Reyrolle
Protection
Devices

7SR10 Argus

Overcurrent Relay

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Document Release History

This document is issue 2020/03. The list of revisions up to and including this issue is:

2020/03	Seventeenth Issue
2020/03	Sixteenth Issue
2019/12	Fifteenth Issue
2019/05	Fourteenth Issue
2019/01	Thirteenth Issue
2018/07	Twelfth Issue
2018/06	Eleventh Issue
2017/09	Tenth Issue
2017/07	Ninth Issue
2017/04	Eighth Issue
2017/03	Seventh Issue
2016/11	Sixth Issue
2015/09	Fifth Issue
2015/06	Fourth Issue
2015/03	Third Issue
2015/02	Second Issue
2013/11	First Issue

Software Revision History (7SR1002/7SR1003)

2019/12	2437H80001R4k-2f	Firmware Maintenance
2019/01	2437H80001 R4j-2e	Firmware Maintenance
2018/05	2437H80001 R4h-2d	Firmware Maintenance
2017/09	2437H80001 R4d-2c	Data Communications improvements
2017/04	2437H80001 R4c-2b	Minor modification in Analog
2016/11	2437H80001 R4b-2b	Support for Reydisp manager tool
2015/09	2437H80001 R4b-2a	Addition of AR variants
2015/06	2437H80001 R4b-1f	81THD function added
2015/03	2437H80001 R4b-1e	Addition of non-directional SEF device variants
2015/02	2437H80001 R4b-1d	First Maintenance
2013/11	2436H80015 R2d-1a	First Release

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2019/12	2437H80008R4j-1c	Firmware Maintenance
2019/05	2437H80008 R4j-1b	50AFD, 50LC, ITHD, Wattmetric functions added
2018/06	2437H80008 R4h-1a	First Release

Hardware Revision History (7SR1002/7SR1003)

2019/08	7SR10/EE	Second Release
2015/01	7SR10/DD	First Release

Hardware Revision History (7SR1004)

2019/08	7SR10/EE	Second Release
2018/07	7SR10/DD	First Release

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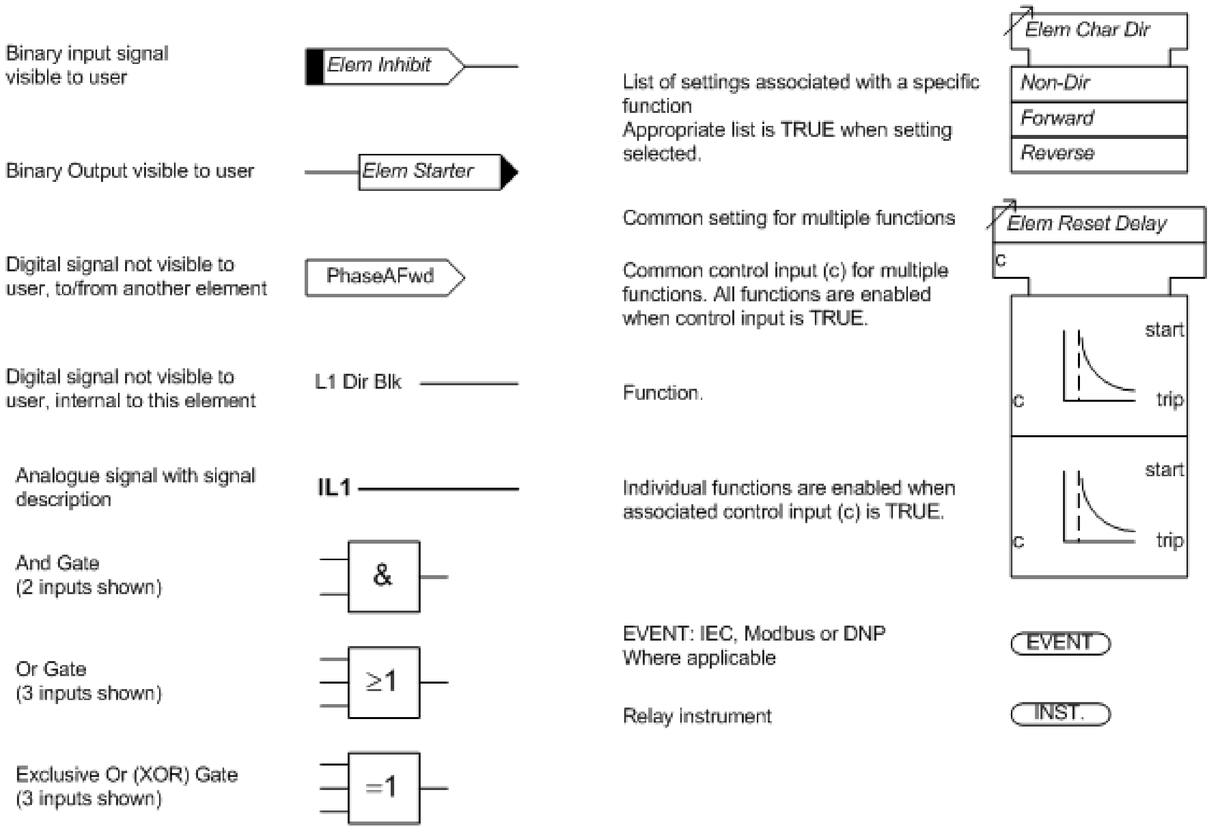
Symbols and Nomenclature

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

- **Setting Menu Location** **MAIN MENU>SUB-MENU**
- **Setting:** ***Elem name -Setting***
- **Setting value:** **value**
- **Alternatives:** **[1st] [2nd] [3rd]**



Section 1: Introduction

This manual is applicable to the following relay:

- 7SR10 Overcurrent Relay

General Safety Precautions

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

1.3 Description

The 7SR10 Overcurrent relay is developed by using the latest generation of hardware technology and is available in multiple variants depending on power supply, binary input/output configuration, voltage input, and data communication facility. 7SR10 is a member of Siemens Reyrolle® protection devices Argus product family.

The 7SR10 overcurrent relay consists of non-directional functions and with additional voltage inputs providing directional functions (based on the ordering option).

The 7SR10 Overcurrent relay is housed in a 4U high, size 4 non draw-out case and these relays provide protection, monitoring, instrumentation, and metering with integrated input and output logic, data logging and fault reports.

Communication access to the relay functionality is via a front USB port for local PC connection or rear electrical RS485 (optional) port for remote connection.

The conformal coating on device electronic modules increases protection against harmful environmental influences such as extreme moisture, corrosive gases and aggressive dust.

NOTE:

The **relay password** which is further referenced in this user manual is only a **Confirmation ID**.
Refer to section 6.9 Confirmation ID (Password Feature) for more information.

1.4 Ordering Options

Product Description **Variants** **Order No.**

Product Description / Variants	1	2	3	4	5	6	7	-	8	9	10	11	12	-	13	14	15		16
7SR10 Argus	7	S	R	1	0	0	□	-	□	□	□	□	0	-	□	□	□	0	□□□□
Non-Directional O/C Relay (Argus)																			
Case, I/O and Fascia																			
Size 4 Moulded case, 4 CT, 3 Binary Inputs/3 Binary Outputs, 10 LEDs							**2**		**1**			**1**					**A**		
Size 4 Moulded case, 4CT, 6 Binary Inputs/6 Binary Outputs, 10 LEDs							**3**					**2**					**A/B**		
Measuring input																			
1/5 A, 50/60Hz [1]							**2/3**		**1**										
1/5 A, 50/60Hz with SEF input [2]							**3**		**2**										
Auxiliary voltage																			
AC/DC 60-240V, Binary input threshold 44 V AC/DC										**L**									
AC/DC 60-240V, Binary input threshold 88 V AC/DC										**K**									
DC 24-60 V, Binary input threshold 19 VDC										**J**									
Protective Cover																			
Standard version – No Cover											**A**								
Plastic Cover with 1 Push Button for Test/Reset											**B**								
Communication																			
Front Port : USB							**2**					**1**							
Front Port : USB and Rear Port : RS-485 supporting IEC 60870-5-103 or Modbus RTU or DNP 3.0							**3**					**2**							
Front Fascia																			
Standard Version – with Breaker Control Push Buttons															**2**				
Protection Function Packages																			
Standard version - included in all models 46BC Broken conductor/Load unbalance 46NPS Negative phase sequence overcurrent 49 Thermal overload 50 Instantaneous phase fault overcurrent 50BF Circuit breaker fail 50G/N Instantaneous earth fault 50SEF [2), 4)] Instantaneous sensitive earth fault overcurrent 51 Timed delayed phase fault overcurrent 51 G/N Timed delayed earth fault 51SEF [2), 4)] Time delayed sensitive earth fault 74T/CCS Trip/close circuit supervision 81HBL2 [3] 2nd Harmonic block/Inrush restraint 86 Hand reset contacts 51C Cold load pickup Programmable logic 81THD Total harmonic distortion supervision																**C**			
Standard version – plus 79 Autoreclose																**D**			
Conformal Coat																			
Standard version – No conformal coating on PCBA																	**A**		
Conformal coating on PCBA																	**B**		
Special version [5]																			**Z Y 2 0**

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[1] 4CT is configured as 3PF + EF

[2] 4CT is configured as 3PF + SEF

[3] Not available on SEF input

[4] Only with position 7 = 3

[5] Special version for Turkey market with thermal withstand capability of 500 A (5 A CT), 1 second and supporting Turkish scripts. Available only with position 8 = 1, position 15 = A.

Product Description	**Variants**	**Order No.**
7SR10 Argus		7 S R 1 0 0 ☐ - ☐ ☐ ☐ ☐ 0 - ☐ ☐ 0

1	2	3	4	5	6	7	-	8	9	10	11	12	-	13	14	15	16
7	S	R	1	0	0	☐	-	☐	☐	☐	☐	0	-	☐		☐	0

Directional Overcurrent Relay (Argus)

Variant	Position	Code
Case, I/O and Fascia		
Size 4 Moulded case, 4CT, 3 VT, 9 Binary Inputs/6 Binary Outputs, 10 LEDs	7	4
Measuring input		
1 A/5 A, 40 V to 160 V, 50 Hz/60 Hz 1)	8	3
1 A/5 A, with SEF input, 40 V to 160 V, 50 Hz/60 Hz 2)	8	4
1 A/5 A, 50 Hz/60Hz with SEF input, 63.5 V/110 V 6)	8	5
Auxiliary voltage		
AC/DC 60-240V, Binary input threshold 44V AC/DC	9	L
AC/DC 60-240V, Binary input threshold 88V AC/DC	9	K
DC 24-60V, Binary input threshold 19V DC	9	J
Protective Cover		
Standard version – No Cover	10	A
Plastic Cover with 1 Push Button for Test/Reset	10	B
Communication		
Front Port: USB and Rear Port:RS-485 supporting IEC 60870-5-103 or Modbus RTU or DNP 3.0	11	2
Front Fascia		
Standard Version – with Breaker Control Push Buttons	13	2
Protection Function Packages		
Standard version - included in all models	14	C
Standard version – plus 79 Auto-reclose	14	D
Conformal Coat		
Standard version – No conformal coating on PCBA	15	A
Conformal coating on PCBA	15	B

Standard version - included in all models

27/59	Under/overvoltage
32	Power
32S	Sensitive Power
37/37SEF 1), 2), 4)	Undercurrent
46BC	Broken conductor/Load Unbalance
46NPS	Negative phase sequence overcurrent
47	Negative phase sequence overvoltage
49	Thermal overload
50LC	Line check
50AFD 4)	Arc Flash Detection
50BF	Circuit breaker fail
50LC/50G LC/50SEF LC 5)	Line check
51V	Voltage dependent overcurrent
55	Power Factor
59N	Neutral voltage displacement
60CTS	CT supervision
60VTS	VT supervision
64H	High impedance REF
67/50	Directional instantaneous phase fault overcurrent
67/50G 1) 67/50N	Directional instantaneous earth fault
67/50SEF 2)	Instantaneous sensitive earth fault - measured
67/51	Directional time delayed phase fault overcurrent
67/51G 1) 67/51N	Directional time delayed earth fault
67/51SEF 2)	Directional time delayed sensitive earth fault
67SEF 6)	Directional sensitive earth fault – measured $3V_0/I_0$-Φ
81HBL2 3)	2nd Harmonic block/Inrush restraint
74T/CC	Trip & close circuit supervision
51C	Cold load pickup/Programmable Logic
81U/O	Under/Over Frequency
86	Hand reset contacts
81I_THD	Total Harmonic Distortion Supervision

Standard version – plus

79	Auto-reclose

1) 4CT is configured as 3PF + EF

2) 4CT is configured as 3PF + SEF

3) Not available on SEF input

4) Refer 7XG31XX documents for Arc Fault Interface Module and sensor ordering information

5) Not available on 79 Auto-reclose variant

6) 4CT is configured as 3PF+SEF and this hardware supports Directional Earth fault V_0/I_0 Phase angle measurement function as per CEI 0-16:2012 specification. Refer to setting range for 7SR1004-5-2CAO for 50SEF and 50SEFLC functions. 81I_THD function is not available.

1.5 Functional Diagram

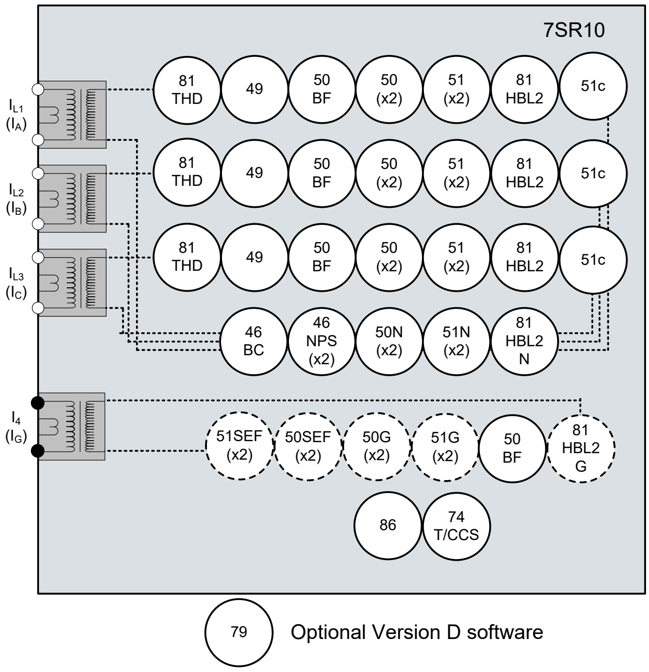


Fig 1. 7SR10 Overcurrent Relay (Non-Directional)

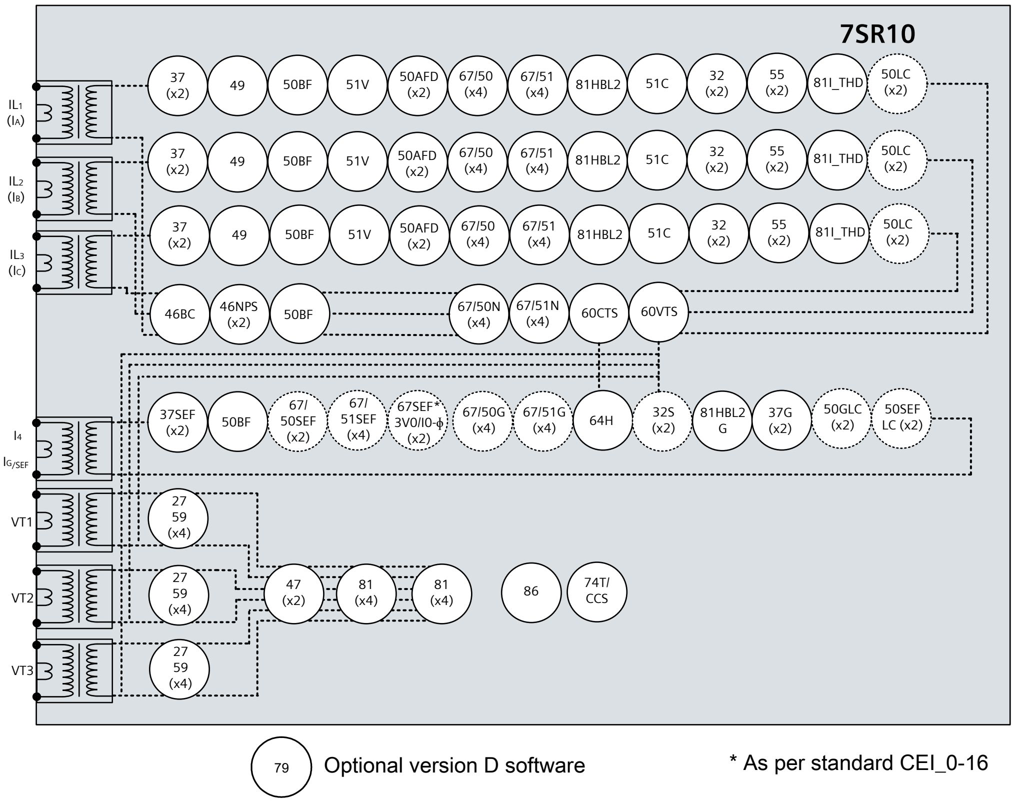


Fig 2. 7SR10 Overcurrrent Relay (Directional)

1.6 Terminal Diagram

The relay is housed in a non draw-out case 4U high Size 4 case. The rear connection comprises of user friendly pluggable type terminals for the Voltage Inputs, Binary Inputs, Binary Outputs, Communication, and Power Supply.

The CT terminals are fixed type and suitable for ring type lug connection to provide a secure and reliable termination.

1.6.1 Terminal Diagram with Control Push Buttons

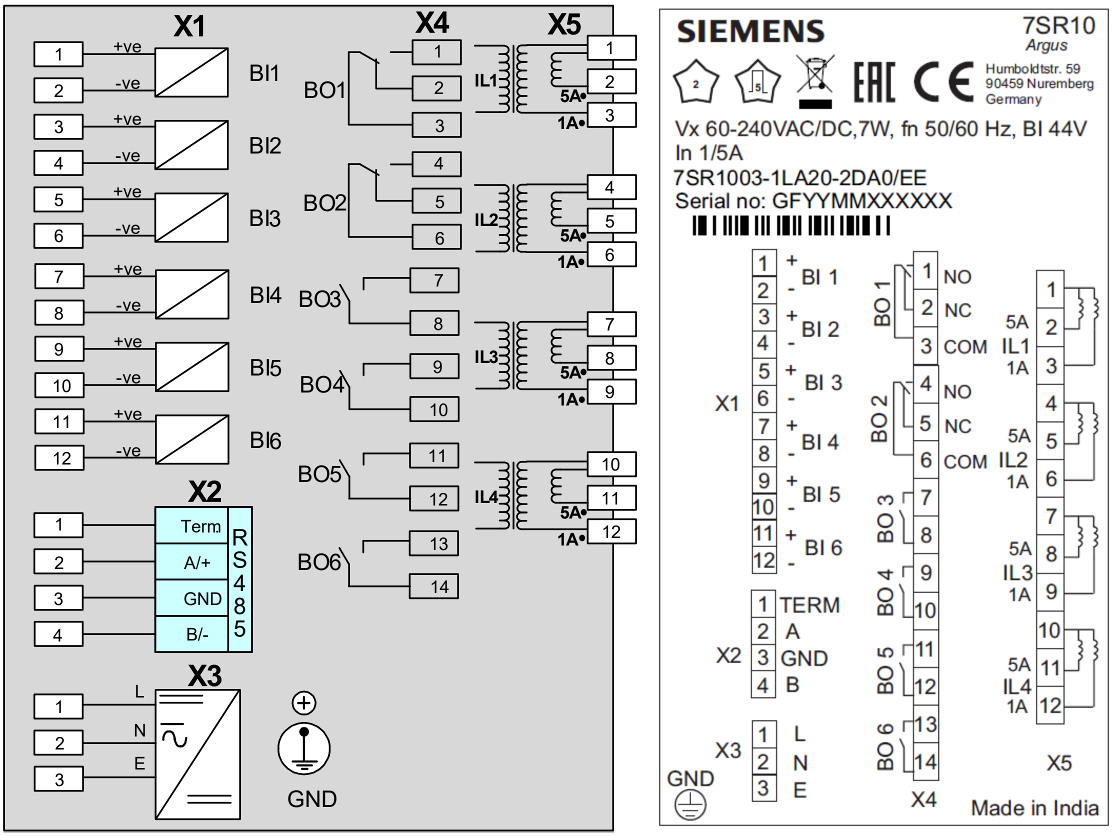


Fig 3. Terminal/Wiring Diagram of 7SR10 Non-Directional Overcurrent Relay

NOTE:

For DC variants, connect the positive and negative terminals to **X3: L** and **X3: N** terminals respectively.

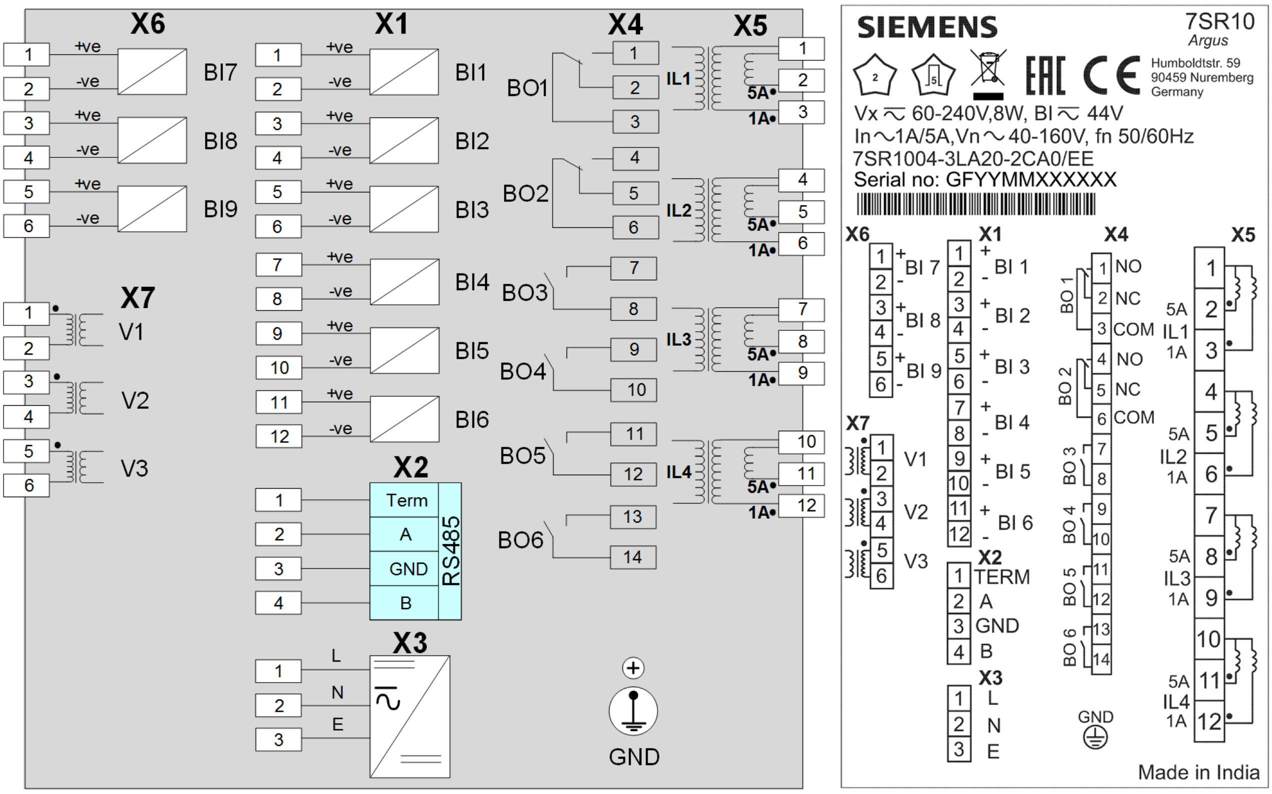


Fig 4. Terminal/Wiring Diagram of 7SR10 Directional Overcurrent Relay

NOTE:

For DC variants, connect the positive and negative terminals to **X3: L** and **X3: N** terminals respectively.

Section 2: Hardware Description

2.1 General

The structure of the relay is based upon the compact hardware platform. The relays are supplied in a Size 4 case. The hardware design provides a commonality between the products and components across the range of relays.

Table 2-1 Summary of 7SR10 Argus Overcurrent Relay Configurations

Relay	Current Inputs	Voltage Inputs	Binary Inputs	Binary Outputs	LEDs
7SR1002	4	0	3	3	10
7SR1003	4	0	6	6	10
7SR1004	4	3	9	6	10

The 7SR10 Argus Overcurrent Relay is assembled from the following modules:

1. Front Fascia with 9 configurable LEDs and 1 Relay Healthy LED
2. Processor module
3. Current Analogue, Voltage Analogue, Input module and Output module

With control push buttons
4 x Current (Terminal X5)
6 x Binary Input (Terminal X1)
6 x Binary Outputs (Terminal X4)
3 x Voltage Inputs (Terminal X7)
3 x Binary Input (Terminal X6)

4. Communication and Power Supply module

With control push buttons
RS485 (Terminal X2)
Power supply (Terminal X3)

2.2 Front Fascia

The front fascia is an integral part of the relay and allows the user to access all the push buttons and performs the setting changes and control actions. The fascia provides an option to reset the fault data display, latched binary outputs, and LEDs by using the TEST/RESET► button. The front fascia contains the label strip which provides the information about LED indicators.

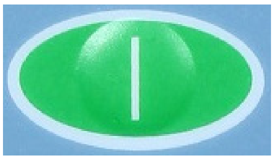
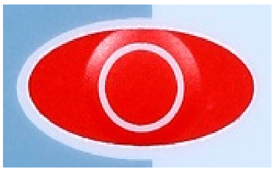
Front Fascia consists of CB control push buttons to open and close.

2.2.1 Front Fascia with Control Push Buttons

Figure 2-1 7SR10 Argus Overcurrent Relay with Control Push Buttons

2.3 CB Open/Close

The circuit breaker (CB) control function is used to manually open and close the CB when it is connected to the network. Two dedicated push buttons are provided on the HMI to execute the CB manual close and open operations.

Button	Function	Description
	**Close**	Press **Close** button and confirm ENTER to execute the close operation of circuit breaker.
	**Open**	Press **Open** button and confirm ENTER to execute the open operation of circuit breaker.

The user can configure the binary input, binary output, and LED configuration for the CB open and close control functions.

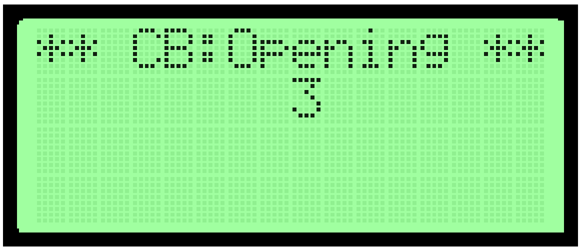
To perform the CB open and close control operations, follow the procedure given below:

1. Press **CB Close** Binary Input (BI) to get the breaker status.
2. Press **CB OPEN** control key. The confirmation pop-up appears.

CB OPEN

ENTER to confirm

3. Press **ENTER** key to confirm.
4. The **CB Open** delay count-down starts and reaches to zero.



** CB:Opening **
3

5. The configured BO and LED's for the **CB OPEN** control functions will operate.
6. Press **RESET** button to reset LED and BO states.

   Repeat the same procedure for CB CLOSE control logic operation.

NOTE:

If the "Control Password" is already configured in the settings, use the control password to execute the CB open/close via control keys. For more information about the Control Password function, see Section 6.9

NOTE:

If the operating mode of 7SR10 Relay is remote, the user can perform the CB open and close operations when the "FUNCTION KEY CONFIG" setting is enabled.

2.4 Power Supply Unit (PSU)

The relay is supplied with the following nominal power supply ranges:

- AC 60 V to 240 V/ DC 60 V to 240 V, Binary input threshold AC 44 V/ DC 44 V
- AC 60 V to 240 V/ DC 60 V to 240 V, Binary input threshold AC 88 V/ DC 88 V
- DC 24 V to 60 V, Binary input threshold DC 19 V

The power supply module is equipped with 3 or 6 Binary Inputs. It also consists of one RS485 communication interface (half duplex) for communicating with RTUs and parameterization of relays via remote locations.

For AC connections, the auxiliary supply is made with the live connection to positive terminal and neutral connection to negative for consistency and safety.

For DC connections, the auxiliary supply is made with the positive connection to Line terminal (L) and negative connection to Neutral (N) for consistency and safety.

In the event of the supply voltage levels are falling below the relay minimum operate level, the PSU will automatically switch off itself and latch out and this prevents any PSU overload conditions occurring. The PSU is reset by switching the auxiliary supply off and on.

2.5 Connectors

In 7SR10 Argus Overcurrent relay, all the connectors are pluggable type except the CT connectors and it consists of Binary Inputs and Binary Outputs connectors. The connector terminals are designated suitably.

In 7SR10 Argus Overcurrent relay, the CT connectors are fixed type. The other connectors for Voltage Inputs, Binary Inputs, Binary Outputs, Communication, and Power Supply are pluggable type and designated suitably.

2.5.1 Connectors with Control Push Buttons

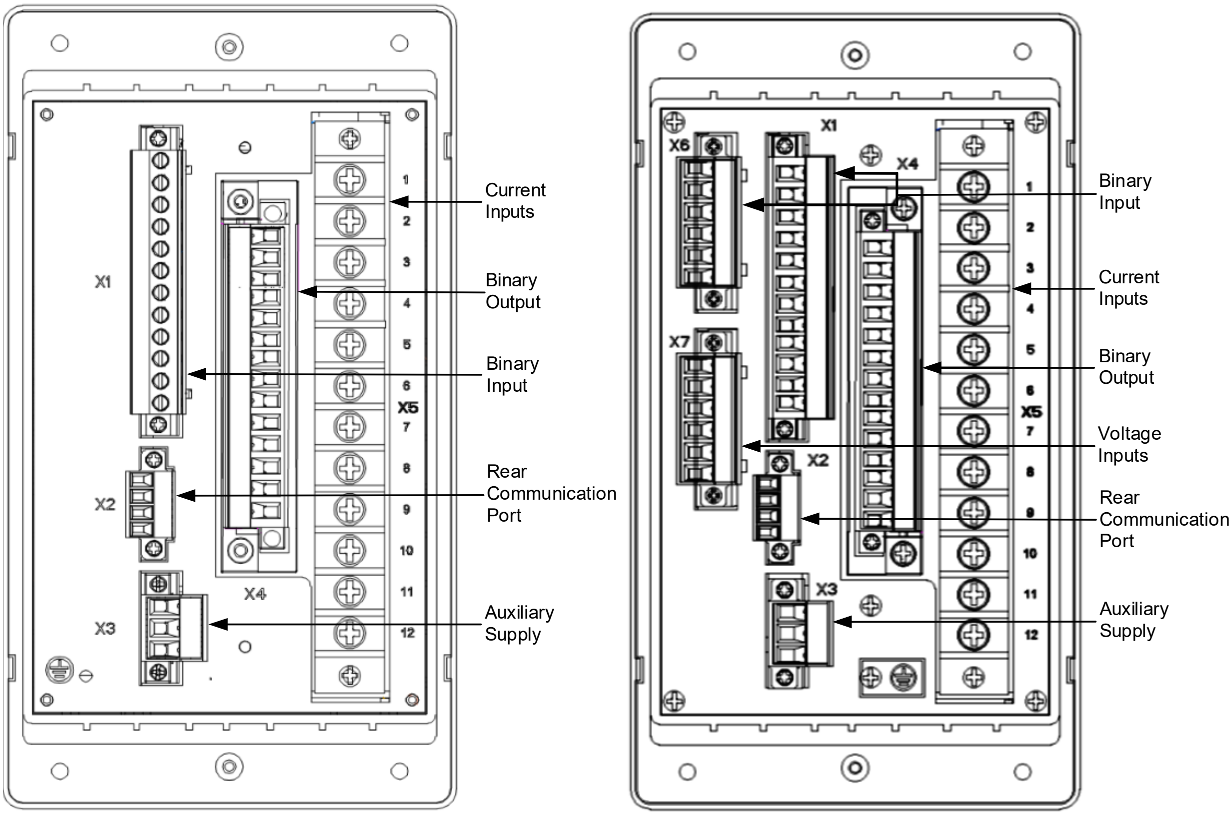


Figure 2-2 7SR10 Non-Directional and Directional Overcurrent Relay with Connectors

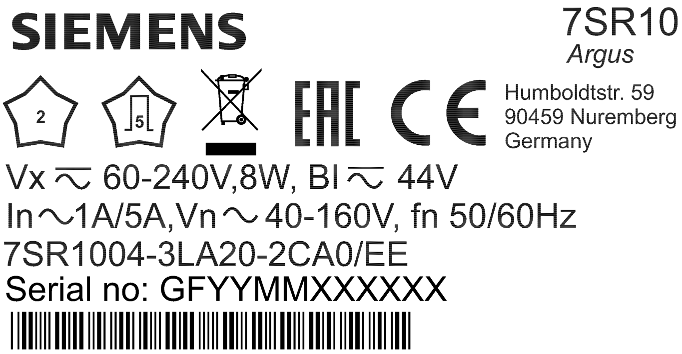
2.6 Relay Information

The rating label is located on the housing and provides more technical information about 7SR10 Argus Overcurrent relay.

Relay Information

The rating label contains the following product Information:

- Product name
- MLFB ordering code, with hardware version suffix
- Nominal current rating
- Nominal voltage rating
- Rated frequency
- Auxiliary supply range
- Binary input supply rating
- Serial number


SIEMENS

7SR10
Argus

Humboldtstr. 59
90459 Nuremberg
Germany

Vx ≂ 60-240V,8W, BI ≂ 44V
In∼1A/5A,Vn∼40-160V, fn 50/60Hz
7SR1004-3LA20-2CA0/EE
Serial no: GFYYMMXXXXXX

Figure 2-3 Relay Rating Label

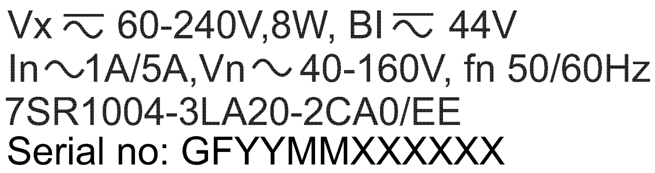

Vx ≂ 60-240V,8W, BI ≂ 44V
In∼1A/5A,Vn∼40-160V, fn 50/60Hz
7SR1004-3LA20-2CA0/EE
Serial no: GFYYMMXXXXXX

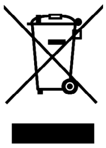
Figure 2-4 Fascia Relay Rating Label

Safety Symbols

For safety reasons, the following symbols are shown on the 7SR10 Argus Overcurrent relay.

Dielectric test voltage 2kV

Impulse voltage with stand 5kV



“Waste Electrical and Electronic Equipment Directive (WEEE)

Guideline for the Eurasian Market

European CE marking

For safety reasons the following symbols are shown on the fascia.

Caution, Risk of Danger

Refer to device documentation before operation

Caution: Risk of Electrical Shock

2.7 Operator Interface

2.7.1 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 to 60 minutes and “Off” (backlight permanently on). Pressing any key will reactivate the display.

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

Figure 2-5 Close up of Relay Identifier

2.7.2 LCD Indication

General Alarms are user defined text messages displayed on the LCD when mapped to binary inputs 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 are raised when a fault trigger is generated and will be logged into the Fault Data record.

2.7.3 Standard Keys

The relay is supplied as standard with seven push buttons. The buttons are used to navigate the menu structure and control the 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.
OPEN	Used to execute the open of circuit breaker
CLOSE	Used to execute the close of circuit breaker

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

2.7.4 Protection Healthy LED

This green LED is steadily illuminated to indicate that auxiliary 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 the LED will continuously flash.

2.7.5 Indication LEDs

Relays have 9 user programmable LED indicators. Each LED can be programmed to be illuminated as either green, yellow, or red. Where an LED is programmed to be lit both red and green, it will illuminate yellow. The same LED can be assigned two different colours dependent upon whether a Start/Pickup or Operate condition exists. LED's can be assigned to the pickup 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 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 programmed as hand reset or self reset. Hand reset LEDs can be reset either by 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 supply voltage.

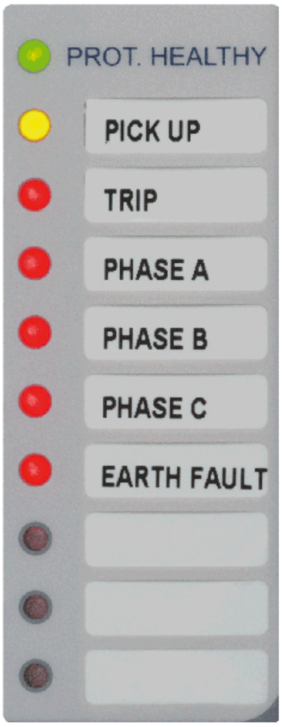


Figure 2-6 LED Indication Label

2.8 Current Inputs

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

The current input is incorporated within the relay and is used for 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/VT configuration menu.

2.9 Voltage Inputs

Three voltage inputs are provided on the Analogue Input module on the 7SR10 relay.

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

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

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

2.10 Binary Inputs

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

Relays are fitted with 3 or 6 or 9 binary inputs (BI) 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 and DO time delay.

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.

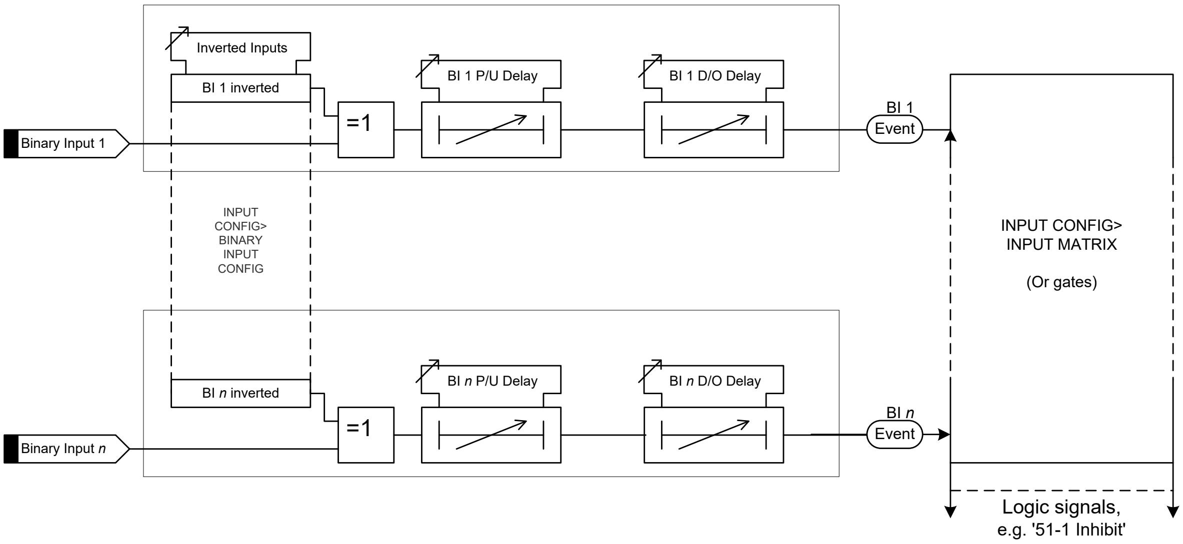


Figure 2-7 Binary Input Logic

2.11 Binary Outputs (Output Relays)

Relays are fitted with 3 or 6 binary outputs (BO). 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 s. If required, the 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.

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 s regardless of the initiating condition.

Notes on Self Reset Outputs

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. When 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.

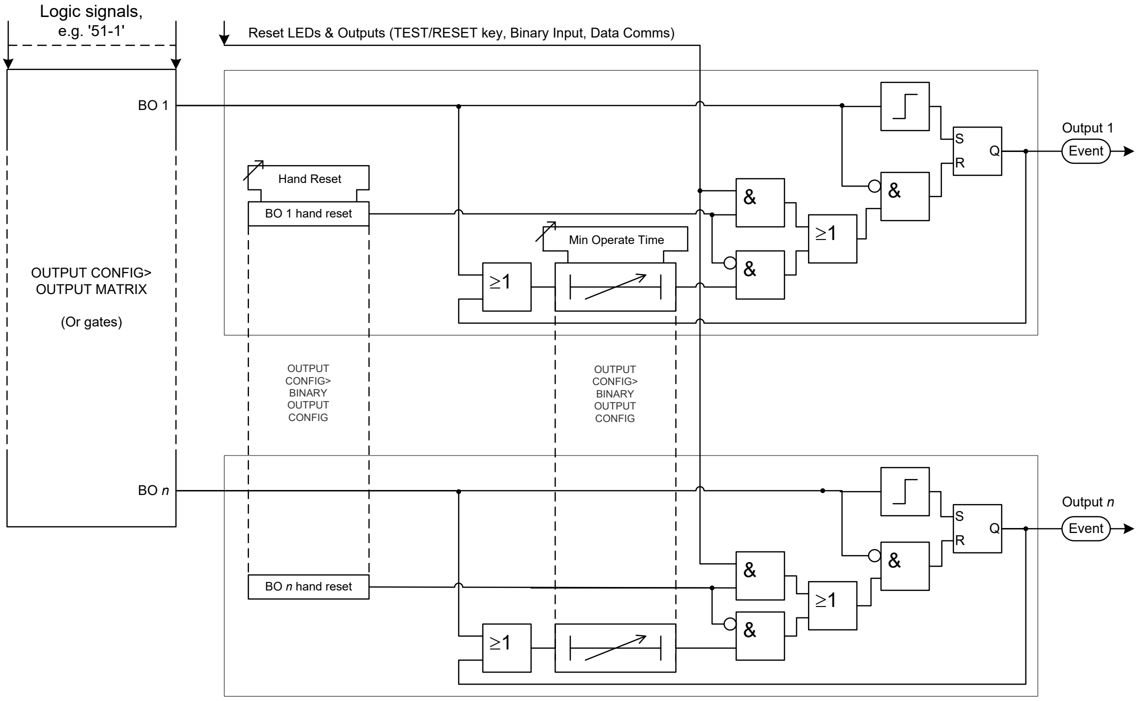


Figure 2-8 Binary Output Logic

2.12 Virtual Input/Outputs

The relays have 8 virtual input/outputs these are internal binary stores. By assigning the status of data items like starters, alarms, and equations 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.

Virtual input/outputs can be used as inputs to various functions including blocks, inhibits, triggers, and alarms 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.

2.13 Self Monitoring

The relay incorporates a number of 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.

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.

```
 --------------------
|Start Alarm         |
|Count              1|
|Target           100|
|                    |
 --------------------
```

Figure 2-9 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
2. **expected starts** (user initiated via communications)
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 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 Count Target*** setting.

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

The following screen-shot show the events which are generated when the relay restarts. 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 an error message:

```
|UNEXPECTED RESTART  |
|COUNTS EXCEEDED!    |
|DEVICE LOCKED OUT   |
|                    |

 --------------------
```

Figure 2-10 Unexpected Restarts Lockout Text

And enter a locked-up mode. In this mode the Relay will disable operation of all LED’s and Binary Outputs, including Protection Healthy, all pushbuttons and any data communications.

Once the Relay has failed in this manner, it is non-recoverable at site and must be returned to the manufacturer for repair.

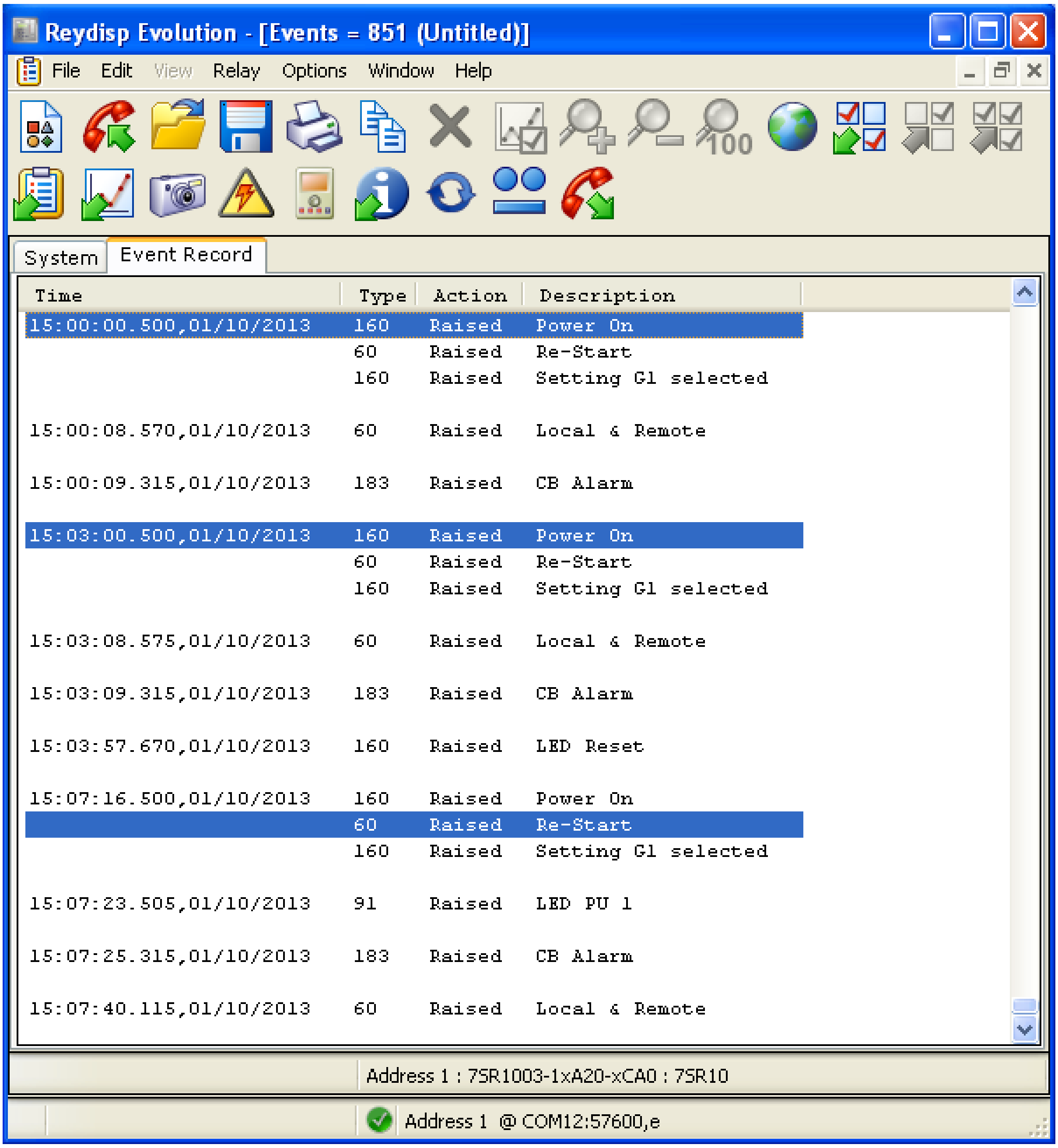
A meter, Miscellaneous Meters>Unexpected Restarts, is provided to show how many Unexpected Restarts have occurred during the previous Unexpected Restart Period. This is resettable from the front fascia.

2.13.1 Protection Healthy/Defective

When the relay has an auxiliary 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 supply is not applied to the relay or a problem is detected within the relay then this output contact closes to provide external indication.



Time	Type	Action	Description
15:00:00.500,01/10/2013	160	Raised	Power On
	60	Raised	Re-Start
	160	Raised	Setting G1 selected
15:00:08.570,01/10/2013	60	Raised	Local & Remote
15:00:09.315,01/10/2013	183	Raised	CB Alarm
15:03:00.500,01/10/2013	160	Raised	Power On
	60	Raised	Re-Start
	160	Raised	Setting G1 selected
15:03:08.575,01/10/2013	60	Raised	Local & Remote
15:03:09.315,01/10/2013	183	Raised	CB Alarm
15:03:57.670,01/10/2013	160	Raised	LED Reset
15:07:16.500,01/10/2013	160	Raised	Power On
	60	Raised	Re-Start
	160	Raised	Setting G1 selected
15:07:23.505,01/10/2013	91	Raised	LED PU 1
15:07:25.315,01/10/2013	183	Raised	CB Alarm
15:07:40.115,01/10/2013	60	Raised	Local & Remote

Address 1 : 7SR1003-1xA20-xCA0 : 7SR10

Address 1 @ COM12:57600,e

Figure 2-11 Start-up Events

Section 3: Protection Functions

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

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**

3.1.1 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:

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

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° using the ***67 Char Angle*** setting. The voltage is the reference phasor (Vref) 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 (Vref Angle + ***67 Char Angle***) and should be set to correspond with Ifault Angle for maximum sensitivity i.e.

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

OR

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

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.

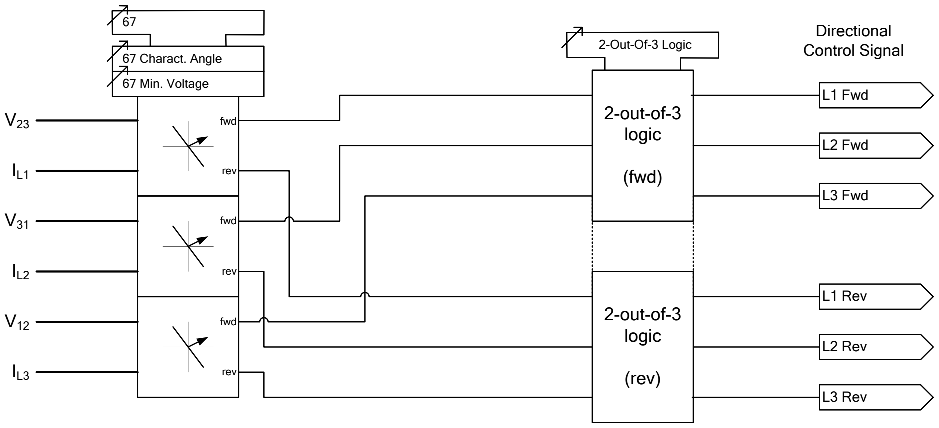


Figure 3-1 Logic Diagram: Directional Control of Overcurrent Protection (67)

3.1.2 Instantaneous and DTL Overcurrent Protection (50)

Two overcurrent elements are provided in the 7SR1002/7SR1003 relay and four elements are provided in the 7SR1004 relay.

50-1, 50-2, (50-3 & 50-4 – 7SR1004)

Each overcurrent 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 elements set to reverse.

Operation of the 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.

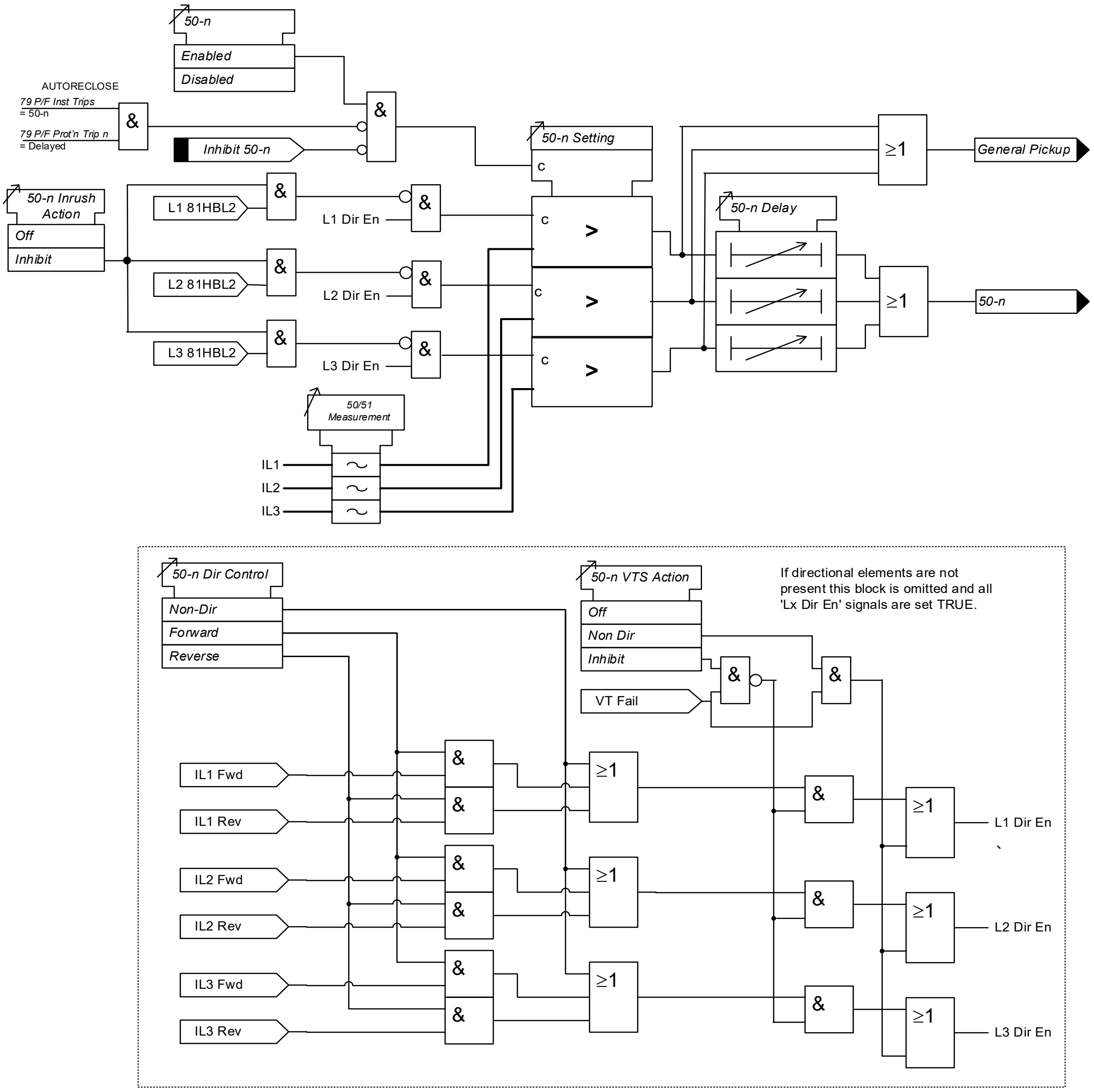


Figure 3-2 Logic Diagram: Instantaneous and DTL Overcurrent Protection

3.1.3 Time Delayed Overcurrent Protection (51)

Two time delayed overcurrent elements are provided in the 7SR1002/7SR1003 relay and four elements are provided in the 7SR1004 relay.

51-1, 51-2, (51-3 & 51-4 – 7SR1004)

51-n Setting sets the pick-up current level. Where the voltage controlled overcurrent function (51VCO) is used a multiplier is applied to this setting where the voltage drops below the setting ***VCO Setting***, see Section 3.1.4.

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. Operating curve characteristics are illustrated in Chapter 3 – '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 e.g. giving the option of using two elements set to forward and two elements set to reverse.

NOTE:
User specific curve is applicable for 7SR1004 variant only.

Operation of the time delayed overcurrent elements can be inhibited from:

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.
51-n Inrush Action: Block	Operation of the inrush current detector function.
***51-n VTSAction:* Inhibit**	Operation of the VT Supervision function.

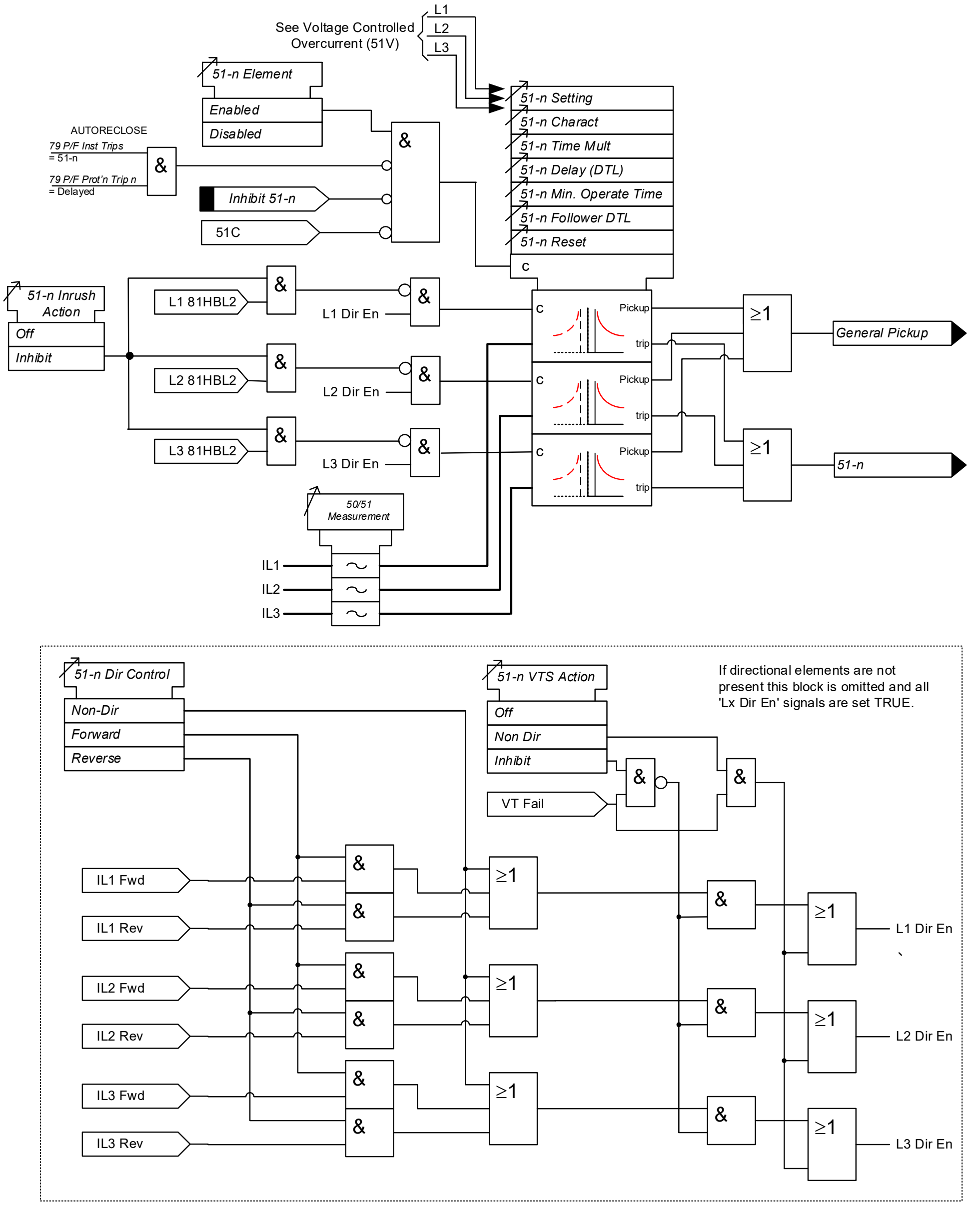


Figure 3-3 Logic Diagram: Time Delayed Overcurrent Protection

3.1.4 Current Protection: 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:

51V VTSAction: **Inhibit** Operation of the VT Supervision function.

