



Reyrolle
Protection
Devices

7SR105 Rho User Manual

Motor Protection Relay

Energy Management

SIEMENS

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Contents

Technical Manual Chapters

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7SR105 Rho

Description of Operation

Document Release History

This document is issue 2016/06. The list of revisions up to and including this issue is:

2015/12	First Issue
2016/06	Second Issue

Software Revision History

2015/12	2437H80007 R4b-1a	First Release
2016/06	2437H80007 R4c-1b	Second Release

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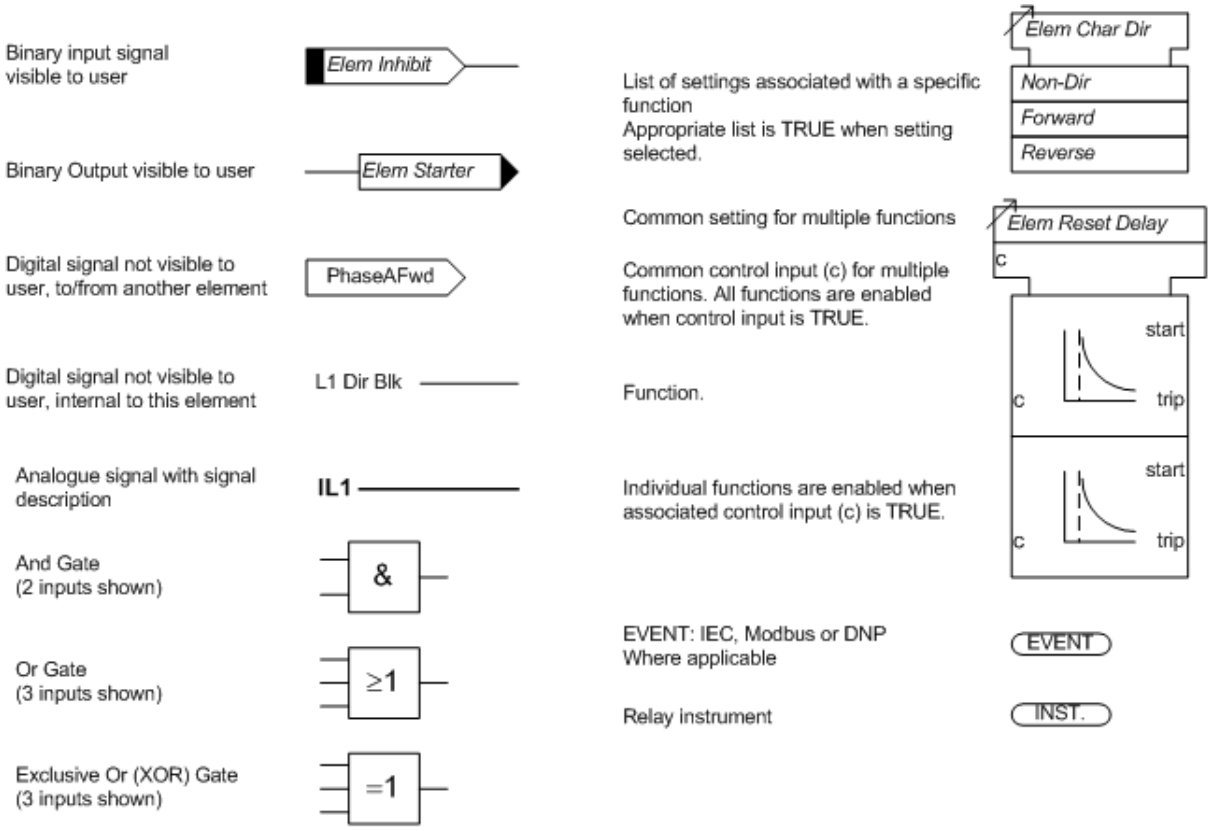
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Symbols and Nomenclature

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:

- 7SR105 Rho Motor Protection 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 7SR105 Rho Motor Protection Relay is developed by using the latest generation of hardware technology. 7SR105 is a member of Siemens Reyrolle® protection devices Rho product family.

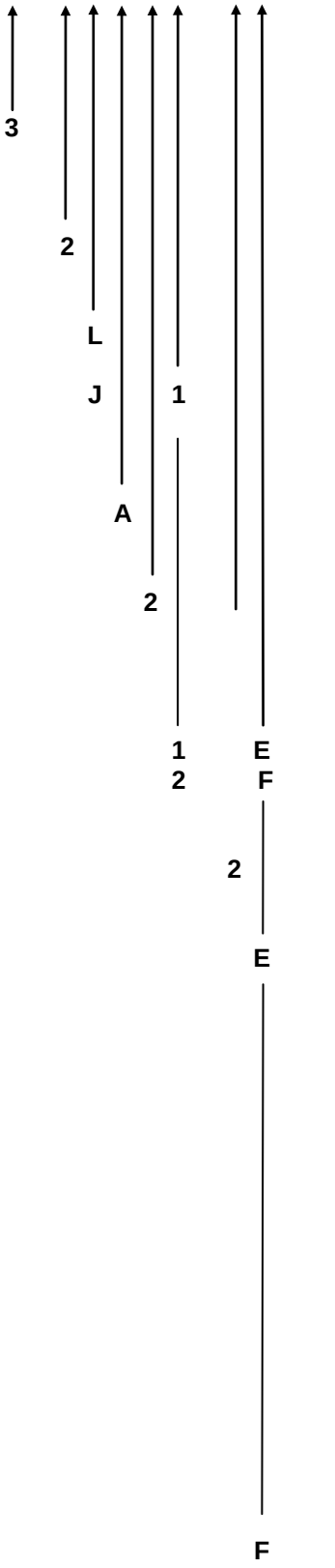
The 7SR105 Rho Motor Protection Relay is housed in a 4U high, size 4 non draw-out case and these relays provide protection, monitoring, instrumentation, and metering with integrated input and output logic, data logging and fault reports.

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.

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1.4 Ordering Options

Product description	Variants	Order No.
7SR105 Rho		**7 S R 1 0 5 □ - □ □□ □□ □□ - □ □ A 0**
Motor Protection Relay		



Case, I/O and Fascia
Size 4 Moulded case, 4CT, 6 Binary Inputs/ 6 Binary Outputs, 10 LEDs — **3**

Measuring input
1/5 A, 50 Hz — **2**

Auxiliary voltage
AC/DC 60-240V , Binary input threshold 44 V AC/V DC — **L**
DC 24-60 V, Binary input threshold 19 V DC — **J**

Protective Cover
Standard version – No Cover — **A**

Communication
Front Port : USB and Rear Port: RS-485 supporting IEC 60870-5-103 or Modbus RTU or DNP 3.0 — **2**

Temperature Input
Without RTD — **1**
6 RTD Input — **2**

Front Fascia
Standard Version – with Breaker Control Push Buttons — **2**

Protection Function Packages
Standard version - included in all models — **E**

14	Stall Protection
37	Undercurrent
46	Phase Unbalance Protection
46PhRev	Phase Reversal
48/66	Start Protection
49	Thermal Overload
50/51	Overcurrent
50/51, GN	Earth fault
50BCL	Break Capacity Limit
50BF	Circuit breaker fail
74T/CCS	Trip/Close circuit supervision
81B	Anti Backspin
CB	Counters
I^2T	CB Wears
Programmable Logic	

Standard Version Plus
Additional Function in Temperature Input version model — **F**

1.5 Functional Diagram

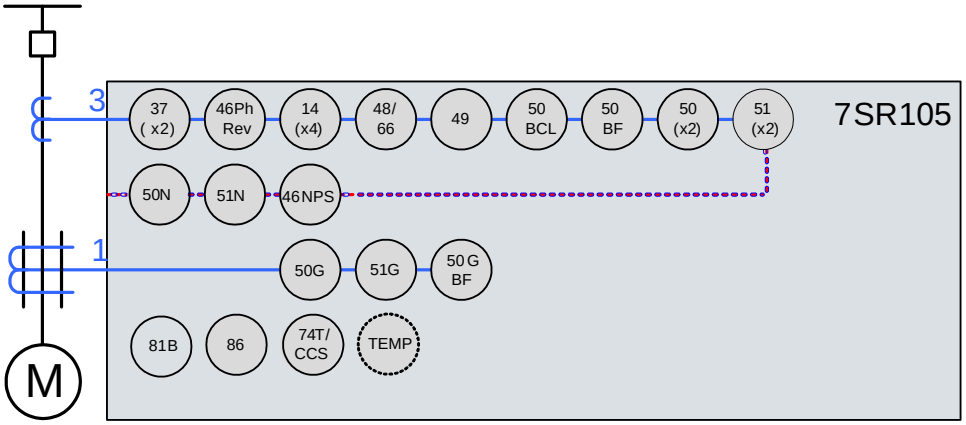


Figure 1-1 Functional Diagram of 7SR105 Rho Motor Protection Relay

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 BI, BO, communication, and power supply wire connections.

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

1.6.1 Terminal Diagram with Control Push Buttons

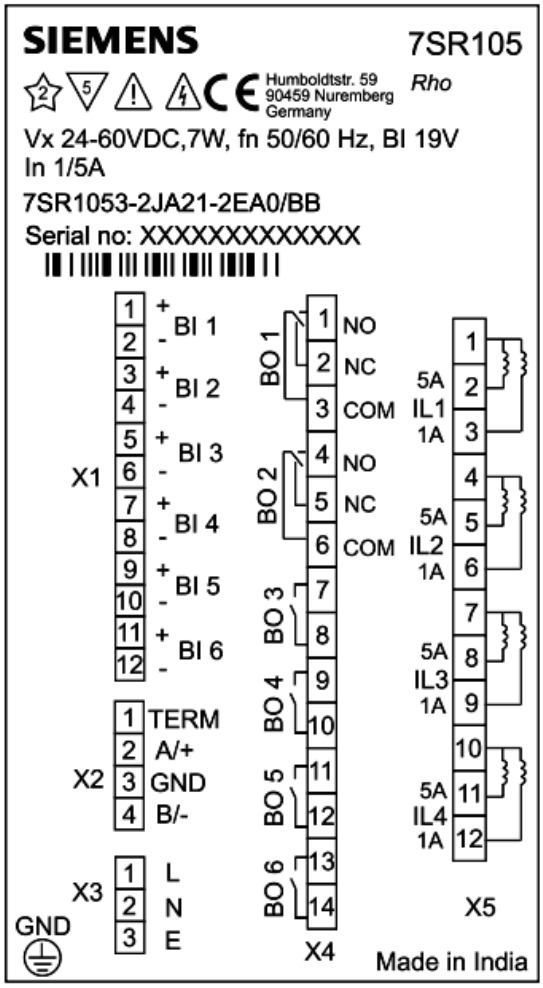


Fig 8. Terminal/Wiring Diagram View (Non RTD)

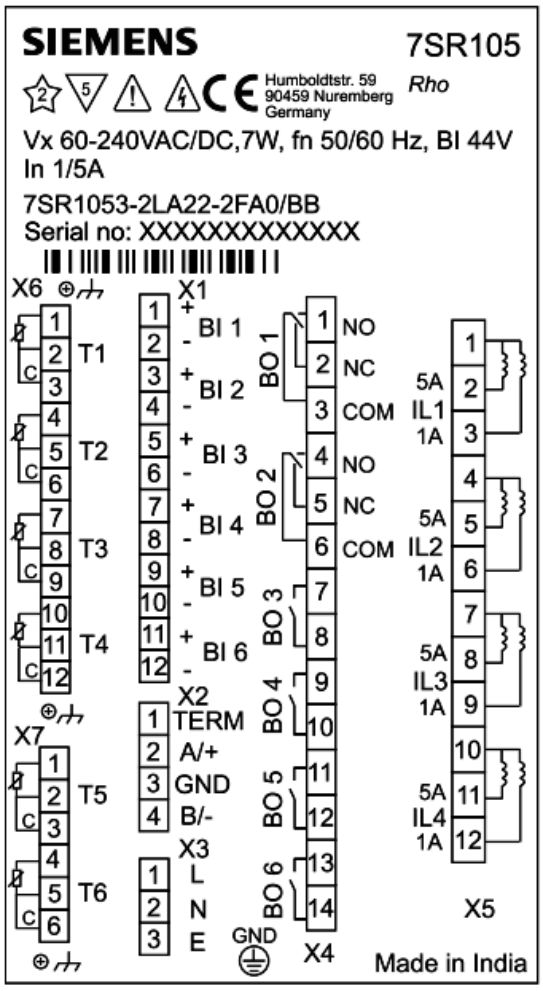


Fig 9. Terminal/Wiring Diagram View (RTD)

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 7SR105 Rho Motor Protection Relay Configurations

Relay	Current Inputs	Voltage Inputs	Binary Inputs	Binary Outputs	Temperature Inputs	LEDs
7SR1053-XXXX-2EA0	4	0	6	6	0	10
7SR1053-XXXX-2FA0	4	0	6	6	6	10

The 7SR105 Rho Motor Protection Relays are assembled from the following modules:

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

4 x Current (Terminal X5)
6 x Binary Input (Terminal X1)
6 x Binary Outputs (Terminal X4)

4. Communication and Power Supply module

RS485 (Terminal X2)
Power supply (Terminal X3)

5. Temperature Inputs

With control push buttons
6 x Temp Inputs (Terminal X6 and X7)

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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 7SR105 Rho Motor Protection Relay with control push buttons

2.3 Start Motor/Stop Motor

The Motor control function is used to manually start and stop the motor when it is connected to the network. Two dedicated push buttons are provided on the HMI to execute the motor manual start and stop operations.

Button	Function	Description
	**Start**	Press **Start** button and confirm **ENTER** to execute the start operation of motor.
	**Stop**	Press **Stop** button and confirm **ENTER** to execute the stop operation of motor.

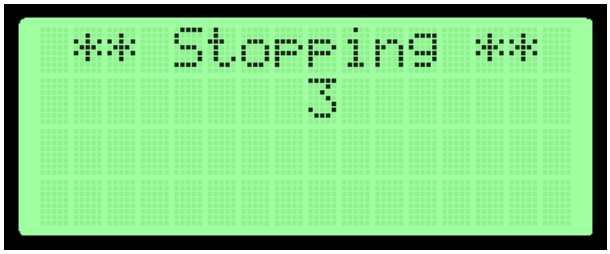
The user can configure the binary input, binary output, and LED configuration for the motor start and stop control functions.

To perform the motor start and stop control operations, follow the procedure given below:

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



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



5. The configured BO and LEDs for the **STOP MOTOR** control functions will operate.
6. Press **RESET** button to reset LED and BO states.

Repeat the same procedure for START MOTOR control logic operation.

NOTE:

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

NOTE:

If the operating mode of 7SR105 Rho Motor Protection Relay is “Remote”, the user can perform the Motor Start/Stop 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:

- 44 V AC/DC BI threshold available with 60 V - 240 V AC/DC power supply version
- 19 V DC BI threshold with 24 V - 60 V DC power supply version

The power supply module is equipped with 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.

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 7SR105 Rho Motor Protection 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.

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2.5.1 Connectors without Temperature Inputs

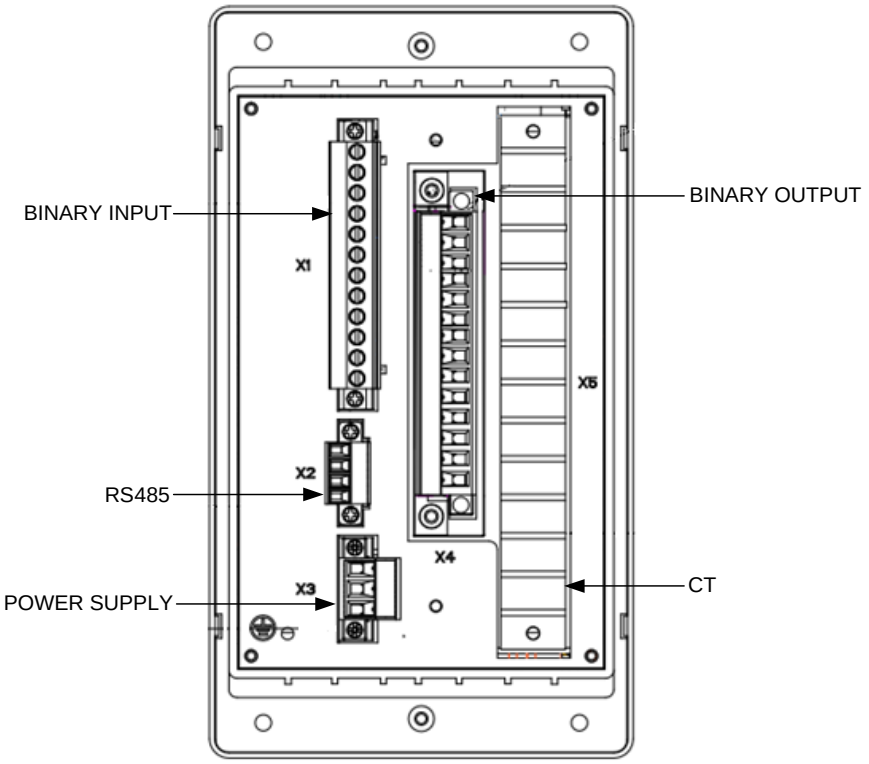


Figure 2-2 7SR105 Rho Motor Protection Relay Connectors without Temperature Inputs

2.5.1 Connectors with Temperature Inputs

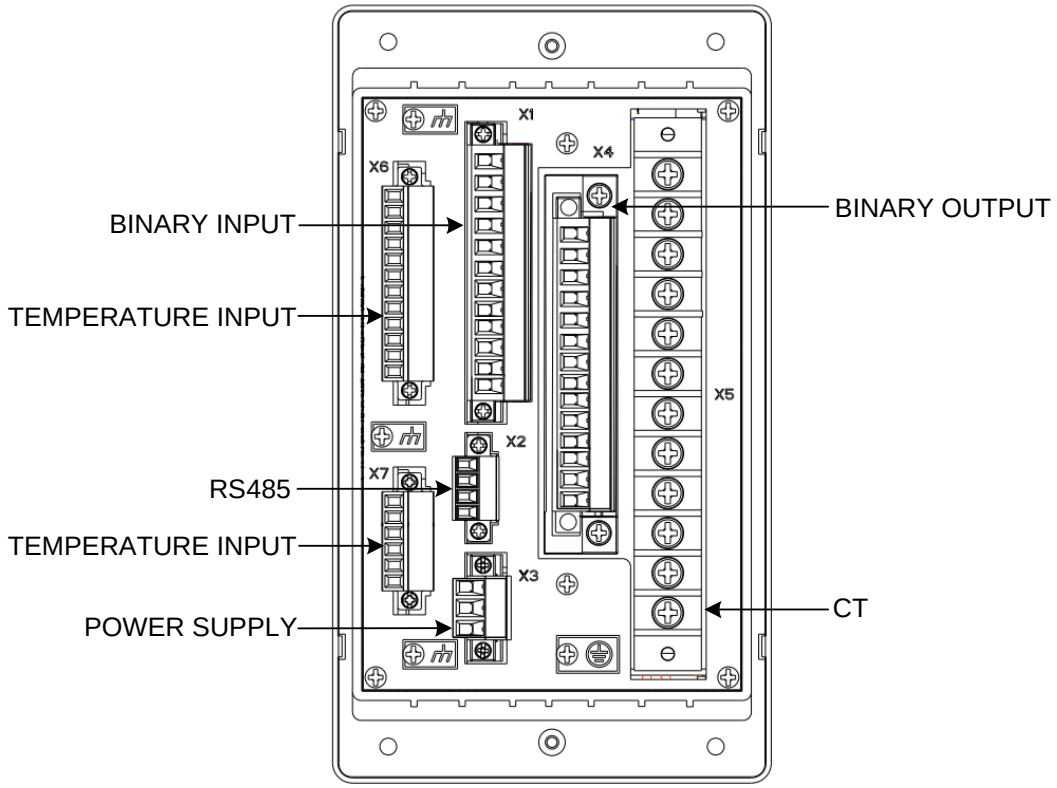


Figure 2-3 7SR105 Rho Motor Protection Relay Connectors with Temperature Inputs

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2.6 Relay Information

The rating label is located on the housing and provides more technical information about the 7SR105 Rho Motor Protection Relay.

Relay Information

The rating label contains the following product Information:

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



Figure 2-4 Relay Rating Label

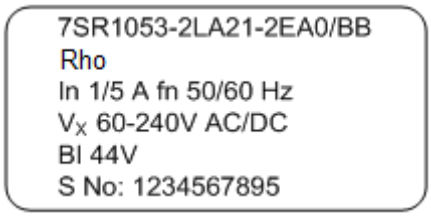


Figure 2-5 Fascia Relay Rating Label

For safety reasons, the following symbols are displayed on the label.

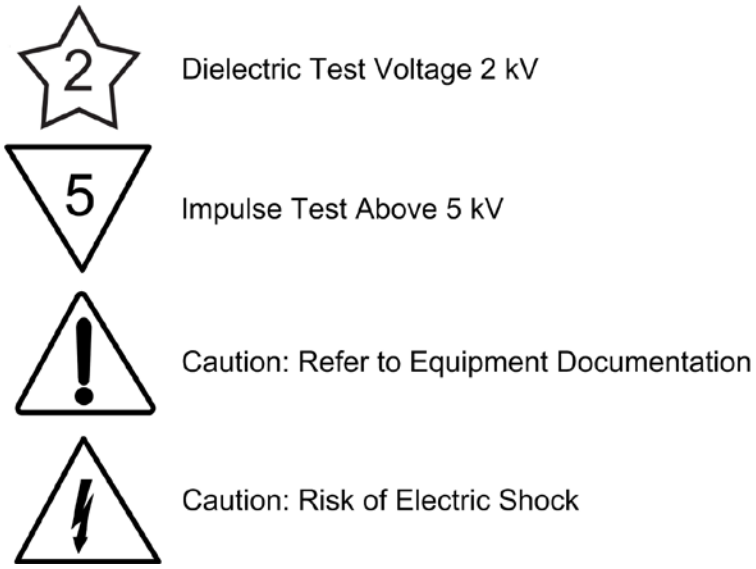


Figure 2-6 Safety Symbols

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 2-7 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.

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2.7.3 Standard Keys

The relay is supplied as standard with five 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.
START	Used to start the motor
STOP	Used to stop the motor

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, orange, 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.

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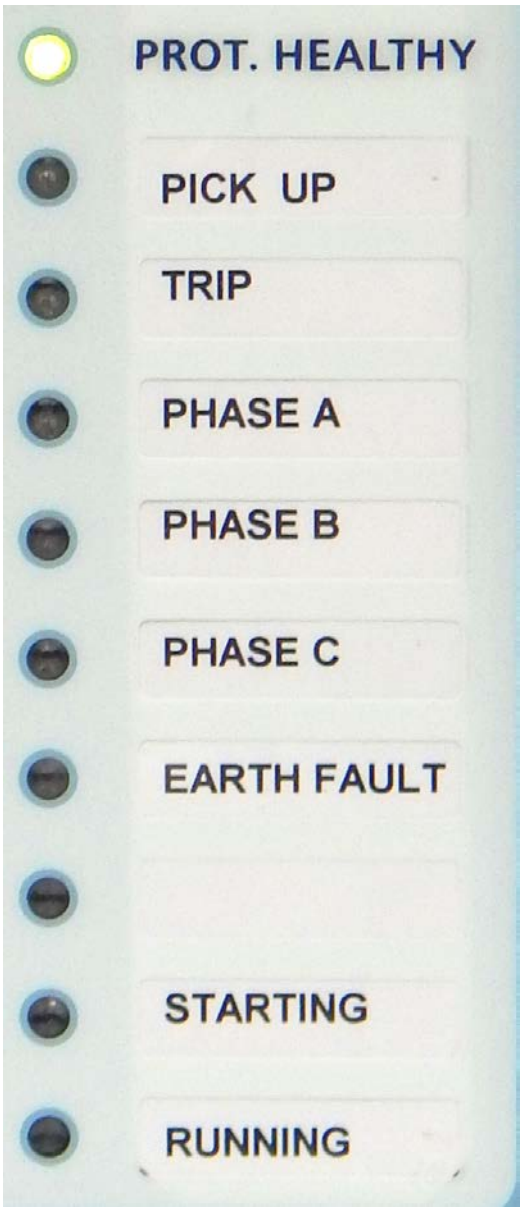


Figure 2-8 LED Indication Label

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.

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2.9 Binary Inputs

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

Relays are fitted with 6 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.

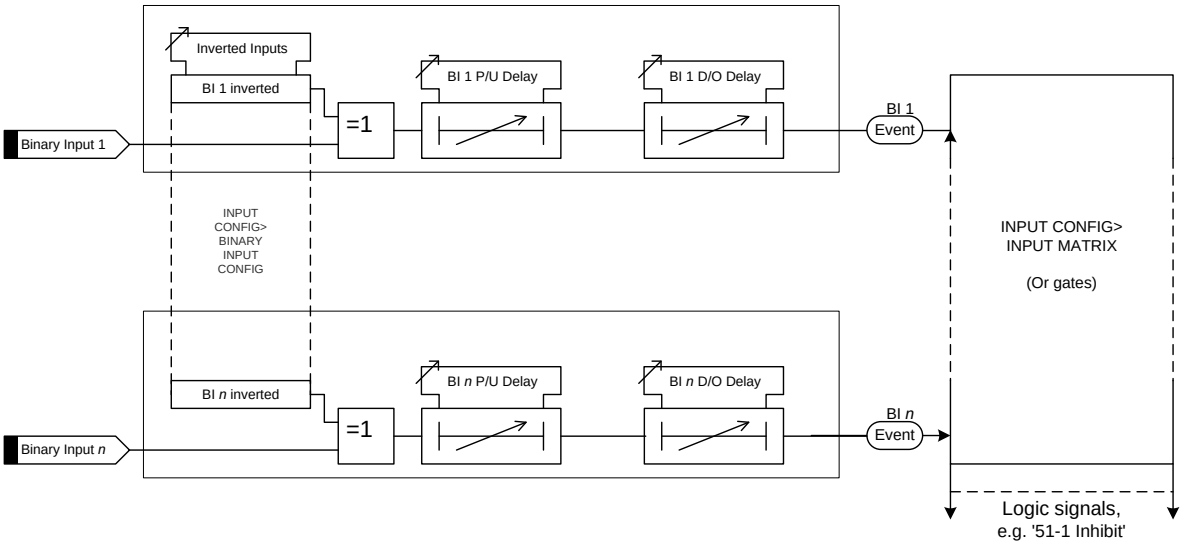


Figure 2-9 Binary Input Logic

2.10 Binary Outputs (Output Relays)

Relays are fitted with 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

Self reset operation has a minimum reset time of 100 ms.

With a failed breaker condition, the relay may remain operated until current flow is interrupted by an upstream device. When the current is removed, the relay will then reset and attempt to interrupt trip coil current flowing via its output contact. 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.

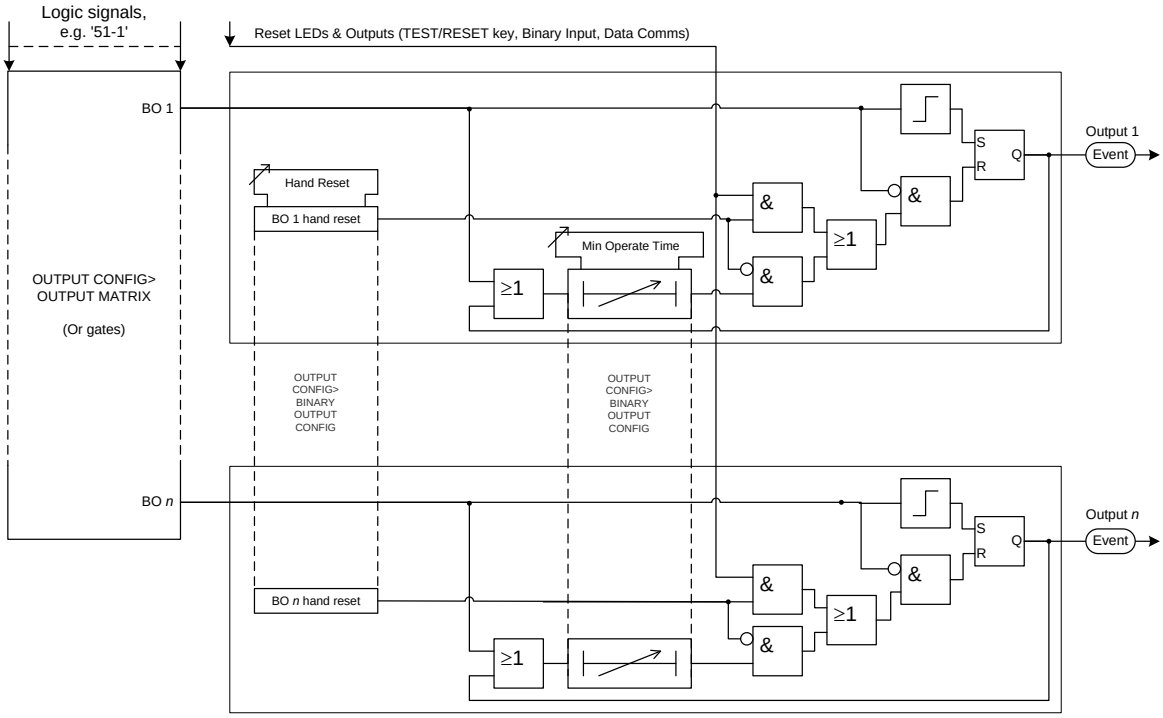


Figure 2-10 Binary Output Logic

2.11 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.

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Motor resistance temperature detectors (RTDs) can be connected via temperature inputs. Up to six RTD sensors can be monitored. Provision to configure seven types of RTD inputs (for 3 wire configuration). Temperature inputs can be configurable for RTD Alarm and Trip application.

2.12 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.



