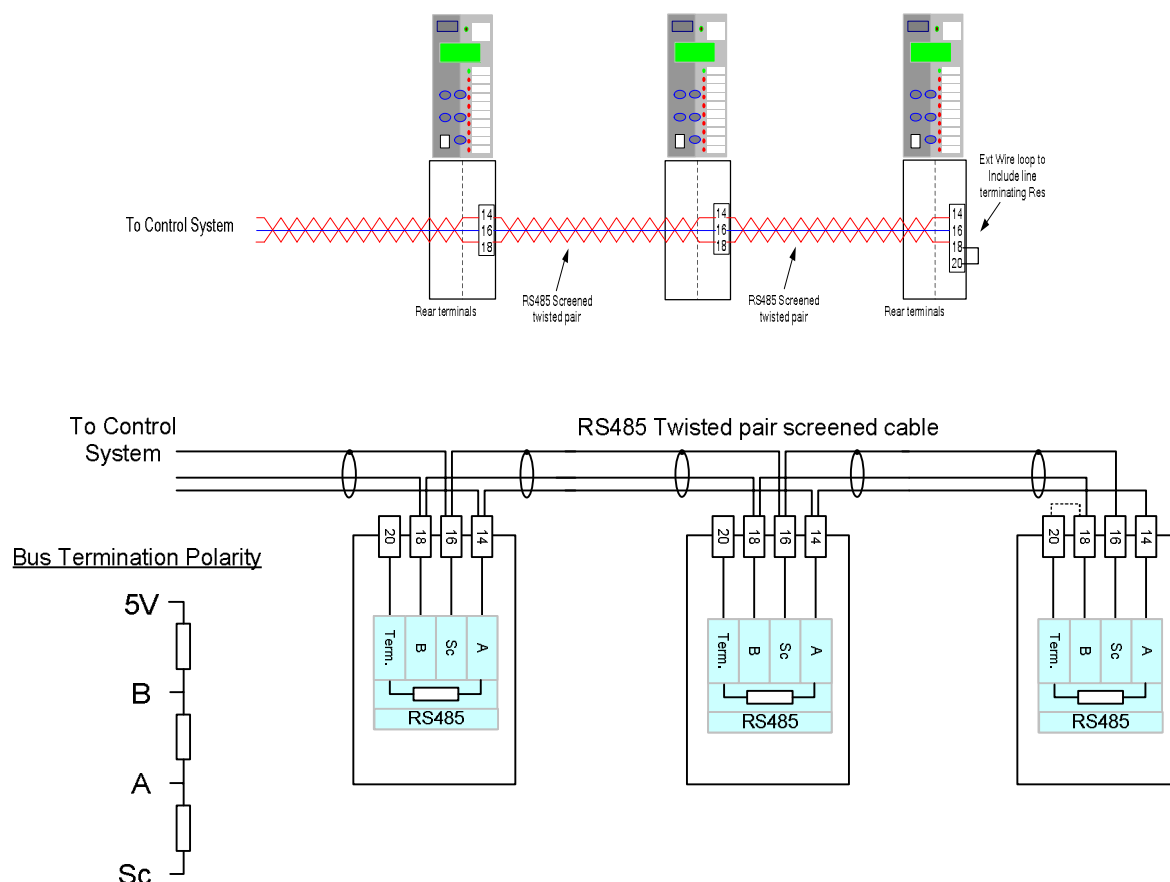


Figure 6.1-1 RS485 Data Comms Connections Between Relays

6.2 Protection Signalling Communication Connection

The connections between Local and Remote relays must be connected in a cross-over manner e.g. Tx on Local relay to RX on Remote relay, or top connection on Local relay to bottom connection on Remote relay.

6.3 Additional (Optional) Ethernet Connection for IEC 61850

Rear Ethernet Comms port Ch 1 and Ch 2 comprises Duplex LC 100BaseF in acc. With IEEE802.3 Fibre–Optic or RJ45 100BaseF in acc. With IEEE802.3 electrical connectors.

When installing fibre, ensure that the fibres' bend radii comply with the recommended minimum for the fibre used—typically 50 mm is acceptable, 62.5/125 μm glass fibre with Duplex-LC connector recommended for all distances.

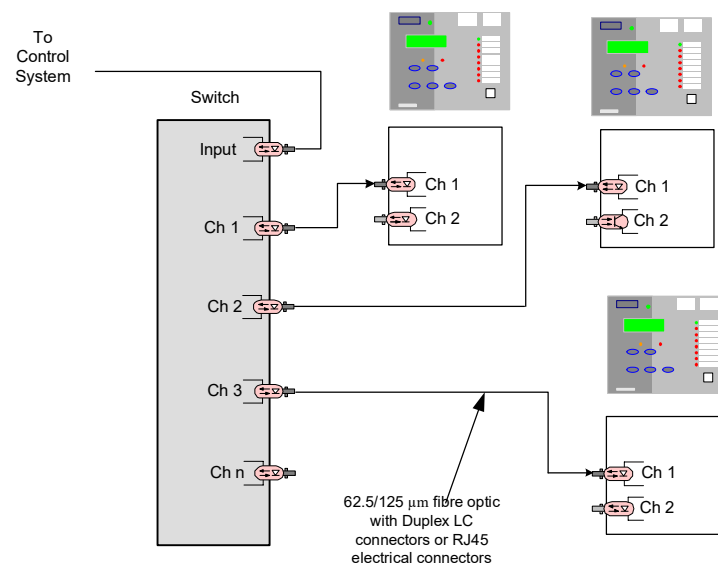


Figure 6.3-1 Ethernet connection for IEC 61850 (star connection)

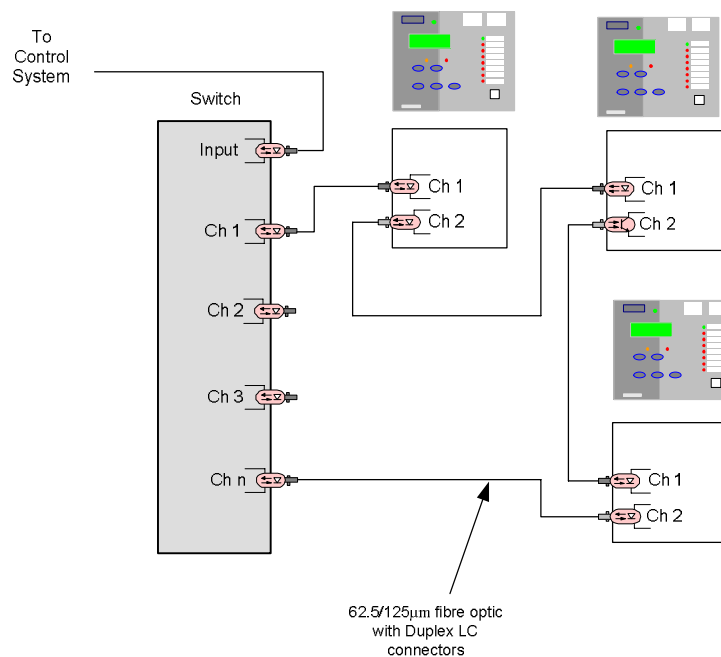


Figure 6.3-2 Ethernet connection for IEC 61850 (ring connection)

6.4 Ethernet Network Redundancy IEC 61850

The EN100 module is used on Reyrolle devices to provide Ethernet/IEC61850 functionality. The EN100 supports RSTP, PRP & HSR redundancy protocols.

All IEC61850 variants are delivered with the EN100+ (Plus) module and firmware 4.21 or later.

The EN100 module firmware can be updated by connecting to the relay via the rear Ethernet port. For more information on connecting to the relay via the Ethernet port, please see the Reydisp Manager Userguide. Depending on the EN100 module type and Firmware version, the following protocol options are available:

Interface Type	EN100 Firmware	Line Mode	Switch Mode			
			RSTP	OSM	PRP	HSR
Electrical RJ45 EN100+	4.08 or earlier	✓	✓	✓	✗	✗
Electrical RJ45 EN100+	4.21 and later	✓	✓	✓	✓	✓
Optical EN100+	4.08 or earlier	✓	✓	✓	✗	✗
Optical EN100+	4.21 and later	✓	✓	✓	✓	✓

Table 1: EN100 Redundancy availability

6.4.1 RSTP – Rapid Spanning Tree Protocol

RSTP is a redundancy protocol with a minimal response time that has been standardized in IEEE-802.1D (2004). The reconfiguration time depends on the topology and starts at 50ms.

RSTP needs to be enabled on the device within Reydisp Manager (See Reydisp Manager userguide). Network rings with up to 30 devices are possible.

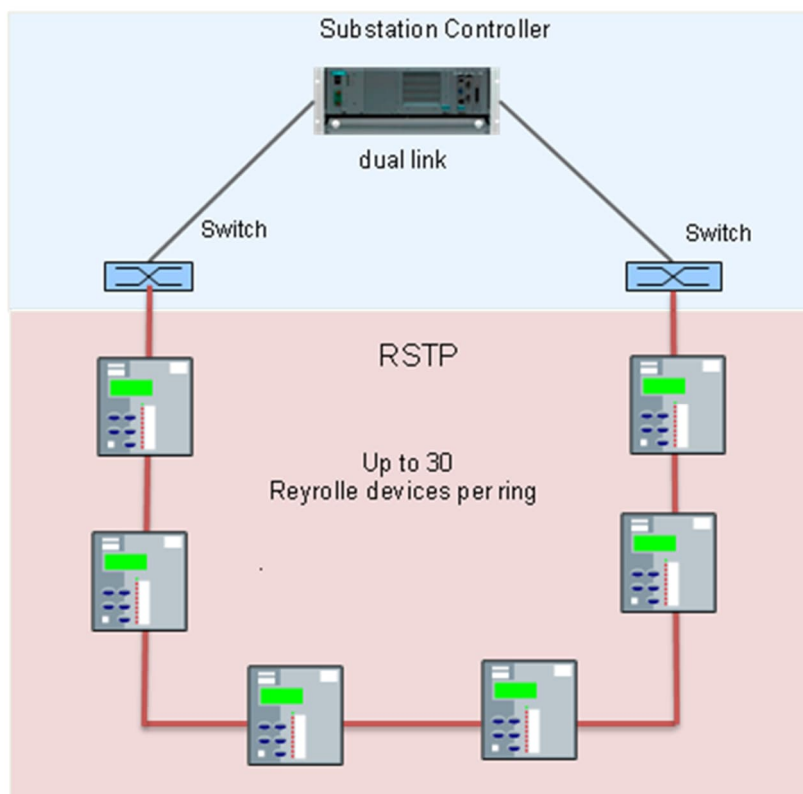


Figure 6.4.1-1 RSTP Ethernet Network Ring configuration

6.4.2 PRP – Parallel Redundancy Protocol

The HSR redundancy protocol according to the IEC 62439-3 standard is based on double transmission of message frames over ring-topology networks in both directions. In the case of an error, the message frame will be transmitted without any delay. No reconfiguration time is necessary for the network, as is the case for RSTP.

PRP need to be enabled on the device within Reydisp Manager (See Reydisp Manager userguide).

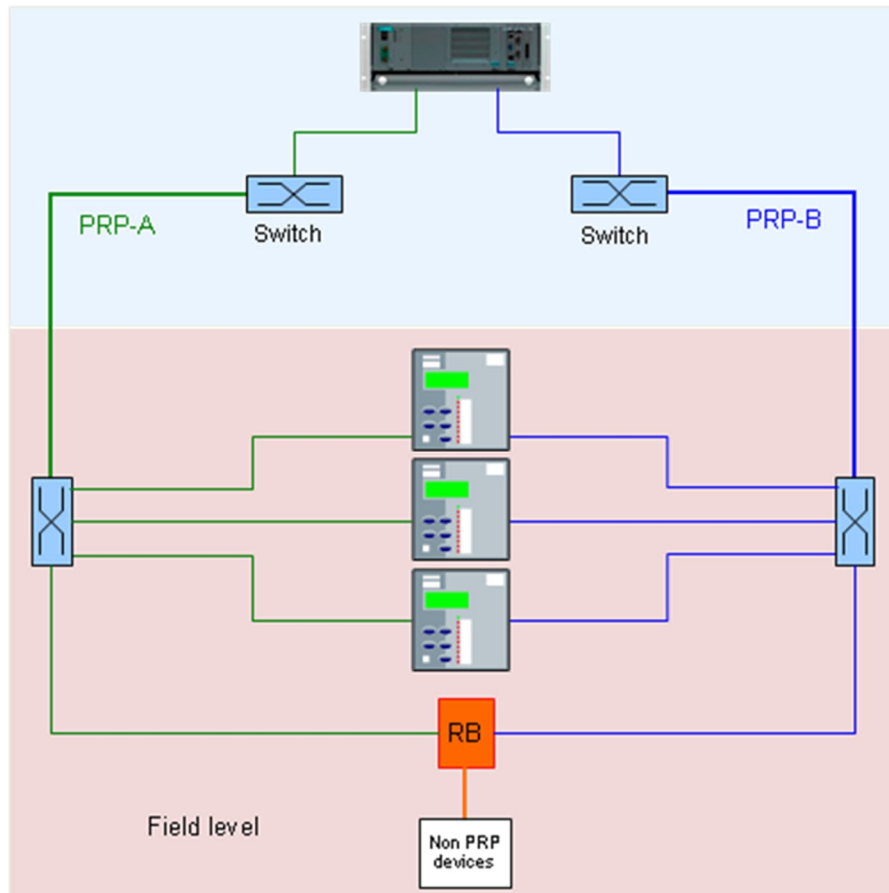


Figure 6.4.2-1 PRP Ethernet Network Configuration

6.4.3 HSR – High Availability Seamless Redundancy Protocol

The HSR redundancy protocol according to the IEC 62439-3 standard is based on double transmission of message frames over ring-topology networks in both directions. In the case of an error, the message frame will be transmitted without any delay. No reconfiguration time is necessary for the network.

HSR needs to be enabled on the device within Reydisp Manager (See Reydisp Manager user guide). Network rings with up to 50 devices is possible.

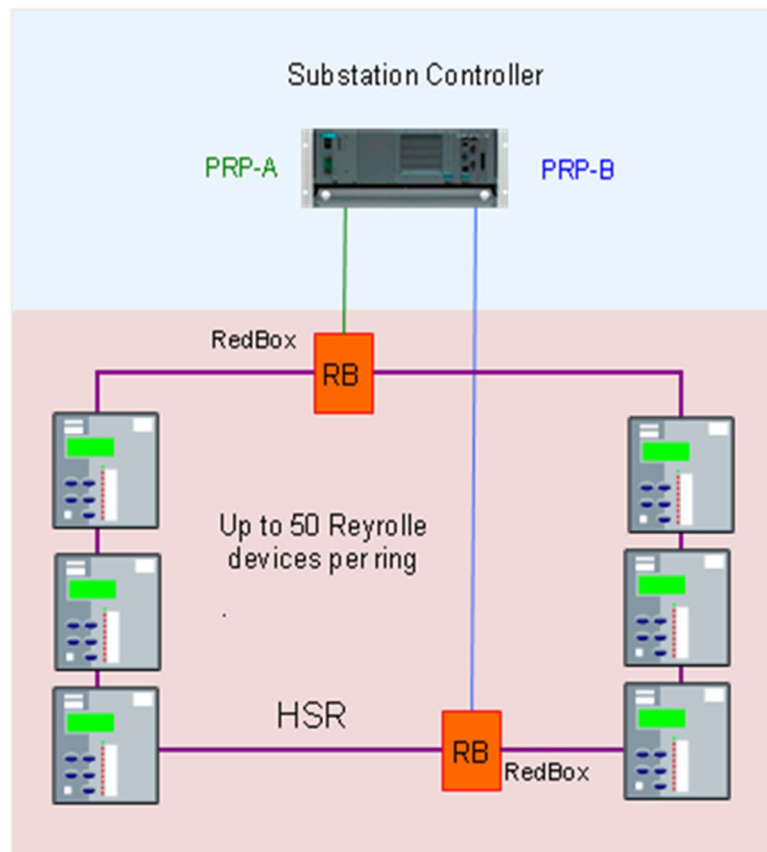


Figure 6.4.3-1 HSR Ethernet Network Ring Configuration

7SR18 Line Differential Protection Performance Specification

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This document is issue 2023/02. The list of revisions up to and including this issue is: -

2016/11	First issue
2017/11	Typographical revisions, drawing amendments, added data.
2018/02	Typographical revisions, drawing amendments, added data.
2018/07	Amended connection diagrams, additional disposal information
2019/03	Typographical revisions, amended data.
2022/05	Typographical revisions to page footer, no changes to content
2023/02	UKCA compliance added 1.1.1

Software Revision History

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2018/07	2436H80016R4i-1c	Software maintenance to address production SW upload.

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Section 1: Common Functions

1.1 General

1.1.1 CE and UKCA Conformity



This product is CE and UKCA compliant to relevant EU directives.

1.1.2 Reference

This product complies with IEC 60255-1

1.1.3 Accuracy Reference Conditions

This product has been tested under the following conditions, unless specifically stated otherwise.

Parameter	Value
Auxiliary supply	nominal
Frequency	nominal
Ambient temperature	20 °C

1.1.4 Dimensions

Parameter	Value
Width	155.5 mm
Height	177 mm
Depth behind panel, including clearance for: -	
Wiring	241.5 mm
Fibre Optic	286.5 mm
Ethernet enclosure	261.5 mm
Depth below Ethernet variant for cables	75 mm
Projection (from front of panel)	31 mm

See appropriate case outline and panel drilling drawing, as specified in Diagrams and Parameters of the Installation section, for complete dimensional specifications.

1.1.5 Weights

Parameter	Value (Typical)
Net weight	7SR1811 4.26 kg
	7SR1812 4.26 kg
	7SR1813 4.26 kg
	7SR1814 4.26 kg

1.2 Energising Quantities

1.2.1 Auxiliary Power Supply

IEC60255-26

Nominal Operating Range		Absolute Range*	Comments
V	24 V DC to 250 V DC 100 V AC to 230 V AC	19.2 V DC to 275 V DC, 80 V AC to 253 V AC	Universal voltage PSU suitable for 24 V DC, 48 V DC, 60 V DC, 110 V DC, 125 V DC and 250 V DC 100 V AC, 110 V AC, 115 V AC, 120 V AC, 200 V AC and 230 V AC

*No relay operation outside of this range is permissible or implied.

1.2.1.1 Burden

Battery loading can be estimated from the following approximate figures (Universal PSU): -

Attribute	Watts (DC)					
Voltage (V)	24	48	60	110	220	250
Quiescent Relay (inc. PROT HEALTHY LED)	10.87	10.18	10.02	9.68	9.02	9.10
PROT HEALTHY LED, all BI, all BO, all LEDs, LCD on	12.38	11.47	11.34	11.00	10.34	10.45
PROT HEALTHY LED, BO 1 on, LCD on	9.60	8.93	8.76	8.58	7.92	7.98
PROT HEALTHY LED, BO 1 on, LCD off	8.30	7.87	7.74	7.48	7.04	7.15

Attribute	VA (AC) 50 Hz					
Voltage (V)	100	110	115	120	200	230
Quiescent Relay (inc. PROT HEALTHY LED)	18.20	19.36	20.01	20.64	26.60	28.29
PROT HEALTHY LED, all BI, all BO, all LEDs, LCD on	19.40	20.79	21.39	22.20	30.00	30.36
PROT HEALTHY LED, BO 1 on, LCD on	17.10	18.15	18.63	19.08	23.80	25.30
PROT HEALTHY LED, BO 1 on, LCD off	17.00	17.49	17.71	18.00	21.40	22.77

Attribute	VA (AC) 60 Hz					
Voltage (V)	100	110	115	120	200	230
Quiescent Relay (inc. PROT HEALTHY LED)	21.40	22.44	22.66	23.04	26.60	28.06
PROT HEALTHY LED, all BI, all BO, all LEDs, LCD on	23.40	24.75	25.53	26.16	30.00	31.28
PROT HEALTHY LED, BO 1 on, LCD on	19.30	19.91	20.24	20.64	23.80	25.07
PROT HEALTHY LED, BO 1 on, LCD off	17.20	17.82	18.17	18.48	21.20	22.31

1.2.1.2 Operational Features

Attribute	Value	Comments
0 % Dip Withstand Period	50 ms	
Dip Immunity Acquisition Period	5 minutes	Typical time after switch on to attain claimed immunity to dips
NOTE: Dips in supply that fall below the minimum voltage for a period greater than the 0 % Dip Withstand Period will invoke a relay reset.		
During conditions of auxiliary input voltage variations which are not described ⁽¹⁾ in section 1.6.3.1, the relay may enter a safety protection mode where a power supply shutdown occurs. This condition is designed to protect the power supply from damage as well as prevent internal relay faults from developing into dangerous situations. Once the relay has entered this safety mode, it may be necessary to reduce the auxiliary input voltage to zero volts for up to 30 seconds before re-application of the auxiliary supply will cause the relay to power up and operate normally.		
(1) Using fuses as on/off switches or allowing batteries to run at very low cell voltages for extended periods and then attempting to re-charge them, are examples of such auxiliary supply conditions.		

1.2.2 AC Analogue Current

Nominal		Measuring Range
I_n	1 A & 5 A Phase and Earth	$80 \times I_n$
f_n	50 Hz or 60 Hz	47.5 Hz to 52.5 Hz and 57 Hz to 63 Hz

Note. 1 A and 5 A nominal inputs are user selectable on each model.

1.2.2.1 Burden

Attribute	Value – Phase and Earth	
	1 A	5 A
AC Burden	$\leq 0.1 \text{ VA}$	$\leq 0.3 \text{ VA}$
Input Impedance (typical)	0.05Ω	0.01Ω

1.2.2.2 Thermal Withstand

Overload Period	Overload Current	
	Phase and Earth	
	1 A	5 A
Continuous (1 hour)	$4.0 \times I_n$	
3 minutes	$5.0 \times I_n$	
2 minutes	$6.0 \times I_n$	
3 seconds	57.7 A	202 A
2 seconds	70.7 A	247 A
1 second	100 A	350 A
1 cycle	700 A	2500 A

1.2.3 AC Analogue Voltage

Attribute	Nominal	Operating Range
V_n	40 to 160 Vrms	0 to 200 Vrms
f_n	50, 60Hz	47.5 to 52.5Hz and 57 to 63Hz

1.2.3.1 Burden

Attribute	Value
AC Burden	- 0.02 VA @ 63.5 V , ≤ 0.06 VA @ 110 Vrms

1.2.3.2 Thermal Withstand

Attribute	Value
Overvoltage Withstand (Continuous) (1 hour)	300 Vrms

1.2.4 Binary (Digital) Outputs

Contact rating to IEC 60255-1

Attribute	Value
Carry continuously	5 A AC or DC
Make and carry ($L/R \leq 40$ ms and $V \leq 300$ V)	for 0.5 s 20 A AC or DC
	for 0.2 s 30 A AC or DC
Break (≤ 5 A and ≤ 300 V)	AC resistive 1250 VA
	AC inductive 250 VA at p.f. ≤ 0.4
	DC resistive 75 W
	DC inductive 30 W at $L/R \leq 40$ ms 50 W at $L/R \leq 10$ ms
Contact Operate / Release Time	7 ms / 3 ms
Minimum number of operations	1000 at maximum load
Minimum recommended load	0.5 W at minimum of 10 mA or 5 V

1.2.5 Binary (Digital) Inputs

DC operation

	Nominal	Operating Range
V_{BI}	19 V DC	17 V DC to 320 V DC
	88 V DC	74 V DC to 320 V DC

AC operation

	Nominal	Operating Range
V_{BI}	19 V DC	92 V _{RMS} to 138 V _{RMS}

1.2.5.1 DC Performance

Attribute	Value
Maximum DC current for operation	$V_{BI} = 19$ V 1.5 mA
	$V_{BI} = 88$ V 1.5 mA
Reset/Operate voltage ratio	$\geq 90\%$
Response time	< 9 ms
Response time when programmed to energise an output relay contact (i.e. includes output relay operation)	< 20 ms

The binary inputs have a low minimum operate current and may be set for high speed operation. Where a binary input is both used to influence a control function (e.g. provide a tripping function) and it is considered to be susceptible to mal-operation due to capacitive currents, the external circuitry can be modified to provide immunity to such disturbances.

To achieve immunity from AC interference, a BI pick-up delay of typically one-cycle can be applied.

1.2.5.2 AC Performance

Attribute		Value
Maximum peak current for operation	$V_{BI} = 19 \text{ V}$	1.5 mA
Response time $>115 V_{RMSAC}$		< 16 ms
Response time when programmed to energise an output relay contact (i.e. includes output relay operation)		< 26 ms

For AC operation the BI pick-up delay should be set to 0 ms and the drop-off delay to 25 ms.
For AC operation wiring should be less than 10 metres in length.

1.3 Functional performance**1.3.1 Instrumentation**

	Instrument Value	Reference	Typical accuracy
I	Current	$0.1 \times I_n \leq I \leq 3.0 \times I_n$	$\pm 1 \% I_n$
V	Voltage	$0.8 \times V_n \leq V \leq 1.2 \times V_n$	$\pm 1 \% V_n$
W, Var, VA	Power, real and apparent	$V = V_n, I \geq 0.1 \times I_n, pf \geq 0.8$	$\pm 3\% P_n$, where $P_n = V_n \times I_n$
pf	Power factor	$V = V_n, I \geq 0.1 \times I_n, pf \geq 0.8$	± 0.05
F	Frequency	$F = 47.5 \text{ to } 52.5 \text{ Hz @ } 50 \text{ Hz}$ and $57 \text{ to } 63 \text{ Hz @ } 60 \text{ Hz}$	$\pm 10 \text{ mHz}$

1.3.2 Real Time Clock**1.3.2.1 Internal Clock**

The specification below applies only while no external synchronisation signal (e.g. 60870-5-103) is being received.

Attribute	Value
Accuracy (-10 °C to +55 °C)	$\pm 3.5 \text{ p.p.m}$

1.4 Data Communication Interfaces

1.4.1 USB 2.0 Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	USB-Type Standard B

1.4.2 RS485 Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	4 mm Ring Crimp

1.4.3 Fibre Optic Ethernet Data Communication Interface (IEC61850 Option)

Attribute	Value
Physical layer	Fibre-optic
Connectors	Duplex LC 100BaseF in acc. With IEEE802.3
Recommended fibre	62.5/125 µm glass fibre with Duplex-LC connector
Transmission Speed	100 MBits/s
Optical Wavelength	1300 nm
Bridgeable distance	2 km

1.4.4 Electrical Ethernet Data Communication Interface (IEC61850 Option)

Attribute	Value
Physical layer	Electrical
Connectors	RJ45 100BaseF in acc. With IEEE802.3
Transmission Speed	100 MBits/s
Test Voltage (with regard to socket)	500 VAC 50 Hz
Bridgeable distance	20 m

1.5 Protection Interfaces and Connections

1.5.1 Differential Protection

Description / Attribute	Value
Number of Devices for protected zone	2

1.5.2 Protection Interfaces

Type	Value
Optical Fibre Data Interface	
Maximum Distance Multi-Mode	Up to 2 km ¹⁾
Protocol	Full Duplex
Connector Type	ST TM (BFOC/2.5)
Transmission Level	max -10 dBm _{ave} min -15 dBm _{ave} Typical -12 dBm _{ave}
Receiver Sensitivity	-24 dBm _{ave}
Optical Wavelength	820 nm
Optical Budget	12 dB
LED Class 1	Using multi-mode fibre 62.5 µm / 125 µm
Range	Assume a path attenuation of 3.5 dB/km (5.6 dB / mile) for multi-mode fibre. For multi-mode fibre you must additionally take the product of the bandwidth lengths into consideration.

¹⁾ Based on fibre attenuations: -

Assumes no joins in the fibre, but includes a 3 dB safety margin.

Actual losses for specific application should be calculated using cable manufacturers data or by direct measurement using specialised equipment.

Type	Value
Optical Fibre Data Interface:	
Maximum Distance Single-Mode	Up to 40 km ¹⁾
Protocol	Full Duplex
Connector Type	Duplex LC, Small Form-Factor Pluggable Device
Transmission Level	max -0 dBm _{ave} min -5 dBm _{ave}
Receiver Sensitivity	-34 dBm _{ave}
Optical Wavelength	1300 nm
Optical Budget	16 dB
Laser Class 1 according to EN 60825-1/-2	Using single-mode fibre 9 µm / 125 µm
Range	Assume a path attenuation of 0.5 dB / km (0.8 dB / mile).

¹⁾ Based on fibre attenuations: -

Assumes no joins in the fibre, but includes a 3 dB safety margin.

Actual losses for specific application should be calculated using cable manufacturers data or by direct measurement using specialised equipment.

Maximum Distance (km): -

$$\text{Maximum Distance (km)} = \frac{\text{Power Budget (dB)} - \text{Safety margin (dB)} - \text{Signal Loss}}{\text{Fibre Attenuation per km}}$$

Where: -

Signal Loss = (Splice Attenuation x No of Splices) + (Connection Attenuation x No of Connections) + Safety Margin

Application Note:

Maximum distances are dependent upon good connections / lowest signal losses.

1.6 Environmental Performance

1.6.1 General

1.6.1.1 Temperature

IEC 60068-2-1

Type	Level
Operating range	-10 °C to +55 °C
Storage range	-25 °C to +70 °C

1.6.1.2 Humidity

IEC 60068-2-30, IEC 60068-2-78

Type	Level
Operational test (Indoor)	56 days at 40 °C and 93 % relative humidity
Operational test (Outdoor)	6 cycles at 24 h between +25 °C (97% r.h.) and +55 °C (93% r.h.)

1.6.1.3 Transient Overvoltage

IEC 60255-27

Type	Level
Between all terminals and earth, or between any two independent circuits	5.0 kV, 1.2/50 µs 0.5 j

1.6.1.4 Insulation Class

IEC 60255-27

Type	Level
Insulation Class when mounted in normal position of use	Class I

Insulation

IEC 60255-27

Type	Level
Between any terminal and earth	2.5 kV AC RMS for 1 min
Between independent circuits	
Across normally open contacts	1.0 kV AC RMS for 1 min

1.6.1.5 Installation Category

IEC 60255-27

Type	Level
Installation Category (Overvoltage Category)	Category III

1.6.1.6 Pollution Degree

IEC 60255-27

Level	
Pollution Degree when mounted in its normal position of use.	Pollution Degree 2

1.6.1.7 IP Ratings

IEC60529

Type		Level
Installed with cover on	Rear	IP 10
	Front	IP 51
Installed with cover removed	Rear	IP 10
	Front	IP 20

1.6.2 Emissions**1.6.2.1 Radiated Emissions – Enclosure Port**

IEC 60255-26

Type	Limits at 10 m, Quasi-peak
30 MHz to 230 MHz	40 dB(μ V/m)
230 MHz to 1000 MHz	47 dB(μ V/m)

1.6.2.2 Conducted Emissions – Auxiliary Supply Port

IEC 60255-26

Type	Limits	
	Quasi-peak	Average
0.15 MHz to 0.5 MHz	79 dB(μ V)	66 dB(μ V)
0.5 MHz to 30 MHz	73 dB(μ V)	60 dB(μ V)

1.6.3 Immunity

1.6.3.1 Auxiliary Supply Variation

IEC 60255-26

Type of Phenomena	Test Specifications	Duration	Declared Operation
Voltage Dips (DC auxiliary supply)	0 % RV	50 ms (claimed)	Normal Operation ¹
	40 % RV	200 ms	Normal operation ¹ except where Dip falls below the relay minimum voltage then Relay Restart ²
	70 % RV	500 ms	Normal operation ¹ except where Dip falls below the relay minimum voltage then Relay Restart ²
Voltage Dips (AC auxiliary supply)	0 % RV	2.5/3 cycles @ 50 Hz / 60 Hz (claimed)	Normal operation ¹ except where Dip falls below the relay minimum voltage then Relay Restart ²
	40 % RV	10/12 cycles @ 50 Hz / 60Hz	Normal operation ¹ except where Dip falls below the relay minimum voltage then Relay Restart ²
	70 % RV	25/30 cycles @ 50 Hz / 60 Hz	Normal Operation ¹
Voltage Interruptions (DC auxiliary supply)	0 % RV	5 s	Relay Restart ²
Voltage Interruptions (AC auxiliary supply)	0 % RV	250/300 cycles @ 50 Hz / 60 Hz	Relay Reset ²
Alternating Component In DC (Ripple) (DC auxiliary supply)	15 % max and min RV	Continuous	Normal operation ¹
Gradual Shut-down/ Start-up (DC auxiliary supply)	Max & min RV to 0 V	60 s	Relay Reset
	0V	5 minutes	Relay Off
	0 V to min & max RV	60 s	Relay Restart ²
Reversal of DC Power Supply polarity	Max reversed RV	1 minute	24 V to 250 V DC No operation 100 V to 230 V AC Normal Operation ¹

Key:

RV = Residual Voltage Test Value. Two conditions: (a) range voltage low -20 % and
(b) range voltage high +20 %

¹ No effect on relay performance

² Restart with no mal-operation, loss of data or relay damage

1.6.3.2 Slow Damped Oscillatory Wave

IEC 60255-26

Type	Level
Differential mode	1.0 kV
Common mode	2.5 kV

1.6.3.3 Electrostatic Discharge

IEC 60255-26

Type	Level	Variation
Contact Discharge	6 kV (Level 3)	≤ 5 %
Air Discharge	8 kV (Level 3)	≤ 5 %
Air Discharge	15 kV (Level 4)	≤ 5 %

1.6.3.4 Radiated Radio Frequency Electromagnetic Field Immunity

IEC 60255-26

Type	Level
80 MHz to 1000 MHz (Sweep)	10 V/m
1.4 GHz to 2.7 GHz (Sweep)	10 V/m
80 MHz, 160 MHz, 380 MHz, 450 MHz, 900 MHz, 1850 MHz, 2150 MHz (Spot)	10 V/m

1.6.3.5 Fast Transients

IEC 60255-26

Type	Level (Auxiliary Power, I/O*)	Level (Comms Port)
5/50 ns 5 kHz repetitive	4 kV	2 kV

* Note 20 ms drop-off delay applied to binary inputs

1.6.3.6 Surge Immunity

IEC 60255-26

Type	Level	Variation
Analogue Inputs, Auxiliary Power: Line to Earth	4.0 kV	≤ 10%
I/O: Line to Earth	2.0 kV *	≤ 10%
RS485 Comms port: Line to Earth	1.0 kV	No Data Loss
Analogue Inputs, Auxiliary Power: Line to Line	2.0 kV	≤ 10%
I/O: Line to Line	1.0 kV *	≤ 10%

* Note 50 ms pick-up delay and 20 ms drop-off delay applied to binary inputs

1.6.3.7 Conducted Disturbance Induced by Radio Frequency Interference

IEC 60255-26

Type	Level
0.15 MHz to 80 MHz	10 V

1.6.3.8 Power Frequency Magnetic Field Strength

IEC 61000-4-8

100 A/m, (0.126 mT) continuous	50 Hz
1000 A/m, (1.26 mT) for 3 s	

1.6.4 Mechanical

1.6.4.1 Vibration (Sinusoidal)

IEC 60255-21-1

Type	Level	Variation
Vibration response	0.5 gn	≤ 5 %
Vibration endurance	1.0 gn	

1.6.4.2 Shock and Bump

IEC 60255-21-2

Type	Level	Variation
Shock response	5 gn, 11 ms	≤ 5 %
Shock withstand	15 gn, 11 ms	
Bump test	10 gn, 16 ms	

1.6.4.3 Seismic

IEC 60255-21-3

Type	Level	Variation
Seismic response	X-plane - 3.5 mm displacement below crossover frequency (8 Hz to 9 Hz) 1.0 gn above	≤ 5 %
	Y-plane - 1.5 mm displacement below crossover frequency (8 Hz to 9 Hz) 0.5 gn above	

1.6.4.4 Mechanical Classification

Type	Level
Durability	> 10 ⁶ operations

Section 2: Protection Functions

2.1 37 Undercurrent

2.1.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.10...5.0 $\times I_n$
t_d	Delay setting	0.00, 0.01...20.00, 20.10... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.1.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , ± 5 % or ± 1 % I_n
	Reset level	≤ 105 % I_{op}
	Repeatability	± 1 %
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5$ %

2.1.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.1 to 0.5 $\times I_s$: 35 ms, ± 10 ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 60 ms

2.2 46 Negative Phase Sequence Overcurrent

2.2.1 Reference (46DT)

	Parameter	Value
I_s	Setting	0.05, 0.06... 4.0 xI_n
t_d	Delay setting	0.00, 0.01...20.00, 20.10... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.2.2 Operate and Reset Level (46DT)

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{op}
	Repeatability	$\pm 1\%$
	Transient overreach ($X/R \leq 100$)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5\%$

2.2.3 Operate and Reset Time (46DT)

	Attribute	Value
t_{basic}	Element basic operate time	Switched from 0 to 2 xI_s : 40 ms, ± 10 ms
		Switched from 0 to 5 xI_s : 30 ms, ± 10 ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or ± 10 ms
	Repeatability	$\pm 1\%$ or ± 10 ms
	Overshoot time	<40 ms
	Disengaging time	< 60 ms

2.2.4 Reference (46IT)

	Parameter	Value
$char$	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
T_m	Time Multiplier setting	0.025, 0.05... 1.6, 1.7... 5, 6... 100
I_s	Setting	0.05, 0.06... 2.5 xI_n
I	Applied Current (for operate time) IDMTL	2 to 20 $x I_s$
t_d	Delay setting	0, 0.01... 20 s
t_{res}	Reset setting	ANSI DECAYING, 0, 1... 60 s

2.2.5 Operate and Reset Level (46IT)

	Attribute	Value
I_{op}	Operate level	105 % I_s , $\pm 4\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{op}
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5\%$

2.2.6 Operate and Reset Time (46IT)

	Attribute		Value
	Starter operate time ($\geq 2 \times I_s$)		35 ms, ± 10 ms
t_{op}	Operate time	$char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI$	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5 \% \text{ or } \pm 50 \text{ ms},$ for char = IEC-NI : $K = 0.14, \alpha = 0.02$ IEC-VI : $K = 13.5, \alpha = 1.0$ IEC-EI : $K = 80.0, \alpha = 2.0$ IEC-LTI : $K = 120.0, \alpha = 1.0$
		$char = ANSI-MI, ANSI-VI, ANSI-EI$	$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5 \% \text{ or } \pm 50 \text{ ms},$ for char = ANSI-MI : $A = 0.0515, B = 0.114, P = 0.02$ ANSI-VI : $A = 19.61, B = 0.491, P = 2.0$ ANSI-EI : $A = 28.2, B = 0.1217, P = 2.0$
		$char = DTL$	$t_{\alpha}, \pm 1 \% \text{ or } \pm 20 \text{ ms}$
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5 \% \text{ or } \pm 50 \text{ ms},$ for char = ANSI-MI : $R = 4.85$ ANSI-VI : $R = 21.6$ ANSI-EI : $R = 29.1$
		IEC DECAYING	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5 \% \text{ or } \pm 50 \text{ ms},$ for char = IEC-NI : $R = 9.7$ IEC-VI : $R = 43.2$ IEC-EI : $R = 58.2$ IEC-LTI : $R = 80$
		t_{res}	$t_{res}, \pm 1 \% \text{ or } \pm 20 \text{ ms}$
	Repeatability		$\pm 1 \% \text{ or } \pm 20 \text{ ms}$
	Overshoot time		$< 40 \text{ ms}$
	Disengaging time		$< 60 \text{ ms}$

2.3 49 Thermal Overload

2.3.1 Reference

	Parameter	Value
I_s	Overload setting	$1.0 \times I_n$
i	Applied Current (for operate time)	1.2 to $10 \times I_s$
τ	Time constant setting	$1, 10, 100, 1000$ min

2.3.2 Operate and Reset Level

	Attribute	Value
I_{ol}	Overload level	$100 \% I_s, \pm 5 \% \text{ or } \pm 1 \% I_n$
	Reset level	$\geq 95 \% I_{ol}$
	Repeatability	$\pm 1 \%$
	Variation	$-10\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$
		$f_{nom} \pm 5 \%$

2.3.3 Operate and Reset Time

	Attribute	Value
t_{op}	Overload trip operate time	$t = \tau \times \ln \left\{ \frac{I^2 - I_P^2}{I^2 - (k \times I_B)^2} \right\}$ where I_P = prior current $\pm 5 \% \text{ or } \pm 100 \text{ ms}$
	Repeatability	$\pm 100 \text{ ms}$
Note:- Fastest operate time is at $10 \times I_s$		

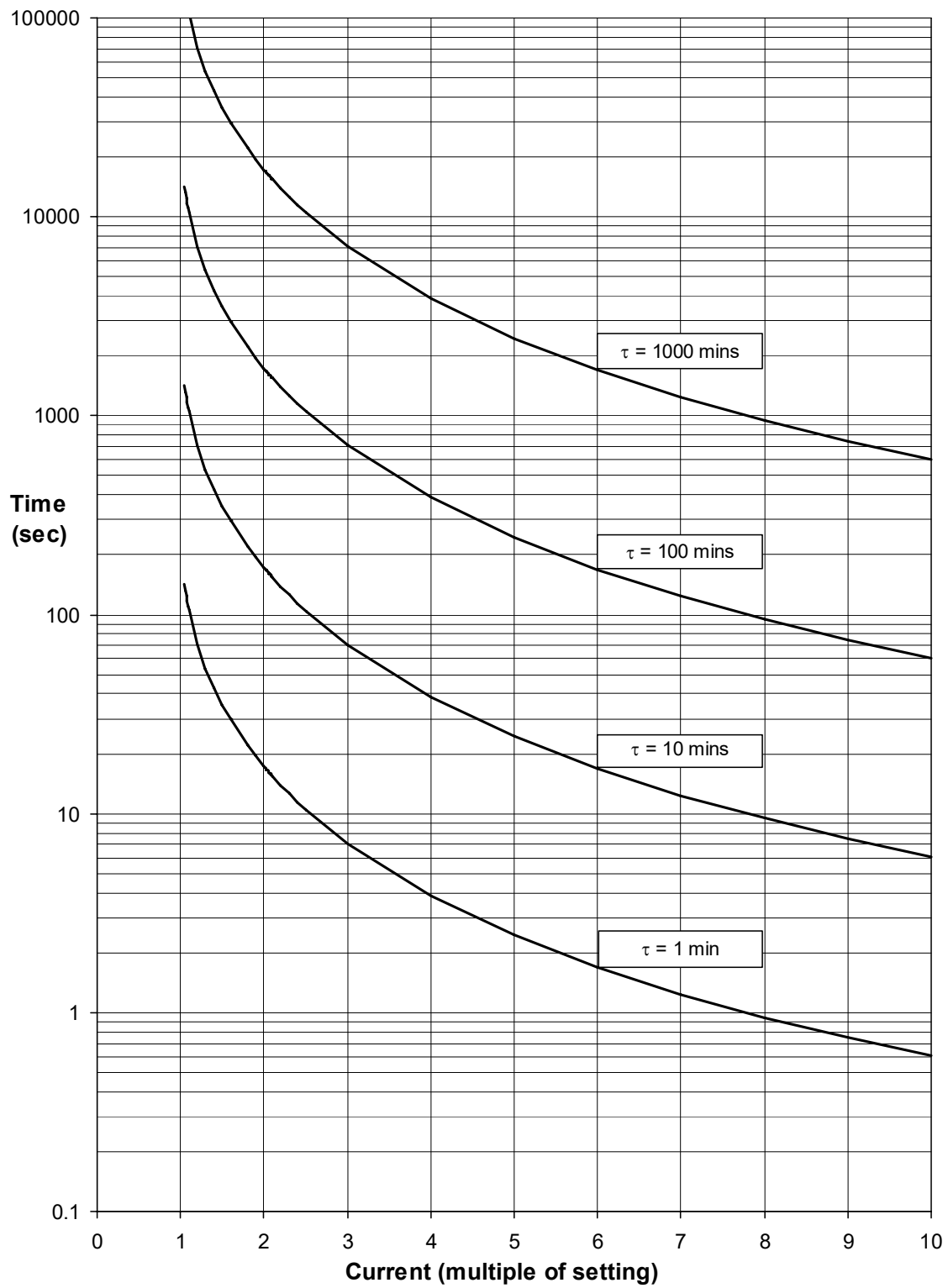


Figure 2.3.3-1 Thermal Overload Protection Curves

2.4 50 Instantaneous Overcurrent

2.4.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.06... 2.5, 2.55... 50 x I_n
t_d	Delay setting	0.00, 0.01...20.00, 20.10... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.4.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{op}
	Repeatability	$\pm 1\%$
	Transient overreach ($X/R \leq 100$)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5\%$

2.4.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	Switched from 0 to 2 x/s: 35 ms, ± 10 ms
		Switched from 0 to 5 x/s: 25 ms, ± 10 ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or ± 10 ms
	Repeatability	$\pm 1\%$ or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

2.5 50G Instantaneous Measured Earth Fault

2.5.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.06...2.5, 2.55 ...25.0, 25.5.... 50 x/n
t_d	Delay setting	0.00, 0.01...20.00, 20.10... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.5.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{op}
	Repeatability	$\pm 1\%$
	Transient overreach (X/R ≤ 100)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5\%$

2.5.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	Switched from 0 to 2 x/s: 35 ms, ± 10 ms
		Switched from 0 to 5 x/s: 25 ms, ± 10 ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or ± 10 ms
	Repeatability	$\pm 1\%$ or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

2.6 50N Instantaneous Derived Earth Fault

2.6.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.06...2.5, 2.55 ...25.0, 25.5.... 50 $\times I_n$
t_d	Delay setting	0.00, 0.01...20.00, 20.10... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.6.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , ± 5 % or ± 1 % I_n
	Reset level	≥ 95 % I_{op}
	Repeatability	± 1 %
	Transient overreach ($X/R \leq 100$)	≤ -5 %
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5$ %

2.6.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	Switched from 0 to 2 $\times I_s$: 40 ms, ± 10 ms
		Switched from 0 to 5 $\times I_s$: 30 ms, ± 10 ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

2.7 51 Time Delayed Overcurrent

2.7.1 Reference

	Parameter		Value
I_s	Setting		0.05, 0.06... 2.5 $x I_n$
$char$	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
T_m	Time Multiplier setting		0.025, 0.05... 1.6, 1.7... 5, 6... 100
t_d	Delay setting		0, 0.01... 20 s
t_{res}	Reset setting		ANSI DECAIVING, 0, 1... 60 s
I	Applied Current (for operate time)	IDMTL	2 to 20 $x I_s$
		DTL	5 $x I_s$

2.7.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I_s , ± 4 % or ± 1 % I_n
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		$f_{nom} \pm 5$ %	≤ 5 %

2.7.3 Operate and Reset Time

Attribute		Value
Starter operate time ($\geq 2 \times I_s$)		20 ms, ± 20 ms
t_{op}	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms},$ for char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
		$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms},$ (ANSI-EI +5% -10 % absolute for $I/I_s > 10$ with TMS >2) for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
	char = DTL	$t_d, \pm 1 \% \text{ or } \pm 20 \text{ ms}$
	Reset time	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^p - 1} \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms},$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^p - 1} \times Tm, \pm 5 \% \text{ or } \pm 50 \text{ ms},$ for char = IEC-NI : R = 9.7 IEC-VI : R = 43.2 IEC-EI : R = 58.2 IEC-LTI : R = 80
	t_{res}	$t_{res}, \pm 1 \% \text{ or } \pm 20 \text{ ms}$
Repeatability		$\pm 1 \% \text{ or } \pm 20 \text{ ms}$
Overshoot time		< 40 ms
Disengaging time		< 50 ms

Figure 2.7.3-1 and Figure 2.7.3-4 show the operate and reset curves for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2.7.3-2 and Figure 2.7.3-3 show the ANSI operate and reset curves. These operate times apply to non-directional characteristics. Where directional control is applied then the directional element operate time should be added to give total maximum operating time.

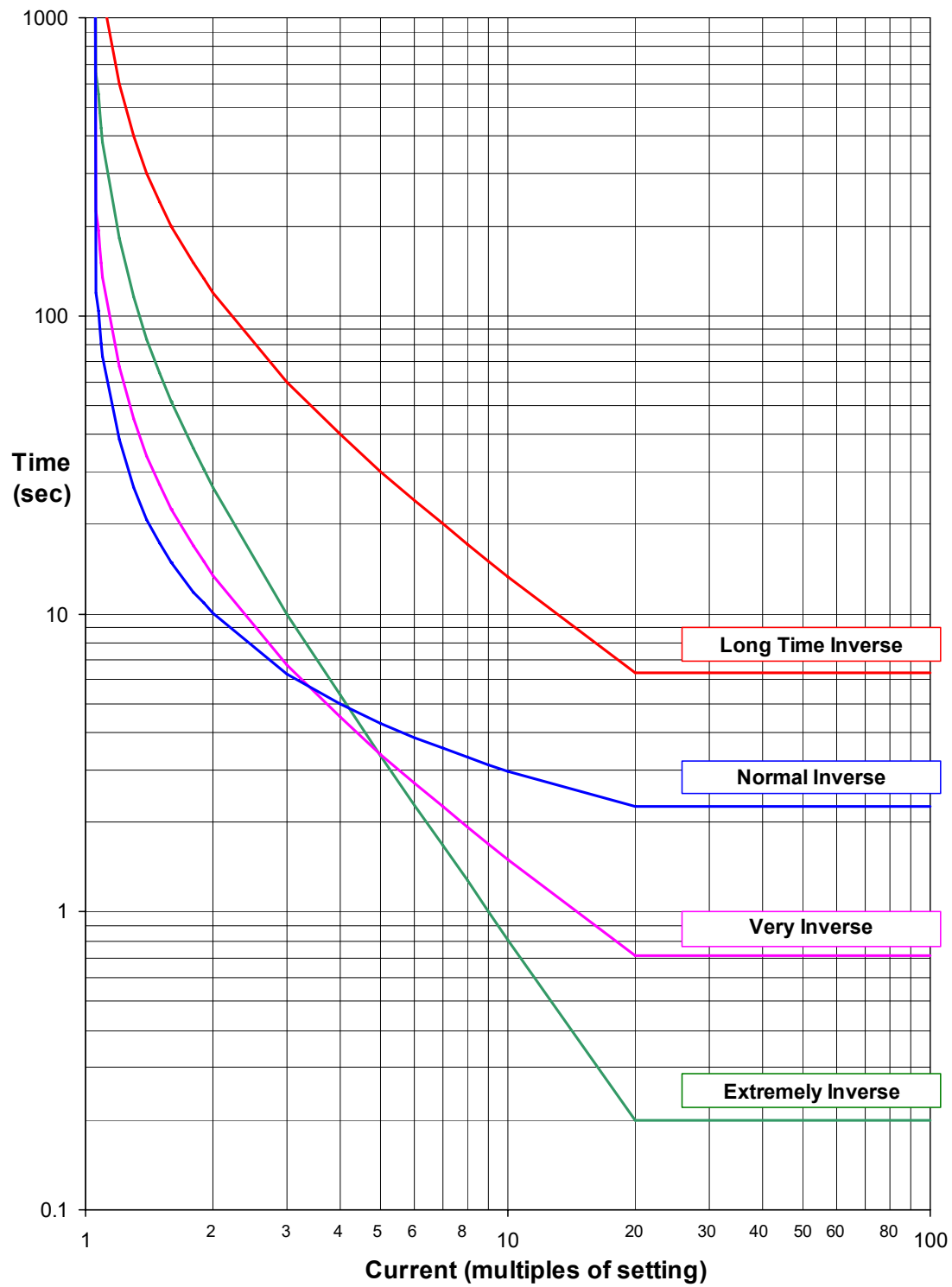


Figure 2.7.3-1 IEC IDMTL Curves (Time Multiplier = 1)

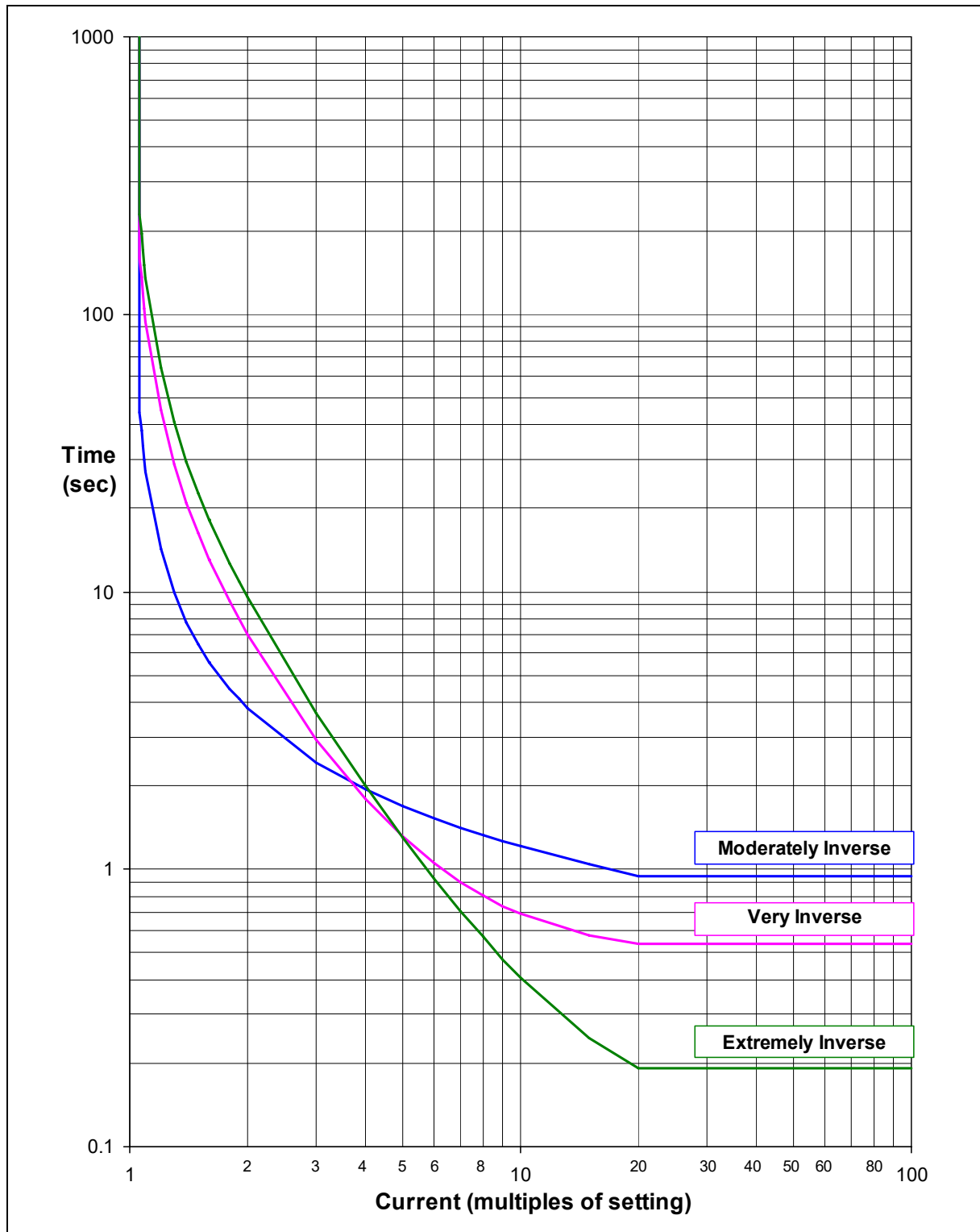


Figure 2.7.3-2 ANSI IDMTL Operate Curves (Time Multiplier = 1)

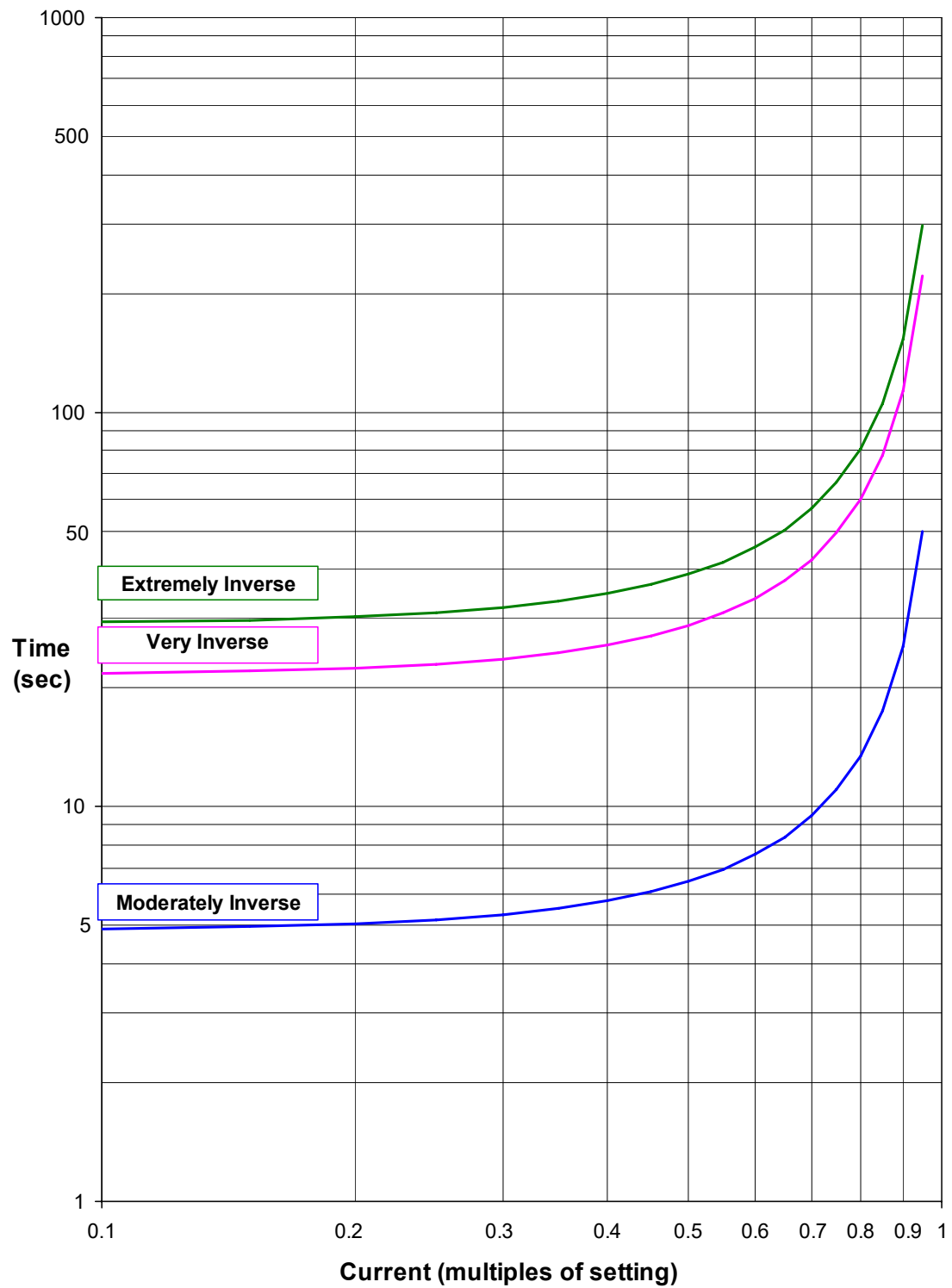


Figure 2.7.3-3 ANSI Reset Curves (Time Multiplier = 1)

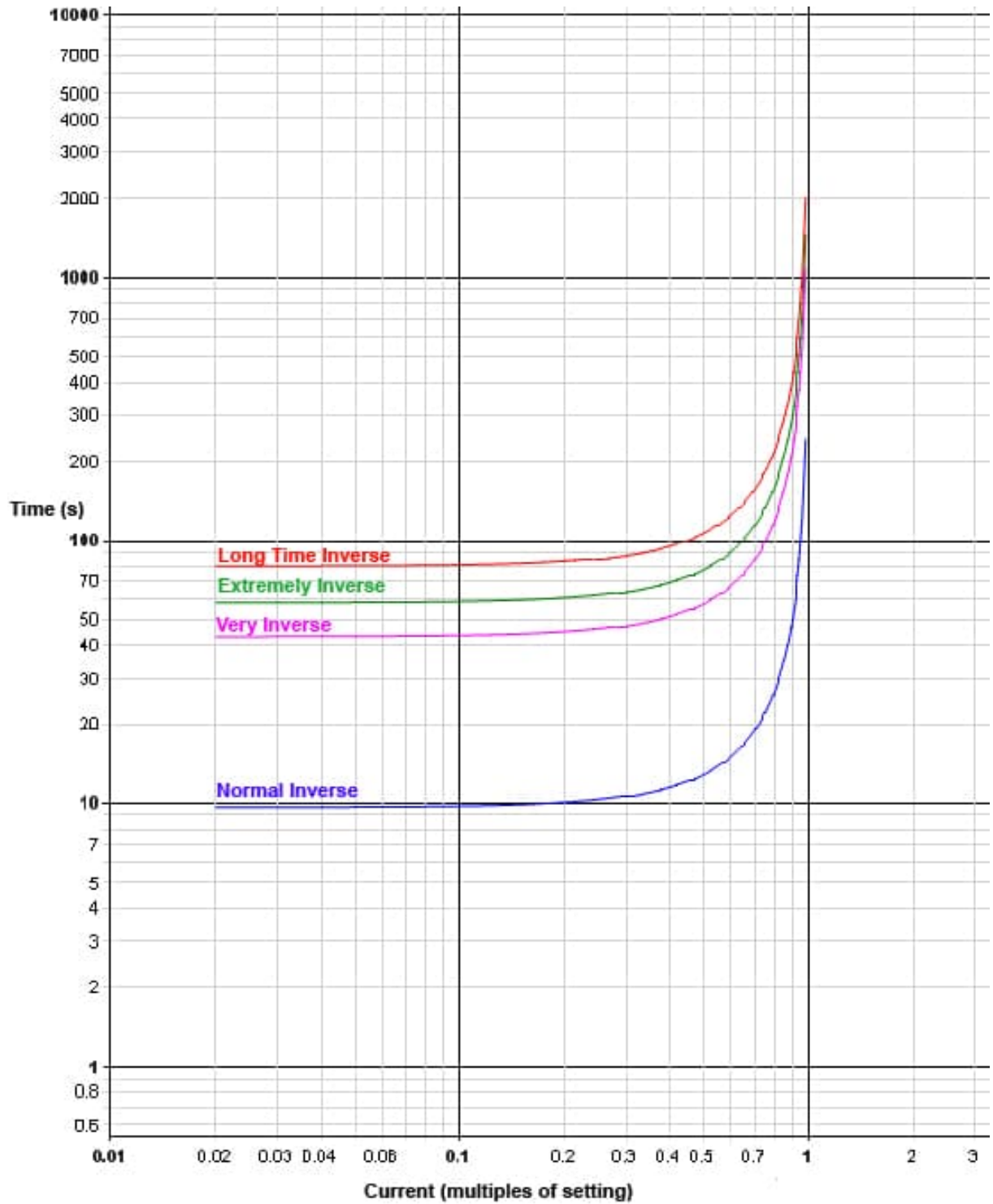


Figure 2.7.3-4 IEC Reset Curves (Time Multiplier = 1)

2.8 51G Time Delayed Measured Earth Fault

2.8.1 Reference

	Parameter		Value
I_s	Setting		0.05, 0.06... 2.5 $\times I_n$
$Char$	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
T_m	Time Multiplier setting		1.0 (0.025, 0.05... 100)
t_d	Delay setting (DTL)		0, 0.01... 20 s
t_{res}	Reset setting		ANSI DECAYING, 0, 1... 60 s
I	Applied current (for operate time)	IDMTL	2 to 20 $\times I_s$
		DTL	5 $\times I_s$

2.8.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I_s , ± 4 % or ± 1 % I_n
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		$f_{nom} \pm 5$ %	≤ 5 %

2.8.3 Operate and Reset Time

Attribute		Value
Starter operate time ($\geq 2x/s$)		20 ms, ± 20 ms
t_{op}	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms,}$ for char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI IEC-NI : $K = 0.14, \alpha = 0.02$ IEC-VI : $K = 13.5, \alpha = 1.0$ IEC-EI : $K = 80.0, \alpha = 2.0$ IEC-LTI : $K = 120.0, \alpha = 1.0$
		$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms,}$ (ANSI-EI +5% -10 % absolute for $I/I_s > 10$ with $TMS > 2$) for char = ANSI-MI : $A = 0.0515, B = 0.114, P = 0.02$ ANSI-VI : $A = 19.61, B = 0.491, P = 2.0$ ANSI-EI : $A = 28.2, B = 0.1217, P = 2.0$
	char = DTL	$t_d, \pm 1 \% \text{ or } \pm 20 \text{ ms}$
	Reset time	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms,}$ for char = ANSI-MI : $R = 4.85$ ANSI-VI : $R = 21.6$ ANSI-EI : $R = 29.1$
		$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5 \% \text{ or } \pm 50 \text{ ms,}$ for char = IEC-NI : $R = 9.7$ IEC-VI : $R = 43.2$ IEC-EI : $R = 58.2$ IEC-LTI : $R = 80$
	t_{res}	$t_{res}, \pm 1 \% \text{ or } \pm 20 \text{ ms}$
Repeatability		$\pm 1 \% \text{ or } \pm 20 \text{ ms}$
Overshoot time		$< 40 \text{ ms}$
Disengaging time		$< 50 \text{ ms}$

Figure 2.7.3-1 and Figure 2.7.3-4 show the operate and reset curves for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2.7.3-2 and Figure 2.7.3-3 show the ANSI operate and reset curves. These operate times apply to non-directional characteristics. Where directional control is applied then the directional element operate time should be added to give total maximum operating time.

2.9 51N Time Delayed Derived Earth Fault

2.9.1 Reference

	Parameter		Value
I_s	Setting		0.05, 0.6... 2.5 $x I_n$
$char$	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
T_m	Time Multiplier setting		1.0 (0.025, 0.05... 100)
t_d	Delay setting		0, 0.01... 20 s
t_{res}	Reset setting		ANSI DECAIVING, 0, 1... 60 s
I	Applied Current (for operate time)	IDMTL	2 to 20 $x I_s$
		DTL	5 $x I_s$

2.9.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I_s , ± 4 % or ± 1 % I_n
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		$f_{nom} \pm 5$ %	≤ 5 %

2.9.3 Operate and Reset Time

Attribute		Value
Starter operate time ($\geq 2x/s$)		30 ms, ± 20 ms
t_{op}	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms},$ for char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
		$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms},$ (ANSI-EI +5% -10 % absolute for $I/I_s > 10$ with TMS >2) for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
	char = DTL	$t_d, \pm 1 \% \text{ or } \pm 20 \text{ ms}$
	Reset time	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^p - 1} \times Tm, \pm 5 \% \text{ or } \pm 30 \text{ ms},$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^p - 1} \times Tm, \pm 5 \% \text{ or } \pm 50 \text{ ms},$ for char = IEC-NI : R = 9.7 IEC-VI : R = 43.2 IEC-EI : R = 58.2 IEC-LTI : R = 80
	t_{res}	$t_{res}, \pm 1 \% \text{ or } \pm 20 \text{ ms}$
Repeatability		$\pm 1 \% \text{ or } \pm 20 \text{ ms}$
Overshoot time		< 40 ms
Disengaging time		< 50 ms

Figure 2.7.3-1 and Figure 2.7.3-4 shows the operate and reset curves for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2.7.3-2 and Figure 2.7.3-3 show the ANSI operate and reset curves. These operate times apply to non-directional characteristics. Where directional control is applied then the directional element operate time should be added to give total maximum operating time.