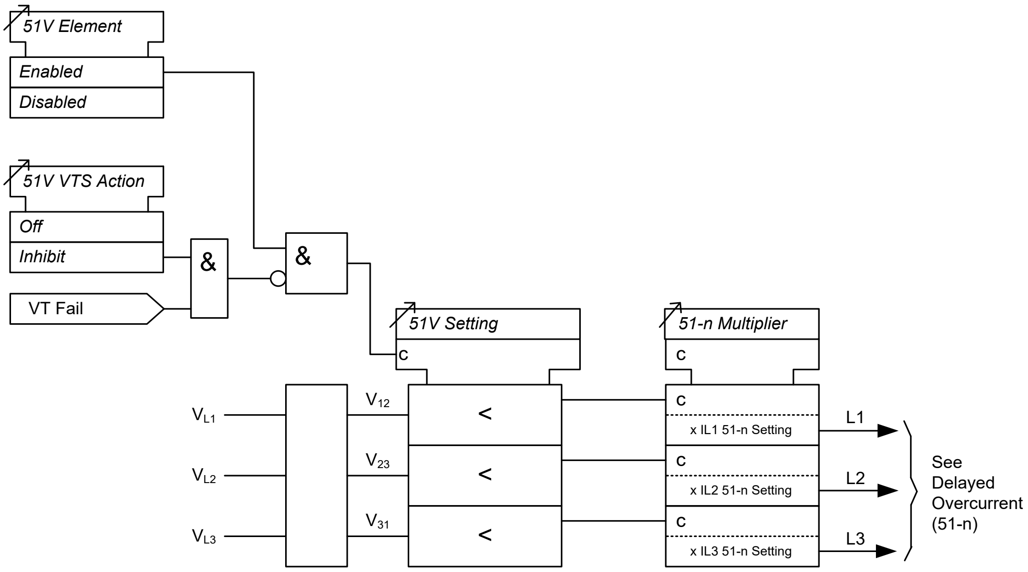


Figure 3-4 Logic Diagram: Voltage Controlled Overcurrent Protection

3.2 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.

3.2.1 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° using the ***67N Char Angle*** setting. The voltage is the reference phasor (Vref) 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 (Vref Angle + ***67N Char Angle***) and should be set to correspond with Ifault 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 ***67N 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.

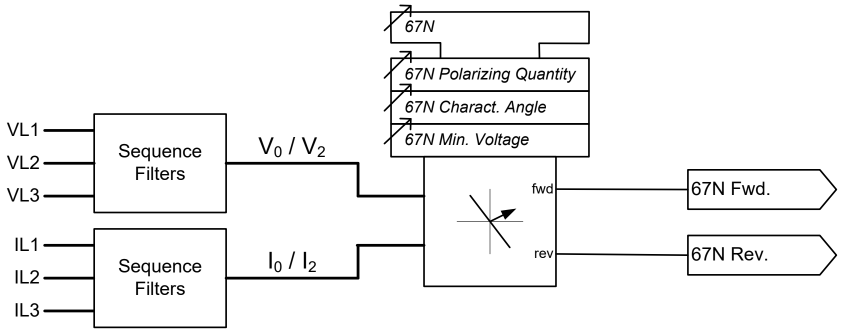


Figure 3-5 Logic Diagram: Directional Control of Derived Earth Fault Protection

3.2.2 Instantaneous and DTL Derived Earth Fault Protection (50N)

Two derived earth fault elements are provided in the 7SR1002/7SR1003 relay and four elements are provided in the 7SR1004 relay.

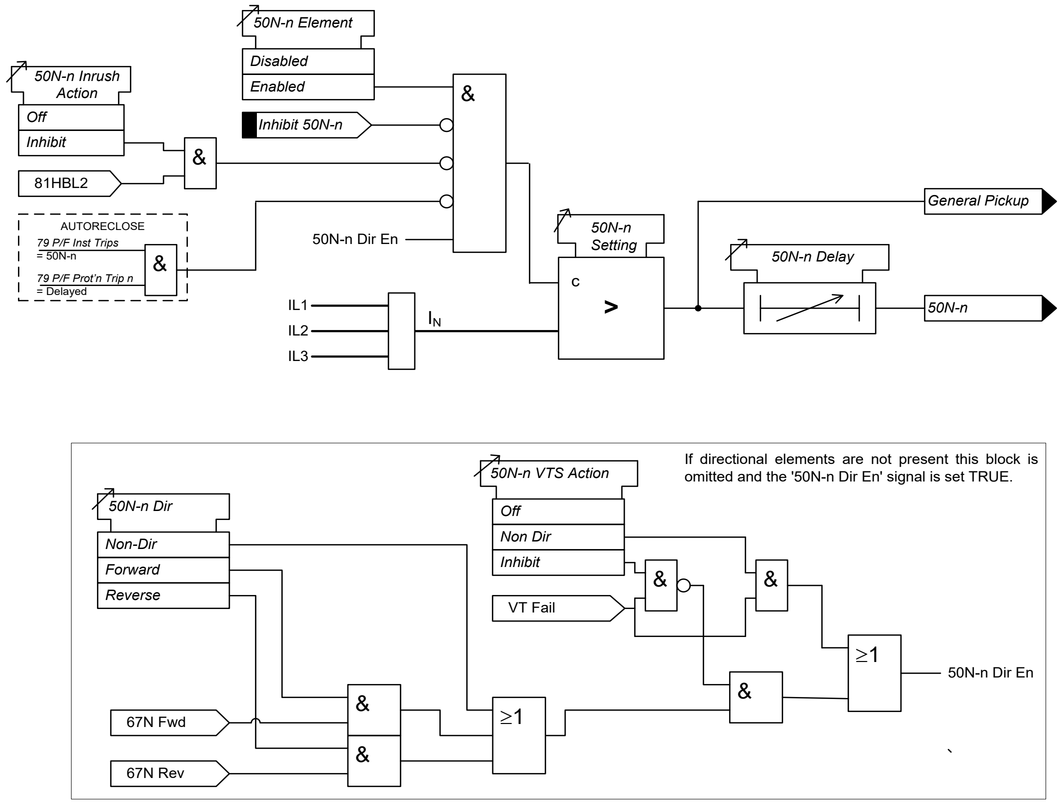
50N-1, 50N-2, (50N-3 & 50N-4 – 7SR1004)

Each 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 50N-n element e.g. giving the option of using two elements set to forward and two elements set to reverse.

Operation of the derived 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**).
50N-n Inrush Action: Block	Operation of the inrush current detector function.
***50N-n VTSAction:* Inhibit**	Operation of the VT Supervision function.



If directional elements are not present this block is omitted and the '50N-n Dir En' signal is set TRUE.

Figure 3-6 Logic Diagram: Instantaneous and DTL Derived Earth Fault Protection

3.2.3 Time Delayed Derived Earth Fault Protection (51N)

Two time delayed derived earth fault elements are provided in the 7SR1002/7SR1003 relay and four elements are provided in the 7SR1004 relay.

51N-1, 51N-2, (51N-3 & 51N-4 – 7SR1004)

51N-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 ***51N-n Char***. A time multiplier is applied to the characteristic curves using the ***51N-n Time Mult*** setting. Alternatively, a definite time lag delay (DTL) can be chosen using ***51N-n Char***. When definite time lag (DTL) is selected the time multiplier is not applied and the ***51N-n Delay (DTL)*** setting is used instead.

The ***51N-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 the ***51N-n Min. Operate Time*** setting.

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

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

NOTE:
User specific curve is applicable for 7SR1004 variant only.

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

Inhibit 51N-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**).
51N-n Inrush Action: Block	Operation of the inrush current detector function.
***51N-n VTSAction:* Inhibit**	Operation of the VT Supervision function.

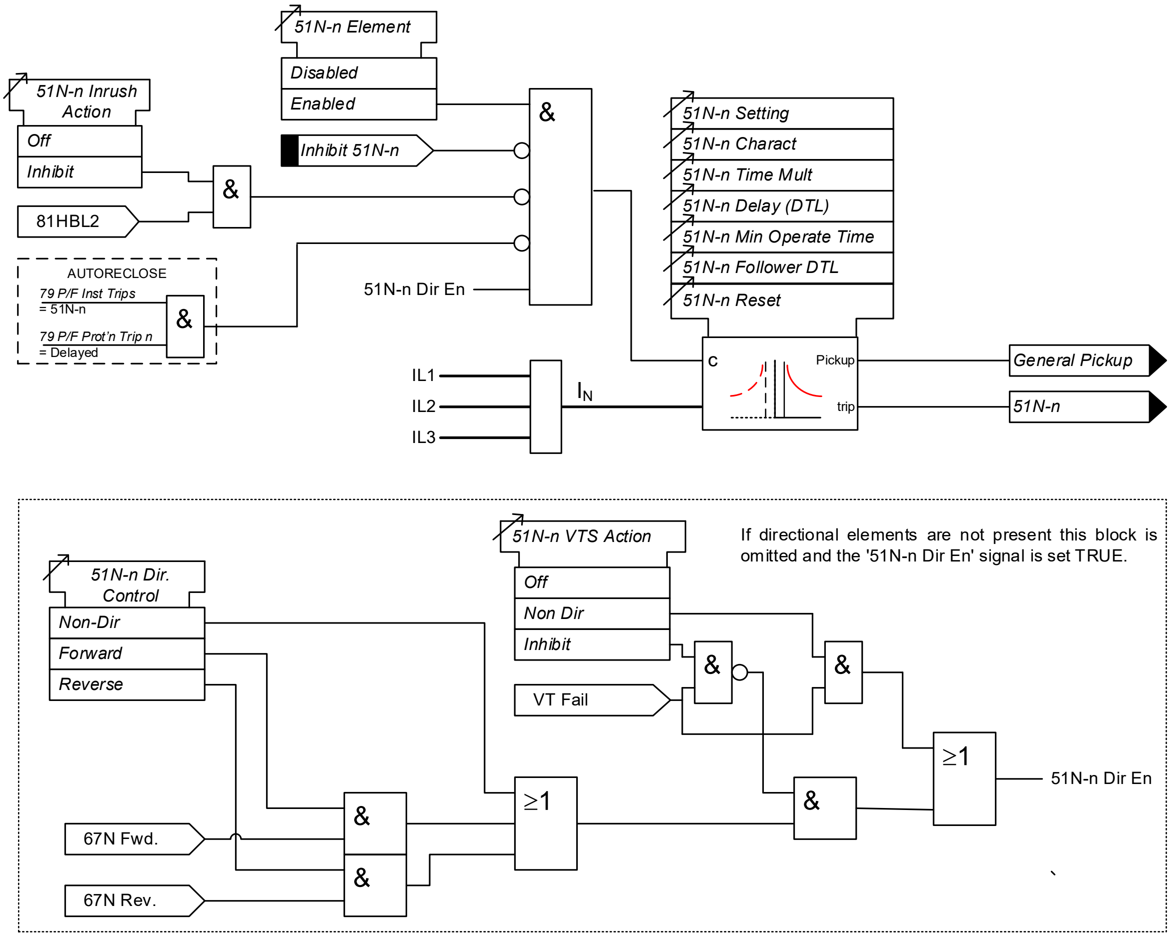


Figure 3-7 Logic Diagram: Time Delayed Derived Earth Fault Protection

3.3 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: ***50G Measurement*** **= RMS,** ***51G Measurement*** **= RMS**

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

3.3.1 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° 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.

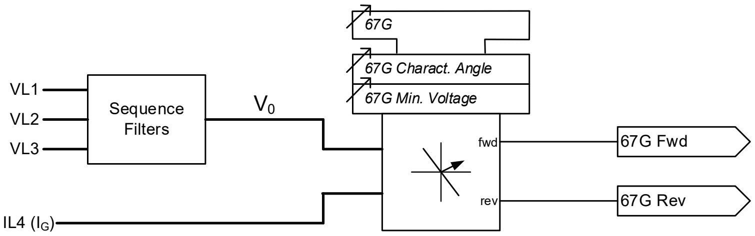


Figure 3-8 Logic Diagram: Directional Control of Measured Earth Fault Protection

3.3.2 Instantaneous and DTL Measured Earth Fault Protection (50G)

Two measured earth fault elements are provided in the 7SR1002/7SR1003 relay and four elements are provided in the 7SR1004 relay.

50G-1, 50G-2, (50G-3 & 50G-4 – 7SR1004)

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

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

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

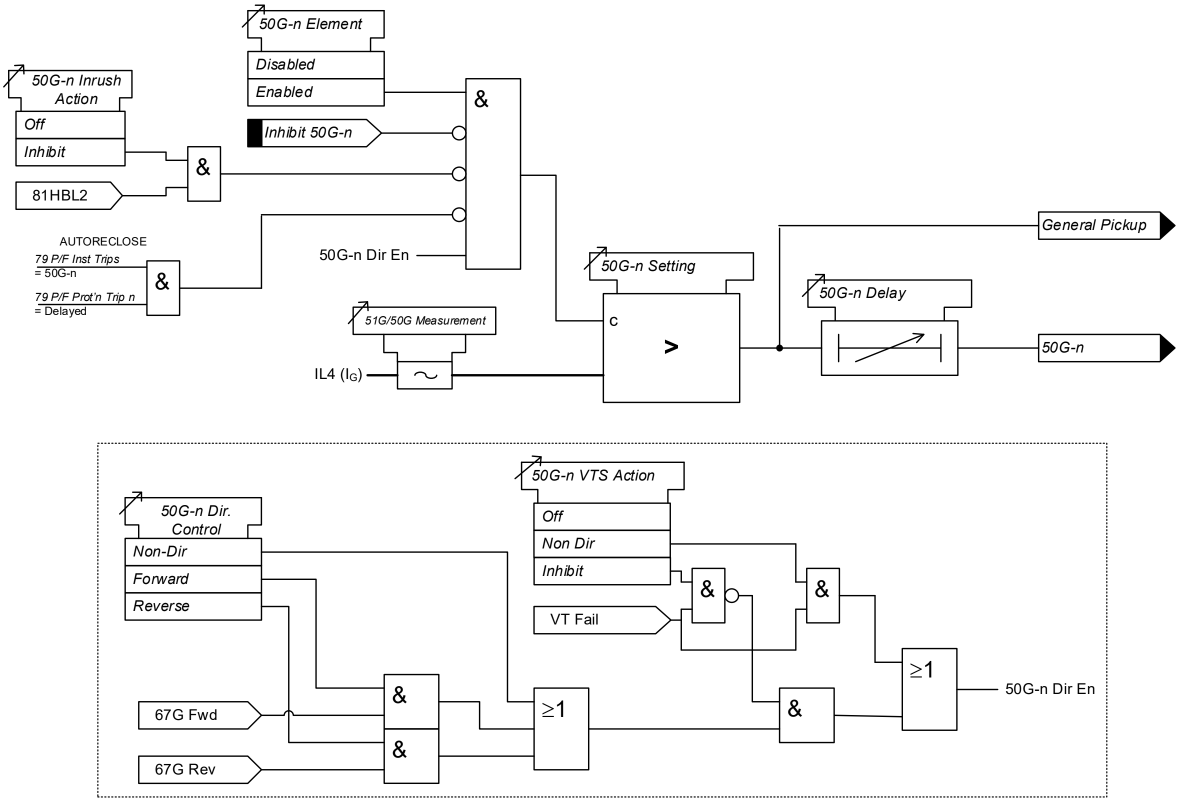


Figure 3-9 Logic Diagram: Instantaneous and DTL Measured Earth Fault Protection

3.3.3 Time Delayed Measured Earth Fault Protection (51G)

Two time delayed measured earth fault elements are provided in the 7SR1002/7SR1003 relay and four elements are provided in the 7SR1004 relay.

51G-1, 51G-2, (51G-3 & 51G-4 – 7SR1004)

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, ANSI or user specific 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. Operating curve characteristics are illustrated in **Section 3 – 'Performance Specification'**.

The ***51G-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 elements set to reverse.

NOTE:
User specific curve is applicable for 7SR1004 variant only

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

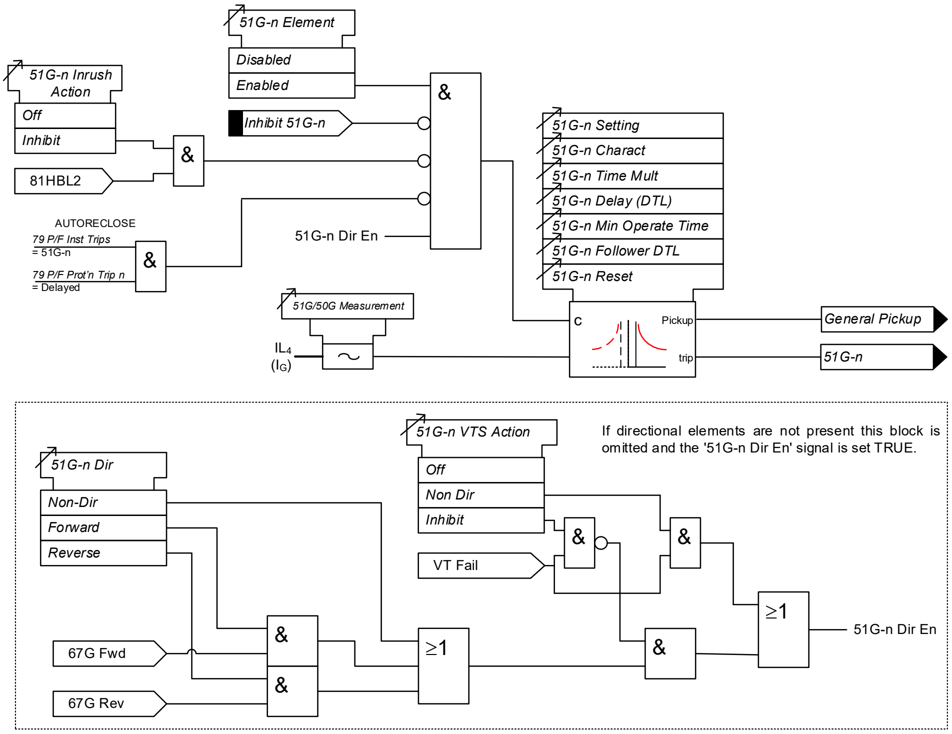


Figure 3-10 Logic Diagram: Time Delayed Measured Earth Fault Protection (51G)

3.4 Current Protection: Sensitive Earth Fault (67SEF, 51SEF, 50SEF)

Current for the Sensitive Earth Fault (SEF) elements is measured directly via a dedicated current analogue input which requires different hardware that must be specially ordered. SEF elements measure the fundamental frequency RMS current.

3.4.1 Directional Control of Sensitive Earth Fault Protection (67SEF)

The directional element produces forward and reverse outputs for use with SEF 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 forward directional zone of the relay is defined by the characteristic angle setting which is the angle by which the polarising voltage differs from the operating current. The forward directional zone is symmetrical around the characteristic angle with angular limits defined in the performance specification. The reverse operate zone is the mirror image of the forward zone.

The directional sensitive 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° using the ***67SEF Char Angle*** setting. The voltage is the reference phasor (V_{ref}) and the ***67SEF 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 + ***67SEF Char Angle***) and should be set to correspond with I_{fault} Angle for maximum sensitivity i.e.

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

OR

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

For resonant grounded systems where compensation (Petersen) coils are fitted, earth fault current is deliberately reduced to zero and therefore is difficult to measure for protection purposes. However, the wattmetric component in the capacitive charging currents, which are close to the directional zone boundary, can be used to indicate fault location. It is advantageous to increase the directional limits towards ±90º so that the directional boundary can be used to discriminate between faulted and healthy circuits. A 67SEF Compensated Network Enable user setting is provided to provide this feature for use with compensated networks only.

Minimum Polarising Voltage

The ***67SEF 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.

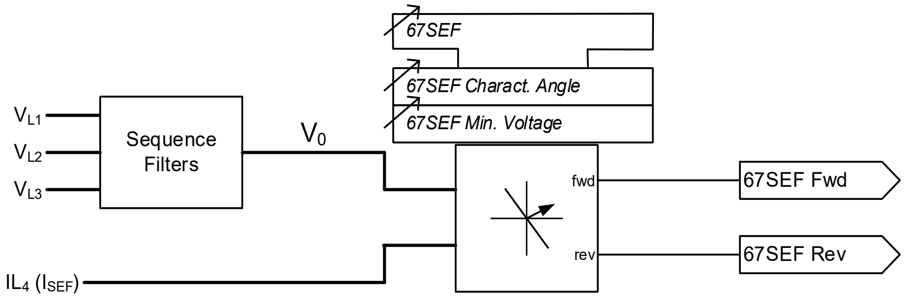


Figure 3-11 Logic Diagram: Directional Control of SEF Protection (67SEF)

3.4.2 Instantaneous and DTL Sensitive Earth Fault Protection (50SEF)

Two sensitive earth fault elements are provided in the 7SR1002/7SR1003 relay and four elements are provided in the 7SR1004 relay.

50SEF-1, 50SEF-2, (50SEF-3 & 50SEF-4 – 7SR1004)

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

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

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

Inhibit 50SEF-n	A binary or virtual input.
***79 SEF Inst Trips:* 50SEF-n**	When 'delayed' trips only are allowed in the auto-reclose sequence (***79 SEF Prot'n Trip n*** = **Delayed**).
***50SEF-n VTSAction:* Inhibit**	Operation of the VT Supervision function.

Directional elements will not operate unless the zero sequence voltage (V_0) is above the ***67SEF Minimum Voltage*** setting i.e. the residual voltage is greater than 3 times this setting and the phase is in the Forward/Reverse operating range. If ***67SEF Wattmetric*** is set to Enabled, the calculated residual real power must be above the ***67SEF Wattmetric Power*** setting for any SEF element operation. The residual power Pres is equal to the wattmetric component of $3V_0I_{SEF}$ and therefore the wattmetric component of $9V_0I_0$.

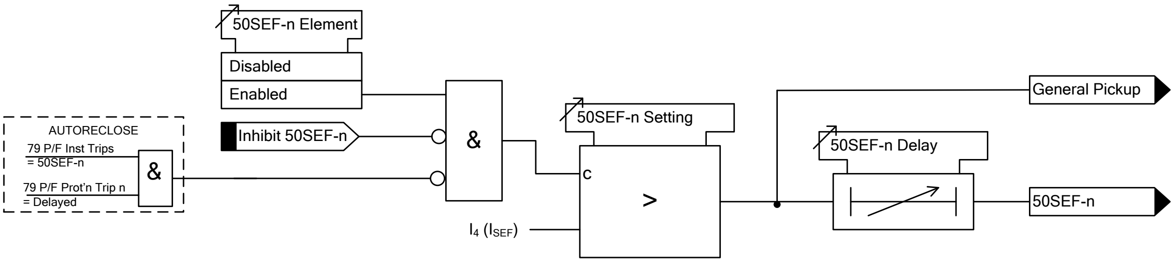


Figure 3-12 Logic Diagram: 7SR1003 Instantaneous and DTL SEF Protection

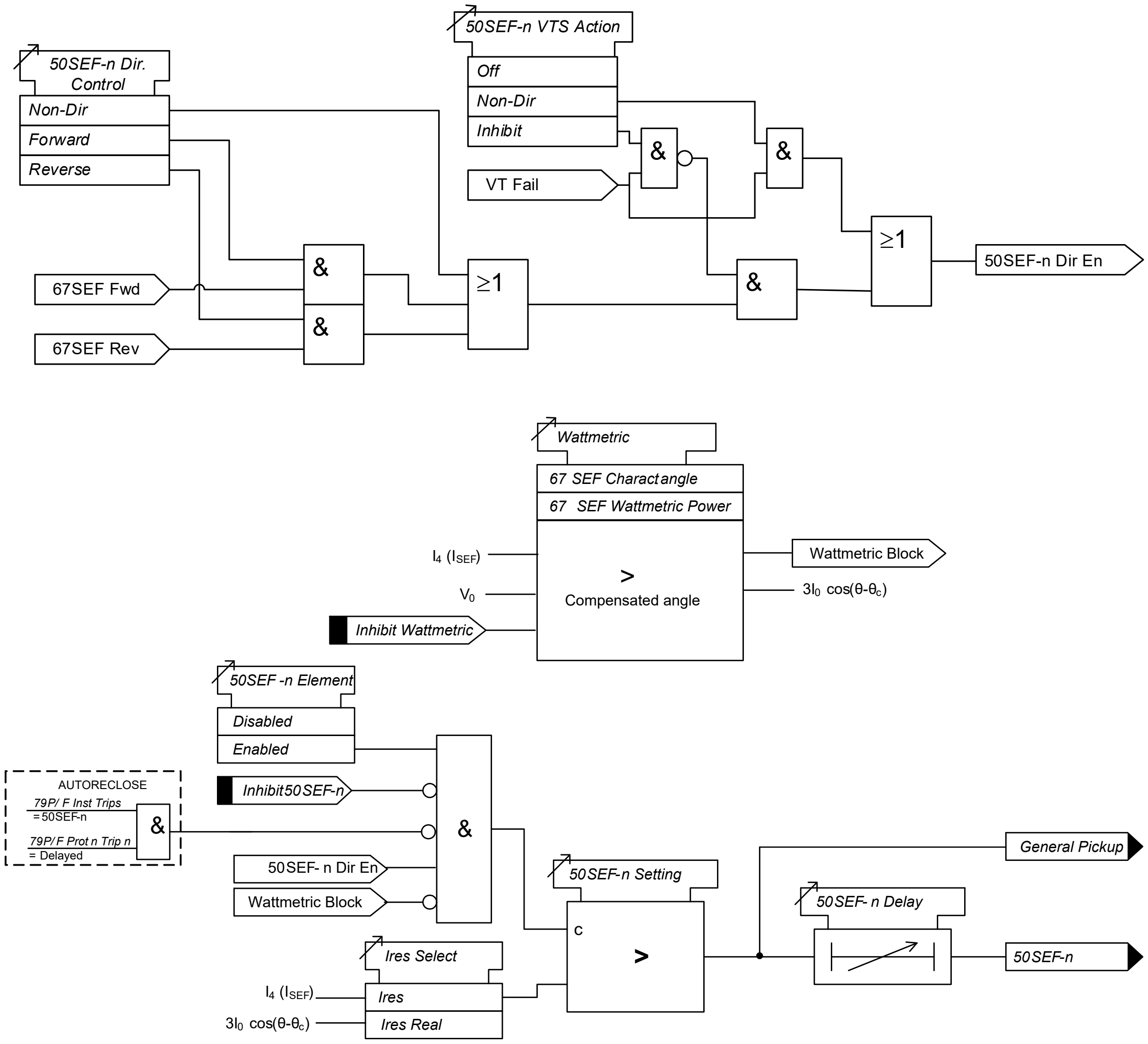


Figure 3-13 Logic Diagram: 7SR1004 Instantaneous and DTL SEF Protection

NOTE:

I_{res}* Select** is only applicable for directional sensitive earth fault (67SEF) and for non-directional SEF select the ***I_{res}.

3.4.3 Directional Sensitive Earth Fault (67SEF) – Measured $3V_0/I_0$-Φ

Directional sensitive earth fault elements in 7SR1004 relay are provided with two elements:

67SEF-1, 67SEF-2

Each sensitive earth fault element has independent settings for pick-up current ***67SEF-n Setting, 67SEF-n Delay, 67SEF-n Char Angle*** and ***67SEF-n Operating Angle***. The instantaneous elements have transient free operation.

Where directional elements are present the direction of operation can be set using ***67SEF-n Dir. Control*** setting. Directional logic is provided independently for each 67SEF-n element e.g. giving the option of using one element set to forward and one element set to non-directional.

Operation of the directional sensitive earth fault elements can be inhibited from:

Inhibit 67SEF-n	A binary or virtual input.
67SEF-n VTS Action: **Inhibit**	Operation of the VT Supervision function.

Directional elements do not operate unless the zero-sequence voltage ($3V_0$) is above the 67SEF minimum voltage setting i.e. the residual voltage is greater than the setting and the phase is in the forward operating range which is based on individual characteristic and operating angle of each element.

The zero-voltage sequence ($3V_0$) can be directly applied to the device, or the summation voltage $3 \cdot V_0$ can be calculated according to the connection type of the voltage transformer, refer to section 1.4 Voltage Transformer Configurations of Chapter 5 - Installation Guide.

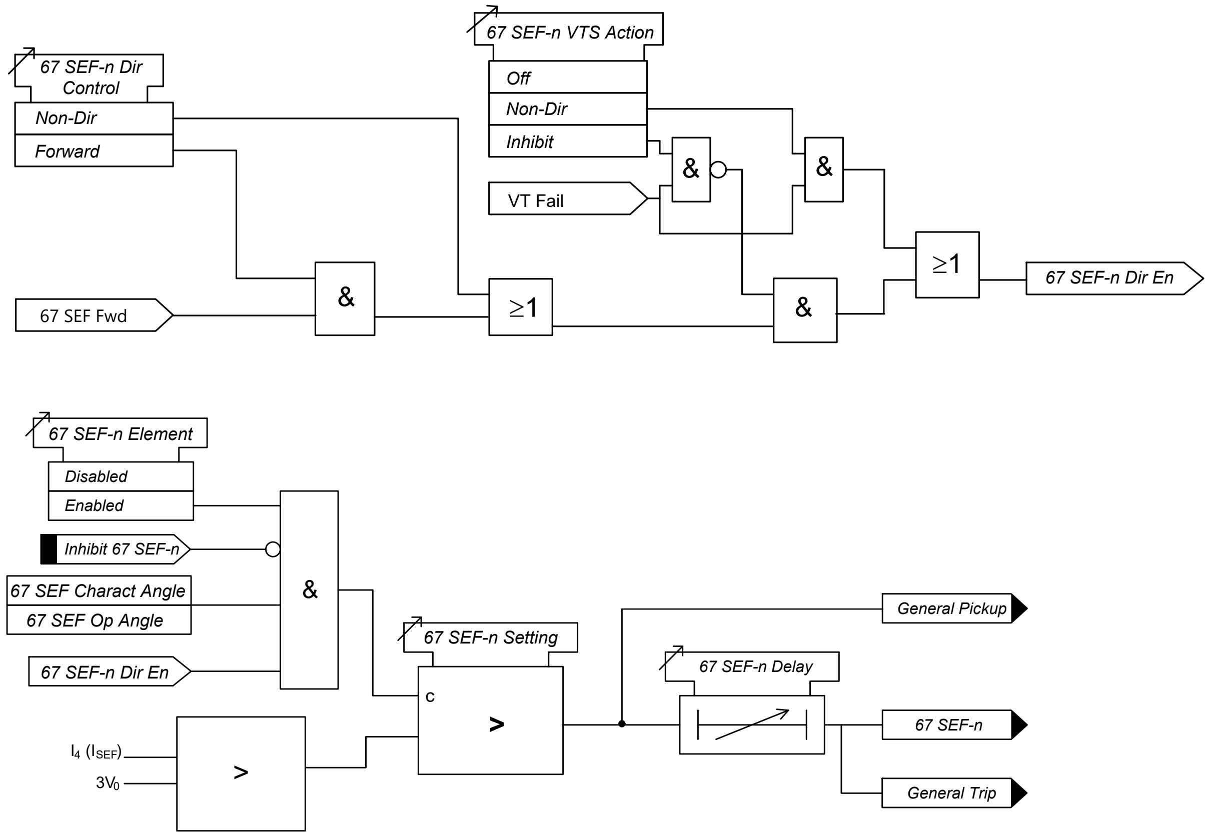


Figure 3-14 Logic Diagram: 7SR1004 Directional Sensitive Earth Fault – Measured $3V_0/I_0$-Φ

3.4.4 Time Delayed Sensitive Earth Fault Protection (51SEF)

Two sensitive earth fault elements are provided in the 7SR1002/7SR1003 relay and four elements are provided in the 7SR1004 relay.

51SEF-1, 51SEF-2, (51SEF-3 & 51SEF-4 – 7SR1004)

51SEF-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 ***51SEF-n Char***. A time multiplier is applied to the characteristic curves using the ***51SEF-n Time Mult*** setting. Alternatively, a definite time lag (DTL) can be chosen using ***51SEF-n Char***. When DTL is selected the time multiplier is not applied and the ***51SEF-n Delay (DTL)*** setting is used instead.

The ***51SEF-n Reset*** setting can apply a **definite time delayed** reset**,** or when configured as an IEC or ANSI characteristic an **IEC/ANSI (DECAYING)** reset. 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 ***51SEF-n Min. Operate Time*** setting.

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

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

NOTE:
User specific curve is applicable for 7SR1004 variant only.

Operation of the time delayed SEF elements can be inhibited from:

Inhibit 51SEF-n	A binary or virtual input
79 SEF Inst Trips: **51SEF-n**	When 'delayed' trips only are allowed in the auto-reclose sequence (***79 SEF Prot'n Trip n*** = **Delayed**).
51SEF-n VTSAction: **Inhibit**	Operation of the VT Supervision function.

Directional elements will not operate unless the zero sequence voltage (V_0) is above the ***67SEF Minimum Voltage*** setting i.e. the residual voltage is greater than 3 times this setting and the phase is in the Forward/Reverse operating range. If ***67SEF Wattmetric*** is set to Enabled, the calculated residual real power must be above the ***67SEF Wattmetric Power*** setting. The residual power Pres is equal to the wattmetric component of $3V_0I_{SEF}$ and therefore the wattmetric component of $9V_0I_0$.

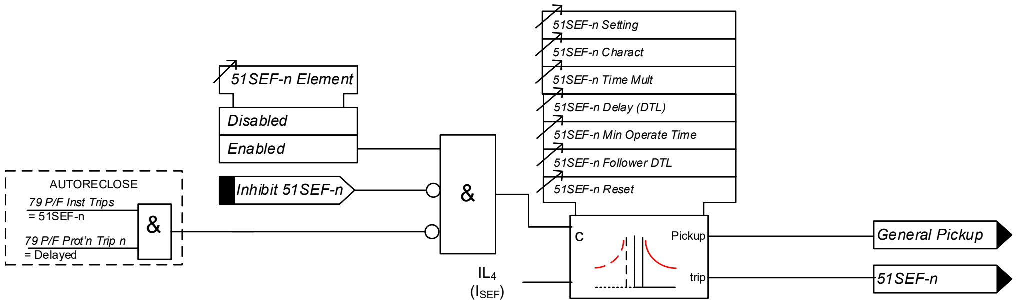


Figure 3-15 Logic Diagram: 7SR1003 Time Delayed SEF protection

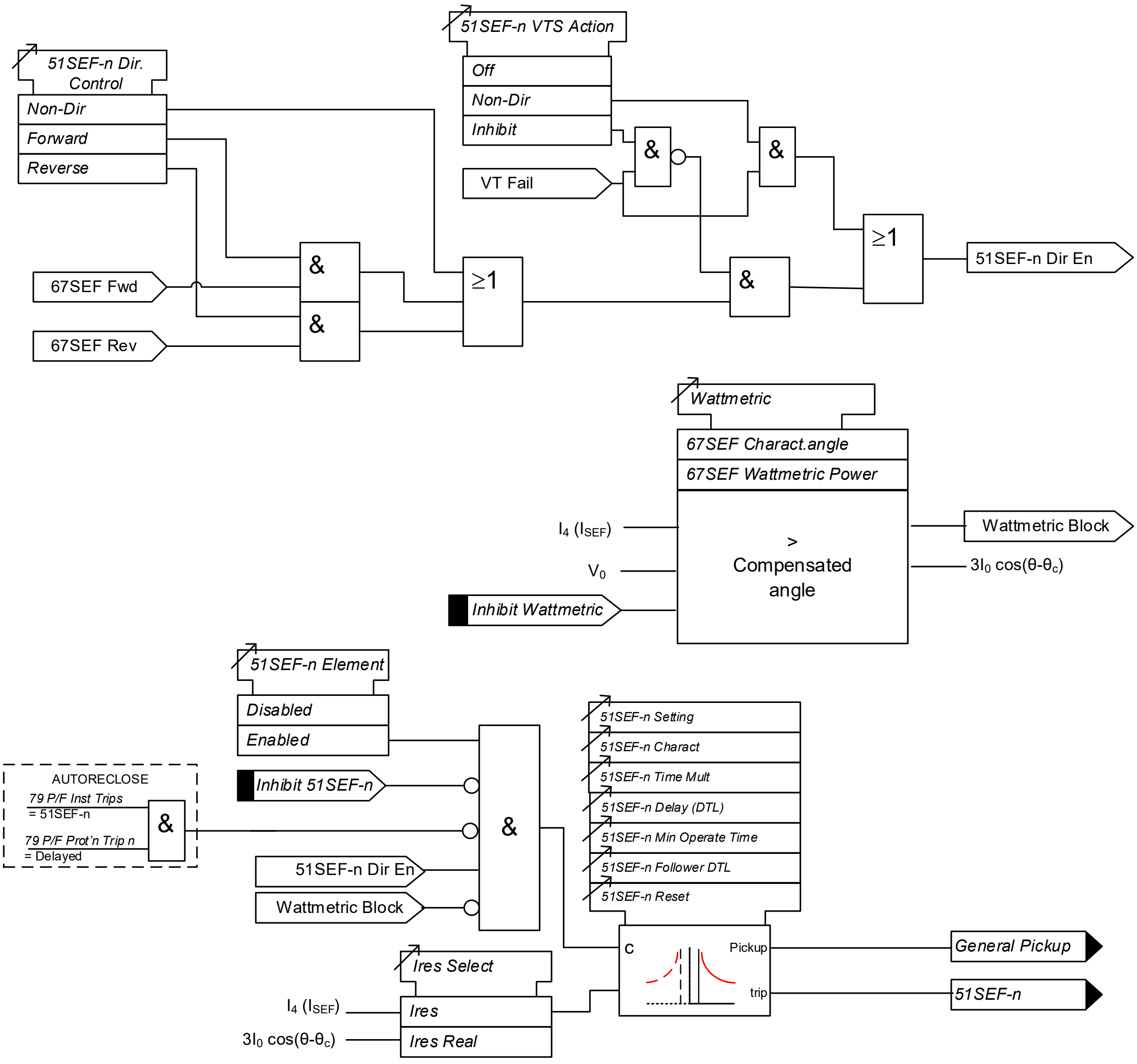


Figure 3-16 Logic Diagram: 7SR1004 Time Delayed SEF Protection

3.4.5 Current Protection: High Impedance Restricted Earth Fault - (64H)

One high impedance Restricted Earth Fault (REF) element is provided ***64H***.

The relay utilises fundamental current measurement values for this function.

The single phase current input is derived from the residual output of line/neutral CTs connected in parallel. An external stabilising resistor must be connected in series with this input to ensure that this element provides a high impedance path.

64H Current Setting sets the pick-up current level. An output is given after elapse of the ***64H Delay*** setting.

External components – a series stabilising resistor and a non-linear resistor – are used with this function. See '**Applications Guide**' for advice in specifying suitable component values.

Operation of the high impedance element can be inhibited from:

Inhibit 64H	A binary or virtual input.

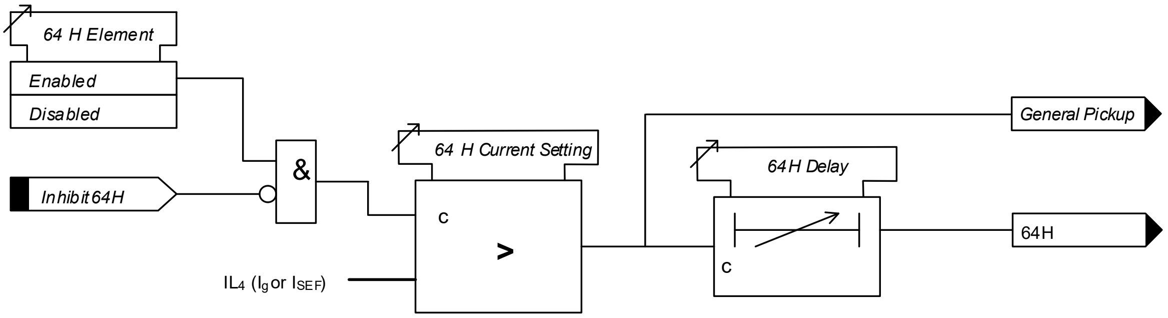


Figure 3-17 Logic Diagram: High Impedance REF (64H)

3.4.6 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:

Inhibit Cold Load	A binary or virtual input.

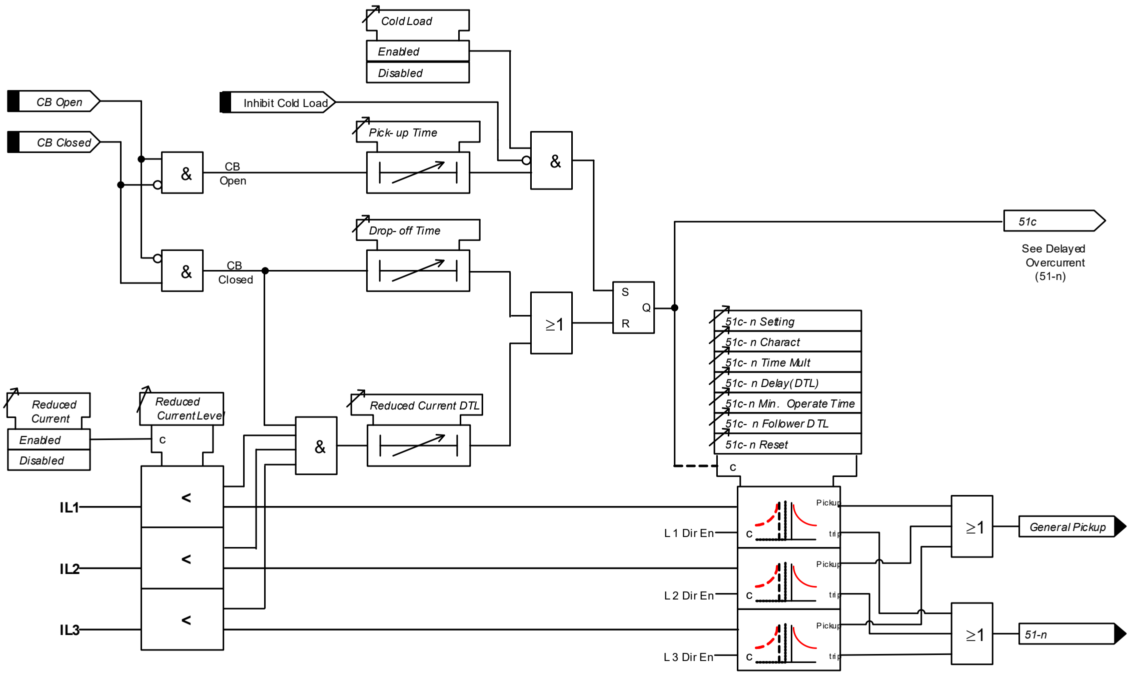


Figure 3-18 Logic Diagram: Cold Load Settings (51C)

3.4.7 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.

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

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, ANSI or user specific 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 ***46ITChar***. 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 **46IT** element returns to reset state instantaneously as soon as the current (I_2) falls below the current set value (I_2) after tripping.

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

NOTE:
User specific curve is applicable for 7SR1004 variant only.

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.

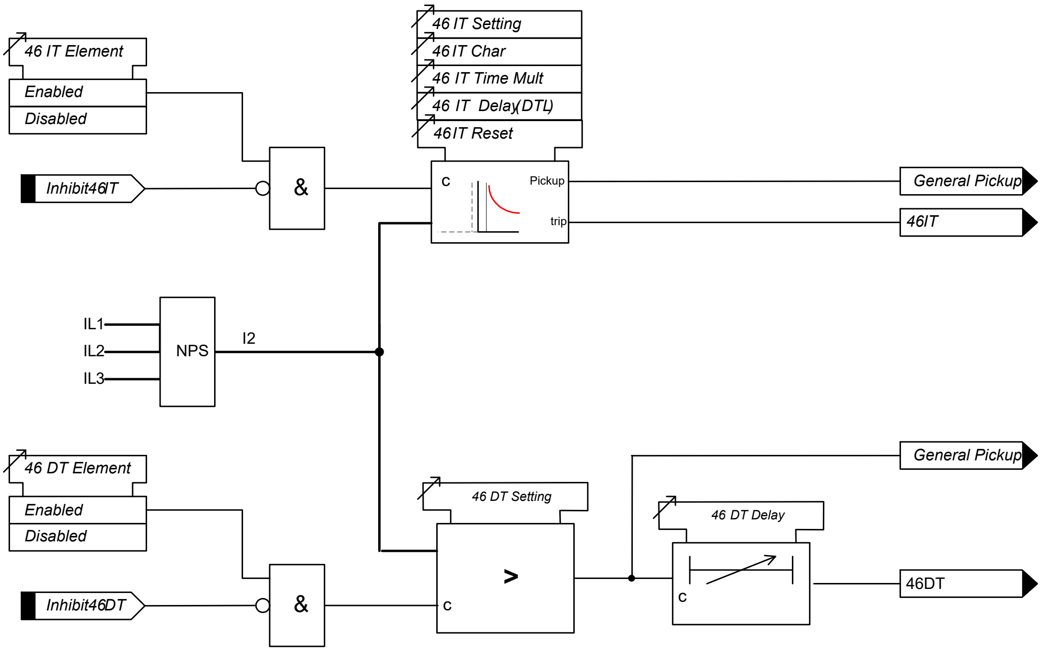


Figure 3-19 Logic Diagram: Negative Phase Sequence Overcurrent (46NPS)

3.4.8 Current Protection: Under-Current (37)

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

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.

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.
37-n U/C Guarded	Under current guard element

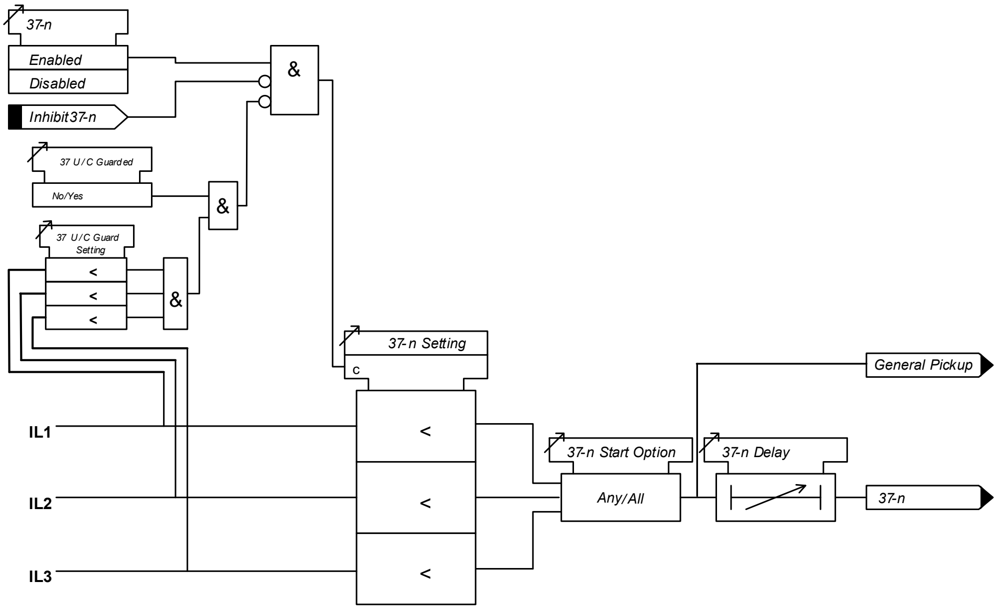


Figure 3-20 Logic Diagram: Phase Current Inputs Undercurrent Detector (37)

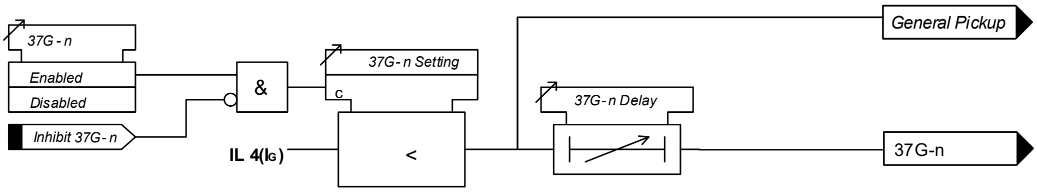


Figure 3-21 Logic Diagram: Earth Current Inputs Undercurrent Detector (37G)

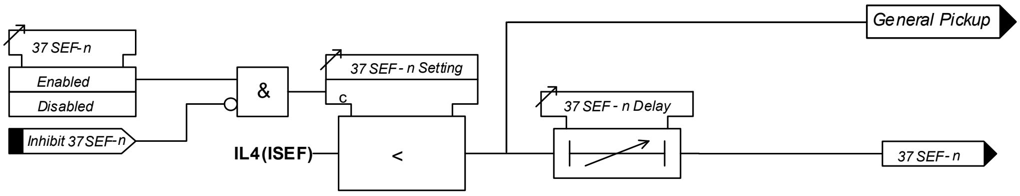


Figure 3-22 Logic Diagram: Sensitive Earth Current Inputs Undercurrent Detector (37SEF)

3.4.9 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)

In = Log Natural

I = Measured thermal current

I_P = Previous steady state current level

k = Constant (predefined, k = 1.05)

I_B = Basic current, typically the same as In

$k.I_B$ = ***49 Overload*** Setting (I_θ)

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:

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

Where: θ = thermal state at time t

I = measured thermal current

I_θ = ***49 Overload*** setting (or $k.I_B$)

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

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

Where: θ_F = final thermal state before disconnection of device

49 Overload Setting I_θ is expressed as a multiple of the relay nominal current and is equivalent to the factor $k.I_B$ as defined in the IEC 60255-149 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.

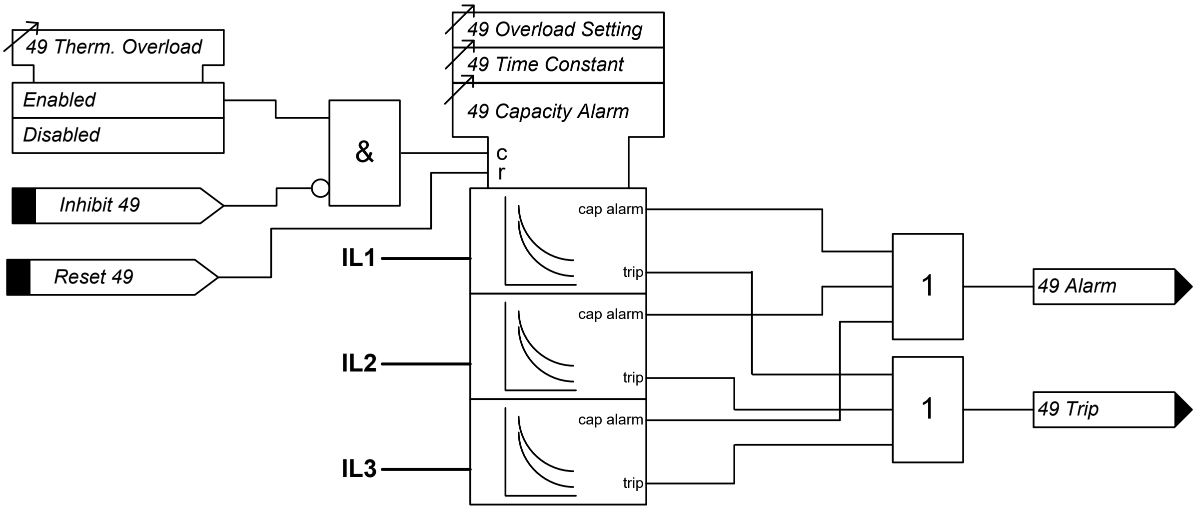


Figure 3-23 Logic Diagram: Thermal Overload Protection (49)

3.4.10 Current Protection: Line Check 50LC,50G LC, and 50SEF LC – Only software option ‘C’

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 / sensitive 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*** settings in the CIRCUIT BREAKER MENU. Alternatively, the element will remain enabled as long as the ***Line Check*** binary input is energised.

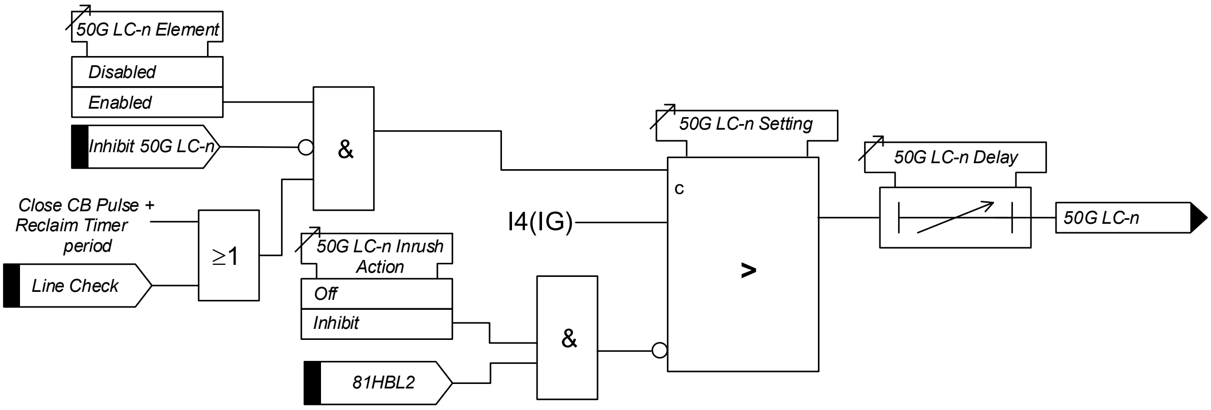


Figure 3-24 Logic Diagram: 50G Line Check Elements (50G LC)

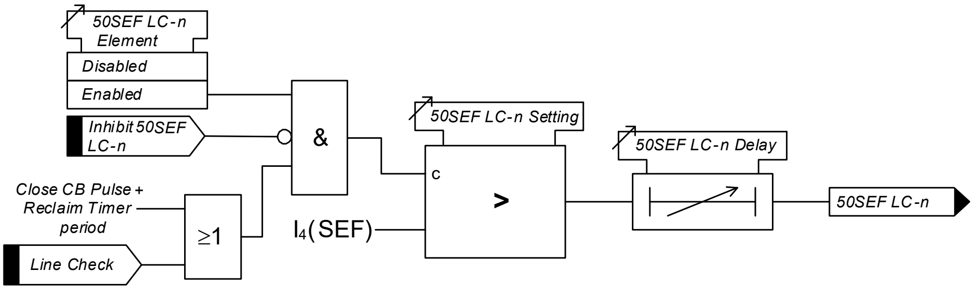


Figure 3-25 Logic Diagram: 50SEF Line Check Elements (50SEF LC)

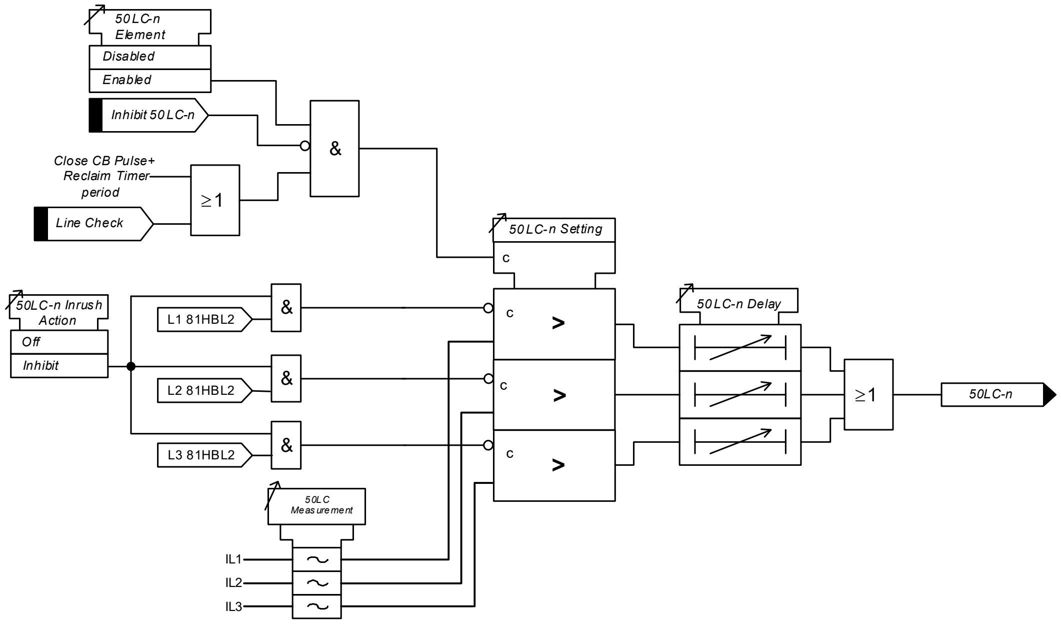


Figure 3-26 Logic Diagram: 50 Line Check Elements (50LC)

3.4.11 Protection: Arc Flash Detector (50 AFD)

By employing an optical detection technique, Arc Fault Protection results in fast clearance of arcing faults.

