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Technical Manual Chapters

1. Description of Operation
2. Settings, Configuration & Instruments
3. Performance Specification
4. Data Communications
5. Installation
6. Commissioning and Maintenance
7. Applications Guide
7SR105 Rho
Description of Operation

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

- **Setting Menu Location**: 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.
## 1.4 Ordering Options

### Product description

**7SR105 Rho**

### Variants

<table>
<thead>
<tr>
<th>Order No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S R 1 0 5</td>
<td>Motor Protection Relay</td>
</tr>
</tbody>
</table>

### Case, I/O and Fascia

- **Size 4 Moulded case, 4CT, 6 Binary Inputs/6 Binary Outputs, 10 LEDs**

### Measuring input

- **1/5 A, 50 Hz**

### Auxiliary voltage

- **AC/DC 60-240V, Binary input**
- **Threshold 44 V AC/V DC**
- **DC 24-60 V, Binary input threshold**
- **19 V DC**

### Protective Cover

- **Standard version – No Cover**

### Communication

- **Front Port: USB and Rear Port: RS-485**
- **Supporting IEC 60870-5-103 or Modbus RTU or DNP 3.0**

### Temperature Input

- **Without RTD**
- **6 RTD Input**

### Front Fascia

- **Standard Version – with Breaker**

### Protection Function Packages

**Standard version - included in all models**

- **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**

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Chapter 1 Page 7 of 57
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

<table>
<thead>
<tr>
<th>Relay</th>
<th>Current Inputs</th>
<th>Voltage Inputs</th>
<th>Binary Inputs</th>
<th>Binary Outputs</th>
<th>Temperature Inputs</th>
<th>LEDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>7SR1053-XXXX-2EA0</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>7SR1053-XXXX-2FA0</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

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)
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](image)

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.

<table>
<thead>
<tr>
<th>Button</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Start" /></td>
<td>Start</td>
<td>Press Start button and confirm ENTER to execute the start operation of motor.</td>
</tr>
<tr>
<td><img src="image" alt="Stop" /></td>
<td>Stop</td>
<td>Press Stop button and confirm ENTER to execute the stop operation of motor.</td>
</tr>
</tbody>
</table>

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.
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
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](image)

![Figure 2-5 Fascia Relay Rating Label](image)

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

2.7.2 LCD Indication

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

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

All general alarms are raised when a fault trigger is generated and will be logged into the Fault Data record.
2.7.3 Standard Keys

The relay is supplied as standard with 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.
2.8 Current Inputs

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

The current input is incorporated within the relay and is used for phase fault and earth fault protection.

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

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

The primary CT ratio used for the relay instruments can be set in the CT/VT configuration menu.
2.9 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.

![Binary Input Logic Diagram](image)

**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.

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.
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.

<table>
<thead>
<tr>
<th>Start Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count 1</td>
</tr>
<tr>
<td>Target 100</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>UNEXPECTED RESTART</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNTS EXCEEDED!</td>
</tr>
<tr>
<td>DEVICE LOCKED OUT</td>
</tr>
</tbody>
</table>

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 settable 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.

---

<table>
<thead>
<tr>
<th>Time</th>
<th>Type</th>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:00:00.500,01/10/2013</td>
<td>160</td>
<td>Raised Power On</td>
<td></td>
</tr>
<tr>
<td>15:00:00.570,01/10/2013</td>
<td>160</td>
<td>Raised Setting Cl selected</td>
<td></td>
</tr>
<tr>
<td>15:00:09.315,01/10/2013</td>
<td>153</td>
<td>Raised CB Alarm</td>
<td></td>
</tr>
<tr>
<td>15:00:00.500,01/10/2013</td>
<td>154</td>
<td>Raised Power On</td>
<td></td>
</tr>
<tr>
<td>15:00:00.570,01/10/2013</td>
<td>160</td>
<td>Raised Setting Cl selected</td>
<td></td>
</tr>
<tr>
<td>15:00:09.315,01/10/2013</td>
<td>153</td>
<td>Raised CB Alarm</td>
<td></td>
</tr>
<tr>
<td>15:03:03.500,01/10/2013</td>
<td>160</td>
<td>Raised Power On</td>
<td></td>
</tr>
<tr>
<td>15:03:03.570,01/10/2013</td>
<td>160</td>
<td>Raised LED Reset</td>
<td></td>
</tr>
<tr>
<td>15:03:09.315,01/10/2013</td>
<td>160</td>
<td>Raised Power On</td>
<td></td>
</tr>
<tr>
<td>15:07:16.500,01/10/2013</td>
<td>60</td>
<td>Raised Re-Start</td>
<td></td>
</tr>
<tr>
<td>15:07:23.505,01/10/2013</td>
<td>91</td>
<td>Raised LED FU l</td>
<td></td>
</tr>
<tr>
<td>15:07:25.315,01/10/2013</td>
<td>160</td>
<td>Raised CB Alarm</td>
<td></td>
</tr>
<tr>
<td>15:07:40.115,01/10/2013</td>
<td>160</td>
<td>Raised Local &amp; Remote</td>
<td></td>
</tr>
</tbody>
</table>

**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 ($\theta$) is reached.

The thermal overload function uses measured 3-phase true RMS current to estimate the thermal state of the motor. The Thermal State ($\theta$) is based on both past and present current levels. $\theta = 0\%$ for unheated equipment, and $\theta = 100\%$ 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.