2.10 67/67N Directional Overcurrent & Earth Fault

2.10.1 Reference

	Parameter	Value
θ_s	Angle setting	-95...+95 °
I	Applied current	I_n
V	Applied voltage	110 V phase-phase (63.5 V phase-earth)

2.10.2 Operate Angle

	Attribute	Value
CA	Characteristic angle (I with respect to V)	$\theta_s, \pm 5^\circ$
	Operating angle	forward
		reverse
	Variation in characteristic angle	10°C to +55°C
		$f_{nom} \pm 5\%$

2.10.3 Operate Threshold

	Attribute	Value
	Minimum levels for operation	I (p/f)
		I (e/f)
		V (p/f)
		V (e/f)

2.10.4 Operate and Reset Time

	Attribute	Value
	Operate time	typically 32 < 40 ms at characteristic angle + element operate time
	Reset time	typically < 65 ms at characteristic angle

2.11 87L Differential

2.11.1 Reference

Parameter	Value
Initial Setting	0.1, 0.15 ... 2.5 xIn
1 st Bias Slope	0.1, 0.15 ... 0.7 x
1 st Bias Slope Limit	0.5, 0.6 ... 20 xIn
2 nd Bias Slope	0.5, 0.55 ... 2 x
Delay setting	0, 0.005 ... 60 s

2.11.2 Operate and Reset Level

	Attribute	Value
I_{OP}	Operate level 2 nd Bias Slope	$I_{OPERATE} > I_{87\text{ INITIAL SETTING}}$ and $I_{OPERATE} > M_1 \times I_{RESTRAIN}$ and $I_{OPERATE} > M_2 \times I_{RESTRAIN}$ (for $I_{RESTRAIN} > B$) Where: - $I_{operate} = I_L + I_R$ $I_{restrain} = \frac{I_L + I_R}{2}$ $B = 87BD\ 1^{st}\ \text{Bias slope limit}$ $M_1 = 87BD\ 1^{st}\ \text{Bias slope}$ $M_2 = 87BD\ 2^{nd}\ \text{Bias slope}$
	Operate Level	$\pm 10\%$ of I_{OP} or $\pm 0.1\text{In}$
	Reset level	$\geq 90\%$ of I_{OP}
	Repeatability	$\pm 2\%$
	Transient overreach	$\leq 5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\ \text{Hz}$ to $f_{nom} + 2\ \text{Hz}$

2.11.1 Operate Time

	Attribute	Value (Typical)
t_{op}	Element operate time (fault line)	30 ms $\pm$ 5 ms (fault line)
		50 ms $\pm$ 5 ms (below fault line)

2.12 87HS High-Set Differential

2.12.1 Reference

Parameter	Value
Setting	1, 2 ... 30 xIn
Delay setting	0, 0.005... 60 s

2.12.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	$\pm 5\%$ of setting or $\pm 0.01I_n$
	Reset level	$\geq 95\%$ of I_{OP}
	Repeatability	$\pm 2\%$
	Transient overreach	$\leq 5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$

2.12.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	$> 1.1 \times I_n$ 30 ms to 50 ms (Typically 30 ms)

2.13 85 Inter-trip Element

2.13.1 Reference

Attribute	Value
Delay setting	0, 0.005... 60 s

2.13.2 Operate Time

Attribute	Value
Inter-trip base element operate time	10 ms + 20 ms

Section 3: Supervision Functions

3.1 46BC Broken Conductor

3.1.1 Reference

	Parameter	Value
	NPS to PPS ratio	20,21...100 %
t_f	Delay setting	0.03,04,20.0,20.1,100,101,1000,1010.....14400 s

3.1.2 Operate and Reset Level

	Attribute		Value
I_{curr}	Operate level		100 % $I_{set} \pm 5 \%$
	Reset level		90 % $I_{curr} \pm 5 \%$
	Repeatability		$\pm 1 \%$
	Variation	-10 °C to +55 °C	$\leq 5 \%$
		$f_{nom} \pm 5 \%$	$\leq 5 \%$
		harmonics to f_{cutoff}	$\leq 5 \%$

3.1.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Basic operate time	1x In to 0 A	40 ms
	Operate time		$t_f + t_{basic} \pm 1 \%$ or $\pm 20 \text{ ms}$
	Repeatability		$\pm 1 \%$ or $\pm 20 \text{ ms}$
	Variation	$f_{nom} \pm 5 \%$	$\leq 5 \%$
		harmonics to f_{cutoff}	$\leq 5 \%$

3.2 50BF Circuit Breaker Fail

3.2.1 Reference

	Parameter	Value
I_s	Setting	0.050, 0.055... 2.0 x I_n
I_4	Setting	0.050, 0.055... 2.0 x I_n
t_{CBF1}	Stage 1 Delay setting	20, 25... 60000 ms
t_{CBF2}	Stage 2 Delay setting	20, 25... 60000 ms

3.2.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
I_{reset}	Reset level	<100 % I_{op} , $\pm 5\%$ or $\pm 1\%$ I_n
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5\%$

3.2.3 Operate and Reset Time

	Attribute	Value
t_{op}	Stage 1	t_{CBF1} , $\pm 1\%$ or ± 20 ms
	Stage 2	t_{CBF2} , $\pm 1\%$ or ± 20 ms
	Repeatability	$\pm 1\%$ or ± 20 ms
	Overshoot	< 2 x 20 ms
	Disengaging time	< 20 ms

3.3 60CTS & 60CTS-I Current Transformer Supervision

3.3.1 Reference

REFERENCE			Value
	Parameter		
I_{thresh}	Current Threshold		0.05, 0.1... 2 xIn
I	Applied Current	Healthy CT Phases	$5 \times I_{thresh}$
	(for operate time)	Failed CT phase	0
t_d	Delay setting		0.3, 20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s
Directional Relays have additional VT settings			
V_{thresh}	Voltage Threshold		7, 8... 110V

3.3.2 Current & Voltage Threshold

	Attribute		Value
I_{op}	CT failed current level		100 % I_{thresh} , $\pm 5\%$ or $\pm 1\%$ In
	Reset level		90 % I_{op} , $\pm 5\%$ or $\pm 1\%$ In
V_{op}	CT failed voltage level		100 % V_{thresh} , $\pm 2\%$ or $\pm 0.5V$
	Reset level		110 % V_{op} , $\pm 2\%$ or $\pm 0.5V$
	Repeatability		$\pm 1\%$
	Variation	-10 °C to +55 °C	$\leq 5\%$
		$f_{nom} \pm 5\%$	$\leq 5\%$
		harmonics to f_{cutoff}	

3.3.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Basic operate time	50 ms ± 20 ms
	Operate time	$t_d + t_{basic}$, $\pm 1\%$ or ± 20 ms
	Repeatability	$\pm 1\%$ or ± 20 ms

3.4 60VTS Voltage Transformer Supervision

3.4.1 Reference

	Parameter	Value
V_{nps}	Vnps Level	7, 8 ... 110V
I_{nps}	Inps Level	0.05, 0.1 ... 1 x In
I_{pps}	Ipps Load Level	0.05, 0.1 ... 1 x In
IF_{pps}	Ipps Fault Level	0.05, 0.1 ... 20 x In
V_{pps}	Vpps Level	1, 2 ... 110V
t_d	60VTS Delay	0.00, 0.01...20.00, 20.10... 100, 101... 1000, 1010... 10000, 10100... 14400 s

3.4.2 Operate and Reset Level

	Attribute	Value
V_{NPSop}	Voltage NPS operate level	100 % V_{nps} , $\pm 5\%$ V_n
	Voltage NPS reset level	90 % V_{NPSop} , $\pm 5\%$ V_n
V_{PPSop}	Voltage PPS operate level	100 % V_{pps} , $\pm 5\%$ V_n
	Voltage PPS reset level	110 % V_{PPSop} , $\pm 5\%$ V_n
I_{NPSblk}	Current NPS operate level	100 % I_{nps} , $\pm 5\%$ xI_n
	Current NPS reset level	90 % I_{NPSblk} , $\pm 5\%$ xI_n
I_{PPSblk}	Current PPS operate level	100 % IF_{pps} , $\pm 5\%$ xI_n
	Current PPS reset level	90 % I_{PPSblk} , $\pm 5\%$ xI_n
$I_{PPSload}$	Current PPS operate level	100 % I_{pps} , $\pm 5\%$ xI_n
	Current PPS reset level	90 % $I_{PPSload}$, $\pm 5\%$ xI_n
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5\%$

3.4.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Basic operate time 0V to 2 x Vs	32 ms ± 10 ms
	Operate time	$t_d + t_{basic} \pm 1\%$ or ± 10 ms
	Repeatability	$\pm 1\%$ or ± 10 ms

3.5 74TCS & 74CCS Trip & Close Circuit Supervision

3.5.1 Reference

	Parameter	Value
t_d	Delay setting	0, 0.02...60 s

3.5.2 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	30 ms $\pm$ 10 ms
t_{op}	Operate time following delay	$t_{basic} + t_d, \pm 1 \% \text{ or } \pm 10 \text{ ms}$
	Repeatability	$\pm 1 \% \text{ or } \pm 10 \text{ ms}$
	Variation	-10 °C to +55 °C
		$f_{nom} \pm 5 \%$

3.6 81HBL2 Inrush Detector

3.6.1 Reference

	Parameter	Value
I	Setting (Ratio of 2nd Harmonic current to Fundamental component current)	0.10, 0.11... 0.5

3.6.2 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	Will pick-up before operation of any protection element due to magnetic inrush
	Reset Time	Will operate until drop-off of any protection element due to magnetic inrush

7SR18 Line Differential Protection Instrumentation Guide

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Document Release History

This document is issue 2022/05.

2016/11	First Issue
2017/05	Typographical revisions, drawing amendments
2017/11	Typographical revisions.
2018/07	Amended connection diagrams, additional disposal information
2022/05	Typographical revisions to page footer, no changes to content

Software Revision History

2016/11	2436H80016R4d-1b	First Release
2018/07	2436H80016R4i-1c	Software maintenance to address production SW upload.

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1. Relay Instrumentation

The Instrument Mode sub-menu displays key quantities and information to aid with commissioning. The following meters are available and are navigated around by using the ▲, ▼ and TEST/RESET buttons. The text description shown here is the default information. Depending upon the relay model you have, you may not have all of the meters shown.

1.1 Favourite Meters

Instrument	Description
----- FAVOURITE METERS > to view -----	This allows the user to view his previously constructed list of 'favourite meters' by pressing TEST/RESET ► button and the READ DOWN button to scroll though the meters added to this sub-group To construct a sub-group of favourite meters, first go to the desired meter then press ENTER this will cause a message to appear on the LCD 'Add To Favourites YES' pressing ENTER again will add this to the FAVOURITE METERS Sub-menu. To remove a meter from the FAVOURITE METERS sub-menu go to that meter each in the FAVOURITE METERS sub-menu or at its Primary location press ENTER and the message 'Remove From Favourites' will appear press ENTER again and this meter will be removed from the FAVOURITE METERS sub-group

1.2 Current Meters

Instrument	Description
----- CURRENT METERS > to view -----	This is the sub-group that includes all the meters that are associated with Current TEST/RESET ► allows access to this sub-group
Primary Current Ia 0.00A Ib 0.00A Ic 0.00A	Displays the 3 phase-currents Primary RMS values
Secondary Current Ia 0.00A Ib 0.00A Ic 0.00A	Displays the 3 phase-currents Secondary RMS values
Nom Current Ia 0.00xIn ----° Ib 0.00xIn ----° Ic 0.00xIn ----°	Displays the 3 phase-currents Nominal RMS values & phase angles with respect to PPS current.
Pri Earth Current In 0.00A Ig 0.00A	Displays the 3 Earth-currents Primary RMS values
Sec Earth Current In 0.00A Ig 0.00A	Displays the 3 Earth-currents Secondary RMS values
Nom Earth Current In 0.00xIn ----° Ig 0.00xIn ----°	Displays the 3 Earth-currents Nominal RMS values & phase angles with respect to PPS current.
Remote Pri Current Ia 0.00A Ib 0.00A Ic 0.00A	Displays the 3 phase-currents Remote Primary RMS values
Remote Sec Current Ia 0.00A	Displays the 3 phase-currents Remote Secondary RMS values

Instrument	Description
Ib 0.00A Ic 0.00A	
Remote Nom Current Ia 0.00xIn ----° Ib 0.00xIn ----° Ic 0.00xIn ----°	Displays the 3 phase-currents Remote Nominal RMS values & phase angles with respect to PPS current.
Remote Pri Earth Cur In 0.00A Ig 0.00A	Displays the 3 Earth-currents Remote Primary RMS values
Remote Sec Earth Cur In 0.00A Ig 0.00A	Displays the 3 Earth-currents Remote Secondary RMS values
Remote Nom Earth Cur In 0.00xIn ----° Ig 0.00xIn ----°	Displays the 3 Earth-currents Remote Nominal RMS values & phase angles with respect to PPS current.
I Seq Components Izps 0.00xIn ----° Ipps 0.00xIn ----° Inps 0.00xIn ----°	Displays the Current Sequence components Nominal RMS values & phase angles with respect to PPS current.
2 nd Harmonic Current Ia 0.00xIn Ib 0.00xIn Ic 0.00xIn	Displays the 3 phase-currents 2 nd Harmonic components Nominal RMS values.
Last Trip P/F Ia 0.00A Ib 0.00A Ic 0.00A	Displays the 3 phase-currents Last Trip RMS values
Remote Last Trip P/F Ia 0.00A Ib 0.00A Ic 0.00A	Displays the Remote 3 phase-currents Last Trip RMS values
Last Trip E/F In 0.00A Ig 0.00A	Displays the Earth phase-current Last Trip RMS values
Remote Last Trip E/F In 0.00A Ig 0.00A	Displays the Remote Earth phase-current Last Trip RMS values
Last Trip Operate Ia 0.00A Ib 0.00A Ic 0.00A	Displays the 3 phase-currents Last Trip Operate RMS values
Last Trip Restrain Ia 0.00A Ib 0.00A Ic 0.00A	Displays the 3 phase-currents Last Trip Restrain RMS values

1.3 Voltage Meters

----- VOLTAGE METERS > to view -----	This is the sub-group that includes all the meters that are associated with Voltage TEST/RESET ► allows access to this sub-group
Prim Ph-Ph Voltage Vab 0.00V Vbc 0.00V Vca 0.00V	Displays the Phase to Phase Voltage Primary RMS values
Sec Ph-Ph Voltage Vab 0.00V Vbc 0.00V Vca 0.00V	Displays the Phase to Phase Voltage Secondary RMS values & Angles with respect to PPS voltage.
Nominal Ph-Ph Voltage Vab 0.00xVn ----o Vbc 0.00xVn ----o Vca 0.00xVn ----o	Displays the Phase to Phase Voltage Nominal RMS values
Prim Ph-N Voltage Va 0.00V Vb 0.00V Vc 0.00V	Displays the Phase to Neutral Voltage Primary RMS values
Sec Ph-N Voltage Va 0.00V Vb 0.00V Vc 0.00V	Displays the Phase to Neutral Voltage Secondary RMS values & Angles with respect to PPS voltage.
Nom Ph-N Voltage Va 0.00xVn ----o Vb 0.00xVn ----o Vc 0.00xVn ----o	Displays the Phase to Neutral Voltage Nominal RMS values
V Seq Components Izps 0.00V ----o Ipps 0.00V ----o Inps 0.00V ----o	Displays the Voltage Sequence components Nominal RMS values & phase angles with respect to PPS voltage.
Calc Earth Voltage Pri 0.00V Sec 0.00V ----o	Displays the calculated Earth voltage both primary and secondary which also shows the secondary angle
Last Trip Voltage Va 0.00V Vb 0.00V Vc 0.00V	Displays the Last Trip Voltage.

1.4 Power Meters

Instrument	Description
----- POWER METERS > to view -----	This is the sub-group that includes all the meters that are associated with Power TEST/RESET ► allows access to this sub-group
P Phase A 0.0W P Phase B 0.0W P Phase C 0.0W P (3P)	Displays Real Power
Q Phase A 0.0VAr Q Phase B 0.0VAr Q Phase C 0.0VAr Q (3P)	Displays Reactive Power
S Phase A 0.0VA S Phase B 0.0VA S Phase C 0.0VA S (3P)	Displays Apparent Power
PF A 0.00 PF B 0.00 PF C 0.00 PF (3P) 0.00	Displays Power factor
P Phase A 0.00xSn P Phase B 0.00XSn P Phase C 0.00xSn (3P)	Displays Real Power
Q Phase A 0.00xSn Q Phase B 0.00xSn Q Phase C 0.00xSn Q (3P)	Displays Reactive Power
S Phase A 0.00xSn S Phase B 0.00xSn S Phase C 0.00xSn S (3P)	Displays Apparent Power

1.5 Energy Meters

Instrument	Description
----- ENERGY METERS > to view -----	This is the sub-group that includes all the meters that are associated with Energy TEST/RESET ► allows access to this sub-group
Active Energy Exp 000000x10kWh Imp 000000x10kWh	Displays both imported and exported Active Energy
Reactive Energy Exp 000000x10kVArh Imp 000000x10kVArh	Displays both imported and exported Reactive Energy

1.6 Directional Meters

Instrument	Description
----- DIRECTIONAL METERS > to view -----	This is the sub-group that includes all the meters that are associated with Directional elements TEST/RESET ► allows access to this sub-group. Only seen on models that have the 67 option
P/F Dir (67) ----- No Dir	The appropriate values from the selection will be displayed. No Dir, PhA Fwd, PhA Rev, PhB Fwd, PhB Rev, PhC Fwd, PhC Rev
Calc E/F Dir (67N) ----- No Dir	The appropriate values from the selection will be displayed. No Dir, E/F Fwd, E/F Rev
Meas E/F Dir (67G) ----- No Dir	The appropriate values from the selection will be displayed. No Dir, E/F Fwd, E/F Rev

1.7 Prot'n Comms Meters

Instrument	Description
----- PROT'N COMMS METERS > to view -----	This is the sub-group that includes all the meters that are associated with Current TEST/RESET ► allows access to this sub-group
PROT'N Info Status IN SYNC	Displays the Protection Signalling Information
PROT'N Stats Frames OK 00000000 Errors 0000 Skew 0.000ms	Displays the Protection Signalling Status
PROT'N 0.1s Quality Errors 00 Severe Errors 00 Performance 00.0%	Displays the Protection Signalling 0.1 s Quality
PROT'N 1s Quality Errors 00 Severe Errors 00 Performance 00.0%	Displays the Protection Signalling 1 s Quality
PHY Info Media 2Km FIBRE Rx Errors 000	Displays the Protection Signalling PHY Information (2 km)
PHY Info Media 40Km FIBRE Status OK Rx Errors 000	Displays the Protection Signalling PHY Information (40 km)
FIBRE Info Status OK Temperature 46.8DegC Vcc 3.3 V	Displays the Protection Signalling FIBRE Information (40 km)
FIBRE Power dBm Tx Power 0.0 dBm Rx Power 0.0 dBm	Displays the Protection Signalling FIBRE Information (40 km)
FIBRE Power mW Tx Power 0.000 mW Rx Power 0.000 mW	Displays the Protection Signalling FIBRE Information (40 km)

1.8 Differential Meters

Instrument	Description
----- DIFFERENTIAL METERS > to view -----	This is the sub-group that includes all the meters that are associated with Current TEST/RESET ► allows access to this sub-group
Line Current Ia 0.000xIn ----° Ib 0.000xIn ----° Ic 0.000xIn ----°	Displays 3 Phase Line currents Nominal RMS values & phase angles with respect to PPS voltage.
Remote Line Current Ia 0.000xIn ----° Ib 0.000xIn ----° Ic 0.000xIn ----°	Displays 3 Phase Remote Line currents Nominal RMS values & phase angles with respect to PPS voltage.
Relay Current Ia 0.000xIn ----° Ib 0.000xIn ----° Ic 0.000xIn ----°	Displays Relay currents Nominal RMS values & phase angles with respect to PPS voltage.
Remote Relay Current Ia 0.000xIn ----° Ib 0.000xIn ----° Ic 0.000xIn ----°	Displays Remote Relay currents Nominal RMS values & phase angles with respect to PPS voltage.
Operate Current Ia 0.000xIn ----° Ib 0.000xIn ----° Ic 0.000xIn ----°	Displays the 3 phase operate currents' relevant to the Line differential (87L) and highset differential (87HS) functions.
Restrain Current Ia 0.000xIn Ib 0.000xIn Ic 0.000xIn	Displays the 3 phase restrain currents relevant to the Line differential (87L) function.

1.9 Thermal Meters

Instrument	Description
----- THERMAL METERS > to view -----	This is the sub-group that includes all the meters that are associated with Thermal TEST/RESET ► allows access to this sub-group
Thermal Status Phase A 0.0% Phase B 0.0% Phase C 0.0%	Displays the thermal capacity

1.10 Maintenance Meters

Instrument	Description
----- MAINTENANCE METERS > to view -----	This is the sub-group that includes all the meters that are associated with Maintenance TEST/RESET ► allows access to this sub-group
CB Total Trips Count 0 Target 100	Displays the number of CB trips experienced by the CB
CB Ph A Trips Count 0 Target 100	Displays the number of CB Phase A trips experienced by the CB
CB Ph B Trips Count 0 Target 100	Displays the number of CB Phase B trips experienced by the CB
CB Ph C Trips Count 0 Target 100	Displays the number of CB Phase C trips experienced by the CB
CB E/F Trips Count 0 Target 100	Displays the number of CB Earth Fault trips experienced by the CB
CB Delta Trips Count 0 Target 100	Displays the number of CB trips experienced by the CB
CB Count To AR Block Count 0 Target 100	Displays the number of CB trips experienced by the CB. When the target is reached the relay will only do 1 Delayed Trip to Lockout.
CB Freq Ops Count Count 0 Target 10	Displays the number of CB trips experienced by the CB over the last rolling 1 hr period. When the target is reached the relay will only do 1 Delayed Trip to Lockout.
CB Wear Phase A 0.00MA^2s Phase B 0.00MA^2s Phase C 0.00MA^2s	Displays the current measure of circuit breaker wear.
CB Wear Remaining Phase A 100% Phase B 100% Phase C 100%	Displays the current measure of circuit breaker wear remaining.
CB Trip Time Time 0ms	Displays the trip time for the circuit breaker.

1.11 General Alarm Meters

Instrument	Description
----- GENERAL ALARM METERS > to view -----	This is the sub-group that includes all the meters that are associated with the Binary inputs TEST/RESET ► allows access to this sub-group
General Alarms ----- ALARM 1 Cleared ... General Alarms ----- ALARM 6 Cleared Test Mode ----- Cleared	Displays the state of General Alarm

1.12 Frequency Meters

Instrument	Description
----- FREQUENCY METERS > to view -----	This is the sub-group that includes all the meters that are associated with Thermal TEST/RESET ► allows access to this sub-group
Frequency 0.000Hz	Displays the power system frequency (2 km)
Frequency 0.000Hz	Displays the power system frequency (40 km)
Last Trip 0.000Hz	

1.13 Demand Meters

Instrument	Description
----- DEMAND METERS > to view -----	This is the sub-group that includes all the meters that are associated with the demand metering. TEST/RESET ► allows access to this sub-group
I Phase A Demand Max 0.00A Min 0.00A Mean 0.00A	Shows the Max, Min and Mean for Phase A.
I Phase B Demand Max 0.00A Min 0.00A Mean 0.00A	Shows the Max, Min and Mean for Phase B.
I Phase C Demand Max 0.00A Min 0.00A Mean 0.00A	Shows the Max, Min and Mean for Phase C.
V Phase A Demand Max 0.00V Min 0.00V Mean 0.00V	Shows the Max, Min and Mean Voltage for Phase A.
V Phase B Demand Max 0.00V Min 0.00V	Shows the Max, Min and Mean Voltage for Phase AB.

Instrument	Description
Mean 0.00V	
V Phase C Demand	Shows the Max, Min and Mean Voltage for Phase AC.
Max 0.00V	
Min 0.00V	
Mean 0.00V	
V Phase AB Demand	Shows the Max, Min and Mean Voltage for Phase AB.
Max 0.00V	
Min 0.00V	
Mean 0.00V	
V Phase BC Demand	Shows the Max, Min and Mean Voltage for Phase BC.
Max 0.00V	
Min 0.00V	
Mean 0.00V	
V Phase CA Demand	Shows the Max, Min and Mean Voltage for Phase CA.
Max 0.00V	
Min 0.00V	
Mean 0.00V	
Power P 3P Demand	Shows the Max, Min and Mean for Power P 3P Demand.
Max 0.0W	
Min 0.0W	
Mean 0.0W	
Power Q 3P Demand	Shows the Max, Min and Mean for Power Q 3P Demand.
Max 0.0VAr	
Min 0.0VAr	
Mean 0.0VAr	
Power S 3P Demand	Shows the Max, Min and Mean for Power S 3P Demand.
Max 0.0VA	
Min 0.0VA	
Mean 0.0VA	
Frequency Demand	Shows the Max, Min and Mean for System Frequency Demand.
Max 0.000Hz	
Min 0.000Hz	
Mean 0.000Hz	
Power Factor Demand	Shows the Max, Min and Mean for System Power Factor Demand.
Max 0.00	
Min 0.00	
Mean 0.00	

1.14 Binary Input Meters

Instrument	Description
----- BINARY INPUT METERS > to view -----	This is the sub-group that includes all the meters that are associated with the Binary inputs TEST/RESET ► allows access to this sub-group
BI 1-6 -----	Displays the state of DC binary inputs 1 to 6 (The number of binary inputs may vary depending on model)

1.15 Binary Output Meters

Instrument	Description
----- BINARY OUTPUT METERS > to view -----	This is the sub-group that includes all the meters that are associated with the Binary Outputs TEST/RESET ► allows access to this sub-group
BO 1-8 ----	Displays the state of DC binary Outputs 1 to 8. (The number of binary outputs may vary depending on model)

1.16 Virtual Meters

Instrument	Description
----- VIRTUAL METERS > to view -----	This is the sub-group that shows the state of the virtual status inputs in the relay TEST/RESET ► allows access to this sub-group
V 1-8 ----	Displays the state of Virtual Outputs 1 to 8 (The number of virtual inputs will vary depending on model)

1.17 Miscellaneous Meters

Instrument	Description
----- MISCELLANEOUS METERS > to view -----	This is the sub-group that includes indication such as the relays time and date, the amount of fault and waveform records stored in the relay TEST/RESET ► allows access to this sub-group
Start Alarm Count 00 Target 000	Displays the number of Start Up operations experienced by the relay
Date 01/01/2000 Time 22:41:44 Waveform Recs 0 Fault Recs 0	This meter displays the Date, Time, the number of Waveform Records and Fault Records stored in the relay.
Event Recs 0 Data Log Recs 0 Settings Group 1	This meter displays the number of Event Records, Data Log Records and the Active Settings Group number stored in the relay.

1.18 Auto-Reclose Meters

Instrument	Description
----- AUTORECLOSE METERS > to view -----	This is the sub-group that includes all the meters that are associated with Autoreclose TEST/RESET ► allows access to this sub-group. Only seen on models that have the 79 option
Autoreclose Status Out Of Service Close Shot 0	Status of the autoreclose.

1.19 Communication Meters

Instrument	Description
----- COMMUNICATION METERS > to view -----	This is the sub-group that includes all the meters that are associated with Communications ports TEST/RESET ► allows access to this sub-group
COM1 COM2	Displays which com ports are currently active
COM1 TRAFFIC Tx1 0 Rx1 0 Rx1 Errors 0	Displays traffic on Com1
COM2 TRAFFIC Tx2 0 Rx2 0 Rx2 Errors 0	Displays traffic on Com2
EN100 INFORMATION Version : EN100 Version Info Part# BF1111111111	Displays EN100 information
Network Config Mac 00000000 IP 000.000.000.000 NM 255.255.255.000	Displays EN100 network information
Gateway: 000.000.000.000 EN100 NTP info: EN100 Link ½ status info: EN100 Rx/Tx Count	Displays further EN100 61850 information
En100 Rx/Tx Error En100 Rx/Tx 10s CPU Load % EN100 Info Meters : 1-n	Displays further EN100 61850 information

1.20 Quick Logic Meters

Instrument	Description
----- QUICK LOGIC METERS > to view -----	This is the sub-group that includes all the meters that are associated with QuickLogic. TEST/RESET ► allows access to this sub-group
E 1-4 ----	Shows the state of all the equations
E1 Equation EQN =0 TMR 0-0 =0 CNT 0-1 =0	Shows the state of an individual equation. EQN shows the equation state. TMR shows the timer progress and state for the equation. CNT shows the count progress and state for the equation.
...	
E4 Equation EQN =0 TMR 0-0 =0 CNT 0-1 =0	Shows the state of an individual equation. EQN shows the equation state. TMR shows the timer progress and state for the equation. CNT shows the count progress and state for the equation.

7SR18 Line Differential Protection Settings Guide

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Document Release History

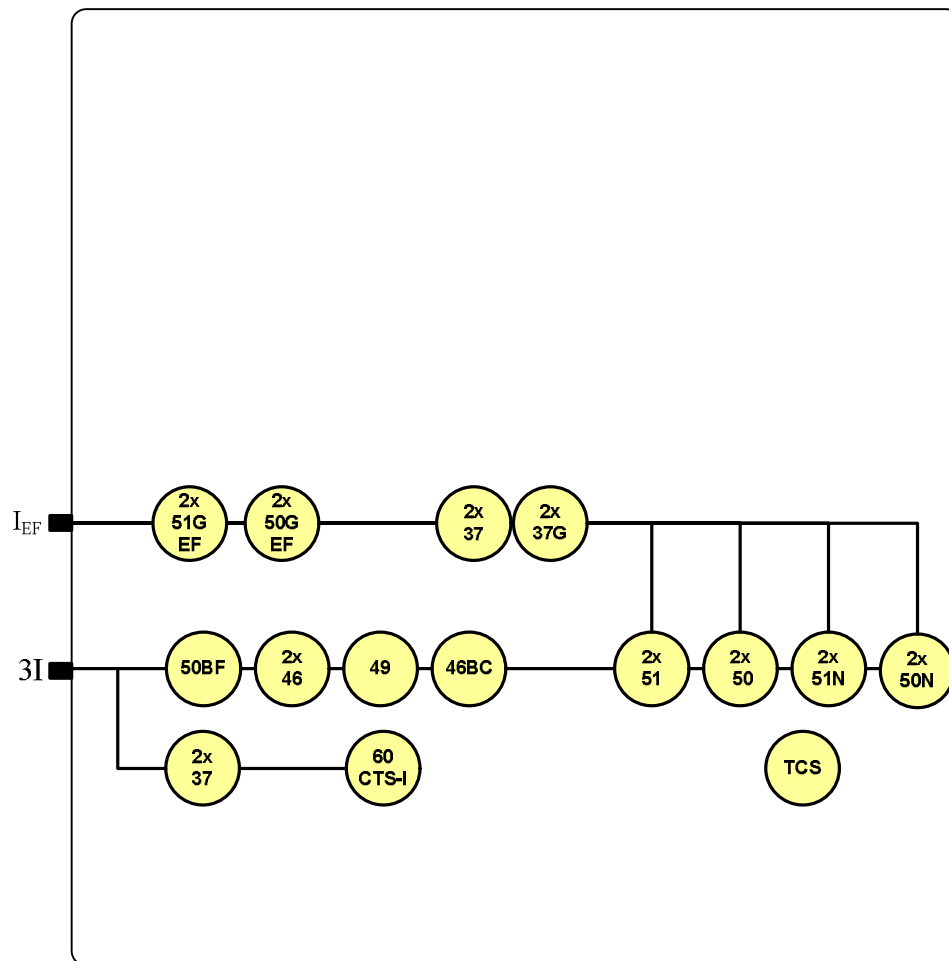
This document is issue 2022/05. The list of revisions up to and including this issue is: -

2016/11	First issue
2017/05	Typographical revisions, drawing amendments
2017/11	Typographical revisions
2018/07	Amended connection diagrams, additional disposal information
2022/05	Typographical revisions to page footer, no changes to content

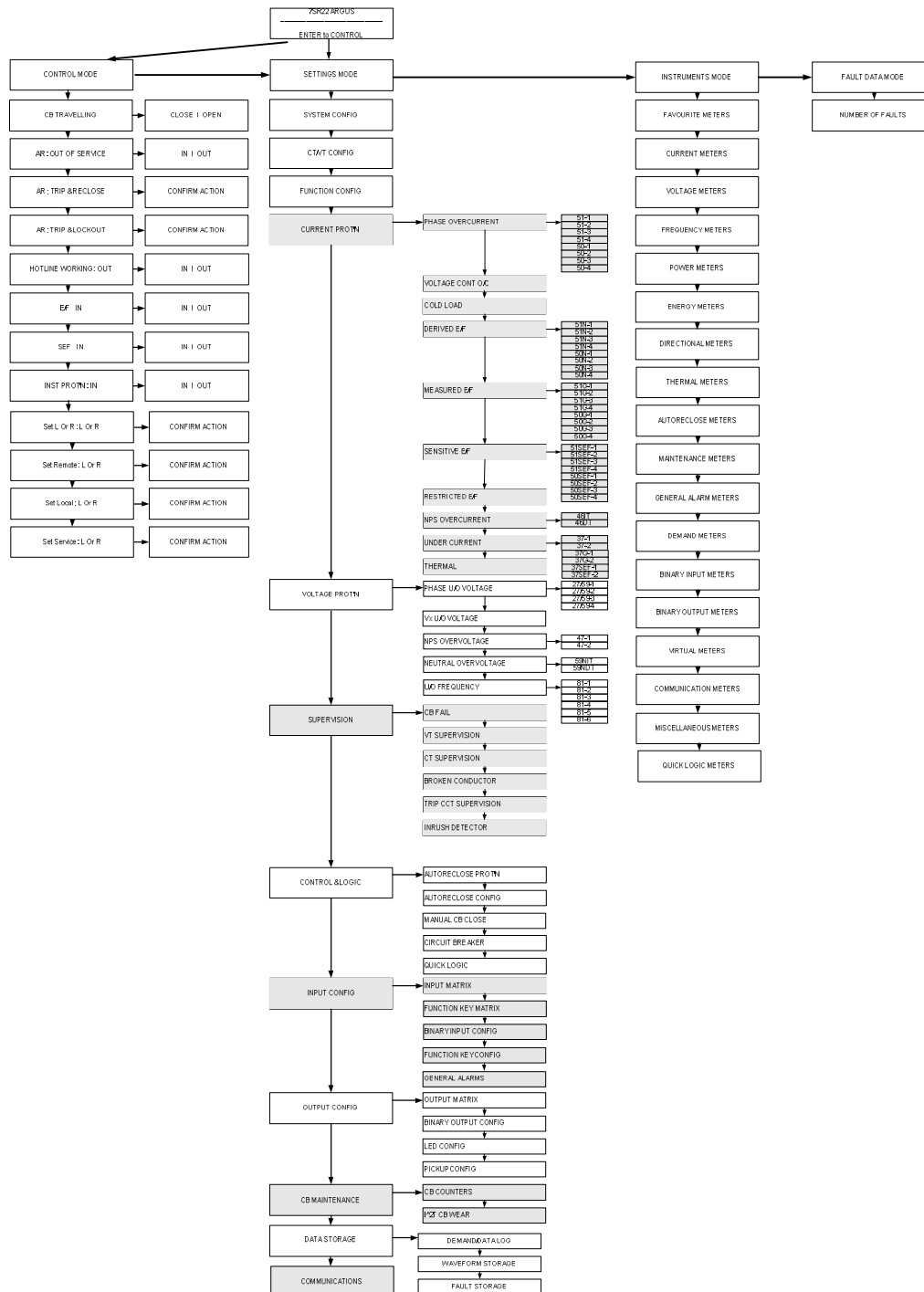
Software Revision History

2016/11	2436H80016R4d-1b	First Release
2018/07	2436H80016R4i-1c	Software maintenance to address production SW upload.

Function Diagram



Typical Menu Structure



Relay Settings

1 SYSTEM CONFIG

Description	Range	Default
System Frequency	50, 60	50Hz
Setting Dependencies	Disabled, Enabled	Enabled
Favourite Meters Timer	Off, 1, 2, 5, 10, 15, 30, 60	60min
Backlight timer	Off, 1, 2, 5, 10, 15, 30, 60	Off
Curr Set Display	xNom, Primary, Secondary	xNom
E/F Curr Set Display	xNom, Primary, Secondary	xNom
Export Power/Lag VAr	+ve/+ve, +ve/-ve, -ve/+ve, -ve/-ve	+ve/+ve
Select Grp Mode	Edge triggered, Level triggered	Edge triggered
Clock Sync. From BI	Disabled, Seconds, Minutes	Disabled
Operating Mode	Out Of Service, Local, Remote, Local Or Remote	Local Or Remote
Disk Activity Symbol	Disabled, Enabled	Disabled
Archiver Blocking Time	0, 0.5 ... 59.5, 60	0.5min
Unexpected Restart Blocking	Disabled, Enabled	Disabled
Unexpected Restart Count	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20	3
Unexpected Restart Period	1, 2 ... 99, 100	1hrs
Setting Password	(Password)	NONE
Control Password	(Password)	AAAA
Trip Alert	Disabled, Enabled	Enabled
General Alarm Alert	Disabled, Enabled	Enabled
Relay Identifier	(16 Character String)	FINISHED
Circuit Identifier	(16 Character String)	

2 CT/VT CONFIG

Description	Range	Default
Phase Rotation	A,B,C, A,C,B	A,B,C
Phase Nom Voltage	40, 40.1 ... 159.9, 160	63.5V
Phase Voltage Trim Magnitude	0, 0.1 ... 19.9, 20	0V
Phase Voltage Trim Angle	-45, -44.9 ... 44.9, 45	0deg
Phase Voltage Config	Van,Vbn,Vcn, Vab,Vbc,3V0, Va,Vb,Vc	Van,Vbn,Vcn
Phase VT Ratio Prim	(6 Character String)	132000
Phase VT Ratio Sec	40, 40.5 ... 159.5, 160	110
Phase Current Input	1, 5	1A
Phase CT Ratio Prim	(6 Character String)	2000
Phase CT Ratio Sec	0.2, 0.21 ... 6.9, 7	1
Earth Current Input	1, 5	1A
Earth CT Ratio Prim	(6 Character String)	2000
Earth CT Ratio Sec	0.2, 0.21 ... 6.9, 7	1

Description	Range	Default
Remote Phase Current Input	1, 5	1A
Remote Phase CT Ratio Prim	(6 Character String)	2000
Remote Phase CT Ratio Sec	0.2, 0.21 ... 6.9, 7	1
Remote Earth Current Input	1, 5	1A
Remote Earth CT Ratio Prim	(6 Character String)	2000
Remote Earth CT Ratio Sec	0.2, 0.21 ... 6.9, 7	1
Gn Phase A Reversal	Disabled, Enabled	Disabled
Gn Phase B Reversal	Disabled, Enabled	Disabled
Gn Phase C Reversal	Disabled, Enabled	Disabled

3 FUNCTION CONFIG

Description	Range	Default
Gn Prot'n Comms	Enabled, Disabled	Enabled
Gn Differential	Enabled, Disabled	Enabled
Gn Intertrip	Enabled, Disabled	Disabled
Gn Phase Overcurrent	Enabled, Disabled	Enabled
Gn Voltage Cont O/C	Enabled, Disabled	Disabled
Gn Cold Load	Enabled, Disabled	Disabled
Gn Derived E/F	Enabled, Disabled	Disabled
Gn Measured E/F	Enabled, Disabled	Enabled
Gn NPS Overcurrent	Enabled, Disabled	Disabled
Gn Under Current	Enabled, Disabled	Disabled
Gn Thermal	Enabled, Disabled	Disabled
Gn Line Check	Enabled, Disabled	Disabled
Gn CB Fail	Enabled, Disabled	Disabled
Gn VT Supervision	Enabled, Disabled	Disabled
Gn CT Supervision	Enabled, Disabled	Disabled
Gn Broken Conductor	Enabled, Disabled	Disabled
Gn Trip Cct Supervision	Enabled, Disabled	Disabled
Gn Close Cct Supervis'n	Enabled, Disabled	Disabled
Gn Inrush Detector	Enabled, Disabled	Disabled
Gn CB Counters	Enabled, Disabled	Disabled
Gn I ² t CB Wear	Enabled, Disabled	Disabled

4 PROT'N COMMS

4.1 PROTECTION COMMS

Description	Range	Default
Prot'n Address	1, 2 ... 253, 254	1
Prot'n Comms Alarm	Disabled, Enabled	Enabled
Prot'n Comms Alarm Delay	1, 2 ... 59, 60	5s
Prot'n Test Mode	Off, Loop Test, Line Test	Off

4.2 INTERTRIP

4.2.1 85

Description	Range	Default
Gn 85	Enabled, Disabled	Disabled

5 DIFFERENTIAL PROT'N

Description	Range	Default
Local CT Multiplier	0.25, 0.26 ... 2.99, 3	1x
Remote CT Multiplier	0.25, 0.26 ... 2.99, 3	1x

5.1 LINE DIFFERENTIAL

5.1.1 87L-1

Description	Range	Default
Gn 87L-1 Element	Disabled, Enabled	Enabled
Gn 87L-1 Initial Setting	0.1, 0.15 ... 2.45, 2.5	0.3xIn
Gn 87L-1 1st Bias Slope	0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7	0.3x
Gn 87L-1 1st Bias Slope Limit	0.5, 0.6 ... 19.9, 20	2xIn
Gn 87L-1 2nd Bias Slope	0.5, 0.55 ... 1.95, 2	1.5x
Gn 87L-1 Delay	0, 0.005 ... 59.9, 60	1s
Gn 87L-1 Offset	Disabled, Enabled	Enabled

5.1.2 87L-2

Description	Range	Default
Gn 87L-2 Element	Disabled, Enabled	Disabled
Gn 87L-2 Initial Setting	0.1, 0.15 ... 2.45, 2.5	0.3xIn
Gn 87L-2 1st Bias Slope	0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7	0.3x
Gn 87L-2 1st Bias Slope Limit	0.5, 0.6 ... 19.9, 20	2xIn
Gn 87L-2 2nd Bias Slope	0.5, 0.55 ... 1.95, 2	1.5x
Gn 87L-2 Delay	0, 0.005 ... 59.9, 60	0s
Gn 87L-2 Offset	Disabled, Enabled	Enabled

6 DIFFERENTIAL HS

6.1 87HS-1

Description	Range	Default
Gn 87HS-1 Element	Disabled, Enabled	Enabled
Gn 87HS-1 Setting	1, 2 ... 29, 30	4xIn
Gn 87HS-1 Delay	0, 0.005 ... 59.9, 60	1s

6.2 87HS-2

Description	Range	Default
Gn 87HS-2 Element	Disabled, Enabled	Disabled
Gn 87HS-2 Setting	1, 2 ... 29, 30	20xIn
Gn 87HS-2 Delay	0, 0.005 ... 59.9, 60	0s

7 DIFFERENTIAL IT

7.1 87R

Description	Range	Default
Gn 87R Element	Disabled, Enabled	Disabled
Gn 87R Delay	0, 0.005 ... 59.9, 60	0.005s

8 CURRENT PROT'N

8.1 PHASE OVERCURRENT

Description	Range	Default
Gn 67 Char Angle	-95, -94 ... 94, 95	45deg
Gn 67 Minimum Voltage	1, 1.5 ... 19.5, 20	1V
Gn 67 2-out-of-3 Logic	Enabled, Disabled	Disabled
Gn 50 Measurement	RMS, Fundamental	RMS
Gn 51 Measurement	RMS, Fundamental	RMS

8.1.1 51-1

Description	Range	Default
Gn 51-1 Element	Disabled, Enabled	Enabled
Gn 51-1 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51-1 Setting	0.05, 0.06 ... 2.49, 2.5	1xIn
Gn 51-1 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51-1 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51-1 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51-1 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51-1 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51-1 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51-1 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51-1 Inrush Action	Off, Inhibit	Off

8.1.2 51-2

Description	Range	Default
Gn 51-2 Element	Disabled, Enabled	Disabled
Gn 51-2 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51-2 Setting	0.05, 0.06 ... 2.49, 2.5	1xIn
Gn 51-2 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI

Description	Range	Default
Gn 51-2 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51-2 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51-2 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51-2 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51-2 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51-2 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51-2 Inrush Action	Off, Inhibit	Off

8.1.3 51-3

Description	Range	Default
Gn 51-3 Element	Disabled, Enabled	Disabled
Gn 51-3 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51-3 Setting	0.05, 0.06 ... 2.49, 2.5	1xIn
Gn 51-3 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51-3 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51-3 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51-3 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51-3 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51-3 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51-3 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51-3 Inrush Action	Off, Inhibit	Off

8.1.4 51-4

Description	Range	Default
Gn 51-4 Element	Disabled, Enabled	Disabled
Gn 51-4 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51-4 Setting	0.05, 0.06 ... 2.49, 2.5	1xIn
Gn 51-4 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51-4 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51-4 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51-4 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51-4 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51-4 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51-4 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51-4 Inrush Action	Off, Inhibit	Off

8.1.5 50-1

Description	Range	Default
Gn 50-1 Element	Disabled, Enabled	Disabled
Gn 50-1 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50-1 Setting	0.05, 0.06 ... 49.5, 50	1xIn

Description	Range	Default
Gn 50-1 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50-1 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50-1 Inrush Action	Off, Inhibit	Off

8.1.6 50-2

Description	Range	Default
Gn 50-2 Element	Disabled, Enabled	Disabled
Gn 50-2 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50-2 Setting	0.05, 0.06 ... 49.5, 50	1xIn
Gn 50-2 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50-2 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50-2 Inrush Action	Off, Inhibit	Off

8.1.7 50-3

Description	Range	Default
Gn 50-3 Element	Disabled, Enabled	Disabled
Gn 50-3 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50-3 Setting	0.05, 0.06 ... 49.5, 50	1xIn
Gn 50-3 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50-3 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50-3 Inrush Action	Off, Inhibit	Off

8.1.8 50-4

Description	Range	Default
Gn 50-4 Element	Disabled, Enabled	Disabled
Gn 50-4 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50-4 Setting	0.05, 0.06 ... 49.5, 50	1xIn
Gn 50-4 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50-4 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50-4 Inrush Action	Off, Inhibit	Off

9 VOLTAGE CONT O/C

Description	Range	Default
Gn 51V Element (Ph-Ph)	Disabled, Enabled	Disabled
Gn 51V Setting	5, 5.5 ... 199.5, 200	30V
Gn 51V VTS Action	Off, Inhibit	Off
Gn 51-1 Multiplier	0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1	0.5
Gn 51-2 Multiplier	0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1	0.5
Gn 51-3 Multiplier	0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1	0.5

Description	Range	Default
Gn 51-4 Multiplier	0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1	0.5

10 COLD LOAD

Description	Range	Default
Cold Load	Disabled, Enabled	Disabled
Pick-up Time	1, 1.1 ... 14100, 14400	600s
Drop-off Time	1, 1.1 ... 14100, 14400	600s
Reduced Current	Disabled, Enabled	Disabled
Reduced Current Level	0.05, 0.1 ... 2.45, 2.5	0.25xIn
Reduced Current Time	1, 1.1 ... 14100, 14400	600s
Gn 51c-1 Setting	0.05, 0.06 ... 2.49, 2.5	1xIn
Gn 51c-1 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51c-1 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51c-1 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51c-1 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51c-1 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51c-1 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51c-2 Setting	0.05, 0.06 ... 2.49, 2.5	1xIn
Gn 51c-2 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51c-2 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51c-2 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51c-2 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51c-2 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51c-2 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51c-3 Setting	0.05, 0.06 ... 2.49, 2.5	1xIn
Gn 51c-3 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51c-3 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51c-3 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51c-3 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51c-3 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51c-3 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51c-4 Setting	0.05, 0.06 ... 2.49, 2.5	1xIn
Gn 51c-4 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51c-4 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51c-4 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51c-4 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51c-4 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51c-4 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s

11 DERIVED E/F

Description	Range	Default
Gn 67N Polarizing Quantity	ZPS, NPS	ZPS
Gn 67N Char Angle	-95, -94 ... 94, 95	-15deg
Gn 67N Minimum Voltage	0.33, 0.5, 1, 1.5, 2, 2.5, 3	0.33V

11.1 51N-1

Description	Range	Default
Gn 51N-1 Element	Disabled, Enabled	Disabled
Gn 51N-1 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51N-1 Setting	0.05, 0.06 ... 2.49, 2.5	0.5xIn
Gn 51N-1 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51N-1 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51N-1 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51N-1 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51N-1 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51N-1 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51N-1 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51N-1 Inrush Action	Off, Inhibit	Off

11.2 51N-2

Description	Range	Default
Gn 51N-2 Element	Disabled, Enabled	Disabled
Gn 51N-2 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51N-2 Setting	0.05, 0.06 ... 2.49, 2.5	0.5xIn
Gn 51N-2 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51N-2 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51N-2 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51N-2 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51N-2 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51N-2 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51N-2 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51N-2 Inrush Action	Off, Inhibit	Off

11.3 51N-3

Description	Range	Default
Gn 51N-3 Element	Disabled, Enabled	Disabled
Gn 51N-3 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51N-3 Setting	0.05, 0.06 ... 2.49, 2.5	0.5xIn
Gn 51N-3 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51N-3 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51N-3 Delay (DTL)	0, 0.01 ... 19.99, 20	5s

Description	Range	Default
Gn 51N-3 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51N-3 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51N-3 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51N-3 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51N-3 Inrush Action	Off, Inhibit	Off

11.4 51N-4

Description	Range	Default
Gn 51N-4 Element	Disabled, Enabled	Disabled
Gn 51N-4 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51N-4 Setting	0.05, 0.06 ... 2.49, 2.5	0.5xIn
Gn 51N-4 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51N-4 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51N-4 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51N-4 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51N-4 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51N-4 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51N-4 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51N-4 Inrush Action	Off, Inhibit	Off

11.5 50N-1

Description	Range	Default
Gn 50N-1 Element	Disabled, Enabled	Disabled
Gn 50N-1 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50N-1 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50N-1 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50N-1 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50N-1 Inrush Action	Off, Inhibit	Off

11.6 50N-2

Description	Range	Default
Gn 50N-2 Element	Disabled, Enabled	Disabled
Gn 50N-2 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50N-2 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50N-2 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50N-2 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50N-2 Inrush Action	Off, Inhibit	Off

11.7 50N-3

Description	Range	Default
Gn 50N-3 Element	Disabled, Enabled	Disabled
Gn 50N-3 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir

Description	Range	Default
Gn 50N-3 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50N-3 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50N-3 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50N-3 Inrush Action	Off, Inhibit	Off

11.8 50N-4

Description	Range	Default
Gn 50N-4 Element	Disabled, Enabled	Disabled
Gn 50N-4 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50N-4 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50N-4 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50N-4 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50N-4 Inrush Action	Off, Inhibit	Off

12 MEASURED E/F

Description	Range	Default
Gn 67G Char Angle	-95, -94 ... 94, 95	-15deg
Gn 67G Minimum Voltage	0.33, 0.5, 1, 1.5, 2, 2.5, 3	0.33V
Gn 50G Measurement	RMS, Fundamental	RMS
Gn 51G Measurement	RMS, Fundamental	RMS

12.1 51G-1

Description	Range	Default
Gn 51G-1 Element	Disabled, Enabled	Enabled
Gn 51G-1 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51G-1 Setting	0.05, 0.06 ... 2.49, 2.5	0.5xIn
Gn 51G-1 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51G-1 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51G-1 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51G-1 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51G-1 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51G-1 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51G-1 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51G-1 Inrush Action	Off, Inhibit	Off

12.2 51G-2

Description	Range	Default
Gn 51G-2 Element	Disabled, Enabled	Disabled
Gn 51G-2 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51G-2 Setting	0.05, 0.06 ... 2.49, 2.5	0.5xIn
Gn 51G-2 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI

Description	Range	Default
Gn 51G-2 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51G-2 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51G-2 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51G-2 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51G-2 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51G-2 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51G-2 Inrush Action	Off, Inhibit	Off

12.3 51G-3

Description	Range	Default
Gn 51G-3 Element	Disabled, Enabled	Disabled
Gn 51G-3 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51G-3 Setting	0.05, 0.06 ... 2.49, 2.5	0.5xIn
Gn 51G-3 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51G-3 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51G-3 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51G-3 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51G-3 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51G-3 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51G-3 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51G-3 Inrush Action	Off, Inhibit	Off

12.4 51G-4

Description	Range	Default
Gn 51G-4 Element	Disabled, Enabled	Disabled
Gn 51G-4 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 51G-4 Setting	0.05, 0.06 ... 2.49, 2.5	0.5xIn
Gn 51G-4 Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 51G-4 Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 51G-4 Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 51G-4 Min Operate Time	0, 0.01 ... 19.99, 20	0s
Gn 51G-4 Follower DTL	0, 0.01 ... 19.99, 20	0s
Gn 51G-4 Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s
Gn 51G-4 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 51G-4 Inrush Action	Off, Inhibit	Off

12.5 50G-1

Description	Range	Default
Gn 50G-1 Element	Disabled, Enabled	Disabled
Gn 50G-1 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50G-1 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn

Description	Range	Default
Gn 50G-1 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50G-1 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50G-1 Inrush Action	Off, Inhibit	Off

12.6 50G-2

Description	Range	Default
Gn 50G-2 Element	Disabled, Enabled	Disabled
Gn 50G-2 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50G-2 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50G-2 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50G-2 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50G-2 Inrush Action	Off, Inhibit	Off

12.7 50G-3

Description	Range	Default
Gn 50G-3 Element	Disabled, Enabled	Disabled
Gn 50G-3 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50G-3 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50G-3 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50G-3 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50G-3 Inrush Action	Off, Inhibit	Off

12.8 50G-4

Description	Range	Default
Gn 50G-4 Element	Disabled, Enabled	Disabled
Gn 50G-4 Dir. Control	Non-Dir, Forward, Reverse	Non-Dir
Gn 50G-4 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50G-4 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50G-4 VTS Action	Off, Inhibit, Non-Dir	Off
Gn 50G-4 Inrush Action	Off, Inhibit	Off

13 NPS OVERCURRENT

13.1 46IT

Description	Range	Default
Gn 46IT Element	Disabled, Enabled	Disabled
Gn 46IT Setting	0.05, 0.06 ... 2.49, 2.5	0.25xIn
Gn 46IT Char	DTL, IEC-NI, IEC-VI, IEC-EI, IEC-LTI, ANSI-MI, ANSI-VI, ANSI-EI	IEC-NI
Gn 46IT Time Mult (IEC/ANSI)	0.025, 0.03 ... 99, 100	1
Gn 46IT Delay (DTL)	0, 0.01 ... 19.99, 20	5s
Gn 46IT Reset	(IEC/ANSI) Decaying, 0 ... 59, 60	0s

13.2 46DT

Description	Range	Default
Gn 46DT Element	Disabled, Enabled	Disabled
Gn 46DT Setting	0.05, 0.06 ... 3.99, 4	0.1xIn
Gn 46DT Delay	0, 0.01 ... 14300, 14400	0.02s

14 UNDER CURRENT

Description	Range	Default
Gn 37 U/C Guard Setting	0.05, 0.1 ... 4.95, 5	0.1xIn

14.1 37-1

Description	Range	Default
Gn 37-1 Element	Disabled, Enabled	Disabled
Gn 37-1 Setting	0.05, 0.1 ... 4.95, 5	0.25xIn
Gn 37-1 Delay	0, 0.01 ... 14300, 14400	0s
Gn 37-1 U/C Guarded	No, Yes	Yes
Gn 37-1 Start Option	All, Any	All

14.2 37-2

Description	Range	Default
Gn 37-2 Element	Disabled, Enabled	Disabled
Gn 37-2 Setting	0.05, 0.1 ... 4.95, 5	0.25xIn
Gn 37-2 Delay	0, 0.01 ... 14300, 14400	0s
Gn 37-2 U/C Guarded	No, Yes	Yes
Gn 37-2 Start Option	All, Any	All

14.3 37G-1

Description	Range	Default
Gn 37G-1 Element	Disabled, Enabled	Disabled
Gn 37G-1 Setting	0.05, 0.1 ... 4.95, 5	0.2xIn
Gn 37G-1 Delay	0, 0.01 ... 14300, 14400	0s

14.4 37G-2

Description	Range	Default
Gn 37G-2 Element	Disabled, Enabled	Disabled
Gn 37G-2 Setting	0.05, 0.1 ... 4.95, 5	0.2xIn
Gn 37G-2 Delay	0, 0.01 ... 14300, 14400	0s

15 THERMAL

Description	Range	Default
Gn 49 Thermal Overload	Disabled, Enabled	Disabled
Gn 49 Overload Setting	0.1, 0.11 ... 2.99, 3	1.05xIn
Gn 49 Time Constant	1, 1.5 ... 999.5, 1000	10m

Description	Range	Default
Gn 49 Capacity Alarm	Disabled, Enabled	Disabled
Gn 49 Capacity Alarm Setting	50, 51 ... 99, 100	50%

16 LINE CHECK

Description	Range	Default
Gn 50 LC Measurement	RMS, Fundamental	RMS
Gn 50G LC Measurement	RMS, Fundamental	RMS

16.1 50 LC-1

Description	Range	Default
Gn 50 LC-1 Element	Disabled, Enabled	Disabled
Gn 50 LC-1 Setting	0.05, 0.06 ... 49.5, 50	1xIn
Gn 50 LC-1 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50 LC-1 Inrush Action	Off, Inhibit	Off

16.2 50 LC-2

Description	Range	Default
Gn 50 LC-2 Element	Disabled, Enabled	Disabled
Gn 50 LC-2 Setting	0.05, 0.06 ... 49.5, 50	1xIn
Gn 50 LC-2 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50 LC-2 Inrush Action	Off, Inhibit	Off

16.3 50G LC-1

Description	Range	Default
Gn 50G LC-1 Element	Disabled, Enabled	Disabled
Gn 50G LC-1 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50G LC-1 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50G LC-1 Inrush Action	Off, Inhibit	Off

16.4 50G LC-2

Description	Range	Default
Gn 50G LC-2 Element	Disabled, Enabled	Disabled
Gn 50G LC-2 Setting	0.05, 0.06 ... 49.5, 50	0.5xIn
Gn 50G LC-2 Delay	0, 0.01 ... 14300, 14400	0s
Gn 50G LC-2 Inrush Action	Off, Inhibit	Off

17 SUPERVISION

17.1 CB FAIL

Description	Range	Default
Gn 50BF Element	Disabled, Enabled	Disabled
Gn 50BF Setting	0.05, 0.055 ... 1.995, 2	0.2xIn

Description	Range	Default
Gn 50BF-I4 Setting	0.05, 0.055 ... 1.995, 2	0.05xIn
Gn 50BF-1 Delay	20, 25 ... 59995, 60000	60ms
Gn 50BF-2 Delay	20, 25 ... 59995, 60000	120ms

17.2 VT SUPERVISION

Description	Range	Default
Gn 60VTS Element	Disabled, Enabled	Disabled
Gn 60VTS Component	NPS, ZPS	NPS
Gn 60VTS V	7, 8 ... 109, 110	7V
Gn 60VTS I	0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1	0.05xIn
Gn 60VTS Vpps	1, 2 ... 109, 110	15V
Gn 60VTS Ipps Load	0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1	0.1xIn
Gn 60VTS Ipps Fault	0.05, 0.1 ... 19.95, 20	10xIn
Gn 60VTS Delay	0.03, 0.04 ... 14300, 14400	0.03s

17.3 CT SUPERVISION

Description	Range	Default
Gn 60CTS-I Element	Disabled, Enabled	Disabled
Gn 60CTS-I Setting	0.05, 0.1 ... 1.95, 2	0.05xIn
Gn 60CTS-I Delay	0.03, 0.04 ... 14300, 14400	10s
Gn 60CTS Element	Disabled, Enabled	Disabled
Gn 60CTS Inps	0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1	0.1xIn
Gn 60CTS Vnps	7, 8 ... 109, 110	10V
Gn 60CTS Delay	0.03, 0.04 ... 14300, 14400	10s

17.4 BROKEN CONDUCTOR

Description	Range	Default
Gn 46BC U/C Guard Setting	0.05, 0.1 ... 4.95, 5	0.25xIn
Gn 46BC U/C Guarded	No, Yes	No
Gn 46BC Element	Disabled, Enabled	Disabled
Gn 46BC Setting	20, 21 ... 99, 100	20%
Gn 46BC Delay	0.03, 0.04 ... 14300, 14400	20s

17.5 TRIP CCT SUPERVISION

Description	Range	Default
Gn 74TCS-1	Disabled, Enabled	Disabled
Gn 74TCS-1 Delay	0, 0.02 ... 59.98, 60	0.4s

Description	Range	Default
Gn 74TCS-2	Disabled, Enabled	Disabled
Gn 74TCS-2 Delay	0, 0.02 ... 59.98, 60	0.4s
Gn 74TCS-3	Disabled, Enabled	Disabled
Gn 74TCS-3 Delay	0, 0.02 ... 59.98, 60	0.4s

17.6 CLOSE CCT SUPERVIS'N

Description	Range	Default
Gn 74CCS-1	Disabled, Enabled	Disabled
Gn 74CCS-1 Delay	0, 0.02 ... 59.98, 60	0.4s
Gn 74CCS-2	Disabled, Enabled	Disabled
Gn 74CCS-2 Delay	0, 0.02 ... 59.98, 60	0.4s
Gn 74CCS-3	Disabled, Enabled	Disabled
Gn 74CCS-3 Delay	0, 0.02 ... 59.98, 60	0.4s

17.7 INRUSH DETECTOR

Description	Range	Default
Gn 81HBL2 Element	Disabled, Enabled	Disabled
Gn 81HBL2 Bias	Phase, Cross, Sum	Cross
Gn 81HBL2 Setting	0.1, 0.11 ... 0.49, 0.5	0.2xl

18 CONTROL & LOGIC

18.1 AUTORECLOSE PROT'N

Description	Range	Default
Gn 79 P/F Inst Trips <i>Selects which phase fault protection elements are classed as Instantaneous elements and start an autoreclose sequence. These will be blocked from operating during Delayed autoreclose sequences. See autoreclose section of manual for detail of what elements can cause only Delayed protection to be used.</i>	Combination of (51-1, 51-2, 51-3, 51-4, 50-1, 50-2, 50-3, 50-4)	-----
Gn 79 E/F Inst Trips <i>Selects which earth fault protection elements are classed as Instantaneous elements and start an autoreclose sequence. These will be blocked from operating during Delayed autoreclose sequences. See autoreclose section of manual for detail of what elements can cause only Delayed protection to be used.</i>	Combination of (51N-1, 51N-2, 51N-3, 51N-4, 50N-1, 50N-2, 50N-3, 50N-4, 51G-1, 51G-2, 51G-3, 51G-4, 50G-1, 50G-2, 50G-3, 50G-4)	-----
Gn 79 P/F Delayed Trips <i>Selects which phase fault protection are classed as Delayed elements, any selected elements operating will start an autoreclose sequence.</i>	Combination of (51-1, 51-2, 51-3, 51-4, 50-1, 50-2, 50-3, 50-4)	51-1, 51-2, 51-3, 51-4, 50-1, 50-2, 50-3, 50-4
Gn 79 E/F Delayed Trips <i>Selects which earth fault protection are classed as Delayed elements, any selected elements operating will start an autoreclose sequence.</i>	Combination of (51N-1, 51N-2, 51N-3, 51N-4, 50N-1, 50N-2, 50N-3, 50N-4, 51G-1, 51G-2, 51G-3, 51G-4, 50G-1, 50G-2, 50G-3, 50G-4)	51N-1, 51N-2, 51N-3, 51N-4, 50N-1, 50N-2, 50N-3, 50N-4, 51G-1, 51G-2, 51G-3, 51G-4, 50G-1, 50G-2, 50G-3, 50G-4

Description	Range	Default
Gn 79 P/F HS Trips <i>Selects which phase fault elements are classed as High Set elements, any selected elements operating will start an autoreclose sequence.</i>	Combination of (50-1, 50-2, 50-3, 50-4)	----
Gn 79 E/F HS Trips <i>Selects which earth fault elements are classed as High Set elements, any selected elements operating will start an autoreclose sequence.</i>	Combination of (50N-1, 50N-2, 50N-3, 50N-4, 50G-1, 50G-2, 50G-3, 50G-4)	-----

18.2 AUTORECLOSE CONFIG

Description	Range	Default
Gn 79 Autoreclose <i>If disabled then all attempts to control the AR IN/OUT status will fail and the AR will be permanently Out Of Service. When enabled the AR IN/OUT state may be controlled via the CONTROL MODE menu option, via Binary Input or via local or remote communications.</i>	Disabled, Enabled	Enabled
Gn 79 Num Shots <i>Selects the number of auto-reclose attempts before the Autorecloser locks out</i>	1, 2, 3, 4	1
Gn 79 Retry Enable <i>Selects whether the Retry close functionality is enabled</i>	Disabled, Enabled	Disabled
Gn 79 Retry Attempts <i>Selects the number of retries allowed per shot</i>	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	1
Gn 79 Retry Interval <i>Time delay between retries</i>	0, 1 ... 599, 600	60 s
Gn 79 Reclose Blocked Delay <i>Specifies the maximum time that the Autorecloser can be blocked before proceeding to the lockout state. (NOTE: The block delay timer only starts after the Deadtime.)</i>	0, 1 ... 599, 600	60 s
Gn 79 Sequence Fail Timer <i>Time before lockout occurs on an incomplete reclose sequence. (i.e Trip & starter conditions have not been cleared after Sequence Fail Time.)</i>	0, 1 ... 599, 600	60 s
Gn 79 Sequence Co-ord <i>Selects whether Sequence co-ordination functionality is used or not.</i>	Disabled, Enabled	Enabled
Gn 79 Cold Load Action <i>Selects whether whist Cold Load is active the relay will perform only Delayed Trips or not.</i>	Off, Delayed	Off

18.2.1 P/F SHOTS

Description	Range	Default
Gn 79 P/F Prot'n Trip 1 <i>Selects whether the first phase fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all P/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Inst
Gn 79 P/F Deadtime 1 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 P/F Prot'n Trip 2 <i>Selects whether the second phase fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all P/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Inst

Description	Range	Default
Gn 79 P/F Deadtime 2 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 P/F Prot'n Trip 3 <i>Selects whether the third phase fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all P/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Delayed
Gn 79 P/F Deadtime 3 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 P/F Prot'n Trip 4 <i>Selects whether the fourth phase fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all P/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Delayed
Gn 79 P/F Deadtime 4 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 P/F Prot'n Trip 5 <i>Selects whether the fifth phase fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all P/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Delayed
Gn 79 P/F HS Trips To Lockout <i>Selects how many High Set trips are allowed before going to Lockout</i>	1, 2, 3, 4, 5	5
Gn 79 P/F Delayed Trips To Lockout <i>Selects how many Delayed trips are allowed before going to Lockout</i>	1, 2, 3, 4, 5	5

18.2.2 E/F SHOTS

Description	Range	Default
Gn 79 E/F Prot'n Trip 1 <i>Selects whether the first earth fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all E/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Inst
Gn 79 E/F Deadtime 1 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 E/F Prot'n Trip 2 <i>Selects whether the second earth fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all E/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Inst
Gn 79 E/F Deadtime 2 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 E/F Prot'n Trip 3 <i>Selects whether the third earth fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all E/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Delayed
Gn 79 E/F Deadtime 3 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 E/F Prot'n Trip 4 <i>Selects whether the fourth earth fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all E/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Delayed
Gn 79 E/F Deadtime 4 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s