Arc fault protection is achieved in the 7SR1 range of relays via the **7XG31xx** series of equipment being connected to the binary inputs.

Should the sensor operate when the phase current is above the ***50AFD Setting*** in any phase then an output signal will be initiated.

Refer to **7XG31xx** documentation for further details.

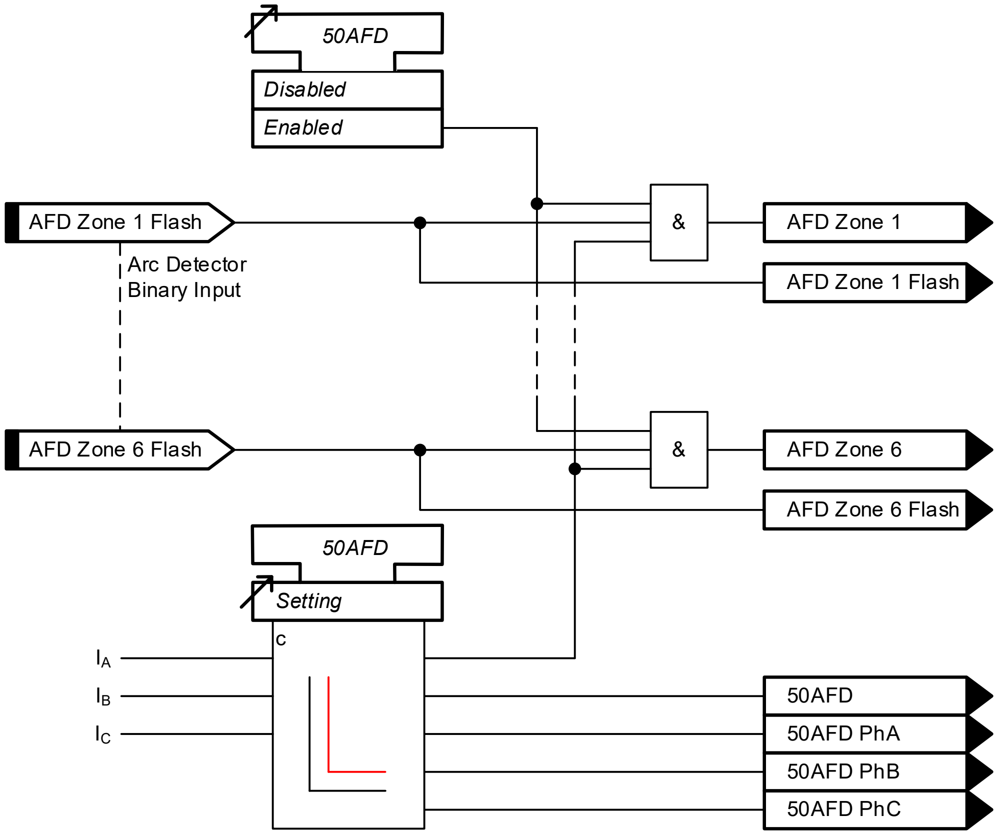


Figure 3-27 Logic Diagram: Arc Flash Detector (50 AFD)

3.4.12 Voltage Protection: Phase Under/Over Voltage (27/59)

In total four under/over voltage elements are provided ***27/59-1, 27/59-2, 27/59-3 & 27/59-4.***

The relay utilises fundamental frequency RMS voltage for this function. All under/over voltage elements have a common setting to measure phase to phase **(Ph-Ph)** or phase to neutral **(Ph-N)** voltage using the ***Voltage Input Mode*** setting.

Voltage elements can be blocked if all phase voltages fall below the ***27/59 U/V Guard*** setting.

27/59-n Setting sets the pick-up voltage level for the element.

The sense of the element (undervoltage or overvoltage) is set by the ***27/59-n Operation*** setting.

The ***27/59-n O/P Phases*** setting determines whether the time delay is initiated for operation of any phase or only when all phases have detected the appropriate voltage condition. An output is given after elapse of the ***27/59-n Delay*** setting.

The ***27/59-n Hysteresis*** setting allows the user to vary the pick-up/drop-off ratio for the element.

Operation of the under/over voltage elements can be inhibited from:

Inhibit 27/59-n	A binary or virtual input.
***27/59-n VTSInhibit:* Yes**	Operation of the VT Supervision function
27/59-n U/V Guarded	Under voltage guard element.

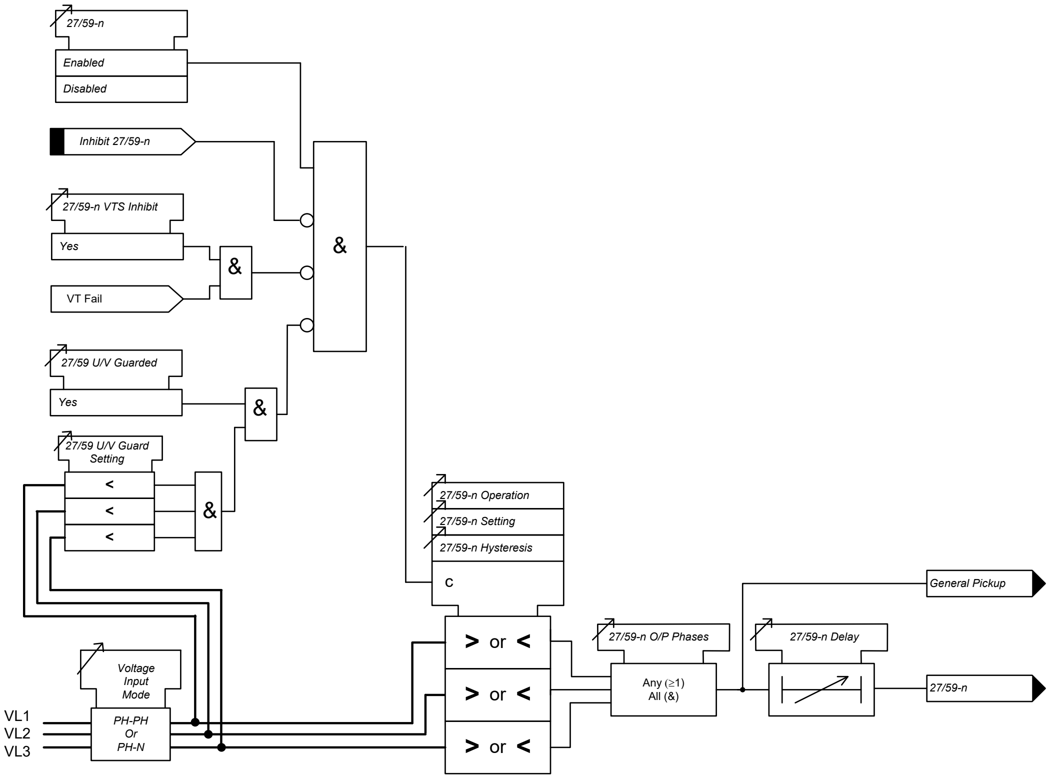


Figure 3-28 Logic Diagram: Under/Over Voltage Elements (27/59)

3.4.13 Voltage Protection: Negative Phase Sequence Overvoltage (47NPS)

Negative phase sequence (NPS) voltage (V2) is a measure of the quantity of unbalanced voltage in the system. The relay derives the NPS voltage from the three input voltages (VL1, VL2 and VL3).

Two elements are provided ***47-1 & 47-2.***

Voltage elements can be blocked if all phase voltages fall below the ***47 U/V Guard*** setting.

47-n Setting sets the pick-up voltage level for the element.

The ***47-n Hysteresis*** setting allows the user to vary the pick-up/drop-off ratio for the element.

An output is given after elapse of the ***47-n Delay*** setting.

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

Inhibit 47-n	A binary or virtual input.
47-n U/V Guarded	Under voltage guard element.

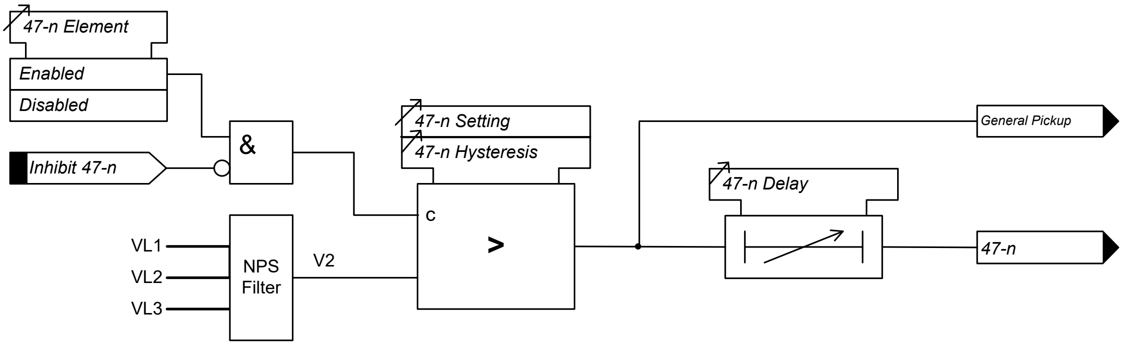


Figure 3-29 Logic Diagram: NPS Overvoltage Protection (47)

3.4.14 Voltage Protection: Neutral Overvoltage (59N)

Two Neutral Overvoltage (or Neutral Voltage Displacement) elements are provided ***59NIT & 59NDT***.

The relay utilises fundamental voltage measurement values for this function. The element can use a direct measurement 3V0 connection from the voltage transformer or calculate values from a phase to neutral connections from the voltage transformer.

The 59NIT element can be configured to be either definite time lag (DTL) or inverse definite minimum time (IDMT),

59NIT Setting sets the pick-up voltage level (3V0) for the element.

An inverse definite minimum time (IDMT) or user specific curves can be selected using ***59NIT Char***. A time multiplier is applied to the characteristic curves using the ***59NIT Time Mult*** setting (M):

$$t_{op} = \left[\frac{1000 * M}{\left[\frac{3V0}{Vs}\right] - 1} \right] ms$$

Alternatively, a definite time lag delay (DTL) can be chosen using ***59NITChar***. When Delay (DTL) is selected the time multiplier is not applied and the ***59NIT Delay (DTL)*** setting is used instead.

An instantaneous or definite time delayed reset can be applied using the ***59NIT Reset*** setting.

The 59NDT element has a DTL characteristic. ***59NDT Setting*** sets the pick-up voltage (3V0) and ***59NDT Delay*** the follower time delay.

The 59NIT element returns to its reset state instantaneously as soon as the (3V0) falls below the voltage set value (Vs) after tripping.

Operation of the neutral overvoltage elements can be inhibited from:

Inhibit 59NIT	A binary or virtual input.
Inhibit59NDT	A binary or virtual input.

It should be noted that neutral voltage displacement can only be applied to VT arrangements that allow zero sequence flux to flow in the core i.e. a 5-limb VT or 3 single phase VTs. The VT primary winding neutral must be earthed to allow the flow of zero sequence current.

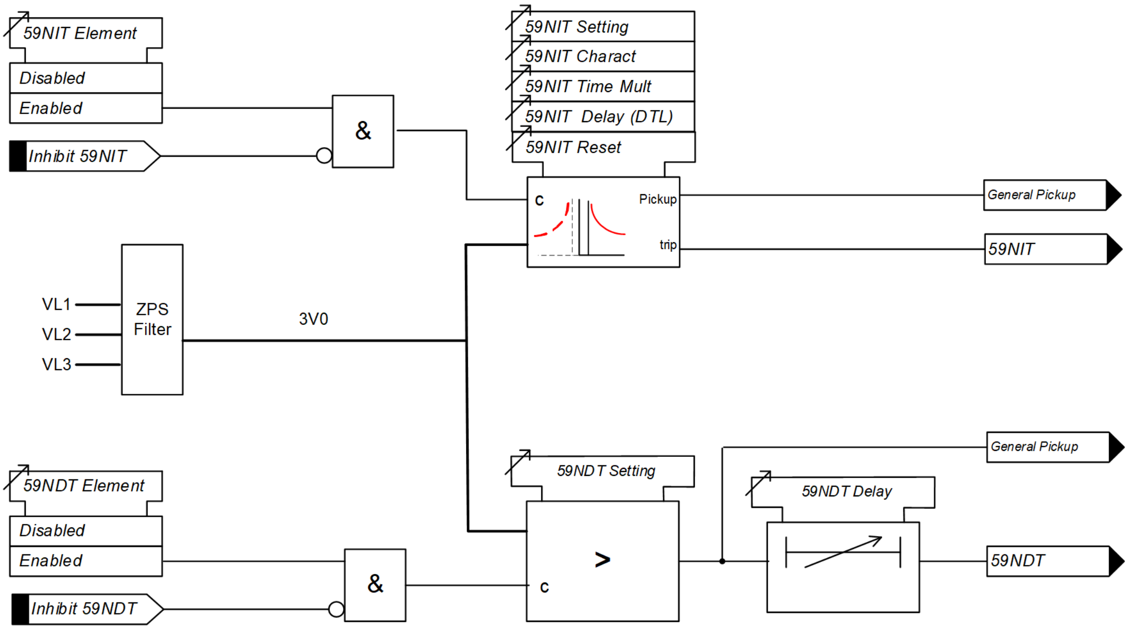


Figure 3-30 Logic Diagram: Neutral Overvoltage Element (59N)

3.4.15 Voltage Protection: Under/Over Frequency (81)

Four under/over frequency elements are provided in the 7SR1004 relay – ***81-1, 81-2, 81-3 & 81-4.***

The relay utilises fundamental voltage measurement values for this function. The frequency calculation is based on the highest input voltage derived from the voltage selection algorithm.

The relay utilises fundamental frequency RMS voltage for this function. All under/over frequency elements have a common setting to measure phase to phase **(Ph-Ph)** or phase to neutral **(Ph-N)** voltage using the **Frequency Input mode** setting.

Frequency elements are blocked if all phase voltages fall below the ***81 U/V Guard*** setting.

The sense of the element (under-frequency or over-frequency) is set by the ***81-n Operation*** setting.

81-n Setting sets the pick-up voltage level for the element.

An output is given after elapse of the ***81-n Delay*** setting.

The ***81-n Hysteresis*** setting allows the user to vary the pick-up/drop-off ratio for the element.

Operation of the under/over frequency elements is inhibited when Vph < 35V (Frequency Input Mode = Ph- Ph) or Vn < 35V (Frequency Input Mode = Ph- N) and from:

Inhibit 81-n	A binary or virtual input, or function key.
81-n U/V Guarded	Under voltage guard element.

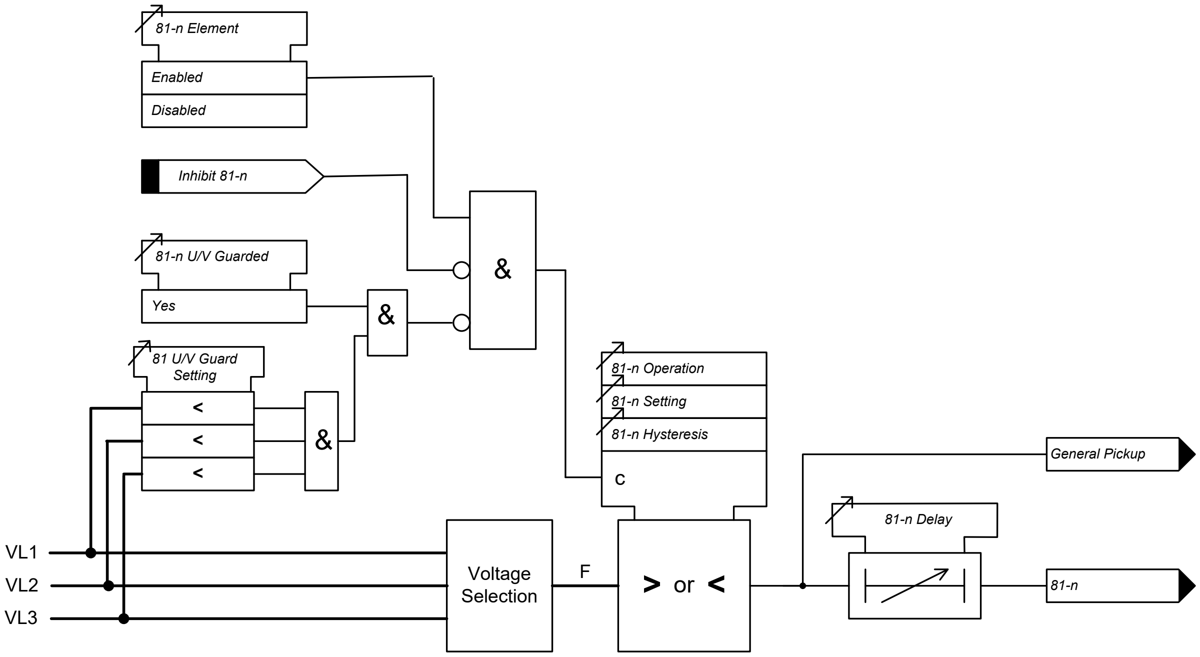


Figure 3-31 Logic Diagram: Under/Over Frequency Detector (81)

3.4.16 Power Protection: Power (32)

Two under/over power elements are provided and can measure real, reactive or apparent power.

Gn 32-n Setting sets the pick-up power level for the element.

Under-power or over-power operation can be set by the ***Gn 32-n Operation*** setting.

Gn 32-n 1ph/3ph Power allows the settings to be based on any one phase exceeding the power pick up level or on the total power of all three phases.

An output is given after elapse of the ***Gn 32-n Delay*** setting.

Operation of the under/over power elements can be inhibited when:

The measured current is below the ***Gn 32-n U/C Guard*** setting

A VT Fail condition is detected

Inhibit 32-n A binary or virtual input.

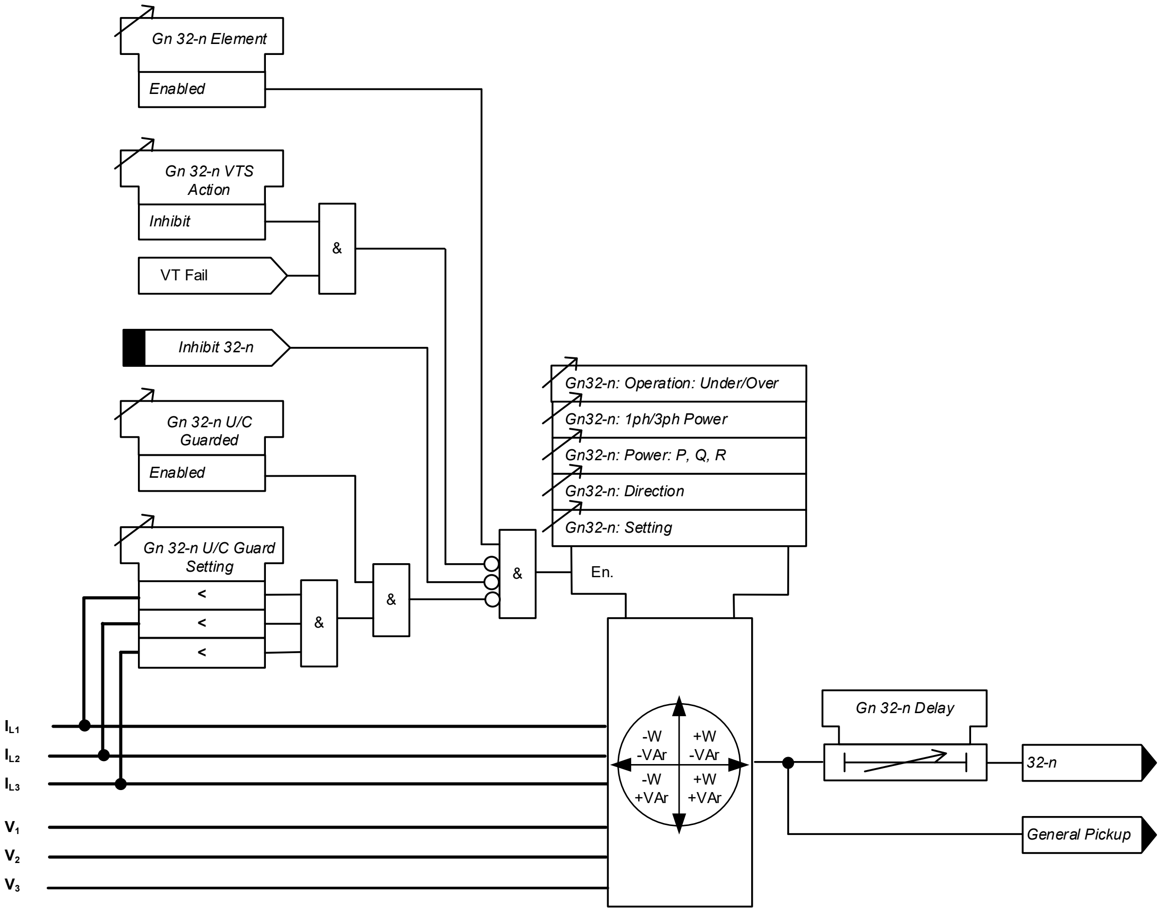


Figure 3-32 Logic Diagram: Power Protection (32)

3.4.17 Power Protection: Sensitive Power (32S)

Two under/over sensitive power elements are provided in the 4 pole 7SR1004 SEF models, The elements can measure real, reactive or apparent power.

Sensitive power functionality utilises the I_{SEF} current input i.e. a single CT input is used. Balanced load conditions are assumed. Any one of the three phase currents can be wired to the I_{SEF} current input – the POWER PROT'N > SENSITIVE POWER > ***Gn 32S Phase Selection*** setting is used to ensure that the correct power is measured.

Gn 32S-n Setting sets the pick-up power level for the element.

Under-power or over-power operation can be set by the ***Gn 32S-n Operation*** setting.

An output is given after elapse of the ***Gn 32S-n Delay*** setting.

Operation of the under/over power elements can be inhibited when:

The measured current is below the ***Gn 32S U/C Guard*** setting

A VT Fail condition is detected

Inhibit 32S-n	A binary or virtual input.

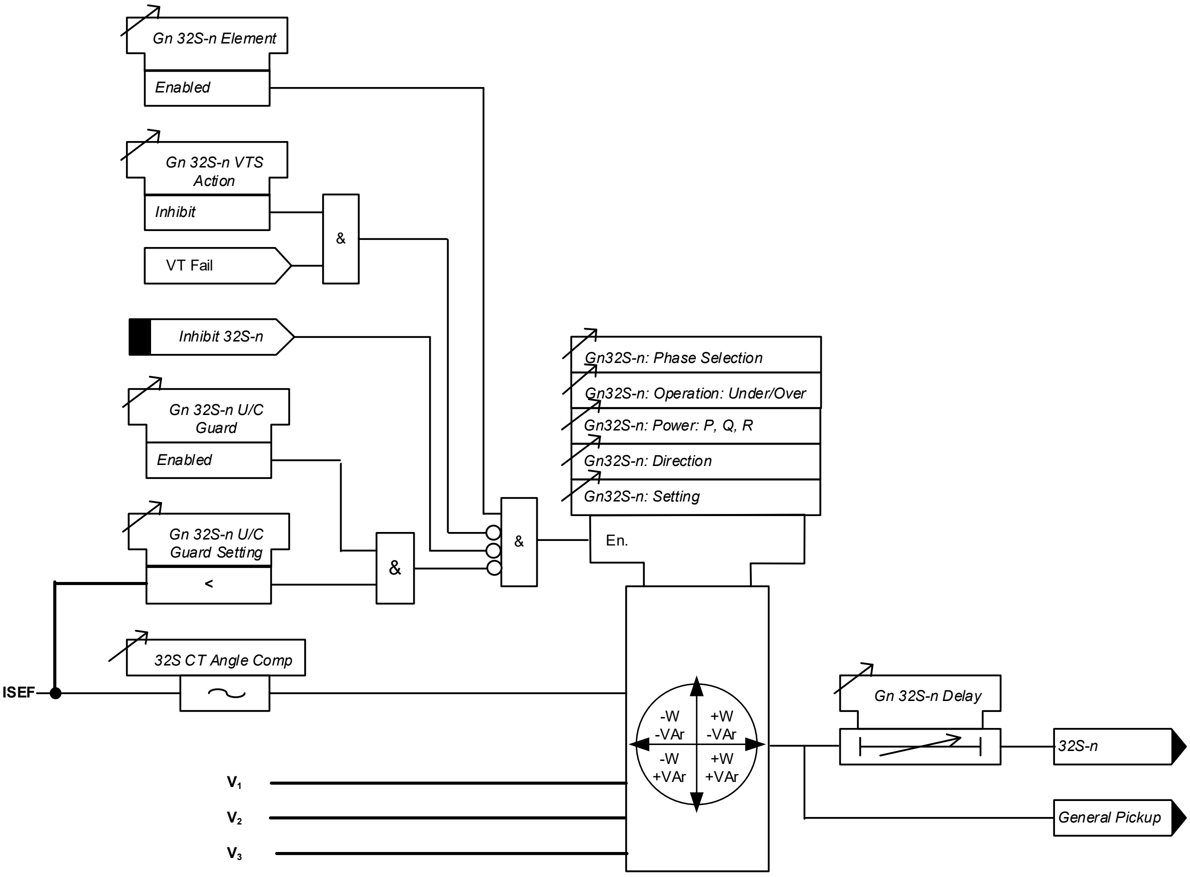


Figure 3-33 Logic Diagram: Sensitive Power Protection (32S)

3.4.18 Power Protection: Power Factor (55)

Two power factor elements are provided.

Gn 55-n Setting sets the pick-up power factor of the element.

Under-power factor or over-power factor operation can be set by the ***Gn 55-n Operation*** setting.

Gn 55-n 1ph/3ph Power allows the settings to be based on any one phase power factor or the average power factor of all three phases.

An output is given after elapse of the ***Gn 55-n Delay*** setting.

Operation of the power factor elements can be inhibited when:

The measured current is below the ***Gn 55 U/C Guard*** setting

A VT Fail condition is detected

Inhibit 55-n A binary or virtual input.

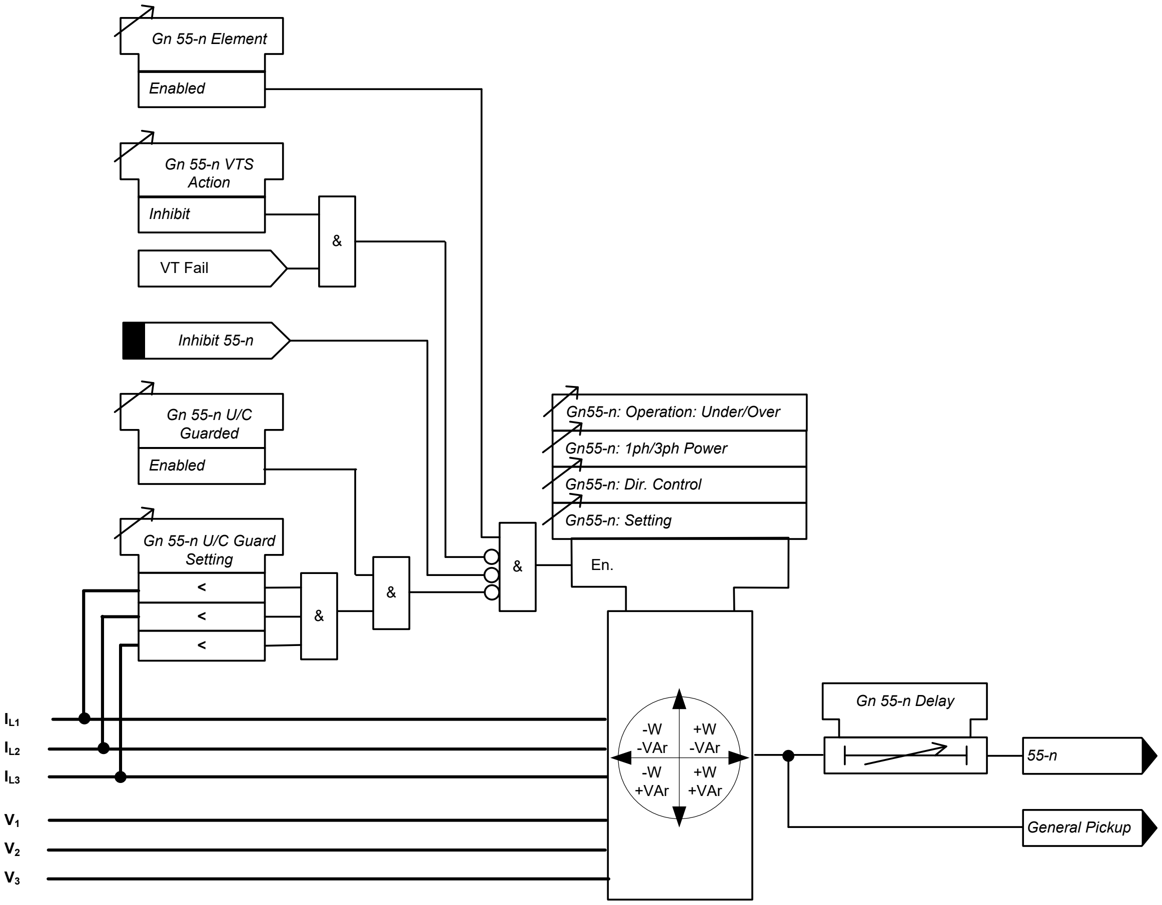


Figure 3-34 Logic Diagram: Power Factor Protection (55)

Section 4: Auto-Reclose (79) Optional Function

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 reclosures after the line has been dead for a short time, this 'deadtime' allows the fault current arc to fully extinguish.

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 (shot) 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 Instantaneous/Highset+1Delayed/HighSet Trips with 1 sec & 10 sec dead times.

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

> Changing Relay Setting ***79 Autoreclose*** **ENABLE/DISABLE** (AUTORECLOSE CONFIG menu)
>
> Enable/Disable in the CONTROL MODE accessed from the fascia
>
> 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 four fault types – P/F, E/F, SEF 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: -

> Status of the AR sequence , AR Shot Count, CB Open Countdown Timer and CB Close Countdown Timer

Inputs

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

79 In (edge triggered)

79 Out (level detected)

CB Closed

CB Open

79 Ext Trip

79 Ext Pickup

79 Block Reclose

Block Close CB

Close CB

Open CB

79 Trip & Reclose

79 Trip & Lockout

79 Line Check

79 Reset Lockout

79 Lockout

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

Manual Close CB

79 Successful AR

79 Lockout

79 Close Onto Fault

79 Trip & Reclose

79 Trip & Lockout

79 Block External

Successful Manual Close

79 Last Trip Lockout

CB fail to close

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), Sensitive Earth Fault (SEF) 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, ie.. 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, SEF 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.

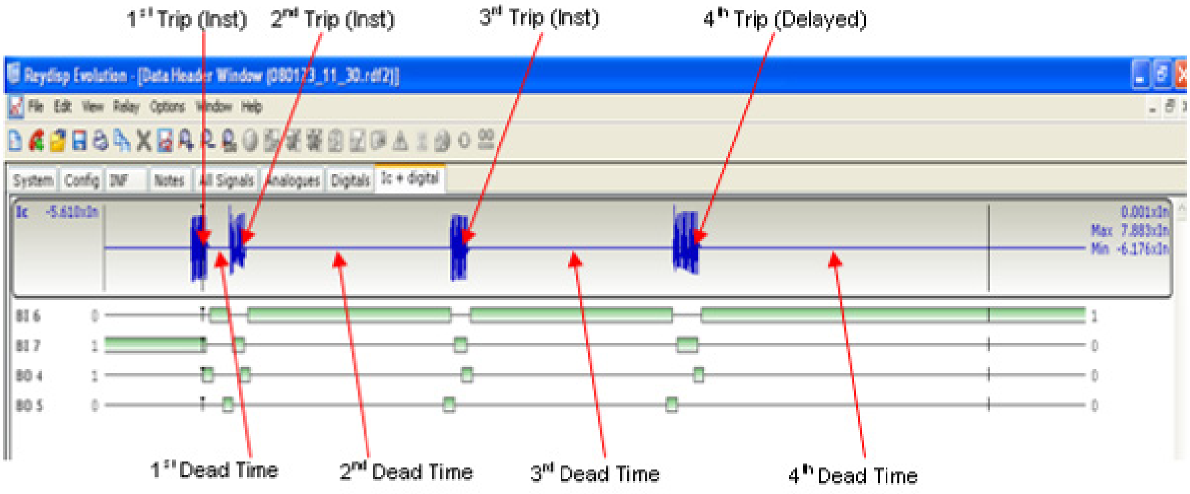


Figure 4-1 Typical AR Sequence with 3 Inst and 1 Delayed trip

4.1.3 Autoreclose Prot'n Menu

This menu presents the Overcurrent Protection elements available for each type of Fault i.e. P/F, E/F (N/G) or SEF and allows the user to select those that are to be applied as **Inst trips**; those that are to be applied as **Delayed Trips**; and those that are to be applied as **HS Trips** (HighSet), as required by the selected sequence. There is no corresponding setting for External as the External protection type is not normally controlled by the Auto Reclose Relay. The resultant configuration enables the Auto Reclose function to correctly apply the required Protection for each shot in a sequence.

4.1.4 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. Dead Time + Reclose Blocked Delay = 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.
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 but has dropped-off before its associated time delay has expired, it then increments its Shot count and advances to the next stage of the 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.

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.**

An alarm output is provided to indicate ***last trip to lockout***.

Once lockout has occurred, an alarm (***79 Lockout***) is issued and all further Close commands, except manual close, are inhibited.

If the Lockout command is received while a Manual Close operation is in progress, the feature is immediately locked-out.

Once the Lockout condition has been reached, it will be maintained until reset. The following will reset lockout: -

- **By a Manual Close command, from fascia, comms or** *Close CB* **binary input.**
- **By a** *79 Reset Lockout* **binary input, provided there is no signal present that will cause Lockout.**
- **At the end of the** *79 Minimum LO Delay* **time setting if** *79 Reset LO by Timer* **is selected to** ENABLED**, provided there is no signal present which will cause Lockout.**
- **Where Lockout was entered by an A/R Out signal during an Autoreclose sequence then a** *79 In* **signal must be received before Lockout can reset.**
- **By the** *CB Closed* **binary input, provided there is no signal present which will cause Lockout.**

The Lockout condition has a delayed drop-off of 2s. The Lockout condition can not be reset if there is an active lockout input.

4.1.5 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.

4.1.6 E/F Shots sub-menu

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

As above but E/F settings.

4.1.7 SEF Shots sub-menu

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

As above but SEF Settings, Note: - SEF does not have HighSets

4.1.8 External 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, E/F or SEF 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 or SEF 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.

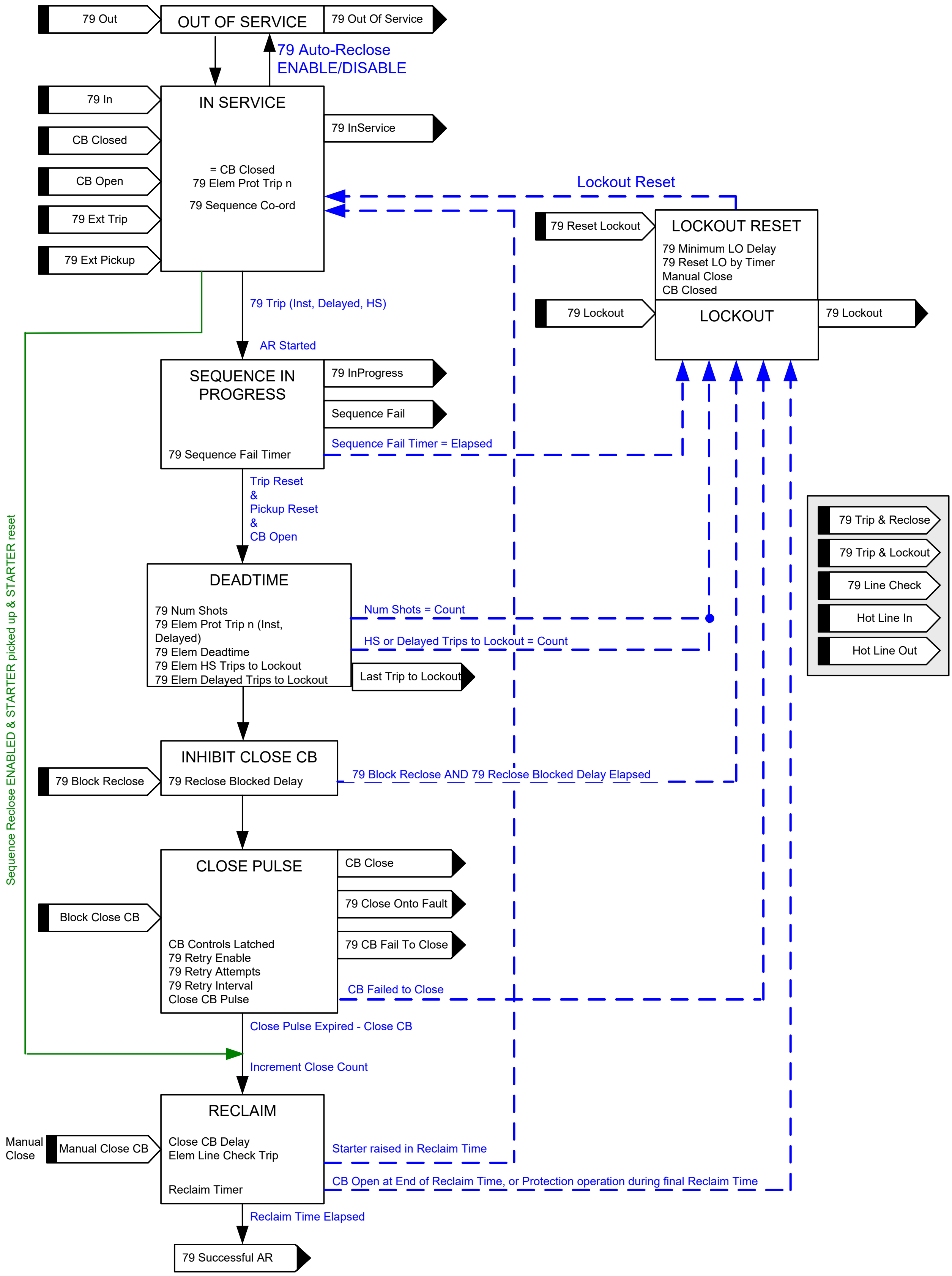


Figure 4-2 Basic Auto-Reclose Sequence Diagram

4.2 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 the control characters. Each can be up to 20 characters long. The allowable characters are:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9	Digit
( )	Parenthesis
!	‘NOT’ Function
.	‘AND’ Function
^	‘EXCLUSIVE OR’ Function
+	‘OR’ Function
E*n*	Equation (number)
I*n*	Binary Input (number)
	‘1’ = Input energised, ‘0’ = Input de-energised
L*n*	LED (number)
	‘1’ = LED energised, ‘0’ = LED de-energised
O*n*	Binary output (number)
	‘1’ = Output energised, ‘0’ = Output de-energised
V*n*	Virtual Input/Output (number)
	‘1’ = Virtual I/O energised, ‘0’ = Virtual I/O de-energised

Example Showing Use of Nomenclature

E1= ((I1^F1).!O2)+L1

Equation 1 = ((Binary Input 1 XOR Function Key 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***).

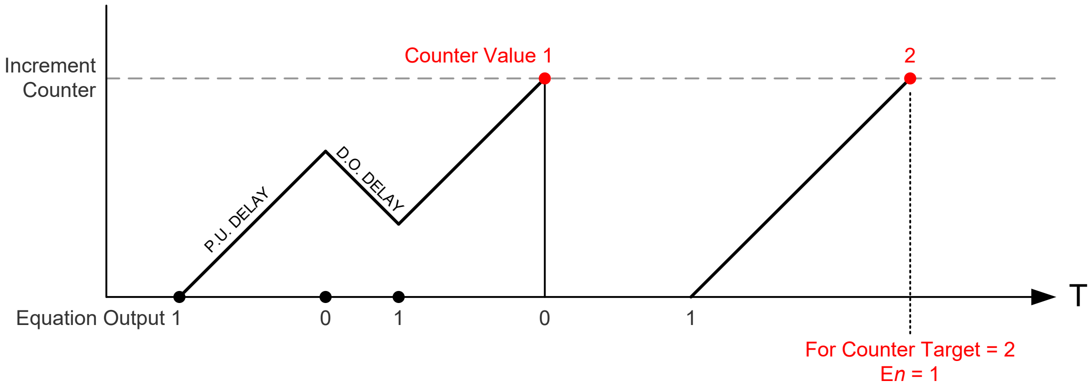


Figure 4-3 Sequence Diagram: Quick Logic PU/DO Timers (Counter Reset Mode Off)

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

The output of En is assigned in the OUTPUT CONFIG > OUTPUT MATRIX menu where it can be programmed to any Binary Output (O), LED (L) or Virtual Input/Output (V) combination.

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

4.3 Manual CB Control

A Manual Close Command can be initiated in one of four ways: via a ***Close CB*** binary input, via the data communication Channel(s) or CB close push button or from the relay CONTROL MODE menu. It causes an instantaneous operation via ***Manual Close CB*** binary output, over-riding any DAR sequence in progress.

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 or during the Reclaim Time 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.

With the Autoreclose function set to Disabled the Manual Close control is still active.

If a fault appears on the line during the Close Pulse or during the Reclaim Time with protection function is enabled, the relay will initiate a trip. If the there is no fault appears during the reclaim time, then 'Successful Man Close' indication will be initiated.

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.

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. 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, I^2t measurement and operation counters.

4.4 Circuit Breaker (CB)

This menu includes relay settings applicable to both manual close (MC) and auto-reclose (AR) 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. If a CB fails to operate, the DAR feature will go to lockout.

Close CB Pulse

The duration of the ***CB Close 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*** 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***.

Reclaim Timer

The 'Reclaim time' will start each time a Close Pulse has timed out and the CB has closed.

Where a protection pickup is raised during the reclaim time the relay advances to the next part of the reclose sequence.

The relay goes to the Lockout state if the CB is open at the end of the reclaim time or a protection operates during the final reclaim time.

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 3 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.

CB DBI Delay

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

A Don't Believe it (DBI) condition exists for a 1/1 state– i.e. where the CB indicates it is both Open and Closed at the same time

The Relay goes to Lockout and the ***CB Alarm*** output is given where the DBI condition exists for longer than the ***CB DBI Delay*** setting.

Hot Line In/Out

When 'Hot Line' is enabled all auto reclose sequences are inhibited and any fault causes an instantaneous trip to lockout.

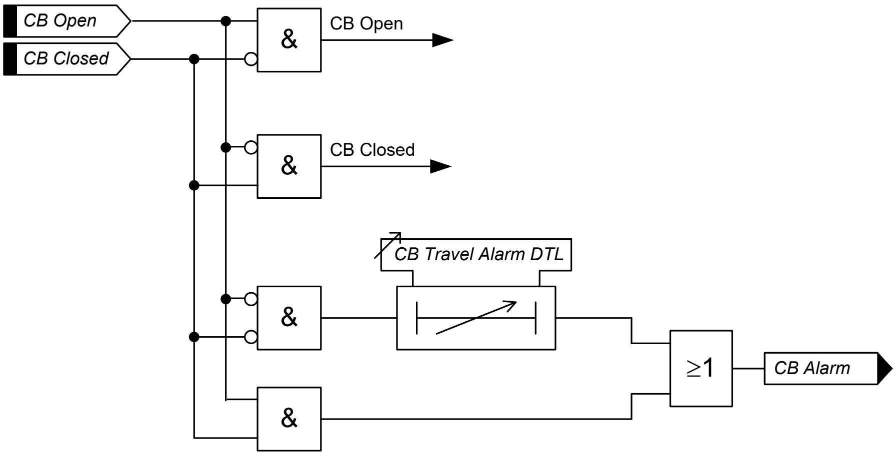


Figure 4-4 Logic Diagram: Circuit Breaker Status

79 Minimum LO Delay (Only in Auto-reclose models)

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 ***79 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.

79 Reset LO by Timer(Only in Auto-reclose models)

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.

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.

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 by 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.

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.

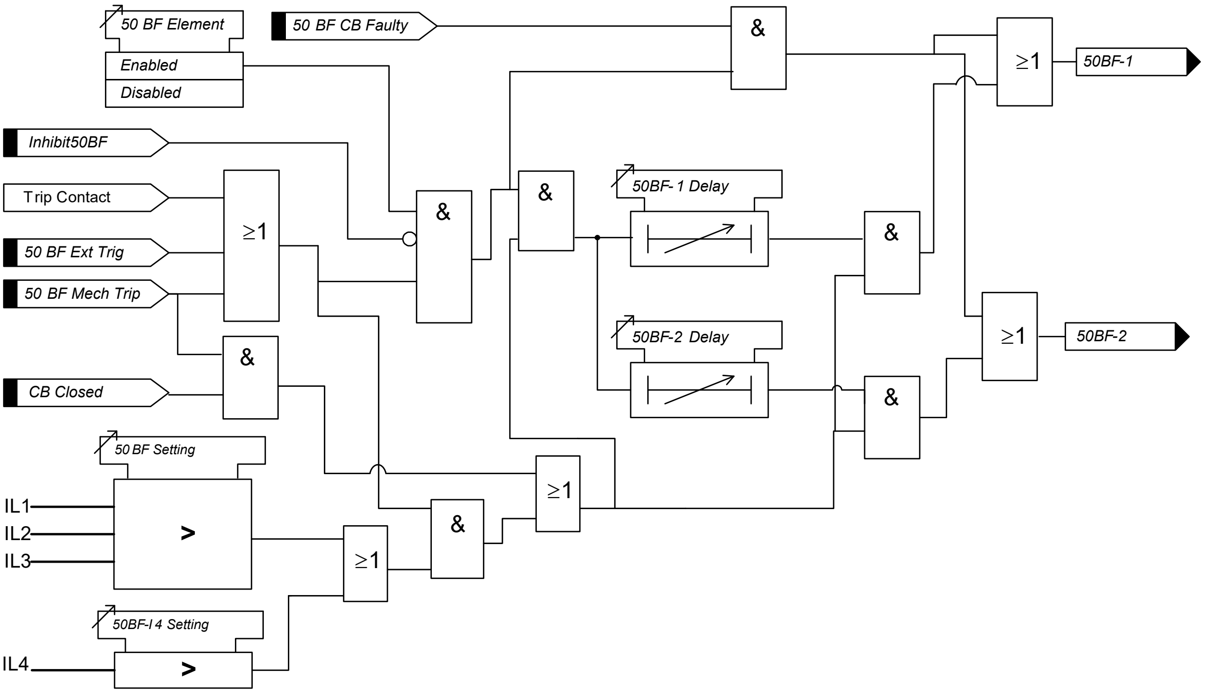


Figure 5-1 Logic Diagram: Circuit Breaker Fail Protection (50BF)

5.2 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.

NOTE: The output should be configured as either "Pulse output" or "Hand-reset output" only.

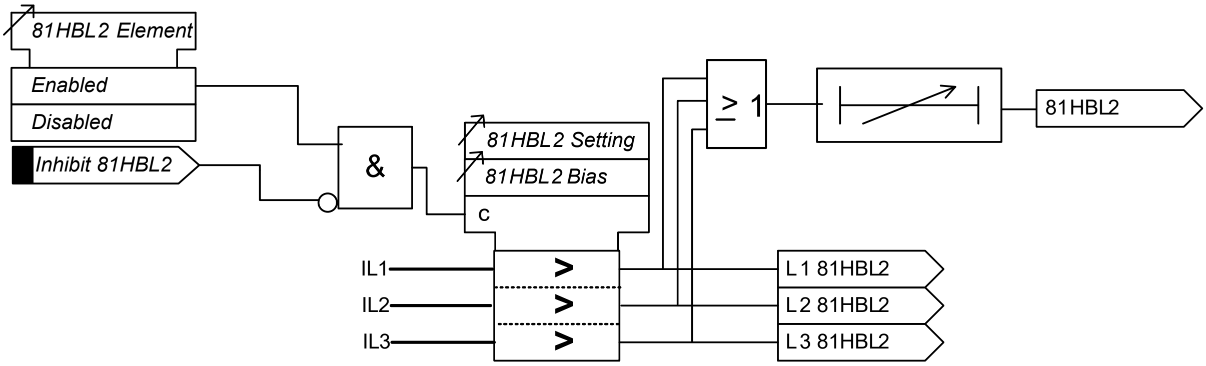


Figure 5-2 Logic Diagram: Harmonic Block Feature (81HBL2)

5.3 Total Harmonic Distortion Supervision (81I_THD)

Single stage THD supervision element is provided in the 7SR10 Overcurrent Relay.

THD calculates the 2nd to 15th harmonic currents presents in line current and displayed in the 'THD Meter' window as a percentage of fundamental frequency current.

81I_THD

Total harmonic distortion supervision (81I_THD) has independent settings. ***81I_THD Setting*** for pick-up current and
81I_THD Delay follower time delay.

Operation of the Total harmonic distortion supervision elements can be inhibited from:

Inhibit 81I_THD	A binary or virtual input.
***81I_THD Inrush Action:* Block**	Operation of the inrush current detector function.

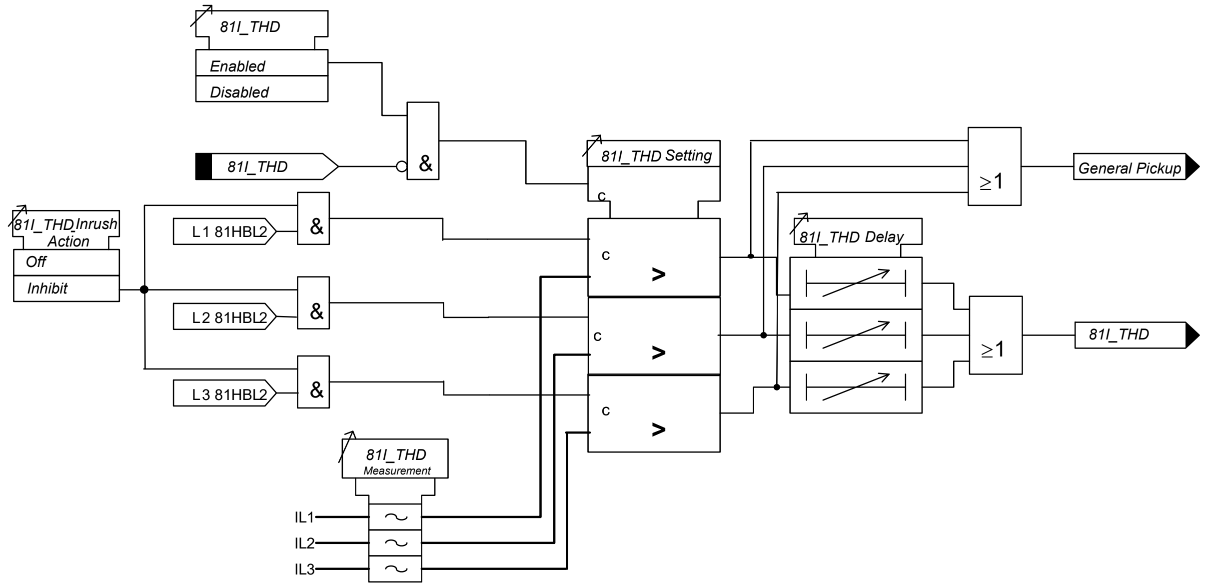


Figure 5-3 Logic Diagram: Total Harmonic Distortion Supervision Element (81I_THD)

5.4 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.

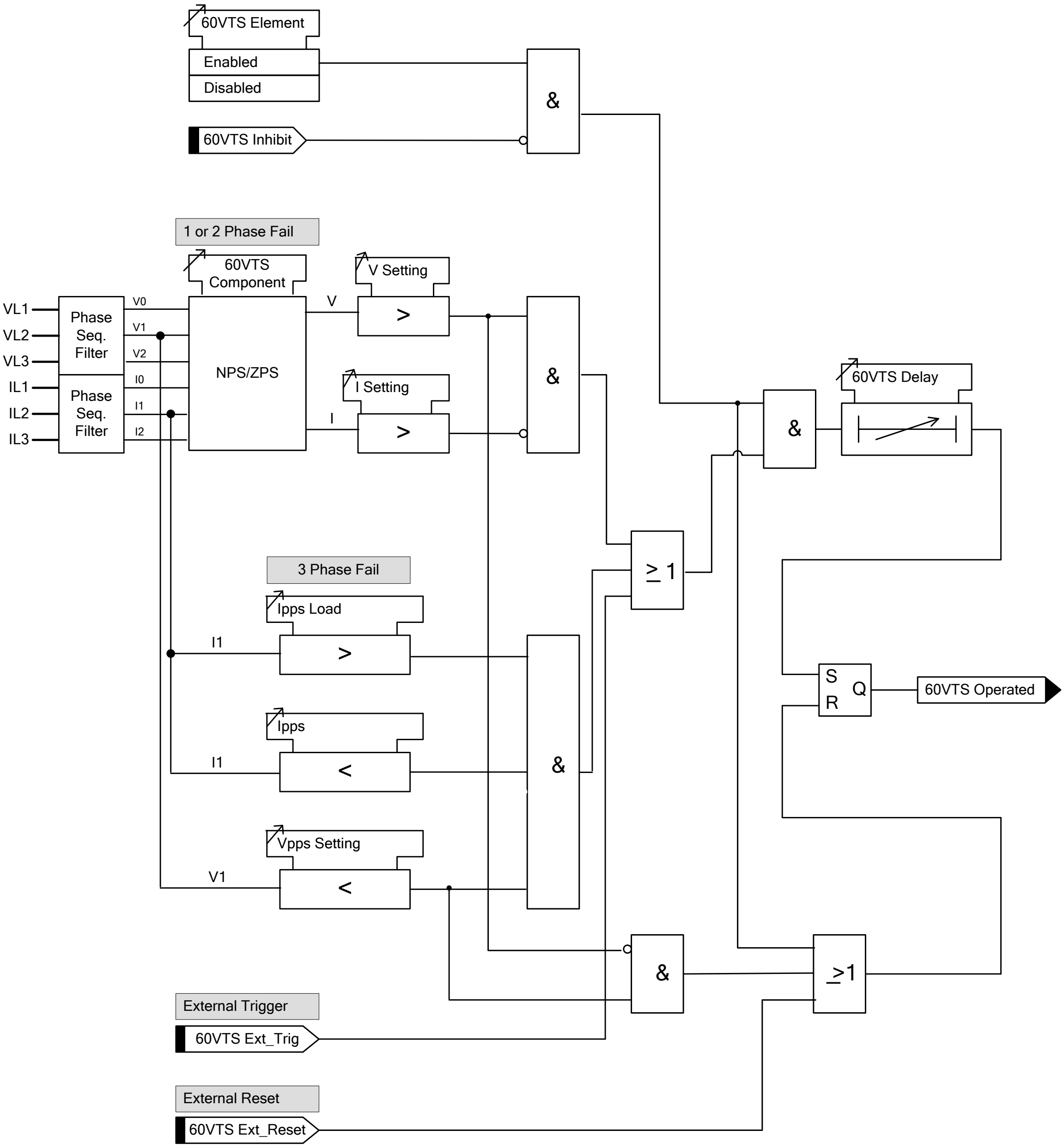


Figure 5-4 Logic Diagram: VT Supervision Function (60VTS)

5.5 CT Supervision (60CTS)

The relay has two methods of detecting a CT failure. CT Supervision is only available in relays with four current inputs and three voltage inputs.

5.5.1 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 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 A binary or virtual input.

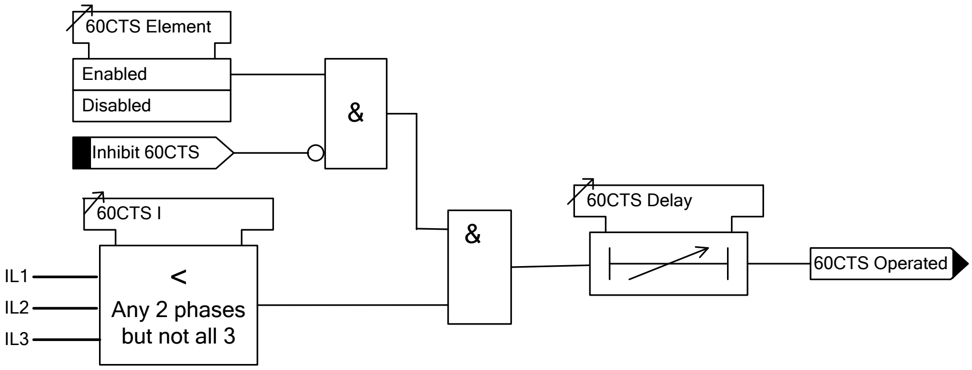


Figure 5-5 Logic Diagram: CT Supervision Function (60CTS)

5.5.2 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.