Figure 2-11 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:

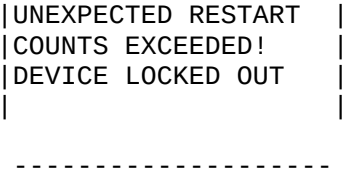


Figure 2-12 Unexpected Restarts Lockout Text

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.

2.12.1 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.

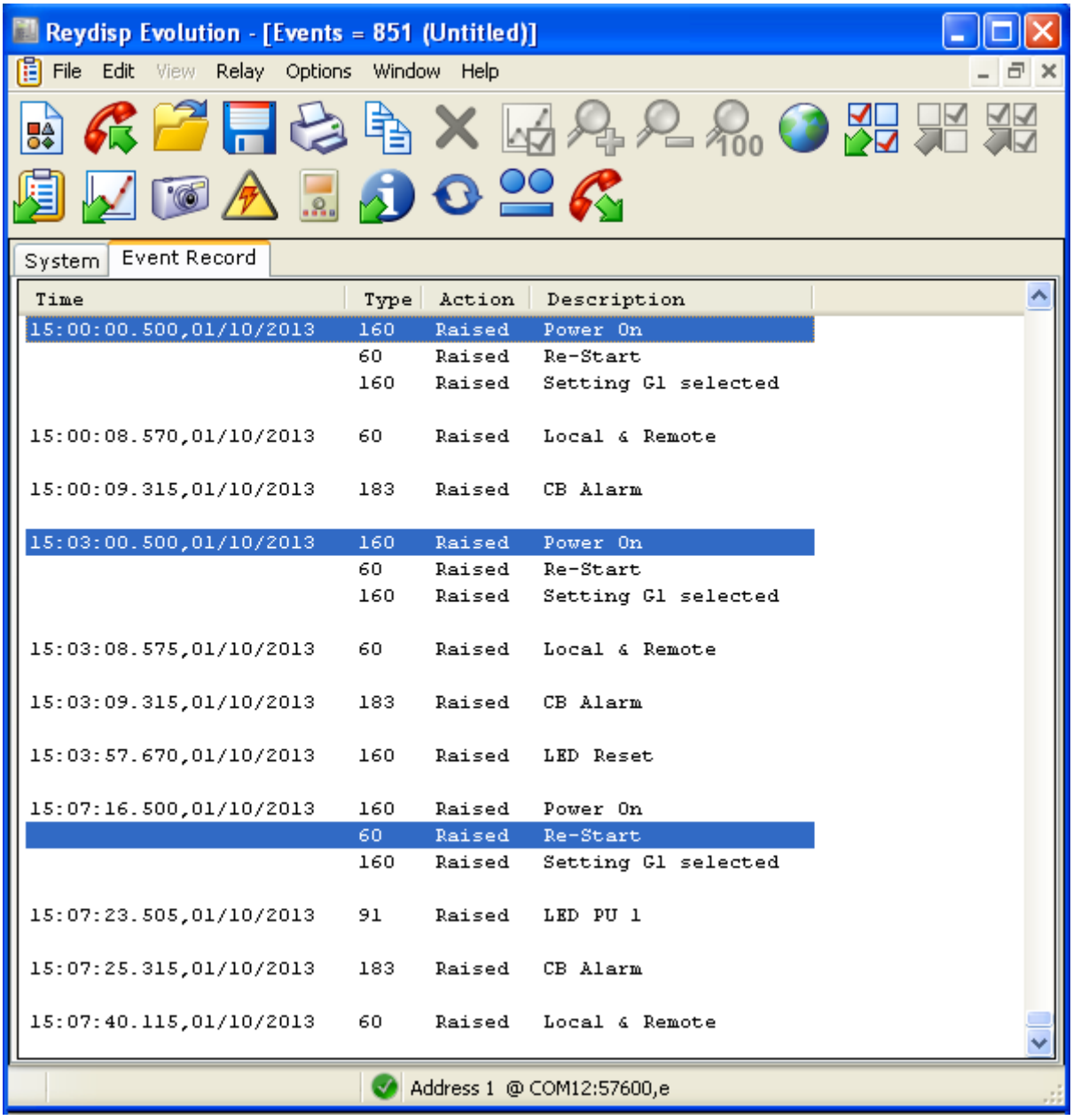


Figure 2-13 Start-up Events

Section 3: Protection Functions

3.1 THERMAL PROTECTION

To prevent overheating of the motor thermal overload protection is used to remove the motor supply when a nominated thermal state (θ) is reached.

The thermal overload function uses measured 3-phase true RMS current to estimate the thermal state of the motor. The Thermal State (θ) is based on both past and present current levels. θ = 0% for unheated equipment, and θ = 100% for maximum thermal state of equipment i.e. the trip threshold. For given current level, the Thermal State will ramp up over time, dependent on the thermal time constant, until Thermal Equilibrium is reached when Heating Effects of Current = Thermal Losses.

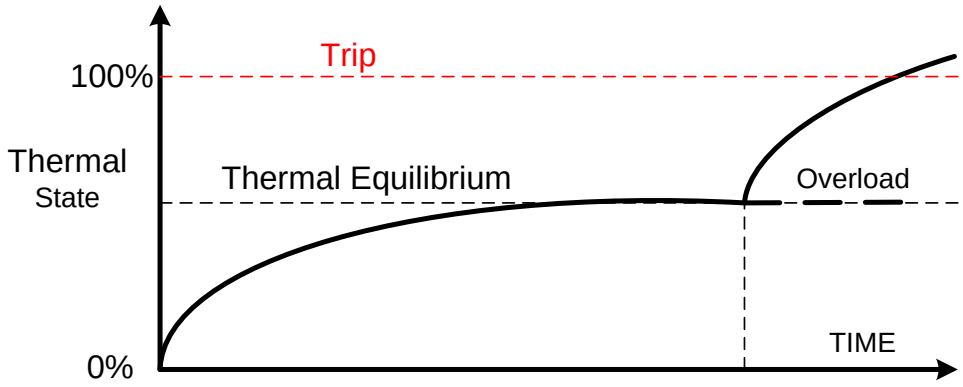


Figure 3.1-1 Thermal Overload Heating and Cooling Characteristic

The NPS component of unbalanced current has a greater heating effect on the motor than the PPS current component. An NPS component can be included within an 'equivalent thermal current' (I_{EQ}) used in the thermal overload algorithm. The NPS weighting factor K can be used to increase overload protection sensitivity to NPS current.

The thermal model accommodates both heating and cooling conditions with exponential curves as illustrated below:

For the heating curve: $$\theta = \frac{I_{EQ}^2}{I_\theta^2} \cdot (1 - e^{\frac{-t}{\tau}}) \times 100\%, \text{ or, } t(\text{mins}) = \tau \times \ln\left(\frac{I_{EQ}^2}{I_{EQ}^2 - I_\theta}\right)$$

For the cooling curve: $$\theta = \theta_F \times e^{\frac{-t}{\tau}} \quad or \quad t = \tau . \ln \frac{\theta}{\theta_F}$$

The time constant of the thermal protection is dependent on the operate state of the motor i.e. whether it is starting, running or stopped. Three values of thermal time constant are used during the different states of motor operation – see **Table 3-1**

Table 3-1 Application of Thermal Time Constants

Gn 49 TauH (mins)	*Heating Time Constant:* Used during normal motor running conditions and overloads.
Gn 49 TauS (mins)	*Starting Time Constant:* Multiple of heating time constant takes into consideration the reduced cooling available when the motor is running up to full speed.
Gn 49 TauC (mins)	*Cooling Time Constant:* Multiple of heating time constant takes into consideration the reduced rate of cooling of a stopped motor.

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

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

The Hot/Cold ratio setting determines the percentage of thermal capacity available for a motor running at thermal equilibrium compared to that available when the motor is cold.
The thermal model is modified under normal load conditions (i.e. when $I_{EQ} < I_\theta$) by multiplying the predicted final steady thermal state by (1-H/C). The hot curve is modified as below:

$$\theta_F = \frac{I_{EQ}^2}{I_\theta^2} \times (1 - H/C) \times 100\%$$

The hot to cold ratio (H/C) in the above "hot" equation is used to adapt the thermal model to incorporate the thermal over design of motors to withstand start conditions rather than normal running conditions.

The thermal protection menu structure of the relay includes sub-menus for thermal overload, stall, start and phase unbalance functions. Settings common to all of thermal functions are:

Gn 49 NPS Weighting: When set to Average the average true RMS current of the three phases is used as I_{EQ}. When set to Sequence Components the pps and nps current of the rated frequency are used to calculate I_{EQ}.

Gn 49 NPS Weighting Factor (K): Applied when above is set to Sequence Components.

Gn 49 Itheta Thermal Overload sets the overload pick up level (I_θ).

Gn 49 Motor Start Type sets the criteria for determining that the motor has started. Defined by:

%Itheta: Current above 'Gn 49 Motor Start Current', or

Operation of a binary input configured as 'Start Motor I/P' (requires CB open/closed monitoring connections).

(Note that a motor running condition is recognised by the relay when current increases from the 'motor stopped' level to a 'NOT motor stopped' level. For a VFD motor the running condition will be recognised where the start current is not appreciably greater than the running current.

Gn 49 Motor Start Current sets the current level over which the motor has deemed to have started.

Gn 49 End of Start selects whether this is determined by measured current level or from an energised binary input set as 'Motor Running'.

Gn 49 Motor Stop Current sets the current level under which the motor has deemed to have stopped. Motor stop condition is detected on the basis I_{EQ} current.

Gn 49 Motor Stop Type sets the criteria for determining that the motor has stopped. Defined by:

% Itheta: Current below 'Gn 49 Motor Stop Current' AND Gn 49 Motor Stop Delay

% Itheta + CB Open: Current below 'Gn 49 Motor Stop Current' AND 'CB Open' binary input AND Gn 49 Motor Stop Delay.

% Itheta + No Accel: Current below 'Gn 49 Motor Stop Current' AND BI programmed to 'No Accel' energised.

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3.1.1 Thermal Protection: Overload (49)

Where *Gn 49 NPS Weighting* setting is selected to 'Average' the thermal protection uses the average of the three RMS phase currents.

Where *Gn 49 NPS Weighting* setting is selected to 'Seq Comp' the relay calculates the positive and negative phase sequence components from the three phase currents. These are then used to generate an equivalent thermal current I_{EQ} which replaces the relay current in the IEC60255-8 operating characteristics. The equivalent current is defined as follows:

$$I_{EQ} = \sqrt{I_1^2 + KI_2^2}$$

Where K = *Gn 49 NPS Weighting Factor* setting.

Hot and Cold Operating Characteristics

When the thermal equivalent current is less than the thermal pickup level the relay uses the hot curve with which to calculate the thermal capacity used. If the Thermal Equivalent current exceeds the thermal pickup setting, i.e. when the motor is overloaded, then the relay reverts to cold curve.

'Cold' Operating Characteristic

In the 7SR105 Rho the ***49 Overload*** setting (I_θ) replaces $k.I_B$ found in the expressions of the IEC255-8 standard and the 'Cold' operating characteristic becomes:

$$t = \tau \times \ln\left[\frac{I^2}{I^2 - I_\theta^2}\right]$$

'Hot' Operating Characteristic

The time to trip is defined as:-

$$t = \tau \times \ln\left[\frac{I^2 - I_P^2}{I^2 - I_\theta^2}\right]$$

Gn 49 Char (Thermal Characteristic)

The IEC thermal characteristic of the Rho conforms to IEC60255-8 (Thermal Electrical Relays).

A user definable thermal curve is available to allow matching of the relay thermal characteristic to all motor and cooling system types.

'Starting' and 'cooling' constants modify the thermal heating time constant during motor run-up and stopped conditions.

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,

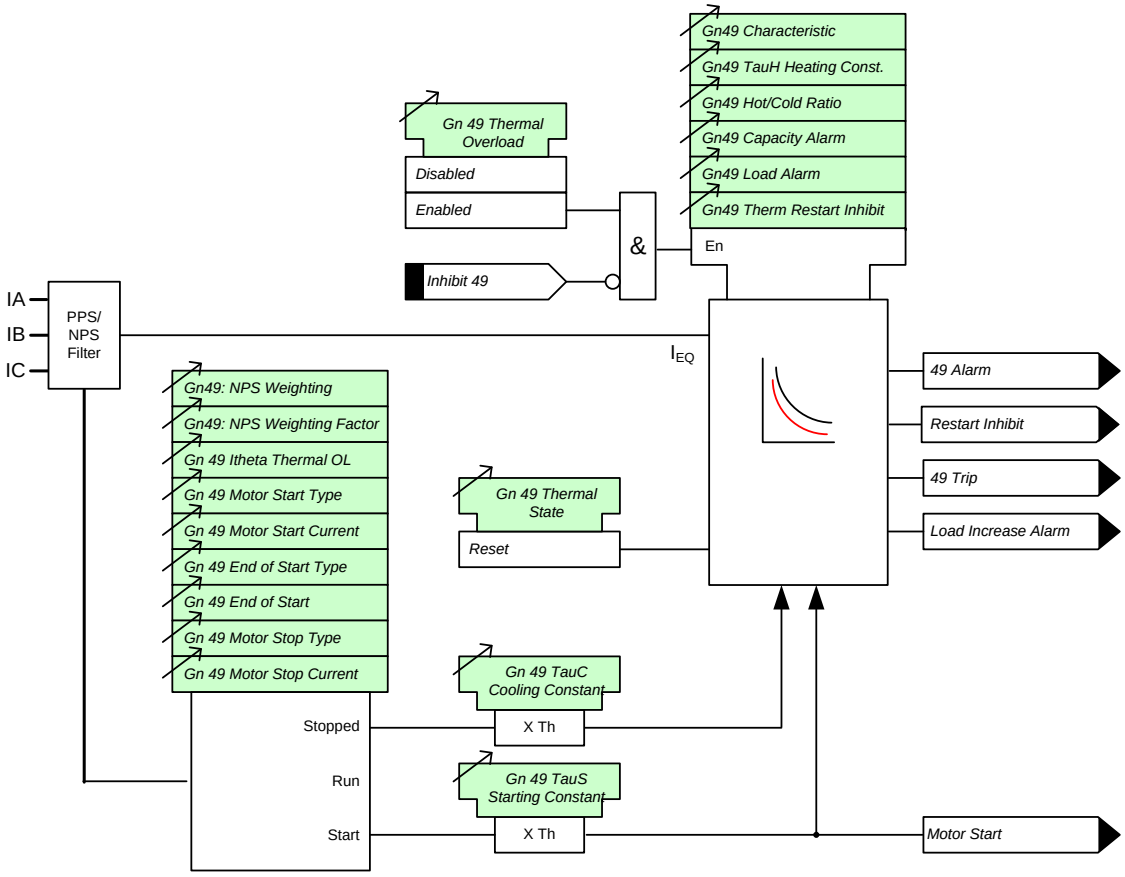


Figure 3-2 Logic Diagram: Motor Thermal Overload Protection (49)

Gn 49 TauH Heating Constant (Heating Time Constant)

Used during normal motor running conditions and overloads.

Gn 49 TauS Starting Constant

Multiple of heating time constant takes into consideration the reduced cooling available during motor starting.

Gn 49 TauC Cooling Constant

Multiple of heating time constant takes into consideration the reduced rate of cooling of a stopped motor.

Gn 49 Hot/Cold Ratio

The hot/cold ratio setting determines the percentage of thermal capacity available for a motor running at full load current compared to that available when the motor is cold. It modifies the IEC255-8 hot curve as below:

$$t = \tau . ln \frac{I^2 - (1 - \frac{H}{C}) I_P^2}{I^2 - I_\theta^{\ 2}}$$

Where;

H/C = hot spot weighting factor = ***49 Hot/Cold Ratio*** setting

A setting is available to switch this feature out of service, however this Hot/Cold ratio setting will normally be used on all motors as it will assist with the accuracy of the thermal modelling. The hot curve is only operational when

the equivalent thermal current calculated by the relay is less than the thermal pickup setting. Once the equivalent thermal current exceeds the thermal pickup setting the relay operates on the Cold thermal curve.

The purpose of the H/C ratio is to allow for the fact most motors are designed thermally to withstand the onerous starting conditions rather than the running conditions. This leads to the fact the motors will tend to run at a much lower temperature than their insulation class allows when thermal equilibrium is reached

The thermal algorithm uses 'hot' and 'cold' curves, it also uses alternate time constants during different phases of motor operation, to summarise:

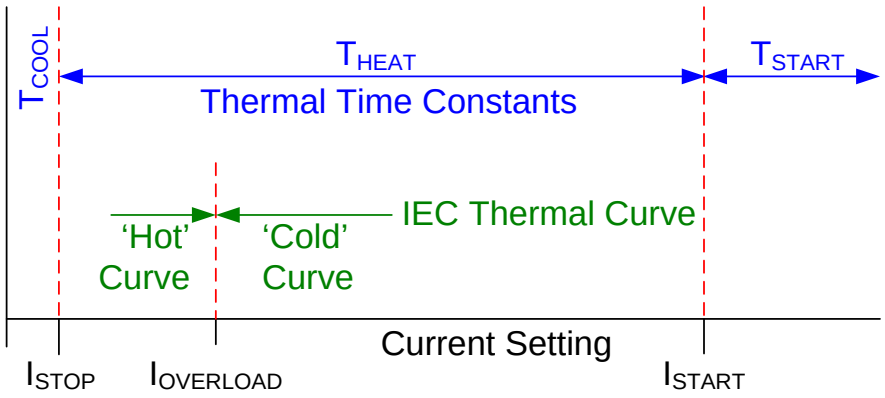


Figure 3.1-3 Application of Thermal Overload Time Constants

Gn 49 Capacity Alarm

An alarm can be given if the thermal state of the system exceeds a specified percentage of the protected equipment's thermal capacity setting. This can be used to warn the operator that a relay thermal trip will occur if this level of motor current continues.

Gn 49 Load Alarm

An alarm is available to provide warning of a sudden increase in load. The ***Load Increase Alarm*** setting is set as a multiple of the thermal overload setting I_θ.

Gn 49 Overload Alarm

An instantaneous alarm output is given if the equivalent thermal current I_e exceeds the thermal overload setting I_θ whilst the motor is in it running state.

Gn 49 Restart Inhibit Mode

The restart inhibit feature can be assigned to an output contact which can be used to prevent the motor from being started until sufficient thermal capacity is available. A normally closed contact can be connected in the motor starting circuit, thus breaking the circuit when the restart inhibit feature registers thermal state available.

A user thermal capacity value can be used (***Gn 49 Thermal Restart Inhibit* setting).** Alternatively this can be set 'Auto' the relay then uses the value recorded from the previous start plus 15% safety margin.

Gn 49 Thermal Restart Mode

When 'Restart Inhibit Mode' is set to Auto then the motor restart can be inhibited until the relay determines that sufficient time or capacity or capacity + time is available to allow the start.

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Gn 49 Restore After Power Down

Where enabled the relay will indicate the thermal state prior to auxiliary supply removal when the auxiliary supply is re-applied. When disabled the relay thermal state will be reset (0%) when the auxiliary supply is re-applied.

3.1.2 Thermal Protection: Stall Protection (14)

Stall protection can be applied where the thermal characteristic does not offer sufficient protection against stalling during running or during a locked rotor condition on starting.

Pick up is initiated when any phase current is above ***Gn 14-n Setting***

Gn 14-n Delay is initiated when the measured current exceeds the ***Gn 14-n Setting***

The time delayed overcurrent elements are enabled for the following 'Control' criteria:

Gn 14-n Control = None: Element operation begins when current exceeds Gn 14-n setting.

Gn 14-n Control = Stopped: When the relay has determined a motor stopped condition this control is latched for the period where the current increases from Istopped for the time until the current falls below the Gn 14-n setting level. Element operation begins when current exceeds Gn 14-n setting

Gn 14-n Control = No Accel: A tachometric 'zero speed' switch mounted on the rotor shaft can be used to identify that the motor is not running up to speed. A relay binary input programmed to 'No Accel' can be connected to this switch. Element operation begins when current exceeds Gn 14-n setting and the relay has determined that the motor is not starting.

Gn 14-n Control = Running: Element operation begins when current exceeds Gn 14-n setting and the relay has determined a motor running condition. See section 3.1.

Operation of the stall elements can be inhibited from:

Inhibit 14-n A binary or virtual input

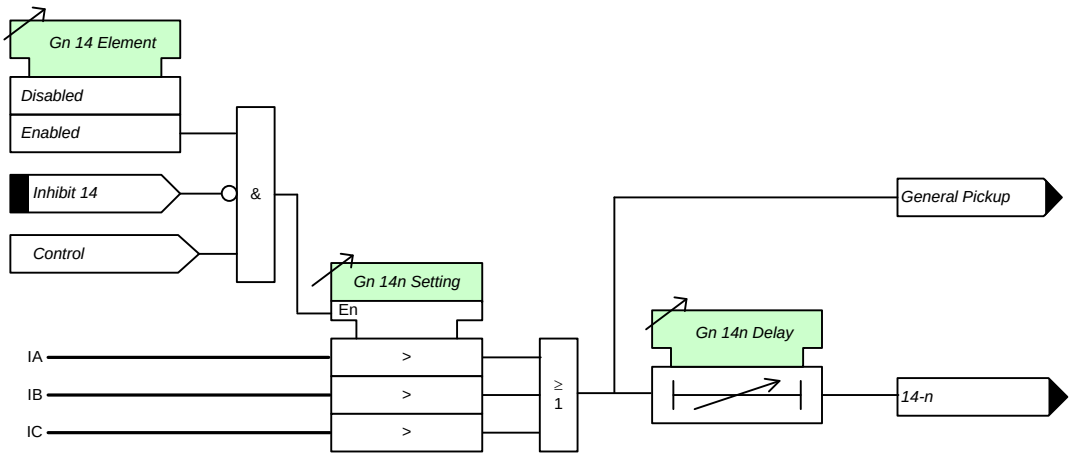


Figure 3-4 Stall Protection (14)

3.1.3 Thermal Protection: Start Protection (48, 66)

A motor start is detected as described in section 3.1.

3.1.3.1 Number of Starts (66)

This feature is used where plant or motor operational constraints are to be considered or to ensure that permitted winding temperatures are not exceeded.

Gn 66 Max. Number of Starts setting allows the user to select the maximum permissible number of starts Once the maximum permissible number of starts has occurred within the defined period then starting is inhibited for the duration of the start inhibit delay setting.

Gn 66 Max. Starts Period setting is the minimum time interval within which the assigned number of starts may occur (e.g. starts per hour for a notching or jogging device.

Gn 66 Start Inhibit Delay setting: Where the number of starts has been exceeded within the 'max starts period' starting is inhibited until this time delay has elapsed.

Gn 66 Time Between Starts setting is provided to determine the minimum permissible time between two consecutive starts.

Gn 66 Restore After Power Down setting: Where enabled the number of motor starts recorded to the relay powering down is restored when the relay is powered up again.

A restart is inhibited by the same output contact used for the thermal restart inhibit feature. The restart inhibit output is only energised after the motor has stopped (current falls below I_{STOP}) so that the start sequence in progress is not interrupted.

A 'Start Protection Reset' command is available in the 'Maintenance Menu' which allows the user to reset both the Number of Starts and the Minimum Time Between Starts features.

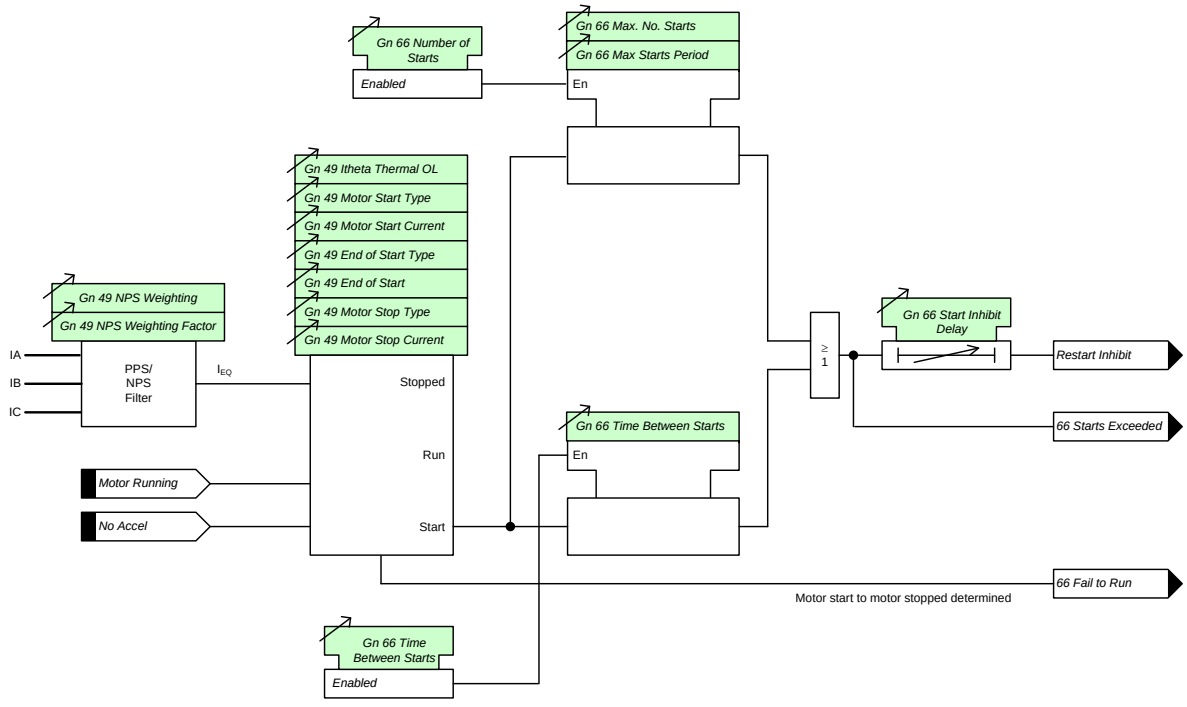


Figure 3-5 Number of Starts Protection (66)

3.1.3.2 Start Time Supervision (48)

An output can be provided where the motor start time is too long i.e. where the start time exceeds the ***Gn 48-n Delay*** setting.

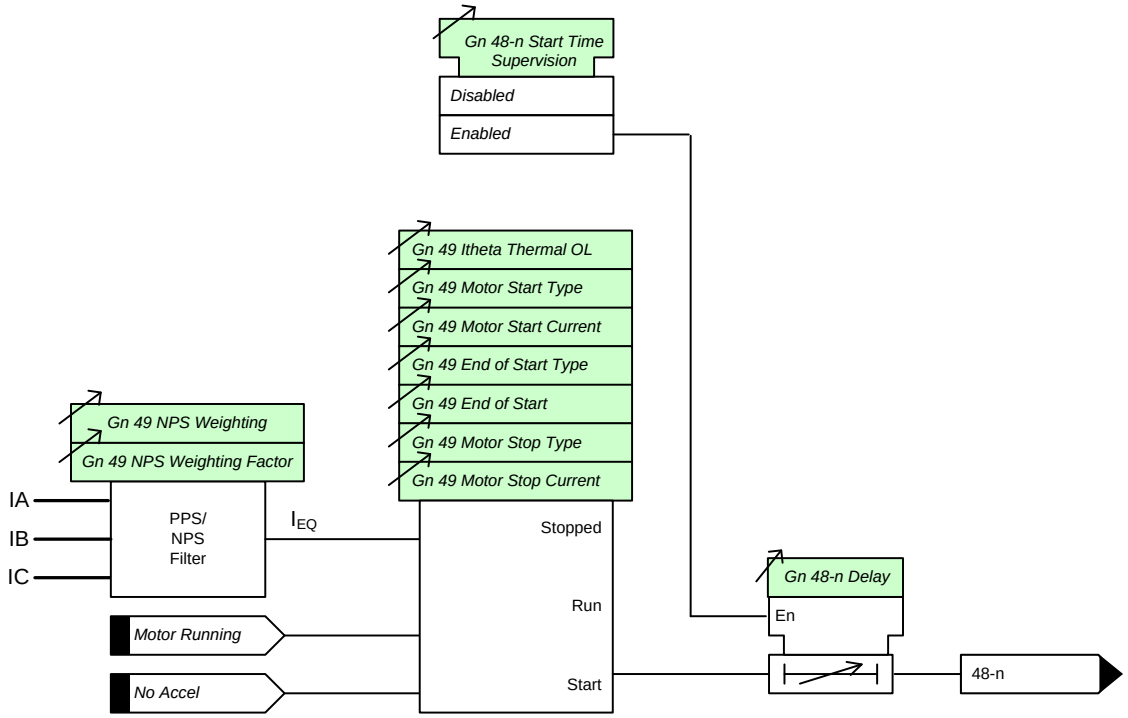


Figure 3-6 Start Time Supervision (48)

3.1.4 Thermal Protection: Phase Unbalance (46)

This provides separate protection for the conditions of phase unbalance, loss of phase and reverse phase sequence. When enabled this feature can be programmed to operate either as a magnitude difference protection or as a negative phase sequence (NPS) overcurrent protection.

Gn 46 Type Setting determines the method of phase unbalance protection to be used - either NPS or magnitude difference.

Gn 46 Setting sets the pick-up level for the element.

Gn 46 Characteristic Setting allow the user to select the operate characteristic to either inverse or definite time lag.

Gn 46 Time Mult Setting

Gn 46 Delay (DTL) Setting is used to define the minimum operate time for the protection characteristic.