Description	Range	Default
Gn 79 E/F Prot'n Trip 5 <i>Selects whether the fifth earth fault trip is Instantaneous (Fast) or Delayed. When set to Delayed all E/F Inst Trips will be Inhibited for this shot.</i>	Inst, Delayed	Delayed
Gn 79 E/F HS Trips To Lockout <i>Selects how many High Set trips are allowed before going to Lockout</i>	1, 2, 3, 4, 5	5
Gn 79 E/F Delayed Trips To Lockout <i>Selects how many Delayed trips are allowed before going to Lockout</i>	1, 2, 3, 4, 5	5

18.2.4 EXTERN SHOTS

Description	Range	Default
Gn 79 Extern Prot'n Trip 1 <i>Selects whether the first external trip is Instantaneous or Delayed</i>	Not Blocked, Blocked	Not Blocked
Gn 79 Extern Dearthime 1 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 Extern Prot'n Trip 2 <i>Selects whether the second external trip is Instantaneous or Delayed</i>	Not Blocked, Blocked	Not Blocked
Gn 79 Extern Dearthime 2 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 Extern Prot'n Trip 3 <i>Selects whether the third external trip is Instantaneous or Delayed</i>	Not Blocked, Blocked	Not Blocked
Gn 79 Extern Dearthime 3 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 Extern Prot'n Trip 4 <i>Selects whether the fourth external trip is Instantaneous or Delayed</i>	Not Blocked, Blocked	Not Blocked
Gn 79 Extern Dearthime 4 <i>Time period between the fault being cleared and the close pulse being issued</i>	0, 0.1 ... 14300, 14400	5 s
Gn 79 Extern Prot'n Trip 5 <i>Selects whether the fifth external trip is Instantaneous or Delayed</i>	Not Blocked, Blocked	Not Blocked
Gn 79 Extern Trips To Lockout <i>Selects how many external trips are allowed before going to Lockout</i>	1, 2, 3, 4, 5	5

19 MANUAL CB CONTROL

Description	Range	Default
Gn Close CB Delay	0, 0.1 ... 899, 900	10s
Gn Blocked Close Delay	0, 1 ... 599, 600	5s
Gn Open CB Delay	0, 0.1 ... 899, 900	10s
Gn CB Controls Latched	Latch, Reset	Latch

20 CIRCUIT BREAKER

Description	Range	Default
Gn CB Control Trip Time	Disabled, Enabled	Enabled
Gn Trip Time Alarm	0, 0.01 ... 1.99, 2	0.2s
Gn Trip Time Adjust	0, 0.005 ... 1.995, 2	0.015s
Gn Close CB Pulse	0, 0.1 ... 19.9, 20	2s
Gn CB Travel Alarm	0.01, 0.02 ... 1.99, 2	1s
Gn Open CB Pulse	0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2	1s
Gn CB DBI Delay	0, 0.01 ... 1.99, 2	0s

21 QUICK LOGIC

Description	Range	Default
Quick Logic	Disabled, Enabled	Disabled
E1 Equation	Disabled, Enabled	Disabled
E1	(20 Character String)	
E1 Pickup Delay	0, 0.01 ... 14300, 14400	0s
E1 Dropoff Delay	0, 0.01 ... 14300, 14400	0s
E1 Counter Target	1, 2 ... 998, 999	1
E1 Counter Reset Mode	Off, Multi-shot, Single-shot	Off
E1 Counter Reset Time	0, 0.01 ... 14300, 14400	0s
E2 Equation	Disabled, Enabled	Disabled
E2	(20 Character String)	
E2 Pickup Delay	0, 0.01 ... 14300, 14400	0s
E2 Dropoff Delay	0, 0.01 ... 14300, 14400	0s
E2 Counter Target	1, 2 ... 998, 999	1
E2 Counter Reset Mode	Off, Multi-shot, Single-shot	Off
E2 Counter Reset Time	0, 0.01 ... 14300, 14400	0s
E3 Equation	Disabled, Enabled	Disabled
E3	(20 Character String)	
E3 Pickup Delay	0, 0.01 ... 14300, 14400	0s
E3 Dropoff Delay	0, 0.01 ... 14300, 14400	0s
E3 Counter Target	1, 2 ... 998, 999	1
E3 Counter Reset Mode	Off, Multi-shot, Single-shot	Off
E3 Counter Reset Time	0, 0.01 ... 14300, 14400	0s
E4 Equation	Disabled, Enabled	Disabled
E4	(20 Character String)	
E4 Pickup Delay	0, 0.01 ... 14300, 14400	0s
E4 Dropoff Delay	0, 0.01 ... 14300, 14400	0s
E4 Counter Target	1, 2 ... 998, 999	1
E4 Counter Reset Mode	Off, Multi-shot, Single-shot	Off
E4 Counter Reset Time	0, 0.01 ... 14300, 14400	0s

22 INPUT CONFIG

22.1 INPUT MATRIX

Description	Range	Default
Line Check	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 81HBL2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
85S-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
85S-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
85S-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
85S-4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
85S-5	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
85S-6	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 87HS-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 87HS-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 87L-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 87L-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 87R	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit Cold Load	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51-4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50-4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51N-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51N-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51N-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----

Description	Range	Default
Inhibit 51N-4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50N-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50N-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50N-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50N-4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51G-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51G-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51G-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 51G-4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50G-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50G-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50G-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50G-4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 49	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset 49	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 46IT	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 46DT	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 37-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 37-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 37G-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 37G-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 60CTS-I	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 60CTS	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 46BC	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
74TCS-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
74TCS-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----

Description	Range	Default
74TCS-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
74CCS-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
74CCS-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
74CCS-3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50 LC-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50 LC-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50G LC-1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50G LC-2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Trig Trip Contacts	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 50BF	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
50BF CB Faulty	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
50BF Mech Trip	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
50BF Ext Trip	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Inhibit 60VTS	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Ext Trig 60VTS	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Ext Reset 60VTS	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset CB Total Trip	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset CB Ph A Count	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset CB Ph B Count	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset CB Ph C Count	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset CB E/F Count	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset CB Delta Trip	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset I ² t CB Wear	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Trigger I ² t CB Wear	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset Trip Time	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset Energy Meters	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----

Description	Range	Default
General Alarm 1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
General Alarm 2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
General Alarm 3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
General Alarm 4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
General Alarm 5	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
General Alarm 6	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
CB Open	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
CB Closed	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset Demand	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Reset Start Count	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
E/F Out	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
E/F In	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Trigger Wave Rec	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Trigger Fault Rec	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Select Group 1	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Select Group 2	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Select Group 3	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Select Group 4	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Out Of Service Mode	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Local Mode	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Remote Mode	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Local Or Remote Mode	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Close CB	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Block Close CB	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Open CB	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----
Clock Sync.	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----

Description	Range	Default
Reset LEDs & O/Ps	Combination of (BI1, BI2, BI3, V1, V2, V3, V4, V5, V6, V7, V8)	-----

22.2 FUNCTION KEY MATRIX

Description	Range	Default
Open CB	Combination of (1, 2, 3, 4, 5, 6)	-----
Close CB	Combination of (1, 2, 3, 4, 5, 6)	-----
E/F In/Out	Combination of (1, 2, 3, 4, 5, 6)	-----
Out Of Service Mode	Combination of (1, 2, 3, 4, 5, 6)	-----
Local Mode	Combination of (1, 2, 3, 4, 5, 6)	-----
Remote Mode	Combination of (1, 2, 3, 4, 5, 6)	-----
Local Or Remote Mode	Combination of (1, 2, 3, 4, 5, 6)	-----

22.3 BINARY INPUT CONFIG

Description	Range	Default
Inverted Inputs	Combination of (1, 2, 3)	---
BI 1 Pickup Delay	0, 0.005 ... 14300, 14400	0.02s
BI 1 Droptoff Delay	0, 0.005 ... 14300, 14400	0s
BI 2 Pickup Delay	0, 0.005 ... 14300, 14400	0.02s
BI 2 Droptoff Delay	0, 0.005 ... 14300, 14400	0s
BI 3 Pickup Delay	0, 0.005 ... 14300, 14400	0.02s
BI 3 Droptoff Delay	0, 0.005 ... 14300, 14400	0s
Enabled In Local	Combination of (1, 2, 3)	1, 2, 3
Enabled In Remote	Combination of (1, 2, 3)	1, 2, 3

22.4 FUNCTION KEY CONFIG

Description	Range	Default
Function Key 1 Text	(20 Character String)	Function Key 1
Function Key 2 Text	(20 Character String)	Function Key 2
Function Key 3 Text	(20 Character String)	Function Key 3
Function Key 4 Text	(20 Character String)	Function Key 4
Function Key 5 Text	(20 Character String)	Function Key 5
Function Key 6 Text	(20 Character String)	Function Key 6
Enabled In Remote	Combination of (1, 2, 3, 4, 5, 6)	-----

22.5 GENERAL ALARMS

Description	Range	Default
General Alarm-1	(16 Character String)	ALARM 1
General Alarm-2	(16 Character String)	ALARM 2
General Alarm-3	(16 Character String)	ALARM 3
General Alarm-4	(16 Character String)	ALARM 4
General Alarm-5	(16 Character String)	ALARM 5
General Alarm-6	(16 Character String)	ALARM 6

23 OUTPUT CONFIG

23.1 OUTPUT MATRIX

Description	Range	Default
Protection Healthy	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
Active Setting Grp 1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
Active Setting Grp 2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
Active Setting Grp 3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
Active Setting Grp 4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
+ve P (3P)	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
-ve P (3P)	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
+ve Q (3P)	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
-ve Q (3P)	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
Active Exp Pulse	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
Active Imp Pulse	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----

Description	Range	Default
Reactive Exp Pulse	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Reactive Imp Pulse	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
81HBL2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Prot'n Comms Alarm	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Prot'n Comms Disturb	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L15
Prot'n Comms Test	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Prot'n Comms In Sync	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
85R-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
85R-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
85R-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
85R-4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
85R-5	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----

Description	Range	Default
85R-6	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
87HS-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
87HS-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
87L-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	BO3
87L-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
87R-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
87R-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Cold Load Active	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
51-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	BO3
51-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
51-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
51-4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----

Description	Range	Default
50-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50-4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
51N-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
51N-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
51N-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
51N-4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
50N-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
50N-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
50N-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
50N-4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6

Description	Range	Default
51G-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	BO3
51G-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
51G-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
51G-4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
50G-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
50G-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
50G-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
50G-4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L6
49 Trip	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
49 Alarm	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
46IT	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----
46DT	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- -----

Description	Range	Default
37 PhA	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
37 PhB	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
37 PhC	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
37-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
37-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
37G-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
37G-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
60CTS-I	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
60CTS-I PhA	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
60CTS-I PhB	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
60CTS-I PhC	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
60CTS	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----

Description	Range	Default
46BC	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
74TCS-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
74TCS-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
74TCS-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
74CCS-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
74CCS-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
74CCS-3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
General Pickup	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	BO2
50 LC-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50 LC-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50G LC-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50G LC-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----

Description	Range	Default
50BF-1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50BF-2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
60VTS	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50BF PhA	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50BF PhB	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50BF PhC	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
50BF EF	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Total Trip Count	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Ph A Trip Count	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Ph B Trip Count	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Ph C Trip Count	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB E/F Trip Count	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----

Description	Range	Default
CB Delta Trip Count	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
I ² t CB Wear	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Trip Time Alarm	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Open	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Closed	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Successful Close	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Fail To Close	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Close CB Blocked	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
CB Alarm	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Close CB	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Open CB	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Phase A	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L3

Description	Range	Default
Phase B	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L4
Phase C	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L5
Derived E/F	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Measured E/F	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Start Count Alarm	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
User Output 1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L7
User Output 2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	BO4, L8
User Output 3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
User Output 4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
User Output 5	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
User Output 6	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
User Output 7	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----

Description	Range	Default
User Output 8	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
En100 Life	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
En100 Error	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
IEC61850 Configured	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
En100 Ch1 Link Down	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
En100 Ch2 Link Down	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
E/F Out	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
New Wave Stored	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
New Fault Stored	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Out Of Service Mode	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Local Mode	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
Remote Mode	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----

Description	Range	Default
BI 1 Operated	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	BO2
BI 2 Operated	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	BO3
BI 3 Operated	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	BO4, BO5
E1	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
E2	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
E3	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----
E4	Combination of (BO1, BO2, BO3, BO4, BO5, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	----- ----

23.2 BINARY OUTPUT CONFIG

Description	Range	Default
Hand Reset Outputs	Combination of (1, 2, 3, 4, 5)	----
Min Operate Time 1	0, 0.01 ... 59, 60	0.1s
Min Operate Time 2	0, 0.01 ... 59, 60	0.1s
Min Operate Time 3	0, 0.01 ... 59, 60	0.1s
Min Operate Time 4	0, 0.01 ... 59, 60	0.1s
Min Operate Time 5	0, 0.01 ... 59, 60	0.1s
Pickup Outputs	Combination of (1, 2, 3, 4, 5)	----
Pulsed Outputs	Combination of (1, 2, 3, 4, 5)	----

23.3 LED CONFIG

Description	Range	Default
Self Reset LEDs	Combination of (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)	7
PU Self Reset LEDs	Combination of (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)	1, 2, 3, 4, 5, 6, 7, 8, 9

Description	Range	Default
Green LEDs	Combination of (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)	1
Red LEDs	Combination of (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
PU Green LEDs	Combination of (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)	1, 2, 3, 4, 5, 6, 7, 8, 9
PU Red LEDs	Combination of (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)	1, 2, 3, 4, 5, 6, 7, 8, 9

23.4 PICKUP CONFIG

Description	Range	Default
Gn P/F Pickups	Combination of (51-1, 51-2, 51-3, 51-4, 50-1, 50-2, 50-3, 50-4, 87L-1, 87L-2, 87HS-1, 87HS-2)	51-1, 51-2, 51-3, 51-4, 50-1, 50-2, 50-3, 50-4
Gn E/F Pickups	Combination of (51N-1, 51N-2, 51N-3, 51N-4, 50N-1, 50N-2, 50N-3, 50N-4, 51G-1, 51G-2, 51G-3, 51G-4, 50G-1, 50G-2, 50G-3, 50G-4)	51N-1, 51N-2, 51N-3, 51N-4, 50N-1, 50N-2, 50N-3, 50N-4, 51G-1, 51G-2, 51G-3, 51G-4, 50G-1, 50G-2, 50G-3, 50G-4
Gn Misc Pickups	Combination of (46IT, 46DT, 37-1, 37-2, 37G-1, 37G-2)	46IT, 46DT, 37-1, 37-2, 37G-1, 37G-2
Gn Line Check Pickups	Combination of (50-1LC, 50-2LC, 50G-1LC, 50G-2LC)	50-1LC, 50-2LC, 50G-1LC, 50G-2LC

23.5 TRIP CONFIG

Description	Range	Default
Trip Contacts	Combination of (BO1, BO2, BO3, BO4, BO5)	----
Trip Triggered	Combination of (L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, V1, V2, V3, V4, V5, V6, V7, V8)	L2

24 MAINTENANCE

24.1 CB COUNTERS

Description	Range	Default
Gn CB Total Trip Manual Open	Disabled, Enabled	Disabled
Gn CB Total Trip Count	Disabled, Enabled	Disabled
Gn CB Total Trip Count Target	0, 1 ... 9999, 10000	100
Gn CB Phase Trip Counters	Disabled, Enabled	Disabled
Gn CB Ph A Trip Count	Disabled, Enabled	Enabled
Gn CB Ph A Trip Count Target	0, 1 ... 9999, 10000	100
Gn CB Ph B Trip Count	Disabled, Enabled	Enabled
Gn CB Ph B Trip Count Target	0, 1 ... 9999, 10000	100

Description	Range	Default
Gn CB Ph C Trip Count	Disabled, Enabled	Enabled
Gn CB Ph C Trip Count Target	0, 1 ... 9999, 10000	100
Gn CB E/F Trip Count	Disabled, Enabled	Enabled
Gn CB E/F Trip Count Target	0, 1 ... 9999, 10000	100
Gn CB Delta Trip Manual Open	Disabled, Enabled	Disabled
Gn CB Delta Trip Count	Disabled, Enabled	Disabled
Gn CB Delta Trip Count Target	0, 1 ... 9999, 10000	100

24.2 I^Δ2T CB WEAR

Description	Range	Default
Gn I ^Δ 2t Counter	Disabled, Enabled	Disabled
Gn Alarm Limit	10, 11 ... 99000, 100000	10MA ^Δ 2s
Gn Separation Time	0, 0.001 ... 0.199, 0.2	0.02s
Gn Clearance Time	0, 0.001 ... 0.199, 0.2	0.04s

24.3 START COUNT

Description	Range	Default
Start Type(s)	Combination of (Power On, Expected, Unexpected)	Power On, Expected, Unexpected
Start Count Target	0, 1 ... 9999, 10000	100

25 DATA STORAGE

25.1 DEMAND/DATA LOG

Description	Range	Default
Gn Demand Window	1, 2 ... 23, 24	24hrs
Gn Demand Window Type	Fixed, Peak, Rolling	Fixed

25.2 WAVEFORM STORAGE

Description	Range	Default
Gn P/F Trig Storage	Combination of (51-1, 51-2, 51-3, 51-4, 50-1, 50-2, 50-3, 50-4)	51-1, 51-2, 51-3, 51-4, 50-1, 50-2, 50-3, 50-4
Gn E/F Trig Storage	Combination of (51N-1, 51N-2, 51N-3, 51N-4, 50N-1, 50N-2, 50N-3, 50N-4, 51G-1, 51G-2, 51G-3, 51G-4, 50G-1, 50G-2, 50G-3, 50G-4)	51N-1, 51N-2, 51N-3, 51N-4, 50N-1, 50N-2, 50N-3, 50N-4, 51G-1, 51G-2, 51G-3, 51G-4, 50G-1, 50G-2, 50G-3, 50G-4
Gn L/C Trig Storage	Combination of (50-1LC, 50-2LC, 50G-1LC, 50G-2LC)	50-1LC, 50-2LC, 50G-1LC, 50G-2LC
Gn Diff Current Storage	Combination of (87L-1, 87L-2, 87HS-1, 87HS-2)	87L-1, 87L-2, 87HS-1, 87HS-2

Description	Range	Default
Gn Misc Current Storage	Combination of (46IT, 46DT, 37-1, 37-2, 37G-1, 37G-2, 49 Trip, 49 Alarm)	-----
Pre-trigger Storage	10, 20, 30, 40, 50, 60, 70, 80, 90	20%
Record Duration	10 Rec x 1 Sec, 5 Rec x 2 Sec, 2 Rec x 5 Sec, 1 Rec x 10 Sec	10 Rec x 1 Sec

25.3 FAULT STORAGE

Description	Range	Default
Gn Max Fault Rec Time	0, 1 ... 59900, 60000	2000ms

25.4 EVENT STORAGE

Description	Range	Default
Clear Events <i>Clear all stored event records</i>		

25.5 ENERGY STORAGE

Description	Range	Default
Gn Active Exp Energy Unit	1kWh, 10kWh, 100kWh, 1MWh, 10MWh, 100MWh	10kWh
Gn Active Imp Energy Unit	1kWh, 10kWh, 100kWh, 1MWh, 10MWh, 100MWh	10kWh
Gn Reactive Exp Energy Unit	1kVArh, 10kVArh, 100kVArh, 1MVArh, 10MVArh, 100MVArh	10kVArh
Gn Reactive Imp Energy Unit	1kVArh, 10kVArh, 100kVArh, 1MVArh, 10MVArh, 100MVArh	10kVArh

26 COMMUNICATIONS

Description	Range	Default
COM1-RS485 Protocol	OFF, IEC60870-5-103, MODBUS-RTU, DNP3	IEC60870-5-103
COM1-RS485 Station Address	0, 1 ... 65533, 65534	0
COM1-RS485 Baud Rate	75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400	19200
COM1-RS485 Parity	NONE, ODD, EVEN	EVEN
COM1-RS485 Mode	Local, Remote, Local Or Remote	Remote
LAN Protocol	OFF, IEC60870-5-103	IEC60870-5-103
DNP3 Unsolicited Events	Disabled, Enabled	Disabled
DNP3 Destination Address	0, 1 ... 65533, 65534	0
DNP3 Application Timeout	5, 6 ... 299, 300	10s

7SR181 Solkor

Line Differential Protection

7SR181[1234]-[12]xxxx-x[CD]A0

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Fig. A1 Operating Mode Table..... 79

1. Introduction

This section describes how to use the Communication Interface with a control system or interrogating computer.

The interface is compatible with control and automation systems using industry standard communications protocols **DNP3** , **IEC 60870-5-103** , **IEC 61850** and **MODBUS-RTU**. Note, not all protocols are available on all devices.

Reydisp Evolution or Reydisp Manager Software is available, for computers running Microsoft Windows™, to connect to devices to provide operational information, post-fault analysis, setting interrogation and editing facilities etc. Configuration software can be downloaded from our website <http://www.siemens.com/energy>.

This section specifies connection details and lists the information available through the individual protocols.

2. Physical Connection

2.1 Introduction

The relay provides one “Front” USB communication interface (Com2) located on the fascia and one RS485 (Com1) located on the “Rear” as standard.

A detailed description of the ports is given below.

- | | |
|-------------|--|
| COM1-RS485: | This port can be used for IEC60870-5-103, MODBUS-RTU or DNP3 communications to a substation SCADA or integrated control system or for engineer remote access. This port can also be used for connection to Reydisp software. |
| COM2-USB: | <p>This port is used for IEC60870-5-103 (default setting) communication with the Reydisp software.</p> <p>An ASCII protocol is also available through this port, the main use of this protocol is to allow the Relay firmware to be updated via the front connection.</p> <p>MODBUS-RTU or the optional DNP3 protocols are also available.</p> |
| COM3-LAN: | When the Ethernet module is fitted, in addition to IEC61850 a LAN connection is provided to allow the Reydisp software to connect to the Relay via the network. This port only supports the IEC60870-5-103 protocol. |

Any or all serial ports can be mapped to the IEC60870-5-103, DNP3 or MODBUS-RTU protocol at any one time, protocols available will depend upon relay model. The optional ethernet port uses IEC 61850 protocol and can also provide an IEC 60870-5-103 protocol connection to Reydisp. Any port not required can be disabled by setting its protocol to OFF.

When connecting to Reydisp Evolution software the protocol for the relevant port should be set to IEC60870-5-103.

2.2 USB Interface (COM2)

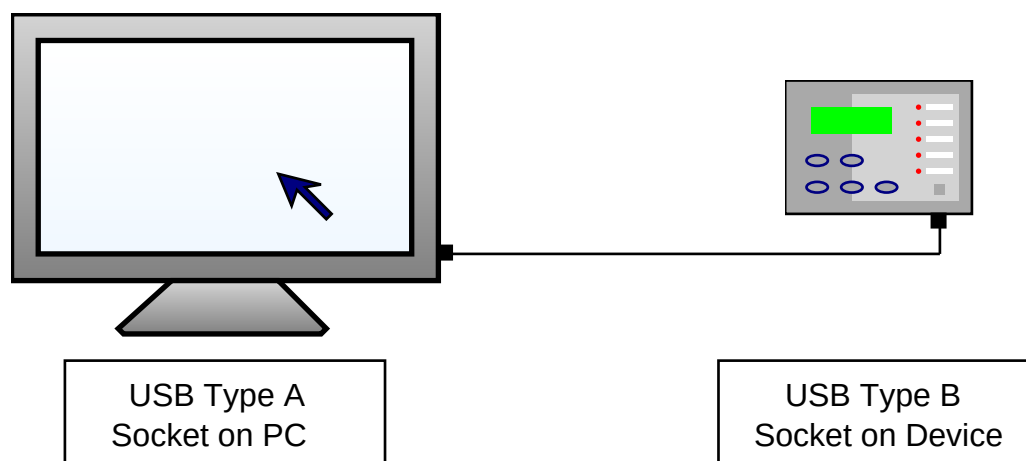
The USB communication port is connected using a standard USB cable with a type B connection to the relay and type A to the PC.

The PC will require a suitable USB driver to be installed; this will be carried out automatically when the Reydisp software is installed. When the Reydisp software is running with the USB cable connected to a device an additional connection is shown. Connections to these devices are not shown when they are not connected.

The USB communication interface on the relay is labelled Com 2 and its associated settings are located in the Data communications menu. When connecting to Reydisp using this connection the default settings can be used without the need to first change any settings.

Access to the communication settings for the USB port is only available from the relay front fascia via the key pad setting menu COMMUNICATIONS MENU.

Setting Name	Range/Options	Default	Setting	Notes
COM2-USB Protocol	OFF IEC60870-5-103 MODBUS-RTU ASCII DNP3	IEC60870-5-103		Reydisp software requires IEC60870-5-103.
COM2-USB Station Address	0 - 254 for IEC60870-5-103 1 - 247 for Modbus RTU 0 - 65534 for DNP3.0	0		An address within the range of the relevant protocol must be given to identify the relay. Each relay in a network must have a unique address.
COM2-USB Mode	Local Local or Remote Remote	Local		Refer to Appendix 1 , page 79, for further explanation



Local Engineer Access

Fig. 2-1 Communication to Front USB Port

2.3 RS485 Interface (COM1)

The 2-wire RS485 communication port is located on the rear of the relay and can be connected using a suitable RS485 120 Ohm screened twisted pair cable.

The RS485 electrical connection can be used in a single or multi-drop configuration. The RS485 master must support and use the Auto Device Enable (ADE) feature. The last device in the connection must be terminated correctly in accordance with the master device driving the connection. This can be done via the internal 120 ohm terminating resistor, which can be connected between 14 (A) and 18 (B) by fitting an external wire loop between terminals 18 and 20 on the power supply module.

The polarity of the signal terminals is marked as A and B in line with the RS485 standard. The polarity is that when the bus is in the quiescent state and no communication is taking place, the B terminal is more positive than A. This can be used to identify the polarity of any equipment to be connected, typically measured at each terminal in turn to ground. Connection of the device to a termination network at the end of the bus will also be to suit the quiescent state as shown in the diagram below.

The polarity marking is often found to be reversed or marked as +/- on other equipment so care is required. If the devices are connected in reverse, communication to all devices will be disturbed but no damage will occur. If problems are experienced during commissioning, the connections should be tried in reverse.

The maximum number of relays that can be connected to the bus is 64.

The RS485 data comms link will be broken for that particular relay element if it is withdrawn from the case but the chain of communication to the other relays is maintained.

The following settings, on the COMMUNICATIONS MENU, must be configured when using the RS485 interface.

Setting Name	Range/Options	Default	Setting	Notes
COM1-RS485 Protocol	OFF IEC60870-5-103 MODBUS-RTU DNP3	IEC60870-5-103		The protocol used to communicate on the standard RS485 connection.
COM1-RS485 Station Address	0 - 254 for IEC60870-5-103 1 - 247 for Modbus RTU 0 - 65534 for DNP3.0	0		An address within the range of the relevant protocol must be given to identify the relay. Each relay in a network must have a unique address.
COM1-RS485 Baud Rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400	19200		The baud rate set on all of the relays connected to the control system must be the same as the one set on the master device.
COM1-RS485 Parity	NONE ODD EVEN	EVEN		The parity set on all of the relays connected to the control system must be the same and in accordance with the master device.
COM1-RS485 Mode	Local Local or Remote Remote	Remote		Refer to Appendix 1 , page 79, for further explanation

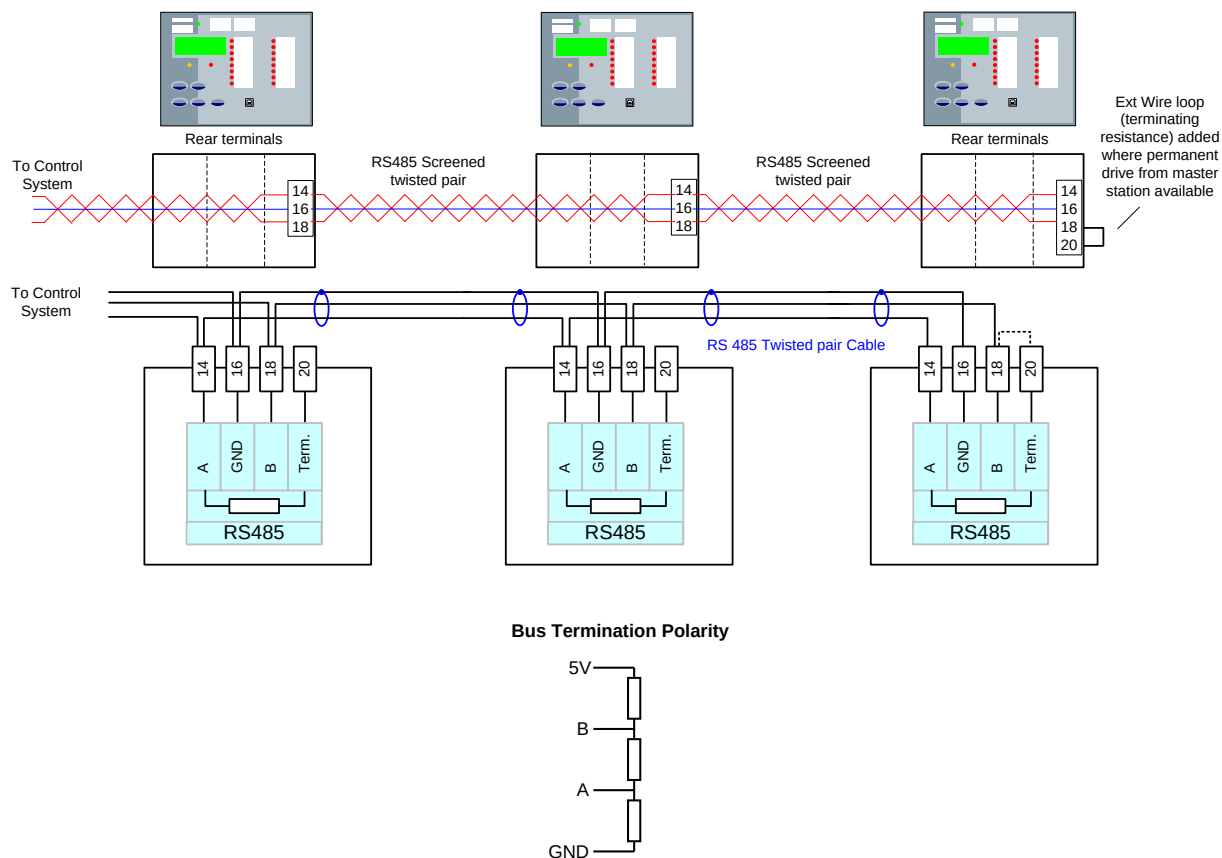


Fig. 2-2 Communication to Multiple Devices using RS485 (Standard Port)

3. IEC 60870-5-103 Definitions

3.1 Introduction

This section describes the IEC 60870-5-103 protocol implementation in the relays. This protocol is used for the communication with Reydisp software and can also be used for communication with a suitable control system. The control system or local PC acts as the master in the system with the relay operating as a slave responding to the master's commands. The implementation provides event information, time synchronising, commands and measurands and also supports the transfer of disturbance records.

This protocol can be set to use any or all of the relays hardware interfaces (USB, Fibre Optic, RS232, RS485 and Ethernet) where fitted and is the standard protocol used by the USB port. The relay can communicate simultaneously on all ports regardless of protocol used.

The Station Address of the port being used must be set to a suitable address within the range 0 - 254 to enable communication. This can be set by the **Communications Menu : COM n-xxxxx Station Address** setting.

3.2 Cause of Transmission

The cause of transmission (COT) column of the “[Information Number and Function](#)” table lists possible causes of transmission for these frames. The following abbreviations are used:

Abbreviation	Description
SE	spontaneous event
T	test mode
GI	general interrogation
Loc	local operation
Rem	remote operation
Ack	command acknowledge
Nak	Negative command acknowledge

Note: Events listing a GI cause of transmission can be raised and cleared; other events are raised only.

3.3 Application Service Data Unit (ASDU) Type

The Application Service Data Unit (ASDU) column of the “[Information Number and Function](#)” table lists the possible ASDUs returned for a point.

ASDU #	Description
1	Time tagged message (monitor direction)
2	Time tagged message (relative time) (monitor direction)
3.1	Measurands I
4	Time-tagged measurands with relative time
5	Identification message
6	Time synchronisation
7	General Interrogation Initialization
9	Measurands II
20	General command

3.4 Point List

The following sub-sections contain tables listing the data points available via the IEC60870-5-103 protocol.

The information shown below is the default configuration. This can be modified using the Communications Configuration Editor tool, refer [section 9](#) for details.

The information shown below is the default configuration. This can be modified using the Communications Configuration Editor tool, refer [section 9](#) for details.

3.4.1 Event Function (FUN) & Information (INF) Numbers

The following Event EVT and INF numbers apply to this device.

FUN	INF	Description	ASDU	COT
60	4	Remote Mode	1	SE, GI
			20	Ack, Nak
60	5	Out Of Service Mode	1	SE, GI
			20	Ack, Nak
60	6	Local Mode	1	SE, GI
			20	Ack, Nak
60	7	Local & Remote	1	SE, GI
			20	Ack, Nak
60	12	Control Received	1	SE
60	13	Command Received	1	SE
60	128	Cold Start	1	SE
60	129	Warm Start	1	SE
60	130	Re-Start	1	SE
60	131	Expected Restart	1	SE, GI
60	132	Unexpected Restart	1	SE, GI
60	133	Reset Start Count	1	SE
			20	Ack, Nak
60	135	Trigger Storage	1	SE
60	136	Clear Waveform Records	1	SE
60	137	Clear Fault Records	1	SE
60	138	Clear Event Records	1	SE
60	140	Demand metering reset	1	SE
			20	Ack, Nak
60	170	General Alarm 1	1	SE, GI
60	171	General Alarm 2	1	SE, GI
60	172	General Alarm 3	1	SE, GI
60	173	General Alarm 4	1	SE, GI
60	174	General Alarm 5	1	SE, GI
60	175	General Alarm 6	1	SE, GI
60	176	General Alarm 7	1	SE, GI
60	182	Quick Logic E1	1	SE, GI
60	183	Quick Logic E2	1	SE, GI
60	184	Quick Logic E3	1	SE, GI
60	185	Quick Logic E4	1	SE, GI
60	214	Function Key 1	1	SE
60	215	Function Key 2	1	SE

FUN	INF	Description	ASDU	COT
60	216	Function Key 3	1	SE
60	217	Function Key 4	1	SE
60	218	Function Key 5	1	SE
60	219	Function Key 6	1	SE
70	5	Binary Input 5	1	SE, GI
70	6	Binary Input 6	1	SE, GI
75	1	Virtual Input 1	1	SE, GI
75	2	Virtual Input 2	1	SE, GI
75	3	Virtual Input 3	1	SE, GI
75	4	Virtual Input 4	1	SE, GI
75	5	Virtual Input 5	1	SE, GI
75	6	Virtual Input 6	1	SE, GI
75	7	Virtual Input 7	1	SE, GI
75	8	Virtual Input 8	1	SE, GI
80	1	Binary Output 1	1	SE, GI
			20	Ack, Nak
80	2	Binary Output 2	1	SE, GI
			20	Ack, Nak
80	3	Binary Output 3	1	SE, GI
			20	Ack, Nak
80	4	Binary Output 4	1	SE, GI
			20	Ack, Nak
80	5	Binary Output 5	1	SE, GI
			20	Ack, Nak
80	6	Binary Output 6	1	SE, GI
			20	Ack, Nak
80	7	Binary Output 7	1	SE, GI
			20	Ack, Nak
80	8	Binary Output 8	1	SE, GI
			20	Ack, Nak
90	1	LED 1	1	SE, GI
90	2	LED 2	1	SE, GI
90	3	LED 3	1	SE, GI
90	4	LED 4	1	SE, GI
90	5	LED 5	1	SE, GI
90	6	LED 6	1	SE, GI
90	7	LED 7	1	SE, GI
90	8	LED 8	1	SE, GI
90	9	LED 9	1	SE, GI
90	10	LED 10	1	SE, GI
90	11	LED 11	1	SE, GI
90	12	LED 12	1	SE, GI
90	13	LED 13	1	SE, GI
90	14	LED 14	1	SE, GI
90	15	LED 15	1	SE, GI
90	16	LED 16	1	SE, GI
90	17	LED 17	1	SE, GI
90	18	LED 18	1	SE, GI

FUN	INF	Description	ASDU	COT
91	1	LED PU 1	1	SE, GI
91	2	LED PU 2	1	SE, GI
91	3	LED PU 3	1	SE, GI
91	4	LED PU 4	1	SE, GI
91	5	LED PU 5	1	SE, GI
91	6	LED PU 6	1	SE, GI
91	7	LED PU 7	1	SE, GI
91	8	LED PU 8	1	SE, GI
91	9	LED PU 9	1	SE, GI
91	10	LED PU 10	1	SE, GI
91	11	LED PU 11	1	SE, GI
91	12	LED PU 12	1	SE, GI
91	13	LED PU 13	1	SE, GI
91	14	LED PU 14	1	SE, GI
91	15	LED PU 15	1	SE, GI
91	16	LED PU 16	1	SE, GI
91	17	LED PU 17	1	SE, GI
91	18	LED PU 18	1	SE, GI
183	10	51-1	2	SE, GI
183	11	50-1	2	SE, GI
183	12	51N-1	2	SE, GI
183	13	50N-1	2	SE, GI
183	14	51G-1	2	SE, GI
183	15	50G-1	2	SE, GI
183	16	51-2	2	SE, GI
183	17	50-2	2	SE, GI
183	18	51N-2	2	SE, GI
183	19	50N-2	2	SE, GI
183	20	51G-2	2	SE, GI
183	21	50G-2	2	SE, GI
183	22	51-3	2	SE, GI
183	23	50-3	2	SE, GI
183	24	51N-3	2	SE, GI
183	25	50N-3	2	SE, GI
183	26	51G-3	2	SE, GI
183	27	50G-3	2	SE, GI
183	28	51-4	2	SE, GI
183	29	50-4	2	SE, GI
183	30	51N-4	2	SE, GI
183	31	50N-4	2	SE, GI
183	32	51G-4	2	SE, GI
183	33	50G-4	2	SE, GI
183	34	50BF Stage 2	2	SE, GI
183	35	49-Alarm	2	SE, GI
183	36	49-Trip	2	SE, GI
183	40	60 CTS	2	SE, GI
183	50	46IT	2	SE, GI
183	51	46DT	2	SE, GI
183	53	E/F Out	2	SE, GI

FUN	INF	Description	ASDU	COT
			20	Ack, Nak
183	56	50BF Stage 1	2	SE, GI
183	62	37-1	2	SE, GI
183	63	37-2	2	SE, GI
183	64	37G-1	2	SE, GI
183	65	37G-2	2	SE, GI
183	70	46BC	2	SE, GI
183	96	81HBL2	1	SE, GI
183	100	CB Alarm	1	SE, GI
183	101	Trip Circuit Fail 1	2	SE, GI
183	102	Trip Circuit Fail 2	2	SE, GI
183	103	Trip Circuit Fail 3	2	SE, GI
183	114	Close CB Failed	1	SE, GI
183	115	Open CB Failed	1	SE, GI
183	116	Reclaim	1	SE, GI
183	117	Lockout	1	SE, GI
183	118	Successful Close	1	SE
183	119	Successful DAR Close	1	SE
183	120	Successful Man Close	1	SE
183	121	HotLine Working	1	SE, GI
			20	Ack, Nak
183	122	Inst Protection Out	1	SE, GI
			20	Ack, Nak
183	123	CB Total Trip Count	1	SE, GI
183	124	CB Delta Trip Count	1	SE, GI
183	125	CB Count To AR Block	1	SE, GI
183	126	Reset CB Total Trip Count	1	SE
			20	Ack, Nak
183	127	Reset CB Delta Trip Count	1	SE
			20	Ack, Nak
183	128	Reset CB Count To AR Block	1	SE
			20	Ack, Nak
183	129	I ² t CB Wear	1	SE, GI
183	130	Reset I ² t CB Wear	1	SE
			20	Ack, Nak
183	131	79 AR In progress	1	SE, GI
183	132	CB Frequent Ops Count	1	SE, GI
183	133	Reset CB Frequent Ops Count	1	SE
			20	Ack, Nak
183	137	CB on by auto reclose	1	SE, GI
183	140	Cold Load Active	1	SE, GI
183	141	P/F Inst Protection Inhibited	1	SE, GI
183	142	E/F Inst Protection Inhibited	1	SE, GI
183	144	Ext Inst Protection Inhibited	1	SE, GI
183	163	Trip Time Alarm	1	SE
183	164	Close Circuit Fail 1	2	SE, GI
183	165	Close Circuit Fail 2	2	SE, GI
183	166	Close Circuit Fail 3	2	SE, GI

FUN	INF	Description	ASDU	COT
183	167	Close Circuit Fail	2	SE, GI
183	171	60 CTS-I	2	SE, GI
183	172	Act Energy Exp	4	SE
183	173	Act Energy Imp	4	SE
183	174	React Energy Exp	4	SE
183	175	React Energy Imp	4	SE
183	176	Reset Energy Meters	1	SE
183	177	Active Exp Meter Reset	1	SE
183	178	Active Imp Meter Reset	1	SE
183	179	Reactive Exp Meter Reset	1	SE
183	180	Reactive Imp Meter Reset	1	SE
183	181	CB Total Trip Count	4	SE
183	182	CB Delta Trip Count	4	SE
183	183	CB Count To AR Block	4	SE
183	184	CB Freq Ops Count	4	SE
183	222	37-PhA	2	SE, GI
183	223	37-PhB	2	SE, GI
183	224	37-PhC	2	SE, GI
183	225	50 LC-1	2	SE, GI
183	226	50 LC-2	2	SE, GI
183	227	50G LC-1	2	SE, GI
183	228	50G LC-2	2	SE, GI
183	231	50BF-PhA	2	SE, GI
183	232	50BF-PhB	2	SE, GI
183	233	50BF-PhC	2	SE, GI
183	234	50BF-EF	2	SE, GI
183	235	79 Last Trip Lockout	2	SE, GI
183	237	CB DBI	1	SE, GI
183	238	CB Travelling	1	SE, GI
183	239	In Fault Current	4	SE
183	240	Ia Fault Current	4	SE
183	241	Ib Fault Current	4	SE
183	242	Ic Fault Current	4	SE
183	243	Ig Fault Current	4	SE
183	245	Va Fault Voltage	4	SE
183	246	Vb Fault Voltage	4	SE
183	247	Vc Fault Voltage	4	SE
183	249	60 CTS-I-PhA	2	SE, GI
183	250	60 CTS-I-PhB	2	SE, GI
183	251	60 CTS-I-PhC	2	SE, GI
183	252	Trip PhA	2	SE, GI
183	253	Trip PhB	2	SE, GI
183	254	Trip PhC	2	SE, GI
185	9	CB Phase A Trip Count	4	SE
185	10	CB Phase B Trip Count	4	SE
185	11	CB Phase C Trip Count	4	SE
185	12	CB E/F Trip Count	4	SE
185	43	General Trip	2	SE, GI
185	110	CB Wear CB A	4	SE

FUN	INF	Description	ASDU	COT
185	111	CB Wear CB B	4	SE
185	112	CB Wear CB C	4	SE
185	113	CB Wear CB A Remaining	4	SE
185	114	CB Wear CB B Remaining	4	SE
185	115	CB Wear CB C Remaining	4	SE
185	241	Start Count Alarm	1	SE, GI
186	23	87L-1	1	SE, GI
186	24	87L-2	1	SE, GI
186	25	87HS-1	1	SE, GI
186	26	87HS-2	1	SE, GI
186	27	Rem-In Fault Current	4	SE
186	28	Rem-Ia Fault Current	4	SE
186	29	Rem-Ib Fault Current	4	SE
186	30	Rem-Ic Fault Current	4	SE
186	31	Rem-Ig Fault Current	4	SE
186	32	87-Ia-Operate Fault Current	4	SE
186	33	87-Ib-Operate Fault Current	4	SE
186	34	87-Ic-Operate Fault Current	4	SE
186	35	87-Ia-Restrain Fault Current	4	SE
186	36	87-Ib-Restrain Fault Current	4	SE
186	37	87-Ic-Restrain Fault Current	4	SE
186	38	85S-1	1	SE, GI
186	39	85S-2	1	SE, GI
186	40	85S-3	1	SE, GI
186	41	85S-4	1	SE, GI
186	42	85S-5	1	SE, GI
186	43	85S-6	1	SE, GI
186	44	85R-1	1	SE, GI
186	45	85R-2	1	SE, GI
186	46	85R-3	1	SE, GI
186	47	85R-4	1	SE, GI
186	48	85R-5	1	SE, GI
186	49	85R-6	1	SE, GI
186	50	87R-1	1	SE, GI
186	51	87R-2	1	SE, GI
186	52	Protection Comms Alarm	1	SE, GI
186	53	Protection Comms Test Mode	1	SE, GI
186	54	79 Deadtime Inhibit	1	SE, GI
192	2	Reset FCB	5	SE
192	3	Reset CU	5	SE
192	4	Start/Restart	5	SE
192	5	Power On	1	SE, GI
192	16	Auto-reclose active	1	SE, GI
			20	Ack, Nak
192	19	LED Reset	1	SE
			20	Ack, Nak
192	22	Settings changed	1	SE
192	23	Setting G1 selected	1	SE, GI

FUN	INF	Description	ASDU	COT
			20	Ack, Nak
192	24	Setting G2 selected	1	SE, GI
			20	Ack, Nak
192	25	Setting G3 selected	1	SE, GI
			20	Ack, Nak
192	26	Setting G4 selected	1	SE, GI
			20	Ack, Nak
192	27	Binary Input 1	1	SE, GI
192	28	Binary Input 2	1	SE, GI
192	29	Binary Input 3	1	SE, GI
192	30	Binary Input 4	1	SE, GI
192	36	Trip Circuit Fail	1	SE, GI
192	38	VT Fuse Failure	1	SE, GI
192	51	Earth Fault Forward/Line	2	SE, GI
192	52	Earth Fault Reverse/Busbar	2	SE, GI
192	64	Start/Pick-up L1	2	SE, GI
192	65	Start/Pick-up L2	2	SE, GI
192	66	Start/Pick-up L3	2	SE, GI
192	67	Start/Pick-up N	2	SE, GI
192	68	General Trip	2	SE
192	69	Trip L1	2	SE
192	70	Trip L2	2	SE
192	71	Trip L3	2	SE
192	74	Fault Forward/Line	2	SE, GI
192	75	Fault Reverse/Busbar	2	SE, GI
192	84	General Start/Pick-up	2	SE, GI
192	85	Breaker Failure	2	SE
192	90	Trip I>	2	SE
192	91	Trip I>>	2	SE
192	92	Trip In>	2	SE
192	93	Trip In>>	2	SE
192	128	CB on by auto reclose	1	SE
200	1	CB 1	1	SE
			20	Ack, Nak
200	6	CB 1 Opened	1	SE, GI
200	7	CB 1 Closed	1	SE, GI
200	150	User SP Command 1	1	SE, GI
			20	Ack, Nak
200	151	User SP Command 2	1	SE, GI
			20	Ack, Nak
200	152	User SP Command 3	1	SE, GI
			20	Ack, Nak
200	153	User SP Command 4	1	SE, GI
			20	Ack, Nak
200	154	User SP Command 5	1	SE, GI
			20	Ack, Nak
200	155	User SP Command 6	1	SE, GI
			20	Ack, Nak
200	156	User SP Command 7	1	SE, GI

FUN	INF	Description	ASDU	COT
			20	Ack, Nak
200	157	User SP Command 8	1	SE, GI
			20	Ack, Nak
200	158	User DP Command 1	1	SE
			20	Ack, Nak
200	159	User DP Command 2	1	SE
			20	Ack, Nak
200	160	User DP Command 3	1	SE
			20	Ack, Nak
200	161	User DP Command 4	1	SE
			20	Ack, Nak
200	162	User DP Command 5	1	SE
			20	Ack, Nak
200	163	User DP Command 6	1	SE
			20	Ack, Nak
200	164	User DP Command 7	1	SE
			20	Ack, Nak
200	165	User DP Command 8	1	SE
			20	Ack, Nak
200	200	CB 1 Trip & Reclose	1	SE
			20	Ack, Nak
200	201	CB 1 Trip & Lockout	1	SE
			20	Ack, Nak
200	255	Blocked By Interlocking	1	SE, GI
255	0	General Interrogation (GI) Initiation	7	Init. GI
255	0	General Interrogation (GI) End	8	End of GI
255	0	Time Synchronisation	6	Time Synch.

3.4.2 Measurands

The following Measurand EVT and INF numbers apply to this device.

FUN	INF	Description	ASDU	COT
183	148	Measurand $I_{L1,2,3}$, $V_{L1,2,3}$, P, Q, F, $V_{L1-2,L2-3,L3-1}$	9	Cyclic - Refresh rate 5 seconds or value change greater than Window x %.

		I_{L1} (2.4x) (Window 1%)		
		I_{L2} (2.4x) (Window 1%)		
		I_{L3} (2.4x) (Window 1%)		
		V_{L1} (1.2x) (Window 1%)		
		V_{L2} (1.2x) (Window 1%)		
		V_{L3} (1.2x) (Window 1%)		
		P (2.4x) (Window 1%)		
		Q (2.4x) (Window 1%)		
		F (1.2x) (Window 0.1%)		
		V_{L1-2} (1.2x) (Window 1%)		
		V_{L2-3} (1.2x) (Window 1%)		
		V_{L3-1} (1.2x) (Window 1%)		

FUN	INF	Description	ASDU	COT
183	236	Measurand Max $I_{a,b,c}$, $V_{an,bn,cn}$, P , Q , $V_{ab,bc,ca}$ --- I_a Max (2.4x) (Window 1%) I_b Max (2.4x) (Window 1%) I_c Max (2.4x) (Window 1%) V_{an} Max ₁ (1.2x) (Window 1%) V_{bn} Max ₂ (1.2x) (Window 1%) V_{cn} Max ₃ (1.2x) (Window 1%) P Max (2.4x) (Window 1%) Q Max (2.4x) (Window 1%) V_{ab} Max (1.2x) (Window 1%) V_{bc} Max (1.2x) (Window 1%) V_{ca} Max (1.2x) (Window 1%)	9	Cyclic - Refresh rate 5 seconds or value change greater than Window x %.

3.4.3 Disturbance Recorder Actual Channel (ACC) Numbers

The following Disturbance Recorder channel numbers apply to this device.

FUN	ACC	Description
182	1	V1
182	2	V2
182	3	V3
182	5	Ia
182	6	Ib
182	7	Ic
182	8	Ig1
182	14	Remote-Ia
182	15	Remote-Ib
182	16	Remote-Ic
182	17	Remote-Ig1

4. MODBUS Definitions

4.1 Introduction

This section describes the MODBUS-RTU protocol implementation in the relays. This protocol is used for communication with a suitable control system.

This protocol can be set to use any or all of the relays hardware interfaces (USB, Fibre Optic, RS232 and RS485) where fitted. The relay can communicate simultaneously on all ports regardless of protocol used.

The Station Address of the port being used must be set to a suitable address within the range 1 - 247 to enable communication. This can be set by the **Communications Menu : COM *n*-xxxxx Station Address** setting.

Communication via MODBUS over Ethernet requires external devices. Please refer to the documents ***TCPIP Catalogue Sheet*** and ***TCPIP Interface Technical Guidance Notes*** for more information.

Definitions with shaded area are not available on all relay models.

The float data type conforms to the IEEE 754 floating point definition. This specifies that 32 bits of data will be formatted as a sign bit in the most significant bit (MSB) followed by an 8 bit exponent then a 23 bit mantissa, down to the least significant bit (LSB).

Address	Value
30002	2400

On reception these two registers should be interpreted in the correct order as IEEE754 floating point representation.

4.2.2 FP_32BITS_3DP

The FP_32BITS_3DP is a 32 bit integer fixed point value, containing 3 decimal places of information. It is used to send a real value to 3 decimal places as an integer. For example, if the value in a device is 123.456 it will be sent as 123456. As it is an integer, negative numbers are sent as 2's complement.

FP_32BITS_3DP & MODBUS

In this MODBUS implementation the 32 bit value is stored in 2 16 registers in Big-Endian format. As an example, if we take the hex representation of 123456, we have 1E240h. Assume this is stored in the registers 30001 and 30002, it would look as follows:

Address	Value
30001	1
30002	E240

On reception these two registers should be interpreted in the correct order as a 32 bit integer.

4.2.3 UINT32

The UINT32 is a signed 32 bit integer. As it is an integer, negative numbers are sent as 2's complement.

UINT32 & MODBUS

In this MODBUS implementation the 32 bit value is stored in 2 16 bit registers in Big-Endian format. As an example, if we take the hex representation of -123456, in 2's complement, we have FFFE1DC0h. Assume this is stored in the registers 30001 and 30002, it would look as follows:

Address	Value
30001	FFFE
30002	1DC0

On reception these two registers should be interpreted in the correct order as a 32 bit integer.

4.2.4 UINT16

The UINT16 is a signed 16 bit integer. As it is an integer, negative numbers are sent as 2's complement.

UINT16 & MODBUS

In this MODBUS implementation the 16 bit value is stored in a 16 bit register in Big-Endian format. As an example, if we take the hex representation of 5678 we have 162Eh. Assume this is stored in the register 30001, it would look as follows:

Address	Value
30001	162E

On reception this register should be interpreted as a 16 bit integer.

Truncation

Calculations are performed as 32 bit. The 16 bit value is the lowest 16 bits of the 32 bit value. Therefore, when values overflow the returned value is the lowest 16 bits of the calculated value. For Example, if the value is 85400 = 14D98h, the value returned would be the lowest 16 bits = 4D98h which equals 19864.

4.2.5 EVENT

MODBUS does not define a method for extracting events; therefore a private method has been defined based on that defined by IEC60870-5-103.

The EVENT register contains the earliest event record available. The event record is 8 registers (16 bytes) of information, whose format is described below. When this record has been read it will be replaced by the next available record. Event records must be read completely; therefore the quantity value must be set to 8 before reading. Failing to do this will result in an exception code 2. If no event record is present the exception code 2 will be returned. The EVENT register should be polled regularly by the master for events.

The **EVENTCOUNT** register can be checked periodically to determine how many events are stored.

The format of the event record is defined by the zero byte. It signifies the type of record which is used to decode the event information. The zero byte can be one of the following.

Format

The format of the event record is defined by the zero byte. It signifies the type of record which is used to decode the event information. The zero byte can be one of the following.

Type	Description
1	Event
2	Event with Relative Time
4	Measurand Event with Relative Time

The following table describes the fields in the event record.

Key	Description
FUN	Function Type, as defined for IEC870-5-103.
INF	Information Number, as defined for IEC870-5-103.
DPI	Measurand Event with Relative Time, values 1 = OFF, 2 = ON.
ms L	Time Stamp Milliseconds low byte.
ms H	Time Stamp Milliseconds high byte.
Mi	Time Stamp Minutes (MSB = invalid, time not set > 23 hours).
Ho	Time Stamp Hours (MSB = Summer time flag).
RT L	Relative Time low byte.
RT H	Relative Time high byte.
F# L	Fault Number low byte.
F# H	Fault Number high byte.
Meas	Measurand format R32.23, sent least significant byte first.

The following tables show the fields in the different event records as they are returned.

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	1	0	FUN	INF	DPI	0	0	0	0	0	0	0	ms L	ms H	Mi	Ho

Event Type 1 Format.

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	2	0	FUN	INF	DPI	RT L	RT H	F# L	F# H	0	0	0	ms L	ms H	Mi	Ho

Event Type 2 Format.

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	4	0	FUN	INF	Meas				0	0	0	0	ms L	ms H	Mi	Ho

Event Type 4 Format.

4.2.6 EVENTCOUNT

The EVENTCOUNT register contains the current number of events in the relay's event buffer.

On reception this register should be interpreted as a 16 bit integer.

4.2.7 TIME_METER

The TIME_METER register contains the device's time. The time must be read or written in one step; therefore the quantity should be 4 registers. Failing to do this will result in an exception code 2. The time format is 8 bytes as follows.

The following table describes the fields in the time.

Key	Description
ms L	Time Stamp Milliseconds low byte.
ms H	Time Stamp Milliseconds high byte.
Mi	Time Stamp Minutes (MSB = invalid, time not set > 23 hours).
Ho	Time Stamp Hours (MSB = Summer time flag).
Da	Time Stamp Days.
Mo	Time Stamp Months.
Ye L	Time Stamp Years low byte.
Ye H	Time Stamp Years high byte (Not Used).

The following table shows the fields in the time as they are returned.

Byte	0	1	2	3	4	5	6	7
Content	ms L	ms H	Mi	Ho	Da	Mo	Ye L	Ye H

Time Format.

4.2.8 STR32 & STR64

4.2.9 BITSTRING

A Bit-String (or Bit-Array) is a method of compactly storing a number of bits of data. In this instance we store up to 16 bit values, for example the states of binary inputs, in a single 16 bit register. The first bit value is stored in the Least Significant Bit (LSB) of the register. The 16th value would be in the Most Significant Bit (MSB). Bit values can only be zero or one. Any unused bits will be set to zero.

BITSTRING & MODBUS

In this MODBUS implementation the 16 bit value is stored in a 16 bit register in Big-Endian format. As an example, assume bits 1, 3, 9 and 12 are set. The binary representation of this would be 0000100100000101_2 giving a hex representation of 0905h. Assume this is stored in the register 30001, it would look as follows:

Address	Value
30001	0905

On reception this register should be interpreted as a 16 bit integer.

4.3 Point List

The information shown below is the default configuration. This can be modified using the Communications Configuration Editor tool, refer [section 9](#) for details.