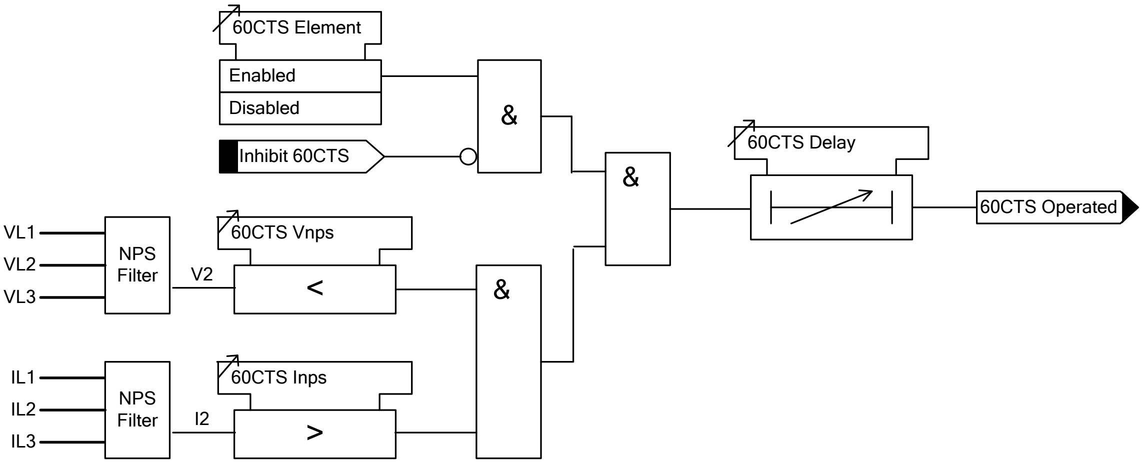


Figure 5-6 Logic Diagram: CT Supervision Function (60CTS)

5.6 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/CGuard	Under current guard

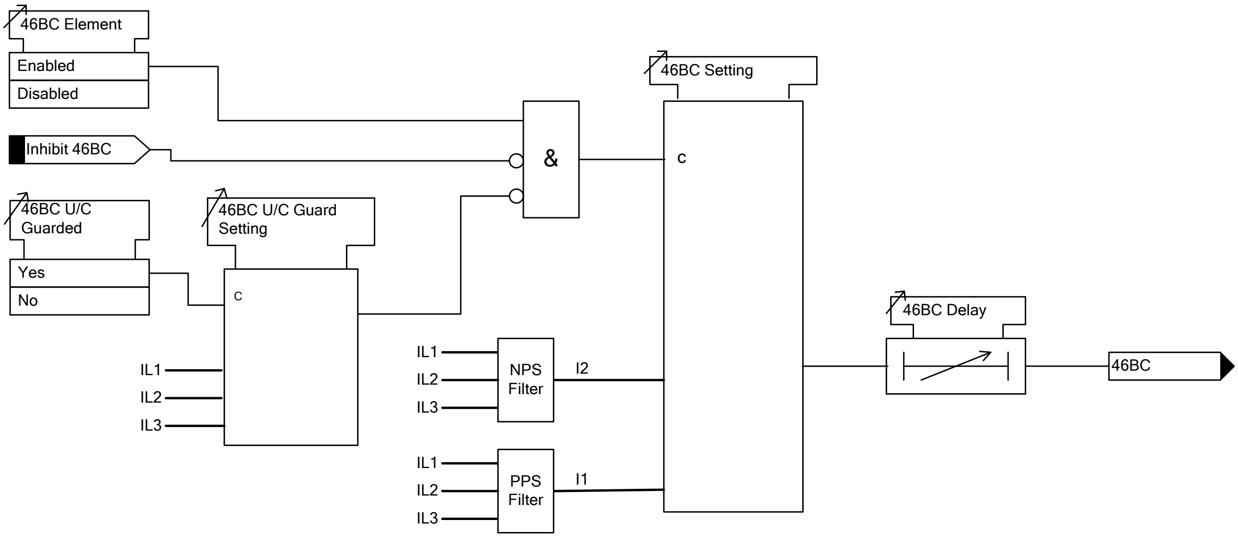


Figure 5-7 Logic Diagram: Broken Conductor Function (46BC)

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

The relay provides three trip 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.

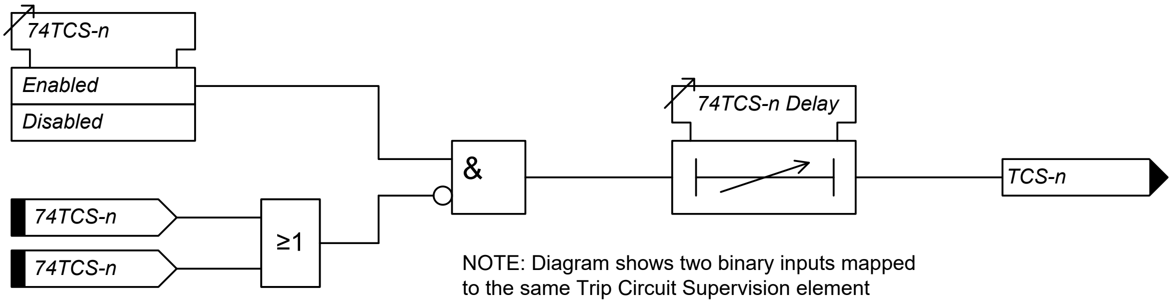
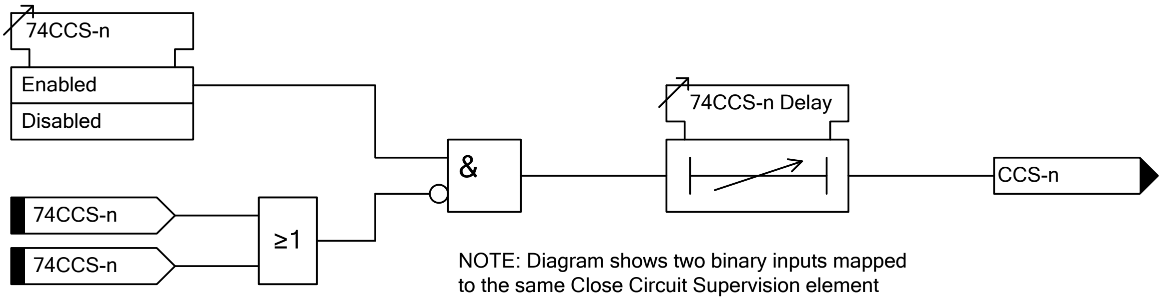


Figure 5-8 Logic Diagram: Trip Circuit Supervision Feature (74TCS)



NOTE: Diagram shows two binary inputs mapped to the same Close Circuit Supervision element

Figure 5-9 Logic Diagram: Close Circuit Supervision Feature (74CCS)

Section 6: Other Features

6.1 Data Communications

Two communication ports, COM1 and COM2 are provided. RS485 connections are available on the terminal blocks at the rear of the relay (COM1). A USB port, (COM 2) is provided at the front of the relay for local access using a PC.

The rear com1 port can be selected to operate as a local or a remote port operation.

Communication is compatible with Modbus RTU, IEC 60870-5-103 FT 1.2, and DNP 3.0 transmission and application standards.

For communication with the relay via a PC (personal computer) a user-friendly software package, Reydisp is available to allow transfer of relay settings, waveform records, event records, fault data records, Instruments/meters, and control functions. Reydisp is compatible with IEC 60870-5-103.

6.1.1 Communication Ports

6.1.1.1 USB Interface

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 in the Reydisp connection window, connections to the USB port 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, otherwise the Com 2 port must be set to IEC60870-5-103 (the relay address and baud rate do not need to be set).

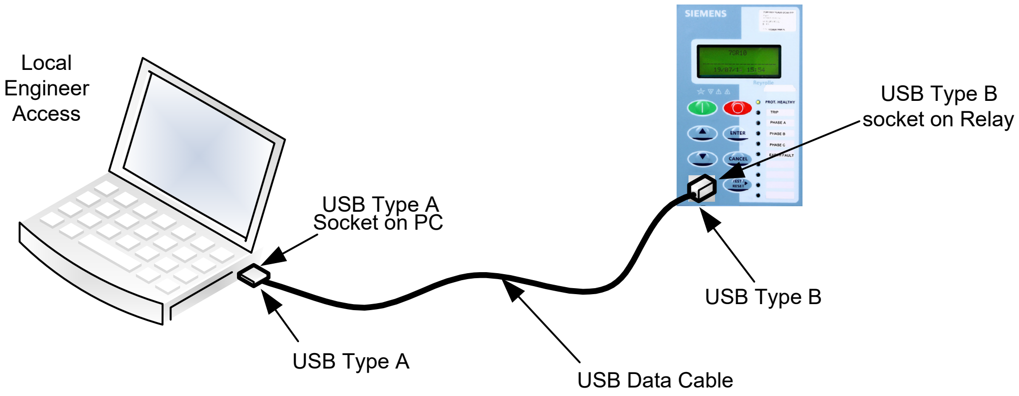


Figure 6-1 Communication to Front USB Port

To establish the connection between the Relay and Reydisp software, follow the procedure given below:

1. Click **Connect**.

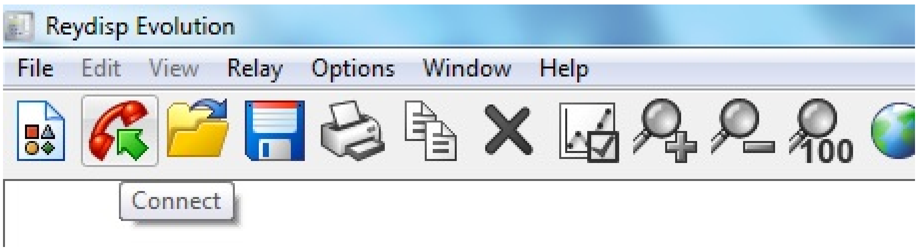


Figure 6-2 Connect Icon

2. Select **COM port** where the 7SR10 relay is connected.

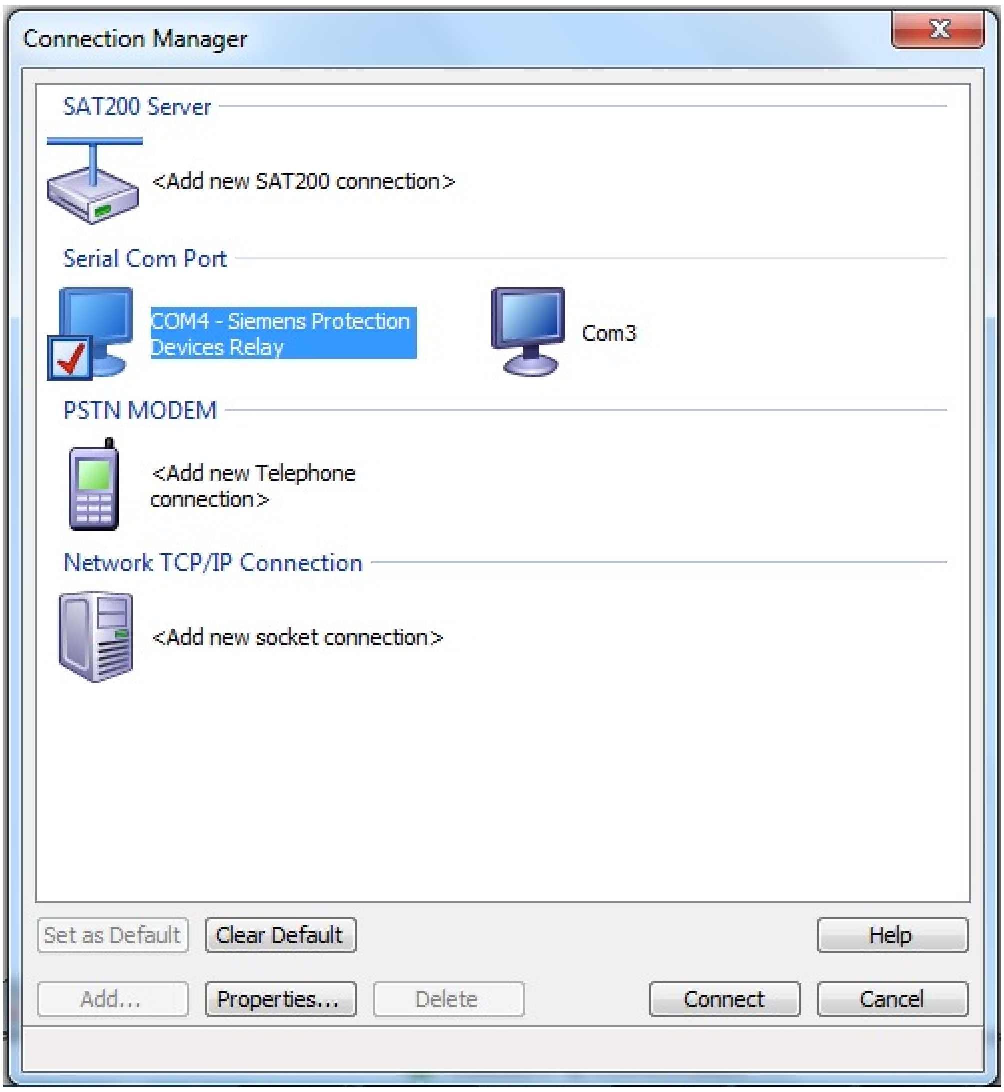


Figure 6-3 Port Selection in Connection Manager

3. Select **System Information** icon.

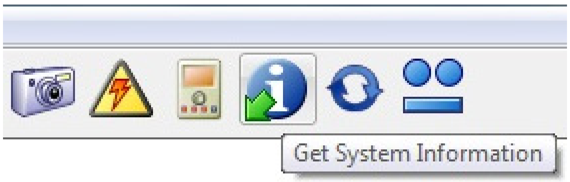
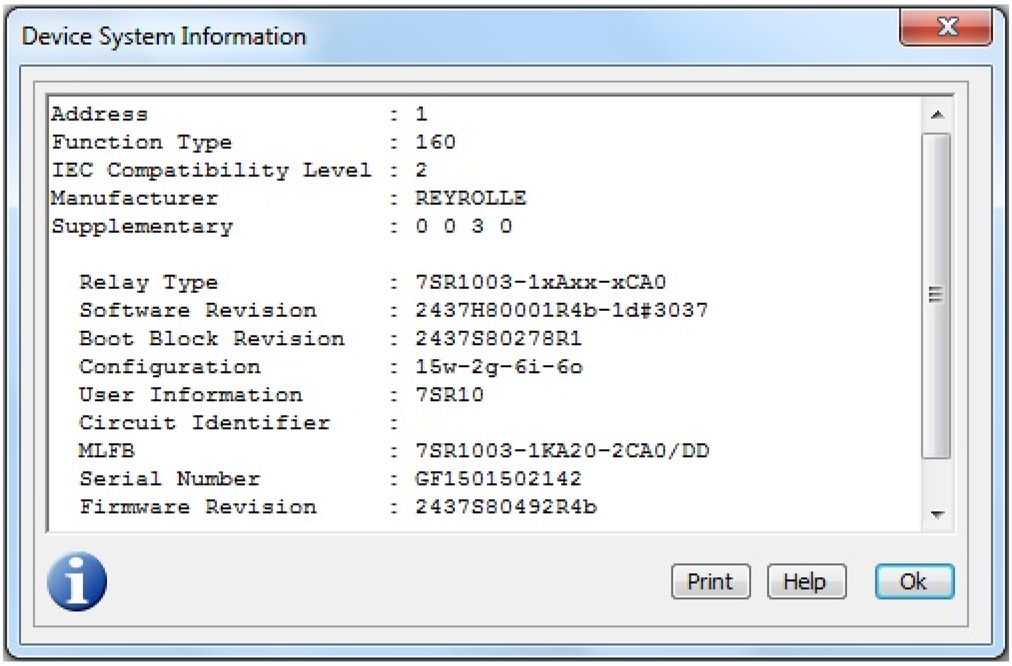


Figure 6-4 System Information Icon

4. Confirm the connection establishment with the Reydisp.



```
Address                 : 1
Function Type           : 160
IEC Compatibility Level : 2
Manufacturer            : REYROLLE
Supplementary           : 0 0 3 0

  Relay Type            : 7SR1003-1xAxx-xCA0
  Software Revision     : 2437H80001R4b-1d#3037
  Boot Block Revision   : 2437S80278R1
  Configuration         : 15w-2g-6i-6o
  User Information      : 7SR10
  Circuit Identifier    :
  MLFB                  : 7SR1003-1KA20-2CA0/DD
  Serial Number         : GF1501502142
  Firmware Revision     : 2437S80492R4b
```

Figure 6-5 System Information Icon

NOTE

The Reydisp and the relay will show only the standard MLFB information. For special variant (for example, ZY20), refer to the label information on the device.

6.1.1.2 RS485 Interface

The 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. The relays are fitted with an internal terminating resistor which can be connected between A and B by fitting an external wire loop between terminals X2: TERM and X2: B terminals.

The maximum number of relays that can be connected to the bus is 64.

The following settings must be configured via the relay fascia when using the RS485 interface. The shaded settings are only visible when DNP3.0 is selected.

Setting name	Range	Default	Setting	Notes
Station Address	0 … 254 (IEC60870-5-103) 0 … 247 (MODBUS) 0 … 65534 (DNP3)	0	1…	An address must be given to identify the relay. Each relay must have a unique address.
COM1-RS485 Protocol	OFF, IEC60870-5-103, MODBUS-RTU, DNP3.0	IEC60870-5-103	As Required	Sets the protocol used to communicate on the RS485 connection.
COM1-RS485 Baud Rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400	19200	As Required	The baud rate set on all of the relays connected to the same RS485 bus must be the same as the one set on the master device.

Setting name	Range	Default	Setting	Notes
COM1-RS485 Parity	NONE, ODD, EVEN	EVEN	As Required	The parity set on all of the relays connected to the same RS485 bus must be the same and in accordance with the master device.
COM1-RS485 Mode	Local, Remote, Local Or Remote	Remote	Remote	Selects whether the port is Local or Remote.
Unsolicited Mode	DISABLED ENABLED	DISABLED	As Required	Setting is only visible when COM1 Protocol is set to DNP3
Destination Address	0 … 65534	0	As Required	Setting is only visible when COM1 Protocol is set to DNP3

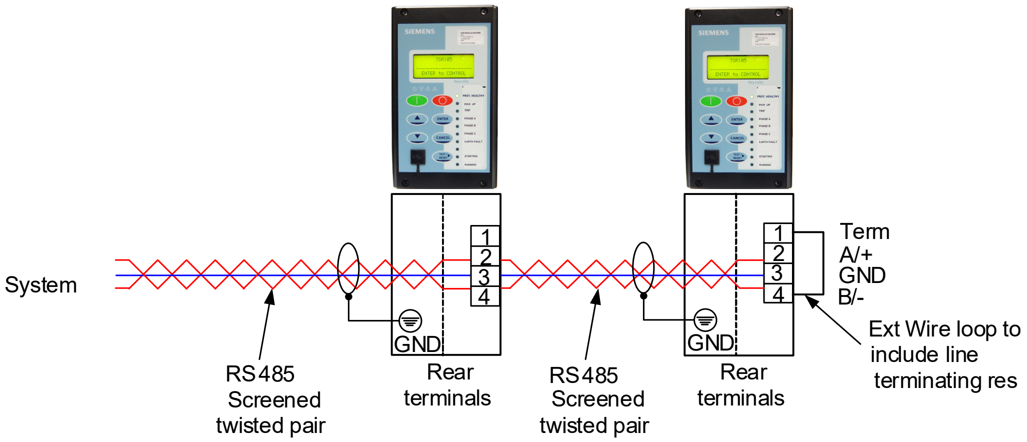


Figure 6-6 Communication to Multiple Devices from Control System using RS485

6.2 CB Maintenance

6.2.1 Output Matrix Test

The 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.

6.2.2 CB Counters

The following CB maintenance counters are provided:

CB Total Trip Count:	Increments on each trip command issued.
CB Total Trip Manual Open	Selects whether the CB Total Trip Counter is incremented for Manual Open Operations. If disabled, the CB Total Counter will only increment for protection trip commands.
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 Delta Trip Manual Open	Selects whether the CB Delta Trip Counter is incremented for Manual Open Operations. If disabled, the CB Delta Trip Counter will only increment for protection trip commands.
CB Count to AR Block: (Only in Auto-reclose models)	Displays the number of CB trips experienced by the CB before the AR is blocked. When the target is reached the

	relay will only do 1 Delayed Trip to Lockout. An output is available to reset this value.
CB Count to AR Block Manual Open: (Only in Auto-reclose models)	Selects whether the CB Count to AR Block is incremented for Manual Open Operations. If disabled, the CB Count to AR Block will only increment for protection trip commands.
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.

6.2.3 I^2t CB Wear

An I^2t counter is also included and 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 I^2t value at the time of trip is added to the previously stored value and an alarm is given when any one of the 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 I^2t value can also triggered and reset from a binary input or command.

6.3 Data Storage

6.3.1 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.

NOTE

ZY20 - The user selectable language parameter will be available in Turkish, while the default data like events and waveform recorder will be available in English.

6.3.2 Demand

Maximum, minimum and mean values of line currents, voltages and power (where applicable) 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.

6.3.3 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 ms. 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.

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.

6.3.4 Waveform Records

Relay waveform storage can be triggered either by user selecting the relay operations from the relay fascia from a suitably programmed binary input or via the data communications channel(s). The stored analogue and digital waveforms illustrates the system and relay conditions at the time of trigger. An output is provided to indicate when a new record has been stored.

A waveform can also be stored from the fascia using the **DATA STORAGE/Waveform Storage > Trigger Waveform** setting.

In total, the relay provides 15 s of waveform storage; this is user selectable to 15 Rec x 1 Sec, 7 Rec x 2 Sec, 3 Rec x 5 Sec, 1 Rec x 15 Sec records. When the waveform recorder buffer is full any new waveform record will over-write the oldest. The most recent record is Waveform 1.

As well as defining the stored waveform record duration, the user can select the percentage of the waveform storage prior to triggering.

Waveforms are sampled at a rate of 1600 Hz.

Stored waveforms can be erased using the **DATA STORAGE >** ***Clear Waveforms*** setting or from Reydisp.

6.3.5 Fault Records

Up to fifteen fault records can be stored and displayed on the Fascia LCD. Fault records can be triggered by user selected via 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.

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 >** ***Clear Faults*** setting or from Reydisp.

6.3.6 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.

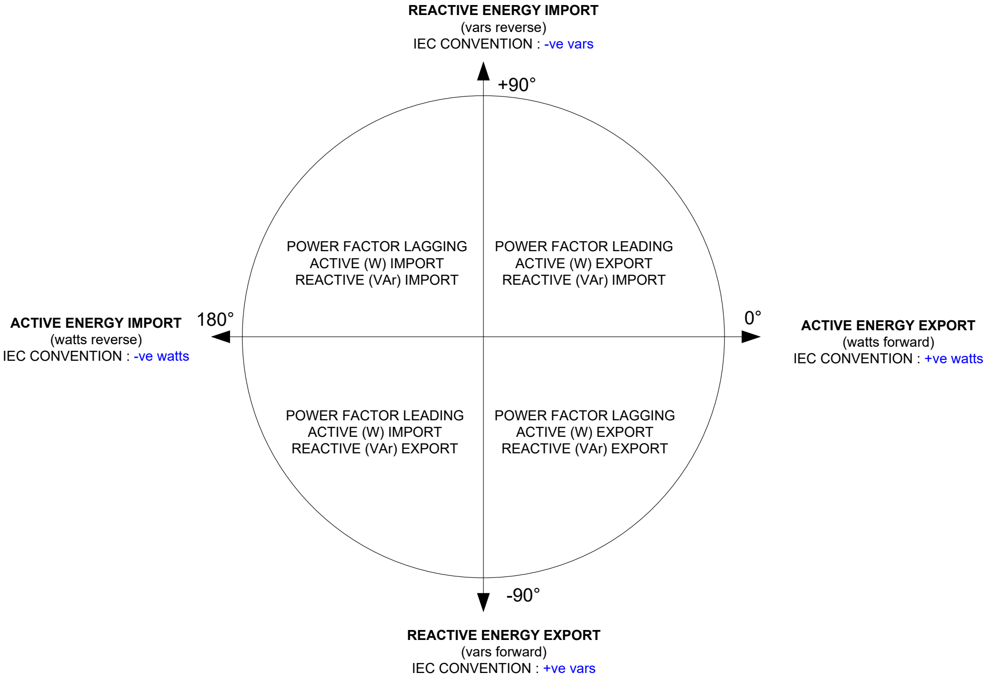


Figure 6-7 Energy Direction Convention

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.

6.3.7 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 'œ' 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 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.

6.5 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 6-1 Operation Mode

OPERATION	REMOTE MODE	LOCAL MODE	OUT OF SERVICE MODE
Control			
Rear Ports	Enabled	Disabled	Disabled
Fascia (Control Mode)	Disabled	Enabled	Disabled
USB	Disabled	Enabled	Disabled
Binary Inputs	Setting Option	Setting Option	Disabled
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	Enabled
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

6.6 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 6.9.

6.7 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 communications 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 1.0 day.

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 devices without an external synchronization can have a maximum drift of ±2 s/day. The following attribute is applicable only when no synchronization signal (e.g. IEC 60870-5-103) is received.

Attribute	**Value**
Accuracy (-10 °C to 60°C)	±60 p.p.m

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.

6.7.1 Time Synchronisation – Data Communication Interface

Where the data communications 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.

6.7.2 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.

6.8 Settings Groups

The relay provides four groups of settings – Group number (Gn) 1 to 2 for 7SR1003 and 1 to 4 for 7SR1004. At any one time, only one group of settings can be 'active' – **SYSTEM CONFIG >*Active Group*** setting.

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 both locally at the relay fascia and remotely over the data communications 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 a non-volatile memory.

6.9 User Specific Curves

User specific curves can be configured in Reydisp Manager or curve editor and added to the device configuration. The custom curve will appear as an additional option in the Char setting list using the name that is entered in Reydisp Manager for all elements for which the curve is applicable. The relay will support a maximum of 5 user curves in a device configuration. The name of the curve must be a maximum of 20 characters, consisting of the characters A-Z, a-z, 0-9 and space.

For a more detailed guide on using Curve Editor, refer to the Reyrolle Curve Editor User Manual. The user manual for the Curve Editor can be accessed by opening the Curve Editor main window and clicking Help > User Guide.

6.10 Confirmation ID (Password Feature)

The relay incorporates 2 levels of confirmation IDs - one for settings and other for control functions.
A confirmation ID (shown as **Password** in the device LCD display) serves to prevent users from carrying out critical operations inadvertently. By entering the confirmation ID for settings and control functions, the chances of performing operations inadvertently with potentially failure-inducing effects are reduced.

The programmable confirmation ID feature enables the user to enter a 4-character alpha-numeric code to perform setting changes and control functions in the relay. The confirmation ID in factory supplied relay is set to **NONE**, i.e. the confirmation ID feature is disabled. The confirmation ID must be entered twice as a measure against accidental changes. Once a confirmation ID is entered then it is required thereafter to change settings or initiate control commands. Confirmation IDs can be de-activated by using the confirmation ID to gain access and by entering the confirmation ID to **NONE**. Again, this must be entered twice to deactivate the confirmation ID feature.

As soon as the user attempts to change a setting or initiate control, the confirmation ID is requested before any changes are allowed. Once the confirmation ID has been validated, the user is not prompted for the confirmation ID for the next 1 hour. If no more changes are made within 1 hour, then the confirmation ID prompts are automatically activated.

The setting confirmation ID is a confirmation mechanism to prevent inadvertent changes to settings from the front fascia or over the rear serial communication channel(s). The control confirmation ID is confirmation mechanism to prevent the inadvertent operation of control operations and commands from the Control menu on the relay fascia.

The confirmation ID validation screen also displays a numerical code. If the confirmation ID is lost or forgotten, this code should be communicated to Siemens Limited and the confirmation ID can be retrieved.

NOTE:

The default control confirmation ID is "**AAAA**". It is recommended to change the default confirmation ID after the final configuration.

7SR10

Settings and Instruments

Document Release History

This document is issue 2020/03. The list of revisions up to and including this issue is:

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2015/09	Fifth Issue
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Section 1: Introduction

1.1 Relay Menus and Display

All relay fascias have the same appearance and support the same access keys. 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 passwords) change settings in the relay.

Instruments Mode - allows the user to see the conditions that the relay is experiencing i.e. current.

Fault Data Mode - allows the user to see 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

All menus may be viewed without entering a password but actions will not be permitted if the relevant passwords have been set.

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

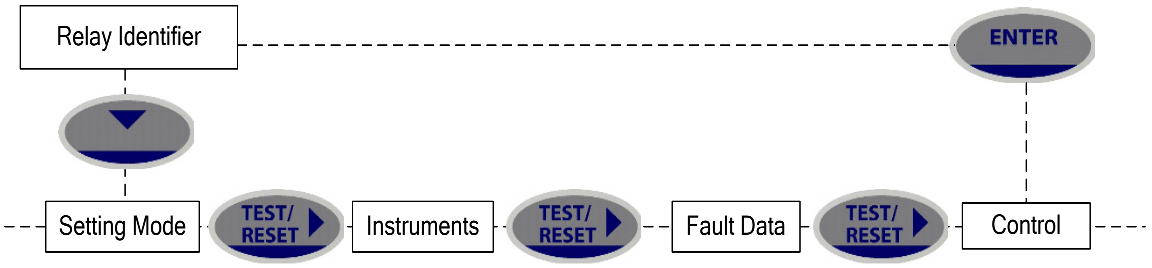


Figure 1-1 Menu

Pressing CANCEL returns to the Identifier screen

This document describes the text descriptions as they appear in the menu structure when the relay is using the default files. The user can programme the relay to use alternative text descriptions by installing user language files through the Reydisp Evolution software language configuration tool – see 2.1.5

Figure 1-2 Fascia of a 7SR10 Relay (Size 4 Case)

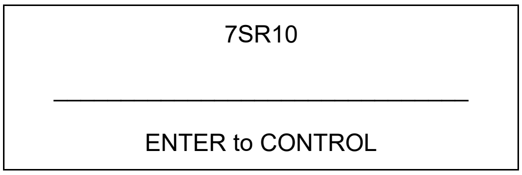
1.2 Operation Guide

1.2.1 User Interface Operation

The basic menu structure flow diagram is shown in Figure 1-4. 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, or similar, message:-



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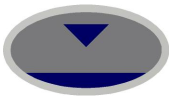
ENTER to CONTROL

Figure 1-3 Relay Identifier Screen

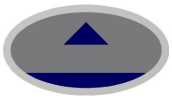
On the factory default setup the relay LCD should display the relay identifier, on each subsequent power-on the screen that was showing before the last power-off will be displayed.

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 also moves the cursor right ► when navigating through menus and settings.

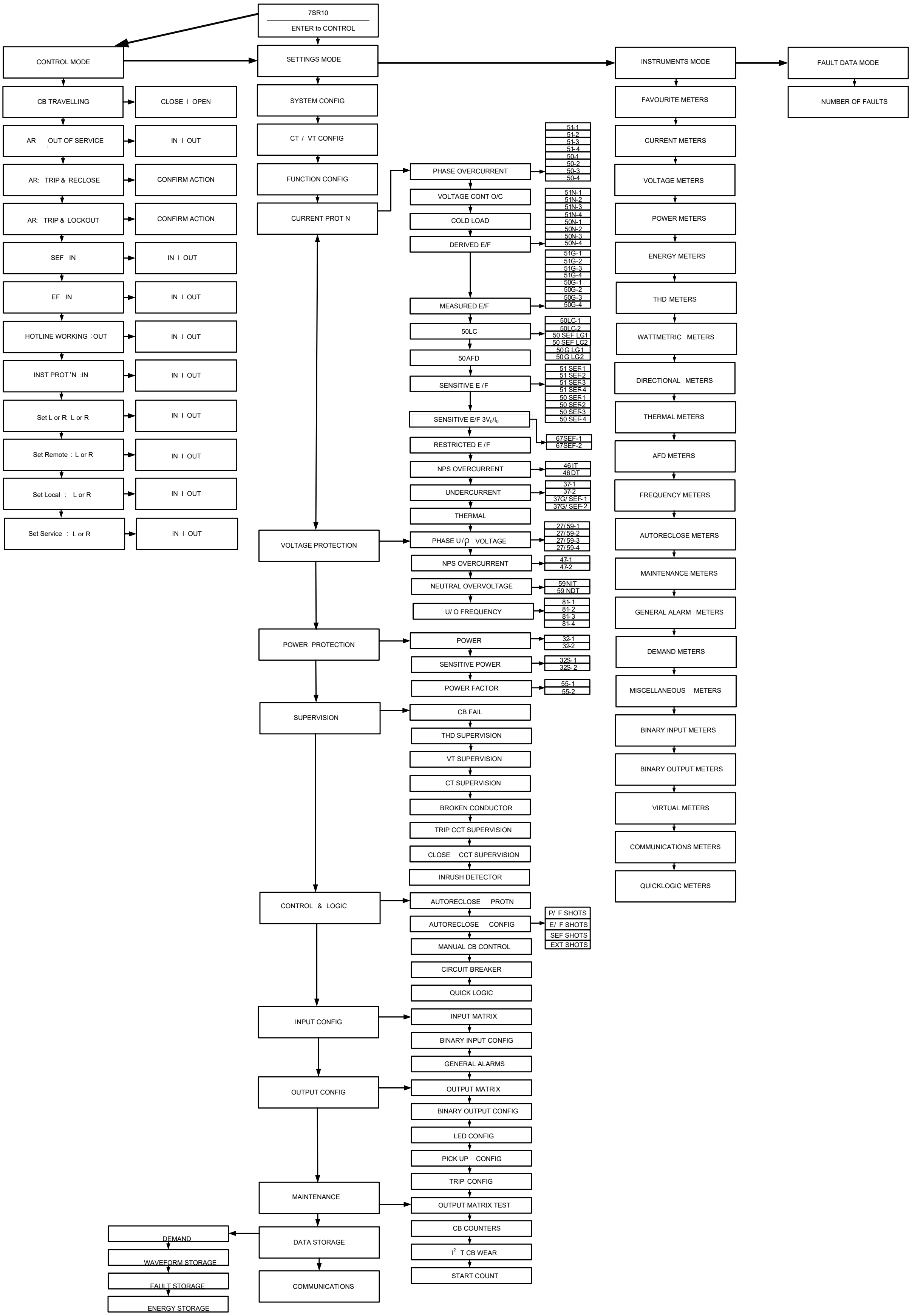


Figure 1-4 Menu Structure

1.3 Setting Mode

The Settings Mode is reached by pressing the READ DOWN ▼ button from the relay identifier screen.

Once the Settings Mode title screen has been located pressing the READ DOWN ▼ button takes the user into the Settings mode sub-menus.

Each sub-menu contains the programmable settings of the relay in separate logical groups. The sub menus are accessed by pressing the TEST/RESET► button. Pressing the ▼ button will scroll through the settings, after the last setting in each sub menu is reached the next sub menu will be displayed. If a particular sub menu is not required to be viewed then pressing ▼ will move directly to the next one in the list.

While a setting is being displayed on the screen the ENTER button can be pressed to edit the setting value. If the relay is setting password protected the user will be asked to enter the password. If an incorrect password is entered editing will not be permitted. All screens can be viewed if the password is not known.

While a setting is being edited flashing characters indicate the edit field. Pressing the ▲ or ▼ buttons will scroll through the valid field values. If these buttons are held on, the rate of scrolling will increase.

Once editing is complete pressing the ENTER button stores the new setting into the non-volatile memory.

The actual setting ranges and default values for each relay model can be found in the appendix to this manual.

1.4 Instruments Mode

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/REST 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.

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
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 Ib Ic	 0.00A 0.00A 0.00A	Displays the 3 phase currents Primary RMS values
Secondary Current Ia Ib Ic	 0.00A 0.00A 0.00A	Displays the 3 phase currents Secondary RMS values
Nom Current Ia Ib Ic	 0.00xIn ---° 0.00xIn ---° 0.00xIn ---°	Displays the 3 Phase currents Nominal RMS values & phase angles with respect to PPS voltage.
Pri Earth Current In Ig	 0.00A 0.00A	Displays the 3 Earth currents Primary RMS values

Instrument	Description
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 voltage.
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 voltage.
2nd Harmonic Current Ia 0.00xIn Ib 0.00xIn Ic 0.00xIn	Displays the Second Harmonic Current.
Last Trip P/F Ia 0.00A Ib 0.00A Ic 0.00A	Displays the Last Trip Fault Current..
Last Trip E/F In 0.00A Ig 0.00A	Displays the Last Trip Fault Current.
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 0.00kV Vbc 0.00kV Vca 0.00kV	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
Nominal Ph-Ph Voltage Vab 0.00V ----o Vbc 0.00V ----o Vca 0.00V ----o	Displays the Phase to Phase Voltage Nominal RMS values & Angles with respect to PPS voltage.
Prim Ph-N Voltage Va 0.00kV Vb 0.00kV Vc 0.00kV	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.
Nom Ph-N Voltage Va 0.00V ----o Vb 0.00V ----o Vc 0.00V ----o	Displays the Phase to Neutral Voltage Nominal RMS values & Angles with respect to PPS voltage.
V Seq Components Vzps 0.00V ----o Vpps 0.00V ----o Vnps 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 Phase to Neutral Voltage Nominal RMS values from Last Trip

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
Phase A 0.0MW Phase B 0.0MW Phase C 0.0MW P (3P) 0.0MW	Displays Real Power
Phase A 0.0MVAr Phase B 0.0MVAr Phase C 0.0MVAr Q (3P) 0.0MVAr	Displays Reactive Power
Phase A 0.0MVA Phase B 0.0MVA Phase C 0.0MVA S (3P) 0.0MVA	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 0.0 Sn P Phase B 0.0 Sn P Phase C 0.0 Sn P (3P) 0.0 Sn	Displays Real Power nominal values
Q Phase A 0.0 Sn Q Phase B 0.0 Sn Q Phase C 0.0 Sn Q (3P) 0.0 Sn	Displays Reactive Power nominal values
S Phase A 0.0 Sn S Phase B 0.0 Sn S Phase C 0.0 Sn S (3P) 0.0 Sn	Displays Apparent Power nominal values
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 0.00kWh Imp 0.00kWh	Displays both imported and exported Active Energy
Reactive Energy Exp 0.00kVArh Imp 0.00kVArh	Displays both imported and exported Reactive Energy
WATTMETRIC METERS →to view	This is the sub-group that includes all the meters that are associated with Wattmetric TEST/RESET ► allows access to this sub-group
Ires R 0.000 A Pres 0.00 W Ires R Angle 0.0º I_0-V_0 Angle 0.0º	The Wattmetric component of residual current Wattmetric residual power Compensated residual phase angle Applied residual phase angle
SEF $3V_0$/I_0 METERS I_0 0.00 A---º $3V_0$ 0.000 V---º I_0-V_0 Angle 0.0º	The appropriate values from the selection will be displayed.
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 on models that have the 67 option
P/F Dir (67) -- No Dir, PhA Fwd, PhA Rev, PhB Fwd, PhB Rev, PhC Fwd, PhC Rev	The appropriate values from the selection will be displayed.

Instrument	Description
Calc E/F Dir (67N) --- No Dir, E/F Fwd, E/F Rev	The appropriate values from the selection will be displayed.
Meas E/F Dir (67G) --- No Dir, E/F Fwd, E/F Rev	The appropriate values from the selection will be displayed.
SEF Dir (67SEF) --- No Dir, SEF Fwd, SEF Rev	The appropriate values from the selection will be displayed.
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
THD METERS →to view	This is the sub-group that includes all the meters that are associated with THD TEST/RESET ► allows access to this sub-group
THD METERS Total Harmonic Dist. Ia THD 0.0% Ib THD 0.0% Ic THD 0.0%	This displays the percentage of 2nd to 15th harmonics current present in the fundamental frequency current.
AFD METERS →to view AFD Zone 1 count AFD Zone 2 count AFD Zone 3 count AFD Zone 4 count AFD Zone 5 count AFD Zone 6 count	This displays the zone wise AFD counts.
FREQUENCY METERS →to view	This is the sub-group that includes all the meters that are associated with Frequency TEST/RESET ► allows access to this sub-group. Available on selected variants.
Frequency 0.000Hz Last Trip 0.000Hz	Displays the frequency
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 79 AR State AR Close Shot 0	
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 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	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

Instrument	Description
Target 10	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 A 100% Phase A 100%	Displays the current measure of circuit breaker wear remaining.
CB Trip Time Time 0.0ms	Displays the circuit breaker trip time to open time. Measured from CB auxiliary contacts.
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	Displays the state of General Alarm
General Alarms ALARM 2 Cleared	
General Alarms ALARM 3 Cleared	
General Alarms ALARM 4 Cleared	
General Alarms ALARM 5 Cleared	
General Alarms ALARM 6 Cleared	
DEMAND METERS →to view	This is the sub-group that includes all the meters that are associated with DEMAND. TEST/RESET ► allows access to this sub-group
I Phase A Demand Max 0.00A Min 0.00A Mean 0.00A	Displays the Current demand based on Ia.
I Phase B Demand Max 0.00A Min 0.00A Mean 0.00A	Displays the Current demand based on Ib.
I Phase C Demand Max 0.00A Min 0.00A Mean 0.00A	Displays the Current demand based on Ic.
V Phase A Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Va.
V Phase B Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vb.
V Phase C Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vc.
V Phase AB Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vab.

Instrument	Description
V Phase BC Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vbc.
V Phase CA Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vca.
Power P 3P Demand Max 0.00W Min 0.00W Mean 0.00W	Displays the Active Power demand.
Power Q 3P Demand Max 0.00VAr Min 0.00VAr Mean 0.00VAr	Displays the Reactive Power demand.
Power S 3P Demand Max 0.00VA Min 0.00VA Mean 0.00VA	Displays the Apparent Power demand.
Frequency Demand Max 0.000Hz Min 0.000Hz Mean 0.000Hz	Displays the Frequency demand.
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 0 Target 100	Count of configurable type of Relay starts and target setting for start alarm.
Date 01/01/2000 Time 22:41:44 Waveform Recs 0 Fault Recs 0	This meter displays the date and time and the number of Fault records and Event records stored in the relay
Event Recs 0 Data Log Recs 0 Setting Group 1	
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 1-9 ---- --	Displays the state of DC binary inputs 1 to 9 (The number of binary inputs may vary depending on model)
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 1-6 ---- ----	Displays the state of DC binary Outputs 1 to 6. (The number of binary outputs may vary depending on model)
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
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
	Displays the active ports

Instrument	Description
COM1 X COM2	
COM1 TRAFFIC COM1 Tx1 0 COM1 Rx1 Error 0 COM1 Rx1 0	Displays data traffic on Communications Port 1
COM2 TRAFFIC COM2 Tx1 0 COM2 Rx1 Error 0 COM2 Rx1 0	Displays data traffic on Communications Port 2
QUICK LOGIC METERS →to view	This is the sub-group that includes all the meters that are associated with QuickLogic Equations TEST/RESET ► allows access to this sub-group
E 1-4 ----	
E1 Equation EQN =0 TMR 0-0 =0 CNT 0-1 =0	
E2 Equation EQN =0 TMR 0-0 =0 CNT 0-1 =0	
E3 Equation EQN =0 TMR 0-0 =0 CNT 0-1 =0	
E4 Equation EQN =0 TMR 0-0 =0 CNT 0-1 =0	

1.5 Fault Data Mode

The Fault Data Mode sub menu lists the time and date of the previous ten protection operations. The stored data about each fault can be viewed by pressing the TEST/RESET► button. Each record contains data on the operated elements, analogue values and LED flag states at the time of the fault. The data is viewed by scrolling down using the ▼ button.

Section 2: Setting & Configuring the Relay Using Reydisp Evolution

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

PC with Reydisp Evolution Version 7.1.5.6 or later Installed. (This can be downloaded from our website 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 and Microsoft.NET framework for tools.

2.1 Physical Connection

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

2.1.1 Front USB connection

To connect your pc locally via the front USB port.

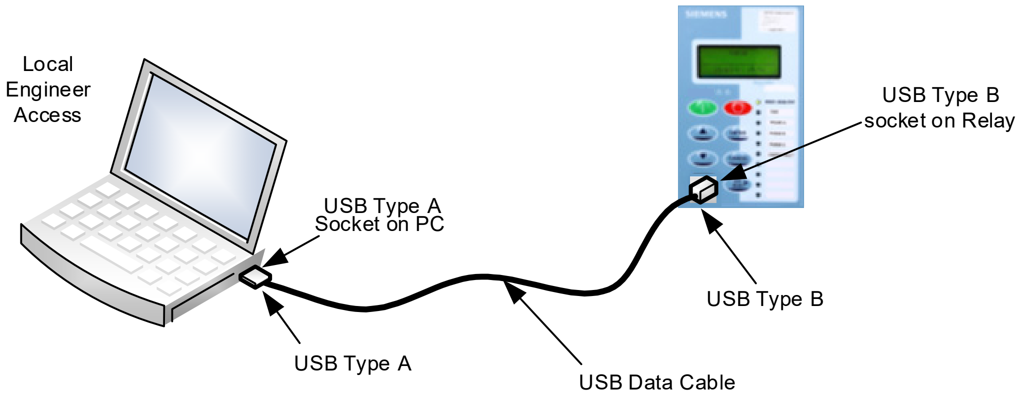


Figure 2-1 USB connection to PC

2.1.2 Rear RS485 connection

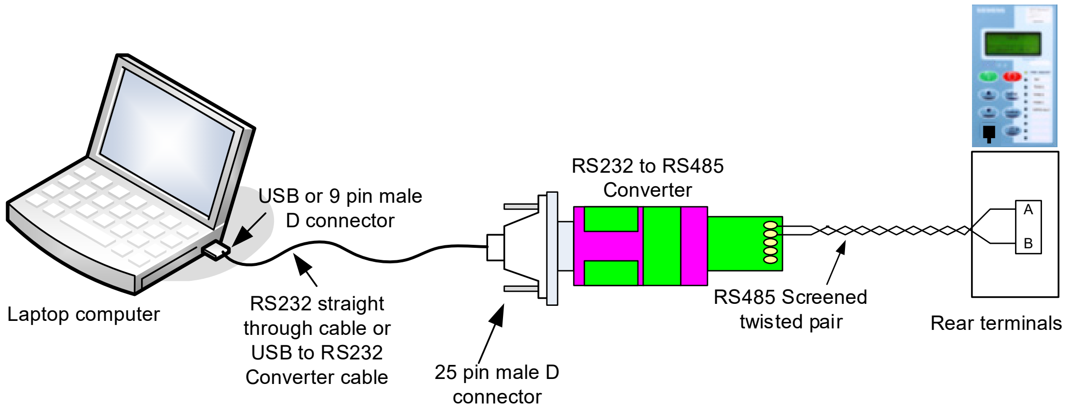


Figure 2-2 RS485 connection to PC

2.1.3 Configuring Relay Serial Data Communication

Using the keys on the relay fascia scroll down the settings menus into the ‘communications’ menu and if necessary change the settings for the communication port you are using on the relay. Reydisp software uses IEC60870-5-103 protocol to communicate.

When connecting the relay to a pc using the front USB port, the Reydisp setting software will automatically detect the relay without making any setting changes in the relay first as long as the USB is selected to IEC60870-5-103.

COM1-RS485 Port and COM2-USB Port

Description	**Range**	**Default**	**Notes**
COM1-RS485 Protocol *Selects protocol to use for COM1-RS485*	OFF, IEC60870-5-103, MODBUS-RTU, DNP3	IEC60870-5-103	
COM1-RS485 Station Address *IEC 60870-5-103 Station Address*	0, 1 ... 65533, 65534	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 Baud Rate *Sets the communications baud rate for COM1-RS485*	75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400	19200	19200
COM1-RS485 Parity *Selects whether parity information is used*	NONE, ODD, EVEN	EVEN	EVEN
COM1-RS485 Mode *Selects whether the port is Local or Remote.*	Local, Remote, Local Or Remote	Remote	Remote
COM2-USB Protocol *Selects protocol to use for COM2-USB*	OFF, DNP3, ASCII, MODBUS-RTU, IEC60870-5-103	IEC60870-5-103	
COM2-USB Station Address *IEC 60870-5-103 Station Address*	0, 1 ... 65533, 65534	0	Address given to relay to identify it for connection to the USB front port
COM2-USB Mode *Selects whether the port is Local or Remote.*	Local, Remote, Local or Remote	Local	Local
DNP3 Unsolicited Events *Allows unsolicited event support in the relay. When Enabled, unsolicited event transmission can be controlled by the Master. When Disabled, Master requests are ignored.*	Disabled, Enabled	Disabled	Disabled
DNP3 Destination Address *The address of the master to which unsolicited events will be sent.*	0, 1 ... 65533, 65534	0	This setting is only visible when DNP3 Unsolicited Events is Enabled
DNP3 Application Timeout	5, 6 ... 299, 300	10s	10s

2.1.4 Connecting to the Relay for setting via Reydisp

When Reydisp software is running all available communication ports will automatically be detected.
On the start page tool bar open up the sub-menu ‘File’ and select ‘Connect’.

The ‘Connection 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 settings. Select ‘Connect’ to initiate the relay-PC connection.

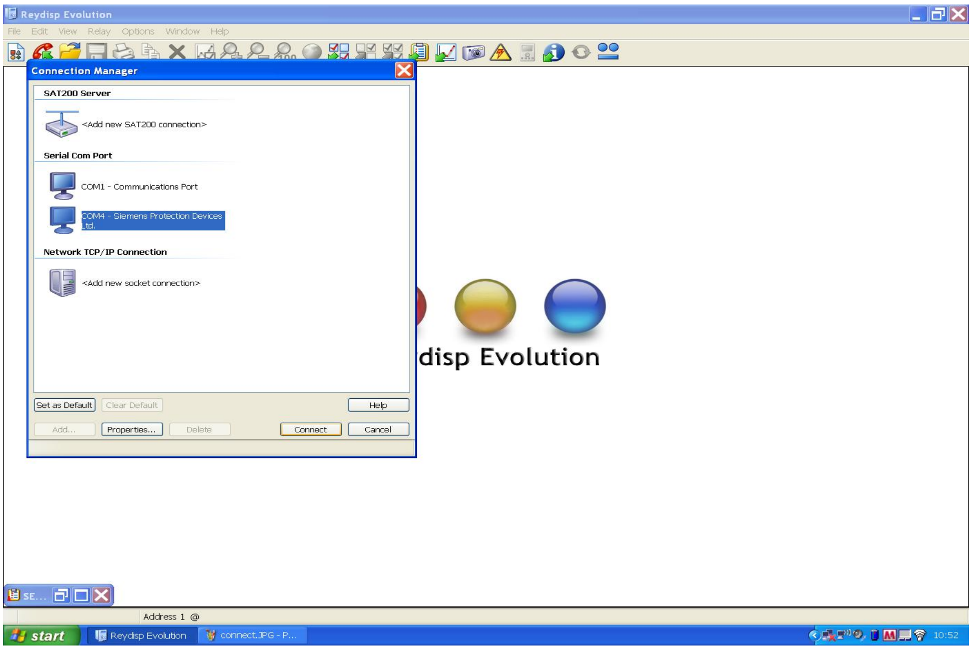


Figure 2-3 PC Comm Port Selection

The relay settings can now be configured using the Reydisp software. Please refer to the Reydisp Evolution Manual for further guidance.

2.1.5 Configuring the user texts using Reydisp Language Editor

As default the relay uses the text descriptions in all menus as they appear in this manual. These descriptions can be changed by installing a user language file in the relay, allowing the user to edit all views to meet their needs and provide easier operation.

The Reyrolle Language File Editor tool and its user manual are installed as part of the Reydisp Evolution software package. They can be found in your pc as sub menus of the Reydisp Evolution installation.

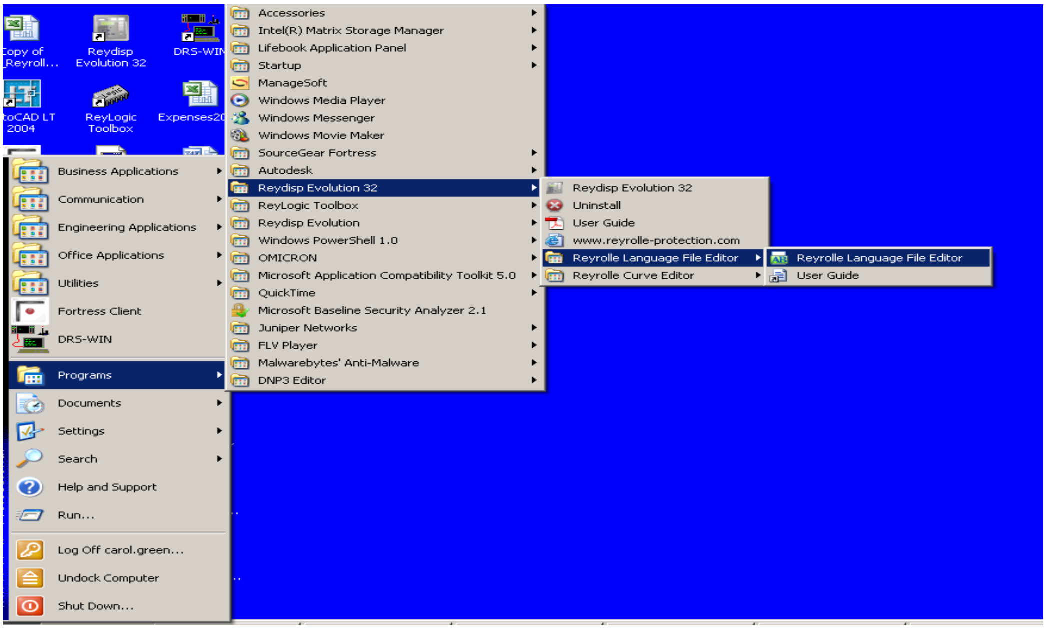


Figure 2-4 PC Language File Editor

When the software is opened a ‘new project from template’ should be used to generate your file. The file will display all default ‘Original’ text descriptions in one column and the ‘Alternative’ text in the other column. The descriptions in the ‘Alternative’ list can be changed and will be used in the relays menu structures. Once the file is complete, a language file can be created and loaded into the relay using the ‘send file to relay’ function. The communication properties in the software and on the relay must be set. The relay must be restarted after the file is installed.

To activate the language file it must be selected in the relay configuration menu, the ‘Original’ file is the file labelled ‘ENGLISH’ and the new file will be displayed using the file name allocated by the user.

Care should be taken to ensure a unique file name is given including a version control reference. The user will be prompted to restart the relay to activate the language file.

Please refer to the Language Editor Manual for further guidance.

7SR10

Performance Specification

Document Release History

This document is issue 2020/03. The list of revisions up to and including this issue is:

2020/03	Sixteenth Issue
2020/03	Fifteenth Issue
2019/05	Fourteenth Issue
2019/01	Thirteenth Issue
2018/07	Twelfth Issue
2018/06	Eleventh Issue
2017/09	Tenth Issue
2017/07	Ninth Issue
2017/04	Eighth Issue
2017/03	Seventh Issue
2016/11	Sixth Issue
2015/09	Fifth Issue
2015/06	Fourth Issue
2015/03	Third Issue
2015/02	Second Issue
2013/11	First Issue

Contents

List of Tables

Section 1: Performance Specification

1.1 Indication of Conformity

This product complies with the directive of the Council of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU) as well as restriction on usage of hazardous substances in electrical and electronic equipment (RoHS Directive 2011/65/EU).

This conformity has been proved by tests conducted by Siemens AG in accordance of the Council Directive in accordance with the product standard IEC/EN 60255-26 for the EMC directives, and with the standard IEC/EN 60255-27 for the low-voltage directive.

RoHS directive 2011/65/EU is met using the standard EN 50581. The device has been designed and produced for industrial use.

1.2 Technical Specifications

This section provides the technical information of 7SR10 Over current Relay.

Table 1-1 Technical Data Overview

Product Family (Auxiliary powered)	Overcurrent Relay
Case and LEDs	Non Draw-out Polycarbonate case (Size 4 standard, Non Draw-out design), 10 LEDs
Measuring Inputs	Current: 1 A/5 A, 50 Hz/60 Hz Voltage: 40 V to 160 V
Auxiliary Voltage	AC 60 V to AC 240 V DC 60 V to DC 240 V DC 24 V to DC 60 V
Communication	Default front communication port Back port: RS485 (optional – IEC 60870-5-103 or Modbus RTU or DNP 3.0)
Protection Functions	27/59, 32, 32S, 37, 37G, 37SEF, 46BC, 46NPS, 47, 49, 50, 50 AFD, 50BF, 50G/N, 50LC,50G LC,50SEF LC, 50SEF, 51, 51C, 51G/N, 51V, 51SEF, 55, 59N, 64H, 67, 67N/G/SEF, 81, Wattmetric
Supervision and control functions	74 T/CCS, 86, 81HBL2 (Inrush detector), 60 CTS, 60 VTS, 81THD, 79 AR
Binary Input and Binary Output	3 BI or 6 BIor 9 BI 3 BO or 6 BO (2 changeover contact) Threshold voltage • AC 88 V or AC 44 V/DC 88 V or DC 44 V available with AC 60 V to AC 240 V/DC 60 V to DC 240 V power supply version • DC 19 V with DC 24 V to DC 60 V power supply version
Overvoltage	Category III
Pollution Degree	2

Table 1-2 Mechanical Specifications

Design	Flush mounting, Non Draw-out Polycarbonate moulded case
Enclosure	IP 54 (front panel) IP 20 protection for terminals (rear side) Depth is 199 mm
Weight	1.6 kg (appx)

Table 1-3 Terminal Blocks

Current Inputs (X5)	TE connectivity PIDG Series insulated tin plated crimp ring terminal, M3.5 Stud size, 2.6 mm^2 to 6.6 mm^2, 12 AWG; Torque required 1.0 Nm
Voltage Inputs (X7)	6 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.57 Nm ±10%
Auxiliary Supply (X3)	3 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.5 Nm to 0.6 Nm
Rear Communication Port (X2)	4 position, M2 screw-type plug-in terminals suitable for 1.5 mm^2 cable; Torque required 0.34 Nm ±10%
Front Communication Port	USB, Type B
Binary Input (X1)	6 or 12 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.5 Nm to 0.6 Nm
Binary Input (X6)	6 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.57 Nm ±10%
Binary Output (X4)	8 or 14 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.5 Nm to 0.6 Nm
Ground Terminal	Tin plated crimp ring Terminal, M3 stud size, 4 mm^2 to 6 mm^2, 12 AWG to 10 AWG, Yellow; Torque required 0.5 Nm to 0.6 Nm

Table 1-4 Current Inputs

Quantity	3 x Phase & 1 x Earth
Rated Current I_n	1 A/5 A
Measuring Range	80xI_n 8xI_n (SEF)
Instrumentation	± 1 % (typical) (0.1xI_n to 3xI_n) ± 3 % (>3xI_n to 80xI_n)
	SEF: ± 1 % (Typical) (0.01xI_n to 0.3xI_n) ± 3 % (> 0.3xI_n to 8xI_n)
Frequency	50 Hz (Range: 47.5 Hz to 52.5 Hz) 60 Hz (Range: 57 Hz to 63 Hz)
Thermal Withstand *	
Continuous	4xI_n
1 s	100 A (1 A) 350 A (5 A)
Burden @ I_n	≤ 0.02 VA (1 A phase and earth element) ≤ 0.2 VA (5 A phase and earth element)

* ZY20 - Special version with Thermal withstand 500 A (5 A CT) for 1 s.