Gn 46 Min Operate Time Setting

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

Inhibit 46 A binary or virtual input

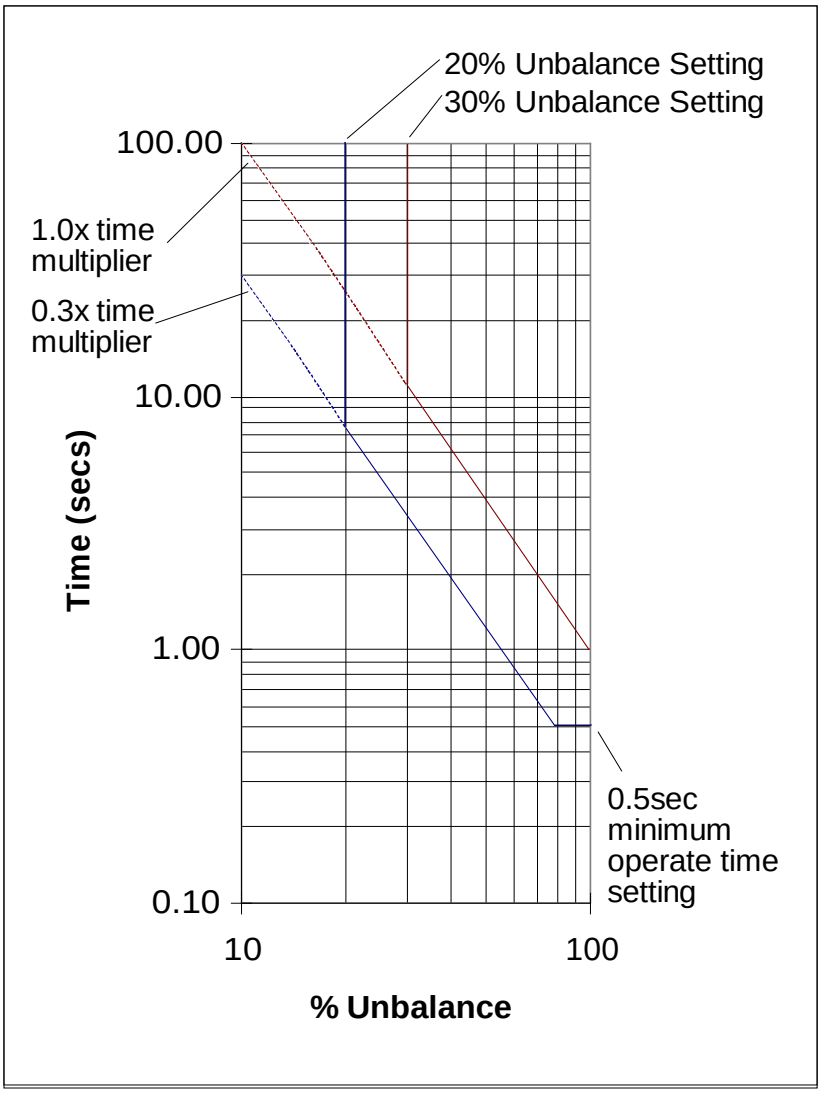


Figure 3-7 Inverse Time Characteristic for Unbalance Protection

3.1.4.1 Negative Phase Sequence

If negative phase sequence (NPS) protection is the selected method of phase unbalance protection then the NPS component derived from the three phase input currents is used.

The operate equation for inverse time characteristic shown in Figure 3-7 is implemented as:

$$t = \frac{1}{\left(\frac{I_2}{I_\theta}\right)^2} \times t_m$$

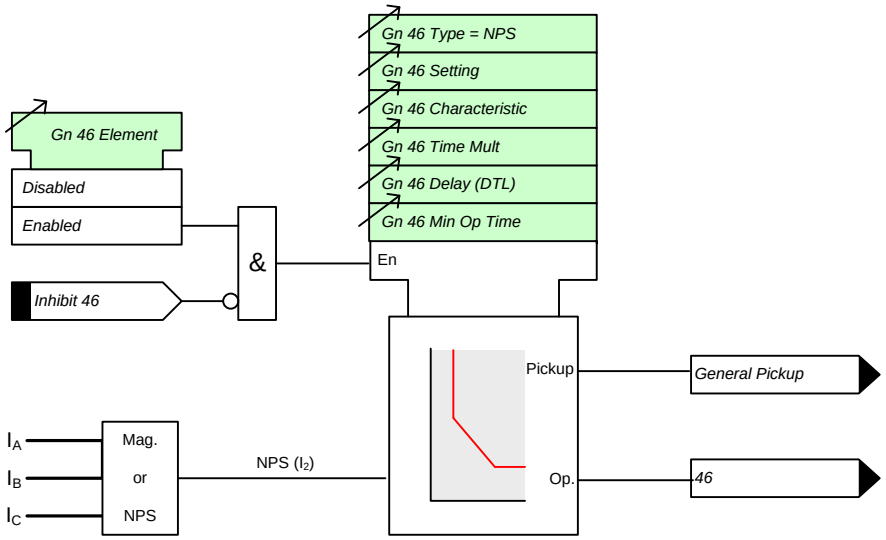


Figure 3-8 Logic Diagram : NPS Phase Unbalance (46NPS)

3.1.4.2 Magnitude Difference Protection

If magnitude difference protection is selected as the method of phase unbalance protection the relay calculates the magnitude difference relative to the thermal overload setting as follows:

$$\text{Percentage Unbalance} = \frac{I_{\Delta}}{I_{\theta}} \times 100\%$$

The operate equation for inverse time characteristic shown in Figure 3-7 is implemented as:

$$t = \frac{1}{\left(\frac{I_{\Delta}}{I_{\theta}}\right)^2} \times t_m$$

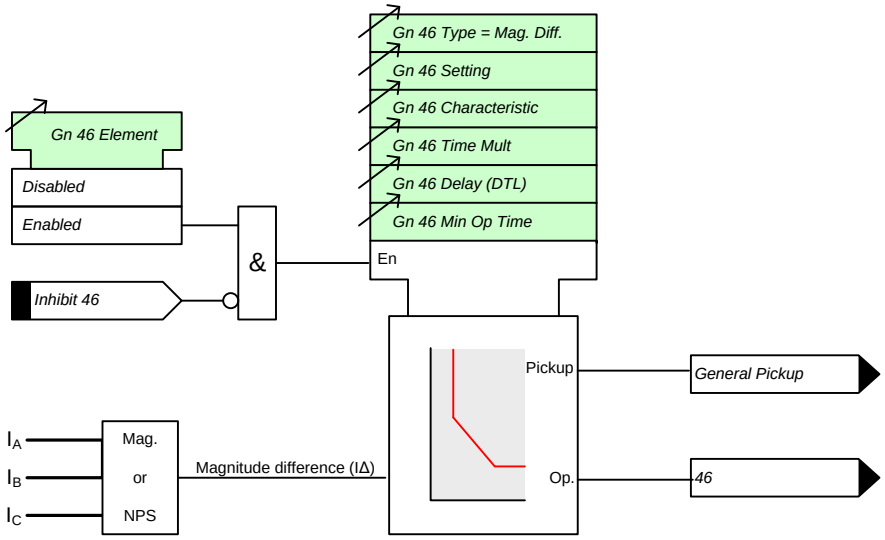


Figure 3-9 Logic Diagram: Phase Difference Phase Unbalance (46PD)

3.2 CURRENT PROTECTION: UNDERCURRENT (37)

Two rms measuring under-current elements are provided.

Each phase has an independent level detector and current-timing element. ***Gn 37-n Setting*** sets the pick-up current. An output is given after elapse of the ***Gn 37-n Delay*** setting.

Operation can be selected for any phase or all phases using ***Gn 37-n Start Option***

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

Inhibit 37-n A binary or virtual input

Gn 37-n U/C Guarded Operation of the undercurrent guard function

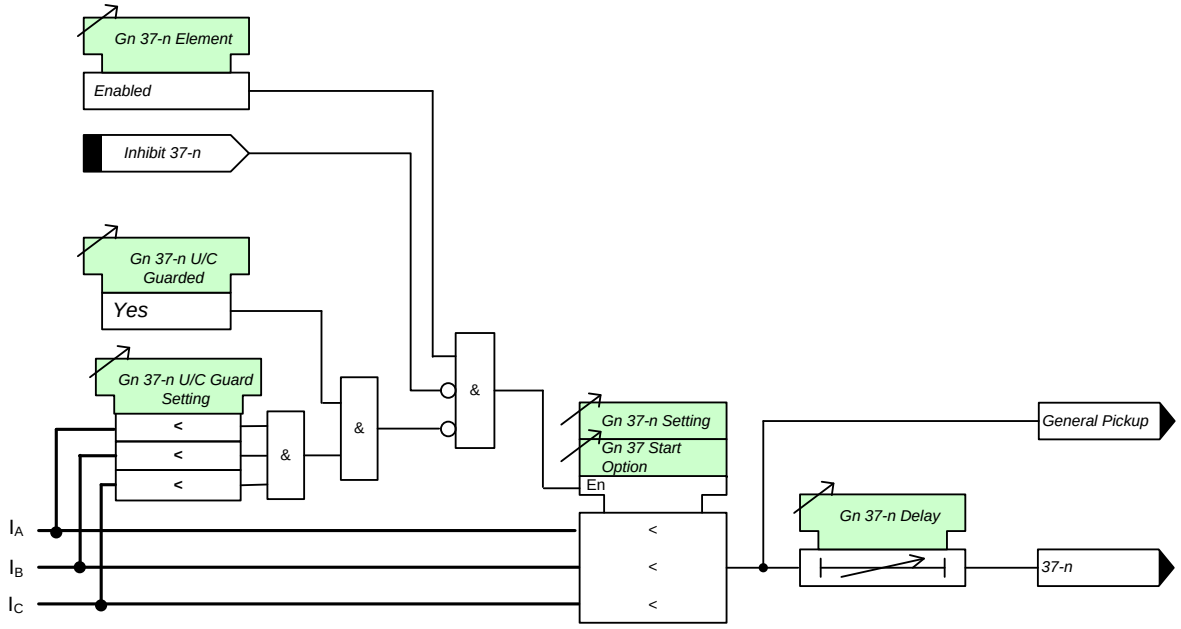


Figure 3-10 Logic Diagram: Undercurrent Detector (37)

3.3 Current Protection: Phase Overcurrent (50, 51)

All phase overcurrent elements have a common setting for the 50 elements and 51 elements to measure either the 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

3.3.1 Instantaneous Overcurrent Protection (50)

Two Instantaneous overcurrent elements are provided in the 7SR105 Rho Motor Protection Relay.

50-1, 50-2

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

Operation of the instantaneous overcurrent elements can be inhibited from:

Inhibit 50-n A binary or virtual input.

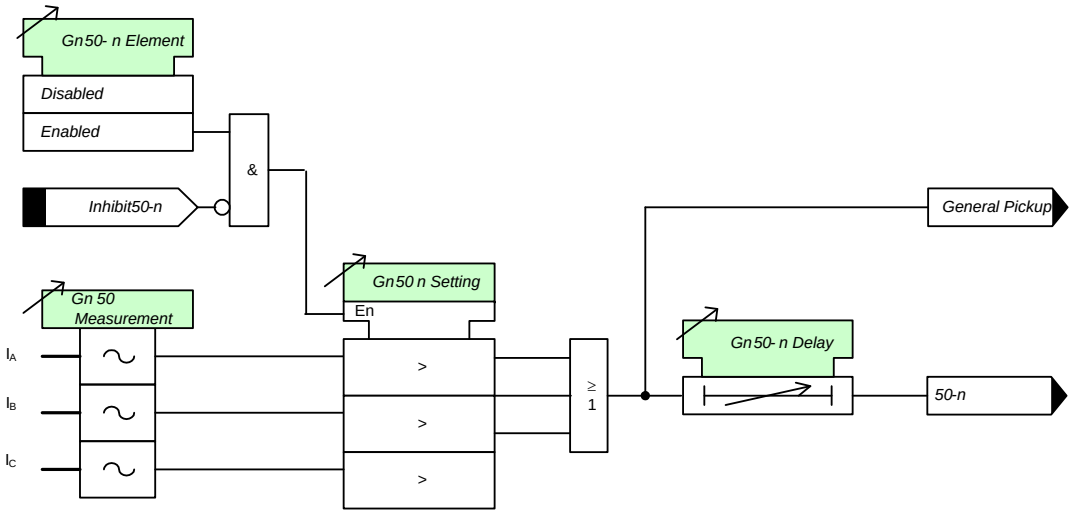


Figure 3-11 Logic Diagram: Instantaneous Overcurrent Element

3.3.2 Time Delayed Overcurrent Protection (51)

Two time delayed overcurrent elements are provided in the 7SR105 Rho Motor Protection Relay.

51-1, 51-2

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

A number of shaped characteristics are provided. An inverse definite minimum time (IDMT) characteristic is selected from IEC, ANSI 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***. Alternatively, a definite time lag (DTL) is selected the time multiplier is not applied and the ***51-n Delay (DTL)*** setting is used instead.

The **51-n Reset** setting can apply a **definite time delayed** reset, or when the operation is configured as an IEC or ANSI 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.

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

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

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

Inhibit 51-n A binary or virtual input.

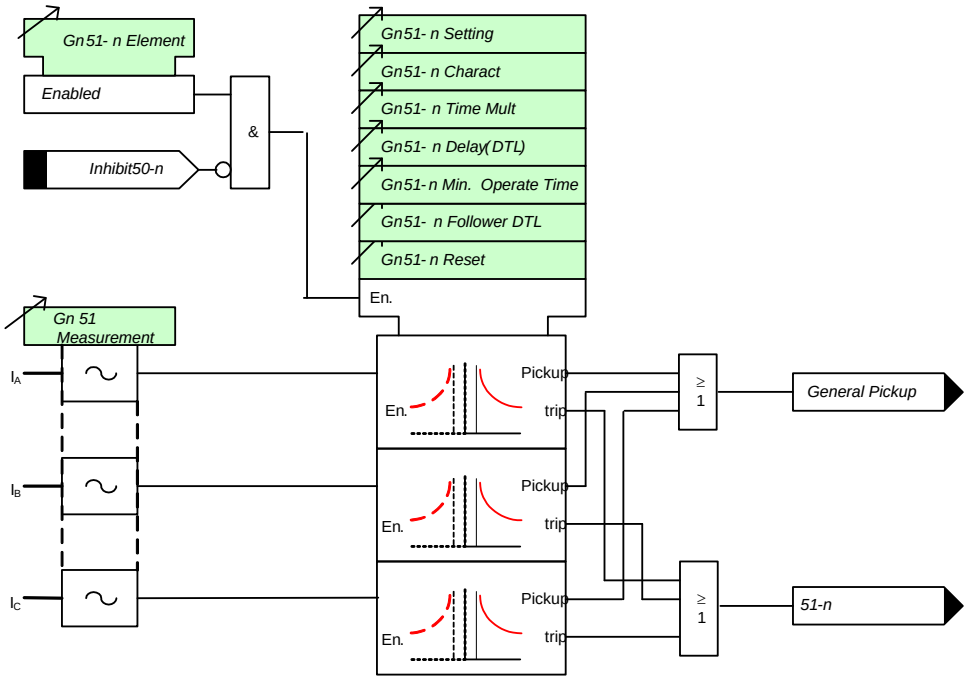


Figure 3-12 Logic Diagram: Time Delayed Overcurrent Element

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

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

3.4.1 Instantaneous Derived Earth Fault Protection (50N)

Two instantaneous derived earth fault elements are provided in the 7SR105 Rho Motor Protection Relay.

50N-1, 50N-2

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

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

Inhibit 50N-n A binary or virtual input.

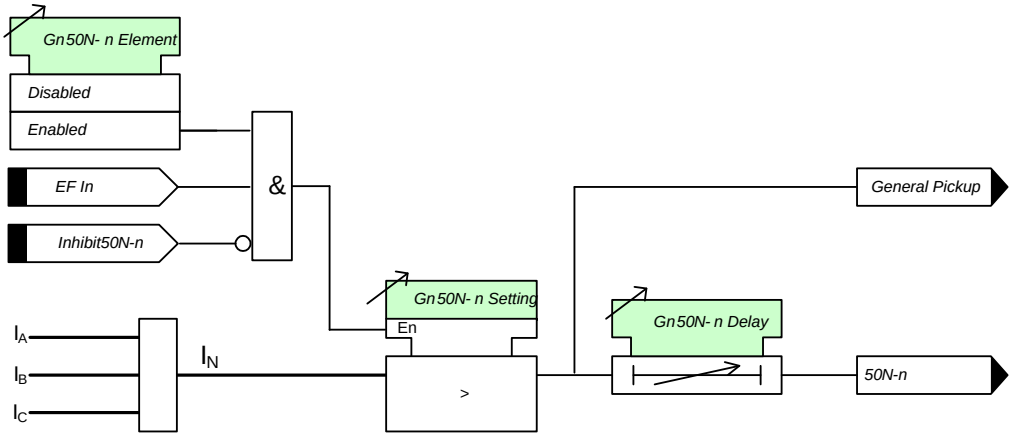


Figure 3-13 Logic Diagram: Derived Instantaneous Earth Fault Element

3.4.2 Time Delayed Derived Earth Fault Protection (51N)

Two time delayed derived earth fault elements are provided in the 7SR105 Rho Motor Protection Relay.

51N-1, 51N-2

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 and ANSI 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 configured as an IEC or ANSI 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.

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.

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

Inhibit 51N-n A binary or virtual input.

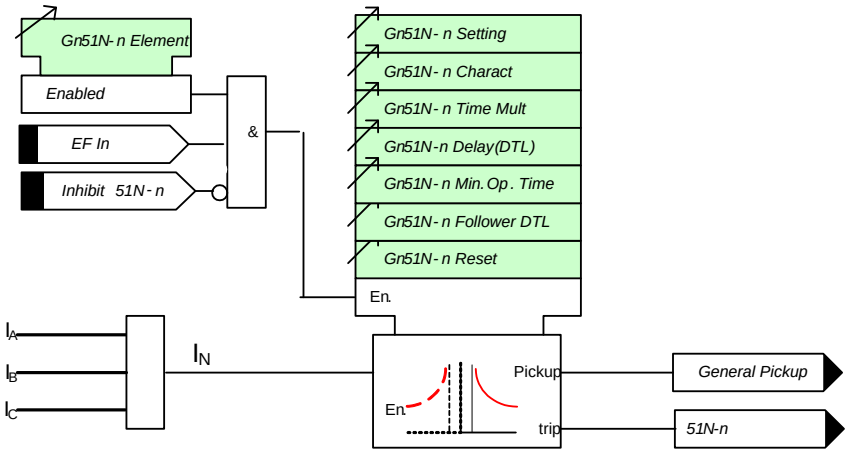


Figure 3-14 Logic Diagram: Derived Time Delayed Earth Fault Protection

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

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 the fundamental frequency RMS or True RMS current:

True RMS current: *51G/50G Measurement* = RMS

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

3.5.1 Instantaneous Measured Earth Fault Protection (50G)

Two instantaneous measured earth fault elements are provided in the 7SR105 Rho Motor Protection Relay.

50G-1, 50G-2

Each instantaneous 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.

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

Inhibit 50G-n A binary or virtual input.

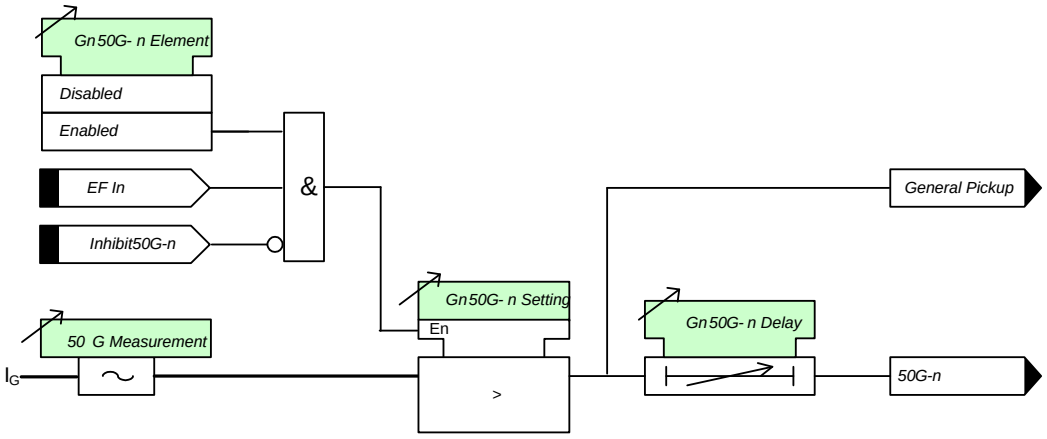


Figure 3-15 Logic Diagram: Measured Instantaneous Earth-fault Element

3.5.2 Time Delayed Measured Earth Fault Protection (51G)

Two instantaneous measured earth fault elements are provided in the 7SR105 Rho Motor Protection Relay.

51G-1, 51G-2

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

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

The ***51G-n Reset*** setting can apply a ***definite time delayed*** reset or when the operation is configured as an IEC or ANSI curves 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.

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.

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

Inhibit 51G-n A binary or virtual input.

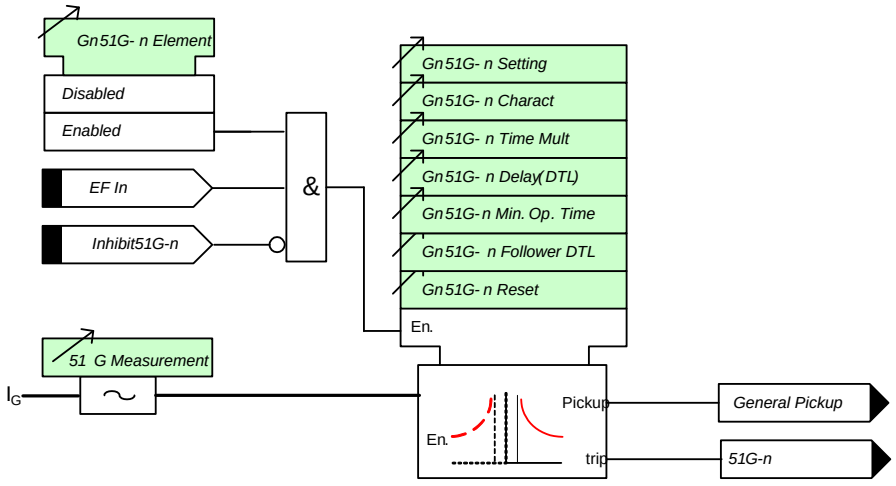


Figure 3-16 Logic Diagram: Measured Time Delayed Earth Fault Element (51G)

Section 4: Supervision Functions

4.1 BREAK CAPACITY LIMIT (50BCL)

An MCCB motor trip or contactor release should not be attempted if the short circuit current exceeds the set Breaking Capacity Limit. The Breaking Capacity Limit setting is provided to prevent the current interrupting capability of the primary switching device being exceeded.

The true RMS current of each phase is measured. If any phase current exceeds the Breaking Capacity Setting then the operation of all output contacts assigned to 'General Trip' are blocked. When this break capacity limit functionality is required all associated high current trips must be assigned in this way.

50BCL is a high speed element, it's instantaneous operation can be used to interrupt protections assigned as a general trip (OUTPUT CONFIG > OUTPUT MATRIX > General Trip). All contacts assigned as 'Gn **** Trips' in the OUTPUT CONFIG > TRIP CONFIG menu (Thermal, P/F, E/F, Misc) are General Trips. A settings example is provided for clarification – see Chapter 7 'Applications Guide'.

The '50BCL' output can be used to trip an upstream CB. CB fail protection initiation can be selected by the user.

Gn 50BCL Setting sets the pick-up current level for the element.

50BCL Block Tripping is enabled where contacts assigned as a 'General Trip' are to be blocked for currents above ***Gn 50BCL Setting.***

50BCL Initiate CBFail is enabled where it is required to start CB Fail for currents above ***Gn 50BCL Setting.***

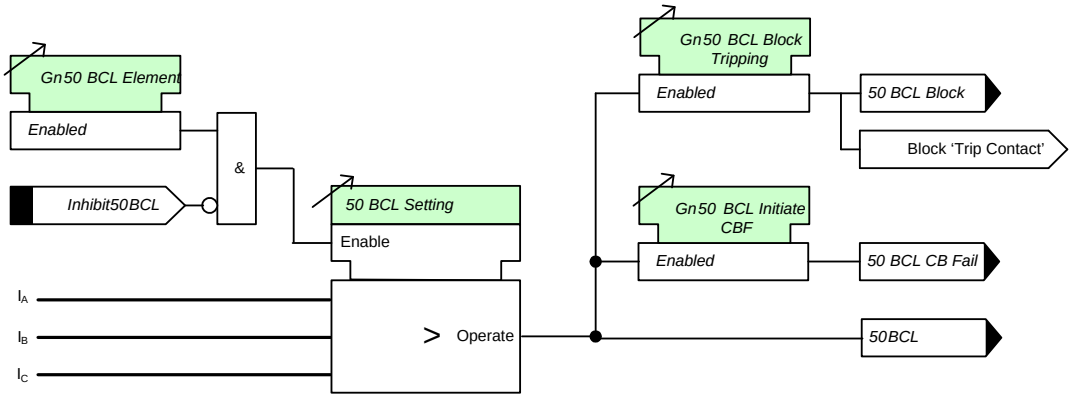


Figure 4-1 Logic Diagram: Breaking Capacity Limit (50BCL)

4.2 ANTI-BACKSPIN (81B)

Anti-backspin is used to inhibit restarting of the motor until after the rotor has completely stopped. The function must be used in conjunction with an auxiliary switch of the motor control device which is used to indicate the open status of the motor controller.

Anti-Backspin - Time Delay Method

When the CB is opened the 'Anti Backspin' DTL is started. CB closing is not allowed until the Anti-Backspin DTL has elapsed.

Anti-Backspin – Tachometer Method

A tachometer signal that provides an output when the motor is stopped can be connected to binary input programmed to 'No Accel'. CB closing is not allowed until the motor has stopped.

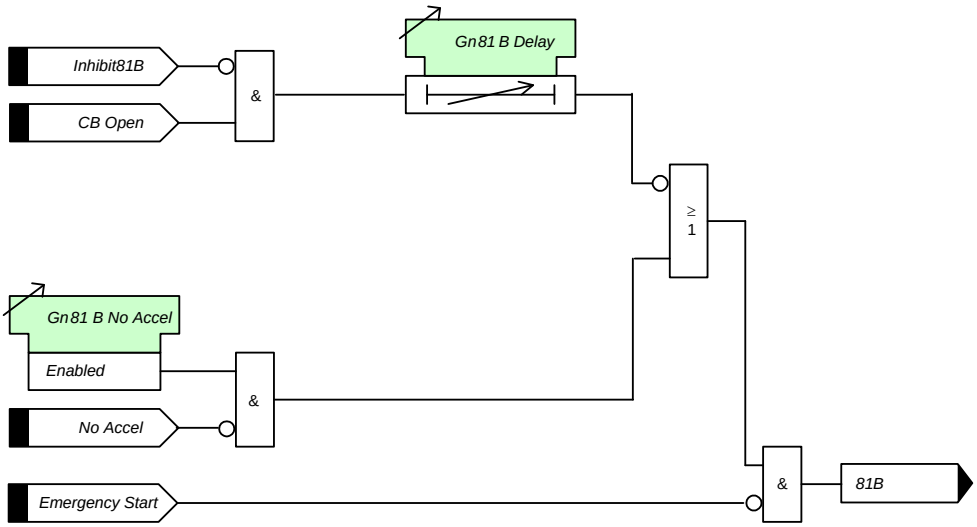


Figure 4-2 Logic Diagram: Anti-Backspin Protection (81B)

4.3 PHASE REVERSAL (46 PH REV)

Gn 46 PH REV Setting is the ratio of NPS:PPS current. A high value indicates incorrect current phase rotation. This can be used to prevent inadvertent reverse operation of the motor.

Gn 46 PH REV Setting sets the NPS:PPS current percentage pick-up.

An output is given after elapse of the ***Gn 46 PH REV Delay*** setting.

Operation of the phase reversal elements can be inhibited from:

Gn 46 PH REV U/C Guarded	Operation of the undercurrent guard function
Inhibit 46 PH REV	A binary or virtual input.

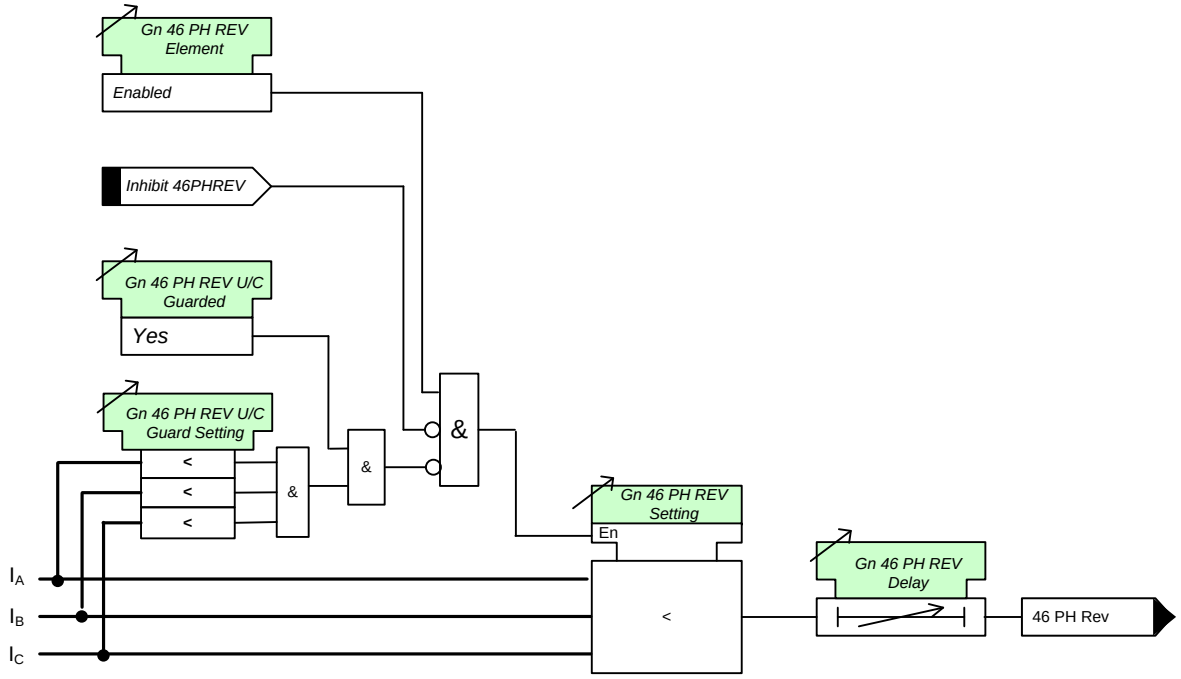


Figure 4-3 Logic Diagram: Phase Reversal Detection (46 PH REV)

4.4 TRIP CIRCUIT SUPERVISION (74TCS)

The relay provides three Trip Circuit Supervision elements.