4.3.1 Coils (Read Write Binary values)

Address	Description
00001	Binary Output 1
00002	Binary Output 2
00003	Binary Output 3
00004	Binary Output 4
00005	Binary Output 5
00006	Binary Output 6
00007	Binary Output 7
00008	Binary Output 8
00101	Setting G1 selected
00102	Setting G2 selected
00103	Setting G3 selected
00104	Setting G4 selected
00109	CB 1
00112	Auto-reclose active
00113	HotLine Working
00114	E/F Out
00116	Inst Protection Out
00155	Remote Mode
00156	Out Of Service Mode
00157	Local Mode
00158	Local & Remote
00165	Reset Start Count
00180	CB 1 Opened
00181	CB 1 Closed
00200	User SP Command 1
00201	User SP Command 2
00202	User SP Command 3
00203	User SP Command 4
00204	User SP Command 5
00205	User SP Command 6
00206	User SP Command 7
00207	User SP Command 8
00208	User DP Command 1
00209	User DP Command 2
00210	User DP Command 3
00211	User DP Command 4
00212	User DP Command 5
00213	User DP Command 6
00214	User DP Command 7
00215	User DP Command 8

4.3.2 Inputs (Read Only Binary values)

Address	Description
10001	Binary Input 1
10002	Binary Input 2
10003	Binary Input 3
10004	Binary Input 4
10005	Binary Input 5
10006	Binary Input 6
10102	Remote Mode
10103	Out Of Service Mode
10104	Local Mode
10105	Local & Remote
10110	General Trip
10111	Trip Circuit Fail
10112	Start/Pick-up L1
10113	Start/Pick-up L2
10114	Start/Pick-up L3
10115	General Start/Pick-up
10116	VT Fuse Failure
10117	Earth Fault Forward/Line
10118	Earth Fault Reverse/Busbar
10119	Start/Pick-up N
10120	Fault Forward/Line
10121	Fault Reverse/Busbar
10122	51-1
10123	50-1
10124	51N-1
10125	50N-1
10126	51G-1
10127	50G-1
10128	51-2
10129	50-2
10130	51N-2
10131	50N-2
10132	51G-2
10133	50G-2
10134	51-3
10135	50-3
10136	51N-3
10137	50N-3
10138	51G-3
10139	50G-3
10140	51-4
10141	50-4
10142	51N-4
10143	50N-4
10144	51G-4

Address	Description
10145	50G-4
10146	50BF Stage 2
10147	49-Alarm
10148	49-Trip
10149	60 CTS
10150	46IT
10151	46DT
10154	46BC
10168	37-1
10169	37-2
10171	Auto-reclose active
10172	CB on by auto reclose
10173	Reclaim
10174	Lockout
10175	HotLine Working
10176	Inst Protection Out
10177	CB Total Trip Count
10178	CB Delta Trip Count
10179	CB Count To AR Block
10180	I ² t CB Wear
10181	79 AR In progress
10182	Cold Load Active
10183	E/F Out
10184	P/F Inst Protection Inhibited
10185	E/F Inst Protection Inhibited
10187	Ext Inst Protection Inhibited
10211	Trip Circuit Fail 1
10212	Trip Circuit Fail 2
10213	Trip Circuit Fail 3
10214	CB Total Trip Count
10215	CB Delta Trip Count
10216	CB Count To AR Block
10217	CB Frequent Ops Count
10218	I ² t CB Wear
10219	CB 1 Opened
10220	CB 1 Closed
10283	Close Circuit Fail 1
10284	Close Circuit Fail 2
10285	Close Circuit Fail 3
10286	Close Circuit Fail
10290	General Alarm 1
10291	General Alarm 2
10292	General Alarm 3
10293	General Alarm 4
10294	General Alarm 5
10295	General Alarm 6
10296	General Alarm 7
10302	Quick Logic E1

Address	Description
10303	Quick Logic E2
10304	Quick Logic E3
10305	Quick Logic E4
10334	60 CTS-I
10335	81HBL2
10336	37G-1
10337	37G-2
10367	50BF Stage 1
10369	37-PhA
10370	37-PhB
10371	37-PhC
10372	50 LC-1
10373	50 LC-2
10374	50G LC-1
10375	50G LC-2
10378	50BF-PhA
10379	50BF-PhB
10380	50BF-PhC
10381	50BF-EF
10383	60 CTS-I-PhA
10384	60 CTS-I-PhB
10385	60 CTS-I-PhC
10390	Trip PhA
10391	Trip PhB
10392	Trip PhC
10410	CB Alarm
10501	Virtual Input 1
10502	Virtual Input 2
10503	Virtual Input 3
10504	Virtual Input 4
10505	Virtual Input 5
10506	Virtual Input 6
10507	Virtual Input 7
10508	Virtual Input 8
10601	LED 1
10602	LED 2
10603	LED 3
10604	LED 4
10605	LED 5
10606	LED 6
10607	LED 7
10608	LED 8
10609	LED 9
10610	LED 10
10611	LED 11
10612	LED 12
10613	LED 13
10614	LED 14
10615	LED 15

Address	Description
10616	LED 16
10617	LED 17
10618	LED 18
10701	LED PU 1
10702	LED PU 2
10703	LED PU 3
10704	LED PU 4
10705	LED PU 5
10706	LED PU 6
10707	LED PU 7
10708	LED PU 8
10709	LED PU 9
10710	LED PU 10
10711	LED PU 11
10712	LED PU 12
10713	LED PU 13
10714	LED PU 14
10715	LED PU 15
10716	LED PU 16
10717	LED PU 17
10718	LED PU 18
10800	Cold Start
10801	Warm Start
10802	Re-Start
10803	Power On
10804	Expected Restart
10805	Unexpected Restart
10806	Reset Start Count
10900	User SP Command 1
10901	User SP Command 2
10902	User SP Command 3
10903	User SP Command 4
10904	User SP Command 5
10905	User SP Command 6
10906	User SP Command 7
10907	User SP Command 8
10908	User DP Command 1
10909	User DP Command 2
10910	User DP Command 3
10911	User DP Command 4
10912	User DP Command 5
10913	User DP Command 6
10914	User DP Command 7
10915	User DP Command 8
11073	CB DBI
11074	CB Travelling
11075	Close CB Failed
11076	Open CB Failed

Address	Description
11077	Start Count Alarm
11098	87L-1
11099	87L-2
11100	87HS-1
11101	87HS-2
11102	85S-1
11103	85S-2
11104	85S-3
11105	85S-4
11106	85S-5
11107	85S-6
11108	85R-1
11109	85R-2
11110	85R-3
11111	85R-4
11112	85R-5
11113	85R-6
11114	87R-1
11115	87R-2
11116	Protection Comms Alarm
11117	Protection Comms Test Mode
11118	79 Deadtime Inhibit

4.3.3 Input Registers (Read Only Registers)

Address	Description	Format	Mult	Description
30001	Event Count	EVENTCOUNT	0.000000	Events Counter
30002	Event	EVENT	0.000000	8 Registers
30010	Vab Primary	FP_32BITS_3DP	1.000000	Vab V
30012	Vbc Primary	FP_32BITS_3DP	1.000000	Vbc V
30014	Vca Primary	FP_32BITS_3DP	1.000000	Vca V
30016	Va Primary	FP_32BITS_3DP	1.000000	Va V
30018	Vb Primary	FP_32BITS_3DP	1.000000	Vb V
30020	Vc Primary	FP_32BITS_3DP	1.000000	Vc V
30022	Va Secondary	FP_32BITS_3DP	1.000000	Va V
30024	Vb Secondary	FP_32BITS_3DP	1.000000	Vb V
30026	Vc Secondary	FP_32BITS_3DP	1.000000	Vc V
30034	Vab Nominal	FP_32BITS_3DP	1.000000	Vab Degrees
30036	Vbc Nominal	FP_32BITS_3DP	1.000000	Vbc Degrees
30038	Vca Nominal	FP_32BITS_3DP	1.000000	Vca Degrees
30040	Va Nominal	FP_32BITS_3DP	1.000000	Va Degrees
30042	Vb Nominal	FP_32BITS_3DP	1.000000	Vb Degrees
30044	Vc Nominal	FP_32BITS_3DP	1.000000	Vc Degrees
30048	Vzps	FP_32BITS_3DP	1.000000	Vzps V
30050	Vpps	FP_32BITS_3DP	1.000000	Vpps V
30052	Vnps	FP_32BITS_3DP	1.000000	Vnps V
30054	Vzps	FP_32BITS_3DP	1.000000	Vzps Degrees
30056	Vpps	FP_32BITS_3DP	1.000000	Vpps Degrees

Address	Description	Format	Mult	Description
30058	Vnps	FP_32BITS_3DP	1.000000	Vnps Degrees
30060	Frequency	FP_32BITS_3DP	1.000000	Frequency Hz
30064	Ia Primary	FP_32BITS_3DP	1.000000	Ia A
30066	Ib Primary	FP_32BITS_3DP	1.000000	Ib A
30068	Ic Primary	FP_32BITS_3DP	1.000000	Ic A
30070	Ia Secondary	FP_32BITS_3DP	1.000000	Ia A
30072	Ib Secondary	FP_32BITS_3DP	1.000000	Ib A
30074	Ic Secondary	FP_32BITS_3DP	1.000000	Ic A
30076	Ia Nominal	FP_32BITS_3DP	1.000000	Ia xIn
30078	Ib Nominal	FP_32BITS_3DP	1.000000	Ib xIn
30080	Ic Nominal	FP_32BITS_3DP	1.000000	Ic xIn
30082	Ia Nominal	FP_32BITS_3DP	1.000000	Ia Degrees
30084	Ib Nominal	FP_32BITS_3DP	1.000000	Ib Degrees
30086	Ic Nominal	FP_32BITS_3DP	1.000000	Ic Degrees
30088	In Primary	FP_32BITS_3DP	1.000000	In A
30090	In Secondary	FP_32BITS_3DP	1.000000	In A
30092	In Nominal	FP_32BITS_3DP	1.000000	In xInom
30094	Ig Primary	FP_32BITS_3DP	1.000000	Ig A
30096	Ig Secondary	FP_32BITS_3DP	1.000000	Ig A
30098	Ig Nominal	FP_32BITS_3DP	1.000000	Ig xInom
30100	Izps Nominal	FP_32BITS_3DP	1.000000	Izps xIn
30102	Ipps Nominal	FP_32BITS_3DP	1.000000	Ipps xIn
30104	Inps Nominal	FP_32BITS_3DP	1.000000	Inps xIn
30106	Izps Nominal	FP_32BITS_3DP	1.000000	Izps Degrees
30108	Ipps Nominal	FP_32BITS_3DP	1.000000	Ipps Degrees
30110	Inps Nominal	FP_32BITS_3DP	1.000000	Inps Degrees
30112	Active Power A	FP_32BITS_3DP	0.000001	A Phase W
30114	Active Power B	FP_32BITS_3DP	0.000001	B Phase W
30116	Active Power C	FP_32BITS_3DP	0.000001	C Phase W
30118	P (3P)	FP_32BITS_3DP	0.000001	3 Phase W
30120	Reactive Power A	FP_32BITS_3DP	0.000001	Phase A VAr
30122	Reactive Power B	FP_32BITS_3DP	0.000001	Phase B VAr
30124	Reactive Power C	FP_32BITS_3DP	0.000001	Phase C VAr
30126	Q (3P)	FP_32BITS_3DP	0.000001	3 Phase VAr
30128	Apparent Power A	FP_32BITS_3DP	0.000001	Phase A VA
30130	Apparent Power B	FP_32BITS_3DP	0.000001	Phase B VA
30132	Apparent Power C	FP_32BITS_3DP	0.000001	Phase C VA
30134	S (3P)	FP_32BITS_3DP	0.000001	3 Phase VA
30136	Power Factor A	FP_32BITS_3DP	1.000000	Phase A
30138	Power Factor B	FP_32BITS_3DP	1.000000	Phase B
30140	Power Factor C	FP_32BITS_3DP	1.000000	Phase C
30142	Power Factor(3P)	FP_32BITS_3DP	1.000000	3 Phase
30144	Act Energy Exp	UINT32	1.000000	Act Energy Exp
30146	Act Energy Imp	UINT32	1.000000	Act Energy Imp
30148	React Energy Exp	UINT32	1.000000	React Energy Exp
30150	React Energy Imp	UINT32	1.000000	React Energy Imp
30152	Thermal Status Ph A	UINT16	1.000000	Thermal Status Ph A %
30153	Thermal Status Ph B	UINT16	1.000000	Thermal Status Ph B %

Address	Description	Format	Mult	Description
30154	Thermal Status Ph C	UINT16	1.000000	Thermal Status Ph C %
30167	Fault Records	UINT16	1.000000	Fault Records
30168	Event Records	UINT16	1.000000	Event Records
30169	Waveform Records	UINT16	1.000000	Waveform Records
30170	Vab Secondary	FP_32BITS_3DP	1.000000	Vab V
30172	Vbc Secondary	FP_32BITS_3DP	1.000000	Vbc V
30174	Vca Secondary	FP_32BITS_3DP	1.000000	Vca V
30176	Vn Primary	FP_32BITS_3DP	1.000000	Vn V
30178	Vn Secondary	FP_32BITS_3DP	1.000000	Vn V
30180	Vn Secondary	FP_32BITS_3DP	1.000000	Vn Degrees
30193	I Phase A Max	FP_32BITS_3DP	1.000000	Ia Max Demand
30195	I Phase B Max	FP_32BITS_3DP	1.000000	Ib Max Demand
30197	I Phase C Max	FP_32BITS_3DP	1.000000	Ic Max Demand
30199	P 3P Max	FP_32BITS_3DP	0.000001	Power Max Demand
30201	Q 3P Max	FP_32BITS_3DP	0.000001	VARs Max Demand
30241	CB Total Trip Count	UINT32	1.000000	CB Total Trip Count
30243	CB Delta Trip Count	UINT32	1.000000	CB Delta Trip Count
30245	CB Count To AR Block	UINT32	1.000000	CB Count to AR Block
30247	CB Frequent Ops Count	UINT32	1.000000	CB Frequent Ops Count
30301	Ia Last Trip	FP_32BITS_3DP	1.000000	Ia Fault
30303	Ib Last Trip	FP_32BITS_3DP	1.000000	Ib Fault
30305	Ic Last Trip	FP_32BITS_3DP	1.000000	Ic Fault
30307	Va Last Trip	FP_32BITS_3DP	1.000000	Va Fault
30309	Vb Last Trip	FP_32BITS_3DP	1.000000	Vb Fault
30311	Vc Last Trip	FP_32BITS_3DP	1.000000	Vc Fault
30313	In Last Trip	FP_32BITS_3DP	1.000000	In Fault
30315	Ig Last Trip	FP_32BITS_3DP	1.000000	Ig Fault
30319	V Phase A Max	FP_32BITS_3DP	1.000000	Va Max Demand
30321	V Phase B Max	FP_32BITS_3DP	1.000000	Vb Max Demand
30323	V Phase C Max	FP_32BITS_3DP	1.000000	Vc Max Demand
30325	V Phase AB Max	FP_32BITS_3DP	1.000000	Vab Max Demand
30327	V Phase BC Max	FP_32BITS_3DP	1.000000	Vbc Max Demand
30329	V Phase CA Max	FP_32BITS_3DP	1.000000	Vca Max Demand
30331	CB Ph A Trip Count	UINT32	1.000000	CB Phase A Trip Count
30333	CB Ph B Trip Count	UINT32	1.000000	CB Phase B Trip Count
30335	CB Ph C Trip Count	UINT32	1.000000	CB Phase C Trip Count
30337	CB E/F Trip Count	UINT32	1.000000	CB EF Trip Count
30341	LED1-n	BITSTRING	0.000000	Led 1-16 status
30342	LED1-n	BITSTRING	0.000000	Led 17-32 status
30343	INP1-n	BITSTRING	0.000000	Input 1-16 status
30344	INP1-n	BITSTRING	0.000000	Input 17-32 status
30345	OUT1-n	BITSTRING	0.000000	Output 1-16 status
30346	OUT1-n	BITSTRING	0.000000	Output 17-32 status
30347	VRT1-n	BITSTRING	0.000000	Virtual 1-16 status
30348	VRT1-n	BITSTRING	0.000000	Virtual 17-32 status
30349	EQN1-n	BITSTRING	0.000000	Equation 1-16 status
30350	EQN1-n	BITSTRING	0.000000	Equation 17-32 status
30354	CB Wear A	FP_32BITS_3DP	0.000001	CB Wear A
30356	CB Wear B	FP_32BITS_3DP	0.000001	CB Wear B

Address	Description	Format	Mult	Description
30358	CB Wear C	FP_32BITS_3DP	0.000001	CB Wear C
30360	CB Wear A Remaining	FP_32BITS_3DP	1.000000	CB Wear A Remaining
30362	CB Wear B Remaining	FP_32BITS_3DP	1.000000	CB Wear B Remaining
30364	CB Wear C Remaining	FP_32BITS_3DP	1.000000	CB Wear C Remaining
30366	CB Wear Minimum	FP_32BITS_3DP	1.000000	CB Wear Minimum
30380	StartCount	FP_32BITS_3DP	1.000000	Start Count
30382	Start Count Target	FP_32BITS_3DP	1.000000	Start Count Target
30390	Freq Last Trip	FP_32BITS_3DP	1.000000	Freq Last Trip
30392	Active Setting Group	UINT16	1.000000	Active Setting Group
30400	Frequency Max	FP_32BITS_3DP	1.000000	Frequency Max
30402	S 3P Max	FP_32BITS_3DP	0.000010	S 3P Max
30468	CB Trip Time Meter	FP_32BITS_3DP	1.000000	CB Trip Time
30484	Remote Ia Last Trip	FP_32BITS_3DP	1.000000	Remote Ia Fault
30486	Remote Ib Last Trip	FP_32BITS_3DP	1.000000	Remote Ib Fault
30488	Remote Ic Last Trip	FP_32BITS_3DP	1.000000	Remote Ic Fault
30490	Remote In Last Trip	FP_32BITS_3DP	1.000000	Remote In Fault
30492	Remote Ig Last Trip	FP_32BITS_3DP	1.000000	Remote Ig Fault
30494	Op Ia Last Trip	FP_32BITS_3DP	1.000000	Operate Ia Fault
30496	Op Ib Last Trip	FP_32BITS_3DP	1.000000	Operate Ib Fault
30498	Op Ic Last Trip	FP_32BITS_3DP	1.000000	Operate Ic Fault
30500	Res Ia Last Trip	FP_32BITS_3DP	1.000000	Restrain Ia Fault
30502	Res Ib Last Trip	FP_32BITS_3DP	1.000000	Restrain Ib Fault
30504	Res Ic Last Trip	FP_32BITS_3DP	1.000000	Restrain Ic Fault
30506	Remote Ia Primary	FP_32BITS_3DP	1.000000	Remote Ia A
30508	Remote Ib Primary	FP_32BITS_3DP	1.000000	Remote Ib A
30510	Remote Ic Primary	FP_32BITS_3DP	1.000000	Remote Ic A
30512	Remote Ia Secondary	FP_32BITS_3DP	1.000000	Remote Ia A
30514	Remote Ib Secondary	FP_32BITS_3DP	1.000000	Remote Ib A
30516	Remote Ic Secondary	FP_32BITS_3DP	1.000000	Remote Ic A
30518	Remote Ia Nominal	FP_32BITS_3DP	1.000000	Remote Ia xIn
30520	Remote Ib Nominal	FP_32BITS_3DP	1.000000	Remote Ib xIn
30522	Remote Ic Nominal	FP_32BITS_3DP	1.000000	Remote Ic xIn
30524	Remote Ia Nominal	FP_32BITS_3DP	1.000000	Remote Ia Degrees
30526	Remote Ib Nominal	FP_32BITS_3DP	1.000000	Remote Ib Degrees
30528	Remote Ic Nominal	FP_32BITS_3DP	1.000000	Remote Ic Degrees
30530	Remote In Primary	FP_32BITS_3DP	1.000000	Remote In A
30532	Remote In Secondary	FP_32BITS_3DP	1.000000	Remote In A
30534	Remote In Nominal	FP_32BITS_3DP	1.000000	Remote In xInom
30536	Remote Ig Primary	FP_32BITS_3DP	1.000000	Remote Ig A
30538	Remote Ig Secondary	FP_32BITS_3DP	1.000000	Remote Ig A
30540	Remote Ig Nominal	FP_32BITS_3DP	1.000000	Remote Ig xInom
30542	Line Ia	FP_32BITS_3DP	1.000000	Local Line Ia
30544	Line Ib	FP_32BITS_3DP	1.000000	Local Line Ib
30546	Line Ic	FP_32BITS_3DP	1.000000	Local Line Ic
30548	Relay Ia	FP_32BITS_3DP	1.000000	Local Relay Ia
30550	Relay Ib	FP_32BITS_3DP	1.000000	Local Relay Ib
30552	Relay Ic	FP_32BITS_3DP	1.000000	Local Relay Ic
30554	Remote Line Ia	FP_32BITS_3DP	1.000000	Remote Line Ia

Address	Description	Format	Mult	Description
30556	Remote Line Ib	FP_32BITS_3DP	1.000000	Remote Line Ib
30558	Remote Line Ic	FP_32BITS_3DP	1.000000	Remote Line Ic
30560	Remote Relay Ia	FP_32BITS_3DP	1.000000	Remote Relay Ia
30562	Remote Relay Ib	FP_32BITS_3DP	1.000000	Remote Relay Ib
30564	Remote Relay Ic	FP_32BITS_3DP	1.000000	Remote Relay Ic
30566	Operate Ia	FP_32BITS_3DP	1.000000	Operate Ia
30568	Operate Ib	FP_32BITS_3DP	1.000000	Operate Ib
30570	Operate Ic	FP_32BITS_3DP	1.000000	Operate Ic
30572	Restrain Ia	FP_32BITS_3DP	1.000000	Restrain Ia
30574	Restrain Ib	FP_32BITS_3DP	1.000000	Restrain Ib
30576	Restrain Ic	FP_32BITS_3DP	1.000000	Restrain Ic

4.3.4 Holding Registers (Read Write Registers)

Address	Description	Format	Mult	Description
40001	Time	TIME_METER	0.000000	Time
40010	Vab Primary	FP_32BITS_3DP	1.000000	Vab V
40012	Vbc Primary	FP_32BITS_3DP	1.000000	Vbc V
40014	Vca Primary	FP_32BITS_3DP	1.000000	Vca V
40016	Va Primary	FP_32BITS_3DP	1.000000	Va V
40018	Vb Primary	FP_32BITS_3DP	1.000000	Vb V
40020	Vc Primary	FP_32BITS_3DP	1.000000	Vc V
40022	Va Secondary	FP_32BITS_3DP	1.000000	Va V
40024	Vb Secondary	FP_32BITS_3DP	1.000000	Vb V
40026	Vc Secondary	FP_32BITS_3DP	1.000000	Vc V
40034	Vab Nominal	FP_32BITS_3DP	1.000000	Vab Degrees
40036	Vbc Nominal	FP_32BITS_3DP	1.000000	Vbc Degrees
40038	Vca Nominal	FP_32BITS_3DP	1.000000	Vca Degrees
40040	Va Nominal	FP_32BITS_3DP	1.000000	Va Degrees
40042	Vb Nominal	FP_32BITS_3DP	1.000000	Vb Degrees
40044	Vc Nominal	FP_32BITS_3DP	1.000000	Vc Degrees
40048	Vzps	FP_32BITS_3DP	1.000000	Vzps V
40050	Vpps	FP_32BITS_3DP	1.000000	Vpps V
40052	Vnps	FP_32BITS_3DP	1.000000	Vnps V
40054	Vzps	FP_32BITS_3DP	1.000000	Vzps Degrees
40056	Vpps	FP_32BITS_3DP	1.000000	Vpps Degrees
40058	Vnps	FP_32BITS_3DP	1.000000	Vnps Degrees
40060	Frequency	FP_32BITS_3DP	1.000000	Frequency Hz
40064	Ia Primary	FP_32BITS_3DP	1.000000	Ia A
40066	Ib Primary	FP_32BITS_3DP	1.000000	Ib A
40068	Ic Primary	FP_32BITS_3DP	1.000000	Ic A
40070	Ia Secondary	FP_32BITS_3DP	1.000000	Ia A
40072	Ib Secondary	FP_32BITS_3DP	1.000000	Ib A
40074	Ic Secondary	FP_32BITS_3DP	1.000000	Ic A
40076	Ia Nominal	FP_32BITS_3DP	1.000000	Ia xIn
40078	Ib Nominal	FP_32BITS_3DP	1.000000	Ib xIn
40080	Ic Nominal	FP_32BITS_3DP	1.000000	Ic xIn
40082	Ia Nominal	FP_32BITS_3DP	1.000000	Ia Degrees

Address	Description	Format	Mult	Description
40084	Ib Nominal	FP_32BITS_3DP	1.000000	Ib Degrees
40086	Ic Nominal	FP_32BITS_3DP	1.000000	Ic Degrees
40088	In Primary	FP_32BITS_3DP	1.000000	In A
40090	In Secondary	FP_32BITS_3DP	1.000000	In A
40092	In Nominal	FP_32BITS_3DP	1.000000	In xInom
40094	Ig Primary	FP_32BITS_3DP	1.000000	Ig A
40096	Ig Secondary	FP_32BITS_3DP	1.000000	Ig A
40098	Ig Nominal	FP_32BITS_3DP	1.000000	Ig xInom
40100	Izps Nominal	FP_32BITS_3DP	1.000000	Izps xIn
40102	Ipps Nominal	FP_32BITS_3DP	1.000000	Ipps xIn
40104	Inps Nominal	FP_32BITS_3DP	1.000000	Inps xIn
40106	Izps Nominal	FP_32BITS_3DP	1.000000	Izps Degrees
40108	Ipps Nominal	FP_32BITS_3DP	1.000000	Ipps Degrees
40110	Inps Nominal	FP_32BITS_3DP	1.000000	Inps Degrees
40112	Active Power A	FP_32BITS_3DP	0.000001	A Phase W
40114	Active Power B	FP_32BITS_3DP	0.000001	B Phase W
40116	Active Power C	FP_32BITS_3DP	0.000001	C Phase W
40118	P (3P)	FP_32BITS_3DP	0.000001	3 Phase W
40120	Reactive Power A	FP_32BITS_3DP	0.000001	Phase A VAr
40122	Reactive Power B	FP_32BITS_3DP	0.000001	Phase B VAr
40124	Reactive Power C	FP_32BITS_3DP	0.000001	Phase C VAr
40126	Q (3P)	FP_32BITS_3DP	0.000001	3 Phase VAr
40128	Apparent Power A	FP_32BITS_3DP	0.000001	Phase A VA
40130	Apparent Power B	FP_32BITS_3DP	0.000001	Phase B VA
40132	Apparent Power C	FP_32BITS_3DP	0.000001	Phase C VA
40134	S (3P)	FP_32BITS_3DP	0.000001	3 Phase VA
40136	Power Factor A	FP_32BITS_3DP	1.000000	Phase A
40138	Power Factor B	FP_32BITS_3DP	1.000000	Phase B
40140	Power Factor C	FP_32BITS_3DP	1.000000	Phase C
40142	Power Factor(3P)	FP_32BITS_3DP	1.000000	3 Phase
40144	Act Energy Exp	UINT32	1.000000	Act Energy Exp
40146	Act Energy Imp	UINT32	1.000000	Act Energy Imp
40148	React Energy Exp	UINT32	1.000000	React Energy Exp
40150	React Energy Imp	UINT32	1.000000	React Energy Imp
40152	Thermal Status Ph A	UINT16	1.000000	Thermal Status Ph A %
40153	Thermal Status Ph B	UINT16	1.000000	Thermal Status Ph B %
40154	Thermal Status Ph C	UINT16	1.000000	Thermal Status Ph C %
40167	Fault Records	UINT16	1.000000	Fault Records
40168	Event Records	UINT16	1.000000	Event Records
40169	Waveform Records	UINT16	1.000000	Waveform Records
40170	Vab Secondary	FP_32BITS_3DP	1.000000	Vab V
40172	Vbc Secondary	FP_32BITS_3DP	1.000000	Vbc V
40174	Vca Secondary	FP_32BITS_3DP	1.000000	Vca V
40176	Vn Primary	FP_32BITS_3DP	1.000000	Vn V
40178	Vn Secondary	FP_32BITS_3DP	1.000000	Vn V
40180	Vn Secondary	FP_32BITS_3DP	1.000000	Vn Degrees
40193	I Phase A Max	FP_32BITS_3DP	1.000000	Ia Max Demand
40195	I Phase B Max	FP_32BITS_3DP	1.000000	Ib Max Demand

Address	Description	Format	Mult	Description
40197	I Phase C Max	FP_32BITS_3DP	1.000000	Ic Max Demand
40199	P 3P Max	FP_32BITS_3DP	0.000001	Power Max Demand
40201	Q 3P Max	FP_32BITS_3DP	0.000001	VARs Max Demand
40241	CB Total Trip Count	UINT32	1.000000	CB Total Trip Count
40243	CB Delta Trip Count	UINT32	1.000000	CB Delta Trip Count
40245	CB Count To AR Block	UINT32	1.000000	CB Count to AR Block
40247	CB Frequent Ops Count	UINT32	1.000000	CB Frequent Ops Count
40301	Ia Last Trip	FP_32BITS_3DP	1.000000	Ia Fault
40303	Ib Last Trip	FP_32BITS_3DP	1.000000	Ib Fault
40305	Ic Last Trip	FP_32BITS_3DP	1.000000	Ic Fault
40307	Va Last Trip	FP_32BITS_3DP	1.000000	Va Fault
40309	Vb Last Trip	FP_32BITS_3DP	1.000000	Vb Fault
40311	Vc Last Trip	FP_32BITS_3DP	1.000000	Vc Fault
40313	In Last Trip	FP_32BITS_3DP	1.000000	In Fault
40315	Ig Last Trip	FP_32BITS_3DP	1.000000	Ig Fault
40319	V Phase A Max	FP_32BITS_3DP	1.000000	Va Max Demand
40321	V Phase B Max	FP_32BITS_3DP	1.000000	Vb Max Demand
40323	V Phase C Max	FP_32BITS_3DP	1.000000	Vc Max Demand
40331	CB Ph A Trip Count	UINT32	1.000000	CB Phase A Trip Count
40333	CB Ph B Trip Count	UINT32	1.000000	CB Phase B Trip Count
40335	CB Ph C Trip Count	UINT32	1.000000	CB Phase C Trip Count
40337	CB E/F Trip Count	UINT32	1.000000	CB EF Trip Count
40341	LED1-n	BITSTRING	0.000000	Led 1-16 status
40342	LED1-n	BITSTRING	0.000000	Led 17-32 status
40343	INP1-n	BITSTRING	0.000000	Input 1-16 status
40344	INP1-n	BITSTRING	0.000000	Input 17-32 status
40345	OUT1-n	BITSTRING	0.000000	Output 1-16 status
40346	OUT1-n	BITSTRING	0.000000	Output 17-32 status
40347	VRT1-n	BITSTRING	0.000000	Virtual 1-16 status
40348	VRT1-n	BITSTRING	0.000000	Virtual 17-32 status
40349	EQN1-n	BITSTRING	0.000000	Equation 1-16 status
40350	EQN1-n	BITSTRING	0.000000	Equation 17-32 status
40354	CB Wear A	FP_32BITS_3DP	0.000001	CB Wear A
40356	CB Wear B	FP_32BITS_3DP	0.000001	CB Wear B
40358	CB Wear C	FP_32BITS_3DP	0.000001	CB Wear C
40360	CB Wear A Remaining	FP_32BITS_3DP	1.000000	CB Wear A Remaining
40362	CB Wear B Remaining	FP_32BITS_3DP	1.000000	CB Wear B Remaining
40364	CB Wear C Remaining	FP_32BITS_3DP	1.000000	CB Wear C Remaining
40366	CB Wear Minimum	FP_32BITS_3DP	1.000000	CB Wear Minimum
40368	Active Setting Group	UINT16	1.000000	Active Setting Group
40394	Ia 2nd Harmonic Nominal	FP_32BITS_3DP	1.000000	81HBL2 PhA xIn
40396	Ib 2nd Harmonic Nominal	FP_32BITS_3DP	1.000000	81HBL2 PhB xIn
40398	Ic 2nd Harmonic Nominal	FP_32BITS_3DP	1.000000	81HBL2 PhC xIn
40401	Event Count	EVENTCOUNT	0.000000	Events Counter
40402	Event	EVENT	0.000000	8 Registers
40404	Frequency Max	FP_32BITS_3DP	1.000000	Frequency Max
40406	S 3P Max	FP_32BITS_3DP	0.000010	S 3P Max
40472	CB Trip Time Meter	FP_32BITS_3DP	1.000000	CB Trip Time

5. DNP3 Definitions

5.1 Device Profile

The following table provides a “Device Profile Document” in the standard format defined in the DNP 3.0 Subset Definitions Document. While it is referred to in the DNP 3.0 Subset Definitions as a “Document,” it is in fact a table, and only a component of a total interoperability guide. The table, in combination with the Implementation Table provided in Section 5.2 (beginning on page 44), and the Point List Tables provided in Section 5.3 (beginning on page 50), should provide a complete configuration/interoperability guide for communicating with a device implementing the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library.

DNP V3.0 DEVICE PROFILE DOCUMENT (Also see the DNP 3.0 Implementation Table in Section 5.2 , beginning on page 44).																					
Vendor Name: Siemens Protection Devices Ltd.																					
Device Name: 7SR181 Solkor, using the Triangle MicroWorks, Inc. DNP3 Slave Source Code Library, Version 3.																					
Highest DNP Level Supported: For Requests: Level 3 For Responses: Level 3	Device Function: ☐ Master ☒ Slave																				
Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table): For static (non-change-event) object requests, request qualifier codes 07 and 08 (limited quantity), and 17 and 28 (index) are supported. Static object requests sent with qualifiers 07, or 08, will be responded with qualifiers 00 or 01. Output Event Object 11 is supported.																					
Maximum Data Link Frame Size (octets): Transmitted: 256 Received: 256	Maximum Application Fragment Size (octets): Transmitted: 2048 Received: 2048																				
Maximum Data Link Re-tries: ☐ None ☐ Fixed (3) ☒ Configurable from 0 to 65535 (Default 3)	Maximum Application Layer Re-tries: ☒ None ☐ Configurable																				
Requires Data Link Layer Confirmation: ☐ Never ☐ Always ☐ Sometimes ☒ Configurable as: Never, Only for multi-frame messages, or Always																					
Requires Application Layer Confirmation: ☐ Never ☐ Always ☒ When reporting Event Data (Slave devices only) ☒ When sending multi-fragment responses (Slave devices only) ☐ Sometimes ☐ Configurable as: “Only when reporting event data”, or “When reporting event data or multi-fragment messages.”																					
Timeouts while waiting for: <table> <tr> <td>Data Link Confirm:</td> <td>☐ None</td> <td>☐ Fixed at ____</td> <td>☐ Variable</td> <td>☒ Configurable (2sec)</td> </tr> <tr> <td>Complete Appl. Fragment:</td> <td>☒ None</td> <td>☐ Fixed at ____</td> <td>☐ Variable</td> <td>☐ Configurable</td> </tr> <tr> <td>Application Confirm:</td> <td>☐ None</td> <td>☐ Fixed at ____</td> <td>☐ Variable</td> <td>☒ Configurable (10sec)</td> </tr> <tr> <td>Complete Appl. Response:</td> <td>☒ None</td> <td>☐ Fixed at ____</td> <td>☐ Variable</td> <td>☐ Configurable</td> </tr> </table> Others: Transmission Delay, (Configurable, default 0 sec) Select/Operate Arm Timeout, (Configurable, default 5 sec)		Data Link Confirm:	☐ None	☐ Fixed at ____	☐ Variable	☒ Configurable (2sec)	Complete Appl. Fragment:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable	Application Confirm:	☐ None	☐ Fixed at ____	☐ Variable	☒ Configurable (10sec)	Complete Appl. Response:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Data Link Confirm:	☐ None	☐ Fixed at ____	☐ Variable	☒ Configurable (2sec)																	
Complete Appl. Fragment:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable																	
Application Confirm:	☐ None	☐ Fixed at ____	☐ Variable	☒ Configurable (10sec)																	
Complete Appl. Response:	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable																	

DNP V3.0 DEVICE PROFILE DOCUMENT (Also see the DNP 3.0 Implementation Table in Section 5.2 , beginning on page 44).																																																										
Need Time Interval, (Configurable, default 30 minutes) Unsolicited Notification Delay, (Configurable, default 5 seconds) Unsolicited Response Retry Delay, (Configurable (between 3 - 9), default 5 seconds) Unsolicited Offline Interval, (Configurable, default 30 seconds) Binary Change Event Scan Period, (Polled, Not Applicable) Double Bit Change Event Scan Period, (Polled - Not Applicable) Analog Change Event Scan Period, (Polled - Not Applicable) Counter Change Event Scan Period, (Polled - Not Applicable) Frozen Counter Change Event Scan Period, (Polled - Not Applicable) String Change Event Scan Period, (Unsupported - Not Applicable) Virtual Terminal Event Scan Period, (Unsupported - Not Applicable)																																																										
Sends/Executes Control Operations: <table style="width: 100%; border: none;"> <tr> <td style="width: 35%;">WRITE Binary Outputs</td> <td style="width: 15%;">☒ Never</td> <td style="width: 15%;">☐ Always</td> <td style="width: 15%;">☐ Sometimes</td> <td style="width: 20%;">☐ Configurable</td> </tr> <tr> <td>SELECT/OPERATE</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>DIRECT OPERATE</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>DIRECT OPERATE - NO ACK</td> <td>☐ Never</td> <td>☒ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Count > 1</td> <td>☒ Never</td> <td>☐ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Pulse On</td> <td>☐ Never</td> <td>☐ Always</td> <td>☒ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Pulse Off</td> <td>☐ Never</td> <td>☐ Always</td> <td>☒ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Latch On</td> <td>☐ Never</td> <td>☐ Always</td> <td>☒ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Latch Off</td> <td>☐ Never</td> <td>☐ Always</td> <td>☒ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Queue</td> <td>☒ Never</td> <td>☐ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> <tr> <td>Clear Queue</td> <td>☒ Never</td> <td>☐ Always</td> <td>☐ Sometimes</td> <td>☐ Configurable</td> </tr> </table> Attach explanation if "Sometimes" or "Configurable" was checked for any operation.				WRITE Binary Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable	SELECT/OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	DIRECT OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	DIRECT OPERATE - NO ACK	☐ Never	☒ Always	☐ Sometimes	☐ Configurable	Count > 1	☒ Never	☐ Always	☐ Sometimes	☐ Configurable	Pulse On	☐ Never	☐ Always	☒ Sometimes	☐ Configurable	Pulse Off	☐ Never	☐ Always	☒ Sometimes	☐ Configurable	Latch On	☐ Never	☐ Always	☒ Sometimes	☐ Configurable	Latch Off	☐ Never	☐ Always	☒ Sometimes	☐ Configurable	Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable	Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
WRITE Binary Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable																																																						
SELECT/OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																						
DIRECT OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																						
DIRECT OPERATE - NO ACK	☐ Never	☒ Always	☐ Sometimes	☐ Configurable																																																						
Count > 1	☒ Never	☐ Always	☐ Sometimes	☐ Configurable																																																						
Pulse On	☐ Never	☐ Always	☒ Sometimes	☐ Configurable																																																						
Pulse Off	☐ Never	☐ Always	☒ Sometimes	☐ Configurable																																																						
Latch On	☐ Never	☐ Always	☒ Sometimes	☐ Configurable																																																						
Latch Off	☐ Never	☐ Always	☒ Sometimes	☐ Configurable																																																						
Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable																																																						
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable																																																						
Reports Binary Input Change Events when no specific variation requested: ☐ Never ☐ Only time-tagged ☐ Only non-time-tagged ☒ Configurable to send one or the other	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐ Never ☐ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☒ Configurable																																																									
Sends Unsolicited Responses: ☐ Never ☒ Configurable ☐ Only certain objects ☐ Sometimes (attach explanation) ☒ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☒ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.																																																									
Default Counter Object/Variation: ☐ No Counters Reported ☒ Configurable ☐ Default Object - Default Variation: _____ ☒ Point-by-point list attached	Counters Roll Over at: ☐ No Counters Reported ☐ Configurable (attach explanation) ☐ 16 Bits ☒ 32 Bits ☐ Other Value: _____ ☒ Point-by-point list attached																																																									
Sends Multi-Fragment Responses: ☒ Yes ☐ No ☐ Configurable																																																										

DNP V3.0**DEVICE PROFILE DOCUMENT**(Also see the DNP 3.0 Implementation Table in [Section 5.2](#), beginning on page 44).**Sequential File Transfer Support:**

File Transfer Support	☐ Yes	☒ No
Append File Mode	☐ Yes	☒ No
Custom Status Code Strings	☐ Yes	☒ No
Permissions Field	☐ Yes	☒ No
File Events Assigned to Class	☐ Yes	☒ No
File Events Send Immediately	☐ Yes	☒ No
Multiple Blocks in a Fragment	☐ Yes	☒ No
Max Number of Files Open	0	

5.2 Implementation Table

The following table identifies which object variations, function codes, and qualifiers the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library supports in both request messages and in response messages. For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event objects, qualifiers 17 or 28 are always responded.

In the table below, text shaded as **00, 01 (start-stop)** indicates Subset Level 3 functionality (beyond Subset Level 2).

In the table below, text shaded as **07, 08 (limited qty)** indicates functionality beyond Subset Level 3.

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
1	0	Binary Input - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
1	1	Binary Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
1	2 (default - see note 1)	Binary Input with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
2	0	Binary Input Change - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
2	1	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	2 (default - see note 1)	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	3	Binary Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
3	0	Double Bit Input - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
3	1 (default - see note 1)	Double Bit Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 1
3	2	Double Bit Input with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 1
4	0	Double Bit Input Change - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
4	1	Double Bit Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
4	2	Double Bit Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
4	3 (default - see note 1)	Double Bit Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
10	0	Binary Output - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
10	1	Binary Output	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
			2 (write)	00, 01 (start-stop)		
10	2 (default - see note 1)	Binary Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
11	0	Binary Output Change - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
11	1	Binary Output Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
11	2 (default - see note 1)	Binary Output Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
12	0	Control Relay Output Block	22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index)	129 (response)	echo of request
12	2	Pattern Control Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	7 (limited quantity)	129 (response)	echo of request
12	3	Pattern Mask	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	00, 01 (start-stop)	129 (response)	echo of request
13	0	Binary Output Command Event - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
13	1 (default - see note 1)	Binary Output Command Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
13	2	Binary Output Command Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
20	0	Binary Counter - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
			7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty)		
20	1	32-Bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
20	2	16-Bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
20	3	32-Bit Delta Counter (with Flag)				
20	4	16-Bit Delta Counter (with Flag)				
20	5 (default see note 1)	32-Bit Binary Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
20	6	16-Bit Binary Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
20	7	32-Bit Delta Counter (without Flag)				
20	8	16-Bit Delta Counter (without Flag)				
21	0	Frozen Counter - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
21	1	32-Bit Frozen Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
21	2	16-Bit Frozen Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
21	3	32-Bit Frozen Delta Counter (with Flag)				
21	4	16-Bit Frozen Delta Counter (with Flag)				
21	5	32-Bit Frozen Counter (without Time Of Freeze)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
21	6	16-Bit Frozen Counter (without Time Of Freeze)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
21	7	32-Bit Frozen Delta Counter (with Time Of Freeze)				
21	8	16-Bit Frozen Delta Counter (with Time Of Freeze)				
21	9 (default - see note 1)	32-Bit Frozen Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
21	10	16-Bit Frozen Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
21	11	32-Bit Frozen Delta Counter (without Flag)				
21	12	16-Bit Frozen Delta Counter (without Flag)				
22	0	Counter Change Event - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
22	1 (default - see note 1)	32-Bit Counter Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	2	16-Bit Counter Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	3	32-Bit Delta Counter Change Event (without Time)				
22	4	16-Bit Delta Counter Change Event (without Time)				
22	5	32-Bit Counter Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	6	16-Bit Counter Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130	17, 28 (index)

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
					(unsol. resp)	
22	7	32-Bit Delta Counter Change Event (with Time)				
22	8	16-Bit Delta Counter Change Event (with Time)				
23	0	Frozen Counter Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
23	1 (default - see note 1)	32-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
23	2	16-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
23	3	32-Bit Frozen Delta Counter Event				
23	4	16-Bit Frozen Delta Counter Event				
23	5	32-Bit Frozen Counter Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
23	6	32-Bit Frozen Counter Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
23	7	32-Bit Frozen Delta Counter Event (with Time)				
23	8	16-Bit Frozen Delta Counter Event (with Time)				
30	0	Analog Input - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
30	1	32-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2)
30	2 (default - see note 1)	16-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2)
30	3	32-Bit Analog Input (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2)
30	4	16-Bit Analog Input (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2)
30	5	short floating point	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2)
30	6	long floating point	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2)
31	0	Frozen Analog Input - Any Variation				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input (with Time of freeze)				
31	4	16-Bit Frozen Analog Input (with Time of freeze)				
31	5	32-Bit Frozen Analog Input (without Flag)				
31	6	16-Bit Frozen Analog Input (without Flag)				

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
32	0	Analog Change Event - Any Variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
32	1	32Bit-Analog Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	2	16Bit-Analog Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	3	32Bit-Analog Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	4 (default - see note 1)	16Bit-Analog Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	5	short floating point Analog Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	6	long floating point Analog Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	7	short floating point Analog Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	8	long floating point Analog Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
33	0	Frozen Analog Event - Any Variation				
33	1	32-Bit Frozen Analog Event (without Time)				
33	2	16-Bit Frozen Analog Event (without Time)				
33	3	32-Bit Frozen Analog Event (with Time)				
33	4	16-Bit Frozen Analog Event (with Time)				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Extended Floating Point Frozen Analog Event				
34	0	Analog Input Deadband (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
34	1	16 bit Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
34	2 (default - see note 1)	32 bit Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
34	3	Short Floating Point Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty)	129 (response)	00, 01 (start-stop) 17, 28 (index) - see note 2

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	Variation	Description	Function Codes (dec)	Qualifier Codes (hex)	Function Codes (dec)	Qualifier Codes (hex)
				17, 27, 28 (index)		
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
50	0	Time and Date				
50	1 (default - see note 1)	Time and Date	1 (read)	07, 08 (limited qty)	129 (response)	07 (limited qty = 1)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
50	3	Time and Date Last Recorded Time	2 (write)	07 (limited qty)		
51	1	Time and Date CTO			129 (response) 130 (unsol. resp)	(limited qty = 1)
51	2	Unsynchronized Time and Date CTO			129 (response) 130 (unsol. resp)	(limited qty = 1)
52	1	Time Delay Coarse			129 (response)	(limited qty = 1)
52	2	Time Delay Fine			129 (response)	(limited qty = 1)
60	0	Not Defined				
60	1	Class 0 Data	1 (read)	06 (no range, or all)		
60	2	Class 1 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
60	3	Class 2 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
60	4	Class 3 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
80	1	Internal Indications	1 (read)	00, 01 (start-stop)	129 (response)	00, 01 (start-stop)
			2 (write)(see note 3)	00 (start-stop) index=7		
		No Object (function code only)	13 (cold restart)			
		No Object (function code only)	14 (warm restart)			
		No Object (function code only)	23 (delay meas.)			
		No Object (function code only)	24 (record current time)			

Note 1: A Default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. Default variations are configurable; however, default settings for the configuration parameters are indicated in the table above.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. (For change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Writes of Internal Indications are only supported for index 7 (Restart IIN1-7).

This protocol can be set to use any or all of the relays hardware interfaces (USB, Fibre Optic, RS232 and RS485) where fitted. The relay can communicate simultaneously on all ports regardless of protocol used.

Communication via DNP3 over Ethernet requires external devices. Please refer to the documents ***TCPIP Catalogue Sheet*** and ***TCPIP Interface Technical Guidance Notes*** for more information.

The information shown below is the default configuration. This can be modified using the Communications Configuration Editor tool, refer [section 9](#) for details.

5.3.1 Binary Input Points

Binary inputs are by default returned in a class zero interrogation.

Note, not all points listed here apply to all builds of devices.

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Binary Input PointsStatic (Steady-State) Object Number: **1 (Packed Format)**Change Event Object Number: **1 (w/o Time)**Static Variation reported when variation 0 requested: **1 (Binary Input w/o status)**
or **2 (Binary Input with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Input Change w/o Time)**
or **2 (Binary Input Change with Absolute Time)**
or **3 (Binary Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
50	Fault Forward/Line	0,2	2	2
51	Fault Reverse/Busbar	0,2	2	2
52	51-1	0,2	2	2
53	50-1	0,2	2	2
54	51N-1	0,2	2	2
55	50N-1	0,2	2	2
56	51G-1	0,2	2	2
57	50G-1	0,2	2	2
58	51-2	0,2	2	2
59	50-2	0,2	2	2
60	51N-2	0,2	2	2
61	50N-2	0,2	2	2
62	51G-2	0,2	2	2
63	50G-2	0,2	2	2
64	60 CTS	0,2	2	2
65	46IT	0,2	2	2
66	46DT	0,2	2	2
69	46BC	0,2	2	2
80	Auto-reclose active	0,2	2	2
81	CB on by auto reclose	0,2	2	2
82	Reclaim	0,2	2	2
83	Lockout	0,2	2	2
86	51-3	0,2	2	2
87	50-3	0,2	2	2
88	51N-3	0,2	2	2
89	50N-3	0,2	2	2
90	51G-3	0,2	2	2
91	50G-3	0,2	2	2
92	51-4	0,2	2	2
93	50-4	0,2	2	2
94	51N-4	0,2	2	2
95	50N-4	0,2	2	2
96	51G-4	0,2	2	2
97	50G-4	0,2	2	2
98	Cold Load Active	0,2	2	2
99	E/F Out	0,2	2	2
100	P/F Inst Protection Inhibited	0,2	2	2
101	E/F Inst Protection Inhibited	0,2	2	2
103	Ext Inst Protection Inhibited	0,2	2	2
126	Trip Circuit Fail 1	0,2	2	2
127	Trip Circuit Fail 2	0,2	2	2

Binary Input PointsStatic (Steady-State) Object Number: **1 (Packed Format)**Change Event Object Number: **1 (w/o Time)**Static Variation reported when variation 0 requested: **1 (Binary Input w/o status)**
or **2 (Binary Input with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Input Change w/o Time)**
or **2 (Binary Input Change with Absolute Time)**
or **3 (Binary Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
128	Trip Circuit Fail 3	0,2	2	2
129	CB Total Trip Count	0,2	2	2
130	CB Delta Trip Count	0,2	2	2
131	CB Count To AR Block	0,2	2	2
132	CB Frequent Ops Count	0,2	2	2
133	I ² t CB Wear	0,2	2	2
207	Close Circuit Fail 1	0,2	2	2
208	Close Circuit Fail 2	0,2	2	2
209	Close Circuit Fail 3	0,2	2	2
210	Close Circuit Fail	0,2	2	2
211	50BF Stage 1	0,2	2	2
212	50BF Stage 2	0,2	2	2
213	49-Alarm	0,2	2	2
214	49-Trip	0,2	2	2
217	37-1	0,2	2	2
218	37-2	0,2	2	2
219	CB Alarm	0,2	2	2
225	General Alarm 1	0,2	2	2
226	General Alarm 2	0,2	2	2
227	General Alarm 3	0,2	2	2
228	General Alarm 4	0,2	2	2
229	General Alarm 5	0,2	2	2
230	General Alarm 6	0,2	2	2
231	General Alarm 7	0,2	2	2
237	Quick Logic E1	0,2	2	2
238	Quick Logic E2	0,2	2	2
239	Quick Logic E3	0,2	2	2
240	Quick Logic E4	0,2	2	2
269	60 CTS-I	0,2	2	2
270	81HBL2	0,2	2	2
271	37G-1	0,2	2	2
272	37G-2	0,2	2	2
274	37-PhA	0,2	2	2
275	37-PhB	0,2	2	2
276	37-PhC	0,2	2	2
277	50 LC-1	0,2	2	2
278	50 LC-2	0,2	2	2
279	50G LC-1	0,2	2	2
280	50G LC-2	0,2	2	2
283	50BF-PhA	0,2	2	2
284	50BF-PhB	0,2	2	2
285	50BF-PhC	0,2	2	2

Binary Input PointsStatic (Steady-State) Object Number: **1 (Packed Format)**Change Event Object Number: **1 (w/o Time)**Static Variation reported when variation 0 requested: **1 (Binary Input w/o status)**
or **2 (Binary Input with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Input Change w/o Time)**
or **2 (Binary Input Change with Absolute Time)**
or **3 (Binary Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
286	50BF-EF	0,2	2	2
287	79 Last Trip Lockout	0,2	2	2
288	60 CTS-I-PhA	0,2	2	2
289	60 CTS-I-PhB	0,2	2	2
290	60 CTS-I-PhC	0,2	2	2
291	Trip PhA	0,2	2	2
292	Trip PhB	0,2	2	2
293	Trip PhC	0,2	2	2
411	Setting G1 selected	0,2	2	2
412	Setting G2 selected	0,2	2	2
413	Setting G3 selected	0,2	2	2
414	Setting G4 selected	0,2	2	2
420	79 AR In progress	0,2	2	2
422	HotLine Working	0,2	2	2
425	Inst Protection Out	0,2	2	2
427	CB 1	0,2	2	2
501	Virtual Input 1	0,2	2	2
502	Virtual Input 2	0,2	2	2
503	Virtual Input 3	0,2	2	2
504	Virtual Input 4	0,2	2	2
505	Virtual Input 5	0,2	2	2
506	Virtual Input 6	0,2	2	2
507	Virtual Input 7	0,2	2	2
508	Virtual Input 8	0,2	2	2
601	LED 1	0,2	2	2
602	LED 2	0,2	2	2
603	LED 3	0,2	2	2
604	LED 4	0,2	2	2
605	LED 5	0,2	2	2
606	LED 6	0,2	2	2
607	LED 7	0,2	2	2
608	LED 8	0,2	2	2
609	LED 9	0,2	2	2
610	LED 10	0,2	2	2
611	LED 11	0,2	2	2
612	LED 12	0,2	2	2
613	LED 13	0,2	2	2
614	LED 14	0,2	2	2
615	LED 15	0,2	2	2
616	LED 16	0,2	2	2
617	LED 17	0,2	2	2

Binary Input PointsStatic (Steady-State) Object Number: **1 (Packed Format)**Change Event Object Number: **1 (w/o Time)**Static Variation reported when variation 0 requested: **1 (Binary Input w/o status)**
or **2 (Binary Input with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Input Change w/o Time)**
or **2 (Binary Input Change with Absolute Time)**
or **3 (Binary Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
618	LED 18	0,2	2	2
701	LED PU 1	0,2	2	2
702	LED PU 2	0,2	2	2
703	LED PU 3	0,2	2	2
704	LED PU 4	0,2	2	2
705	LED PU 5	0,2	2	2
706	LED PU 6	0,2	2	2
707	LED PU 7	0,2	2	2
708	LED PU 8	0,2	2	2
709	LED PU 9	0,2	2	2
710	LED PU 10	0,2	2	2
711	LED PU 11	0,2	2	2
712	LED PU 12	0,2	2	2
713	LED PU 13	0,2	2	2
714	LED PU 14	0,2	2	2
715	LED PU 15	0,2	2	2
716	LED PU 16	0,2	2	2
717	LED PU 17	0,2	2	2
718	LED PU 18	0,2	2	2
801	Binary Output 1	0,2	2	2
802	Binary Output 2	0,2	2	2
803	Binary Output 3	0,2	2	2
804	Binary Output 4	0,2	2	2
805	Binary Output 5	0,2	2	2
806	Binary Output 6	0,2	2	2
807	Binary Output 7	0,2	2	2
808	Binary Output 8	0,2	2	2
871	Cold Start	0,2	2	2
872	Warm Start	0,2	2	2
873	Re-Start	0,2	2	2
874	Power On	0,2	2	2
875	Expected Restart	0,2	2	2
876	Unexpected Restart	0,2	2	2
877	Reset Start Count	0,2	2	2
890	CB 1 Opened	0,2	2	2
891	CB 1 Closed	0,2	2	2
900	User SP Command 1	0,2	2	2
901	User SP Command 2	0,2	2	2
902	User SP Command 3	0,2	2	2
903	User SP Command 4	0,2	2	2
904	User SP Command 5	0,2	2	2
905	User SP Command 6	0,2	2	2

Binary Input PointsStatic (Steady-State) Object Number: **1 (Packed Format)**Change Event Object Number: **1 (w/o Time)**Static Variation reported when variation 0 requested: **1 (Binary Input w/o status)**
or **2 (Binary Input with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Input Change w/o Time)**
or **2 (Binary Input Change with Absolute Time)**
or **3 (Binary Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
906	User SP Command 7	0,2	2	2
907	User SP Command 8	0,2	2	2
1063	CB DBI	0,2	2	2
1064	CB Travelling	0,2	2	2
1065	Close CB Failed	0,2	2	2
1066	Open CB Failed	0,2	2	2
1067	Start Count Alarm	0,2	2	2
1088	87L-1	0,2	2	2
1089	87L-2	0,2	2	2
1090	87HS-1	0,2	2	2
1091	87HS-2	0,2	2	2
1092	85S-1	0,2	2	2
1093	85S-2	0,2	2	2
1094	85S-3	0,2	2	2
1095	85S-4	0,2	2	2
1096	85S-5	0,2	2	2
1097	85S-6	0,2	2	2
1098	85R-1	0,2	2	2
1099	85R-2	0,2	2	2
1100	85R-3	0,2	2	2
1101	85R-4	0,2	2	2
1102	85R-5	0,2	2	2
1103	85R-6	0,2	2	2
1104	87R-1	0,2	2	2
1105	87R-2	0,2	2	2
1106	Protection Comms Alarm	0,2	2	2
1107	Protection Comms Test Mode	0,2	2	2
1108	79 Deadtime Inhibit	0,2	2	2

5.3.2 Double Bit Input Points

The default double bit input event buffer size is set to allow 100 events.

Double bit inputs are by default returned in a class zero interrogation.

Note, not all points listed here apply to all builds of devices.

Double Bit Input Points				
Static (Steady-State) Object Number: 3				
Change Event Object Number: 4				
Static Variation reported when variation 0 requested: 1 (Double Bit Input w/o status) or 2 (Double Bit Input with status)				
Change Event Variation reported when variation 0 requested: 1 (Double Bit Input Change w/o Time) or 2 (Double Bit Input Change with Absolute Time) or 3 (Double Bit Input Change with Relative Time)				
Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 3	Default Variation Event Object 4
0	CB 1	0,2	1	3
10	User DP Command 1	0,2	1	3
11	User DP Command 2	0,2	1	3
12	User DP Command 3	0,2	1	3
13	User DP Command 4	0,2	1	3
14	User DP Command 5	0,2	1	3
15	User DP Command 6	0,2	1	3
16	User DP Command 7	0,2	1	3
17	User DP Command 8	0,2	1	3

5.3.3 Binary Output Status Points and Control Relay Output Blocks

The following table lists both the Binary Output Status Points (Object 10) and the Control Relay Output Blocks (Object 12).

While Binary Output Status Points are included here for completeness, they are not often polled by DNP 3.0 Masters. Binary Output Status points are not recommended to be included in class 0 polls.

As an alternative, it is recommended that “actual” status values of Control Relay Output Block points be looped around and mapped as Binary Inputs. (The “actual” status value, as opposed to the “commanded” status value, is the value of the actuated control. For example, a DNP control command may be blocked through hardware or software mechanisms; in this case, the actual status value would indicate the control failed because of the blocking. Looping Control Relay Output Block actual status values as Binary Inputs has several advantages:

- it allows actual statuses to be included in class 0 polls,
- it allows change event reporting of the actual statuses, which is a more efficient and time-accurate method of communicating control values,
- and it allows reporting of time-based information associated with controls, including any delays before controls are actuated, and any durations if the controls are pulsed.

The default select/control buffer size is large enough to hold 10 of the largest select requests possible.

Binary outputs are by default **NOT** returned in a class zero interrogation.

Note, not all points listed here apply to all builds of devices.

Binary Output Status PointsStatic (Steady-State) Object Number: **10**Change Event Object Number: **11**Control Relay Output Blocks (CROB) Object Number: **12**Binary Output Command Event Object Number: **13**Static Variation reported when variation 0 requested: **1 (Binary Output w/o status)**
or **2 (Binary Output with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Output Event w/o Time)**
or **2 (Binary Output Event with Time)**Command Event Variation reported when variation 0 requested: **1 (Command Status w/o Time)**
or **2 (Command Status with Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
1	RL 1	0	2	2	0	1	Pulse On Latch On Close	Pulse On
2	RL 2	0	2	2	0	1	Pulse On Latch On Close	Pulse On
3	RL 3	0	2	2	0	1	Pulse On Latch On Close	Pulse On
4	RL 4	0	2	2	0	1	Pulse On Latch On Close	Pulse On
5	RL 5	0	2	2	0	1	Pulse On Latch On Close	Pulse On
6	RL 6	0	2	2	0	1	Pulse On Latch On Close	Pulse On
7	RL 7	0	2	2	0	1	Pulse On Latch On Close	Pulse On
8	RL 8	0	2	2	0	1	Pulse On Latch On Close	Pulse On
33	LED reset, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
34	Settings Group 1	0	2	2	0	1	Pulse On Latch On Close	Latch On
35	Settings Group 2	0	2	2	0	1	Pulse On Latch On Close	Latch On
36	Settings Group 3	0	2	2	0	1	Pulse On Latch On Close	Latch On
37	Settings Group 4	0	2	2	0	1	Pulse On Latch On Close	Latch On
42	Auto-reclose on/off	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close	Pulse On Pulse Off Latch On Latch Off

Binary Output Status PointsStatic (Steady-State) Object Number: **10**Change Event Object Number: **11**Control Relay Output Blocks (CROB) Object Number: **12**Binary Output Command Event Object Number: **13**Static Variation reported when variation 0 requested: **1 (Binary Output w/o status)**
or **2 (Binary Output with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Output Event w/o Time)**
or **2 (Binary Output Event with Time)**Command Event Variation reported when variation 0 requested: **1 (Command Status w/o Time)**
or **2 (Command Status with Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
							Trip	
43	Hot Line Working on/off	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off Latch On Latch Off
44	E/F off/on	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off Latch On Latch Off
46	Inst Protection off/on	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off Latch On Latch Off
48	Reset CB Total Trip Count, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
49	Reset CB Delta Trip Count, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
50	Reset CB Count To AR Block, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
51	Reset CB Frequent Ops Count, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
53	Reset I ² t CB Wear	0	2	2	0	1	Pulse On Latch On Close	Pulse On
54	CB 1	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off Latch On Latch Off
55	CB 1 Trip & Reclose, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
56	CB 1 Trip & Lockout, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On

Binary Output Status PointsStatic (Steady-State) Object Number: **10**Change Event Object Number: **11**Control Relay Output Blocks (CROB) Object Number: **12**Binary Output Command Event Object Number: **13**Static Variation reported when variation 0 requested: **1 (Binary Output w/o status)**
or **2 (Binary Output with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Output Event w/o Time)**
or **2 (Binary Output Event with Time)**Command Event Variation reported when variation 0 requested: **1 (Command Status w/o Time)**
or **2 (Command Status with Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
59	Demand metering reset, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
88	Remote mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On
89	Service mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On
90	Local mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On
91	Local & Remote	0	2	2	0	1	Pulse On Latch On Close	Pulse On
98	Reset Start Count (Action)	0	2	2	0	1	Pulse On Latch On Close	Pulse On Latch On
99	User SP Command 1.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
100	User SP Command 2.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
101	User SP Command 3.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
102	User SP Command 4.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
103	User SP Command 5.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
104	User SP Command 6.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
105	User SP Command 7.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
106	User SP Command 8.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
107	User DP Command 1.	0	2	2	0	1	Pulse On Pulse Off Latch On	Pulse On Pulse Off

Binary Output Status PointsStatic (Steady-State) Object Number: **10**Change Event Object Number: **11**Control Relay Output Blocks (CROB) Object Number: **12**Binary Output Command Event Object Number: **13**Static Variation reported when variation 0 requested: **1 (Binary Output w/o status)**
or **2 (Binary Output with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Output Event w/o Time)**
or **2 (Binary Output Event with Time)**Command Event Variation reported when variation 0 requested: **1 (Command Status w/o Time)**
or **2 (Command Status with Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
							Latch Off Close Trip	
108	User DP Command 2.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
109	User DP Command 3.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
110	User DP Command 4.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
111	User DP Command 5.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
112	User DP Command 6.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
113	User DP Command 7.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
114	User DP Command 8.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
115	CB-1 Open	0	2	2	0	1	Pulse On Latch On Close	Pulse On Latch On
116	CB-1 Close	0	2	2	0	1	Pulse On	Pulse On

Binary Output Status PointsStatic (Steady-State) Object Number: **10**Change Event Object Number: **11**Control Relay Output Blocks (CROB) Object Number: **12**Binary Output Command Event Object Number: **13**Static Variation reported when variation 0 requested: **1 (Binary Output w/o status)**
or **2 (Binary Output with status)**Change Event Variation reported when variation 0 requested: **1 (Binary Output Event w/o Time)**
or **2 (Binary Output Event with Time)**Command Event Variation reported when variation 0 requested: **1 (Command Status w/o Time)**
or **2 (Command Status with Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
							Latch On Close	Latch On

5.3.4 Counters

The following table lists both Binary Counters (Object 20) and Frozen Counters (Object 21). When a freeze function is performed on a Binary Counter point, the frozen value is available in the corresponding Frozen Counter point. The default Binary Counter and Frozen Counter event buffer sizes are set to 30.

The “Default Deadband,” and the “Default Change Event Assigned Class” columns are used to represent the absolute amount by which the point must change before a Counter change event will be generated, and once generated in which class poll (1, 2, 3, or none) will the change event be reported.

The default counter event buffer size is set 30. The counter event mode is set to Most Recent, only most recent event for each point is stored.

Counters are by default returned in a class zero interrogation.

Note, not all points listed here apply to all builds of devices.

CountersStatic (Steady-State) Object Number: **20**Change Event Object Number: **22**

Static Variation reported when variation 0 requested: **1 (32-Bit Counter with Flag)**
 or **2 (16-Bit Counter with Flag)**
 or **5 (32-Bit Counter w/o Flag)**
 or **6 (16-Bit Counter w/o Flag)**

Change Event Variation reported when variation 0 requested: **1 (32-Bit Counter Event with Flag)**
 or **2 (16-Bit Counter Event with Flag)**
 or **5 (32-Bit Counter Event with Flag and Time)**
 or **6 (16-Bit Counter Event with Flag and Time)**

Frozen CountersStatic (Steady-State) Object Number: **21**Change Event Object Number: **23**

Static Variation reported when variation 0 requested: **1 (32-Bit Frozen Counter with Flag)**
 or **2 (16-Bit Frozen Counter with Flag)**
 or **5 (32-Bit Frozen Counter with Flag and Time)**
 or **6 (16-Bit Frozen Counter with Flag and Time)**
 or **9 (32-Bit Frozen Counter w/o Flag)**
 or **10 (16-Bit Frozen Counter w/o Flag)**

Change Event Variation reported when variation 0 requested: **1 (32-Bit Frozen Counter Event with Flag)**
 or **2 (16-Bit Frozen Counter Event with Flag)**
 or **5 (32-Bit Frozen Counter Event with Flag and Time)**
 or **6 (16-Bit Frozen Counter Event with Flag and Time)**

		Counter						Frozen Counter		
Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 20	Default Variation Event Object 22	Deadband	Is Resettable	Is Freezable	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 21	Default Variation Event Object 23
0	Waveform Records	0,3	5	1	1		✓	0,2	9	1
1	Fault Records	0,3	5	1	1		✓	0,2	9	1
2	Event Records	0,3	5	1	1		✓	0,2	9	1
3	Data Log Records	0,3	5	1	1		✓	0,2	9	1
5	StartCount	0,3	5	1	1	✓	✓	0,2	9	1
6	Start Count Target	0,3	5	1	1		✓	0,2	9	1
7	Active Setting Group	0,3	5	1	1		✓	0,2	9	1
11	CB Total Trip Count	0,3	5	1	1	✓	✓	0,2	9	1
12	CB Ph A Trip Count	0,3	5	1	1	✓	✓	0,2	9	1
13	CB Ph B Trip Count	0,3	5	1	1	✓	✓	0,2	9	1
14	CB Ph C Trip Count	0,3	5	1	1	✓	✓	0,2	9	1
15	CB E/F Trip Count	0,3	5	1	1	✓	✓	0,2	9	1
16	CB Delta Trip Count	0,3	5	1	1	✓	✓	0,2	9	1
17	CB Count To AR Block	0,3	5	1	1	✓	✓	0,2	9	1
18	CB Frequent Ops Count	0,3	5	1	1	✓	✓	0,2	9	1
21	E1 Counter	0,3	5	1	1		✓	0,2	9	1
22	E2 Counter	0,3	5	1	1		✓	0,2	9	1
23	E3 Counter	0,3	5	1	1		✓	0,2	9	1
24	E4 Counter	0,3	5	1	1		✓	0,2	9	1

5.3.5 Analog Inputs

The following table lists Analog Inputs (Object 30). It is important to note that 16-bit and 32-bit variations of Analog Inputs, Analog Output Control Blocks, and Analog Output Statuses are transmitted through DNP as signed numbers.

Analog InputsStatic (Steady-State) Object Number: **30**Change Event Object Number: **32**Analog Input Deadband: **34**Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input with Flag)**or **2 (16-Bit Analog Input with Flag)**or **3 (32-Bit Analog Input w/o Flag)**or **4 (16-Bit Analog Input w/o Flag)**or **5 (Single Precision, floating point Analog Input with Flag)**Change Event Variation reported when variation 0 requested: **1 (32-Bit Analog Change Event w/o Time)**or **2 (16-Bit Analog Input w/o Time)**or **3 (32-Bit Analog Input with Time)**or **4 (16-Bit Analog Input with Time)**or **5 (Single Precision, floating point Analog Input w/o Time)**or **7 (Single Precision, floating point Analog Input with Time)**Analog Input Reporting Deadband Variation reported when variation 0 requested: **1 (16-Bit)**or **2 (32-Bit)**or **3 (Single Precision, floating point)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 30	Default Variation Event Object 32	Default Multiplier	Default Deadband
45	In Nominal	0,3	2	4	100.000	0.100
46	Ig Primary	0,3	2	4	1.000	100.000
47	Ig Secondary	0,3	2	4	1000.000	0.100
48	Ig Nominal	0,3	2	4	1000.000	0.100
51	Izps Nominal	0,3	2	4	100.000	0.100
52	Ipps Nominal	0,3	2	4	100.000	0.100
53	Inps Nominal	0,3	2	4	100.000	0.100
57	Active Power A	0,3	2	4	0.000	1000000.000
58	Active Power B	0,3	2	4	0.000	1000000.000
59	Active Power C	0,3	2	4	0.000	1000000.000
60	P (3P)	0,3	2	4	0.000	1000000.000
61	Reactive Power A	0,3	2	4	0.000	1000000.000
62	Reactive Power B	0,3	2	4	0.000	1000000.000
63	Reactive Power C	0,3	2	4	0.000	1000000.000
64	Q (3P)	0,3	2	4	0.000	1000000.000
65	Apparent Power A	0,3	2	4	0.000	1000000.000
66	Apparent Power B	0,3	2	4	0.000	1000000.000
67	Apparent Power C	0,3	2	4	0.000	1000000.000
68	S (3P)	0,3	2	4	0.000	1000000.000
71	Power Factor A	0,3	2	4	1000.000	0.100
72	Power Factor B	0,3	2	4	1000.000	0.100
73	Power Factor C	0,3	2	4	1000.000	0.100
74	Power Factor(3P)	0,3	2	4	1000.000	0.100
75	Act Energy Exp	0,3	1	3	1.000	Disabled
76	Act Energy Imp	0,3	1	3	1.000	Disabled
77	React Energy Exp	0,3	1	3	1.000	Disabled
78	React Energy Imp	0,3	1	3	1.000	Disabled
81	Thermal Status Ph A	0,1	4	4	100.000	1.000
82	Thermal Status Ph B	0,1	4	4	100.000	1.000
83	Thermal Status Ph C	0,1	4	4	100.000	1.000
95	Active Setting Group	0,3	2	4	1.000	1.000
99	Vab Secondary	0,3	2	4	10.000	1.000
100	Vbc Secondary	0,3	2	4	10.000	1.000
101	Vca Secondary	0,3	2	4	10.000	1.000

Analog InputsStatic (Steady-State) Object Number: **30**Change Event Object Number: **32**Analog Input Deadband: **34**Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input with Flag)**or **2 (16-Bit Analog Input with Flag)**or **3 (32-Bit Analog Input w/o Flag)**or **4 (16-Bit Analog Input w/o Flag)**or **5 (Single Precision, floating point Analog Input with Flag)**Change Event Variation reported when variation 0 requested: **1 (32-Bit Analog Change Event w/o Time)**or **2 (16-Bit Analog Input w/o Time)**or **3 (32-Bit Analog Input with Time)**or **4 (16-Bit Analog Input with Time)**or **5 (Single Precision, floating point Analog Input w/o Time)**or **7 (Single Precision, floating point Analog Input with Time)**Analog Input Reporting Deadband Variation reported when variation 0 requested: **1 (16-Bit)**or **2 (32-Bit)**or **3 (Single Precision, floating point)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 30	Default Variation Event Object 32	Default Multiplier	Default Deadband
102	Vn Primary	0,3	2	4	0.010	100.000
103	Vn Secondary	0,3	2	4	10.000	1.000
108	I Phase A Max	0,3	2	4	1.000	100.000
109	I Phase B Max	0,3	2	4	1.000	100.000
110	I Phase C Max	0,3	2	4	1.000	100.000
111	P 3P Max	0,3	2	4	0.000	1000000.000
112	Q 3P Max	0,3	2	4	0.000	1000000.000
135	CB Total Trip Count	0,3	1	3	1.000	1.000
136	CB Delta Trip Count	0,3	1	3	1.000	1.000
137	CB Count To AR Block	0,3	1	3	1.000	1.000
138	CB Frequent Ops Count	0,3	1	3	1.000	1.000
165	Ia Last Trip	0,3	1	3	1.000	Disabled
166	Ib Last Trip	0,3	1	3	1.000	Disabled
167	Ic Last Trip	0,3	1	3	1.000	Disabled
168	Va Last Trip	0,3	1	3	1.000	Disabled
169	Vb Last Trip	0,3	1	3	1.000	Disabled
170	Vc Last Trip	0,3	1	3	1.000	Disabled
171	In Last Trip	0,3	1	3	1.000	Disabled
172	Ig Last Trip	0,3	1	3	1.000	Disabled
174	V Phase A Max	0,3	2	4	0.010	100.000
175	V Phase B Max	0,3	2	4	0.010	100.000
176	V Phase C Max	0,3	2	4	0.010	100.000
177	V Phase AB Max	0,3	2	4	0.010	100.000
178	V Phase BC Max	0,3	2	4	0.010	100.000
179	V Phase CA Max	0,3	2	4	0.010	100.000
180	CB Ph A Trip Count	0,3	1	3	1.000	1.000
181	CB Ph B Trip Count	0,3	1	3	1.000	1.000
182	CB Ph C Trip Count	0,3	1	3	1.000	1.000
183	CB E/F Trip Count	0,3	1	3	1.000	1.000
184	CB Wear A	0,3	1	3	0.000	1000000.000
185	CB Wear B	0,3	1	3	0.000	1000000.000
186	CB Wear C	0,3	1	3	0.000	1000000.000
187	CB Wear A Remaining	0,3	1	3	1.000	1.000

Analog InputsStatic (Steady-State) Object Number: **30**Change Event Object Number: **32**Analog Input Deadband: **34**Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input with Flag)**or **2 (16-Bit Analog Input with Flag)**or **3 (32-Bit Analog Input w/o Flag)**or **4 (16-Bit Analog Input w/o Flag)**or **5 (Single Precision, floating point Analog Input with Flag)**Change Event Variation reported when variation 0 requested: **1 (32-Bit Analog Change Event w/o Time)**or **2 (16-Bit Analog Input w/o Time)**or **3 (32-Bit Analog Input with Time)**or **4 (16-Bit Analog Input with Time)**or **5 (Single Precision, floating point Analog Input w/o Time)**or **7 (Single Precision, floating point Analog Input with Time)**Analog Input Reporting Deadband Variation reported when variation 0 requested: **1 (16-Bit)**or **2 (32-Bit)**or **3 (Single Precision, floating point)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 30	Default Variation Event Object 32	Default Multiplier	Default Deadband
188	CB Wear B Remaining	0,3	1	3	1.000	1.000
189	CB Wear C Remaining	0,3	1	3	1.000	1.000
190	CB Wear Minimum	0,3	1	3	1.000	1.000
192	Freq Last Trip	0,3	5	7	1.000	1.000
196	Frequency Max	0,3	2	4	100.000	1.000
197	S 3P Max	0,3	2	4	0.000	1000000.000
330	CB Trip Time Meter	0,3	2	4	1000.000	0.010
338	Remote Ia Last Trip	0,3	1	3	1.000	Disabled
339	Remote Ib Last Trip	0,3	1	3	1.000	Disabled
340	Remote Ic Last Trip	0,3	1	3	1.000	Disabled
341	Remote In Last Trip	0,3	1	3	1.000	Disabled
342	Remote Ig Last Trip	0,3	1	3	1.000	Disabled
343	Op Ia Last Trip	0,3	1	3	1.000	Disabled
344	Op Ib Last Trip	0,3	1	3	1.000	Disabled
345	Op Ic Last Trip	0,3	1	3	1.000	Disabled
346	Res Ia Last Trip	0,3	1	3	1.000	Disabled
347	Res Ib Last Trip	0,3	1	3	1.000	Disabled
348	Res Ic Last Trip	0,3	1	3	1.000	Disabled
349	Remote Ia Primary	0,3	2	4	1.000	100.000
350	Remote Ib Primary	0,3	2	4	1.000	100.000
351	Remote Ic Primary	0,3	2	4	1.000	100.000
352	Remote Ia Secondary	0,3	2	4	100.000	0.100
353	Remote Ib Secondary	0,3	2	4	100.000	0.100
354	Remote Ic Secondary	0,3	2	4	100.000	0.100
355	Remote Ia Nominal	0,3	2	4	100.000	0.100
356	Remote Ib Nominal	0,3	2	4	100.000	0.100
357	Remote Ic Nominal	0,3	2	4	100.000	0.100
361	Remote In Primary	0,3	2	4	1.000	100.000
362	Remote In Secondary	0,3	2	4	100.000	0.100
363	Remote In Nominal	0,3	2	4	100.000	0.100
364	Remote Ig Primary	0,3	2	4	1.000	100.000
365	Remote Ig Secondary	0,3	2	4	1000.000	0.100
366	Remote Ig Nominal	0,3	2	4	1000.000	0.100
367	Line Ia	0,3	2	4	100.000	0.100

Analog InputsStatic (Steady-State) Object Number: **30**Change Event Object Number: **32**Analog Input Deadband: **34**Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input with Flag)**or **2 (16-Bit Analog Input with Flag)**or **3 (32-Bit Analog Input w/o Flag)**or **4 (16-Bit Analog Input w/o Flag)**or **5 (Single Precision, floating point Analog Input with Flag)**Change Event Variation reported when variation 0 requested: **1 (32-Bit Analog Change Event w/o Time)**or **2 (16-Bit Analog Input w/o Time)**or **3 (32-Bit Analog Input with Time)**or **4 (16-Bit Analog Input with Time)**or **5 (Single Precision, floating point Analog Input w/o Time)**or **7 (Single Precision, floating point Analog Input with Time)**Analog Input Reporting Deadband Variation reported when variation 0 requested: **1 (16-Bit)**or **2 (32-Bit)**or **3 (Single Precision, floating point)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 30	Default Variation Event Object 32	Default Multiplier	Default Deadband
368	Line Ib	0,3	2	4	100.000	0.100
369	Line Ic	0,3	2	4	100.000	0.100
370	Relay Ia	0,3	2	4	100.000	0.100
371	Relay Ib	0,3	2	4	100.000	0.100
372	Relay Ic	0,3	2	4	100.000	0.100
373	Remote Line Ia	0,3	2	4	100.000	0.100
374	Remote Line Ib	0,3	2	4	100.000	0.100
375	Remote Line Ic	0,3	2	4	100.000	0.100
376	Remote Relay Ia	0,3	2	4	100.000	0.100
377	Remote Relay Ib	0,3	2	4	100.000	0.100
378	Remote Relay Ic	0,3	2	4	100.000	0.100
379	Operate Ia	0,3	1	3	100.000	0.100
380	Operate Ib	0,3	1	3	100.000	0.100
381	Operate Ic	0,3	1	3	100.000	0.100
382	Restrain Ia	0,3	1	3	100.000	0.100
383	Restrain Ib	0,3	1	3	100.000	0.100
384	Restrain Ic	0,3	1	3	100.000	0.100

5.4 Additional Settings

The following relay settings are provided for configuration of the DNP 3.0 implementation when available and are common to all ports using this protocol.