Table 1-5 Voltage Inputs

Nominal Voltage (V_n)	40…160 Vrms
Operating Range	0… 200 Vrms
Instrumentation ≥ 0.8xV_n	±1% V_n
Burden @ 110V	Approx 0.06 VA
Overvoltage Withstand	300 Vrms

Table 1-6 Auxiliary Supply

Rated Voltage	AC 60 V to AC 240 V, DC 60 V to DC 240 V Tolerance -20 % to +10 %
Allowable super imposed AC component	15 % of DC voltage
Typical power consumption (DC) Typical power consumption (AC)	< 8 W <16 VA
Max Interruption time (Collapse to Zero)	≤ 100 ms (DC 110 V) ≤ 1000 ms (AC 230 V)

Table 1-7 Auxiliary Supply

Rated Voltage	DC 24 V to DC 60 V Tolerance -20 % to +10 %
Allowable super imposed AC component	15 % of DC voltage
Typical Power consumption (DC)	< 8 W
Max Interruption time (Collapse to Zero)	20 ms (DC 24 V)

Table 1-8 Binary Inputs

Number	3 or 6	
BI Threshold/Operating Range *	**BI Voltage rating**	**BI Operating range**
	DC 19 V	DC 19 V to DC 66 V
	AC 44 V/DC 44 V	AC 36 V to AC 265 V DC 44 V to DC 265 V
	AC 88 V/DC 88 V	AC 71 V to AC 265 V DC 88 V to DC 265 V
Current for operation	2 mA to 3.5 mA	
Pick Up Delay	User selectable 0 to 14,400,000 ms (up to 4 hours)	
Drop Off Delay	User selectable 0 to 14,400,000 ms (up to 4 hours)	

* Refer to ordering information for more details.

Table 1-9 DC Performance

Attribute	Value
Reset/Operate voltage ratio	≥ 90 %
Response time	< 9 ms
Response time when programmed to energise an output relay contact (i.e. includes output relay operation)	< 20 ms

Table 1-10 Binary Outputs

Number	3 or 6 (2 change over contacts)	
Operating Voltage	Voltage Free	
Operating Mode	User selectable - Self or Hand/Electrical Reset or pulsed	
Operating Time from energizing Binary Input	< 20 ms	
Disengaging time	< 20 ms	
Switching Voltage	AC 250 V and DC 250 V	
Contact current rating: Continuous Short time	 5 A AC or DC 30 A AC or DC for 0.5 s	
Limiting Making Capacity: (L/R ≤ 40 ms)	1000 W	
Limiting Breaking Capacity:		
AC Resistive	1250 VA	V/I = 250/5
AC Inductive	250 VA	V/I = 250/1@ p.f. ≤ 0.4
DC Resistive	75 W	V/I = 48/1.5; 110/0.7; 220/0.3
DC Inductive (L/R ≤ 40 ms)	30 W	V/I = 48/0.7; 110/0.3; 220/0.14
Mechanical/Electrical Endurance	10000 operations	

Table 1-11 Rear Communication Port

Quantity	1 No. (Optional)
Electrical connection	RS485, 2 wire electrical
Protocol Support	MODBUS RTU, IEC 60870-5-103, DNP 3.0
Rate	Data Transfer rate: 75 bps to 38400 bps

Table 1-12 Data Storage

Fault Record	15
Waveform Record	15 Rec x 1 s 7 Rec x 2 s 3 Rec x 5 s 1 Rec x 15 s Pre trigger 10…90 %
Events	1000 events (1 ms resolution)

1.3 Environmental Performance

This section describes about the environmental tests performed with 7SR10 Overcurrent relay under different conditions.

Table 1-13 Mechanical Tests

Type Test	**Reference**	**Requirement**
Degree of Protection	IEC 60529	IP54 front IP20 back
Vibration	IEC 60255-21-1	Vibration Endurance, Class I, Peak Acceleration 1 gn X, Y, Z axis (20 sweeps/axis) Vibration Response, Class I, Peak Acceleration 0.5 gn X, Y, Z axis (1 sweeps/axis) Frequency Range : 10 Hz to 150 Hz Sweep rate : 1 octave/min
Shock and Bump	IEC 60255-21-2	Shock response, Class I, Peak Acceleration 5 gn X, Y, Z axis (3 per direction) Total number of shocks: 18 Shock withstand, Class I, Peak Acceleration 15 gn X, Y, Z axis (3 per direction) Total number of shocks: 18 Bump, Class I, Peak Acceleration 10 gn X, Y, Z axis (1000 per direction) Total number of Bumps: 6000
Seismic	IEC 60255-21-3	In single axis sine sweep in X axis, Class I, Peak Acceleration 1gn In single axis sine sweep in Y axis, Class I, Peak Acceleration 0.5gn Frequency Range : 1 Hz to 35 Hz Sweep rate : 1 octave/min
Contact	IEC 60255-1 (Ref: Std IEC 61810-1)	Making capacity, Make and carry capacity, Breaking capacity

Type Test	Reference	Requirement
Electrical Endurance Test	IEC 60255-1 (Ref: Std IEC 61810-1)	10000 operations at 250 V, 5 A

Table 1-14 Electrical Tests

Type Test	Reference	Requirement
Insulation Resistance	IEC 60255-27#	Insulation resistance >100 MOhm at 500 V DC Test Duration: > 5 s
Impulse Voltage Withstand	IEC 60255-27#	5 kV, 1.2/50 µs, 0.5 J 5 +ve, -ve pulses Between all terminals and case earth and any two independent circuits.
AC Dielectric Voltage	IEC 60255-27#	• All case terminals connected together 2.0 kV AC RMS, 50 Hz, 1 min between terminals of independent circuits • 1.0 kV AC RMS, 1 min across normally open contacts
Slow Damped Oscillatory Wave	IEC 60255-26	• **Common-mode test voltage:** 2.5 kV peak voltage • **Differential mode:** 1.0 kV peak voltage • Test duration: 2 s • Source impedance: 200 Ω • Voltage oscillation frequency: 1 MHz • Repetition frequency: 400 Hz
Electrostatic Discharge	IEC 60255-26	• 8 kV air discharge • 6 kV contact discharge
Electrical Fast Transient or Burst *	IEC 60255-26	Zone A Test severity Amplitude : ± 4 kV Repetition frequency : 5 kHz
Surge Immunity *	IEC 60255-26	Test Level : Zone A Line to Line : 0.5, 1, 2 kV Line to Earth : 0.5, 1, 2, 4 kV Front time/Time to half-value : 1.2/50 µs Source Impedance : 2 Ohm
Radiated Immunity	IEC 60255-26	Test field strength, frequency band 80 MHz to 1.0 GHz and 1.4 GHz to 2.7 GHz: 10 V/m, Test using AM: 1 kHz/80 %
Conducted Radio Frequency Interference	IEC 60255-26	0.15 MHz to 80 MHz 10 V RMS Dwell time: 0.5 s
Power Frequency Magnetic Field	IEC 60255-26	30 A/m applied continuously, 300 A/m applied for 3 s **
Conducted Emissions	IEC 60255-26	0.15 MHz to 0.5 MHz, 79dB µV (quasi peak) 66 dB µ V (average) 0.5 MHz to 30 MHz, 73dB µ V (quasi peak) 60 dB µV (average)
Radiated Emissions	IEC 60255-26	30 MHz to 230 MHz, 40 dB µ V/m at 10 m measurement distance 230 MHz to 1 GHz, 47 dB µ V/m at 10 m measurement distance

Thermal & Burden	IEC 60255-27 and IEC 60255-1	**Thermal:** **1 A CT:** 4 A continuous 100 A for 1 s **5 A CT:** 20 A Continuous 350 A for 1 s *** **Burden:** ≤ 0.3 VA for 1 A and 5 A CT
Functional	IEC 60255-1 IEC 60255-12 IEC 60255-127 IEC 60255-149 IEC 60255-151	For the 1 A and 5 A CTs and VT variants
Maximum Allowable Temperature	IEC 60255-6	Max. temperature limit +100 ^{0}C
Limiting Dynamic Value	IEC 60255-6	**1 A CT**: 700 A for 10 ms **5 A CT**: 2500 A for 10 ms
Power Frequency Immunity Test[##]	IEC 60255-26	Common-mode test parameters: • Test voltage: 300 V • Coupling resistor: 220 Ω • Coupling capacitor: 0.47 μF

NOTE:
* 45 ms DTL pick-up delay applied to binary inputs

NOTE:
[#] All aspect of IEC 60255-5 have been covered under IEC 60255-27

NOTE:
** 5%xI$_n$ additional tolerance needs to be considered for SEF CT

NOTE:
*** ZY20 - Special version with Thermal withstand 500 A (5 A CT) for 1 s.

NOTE:
[##] DC binary input ports interfacing with cables whose total length is more than 10 m, need to have a multi core twisted screened cable for providing immunity against high level of power frequency interferences.

Table 1-15 Safety Test

Type Test	**Reference**	**Requirement**
Safety IEC 61010-1 (Third Edition): 2010	IEC 61010-1	Protection Against Electric Shock as per Cl.No.6 Resistance to mechanical stresses as per Cl.No.8 Protection Against Spread of Fire as per Cl.No.9 Equipment Temperature Limits and Resistance to heat as per Cl.No.10

Table 1-16 Auxiliary Supply Variation

Type Test	Reference	Parameters	Declared Operation
Voltage Dips (AC auxiliary supply) RV = 230 V AC	IEC 60255-26	0 % RV for 50 cycles @ 50 Hz 0 % RV for 60 cycles @ 60Hz	Normal Operation[1]
		40 % RV for 10 cycles @ 50Hz 40 % RV for 12 cycles @ 60Hz	Normal Operation[1] except where Dip falls below the relay minimum voltage then Relay Restart[2]
		70 % RV for 25 cycles @ 50Hz 70 % RV for 30 cycles @ 60Hz	Normal Operation[1] except where Dip falls below the relay minimum voltage then Relay Restart [2]
Voltage Dips (DC auxiliary supply) RV = 110 V DC	IEC 60255-26	0 % RV at 100 ms	Normal Operation[1]
		40 % RV at 200 ms	Normal Operation[1] except where Dip falls below the relay minimum voltage then Relay Restart[2]
		70 % RV at 500 ms	Normal Operation[1] except where Dip falls below the relay minimum voltage then Relay Restart[2]
Voltage Dips (DC auxiliary supply) RV = 24 V DC	IEC 60255-26	0 % RV at 20 ms	Normal Operation[1]
		40 % RV at 200 ms	Normal Operation[1] except where Dip falls below the relay minimum voltage then Relay Restart[2]
		70 % RV at 500 ms	Normal Operation[1] except where Dip falls below the relay minimum voltage then Relay Restart[2]
Gradual shutdown / Start-up test	IEC 60255-26		Shut down ramp 60 s Power off 5 min Start up ramp 60 s
Voltage interruption (AC/DC auxiliary supply) RV = 110 V DC RV = 24 V DC RV = 230 V AC	IEC 60255-26	0 % RV at 5 s	Normal Operation[2]

[1] No effect on relay performance

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

Table 1-17 Environmental Test

Type Test	**Reference**	**Requirement**
Climatic Environmental Test	IEC 60068-2-1, IEC 60068-2-2 IEC 60255-1	Operating Temperature -10 ^{0}C to + 60 ^{0}C Storage Range - 25 ^{0}C to + 70 ^{0}C
Humidity	IEC 60068-2-30, IEC 60255-1	Damp heat test, Cyclic 6 days at 25 ^{0}C to 40 ^{0}C (12 h + 12 h cycle) and At lower temperature, 97 %, -2 % +3 % RH At upper temperature, 93 %, ±3 % RH
	IEC 60068-2-78, IEC 60255-1	Damp heat test, Steady state 10 days at 95 % RH, +40 ^{0}C
Maximum Altitude of Operation	--	Up to 2000 m
Mixed Gas Corrosion Test (Environment condition as per ISA 71.04: 2013 G3)	IEC 60068-2-60:2015 (Method 4)	H_2S 10 ppb, NO_2 200 ppb, Cl_2 10 ppb and SO_2 200 ppb

Table 1-18 Product Safety Test

Type Test	**Reference**	**Parameters**	**Values**
Clearances and Creepage Distances	IEC/EN 60255-27: Edition 2: 2013-10	Clearances and creepage distances between external circuits mutual and to the enclosure	≥ 4 mm
IP Rating	IEC/EN 60255-27: Edition 2: 2013-10	For Unit Front side	IP54
		For Unit Rear side	IP20
AC Dielectric Voltage	IEC/EN 60255-27: Edition 2: 2013-10	Test voltage (AC): 2 kV	After test, the relay should be operative (Reinforced Insulation with communication circuit)
		Test frequency: 50 Hz	
		Test duration: 1 min	
Insulation Resistance	IEC/EN 60255-27: Edition 2: 2013-10	Test voltage: 500 V DC	> 100 Mohm
		Test duration: > 5 s	
Protective Bonding Resistance	IEC/EN 60255-27: Edition 2: 2013-10	Test voltage: < 12 V AC/DC	
		Test duration: 1 min	
		Bonding resistance	< 0.1 Ohm
Protective Bonding Continuity	IEC/EN 60255-27: Edition 2: 2013-10	Accessible conductive parts should be bonded with the protective conductor terminal	Low current continuity test
Flammability of Insulating Materials, Components and Fire	IEC/EN 60255-27: Edition 2: 2013-10	Structure Part	Standard for insulating material of flammability class

Type Test	Reference	Parameters	Values
enclosures		Terminals	Class UL 94 V-0
		Terminal Mounting	Class UL 94 V-0
		Wiring (CT)	(N)2GFAF (VDE)
		Components mounting	Class UL 94 V-0
		Enclosure	Class UL 94 V-0
		PCB	Class UL 94 V-0
		LCD	Class UL 94 V-0
Single Fault Condition	IEC/EN 60255-27: Edition 2: 2013-10	Assessment of: • Insulation between circuits and parts • Compliance with requirements for protection against the spread of fire • Overloads • Intermittently rated resistors • Compliance with requirements for mechanical protection	The equipment shall not present a risk of electric shock or fire after a single-fault test.
Marking and Documentation	IEC 61010-1: 2010	Clause No. 5	-
Protection against electric shock		Clause No. 6	-
Protection against mechanical hazard		Clause No. 7	-
Resistance to mechanical stresses		Clause No. 8	-
Protection against the spread of fire		Clause No. 9	-
Equipment temperature limits and resistance to heat		Clause No. 10	-
Protection against liberated gases and substances, explosion and implosion		Clause No. 13	-
Components and sub assemblies		Clause No. 14	-
HAZARDS resulting from application		Clause No. 16	-
Risk Assessment		Clause No. 17	-

Section 2: Protection Functions

This section describes about the settings available for different protection functions and its tolerance limits.

2.1 27/59 Under/over voltage

2.1.1 Reference

	Parameter	Value
V_s	Setting	5, 5.5…200 V
V_g	Voltage guard	1,1.5,.... 200 V
hyst	Hysteresis setting	0, 0.1… 80.0 %
t_d	Delay setting	0.00, 0.01…20.00, 20.50… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.1.2 Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		100 % Vs, ± 1 % or ± 0.25 V
	Reset level	Overvoltage	= (100 % - hyst) x $V_{op,}$ ± 1 % or ± 0.25 V
		Undervoltage	= (100 % + hyst) x V_{op} ± 1 % or ± 0.25 V
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.1.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time	Overvoltage	0 to 1.1xV_s: 73 ms, ± 10 ms
			0 to 2.0xV_s: 63 ms, ± 10 ms
		Undervoltage	1.1 to 0.5xV_s: 58 ms, ± 10 ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10 ms
	Repeatability		± 1 % or ± 10ms
	Disengaging time		< 80 ms

2.2 32 Power

2.2.1 Reference

	Parameter	Value
Ss	32-n Setting	0.05…2 x Sn
t_d	32-n Delay setting	0.00 … 14400 s

2.2.2 Operate and Reset Level

	Attribute		Value
S_{op}	Operate level		100 % Ss, ± 5 % or ± 2 % Sn
	Reset level	Over-power	≥ 95 % S_{op}
		Under-power	≤ 105 % S_{op}
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.2.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time	Over-power	1.1 x Ss: 60 ms ± 10 ms
			2.0 x Ss: 45 ms ± 10 ms
		Under-power	0.5 x Ss: 30 ms ± 10 ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10 ms
	Disengaging time		< 40 ms

2.2.4 Operate Threshold

	Attribute		Value
	Minimum levels for operation	I	2.5 % I_n
		V	2.5 % V_n
		P	0.01Sn

2.3 32S Sensitive Power

2.3.1 Reference

	Parameter	**Value**
S_s	32S-n Setting	0.005…2xSn
t_d	32S-n Delay setting	0.00 … 14400 s
	U/C Guard	0.005 to 1.0xI_n

2.3.2 Operate and Reset Level

	Attribute		**Value**
S_{op}	Operate level		100 % Ss, ± 5 % or ± 2 % Sn
	Reset level	Over-power	≥ 95 % S_{op}
		Under-power	≤ 105 % S_{op}
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.3.3 Operate and Reset Time

	Attribute		**Value**
t_{basic}	Element basic operate time	Over-power	1.1 x Ss: 60 ms ± 10 ms
			2.0 x Ss: 45 ms ± 10 ms
		Under-power	0.5 x Ss: 30 ms ± 10 ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10 ms
	Disengaging time		< 40 ms

2.3.4 Operate Threshold

	Attribute		**Value**
	Minimum levels for operation	I	2.5 % I_n
		V	2.5 % V_n

2.4 37 Undercurrent

2.4.1 Reference

	Parameter	Value
Is	Setting	0.05, 0.10…5.0xI_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, ± 5 % or ± 1% I_n
	Reset level		≤ 105 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.4.3 Operate and Reset Time

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

2.5 46 Negative Phase Sequence Overcurrent

2.5.1 Reference (46DT)

	Parameter	Value
I_s	Setting	0.05, 0.06... 4.0xI_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 (46DT)

	Attribute		Value
I_{op}	Operate level		100 % Is, ± 5 % or ± 1 % I_n
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.5.3 Operate and Reset Time (46DT)

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2xI_s: 40 ms, ± 10 ms
		0 to 5xI_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	< 60 ms

2.5.4 Reference (46IT)

	Parameter	Value
char	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time Multiplier setting	0.025, 0.030… 1.0
I_s	Setting	0.05, 0.06… 2.5xI_n
I	Applied Current (for operate time) IDMTL	2 to 20xI_s
t_d	Delay setting	0, 0.01… 20 s
t_{res}	Reset setting	ANSI DECAYING, 0, 1… 60 s

2.5.5 Operate and Reset Level (46IT)

	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 +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.5.6 Operate and Reset Time (46IT)

	Attribute		**Value**
	Starter operate time (≥ 2xI_s)		35 ms, ± 10 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5 % or absolute ± 50 ms, for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5 % or absolute ± 50 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, ± 1 % or ± 20 ms
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{1 - \left[\frac{I}{Is}\right]^{2}} \times Tm$, ± 5 % or absolute ± 50 ms, for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		IEC DECAYING	$t_{res} = \frac{R}{1 - \left[\frac{I}{Is}\right]^{2}} \times Tm$, ± 5 % or absolute ± 50 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}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 60 ms

2.6 47 Negative Phase Sequence Voltage

2.6.1 Reference (47)

	Parameter	Value
Vs	Setting	1, 1.5… 90 V
V_s Guard	Guard Setting	1, 1.5, …199.5, 200 V
Hyst.	Hysteresis	0, 0.1… 80 %
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 (47)

	Attribute		Value
V_{op}	Operate level		100 % Vs, ± 2 % or ± 0.5 V
	Reset level		(100%-Hyst.) x V_{op} ± 1 % or ± 0.25 V
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.6.3 Operate and Reset Time (47)

	Attribute	Value
t_{basic}	Element basic operate time	0 V to 2.0xVs, 80 ms, ± 20 ms
		0 V to 10xVs, 55 ms, ± 20 ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 2 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms
	Overshoot time	< 40 ms
	Disengaging time	< 100 ms

2.7 49 Thermal Overload

2.7.1 Reference

	Parameter	**Value**
Iθ	Overload setting	0.1...to 3.0xI_n
τ	Time constant setting	1, 10, 100, 1000 min
i	Applied Current (for operate time)	1.2 to 10xI_s

2.7.2 Operate and Reset Level

	Attribute		**Value**
I_{ol}	Overload level		100 % I_s, ± 5 % or ± 1 % I_n
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.7.3 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	± 5 % or absolute ± 100 ms, (I_s: 0.3 – 3 x I_n)
	Repeatability	± 100 ms	
Note:- Fastest operate time is at 10xI_s			

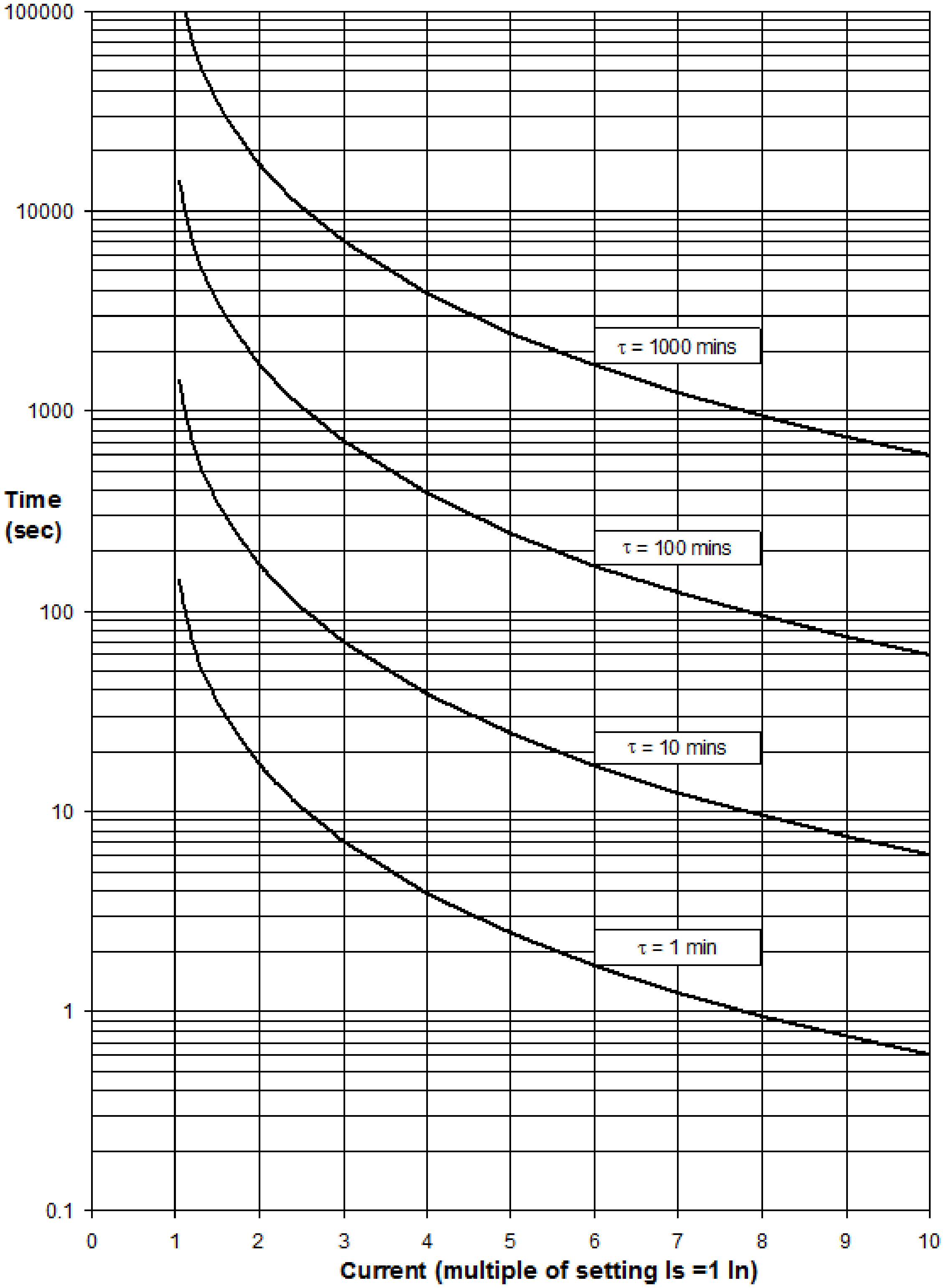


Figure 2.7-1 **Thermal Overload Protection Curves**

2.8 50 Instantaneous Overcurrent

2.8.1 Reference

	Parameter	**Value**
Is	Setting	0.05, 0.06… 2.5, 2.55… 50xI_n
t_d	Delay setting	0.00, 0.01…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.8.2 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 ≤ 100)		≤ -5 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.8.3 Operate and Reset Time

	Attribute	**Value**
t_{basic}	Element basic operate time [#]	0 to 2 xI_s: 35 ms, ± 10 ms
		0 to 5 xI_s: 25 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

[#] The operating timings are measured on the basis of fundamental measurement algorithm, with protection functions and communication ports configured in the relay.

2.9 50G Instantaneous Measured Earth Fault

2.9.1 Reference

	Parameter	Value
Is	Setting	0.05, 0.06…2.5,2.55 …25.0,25.5…. 50xI_n
t_d	Delay setting	0.00, 0.01…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.9.2 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 ≤ 100)		≤ -5 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.9.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time #	0 to 2 xI_s: 35 ms, ± 10 ms
		0 to 5 xI_s: 25 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

The operating timings are measured on the basis of fundamental measurement algorithm, with protection functions and communication ports configured in the relay.

2.10 50N Instantaneous Derived Earth Fault

2.10.1 Reference

	Parameter	Value
Is	Setting	0.05, 0.06…2.5,2.55 …25.0,25.5…. 50xI_n
t_d	Delay setting	0.00, 0.01…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.10.2 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 ≤ 100)		≤ -5 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.10.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time #	0 to 2xI_s: 40 ms, ± 10 ms
		0 to 5xI_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	< 57 ms

The operating timings are measured on the basis of fundamental measurement algorithm, with protection functions and communication ports configured in the relay.

2.11 50SEF Instantaneous Sensitive Earth Fault

2.11.1 Reference

	Parameter	**Value**
Is	Setting	0.005 to 5.0 x I_n
		0.005 to 1.6 x I_n*
t_d	Delay setting	0.00, 0.01…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.11.2 Operate and Reset Level

	Attribute		**Value**
I_{op}	Operate level		100 % I_s, ± 5 % or ± 1 % I_n
	Reset level		≥ 95 % I_{op} or I_{op} - 0.1 % I_n
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 % harmonics to f_{cutoff}	≤ 5 %

2.11.3 Operate and Reset Time

	Attribute		**Value**
t_{basic}	Element basic operate time #		0 to 2xI_s: 35 ms, ± 10 ms
			0 to 5xI_s: 25 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
	Variation	f_{nom} ± 5 %	≤ 5 %

The operating timings are measured on the basis of fundamental measurement algorithm, with protection functions and communication ports configured in the relay.

* Applicable for MLFB 7SR1004-5-20-2CAO

2.12 50AFD ARC Flash Detector

(Refer to 7XG31 Technical Manual for performance characteristics)

2.12.1 Reference

	Parameter	Value
50 AFD	Setting	1, 2,...10 xIn

2.12.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level (no DC transient)		100 % *Is*, ± 10 %
	Reset level		≥ 95 % I_{op}
	Repeatability		± 5 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.12.3 Operate and Reset Time

	Attribute	Value
t_{basic}	50AFD Overcurrent operate time	10 ms – 16 ms
t_{op}	AFD Zone Operate time (Flash & 50AFD)	15 ms – 25 ms
	Repeatability	± 10 ms
	Disengaging time	< 50 ms

2.13 Line Check 50LC, 50G LC

2.13.1 Reference

	Parameter	Value
Is	Setting	0.05, 0.06… 2.5, 2.55… 50 x*In*
t_d	Delay setting	0.00, 0.01…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.13.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ± 1% *In*
	Reset level		≥ 95 % I_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.13.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time[#]	0 to 2 x*Is*: 35 ms, ± 10ms
		0 to 5 xIs: 25 ms, ± 10ms
t_{op}	Operate time following delay[#]	t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability	± 1 % or ± 10ms
	Disengaging time	< 50 ms

[#] Additional binary input response time to be considered for operating time when binary input is used for initiating 50LC.

2.14 Line Check 50SEF LC

2.14.1 Reference

	Parameter	Value
Is	Setting	0.005, 0.006, 0.010, 0.105,… 5.0 x*In*
		0.005, 0.006, 0.010, 0.105,… 1.6 x*In* ##
t_d	Delay setting	0.00, 0.01…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.14.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % *Is*, ± 5 % or ± 1% In
	Reset level		≥ 95 % I_{op} or I_{op} - 0.1% In
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} ± 5 % harmonics to f_{cutoff}	≤ 5 %

2.14.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		0 to 2 x*Is*: 35 ms, ± *10ms*
			0 to 5 xIs: 25 ms, ± *10ms*
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability		± 1 % or ± *10ms*
	Disengaging time		< 50 ms
	Variation	f_{nom} ± 5 %	≤ 5 %

Applicable for MLFB 7SR1004-5-20-2CAO

2.15 51 Time Delayed Overcurrent

2.15.1 Reference

	Parameter		Value
Is	Setting		0.05, 0.06… 4 xI$_n$
char	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time Multiplier setting		0.01, 0.015,… 1.6, 1.7,...5, 6,...100
t$_d$	Delay setting		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 x I$_s$
		DTL	5 x I$_s$

2.15.2 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 +60 °C	≤ 5 %
		f$_{nom}$ ± 5 %	≤ 5 %

2.15.3 Operate and Reset Time

	Attribute		Value
	Starter operate time (≥ 2xIs)		20 ms, ± 20 ms
t$_{op}$	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5 % absolute or ± 40 ms for TMS setting (0.01 to 0.245) ± 5 % absolute or ± 30 ms for TMS setting (0.25 to 100) for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5 % absolute or ± 40 ms for TMS setting (0.01 to 0.245) ± 5 % absolute or ± 30 ms for TMS setting (0.25 to 100) 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$_d$, ± 1 % or ± 20 ms

	Attribute		**Value**
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{1-\left[\frac{I}{Is}\right]^2} \times Tm$, ± 5 % or absolute ± 50 ms, for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		IEC DECAYING	$t_{res} = \frac{R}{1-\left[\frac{I}{Is}\right]^2} \times Tm$, ± 5 % or absolute ± 50 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}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

Figure 2.15-1and

Figure 2.15-4 show the operate and reset curves for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2.15-2 and

Figure 2.15-3 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.

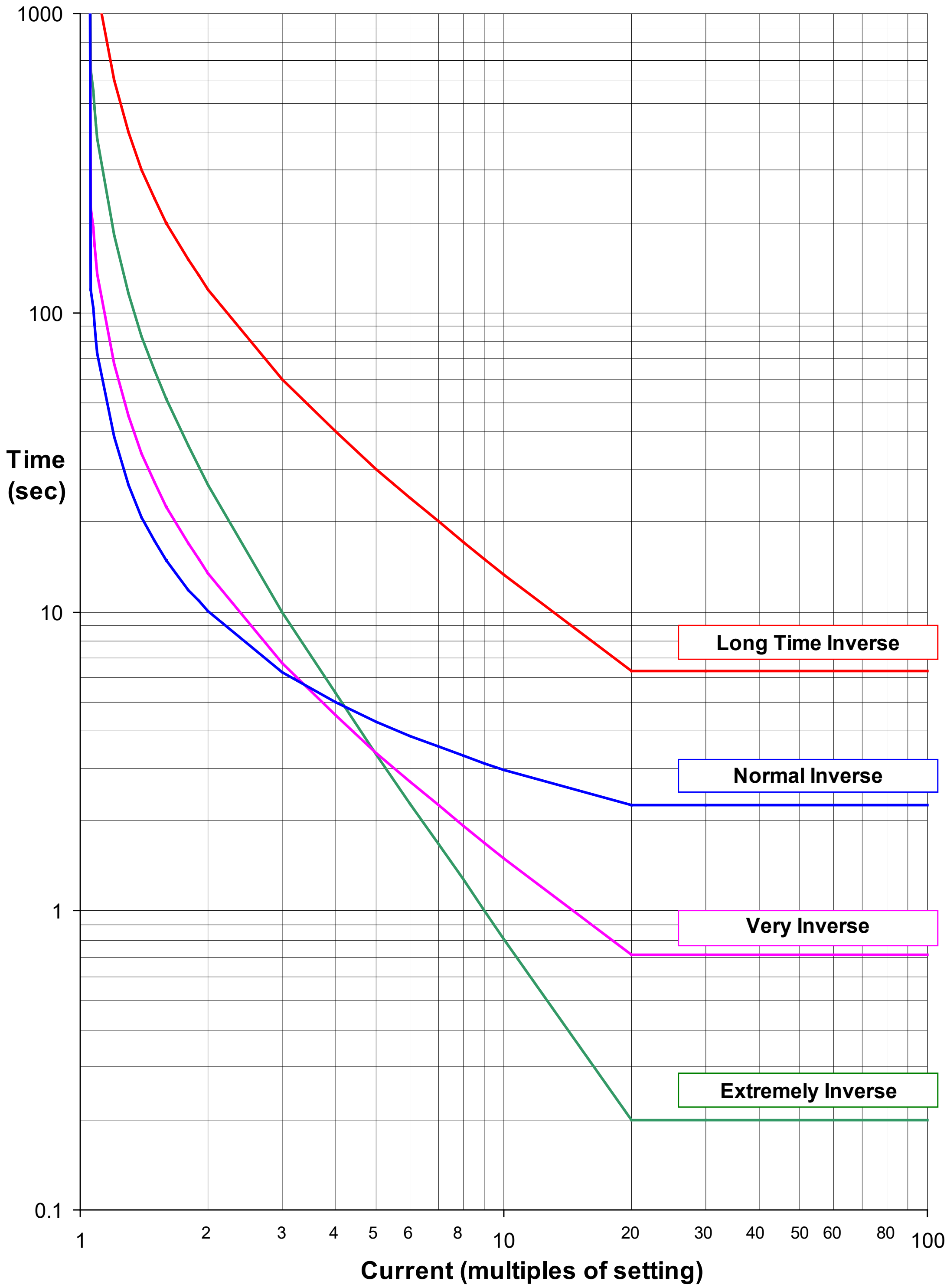


Figure 2.15-1 IEC IDMTL Curves (Time Multiplier=1)

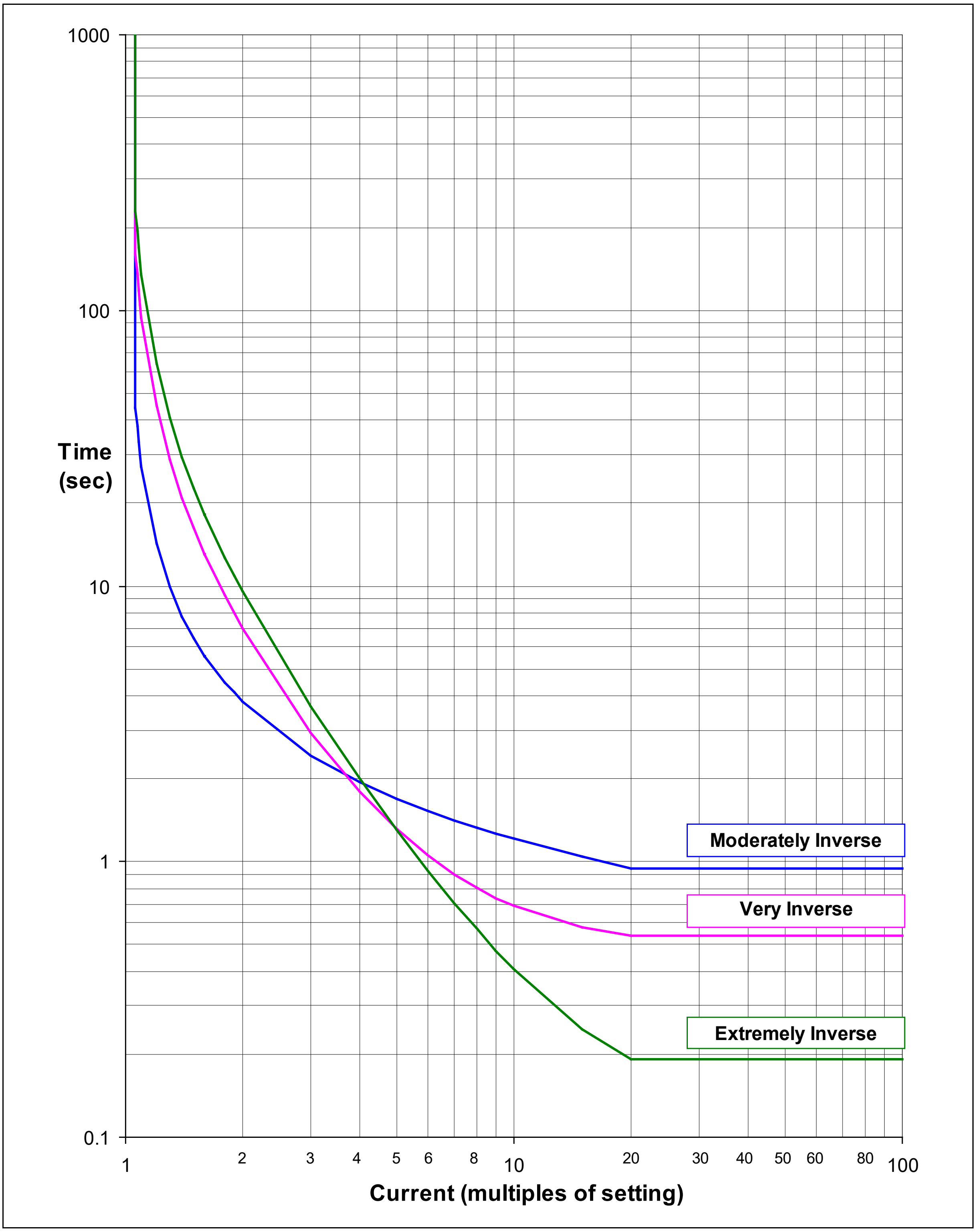


Figure 2.15-2 ANSI IDMTL Operate Curves (Time Multiplier=1)

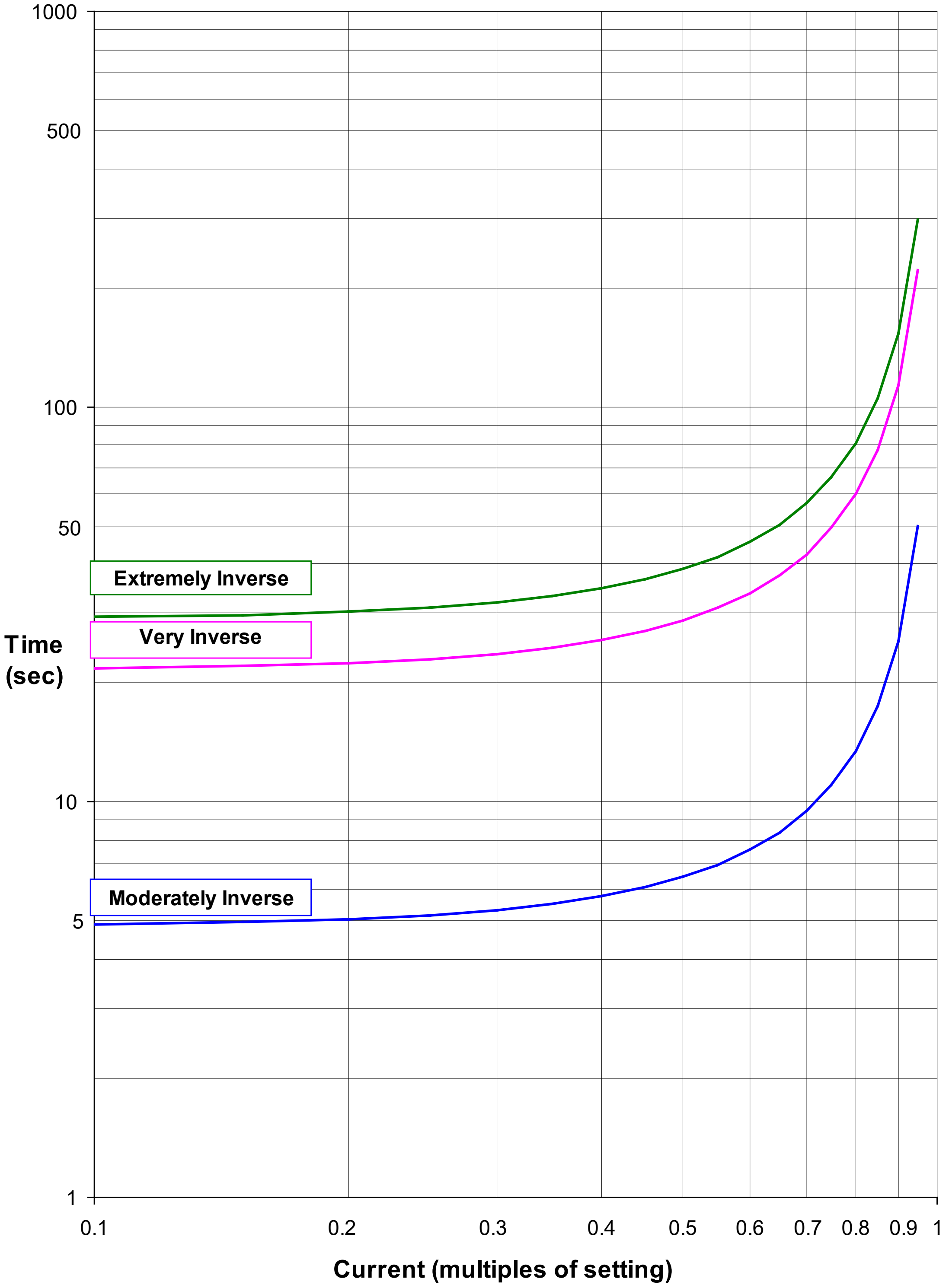


Figure 2.15-3 ANSI Reset Curves (Time Multiplier=1)

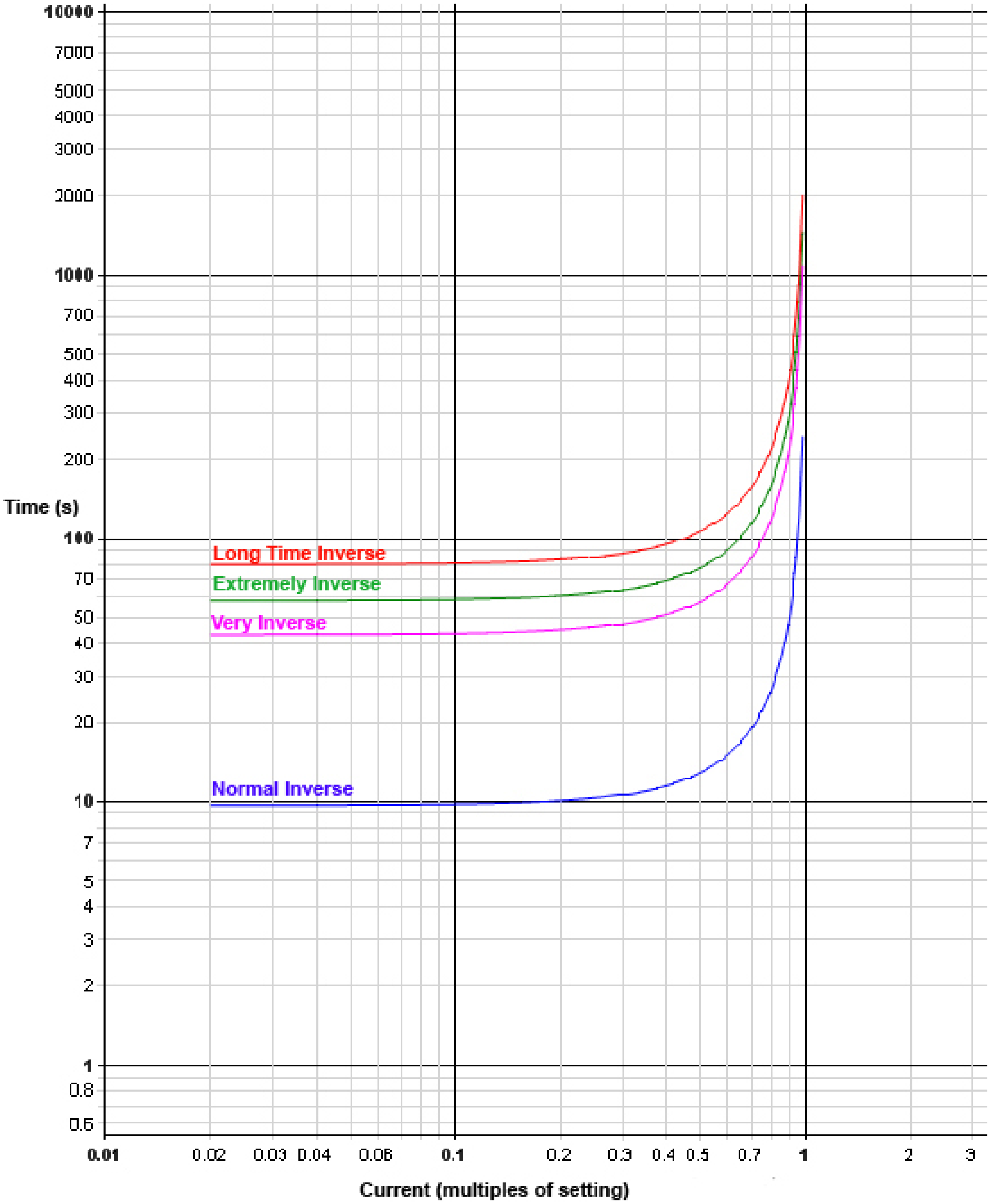


Figure 2.15-4 IEC Reset Curves (Time Multiplier=1)

2.16 51G Time Delayed Measured Earth Fault

2.16.1 Reference

	Parameter		Value
Is	Setting		0.05, 0.06… 4xI_n
Char	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time Multiplier setting		0.01, 0.015,… 1.6, 1.7,...5, 6,...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 20xI_s
		DTL	5xI_s

2.16.2 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 +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.16.3 Operate and Reset Time

	Attribute		Value
	Starter operate time (≥ 2xIs)		20 ms, ± 20 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5% absolute or ± 40 ms for TMS setting (0.01 to 0.245) ± 5% absolute or ± 30 ms for TMS setting (0.25 to 100) for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5% absolute or ± 40 ms for TMS setting (0.01 to 0.245) ± 5% absolute or ± 30 ms for TMS setting (0.25 to 100) 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, ± 1 % or ± 20 ms

	Attribute		Value
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{1-\left[\frac{I}{Is}\right]^{2}} \times Tm$ ± 5 % or absolute ± 50 ms, , for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		IEC DECAYING	$t_{res} = \frac{R}{1-\left[\frac{I}{Is}\right]^{2}} \times Tm$, ± 5 % or absolute ± 50 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}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

Figure 2.15-1and

Figure 2.15-4 show the operate and reset curves for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2.15-2 and

Figure 2.15-3 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.

2.17 51N Time Delayed Derived Earth Fault

2.17.1 Reference

	Parameter		Value
Is	Setting		0.05, 0.06… 4xI$_n$
char	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time Multiplier setting		0.01, 0.015,… 1.6, 1.7,...5, 6,...100
t_d	Delay setting		0, 0.01… 20 s
t_{res}	Reset setting		ANSI DECAYING, 0, 1… 60 s
I	Applied Current (for operate time)	IDMTL	2 to 20xI$_s$
		DTL	5xI$_s$

2.17.2 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 +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.17.3 Operate and Reset Time

	Attribute		Value
	Starter operate time (≥ 2xI$_s$)		30 ms, ± 20 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5% absolute or ± 40 ms for TMS setting (0.01 to 0.245) ± 5% absolute or ± 30 ms for TMS setting (0.25 to 100) for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5% absolute or ± 40 ms for TMS setting (0.01 to 0.245) ± 5% absolute or ± 30 ms for TMS setting (0.25 to 100) 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, ± 1 % or ± 20 ms

	Attribute		**Value**
	Reset time	ANSI DECAYING	$t_{res} = \frac{R}{1-\left[\frac{I}{Is}\right]^2} \times Tm$, ± 5 % or absolute ± 50 ms, for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		IEC DECAYING	$t_{res} = \frac{R}{1-\left[\frac{I}{Is}\right]^2} \times Tm$, ± 5 % or absolute ± 50 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}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 57 ms

Figure 2.15-1 and

Figure 2.15-4 show the operate and reset curves for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2.15-2 and

Figure 2.15-3 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.

2.18 51SEF Time Delayed Sensitive Earth Fault

2.18.1 Reference

	Parameter		Value
Is	Setting		0.005, 0.006,...0.1, 0.105, 0.110...0.5xI$_n$
char	Characteristic setting		IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Tm	Time multiplier		0.01, 0.015,… 1.6, 1.7,...5, 6,...100
t_d	Delay setting		0.00…20.00 s
t_{res}	Reset setting		DECAYING, 0, 1…60 s
I	Applied Current (for operate time)	IDMTL	2 to 20xI$_s$
		DTL	5xI$_s$

2.18.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		105 % I$_s$, ± 4 % or ± 1 % I$_n$
	Reset level		95 % I$_{op}$ ± 4 % or ± 1 % I$_n$
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f$_{nom}$ ± 5 % harmonics to f$_{cutoff}$	≤ 5 %

2.18.3 Operate and Reset Time

	Attribute		Value
	Starter operate time		20 ms, ± 20 ms
t_{op}	Operate time	char = IEC-NI, IEC-VI, IEC-EI, IEC-LTI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$, ± 5 % absolute or ± 40 ms for TMS setting (0.01 to 0.245) ± 5 % absolute or ± 30 ms for TMS setting (0.25 to 100) for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		char = ANSI-MI, ANSI-VI, ANSI-EI,	$t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$, ± 5 % absolute or ± 40 ms for TMS setting (0.01 to 0.245) ± 5 % absolute or ± 30 ms for TMS setting (0.25 to 100) 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

	Attribute		**Value**
		char = DTL	t_d, ± 1 % or ± t_{cycle}
	Reset time	char = ANSI and t_{res} = DECAYING	$t_{res} = \frac{R}{1-\left[\frac{I}{Is}\right]^2} \times Tm$, ± 5 % or absolute ± 50 ms, for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		IEC DECAYING	$t_{res} = \frac{R}{1-\left[\frac{I}{Is}\right]^2} \times Tm$, ± 5 % or absolute ± 50 ms, for char = IEC-NI : R = 9.7 IEC-VI : R = 43.2 IEC-EI : R = 58.2 IEC-LTI : R = 80
		$t_{res} \neq$ DECAYING	t_{res}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms
	Variation	f_{nom} ± 5 % harmonics to f_{cutoff}	≤ 5 %

Figure 2.15-1 and

Figure 2.15-4 show the operate and reset curves for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2.15-2 and

Figure 2.15-3 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.

2.19 51V Voltage Controlled Overcurrent

2.19.1 Reference

	Parameter	Value
Vs	Setting	60 V
m	multiplier	0.5
Is	Setting	1xI_n

2.19.2 Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		100 % V_s, ± 1 % or ± 0.25 V
	Reset level		≤ 105 % V_{op}
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 % harmonics to f_{cutoff}	≤ 5 %

Operate and Reset Time

As per Phase Fault Shaped Characteristic Element (ANSI 51).