One or more binary inputs can be mapped to ***Gn 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 ***Gn 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 – see 'Applications Guide'.

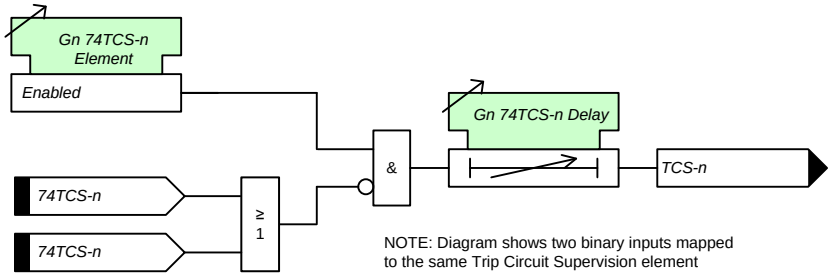


Figure 4-4 Logic Diagram: Trip Circuit Supervision Feature (74TCS)

4.5 CLOSE CIRCUIT SUPERVISION (74CCS)

The relay provides three Close Circuit Supervision elements.

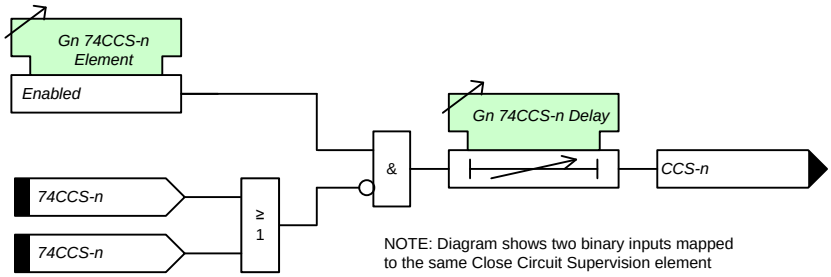


Figure 4-5 Logic Diagram: Close Circuit Supervision Feature (74CCS)

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

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

A binary input configured **50BF Ext Trip** (MENU: INPUT CONFIG\BINARY INPUT MATRIX\50BF Ext Trip).

CB Fail outputs will be issued providing any of the 3 phase currents are above the ***50BF Setting*** for longer than the ***50BF-n Delay*** setting – indicating that the fault has not been cleared.

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

Operation of the CB Fail elements can be inhibited from:

Inhibit 50BF A binary or virtual input.

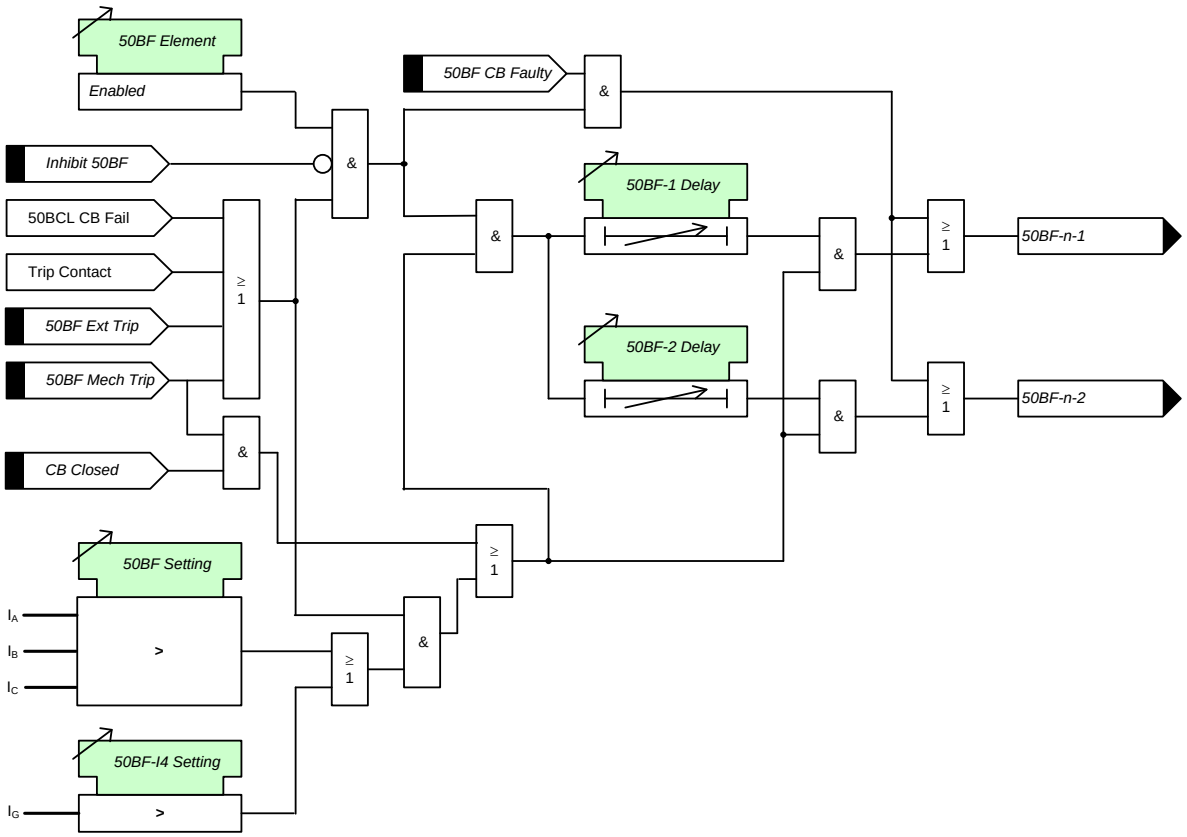


Figure 4-6 Logic Diagram: Circuit Breaker Fail Protection (50BF)

4.7 TEMPERATURE INPUTS (TEMP)

Temperature inputs (Six RTDs) can be selected from the following types:

- Pt100
- Pt250
- Pt1000
- Ni100
- Ni120
- Ni250
- Cu10

Each monitored input can be independently programmed to provide alarm and trip thresholds giving instantaneous outputs. Outputs can be assigned to each of the temperature inputs. The value returned by each temperature input can be displayed.

Temperature Input n Enable setting

Up to Six Temperature Inputs (RTD) can be monitored.

Temp Input n Alarm setting

An alarm output is available where the measured temperature exceeds the alarm setting.

Temp Input n Trip setting

A trip output is available where the measured temperature exceeds the trip setting.

Temp Input n Gating setting

Further security is provided by allowing each temperature input to be AND gated with other input(s). If this feature is selected then no trip will be issued unless all gated inputs detect temperature above the trip setting. The temperature input alarm outputs are not gated.

Temp Input Fail Protection

Each active temperature input can be internally monitored for short circuit, open circuit failure and out of limit. A temperature input fail alarm output is generated by a failure condition and the failed input is identified in the Instruments Menu. No trip or alarm output is given by a failed input.

Temp Input Scaling factor

Each Temperature input can be multiplied by different scaling factors. The scaling factor is applied in the temperature input values and the Temp Trip & Alarm functions will operate on the basis of scaled input. If the scaling factor is less than 1, then the Maximum Trip and Alarm settings also will get reduced. (For example,for scaling factor 0.5, the maximum Trip & Alarm settings will be 0.5 x 260°= 130°).

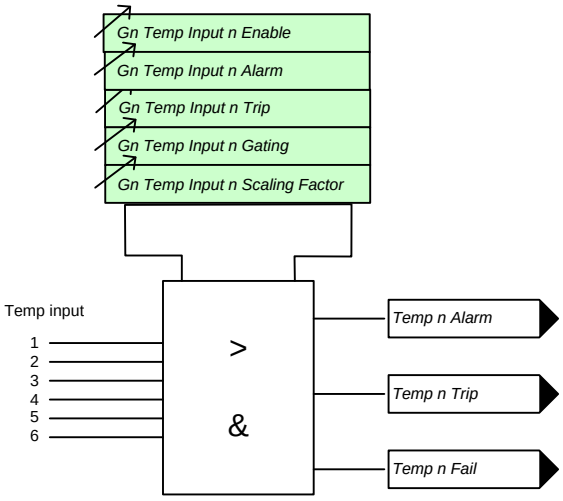


Figure 4-7 Logic Diagram: Temperature Inputs (TEMP)

Section 5: Control and Logic Functions

5.1 MOTOR START/STOP

Settings are included for CB monitoring and CB control i.e. motor stop/start.

Motor start and stop commands can be initiated in one of three ways: via a binary input, via the data communication Channel(s) or from the relay CONTROL MODE menu.

Gn 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.

Gn 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.

Gn Start Motor Delay

The Start Motor Delay is applicable to a motor start commands received through a ***Motor Start*** 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 start motor command be issued and related functionality initiated.

Gn Blocked Start Delay

The Start Motor command may be delayed by a ***Block Start*** signal applied to a binary input. This restrains the start motor output whilst energised. If the Block signal has not been removed before the end of the defined time, ***Blocked Start Delay***, the relay will abort the start operation.

Gn Stop Motor Delay

The Stop Motor Delay setting is applicable to stop motor commands received through a ***Stop Motor*** binary input or via the Control Menu. Operation of the ***Stop Motor*** binary output is delayed by the ***Stop Motor 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. Unlike a CB trip initiated by a protection function a CB trip operation caused by a *Motor Stop* command will not initiate functionality such as circuit-breaker fail, fault data storage, I^2t measurement and operation counter.

Gn CB Controls Latched

CB/contactor control for motor start and stop can be latched for extra security.

When Reset operation is selected, the control resets when the binary input drops off. This can lead to multiple control restarts due to bounce on the binary input signal. Reset operation allows a close or trip sequence to be aborted by dropping off the binary input signal.

When Latch operation is selected, the close or trip sequence continues to completion and bounce on the binary input is ignored.

Gn Start Motor Pulse

The duration of the ***Start Motor Pulse*** is settable to allow a range of control devices to be used. CB antipumping is provided to prevent Start and Stop Command pulses existing simultaneously.

The 'CB Fail to Close' feature is used to confirm that the control device is open at the end of the Close Command.

Gn CB Travel Alarm

The CB Open/CB Closed binary inputs are continually monitored to track the motor control device Status.

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The controller 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 CB Alarm output is given where the Travelling condition exists for longer than the ***CB Travel Alarm*** setting.

An instantaneous CB Alarm is given for a 1/1 state – i.e. where the CB indicates it is both Open and Closed at the same time.

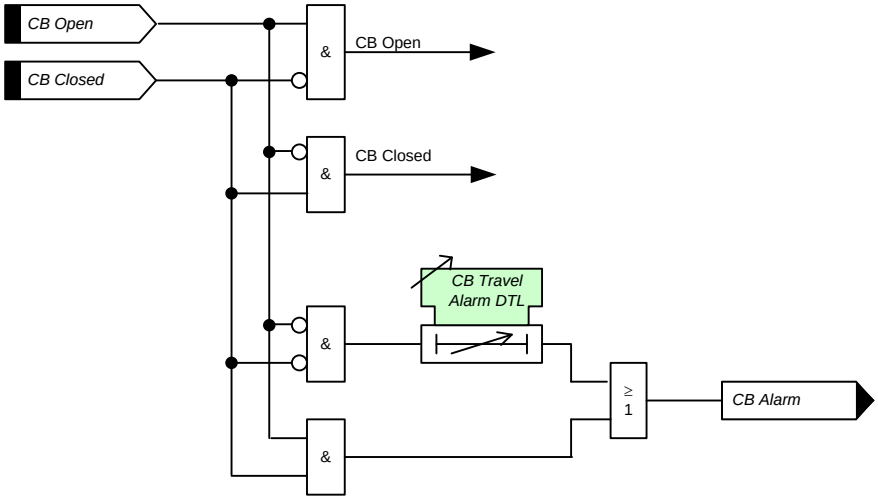


Figure 5-1 Logic Diagram: Circuit Breaker Status

Gn Stop Motor 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.

Emergency Start

Operation of the ***Emergency Start*** binary input resets thermal capacity, resets number of starts, bypasses the backspin check, checks plant conditions and then operates the assigned binary output contact.

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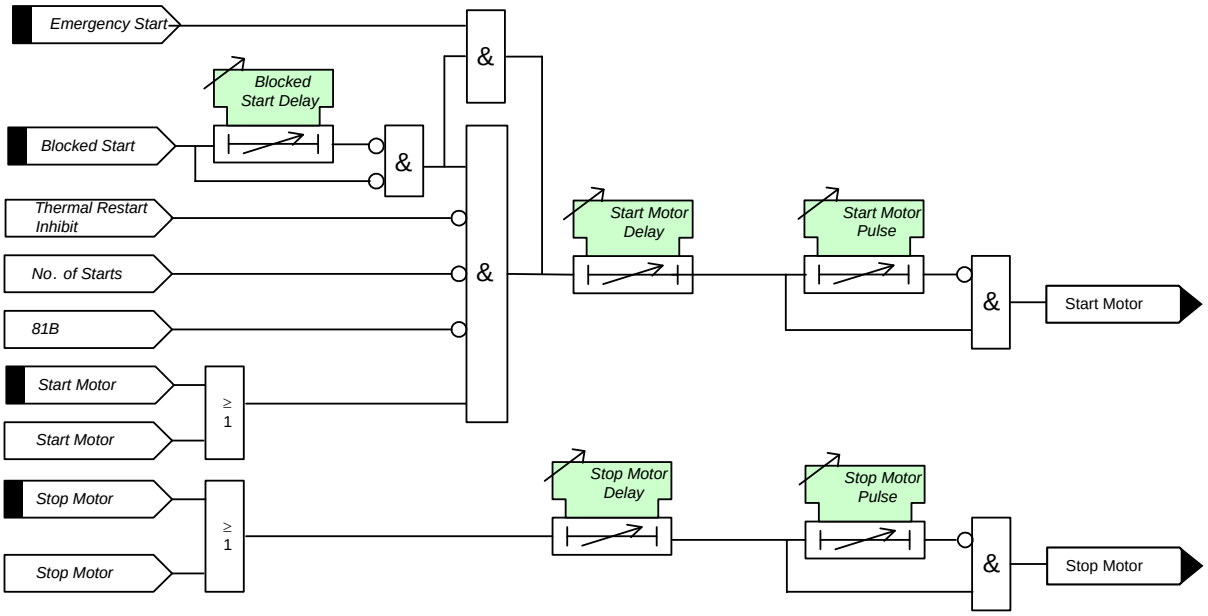


Figure 5-2 Logic Diagram: Motor Control

5.2 USER LOGIC

5.2.1 Quick Logic

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

Each logic equation is built up from text representing control characters. Each can be up to 20 characters long. Allowable characters are:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9	Digit
( )	Parenthesis
!	'NOT' Function
.	'AND' Function
^	'EXCLUSIVE OR' Function
+	'OR' Function
E*n*	Equation (number)
F*n*	Function Key (number)
	'1' = Key pressed, '0' = Key not pressed
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

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

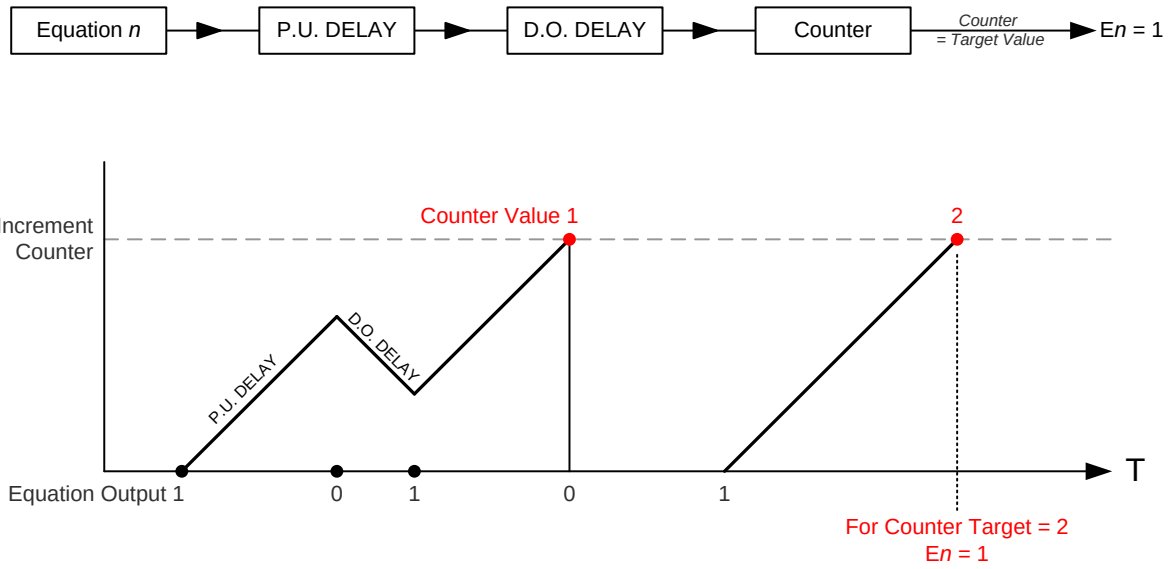


Figure 5-3 Sequence Diagram: Quick Logic PU/DO Timers (Counter Reset Mode Off)

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 E*n* is assigned in the OUTPUT CONFIG>OUTPUT MATRIX menu where it can be programmed to any binary output (O), LED (L) or Virtual Input/Output (V) combination.

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

Refer to Section 7 – Applications Guide for examples of Logic schemes.

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).

NOTE:
To view the applicable settings in the relay, TURN ON the **Setting relationship** in Reydisp.

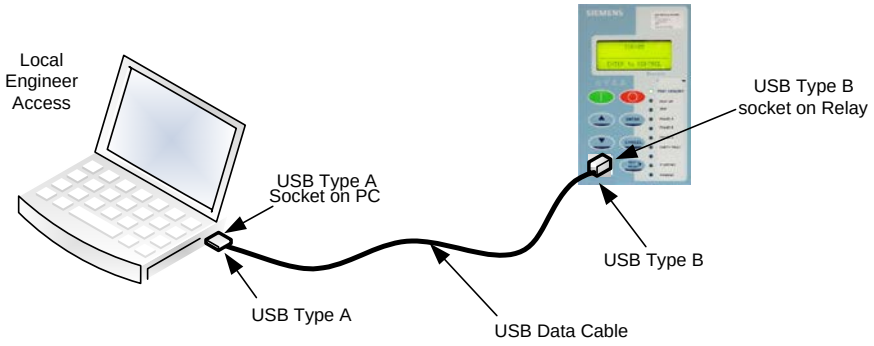


Figure 6-1 Communication to Front USB Port

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

1. Click **Connect**.

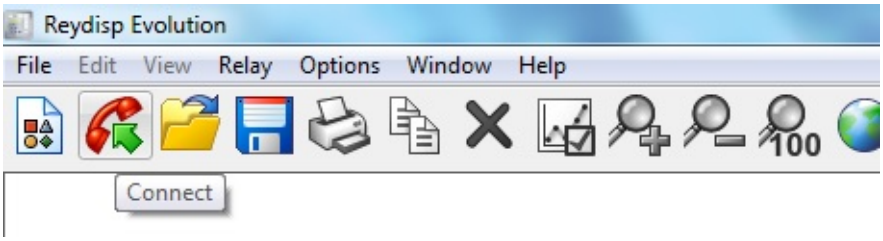


Figure 6-2 Connect Icon

2. Select **COM port** where the 7SR105 Rho Motor Protection Relay is connected.

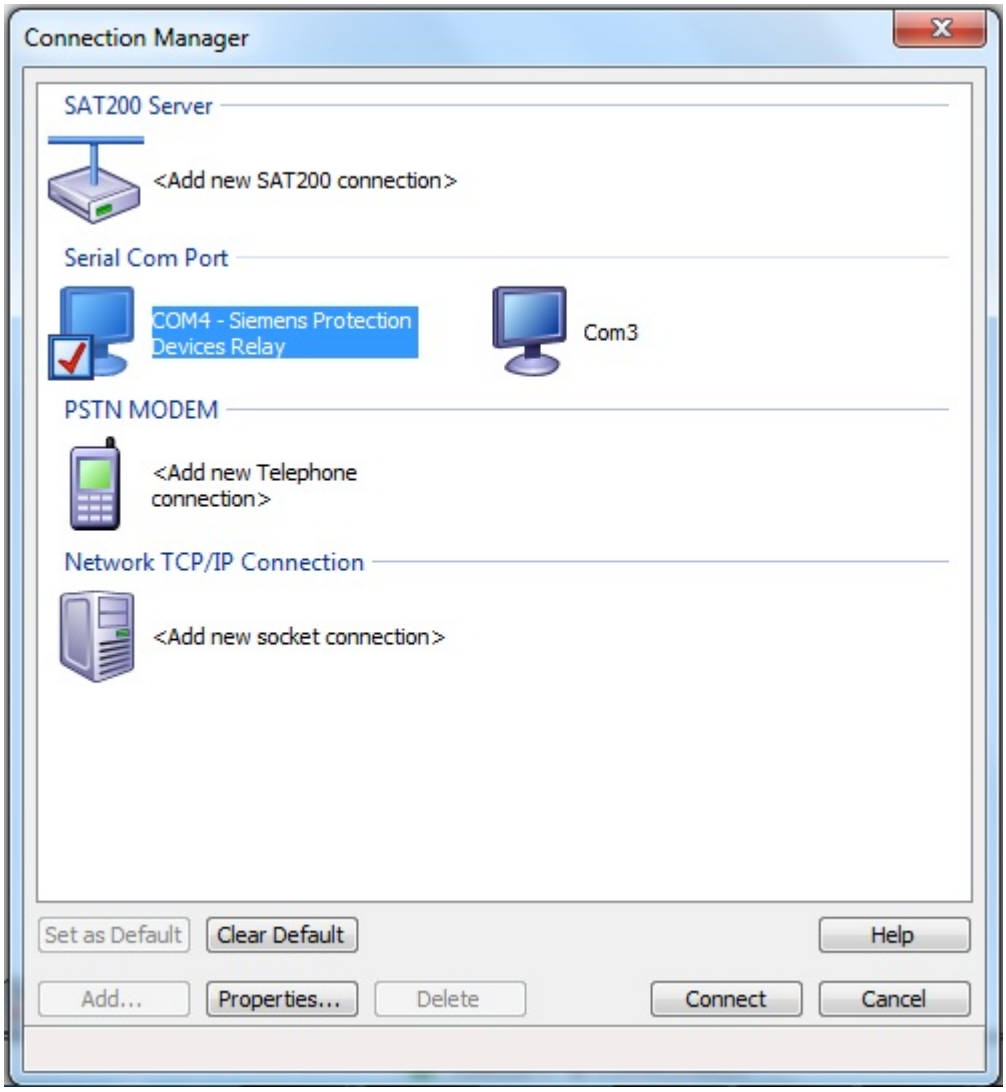


Figure 6-3 Port Selection in Connection Manager

3. Select **System Information** icon.



Figure 6-4 System Information Icon

4. Confirm the connection establishment with the Reydisp.

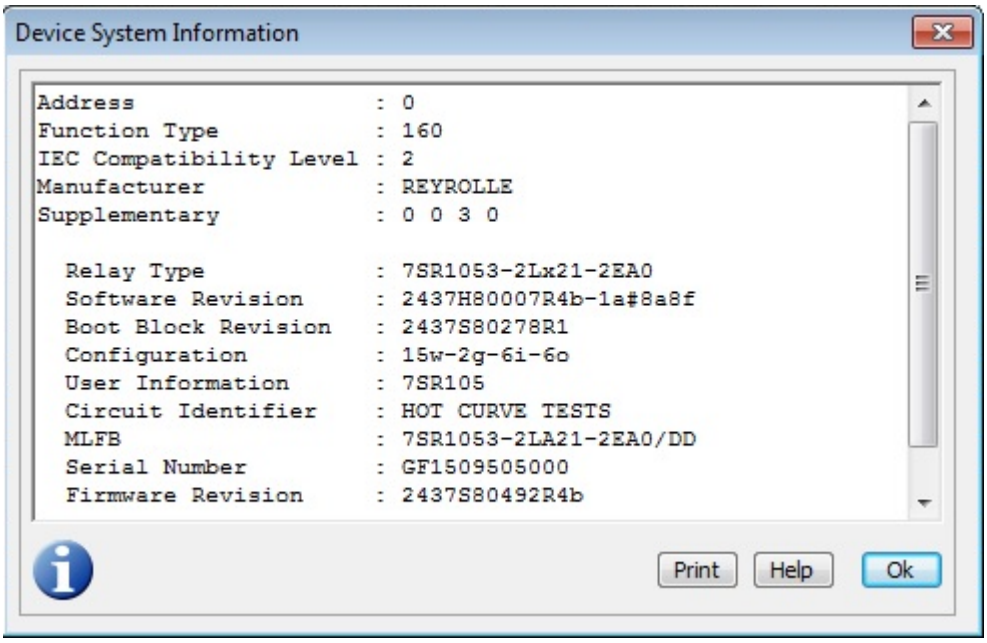


Figure 6-5 System Information Icon

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 18 and 20 on the power supply module.

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.
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.

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Setting name	Range	Default	Setting	Notes
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

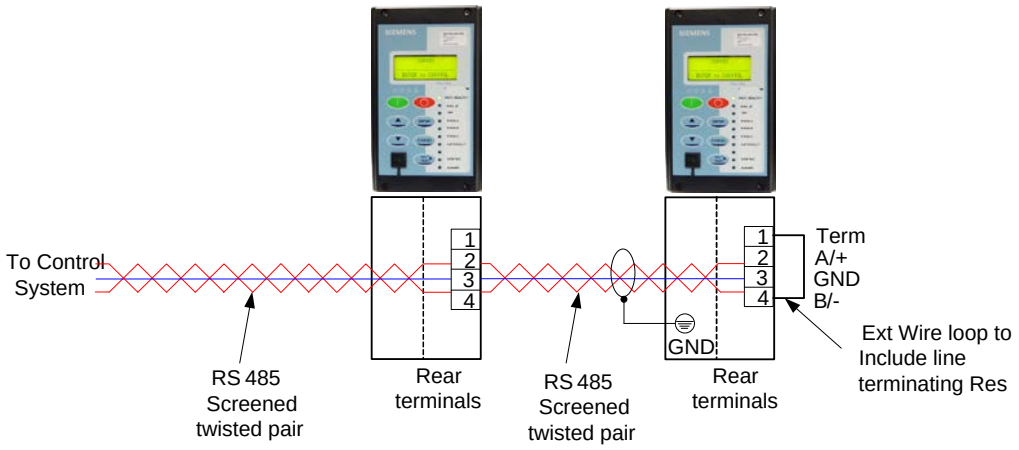


Figure 6-6 Communication to Multiple Devices from Control System using RS485

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 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.

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.

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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.

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.

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Waveforms are not available for the Temperature input trips.

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. Fault record will be triggered for the Temperature input trip also, but the fault temperature magnitude will not be displayed in the record. In the fault recorder, which temperature input has tripped information will be there. 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 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.

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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	SERVICE MODE
Control			
Rear Ports	Enabled	Disabled	Disabled
Fascia (Control Mode)	Disabled	Enabled	Disabled
USB	Disabled	Enabled	Disabled
Binary Inputs	Setting Option	Setting Option	Enabled
Binary Outputs	Enabled	Enabled	Disabled
Reporting			
Spontaneous			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
General Interrogation			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
MODBUS	Enabled	Enabled	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 the relay control functions listed below. When any of the items listed below 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.

CB Control

E/F In

Set Local or Remote

Set Remote

Set Local

Set Service

Note that the CB must be in a Closed state before an Stop command will be accepted. And that the CB must be in an Open state before a Start command will be accepted.

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

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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 vale 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. 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 Password Feature

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

The programmable password feature enables the user to enter a 4 character alpha-numeric code to secure access to the relay functions. The relay is supplied with the passwords set to **NONE**, i.e. the password feature is disabled. The password must be entered twice as a security measure against the accidental changes. Once a password has been entered then it will be required thereafter to change settings or initiate control commands. Passwords can be de-activated by using the password to gain access and by entering the password **NONE**. Again this must be entered twice to deactivate the security system.

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

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

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

NOTE:

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

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7SR105 Rho

Settings and Instruments

This document is issue 2016/06. The list of revisions up to and including this issue is:

2015/12	First Issue
2016/06	Second Issue

Software Revision History

2015/12	2437H80007 R4b-1a	First Release
2016/06	2437H80007 R4c-1b	Second Release

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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,

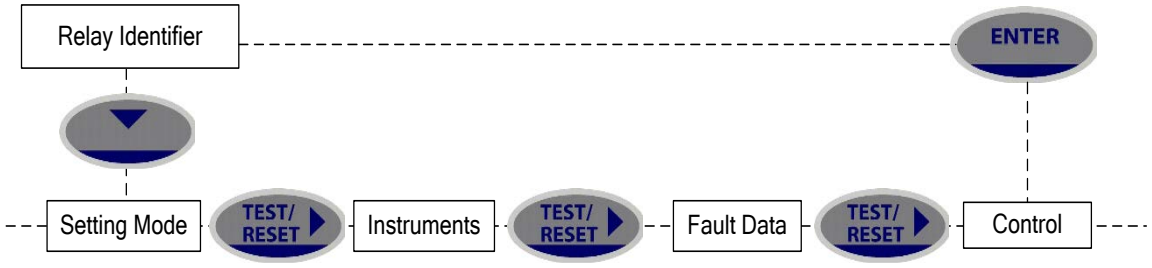


Figure 1.1-1 Menu

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 1.1-3 Fascia of a 7SR105 Rho Motor Protection Relay (Size 4 Case)

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1.2 Operation Guide

1.2.1 User Interface Operation

The basic menu structure flow diagram is shown in Figure 1.2-2. This diagram shows the main modes of display: Settings Mode, Instrument Mode, Fault Data Mode and Control Mode.