Setting Name	Range/Options	Default	Setting	Notes
Unsolicited Mode	DISABLED, ENABLED	DISABLED	As Required	Setting is only visible when any port Protocol is set to DNP3.
Destination Address	0 - 65534	0	As Required	Setting is only visible when DNP3 Unsolicited Events set to Enabled.
DNP3 Application Timeout	5, 6 ... 299, 300	10s	As Required	Setting is only visible when any port

Setting Name	Range/Options	Default	Setting	Notes
				Protocol is set to DNP3.

6. Not Applicable

This section intentionally left blank.

7. IEC61850 Protocol Support

7.1 Introduction

The relay can optionally be provided with IEC61850 comms.

For further details refer to the following publications:

- Model Implementation Conformance Statement (MICS)
- Protocol Implementation Conformance Statement (PICS)
- Protocol Implementation Extra Information for Testing (PIXIT)

8. Serial Modems

8.1 Introduction

The communications interface has been designed to allow data transfer via modems. A suitable Modem can be connected directly to the Relay's serial interface, for example RS232, RS485 or fibre-optic port where fitted.

8.2 Connecting a Modem to the Relay(s)

RS232C defines devices as being either Data Terminal Equipment (DTE) e.g. computers, or data Communications Equipment (DCE), e.g. modems, where one is designed to be connected to the other.

The optional RS232 port of the Relay is wired as a DTE device and can therefore be connected directly to a Modem.

The 7XV5652 RS232 fibre-optic converter is wired as a DCE device, the same as a Modem. Where two DCE devices e.g. the modem and the fibre-optic converter are being connected together a null terminal connector is required which switches various control lines. The fibre-optic converter is then connected to the relay Network Tx to Relay Rx and Network Rx to Relay Tx.

8.3 Setting the Remote Modem

The exact settings of the modem are dependent on the type of modem. Although most modems support the basic Hayes "AT" command format, different manufacturers use different commands for the same functions. In addition, some modems use DIP switches to set parameters, others are entirely software configured.

Before applying settings, the modem's factory default settings should be applied, to ensure it is in a known state.

Several factors must be considered to allow remote dialling to the relays. The first is that the modem at the remote end must be configured as auto answer. This will allow it to initiate communications with the relays. Next, the user should set the data configuration at the local port, i.e. baud rate and parity, so that communication will be at the same rate and format as that set on the relay and the error correction is disabled.

Auto-answer usually requires two parameters to be set. The auto-answer setting should be switched on and the number of rings after which it will answer. The Data Terminal Ready (DTR) settings should be forced on. This tells the modem that the device connected to it is ready to receive data.

The parameters of the modem's RS232C port are set to match those set on the relay, set baud rate and parity to be the same as the settings on the relay and number of data bits to be 8 and stop bits 1. Note, although the device may be able to communicate with the modem at, for example, 19200 bps, the modem may only be able to transmit over the telephone lines at 14400 bps. Therefore, a baud rate setting on which the modem can transmit should be chosen. In the above example, a baud rate of 9600 should be chosen.

As the modems are required to be transparent, simply passing on the data sent from the controller to the device and vice versa, error correction and buffering is turned off.

Finally, the settings selected for configuration should be stored in the modem's memory for power on defaults.

8.4 Connecting to the Remote Modem

Once the remote modem has been configured correctly, it should be possible to make connection to the relay.

Where a "dial-up" modem system is installed the settings on the remote modem are fixed so the local modem should negotiate with it on connection, choosing suitable matching settings. Where this is not possible the local modem should be set with settings equivalent to those of the remote modem as described above.

9. Configuration

The data points and control features which are possible within the relay is fixed and can be transmitted over the communication channel(s) protocols in the default format described earlier in this document. The default data transmitted is not always directly compatible with the needs of the substation control system and will require some tailoring; this can be done by the user with the Reydisp software Communications Editor tool.

The Communications Editor is provided to allow its users to configure the Communication Protocol's Files in Reyrolle brand Relays manufactured by Siemens Protection Devices Limited (SPDL).

The editor supports configuring DNP3, IEC60870-5-103, IEC60870-5-101 and MODBUS protocols.

The editor allows configuration files to be retrieved from the relay, edited, and then uploaded back to the relay. Files may also be saved to and loaded from disc to work offline. The protocols will be stored in a Reyrolle Protection Device Comms file (RPDC), which will be stored locally, so that the editor can be used when the relay is not connected.

DNP3

The tool will allow:

- Data Points to be enabled or disabled.
- Changing the point numbers for the Binary Inputs, Double Bit Inputs, Binary Outputs, Counters and Analogue Inputs.
- Changing their assigned class and static and event variants.
- Specifying inclusion in a Class 0 poll.
- Setting Binary points to be inverted before transmission.
- Setting the Control Relay Output Block (CROB) commands that can be used with a Binary Output (Object 12).
- Specifying a dead-band outside which Analogue Events will be generated.
- Specifying a multiplier that will be applied to an analogue value before transmission.
- Configuring a Counter's respective Frozen Counter.

IEC60870-5-103

The tool will allow:

- Data Points to be enabled or disabled.
- Changing the point numbers Function Type (FUN) and Information (INF), returned by each point.
- Changing the text returned to Reydisp for display in its event viewer.

MODBUS

Note, as MODBUS points are polled they do not need to be enabled or disabled.

The tool will allow:

- Changing the Addresses for the Coils, Inputs and Registers.
- Changing the format of the instrument returned in a register, e.g. 16 or 32 bit.
- Specifying a multiplier that will be applied to an analogue value before transmission.

The user can check if the relay contains user configured communication files via a meter in the relay menus. Pressing the Enter and down arrow buttons on the fascia, then scrolling down, the number of files stored in the relay is displayed. The file name can also be viewed by pressing the Cancel and Test/Reset buttons together when in the relay Instruments menu. The user must ensure when naming the file, they use a unique file name including the version number.

Please refer to the Communications Editor User Guide for further guidance.

10. Glossary

Baud Rate

Data transmission speed.

Bit

The smallest measure of computer data.

Bits Per Second (bps)

Measurement of data transmission speed.

Data Bits

A number of bits containing the data. Sent after the start bit.

Data Echo

When connecting relays in an optical ring architecture, the data must be passed from one relay to the next, therefore when connecting in this method all relays must have the Data Echo ON.

EN100

Siemens' Ethernet communications module supporting IEC61850, available in optical and electrical versions.

Ethernet

A computer networking technology.

Full-Duplex Asynchronous Communications

Communications in two directions simultaneously.

Half-Duplex Asynchronous Communications

Communications in two directions, but only one at a time.

Hayes "AT"

Modem command set developed by Hayes Microcomputer products, Inc.

LAN

Local Area Network. A computer network covering a small geographic area.

LC

Fibre optic connector type designed by Lucent Technologies, Inc.

Line Idle

Determines when the device is not communicating if the idle state transmits light.

Modem

MODulator / DEModulator device for connecting computer equipment to a telephone line.

Parity

Method of error checking by counting the value of the bits in a sequence, and adding a parity bit to make the outcome, for example, even.

Parity Bit

Bit used for implementing parity checking. Sent after the data bits.

RS232C

Serial Communications Standard. Electronic Industries Association Recommended Standard Number 232, Revision C.

RS485

Serial Communications Standard. Electronic Industries Association Recommended Standard Number 485.

Start Bit

Bit (logical 0) sent to signify the start of a byte during data transmission.

Stop Bit

Bit (logical 1) sent to signify the end.

USB

Universal Serial Bus standard for the transfer of data.

WAN

Wide Area Network. A computer network covering a large geographic area.

Appendix 1

The operating mode of the device is set via the setting, or through a command sent to a communications port. There are four options; **Local**, **Remote**, **Local or Remote** and **Service**.

The following table illustrates whether a function is Enabled (✓) or Disabled (✗) in each mode.

Function	Operation Mode		
	Local	Remote	Service
Control			
Com1	✓ when Com1-Mode = Local	✓ when Com1-Mode = Remote	✗
Com2 (USB)	✓ when Com2-Mode = Local	✓ when Com2-Mode = Remote	✗
Fascia (Control Mode)	✓	✗	✗
Function Key (n)	✓	✓ when F Key(n) Mode = Remote	✗
Binary Input (n)	✓ when BI (n) Mode = Local	✓ when BI (n) Mode = Remote	✓
Binary Outputs	✓	✓	✗
Reporting			
Spontaneous			
IEC	✓	✓	✗
DNP3	✓	✓	✗
General Interrogation			
IEC	✓	✓	✗
DNP3	✓	✓	✗
MODBUS	✓	✓	✓
Change Settings			
Com1	✓ when Com1-Mode = Local	✓ when Com1-Mode = Remote	✓
Com2 (USB)	✓ when Com2-Mode = Local	✓ when Com2-Mode = Remote	✓
Fascia	✓	✓	✓
Historical Information			
Waveform Records	✓	✓	✓
Event Records	✓	✓	✓
Fault Information	✓	✓	✓
Setting Information	✓	✓	✓

Fig. A1 Operating Mode Table

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7SR18 Line Differential Protection Commissioning and Maintenance Guide

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Section 1: Common Functions

1.1 OVERVIEW

Commissioning tests are carried out to prove: -

- a) Equipment has not been damaged in transit.
- b) Equipment has been correctly connected and installed.
- c) Characteristics of the protection and settings which are based on calculations.
- d) Confirm that settings have been correctly applied.
- e) To obtain a set of test results for future reference.

1.2 BEFORE TESTING

1.2.1 SAFETY

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 and also the associated primary plant.

The integrity of any protective conductor connection shall be checked before carrying out any other actions.

The equipment ratings, operating instructions and installation instructions shall be checked before commissioning or maintenance.

Ensure that all test equipment and leads have been correctly maintained and are in good condition. It is recommended that all power supplies to test equipment be connected via a Residual Current Device (RCD), which should be located as close to the supply source as possible.

The choice of test instrument and test leads must be appropriate to the application. Fused instrument leads should be used when measurements of power sources are involved, since the selection of an inappropriate range on a multi-range instrument could lead to a dangerous flashover. Fused test leads should not be used where the measurement of a current transformer (CT) secondary current is involved, the failure of an instrument fuse or the operation of an instrument cut-out could cause the secondary winding of the CT to become an open circuit.

Open circuit secondary windings on energised current transformers are a hazard that can produce high voltages dangerous to personnel and damaging to equipment, test procedures must be devised so as to eliminate this risk.

1.2.2 SEQUENCE OF TESTS

If other equipment is to be tested at the same time, then such testing must be co-ordinated to avoid danger to personnel and equipment.

When cabling and wiring is complete, a comprehensive check of all terminations for tightness and compliance with the approved diagrams must be carried out. This can then be followed by the insulation resistance tests, which if satisfactory allows the wiring to be energised by either the appropriate supply or test supplies.

When primary injection tests are completed satisfactorily, all remaining systems can be functionally tested before the primary circuit is energised. Some circuits may require further tests before being put on load.

Protection relay testing will require access to the protection system wiring diagrams; relay configuration information and protection settings. The following sequence of tests is loosely based on the arrangement of the relay menu structure. A test log based on the actual tests completed should be recorded for each relay tested.

The 'Description of Operation' section of this manual provides detailed information regarding the operation of each function of the relay. All functions are not available in all devices; please refer to the 'Description of Operation' section of the technical manual to establish your function set.

1.2.3 TEST EQUIPMENT

Required test equipment is: -

1. Secondary injection equipment with integral time interval meter
2. Primary injection equipment
3. A power source with nominal voltage within the working range of the relay's auxiliary supply rating.
4. A power source with nominal voltage within the working range of the relay's binary input rating.
5. Other equipment as appropriate to the protection being commissioned – this will be specified in the product specific documentation.

The secondary injection equipment should be appropriate to the protection functions to be tested. Additional equipment for general tests and for testing the communications channel is: -

6. Portable PC with appropriate interface equipment.
7. Printer to operate from the above PC (Optional).

1.2.4 USE OF PC TO FACILITATE TESTING

The functions of Reydisp Evolution (see Settings Guide and Instruments Guide sections of the manual) can be used during the commissioning tests to assist with test procedures or to provide documentation recording the test and test parameters. One method is to clear both the waveform and event records before each test is started, then following the test; upload from the relay the settings, events and waveform files generated as a result of application of the test. These can then be saved off to retain a comprehensive record of that test.

Relay settings files can be prepared on the PC (offline) or on the relay before testing commences. These settings should be saved for reference and compared with the settings at the end of testing to check that errors have not been introduced during testing and that any temporary changes to settings to suit the test process are returned to the required service state.

A copy of the Relay Settings as a Rich Text Format (.rtf) file suitable for printing or for record purposes can be produced from Reydisp as follows. From the *File* menu select *Save As*, change the file type to *Export Default/Actual Setting (.RTF)* and input a suitable filename.

When testing is completed the event and waveform records should be cleared and the settings file checked to ensure that the required in-service settings are being applied.

1.2.5 PRECAUTIONS

Before electrical testing commences the equipment should be isolated from the current and voltage transformers. The current transformers should be short-circuited in line with the local site procedure. The tripping and alarm circuits should also be isolated where practical. The provision and use of secondary injection test sockets on the panel simplifies the isolation and test procedure.

Ensure that the correct auxiliary supply voltage and polarity is applied. See the relevant scheme diagrams for the relay connections.

Check that the nominal secondary current rating of the current and voltage transformers has been correctly set in the System Config. menu of the relay.

1.2.6 APPLYING SETTINGS

The relay settings for the particular application should be applied before any secondary testing occurs. If they are not available then the relay has default settings that can be used for pre-commissioning tests. See the Relay Settings section of this manual for the default settings.

Note that the tripping and alarm contacts for any function must be programmed correctly before any scheme tests are carried out.

Relays feature multiple settings groups, only one of which is active at a time. In applications where more than one settings group is to be used it may be necessary to test the relay in more than one configuration.

Note. One group may be used as a 'Test' group to hold test-only settings that can be used for regular maintenance testing, eliminating the need for the Test Engineer to interfere with the actual in-service settings in the normally active group. This Test group may also be used for functional testing where it is necessary to disable or change settings to facilitate testing.

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. 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 altered. This allows the settings in one 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 'System Configuration 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 System Config Menu.

After applying a settings change to the relay, which may involve a change to the indication and output contacts, the **TEST/RESET** key should be pressed to ensure any existing indication and output is correctly cleared.

1.2.7 TESTS

1.2.8 INSPECTION

Ensure that all connections are tight and correct to the relay wiring diagram and the scheme diagram. Record any deviations. Check that the relay is correctly programmed and that it is fully inserted into the case; refer to the Settings Guide and Instrumentation Guide sections of the technical manual for information on programming the relay.

1.2.9 SECONDARY INJECTION TESTS

Select the required relay configuration and settings for the application.

Isolate the auxiliary D.C. supplies for alarm and tripping from the relay and remove the trip and inter-trip links.

Carry out injection tests for each relay function, as described in this document.

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.

1.2.10 PRIMARY INJECTION TESTS

Primary injection tests are essential to check the ratio and polarity of the transformers as well as the secondary wiring.

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.

1.2.11 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 m.c.b.

Ensure the Protection Healthy LED is on, steady, and that all LED indications are correct. If necessary press **CANCEL** until the Relay Identifier screen is displayed, then press **TEST/RESET** 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 printout 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 Evolution using the *Compare Settings Groups* function in the *Edit* menu. Any modified settings will be clearly highlighted.

1.2.12 AC ANALOGUE ENERGISING QUANTITIES

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 Performance Specification.

	Applied Current.....				
	I _A	I _B	I _C	I _G	Tol
Secondary					
Primary					

Apply 3 phase balanced Current and Voltage at nominal levels and ensure that the measured Zero Phase Sequence and Negative Phase Sequence quantities are approximately zero.

	ZPS	NPS
Current		

1.2.13 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 as set as part of the Scheme Operation tests.

Where the pick-up timers associated with a binary input are set for DC operation, these delays should be checked either as part of the scheme logic or individually. To check a binary pick-up time delay, temporarily map the binary input to an output relay that has a normally open contact. This can be achieved in the Output Matrix sub-menu by utilising the *BI n Operated* settings. Use an external timer to measure the interval between binary input energisation 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-energisation and closure of the output contacts.

For AC operation of binary inputs, these timers are used to ensure correct operation from AC voltage and if a delayed pickup is required this must be provided by additional Quick logic configuration. An example is shown in the Applications Guide.

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	D.O. Delay	Measured	P.U. Delay	Measured	Notes (method of initiation)
1						
2						
3						
4						
5						
6						

1.2.14 BINARY OUTPUTS

A minimum of five output relays are provided. Two of these have change over contacts, BO1 & BO2 and 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 energisation can cause contact failure due to exceeding the break capacity when connected to inductive load such as electrically reset trip relays.

Close each output relay in turn from the Reydisp Evolution PC programme, Relay – Control - Close output relay. This function will energise the output for its' minimum operate time. This time is specified in the Output Config - Binary Output Config menu for each output relay and may be too short to measure with a continuity tester.

An alternative method of energising 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 energised the mapped relay will be held energised, normally open contacts will be closed and vice versa.

BO	Checked	Notes (method of test)
1NO		
1NC		
2NO		
2NC		
3NO		
4NO		
5NO		
6NO		
7NO		
8NO		

1.2.15 RELAY CASE SHORTING CONTACTS

CT input terminals and the terminals of normally closed contacts of BO1 & BO2 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.

CT Shorting contacts checked	
Binary Output 1 terminals A1 & A2 Alarm Checked	
Binary Output 2 terminals A5 & A6 Alarm Checked	

Section 2: Protection Functions

This section details the procedures for testing each protection function of the relay. They are carried out to verify the accuracy of the protection pick-ups and time delays at setting and to confirm correct operation of any associated input and output functionality.

The exact model type must be checked to confirm the functions available in each type.

Guidance for calculating test input quantities is given in the relevant test description where required. In many cases it may be necessary to disable some functions during the testing of other functions; this prevents any ambiguity caused by the operation of multiple functions from one set 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.

The matrix below indicates functions where function conflicts may occur during testing, consideration should be given to disabling functions to avoid interference.

Function Under Test	Phase Overcurrent	Cold Load	Derived E/F	Measured E/F	NPS Overcurrent	Undercurrent	Thermal	CB Fail	CT supervision	Broken Conductor	Trip cct Supervision	Inrush Detector
Phase Overcurrent		O			O	O	O	O		O		
Cold Load	O				O	O	O	O		O		
Derived E/F				O	O	O	O	O	O	O		
Measured E/F			O		O	O	O					
NPS Overcurrent	O	O				O	O	O	O			
Undercurrent			O	O	O							
Thermal	O	O						O				
CB Fail	O	O	O	O	O		O					
CT supervision			O							O		
Broken Conductor			O		O	O			O			
Trip cct Supervision												
Inrush Detector												

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.

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. 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.

2.1 BIASED DIFFERENTIAL (87BD, 87HS)

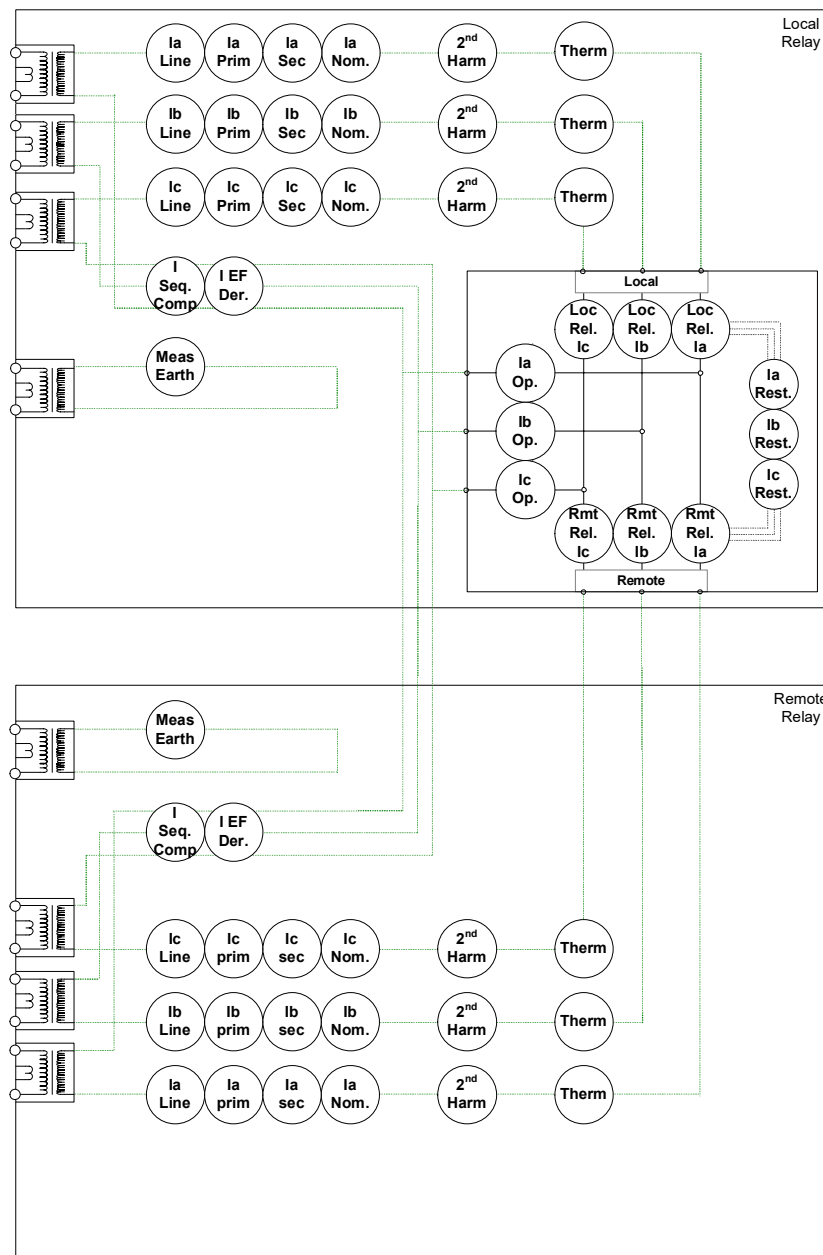


Figure 2.1-1 Biased Differential

Current Inputs:	I _A , I _B , I _C ,
Disable:	46, 49, 50, 51, 50N, 51N, 50BF,
Map Pickup LED:	87BD, 87HS - Self Reset

The differential elements are subjected to CT multipliers, Vector Group Compensation and Zero Sequence filters when applied to power transformers. The complexity of these features can cause confusion during testing and lead to incorrect relay settings being applied. It is recommended that the accuracy of the differential elements are tested by secondary injection with simplified differential settings applied to avoid ambiguity before reinstating the required site settings which can be tested more thoroughly by primary injection followed by final checking with the protected transformer on load.

2.2 SECONDARY INJECTION TESTING

It is important that relay elements are tested individually, as spurious results may be recorded if more than one element operates from an injection. Some functional elements may need to be set to 'Disabled' others may require pick-up and time delay settings to be increased, thus avoiding simultaneous operation of relay functions.

2.3 CURRENT DIFFERENTIAL

It is only necessary to test the relay operation at the settings to be used. Apply the settings to the relay in accordance to the requirements for the circuit and scheme.

The differential elements can be tested for accuracy of current magnitude comparison with the relays in three different configurations: -

- a) Normal - with healthy communications between relays.
- b) Loop Test Mode – Single relay test without communications.
- c) Line Test Mode – Single relay test with communications.

The relays at both ends of the feeder should be tested using one and the same of these modes at any particular time. The injection will test the relay accuracy at the differential setting (I_s). The differential pick-up level should be approximately the Phase Fault differential setting applied to the relays. The results should be recorded e.g. in the Sample Test Record, see below.

Current Input	P/F differential Setting	Measured Pick-up	*Pick-up Error($\pm 10\%$ of 100 % Max)	Measured Reset	Reset ($\geq 95\%$ of pick-up)
Phase A					
Phase B					
Phase C					

a) Normal Connection

This test requires both relays to be powered up, settings applied and a healthy communications channel between them. Inject single-phase or three-phase current into the current inputs of each relay in turn. Slowly increase the current until the TRIP LED operates and record the pick-up current. The remote relay will also operate on current differential as the relay can operate for a single end fed fault. Reduce the current and record the drop-off level.

Check that all pick-up current levels are measured within $100\% \pm 10\%$ for 1 A rated inputs, and $100\% \pm 15\%$ for 5 A rated inputs, of the applied setting. Check that the reset levels are $\geq 95\%$ of the measured pick-up value.

The stability of the differential protection system can only be checked when primary load current is applied, refer to Section 2.8.

b) Loop Test Mode

A single relay can be tested on its own in this mode. To select this mode, press the [Down] arrow button on the relay until the PROT'N COMMS appears, then press [Right] arrow button on the relay until the PROTECTION COMMS appears, then press the [Down] arrows until Prot'n Test Mode appears. Press [Enter] and then use [Up] / [Down] arrows to select 'Loop Test' and press [ENTER] to confirm.

The relay can be tested by connecting a single fibre optic between the Tx to the Rx ports on the same relay. In this mode, the relay will test as a single end relay, as the received signal is ignored. Inject Current as described above and record the pick-up and drop-off values of current. Using this method it is only possible to check the P/F Differential Setting and perform a local end trip test.

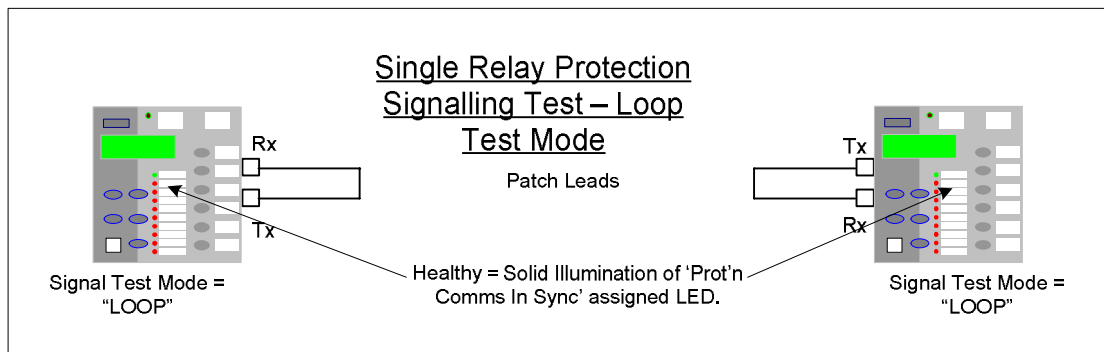


Figure 2.3-1 Loop Test Mode

c) Line Test Mode

If the communications path exists and both relays are capable of being powered up, this method may be used. The communications channel can be checked by assigning a LED to the 'Prot'n Comms In Sync' signal in the Output Matrix. It will remain illuminated if it is in a healthy state. If an end to end communications problem exists, the LED will extinguish.

Connect relays at either end to the communications channel.

Set the relay required to be tested into 'Line Test' mode, via the PROT'N COMMS menu. Only one relay must be put in 'Line Test' mode at a time as this enables a complete test of the signal path from one end of the feeder.

To select this mode, press the [Down] arrow button on the relay until the PROT'N COMMS appears, then press [Right] arrow button on the relay until the PROTECTION COMMS appears, then press the [Down] arrows until Prot'n Test Mode appears. Press [Enter] and then use [Up] / [Down] arrows to select 'Line Test' and press [ENTER] to confirm.

The relay in 'Line Test' mode can now be tested as in the 'Loop Test' mode i.e. injection will simulate a single end fed fault. The pickup and drop-off accuracy of the differential elements of the relay in 'Line Test' can be performed in a similar way to the 'Loop Test' above. Only the relay injected will operate for that level.

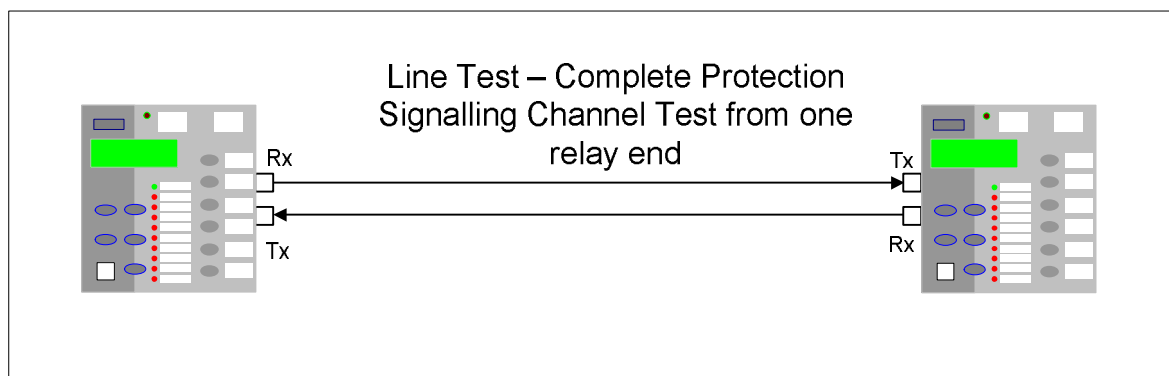


Figure 2.3-2 Line Test Mode

Secondary testing of the bias characteristic will be greatly simplified by the use of automated numeric protection test equipment such as the Omicron CMC256. This equipment can be programmed using settings which match those of the relay, to test for accuracy over the whole operating range and give a clear easy to use graphical display of relay performance against the specified characteristic.

During manual testing the Operate and Restrain currents can be monitored on the relay in the Differential Meters in the Instruments menu.

For manual testing, the bias slope is usually checked for Restrain current up to 250 % of nominal current. For testing above this level the continuous current rating of the relay inputs is likely to be exceeded, equipment or test procedure should be arranged in such a way that the short term thermal withstand of the relay current inputs is not exceeded during testing.

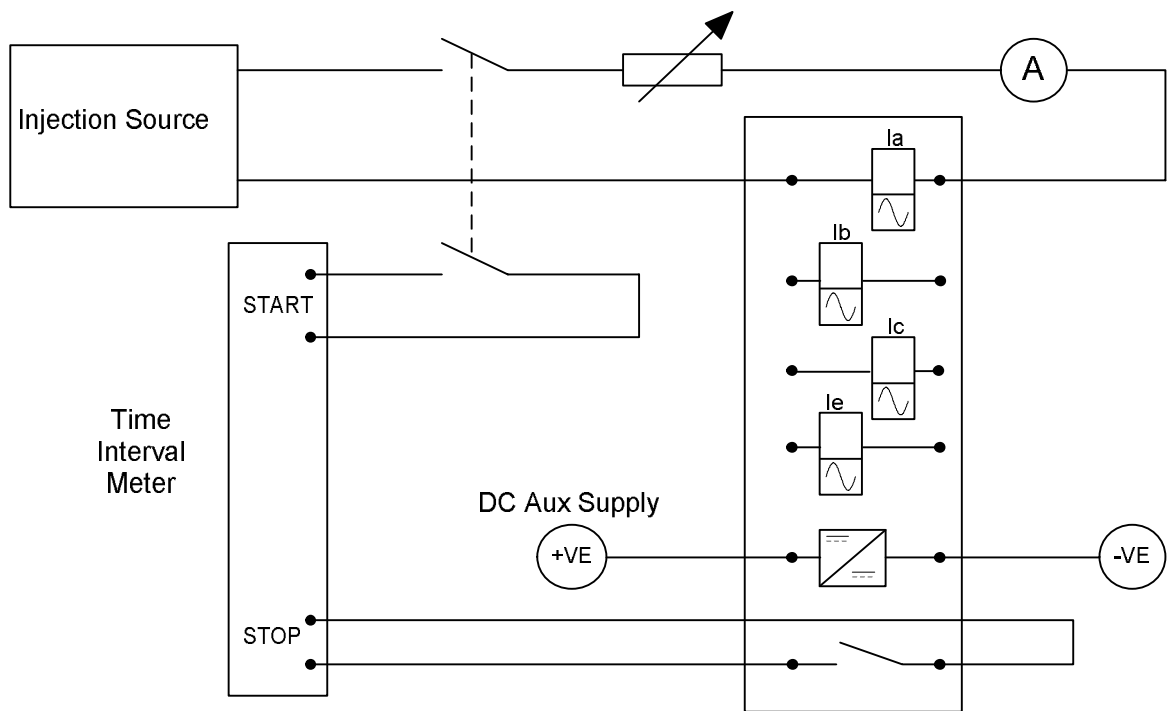


Figure 2.3-3 Secondary Injection

2.4 TYPICAL RESULTS FOR TESTING 87BD

87BD INITIAL SETTING	87BD 1ST BIAS SLOPE SETTING	BIAS CURRENT ($\times I_n$) MEASURED ON AMMETER A1				
		0.00	1.00	1.50	2.00	2.50
		Operate Current Measured on Ammeter A2				
0.10	0.10	0.10	0.11	0.16	0.21	0.26
0.20	0.20	0.20	0.22	0.33	0.44	0.56
0.30	0.30	0.30	0.35	0.53	0.71	0.88
0.40	0.40	0.40	0.50	0.75	1.00	1.25
0.50	0.50	0.50	0.67	1.00	1.33	1.67
0.50	0.60	0.50	0.86	1.29	1.71	2.14
0.50	0.70	0.50	1.08	1.62	2.15	2.69
Selected Settings		Test Results				
		0.00	1.00	1.50	2.00	2.50
Phase A Pickup						
Phase B Pickup						
Phase C Pickup						

2.5 DIFFERENTIAL HIGHSET 87HS

Differential Highset can be tested by single-phase secondary current injection. These settings will usually be higher than the continuous thermal rating of the relay current inputs and equipment or test procedure should be arranged in such a way that the short-term thermal withstand of the relay current inputs is not exceeded during testing. 50 % of relay setting current can be injected into each relay simultaneously to achieve a differential current level of 100 % if test current is limited by test equipment capacity.

During testing the Operate current can be monitored on the relay in the Instruments menu.

2.6 PRIMARY INJECTION TESTS

Primary injection tests are to check the ratio and polarity of the current transformers as well as the secondary wiring. Alternatively 'On-Load' tests may be conducted to speed up test procedure.

Use the circuit shown in Figure 2.6-1 to check the current transformer ratio and the phase to earth connections. Inject a current of sufficient magnitude for the relay ammeters to display. These values should be compared with the ammeters connected in series with the relay.

The secondary current is: $I_s = \frac{\text{Primary current}}{\text{C.T. ratio}}$

Use the circuit shown in Figure 2.6-2 to check the current transformer ratio and the phase to phase connections.

Record the results: -

Phase Injected	Primary Current	Secondary Current			
		A	B	C	N
A-B				Nil	Nil
B-C		Nil			Nil
B-E		Nil		Nil	

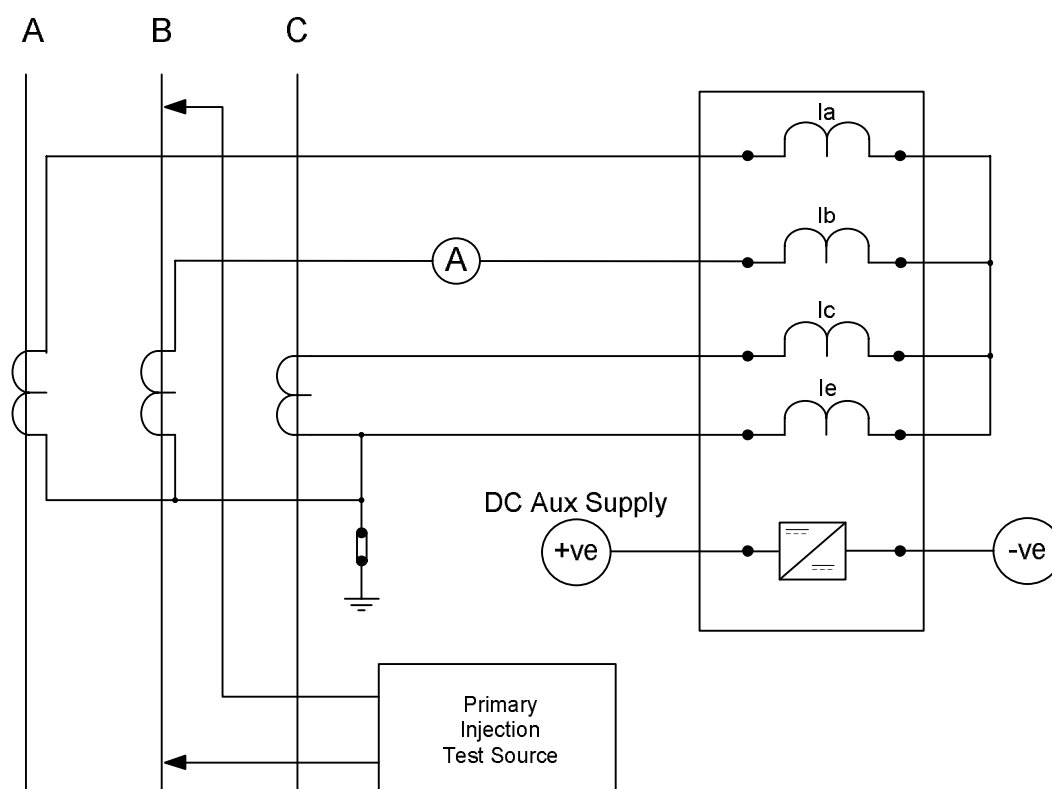


Figure 2.6-1 Primary Injection Phase to Earth

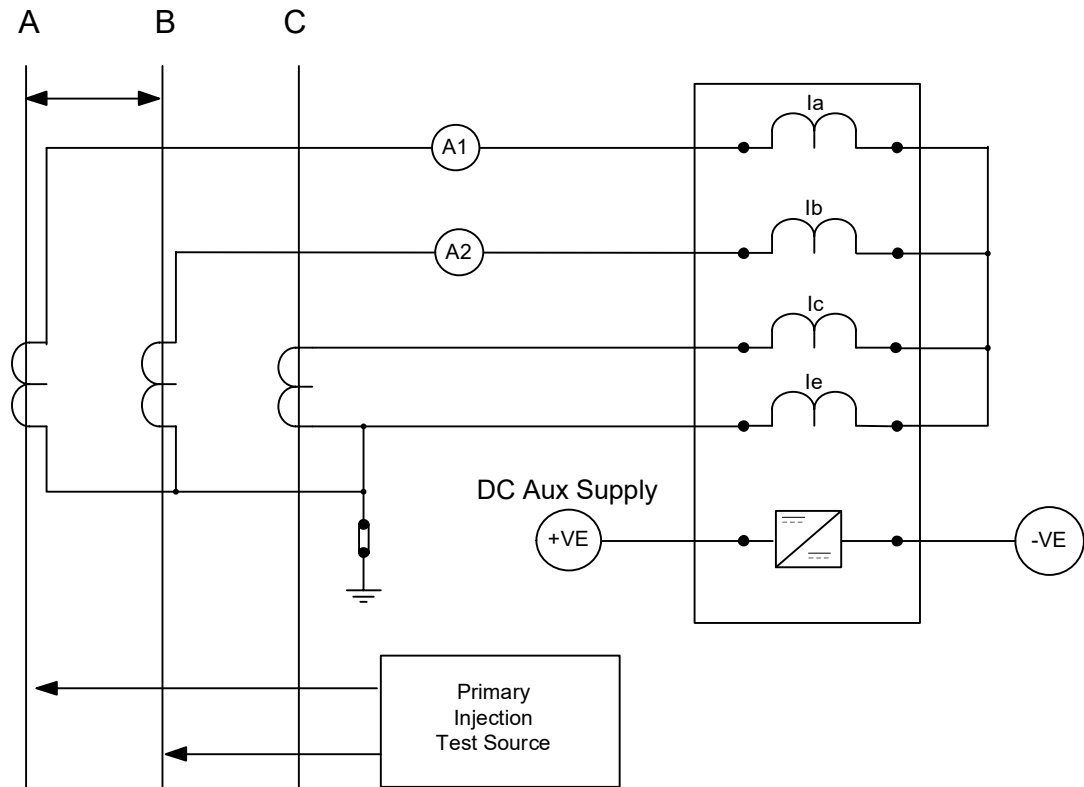


Figure 2.6-2 Primary Injection Phase to Phase

2.7 END TO END SIGNALLING

Healthy Protection Signalling Communication is required end-to-end for the differential feature to operate correctly. Protection Signalling Communication failure between relays can be programmed to provide indication via binary output contact or illuminate an LED on the fascia utilising 'Prot'n Comms Alarm' in the output matrix. The SIGNAL HEALTHY LED of both relays should be checked, as they are independent of each other.

2.8 ON-LOAD TESTS

The directional feature can be tested using load current. The test undertaken (Test 1 or Test 2) is depending upon the level of load current flowing in the feeder at the time of the test. The level of load current can be checked via the restraint current measurement in the Instruments mode. The levels of load, restraint and differential currents should be recorded. One of the following tests should be performed to test the directional capability. Which of these two tests to do, will depend upon the restraint (feeder load) current flowing at the time of the test: -

- (i) **Test 1** - If restraint current is greater than the P/F Differential Setting /2
- (ii) **Test 2** - If the load current is less than P/F Differential Setting /2

The test procedure is as follows: -

Close both circuit breakers at either end of the feeder to permit load current to flow. Both relays should be stable and the "Signal Healthy" LED on both relays should be permanently illuminated, i.e. not flashing.

Test 1 – Where Load Current is High

This test applies when the load current is high enough to ensure that the restraint current is higher than half of "P/F Differential" setting. The restraint current is the average of the load current measured at each end. Since these two values are normally the same (e.g. unless there are significant values of in-zone capacitance current or load current of a small auxiliary power transformer in the protected zone), then the restraint current will equal the load current.

The load current at the local end and the remote end can both be read from either relay using the Instrument display. This allows the restraint current to be established.

With the relays connected normally and load current flowing the relay should be stable and minimum differential current displayed on the instruments.

Reversing the CT connections will cause the relays to become unstable and they will issue a trip signal. High levels of differential current can be observed on the instruments.

- The "Phase Reversal" setting in the relay's "CT/VT Config" setting menu is employed to swing the current vector on one relay by 180°.
- Use the [ENTER], [↓] and [↑] pushbuttons or Reydisp Evolution to change the "Phase Reversal" setting from "Disabled" to "Enabled".

Note: When the [ENTER] pushbutton is pressed to initiate the Phase reversal of 180°, the trip output will be initiated immediately! Phase reversal can then be turned back to the Disabled setting.

P/F Differential Setting (Secondary A)	
Restraint Current (Secondary A)	
Phase Reversal – Disabled	No trip – Yes/No
*Phase Reversal – Enabled	Relay Trip – Yes/No
Phase Reversal – Disabled	Relay Reset – Yes/No
Waveform record obtained	Yes/No

Directional test results with feeder load current > P/f Bias Setting /2

*Note, for correct operation, when the Phase Reversal is activated both relays operate.

Often this test is conducted to operate the trip relay only, without tripping the feeder, by removal of the CB Trip - Fuse and Link. For this test, the relay will be in permanent trip state. The relay does not accept setting changes when in the tripped state, as the relay trip operation takes priority over implementing setting changes. To revert the relay to its normal state, change the Phase Reversal setting(s) to normal and select "Update Changed Setting" in the Relay Menu of Reydisp Evolution. Then remove the relay supply by extracting either its supply fuse or link, to power the relay down. Immediately after the LCD powers down, power the relay up by re-inserting the fuse or link. The setting change will then be implemented to and the Phase Reversal removed (set to Disabled) to allow the relay to reset.

Test 2 – Where Load Current is Low

This test applies when the restraint current is below the P/F differential settings /2.

The connections are correct if the relay indicates an increase in differential current when the Phase Reversal applied to one relay only. The Phase Reversal Setting is found in the CT/VT Config Menu. In this state, the differential current should be approximately double the restraint current. The differential current should increase significantly when Phase Reversal is implemented. Check the differential and restraint currents for all three phases.

The Phase Reversal is implemented as described in Test No 1 above. The Phase Reversal should then be de-selected.

P/F Differential Setting (Secondary A)	
Restraint Current (Secondary A)	
Phase Reversal – Disabled	No trip – Yes/No
*Phase Reversal – Enabled	Relay Trip – Yes/No
Phase Reversal – Disabled	Relay Reset – Yes/No
Waveform record obtained (e.g. from status input initiation)	Yes/No

Comparator tests with feeder load current < P/F Bias Setting/2.

If load current levels measured by the relay are very low then settings may have to be altered to allow the increase in differential currents to be registered, when the Phase Reversal is applied.

P/F Differential Setting Selected	Secondary Current Required to activate Phase Reversal	
	Relay 1 Ampere Rated Inputs used (mA)	Relay 5 Ampere Rated Inputs used (mA)
0.10 x I _n		
0.15 x I _n		
0.20 x I _n		
0.25 x I _n		
0.30 x I _n		
0.35 x I _n		
0.40 x I _n		
0.45 x I _n		
0.50 x I _n		

If load levels are very low set both relays to the minimum P/F Differential of $0.1 \times I_n$. As indicated above the minimum levels are 13 mA for 1 A and 60 mA for 5 A terminals. If 5 A CT's are used and the secondary current is below 60 mA, the check for an increase in differential current may be carried out by temporarily connecting the 5 A CT wiring to the 1 A relay input terminals.

Test Waveform Records

The Reydisp Evolution software program can be employed to trigger waveform storage to provide a record of these tests. A snapshot of the load current can be taken for both of the above tests and in the case of Test No 1 the trip record can also be taken.

Waveform storage can be triggered either by the trip initiation (i.e. Test No 1) or by energising a status input which has been programmed to trigger a waveform record (i.e. Test No 2). These records can be used as part of the protection commissioning report for the relay under test.

Section 3: Putting Into Service

After tests have been performed satisfactorily the relay should be put back into service as follows:

Remove all test connections.

Where possible, the relay settings should be down-loaded to a computer and a printout of the settings produced. This should then be compared against the required settings. The Reydisp Evolution Software can compare settings files automatically. To do this open the two settings files for comparison and select [Relay] [Compare Settings]. Select one file to compare to the other and select [Compare]. Differences are highlighted in colour.

It is important that the correct settings group is active if more than one group has been programmed.

Replace all fuses and links.

3.1 PHASE OVERCURRENT (50, 51)

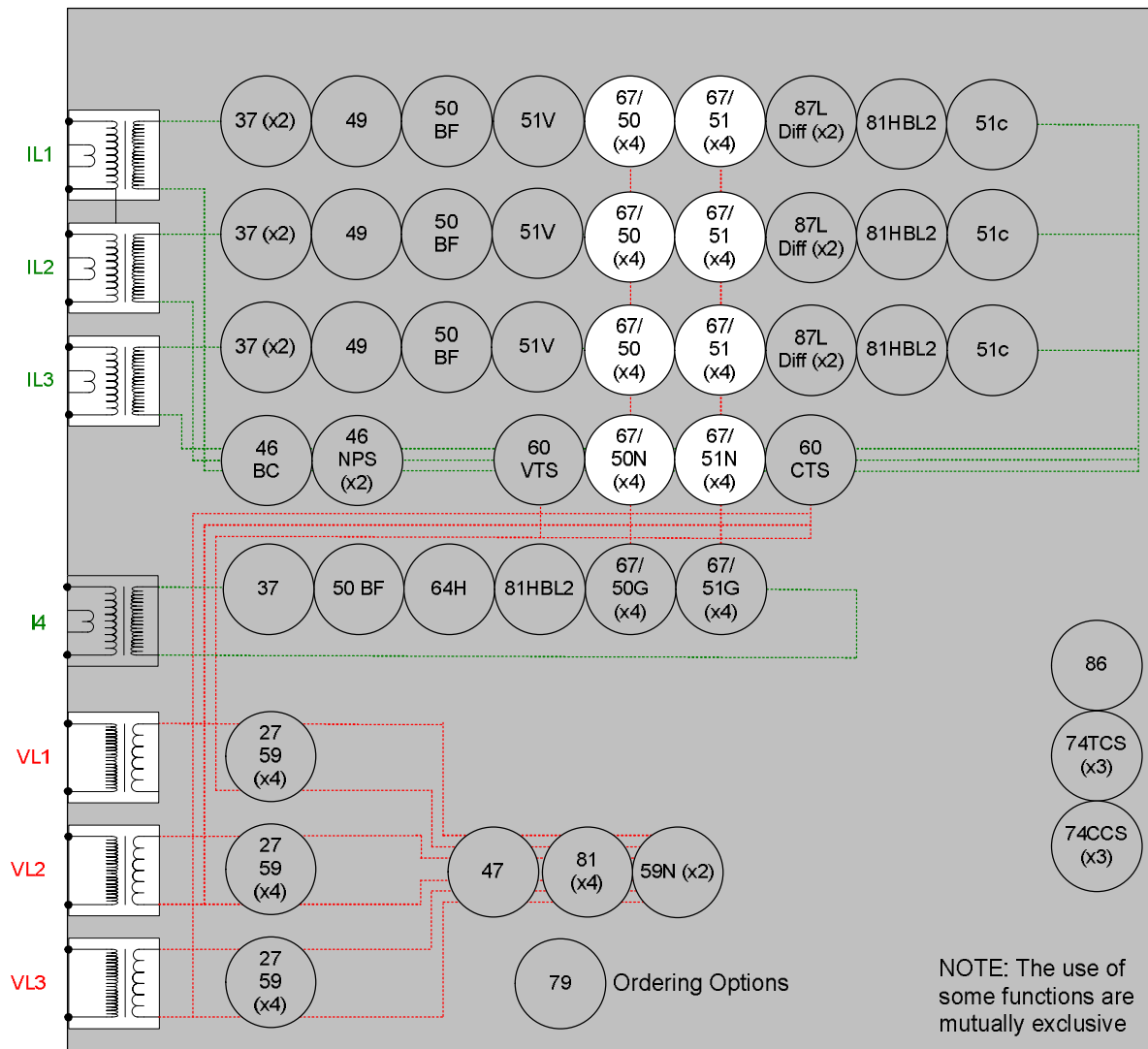


Figure 3.1-1 Phase Overcurrent

Current Inputs: I_{L1} (I_A), I_{L2} (I_B), I_{L3} (I_C),
 Disable: 51C, 46, 49, 50CBF
 Map Pickup LED: 51-n/50-n - Self Reset

Other 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.

Particular care should be taken when testing overcurrent functions that the thermal rating of the current inputs is not exceeded.

3.2 DEFINITE TIME OVERCURRENT (50)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9x setting, check for no operation, apply 1.1x setting, check operation

Apply 2x setting current if possible and record operating time

Phase	Dir.	Is (A)	DTL (s)	P.U. Current (A)	Tol	Operate Time 2 x Is	Tol
I _{L1} (I _A)							
I _{L2} (I _B)							
I _{L3} (I _C)							

Check correct indication, trip output, alarm contacts, waveform record.

3.3 INVERSE TIME OVERCURRENT (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 Pick-up led to operate for the function.

Gradually increase current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x 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.

P.U. D.O. & TIMING TESTS	Ph.	Dir	Char. Curve	Is (A)	TM	Operate Current			Operate Time		
						P.U. (A)	D.O. (A)	Tol	2 x Is (s)	5 x Is (s)	Tol
	I _{L1} (I _A)										
	I _{L2} (I _B)										
	I _{L3} (I _C)										

Calculated Timing values in seconds for TM =1.0

Curve	2 x Is	5 x Is
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.

3.3.1 ELEMENT BLOCKING

The Phase Overcurrent elements can be blocked by Binary Input Inhibit and Inrush Detector operation. The Characteristic can be modified by Cold Load (51-n only). This functionality should be checked.

Element	BI Inhibits	Inrush Detector
51-1		
51-2		
50-1		
50-2		

3.3.2 ANSI RESET

If the element is configured as an ANSI characteristic, it may have an ANSI (decaying) reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 (seconds)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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.

3.3.3 IEC RESET

If the element is configured as an IEC characteristic, it may have an IEC (decaying) reset delay applied. If IEC reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 (seconds)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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.

3.4 COLD LOAD (51C)

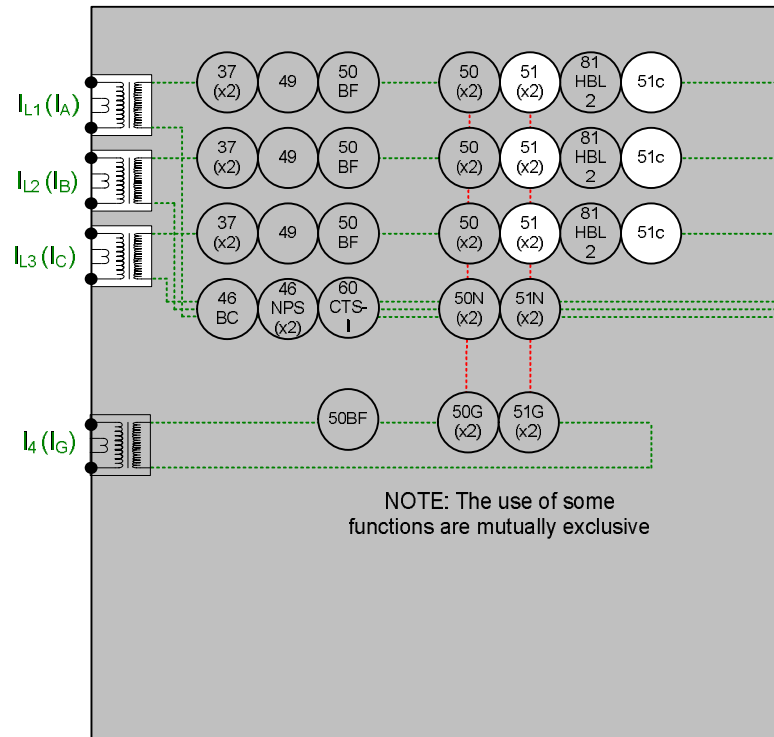


Figure 3.4-1 Cold Load

Current Inputs:	I_{L1} (I_A), I_{L2} (I_B), I_{L3} (I_C),
Disable:	46, 49, 50CBF
Map Pickup LED:	51-n - Self Reset

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.

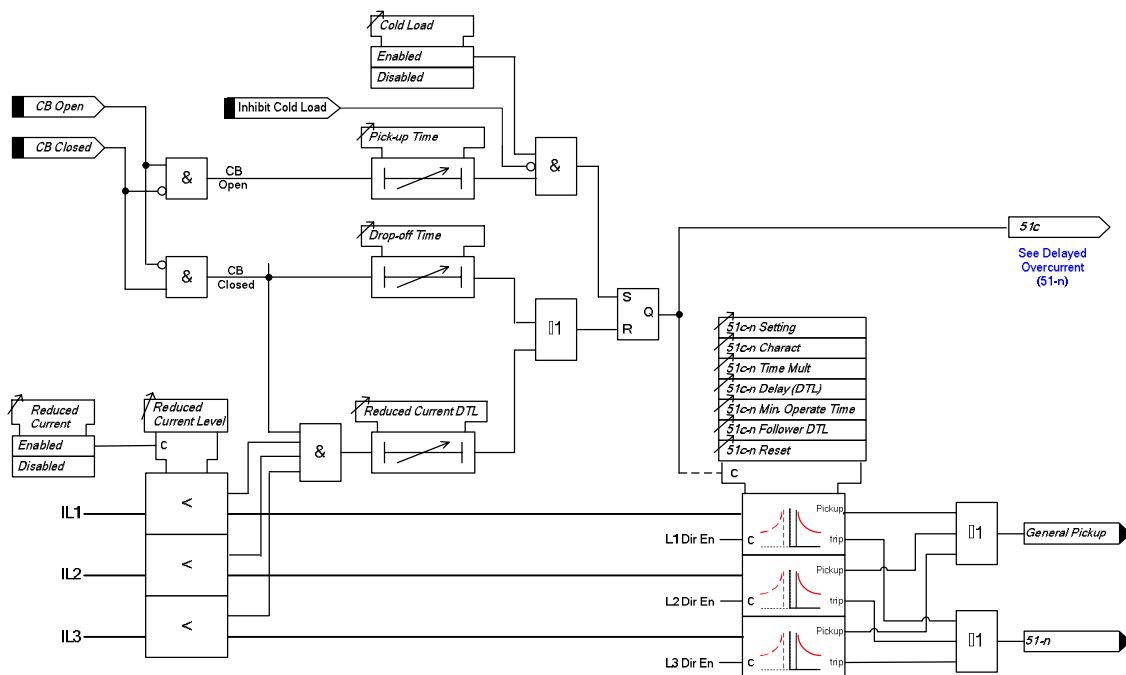


Figure 3.4-2 Cold Load Logic diagram

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.

3.4.1 INVERSE TIME OVERCURRENT (51C)

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 Pick-up led to operate for the function.

Gradually increase current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x 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)	Is (A)	TM	Operate Current			Operate Time		
						P.U. (A)	D.O. (A)	Tol	2 x Is (s)	5 x Is (s)	Tol
	IL1(IA)										
	IL2(IIb)										
	IL3(Ic)										

Calculated Timing values in seconds for TM =1.0

Curve	2 xIs	5 xIs
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.

3.4.2 ANSI RESET

If the element is configured as an ANSI characteristic, it may have a reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 (seconds)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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.

3.4.3 IEC RESET

If the element is configured as an IEC characteristic, it may have an IEC (decaying) reset delay applied. If IEC reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 (seconds)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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)

3.4.4 ELEMENT BLOCKING

The 51c Overcurrent elements can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
51c	

3.5 DERIVED EARTH FAULT (50N, 51N)

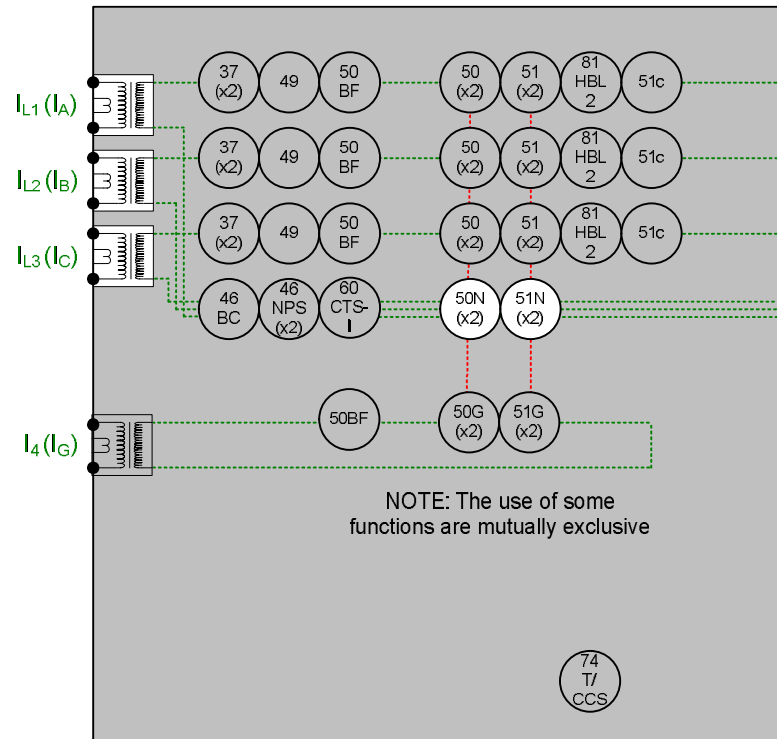


Figure 3.5-1 Derived Earth Fault

Current Inputs:	$I_{L1} (I_A)$, $I_{L2} (I_B)$, $I_{L3} (I_C)$
Disable:	37, 46, 49, 50CBF, 60CTS-I, 46BC
Map Pickup LED:	51N-n/50N-n - Self Reset

Other protection functions may overlap with these functions during testing; it may be useful to disable some functions to avoid ambiguity. Derived EF & Measured EF protections can be Enabled/Disabled individually or as groups in the 'Function Config' menu.

Derived EF elements can be separated from Measured EF by arrangement of the secondary injection circuit by shorting/disconnecting I_4 Input.

3.5.1 DEFINITE TIME OVERCURRENT (50N)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9x setting, check for no operation, apply 1.1x setting, check operation

Apply 2x 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	Is (A)	DTL (s)	P.U. Current (A)	Operate Time 2 x Is	NOTES
E						

3.5.2 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 Pick-up led to operate for the function.

Gradually increase current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x 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)	Is (A)	TM	Operate Current			Operate Time		
						P.U. (A)	D.O. (A)	Tol	2 x Is (s)	5 x Is (s)	Tol
	E										

Calculated Timing values in seconds for TM =1.0

Curve	2 x Is	5 x Is
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.

3.5.3 ELEMENT BLOCKING

The Derived Earth Fault elements can be blocked by Binary Input Inhibit and Inrush Detector operation. This functionality should be checked.

Element	BI Inhibits	Inrush Detector
51N-1		
51N-2		
51N-3		
51N-4		
50N-1		
50N-2		
50N-3		
50N-4		

3.5.4 ANSI RESET

If the element is configured as an ANSI characteristic, it may have a reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 & $TM=1$ (seconds)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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.

3.5.5 IEC RESET

If the element is configured as an IEC characteristic, it may have an IEC (decaying) reset delay applied. If IEC reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 & $TM=1$ (seconds)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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)

3.6 MEASURED EARTH FAULT (50G,51G)

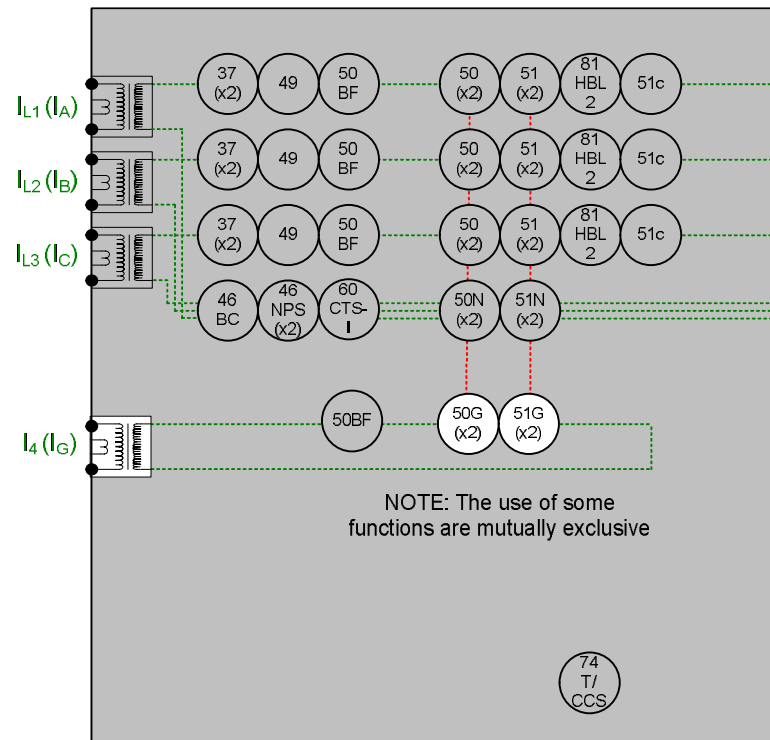


Figure 3.6-1 Measured Earth Fault

Current Inputs:	$I_4 (I_G)$
Disable:	50CBF
Map Pickup LED:	51G-n/50G-n - Self Reset

Other protection functions may overlap with these functions during testing, it may be useful to disable some functions to avoid ambiguity. Derived EF, Measured EF & Restricted EF protections can be Enabled/Disabled individually or as groups in the 'Function Config' menu.

Measured EF elements can be separated from Derived EF by secondary injection of current through the I_4 input circuit only.

3.6.1 DEFINITE TIME OVERCURRENT (50G)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9x setting, check for no operation, apply 1.1x setting, check operation

Apply 2x setting current if possible and record operating time

Phase	Is (Amps)	DTL (sec)	P.U. Current Amps	Operate Time 2 x Is	NOTES
I ₄					

Check correct indication, trip output, alarm contacts, waveform record.