Where Pickup Level = I_s for Voltage > V_s

Pickup Level = (I_s x m) for Voltage < V_s

2.20 55 Power Factor

2.20.1 Reference

	Parameter	**Value**
PF_s	55-n Setting	0.05…0.99
t_d	55-n Delay setting	0.00 … 14400 s

2.20.2 Operate and Reset Level

	Attribute		**Value**
PF_{op}	Operate Level		PF_s ± 0.05
	Reset Level	Under PF	$\leq PF_{op}$ + 0.02
		Over PF	$\geq PF_{op}$ - 0.02
	Repeatability		± 0.05
	Variation	-10 °C to +60 °C	± 0.05
		f_{nom} ± 5 %	± 0.05

2.20.3 Operate and Reset Time

	Attribute	**Value**
t_{basic}	Element basic operate time	≤ 80 ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 10 ms
	Disengaging time	< 80 ms

2.20.4 Operate Threshold

	Attribute		**Value**
	Minimum levels for operation	I	2.5 % I_n
		V	2.5% V_n
		P	0.01 Sn

2.21 59N Neutral Voltage Displacement

2.21.1 Reference (59NDT)

	Parameter	Value
Vs	Setting	1.0, 1.5 ... 100 V
t_d	Delay setting	0.00, 0.01…20.00 s

2.21.2 Operate and Reset Level (59NDT)

	Attribute		Value
V_{op}	Operate level		100 % Vs, ± 2 % or ± 0.5 V
	Reset level		≥ 95 % V_{op} or ± 0.5 V
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.21.3 Operate and Reset Time (59NDT)

	Attribute	Value
t_{basic}	Element basic operate time	0 V to 1.5 xV_s, 76 ms, ± 20 ms
		0V to 10 xV_s, 63 ms, ± 20 ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 20 ms
	Repeatability	± 1 % or ± 20 ms
	Overshoot time	< 40 ms
	Disengaging time	<100 ms

2.21.4 Reference (59NIT)

	Parameter	Value
M	Time Multiplier setting	1
Vs	Setting	1, 1.5… 100 V
$3V_o$	Applied Voltage (for Operate-Time) IDMTL	2xV_s
t_d	Delay setting	0, 0.01… 20 s
t_{res}	Reset setting	0, 1…60 s

2.21.5 Operate and Reset Level (59NIT)

	Attribute		Value
V_{op}	Operate level		100 % V_s, ± 2 % or ± 0.5 V
	Reset level		≥ 95 % V_{op} or ± 0.5 V
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

Operate and Reset Time (59NIT)

	Attribute	Value
t_{basic}	Starter operate time	65 ms, ± 20 ms
$3V_o$	Applied Current (for Operate-Time) DTL	10 x V_s

	Attribute		**Value**
t_{op}	Operate time	char = IDMTL	$t_{op} = \frac{M}{\left[\frac{3V0}{Vs}\right] - 1}$, ± 5 % or ± 65 ms
		char = DTL	t_d, ± 1 % or ± 40 ms
	Reset Time	char = DTL	t_{res}, ± 1 % or ± 40 ms
	Repeatability		± 1 % or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 100 ms

2.22 64H Restricted Earth Fault Protection

2.22.1 Reference

	Parameter	Value	
Is	Setting	SEF Input	0.005, 0.006 … 0.100, 0.105 … 0.950xI_n
		EF Input	0.05, 0.055.… 0.95xI_n
t_d	Delay setting	0.00, 0.01…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s	

2.22.2 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % Is, ± 5 % or ± 1 %xI_n
	Reset level		95 % I_{op}, ± 5 % or ± 0.1 %xI_n
	Repeatability		± 1 %
	Transient overreach (X/R ≤ 100)		≤ -5 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.22.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2xI_s, 45 ms, ± 10 ms
		0 to 5xI_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	< 50 ms

2.23 67/67N/67G/67SEF Directional Overcurrent & Earth Fault

2.23.1 Reference

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

2.23.2 Operate Angle

	Attribute		Value
CA	Characteristic angle (I with respect to V)		θ_s, ± 5 °
	Operating angle	forward	CA - 85 ° ± 5 ° to CA + 85 ° ± 5 °
		reverse	(CA - 180°) – 85 ° ± 5 ° to (CA - 180°) + 85 ° ± 5 °
	Variation in characteristic angle	-10 °C to +60 °C	± 5 °
		f_{nom} ± 5 %	± 5 °

2.23.3 Operate Threshold

	Attribute		Value
	Minimum levels for operation	I (p/f)	> 10 % I_n
		I (e/f)	> 10 % I_n
		I (SEF)	> 5 % I_n
		V (p/f)	> 3 V
		V (e/f)	> 3 V

2.23.4 Operate and Reset Time

	Attribute	Value
	Operate time	typically 32, < 40 ms at characteristic angle + 50/51/50G/51G/50SEF/51SEF/50N/51N element operate time
	Reset time	typically < 65 ms at characteristic angle

2.24 67SEF Directional Sensitive Earth Fault – Measured $3V_0/I_0$-Φ

2.24.1 Reference

	Parameter	Value
	Setting range I_s	0.01 to 0.5 x I_n
(CA)	Characteristic Angle	-180° to +180°
(OA)	Operating Angle	0° to 180°
$3I_0$	Applied current	I_n
$3V_0$	Applied voltage	V_n
	$3V_0$ setting	1 V to 40 V

2.24.2 Operate Angle

	Attribute		Value
	Operating angle accuracy	forward	CA + OA ± 3° to CA - OA ± 3°
	Variation in characteristic angle	-10° C to +60° C	± 5 °
		f_{nom} ± 5 %	± 5 °

2.24.3 Operate and Reset Level

	Attribute		Value
I_{op}	Operate level		100 % I_s, ±5 % or 1 mA for I_n = 1 A
			100 % I_s, ±5 % or 5 mA for I_n = 5 A
	Reset level		≥ 90 % I_{op}
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %
$3V_0$	Measurement and Operating tolerance of minimum pickup voltage		
	$3V_0$ Measured		1V-40V Accuracy ≤ 5% or ≤ 0.3V
	$3V_0$ Calculated		10V-40V Accuracy ≤ 5% or ≤ 1V

2.24.4 Operate and Reset Time

	Attribute	**Value**
	Non-directional element operate time	0 to 2 x I_s-35 ms, ± 10 ms
		0 to 5 x I_s-25 ms, ± 10 ms
	Directional element operate time (t_{basic})	Typically 35 ms, < 50 ms at characteristic angle + non-directional element operate time
	Reset time	< 100 ms at characteristic angle
t_{op}	Operate time following delay	T_{basic} + t_{delay}, ± 1% or ± 10 ms

2.25 Directional SEF - Wattmetric

2.25.1 Reference

	Parameter	**Value**
P_o	Setting	0.05, 0.10,… 20.0 x*InxW* (Where In = 1A or 5A)
I	Applied current @ In = 1A	50mA…5A
V	Applied voltage	10V…200V
θ	Angle	< 87.5deg
CA	67SEF Char Angle (θc)	0
f	Nominal	50/60Hz

2.25.2 Operate and Reset Level

	Attribute		**Value**
P_{op}	Operate level		100 % P_o, ± 25 % or ± 25mW
	Reset level		≥ 90 % P_{op}
	Variation	-10 °C to +55 °C	≤ 5 %

2.25.3 Operate and Reset Time

	Attribute		**Value**
t_{basic}	Element basic operate time		<50ms
	Repeatability		± 1 % or ± *10ms*

2.26 81 Under/over frequency

2.26.1 Reference

	Parameter	Value
Fs	Setting	43, 43.01… 68 Hz
V_s Guard	Guard Setting	35, 35.5, …199.5, 200 V
Hyst	Hysteresis setting	0, 0.1… 2 %
td	Delay setting	0.00, 0.01… 20.0, 20.1… 100.0, 101….1000, 1010 … 10000 , 10100 … 14400 s

2.26.2 Operate and Reset Level

	Attribute		Value
F_{op}	Operate level		100 % F_s, ± 10 mHz
	Reset level	overfrequency	(100 % - hyst) x$F_{op,}$ ± 10 mHz
		underfrequency	(100 % + hyst) x$F_{op,}$ ± 10 mHz
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %

2.26.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time (for ROCOF between 0.1 and 5.0 Hz/sec)	overfrequency	Typically < 150 ms
			Maximum < 190 ms
		underfrequency	Typically < 150 ms
			Maximum < 190 ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10 ms
	Repeatability		± 1 % or ± 10 ms
	Disengaging time		< 140 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} ± 5 %
	Reset level		90 % I_{curr} , ± 5 %
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 % harmonics to f_{cutoff}	≤ 5 %

3.1.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Basic operate time	1xI_n to 0 A	40 ms
	Operate time		t_f + t_{basic}, ± 1 % or ± 20 ms
	Repeatability		± 1 % or ± 20 ms
	Variation	f_{nom} ± 5 % harmonics to f_{cutoff}	≤ 5 %

3.2 50BF Circuit Breaker Fail

3.2.1 Reference

	Parameter	**Value**
Is	Setting	0.050, 0.055… 2.0xI_n
I4	Setting	0.050, 0.055… 2.0xI_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, ± 5 % or ± 1 % I_n
I_{reset}	Reset level		<100 % I_{op}, ± 5 % or ± 1 % I_n
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

3.2.3 Operate and Reset Time

	Attribute	**Value**
t_{op}	Stage 1	t_{CBF1}, ± 1 % or ± 20 ms
	Stage 2	t_{CBF2}, ± 1 % or ± 20 ms
	Repeatability	± 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

	Parameter		**Value**
I_{thresh}	Current Threshold		0.05, 0.1… 2xI$_n$
I	Applied Current (for operate time)	Healthy CT Phases	5 x I_{thresh}
		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… 110 V

3.3.2 Current & Voltage Threshold

	Attribute		**Value**
I_{op}	CT failed current level		100 % I_{thresh}, ± 5 % or ± 1% I_n
	Reset level		90 % I_{op}, ± 5 % or ± 1% I_n
V_{op}	CT failed voltage level		100 % V_{thresh}, ± 2 % or ± 0.5 V
	Reset level		110 % V_{op}, ± 2 % or ± 0.5 V
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 % harmonics to f_{cutoff}	≤ 5 %

3.3.3 Operate and Reset Time

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

3.4 60VTS Voltage Transformer Supervision

3.4.1 Reference

	Parameter	Value
V_{nps}	Vnps Level	7, 8 … 110 V
I_{nps}	Inps Level	0.05, 0.1 … 1xI_n
I_{pps}	Ipps Load Level	0.05, 0.1 … 1xI_n
IF_{pps}	Ipps Fault Level	0.05, 0.1 … 20xI_n
V_{pps}	Vpps Level	1, 2 … 110 V
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}, ± 5 % V_n
	Voltage NPS reset level		90 % V_{NPSop}, ± 5 % V_n
V_{PPSop}	Voltage PPS operate level		100 % V_{pps}, ± 5 % V_n
	Voltage PPS reset level		110 % V_{PPSop}, ± 5 % V_n
I_{NPSblk}	Current NPS operate level		100 % I_{nps}, ± 5 % xI_n
	Current NPS reset level		90 % I_{NPSblk}, ± 5 % xI_n
I_{PPSblk}	Current PPS operate level		100 % IF_{pps}, ± 5 % xI_n
	Current PPS reset level		90 % I_{PPSblk}, ± 5 % xI_n
$I_{PPSload}$	Current PPS operate level		100 % I_{pps}, ± 5 % xI_n
	Current PPS reset level		90 % $I_{PPSload}$, ± 5 % xI_n
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

3.4.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Basic operate time	0 V to 2 x V_s	32 ms ± 10 ms
	Operate time		t_d + t_{basic} ± 1 % or ± 10 ms
	Repeatability		± 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 ± 10 ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10 ms
	Repeatability		± 1 % or ± 10 ms
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 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

NOTE:

Fundamental current should be minimum 0.1xIn for better inrush accuracy.

3.7 81THD Total Harmonic Distortion Supervision

3.7.1 Reference

	Parameter	Value
I_{thd}	Setting	5,6,.....100 %
t_d	Delay setting	0.02, 0.03…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s

3.7.2 Operate and Reset Level

	Attribute		Value
Ithd $_{op}$	Operate level		100 % Ithd, ± 5 % (Applied harmonic magnitude) or ± 1% Ithd
	Operating range		0.2 to 20xI_n
	Repeatability		± 1 %
	Variation	-10 °C to +60 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

3.7.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2xIthd: 55 ms, ± 15 ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 15 ms
	Repeatability	± 1 % or ± 10 ms
	Disengaging time	< 60 ms

7SR10

Document Release History

This document is issue **2020/03**. The list of revisions up to and including this issue is:

Date	Description
2020/03	Addition of function Directional SEF (67SEF) – Measured $3V_0/I_0$-Phi

Contents

List of Figures

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*** 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:	This port is used for IEC60870-5-103 (default setting) communication with the Reydisp software. 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. MODBUS-RTU or the optional DNP3 protocols are also available.

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. 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 77, for further explanation

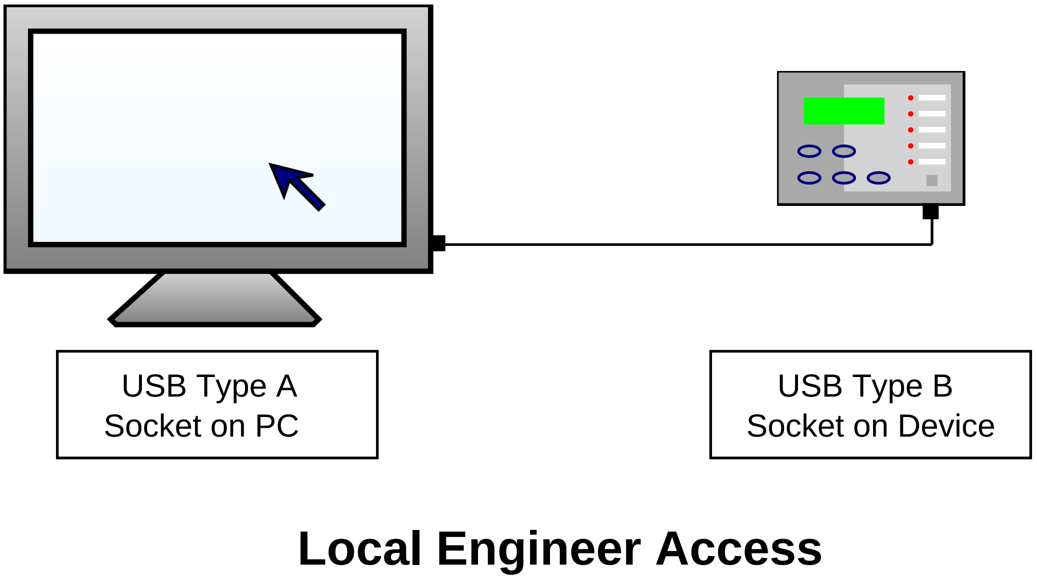


Fig. 2-1 Communication to Front USB Port

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 A and B by fitting an external wire loop between terminals B and TERM on the power supply module. Refer terminal diagram for RS 485 terminal details.

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.

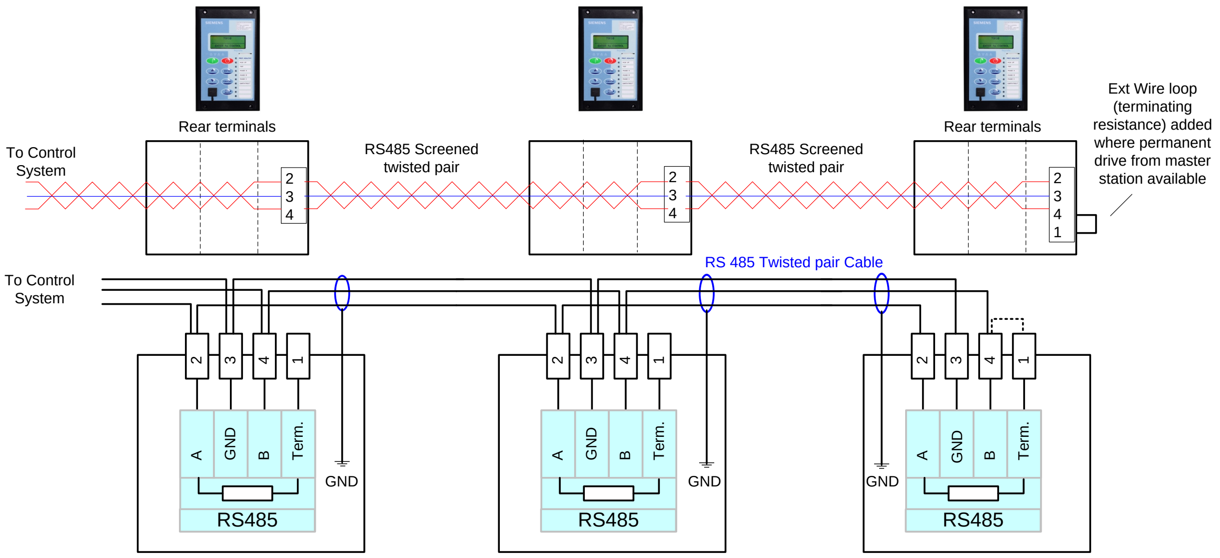
The polarity marking is often found to be reversed or marked as +/- on other equipment so care is required. If the devices are connected in reverse, communication to all devices will be disturbed but no damage will occur. If problems are experienced during commissioning, the connections should be tried 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 77, for further explanation



Bus Termination Polarity

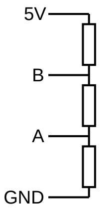


Fig. 2-2 Communication to Multiple Devices using RS485 (Standard Port)

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 and RS485) 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, GI
60	129	Warm Start	1	SE, GI
60	130	Re-Start	1	SE, GI
60	131	Expected Restart	1	SE, GI
60	132	Unexpected Restart	1	SE, GI
60	133	Reset Start Count	1	SE, GI
			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	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
70	5	Binary Input 5	1	SE, GI

FUN	INF	Description	ASDU	COT
70	6	Binary Input 6	1	SE, GI
70	7	Binary Input 7	1	SE, GI
70	8	Binary Input 8	1	SE, GI
70	9	Binary Input 9	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
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
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
160	2	Reset FCB	5	SE
160	3	Reset CU	5	SE
160	4	Start/Restart	5	SE
160	5	Power On	1	SE, GI
160	16	Auto-reclose active	1	SE, GI
			20	Ack, Nak

FUN	INF	Description	ASDU	COT
160	19	LED and O/P Reset	1	SE
			20	Ack, Nak
160	22	Settings changed	1	SE
160	23	Setting G1 selected	1	SE, GI
			20	Ack, Nak
160	24	Setting G2 selected	1	SE, GI
			20	Ack, Nak
160	25	Setting G3 selected	1	SE, GI
			20	Ack, Nak
160	26	Setting G4 selected	1	SE, GI
			20	Ack, Nak
160	27	Binary Input 1	1	SE, GI
160	28	Binary Input 2	1	SE, GI
160	29	Binary Input 3	1	SE, GI
160	30	Binary Input 4	1	SE, GI
160	36	Trip Circuit Fail	1	SE, GI
160	38	VT Fuse Failure	1	SE, GI
160	51	Earth Fault Forward/Line	2	SE, GI
160	52	Earth Fault Reverse/Busbar	2	SE, GI
160	64	Start/Pick-up L1	2	SE, GI
160	65	Start/Pick-up L2	2	SE, GI
160	66	Start/Pick-up L3	2	SE, GI
160	67	Start/Pick-up N	2	SE, GI
160	68	General Trip	2	SE
160	69	Trip L1	2	SE
160	70	Trip L2	2	SE
160	71	Trip L3	2	SE
160	74	Fault Forward/Line	2	SE, GI
160	75	Fault Reverse/Busbar	2	SE, GI
160	84	General Start/Pick-up	2	SE, GI
160	85	Breaker Failure	2	SE
160	90	Trip I>	2	SE
160	91	Trip I>>	2	SE
160	92	Trip In>	2	SE
160	93	Trip In>>	2	SE
160	128	CB on by auto reclose	1	SE
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

FUN	INF	Description	ASDU	COT
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	41	51SEF-1	2	SE, GI
183	42	50SEF-1	2	SE, GI
183	43	51SEF-2	2	SE, GI
183	44	50SEF-2	2	SE, GI
183	45	51SEF-3	2	SE, GI
183	46	50SEF-3	2	SE, GI
183	47	51SEF-4	2	SE, GI
183	48	50SEF-4	2	SE, GI
183	49	SEF Out	2	SE, GI
			20	Ack, Nak
183	50	46IT	2	SE, GI
183	51	46DT	2	SE, GI
183	52	64H	2	SE, GI
183	53	E/F Out	2	SE, GI
			20	Ack, Nak
183	54	SEF Forward/Line	2	SE, GI
183	55	SEF Reverse/Busbar	2	SE, GI
183	56	50BF Stage 1	2	SE, GI
183	60	47-1	2	SE, GI
183	61	47-2	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	66	37SEF-1	2	SE, GI
183	67	37SEF-2	2	SE, GI
183	68	67SEF-1	2	SE, GI
183	69	67SEF-2	2	SE, GI
183	70	46BC	2	SE, GI
183	81	27/59-1	2	SE, GI
183	82	27/59-2	2	SE, GI
183	83	27/59-3	2	SE, GI
183	84	27/59-4	2	SE, GI

FUN	INF	Description	ASDU	COT
183	85	59NIT	2	SE, GI
183	86	59NDT	2	SE, GI
183	90	81-1	2	SE, GI
183	91	81-2	2	SE, GI
183	92	81-3	2	SE, GI
183	93	81-4	2	SE, GI
183	96	81HBL2	1	SE, GI
183	98	81I-THD	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	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^2t CB Wear	1	SE, GI
183	130	Reset I^2t 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, GI
			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	143	SEF 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
183	167	Close Circuit Fail	2	SE, GI

FUN	INF	Description	ASDU	COT
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
			20	Ack, Nak
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	221	Wattmetric Po>	1	SE, GI
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	229	50SEF LC-1	2	SE, GI
183	230	50SEF 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	244	Isef 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	37	27/59 PhA	2	SE, GI

FUN	INF	Description	ASDU	COT
185	38	27/59 PhB	2	SE, GI
185	39	27/59 PhC	2	SE, GI
185	43	General Trip	2	SE, GI
185	44	32-1	1	SE, GI
185	45	32-2	1	SE, GI
185	46	32S-1	1	SE, GI
185	47	32S-2	1	SE, GI
185	48	55-1	1	SE, GI
185	49	55-2	1	SE, GI
185	110	CB Wear CB A	4	SE
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	1	50AFD PhA	1	SE, GI
186	2	50AFD PhB	1	SE, GI
186	3	50AFD PhC	1	SE, GI
186	4	50AFD	1	SE, GI
186	5	AFD Zone 1 Flash	1	SE, GI
186	6	AFD Zone 1	1	SE, GI
186	7	AFD Zone 2 Flash	1	SE, GI
186	8	AFD Zone 2	1	SE, GI
186	9	AFD Zone 3 Flash	1	SE, GI
186	10	AFD Zone 3	1	SE, GI
186	11	AFD Zone 4 Flash	1	SE, GI
186	12	AFD Zone 4	1	SE, GI
186	13	AFD Zone 5 Flash	1	SE, GI
186	14	AFD Zone 5	1	SE, GI
186	15	AFD Zone 6 Flash	1	SE, GI
186	16	AFD Zone 6	1	SE, GI
186	17	AFD Zone1 Count	4	SE
186	18	AFD Zone2 Count	4	SE
186	19	AFD Zone3 Count	4	SE
186	20	AFD Zone4 Count	4	SE
186	21	AFD Zone5 Count	4	SE
186	22	AFD Zone6 Count	4	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

FUN	INF	Description	ASDU	COT
			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
			20	Ack, Nak
200	157	User SP Command 8	1	SE, GI
			20	Ack, Nak
200	158	User DP Command 1	1	SE, GI
			20	Ack, Nak
200	159	User DP Command 2	1	SE, GI
			20	Ack, Nak
200	160	User DP Command 3	1	SE, GI
			20	Ack, Nak
200	161	User DP Command 4	1	SE, GI
			20	Ack, Nak
200	162	User DP Command 5	1	SE, GI
			20	Ack, Nak
200	163	User DP Command 6	1	SE, GI
			20	Ack, Nak
200	164	User DP Command 7	1	SE, GI
			20	Ack, Nak
200	165	User DP Command 8	1	SE, GI
			20	Ack, Nak
200	200	CB 1 Trip & Reclose	1	SE, GI
			20	Ack, Nak
200	201	CB 1 Trip & Lockout	1	SE, GI
			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, $V_{L1-2,L2-3,L3-1}$ --- 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%)	9	Cyclic - Refresh rate 5 seconds or value change greater than Window x %.

FUN	INF	Description	ASDU	COT
		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%)		
183	236	Measurand Max $I_{a,b,c,}$ $V_{an,bn,cn,}$ P, Q, $V_{ab,bc,ca}$ --- Ia Max (2.4x) (Window 1%) Ib Max (2.4x) (Window 1%) Ic Max (2.4x) (Window 1%) Van Max$_1$ (1.2x) (Window 1%) Vbn Max$_2$ (1.2x) (Window 1%) Vcn Max$_3$ (1.2x) (Window 1%) P Max (2.4x) (Window 1%) Q Max (2.4x) (Window 1%) Vab Max (1.2x) (Window 1%) Vbc Max (1.2x) (Window 1%) Vca Max (1.2x) (Window 1%)	9	Cyclic - Refresh rate 5 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

Note: Some of the events which are listed above (applicable for the variant) and not available in the device can be enabled through Communication Editor software.

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 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.

Definitions with shaded area are not available on all relay models.

4.2 MODBUS Register Data Types

4.2.1 FLOAT_IEEE_754

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).

MSB																															LSB
Sign	Exponent								Mantissa																						

FLOAT_IEEE_754 IN DETAIL

The exponent is an 8 bit unsigned integer. To allow for negative exponents, it is offset by 127. Therefore the actual exponent is e - 127. The following table shows a detailed layout of the exponent.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

The mantissa contains the fractional part of a number normalized to the form 1.xyz i.e. in this instance xyz. The mantissa represents the binary fraction of a number; therefore the MSB represents 2^{-1} (or $1/2^1$) and its LSB 2^{-23} (or $1/2^{23}$). The following table shows a detailed layout of the mantissa.

$\frac{1}{2^1}$	$\frac{1}{2^2}$	$\frac{1}{2^3}$	$\frac{1}{2^4}$																	$\frac{1}{2^{21}}$	$\frac{1}{2^{22}}$	$\frac{1}{2^{23}}$
0.5	0.25	0.125	0.0625																	4.768e-7	2.384e-7	1.192e-7

As an example 1,000,000 would be represented as follows (hex 49742400).

4				9				7				4				2				4				0				0			
0	1	0	0	1	0	0	1	0	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0

This calculates out as:

Sign = +1

Exponent = 10010010_2 = 128 + 16 + 2 = 146, subtract 127 = 19.

$$\text{Mantissa} = 1 + \frac{1}{2^1} + \frac{1}{2^2} + \frac{1}{2^3} + \frac{1}{2^5} + \frac{1}{2^{10}} + \frac{1}{2^{13}}$$

$$= 1 + \frac{4096 + 2048 + 1024 + 256 + 8 + 1}{2^{13}} = 1 + \frac{7433}{2^{13}} = 1.907348632$$

Therefore $Sign * 2^{Exponent} * Mantissa = 1 * 2^{19} * 1.907348632 = 1000000$

FLOAT_IEEE_754 & MODBUS

In this MODBUS implementation the 32 bit float is stored in 2 16 registers in Big-Endian format. As an example, if we take the hex representation of 1,000,000 as a float (from above) we have 49742400h. Assume this is stored in the registers 30001 and 30002, it would look as follows.

Address	Value
30001	4974

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
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
00115	SEF 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
10007	Binary Input 7
10008	Binary Input 8
10009	Binary Input 9
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

Address	Description
10142	51N-4
10143	50N-4
10144	51G-4
10145	50G-4
10146	50BF Stage 2
10147	49-Alarm
10148	49-Trip
10149	60 CTS
10150	46IT
10151	46DT
10152	47-1
10153	47-2
10154	46BC
10155	27/59-1
10156	27/59-2
10157	27/59-3
10158	27/59-4
10159	59NIT
10160	59NDT
10161	81-1
10162	81-2
10163	81-3
10164	81-4
10167	64H
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^2t 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
10186	SEF Inst Protection Inhibited
10187	Ext Inst Protection Inhibited
10202	51SEF-1
10203	50SEF-1
10204	51SEF-2
10205	50SEF-2
10206	51SEF-3

Address	Description
10207	50SEF-3
10208	51SEF-4
10209	50SEF-4
10210	SEF Out
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^2t 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
10288	SEF Forward/Line
10289	SEF Reverse/Busbar
10290	General Alarm 1
10291	General Alarm 2
10292	General Alarm 3
10293	General Alarm 4
10294	General Alarm 5
10295	General Alarm 6
10302	Quick Logic E1
10303	Quick Logic E2
10304	Quick Logic E3
10305	Quick Logic E4
10334	60 CTS-I
10335	81HBL2
10336	37G-1
10337	37G-2
10338	37SEF-1
10339	37SEF-2
10367	50BF Stage 1
10368	Wattmetric Po>
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
10376	50SEF LC-1
10377	50SEF LC-2
10378	50BF-PhA
10379	50BF-PhB

Address	Description
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
10401	27/59 PhA
10402	27/59 PhB
10403	27/59 PhC
10410	CB Alarm
10431	67SEF-1
10432	67SEF-2
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
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
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

Address	Description
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
10916	32-1
10917	32-2
10918	32S-1
10919	32S-2
10920	55-1
10921	55-2
11073	CB DBI
11074	CB Travelling
11075	Close CB Failed
11076	Open CB Failed
11077	Start Count Alarm
11078	50AFD PhA
11079	50AFD PhB
11080	50AFD PhC
11081	50AFD
11082	AFD Zone 1 Flash
11083	AFD Zone 1
11084	AFD Zone 2 Flash
11085	AFD Zone 2
11086	AFD Zone 3 Flash
11087	AFD Zone 3
11088	AFD Zone 4 Flash
11089	AFD Zone 4
11090	AFD Zone 5 Flash
11091	AFD Zone 5
11092	AFD Zone 6 Flash
11093	AFD Zone 6
11118	81I-THD

4.3.3 Input Registers (Read Only Registers)

Address	Description	Format	Mult	Description
30001	Event Count	EVENTCOUNT	0.000000	Events Counter

Address	Description	Format	Mult	Description
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
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

Address	Description	Format	Mult	Description
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 %
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
30207	Isef Primary	FP_32BITS_3DP	1.000000	Isef A
30209	Isef Secondary	FP_32BITS_3DP	1.000000	Isef A
30211	Isef Nominal	FP_32BITS_3DP	1.000000	Isef xInom
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

Address	Description	Format	Mult	Description
30313	In Last Trip	FP_32BITS_3DP	1.000000	In Fault
30315	Ig Last Trip	FP_32BITS_3DP	1.000000	Ig Fault
30317	Isef Last Trip	FP_32BITS_3DP	1.000000	Isef 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
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
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	AFDZone1Count	UINT32	1.000000	AFD Zone 1 Count
30486	AFDZone2Count	UINT32	1.000000	AFD Zone 2 Count
30488	AFDZone3Count	UINT32	1.000000	AFD Zone 3 Count
30490	AFDZone4Count	UINT32	1.000000	AFD Zone 4 Count
30492	AFDZone5Count	UINT32	1.000000	AFD Zone 5 Count
30494	AFDZone6Count	UINT32	1.000000	AFD Zone 6 Count
30578	Ia THD	FP_32BITS_3DP	1.000000	81THD Ia %
30580	Ib THD	FP_32BITS_3DP	1.000000	81THD Ib %
30582	Ic THD	FP_32BITS_3DP	1.000000	81THD Ic %

4.3.4 Holding Registers (Read Write Registers)

Address	Description	Format	Mult	Description
40001	Time	TIME_METER	0.000000	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 42), and the Point List Tables provided in Section 5.3 (beginning on page 48), should provide a complete configuration/interoperability guide for communicating with a device implementing the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library.

<table>
<tr><td colspan="2">DNP V3.0
DEVICE PROFILE DOCUMENT
(Also see the DNP 3.0 Implementation Table in Section 5.2, beginning on page 42).</td></tr>
<tr><td colspan="2">Vendor Name: Siemens Protection Devices</td></tr>
<tr><td colspan="2">Device Name: 7SR10, using the Triangle MicroWorks, Inc. DNP3 Slave Source Code Library, Version 3.</td></tr>
<tr><td>Highest DNP Level Supported:
For Requests: Level 3
For Responses: Level 3</td><td>Device Function:
☐ Master
☒ Slave</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):
Transmitted: 256
Received: 256</td><td>Maximum Application Fragment Size (octets):
Transmitted: 2048
Received: 2048</td></tr>
<tr><td>Maximum Data Link Re-tries:
☐ None
☐ Fixed (3)
☒ Configurable from 0 to 65535 (Default 3)</td><td>Maximum Application Layer Re-tries:
☒ None
☐ Configurable</td></tr>
<tr><td colspan="2">Requires Data Link Layer Confirmation:
☐ Never
☐ Always
☐ Sometimes
☒ Configurable as: Never, Only for multi-frame messages, or Always</td></tr>
<tr><td colspan="2">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.”</td></tr>
<tr><td colspan="2">Timeouts while waiting for:
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
Others:
Transmission Delay, (Configurable, default 0 sec)
Select/Operate Arm Timeout, (Configurable, default 5 sec)
Need Time Interval, (Configurable, default 30 minutes)</td></tr>
</table>

DNP V3.0
DEVICE PROFILE DOCUMENT
(Also see the DNP 3.0 Implementation Table in Section 5.2, beginning on page 42).

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:

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

Attach explanation if “Sometimes” or “Configurable” was checked for any operation.

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

Sequential File Transfer Support:

DNP V3.0

DEVICE PROFILE DOCUMENT

(Also see the DNP 3.0 Implementation Table in Section 5.2, beginning on page 42).

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).

5.3 Point List

The tables below identify all the default data points provided by the implementation of the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library.

This protocol can be set to use any or all of the relays hardware interfaces (USB 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 0 - 65534 to enable communication. This can be set by the **Communications Menu : COM *n-xxxxx* Station Address** setting.

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

The default binary input event buffer size is set to allow 100 events.

Binary inputs are by default returned in a class zero interrogation.

Note, not all points listed here apply to all builds of devices.

Binary Input Points
Static (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
1	Binary Input 1	0,2	2	2
2	Binary Input 2	0,2	2	2
3	Binary Input 3	0,2	2	2
4	Binary Input 4	0,2	2	2
5	Binary Input 5	0,2	2	2
6	Binary Input 6	0,2	2	2
7	Binary Input 7	0,2	2	2
8	Binary Input 8	0,2	2	2
9	Binary Input 9	0,2	2	2
35	Remote Mode	0,2	2	2
36	Out Of Service Mode	0,2	2	2
37	Local Mode	0,2	2	2
38	Local & Remote	0,2	2	2
40	General Trip	0,2	2	2
41	Trip Circuit Fail	0,2	2	2
42	Start/Pick-up L1	0,2	2	2
43	Start/Pick-up L2	0,2	2	2
44	Start/Pick-up L3	0,2	2	2
45	General Start/Pick-up	0,2	2	2
46	VT Fuse Failure	0,2	2	2
47	Earth Fault Forward/Line	0,2	2	2
48	Earth Fault Reverse/Busbar	0,2	2	2
49	Start/Pick-up N	0,2	2	2

Binary Input Points
Static (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
67	47-1	0,2	2	2
68	47-2	0,2	2	2
69	46BC	0,2	2	2
70	27/59-1	0,2	2	2
71	27/59-2	0,2	2	2
72	27/59-3	0,2	2	2
73	27/59-4	0,2	2	2
74	59NIT	0,2	2	2
75	59NDT	0,2	2	2
76	81-1	0,2	2	2
77	81-2	0,2	2	2
78	81-3	0,2	2	2
79	81-4	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

Binary Input Points
Static (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
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
102	SEF Inst Protection Inhibited	0,2	2	2
103	Ext Inst Protection Inhibited	0,2	2	2
117	51SEF-1	0,2	2	2
118	50SEF-1	0,2	2	2
119	51SEF-2	0,2	2	2
120	50SEF-2	0,2	2	2
121	51SEF-3	0,2	2	2
122	50SEF-3	0,2	2	2
123	51SEF-4	0,2	2	2
124	50SEF-4	0,2	2	2
125	SEF Out	0,2	2	2
126	Trip Circuit Fail 1	0,2	2	2
127	Trip Circuit Fail 2	0,2	2	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^2t 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
215	64H	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
223	SEF Forward/Line	0,2	2	2
224	SEF Reverse/Busbar	0,2	2	2

Binary Input Points
Static (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
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
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
273	Wattmetric Po>	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
281	50SEF LC-1	0,2	2	2
282	50SEF 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
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
302	27/59 PhA	0,2	2	2
303	27/59 PhB	0,2	2	2
304	27/59 PhC	0,2	2	2
330	32-1	0,2	2	2
331	32-2	0,2	2	2
332	32S-1	0,2	2	2

Binary Input Points
Static (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
333	32S-2	0,2	2	2
334	55-1	0,2	2	2
335	55-2	0,2	2	2
371	67SEF-1	0,2	2	2
372	67SEF-2	0,2	2	2
373	37SEF-1	0,2	2	2
374	37SEF-2	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
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
801	Binary Output 1	0,2	2	2

Binary Input Points
Static (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
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
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
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
1068	50AFD PhA	0,2	2	2
1069	50AFD PhB	0,2	2	2
1070	50AFD PhC	0,2	2	2
1071	50AFD	0,2	2	2
1072	AFD Zone 1 Flash	0,2	2	2
1073	AFD Zone 1	0,2	2	2
1074	AFD Zone 2 Flash	0,2	2	2
1075	AFD Zone 2	0,2	2	2
1076	AFD Zone 3 Flash	0,2	2	2
1077	AFD Zone 3	0,2	2	2
1078	AFD Zone 4 Flash	0,2	2	2
1079	AFD Zone 4	0,2	2	2
1080	AFD Zone 5 Flash	0,2	2	2
1081	AFD Zone 5	0,2	2	2

Binary Input Points
Static (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
1082	AFD Zone 6 Flash	0,2	2	2
1083	AFD Zone 6	0,2	2	2
1108	81I-THD	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 Points
Static (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 Paired Close	Pulse On
2	RL 2	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
3	RL 3	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
4	RL 4	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
5	RL 5	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
6	RL 6	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
33	LED reset, write only location.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
34	Settings Group 1	0	2	2	0	1	Pulse On Latch On Paired Close	Latch On
35	Settings Group 2	0	2	2	0	1	Pulse On Latch On	Latch On

Binary Output Status Points
Static (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**
							Paired Close	
36	Settings Group 3	0	2	2	0	1	Pulse On Latch On Paired Close	Latch On
37	Settings Group 4	0	2	2	0	1	Pulse On Latch On Paired Close	Latch On
42	Auto-reclose on/off	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired Trip	Pulse On Pulse Off Latch On Latch Off
43	Hot Line Working on/off	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired 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 Paired Close Paired Trip	Pulse On Pulse Off Latch On Latch Off
45	SEF off/on	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired 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 Paired Close	Pulse On Pulse Off Latch On Latch Off

Binary Output Status Points
Static (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
							Paired Trip	
48	Reset CB Total Trip Count, write only location.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
49	Reset CB Delta Trip Count, write only location.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
50	Reset CB Count To AR Block, write only location.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
51	Reset CB Frequent Ops Count, write only location.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
53	Reset I^2t CB Wear	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
54	CB 1	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired 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 Paired Close	Pulse On
56	CB 1 Trip & Lockout, write only location.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
59	Demand metering reset, write only location.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
87	Reset Energy Meters	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On

Binary Output Status Points
Static (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
88	Remote mode	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
89	Service mode	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
90	Local mode	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
91	Local & Remote	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
98	Reset Start Count (Action)	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On Latch On
99	User SP Command 1.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
100	User SP Command 2.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
101	User SP Command 3.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
102	User SP Command 4.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
103	User SP Command 5.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
104	User SP Command 6.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
105	User SP Command 7.	0	2	2	0	1	Pulse On Latch On	Pulse On

Binary Output Status Points
Static (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**
							Paired Close	
106	User SP Command 8.	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On
107	User DP Command 1.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired Trip	Pulse On Pulse Off
108	User DP Command 2.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired Trip	Pulse On Pulse Off
109	User DP Command 3.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired Trip	Pulse On Pulse Off
110	User DP Command 4.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired Trip	Pulse On Pulse Off
111	User DP Command 5.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired Trip	Pulse On Pulse Off
112	User DP Command 6.	0	2	2	0	1	Pulse On Pulse Off	Pulse On Pulse Off

Binary Output Status Points
Static (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 Latch Off Paired Close Paired Trip	
113	User DP Command 7.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired Trip	Pulse On Pulse Off
114	User DP Command 8.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Paired Close Paired Trip	Pulse On Pulse Off
115	CB-1 Open	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On Latch On
116	CB-1 Close	0	2	2	0	1	Pulse On Latch On Paired Close	Pulse On 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.

Counters
Static (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 Counters
Static (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**	**IsFreezable**	**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
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.

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 an Analog 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 analog input event buffer size is set 30. The analog input event mode is set to Most Recent, only most recent event for each point is stored.

Analog inputs are by default returned in a class zero interrogation.

Note, not all points listed here apply to all builds of devices.

Analog Inputs
Static (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
0	Frequency	0,3	2	4	100.000	1.000
1	Vab Primary	0,3	2	4	0.010	100.000
2	Vbc Primary	0,3	2	4	0.010	100.000
3	Vca Primary	0,3	2	4	0.010	100.000
4	Va Primary	0,3	2	4	0.010	100.000
5	Vb Primary	0,3	2	4	0.010	100.000
6	Vc Primary	0,3	2	4	0.010	100.000
7	Va Secondary	0,3	2	4	10.000	1.000
8	Vb Secondary	0,3	2	4	10.000	1.000
9	Vc Secondary	0,3	2	4	10.000	1.000
21	Vzps	0,3	2	4	10.000	1.000
22	Vpps	0,3	2	4	10.000	1.000
23	Vnps	0,3	2	4	10.000	1.000
31	Ia Primary	0,3	2	4	1.000	100.000
32	Ib Primary	0,3	2	4	1.000	100.000
33	Ic Primary	0,3	2	4	1.000	100.000
34	Ia Secondary	0,3	2	4	100.000	0.100
35	Ib Secondary	0,3	2	4	100.000	0.100
36	Ic Secondary	0,3	2	4	100.000	0.100
37	Ia Nominal	0,3	2	4	100.000	0.100
38	Ib Nominal	0,3	2	4	100.000	0.100
39	Ic Nominal	0,3	2	4	100.000	0.100
43	In Primary	0,3	2	4	1.000	100.000
44	In Secondary	0,3	2	4	100.000	0.100
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

Analog Inputs
Static (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
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	10.000	1000000.000
58	Active Power B	0,3	2	4	10.000	1000000.000
59	Active Power C	0,3	2	4	10.000	1000000.000
60	P (3P)	0,3	2	4	10.000	1000000.000
61	Reactive Power A	0,3	2	4	10.000	1000000.000
62	Reactive Power B	0,3	2	4	10.000	1000000.000
63	Reactive Power C	0,3	2	4	10.000	1000000.000
64	Q (3P)	0,3	2	4	10.000	1000000.000
65	Apparent Power A	0,3	2	4	10.000	1000000.000
66	Apparent Power B	0,3	2	4	10.000	1000000.000
67	Apparent Power C	0,3	2	4	10.000	1000000.000
68	S (3P)	0,3	2	4	10.000	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
102	Vn Primary	0,3	2	4	0.010	100.000
103	Vn Secondary	0,3	2	4	10.000	1.000

Analog Inputs
Static (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
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	10.000	1000000.000
112	Q 3P Max	0,3	2	4	10.000	1000000.000
115	Isef Primary	0,3	2	4	1.000	10.000
116	Isef Secondary	0,3	2	4	1000.000	0.050
117	Isef Nominal	0,3	2	4	1000.000	0.050
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
173	Isef 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
184	CB Wear A	0,3	1	3	100.000	1000000.000
185	CB Wear B	0,3	1	3	100.000	1000000.000
186	CB Wear C	0,3	1	3	100.000	1000000.000
187	CB Wear A Remaining	0,3	1	3	1.000	1.000
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

Analog Inputs
Static (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
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	10.000	1000000.000
294	Ia THD	0,3	2	4	100.000	0.100
295	Ib THD	0,3	2	4	100.000	0.100
296	Ic THD	0,3	2	4	100.000	0.100
330	CB Trip Time Meter	0,3	2	4	1000.000	0.010

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 Protocol is set to DNP3.

6. Not Applicable

This section intentionally left blank.

7. Not Applicable

This section intentionally left blank.

8. Serial Modems

8.1 Introduction

8.2 Connecting a Modem to the Relay(s)

8.3 Setting the Remote Modem

8.4 Connecting to the Remote Modem

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.

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**	**Out of 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

Energy Management Division
Digital Grid
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E-Mail:support.energy@siemens.com
www.siemens.com/protection

Template Revision 17.

7SR10

Installation Guide

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2015/03	Third Issue
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Section 1: Installation Guide

1.1 Installation

Execute the following procedure to install the 7SR10 Overcurrent relay:

1. Create a slot of dimensions as shown in Figure 1-2 to house the relay in the protection panel.
2. Flush the rear-side of relay into the protection panel cut-out.
3. Fasten the relay using the four M4x20 Pan Phillips SS screws with nut provided in the 7SR10 packing box to the protection panel/cubicle.
4. Carry-out all other installation steps/wiring internally from the protection panel.
5. In the rear terminal of the relay, execute the wiring process as mentioned in scheme requirements. Refer the diagram for more details about terminal connector diagram. Refer the table for the recommended terminal lugs to be used.
6. The earthing cable should be wired using a cable of 2.5 mm^2 (min) and this should be terminated in the shortest possible path to the earth terminal/bus bar in panel or cubicle.
7. Maintain a minimum clearance from the relay as given in Figure 1-1 to ensure safety and accidental touch of terminals. In case of work area is restricted in a cubicle, then suitable protective terminals to be provided in the cubicle.

NOTE:

The earthing point (E) of auxiliary supply is connected to the ground (GND) point of the relay. The earth connection of relay casing should be solidly connected to the panel earth.

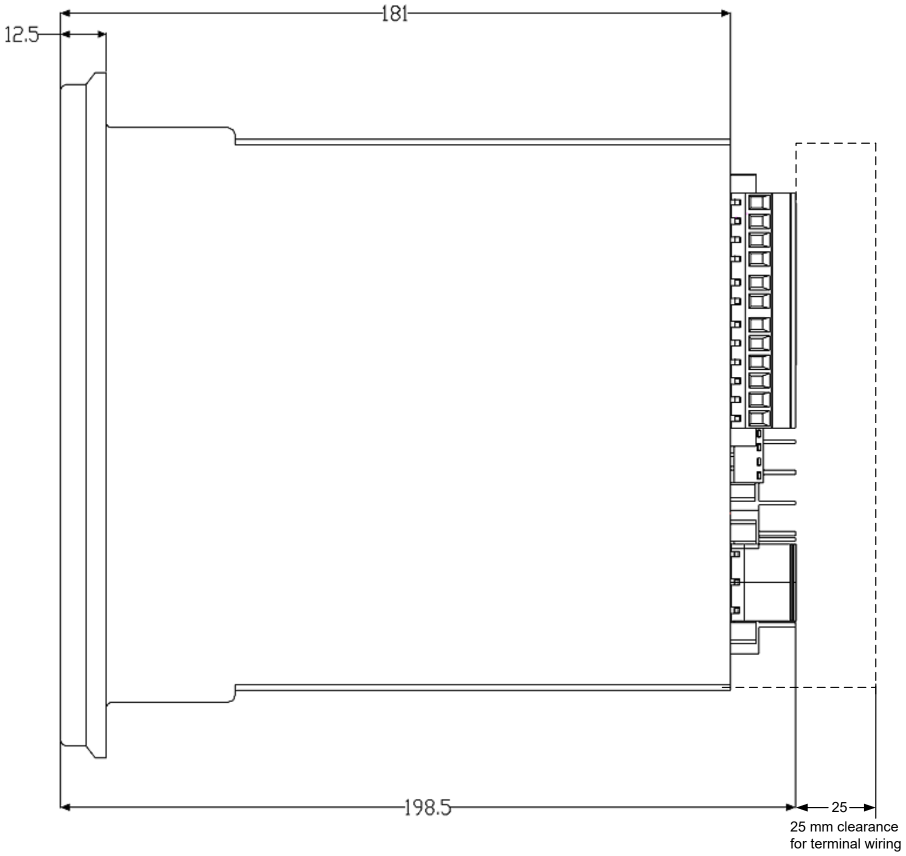


Figure 1-1 Clearance for Terminal Wiring

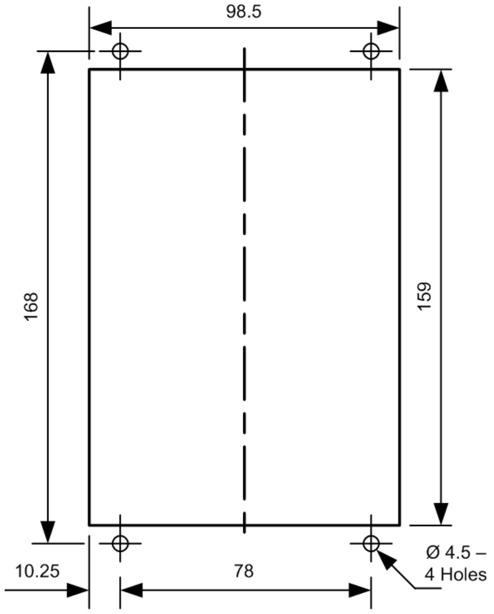


Figure 1-2 Panel cut-out

Table 1-1 Recommended Terminal Lugs Specifications with Control Push Buttons

Terminal Blocks	Type/Cable Specifications	Manufacturer/ Part number
Current Inputs (X5)	TE connectivity PIDG Series insulated tin plated crimp ring terminal, M3.5 Stud size, 2.6 mm² to 6.6 mm², 12 AWG; Torque required 1.0 Nm	TE Connectivity Mfr. Part No. 2-327960-1 or equivalent
Voltage Inputs (X7)	6 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.57 Nm ±10%	End sleeve 3D-8011H or equivalent
Auxiliary Supply (X3)	3 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.5 Nm to 0.6 Nm	End sleeve 3D-8011H or equivalent
Rear Communication Port (X2)	4 position, M2 screw-type plug-in terminals suitable for 1.5 mm^2 cable; Torque required 0.34 Nm ±10%	End sleeve 3D-8009H or equivalent
Front Communication Port	USB, Type B	Tyco/974329-1 or equivalent
Binary Input (X1)	6 or 12 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.5 Nm to 0.6 Nm	End sleeve 3D-8011H or equivalent
Binary Input (X6)	6 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.57 Nm ±10%	End sleeve 3D-8011H or equivalent
Binary Output (X4)	8 or 14 position, M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable; Torque required 0.5 Nm to 0.6 Nm	End sleeve 3D-8011H or equivalent
Ground Terminal	Tin plated crimp ring Terminal, M3 stud size, 4 mm² to 6 mm², 12 AWG to 10 AWG, Yellow; Torque required 0.5 Nm to 0.6 Nm	RS Stock No. 613-9334 or equivalent Mfr. Part no. RVY5-3.2

1.2 Fascia Cover Mounting Instructions

Follow the procedure to fit the 7SR10 overcurrent relay with removable fascia cover:

1. Fix the 7SR10 overcurrent and protection relay on the panel along with mounting brackets.

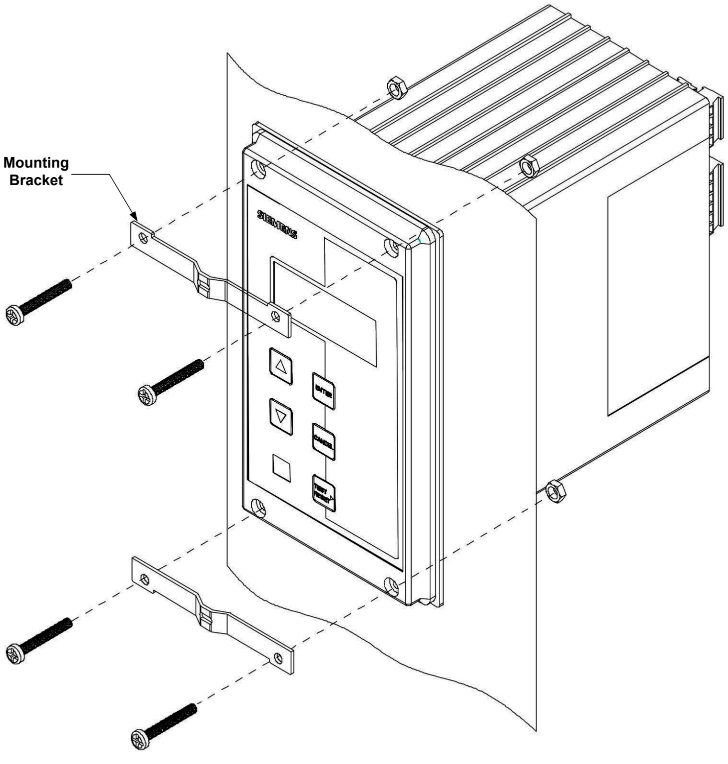


Figure 1-3 7SR10 Relay with Mounting Brackets

2. Assemble the removable fascia cover on the relay by using the sealing knob.

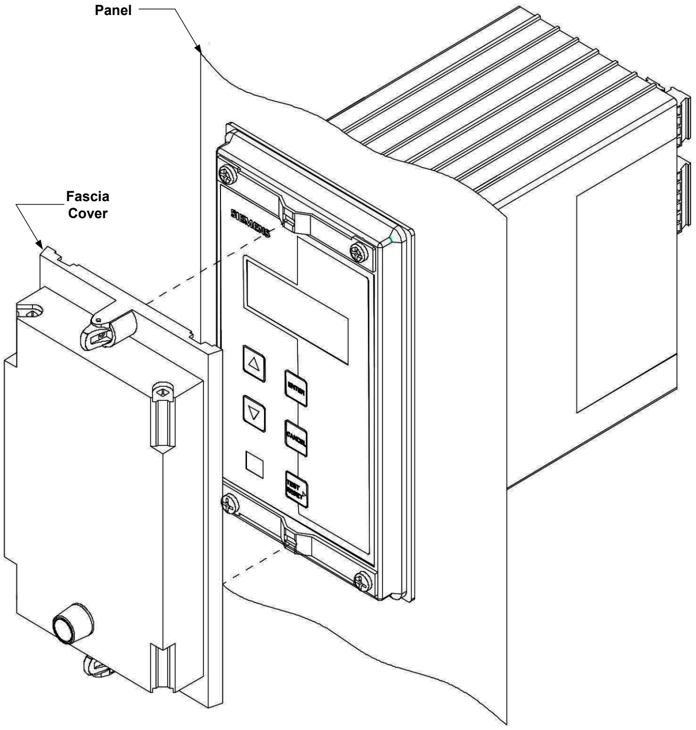


Figure 1-4 7SR10 Relay with Fascia Cover

3. Lock the sealing knob by rotating clockwise direction to lock.

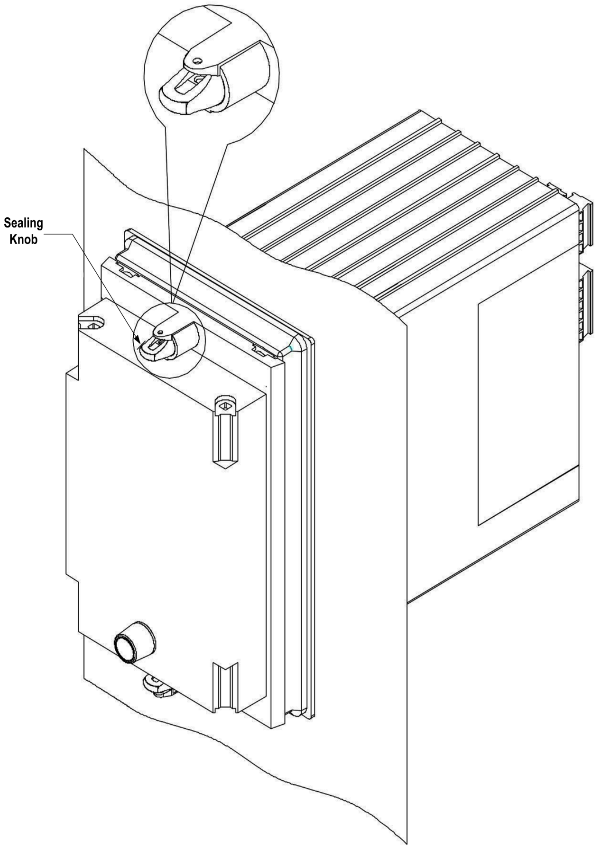
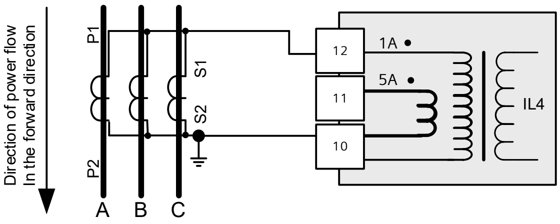
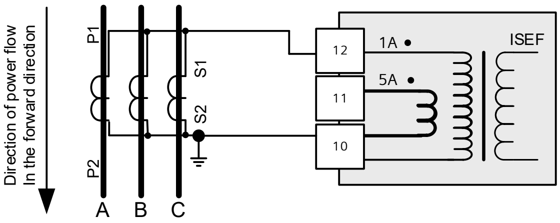
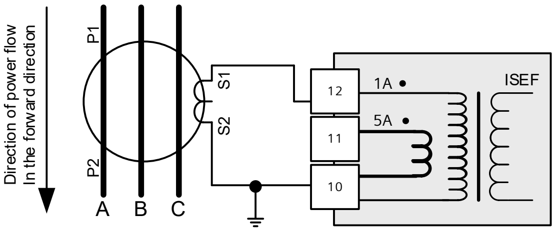
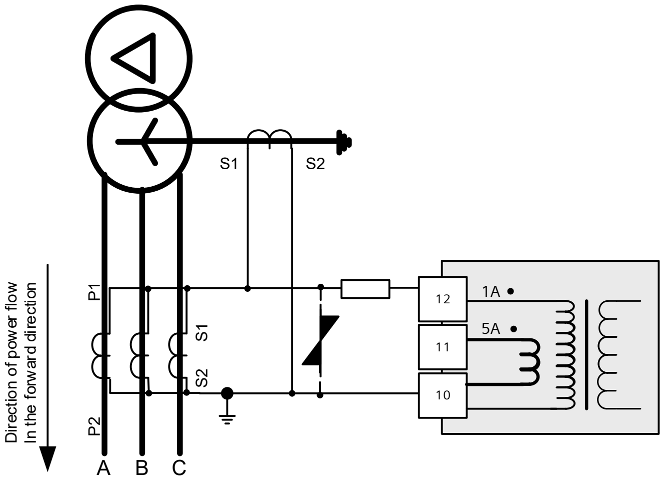
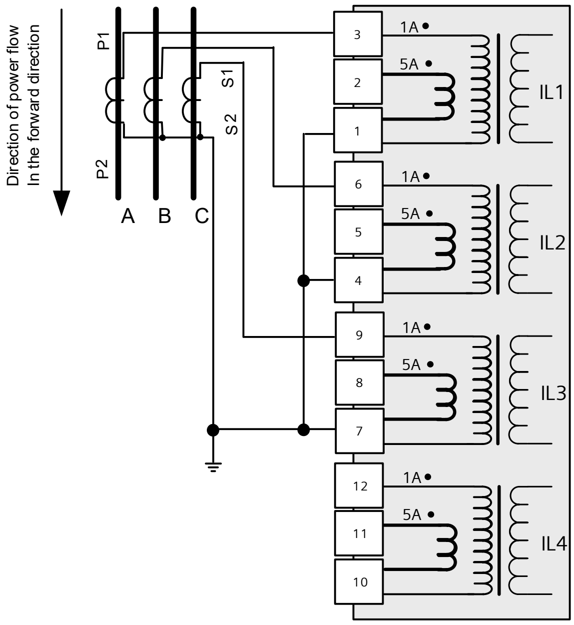
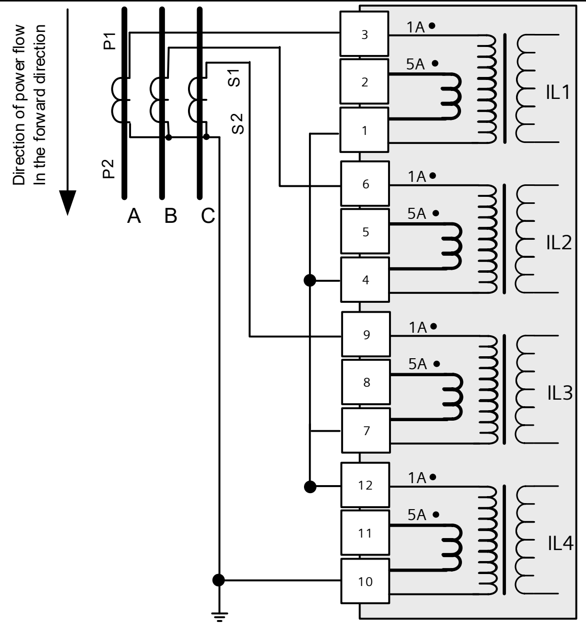
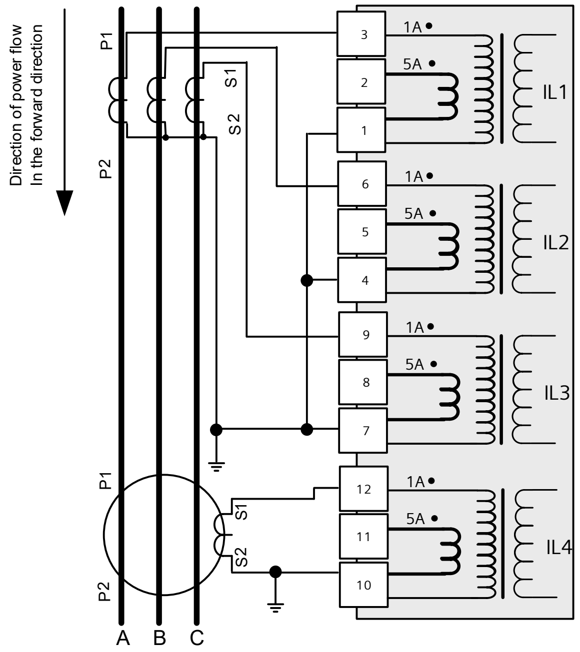