When the relay leaves the factory all data storage areas are cleared and the settings set to default as specified in settings document.

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

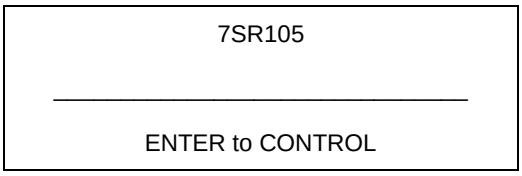


Figure 1.2-1 Relay Identifier Screen

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

The push-buttons on the fascia are used to display and edit the relay settings via the LCD, to display and activate the control segment of the relay, to display the relays instrumentation and Fault data and to reset the output relays and LED's.

The five push-buttons have the following functions:

 **READ DOWN**  **READ UP**

Used to navigate the menu structure.



ENTER

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

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

When an instrument is displayed pressing ENTER will toggle the instruments favourite screen status.



CANCEL

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



TEST/RESET

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

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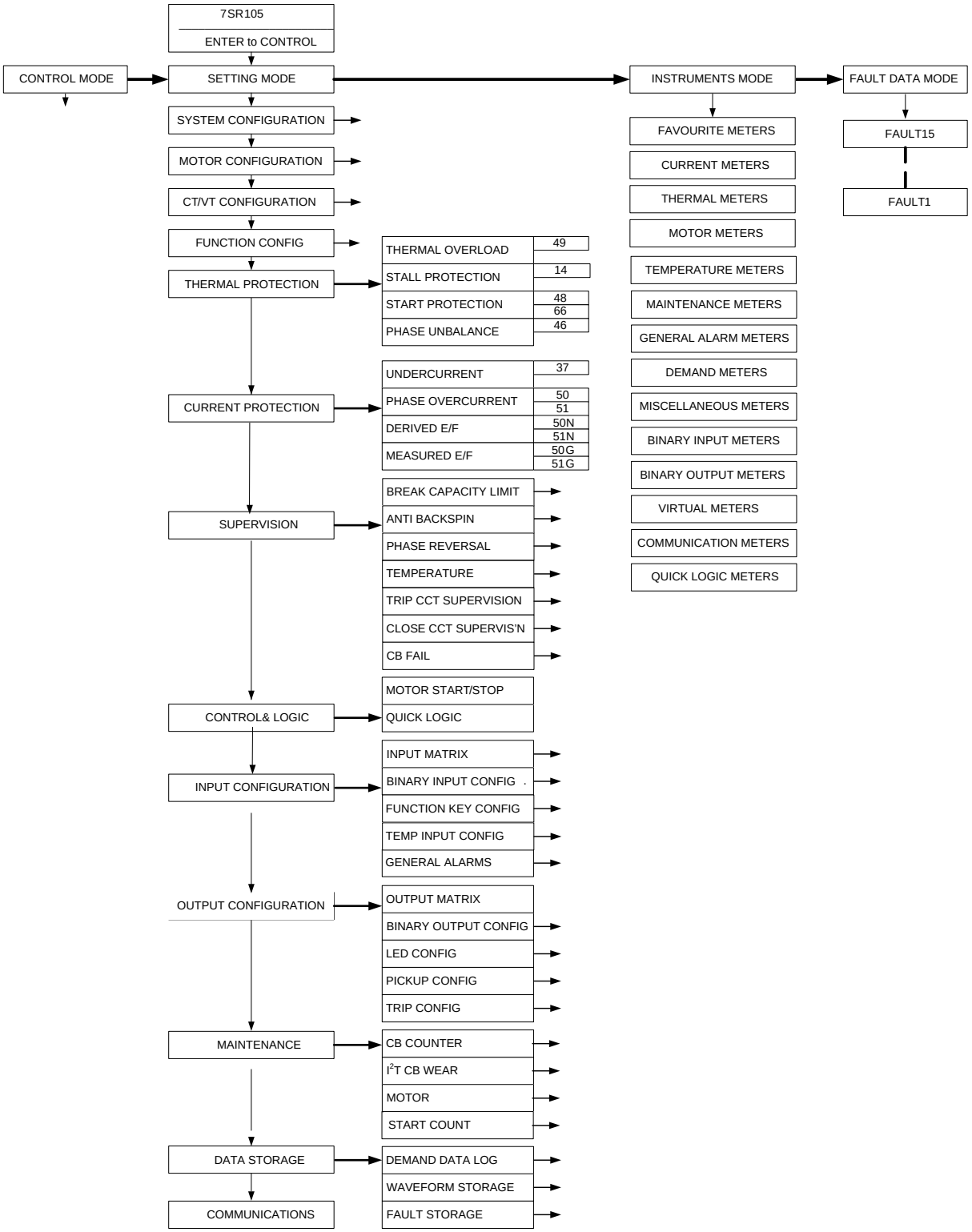


Figure 1.2-2 Menu Structure

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 0.00A Ib 0.00A Ic 0.00A	Displays the 3 phase currents Primary RMS values
Secondary Current Ia 0.000A Ib 0.000A Ic 0.000A	Displays the 3 phase currents Secondary RMS values
Nom Current Ia 0.00xIn----^{o}	Displays the 3 Phase currents Nominal RMS values & phase angles with respect to PPS voltage.

INSTRUMENT		DESCRIPTION
Ib	0.00xIn ----^{o}	
Ic	0.00xIn ----^{o}	
Pri Earth Current		Displays the 2 Earth currents Primary RMS values
In	0.00A	
Ig	0.00A	
Sec Earth Current		Displays the 2 Earth currents Secondary RMS values
In	0.000A	
Ig	0.000A	
Nom Earth Current		Displays the 2 Earth currents Nominal RMS values & phase angles.
In	0.00xIn----^{o}	
Ig	0.00xIn----^{o}	
I Seq Components		Displays the Current Sequence components Nominal RMS values & phase angles with respect to PPS voltage.
Izps	0.00xIn----^{o}	
Ipps	0.00xIn----^{o}	
Inps	0.00xIn----^{o}	
I Eq.		
Pri	0.00A	
Sec	0.000A	
I Unbalance		
Pri	0.00A	
Sec	0.000A	
Last Trip P/F		Displays the Last Trip Fault Current..
Ia	0.00A	
Ib	0.00A	
Ic	0.00A	
Last Trip E/F		Displays the Last Trip Fault Current..
In	0.00A	
Ig	0.00A	
Last Trip Sequence		
I1	0.00A	
I2	0.00A	
Last Trip Motor		
IEq	0.00A	
IUn	0.00A	
THERMAL METERS		This is the sub-group that includes all the meters that are associated with Thermal functionality.
→to view		TEST/RESET ► allows access to this sub-group
Thermal Capacity TC		
TC Used	0.00%	
TC Available	100.00%	

MOTOR METERS →to view		This is the sub-group that includes all the meters that are associated with Thermal functionality. TEST/RESET ► allows access to this sub-group
Motor Status		Stopped, running, starting
Last Motor Start		Start time, capacity used, and max current
49 Thermal Times		To trip, Restart
Motor Run Times	HH:MM:SS	Current, total, average
Motor Stop Time	HH:MM:SS	
Emergency Starts	0	
Motor Data		FLC, Motor Load, Time Running, Rated O/P power, PF, Efficiency, Service Factor, Hot Stall Time, Cold Stall Time, Locked Rotor Current, Start Time, Start Method, Vacuum CB.
TEMPERATURE METERS →to view		This is the sub-group that includes all the meters that are associated with Temperature
Max Temp Recorded Input Temp		Displays the maximum temperature recorded input number Displays the maximum temperature
Temp1		Displays the temperature
Temp2		Displays the temperature
Temp3		Displays the temperature
Temp4		Displays the temperature
Temp5		Displays the temperature
Temp6		Displays the temperature
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 Target	 0 100	Displays the number of CB trips experienced by the CB
CB Delta Trips Count Target	 0 100	Displays the number of CB trips experienced by the CB
CB Wear Phase A Phase B Phase C	 0.00MA^2s 0.00MA^2s 0.00MA^2s	Displays the current measure of circuit breaker wear.
CB Wear Remaining Phase A Phase B Phase C	 0.00MA^2s 0.00MA^2s 0.00MA^2s	
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.
Ig 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 1 Target	
Date DD/MM/YYYY Time HH:MM:SS Waveform Recs 0 Fault Recs 0 Event Recs 0 Data Log Recs 0 Setting Group 1	This meter displays the date Time and the number of Waveform records Fault records Event records Data log records stored in the relay

BINARY INPUT METERS →to view	This is the sub-group that includes all the meters that are associated with the Binary inputs TEST/RESET ► allows access to this sub-group
BI 1-6 ---- --	Displays the state of DC binary inputs 1 to 6 (The number of binary inputs may vary depending on model)
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 (The number of virtual inputs will vary depending on model)
COMMUNICATION METERS →to view	This is the sub-group that includes all the meters that are associated with Communications ports TEST/RESET ► allows access to this sub-group
COM1 COM2	Displays which com ports are currently active
COM1 TRAFFIC COM1 Tx 0 COM1 Rx Error 0 COM1 Rx 0	Displays traffic on Com1
COM2 TRAFFIC COM2 Tx 0 COM2 Rx Error 0 COM2 Rx 0	Displays traffic on Com2
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.

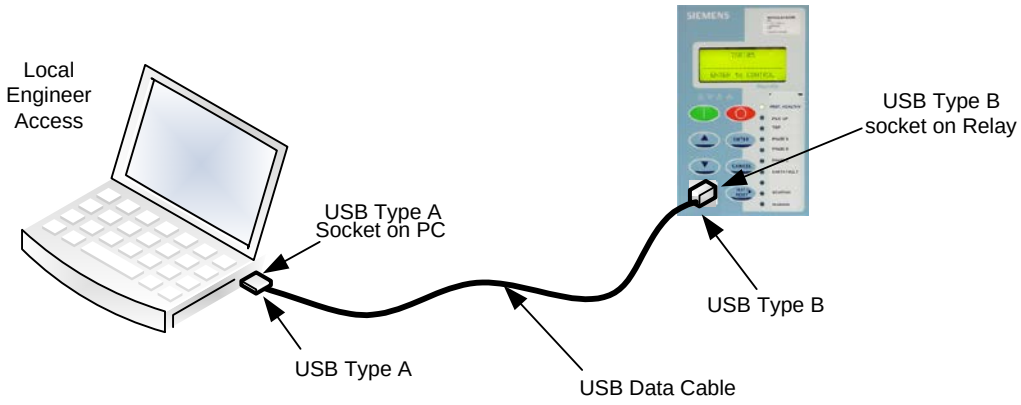


Figure 2.1-1 USB connection to PC

2.1.2 Rear RS485 connection

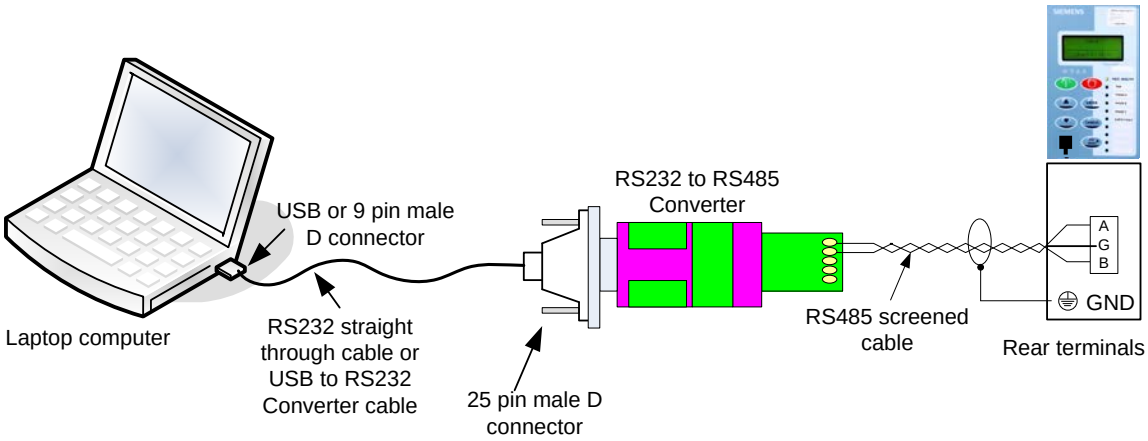


Figure 2.1-2 RS485 Connection to PC

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

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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.

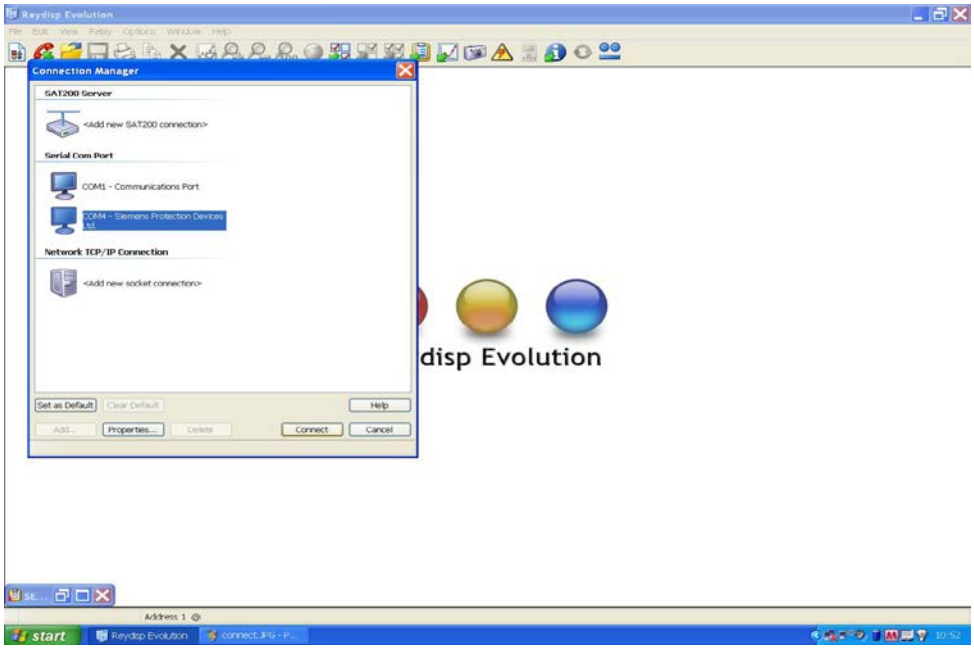


Figure 2.1-3 PC Comm Port Selection

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.

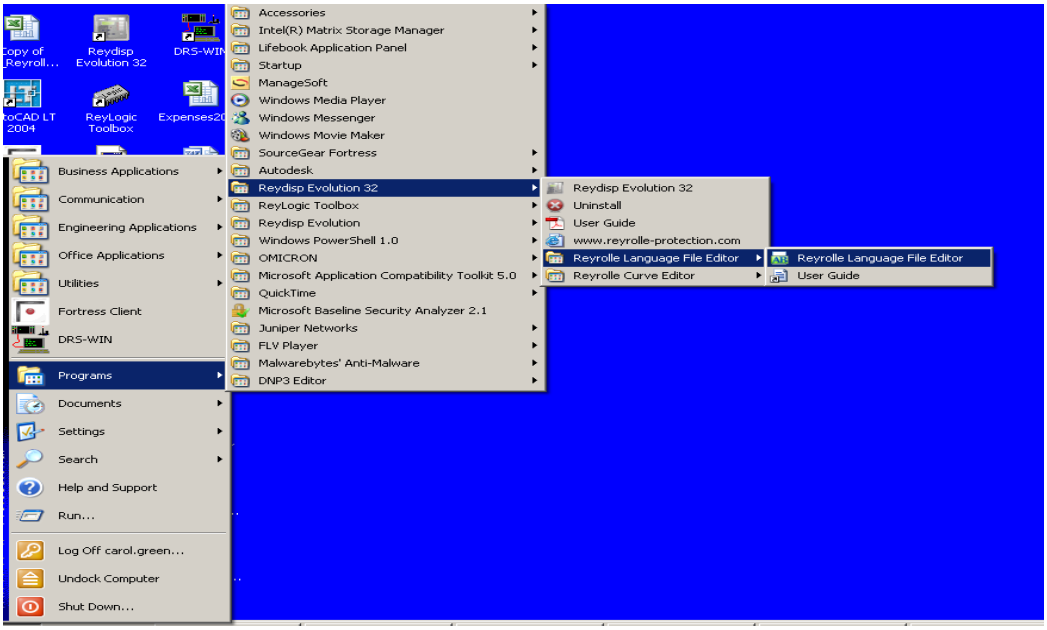


Figure 2.1-4 PC Language File Editor

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.

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7SR105 Rho

Performance Specification

Document Release History

This document is issue 2016/06. The list of revisions up to and including this issue is:

2015/12	First Issue
2016/06	Second Issue

Software Revision History

2015/12	2437H80007 R4b-1a	First Release
2016/06	2437H80007 R4c-1b	Second Release

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Section 1: Performance Specification

1.1 Indication of Conformity



This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2014/30/EU) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the generic standard IEC/EN 60255-26 (for EMC directive) and with the standards IEC/EN 60255-27 (for Low Voltage Directive) by Siemens AG.

1.2 Technical Specifications

This section provides the technical information of 7SR105 Rho Motor Protection Relay.

Table 1-1 Technical Data Overview

Product Family (Auxiliary powered)	Motor Protection 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
Auxiliary Voltage	60 V - 240 V AC/DC 24 V - 60 V DC
Communication	Default front communication port (IEC 60870-5-103 or MODBUS RTU) Rear port: RS485 (optional - IEC 60870-5-103 or Modbus RTU or DNP 3.0)
Protection Functions	14, 37, 48/66, 50, 50G/N, 51, 51G/N, 49, 46
Supervision and control functions	74 T/CCS, 86, 50 BCL, 81 B, 46 Ph Rev, 50BF, TEMP
Binary Input and Binary Output	6 BI and 6 BO (2 changeover contact) Threshold voltage - 44 V AC/DC with 60 V - 240 V AC/DC power supply version - 19 V DC with 24 V - 60 V DC power supply version
Temperature Inputs	6 inputs Measuring Range -50ºC to +250ºC

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 kgs (appx)

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Table 1-3 Terminal Blocks with Push Buttons

Current Inputs	12 position (Terminal X5), M4 Screw-type Barrier Terminal block suitable for 2.5 mm^2/4 mm^2 cable
Auxiliary Supply	3 position (Terminal X3), M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable
Rear Communication Port	4 position (Terminal X2), M2 screw-type plug-in terminals suitable for 1.5 mm^2 cable
Front Communication Port	USB, Type B
Binary Input	6 or 12 position (Terminal X1), M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable
Binary Output	8 or 14 position (Terminal X4), M3 screw-type plug-in terminals suitable for 2.5 mm^2 cable
Temperature Inputs	18 position (Terminal X6, X7), M2 screw-type plug-in terminals suitable for 1.5 mm^2 shielded cable

Table 1-4 Current Inputs

Quantity	3 x Phase & 1 x Earth
Rated Current In	1 A/5 A
Measuring Range	80*In 8*In ((Measured E/F)
Instrumentation	± 1 % (typical) (≥ 0.1xIn to 3xIn) ± 3 % (> 3xIn to 80xIn)
Frequency	50 Hz (Range: 47.5 Hz to 52.5 Hz) 60 Hz (Range: 57 Hz to 63 Hz)
Thermal Withstand: Continuous 10 s 1 s	 4 x In 30 In 100 A (1 A) 350 A (5 A)
Burden @ In	≤ 0.3 VA per phase and earth for both 1 A and 5 A

Table 1-5 Auxiliary Supply

Rated Voltage	60 V - 240 V AC/DC, Tolerance – 20 % to +10 %
Allowable superimposed AC component	15 % of DC voltage
Typical Power consumption (DC) Typical Power consumption (AC)	< 7 W < 7 VA 0.5 PF
Max Interruption time (Collapse to Zero)	≤ 100 ms (110 V DC) ≤ 1000 ms (230 V AC)

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Table 1-6 Auxiliary Supply

Rated Voltage	24 V - 60 V DC Tolerance -20% to +10%
Allowable super imposed AC component	15% of DC voltage
Typical Power consumption (DC)	< 7 W
Max Interruption time (Collapse to Zero)	20 ms (24 V DC)

Table 1-7 Binary Inputs

Number	6	
Operating Voltage*	19 V DC	Range 24 V - 66 V DC
	44 V AC/DC	Range 44 V - 265 V
	Range	DC 44 V - 265 V DC AC 36 V - 265 V AC
Maximum AC/DC current for operation	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 1-8 Binary Outputs

Number	6
	4 NO contacts and 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
Making Capacity: Carry continuously Make and carry (L/R ≤ 40 ms and V ≤ 300 V)	 5 A AC or DC 20 A AC or DC for 0.5 s 30 A AC or DC for 0.5 s
Breaking Capacity (≤ 5 A and ≤ 300 V): AC Resistive AC Inductive DC Resistive DC Inductive	 1250 VA 250 VA at p.f. ≤ 0.4 75 W 30 W at L/R ≤ 40 ms 50 W at L/R ≤ 10 ms

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Table 1-9 Temperature Inputs

Number	6
Measuring Range	-50 ºC to +250ºC 100% Tset, ± 2% or ±2ºC, For Cu10: ± 2 % or ± 5ºC
Response time	< 3 s
Sensing current	< 0.5 mA

Table 1-10 Rear Communication Port

Quantity	1 No.
Electrical connection	RS485, 2 wire electrical
Protocol Support	MODBUS RTU, IEC 60870-5-103, DNP 3.0
Rate	Data Transfer rate: 2400 - 38400 bps

Table 1-11 Front Communication Port

Quantity	1 No.
Electrical connection	USB, Type B

Table 1-12 Data Storage

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

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1.3 Environmental Performance

This section describes about the environmental tests performed with 7SR105 Rho Motor Protection Relay under different conditions.

Table 1-13 Mechanical Tests

Type Test	**Reference**	**Requirement**
Vibration	IEC 60255-21-1	Response, Class I Endurance, Class I
Shock and Bump	IEC 60255-21-2	Shock response, Class I Shock withstand, Class I Bump, Class I
Degree of Protection	IEC 60529	IP54 front IP20 back
Seismic	IEC 60255-21-3, Class I	In single axis sine sweep in X-axis Sweep (@a sweep rate of 1 octave/min) vibration in the frequency range (1 Hz - 35 Hz) at amplitude of 3.5 mm or 1.0 gn (whichever is less) In single axis sine sweep in Y-axis: sweep (@a sweep rate of 1 octave/min) vibration in the frequency range (1 Hz - 35 Hz) at amplitude of 1.5 mm or 0.5 gn (whichever is less)
Contact	IEC 60255-1 (Ref: Std IEC 61810-1)	Making capacity, Make and carry capacity, Breaking capacity
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 M Ohms 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.
Hi Voltage (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

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Type Test	Reference	Requirement
High Frequency Disturbance	IEC 60255-26	• Common-mode test voltage: 2.5 kV • Differential test voltage: 1.0 kV • Test duration: 2 s • Source impedance: 200 Ω
Electrostatic Discharge	IEC 60255-26	• 8 kV air discharge
Electrical Fast Transient or Burst*	IEC 60255-26, Zone A	Test severity Amplitude: Power ports: 4 kV, burst frequency 5 kHz Other ports: 4 kV, burst frequency 5 kHz
Surge Immunity*	IEC 60255-26, Zone A	Time to half-value: 1.2/50 µs • Amplitude: 4 kV between all groups and case earth (CM) • Amplitude: 2 kV between terminals of each group (DM)
Radiated Immunity	IEC 60255-26	Test field strength, frequency band 80 MHz to 1000 MHz and 1400 MHz to 2700 MHz: 10 V/m, Test using AM: 1 kHz/80 %
Conducted Radio Frequency Interference	IEC 60255-26, Class III	0.15 MHz to 80 MHz 10 V
Power Frequency Magnetic Field	IEC 60255-26	30 A/m applied continuously, 300 A/m applied for 3 s
Conducted Emissions	IEC 60255-26 CISPR 22, Class A	0.15 MHz - 0.5 MHz, 79dB µV (quasi peak) 66 dB µ V (average) 0.5 MHz - 30 MHz, 73dB µ V (quasi peak) 60 dB µV (average)
Radiated Emissions	IEC 60255-26 CISPR 11, Class A	30 MHz - 230 MHz, 40 dB µ V/m at 10 m measurement distance 230 MHz - 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 30 A for 10 s 100 A for 1 s **5 A CT:** 20 A Continuous 150 A for 10 s 500 A for 1s **Burden:** ≤ 0.3 VA for 1 A and 5 A CT

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Type Test	Reference	Requirement
Functional	IEC 60255-8 and IEC 60255-3	for both 1 A and 5 A CTs
Temperature Input (Pt100)	IEC 60751	
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

* 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

Table 1-15 Safety Tests

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 (60 -240 V AC/DC Variant)

Type Test	Reference	Parameters	Declared Operation
Voltage Dips (AC auxiliary supply) RV = 230 V AC	IEC 60255-26	0% RV at 1000 ms	Normal Operation[1]
		40% RV at 200 ms	Normal Operation[1]
		70% RV at 500 ms	Normal Operation[1]
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]
		70% RV at 500 ms	Normal Operation[1]
Voltage Dips (DC auxiliary supply) RV = 48 V DC	IEC 60255-26	0% RV at 20 ms	Normal Operation[1]
		40% RV at 200 ms	Normal Operation[1]
		70% RV at 500 ms	Normal Operation[1]

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Gradual shutdown / Start-up test	IEC 60255-26	Shut down ramp 60 s Power off 5 min Start up ramp 60 s	Normal Operation[2]
Voltage interruption (AC/DC auxiliary supply) RV = 48 V/220 V DC RV = 230 V AC	IEC 60255-26	0% RV at 5 s	Normal Operation[2]
Alternating component in DC (Ripple) DC Power supply	IEC 60255-26	15% Max and Min of RV Duration: 10 min	Normal Operation[1]

[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, IEC60255-1	Operating Temperature -10^0 C to + 60^0 C Storage Range - 25^0 C to + 70^0 C
Humidity	IEC 60068-2-30, IEC 60068-2-78, IEC60255-1	Damp heat test, Cyclic 4 days at 40^0 C and 93 % relative humidity Damp heat test, Steady state 4 days at 95 % RH, +40^0 C

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	

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Insulation Resistance	IEC/EN 60255-27: Edition 2: 2013-10	Test voltage: 500 V DC	> 100 M ohm
		Test duration: > 5 s	
Protective Bonding Resistance	IEC/EN 60255-27: Edition 2: 2013-10	Test voltage: < 12V AC/DC	< 0.1 Ohm
		Test duration: 1 min	
		Bonding resistance	
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 enclosures	IEC/EN 60255-27: Edition 2: 2013-10	Structure Part	Standard for insulating material of flammability class
		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	-

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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	-

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1.4 Performance Specification

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

Table 1-19 14 Stall Protection

Number of Elements	4
Setting Range I_s	0.05 to 10 x In
Time Delay	0.00 to 14400 s
Operate Level	100 % Is ±5 % or ±1 % xIn
Operate time 2 x I_s 5 x I_s	 35 ms ± 10 ms, 25 ms ± 10 ms
Operate time following delay	tbasic +td , ±1 % or ±10 ms
Controlled by	Stopped, No acceleration, Running, None
Disengaging time	< 50 ms

Table 1-20 37 Undercurrent

Number of Elements	2
U/C Guard	0.05 to 5.0 x In
Setting Range I_s	0.05 to 5.0 x In
Operate Level	100 % Is ± 5 % or ± 1 % xIn
Delay Setting td	0 to 14400 s
Basic Operate Time: - 0.5 x Is	 35 ms ± 20 ms
Operate time following delay	t_{basic} + t_d , ± 1 % or ± 10 ms
Overshoot Time	< 40 ms
Inhibited by	Binary or Virtual Input
Disengaging time	< 60 ms

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Table 1-21 46 Phase Unbalance Protection

Number of Elements	1 (Magnitude difference or NPS)
Setting Range Is	0.1 to 0.4 x Itheta
Operate Level	100 % I_s ± 5 % or ± 1 % x In
IT Min. Operate Time	0 to 20 s
DT Delay Setting td	0 to 20 s
DT Basic Operate Time for NPS - 2 x I_s 5 x I_s	 65 ms ± 10 ms 60 ms ± 10 ms
DT Basic Operate Time for magnitude - 2 x I_s 5 x I_s	 60 ms ± 10 ms 50 ms ± 10 ms
DT Operate time following delay.	td ± 1 % or ± 30 ms
Tm Time Multiplier	0.025 to 2.0
Disengaging time	< 80 ms
Inhibited by	Binary or Virtual Input

Table 1-22 48/66 Start Protection

Max. No. of Starts	OFF, 1 to 20
Max. Starts Period	1 to 60 minutes
Start Inhibit Delay	1 to 60 minutes
Time Between Starts	OFF, 1 to 60 minutes

Table 1-23 49 Thermal Protection

Setting Range Itheta	0.1 to 3.0 x In
NPS Weighting Factor (K)	0.1 to 10.0 Δ 0.1
TauH Heating Constant	0.5 to 1000 mins, Δ 0.5 mins
TauS Starting Constant	0.005 to 1.0 x TauH , Δ 0.005
TauC Cooling Constant	1 to 100 x TauH , Δ 1
Hot/cold ratio	OFF, 1 to 100 %, Δ 1 %
Operate Level	100 % Is, ±5 % or ±1 % x In
Operate time	$t = \tau \times In\left\{\frac{I_{EQ}^2 - \left(1 - \frac{H}{C}\right)I_p^2}{I_{EQ}^2 - I_\theta^2}\right\}$ ±5 % or ±100 ms (Itheta = 0.3 to 3 x In) (1.2 to 20 x Itheta)
	User defined
Capacity Alarm Level	Disabled, 50,51…100 %
Load Alarm Level	OFF, 0.5 to 1.0 x Itheta , Δ 0.05
Thermal restart inhibit	20 to 100 %, Δ 1 %
Inhibited by	Binary or Virtual Input