3.6.2 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 Pick-up led to operate for the function.

Gradually increase current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x setting current and record operating time.

Compare to calculated values for operating times

P.U. D.O. & TIMING TESTS	Ph.	Char. (NI EI VI LTI, DTL)	Is (A)	TM	Operate Current			Operate Time		
					P.U. (Amps)	D.O. (Amps)	Tol	2 x Is (sec)	5 x Is (sec)	Tol
	I ₄									

Calculated Timing values in seconds for TM =1.0

Curve	2 xls	5 xls
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.

3.6.3 ELEMENT BLOCKING

The Measured Earth Fault elements can be blocked by Binary Input Inhibit and Inrush Detector operation. This functionality should be checked.

Element	BI Inhibits	Inrush Detector
51G-1		
51G-2		
50G-1		
50G-2		

3.6.4 ANSI RESET

If the element is configured as an ANSI characteristic, it may have a reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 & $TM=1$ (seconds)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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.

3.6.5 IEC RESET

If the element is configured as an IEC characteristic, it may have an IEC (decaying) reset delay applied. If IEC reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 & $TM=1$ (seconds)
IEC-NI	9.7
IEC-VI	43.2
IEC-EI	58.2
IEC-LTI	80

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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)

3.7 NEGATIVE PHASE SEQUENCE OVERCURRENT (46NPS)

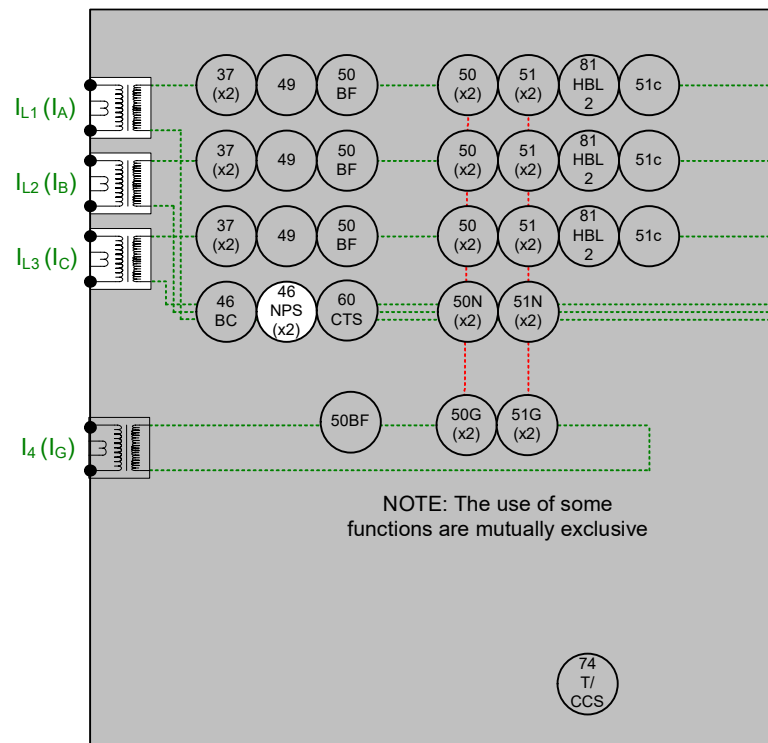


Figure 3.7-1 Negative Phase Sequence Overcurrent

Current Inputs:	$I_{L1} (I_A)$, $I_{L2} (I_B)$, $I_{L3} (I_C)$,
Disable:	51, 51C, 37, 49, 50CBF, 60CTS, 46BC
Map Pickup LED:	46IT/46DT - Self Reset

Where two 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 Performance Specification should always be observed throughout testing.

NPS Overcurrent can be tested using a normal 3P balanced source. Two phase current connections should be reversed so that the applied balanced 3P current is Negative Phase Sequence.

3.7.1 DEFINITE TIME NPS OVERCURRENT (46DT)

If DTL setting is small, gradually increase current until element operates.

If DTL is large apply 0.9x setting, check for no operation, apply 1.1x setting, check operation

Apply 2x setting current if possible and record operating time

Phase	Is (Amps)	DTL (sec)	P.U. Current Amps	Tolerance	Operate Time 2 x Is	Tolerance
NPS						

Check correct indication, trip output, alarm contacts, waveform record.

3.7.2 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 Pick-up led to operate for the function.

Gradually increase current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x 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)	Is (A)	TM	Operate Current			Operate Time		
						P.U. (Amps)	D.O. (Amps)	Tol	2 x Is (sec)	5 x Is (sec)	Tol
	NPS										

Calculated Timing values in seconds for TM =1.0

Curve	2 x Is	5 x Is
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.

3.7.3 ANSI RESET

If the element is configured as an ANSI characteristic, it may have a reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

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 & $TM=1$ (seconds)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x 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)

3.7.4 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.

3.8 UNDERCURRENT (37)

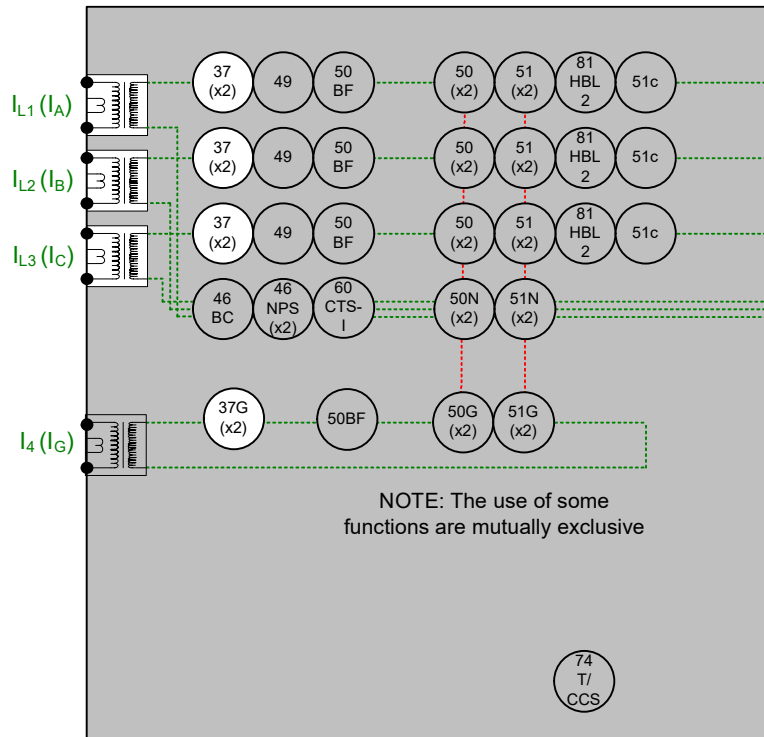


Figure 3.8-1 Undercurrent

Current Inputs:	$I_{L1} (I_A)$, $I_{L2} (I_B)$, $I_{L3} (I_C)$, I_4
Disable:	51N, 51G, 46, 60CTS, 46BC
Map Pickup LED:	37-n - Self Reset
Undercurrent Guard:	As required
Undercurrent start:	Any or ALL

If two 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 3Phase balanced current or single phase current on the single pole relay models and earth fault function 37G/37SEF, at a level above the Undercurrent 37-n setting until the element resets. Check operation with start option set to ANY phase and repeat with it set to operate for ALL phases.

If DTL setting is small, gradually reduce any phase current in turn until element operates.

If DTL is large apply 1.1x setting, check for no operation, apply 0.9x setting, check operation

Testing of this element phase by phase may cause inadvertent operation of the 46 NPS Overcurrent elements.

Apply 0.5x setting current and record operating time

Phase	Is (Amps)	DTL (sec)	P.U. Current Amps	Tolerance	Operate Time 0.5 x Is	Tolerance
I _{L1} (I _A)						
I _{L2} (I _B)						
I _{L3} (I _C)						
I _Δ (I _G)						

3.8.1 ELEMENT BLOCKING

The Undercurrent elements can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
37-1	
37-2	
37G-1 or 37SEF-1	
37G-2 or 37SEF-2	

3.8.2 ELEMENT BLOCKING FROM CURRENT GUARD

The elements can be blocked by 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.

3.9 THERMAL OVERLOAD (49)

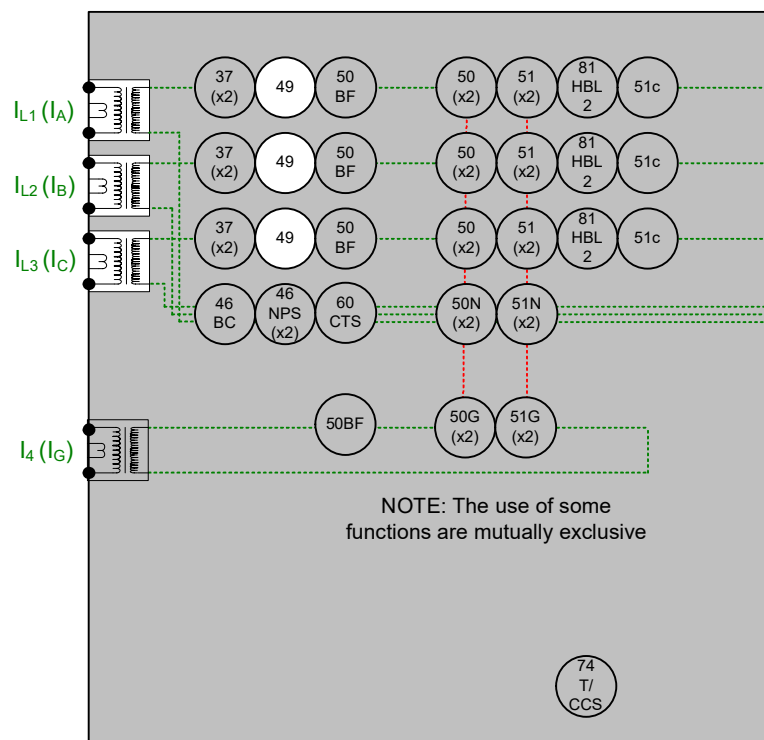


Figure 3.9-1 Thermal Overload

Current Inputs:	I_{L1} (I_A), I_{L2} (I_B), I_{L3} (I_C),
Disable:	51, 50, 37, 50CBF
Map Pickup LED:	49Alarm

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 list below shows operate times for a range of Time Constant Settings for an applied current of 2x the Thermal Overload setting. Ensure that the thermal rating of the relay is not exceeded during this test.

Time Constant (minutes)	Operate Time (seconds)
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 2x 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

3.9.1 ELEMENT BLOCKING

The Thermal element can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
49	

Section 4: Supervision Functions

4.1 CB FAIL (50BF)

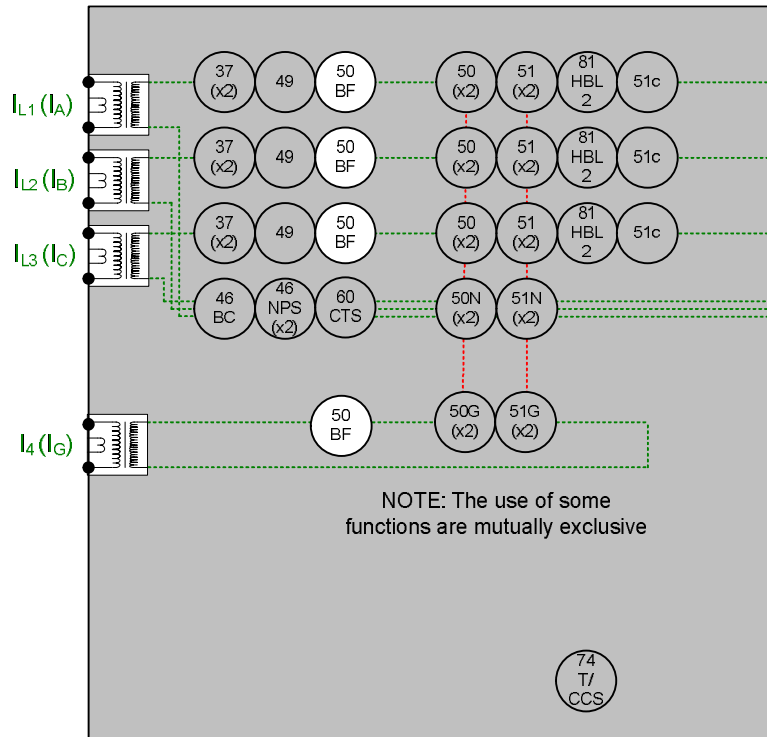


Figure 4.1-1 CB Fail

Current Inputs: $I_{L1} (I_A)$, $I_{L2} (I_B)$, $I_{L3} (I_C)$, I_{L4}

Disable:

Map Pickup LED: 50BF-n - Self Reset

The circuit breaker fail protection time delays are initiated either from:

A binary output mapped as **Trip Contact** in the OUTPUT CONFIG>BINARY OUTPUT CONFIG menu,
or

A binary input mapped as **50BF Ext Trip** in the INPUT CONFIG>INPUT MATRIX menu.

Or

A binary input mapped as **50BF Mech Trip** in the INPUT CONFIG>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 energised 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 I_4 and using the *50BF-I4 Setting*.

50BF Setting (xIn)	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 (xIn)	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 INPUT CONFIG>INPUT MATRIX menu.

Initiate this binary input and simulate the circuit breaker remaining closed by ensuring the CB Closed binary Input is energised 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

4.1.1 ELEMENT BLOCKING

The CB Fail function can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
50BF	

4.2 CURRENT TRANSFORMER SUPERVISION (60CTS)

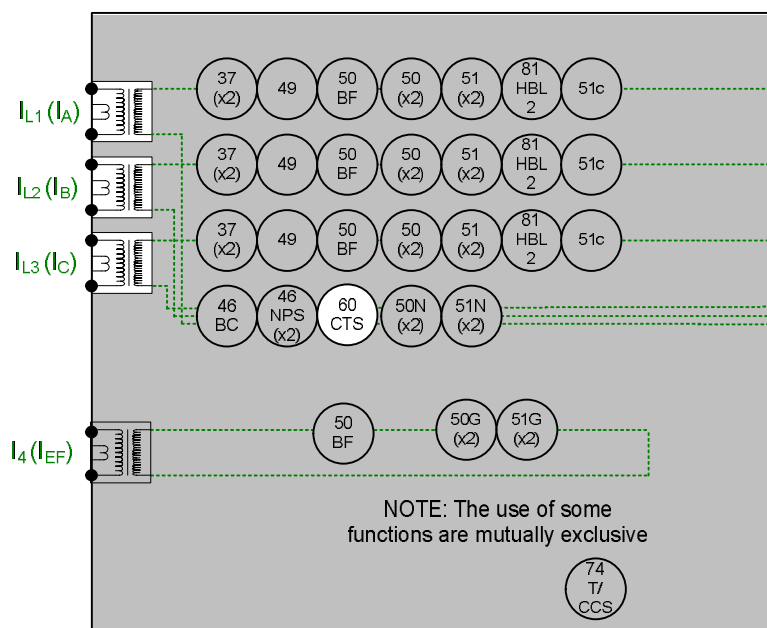


Figure 4.2-1 Current Transformer Supervision

Current Inputs: $I_{L1} (I_A)$, $I_{L2} (I_B)$, $I_{L3} (I_C)$
 Disable: 51N, 46IT, 46DT, 46BC
 Map Pickup LED: 60CTS - Self Reset

Apply 3-Phase balanced current to the relay; reduce the current in any one or two phases to a level below 60CTS / setting. Measure the delay to operation.

Gradually reduce the current until the element resets.

Setting	Measured
60CTS Delay	
60CTS Inps	
60CTS Vnps	

4.3 BROKEN CONDUCTOR (46BC)

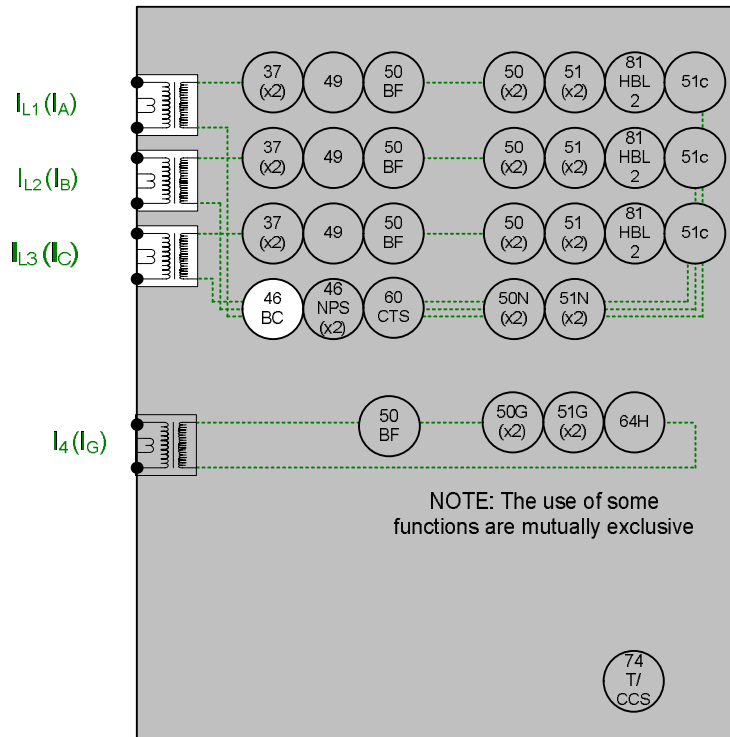


Figure 4.3-1 Broken Conductor

Current Inputs:	$I_{L1} (I_A)$, $I_{L2} (I_B)$, $I_{L3} (I_C)$
Disable:	51N, 46IT, 46DT
Map Pickup LED:	46BC - Self Reset

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 Setting	3P balanced current (A)	1P unbalance current (A)	Measured Unbalance current

Apply 1 A 1P unbalance current without 3P balanced current. Measure 46BC operating time.

46BC Delay setting	Measured

4.3.1 ELEMENT BLOCKING

The Broken Conductor element can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
46BC	

4.4 TRIP/CLOSE CIRCUIT SUPERVISION (74T/CCS)

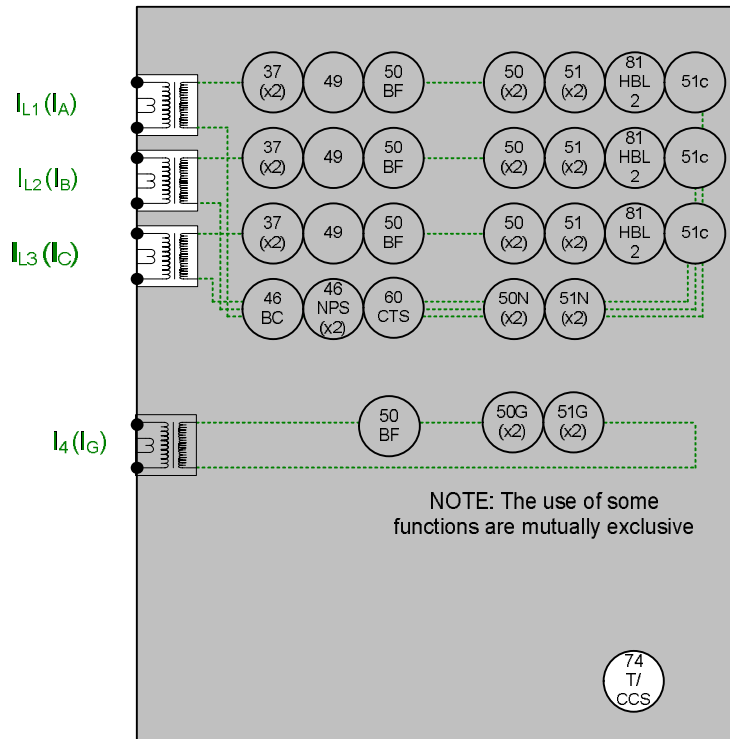


Figure 4.4-1 Trip Circuit Supervision

Current Inputs: n/a

Disable:

Map Pickup LED: 74TCS-n - Self Reset

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.

TCS-n Delay setting	Measured
CCS-n Delay setting	Measured

4.5 MAGNETISING INRUSH DETECTOR (81HBL2)

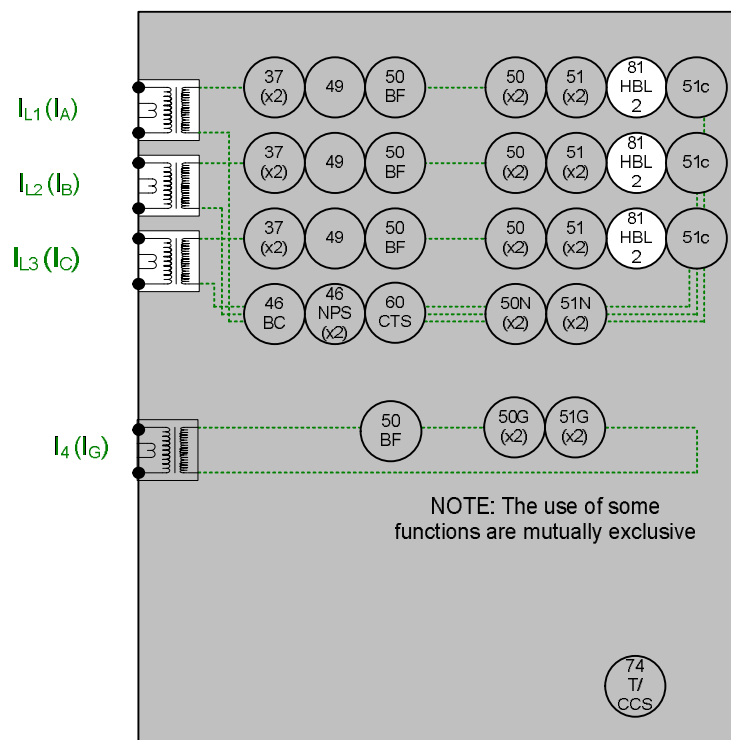


Figure 4.5-1 Magnetising Inrush Detector

Current Inputs: $I_{L1} (I_A)$, $I_{L2} (I_B)$, $I_{L3} (I_C)$,

Disable:

Map Pickup LED:

Logical operation of the harmonic blocking can be tested by current injection at 100 Hz to cause operation of the blocking signals.

Section 5: Control & Logic Functions

5.1 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.

Section 6: Testing and Maintenance

The relays are maintenance free, with no user serviceable parts.

6.1 PERIODIC TESTS

During the life of the relay, it should be checked for operation during the normal maintenance period for the site on which the product is installed. It is recommended the following tests are carried out:-

Visual inspection of the metering display

1. Operation of output contacts
2. Secondary injection of each element

6.2 MAINTENANCE

Relay failure will be indicated by the 'Protection Healthy' LED being off or flashing. A message may also be displayed on the LCD.

The relay should be returned as a complete unit. No attempt should be made to disassemble the unit to isolate and return only the damaged sub-assembly. It may however be convenient to fit the withdrawable relay to the outer case from a spare relay, to avoid the disturbance of relay panel wiring, for return to Siemens Protection Devices Ltd. The withdrawn relay should never be transported without the protection of the outer case.

6.3 TROUBLESHOOTING

Observation	Action
Relay does not power up.	Check that the correct auxiliary AC or DC voltage is applied and that the polarity is correct.
Relay won't accept the password.	The Password being entered is wrong. Enter correct password. If correct password has been forgotten, note down the Numeric Code which is displayed at the Change Password screen e.g. Change password = 1234567 To retrieve the password, communicate this code to a Siemens Protection Devices Ltd. representative.
Protection Healthy LED flashes	General failure. Contact a Siemens Protection Devices Ltd. representative.
LCD screen flashes continuously.	The LCD has many possible error messages which when displayed will flash continuously. These indicate various processor card faults. General failure. Contact a Siemens Protection Devices Ltd. representative.
Backlight is on but no text can be seen.	Adjust the contrast.
Scrolling text messages are unreadable.	Adjust the contrast.
Relay displays one instrument after another with no user intervention.	This is normal operation, default instruments are enabled. Remove all instruments from the default list and only add those that are required. (See Instrumentation Guide).
Cannot communicate with the relay.	Check that all of the communications settings match those used by Reydisp Evolution. Check that all cables, modems and fibre-optic cables work correctly. Ensure that IEC 60870-5-103 is specified for the connected port (COM1 or COM2).
Relays will not communicate in a ring network.	Check that all relays are powered up. Check that all relays have unique addresses.
Status inputs do not work.	Check that the correct DC voltage is applied and that the polarity is correct. Check that the status input settings such as the pick-up and drop-off timers and the status inversion function are correctly set.
Relay instrument displays show small currents or voltages even though the system is dead.	This is normal. The relay is displaying calculation noise. This will not affect any accuracy claims for the relay.

Table 6.3-1 Troubleshooting Guide

If the above checklist does not help in correcting the problem please contact the local Siemens office or contact PTD 24hr Customer Support, Tel: +49 180 524 7000, Fax: +49 180 524 2471, e-mail: support.energy@siemens.com.

7SR18 Line Differential Protection Applications Guide

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Document Release History

This document is issue 2023/01.

2016/11	First Issue
2017/05	Typographical revisions, amended drawings
2017/11	Typographical revisions, amended drawings
2018/07	Amended connection diagrams, additional disposal information
2022/03	Typographical revisions, Protection Comms info added.
2023/01	CT Vk requirements list 4.4 for PX reinstated

Software Revision History

2016/11	2436H80016R4d-1b	First Release
2018/07	2436H80016R4i-1c	Software maintenance to address production SW upload.

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Section 1: Common Functions

1.1 Multiple Settings Groups

Alternate settings groups can be used to reconfigure the relay during significant changes to system conditions e.g.

- Primary plant switching in/out
- Summer/winter or day/night settings
- Switchable earthing connections
- Loss of Grid connection (see below)

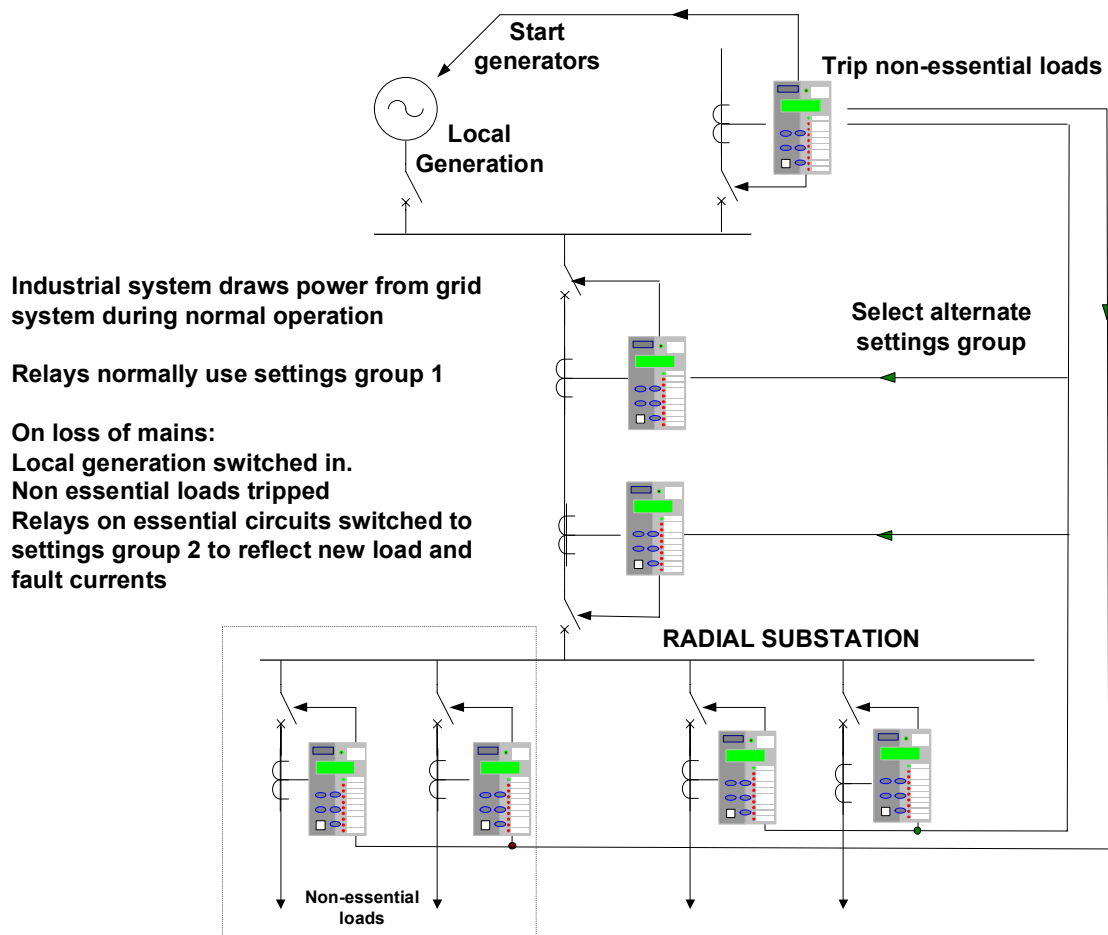


Figure 1.1-1 Example Use of Alternative Settings Groups

1.2 Binary Inputs

Each Binary Input (BI) can be programmed to operate one or more of the relay functions, LEDs, output relays etc. These could be used to bring into the Relay such digital signals as Inhibits for protection elements, trip circuit supervision status etc.

1.2.1 Alarm and Tripping Inputs

A common use of binary inputs is to provide indication of alarm or fault conditions e.g. transformer Buchholz Gas or Buchholz Surge conditions. The Binary Inputs are mapped to LED(s), waveform storage trigger and binary outputs. Note that transformer outputs which require high speed tripping, such as a Buchholz Surge, should be wired to a binary input to provide LED indication and also have a parallel connection wired to directly trip the circuit via a blocking diode, see Figure 1.2.1-1

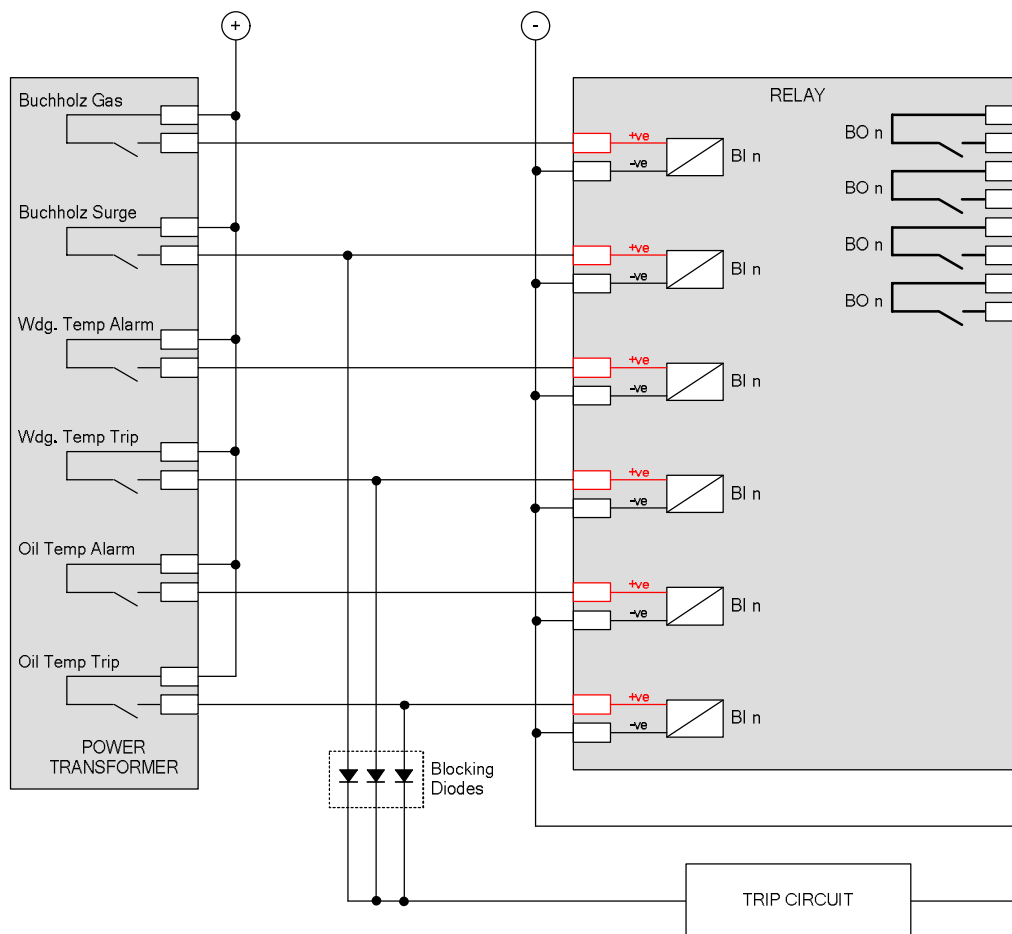


Figure 1.2.1-1 Example of Transformer Alarm and Trip Wiring

1.2.2 The Effects of Capacitance Current

The binary inputs have a low minimum operate current and may be set for instantaneous operation. Consideration should be given to the likelihood of mal-operation due to capacitance current. Capacitance current can flow through the BI for example if an earth-fault occurs on the dc circuits associated with the relay. The binary inputs will be less likely to mal-operate if they:

- 1 Have both the positive and negative switched (double-pole switched).
- 2 Do not have extensive external wiring associated with them e.g. if the wiring is confined to the relay room.

Where a binary input is both used to influence a control function (e.g. provide a tripping function) and it is considered to be susceptible to mal-operation the external circuitry can be modified to provide immunity to such disturbances, see Figure 1.2.4-1.

1.2.3 AC Rejection

The default pick-up time delay of 20 ms provides immunity to ac current for dc applications e.g. induced from cross site wiring.

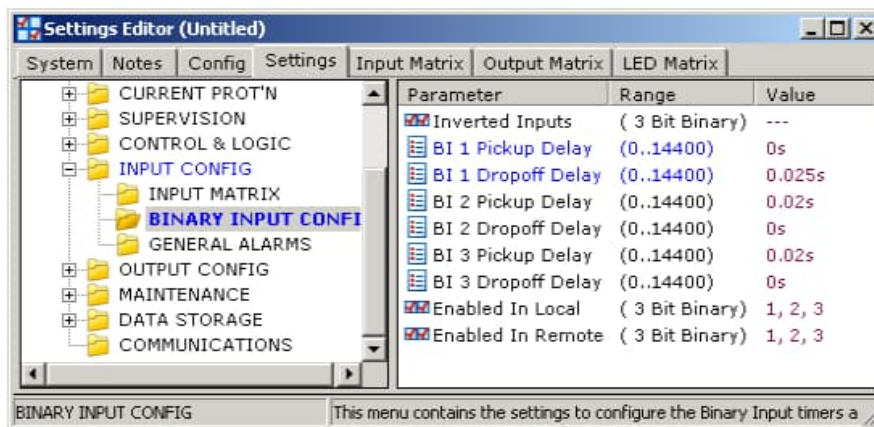
Binary inputs can be configured for intentional operation from an ac power supply by setting pickup (PU) and drop-off (DO) timers for each binary input e.g. 0 ms PU and 25 ms DO. If wiring to AC operate binary inputs is required to have a total length of more than 10 metres, screened twisted pair cable should be used.

If additional pickup or drop-off time delays are required by the scheme logic, this functionality can be achieved by programmable logic within the device.

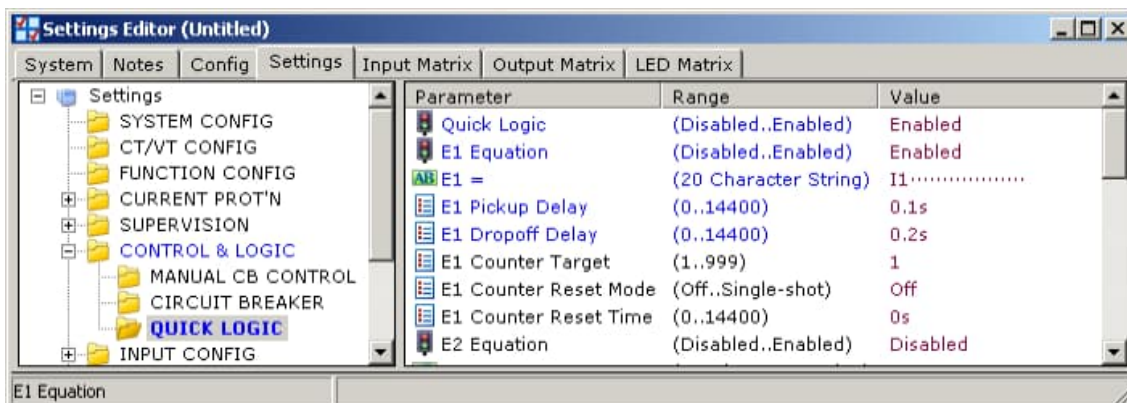
Example: -

An AC operated Binary input is required to inhibit the 50-1 protection element with 100 ms minimum pickup delay and 200 ms minimum drop-off delay.

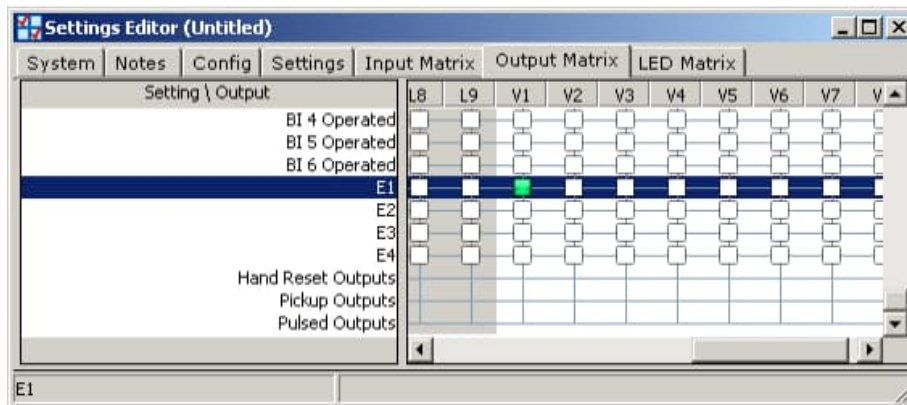
- 1) Set Binary Input 1 for AC operation:



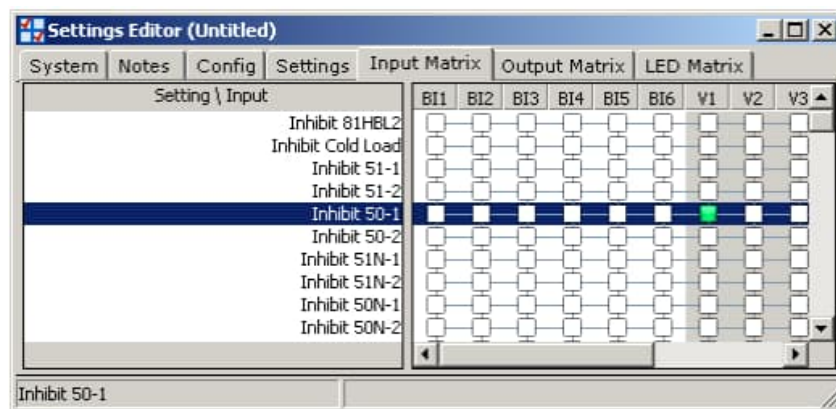
- 2) Set quicklogic equation E1 to operate from Binary Input 1 and apply required delays:



3) Set equation E1 to operate virtual I/O V1 in the Output Matrix:



4) Set virtual I/O V1 to operate Inhibit 51-1 in the Input Matrix:



1.2.4 Use of Binary Inputs in control and tripping circuits

Where a binary input is used to as part of a dc control function, for example tripping or closing a circuit breaker, it may be desirable to provide an enhanced level of immunity to prevent unwanted trips due to induced voltages. This is most important where cross-site cabling is involved, as this is susceptible to induced voltages and will contribute to capacitive discharge currents under DC system earth-fault conditions. One method of enhancing the immunity of the binary input is to switch both positive and negative connections; however this is often not possible or desirable.

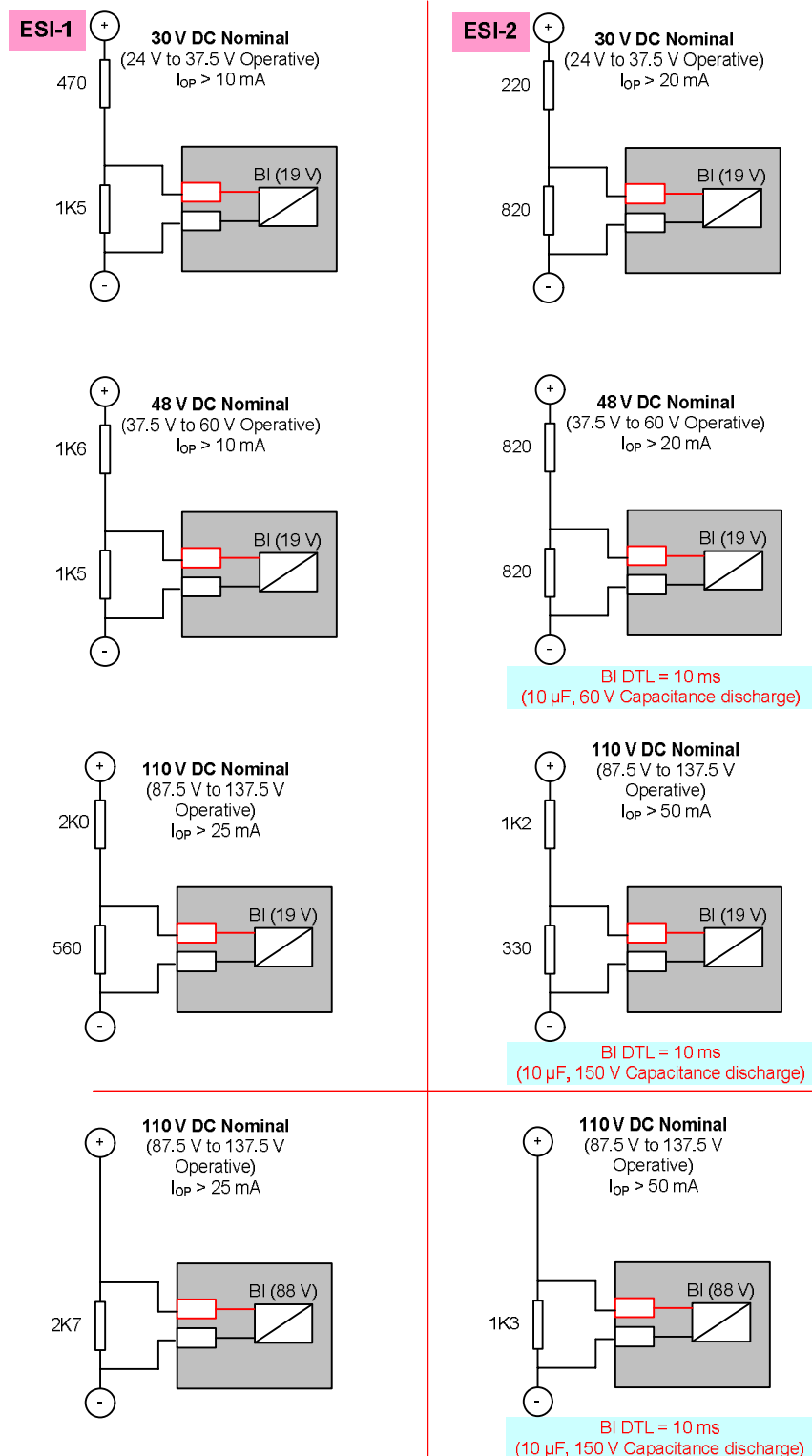
As a guide to suitable degrees of enhanced immunity, we have adopted the parameters laid down in U.K. standard EATS 48-4. This standard identifies two levels of immunity: -

1. Category ESI 1 may be adopted for connections which do not include significant wiring runs or cabling outside the relay enclosure.
2. Category ESI 2 should be used for connections which include significant wiring runs or cabling outside the relay enclosure. This category also gives immunity to capacitive discharge currents.

The following diagrams show the external resistors which should be fitted to allow the binary input to comply with either of the above categories.

Fitting these components will raise the current required to operate the binary input, and hence makes it less susceptible to maloperation.

Where required, the minimum pickup delay for the binary input is stated on the diagram.



Resistor power ratings:

30 V DC Nominal	>3 W
48 V DC Nominal	>3 W
110 V DC Nominal	>10 W (ESI-1)
110 V DC Nominal	>20 W (ESI-2)

Resistors must be wired with crimped connections as they may run hot

Figure 1.2.4-1 Binary Input Configurations Providing Compliance with EATS 48-4 Classes ESI 1 and ESI 2

1.3 Binary Outputs

Binary Outputs are mapped to output functions by means of settings. These could be used to bring out such digital signals as trips, a general pick-up, plant control signals etc.

All Binary Outputs are Trip rated.

Each can be defined as Self or Hand Reset. Self-reset contacts are applicable to most protection applications. Hand-reset contacts are used where the output must remain active until the user expressly clears it e.g. in a control scheme where the output must remain active until some external feature has correctly processed it.

Notes on Self Reset Outputs: -

With a failed breaker condition the relay may remain operated until current flow in the primary system is interrupted by an upstream 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 utilised.

1.4 LEDs

In the Output Configuration menu LEDs can be mapped to output functions by means of settings. These could be used to display such digital signals as trips, a general pick-up, plant control signals etc.

Each LED can be defined as Self or Hand Reset. Hand reset LEDs are used where the user is required to expressly acknowledge the change in status e.g. critical operations such as trips or system failures. Self-reset LEDs are used to display features which routinely change state, such as Circuit-Breaker open or close.

The status of hand reset LEDs is retained in capacitor-backed memory in the event of supply loss.

Each LED can be assigned as red, yellow or green in colour. There are two methods for doing this: -

- 1) In the LED Matrix tab, to assign the LED as a red colour select a box on the red row. To assign the LED as a green colour select a box on the green row. To assign the LED as a yellow colour, select boxes on both the red and green rows.

NB: If there are no boxes selected the LED will not illuminate.

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix	
Setting \ LED							
						1 2 3 4 5 6 7 8 9 10 11 12 13 14	
						Self Reset LEDs	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☒ ☒ ☒ ☒ ☒ ☒
						PU Self Reset LEDs	☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒
						Green LEDs	☐ ☐ ☐ ☐ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒
						Red LEDs	☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒
						PU Green LEDs	☐ ☐ ☐ ☐ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒
						PU Red LEDs	☒ ☒ ☒ ☒ ☐ ☐ ☐ ☐ ☒ ☒ ☒ ☒ ☒ ☒

Figure 1.4-1 LED configuration via the LED Matrix tab

- 2) In the OUTPUT CONFIG\LED CONFIG menu in the Settings tab, to assign the required LED as a particular colour, either red or green, type the LED number in the appropriate row. To assign the required LED as a yellow colour, type the LED number in both red and green rows.

NB: If a LED number is not assigned that particular LED will not illuminate.

System

Notes

Config

Settings

Input Matrix

Output Matrix

LED Matrix

Settings

SYSTEM CONFIG

CT/VT CONFIG

FUNCTION CONFIG

CURRENT PROT'N

CONTROL & LOGIC

INPUT CONFIG

OUTPUT CONFIG

OUTPUT MATRIX

BINARY OUTPUT CONFIG

LED CONFIG

PICKUP CONFIG

Parameter	Value
☒ Self Reset LEDs	9, 10, 11, 12, 13, 14
☒ PU Self Reset LEDs	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
☒ Green LEDs	5, 6, 7, 8, 9, 10, 11, 12
☒ Red LEDs	1, 2, 3, 4, 9, 10, 11, 12
☒ PU Green LEDs	5, 6, 7, 8, 9, 10, 11, 12
☒ PU Red LEDs	1, 2, 3, 4, 9, 10, 11, 12

Figure 1.4-2 LED configuration via the Settings \ OUTPUT CONFIG \ LED CONFIG menu

Section 2: Protection Functions

2.1 Time delayed over-current (51/51G/51N)

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 minimised operating times.

To optimise the grading capability of the relay additional time multiplier, ‘Follower DTL’ (Figure 2.1-1) or ‘Minimum Operate Time’ (Figure 2.1-2) settings can be applied.

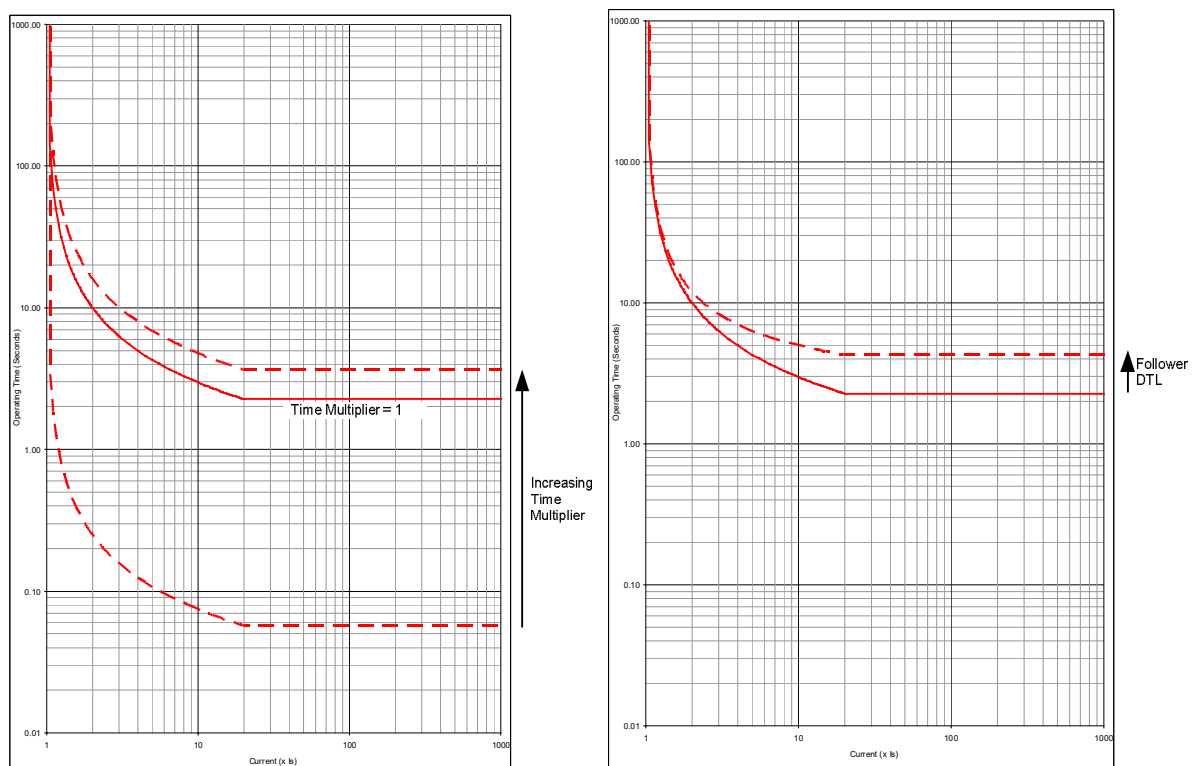


Figure 2.1-1 IEC NI Curve with Time Multiplier and Follower DTL Applied

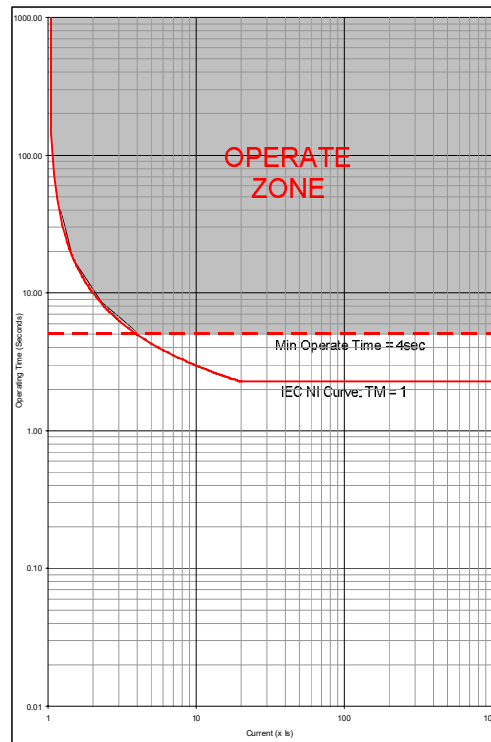


Figure 2.1-2 IEC NI Curve with Minimum Operate Time Setting Applied

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 far lower pick-up levels than relays which detect excess current ($>$ 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.

2.1.1 Selection of Over-current Characteristics

Each pole has two independent over-current characteristics. Where required the two curves can be used: -

- To produce a composite curve
- To provide a two stage tripping scheme

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 summarised in the following table: -

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
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

Table 2.1.1-1 Application of IDMTL Characteristics

2.1.2 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 occurrence 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 IEC/ANSI DECAING 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.

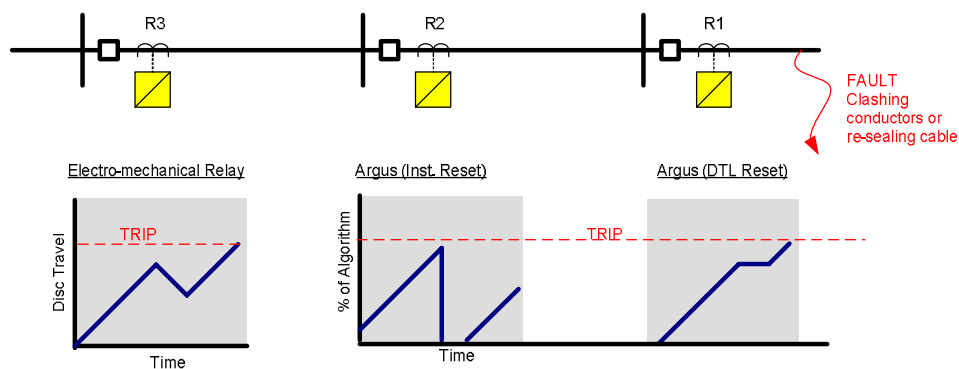


Figure 2.1.2-1 Reset Delay

2.2 Cold Load Settings (51c)

Once a Circuit-Breaker has been open for a period of time, higher than normal levels of load current may flow following CB re-closure e.g. heating or refrigeration plant. The size and duration of this current is dependent upon the type of load and the time that the CB is open.

The feature allows the relay to use alternative Shaped Over-current (51c) settings when a Cold Load condition is identified. The cold load current and time multiplier settings will normally be set higher than those of the normal over-current settings.

The relay will revert to its usual settings (51-n) after elapse of the cold load period. This is determined either by a user set delay, or by the current in all 3-phases falling below a set level (usually related to normal load levels) for a user set period.

2.3 Instantaneous Over-current (50/50G/50N)

Each instantaneous element has an independent setting for pick-up 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 pick-up of the element rather than its operation.

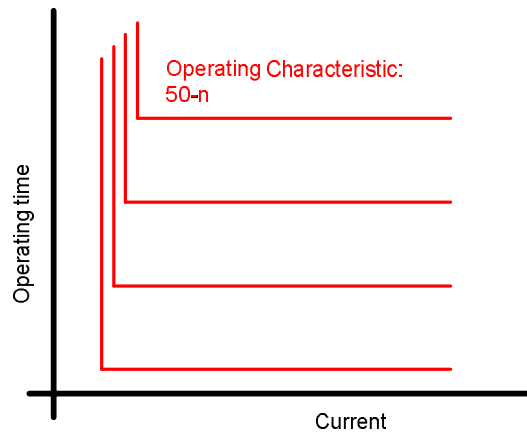


Figure 2.3-1 General Form of DTL Operate Characteristic

Instantaneous elements can be used in current graded schemes where there is a significant difference between the fault current levels at different relay point. The Instantaneous element is set to pick up at a current level above the maximum Fault Current level 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 Over-current’. 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 elements have a very low transient overreach i.e. their accuracy is not appreciably affected by the initial dc offset transient associated with fault inception.

2.3.1 Blocked Over-current Protection Schemes

A combination of instantaneous and DTL elements can be used in blocked over-current protection schemes. These protection schemes are applied to protect substation busbars or interconnectors etc. Blocked over-current protection provides improved fault clearance times when compared against normally graded over-current relays.

The blocked over-current scheme of busbar protection shown in Figure 2.3-2 illustrates that circuit over-current and earth-fault protection relays can additionally be configured with busbar protection logic.

The diagram shows a substation. The relay on the incomer is to trip for busbar faults (F1) but remain inoperative for circuit faults (F2).

In this example the over-current and earth-fault settings for the incomer 50-1 element are set to below the relevant busbar fault levels. 50-1 time delay is set longer than it would take to acknowledge receipt of a blocking signal from an outgoing circuit.

Close up faults on the outgoing circuits will have a similar fault level to busbar faults. As the incomer 50-1 elements would operate for these faults it is necessary to provide a blocking output from the circuit protections. The 50-1 elements of the output relays are given lower current settings than the incomer 50-1 settings, the time delay is set to 0ms. The output is mapped to a contact. The outgoing relay blocking contacts of all circuits are wired in parallel and this wiring is also connected to a BI on the incomer relay. The BI on the incomer relay is mapped to block its 50-1 element.

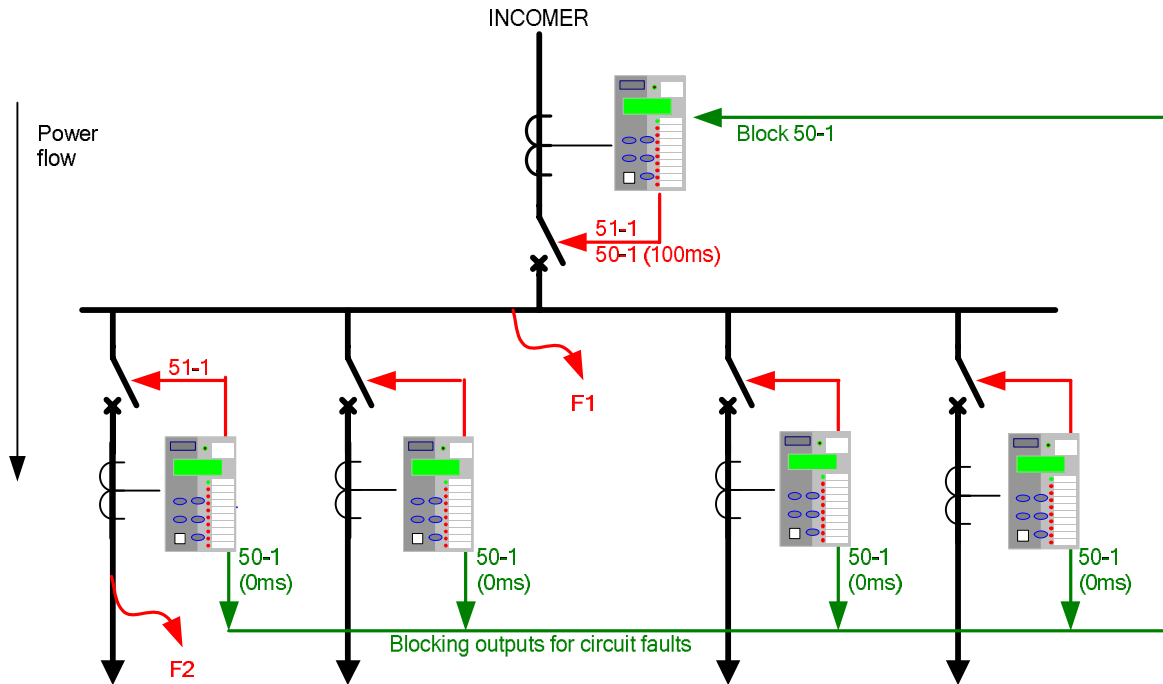


Figure 2.3-2 Blocking Scheme Using Instantaneous Over-current Elements

Typically a time delay as low as 50 ms on the incomer 50-1 element will ensure that the incomer is not tripped for outgoing circuit faults. However, to include for both equipment tolerances and a safety margin a minimum time delay of 100 ms is recommended.

This type of scheme is very cost effective and provides a compromise between back-up over-current busbar protection and dedicated schemes of busbar protection.

2.4 Negative Phase Sequence Over-current (46NPS)

The presence of Negative Phase Sequence (NPS) current indicates an unbalance in the phase currents, either due to a fault or unbalanced load.

NPS current presents a major problem for 3-phase rotating plant. It produces a reaction magnetic field which rotates in the opposite direction, and at twice the frequency, to the main field created by the DC excitation system. This induces double-frequency currents into the rotor which cause very large eddy currents in the rotor body. The resulting heating of the rotor can be severe and is proportional to $(I_2)^2 t$.

Generators and Motors are designed, manufactured and tested to be capable of withstanding unbalanced current for specified limits. Their withstand capability is specified in two parts; continuous capability based on a figure of I_2 , and short time capability based on a constant, K , where $K = (I_2)^2 t$. NPS over-current protection is therefore configured to match these two plant characteristics.

2.5 Undercurrent (37)

Undercurrent elements are used in control logic schemes such as Auto-Changeover Schemes, Auto-Switching Interlock and Loss of Load. They are used to indicate that current has ceased to flow or that a low load situation exists. For this reason simple Definite Time Lag (DTL) elements may be used.

For example, once it has been determined that fault current has been broken – the CB is open and no current flows – an auto-isolation sequence may safely be initiated.

2.6 Thermal Overload (49)

The element uses measured 3-phase current to estimate the real-time Thermal State, θ , of cables or transformers. The Thermal State is based on both past and present current levels.

$\theta = 0\%$ for unheated equipment, and $\theta = 100\%$ for maximum thermal withstand of equipment or the Trip threshold.

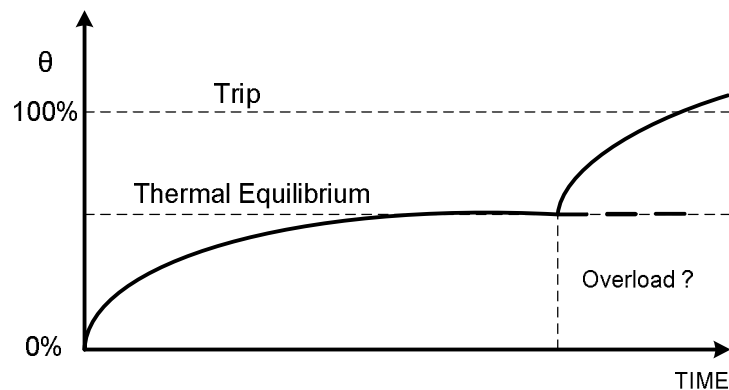


Figure 2.6-1 Thermal Overload Heating and Cooling Characteristic

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 is primarily dependent upon the Thermal Time Constant. This must be matched against that quoted for the item of plant being protected. Similarly the current tripping threshold, I_{θ} , is related to the thermal withstand of the plant.

Thermal Overload is a slow acting protection, detecting faults or system conditions too small to pick-up fast acting protections such as Phase Over-current. 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 scrutinised for abnormalities.

Section 3: CT Requirements

3.1 CT Requirements for Differential, Over-current and Earth-fault Protection

3.1.1 Over-current Protection CTs

- a) For industrial systems with relatively low fault current and no onerous grading requirements - a class 10P10 with suitable VA rating greater than the network CT secondary circuit burden.
- b) For utility distribution networks with relatively high fault current and several grading stages - a class 5P20, with suitable VA rating greater than the network CT secondary circuit.

Note: if an accuracy limit factor is chosen which is much lower than the maximum fault current it will be necessary to consider any effect on the protection system performance and accuracy e.g. grading margins.

For idmtl applications, because the operating time at high fault current is a definite minimum value, partial saturation of the CT at values beyond the over-current factor has only a minimal effect. However, this must be considered in establishing the appropriate setting to ensure proper grading.

- c) For dtl applications utilities as for (b) above - a class 5P10 (or 20), with rated burden to suit the load.

Note: Over-current factors do not need to be high for definite time protection because once the setting is exceeded magnitude accuracy is not important. Often, however, there is also the need to consider instantaneous HighSet over-current protection as part of the same protection system and the settings would normally be of the order of 10x the CT rating or higher. Where higher settings are to be used then the over-current factor must be raised accordingly, e.g. to P20.

3.1.2 Earth-fault Protection CTs

Considerations and requirements for earth-fault protection are the same as for Phase fault. Usually the relay employs the same CT's e.g. three-phase CTs star connected to derive the residual earth-fault current.

The accuracy class and over-current accuracy limit factors are therefore already determined and for both these factors the earth-fault protection requirements are normally less onerous than for over-current.

Section 4: Current Transformer Requirements

The two primary criteria to be met when specifying current transformers (CT) for use with the relay are CT ratio and knee-point voltage. The CT connections and polarity are shown at the end of this section.

4.1 Current Transformer Ratio Selection

The first criterion is to select a CT ratio to step the primary rated current of the protected circuit down to a relay rated current of 1 A or 5 A.

1 A is preferable as there is only 1/5th of the current but 5 times voltage output compared to 5 A CT secondary (see Example. below). This has the advantage of higher driving voltage for relays which may have high impedance, but the 7SR18 has a low impedance i.e. $0.05\ \Omega$ for the 1 A CT input therefore, the voltage is not a great consideration. The majority of the CT burden is the cables from the CT to the relay.

Ratios should be chosen to provide the relay with about rated current at full feeder rating. As a general comment, 1 A secondary rated CT's are superior to 5 A, for all types of protection relays, as they are less prone to saturation. Where possible 1 A rated CT's are recommended, however the relay does have 1 A and 5 A rated CT terminals.

The relay settings can then be chosen to allow the use of sensitive settings. The relay can be connected with 1 A rated CT's at one end and 5 A rated CT's at the other end. CT ratio correction is provided in the range of 0.25 to 3.0 to cater for retrofit applications whereby the ratio at one end may be different to that of the other. This setting operates on the secondary level of current from the line CT's. The setting range of the CT ratio correction factor of 0.25 to 3.0 must be taken into account when considering protection of a circuit with different CT ratios.

Example of Applying CT Ratio Correction

A feeder circuit rated at 600 A with maximum anticipated load of 600 A, has a line CT ratio of 600/1 at one end and 800/5 at the other end. The ratio correction would be set to $600/800 = 0.75$ on the relay connected to the 600/1 CT, and $800/800 = 1.0$ on the other relay. Each relay has 1 A and 5 A inputs for connection to the CT's allowing for example, 600/1 A at one end of the feeder circuit and 800/5 A at the other.

4.2 Current Transformer Class/Rating

The second criterion is the specification of the CT class/rating. The relay is a biased current differential relay and therefore, the most important CT specification parameter is the knee point voltage V_k , rather than the current measurement accuracy. Since the differential protection is biased standard protection class CTs can be used. These parameters are stated for class PX current transformers to IEC61869-2:2012 and can be measured or estimated for other protection class CTs. When standard protection class CTs are applied, to ensure stability for high values of through-fault current (i.e. high multiples of the rated current) a CT class e.g. 5P20 to IEC61869-2:2012 classification, can be obtained.

The CT requirements may be altered by selection of any one of three relay Bias Break Point settings. A lower Bias Break Point setting will lower the CT requirements.

The following page contains formulae that may be used to select appropriate CT knee-point voltages. The CT e.m.f. is chosen to allow the protection to be stable for the worst case through-fault.