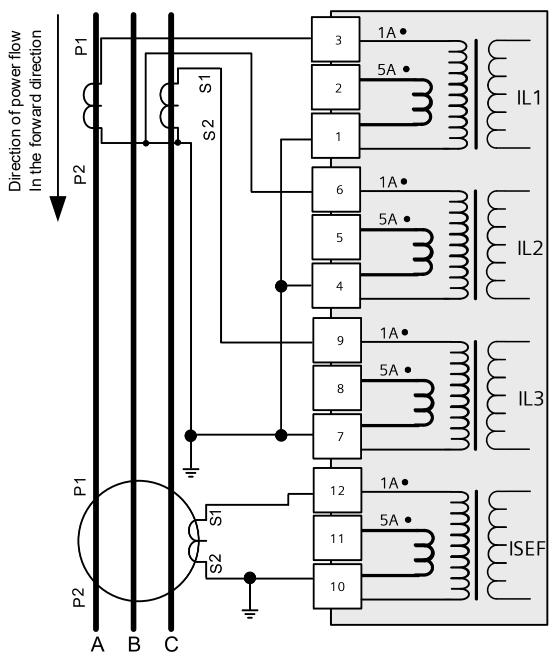
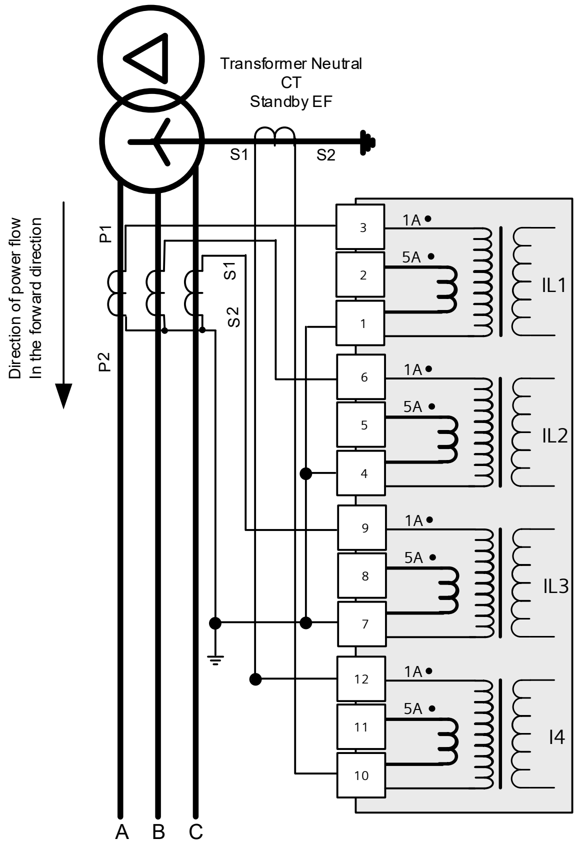
Figure 1-5 7SR10 Relay with Sealing Knob

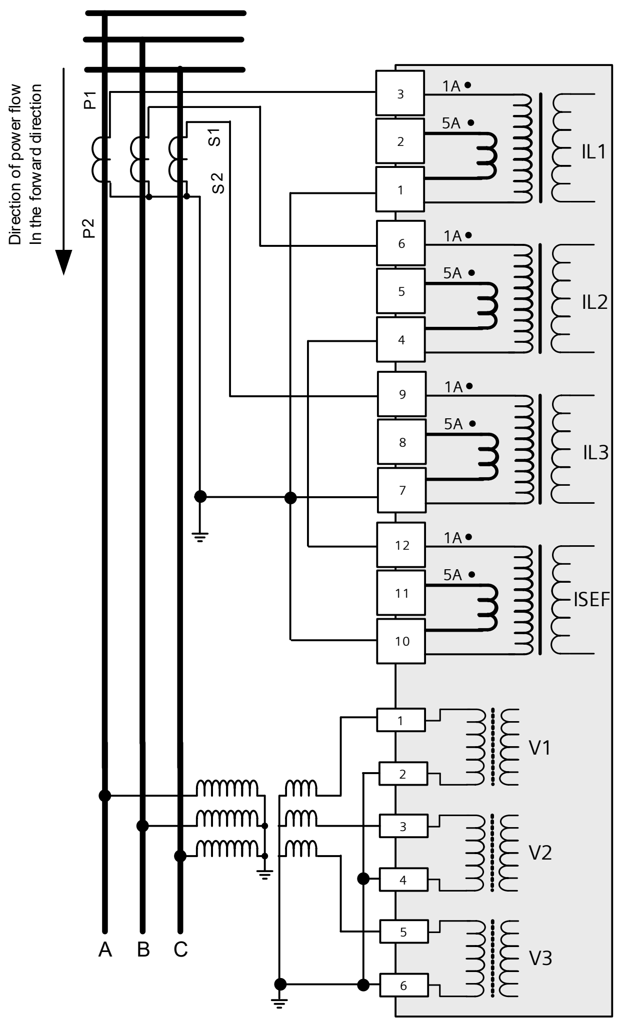
1.3 Current Transformer Configurations

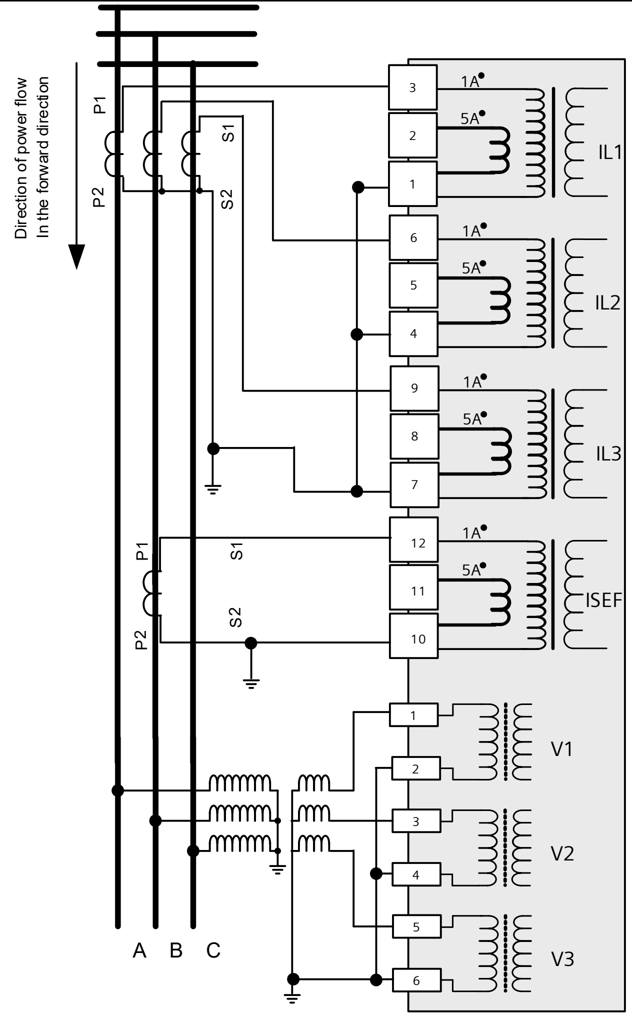
Relay Current Configuration Setting	**Description**	**Connection**
IG	50G/51G - Measured E/F	
ISEF	50SEF/51SEF - Measured Sensitive E/F	 
IREF	64H – High Impedance Restricted E/F	

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	

Ia, Ib, Ic In Ig	50/51 - Phase Overcurrent 50N/51N - Derived E/F 50G/51G - Measured E/F	 
CT/VT CONFIG: Phase Current Input Phase CT Ratio Earth Current Input Earth CT Ratio	Selects 1 or 5A CT ratio for primary meters	

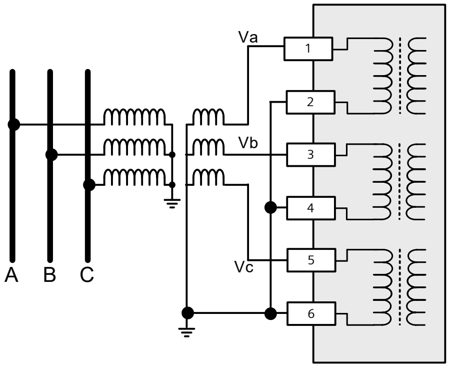
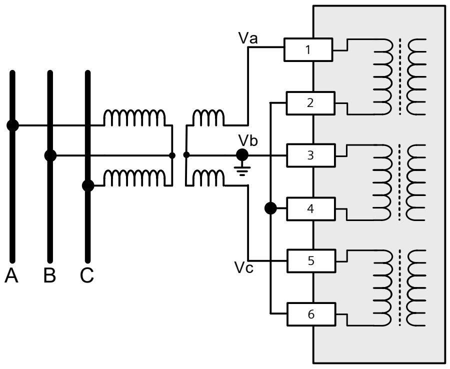
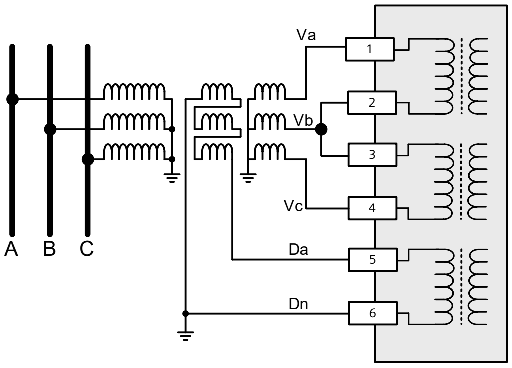
Ia, Ib, Ic ISEF CT/VT CONFIG: Phase Current Input Phase CT Ratio Earth Current Input Earth CT Ratio	2 Phase CT only. For application on isolated or compensated networks. Phase Overcurrent SEF Selects 1 or 5A CT ratio for primary meters	
Ia, Ib, Ic In Ig CT/VT CONFIG: Phase Current Input Phase CT Ratio	Phase Overcurrent Derived E/F Measured Standby E/F Selects 1 or 5A CT ratio for primary meters	

Current Input(s): Ia, Ib, Ic Isef	Phase Overcurrent, Derived E/F & 'B' Phase Sensitive Power	
CT/VT CONFIG: Phase Current Input	Selects 1 or 5A	
CT/VT CONFIG: Phase CT Ratio	CT ratio for primary meters	
CT/VT CONFIG: Earth Current Input	Selects 1 or 5A for Sensitive Power input	
CT/VT CONFIG: Earth CT Ratio	CT ratio for primary meters for Sensitive Power input	

Direction of power flow
In the forward direction
P1
P2
S1
S2
3
2
1
1A
5A
IL1
6
5
4
1A
5A
IL2
9
8
7
1A
5A
IL3
P1
P2
S1
S2
12
11
10
1A
5A
ISEF
1
2
V1
3
4
V2
5
6
V3
A
B
C

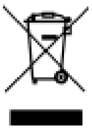
1.4 Voltage Transformer Configurations

Relay Voltage Configuration Setting	Description	Connection
Van, Vbn, Vcn	67 & 67N & 67G, 67SEF, 47, 59N, 27/59 & 81 Phase – Neutral Phase – Phase Calculated NPS ZPS	
Va, Vb, Vc	67, 47, 27/59 & 81 Phase – Neutral Phase – Phase Calculated NPS No ZPS available	
Vab, Vbc, 3V$_0$	67 & 67N & 67G, 67SEF, 47, 59N, 27/59 & 81 Phase – Neutral Calculated Phase – Phase Phase Vca Calculated NPS ZPS	

1.5 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 wheelie 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

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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

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7SR10

Commissioning and Maintenance Guide

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2015/09	Fifth Issue
2015/06	Fourth Issue
2015/03	Third Issue
2015/02	Second Issue
2013/11	First Issue

Contents

Section 1: Commissioning and Maintenance Guide

1.1 Troubleshooting

This section provides the common problems and the recommended solution to resolve the problem.

Observation	Action
Relay does not power up	Check the correct auxiliary AC or DC voltage is applied and the polarity is correct.
Relay won't accept the password	The password entered is wrong. Enter the correct password. If correct password has been forgotten, note down the numeric code displayed at the Change Password screen e.g. Change password = 1234567 To retrieve the password, communicate this numeric code to a Siemens Limited representative.
Protection Healthy LED flashes	General failure. Contact a Siemens Limited representative.
LCD screen flashes continuously	The LCD displays multiple error messages by flashing continuously. These indicate the various processor card faults. General failure. Contact a Siemens Limited representative.
Relay displays one instrument after another with no user intervention	This is normal operation, the default instruments are enabled. Remove all instruments from the default list and add only the instruments that are required.
Cannot communicate with the relay	• Check that all the communications settings matches with the settings 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. • Verify the rear connection of each device as mentioned in the terminal diagram.
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. • For AFD function, refer to 7XG31xx documentation for further details.
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.
Firmware update	It is recommended to restart the relay once the firmware update is completed.
Voltage and current phase angle measurement is not correct in the relay	Refer to the 7SR10 Overcurrent relay terminal diagram. Connect start and stop points of CT and VT as mentioned in the terminal diagram. Start point is mentioned with dot mark in the terminal diagram.

If the above troubleshooting checklist does not help in correcting the problem please contact our Customer Support Center:

Phone: +49 180/524 7000 (24hrs)
Fax: +49 180/524 2471

E-mail: support.energy@siemens.com

7SR10

Applications Guide

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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)

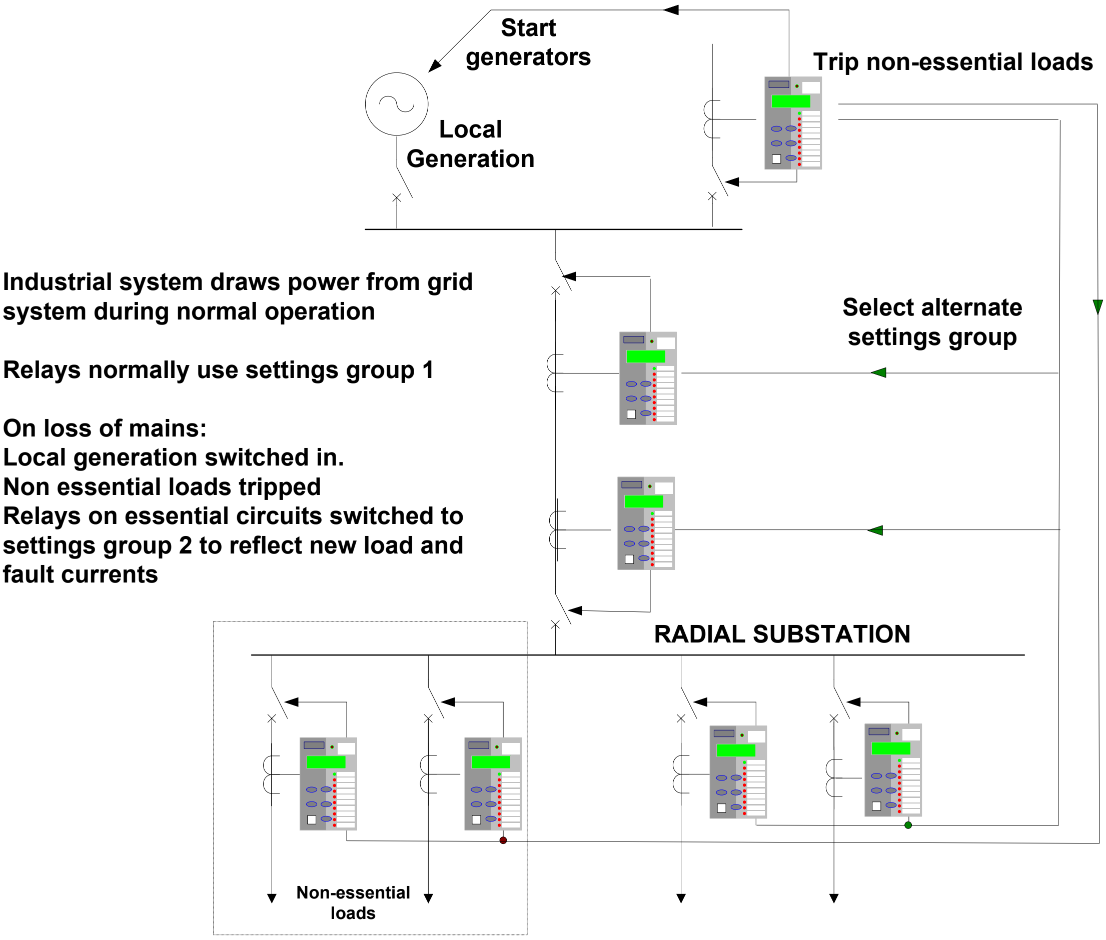


Figure 5-1 Example Use of Alternative Settings Groups

1.2 Binary Inputs

Each Binary Input (BI) can be programmed to operate one or more of the relay functions, LEDs or output relays. These could be used to bring such digital signals as Inhibits for protection elements, the trip circuit supervision status, autoreclose control signals etc. into the Relay.

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.

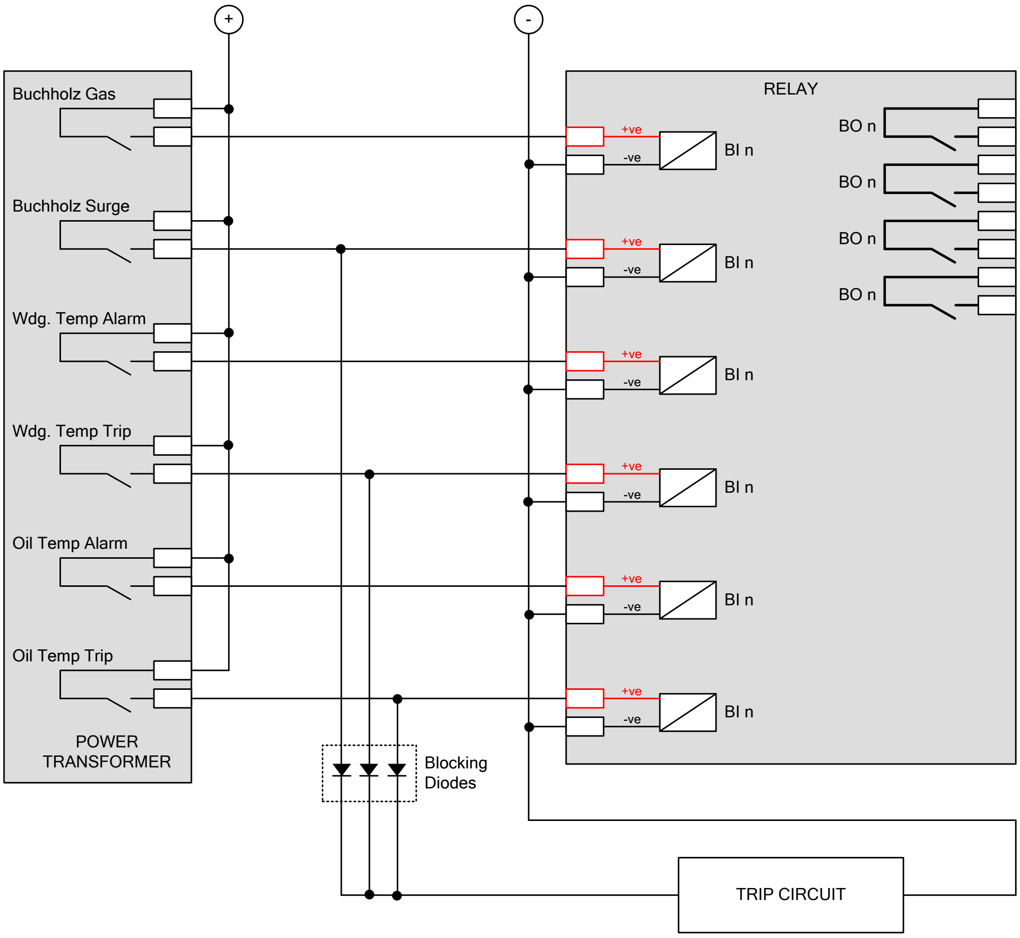


Figure 1-2 Example of Transformer Alarm and Trip Wiring

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.

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.

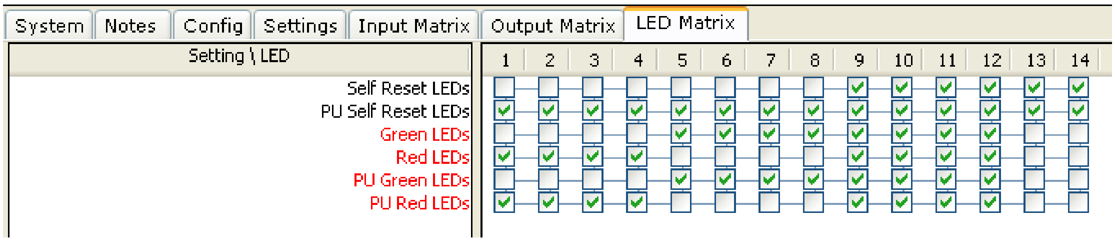
Each LED can be defined as Self or Hand Reset. Hand reset LEDs are used where the user is required to expressly acknowledge the change in status e.g. critical operations such as trips or system failures. Self-reset LEDs are used to display features which routinely change state, such as Circuit-Breaker 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.

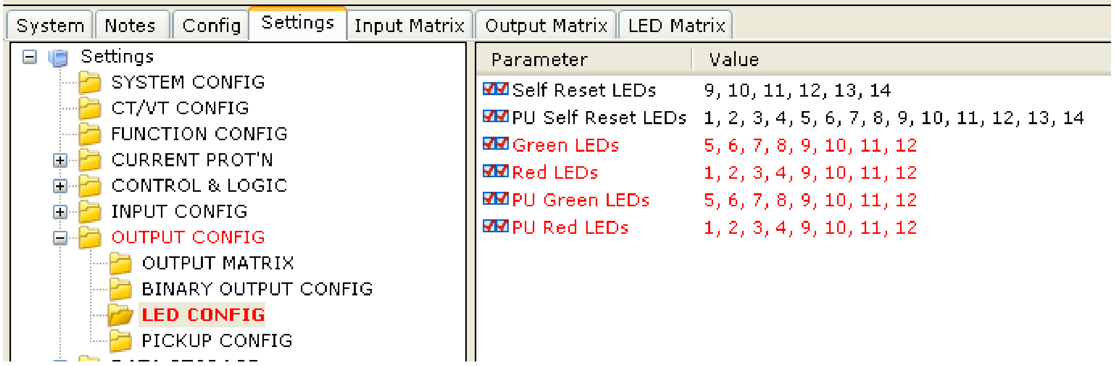


Setting \ LED	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Self Reset LEDs	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☑	☑
PU Self Reset LEDs	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Green LEDs	☐	☐	☐	☐	☑	☑	☑	☑	☑	☑	☑	☑	☐	☐
Red LEDs	☑	☑	☑	☑	☐	☐	☐	☐	☑	☑	☑	☑	☐	☐
PU Green LEDs	☐	☐	☐	☐	☑	☑	☑	☑	☑	☑	☑	☑	☐	☐
PU Red LEDs	☑	☑	☑	☑	☐	☐	☐	☐	☑	☑	☑	☑	☐	☐

Figure 1-3 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.



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 LED configuration via the Settings \ OUTPUT CONFIG \ LED CONFIG menu

Section 2: Protection Functions

2.1 Time delayed overcurrent (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’ (Fig. 2.1) or ‘Minimum Operate Time’ (Fig. 2.2) settings can be applied.

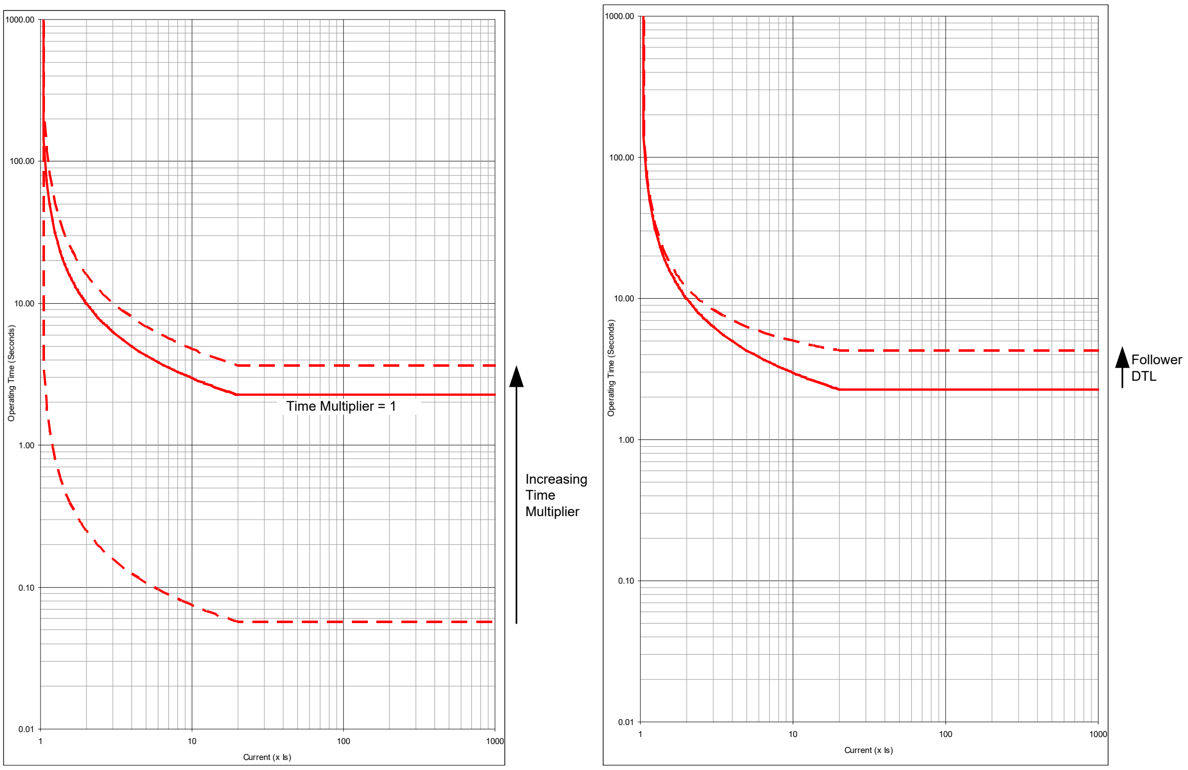


Figure 2-1 IEC NI Curve with Time Multiplier and Follower DTL Applied

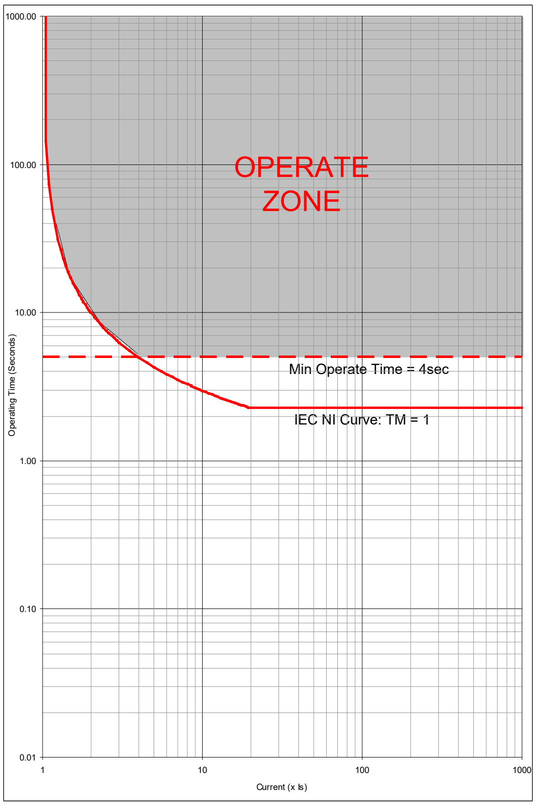


Figure 2-2 IEC NI Curve with Minimum Operate Time Setting Applied

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 Overcurrent 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

Where one curve is to be directionalised in the forward direction the other in the reverse direction.

The characteristic curve shape is selected to be the same type as the other relays on the same circuit or to grade with items of plant e.g. fuses or earthing resistors.

The application of IDMTL characteristic is summarised in the following table:

Table 2-1 Application of IDMTL Characteristics

OC/EF Curve Characteristic	Application
IEC Normal Inverse (NI) ANSI Moderately Inverse (MI)	Generally applied
IEC Very Inverse (VI) ANSI Very Inverse (VI)	Used with high impedance paths where there is a significant difference between fault levels at protection points
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

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 DECAYING characteristic when an ANSI operate characteristic is applied. Alternatively a DTL reset (0 to 60 seconds) can be used with other operate characteristics.

For protection of cable feeders, it is recommended that a 60 second DTL reset be used.

On overhead line networks, particularly where reclosers are incorporated in the protected system, instantaneous resetting is desirable to ensure that, on multiple shot reclosing schemes, correct grading between the source relays and the relays associated with the reclosers is maintained.

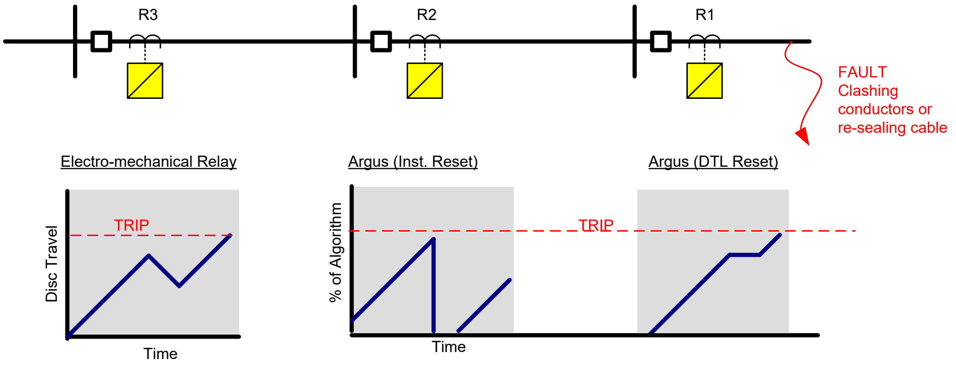


Figure 2-3 Reset Delay

2.2 Voltage dependent overcurrent (51V)

Reduced voltage can indicate a fault on the system, it can be used to make the 51 elements more sensitive.

Typically Voltage Dependent Over-current (VDO) is applied to:

Transformer Incomers: Where the impedance of the transformer limits fault current the measured voltage level can be used to discriminate between load and fault current.

Long lines: Where the impedance of the line limits fault current the measured voltage level can be used to discriminate between load and fault current.

Generator circuits: When a Generator is subjected to a short circuit close to its terminals the short-circuit current follows a complex profile. After the initial "sub-transient" value, generally in the order of 7 to 10 times full load current, it falls rapidly (around 10 to 20ms) to the "transient" value. This is still about 5 to 7 times full load and would be sufficient to operate the protection's over-current elements. However the effect on armature reactance of the highly inductive short-circuit current is to increase significantly the internal impedance to the synchronous reactance value. If the Automatic Voltage Regulation (AVR) system does not respond to increase the excitation, the fault current will decay over the next few seconds to a value below the full load current. This is termed the steady state fault current, determined by the Generator's synchronous reactance (and pre-fault excitation). It will be insufficient to operate the protection's over-current elements and the fault will not be detected. Even if AVR is active, problems may still be encountered. The AVR will have a declared minimum sustained fault current and this must be above the protection over-current settings. Close-in short circuit faults may also cause the AVR to reach its safety limits for supplying maximum excitation boost, in the order of several seconds, and this will result in AVR internal protection devices such as diode fuses to start operating. The generator excitation will then collapse, and the situation will be the same as when no AVR was present. The fault may again not be detected.

Current grading remains important since a significant voltage reduction may be seen for faults on other parts of the system. An inverse time operating characteristic must therefore be used.

The VDO Level - the voltage setting below which the more sensitive operating curve applies - must be set low enough to discriminate between short-circuits and temporary voltage dips due to overloads. However, it must also be high enough to cover a range of voltage drops for different circuit configurations, from around 0.6Vn to almost zero. Typically it will be set in the range 0.6 to 0.8Vn.

2.3 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 Overcurrent (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 overcurrent 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.

2.4 Arc Flash Detection (50AFD)

The overcurrent setting should be set above maximum load current and below the minimum expected arc fault current.

Optical sensor location should be arranged to provide full coverage of the protected chambers. See 7XG31 technical documentation.

Sensor inputs are configured in Zones to provide the required tripping. i.e. the line circuit breaker alone should be tripped for arc faults in the cable termination and CT compartment. The whole busbar must be cleared for arc faults which cannot be identified as being on the line side of the circuit breaker.

Overcurrent supervision can only be applied if the arrangement ensures that current will be measured for all arc faults. In Figure 2-4 Zone 2 can only be supervised by current if the feeders are radial and cannot supply fault current with CB A open. Arc sensor pickup can be transferred between relays using IEC 61850 GOOSE allowing Zone2 50AFD to be duplicated in all relays.

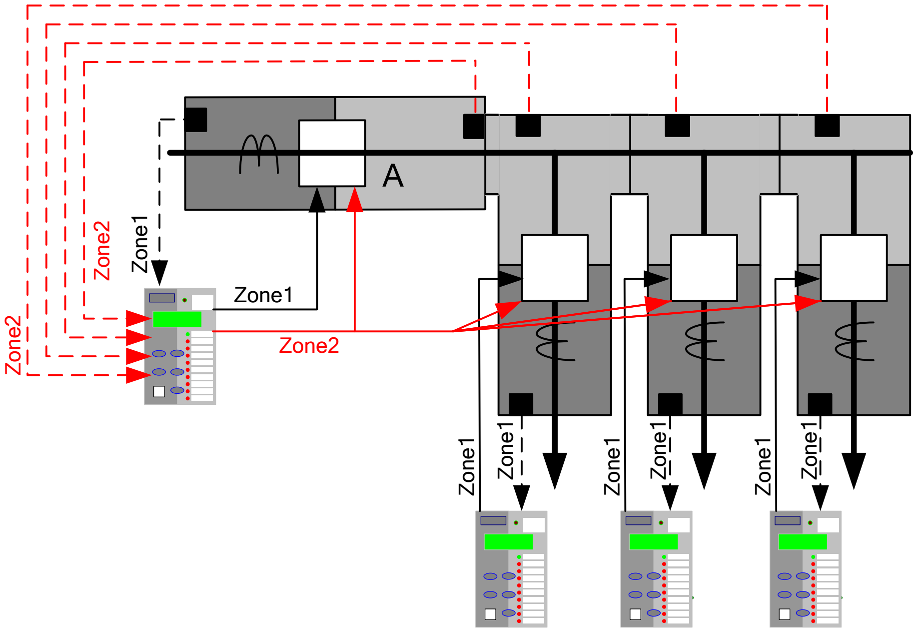


Figure 2-4 Arc Flash Detection

2.5 Instantaneous Overcurrent (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.

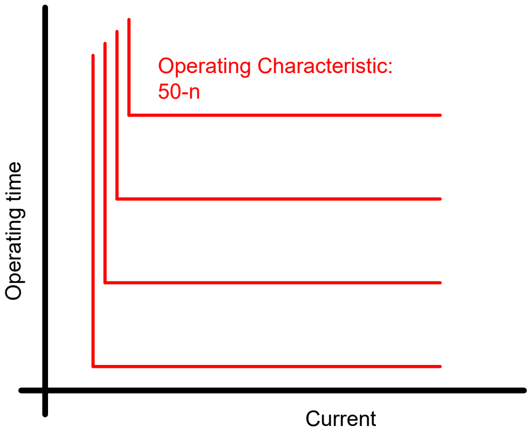


Figure 2-5 General Form of DTL Operate Characteristic

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 Overcurrent’. A typical application is the protection of transformer HV connections – the impedance of the transformer ensuring that the LV side has a much lower level of fault current.

The 50-n 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.

2.5.1 Blocked Overcurrent Protection Schemes

A combination of instantaneous and DTL elements can be used in blocked overcurrent protection schemes. These protection schemes are applied to protect substation busbars or interconnectors etc. Blocked overcurrent protection provides improved fault clearance times when compared against normally graded overcurrent relays.

The blocked overcurrent scheme of busbar protection shown in Figure 2.5 illustrates that circuit overcurrent 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 overcurrent 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.

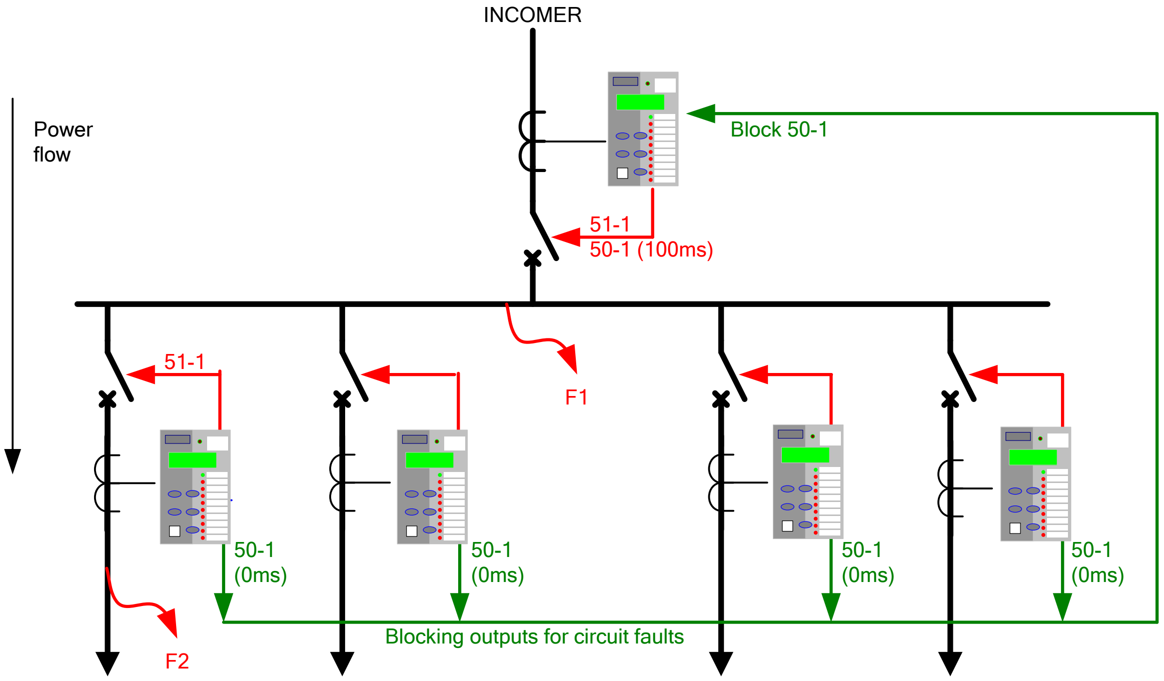


Figure 2-6 Blocking Scheme Using Instantaneous Overcurrent Elements

Typically a time delay as low as 50ms 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 100ms is recommended.

This type of scheme is very cost effective and provides a compromise between back-up overcurrent busbar protection and dedicated schemes of busbar protection.

Instantaneous elements are also commonly applied to autoreclose schemes to grade with downstream circuit reclosers and maximise the probability of a successful auto-reclose sequence – see section 4.

2.6 Sensitive Earth-fault Protection (50SEF)

Earth fault protection is based on the assumption that fault current levels will be limited only by the earth fault impedance of the line and associated plant. However, it may be difficult to make an effective short circuit to earth due to the nature of the terrain e.g. dry earth, desert or mountains. The resulting earth fault current may therefore be limited to very low levels.

Sensitive earth fault (SEF) protection is used to detect such faults. The relays have a low burden, so avoiding unacceptable loading of the CTs at low current settings. Only the fundamental component is used to avoid pick up from harmonics.

SEF provides a backup to the main protection. A DTL characteristic with a time delay of several seconds is typically applied ensuring no interference with other discriminative protections. A relatively long time delay can be tolerated since fault current is low and it is impractical to grade SEF protection with other earth fault protections. Although not suitable for grading with other forms of protection SEF relays may be graded with each other.

Where very sensitive current settings are required then it is preferable to use a core balance CT rather than wire into the residual connection of the line CTs. The turns ratio of a core balance CT can be much smaller than that of phase conductors as they are not related to the rated current of the protected circuit. Since only one core is used, the CT magnetising current losses are also reduced by a factor of 3.

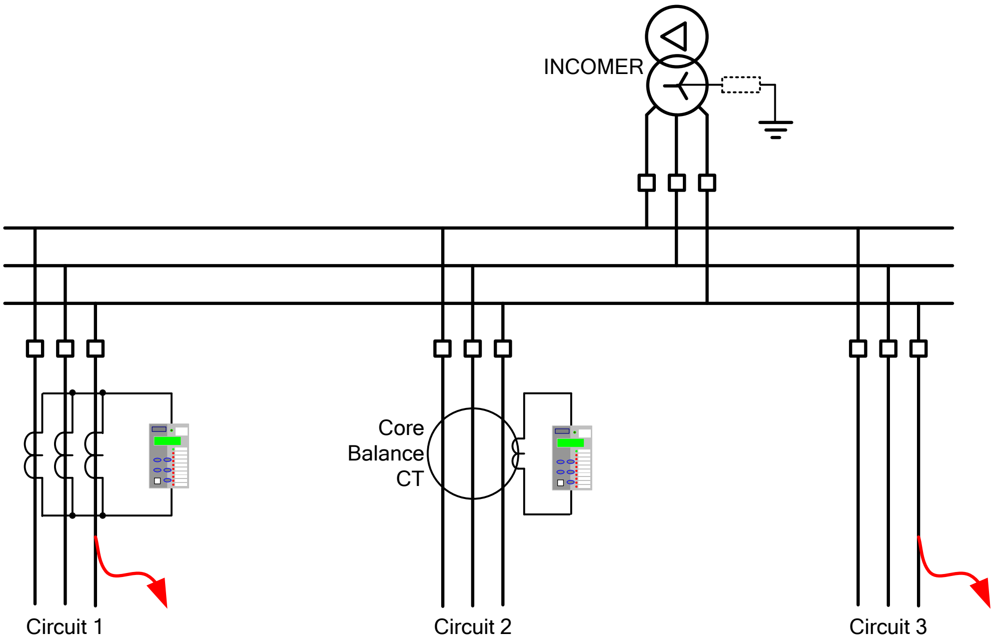


Figure 2-7 Sensitive Earth Fault Protection Application

There are limits to how sensitive an SEF relay may be set since the setting must be above any line charging current levels that can be detected by the relay. On occurrence of an out of zone earth fault e.g. on circuit 3 the elevation of sound phase voltage to earth in a non-effectively earthed system can result in a zero sequence current of up 3 times phase charging current flowing through the relay location.

The step change from balanced 3-phase charging currents to this level of zero sequence current includes transients. It is recommended to allow for a transient factor of 2 to 3 when determining the limit of charging current. Based on the above considerations the minimum setting of a relay in a resistance earthed power system is 6 to 9 times the charging current per phase.

2.7 Directional Protection (67)

Each overcurrent stage can operate for faults in either forward or reverse direction. Convention dictates that forward direction refers to power flow away from the busbar, while reverse direction refers to power flowing towards the busbar.

The directional phase fault elements, 67/50 and 67/51, work with a Quadrature Connection to prevent loss of polarising quantity for close-in phase faults. That is, each of the current elements is directionalised by a voltage derived from the other two phases.

This connection introduces a 90° Phase Shift (Current leading Voltage) between reference and operate quantities which must be allowed for in the Characteristic Angle setting. This is the expected fault angle, sometimes termed the Maximum Torque Angle (MTA) as an analogy to older Electro-mechanical type relays

Example: Expected fault angle is -30º (Current lagging Voltage) so set Directional Angle to: +90° -30° = +60°.

A fault is determined to be in the selected direction if its phase relationship lies within a quadrant +/- 85° either side of the Characteristic Angle setting.

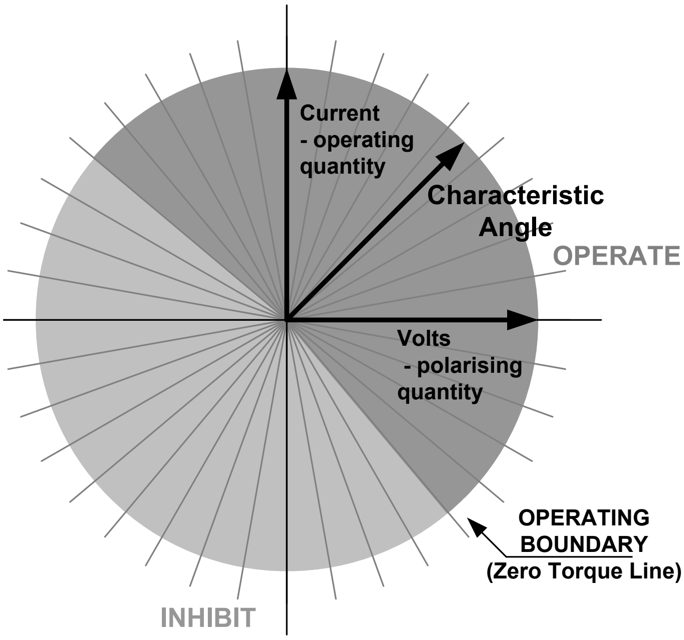


Figure 2-8 Directional Characteristics

A number of studies have been made to determine the optimum MTA settings e.g. W.K Sonnemann’s paper “A Study of Directional Element Connections for Phase Relays”. Figure 2.6 shows the most likely fault angle for phase faults on Overhead Line and Cable circuits.

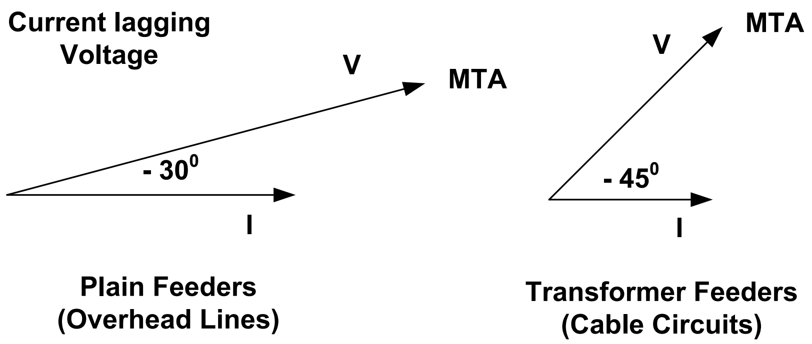


Figure 2-9 Phase Fault Angles

Directional overcurrent elements allow greater fault selectivity than non-directional elements for interconnected systems where fault current can flow in both directions through the relaying point. Consider the network shown in Fig. 2.10.

The Circuit breakers at A, B, E and G have directional overcurrent relays fitted since fault current can flow in both directions at these points. The forward direction is defined as being away from the busbar and against the direction of normal load current flow. These forward looking IDMTL elements can have sensitive settings applied i.e. low current and time multiplier settings. Note that Directional overcurrent relays may be programmed with forward, reverse and non-directional elements simultaneously when required by the protection scheme.

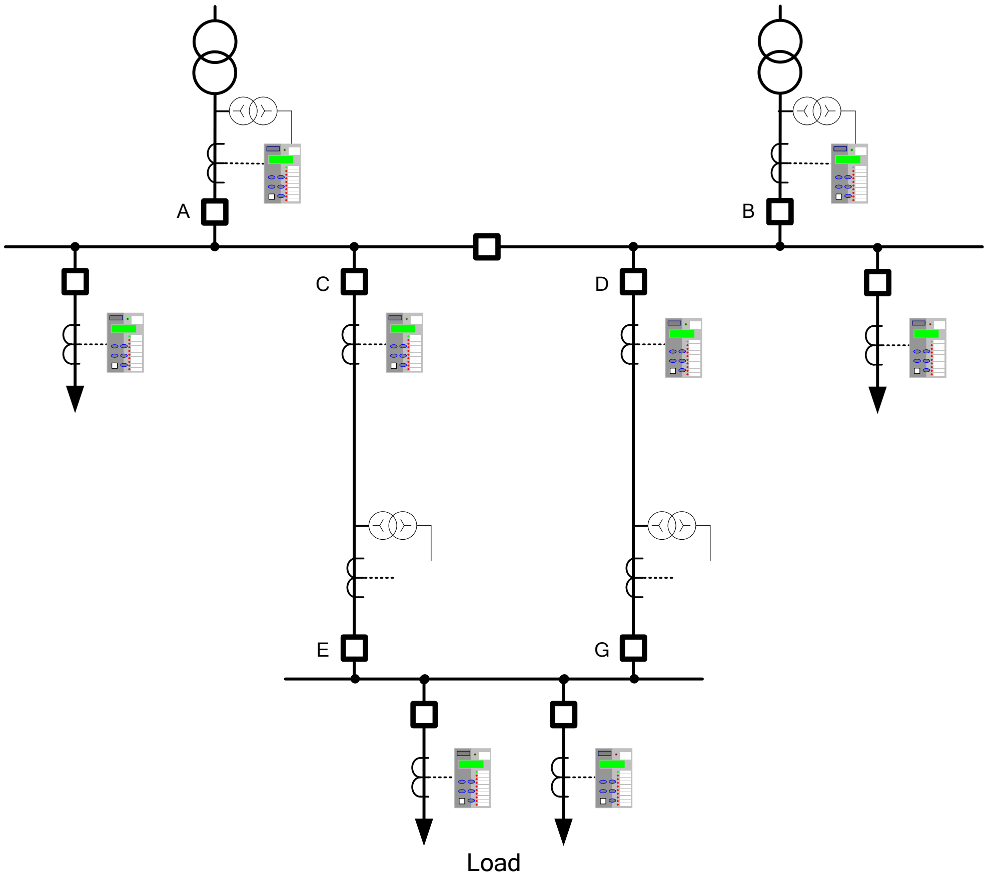


Figure 2-10 Application of Directional Overcurrent Protection

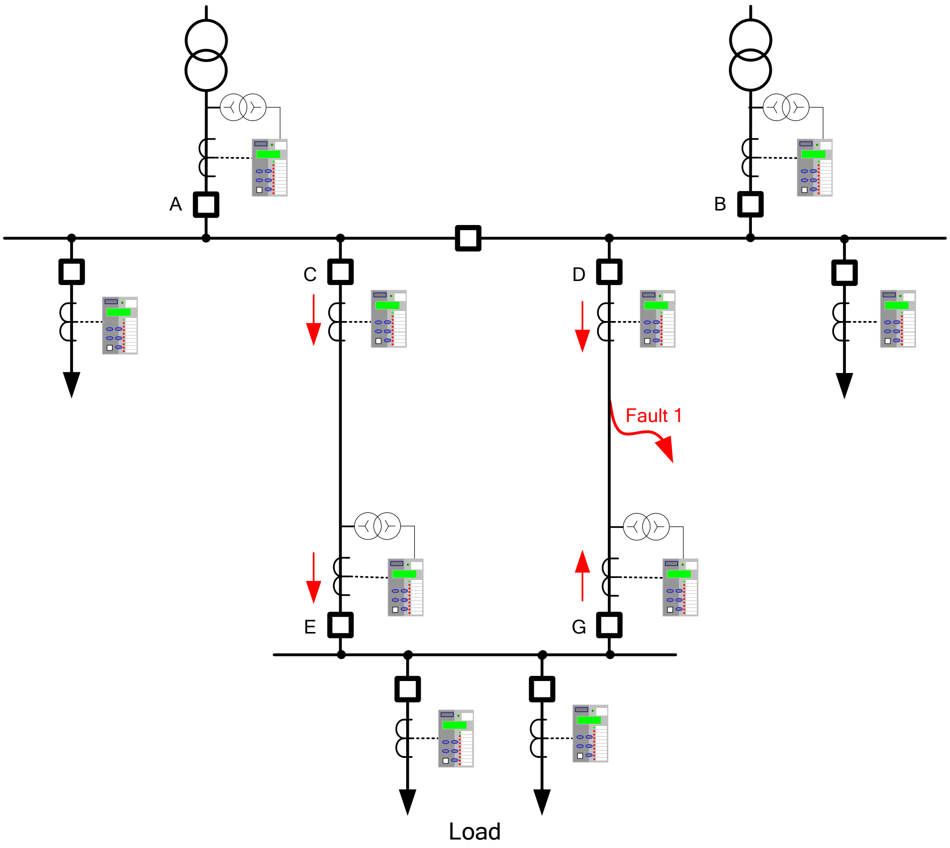


Figure 2-11 Feeder Fault on Interconnected Network

Considering the D-G feeder fault shown in Fig 2-11, the current magnitude through breakers C and D will be similar and their associated relays will have similar prospective operate times. To ensure that only the faulted feeder is isolated G FWD must be set to be faster than C. Relay G will thus Trip first on FWD settings, leaving D to operate to clear the fault. The un-faulted Feeder C-E maintains power to the load.

Relays on circuits C and D at the main substation need not be directional to provide the above protection scheme. However additional directional elements could be mapped to facilitate a blocked overcurrent scheme of busbar protection.

At A and B, forward looking directional elements enable sensitive settings to be applied to detect transformer faults whilst reverse elements can be used to provide back-up protection for the relays at C and D.

By using different settings for forward and reverse directions, closed ring circuits can be set to grade correctly whether fault current flows in a clockwise or counter clockwise direction i.e. it may be practical to use only one relay to provide dual directional protection.

2.7.1 2 Out of 3 Logic

Sensitive settings can be used with directional overcurrent relays since they are directionalised in a way which opposes the flow of normal load current i.e. on the substation incomers as shown on Fig 2-11. However on occurrence of transformer HV or feeder incomer phase-phase faults an unbalanced load current may still flow as an unbalanced driving voltage is present. This unbalanced load current during a fault may be significant where sensitive overcurrent settings are applied - the load current in one phase may be in the operate direction and above the relay setting.

Where this current distribution may occur then the relay is set to CURRENT PROTECTION>PHASE OVERCURRENT> ***67 2-out-of-3 Logic*** **= ENABLED**

Enabling 2-out-of-3 logic will prevent operation of the directional phase fault protection for a single phase to earth fault. Dedicated earth-fault protection should therefore be used if required.

2.8 Directional Earth-Fault (50/51G, 50/51N, 50/51SEF)

The directional earth-fault elements, either measured directly or derived from the three line currents the zero sequence current (operate quantity) and compare this against the derived zero phase sequence voltage (polarising quantity). Chapter 1 of the Technical Manual ‘Description of Operation’ details the method of measurement. The required setting is entered directly as dictated by the system impedances.

Example: Expected fault angle is -45° (i.e. residual current lagging residual voltage) therefore ***67G Char Angle*** = **-45°**

However directional earth elements can be selectable to use either ZPS or NPS Polarising. This is to allow for the situation where ZPS voltage is not available; perhaps because a 3-limb VT is being used. Care must be taken as the Characteristic Angle will change if NPS Polarising is used.

Once again the fault angle is completely predictable, though this is a little more complicated as the method of earthing must be considered.

MTA (I wrt V)				
O^{0}	**-15^{0}**	**-45^{0}**	**-65^{0}**	**-90^{0}**
◄──── **Resistive Neutral**			**Reactive Neutral**────►	

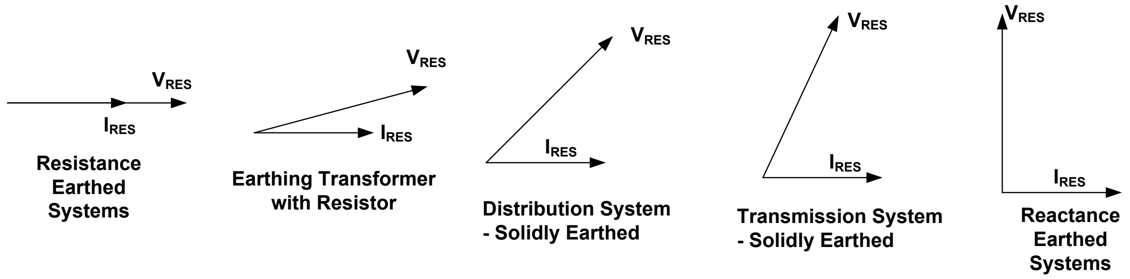


Figure 2-12 Earth Fault Angles

2.8.1 Compensated Coil Earthing Networks

In compensated networks the Resonant Coil (Petersen coil) is tuned to match the capacitive charging currents such that when an earth fault occurs, negligible fault current will flow. However, resistive losses in the primary conductors and also in the earthing coil will lead to resistive (wattmetric) components which can be measured by the 50/51SEF elements and used to indicate fault position. Core balance CTs are recommended for this application to achieve the necessary accuracy of residual current measurement.

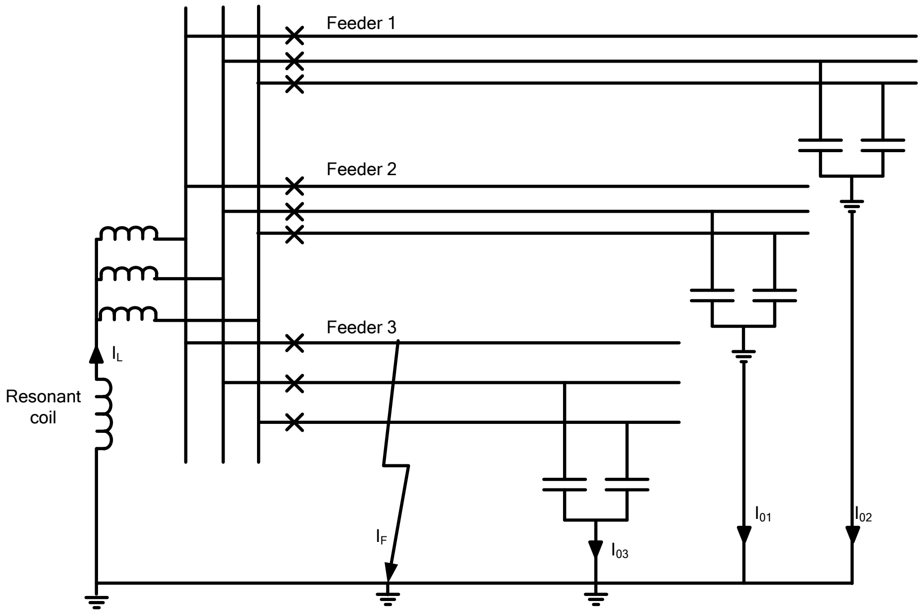


Figure 2-13 Earth fault current distribution in Compensated network

Three methods are commonly employed to detect the wattmetric current. The 7SR10 relay has customer settings that can be configured to provide each of these methods.