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Table 1-24 50 Instantaneous & DTL OC&EF

Operation	Non directional
Elements	Phase, Derived Earth, Measured Earth
Setting Range I_s (50/50N)	0.05,0.06…50 x In
Setting Range I_s (50G)	0.01, 0.011,.... 5 x In
Time Delay	0.00…14400 s
Operate Level I_{op}	100 % Is, ±5 % or ±1 % xIn
Reset level	≥ 95 % I_{op}
Reset level (50G)	>= 95 % I_{op} or I_{op} - 0.1 % In
Operate time: 50, 50G 50N	0 to 2x Is – 35 ms, ±10 ms, 0 to 5x Is – 25 ms, ±10 ms 0 to 2x Is – 40 ms, ±10 ms, 0 to 5x Is – 30 ms, ±10 ms
Operate time following delay	t_{basic} +t_d , ±1 % or ±10 ms
Inhibited by	Binary or Virtual Input Inrush detector
Disengaging time (50G)	< 50 ms

Table 1-25 51 Time Delayed OC&EF

Operation	Non directional
Elements	Phase, Derived Earth, Measured Earth
Characteristic	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
Setting Range I_s (51/51N)	0.05,0.06…4 x In
Setting Range I_s (51G)	0.01,0.011,...0.5 x In
Time Multiplier	0.01, 0.015....1.6, 1.7,....5, 6...100
Time Delay	0,0.01… 20 s
Operate Level	105 % Is, ±4 % or ±1 %x In
Minimum Operate time IEC ANSI	$t_{op} = \frac{K}{\left[\frac{I}{Is}\right]^{\alpha} - 1} \times Tm$ $t_{op} = \left[\frac{A}{\left[\frac{I}{Is}\right]^{P} - 1} + B\right] \times Tm$ ± 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)
Follower Delay	0 s - 20 s
Reset	ANSI decaying, 0 s - 60 s
Inhibited by	Binary or Virtual Input Inrush detector

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Table 1-26 50 BF Circuit Breaker Fail

Operation	Current check - Phase and Measured Earth with independent settings Mechanical Trip CB Faulty Monitor
Setting Range I_s	0.05,0.055…2.0 x In
Setting Range I_s	0.01,0.015,...2.0 x In
2 Stage Time Delays	Timer 1 20…60000 ms Timer 2 20…60000 ms
Operate Level	100 % Is, ±5 % or ±1 %x In
Disengaging time	< 20 ms
Operate time following delay	Tcbf ±1 % or ±20 ms
Triggered by	Any function mapped as trip contact
Inhibited by	Binary/Virtual Input
Timer By pass	Yes, 50BF CB Faulty Input

Table 1-27 Temperature Inputs

Temperature input type (Temperature Coefficient Resistance based on DIN/IEC 60751 standard)	Cu10 (0.00427), Ni100 (0.00618), Pt100 (0.00385), Ni120 (0.00672), Pt250 (0.00385), Ni250 (0.00618), and Pt1000 (0.00385)
Temperature input Alarm	0,1,2...250ºC
Temperature input Trip	0,1,2...250ºC
Operate value	100 % Tset, ± 2% or ±2ºC, For Cu10: ± 2 % or ± 5ºC
Response time	< 3 s
Sensing current	< 0.5 mA
Maximum lead resistance	25 Ω/lead For Cu10: 2.5 Ω/lead

Table 1-28 74 T/CCS Trip/Close Circuit Supervision

Number of supervisable circuits	3 x Trip and 3 x Close
Number of BI's Required	1 or 2 per function

Table 1-29 50BCL Break Capacity Limit

Setting	1.0, 1.5… 50 xIn
Operate level	100 % Is, ± 5 % or ± 1% In
Reset level	≥ 95 % I_{op}
Element basic operate time	0 to 2 xIs: 20 ms or ± 10 ms 0 to 5 xIs: 15 ms or ± 10 ms

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Table 1-30 46PH REV Phase Reversal

NPS to PPS ratio	20…100 %
Delay setting	0…14400 s
Operate level	100 % I s ± 5 %
Reset level	>85 % I_{op}
Basic operate time	1x In to 0 A 60 ms
Operate time	t_f + t_{basic}, ±1 % or ± 20 ms

Table 1-31 Control Functions

Motor	Start/Stop
EF	IN/OUT
Relay Mode	Local/Remote/Local or Remote/Out of service
Reset	LED's & O/P's (Test/Reset key)

Table 1-32 CB Maintenance

Trip Counter	Total & Delta 0…10000
I^2t Alarm	10…100000

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Data Communications Definitions

Document Release History

This document is issue 2016/06. The list of revisions up to and including this issue is:

2015/12	First Issue
2016/06	Second Issue

Software Revision History

2015/12	2437H80007 R4b-1a	First Release
2016/06	2437H80007 R4c-1b	Second Release

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7SR105 Rho

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Document Release History

This document is issue 2016/06. The list of revisions up to and including this issue is:

2015/12	First Issue
2016/06	Second Issue

Software Revision History

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Section 1: Installation Guide

1.1 Installation

Execute the following procedure to install the 7SR105 Rho Motor Protection 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 7SR105 Rho 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.

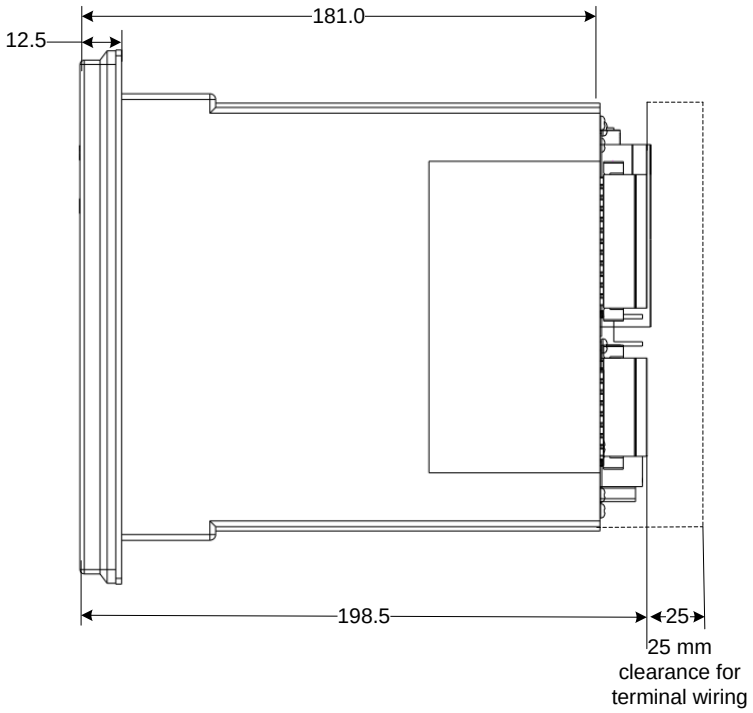


Figure 1-1 Clearance for Terminal Wiring

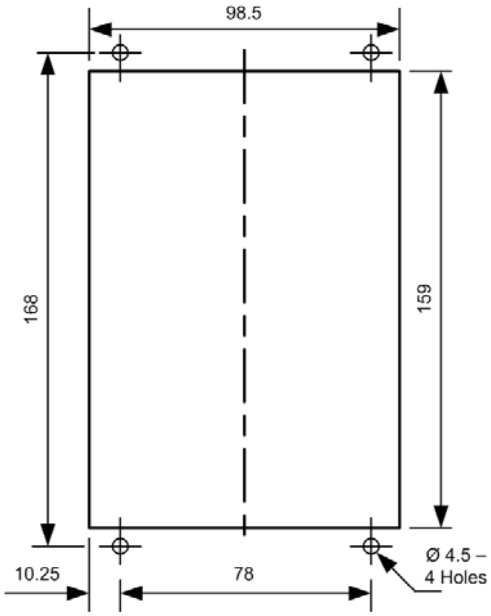


Figure 1-2 Panel cut-out

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

Terminal Blocks	Type/Cable Specifications	Manufacturer/Part number
Current Inputs (Terminal X5)	Ring type lug/2.5 mm^2 or 4 mm^2 control cable	Dowell's/RS007 or equivalent
Auxiliary Supply (Terminal X3)	Pin type lug/1.5 mm^2 /2.5 mm^2 control cable	Dowell's/CP9/CP1 or equivalent
Rear Communication Port (Terminal X2)	Pin type lug/1.5 mm^2 control cable	Dowell's/CP9 or equivalent
Front Communication Port	USB, Type B	Tyco/974329-1 or equivalent
Binary Input (Terminal X1)	Pin type lug/1.5 mm^2 /2.5 mm^2 control cable	Dowell's/CP9/CP1 or equivalent
Temperature Inputs (Terminal X6, X7)	Pin type lug/1.5 mm^2 shielded cable	Dowell's/CP9 or equivalent
Binary Output (Terminal X4)	Pin type lug/1.5 mm^2 /2.5 mm^2 control cable	Dowell's/CP9/CP1 or equivalent
Earth Connections	Ring type lug/2.5 mm^2 or 4 mm^2 control cable	Dowell's/RS007 or equivalent

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1.2 Temperature Input Connection Diagram

The connection between the relay and the temperature inputs can be used with 3-wire connection using the three core cables. The screened type of cable is used for the termination.

The maximum two temperature inputs shield can be connected to the one shield earthing screws.

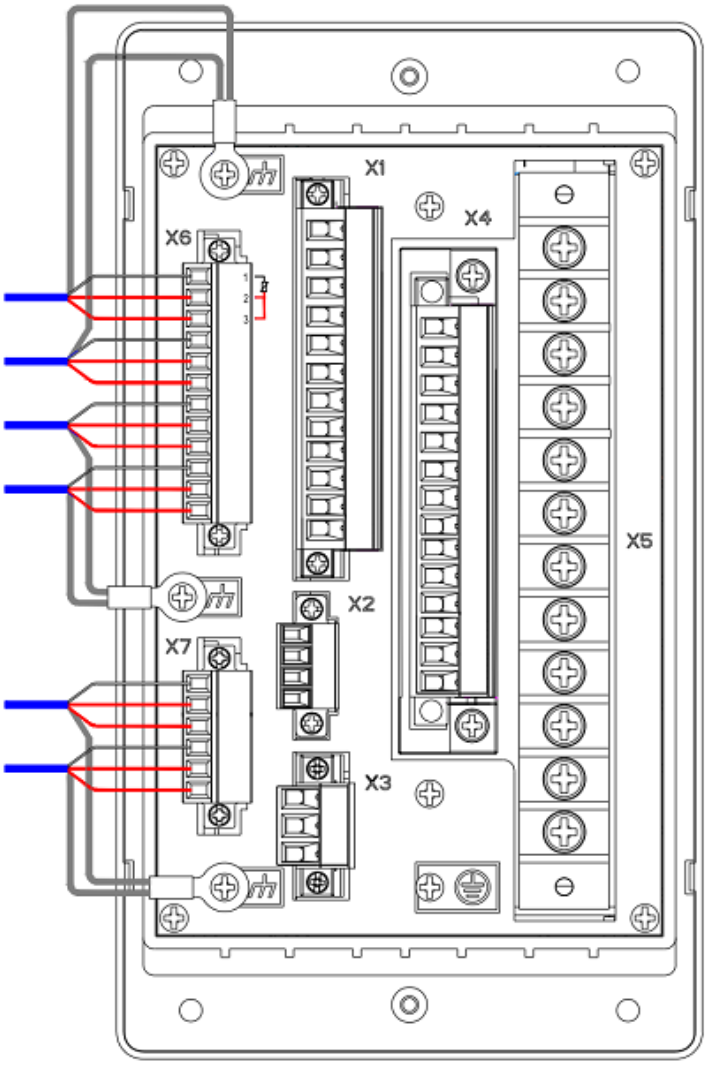


Figure 1-3 Temperature input connection diagram

Figure 1-3 shows the shields of 2 terminals are connected to the 1 earthing screw. The 3 screws are provided for the shield termination of temperature inputs.

NOTE:

Do not connect the protective earth screw to the shield termination screws.

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7SR105 Rho

Commissioning and Maintenance Guide

Document Release History

This document is issue 2016/06. The list of revisions up to and including this issue is:

2015/12	First Issue
2016/06	Second Issue

Software Revision History

2015/12	2437H80007 R4b-1a	First Release
2016/06	2437H80007 R4c-1b	Second Release

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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.
Status inputs do not work	• Check that the correct DC voltage is applied and that the polarity is correct. • Check that the status input settings such as the pick-up and drop-off timers and the status inversion function are correctly set.
Relay instrument displays show small currents or voltages even though the system is dead	This is normal. The relay is displaying calculation noise. This will not affect any accuracy claims for the relay.
Temperature input meter displays the open and short indications	Check the wiring of temperature inputs as per the connection diagram.
Temperature inputs are displaying OPEN and SHORT indication in the Instrument mode	• When the Temperature inputs is in OPEN: 1. Check the terminal. 2. In the Temperature inputs, none of the terminal should not be open at both ends (Relay and Temperature sensor side) • When the Temperature inputs is in SHORT: 1. Check the rear terminal connection. 2. Connect the terminals as shown in the 7SR105 Rho Technical Manual, Chapter 5.

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

Phone: +49 180/524 8437 (24hrs)

Fax: +49 180/524 24 71

E-mail: support.energy@siemens.com

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7SR105 Rho and 7SR17 Rho

Applications Guide

Document Release History

This document is issue 2016/06. The list of revisions up to and including this issue is:

2015/12	First Issue
2016/06	Second Issue

Software Revision History

2015/12	2437H80007 R4b-1a	First Release
2016/06	2437H80007 R4c-1b	Second Release

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Section 1: Introduction

1.1 PLANT DESIGN - MOTORS

Three phase AC motors use the synchronous or induction principle and have wide ranging power outputs from a few kW to several MW.

Three phase induction motors are employed for all general purposes, typically in fixed speed applications to drive machinery, pumps, fans, compressors, conveyors, hoists etc. Induction motors are also used with variable frequency inverters as controlled speed machines.

In a squirrel cage induction motor the 3-phase supply voltage produces a current in the stator winding which sets up a rotating magnetic field. This field flux cuts the short-circuited rotor conductors and induces a current in them. The interaction of the current and flux produces a torque which causes rotation.

LV motors are typically switched by contactors and HV motors by circuit breakers. Circuit breakers will make and break fault current whereas contactors will make but not break fault current. This means that tripping by a contactor must only be undertaken when the current is less than the contactor capability e.g. when the condition detected is overload, unbalance or stalling.

Induction motors behave as transformers with shorted secondary winding until the rotor begins to move.

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Section 2: Protection Functions

This section provides guidance on the application and recommended settings of the 7SR105 and 7SR105 protection functions.

Motor faults can be divided into two categories – system faults affecting plant up to the motor terminals and faults within the motor.

2.1 THERMAL PROTECTION

The motor heats due to power lost to the windings. The loss of heat is proportional to I^2. The motor heating time characteristic is determined by its heat storage capability and heat transfer properties. Operating temperatures will determine the life of the motor insulation, each occurrence of increased temperature reduces the life of the motor.

A number of conditions can cause the temperature of the motor to increase beyond normal working levels and beyond the thermal limits of the motor:

- Motor running overloaded
- Stalling (over-torque, load jam)
- Frequent starting or excessive start time
- Unbalance/NPS current heating e.g. caused by unbalanced supply voltages or single phasing.

When a motor is started the rotor is initially stationary followed by a period of acceleration i.e. a reducing level of slip. The motor initially behaves as a Transformer with the rotor acting as a shorted secondary winding. The Line input currents are at a maximum and can typically be up to times 6x the normal full load (I_{FLA}) running level if the motor is started Direct On Line (D.O.L.). As heating is proportional to I^2 the motor is subject to increased heating.

Figure 2-1 is a time/current plot illustrating the motor start (D.O.L.) and running currents, the current withstand levels of the motor during running and stalled conditions and the operating characteristic of the thermal overload protection.

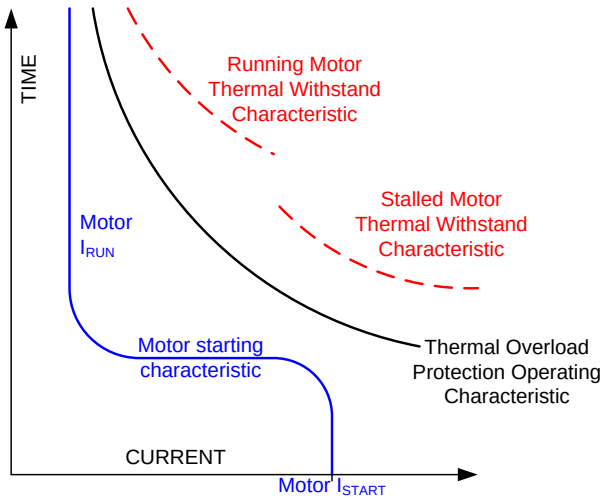


Figure 2-1 Thermal Overload Protection

The thermal overload protection above provides protection for all motor operate modes and will not operate during motor starting.

Generally the relay thermal setting calculation is carried out in the following order:-

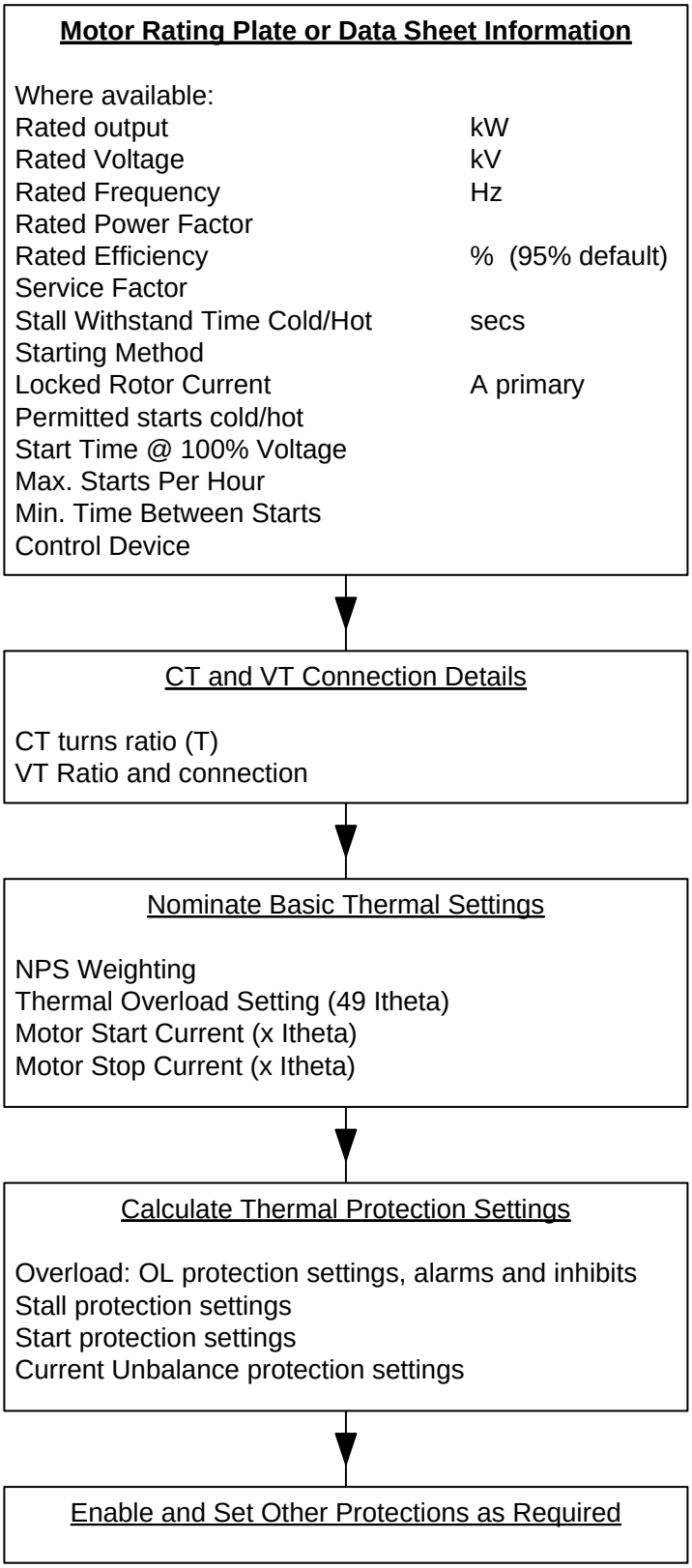


Figure 2-2 Summary of Protection Settings Calculation Procedure

Gn 49 NPS Weighting

Where 'Average' is selected the relay uses the average 3-phase RMS current in the thermal algorithm, this is suitable for static plant e.g. thermal protection of a cable.

Negative phase sequence current has an increased heating effect on rotating plant e.g. a motor. The relay should be set to 'Sequence Components' when applied to a motor.

Gn 49 NPS Weighting Factor (K)

The NPS component weighting factor value (K) should be in line with manufacturers data where provided. Where this data is not available it is recommended that the default value (K = 3) is used.

Gn 49 Thermal Overload

The thermal overload setting takes into account both the motor full load current and the CT ratio.

Typically 'Itheta thermal Overload' setting = 1.05 x motor rated current.

If it known that the rating of the motor is well in excess of the requirements of the drive the normal motor load current will be less than the motor rated current. A thermal overload setting can be chosen to protect the drive and over protect the motor.

Gn 49 Motor Start Type

Selected to '%Itheta' where the motor start current is above it's running current.

For a VFD the start current may not be appreciably higher than the running current a binary input programmed to 'Start Motor I/P' can be used, see below. Note that a motor running condition is recognised by the relay when current increases from the 'motor stopped' level to a 'NOT motor stopped level'.

'Start Motor I/P' triggers a Data Report File and initialises the start prtotection

Gn 49 Motor Start Current

The motor starting current is usually taken to be the same as the locked rotor current. The Motor Start Current setting should be less than this value and above the full load running current. The default value is 1.5 x Itheta (I_θ).

The starting current of a VFD motor may not be appreciably higher than the running current, a Motor Start Current setting cannot be applied. When the motor runs up to speed the heating time constant will be applied (rather than the starting time constant).

End of Start Type

Can be either by measured current (%Itheta) or for VFD motors a binary input programmed to 'Motor Running I/P' can be used.

The default setting (% Itheta) requires no wiring to a relay BI.

Gn49 End of Start

The end of the start can be defined when the current returns to below the thermal overload setting. The default Gn 49 End of Start setting is 1.05 x Itheta (I_θ).

Gn 49 Motor Stop Type

This can be determined from current level (%Itheta), from current level checked by a binary input programmed to 'CB Open' condition or from current level checked by a binary input programmed to 'No Accel'.

The default setting (% Itheta) requires no wiring to a relay BI.

Gn 49 Motor Stop Current

This is set at a value of current below which the motor is considered to be stopped. Typically a setting of 0.1 x Iθ is used.

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2.1.1.1 Thermal Overload (49)

Gn 49 Characteristic

The IEC characteristic is used for general applications, see Figure 2.1-3.

Additionally 'User Defined' curves are selectable, these are used where the thermal characteristic of the motor is significantly different e.g. where forced cooling is applied.

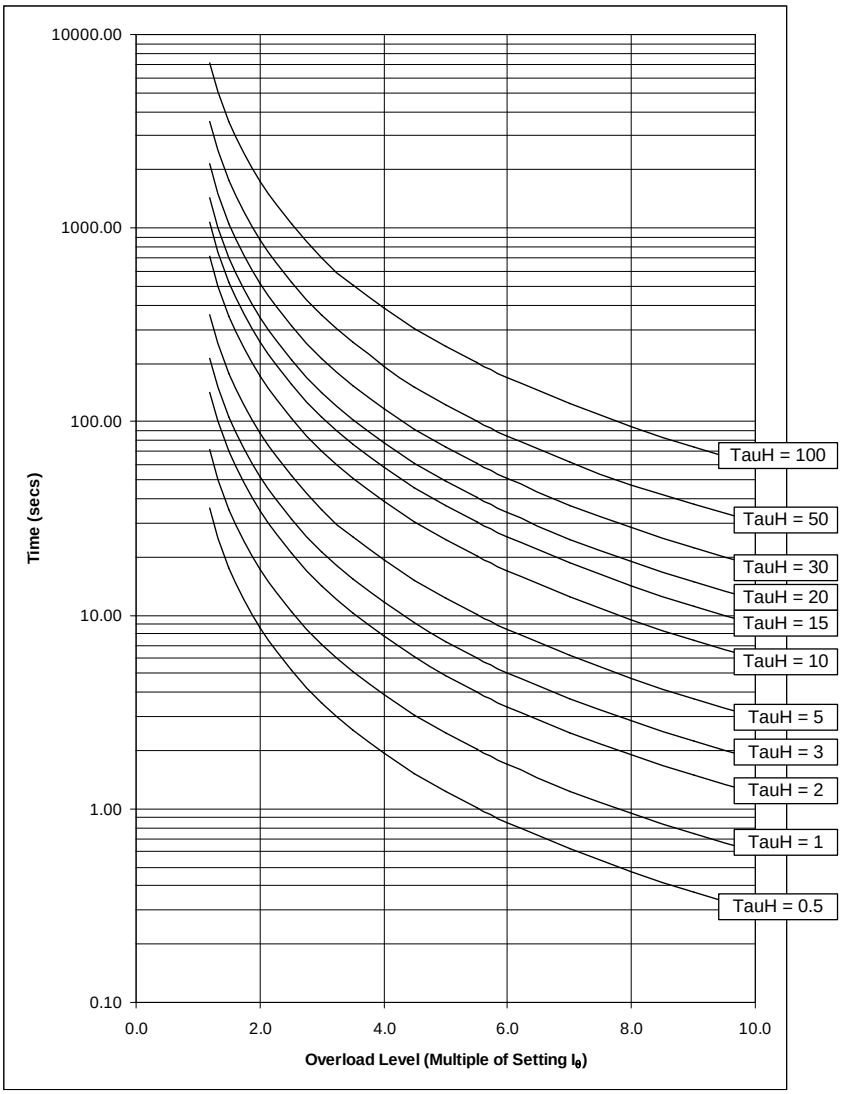


Figure 2.1-3 Thermal Heating (Cold) Characteristics

Gn49 TauH Heating Constant

Where the actual motor heating time constant is given by the manufacturer, then this figure can be used to determine the TauH setting, see Figure 2.1-3.

Gn49 TauS Starting Constant

When a motor is running at full speed, the airflow and ventilation give optimum cooling. During starting the ventilation is reduced. If this time constant is known, it can be set on the relay. If not, then set the time constant TauS to 1.0, i.e. the same as TauH. The time constant switches from TauH to TauS when a motor start is determined.

The applied time constant switches from TauS to TauH when the 'end of start' is determined.

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Gn49 TauC Cooling Constant

After an overload trip or when the motor is switched off the rotor slows until it stops. During the run-down and standstill states the motor will cool down but as the rotor does not produce forced cooling the thermal time constant will be different from the running state. The 'thermal capacity used' value decreases exponentially to mimic the cooling characteristic of the motor.

The cooling time constant is set to reflect the time taken for a stopped motor to reach steady state ambient temperature from its running temperature. The cooling time constant of the motor is always longer than the heating time constant applicable for running. The factor of TauC / TauH is not typically specified by the motor manufacturer. Typical factors are 5 to 10 x, however for large motors which are totally enclosed and also ones that normally rely heavily on forced cooling due to motion of the rotor, the factor can be as high as 60x.

Gn49 Hot/Cold Ratio Setting

Most motors are designed thermally to withstand onerous starting conditions rather than running conditions, motors therefore tend to run at a much lower temperature than their insulation class allows when thermal equilibrium is reached.

Normally, approximately half of the thermal capacity is used when a motor is running at full load. A hot/Cold Ratio setting of 50% will take this into account. Specific settings are often determined from the motor thermal damage curves or locked rotor time (LRT) hot and cold data curves.

Selecting the Hot/Cold ratio (H/C) to 100% (i.e. a high weighting factor) results in identical hot and cold operating time curves i.e. Hot Safe Stall Time (HSST) = Cold Safe Stall Time (CSST). A Hot/Cold Ratio setting approaching 100% may allow overheating of the motor as the thermal history of the motor has not been sufficiently considered.

A motor requiring negligible hot spot consideration may have a low weighting factor of 5%. In this case, when operating at full load, the relay would indicate little remaining thermal capacity available, e.g. 95% used. The hot operating time curve is then much faster than the cold operating time curve.

Disabling the Hot/Cold Ratio feature (i.e. H/C = 0) is appropriate to a motor with no hot spots or for static plant such as cables. Full consideration is made of prior loading and the 'hot' trip time is at a minimum relative to the 'cold' trip time.