4.3 CT Formulae P Class CTs

Example. For 5P20 15 VA CT: -

$$\text{Knee point } V_k (1 \text{ A}) = \frac{VA \times A.L.F.}{I_n} + (R_{CT} \times A.L.F. \times I_n) = \frac{15 \times 20}{1} + (0.05 \times 20 \times 1) = 301 \text{ V}$$

$$\text{Knee point } V_k (5 \text{ A}) = \frac{VA \times A.L.F.}{I_n} + (R_{CT} \times A.L.F. \times I_n) = \frac{15 \times 20}{5} + (0.01 \times 20 \times 5) = 61 \text{ V}$$

If the R_{CT} is not known the second term i.e. $(R_{CT} \times A.L.F. \times I_n)$ can be ignored as this term would be a low value.

CT ratio selection would typically be: -

$$\text{e.g. } \frac{I_{fmax}}{ALF} = \frac{50000}{20} = 2500:1$$

An ALF of 20 means the CT is accurate to 20 x the primary CT current i.e. $20 \times 2500 = 50000$

$$\text{e.g. } \frac{I_{fmax}}{ALF} = \frac{25000}{20} = 1250:1$$

Select a ratio of 1500:1 from Standard CT Series.

An ALF of 20 means the CT is accurate to 20 x the primary CT current i.e. $20 \times 1500 = 30000$

Alternately for 5P20 15 VA System CT: -

$$\text{Knee point } V_k (1 \text{ A}) = A.L.F \times I_{sec} \times (R_{Relay} + \frac{VA}{(I_{sec})^2}) = 20 \times 1 \times (0.05 + \frac{15}{1}) = 301 \text{ V}$$

$$\text{Knee point } V_k (5 \text{ A}) = A.L.F \times I_{sec} \times (R_{Relay} + \frac{VA}{(I_{sec})^2}) = 20 \times 5 \times (0.01 + \frac{15}{25}) = 61 \text{ V}$$

4.4 CT knee point voltage requirements

The minimum knee-point voltage of the CT's is dependent on the settings used:

With Bias Slope 2 = 150% and Bias Break Point = 2 x I_N

$$V_k = \left(0.6 + 0.05 \frac{X}{R} \right) \times I_{FM} \times R_s \quad \text{for} \quad \frac{X}{R} \leq 18$$

$$V_k = \left(1.5 + 0.3 \left(\frac{X}{R} - 18 \right) \right) \times I_{FM} \times R_s \quad \text{for} \quad 18 < \frac{X}{R} \leq 25$$

$$V_k = \left(3.6 + 0.08 \left(\frac{X}{R} - 25 \right) \right) \times I_{FM} \times R_s \quad \text{for} \quad \frac{X}{R} > 25$$

With Bias Slope 2 = 150% and Bias Break Point = 1 x I_N

$$V_k = 1 \times I_{FM} \times R_s \quad \text{for} \quad \frac{X}{R} \leq 15$$

$$V_k = \left(1.0 + 0.13 \left(\frac{X}{R} - 15 \right) \right) \times I_{FM} \times R_s \quad \text{for} \quad 15 < \frac{X}{R} \leq 30$$

$$V_k = \left(2.95 + 0.033 \left(\frac{X}{R} - 30 \right) \right) \times I_{FM} \times R_s \quad \text{for} \quad \frac{X}{R} > 30$$

With Bias Slope 2 = 150% and Bias Break Point = 0.5 x I_N

$$V_k = 1 \times I_{FM} \times R_s \quad \text{for} \quad \frac{X}{R} \leq 20$$

$$V_k = \left(1.0 + 0.135 \left(\frac{X}{R} - 20 \right) \right) \times I_{FM} \times R_s \quad \text{for} \quad 20 < \frac{X}{R} \leq 30$$

$$V_k = \left(2.35 + 0.029 \left(\frac{X}{R} - 30 \right) \right) \times I_{FM} \times R_s \quad \text{for} \quad \frac{X}{R} > 30$$

Where: -

V_k - is the knee-point voltage of the CT defined as the point where a 10% increase in excitation voltage produces a 50% increase in magnetising or excitation current.

X/R - is the system reactance to resistance ratio for a three-phase **through-fault** on the protected feeder.

I_{FM} - is the feeder maximum primary three-phase **through-fault** current referred to the secondary side.

R_s - is the total resistive burden of the secondary circuit, including CT secondary winding, relay phase input and lead loop resistance.

The above formulae include a minimum safety margin in excess of 120%. This may be utilised if the CT's calculated above are too large to fit in the Circuit Breaker chamber. Therefore a 120% reduction may be made to the above minimum knee-point requirements. This margin is present, as the above expressions were based on tests using the saturation e.m.f (E_{sat}) level of the CT. As the knee-point voltage (V_k) of the CT is a measurable constant, this was instead of E_{sat} in the expression above. E_{sat} is always at between 120% and 160% of the knee-point voltage V_k and therefore reducing the V_k calculated above by up to 20% is valid.

The above expressions are derived from system conjunctive tests and power system simulations. The lower the Bias Break Point setting becomes the greater the level of saturation that may be tolerated as is shown in the following figure. This must be offset against fault sensitivity for load bias that may continue during an internal earth-fault on resistance earthed power systems.

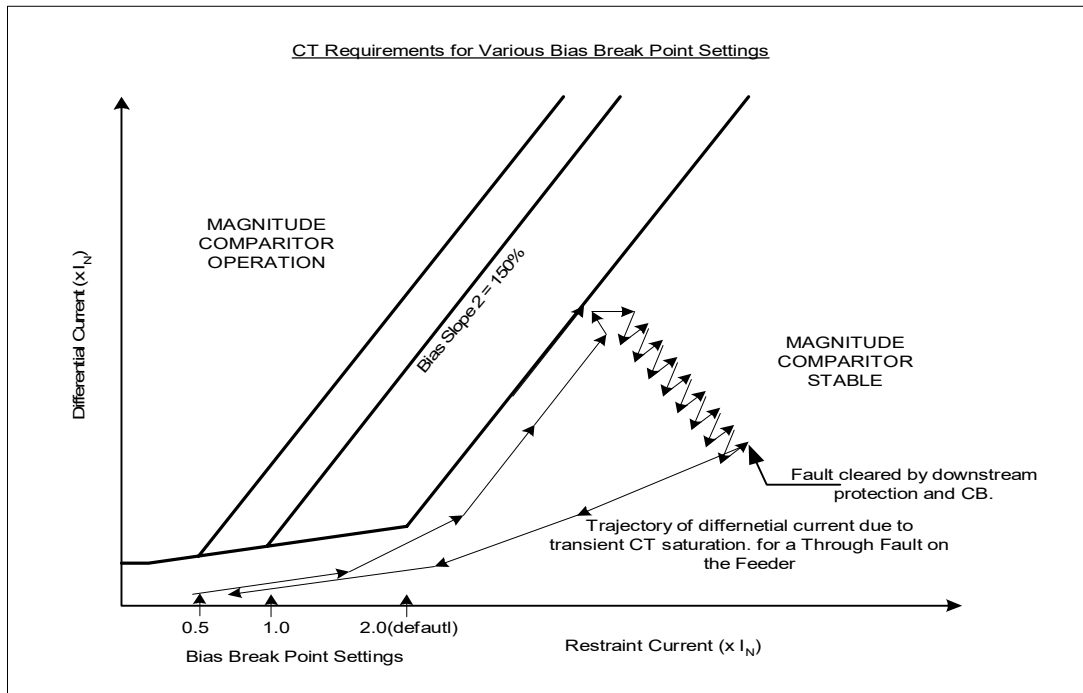


Figure 4.4-1 Relay Amplitude for CT Saturation for an external Phase Fault

The above demonstrates that decreasing the Bias Break Point (B_2) setting has the effect of lowering the Minimum CT requirements. The reduction in Bias Break Point setting must be balanced against making sure the relay will operate for load bias due to arc resistance and non-effectively earth systems for single-end fed internal faults.

For example, if the system was resistance earthed and an earth-fault occurred on a cable at a very high load a Bias Break Point of 0.5 may not be suitable. A typical example for setting the relay with a resistance earthed power system is given later.

Section 5: Determining Current Transformer Requirements

There are four parameters that must be established before the minimum CT knee-point voltage can be specified for a particular circuit. This assumes the Bias Slope 2 setting is set to its default of 150%. For all applications of the relay this setting should be set to 150%.

- Bias Breakpoint Setting.
- Maximum Three-phase Fault Through-fault Level.
- X/R of the through-fault.
- Estimation of the total CT secondary resistance

The process of specifying the CT knee-point voltage required is done in three steps:

5.1 Step 1 - Determine the Bias Break Point Setting

As discussed above the Bias Breakpoint setting is established by examining the earth-fault sensitivity required to detect the minimum internal earth-fault. The relay settings are selected so that the relay measures this fault to be in the operate region. This setting should be set as low as possible to lower CT requirements and add stability for through-faults.

As a general guideline, cable feeders used on power systems with solidly earthed neutrals allow for lower Bias Breakpoint Setting of 0.5 to 1 xIn to be selected. Cable and all overhead line feeders that are resistively earthed may require a setting of 1.0 to 2.0 xIn, to detect the minimum earth-fault, as some load bias will also be measured during the fault. The Bias Break Point setting should therefore be set as low as possible but should be set to attempt to allow tripping of the minimum earth-fault on the feeder. This compromise between lowered CT requirements for through phase faults and detection of low-level internal earth-faults with load bias dictate the best setting to adopt.

5.2 Step 2 - Determine the Fault Level and X/R Ratio of a Through-fault

This maximum level for a three-phase **through-fault** can be calculated if the source and feeder primary resistance (R) and reactance (X) values are known. Sometimes only the source fault level at the busbars will be known. The system primary time-constant L/R, [inductance (L) / resistance (R)], can also be used to calculate the source reactance ratio (X/R), as the time-constant $(L/R) = (2\pi \times f \times L) / R$. Time constant is L/R, typically 45 ms.

The maximum through-fault and maximum X/R ratio cannot occur simultaneously as one counter acts the other. Therefore, it is not technically sound to use both the circuit-breaker breaking capacity and maximum system X/R simultaneously when calculating the CT requirements. If the source X/R is at a maximum the external fault level will tend towards a minimum.

System Voltage (kV)	Source - Transient Current Multiple(TCM) X/R x Fault Level (kA)
33 and Below	500
66	600
132	700
275	900
400	1000

The above Transient Current Multiple (TCM) limits are the extremes taken from the system data contained in international power system standards. The above figures can be used for all circuits, except for circuits where the feeder protected by the relays is fed from a busbar source with several directly connected (i.e. no step-up transformer) generators, such as at 11kV. In this case the source TCM may exceed the above limits, and such circuit will need careful consideration for the CT's requirements.

For example, at the 132kV busbar, the source X/R is considered to be 50 and the circuit breaker has a fault current breaking capacity of 40kA, this produces a TCM of 2000. This value is not practical for a through-fault on any power system, so the practical maximum limit of 700 is imposed.

The maximum source fault level and X/R can then be calculated. The two cases are studied separately. The first considers the maximum source X/R and the second the maximum fault level.

Example

Case 1 – Maximum Source X/R

The source fault level to use in the CT calculations = $700 / 50 = 14$ kA.

Therefore a check of each feeder should be done with an X/R of 50 and a fault level of 14 kA.

Case 2 – Maximum Fault Level

The source X/R to use with the maximum source fault level = $700 / 40 = 17.5$

The second case should be done with an X/R of 17.5 and a fault level of 40 kA

For the above example the three-phase fault level may be quoted in MVA instead of kA. In this case, the fault current can be calculated by using:

3-Phase Fault MVA / (Rated Voltage Line Voltage x root 3)

System positive sequence impedance information is required to accurately estimate both values. The calculation process needs to evaluate the following:

$X/R \text{ used in CT equation} = (X_S + X_F) / (R_S + R_F)$

The source reactance (X_S) and resistance (R_S) will be fixed, but the feeder reactance (X_F) and resistance (R_F) will increase with the length of the circuit. This means the line impedance dominating the overall X/R for the external fault as the circuit length increases.

Several sources feeding the busbar will have the effect of magnifying the feeder impedance. For example, four transformers feeding the busbar in parallel will have effect of keeping the source X/R ($=X/4 / R/4$) at around 40 to 50 but means the effect of the feeder impedance is magnified by a factor of 4, in dominating the overall X/R of the feeder external phase fault.

5.3 Step 3 – Estimate of Total Resistance of the CT Secondary Circuit

The lead loop resistance may be estimated by examining the cable run. For 2.5 mm² multi-cores used with a one ampere secondary rating, the resistance is approximately 7.4 Ohms per km. For 4 mm² multi-core the resistance is about 4.6 Ohms per km. The CT secondary winding resistance and relay phase input burden should be added to this.

The relay burden is 0.05 Ohms when using one ampere rated CT's and relay inputs.

The relay burden is 0.01 Ohms when using five ampere rated CT's and relay inputs.

$R_S = \text{CT Secondary Winding Resistance} + \text{Relay Phase Input} + \text{Lead Loop Resistance}$

$R_S = (R_{CT} + R_{PH} + R_{LL})$

5.3.1 Example CT Requirement - Solidly Earthed 10 km 132 kV Feeder

The cable feeder is 10 km in length and uses single-core 630 mm² cables. The 132 kV power system is solidly earthed and has a minimum internal earth-fault level of 15000 A with a cable circuit rating of 840 A. The CT ratio is chosen to be 1000/1 A. Cables rated at 132 kV have earthed sheaths and are cross-bonded. All internal feeder faults will therefore be earth-faults.

As shown later the P/F Differential setting should be chosen so that the minimum internal earth-fault level is detected. Where the power system is non-effectively earthed such as resistance or reactance type earthing, the load current will continue during the fault. The load current will have an effect of biasing the relay towards stability.

In this case, as the system is solidly earthed, and the cables are cross-bonded to earth at each substation and cable joint all internal earth-faults will be large. The fault current will almost exclusively return to the source via the cable sheathed, which will cancel most of the induction effect of the fault current.

The minimum earth-fault level is estimated to be not less than 15,000 A, are the minimum setting of $0.5 \times I_N$ can be chosen. This level of earth-fault will always produce a large differential current and a fast and definite relay operation. If the circuit were resistance or reactance earthed a higher setting would be required.

Differential Current = $15000/1000 \text{ A} = 15 \times I_N$, Bias Current = $(15 + 0) / 2 = 7.5 \times I_N$. This fault would appear in the operate region of the bias characteristic at a percentage slope of approximately 200%.

If we assume the total secondary resistance is 5 Ohms, then the V_k requirement can be established.

The cable feeder is fed from a busbar with a three-phase fault level of 40 kA and a maximum X/R of 50. As explained earlier these two extremes cannot occur together as they would compromise the circuit-breaker breaking capacity. The above Transient Current Multiples (TCM) are used to limit the parameters used to practical maximum values. The maximum TCM of 700 is applied to 132 kV systems. The parameters to use for each of the two cases were calculated previously to be:

Case 1 – CT required with a maximum X/R of 50 and a fault level of 14 kA.

Case 2 – CT required with a maximum fault level of 40 kA and an X/R of 17.5.

The CT's are 1000/1 A and have a secondary winding resistance of 4 Ohms. The lead loop resistance (R_{LL}), CT secondary winding resistance and relay phase input resistance of 0.05 Ohms, must be added together to find the total circuit resistance of the secondary circuit (R_s).

The cable has a characteristic impedance of $X = -j 0.1277 \text{ Ohms per km}$, and $R = 0.039 \text{ Ohms per km}$. The charging current for this type of cable is 8 A per km.

Example calculation

Case 1: Source X/R = 50 FL = 14 kA

$I_F = 14 \text{ kA}, X/R = 50$

$Z_S = 132,000 / (\sqrt{3} \times 14,000) = 5.443 \text{ Ohms}$

As the busbar X/R is known for both cases the X and R components of the source impedance may be found.

$X_S = \cos(\tan^{-1}(1/X/R)) \times Z_S = j5.442 \text{ Ohms}$

$R_S = \sin(\tan^{-1}(1/X/R)) \times Z_S = 0.109 \text{ Ohms}$

Cable Impedance = $0.39 - j1.277 \text{ Ohms}$

Total Impedance = $0.499 - j6.719 \text{ Ohms}$

The X/R for external fault = 13.46

$Z_T = \sqrt{(0.499^2 + 6.719^2)} = 6.737 \text{ Ohms}$

External Fault Level = $132 \text{ kV} / (\sqrt{3} \times Z_T)$
= 11,312 A

Case 2: Source X/R = 17.5 FL = 40 kA

$I_F = 40 \text{ kA}, X/R = 17.5$

$Z_S = 132,000 / (\sqrt{3} \times 40,000) = 1.905 \text{ Ohms}$

$X_S = \cos(\tan^{-1}(1/X/R)) \times Z_S = j1.9046 \text{ Ohms}$

$R_S = \sin(\tan^{-1}(1/X/R)) \times Z_S = 0.0381 \text{ Ohms}$

Cable Impedance = $0.39 - j1.277 \text{ Ohms}$

Total Impedance = $0.4281 - j3.1816 \text{ Ohms}$

The X/R for external fault = 8.91

$Z_T = \sqrt{(0.4281^2 + 3.1816^2)} = 3.210 \text{ Ohms}$

External Fault Level = $132 \text{ kV} / (\sqrt{3} \times Z_T)$
= 23,741 A

Both Cases should be considered when arriving at the CT minimum e.m.f. requirements

The X/R ranges from 8.91 to 13.46. The through-fault level ranges from 11.312 A to 23.741 A.

As the bias break point is being set to 0.5 xIN the following CT formula is applicable:

$$V_k = 1 \times I_{FM} \times R_s \quad \text{for} \quad \frac{X}{R} \leq 20$$

CT Requirements:**Case 1: Source $X/R=50$ FL=14 kA**

$$V_k \geq 1 \times 11312/1000 \times (R_{LL} + R_{PH} + R_{CT})$$

Case 2: Source $X/R=17.5$ FL=40 kA

$$V_k \geq 1 \times 23741/1000 \times (R_{LL} + R_{PH} + R_{CT})$$

From the above, Case 2 requirements are more onerous and should be used to calculate the V_k minimum required.

CT's for Substation A:

$$V_k \geq 1 \times 23741/1000 \times (1.95+0.05+5)$$

$$V_k \geq 167 \text{ volts}$$

CT's for Substation B:

$$V_k \geq 1 \times 23741/1000 \times (3.5+0.05+5)$$

$$V_k \geq 203 \text{ volts}$$

The above figures are recommended for the relay, however the safety margin of 20% may be used if CT core size makes fitting the CT into the switchgear chamber difficult. In the above example the absolute lower limits would be:

$$V_k \geq 167 / 1.2 = 140 \text{ volts}$$

$$V_k \geq 203 / 1.2 = 170 \text{ volts}$$

This 20% reduction is attributable to the fact the CT formulae were based on the saturation emf (e_{sat}). The e_{sat} of a CT is always $\geq 120\%$ of the CT knee-point voltage. The relay would remain stable for these CT knee-point voltages as there are other safety margins built into the formulae.

These additional safety margins are:

- The CT requirements was based on three-phase fault levels, therefore only the single core run between the relay and CT needed to be considered as the lead burden. The formulae used included the full lead loop resistance.
- The CT core was induced with a one Tesla of remnant flux prior to the fault being applied.
- The fault inception point was set at zero degrees, which produces the largest dc offset in the primary fault current and the highest dc transient flux requirement in the CT core. Most short circuit faults occur at between forty-five and ninety degrees.

On solidly earthed systems the earth-fault level can exceed the phase fault level by up to a factor of 1.2. However, the X/R of the earth-fault will always be less than the three-phase fault as the return path via the earth/sheath is mainly resistive. This will reduce any dc offsets in the primary fault current for an earth-fault. It is therefore enough to consider three-phase faults only.

The above figures demonstrate the feeder impedance reduces the CT minimum requirements as the feeder length increases. The Feeder reactance and resistance will become more dominant as the feeder length increases. This is shown graphically for the 132 kV cable feeder used in the example.

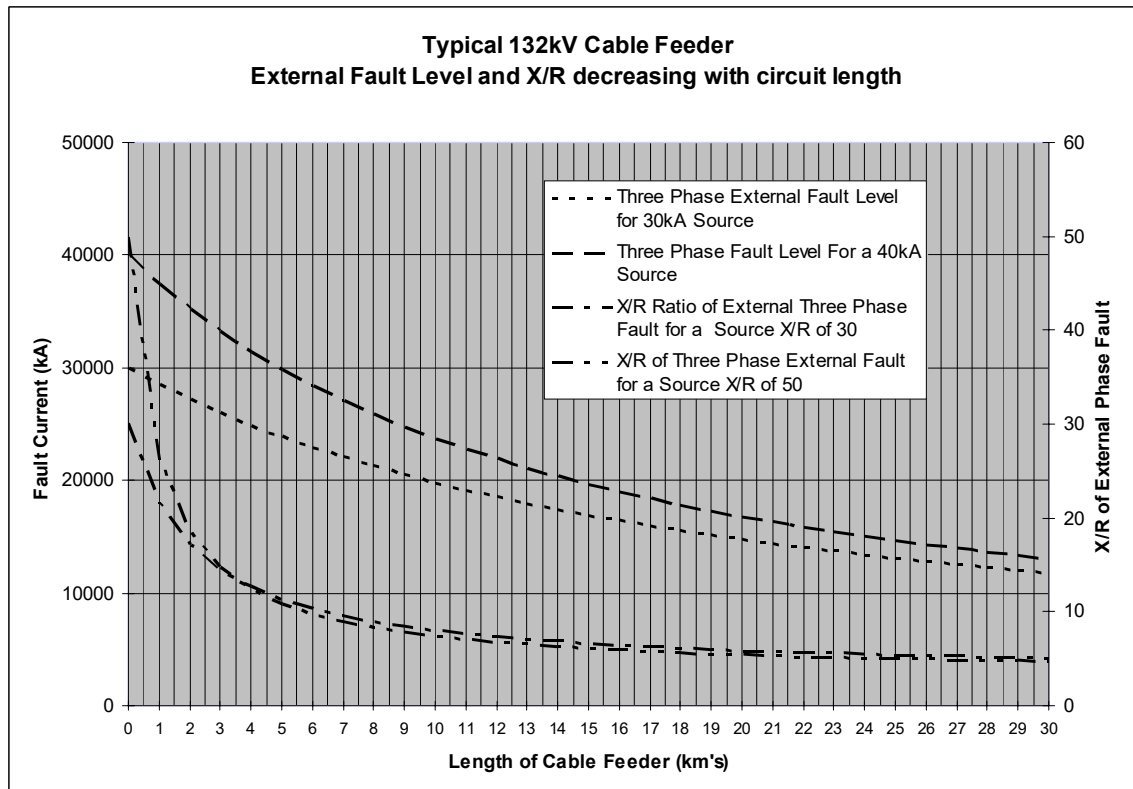


Figure 5.3.1-1 Fault Level and X/R reducing with feeder length

The above shows the X/R ratio of feeder through-fault current is less than half the source X/R when the cable exceeds only 3 km's in length. The fault level also reduces with increasing length and may allow the use of an instantaneous high set over current element for longer feeders. This may be set to provide fast tripping for close-up faults, if say a flexible earth clamp was inadvertently left connected when the circuit is energised.

5.4 Fault Level and X/R for a Phase Through-fault

Combinations of X/R and Fault level will rarely exceed a maximum of 1000 on any power system. This is because a high X/R will tend to reduce the fault level. System X/R and fault level therefore have an inverse relationship. In the above example the source reactance (X_s) and resistance (R_s) are calculated and additional feeder reactance (X_f) and resistance (R_f) are added as the feeder length increases, to arrive at the profile shown above.

Therefore, using the Maximum Breaking capacity of the CB and maximum system X/R together is not technically valid as the both of these values cannot occur at the same time. If one of these parameters is at a maximum the other tends towards its minimum value. This is why a limit is imposed on the product of these two parameters. These limits are the maximum practical case possible.

The circuit type also affects the CT requirements. Cables have much lower X/R ratios than overhead lines and therefore tend to dominate as feeder length increases.

Cables will reduce the through-fault X/R ratio, as they have small X/R ratios in the 5 to 0.3 range. Higher voltage single phase cables tending towards the higher figure and lower voltage tri-foil cable tend towards the lower end of this range. If the cable feeder is longer than a few miles, then it is safe to use the X/R of the cable. Using more than one cable per phase will of course reduce this affect and increase charging current. In all cases it is better to calculate the X/R and fault level of the through-fault if the data is available. Where multiple sources are present to feed the fault, this has a magnifying affect in reducing the overall X/R of the external fault as the feeder circuit impedance will dominate.

Section 6: Relay Functions & Settings

6.1 Current Differential Protection

The current differential elements operate on a current magnitude comparator. This has four settings; Initial Setting (I_S), 1st Bias Slope (S_1), 1st Bias Slope Limit (B_2) and 2nd Bias Slope (S_2). The relay operates by comparing the magnitude of the local and remote relay currents. The characteristics and equations are shown in Figure 6.1-1. The differential algorithm is phase segregated and will produce a trip for the operation of any of the three-phase differential elements.

It is imperative that the relay differential settings and software revisions are identical for each pair of relays protecting a feeder at all times. The Software Revision can be checked by pressing and holding the fascia [TEST/RESET] and [CANCEL] pushbutton simultaneously, when the relay displaying its identifier at the top of the menu structure. The Software Revision number installed is scrolled across the LCD.

Advice on setting the differential elements for various types of circuits and earthing methods are covered later. But a summary of the technical aspects to consider is listed.

Initial Setting - this setting defines the minimum sensitivity of the internal fault that the protection can detect. This setting also defines the bias current. The feeder charging current must be assessed when defining the lowest setting that could be applied to a feeder. The accuracy and correct ratio of the CT's is the main consideration when setting this. This setting is default at 30%.

1st Bias Slope - this is used to allow the relay to detect lower level internal earth-faults. It will generally be selected to 20% for resistance earthed power systems and 30% for solidly earthed power systems.

2nd Bias Slope - this setting is used to accommodate some saturation of the CT's caused by through phase faults on the feeder. This setting should always be selected to 150%.

1st Bias Slope Limit - this setting as a multiple of rated current, defines where Slope 1 ends and Slope 2 begins. This setting is critical as it defines the CT formula to use and the ability of the relay to detect earth-faults on resistance earthed networks. A lower setting makes the relay more stable for through-faults but may compromise earth-fault detection. Non-effectively earthed power systems will tend to require a higher setting than solidly earthed power systems, as some load will tend to continue to flow during the earthed. This will provide extra bias and shift the fault point towards a more stable position.

The following page illustrates the relay differential characteristics and settings.

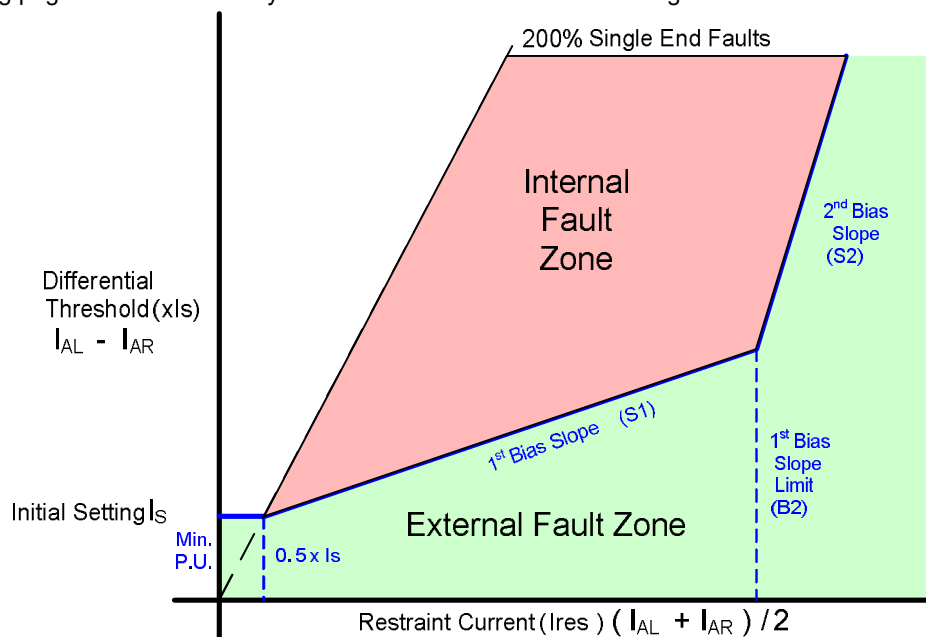


Figure 6.1-1 Relay Protected Zones

6.2 Backup Over Current and Earth-fault Protection

The relay provides 51-n elements which can be configured as inverse definite minimum time lag (IDMTL) elements or instantaneous / definite time lag (DTL) elements, for both phase and earth-faults. There are also 50-n DTL elements pre-configured to DTL.

Any of these elements can be set to be in service permanently, or only when the end to end protection signal becomes corrupted, i.e. when differential protection is no longer possible.

These elements can be set and used as guard relays for the differential protection, i.e. the differential protection will only operate and trip when the local relay current exceeds the guard element setting(s).

The IDMTL/DTL elements can be set to grade with relays or fuses up and down-stream of the protected feeder. In most applications, the selection of relay IDMTL characteristics will be dictated by the type of curve used on the over current and earth-fault protection relays on the source and load side of this relay. Usually normal inverse curves are selected for grading between relays. Extremely Inverse curves type C to IEC 60255 are often used on H.V. transformer circuits, since this type of curve grades with L.V. fuses or moulded case circuit breakers. The setting applied to the earth-fault elements must consider residual current caused by charging current under normal load and under fault conditions.

6.3 Line Differential Enabled with Overcurrent Inhibited – Overcurrent Enabled when Line Differential Inhibited Switch-Over

The relay can be configured to switch between Line Differential Protection only and Overcurrent Protection only in the event of Protection Communication Signalling failure i.e. have Line Differential only and Inhibit overcurrent (back-up protection) or have Line Differential disabled and Overcurrent (back-up protection) Enabled.

This can be achieved by the use of a Quick Logic equation and some Virtual connections.

With healthy protection signalling between relays there will not be an output from the 'Prot'n Comms Alarm'. This is mapped to V1 (see Figure 6.3-1). Quick Logic equation E1 will utilise V1 by inverting it e.g. !V1 (NOT V1) (see Figure 6.3-3). This means the equation E1 will be 'True' when the Comms is healthy and give an output from E1 to virtual connection V2 in the Output Matrix (see Figure 6.4-3). This is then connected to the Input Matrix V2 which in turn is mapped to Inhibit 51-1 & 51-2 in this example (see Figure 6.3-5).

With the protection communication signalling lost between relays there will be an output from 'Prot'n Comms Alarm'. This condition will make equation E1 become 'False' and not give an output from E1 to virtual V2 and the Inhibit will be removed from 51-1 & 51-2 thus enabling overcurrent protection. The Line Differential Protection will be automatically Inhibited within the software.

Setting \ Output	L8	L9	L10	L11	L12	L13	L14	L15	V1
Reactive Exp Pulse	☐	☐	☐	☐	☐	☐	☐	☐	☐
Reactive Imp Pulse	☐	☐	☐	☐	☐	☐	☐	☐	☐
81HBL2	☐	☐	☐	☐	☐	☐	☐	☐	☐
Prot'n Comms Alarm	☒	☐	☐	☐	☐	☐	☐	☐	☒
Prot'n Comms Disturb	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 6.3-1 Output Matrix Protection Comms Alarm / Virtual Mapping

Parameter	Value
Prot'n Address	1
Prot'n Comms Alarm	Enabled
Prot'n Comms Alarm Delay	5s
Prot'n Test Mode	Off

Figure 6.3-2 Protection Comms Alarm settings

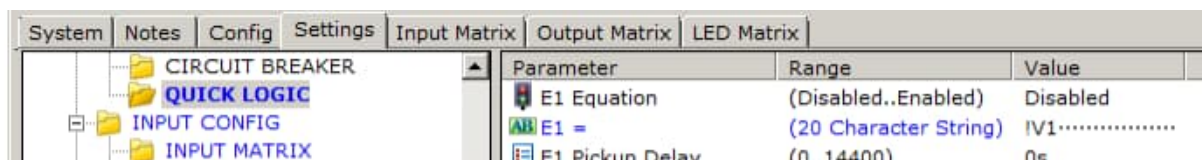


Figure 6.3-3 Quick Logic Equation E1 Programming

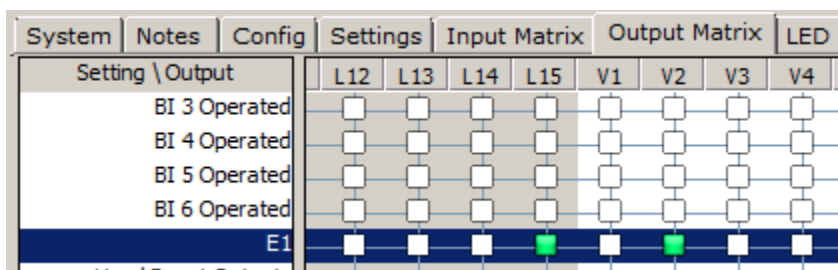


Figure 6.3-4 Output Matrix Equation E1 / Virtual 2 & LED Mapping

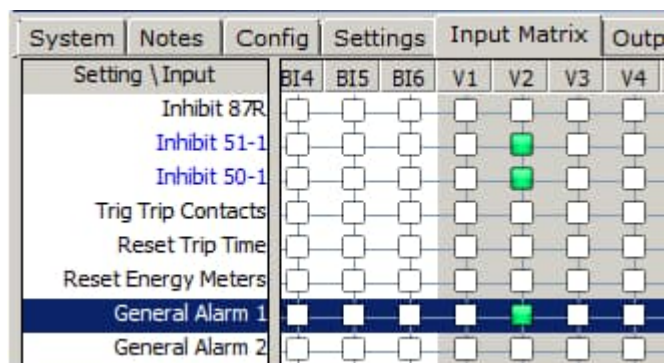


Figure 6.3-5 Input Matrix Equation Virtual / Overcurrent Inhibit 51-1 & 50-1 with Alarm 1 Mapping

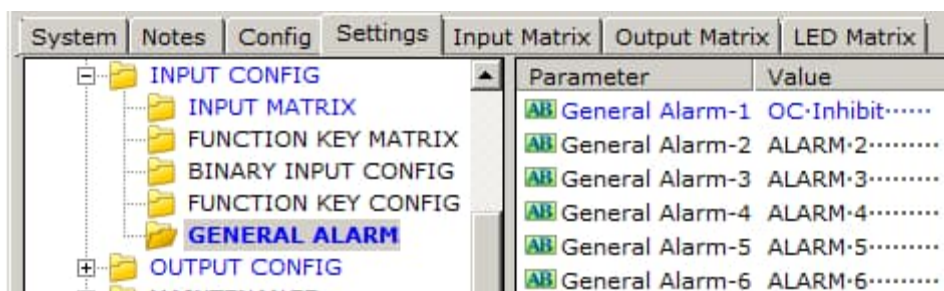


Figure 6.3-6 General Alarm 1 & Overcurrent Inhibit suitable text

6.4 Guard Operation

Generally Guard Operation is not required for this relay as the Protection Data Communications is extremely reliable. The relay's ability to detect Protection Data Signal Loss will inhibit differential operation if there is a break in Protection Communication between relays. However, in areas where there is perceived to be a possibility of loss of data frame synchronisation, it is possible to use over-current elements in conjunction with differential elements to formulate a Guard feature and hence avoid any unwanted relay operation.

This can be achieved by utilising a Quick Logic equation. This example uses a 50-1 DTL element and also an 87L-1 differential element to logically AND together in an equation. The current has to be above the 50-1 setting and there must also be a difference between local and remote current to produce an 87L-1 differential output. These two parameters when energised will render the equation to be 'true' and hence operate a circuit-breaker.

System	Notes	Config	Settings	Input Matrix			Output Matrix			LED Matrix		
Setting \ Output		L5	L6	L7	L8	L9	V1	V2	V3	V4	V5	V6
	85R-6	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	87L-1	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐
	51-1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	50-1	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	General Pickup	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 6.4-1 Output Matrix Element Mapping

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix
Settings				Parameter	Range	Value
SYSTEM CONFIG				Quick Logic	(Disabled..Enabled)	Enabled
CT/VT CONFIG				E1 Equation	(Disabled..Enabled)	Enabled
FUNCTION CONFIG				E1 =	(20 Character St...	V1.V2
PROT'N COMMS				E1 Pickup Delay	(0..14400)	0s
DIFFERENTIAL PROT'N				E1 Droptoff Delay	(0..14400)	0s
CURRENT PROT'N				E1 Counter Target	(1..999)	1
CONTROL & LOGIC				E2 Equation	(Disabled..Enabled)	Disabled
MANUAL CB CONTROL				E3 Equation	(Disabled..Enabled)	Disabled
CIRCUIT BREAKER				E4 Equation	(Disabled..Enabled)	Disabled
QUICK LOGIC						

Figure 6.4-2 Quick Logic Equation

System	Notes	Config	Settings	Input Matrix					Output Matrix				LED Matrix		
Setting \ Output		BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	L1	L2	L3	L4	L5	L6
BI 3 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 4 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 5 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 6 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
E1		☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒
Hand Reset Outputs		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 6.4-3 Output Matrix Equation / BO Mapping

The differential elements are automatically blocked if a protection signalling disturbance occurs; i.e. a discrete guard element does not have to be set to ensure stability.

6.6.1 External Inter-trip example using separate CB Fail device.

The CBs of both Local and Remote Relays can be operated by a single external device e.g. CB Fail relay, via suitable relay programming.

The following example assumes a CB Fail Relay connected to the Binary Input BI 1 of the Local Relay. Once this BI 1 is energised, Binary Output contact BO 2 is operated which in turn opens the Local CB, see Figure 6.6.1-1. At the same time a signal is sent to the Remote Relay via inter-trip channel 85S-4, see Figure 6.6.1-2. This is received in the Remote Relay and is mapped in the Output Matrix to Binary Output BO 2 which in turn opens the Remote CB, see Figure 6.6.1-3.

Setting \ Output	BO1	BO2	BO3	BO4	BO5	BO6	BO7
Close CB Blocked	☐	☐	☐	☐	☐	☐	☐
CB Alarm	☐	☐	☐	☐	☐	☐	☐
Close CB	☐	☐	☐	☐	☐	☐	☐
Open CB	☐	☐	☐	☐	☐	☐	☐
Phase A	☐	☐	☐	☐	☐	☐	☐
Phase B	☐	☐	☐	☐	☐	☐	☐
Phase C	☐	☐	☐	☐	☐	☐	☐
Start Count Alarm	☐	☐	☐	☐	☐	☐	☐
User Output 1	☐	☐	☐	☐	☐	☐	☐
User Output 2	☐	☐	☐	☐	☐	☐	☐
User Output 3	☐	☐	☐	☐	☐	☐	☐
User Output 4	☐	☐	☐	☐	☐	☐	☐
User Output 5	☐	☐	☐	☐	☐	☐	☐
User Output 6	☐	☐	☐	☐	☐	☐	☐
User Output 7	☐	☐	☐	☐	☐	☐	☐
User Output 8	☐	☐	☐	☐	☐	☐	☐
E/F Out	☐	☐	☐	☐	☐	☐	☐
New Wave Stored	☐	☐	☐	☐	☐	☐	☐
New Fault Stored	☐	☐	☐	☐	☐	☐	☐
Out Of Service Mode	☐	☐	☐	☐	☐	☐	☐
Local Mode	☐	☐	☐	☐	☐	☐	☐
Remote Mode	☐	☐	☐	☐	☐	☐	☐
BI 1 Operated	☐	☒	☐	☐	☐	☐	☐

Figure 6.6.1-1 Local Relay Output Matrix Mapping

Setting \ Input	BI1	BI2	BI3	BI4	BI5	BI6	V1	V2
Line Check	☐	☐	☐	☐	☐	☐	☐	☐
85S-1	☐	☐	☐	☐	☐	☐	☐	☐
85S-2	☐	☐	☐	☐	☐	☐	☐	☐
85S-3	☐	☐	☐	☐	☐	☐	☐	☐
85S-4	☒	☐	☐	☐	☐	☐	☐	☐
85S-5	☐	☐	☐	☐	☐	☐	☐	☐
85S-6	☐	☐	☐	☐	☐	☐	☐	☐

Figure 6.6.1-2 Local Relay Input Matrix Mapping

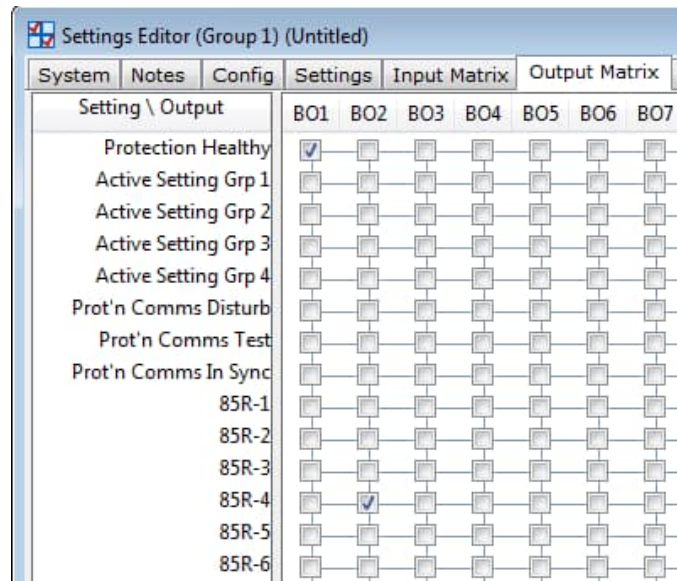


Figure 6.6.1-3 Remote Relay Output Matrix Mapping

6.6.2 Inter-trip example using Fascia Function Keys to operate CBs.

The CBs of both Local and Remote Relays can be operated by the operation of a fascia Function Key. Local Control of CBs can be achieved by programming function keys F1 & F2 as shown in Figure 6.6.2-1. & Figure 6.6.2-2.

Function Keys F3 & F4 on the local relay can be used to control the remote relay CB as shown in Figure 6.6.2-3 to Figure 6.6.2-7. This is achieved by utilising a Quick Logic equations E1 & E2 set-up to provide an output in the Output Matrix when a Function Key is pressed. The equation E1 is set-up as in Figure 6.6.2-3, such that when Function Key F3 is pressed, E1 is 'True' producing an output which is mapped in the Output Matrix to V1, see Figure 6.6.2-5. Similarly with F4 pressed, E2 is 'True' producing an output which is mapped in the Output Matrix to V2. These Virtuals connect to the Input Matrix and are mapped to Inter-trip channels 85S-5 & 85S-6. These send the inter-trip signal to the Remote Relay Output Matrix 85R-5 & 85R-6 see Figure 6.6.2-6, which are in-turn mapped to Binary Output contacts BO4 & BO5, these could be connected to the CB trip and close coils.

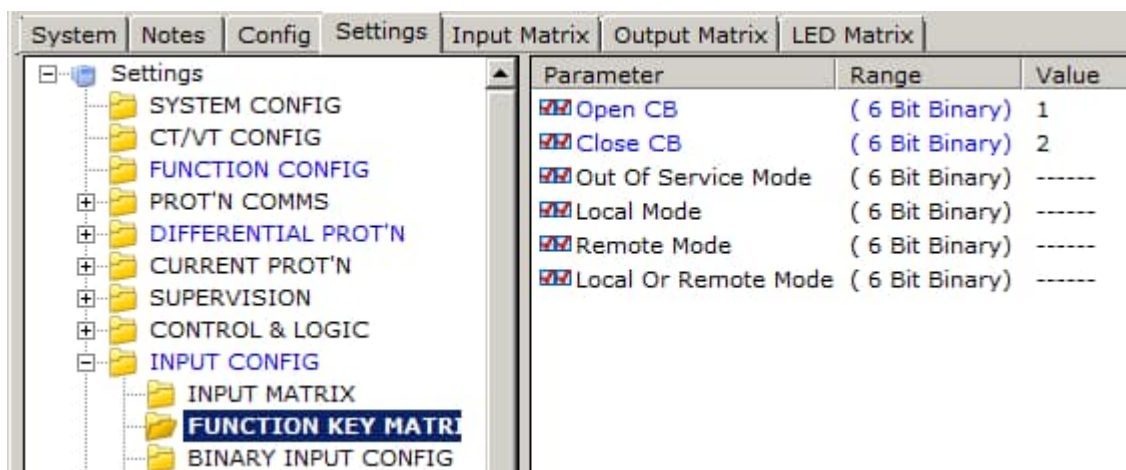


Figure 6.6.2-1 Local Relay Function Key Programming for Local CB Control

System	Notes	Config	Settings	Input	
Setting \ Output		BO1	BO2	BO3	BO4
87L-1		☐	☒	☐	☒
General Pickup		☐	☐	☐	☐
Trip Time Alarm		☐	☐	☐	☐
CB Open		☐	☐	☐	☐
CB Closed		☐	☐	☐	☐
Close CB Blocked		☐	☐	☐	☐
CB Alarm		☐	☐	☐	☐
Open CB		☐	☒	☐	☒
Start Count Alarm		☐	☐	☐	☐
User Output 1		☐	☐	☐	☐
User Output 2		☐	☐	☐	☐
User Output 3		☐	☐	☐	☐
User Output 4		☐	☐	☐	☐
User Output 5		☐	☐	☐	☐
User Output 6		☐	☐	☐	☐
User Output 7		☐	☐	☐	☐
User Output 8		☐	☐	☐	☐
Manual Close CB		☐	☐	☒	☐
79 Block Extern		☐	☐	☐	☐

Figure 6.6.2-2 Local Relay Binary Output Mapping for Local CB Control

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix																																	
Settings SYSTEM CONFIG CT/VT CONFIG FUNCTION CONFIG PROT'N COMMS DIFFERENTIAL PROT'N CONTROL & LOGIC AUTORECLOSE PROT'N AUTORECLOSE CONFIG MANUAL CB CONTROL CIRCUIT BREAKER QUICK LOGIC				<table><tr><th>Parameter</th><th>Range</th><th>Value</th></tr><tr><td> Quick Logic</td><td>(Disabled..Enabled)</td><td>Enabled</td></tr><tr><td> E1 Equation</td><td>(Disabled..Enabled)</td><td>Enabled</td></tr><tr><td> E1 =</td><td>(20 Character String)</td><td>F3.....</td></tr><tr><td> E1 Pickup Delay</td><td>(0..14400)</td><td>0s</td></tr><tr><td> E1 Dropoff Delay</td><td>(0..14400)</td><td>0.5s</td></tr><tr><td> E1 Counter Target</td><td>(1..999)</td><td>1</td></tr><tr><td> E2 Equation</td><td>(Disabled..Enabled)</td><td>Enabled</td></tr><tr><td> E2 =</td><td>(20 Character String)</td><td>F4.....</td></tr><tr><td> E2 Pickup Delay</td><td>(0..14400)</td><td>0s</td></tr><tr><td> E2 Dropoff Delay</td><td>(0..14400)</td><td>0.5s</td></tr></table>			Parameter	Range	Value	Quick Logic	(Disabled..Enabled)	Enabled	E1 Equation	(Disabled..Enabled)	Enabled	E1 =	(20 Character String)	F3.....	E1 Pickup Delay	(0..14400)	0s	E1 Dropoff Delay	(0..14400)	0.5s	E1 Counter Target	(1..999)	1	E2 Equation	(Disabled..Enabled)	Enabled	E2 =	(20 Character String)	F4.....	E2 Pickup Delay	(0..14400)	0s	E2 Dropoff Delay	(0..14400)	0.5s
Parameter	Range	Value																																					
Quick Logic	(Disabled..Enabled)	Enabled																																					
E1 Equation	(Disabled..Enabled)	Enabled																																					
E1 =	(20 Character String)	F3.....																																					
E1 Pickup Delay	(0..14400)	0s																																					
E1 Dropoff Delay	(0..14400)	0.5s																																					
E1 Counter Target	(1..999)	1																																					
E2 Equation	(Disabled..Enabled)	Enabled																																					
E2 =	(20 Character String)	F4.....																																					
E2 Pickup Delay	(0..14400)	0s																																					
E2 Dropoff Delay	(0..14400)	0.5s																																					

Figure 6.6.2-3 Local Relay Quick Logic E1 & E2 Programming for Remote Relay CB control

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix																								
Settings SYSTEM CONFIG CT/VT CONFIG FUNCTION CONFIG PROT'N COMMS DIFFERENTIAL PROT'N CONTROL & LOGIC AUTORECLOSE PROT'N AUTORECLOSE CONFIG MANUAL CB CONTROL CIRCUIT BREAKER QUICK LOGIC INPUT CONFIG INPUT MATRIX FUNCTION KEY MATRIX BINARY INPUT CONFIG FUNCTION KEY CONF GENERAL ALARMS <table><thead><tr><th>Parameter</th><th>Range</th><th>Value</th></tr></thead><tbody><tr><td> Function Key 1 Text</td><td>(20 Character String)</td><td>F1·Open·CB·····</td></tr><tr><td> Function Key 2 Text</td><td>(20 Character String)</td><td>F2·Close·CB·····</td></tr><tr><td> Function Key 3 Text</td><td>(20 Character String)</td><td>F3·Rem·Open·CB·····</td></tr><tr><td> Function Key 4 Text</td><td>(20 Character String)</td><td>F4·Rem·Close·CB·····</td></tr><tr><td> Function Key 5 Text</td><td>(20 Character String)</td><td>Function·Key·5·····</td></tr><tr><td> Function Key 6 Text</td><td>(20 Character String)</td><td>Function·Key·6·····</td></tr><tr><td> Enabled In Remote</td><td>(6 Bit Binary)</td><td>-----</td></tr></tbody></table>				Parameter	Range	Value	Function Key 1 Text	(20 Character String)	F1·Open·CB·····	Function Key 2 Text	(20 Character String)	F2·Close·CB·····	Function Key 3 Text	(20 Character String)	F3·Rem·Open·CB·····	Function Key 4 Text	(20 Character String)	F4·Rem·Close·CB·····	Function Key 5 Text	(20 Character String)	Function·Key·5·····	Function Key 6 Text	(20 Character String)	Function·Key·6·····	Enabled In Remote	(6 Bit Binary)	-----			
Parameter	Range	Value																												
Function Key 1 Text	(20 Character String)	F1·Open·CB·····																												
Function Key 2 Text	(20 Character String)	F2·Close·CB·····																												
Function Key 3 Text	(20 Character String)	F3·Rem·Open·CB·····																												
Function Key 4 Text	(20 Character String)	F4·Rem·Close·CB·····																												
Function Key 5 Text	(20 Character String)	Function·Key·5·····																												
Function Key 6 Text	(20 Character String)	Function·Key·6·····																												
Enabled In Remote	(6 Bit Binary)	-----																												

Figure 6.6.2-4 Local Relay Suitable Text for Function Key Operation Description

System	Notes	Config	Settings	Input Matrix			Output Matrix			LED
Setting \ Output		B	L14	L15	V1	V2	V3	V4	V5	V6
New Wave Stored		☐	☐	☐	☐	☐	☐	☐	☐	☐
New Fault Stored		☐	☐	☐	☐	☐	☐	☐	☐	☐
Out Of Service Mode		☐	☐	☐	☐	☐	☐	☐	☐	☐
Local Mode		☐	☐	☐	☐	☐	☐	☐	☐	☐
Remote Mode		☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 1 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 2 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 3 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 4 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 5 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐
BI 6 Operated		☐	☐	☐	☐	☐	☐	☐	☐	☐
E1		☐	☐	☒	☐	☐	☐	☐	☐	☐
E2		☐	☐	☐	☒	☐	☐	☐	☐	☐
E3		☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 6.6.2-5 Local Relay E1 & E2 Output Matrix Mapping to Virtual Connections

System	Notes	Config	Settings	Input Matrix			Output		
Setting \ Input		BI1	BI2	BI3	BI4	BI5	BI6	V1	V2
	85S-1	☐	☐	☐	☐	☐	☐	☐	☐
	85S-2	☐	☐	☐	☐	☐	☐	☐	☐
	85S-3	☐	☐	☐	☐	☐	☐	☐	☐
	85S-4	☐	☐	☐	☐	☐	☐	☐	☐
	85S-5	☐	☐	☐	☐	☐	☐	☒	☐
	85S-6	☐	☐	☐	☐	☐	☐	☐	☒
	Inhibit 87L-1	☐	☐	☐	☐	☐	☐	☐	☐

Figure 6.6.2-6 Local Relay Input Matrix Mapping Inter-trip 85S-5 & 85S-6 to Remote Relay

System	Notes	Config					Settings					Input Matrix					Output Matrix					LED Matrix				
Setting \ Output		BO4	BO5	BO6	BO7	BO8	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13							
85R-4		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐							
85R-5		☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐							
85R-6		☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒							
87HS-1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐							
87HS-2		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐							
87L-1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐							
87L-2		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐							
87R-1		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐							
87R-2		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐							

Figure 6.6.2-7 Remote Relay Output Matrix Inter-trip Mapping 85R-5 & 85R-6 to BO4 & BO5

Section 7: Differential Protection Settings For Feeder Circuits

The relay provides protection for two ended sub-transmission and distribution feeders. It combines current differential feeder protection with back-up over current and earth-fault protection suitable for these feeders. There are various primary circuit types each requiring specific considerations.

These include: -

- Plain poly-phase Tri-foil cable Feeders.
- Phase segregated, single phase cables Feeders.
- Overhead line feeders.
- A Feeder with a mixture of the above.

Each of these configurations is discussed below:

Special consideration is also given to earth-fault protection provided by the relay for different network designs with respect to the method of grounding. The feeder charging current will have the most impact on the minimum differential setting that may be chosen.

7.1 Capacitive Charging Current – Cable and Hybrid Feeders

Significant Charging currents are to be expected on cable or hybrid (a mix of cable and over head line) feeder circuits. Pure overhead line feeders will not have significant charging currents and will not generally affect the lowest differential setting that may be chosen. The cable charging current will increase linearly with circuit length. The capacitive charging current is at leading power factor to the feeder load current and has the affect of causing a phase and magnitude difference to arise between the current measured at each end of the feeder. This normal steady state difference in currents will have an impact on the minimum differential settings that may be used.

The relay must be set with a P/F Differential setting that must be minimum multiple of the steady state charging current. The steady state charging current may be calculated from the cable data and the circuit length. This multiple of charging current is necessary to accommodate transient charging current, steady state charging current and rises in phase to neutral voltages during system faults.

Typical figures are in terms of a multiple of the steady state feeder charging current (I_c).

Feeder Type and System Earth Method	Pure Cable Feeder	Hybrid Feeder (OHL+Cable)	Pure OHL Feeder
Solidly Earthed	2.5 x I_c	4 x I_c	4 x I_c
Resistance Earthed	4 x I_c	4 x I_c	4 x I_c
Reactance Earthed	5 x I_c	5 x I_c	5 x I_c
Isolated	5 x I_c	5 x I_c	5 x I_c

A significant transient charging current will flow a cable feeder is first energised. The relay digital filtering is designed to remove almost all of this transient current. The frequency of this current tends to be a high multiple of power system frequency. Therefore the steady state charging current only need to be considered when selecting the differential setting.

The revision of the relay software installed, may be found moving to the top of the menu structure to display the relay identifier and holding the [Cancel] and [Test/Reset] pushbuttons depressed or by selecting [Relay] [Information][Get System Information] in Reydisp Evolution. If the setting file for the relay is saved, open the .set file in Reydisp Evolution, clicking on the Info (i) tab at the top right hand corner of the “Settings Editor” window. The Software Revision should now be displayed in the “Settings Source Information” window.

These above figures include provision for transient increases in healthy phase charging current during external earth-faults on non-effectively earthed power systems.

Some typical Examples of Cable Charging Currents are given in the Table below:

Voltage kV	Charging current (A) per km
3.3	0.2 to 0.7
6.6	0.5 to 1.6
11	0.7 to 2.4
22	1.1 to 3.2
33	1.3 to 3.5
66	4 to 7.5
132	5 to 11
220	10 to 20
400	15 to 30

The above figures are for single cables only. Where two cables per phase are used the feeder charging current will double. The highest charging current figures at the top end of the range are for the largest cross-sectional area single core cables and for small diameter three core cables at the bottom of the table. If the charging current is not known the top figure in the range may be used with confidence, as it will tend to overestimate the feeder charging current and set the relay to a more stable differential setting.

The above table should only be used as a worst case estimate. For optimum relay settings the differential setting to select should be based on a multiple on the true charging current or susceptance of the cable.

7.2 Plain Poly Phase Cable Feeders

This type of cable is usually used at 33 kV and below. The reactance of these cables tends to be low as the phase currents tend to cancel in each cable. The X/R of the external fault to use in the CT formula will tend towards the cable X/R if the cable exceeds 2 km to 3 km. This assists in reducing the CT requirements.

7.3 Single Phase Cable Feeders

The major difference between this type of circuit and poly-phase cable circuits, is that the transient and steady state charging current will be higher. The charging current will rise with rated voltage and the length of the circuit. The variable setting relay is recommended for this type of circuit, as it offers the flexibility to cope with a variable level of charging current. The P/F differential setting must be set above the charging current on the feeder. The waveform recorder in the relay can be used to assess the magnitude of charging current. Several Cables per phase may be used and this may increase overall charging current by a multiple of a single cable.

The P/F Differential should be set as per the recommendations in 6.1.

The cable X/R will reduce the external fault X/R to a significant extent if the cable is more than a few kilometres in length.

7.4 Overhead Line Feeder

The relay is suitable for protecting circuits of this type. The settings can be set more sensitively than for cable feeders as charging current is much lower. The P/F differential setting may need to be set towards the lower settings of 10% to 20% to cover arc resistance and/or resistively earthed neutral. The Slope 1 Setting should also be set to 20% and the Bias Break Point may need to be set to 1.0, 1.5 or 2.0 to allow for load current flow during the internal earth-fault. The Bias Break Point will usually have to be set higher for overhead lines, than for cable circuits, to allow for load bias during a high resistance earth-fault on the feeder.

7.5 Earth Fault Sensitivity

The method adopted for earthing the power system network will determine the amount of fault current available to operate the differential elements. As mentioned above care must be taken when assessing the best combination of settings to use.

Network feeder circuits of the type that this relay is likely to be applied on, e.g. 3 kV to 150 kV, may operate with their neutral points either solidly earthed (typical for the 150 kV end of the range), unearthed (often employed in the middle range of distribution voltage ratings) and impedance earthed at the lower end.

This must be considered when selecting and applying the relay, as outlined below: -

7.5.1 Solid or Effective Neutral Earthing

Solid earthing will normally result in earth fault levels of a similar magnitude or just above the three phase faults. Low impedance earthed generators are normally designed to allow fault current of the order of magnitude of the source incoming circuit rating, typical values being in the range of 100 A to 1600 A.

In either case, solid or low impedance, the standard basic relay, with fixed or variable settings should provide adequate sensitivity for earth faults. Both the differential and the back-up non-unit protection will provide sensitive protection.

For low impedance earthed networks it is only necessary to ensure that the current transformer primary rating and ratio is compatible with the earth fault current, or is of a lower value.

Example: maximum fault current – 800 A
CT ratio $\leq 800/1$ (or 5)

For low impedance earthed networks it is recommended that the differential sensitivity be no more than 80% of the minimum earth fault current. The relay with variable differential settings should allow this to be met.

7.5.2 High Impedance and Resistance Earthed Neutrals

This method is often employed in medium voltage power system, where the fault current in each source neutral is limited to a low value, for reasons of safety and to limit fault damage.

The fault current may be of the order of 100 to 1000 A.

In this type of network, with feeders typically rated 400 A to 800 A and CT ratios chosen appropriately, e.g. 800/400/1 or 5 A, the earth fault current may not be sufficient to operate relay models from the basic range. The minimum relay setting is 10% of nominal current rating for both the differential (i.e. variable setting models) and back-up protection.

For transformer feeders, an earth fault part way into the transformer winding would result in a much lower proportion of maximum fault current. For Delta windings this is usually acceptable, whereas for star connected windings a separate more sensitive restricted earth fault protection is normally provided.

For plain feeders, acceptable settings to apply to the relay are as follows: -

Example:

Maximum earth fault from one source = 40 A
CT ratio $\leq 100/1$ (or 100/5)

Relay settings: -

P/F Differential (I_S)	= $0.10 \times I_N$
Bias slope 1 (S_1)	= 20%
Bias slope 2 (S_2)	= 150%
Bias Break Point (B_2)	= $2.0 \times I_N$

Example - 33kV Earth Fault on Resistance Earthed Cable Feeder

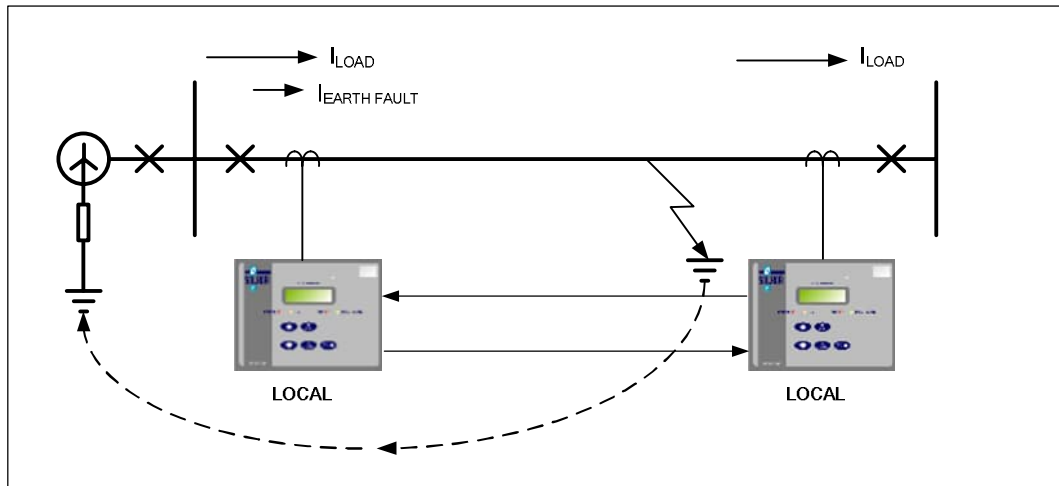


Figure 7.5.2-1 Earth Fault with load bias for Resistance Earthed System

Circuit Parameters:

33 kV Cable Length	= 7 km
Load prior to Fault inception	= 700 A
Load during Earth Fault	≈ 600 A
Circuit Rating	= 800 A
CT Ratio	= 1200/1
Maximum Feeder Earth Fault level	= 800 A (two transformers)
Minimum Feeder Earth Fault Level	= 400 A (one transformer)
Charging Current per cable	= 4.5 A per km

At the fault point the phase to neutral voltage may not fall significantly and therefore load current will continue to flow through the radial cable to the load during the earth fault. The load will usually reduce, but the full circuit rating is used to calculate the fault position on the relay bias characteristic, as this will test the relay setting for the worst case. At one end of the feeder only the load current will be measured. At the other end the load and the superimposed fault current will flow.

As the system is radial the phase comparator will generally not operate as the fault current and load is often of a very similar power factor. Therefore it is essential the relay is set to ensure this minimum earth fault level is detected by the magnitude comparator.

Secondary Currents under Fault conditions:

For a minimum earth fault of 400 A, the currents measured by the relays at either end of the feeder will be: -

$$\text{Local End} = 600 \text{ A} + 400 \text{ A} = 1000 \text{ A} / 1200 = 0.833 \text{ A}$$

$$\text{Remote End} = 600 \text{ A} / 1200 = 0.500 \text{ A}$$

$$\text{Restraint or Bias Current} = (0.833 + 0.500) / 2 = 0.666\text{A}$$

$$\text{Differential Current} = 0.833 - 0.500 = 0.333 \text{ A}$$

The measured relay point is therefore 0.333 A differential current at bias current 0.666 A.

This can be compared graphically with the relay default P/F Diff. Setting of 0.3xIn and 30% Slope.

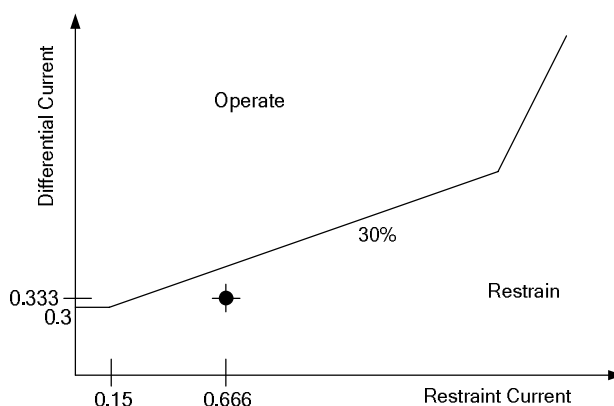


Figure 7.5.2-2 Setting of P/F Diff. Setting for Load Bias

It is clear that the relay will not operate for this fault. To detect this level of fault the relay P/F Differential and/or Slope 1 setting must be reduced. This setting must be set in excess of the multiple of steady state charging current required by the relay to ensure stable operation. For relays with shaped current magnitude comparators the required minimum limit is $4 \times I_c$, where I_c is the steady state cable charging current of the feeder.

Cable Charging Current:

The P/F Differential Setting $> 4 \times$ charging current [Resistance Earthed System]

The secondary charging current can be estimated to be: $7 \text{ km} \times 4.5 \text{ A} \times 1/1200 = 0.0263 \text{ A}$

P/F Differential Setting $> 4 \times 0.0263 \text{ A} / \text{rated current} = 0.106 \times I_N$

The relay should be set to the next highest Differential Setting of $0.15 \times I_N$

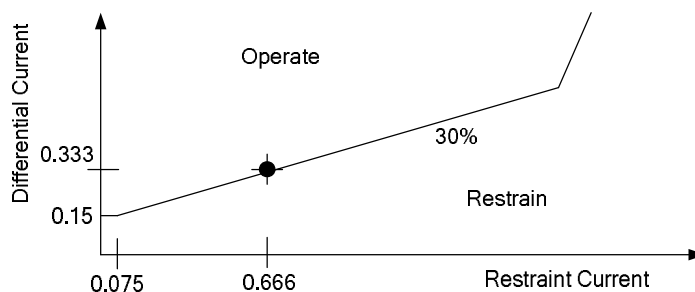


Figure 7.5.2-3 Setting of Bias Slope for Load Bias

Shown graphically it is clear that it would be advantageous to reduce the bias slope.

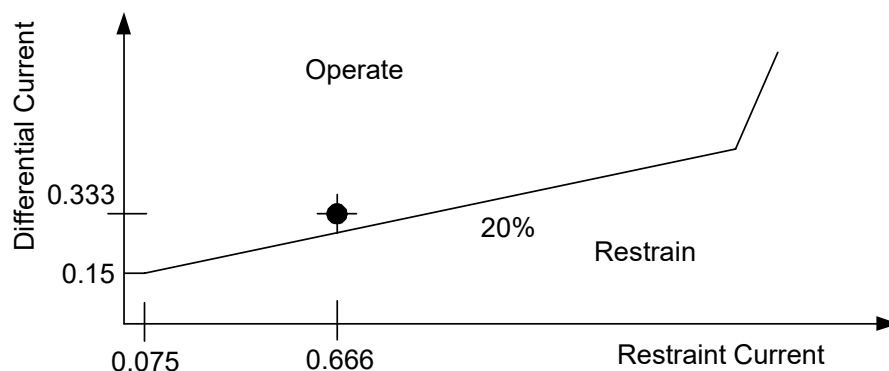


Figure 7.5.2-4 Settings for correct Load Bias

To allow operation of the relay for this minimum earth fault the Bias Break Point must be set to $1.0 \times I_N$ or above. A setting of $1 \times I_N$, rather than $1.5 \times I_N$, would be selected as this help lower the CT requirements. The Figure below, Figure 7.5.2-5, shows the effect of settings applied for detecting earth faults on resistance earthed systems. It also shows the fault point for the above example:

Where the relay is used on interconnected systems and the fault current is fed from both ends of the feeder (double end fed) the phase comparator will generally operate.