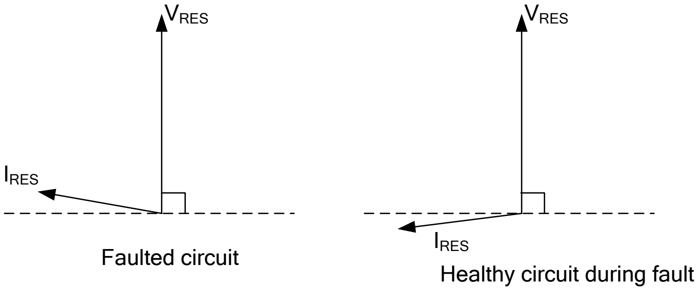


Figure 2-14 Earth fault current direction in compensated network

The directional boundary can be used to discriminate between healthy and faulted feeders. The characteristic angle is set to approximately 0º and the boundary at +90º used to detect the direction of the resistive component within the residual current. Setting of the boundary is critical to discriminate between faulted and unfaulted circuits. Setting '67SEF Compensated Network' to 'Enabled' will set the directional boundaries to ±87º around the characteristic angle, fine adjustment of the boundary may be necessary using the characteristic angle setting.

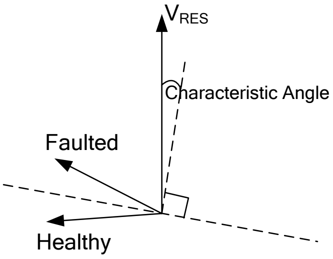


Figure 2-15 Adjustment of Characteristic Angle

The element measuring circuit can be subjected to only the cosine component of residual current i.e. to directly measure the real (wattmetric) current due to losses. The current $I_{RES}Cos(θ-Ø)$ is calculated where θ is the measured phase angle between residual current and voltage and Ø is the characteristic angle. This option is selected by setting 'Ires Select' to 'Ires Real'. The characteristic angle should be set to 0º.

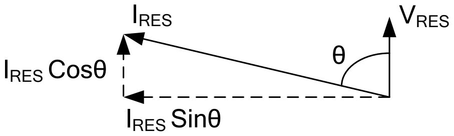


Figure 2-16 Cosine component of current

Application of a Wattmetric power characteristic. The directional 50/51 SEF element operation is subject to an additional sensitive residual power element which operates only on the real (wattmetric) component of residual power.

2.8.2 Isolated Networks

During earth faults on isolated distribution networks there is no fault current path to the source and subsequently no fault current will flow. However, the phase-neutral capacitive charging currents on the three phases will become unbalanced and the healthy phase currents will create an unbalance current which flows to earth. Unbalanced charging current for the whole connected network will return to the source through the fault path. This will produce a current at the relay which can be used to detect the presence of the fault. On each healthy circuit the unbalanced capacitive currents appear as a residual current which LAGS the residual voltage by 90º. On the faulted circuit the charging current creates no residual but the return of the charging current on the other circuits appears as a residual current which LEADS the residual voltage by 90º. The characteristic angle should be set to +90º.

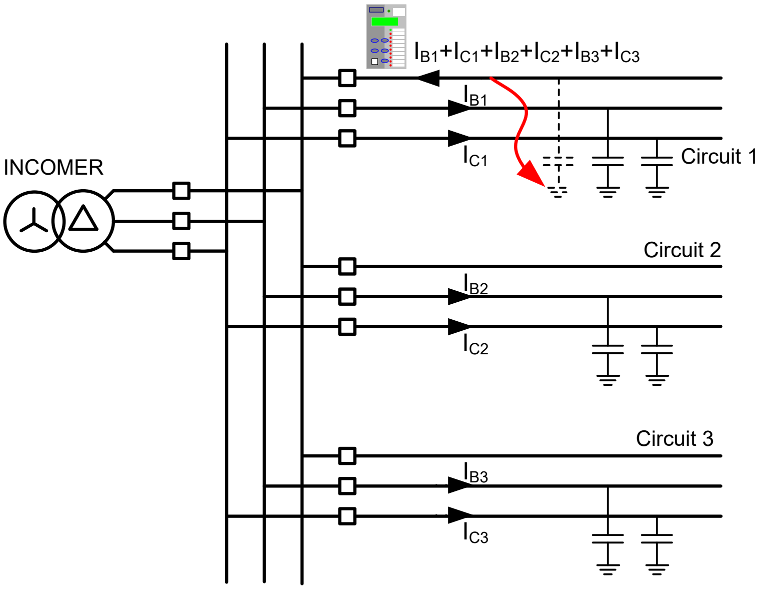


Figure 2-17 Earth fault current in isolated network

Some customers prefer to use only the sine (reactive) component of the residual current which can be easily achieved by setting 'Ires Select' to 'Ires Real' to select the operating current to $I_{RES}Cos(\theta-Ø)$ and setting the characteristic angle Ø to +90º.

2.8.3 Minimum Polarising Voltage

The correct residual voltage direction must be measured to allow a forward/reverse decision to be made. Minimum polarising voltage setting can be used to prevent tripping when fault conditions are such that significant residual voltage is not generated and the directional decision would be unreliable. The setting must allow for error in voltage measurement due to VT inaccuracy and connection. It can be used to improve stability under non-fault conditions during unbalanced load, when earth fault elements with very sensitive current settings are applied. This is ensured by selecting a setting which is near to the minimum expected residual voltage during fault conditions.

High impedance earthing methods, including compensated and isolated systems, will result in high levels of residual voltage, up to 3 times normal phase to neutral voltage, during earth faults. The minimum polarising voltage can therefore be increased to allow very low residual current settings to be applied without risk of operation during unbalanced load conditions.

2.9 Directional Sensitive Earth Fault (67SEF) – Measured $3V_0/I_0$-Φ

The directional earth-fault elements measure zero sequence current directly and compare this against the derived/measured zero sequence voltage (polarising quantity). Refer to 2.8.3 Minimum Polarising Voltage for details on minimum polarising voltage.

Refer to 2.8.1 Compensated Coil Earthing Networks and 2.8.2 Isolated Networks for isolated and compensated grounded systems the ground fault current will be too low to detect. In this condition directional sensitive earth fault detection is required to detect the fault based on $3V_0/I_0$-ϕ method.

This method calculates the angle between measured ground current and residual voltage. This method enables two different directional characteristics to be set.

$3V_0/I_0$-ϕ characteristics are shown in following phasor diagram:

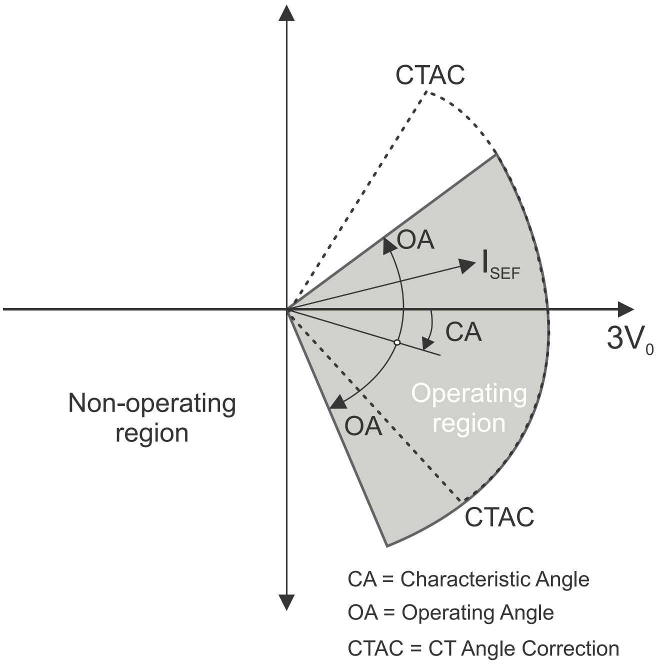


Figure 2-18 Directional Sensitive Earth Fault-Measured $3V_0/I_0$-Φ

2.9.1 Angle Error Compensation

The high reactive component in a resonant grounded system and the inevitable air gap of the toroidal current transformer often require the angle error of the toroidal current transformer to be compensated. In ungrounded or grounded systems angle compensation is not required.

In cable networks, cable-type current transformers are used for measurement of ground current. These transformers typically have a current-dependent phase displacement. This phase displacement can be corrected by the algorithm. After angle error compensation operating region is shown in Figure 2-18.

Following settings can be used for angular compensation of current transformer:

- Gn 67SEF-n I1 for CT Angle corr: First threshold for ground current
- Gn 67SEF-n I2 for CT Angle corr: Second threshold for ground current
- Gn 67SEF-n CT Angle corr at I1: First threshold assigned for correction angle
- Gn 67SEF-n CT Angle corr at I2: Second threshold assigned for correction angle

2.9.2 HIGH IMPEDANCE RESTRICTED EARTH FAULT PROTECTION (64H)

Restricted Earth Fault (REF) protection is applied to Transformers to detect low level earth faults in the transformer windings. Current transformers are located on all connections to the transformer. During normal operation or external fault conditions no current will flow in the relay element. When an internal earth fault occurs, the currents in the CTs will not balance and the resulting unbalance flows through the relay.

The current transformers may saturate when carrying high levels of fault current. The high impedance name is derived from the fact that a resistor is added to the relay leg to prevent relay operation due to CT saturation under through fault conditions.

The REF Trip output is configured to provide an instantaneous trip output from the relay to minimise damage from developing winding faults.

The application of the element to a delta-star transformer is shown in Figure 2.18. Although the connection on the relay winding is more correctly termed a Balanced Earth-Fault element, it is still usually referred to as Restricted Earth Fault because of the presence of the transformer.

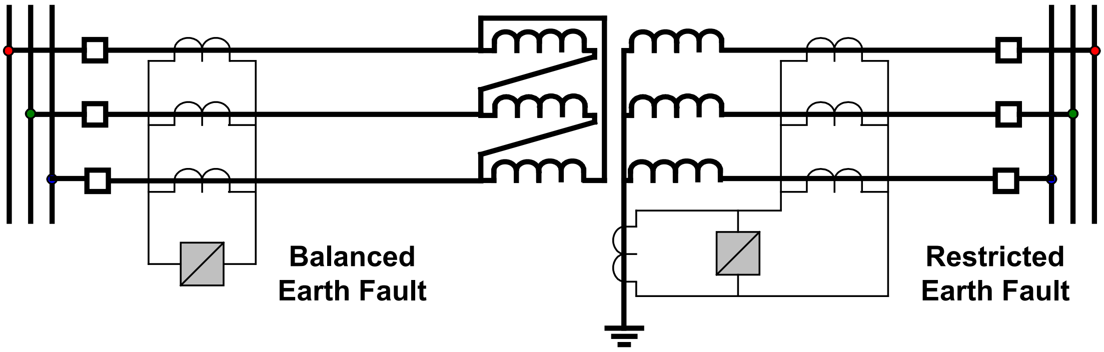


Figure 2-19 Balanced and Restricted Earth-fault protection of Transformers

The calculation of the value of the Stability Resistor is based on the worst case where one CT fully saturates and the other balancing CT does not saturate at all. A separate Siemens Protection Devices Limited Publication is available covering the calculation procedure for REF protection. To summarise this:

The relay Stability (operating) Vs voltage is calculated using worst case lead burden to avoid relay operation for through-fault conditions where one of the CTs may be fully saturated. The required fault setting (primary operate current) of the protection is chosen; typically, this is between 10 % and 25 % of the protected winding rated current. The relay setting current is calculated based on the secondary value of the operate current, note, however, that the summated CT magnetising current @ Vs must be subtracted to obtain the required relay operate current setting.

Since the relay operate current setting and stability/operating voltage are now known, a value for the series resistance can now be calculated.

A check is made as to whether a Non-Linear Resistor is required to limit scheme voltage during internal fault conditions – typically where the calculated voltage is in excess of 2kV.

The required thermal ratings for external circuit components are calculated.

Composite overcurrent and REF protection can be provided using a multi-element relay as shown below.

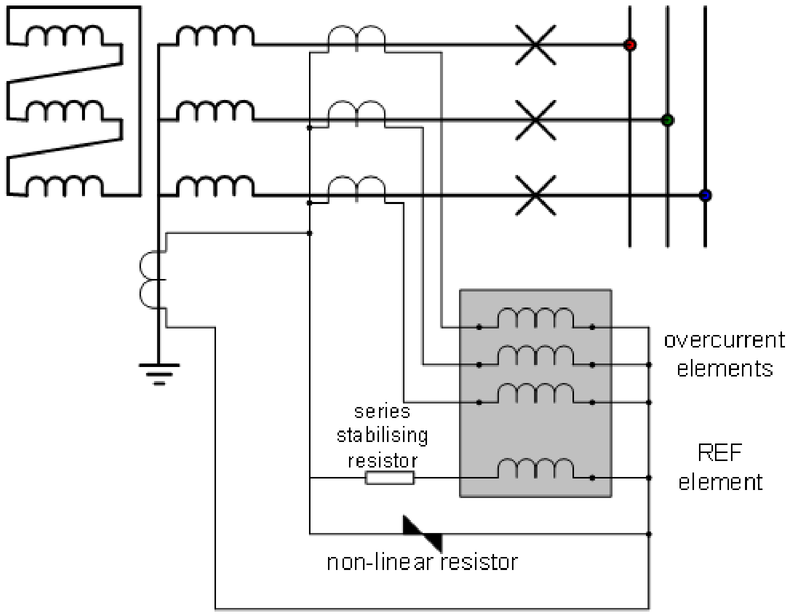


Figure 2-20 Composite Overcurrent and Restricted Earth-fault Protection

Although core-balance CTs are traditionally used with elements requiring sensitive pickup settings, cost and size usually precludes this on REF schemes. Instead single-Phase CTs are used and their secondary's connected in parallel.

Where sensitive settings are required, the setting must be above any line charging current levels that can be detected by the relay.

On occurrence of an out of zone earth fault the elevation of sound phase voltage to earth in a non-effectively earthed system can result in a zero sequence current of up 3 times phase charging current flowing through the relay location.

The step change from balanced 3-phase charging currents to this level of zero sequence current includes transients. It is recommended to allow for a transient factor of 2 to 3 when determining the limit of charging current. Based on the above considerations the minimum setting of a relay in a resistance earthed power system is 6 to 9 times the charging current per phase.

High impedance differential protection is suitable for application to auto transformers as line currents are in phase and the secondary current through the relay is balanced to zero by the use of CTs ratios at all three terminals. High impedance protection of this type is very sensitive and fast operating for internal faults.

2.10 Negative Phase Sequence Overcurrent (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 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 overcurrent protection is therefore configured to match these two plant characteristics.

2.11 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.

2.12 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.

θ = 0% for unheated equipment, and θ = 100% for maximum thermal withstand of equipment or the Trip threshold.

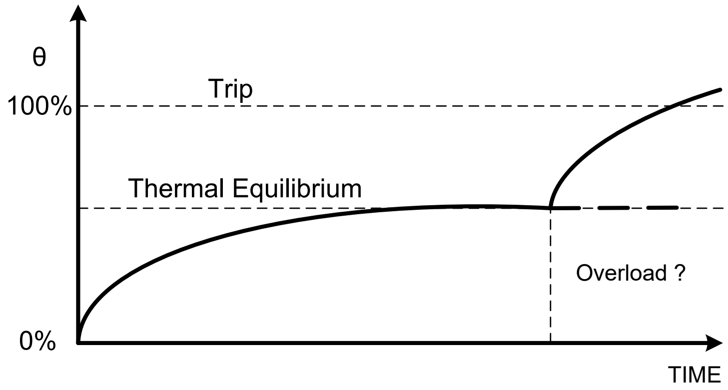


Figure 2-21 Thermal Overload Heating and Cooling Characteristic

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 dependant 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 Overcurrent. 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.

2.13 Under/Over Voltage Protection (27/59)

Power system under-voltages on may occur due to:

System faults.

An increase in system loading,

Non-energized power system e.g. loss of an incoming transformer

During normal system operating conditions regulating equipment such as transformer On Load Tap Changers (OLTC) and generator Automatic Voltage Regulators (AVR) ensure that the system runs within acceptable voltage limits.

Undervoltage/DTL elements can be used to detect abnormal undervoltage conditions due to system overloads. Binary outputs can be used to trip non-essential loads - returning the system back to its normal operating levels. This ‘load shedding’ should be initiated via time delay elements so avoiding operation during transient disturbances. An undervoltage scheme (or a combined under frequency/under voltage scheme) can provide faster tripping of non-essential loads than under-frequency load shedding so minimising the possibility of system instability.

Where a transformer is supplying 3-phase motors a significant voltage drop e.g. to below 80% may cause the motors to stall. An undervoltage element can be set to trip motor circuits when the voltage falls below a preset value so that on restoration of supply an overload is not caused by the simultaneous starting of all the motors. A time delay is required to ensure voltage dips due to remote system faults do not result in an unnecessary disconnection of motors.

To confirm presence/loss of supply, the voltage elements should be set to values safely above/below that where a normal system voltage excursion can be expected. The switchgear/plant design should be considered. The ‘Dead’ level may be very near to the ‘live’ level or may be significantly below it. The variable hysteresis setting allows the relay to be used with all types of switchgear.

System over-voltages can damage component insulation. Excessive voltage may occur for:

Sudden loss of load

A tap changer run-away condition occurs in the high voltage direction,

Generator AVR equipment malfunctions or

Reactive compensation control malfunctions.

System regulating equipment such as transformer tap changers and generator AVRs may correct the overvoltage – unless this equipment mal-functions. The overvoltage/DTL elements can be used to protect against damage caused by system overvoltages.

If the overvoltage condition is small a relatively long DTL time delay can be used. If the overvoltage is more severe then another element, set at a higher pickup level and with a shorter DTL can be used to isolate the circuit more quickly. Alternatively, elements can be set to provide alarm and tripping stages, with the alarm levels set lower than the tripping stages.

The use of DTL settings allows a grading system to be applied to co-ordinate the network design, the regulating plant design, system plant insulation withstand and with other overvoltage relays elsewhere on the system. The DTL also prevents operation during transient disturbances.

The use of IDMTL protection is not recommended because of the difficulty of choosing settings to ensure correct co-ordination and security of supply.

2.14 Neutral Overvoltage (59N)

Neutral Voltage Displacement (NVD) protection is used to detect an earth fault where little or no earth current flows.

This can occur where a feeder has been tripped at its HV side for an earth fault, but the circuit is still energised from the LV side via an unearthed transformer winding. Insufficient earth current would be present to cause a trip, but residual voltage would increase significantly; reaching up to 3-times the normal phase-earth voltage level.

If Neutral Overvoltage protection is used, it must be suitably time graded with other protections in order to prevent unwanted tripping for external system earth faults.

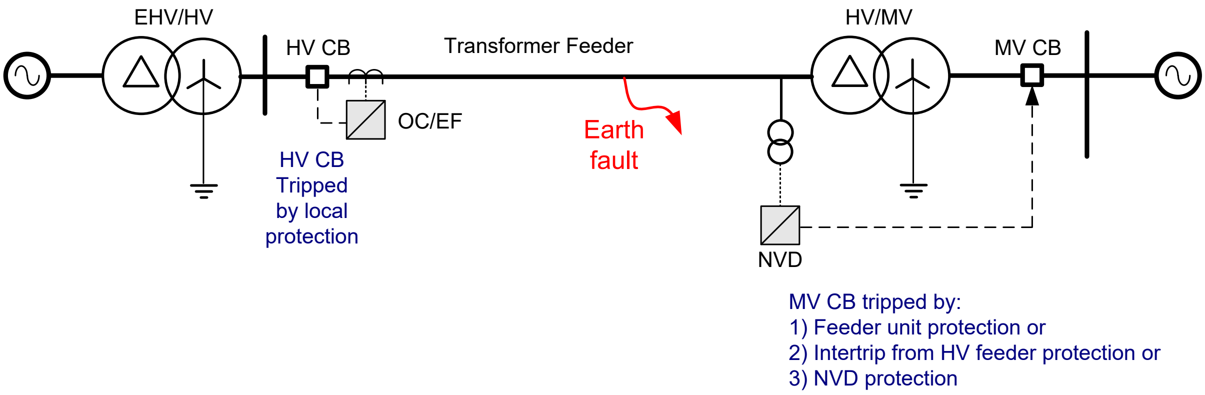


Figure 2-22 NVD Application

Typically NVD protection measures the residual voltage ($3V_0$) directly from an open delta VT or from capacitor cones – see fig. 2.20 below.

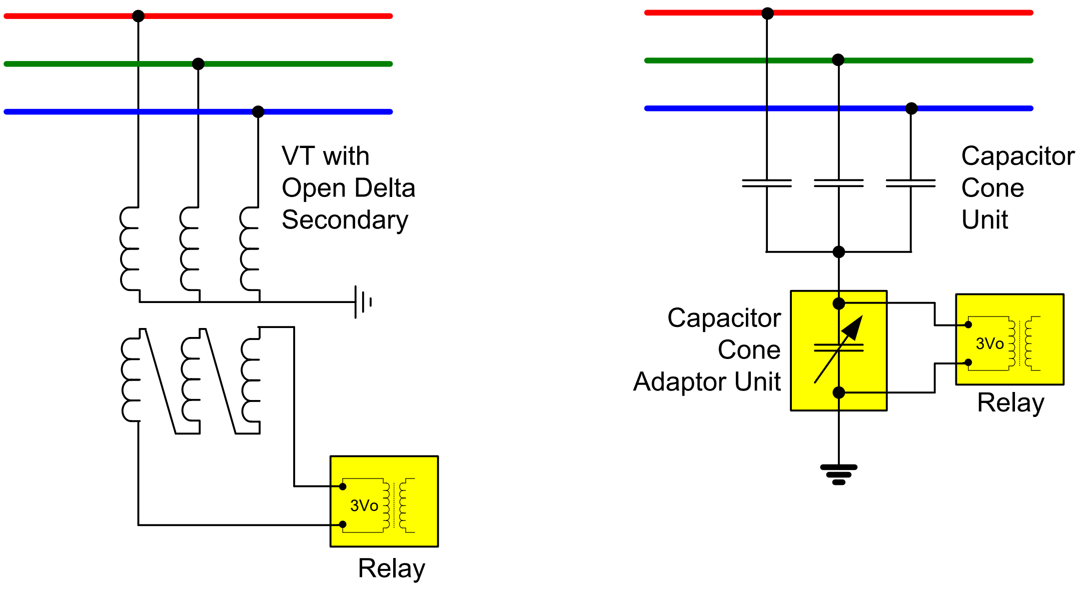


Figure 2-23 NVD Protection Connections

2.14.1 Application with Capacitor Cone Units

Capacitor cones provide a cost effective method of deriving residual voltage. The wide range of capacitor cone component values used by different manufacturers means that the relay cannot be connected directly to the cones.

The external adaptor unit contains parallel switched capacitors that enable a wide range of values to be selected using a DIL switch and hence the Capacitor Cone output can be scaled to the standard relay input range.

2.14.2 Derived NVD Voltage

Alternatively NVD voltage can be derived from the three phase to neutral voltages, this setting is available within the relay. Note with this method the NVD protection may mal-operate during a VT Fail condition.

2.15 Negative Phase Sequence Overvoltage (47)

Negative Phase Sequence (NPS) protection detects phase unbalances and is widely used in protecting rotating plant such as motors and generators. However such protection is almost universally based on detecting NPS Current rather than Voltage. This is because the NPS impedance of motors etc. is much less than the Positive Phase Sequence (PPS) impedance and therefore the ratio of NPS to PPS Current is much higher than the equivalent ratio of NPS to PPS Voltage.

NPS Voltage is instead used for monitoring busbar supply quality rather than detecting system faults. The presence of NPS Voltage is due to unbalanced load on a system. Any system voltage abnormality is important since it will affect every motor connected to the source of supply and can result in mass failures in an industrial plant.

The two NPS Voltage DTL elements should therefore be used as Alarms to indicate that the level of NPS has reached abnormal levels. Remedial action can then be taken, such as introducing a Balancer network of capacitors and inductors. Very high levels of NPS Voltage indicate incorrect phase sequence due to an incorrect connection.

2.16 Under/Over Frequency (81)

During normal system operation the frequency will continuously vary over a relatively small range due to the changing generation/load balance. Excessive frequency variation may occur for:

> Loss of generating capacity, or loss of mains supply (underfrequency): If the governors and other regulating equipment cannot respond to correct the balance, a sustained underfrequency condition may lead to a system collapse.
>
> Loss of load – excess generation (overfrequency): The generator speeds will increase causing a proportional frequency rise. This may be unacceptable to industrial loads, for example, where the running speeds of synchronous motors will be affected.

In the situation where the system frequency is falling rapidly it is common practise to disconnect non-essential loads until the generation-load balance can be restored. Usually, automatic load shedding, based on underfrequency is implemented. Underfrequency relays are usually installed on the transformer incomers of distribution or industrial substations as this provides a convenient position from which to monitor the busbar frequency. Loads are disconnected from the busbar (shed) in stages until the frequency stabilises and returns to an acceptable level.

The relay has four under/over frequency elements.

An example scheme may have the first load shedding stage set just below the nominal frequency, e.g. between 49.0 - 49.5Hz. A time delay element would be associated with this to allow for transient dips in frequency and to provide a time for the system regulating equipment to respond. If the first load shedding stage disconnects sufficient plant the frequency will stabilise and perhaps return to nominal. If, however, this is not sufficient then a second load shedding stage, set at a lower frequency, will shed further loads until the overload is relieved. This process will continue until all stages have operated. In the event of the load shedding being unsuccessful, a final stage of underfrequency protection should be provided to totally isolate all loads before plant is damaged, e.g. due to overfluxing.

An alternative type of load shedding scheme would be to set all underfrequency stages to about the same frequency setting but to have different length time delays set on each stage. If after the first stage is shed the frequency doesn't recover then subsequent stages will shed after longer time delays have elapsed.

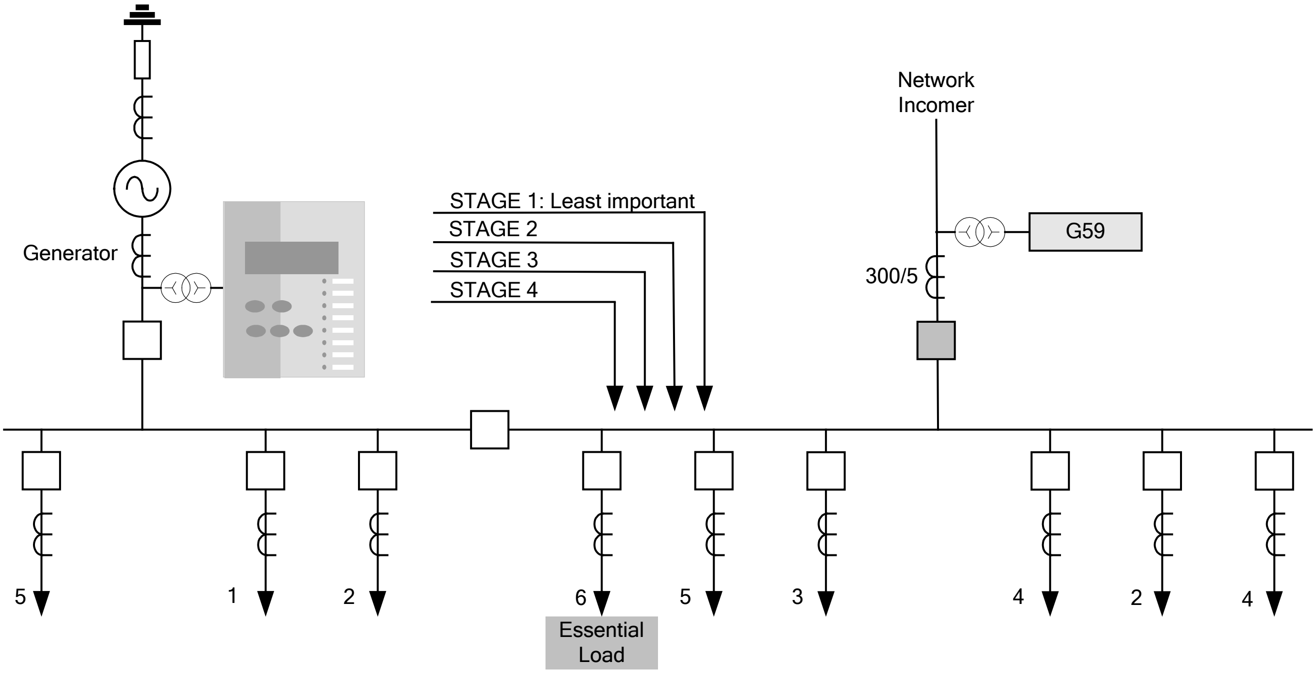


Figure 2-24 Load Shedding Scheme Using Under-Frequency Elements

2.17 Power (32)

Directional power protection is often applied to motor or embedded generator applications to detect loss of load or loss of generation. For these applications, Real power may be a more appropriate operating quantity.
Power direction can also be used to recognise and record particular network operation arrangements such as back feeds or embedded generation conditions.

2.18 Sensitive Power (32S)

The CT accuracy should be considered when setting this function for the application.

2.19 Power Factor (55)

Power factor limits can be set to provide alarms or even tripping for abnormal power factor load.
Power factor can also be used to switch in and out additional plant such as capacitors

Section 3: CT Requirements

3.1 CT Requirements for Overcurrent and Earth Fault Protection

3.1.1 Overcurrent Protection CTs

a) For industrial systems with relatively low fault current and no onerous grading requirements - a class 10P10 with VA rating to match the load.

b) For utility distribution networks with relatively high fault current and several grading stages - a class 5P20, with VA rating to match the load.

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 overcurrent factor has only a minimal effect. However, this must be taken into account 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: Overcurrent 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 overcurrent 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 overcurrent 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 overcurrent accuracy limit factors are therefore already determined and for both these factors the earth fault protection requirements are normally less onerous than for overcurrent.

3.2 CT Requirements for High Impedance Restricted Earth Fault Protection

For high impedance REF it is recommended that:

Low reactance CTs to IEC Class PX are used, this allows a sensitive current setting to be applied.

All CT’s should, if possible have identical turns ratios.

The knee point voltage of the CTs must be greater than 2 x 64H setting voltage Vs.

Where the REF function is used then this dictates that the other protection functions are also used with class PX CTs.

A full explanation of how to specify CTs for use with REF protection, and set REF relays is available on our website: www.siemens.com/energy.

Section 4: Control Functions

4.1 Auto-reclose Applications

- 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 feature attempts to minimise the loss of supply to the customer and reduce the need for manual intervention.

The function supports up to 4 ARC sequences. That is, 4 x Trip / Recloses followed by a Trip & Lockout. A lockout condition prevents any further automatic attempts 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/Sensitive Earth faults).

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 Autoreclose (ARC) sequence and cause unnecessary lockouts.

The Sequence Fail Timer provides an overall maximum time limit on the ARC operation. It should therefore be longer than all the set delays in a complete cycle of ARC 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 ARC 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 ARC 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.
- The next trip will Lockout the ARC sequence and prevent further recloses.

It is important that all the relays in an ARC scheme shadow this process – advancing through their own ARC 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 ARC scheme must be set with identical Instantaneous and Delayed sequence of trips.

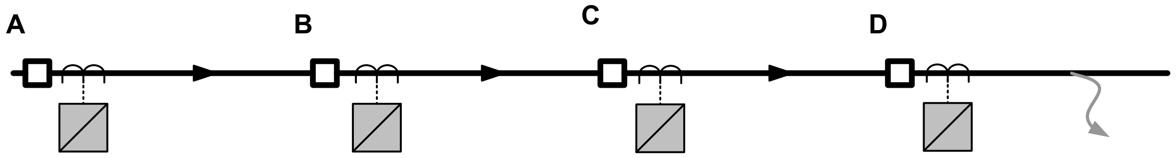


Figure 4-1 Sequence Co-ordination

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 ARC sequences. They would therefore also step to their Delayed Trip to retain co-ordination with the respective downstream devices.

The next Trip would be subject to current grading and Lockout the ARC sequence such that the fault is cleared by the correct CB.

4.1.1 Auto-Reclose Example 1

Requirement: Settings shall provide four phase fault recloses – two instantaneous and two delayed - and only two delayed recloses for faults detected by the SEF protection.

Proposed settings include:

CONTROL & LOGIC > AUTORECLOSE PROT'N:

***79 P/F Inst Trips*: 50-1**

***79 P/F Delayed Trips*: 51-1**

***79 SEF Delayed Trips*: 51SEF-1**

CONTROL & LOGIC > AUTORECLOSE CONFIG

***79 Num Shots*: 4**

CONTROL & LOGIC > AUTORECLOSE CONFIG > P/F SHOTS

***79 P/F Prot'n Trip 1* : Inst**

***79 P/F Prot'n Trip 2* : Inst**

***79 P/F Prot'n Trip 3* : Delayed**

***79 P/F Prot'n Trip 4* : Delayed**

***79 P/F Delayed Trips to Lockout* : 3**

CONTROL & LOGIC > AUTORECLOSE CONFIG > SEF SHOTS

***79 SEF Prot'n Trip 1* : Delayed**

***79 SEF Prot'n Trip 2* : Delayed**

***79 SEF Delayed Trips to Lockout* : 3**

Note that Instantaneous' trips are inhibited if the shot is defined as 'Delayed'

4.1.2 Auto-Reclose Example 2 (Use of Quicklogic with AR)

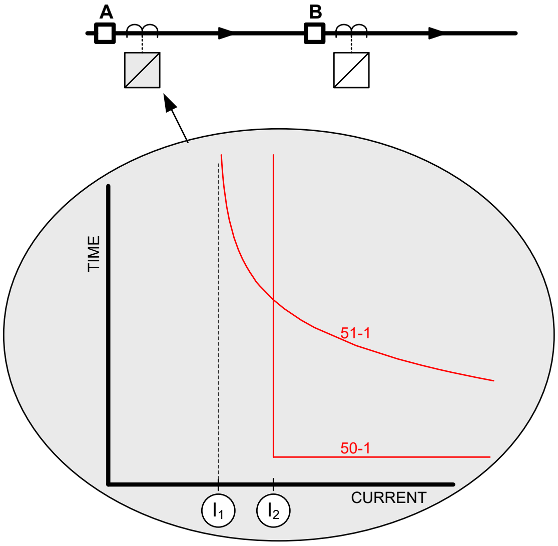


Figure 4-2 Example of Logic Application

Requirement: The relay at location ‘A’ is required to provide a reclose sequence of 2 Instantaneous followed by 2 delayed recloses. Where the fault current level is between the values ‘I1’ and ‘I2’ and the first trip is initiated from the 51-1 (IDMT) element, the IDMT characteristic should trip the CB and lockout the auto-reclose.

Typical settings are:

CONTROL & LOGIC > AUTORECLOSE PROT’N:

***79 P/F Inst Trips*: 50-1**

***79 P/F Delayed Trips*: 51-1**

CONTROL & LOGIC > AUTORECLOSE CONFIG > P/F SHOTS

***79 P/F Prot’n Trip 1* : Inst**

***79 P/F Prot’n Trip 2* : Inst**

***79 P/F Prot’n Trip 3* : Delayed**

***79 P/F Prot’n Trip 4* : Delayed**

The above settings are suitable at values of fault current above ‘I2’ however were a fault to occur with a current value between ‘I1’ and ‘I2’ this would be detected by the 51-1 element only. As ***Prot’n Trip 1*** = **Inst** then the relay would trip and reclose whereas it is required to lockout for this occurrence.

To provide a lockout for the above faults an additional element 50-2 with identical settings to 50-1 is assigned as a Delayed Trip and is used in conjunction with the Quick Logic feature i.e.

OUTPUT CONFIG>OUTPUT MATRIX: ***51-1*** = **V1**

OUTPUT CONFIG>OUTPUT MATRIX: ***50-2*** = **V2**

OUTPUT CONFIG>OUTPUT MATRIX: ***E1*** = **V3**

CONTROL & LOGIC>QUICK LOGIC: ***E1*** = **V1.!V2**

INPUT CONFIG>INPUT MATRIX: ***79 Lockout*** = **V3**

4.2 Quick Logic Applications

4.2.1 Auto-Changeover Scheme Example

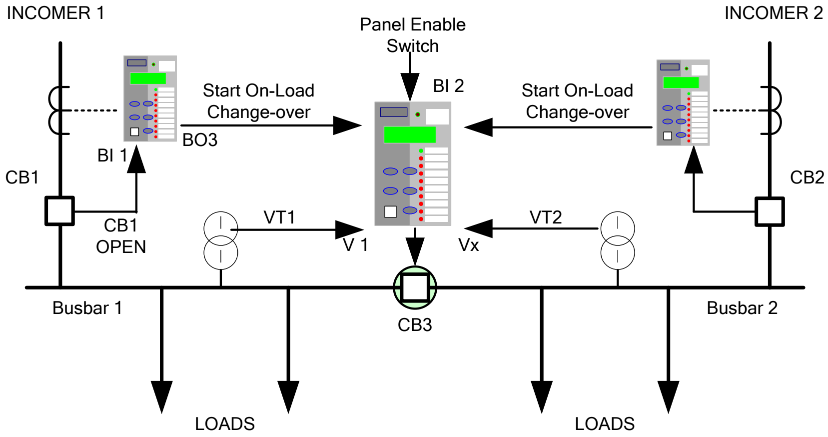


Figure 4-3 Example Use of Quick Logic

The MV installation illustrated above is fed from two incomers. To limit the substation fault level the busbar is run with CB3 open. When a fault occurs on one of the incomers it is isolated by the circuit protection. To re-supply the disconnected loads from the remaining incomer CB3 is closed.

If the line fault occurs on incomer 1 it must be confirmed that CB 1 has opened before CB3 can be closed. The relay on incomer 1 confirms that a trip has been issued to CB1 (e.g. Binary Output 2), that CB 1 has opened (e.g. Binary Input 1) and that no current flows in the circuit (e.g. 37-1 = Virtual 1):

Incomer 1 Relay is Configured:

CB1 Open auxiliary switch wired to BI 1

Trip output to CB1 = BO 2

OUTPUT CONFIG>OUTPUT MATRIX: ***37-1*** = **V1**

OUTPUT CONFIG>OUTPUT MATRIX: ***E1*** = **BO3**

CONTROL & LOGIC>QUICK LOGIC: ***E1*** = **O2.I1.V1**

The output from Incomer 1 (Binary Output 3) relay is input to the relay on CB 3 (Binary Input 1). A panel switch may be used to enable the On-Load Change-over scheme (Binary Input 2). Before Closing CB3 a check may be made that there is no voltage on busbar 1 (27/59-1 = Virtual 1). CB 3 is closed from Binary Output 3.

CB3 Relay is Configured:

Panel switch (ON-Load Change-over Enabled) wired to BI2

OUTPUT CONFIG>OUTPUT MATRIX: ***27/59-1*** = **V1**

OUTPUT CONFIG>OUTPUT MATRIX: ***E1*** = **BO3**

CONTROL & LOGIC>QUICK LOGIC: ***E1*** = **I1.I2.V1**

If required a time delay can be added to the output using the CONTROL & LOGIC > QUICK LOGIC: ***E1 Pickup Delay*** setting**.**

Section 5: Supervision Functions

5.1 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.

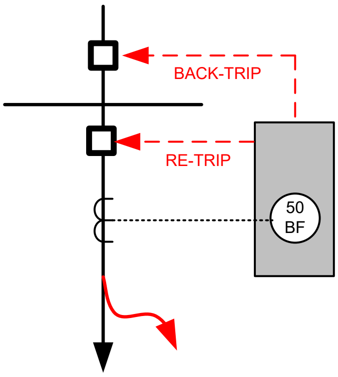


Figure 5-1 Circuit Breaker Fail

5.1.1 Settings Guidelines

<u>50BF Setting</u>

The phase current setting must be set below the minimum protection setting current.

<u>50BF Setting-I4</u>

The EF or SEF current setting must be set below the minimum protection setting current.

<u>50BF Ext Trig</u>

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.

<u>50BF Mech Trip</u>

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.

<u>50BF CB Faulty</u>

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 DTL1/50BF DTL2

The time delays run concurrently within the relay. The time delay applied to the CB Fail protection must be in excess of the longest CB operate time + relay reset time + a safety margin.

First Stage (Retrip)	
Trip Relay operate time	10ms
Reset Time	20ms
CB Tripping time	50ms
Safety Margin	40ms
Overall First Stage CBF Time Delay	**120ms**
Second Stage (Back Trip)	
First CBF Time Delay	120ms
Trip Relay operate time	10ms
CB Tripping time	50ms
Reset Time of measuring element	20ms
Margin	60ms
Overall Second Stage CBF Time Delay	**260ms**

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.

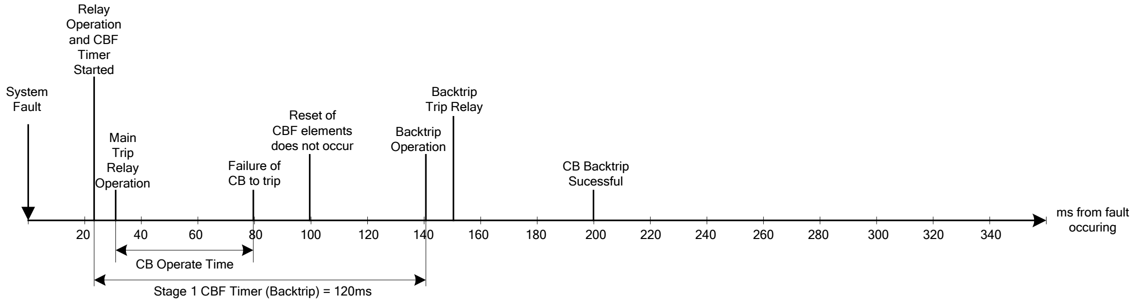


Figure 5-2 Single Stage Circuit Breaker Fail Timing

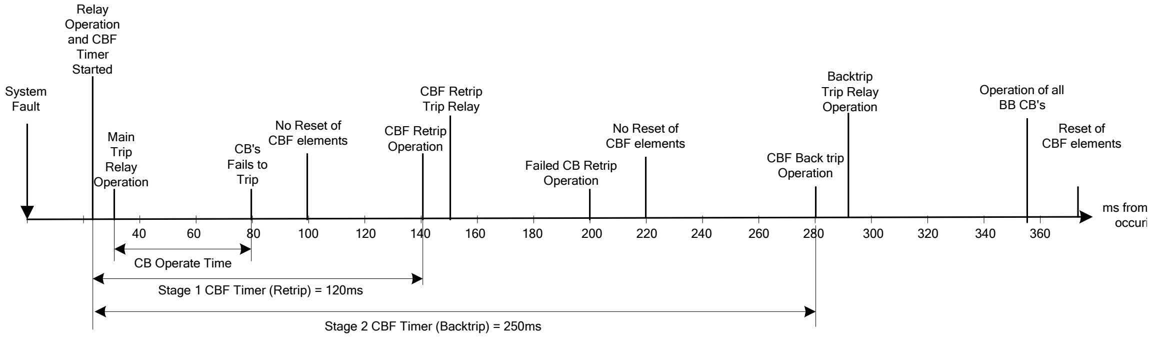


Figure 5-3 Two Stage Circuit Breaker Fail Timing

5.2 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 – 7SR1004)

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.

Current Transformer Supervision (60CTS – 7SR1004)

When a CT fails, the current levels seen by the protection become unbalanced. A large level of NPS current is therefore detected - around 0.3 x In for one or two CT failures. However this condition would also occur for a system fault. To differentiate between the two conditions, the element uses NPS voltage to restrain the CTS algorithm as shown in the accompanying table.

NPS Current	NPS Voltage	Decision
> Setting	> Setting	System Fault
> Setting	< Setting	CT Failure

Table 5-1 Determination of VT Failure (1 or 2 Phases)

Following a CT Failure, there should be little or no NPS voltage. Perhaps 0.1 x Vn as a maximum.

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.

5.3 Voltage Transformer Supervision (60VTS)

Although VTs rarely fail themselves, VT Supervision presents a common application because of the failure of protective Fuses connected in series with the VTs.

When a VT failure occurs on one or two phases, the voltage levels seen by the protection become unbalanced. A large level of NPS voltage is therefore detected - around 0.3 x Vn for one or two VT failures. However this condition would also occur for a system fault. To differentiate between the two conditions, the element uses NPS current to restrain the VTS algorithm as show in the accompanying table.

NPS Voltage	NPS Current	Decision
> Setting	> Setting	System Fault
> Setting	< Setting	VT Failure

Table 5-2 Determination of VT Failure (1 or 2 Phases)

Following a VT Failure, the level of NPS current would be dependent solely upon load imbalance - perhaps 0.1 x In as a maximum.

Operation is subject to a time delay to prevent operation for transitory effects.

NPS voltage and current quantities are used rather than ZPS since the latter makes it difficult to differentiate between a VT failure and a Phase-Phase fault. Both conditions would generate little or no ZPS current. However the element provides an option to use ZPS quantities to meet some older specifications.

There are possible problems with using NPS quantities due to load imbalances. These would also generate significant levels of NPS current and so possibly cause a VT failure to be missed. This problem can be overcome by careful selection of settings, however, setting the NPS current threshold above the level expected for imbalance conditions.

If a failure occurs in all 3 Phases of a Voltage Transformer, then there will be no NPS or ZPS voltage to work with. However the PPS Voltage will fall below expected minimum measurement levels.

This could also be due to a ‘close in’ fault and so PPS Current must remain above minimum load level BUT below minimum fault level.

PPS Voltage	PPS Current	Decision
< Setting	> Minimum Fault Level	System Fault
< Setting	Minimum Load Level < AND < Minimum Fault Level	VT Failure

Table 5-3 Determination of VT Failure (3 Phases)

Operation is again subject to a time delay to prevent operation for transitory effects.

Alternatively a 3 Phase VT failure can be signalled to the relay via a Binary Input taken from the Trip output of an external MCB. This can also be reset by a Binary Input signal.

VTS would not normally be used for tripping - it is an alarm rather than fault condition. However the loss of a VT would cause problems for protection elements that have voltage dependant functionality. For this reason, the relay allows these protection elements - under-voltage, directional over-current, etc. - to be inhibited if a VT failure occurs.

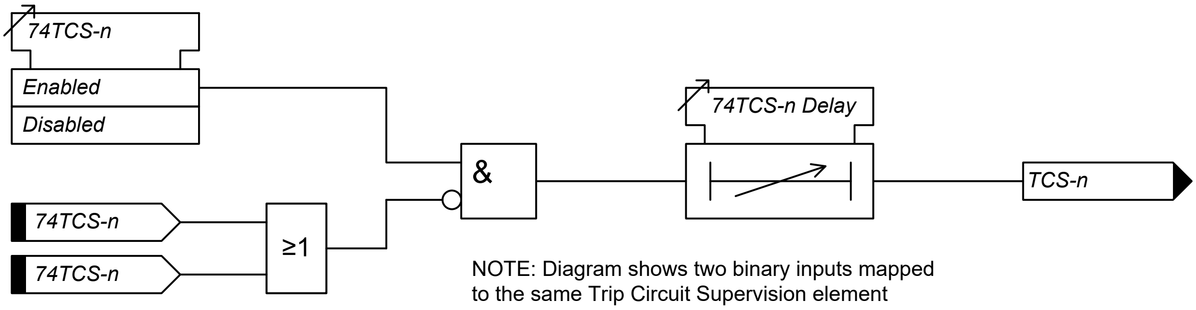
5.4 Trip/Close Circuit Supervision (74T/CCS)

The relay provides three trips 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 the mapped inputs become de-energised, due to a break in the trip circuit wiring or loss of supply an output is given.

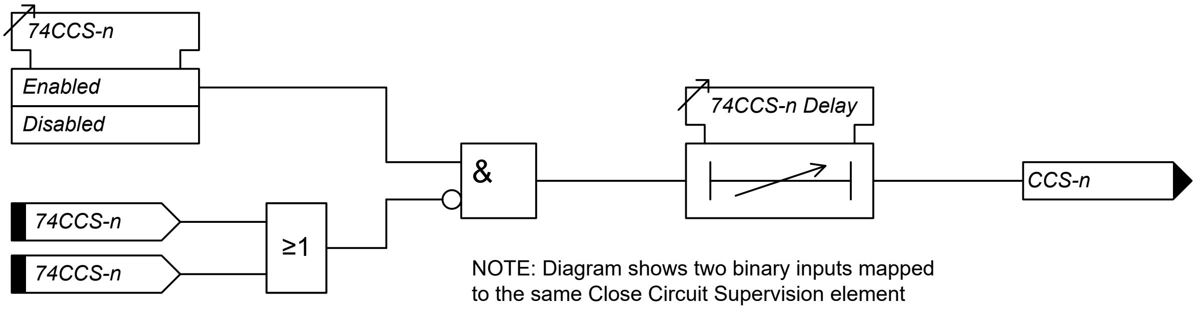
The ***74TCS-n Delay*** setting prevents the failure being incorrectly indicated during circuit breaker operation. This delay should be greater than the operating time of the circuit breaker.

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.



NOTE: Diagram shows two binary inputs mapped to the same Trip Circuit Supervision element

Figure 5-4 Logic Diagram: Trip Circuit Supervision Feature (74TCS)



NOTE: Diagram shows two binary inputs mapped to the same Close Circuit Supervision element

Figure 5-5 Logic Diagram: Close Circuit Supervision Feature (74CCS)

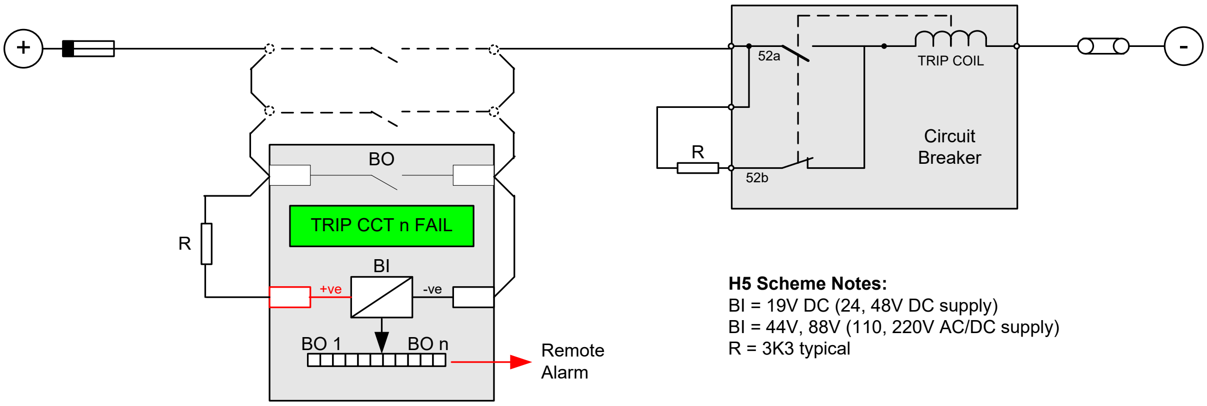
5.4.1 Trip Circuit Supervision Connections

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)



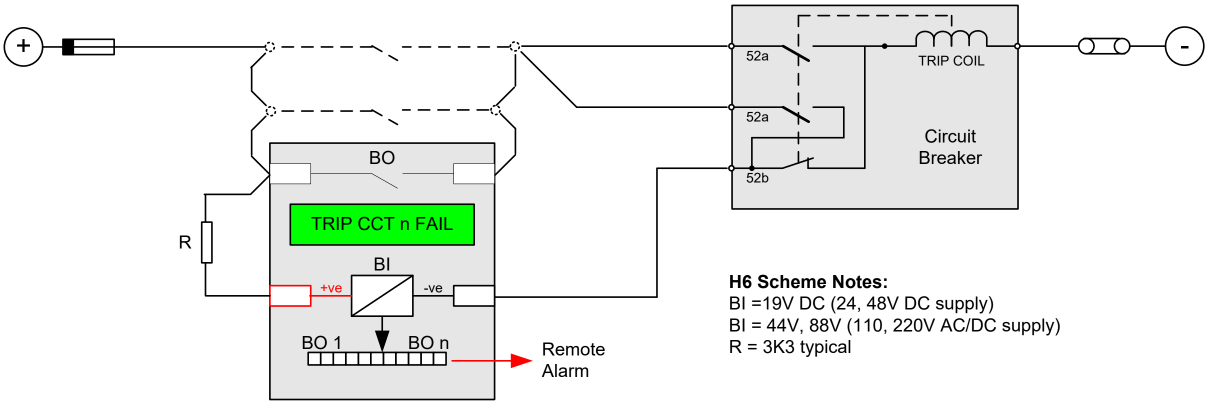
H5 Scheme Notes:
BI = 19V DC (24, 48V DC supply)
BI = 44V, 88V (110, 220V AC/DC supply)
R = 3K3 typical

Figure 5-6 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)



H6 Scheme Notes:
BI =19V DC (24, 48V DC supply)
BI = 44V, 88V (110, 220V AC/DC supply)
R = 3K3 typical

Figure 5-7 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)

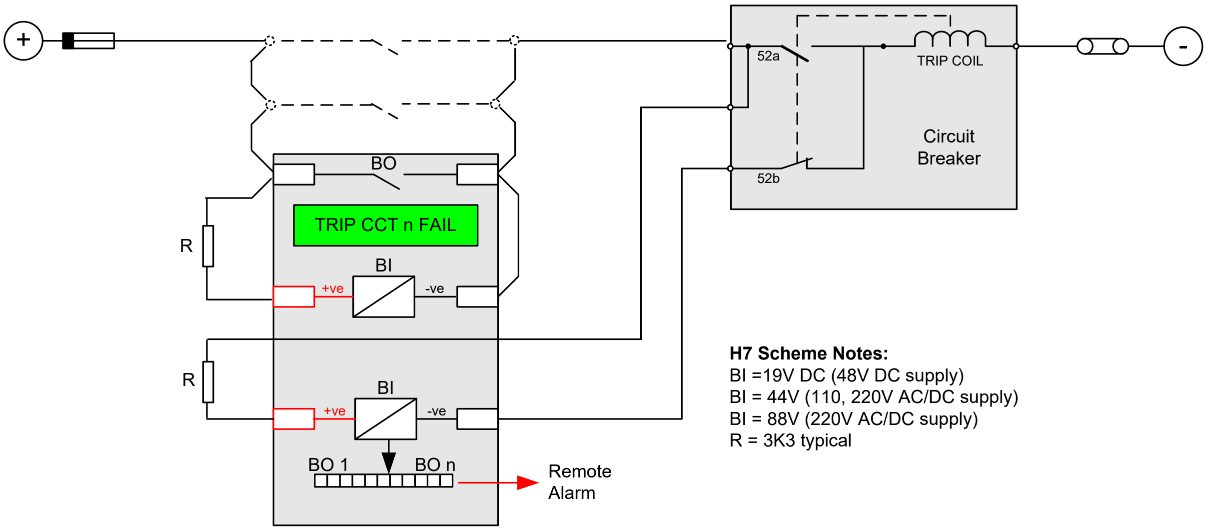


Figure 5-8 Trip Circuit Supervision Scheme 3 (H7)

Scheme 3 provides full Trip supervision with the circuit breaker Open or Closed.

5.4.2 Close Circuit Supervision Connections

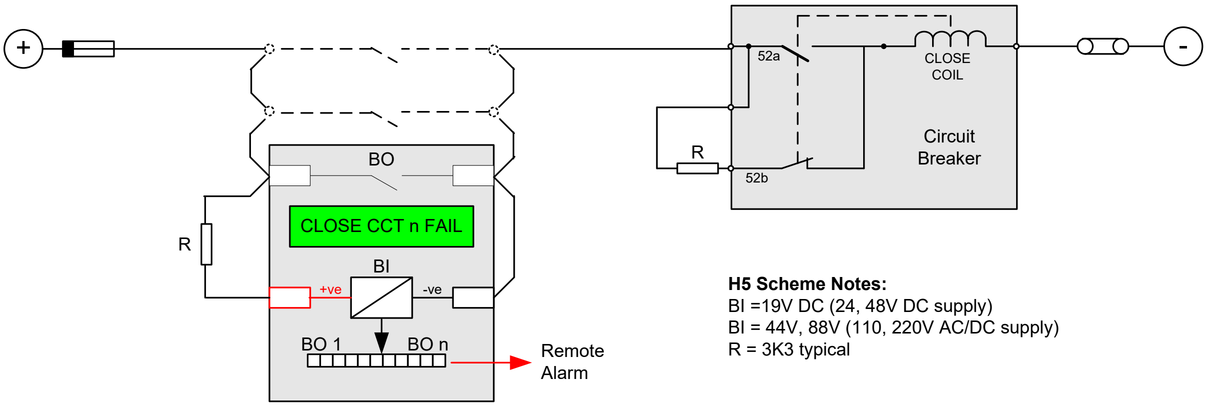


Figure 5-9 Close Circuit Supervision Scheme

Close circuit supervision with the circuit breaker Open or Closed.

NOTE:

To achieve higher isolation, in the dual TCS application, it is recommended to maintain one Binary Input channel should not be connected between 110 V DC and 230 V AC control supply.

NOTE:

Use the correct threshold voltages for BI when using TCS with 2 BI.

NOTE:

It is recommended to use Resistor (R), when the low voltage BI is used in the high voltage application. For e.g: BI44 is used 220 V DC application.

With use of Resistor(R) mentioned above, BI threshold will increase due to voltage drop across external resistor.

5.5 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 overcurrent 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 overcurrent 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 Overcurrent protection.

There are 3 methods of detection and blocking during the passage of magnetising inrush current.

Table 5-4 Magnetic Inrush Bias

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.

5.6 Broken Conductor / Load Imbalance (46BC)

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 overcurrent 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 50sec may be recommended.

5.6.1 Broken Conductor example

Information recorded during commissioning:

I full load = 500A

I NPS = 50A

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 50seconds.

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 x In

5.7 Circuit-Breaker Maintenance

The Relay provides Total, Delta and Frequent CB Operation Counters along with an I^2t 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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