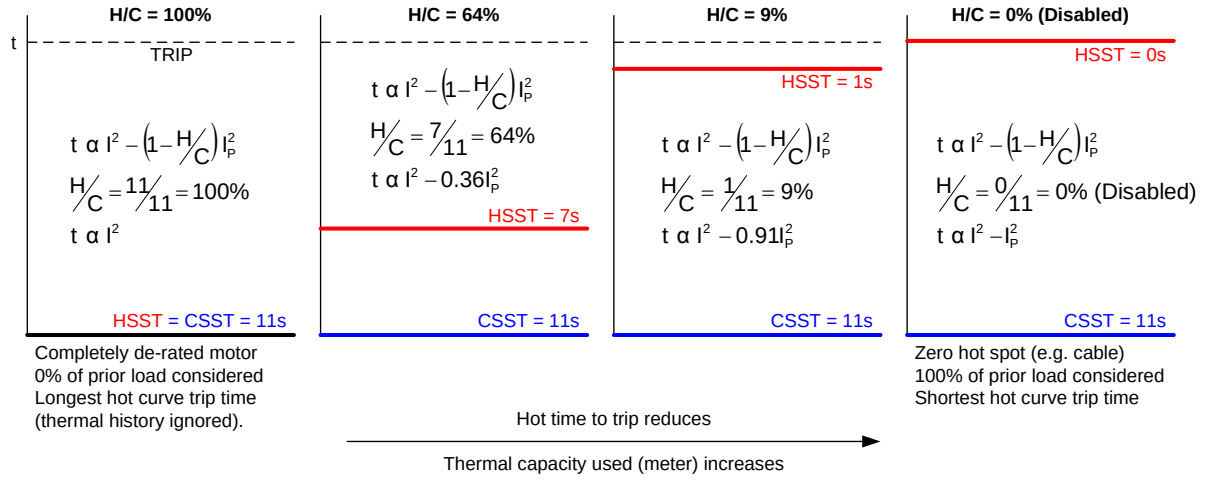


Figure 2.1-4 Effect of Hot/Cold Curve Ratio Setting on Thermal Overload Operate Time

Gn49 Capacity Alarm Setting

This setting is expressed as a percentage of the thermal state. It is settable from 50 to 100% of the set capacity and gives an alarm output if its setting is exceeded. Typically this would be set to 95% to indicate that a potential trip condition exists and that the system should be scrutinised for abnormalities.

Gn 49 Load Alarm

An alarm is provided to indicate load currents above a user set value. High levels of load current may be indicative of bearing wear e.g. due to excessive vibration or loss of lubrication. The supply to the motor can be removed before further damage occurs.

The alarm level is set as a multiple of the thermal overload setting. The range is 0.5 to 1.0 x Itheta Thermal Overload and a measured current above the set value will initiate the alarm if set.

Thermal Restart Inhibit

This feature is used to prevent motor starting if there is insufficient thermal capacity to satisfactorily complete the start operation. This can be initially set to 50% in the absence of further information.

During commissioning, before starting the protected motor, check the thermal state at the motor by accessing the "Thermal Capacity Used" meter and note the value. The motor should then be started with its normal load and, when up to speed the "Thermal Capacity Used" value can be re-checked. The difference between these two values indicates the magnitude of thermal capacity used to start. This amount must always be available before a restart is permitted. For safety, this figure should be multiplied by 1.25. For example, if 20% of capacity is used during starting, then 20% x 1.25 = 25%, and the Thermal Restart Inhibit setting should be 75%.

Alternatively auto-setting can be selected.

2.1.2 Stall Protection (14)

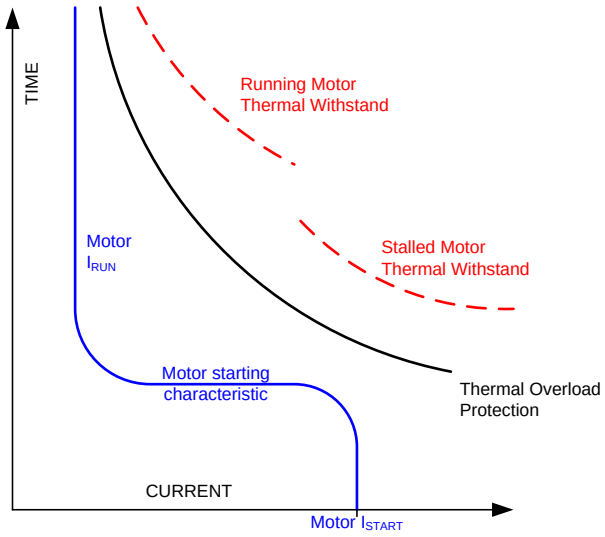


Figure 2-5 Thermal Overload Protection

The motor will stall when the load torque exceeds the breakdown torque. The motor will draw a stall current equal to or approaching locked rotor current. The thermal overload protection may provide protection against stalling during running and starting, however, where this is not possible then the additional dedicated stall protection functions can be used. Quick motor shut down can reduce thermal damage as well as damage to gears, bearings and other drive-train components.

Stalling may occur during running or may be a failure to accelerate during starting e.g.

- Excess shaft load prior to motor start-up (e.g. failure to open the pump's discharge gate)
- Sudden change of increased shaft load torque during normal operation (e.g. bearing failures)

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2.1.2.1 Start Time Less Than Stall Withstand Time

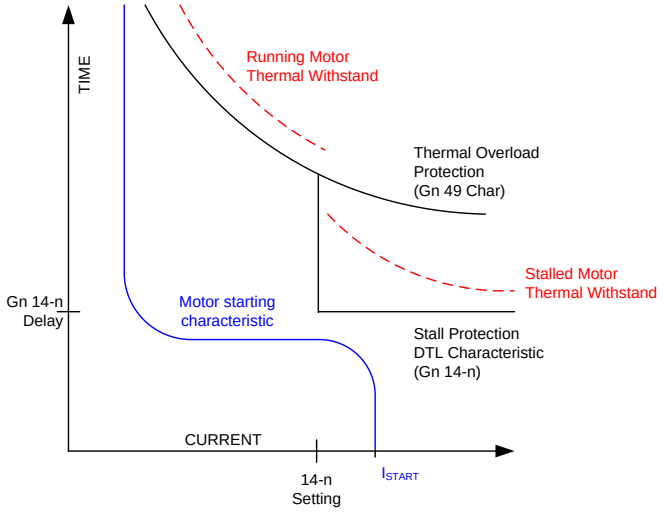


Figure 2.1-6 Start Time Less Than Stall Withstand Time

Figure 2.1-6 illustrates the most common situation where the stalled motor condition can be effectively distinguished from a healthy start by simple time grading. Select Gn14-n Control to 'None'. A single definite time characteristic can give protection during starting and stalling without causing mal-operation during a healthy start sequence.

2.1.2.2 Start Time Greater Than Stall Withstand Time

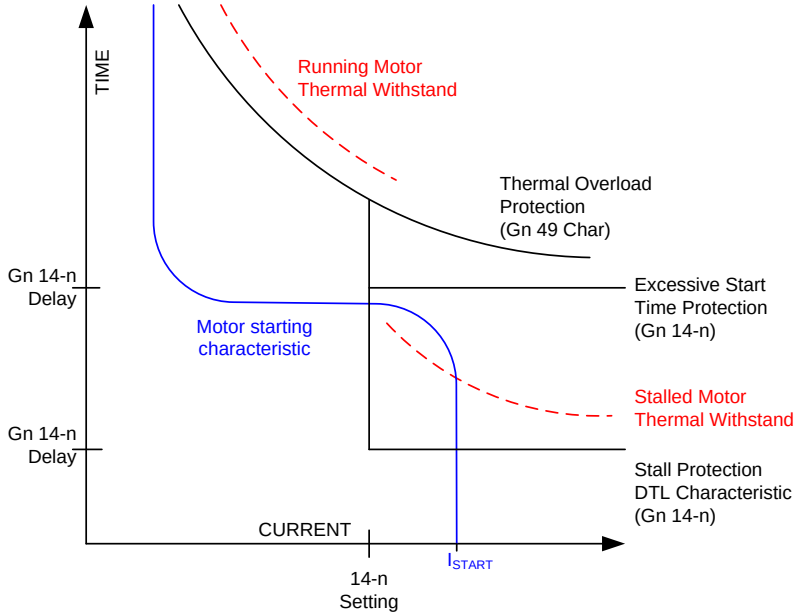


Figure 2.1-7 Start Time Greater Than Locked Rotor Withstand Time

In cases where the motor starting time approaches or exceeds the stall withstand time (e.g. motors driving high inertia loads) then protection discrimination between starting and stalling cannot be provided by simple time grading.

It is required that the stall protection is enabled only when the motor is running, this can be achieved either by:-

Select Gn14-n Control to 'Running', or

A tachometric switch mounted on the rotor is used to signal that the motor is running. A relay binary input is configured to be energised by this switch and is programmed to the 'No Accel.' function in the input configuration menu. Select Gn14-n Control to 'No Accel'.

Under stall conditions, a trip will occur after Gn14-n Delay which should be set with a delay less than the motor stall withstand time.

This can be supplemented by an additional Gn-14-n element (select Gn14-n Control to 'None') used to provide protection against the motor running up but drawing starting current for an excessive time. This timer runs for current above Gn14-n setting to provide excessive start time protection.

2.1.2.3 Over Torque DTL Element

The stall protection can be used to provide an over-torque feature which provides a faster trip where the motor develops a gradual increase in load above rating. Typical causes are bearing failure or control malfunction. Bearings may prematurely wear due to excessive vibration or loss of lubrication.

This feature allows the relay to remove the supply to the motor before further damage occurs to the bearing or load. This function is primed when the current returns to normal load levels immediately after a motor start i.e. Gn14-n Control is selected to 'Running'

The setting must allow for an increase in motor current from a system voltage depression or sudden acceleration and to allow the relay to distinguish between backfed faults.

2.1.3 Start Protection (66)

During a start higher current will be drawn from the supply and will cause higher temperatures to be generated within the motor. This is exacerbated by the fact that the motor is not rotating and hence no cooling due to rotation is available.

The permitted winding temperatures cannot be exceeded therefore the motor will have restrictions on the start duration or on the number of starts that are allowed in a defined period.

2.1.3.1 Number of Starts Protection (66)

Starting can be blocked if the permitted number of starts is exceeded. Typically two or three consecutive starts are permitted for a large motor which means that the motor and driven machine have to slow down to a stop before a start is attempted. The coasting down time may be several minutes and the time interval should reflect this i.e. Gn 66 Max Number of Starts and Gn 66 Max Starts Period settings.

Where the start duty is severe the motor manufacturer may impose a deliberate waiting time between starts, this must be set on the relay (Gn 66 Time Between Starts).

This feature can be used to prevent the operator from jogging the motor. Jogging is defined as multiple start/stops in quick succession.

2.1.3.2 Start Time Supervision (48)

Excessive temperatures may be caused by an unacceptably long start-up time. Excessive starting time may be due to:

Motor overloading

Loss of a supply phase/unsymmetrical voltage

Mechanical failure of the motor or load bearings

Low supply voltage

2.1.4 Phase Unbalance Protection (46)

Unbalanced phase currents can be measured from the difference in phase currents or from the negative phase sequence (NPS) component.

Unbalance current is contributed by the motor or system when an unbalanced voltage condition exists (open phase faults, single phase faults or unbalanced loading) or there are shorted turns on the stator winding

Motors are designed, manufactured and tested to be capable of withstanding unbalanced current for specified limits. NPS 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 $K = (I_2)^2 t$.

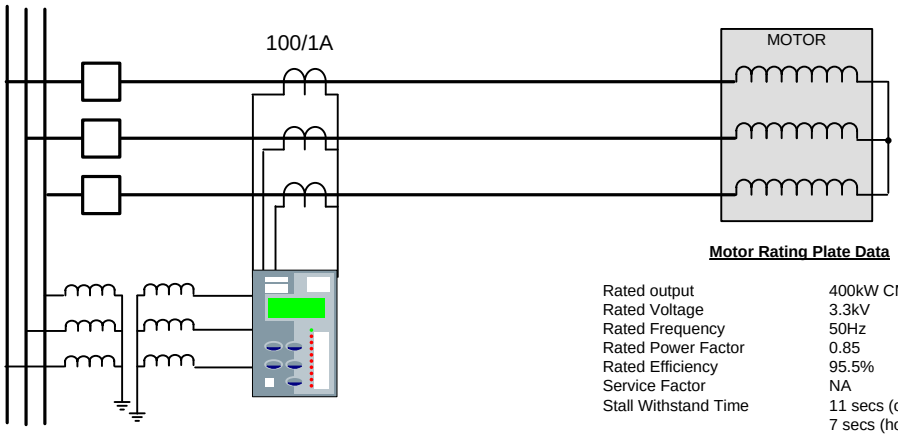
Unbalance current includes a negative phase sequence (NPS) current component. NPS current presents a major problem for 3-phase motors since it produces a magnetic field which rotates in the opposite direction to the main

field created by the rotor. 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.

Note that a 1% voltage unbalance typically translates into a 6% current unbalance. In order to prevent nuisance trips the pick-up level should not be set too low but, as current unbalance can cause serious rotor overheating the motor manufacturers recommendation as to the maximum allowable unbalance or negative sequence should be set.

The NPS withstand figure quoted by the motor manufacturer shall be used where available. Magnitude difference protection should be selected where harmonics are present.

2.2 SETTING EXAMPLE - THERMAL PROTECTION



Motor Rating Plate Data

Rated output	400kW CMR
Rated Voltage	3.3kV
Rated Frequency	50Hz
Rated Power Factor	0.85
Rated Efficiency	95.5%
Service Factor	NA
Stall Withstand Time	11 secs (cold) 7 secs (hot)
Starting Method	Direct-On-Line
Locked Rotor Current	5 x Full Load
Permitted starts cold/hot	2 per hour (hot) N.A. (cold)
Start Time @ 100% Voltage	4 sec
Min. Time Between Starts	NA
Control Device	Vacuum circuit breaker

Figure 2.2-1 Setting Example – Motor Circuit Data

The motor full load current (FLC) and start current can be calculated:-

$$\text{Input power} = \frac{\text{Output}}{\text{P.F.} \times \text{efficiency}} = \frac{400}{0.85 \times 0.955} = 493\text{KVA}$$

$$\text{Full load current} = \frac{\text{KVA}}{\sqrt{3}\,\text{kV}} = \frac{493}{\sqrt{3} \times 3.3} = 86.3\,\text{Amps}$$

CT secondary FLC is:

$$\frac{MotorFLC}{CT\ Ratio} = \frac{86.3 \times 1}{100} = 0.86A\ \ (= 0.86 \times In)$$

Motor starting current can be taken to be the same as the locked rotor current, the motor start CT secondary current is:

5 x 0.86 = 4.3A (= 4.3 x In)

Thermal Protection - Common Settings

NPS Weighting

Negative phase sequence current has an increased heating effect on a motor, NPS Weighting should be set to 'Sequence Components' when applied to a motor.

NPS Weighting Factor (K)

Where machine data is available for the machine negative sequence withstand (NPS weighting factor), this figure should be used. If no figure is available, it is recommended that K is set to the default value (K = 3). Should this setting give nuisance tripping in service a reduced weighting factor can be applied, the relay meters can be used and/or the motor manufacturer consulted to help arrive at a suitable value.

Gn 49 Itheta Thermal Overload

It is usual to choose a thermal overload setting of 1.05 x FLC, above this level the relay picks up and starts timing out before issuing a trip output, This setting allows full utilisation of the output rating of the motor. Here a setting of 1.05 x 0.86 = 0.903 is required, 'Itheta Thermal Overload' should be set to 0.90 x In.

Gn 49 Motor Start Type

The default setting '% Itheta' can be used.

Gn 49 Motor Start Current

The default value (1.5 x Itheta) is chosen, this is below the motor start (locked rotor) current and above motor f.l.c.

Gn 49 End of Start

For a motor started DOL the end of the start can be defined as when the current returns to below the thermal overload setting.

A settable End-of-Start current setting (default 1.05 x Itheta).

Gn 49 Motor Stop Type

The default setting '% Itheta' can be used.

Gn 49 Motor Stop Current

Use default setting, 0.1 x Itheta.

Thermal Protection – Overload Settings

Gn 49 Characteristic

The following settings can be based on 'IEC' characteristic

Heating Time Constant T_{HEAT}

The motor thermal characteristic curve has not been provided so we can consider:

The locked rotor current of 5 x FLC (approximately the start current) and the run-up time of 4 seconds. Allowing two consecutive starts i.e. 8 seconds total run-up time.

5 x F.L.C. = 5 x 0.86 = 4.3A

4.3/Itheta = 4.3/0.9 = 4.8 I_θ

The TauH value can be calculated from:

$$TauH = \frac{t}{\ln\left(\frac{I^2}{I^2 - I_\theta^2}\right)} = \frac{8/60}{\ln\left(\frac{4.3^2}{4.3^2 - 0.9^2}\right)} = 2.96 \text{ minutes}$$ (see Figure 2.1-3.)

As the safe stall time from cold (CSST) is 11 seconds, the TauH value could be set to 4 minutes e.g.

$$TauH = \frac{t}{\ln\left(\frac{I^2}{I^2 - I_\theta^2}\right)} = \frac{11/60}{\ln\left(\frac{4.3^2}{4.3^2 - 0.86^2}\right)} = 4.4 \text{ minutes}$$

The safe stall time from hot (HSST) i.e. 7 seconds gives a T_{HEAT} value of 2.8 minutes. For this lower value a setting of 2.5 could be chosen, there is the possibility of nuisance tripping after the motor has been in service for some time with longer run-up times and higher currents.

A setting of TauH = 4 minutes is preferred allowing two starts in quick succession.

Starting Time Constant T_{START}

This time constant has not been provided set to 1.0 x TauH.

Cooling Time Constant T_{COOL}

In this example, the cooling time constant has not been specified either as a time constant or as a multiple of its heating time constant. We will therefore choose 10x, which is the default.

Hot/Cold Curve Ratio Setting (Hot Spot Weighting)

In our example the hot/cold stall withstand time ratio is 7/11 = 0.64 i.e. H/C setting = 64%. Note that at steady state full load current the relay will stabilize at 'Thermal Capacity Used' of 36% with this setting applied.

Example:

Motor FLC	100A
Actual motor current	80A
HSST	7 seconds
CSST	11 seconds

The thermal capacity used can be determined from the ***Hot/Cold Curve Ratio*** as follows:

$$Hot/Cold\ \ Curve\ \ Ratio = \frac{LRT\ Hot}{LRT\ Cold} \times 100 = \frac{7\,\text{sec}}{11\,\text{sec}} \times 100 = 64\%$$

$$\therefore Thermal\ capacity\ used = \frac{actual\ motor\ current}{FLC} \times (100\% - HOT/COLD\ CURVE\ RATIO)$$

$$= \frac{80A}{100A} \times (100\% - 70\%) = 24\%$$

Capacity Alarm Setting

An output can be configured to indicate that a selected thermal state level has been exceeded.

Typically this would be set to 95%. Of the thermal model

Load Alarm Setting

This current setting can be used to indicate abnormally high loading conditions e.g. 1.0 x Itheta.

Thermal Restart Inhibit Setting

This can be initially set to 50% in the absence of further information.

During commissioning, before starting the protected motor, check the thermal state at the motor by accessing the "Thermal Capacity Used" meter and note the value. The motor should then be started with its normal load and, when up to speed the "Thermal Capacity Used" value can be re-checked. The difference between these two

values indicates the magnitude of thermal capacity used to start. This amount must always be available before a restart is permitted. For safety, this figure should be multiplied by 1.25. For example, if 20% of capacity is used during starting, then 20% x 1.25 = 25%, and the Thermal Restart Inhibit setting should be 75%.

Alternatively auto-setting can be selected.

Thermal Restart Mode

The default setting 'Capacity' can be used.

Summary of Thermal Settings

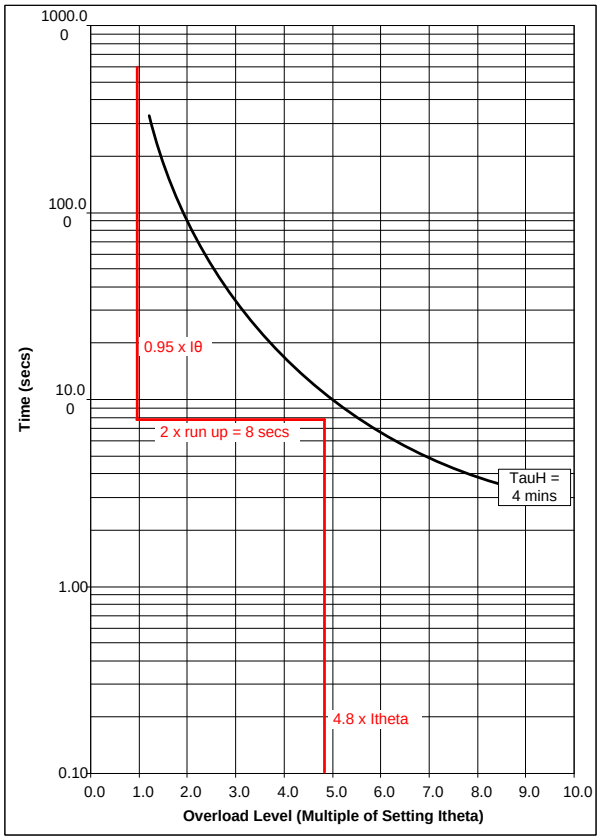


Figure 2.2-2 Summary of Thermal Settings

Thermal overload (Itheta) = 0.9 x In
Heating Constant TauH = 4 minutes
Starting Constant TauS = 1
Cooling Constant TauC = 10
H/C = 64%
49 Capacity Alarm Setting = 95%
Load Alarm Setting = 1.0 x Itheta

Stall Protection

The fundamentals of this protection feature are explained in section 2.1.2.

In the example being considered the run-up time is 4 seconds and the safe stall time is 11 seconds. In this case the thermal characteristic gives sufficient protection for normal starting and a stalled motor condition can be detected by current/time grading. The '14-1 Delay' setting should be set to be longer than the run-up time and less than the safe stall time, a time setting of 5 seconds should be chosen.

If the motor starting time is equal to or exceeds the stall withstand time it is necessary to use a stall element that can operate only when the motor is running, by either:-

Selecting Gn14-2 Control to 'Running', or

Using a tachometric switch mounted on the rotor to signal that the motor is running. A relay binary input is configured to be energised by this switch and is programmed to the 'No Accel.' function in the input configuration menu. Select Gn14-2 Control to 'No Accel'.

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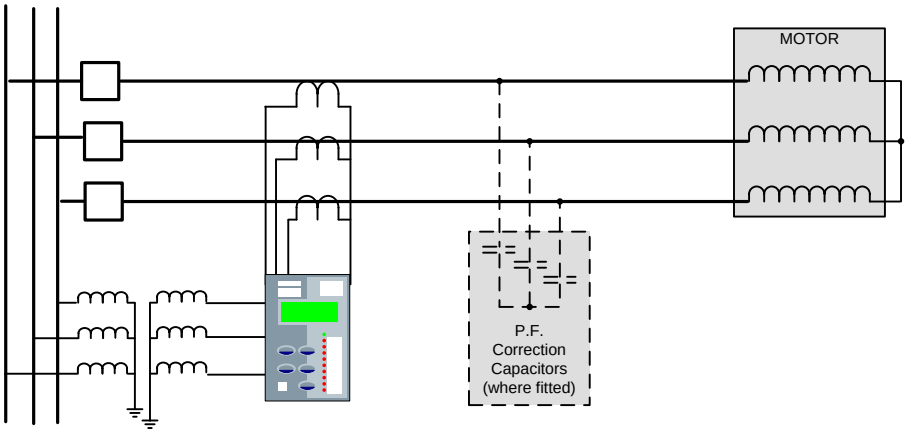
In this configuration Gn-14-1 element (select Gn14-1 Control to 'None') can be used to provide protection against excessive start time. This timer runs for current above Gn14-n setting to provide excessive start time protection.

Notes for Motors Where PF Correction Capacitors Are Fitted

The power factor of a 3-phase induction motor is inductive (typically 0.8 to 0.9). To correct the inductive current (IQ) of the motor, a capacitor producing capacitive current (IQC) is used i.e. a capacitor is connected in parallel with the motor.

Where the capacitor is connected on the motor side of the relay measuring point the 7SR105 and 7SR17 measures the corrected motor current and thus the relay settings must be adjusted to take account of the degree of correction. Where the capacitor is connected on the 'system' side of the relay measuring point the relay will measure pure motor current. In these cases the correction does not affect the relay settings.

Charging of the PF correction capacitors may cause transient inrush currents during motor starting.



2.3 CURRENT PROTECTION: LOSS OF LOAD – UNDERCURRENT (37)

Undercurrent elements are used to indicate that current has ceased to flow or that a low load situation exists. Definite Time Lag (DTL) elements are used. Loss of Load protection is applied to detect:

- Loss of pump flow e.g. motor cooling pumps.
- Loss of airflow for fans
- A failure in a mechanical transmission (e.g. failed shear pin).

The undercurrent setting where enabled can be set to the required level above motor no load current. The applied current setting or time delay setting must take into consideration low load conditions e.g. the various operate cycles of a compressor installation.

Where required the function can be inhibited from a binary input.

The undercurrent guard can be set to avoid inadvertent operation when the motor is stopped.

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2.4 OVERCURRENT (50-n, 51-n)

2.4.1 Instantaneous Overcurrent (50-n)

This is applied to protect the motor connections against phase-phase short circuits. The setting should be either above the motor start current, or inhibited during motor starting e.g. via a binary input. Note that charging of motor PF correction capacitors where fitted will increase motor starting current.

As the motor is the final point of load in the network there is no requirement to coordinate the overcurrent protection with any downstream devices, the protection can be set to operate instantaneously.

2.4.2 Time Delayed Overcurrent (51-n)

Generally instantaneous overcurrent is applied to protect the motor terminal connections. Time delayed overcurrent may be used when the relay is utilised in non motor applications.

2.5 EARTH-FAULT PROTECTION (50G/50N)

Earth fault current levels will be limited by the earth fault impedance the motor and associated plant. It may be difficult to make an effective short circuit to earth due to the nature of the installation and/or system earthing method and the earth fault current may therefore be limited to very low levels.

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 it is 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 three.

There are limits to how sensitive an earth fault 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 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

- Apply directional earth fault protection, or
- 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.

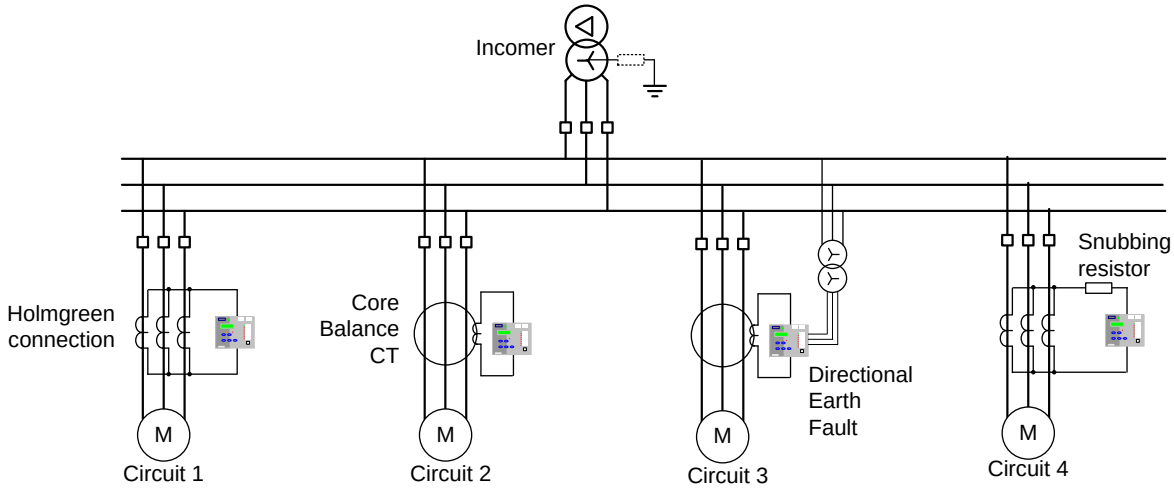


Figure 2.5-1 Earth Fault Protection Applications

During motor starting the higher currents may cause some CT saturation to occur because of the long dc offsets. For the residual (Holmgreen) earth current measuring connection, unequal CT saturation may cause false residual current to flow. It is recommended to use one of the following methods:

- Add a ‘snubbing’ resistor ensure that the earth fault element operate voltage is higher than that which can be produced by current flowing through the saturated CT phase winding. This has the disadvantage of increasing the CT burden for a real motor earth fault. Note that with this method the resistor is only required during motor starting and will reduce the earth fault protection sensitivity.

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The calculation procedure is detailed in document 'Technical Guidance Note (TGN) High Impedance Restricted Earth Fault Protection'. Note that the required stability level shall be taken as 1.3 x motor start current.

- Connect an auxiliary contact from the CB or contactor controlling the motor to a relay binary input (BI). This BI can be used to apply in an alternative Setting Group (e.g. Group 2) for the set drop off delay of the BI. Setting Group 2 can include increased earth fault pickup and/or time delay settings.
- Add a time delay to the earth fault operation.

2.6 HIGH IMPEDANCE RESTRICTED EARTH FAULT PROTECTION (87REF)

Restricted Earth Fault (REF) protection is applied to motors to detect low level earth faults in the stator windings. Current transformers are located as shown in Figure 2.6-1. During normal operation 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 REF function is configured to provide an instantaneous trip output to minimise damage from developing winding faults.

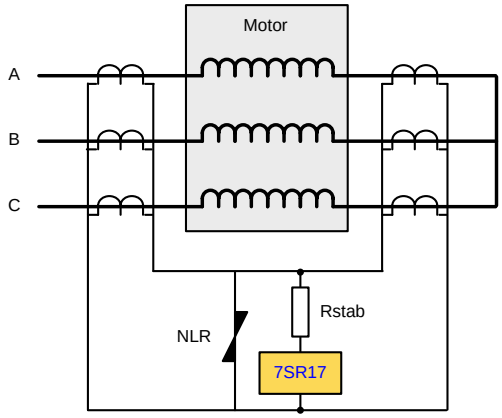


Figure 2.6-1 Restricted Earth-fault protection

The calculation for the value of the Stabilising Resistor (Rstab) is based on the worst case where for the maximum current one CT fully saturates and the other balancing CT does not saturate at all.

The required fault setting (primary operate current) of the protection is chosen; typically, this is less than 10% of the motor rated current.

Additional external Non-Linear Resistor and stabilising resistor components are required.

See separate publication 'Technical Guidance Note (TGN) High Impedance Restricted Earth Fault Protection'.