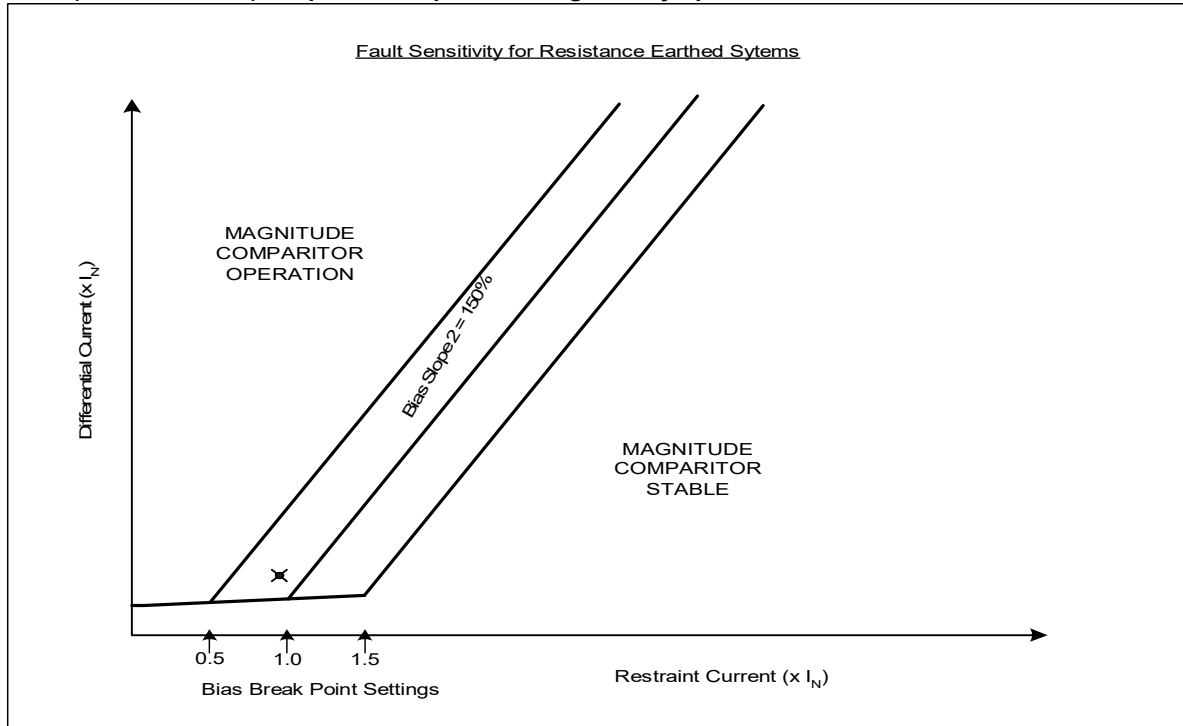


Figure 7.5.2-5 Setting of Bias Break Point for Load Bias

Figure 7.5.2-6 to Figure 7.5.2-8 show typical values chosen for the P/F Differential, Bias Slope 1 and Bias Break Point settings to allow an earth fault with some load biasing to be detected. Three typical relay settings used for resistance earthed systems are shown graphically, to assist with selecting appropriate settings.

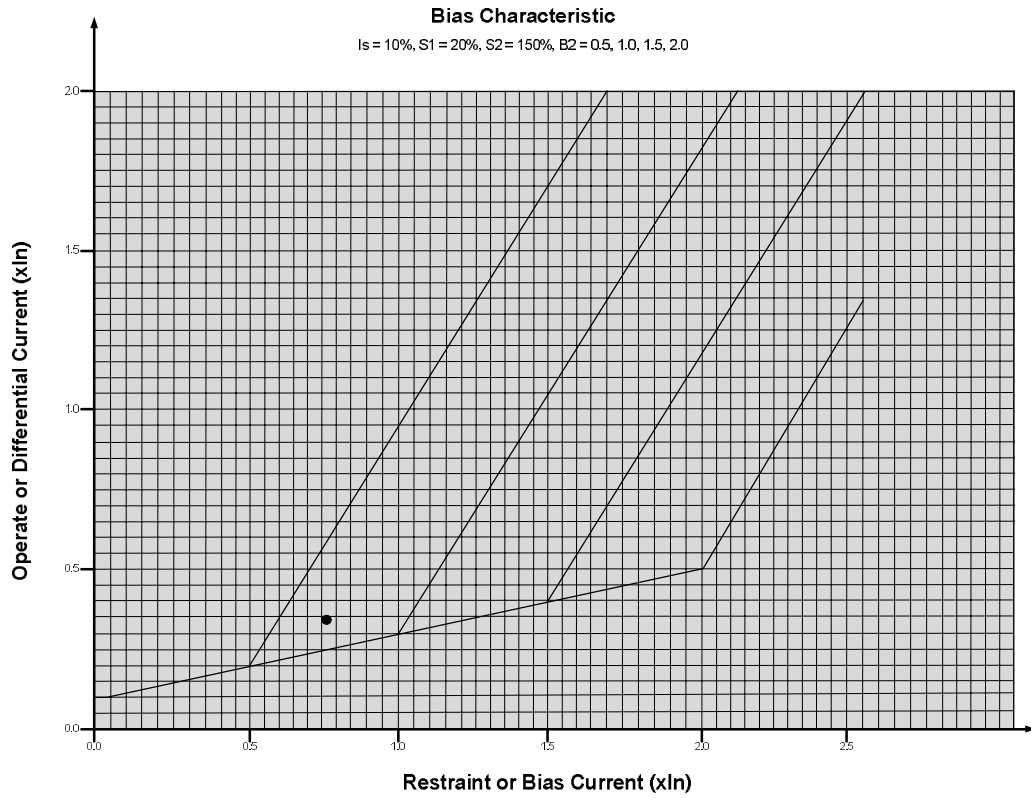


Figure 7.5.2-6 10% P/F Differential and Bias Break Point of 0.5, 1.0, 1.5 and 2.0

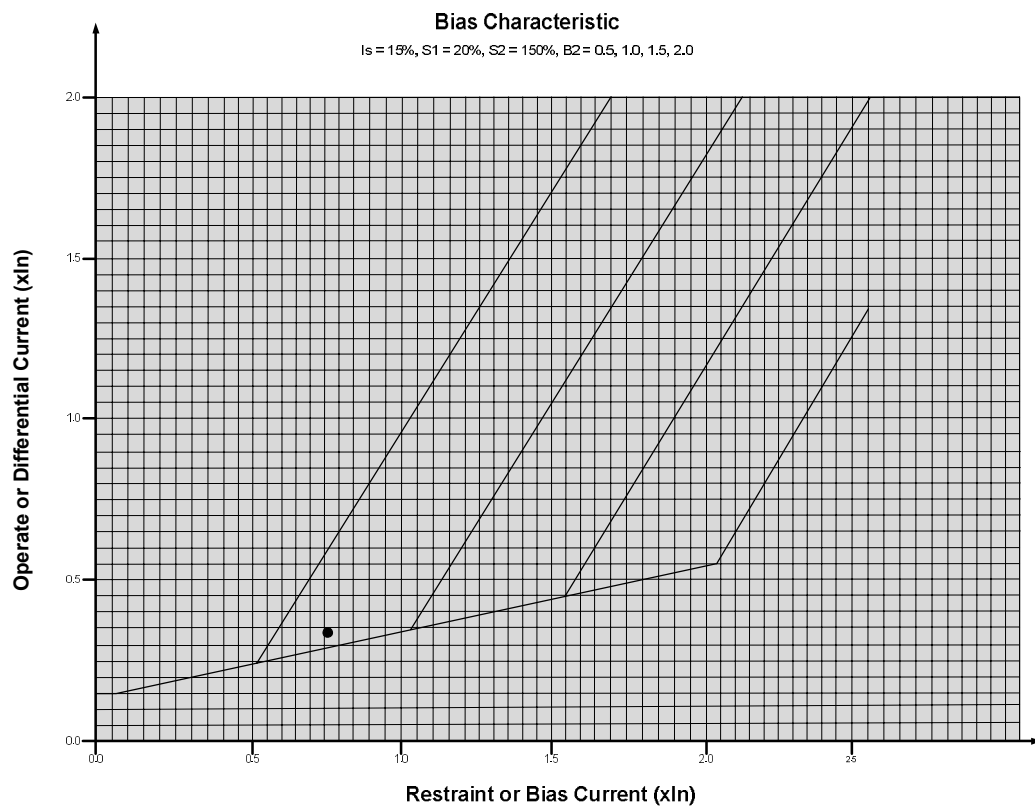


Figure 7.5.2-7 15% Differential and Bias Break Point of 0.5, 1.0, 1.5 and 2.0

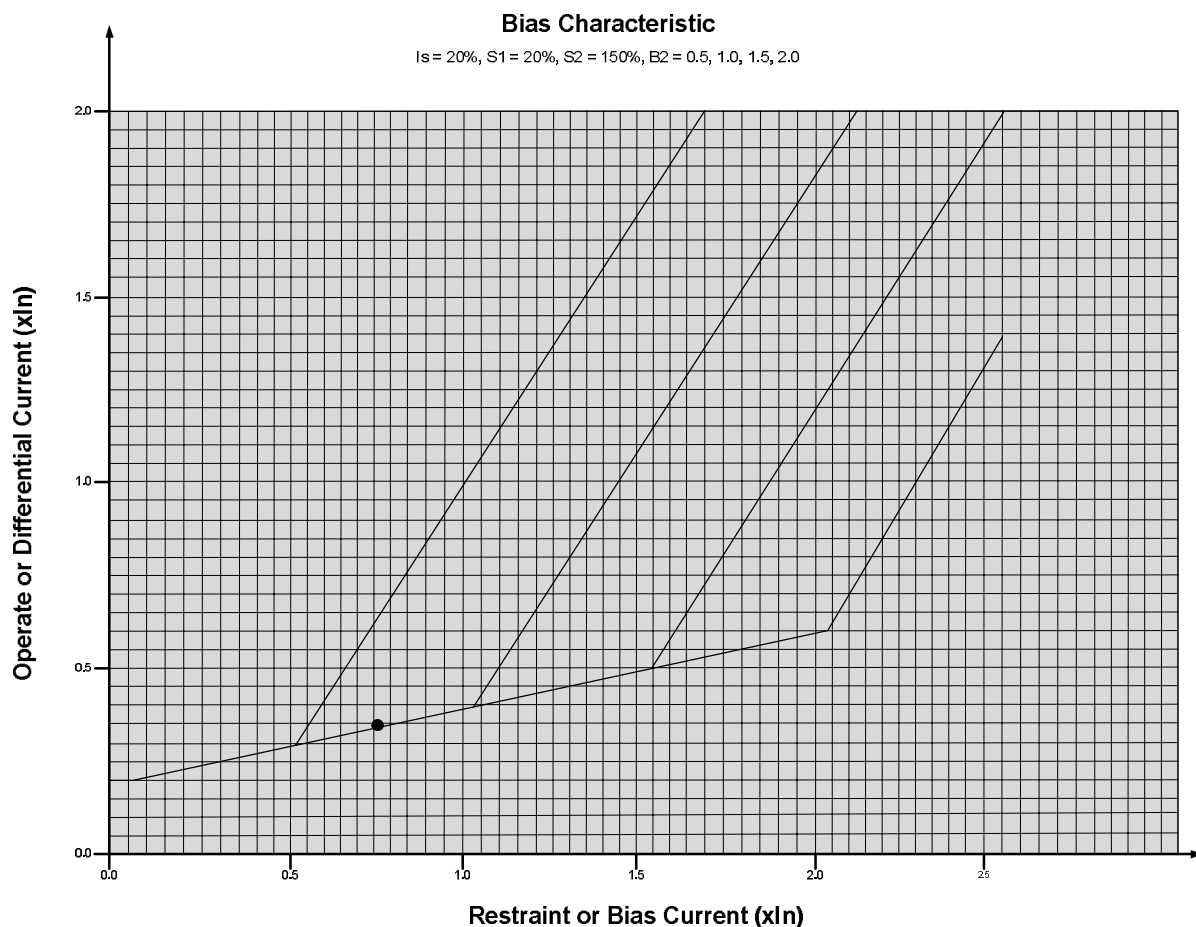


Figure 7.5.2-8 20% Differential and Bias Break Point of 0.5, 1.0, 1.5 and 2.0

7.5.3 Isolated (unearthed) and Reactance Earthing

For these networks, the intention is to ensure that an earthed live conductor does not result in any significant fault current and minimise interruptions to supply. Utility networks of this type do not normally include discriminating protection as a first level, e.g. whilst the network is earthed via a Peterson Coil (reactance earthing).

Often the earth fault position is found by applying a short to the neutral reactance after a time delay. If the fault is within the protected zone of the relay then the device would then trip. Often systems with this type of earthing will have “pecking” type faults that may lead to problems in grading different types of over current and earth fault relays. XLPE cable circuits typically have pecking faults where the arc is extinguished and the fault re-seals.

The reset of the relays may become out of step as the pulses of fault current usually are not long enough to allow relays to time out, and eventually this will often lead to loss of grading. Where circuits have pilot wires often this grading problem may be overcome by the use of this relay type.

For industrial networks, employing the isolated network neutral philosophy, it is usually intended that discriminating protection be employed if possible. This type of protection employs the detection of zero sequence fault current resulting from network cable capacitance, employing a core balance CT, and zero sequence voltage from a neutral displacement voltage transformer winding, in combination, to establish the position of a fault.

During the period where the system is earthed via a variable neutral reactance, the fault current pulse is usually long enough for this relay type to provide satisfactory earth fault protection on such a network. After the neutral control time delay has expired and the reactance earthed system becomes solidly earthed, the relay will operate and trip the faulted circuit.

Section 8: Control Functions

8.1 Auto-reclose Applications Guide

Automatic circuit reclosing is extensively applied to overhead line circuits where a high percentage of faults that occur are of a transient nature. By automatically reclosing the circuit-breaker the function attempts to minimise the loss of supply to the customer and reduce the need for manual intervention.

The function supports up to 4 Auto-reclose (AR) sequences. That is, 4 x Trip / Recloses (shots) followed by a Trip & Lockout. A lockout condition prevents any further attempts, automatic or manual, to close the circuit-breaker. The number of sequences selected depends upon the type of faults expected. If there are a sufficient percentage of semi-permanent faults which could be burnt away, e.g. fallen branches, a multi shot scheme would be appropriate. Alternatively, if there is a high likelihood of permanent faults, a single shot scheme would minimise the chances of causing damage by reclosing onto a fault. In general, 80% of faults will be cleared by a single Trip and Reclose sequence. A further 10% will be cleared by a second Trip and Reclose. Different sequences can be selected for different fault types (Phase/Earth faults and External control).

The Deadtime is the interval between the trip and the CB close pulse being issued. This is to allow for the line to go 'dead' after the fault is cleared. The delay chosen is a compromise between the need to return the line to service as soon as possible and prevented unnecessary trips through re-closing too soon. The Reclaim Time is the delay following a re-closure before the line can be considered back in service. This should be set long enough to allow for protection operation for the same fault, but not so long that two separate faults could occur in the same AR sequence and cause unnecessary lockouts.

The Sequence Fail Timer provides an overall maximum time limit on the AR operation. It should therefore be longer than all the set delays in a complete cycle of AR sequences; trip delays, Deadtimes, Reclaim Time etc. Generally this will only be exceeded if the circuit-breaker has either failed to open or close.

Since large fault currents could potentially damage the system during a prolonged AR sequence, there are also settings to identify which protection elements are High-sets and these can cause an early termination of the sequence.

Where a relay is to operate as part of an AR scheme involving a number of other relays, the feature attempts to clear any faults quickly without regard to normal fault current grading. It does this by setting each Trip element to be either Delayed or Instantaneous. Instantaneous Trips are set to operate at just above maximum load current with small delays while Delayed Trips are set to suit actual fault levels and with delays suitable for current grading.

A typical sequence would be 2 Instantaneous Trips followed by a Delayed Trip & Lockout: -

- When any fault occurs, the relay will trip instantaneously and then reclose.
- If this does not clear the fault, the relay will do the same again.
- If this still does not clear the fault, the fault is presumed to be permanent and the next Trip will be Delayed and so suitable for grading with the rest of the network. Thus allowing downstream protection time to operate.
- This Trip will Lockout the AR sequence and prevent further recloses.

It is important that all the relays in an AR scheme shadow this process – advancing through their own AR sequences when a fault is detected by an element pickup even though they are not actually causing 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 AR scheme must be set with identical Instantaneous and Delayed sequence of trips.

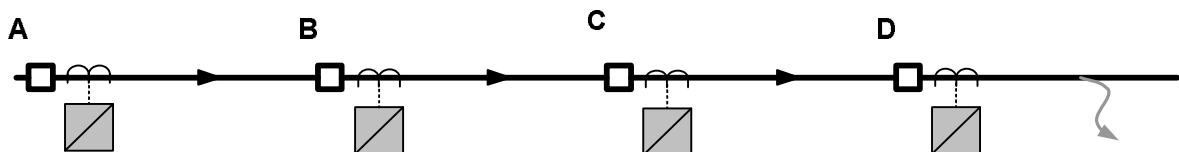


Figure 8.1-1 Sequence Co-ordination

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 recognise the sequence of Pick-up followed by current switch-off as AR 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 AR sequence such that the fault is cleared by the correct CB.

8.1.1 Basic Scheme

Simple auto-reclose scheme with different local and remote dead-times.

If local relay fails it will not stop remote relay from operating e.g. No inhibit from local relay.

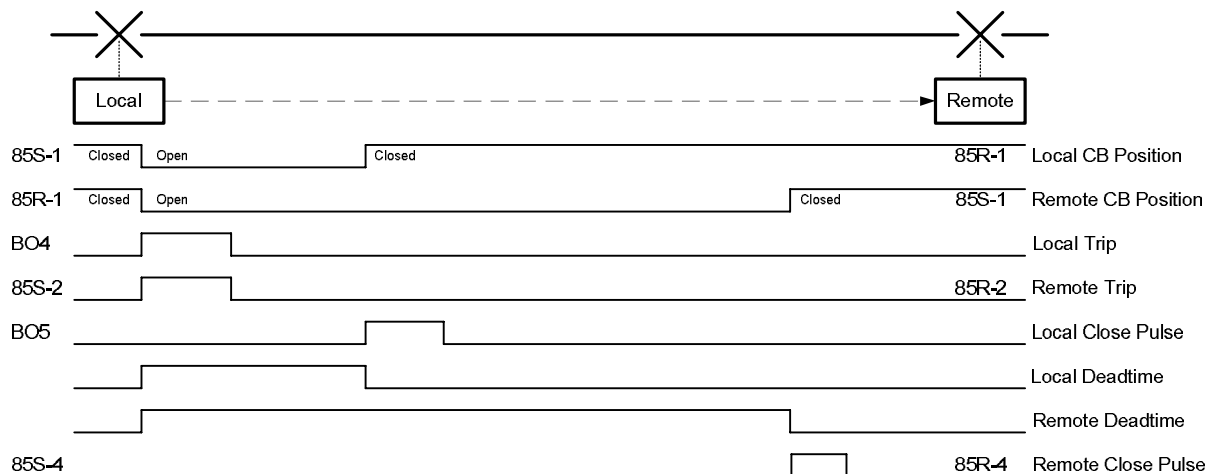


Figure 8.1.1-1 Events pulses

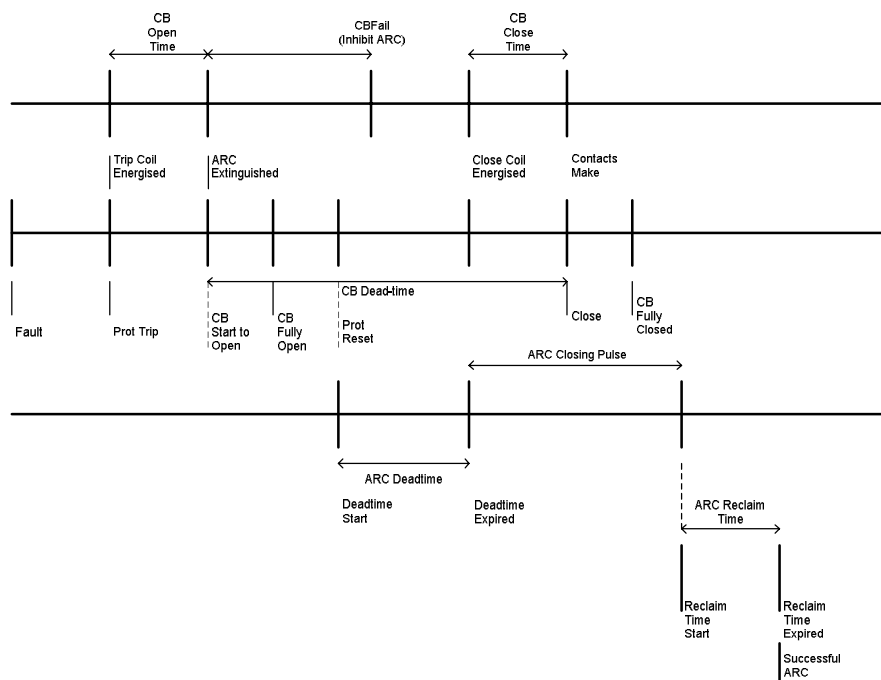


Figure 8.1.1-2 Sequence of events

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix																																																															
Settings SYSTEM CONFIG CT/VT CONFIG FUNCTION CONFIG PROT'N COMMS DIFFERENTIAL PROT'N CURRENT PROT'N SUPERVISION CONTROL & LOGIC INPUT CONFIG OUTPUT CONFIG MAINTENANCE DATA STORAGE COMMUNICATIONS				<table><tr><th>Parameter</th><th>Range</th><th>Value</th></tr><tr><td> Gn Prot'n Comms</td><td>(Enabled..Disabled)</td><td>Enabled</td></tr><tr><td> Gn Differential</td><td>(Enabled..Disabled)</td><td>Enabled</td></tr><tr><td> Gn Intertrip</td><td>(Enabled..Disabled)</td><td>Enabled</td></tr><tr><td> Gn Phase Overcurrent</td><td>(Enabled..Disabled)</td><td>Enabled</td></tr><tr><td> Gn Voltage Cont O/C</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn Cold Load</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn Derived E/F</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn Measured E/F</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn NPS Overcurrent</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn Under Current</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn Thermal</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn CB Fail</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn VT Supervision</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn CT Supervision</td><td>(Enabled..Disabled)</td><td>Enabled</td></tr><tr><td> Gn Broken Conductor</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn Trip Cct Supervision</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn Close Cct Supervis'n</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn Inrush Detector</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn CB Counters</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr><tr><td> Gn I^2t CB Wear</td><td>(Enabled..Disabled)</td><td>Disabled</td></tr></table>			Parameter	Range	Value	Gn Prot'n Comms	(Enabled..Disabled)	Enabled	Gn Differential	(Enabled..Disabled)	Enabled	Gn Intertrip	(Enabled..Disabled)	Enabled	Gn Phase Overcurrent	(Enabled..Disabled)	Enabled	Gn Voltage Cont O/C	(Enabled..Disabled)	Disabled	Gn Cold Load	(Enabled..Disabled)	Disabled	Gn Derived E/F	(Enabled..Disabled)	Disabled	Gn Measured E/F	(Enabled..Disabled)	Disabled	Gn NPS Overcurrent	(Enabled..Disabled)	Disabled	Gn Under Current	(Enabled..Disabled)	Disabled	Gn Thermal	(Enabled..Disabled)	Disabled	Gn CB Fail	(Enabled..Disabled)	Disabled	Gn VT Supervision	(Enabled..Disabled)	Disabled	Gn CT Supervision	(Enabled..Disabled)	Enabled	Gn Broken Conductor	(Enabled..Disabled)	Disabled	Gn Trip Cct Supervision	(Enabled..Disabled)	Disabled	Gn Close Cct Supervis'n	(Enabled..Disabled)	Disabled	Gn Inrush Detector	(Enabled..Disabled)	Disabled	Gn CB Counters	(Enabled..Disabled)	Disabled	Gn I^2t CB Wear	(Enabled..Disabled)	Disabled
Parameter	Range	Value																																																																			
Gn Prot'n Comms	(Enabled..Disabled)	Enabled																																																																			
Gn Differential	(Enabled..Disabled)	Enabled																																																																			
Gn Intertrip	(Enabled..Disabled)	Enabled																																																																			
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Gn Cold Load	(Enabled..Disabled)	Disabled																																																																			
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Gn Measured E/F	(Enabled..Disabled)	Disabled																																																																			
Gn NPS Overcurrent	(Enabled..Disabled)	Disabled																																																																			
Gn Under Current	(Enabled..Disabled)	Disabled																																																																			
Gn Thermal	(Enabled..Disabled)	Disabled																																																																			
Gn CB Fail	(Enabled..Disabled)	Disabled																																																																			
Gn VT Supervision	(Enabled..Disabled)	Disabled																																																																			
Gn CT Supervision	(Enabled..Disabled)	Enabled																																																																			
Gn Broken Conductor	(Enabled..Disabled)	Disabled																																																																			
Gn Trip Cct Supervision	(Enabled..Disabled)	Disabled																																																																			
Gn Close Cct Supervis'n	(Enabled..Disabled)	Disabled																																																																			
Gn Inrush Detector	(Enabled..Disabled)	Disabled																																																																			
Gn CB Counters	(Enabled..Disabled)	Disabled																																																																			
Gn I^2t CB Wear	(Enabled..Disabled)	Disabled																																																																			

Figure 8.1.1-3 Function Selection

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix						
Settings SYSTEM CONFIG CT/VT CONFIG FUNCTION CONFIG PROT'N COMMS PROTECTION COMMS INTERTRIP 85 DIFFERENTIAL PROT'N CURRENT PROT'N SUPERVISION CONTROL & LOGIC INPUT CONFIG OUTPUT CONFIG MAINTENANCE DATA STORAGE COMMUNICATIONS				<table><tr><th>Parameter</th><th>Range</th><th>Value</th></tr><tr><td> Gn 85</td><td>(Enabled..Disabled)</td><td>Enabled</td></tr></table>			Parameter	Range	Value	 Gn 85	(Enabled..Disabled)	Enabled
Parameter	Range	Value										
 Gn 85	(Enabled..Disabled)	Enabled										

Figure 8.1.1-4 Protection Comms / Inter-trip Enable Configuration

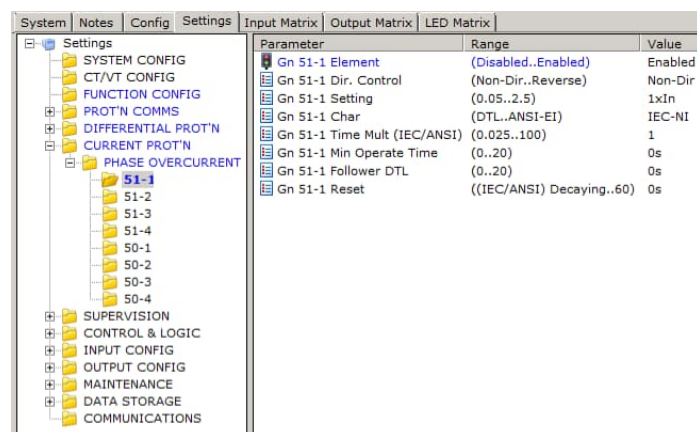


Figure 8.1.1-5 Overcurrent 51-1 Element Parameterisation

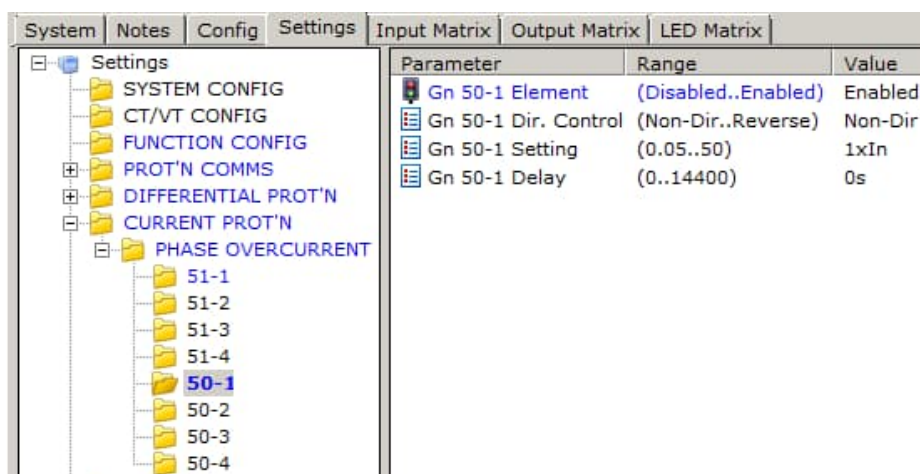


Figure 8.1.1-6 Overcurrent 50-1 Element Parameterisation

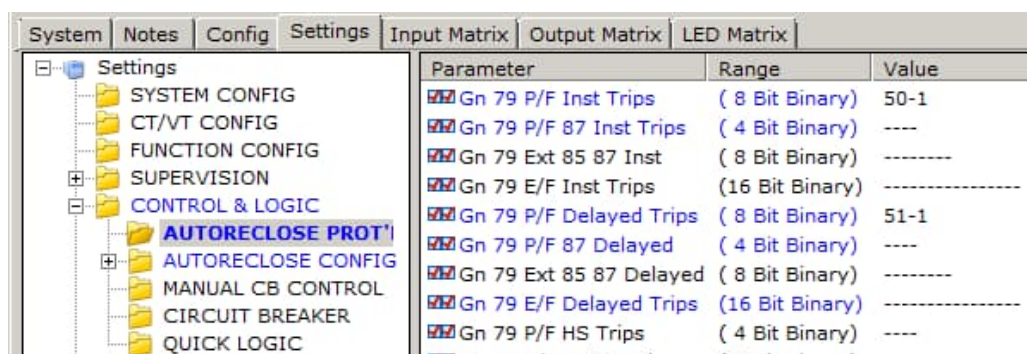


Figure 8.1.1-7 Autoreclose Overcurrent Element Configuration

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix																					
Settings SYSTEM CONFIG CT/VT CONFIG FUNCTION CONFIG PROT'N COMMS DIFFERENTIAL PROT'N CURRENT PROT'N SUPERVISION CONTROL & LOGIC AUTORECLOSE PROT'N AUTORECLOSE CONFIG MANUAL CB CONTROL CIRCUIT BREAKER QUICK LOGIC				<table><tr><th>Parameter</th><th>Range</th><th>Value</th></tr><tr><td> Gn 79 Autoreclose</td><td>(Disabled..Enabled)</td><td>Enabled</td></tr><tr><td> Gn 79 Num Shots</td><td>(1..4)</td><td>2</td></tr><tr><td> Gn 79 Retry Enable</td><td>(Disabled..Enabled)</td><td>Disabled</td></tr><tr><td> Gn 79 Reclose Blocked Delay</td><td>(0..600)</td><td>60s</td></tr><tr><td> Gn 79 Sequence Fail Timer</td><td>(0..600)</td><td>60s</td></tr><tr><td> Gn 79 Sequence Co-ord</td><td>(Disabled..Enabled)</td><td>Enabled</td></tr></table>			Parameter	Range	Value	Gn 79 Autoreclose	(Disabled..Enabled)	Enabled	Gn 79 Num Shots	(1..4)	2	Gn 79 Retry Enable	(Disabled..Enabled)	Disabled	Gn 79 Reclose Blocked Delay	(0..600)	60s	Gn 79 Sequence Fail Timer	(0..600)	60s	Gn 79 Sequence Co-ord	(Disabled..Enabled)	Enabled
Parameter	Range	Value																									
Gn 79 Autoreclose	(Disabled..Enabled)	Enabled																									
Gn 79 Num Shots	(1..4)	2																									
Gn 79 Retry Enable	(Disabled..Enabled)	Disabled																									
Gn 79 Reclose Blocked Delay	(0..600)	60s																									
Gn 79 Sequence Fail Timer	(0..600)	60s																									
Gn 79 Sequence Co-ord	(Disabled..Enabled)	Enabled																									

Figure 8.1.1-8 Autoreclose Sequence Configuration

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix																								
[-] Settings SYSTEM CONFIG CT/VT CONFIG FUNCTION CONFIG PROT'N COMMS [-] DIFFERENTIAL PROT'N [-] LINE DIFFERENTIAL 87L-1 87L-2 [-] DIFFERENTIAL HS [-] DIFFERENTIAL IT [-] CURRENT PROT'N [-] SUPERVISION [-] CONTROL & LOGIC [-] INPUT CONFIG [-] OUTPUT CONFIG [-] MAINTENANCE [-] DATA STORAGE [-] COMMUNICATIONS				<table><tr><th>Parameter</th><th>Range</th><th>Value</th></tr><tr><td> Gn 87L-1 Element</td><td>(Disabled..Enabled)</td><td>Enabled</td></tr><tr><td> Gn 87L-1 Initial Setting</td><td>(0.1..2.5)</td><td>0.3xIn</td></tr><tr><td> Gn 87L-1 1st Bias Slope</td><td>(0.1..0.7)</td><td>0.3x</td></tr><tr><td> Gn 87L-1 1st Bias Slope Limit</td><td>(0.5..20)</td><td>2xIn</td></tr><tr><td> Gn 87L-1 2nd Bias Slope</td><td>(0.5..2)</td><td>1.5x</td></tr><tr><td> Gn 87L-1 Delay</td><td>(0..60)</td><td>0s</td></tr><tr><td> Gn 87L-1 Offset</td><td>(Disabled..Enabled)</td><td>Enabled</td></tr></table>			Parameter	Range	Value	Gn 87L-1 Element	(Disabled..Enabled)	Enabled	Gn 87L-1 Initial Setting	(0.1..2.5)	0.3xIn	Gn 87L-1 1st Bias Slope	(0.1..0.7)	0.3x	Gn 87L-1 1st Bias Slope Limit	(0.5..20)	2xIn	Gn 87L-1 2nd Bias Slope	(0.5..2)	1.5x	Gn 87L-1 Delay	(0..60)	0s	Gn 87L-1 Offset	(Disabled..Enabled)	Enabled
Parameter	Range	Value																												
Gn 87L-1 Element	(Disabled..Enabled)	Enabled																												
Gn 87L-1 Initial Setting	(0.1..2.5)	0.3xIn																												
Gn 87L-1 1st Bias Slope	(0.1..0.7)	0.3x																												
Gn 87L-1 1st Bias Slope Limit	(0.5..20)	2xIn																												
Gn 87L-1 2nd Bias Slope	(0.5..2)	1.5x																												
Gn 87L-1 Delay	(0..60)	0s																												
Gn 87L-1 Offset	(Disabled..Enabled)	Enabled																												

Figure 8.1.1-9 Line Differential Element Parameterisation

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix																														
Settings SYSTEM CONFIG CT/VT CONFIG FUNCTION CONFIG SUPERVISION CONTROL & LOGIC AUTORECLOSE PROT' AUTORECLOSE CONFIG MANUAL CB CONTROL CIRCUIT BREAKER QUICK LOGIC				<table><tr><th>Parameter</th><th>Range</th><th>Value</th></tr><tr><td> Gn 79 P/F Inst Trips</td><td>(8 Bit Binary)</td><td>-----</td></tr><tr><td> Gn 79 P/F 87 Inst Trips</td><td>(4 Bit Binary)</td><td>87HS-1</td></tr><tr><td> Gn 79 Ext 85 87 Inst</td><td>(8 Bit Binary)</td><td>-----</td></tr><tr><td> Gn 79 E/F Inst Trips</td><td>(16 Bit Binary)</td><td>-----</td></tr><tr><td> Gn 79 P/F Delayed Trips</td><td>(8 Bit Binary)</td><td>-----</td></tr><tr><td> Gn 79 P/F 87 Delayed</td><td>(4 Bit Binary)</td><td>87L-1</td></tr><tr><td> Gn 79 Ext 85 87 Delayed</td><td>(8 Bit Binary)</td><td>-----</td></tr><tr><td> Gn 79 E/F Delayed Trips</td><td>(16 Bit Binary)</td><td>-----</td></tr><tr><td> Gn 79 P/F HS Trips</td><td>(4 Bit Binary)</td><td>----</td></tr></table>	Parameter	Range	Value	Gn 79 P/F Inst Trips	(8 Bit Binary)	-----	Gn 79 P/F 87 Inst Trips	(4 Bit Binary)	87HS-1	Gn 79 Ext 85 87 Inst	(8 Bit Binary)	-----	Gn 79 E/F Inst Trips	(16 Bit Binary)	-----	Gn 79 P/F Delayed Trips	(8 Bit Binary)	-----	Gn 79 P/F 87 Delayed	(4 Bit Binary)	87L-1	Gn 79 Ext 85 87 Delayed	(8 Bit Binary)	-----	Gn 79 E/F Delayed Trips	(16 Bit Binary)	-----	Gn 79 P/F HS Trips	(4 Bit Binary)	----		
Parameter	Range	Value																																		
Gn 79 P/F Inst Trips	(8 Bit Binary)	-----																																		
Gn 79 P/F 87 Inst Trips	(4 Bit Binary)	87HS-1																																		
Gn 79 Ext 85 87 Inst	(8 Bit Binary)	-----																																		
Gn 79 E/F Inst Trips	(16 Bit Binary)	-----																																		
Gn 79 P/F Delayed Trips	(8 Bit Binary)	-----																																		
Gn 79 P/F 87 Delayed	(4 Bit Binary)	87L-1																																		
Gn 79 Ext 85 87 Delayed	(8 Bit Binary)	-----																																		
Gn 79 E/F Delayed Trips	(16 Bit Binary)	-----																																		
Gn 79 P/F HS Trips	(4 Bit Binary)	----																																		

Figure 8.1.1-10 Auto-Reclose Line Differential Protection

System

Notes

Config

Settings

Input Matrix

Output Matrix

LED Matrix

[-] Settings

SYSTEM CONFIG

CT/VT CONFIG

FUNCTION CONFIG

PROT'N COMMS

[-] DIFFERENTIAL PROT'N

[-] CURRENT PROT'N

[-] SUPERVISION

[-] CT SUPERVISION

[-] CONTROL & LOGIC

[-] AUTORECLOSE PROT'N

AUTORECLOSE CONFIG

P/F SHOTS

E/F SHOTS

EXTERN SHOTS

MANUAL CB CONTROL

CIRCUIT BREAKER

QUICK LOGIC

[-] INPUT CONFIG

[-] OUTPUT CONFIG

[-] MAINTENANCE

[-] DATA STORAGE

[-] COMMUNICATIONS

Parameter	Range	Value
Gn 79 Autoreclose	(Disabled..Enabled)	Enabled
Gn 79 Num Shots	(1..4)	1
Gn 79 Retry Enable	(Disabled..Enabled)	Disabled
Gn 79 Reclose Blocked Delay	(0..600)	60s
Gn 79 Sequence Fail Timer	(0..600)	60s
Gn 79 Sequence Co-ord	(Disabled..Enabled)	Enabled

Figure 8.1.1-11 Auto-Reclose Configuration

System	Notes	Config	Settings	Input Matrix	Output Matrix	LED Matrix																																				
Settings SYSTEM CONFIG CT/VT CONFIG FUNCTION CONFIG PROT'N COMMS DIFFERENTIAL PROT'N LINE DIFFERENTIAL 87L-1 87L-2 DIFFERENTIAL HS DIFFERENTIAL IT CURRENT PROT'N SUPERVISION CT SUPERVISION CONTROL & LOGIC AUTORECLOSE PROT'N AUTORECLOSE CONFIG P/F SHOT: E/F SHOTS EXTERN SHOTS MANUAL CB CONTROL CIRCUIT BREAKER QUICK LOGIC				<table><tr><th>Parameter</th><th>Range</th><th>Value</th></tr><tr><td> Gn 79 P/F Prot'n Trip 1</td><td>(Inst..Delayed)</td><td>Inst</td></tr><tr><td> Gn 79 P/F Dearthime 1</td><td>(0..14400)</td><td>5s</td></tr><tr><td> Gn 79 P/F Prot'n Trip 2</td><td>(Inst..Delayed)</td><td>Inst</td></tr><tr><td> Gn 79 P/F Dearthime 2</td><td>(0..14400)</td><td>5s</td></tr><tr><td> Gn 79 P/F Prot'n Trip 3</td><td>(Inst..Delayed)</td><td>Delayed</td></tr><tr><td> Gn 79 P/F Dearthime 3</td><td>(0..14400)</td><td>5s</td></tr><tr><td> Gn 79 P/F Prot'n Trip 4</td><td>(Inst..Delayed)</td><td>Delayed</td></tr><tr><td> Gn 79 P/F Dearthime 4</td><td>(0..14400)</td><td>5s</td></tr><tr><td> Gn 79 P/F Prot'n Trip 5</td><td>(Inst..Delayed)</td><td>Delayed</td></tr><tr><td> Gn 79 P/F HS Trips To Lockout</td><td>(1..5)</td><td>5</td></tr><tr><td> Gn 79 P/F Delayed Trips To Lockout</td><td>(1..5)</td><td>5</td></tr></table>			Parameter	Range	Value	 Gn 79 P/F Prot'n Trip 1	(Inst..Delayed)	Inst	 Gn 79 P/F Dearthime 1	(0..14400)	5s	 Gn 79 P/F Prot'n Trip 2	(Inst..Delayed)	Inst	 Gn 79 P/F Dearthime 2	(0..14400)	5s	 Gn 79 P/F Prot'n Trip 3	(Inst..Delayed)	Delayed	 Gn 79 P/F Dearthime 3	(0..14400)	5s	 Gn 79 P/F Prot'n Trip 4	(Inst..Delayed)	Delayed	 Gn 79 P/F Dearthime 4	(0..14400)	5s	 Gn 79 P/F Prot'n Trip 5	(Inst..Delayed)	Delayed	 Gn 79 P/F HS Trips To Lockout	(1..5)	5	 Gn 79 P/F Delayed Trips To Lockout	(1..5)	5
Parameter	Range	Value																																								
 Gn 79 P/F Prot'n Trip 1	(Inst..Delayed)	Inst																																								
 Gn 79 P/F Dearthime 1	(0..14400)	5s																																								
 Gn 79 P/F Prot'n Trip 2	(Inst..Delayed)	Inst																																								
 Gn 79 P/F Dearthime 2	(0..14400)	5s																																								
 Gn 79 P/F Prot'n Trip 3	(Inst..Delayed)	Delayed																																								
 Gn 79 P/F Dearthime 3	(0..14400)	5s																																								
 Gn 79 P/F Prot'n Trip 4	(Inst..Delayed)	Delayed																																								
 Gn 79 P/F Dearthime 4	(0..14400)	5s																																								
 Gn 79 P/F Prot'n Trip 5	(Inst..Delayed)	Delayed																																								
 Gn 79 P/F HS Trips To Lockout	(1..5)	5																																								
 Gn 79 P/F Delayed Trips To Lockout	(1..5)	5																																								

Figure 8.1.1-12 P/F Shot Configuration

8.1.2 Basic Scheme with Remote Deadtime delay

Simple Auto-reclose scheme with added Remote Close after Local CB has Closed by Blocking Remote with Local CB Open (By delaying remote deadtime). If Local fails to Close, Remote will not close.

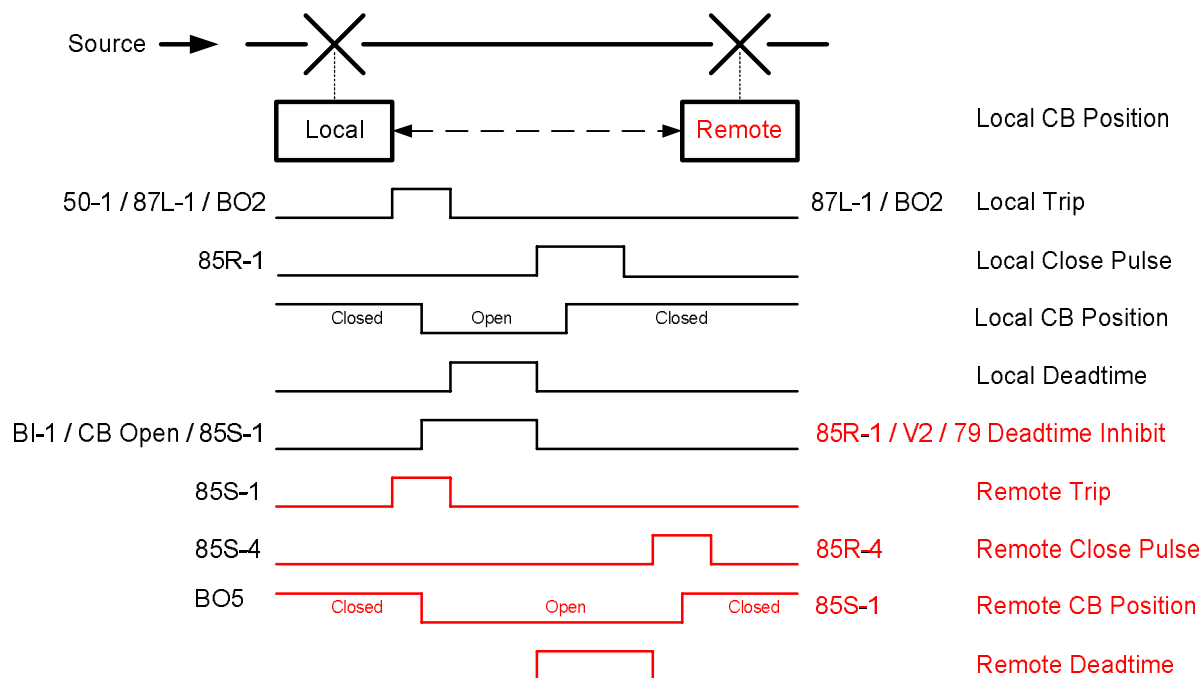


Figure 8.1.2-1 Scheme with Remote Close Sequence of events

System	Notes	Config	Settings	Input Matrix
Setting \ Input	BI1	BI2	BI3	BI4
85S-1	☒	☐	☐	☐
85S-2	☐	☒	☐	☐
85S-3	☐	☐	☐	☐
85S-4	☐	☐	☐	☐
85S-5	☐	☐	☐	☐
85S-6	☐	☐	☐	☐
Inhibit 87L-1	☐	☐	☐	☐
Inhibit 51-1	☐	☐	☐	☐
Inhibit 50-1	☐	☐	☐	☐
Inhibit 60CTS-1	☐	☐	☐	☐
Inhibit 60CTS	☐	☐	☐	☐
Trig Trip Contacts	☐	☐	☐	☐
Reset Trip Time	☐	☐	☐	☐
Reset Energy Meters	☐	☐	☐	☐
General Alarm 1	☐	☐	☐	☐
General Alarm 2	☐	☐	☐	☐
General Alarm 3	☐	☐	☐	☐
General Alarm 4	☐	☐	☐	☐
General Alarm 5	☐	☐	☐	☐
General Alarm 6	☐	☐	☐	☐
CB Open	☒	☐	☐	☐
CB Closed	☐	☒	☐	☐

Figure 8.1.2-2 Local CB Input Mapping

Notes	Config	Settings	Input Matrix			Output Matrix		
Setting \ Output			V1	V2	V3	V4	V5	V6
		Prot'n Comms Disturb	☐	☐	☐	☐	☐	☐
		Prot'n Comms Test	☐	☐	☐	☐	☐	☐
		Prot'n Comms In Sync	☐	☐	☐	☐	☐	☐
		85R-1	☒	☐	☐	☐	☐	☐
		85R-2	☐	☒	☐	☐	☐	☐
		85R-3	☐	☐	☐	☐	☐	☐

Figure 8.1.2-3 Remote CB Output Mapping

System	Notes	Config	Settings	Input Matrix					Output Matrix
Setting \ Output				L11	L12	L13	L14	L15	V1
			Protection Healthy	☐	☐	☐	☐	☐	☐
			Active Setting Grp 1	☐	☐	☐	☐	☐	☐
			Active Setting Grp 2	☐	☐	☐	☐	☐	☐
			Active Setting Grp 3	☐	☐	☐	☐	☐	☐
			Active Setting Grp 4	☐	☐	☐	☐	☐	☐
			+ve P (3P)	☐	☐	☐	☐	☐	☐
			-ve P (3P)	☐	☐	☐	☐	☐	☐
			+ve Q (3P)	☐	☐	☐	☐	☐	☐
			-ve Q (3P)	☐	☐	☐	☐	☐	☐
			Active Exp Pulse	☐	☐	☐	☐	☐	☐
			Active Imp Pulse	☐	☐	☐	☐	☐	☐
			Reactive Exp Pulse	☐	☐	☐	☐	☐	☐
			Reactive Imp Pulse	☐	☐	☐	☐	☐	☐
			Prot'n Comms Disturb	☐	☐	☐	☐	☐	☐
			Prot'n Comms Test	☐	☐	☐	☐	☐	☐
			Prot'n Comms In Sync	☐	☐	☐	☐	☐	☐
			85R-1	☐	☐	☐	☐	☐	☒
			85R-2	☐	☐	☐	☐	☐	☐

Figure 8.1.2-4 Remote CB Output Mapping

8.1.3 Guarded Scheme

Guarded Auto-reclose scheme, Added Blocking and LO.

Guard blocks local protection, Remote is end which trips local and starts the local's AR.

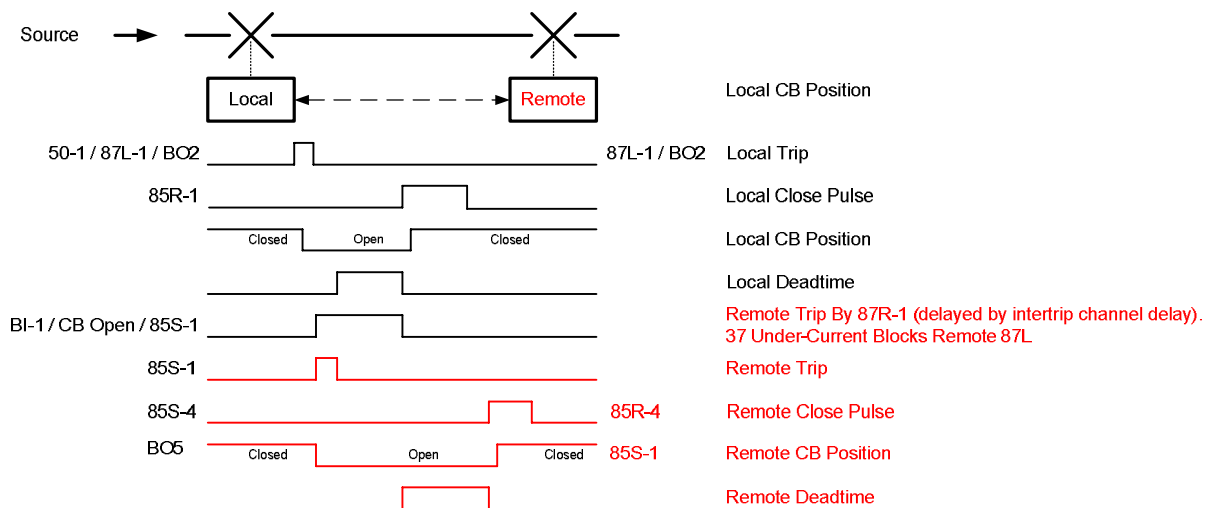


Figure 8.1.3-1 Scheme with Guard Sequence of events

Section 9: Supervision Functions

9.1 Circuit-Breaker Fail (50BF)

Where a circuit breaker fails to operate to clear fault current the power system will remain in a hazardous state until the fault is cleared by remote or back-up protections. To minimise any delay, CB Failure protection provides a signal to either re-trip the local CB or back-trip 'adjacent' CBs.

The function is initiated by the operation of user selectable protection functions 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.

The relay incorporates a two-stage circuit breaker fail feature. 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 minimise 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).

If the CB is faulty and unable to open, a faulty contact can be wired to the CB faulty input of the relay and if a trip occurs while this input is raised the CB fail delay timers may be by-passed to allow back tripping to occur without delay.

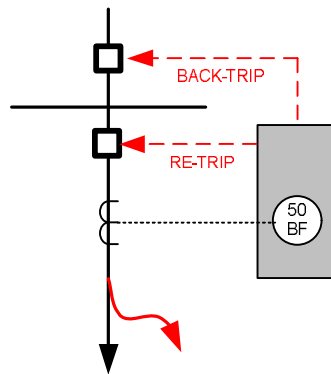


Figure 9.1-1 Circuit Breaker Fail

9.1.1 Settings Guidelines

50BF Setting

The phase current setting must be set below the minimum protection setting current.

50BF Setting-I4

The EF current setting must be set below the minimum protection setting current.

50BF Ext Trig

Any binary input can be mapped to this input to trigger the circuit breaker fail function. Note current must be above setting for the function to operate.

50BF Mech Trip

Any binary input can be mapped to this input to trigger the circuit breaker fail function. Note for the function to operate the circuit breaker closed input is used to detect a failure, not the current.

50BF CB Faulty

Any binary input can be mapped to this input, if it is energised when a trip initiation is received an output will be given immediately (the timers are by-passed).

50BF-1/50BF-2

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 (Re-trip)

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.

The timing sequence for each stage of the circuit breaker fail function is as below.

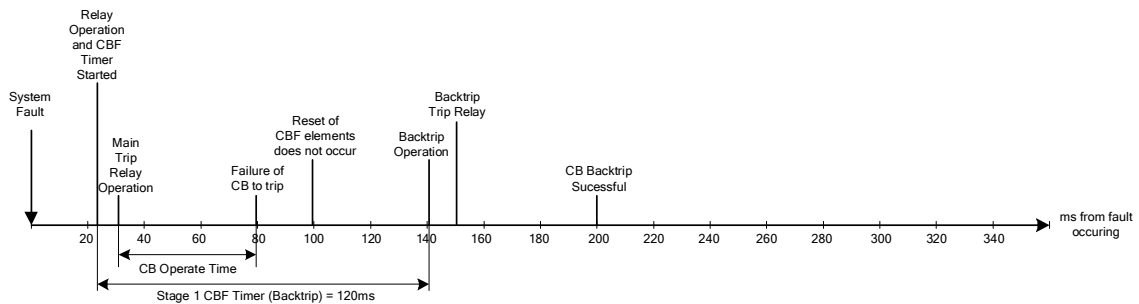


Figure 9.1.1-1 Single Stage Circuit Breaker Fail Timing

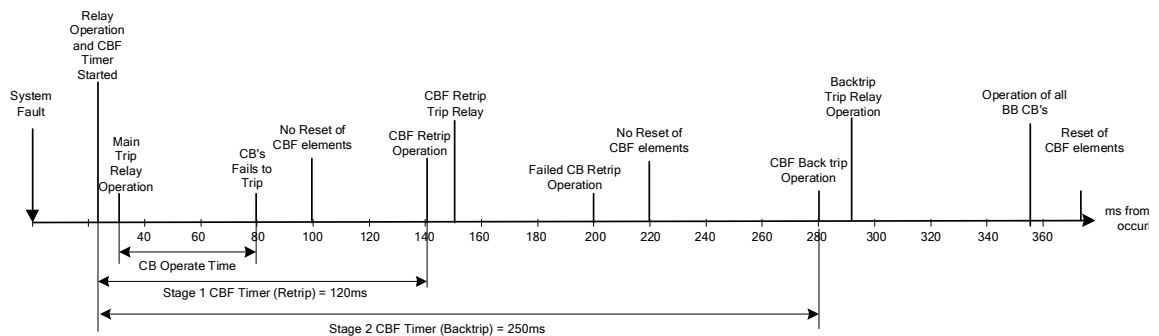


Figure 9.1.1-2 Two Stage Circuit Breaker Fail Timing

9.2 Current Transformer Supervision

When a CT fails, the current levels seen by the protection become unbalanced, however this condition would also occur during a system fault. Depending upon the relay model different methods are used to determine the condition, depending upon the measured quantities available.

Current Transformer Supervision (60CTS – 7SR18 without VTs)

Following a CT Failure, if one or two of the three-phases falls below the CT supervision setting the element will operate.

Operation is subject to a time delay to prevent operation for transitory effects.

A 3-phase CT failure is considered so unlikely (these being independent units) that this condition is not tested for.

9.3 Trip/Close Circuit Supervision (74T/CCS)

Binary Inputs (BI) 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 one 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 BI 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.

9.3.1 Trip Circuit Supervision Connections

The following circuits are derived from UK ENA S15 standard schemes H5, H6 and H7.

For compliance with this standard:

Where more than one 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)

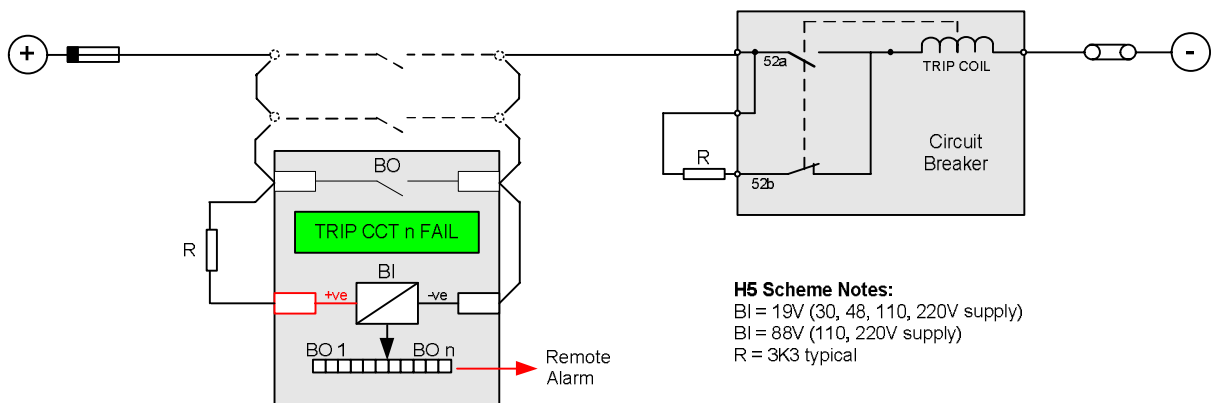
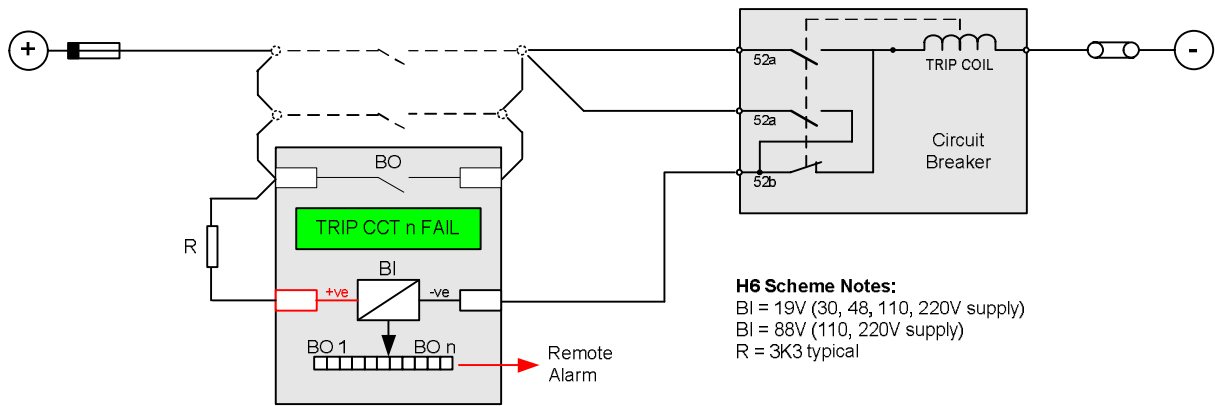


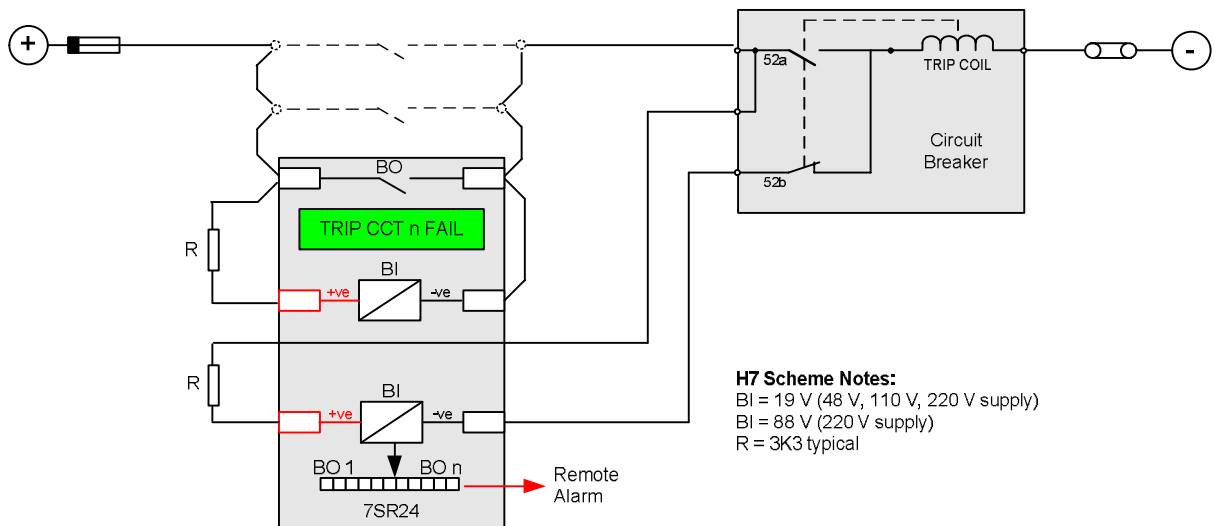
Figure 9.3.1-1 Trip Circuit Supervision Scheme 1 (H5)

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)**Figure 9.3.1-2 Trip Circuit Supervision Scheme 2 (H6)**

Scheme 2 provides continuous Trip Circuit Supervision of 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)**Figure 9.3.1-3 Trip Circuit Supervision Scheme 3 (H7)**

Scheme H7 provides full Trip supervision with the circuit breaker Open or Closed.

9.3.2 Close Circuit Supervision Connections

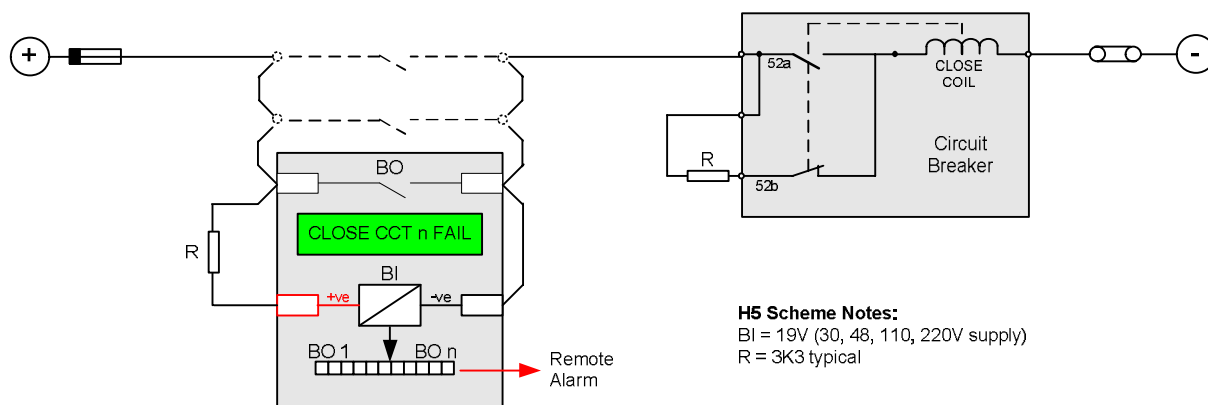


Figure 9.3.2-1 Close Circuit Supervision Scheme

Close circuit supervision with the circuit breaker Open or Closed.

9.4 Inrush Detector (81HBL2)

This element detects the presence of high levels of 2nd Harmonic current which is indicative of transformer Inrush current at switch-on. These currents may be above the operate level of the over-current elements for a short duration and it is important that the relay does not issue an incorrect trip command for this transient network condition.

If a magnetic inrush condition is detected operation of the over-current elements can be blocked.

Calculation of the magnetising inrush current level is complex. However a ratio of 20% 2nd Harmonic to Fundamental current will meet most applications without compromising the integrity of the Over-current protection.

There are 3 methods of detection and blocking during the passage of magnetising inrush current.

Phase	Blocking only occurs in those phases where Inrush is detected. Large, Single Phase Transformers – Auto-transformers.
Cross	All 3-phases are blocked if Inrush is detected in any phase. Traditional application for most Transformers but can give delayed operation for Switch-on to Earth-fault conditions.
Sum	Composite 2nd Harmonic content derived for all 3-phases and then compared to Fundamental current for each individual phase. Provides good compromise between Inrush stability and fast fault detection.

Table 9.4-1 Magnetic Inrush Bias

9.5 Broken Conductor / Load Imbalance (46BC)

This feature can be used to detect an open circuit condition when a conductor breaks or a mal-operation occurs in phase segregated switchgear.

There will be little or no fault current and so over-current elements will not detect the condition. However the condition can be detected because there will be a high content of NPS (unbalance) current present.

However if the line is on light load, the negative phase sequence current may be very close to, to less than the full load steady state unbalance arising from CT errors, load unbalance etc. This means a simple negative phase sequence element would not operate.

With such faults a measurable amount of zero sequence current will be produced, but even this will not be sensitive enough.

To detect such a fault it is necessary to evaluate the ratio of negative phase current (NPS) to positive phase current (PPS), since the ratio is approximately constant with variations in load current and allows a more sensitive setting to be achieved.

In the case of a single point earthed system, there will be little ZPS current and the ratio of NPS/PPS in the protected circuit will approach 100%.

In the case of a multiple earthed system (assuming equal impedances in each sequence network) an NPS / PPS ratio of 50% will result from a Broken Conductor condition. This ratio may vary depending upon the location of the fault and it is therefore recommended to apply a setting as sensitive as possible.

In practice, this minimum setting is governed by the levels of standing NPS current present on the system. This can be determined from a system study or measured during commissioning making sure it is measured during maximum system load conditions to ensure all single phase loads are included.

Operation is subject to a time delay to prevent operation for transitory effects, a minimum delay of 50 seconds may be recommended.

9.5.1 Broken Conductor example

Information recorded during commissioning:

I full load = 500 A

I NPS = 50 A

Therefore the ratio is given by $50/500 = 0.1$

To allow for tolerances and load variation a setting of 200% of this value is recommended and therefore the ratio for **46BC setting** should be set at 20%.

To allow for adequate time for short circuit fault clearance by time delayed protection the **46BC delay** should be set to 50 seconds.

To ensure the broken conductor protection does not operate incorrectly during low load conditions, where the three-phases are less than 10% of normal load, the element should be inhibited by setting the **46BC U/C Guarded** to Yes and selecting a **46BC U/C Guard Setting** to $0.1 \times I_n$

9.6 Circuit-Breaker Maintenance

The Relay provides Total, Delta and Frequent CB Operation Counters along with an I²t Counter to estimate the amount of wear and tear experienced by a Circuit-Breaker. Alarm can be provided once set levels have been exceeded.

Typically estimates obtained from previous circuit-breaker maintenance schedules or manufacturers data sheets are used for setting these alarm levels. The relay instrumentation provides the current values of these counters.

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