2.7 VOLTAGE PROTECTION (27/59)

2.7.1 Under Voltage

Power system under-voltages may last for only a few cycles or continue on a steady-state basis, they can occur due to system faults, an increase in system loading or loss of supply e.g. loss of an incoming transformer.

The motor does not need to be disconnected from the supply for short voltage dips, generally motor running will recover when the voltage is restored.

The motor may stall when subjected to prolonged undervoltage conditions. The motor should be disconnected from the supply and planned staged restoration of motors can be implemented when the supply is re-established.

The undervoltage trip is initiated by a voltage element operating after a definite time delay. The voltage and time delay are set to coordinate with the system and motor undervoltage withstand. The applied settings must take into account:

Prior to motor starting the relay may not detect voltage, depending on the VT connection. Under voltage protection can be inhibited using the Gn 27/59 under voltage guard feature.

In service voltage dips are likely to occur during transient faults and starting of motors. The time delay will consider the voltage dip duration for which re-acceleration is possible.

Motor starting can result in voltage depression to 80% of nominal, the voltage setting is likely to be below this value.

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2.7.2 Over Voltage

Motors can operate on moderate steady state overvoltage within the motor tolerance. Overvoltage causes an increase in magnetisation (no load) current due to an increase in iron loss in the machine. At a given shaft load, the overvoltage also causes a decrease in load current. In general the resulting total current will be less than the motor current at rated voltage. Smaller motors have a relatively high magnetising current and therefore overvoltages will cause the motor operating temperature to increase.

2.8 NEGATIVE PHASE SEQUENCE (NPS) OVERVOLTAGE (47)

Voltage unbalance can be caused by faulty contactors, transformer/OLTC faults or unbalanced loading of the three phases. Very high levels of NPS Voltage indicate a reversed phase sequence due to an incorrect connection. NPS Voltage level is an indicator of the system supply quality.

Unbalanced voltages produce unbalanced currents, see section 2.1.4. The motor NPS impedance is lower than the Positive Phase Sequence (PPS) impedance and therefore the ratio of NPS to PPS Current is higher than the equivalent ratio of NPS to PPS Voltage. A 1% voltage unbalance typically translates into a 6% current unbalance.

NPS Voltage DTL elements can be used as Alarms to indicate that the level of NPS voltage has reached abnormal levels.

2.9 FREQUENCY (81)

At decreased frequency without a corresponding voltage reduction the flux density within the motor core is increased thus increasing the hysteresis and eddy current losses and heating.

Under-frequency elements can be used to provide an alarm.

2.10 POWER PROTECTION

2.10.1 Power (32)

An under power element protects against a loss of load condition by measuring the real power flow to the motor in the running condition. This provides an alternative to under current measurement as load loss may result in only a small change in current (see section 2.3).

To prevent spurious trip operations when the relay is first energised or when a motor is disconnected, the directional power element does not operate for currents below the motor stopped threshold I_{STOP}.

The under power output is initiated by a voltage element operating after a definite time delay. The applied power setting will typically be 10-20% below minimum load, the power and time delay settings must take into account:

Where rated power cannot be reached during starting (for example where the motor is started with no connected load) it may be necessary to inhibit this function for a set time. This feature requires a 52a circuit breaker auxiliary contact mapped to an opto input to get the information CB Closed/CB Open.

Directional power measurement may operate on occurrence of a system power supply fail or system fault. Power flow into the motor will reverse since the motor will act as a generator due to the inertia of the connected load.

2.10.2 Sensitive Power (32S)

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

2.10.3 Power Factor (55)

Power factor is often a more sensitive measurement of underload conditions than current. Settings must take into account:

The power factor is low during motor starting. Start/running conditions of a VSD or synchronous motor can be detected. This function can be used instead of a tacho speed switch to block stall protection for starting, when the stall withstand is within the motor start current profile.

loss of excitation on a synchronous motor. This can be enabled for service once the excitation is applied, it can be disabled during motor starting e.g. by setting the DTL.

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Section 3: Current Transformer (CT) Requirements

3.1 CT RATIO

The CT primary rating is usually chosen to be equal to or greater than the motor full load current.

$$\text{Input power} = \frac{\text{Output}}{\text{P.F.} \times \text{efficiency}} = \frac{400}{0.85 \times 0.955} = 493\text{KVA}$$

$$\text{Full load current} = \frac{\text{KVA}}{\sqrt{3}\,\text{kV}} = \frac{493}{\sqrt{3} \times 3.3} = 86.3\,\text{Amps}$$

The C.T. ratio should be chosen as equal to or the next standard above the motor full load rating here a 100 Amp primary is chosen. The secondary could be either 1 or 5A, to reduce CT burden a 1A secondary is used, so a current ratio of 100/1 is chosen.

The motor full load CT secondary current is:

$$\frac{MotorFLC}{CT\ Ratio} = \frac{86.3 \times 1}{100} = 0.86A\ (= 0.86 \times In)$$

3.2 THERMAL AND OVERCURRENT PROTECTION CTS

Motors are typically located in industrial environments with relatively low fault current. The motor is the end load of the system and therefore has no onerous grading requirements. The CT can typically be a class 10P10 with VA rating to match the load.

Definite Time and Instantaneous Overcurrent

For industrial systems with requirements as for i.d.m.t.l. relays item (a) above, a class 10P10 (or 20).

Note that overcurrent factors do not need to be high for definite time protection because once the setting is exceeded magnitude accuracy is not important.

3.3 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.

3.4 SENSITIVE POWER (32S)

For sensitive reverse power applications e.g. Ps < 5%Pn class 1 metering CTs are recommended with a rated burden to match the secondary load connected.

For higher settings a 5P10 CT can be used.

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Section 4: Supervision and Monitoring Functions

4.1 BREAKING CAPACITY LIMIT (50BCL)

Motors are generally controlled by three methods:

Larger rated motors typically at 3.3kV or 11kV use circuit breakers,

Medium to smaller rated motors use MCCB's or fused contactors.

MCCB's and Contactors both have limited fault breaking capacity. Contactors are typically limited to 8 to 10 times their nominal current rating.

To prevent Contactor operation where fault current is above the contactor rating a check must be made that r.m.s. currents are within the contactor rating, for currents above this level circuit breaking duty should be transferred to the up-stream circuit Breaker. Alternatively, depending on circuit arrangement contactor operation can be time delayed to allow fuses to clear fault current first then the contactor is opened.

If current is above this value then the Trip action is initiated from the 50 BCL output:-

50BCL is a high speed element, it's instantaneous operation can be used to interrupt protections assigned as a general trip (OUTPUT CONFIG > OUTPUT MATRIX > General Trip). All contacts assigned as 'Gn **** Trips' in the OUTPUT CONFIG > TRIP CONFIG menu (thermal, P/F, E/F, Misc, Voltage, Freq, Power) are General Trips. For example:

The 50-1 protection must not trip the contactor for currents in excess of say 6 xIn:

50-1 Element : Current setting and time delay as required. To recognise 50-1 as a 'General Trip' set as 'OUTPUT CONFIG > TRIP CONFIG = P/F Trip'. Trip output to be connected to output relay assigned to 'OUTPUT CONFIG > OUTPUT MATRIX > General Trip'.

50BCL Element: 6 x In. Output relay to be connected to suitably rated current break device.

4.2 BACKSPIN PROTECTION (81B)

The rotor of a pump motor may spin backwards when the pump is stopped. Starting the motor during this period of reverse rotation (back-spinning) may result in motor damage. Backspin detection ensures that the motor can only be started when the motor has stopped or slowed to within acceptable limits.

When backspin protection is used the Gn 81B Delay is always enabled. This delay setting must be coordinated with the undervoltage or tachometer input when these are used.

4.3 CURRENT TRANSFORMER SUPERVISION (60CTS)

When a CT fails, the current level in the failed phase reduces to zero and the protection become unbalanced. The CT output includes a large NPS component, however, this condition would also occur for a system fault. To differentiate between the two conditions NPS voltage is used to restrain the CTS algorithm where the relay has VT inputs.

A 3-phase CT failure is considered so unlikely (these being independent units) that this condition is not tested for.

Operation is subject to a time delay to prevent operation for transitory effects.

Where specific requirements are not available the default settings should be used:

Gn 60CTS Inps = 0.1 x In

Gn 60CTS Vnps = 10V

Gn 60CTS-I Setting = 0.05 x In

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4.4 VOLTAGE TRANSFORMER SUPERVISION (60VTS)

Voltage Transformers (VTs) rarely fail, however, VT Supervision is commonly applied because the fuses connected in series with the VTs may fail.

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.

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.

Care must be taken when using ZPS quantities as it may be 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.

When NPS quantities are used load imbalances generate significant levels of NPS current and so possibly cause a VT failure to be missed. This can be overcome by 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 voltages. The PPS voltage will however 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.

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.

Unless specific information is available the default settings should be used:

Gn 60VTS Component:	NPS
Gn 60VTS V:	7V
Gn 60VTS I:	0.1 x In
Gn 60VTS Vpps:	15V
Gn 60VTS Ipps Load:	0.1 x In
Gn 60VTS Ipps Fault:	10 x In

4.5 TRIP-CIRCUIT SUPERVISION (74TCS)

Binary Inputs may be used to monitor the integrity of the CB trip circuit wiring. A small current flows through the B.I. and the trip circuit. This current operates the B.I. confirming the integrity of the auxiliary supply, CB trip coil, auxiliary switch, C.B. secondary isolating contacts and associated wiring. If monitoring current flow ceases, the B.I. drops off and if it is user programmed to operate one of the output relays, this can provide a remote alarm. In addition, an LED on the relay can be programmed to operate. A user text label can be used to define the operated LED e.g. “Trip CCT Fail”.

The relevant Binary Input is mapped to 74TCS-n in the INPUT CONFIG>INPUT MATRIX menu. To avoid giving spurious alarm messages while the circuit breaker is operating the input is given a 0.4s Drop-off Delay in the INPUT CONFIG>BINARY INPUT CONFIG menu.

To provide an alarm output a normally open binary output is mapped to 74TCS-n.

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4.6 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.

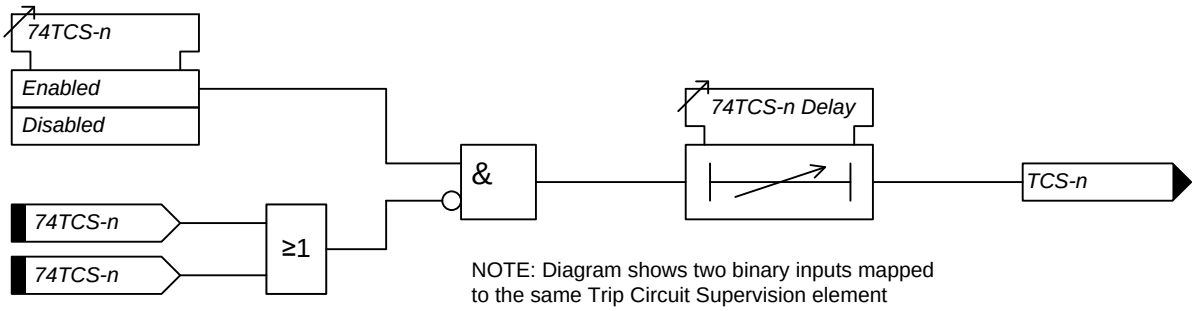


Figure 4-1 Logic Diagram: Trip Circuit Supervision Feature (74TCS)

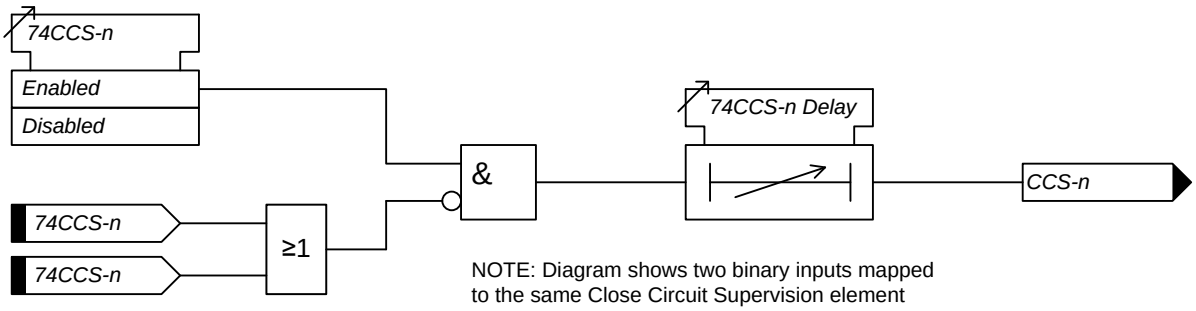


Figure 4-2 Logic Diagram: Close Circuit Supervision Feature (74CCS)

4.6.1 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.

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Scheme 1 (Basic)

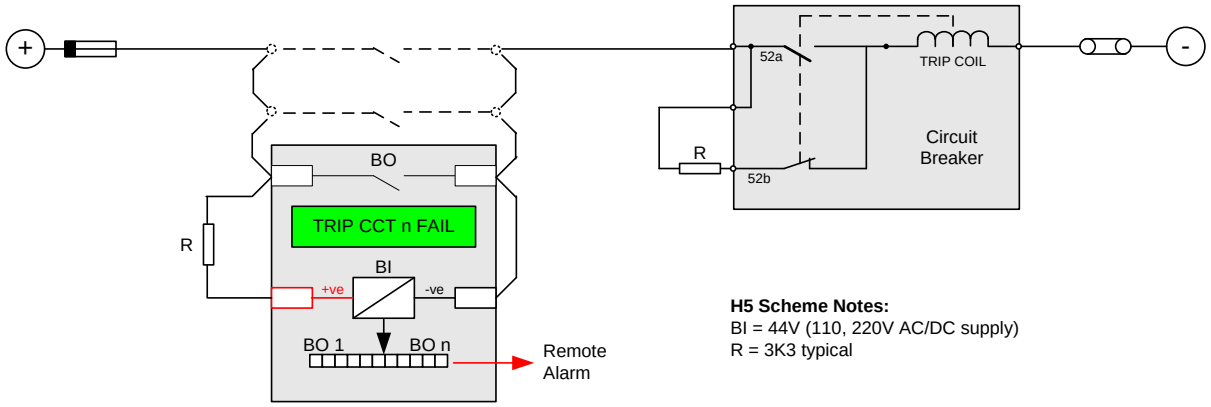


Figure 4-3 Trip Circuit Supervision Scheme 1 (H5)

Scheme 1 provides full Trip supervision with the circuit breaker Open or Closed.

Where a 'Hand Reset' Trip contact is used measures must be taken to inhibit alarm indications after a CB trip.

Scheme 2 (Intermediate)

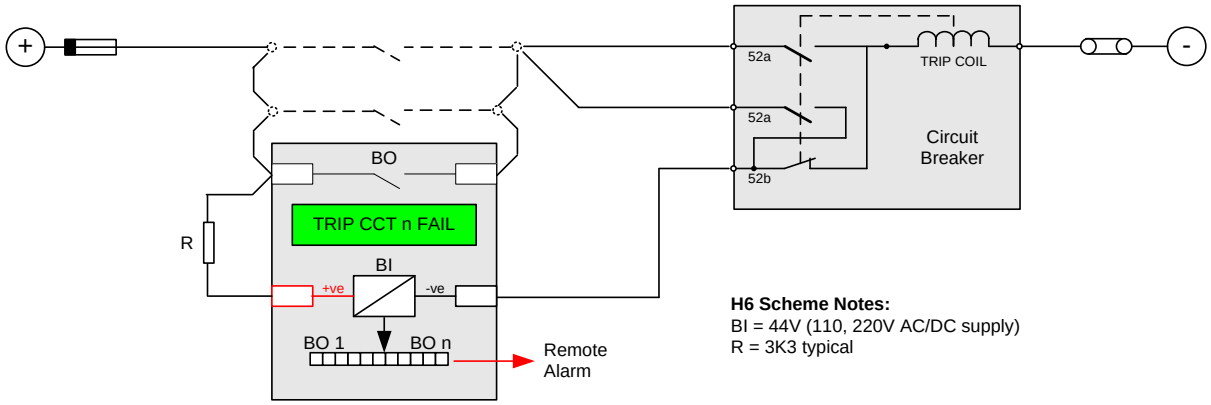


Figure 4-4 Trip Circuit Supervision Scheme 2 (H6)

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.

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Scheme 3 (Comprehensive)

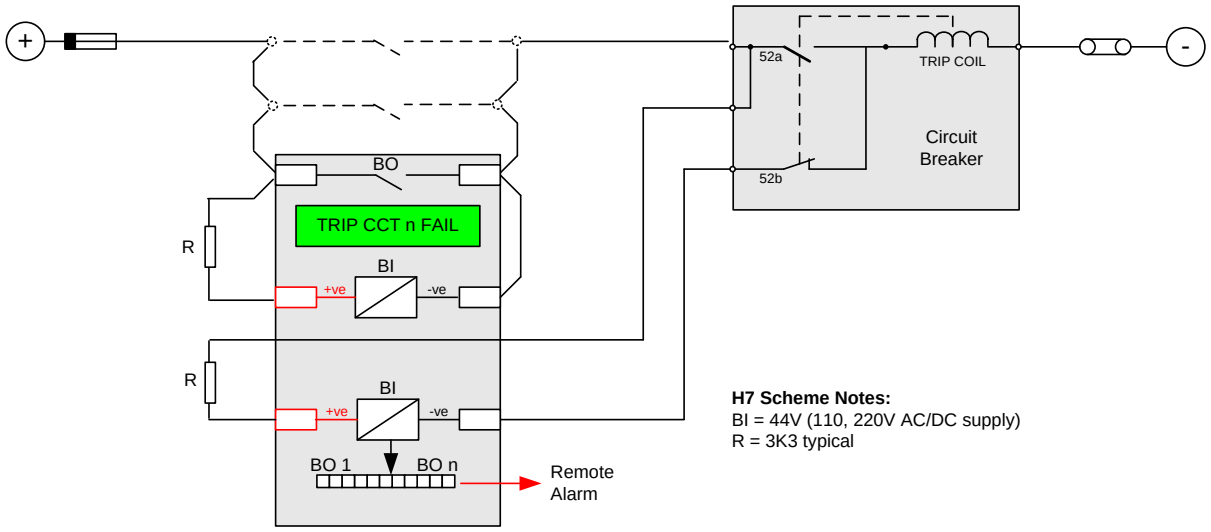


Figure 4-5 Trip Circuit Supervision Scheme 3 (H7)

Scheme 3 provides full Trip supervision with the circuit breaker Open or Closed.

4.6.2 Close Circuit Supervision Connections

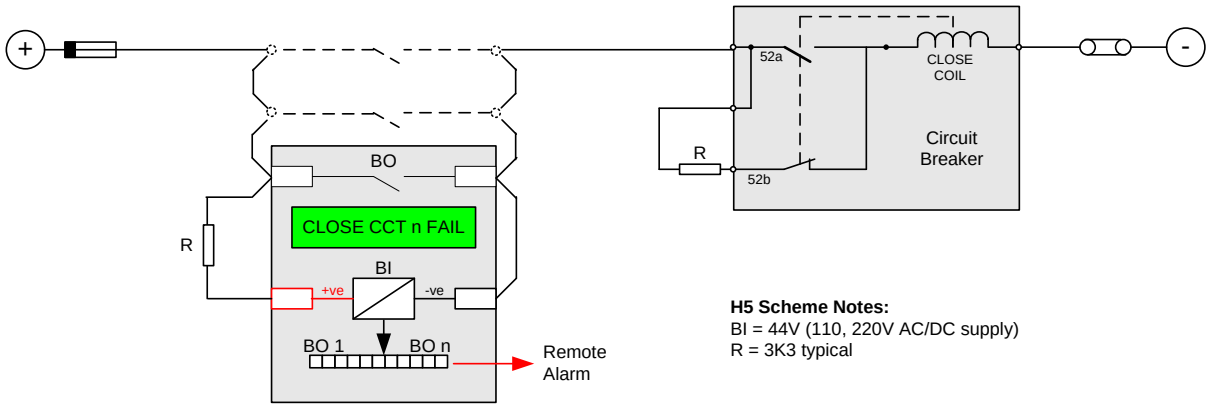


Figure 4-6 Close Circuit Supervision Scheme

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.

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4.7 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.

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) e.g. the busbar incomer. 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).

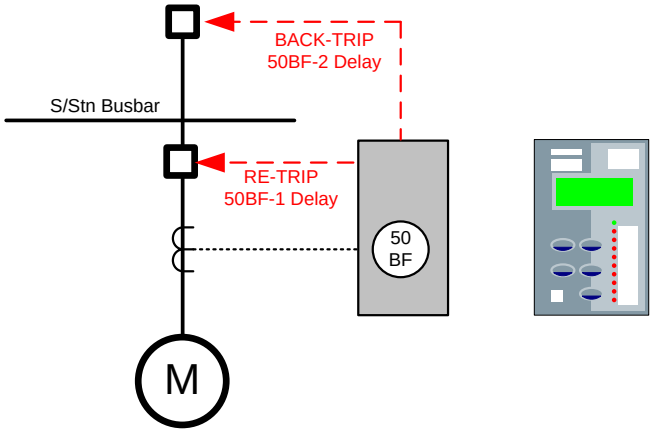


Figure 4.7-1 - Circuit Breaker Fail

50BF Setting

The current setting must be set below the minimum protection setting current.

50BF-1 Delay/50BF-2 Delay

The time delay setting applied to the CB Fail protection must be in excess of the longest CB operate time + relay reset time + a safety margin.

Stage 1 (Retrip)	
Trip Relay operate time	10ms
7SR105 or 7SR17 Disengaging Time	50ms
CB Trip time	80ms
Safety Margin	60ms
50BF-1 Delay	200ms

Stage 2 (Back Trip)	
First BF Time Delay	200ms
Trip Relay operate time	10ms
7SR105 or 7SR17 Disengaging Time	50ms
CB Trip time	80ms
Margin	60ms
50BF-2 Delay	400ms

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4.8 TEMPERATURE INPUTS (TEMP)

The thermal status of the motor can be detected through Temperature inputs (RTD). Motor working temperatures will determine the life of the motor insulation, each occurrence of increased temperature reduces the life of the motor. The ambient temperature, coolant temperature, Oil temperature, winding temperature and bearing temperature of the equipment to be thermally protected can be measured by temperature inputs (RTD).

RTD's can be connected to the Temperature inputs of the Relay, which provide actual temperature detected in motors, generators and even transformers. Normally thermal temperature of motor can be monitored with, two RTD sensors are used to monitor bearing temperature of the rotary machines and the three RTD sensors are used to monitor the stator winding temperature and one RTD sensors can be used for ambient temperature measurement.

The following table shows the temperature values according to the RTD resistance.

Table 4-1 RTD Resistance Vs Temperature

Temperature (ºC)	Pt100	Pt250	Pt1000	Ni100	Ni120	Ni250	Cu10
-50	80.306	200.765	803.062	74.255	86.163	185.637	7.104
-45	82.290	205.725	822.901	76.675	89.450	191.689	7.297
-40	84.270	210.676	842.706	79.131	92.752	197.827	7.490
-35	86.247	215.619	862.477	81.621	96.070	204.053	7.683
-30	88.221	220.554	882.216	84.145	99.406	210.364	7.876
-25	90.192	225.480	901.923	86.704	102.767	216.760	8.069
-20	92.159	230.399	921.598	89.296	106.149	223.241	8.262
-15	94.124	235.310	941.243	91.922	109.560	229.805	8.455
-10	96.085	240.214	960.858	94.581	113.002	236.453	8.648
-5	98.044	245.111	980.444	97.274	116.481	243.185	8.841
0	100.000	250.000	1000.000	100.000	120.000	250.000	9.035
5	101.952	254.881	1019.527	102.759	123.561	256.897	9.228
10	103.902	259.756	1039.025	105.551	127.167	263.878	9.421
15	105.849	264.623	1058.494	108.377	130.819	270.943	9.614
20	107.793	269.483	1077.935	111.236	134.518	278.091	9.807
25	109.734	274.336	1097.346	114.129	138.264	285.323	10.000
30	111.672	279.182	1116.729	117.055	142.059	292.639	10.193
35	113.608	284.020	1136.083	120.016	145.904	300.040	10.386
40	115.540	288.852	1155.408	123.011	149.800	307.527	10.579
45	117.470	293.676	1174.704	126.040	153.747	315.101	10.772
50	119.397	298.492	1193.971	129.105	157.745	322.762	10.965
55	121.320	303.302	1213.209	132.204	161.796	330.511	11.159
60	123.241	308.104	1232.419	135.340	165.900	338.350	11.352
65	125.159	312.899	1251.599	138.512	170.057	346.280	11.545
70	127.075	317.687	1270.751	141.720	174.268	354.301	11.738
75	128.987	322.468	1289.874	144.966	178.532	362.416	11.931

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80	130.896	327.242	1308.968	148.250	182.848	370.625	12.124
85	132.803	332.008	1328.033	151.572	187.218	378.931	12.317
90	134.706	336.767	1347.069	154.934	191.639	387.336	12.510
95	136.607	341.519	1366.076	158.336	196.112	395.840	12.703
100	138.505	346.263	1385.055	161.778	200.639	404.446	12.896
105	140.400	351.001	1404.004	165.262	205.219	413.155	13.089
110	142.292	355.731	1422.925	168.788	209.854	421.971	13.283
115	144.181	360.454	1441.817	172.358	214.543	430.895	13.476
120	146.068	365.170	1460.680	175.971	219.288	439.929	13.669
125	147.951	369.878	1479.514	179.630	224.091	449.075	13.862
130	149.831	374.579	1498.319	183.334	228.949	458.337	14.055
135	151.709	379.273	1517.095	187.086	233.864	467.716	14.248
140	153.584	383.960	1535.843	190.886	238.836	477.216	14.441
145	155.456	388.640	1554.561	194.735	243.864	486.838	14.634
150	157.325	393.312	1573.251	198.634	248.950	496.586	14.827
155	159.191	397.978	1591.912	202.585	254.092	506.463	15.022
160	161.054	402.636	1610.544	206.588	259.295	516.471	15.217
165	162.914	407.286	1629.147	210.645	264.561	526.614	15.411
170	164.772	411.930	1647.721	214.757	269.893	536.894	15.606
175	166.626	416.566	1666.266	218.926	275.295	547.316	15.801
180	168.478	421.195	1684.783	223.152	280.770	557.881	15.996
185	170.327	425.817	1703.270	227.437	286.320	568.593	16.191
190	172.172	430.432	1721.729	231.782	291.949	579.457	16.385
195	174.015	435.039	1740.159	236.189	297.659	590.474	16.580
200	175.856	439.640	1758.560	240.660	303.454	601.650	16.775
205	177.693	444.233	1776.932	245.194	309.337	612.986	16.970
210	179.527	448.818	1795.275	249.795	315.309	624.487	17.165
215	181.358	453.397	1813.589	254.463	321.376	636.157	17.360
220	183.187	457.968	1831.875	259.200	327.536	648.000	17.555
225	185.013	462.532	1850.131	264.007	333.791	660.018	17.750
230	186.835	467.089	1868.359	268.886	340.143	672.217	17.945
235	188.655	471.639	1886.558	273.839	346.592	684.599	18.140
240	190.472	476.182	1904.728	278.868	353.140	697.170	18.335
245	192.286	480.717	1922.869	283.973	359.786	709.932	18.530
250	194.098	485.245	1940.981	289.156	366.531	722.890	18.725

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Section 5: Control & Logic Functions

5.1 USER DEFINED LOGIC

5.1.1 Undervoltage Auto Restart (Restoration of Supply)

As an example user defined logic can be used to provide an undervoltage auto-restart scheme.

Motors can be automatically re-started after a momentary power loss. When the control voltage drops below drop-out voltage the contactors are de-energised. Timers can be initiated to restart the drive upon restoration of supply voltage - if the control voltage is restored within the programmed restart time. For example logic can be implemented to allow an auto-restart, delayed for up to 100s after supply loss for up to 10s.

The logic can be configured using Reylogic Express – refer to the Reydisp Manager User Manual.

5.2 MOTOR START/STOP

The motor can be controlled from the relay fascia (control mode) using these settings. Note that the control mode ‘motor stop’ command is not suitable for use as an emergency stop e.g. an emergency stop requires immediate access (not via menu structure) and the relay may not respond to key presses during archiving. Typically separate motor control pushbuttons will be wired directly to the motor control device or to binary inputs of the 7SR105 and 7SR17.

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Section 6: Application Examples

6.1 FUNCTION AND CONNECTION DIAGRAMS

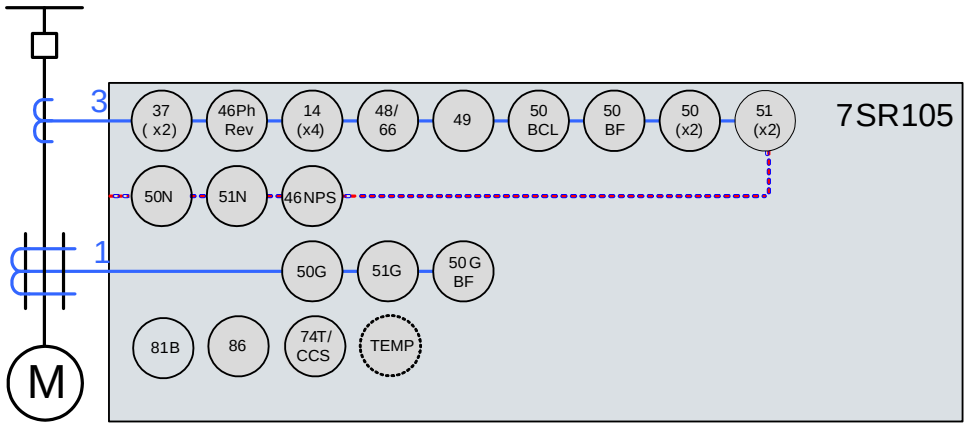


Figure 6.1-1 7SR105 Rho Function Diagrams

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EMDG-T10067-00-76GB

November 2016