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:

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

or,

$$t\text{ (mins)} = \tau \times \ln\left(\frac{I_{EQ}^2}{I_{EQ}^2 - I_{th}^2}\right)$$

For the cooling curve:

$$\theta = \theta_f \times e^{-\frac{t}{\tau}} \text{ or } t = \tau \cdot \ln\left(\frac{\theta}{\theta_f}\right)$$

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>
<thead>
<tr>
<th>Gn 49 TauH (mins)</th>
<th>Heating Time Constant: Used during normal motor running conditions and overloads.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gn 49 TauS (mins)</td>
<td>Starting Time Constant: Multiple of heating time constant takes into consideration the reduced cooling available when the motor is running up to full speed.</td>
</tr>
<tr>
<td>Gn 49 TauC (mins)</td>
<td>Cooling Time Constant: Multiple of heating time constant takes into consideration the reduced rate of cooling of a stopped motor.</td>
</tr>
</tbody>
</table>
The thermal condition can be predicted for any steady state value of input current: where $t >> \tau$,

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

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 $I_{EQ} < I_0$) by multiplying the predicted final steady thermal state by $(1-H/C)$. The hot curve is modified as below:

$$\theta_F = \frac{I_{EQ}^2}{I_0^2} \times (1 - \frac{H}{C}) \times 100\%$$

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 ($I_{theta}$).

- **Gn 49 Motor Start Type** sets the criteria for determining that the motor has started. Defined by:
  - $\%I_{theta}$: 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:
  - $\%I_{theta}$: Current below ‘Gn 49 Motor Stop Current’ AND Gn 49 Motor Stop Delay
  - $\%I_{theta} + CB$ Open: Current below ‘Gn 49 Motor Stop Current’ AND ‘CB Open’ binary input AND Gn 49 Motor Stop Delay.
  - $\%I_{theta} + No \ Accel$: Current below ‘Gn 49 Motor Stop Current’ AND BI programmed to ‘No Accel’ energised.
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 \( (I_\theta) \) 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:-

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

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,
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:

\[ t = \tau \ln \left( \frac{i^2}{i_0^2} \right) \left( 1 - \frac{H}{C} \right) \]

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:

![Thermal Time Constants Diagram](image)

**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 \( I_\theta \).

### Gn 49 Overload Alarm

An instantaneous alarm output is given if the equivalent thermal current \( I_e \) exceeds the thermal overload setting \( I_\theta \) whilst the motor is in its 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.
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 ISTOP) 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.

![Diagram of Number of Starts Protection](image-url)

**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 \textit{\textit{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](image-url)
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:

\[ t = \frac{1}{2} \times t_{\text{inv}} \left( \frac{I_2}{I_0} \right) \]

![Figure 3-8 Logic Diagram: NPS Phase Unbalance (46NPS)](image-url)
### 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:

\[
\text{Percentage Unbalance} = \frac{I_\Delta}{I_b} \times 100\%
\]

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

\[
t = \frac{1}{\left(\frac{I_\Delta}{I_b}\right)^2} \times t_m
\]

![Logic Diagram: Phase Difference Phase Unbalance (46PD)](image-url)

**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)](image)

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
3.3.2 Time Delayed Overcurrent Protection (51)

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

**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.
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.
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.

\[ \text{51N-1, 51N-2} \]

**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.

![Logic Diagram: Derived Time Delayed Earth Fault Protection](image)

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**: $51G/50G \text{ Measurement} = \text{RMS}$
- **Fundamental Frequency RMS current**: $51G/50G \text{ Measurement} = \text{Fundamental}$

3.5.1 Instantaneous Measured Earth Fault Protection (50G)

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

\[ \text{50G-1, 50G-2} \]

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.
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 3-15 Logic Diagram: Measured Instantaneous Earth-fault Element**

**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)](image-url)
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.

![Logic Diagram: Phase Reversal Detection (46 PH REV)](image)

**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 \( G_n 74TCS-n \). 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 \( G_n 74TCS-n \) 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)](image)

4.5 **Close Circuit Supervision (74CCS)**

The relay provides three Close Circuit Supervision elements.

![Figure 4-5 Logic Diagram: Close Circuit Supervision Feature (74CCS)](image)
### 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)](image-url)
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)](image)
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, I2t 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.
The controller should only ever be in 3 states:

<table>
<thead>
<tr>
<th>CB Status</th>
<th>CB Open binary input</th>
<th>CB Closed binary input</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB is Open</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>CB is Closed</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CB is Travelling between the above 2 states</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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.

![Logic Diagram: Circuit Breaker Status](image)

**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.
Start Motor
Stop Motor

Start Motor
Delay
≥ 1
Stop Motor
Delay
≥ 1

81B
No. of Starts

Start Motor
Stop Motor

Start Motor

Stop Motor

Emergency Start
Blocked Start
Thermal Restart
Inhibit

Blocked Start Delay
Start Motor
Delay
Start Motor Pulse
Stop Motor
Delay
Stop Motor Pulse

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:

- **Digit**: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- **Parenthesis**: ( )
- **’NOT’ Function**: !
- **’AND’ Function**: .
- **’EXCLUSIVE OR’ Function**: ^
- **’OR’ Function**: +
- **Equation (number)**: En
- **Function Key (number)**: Fn
- **Binary Input (number)**: In
- **LED (number)**: Ln
- **Binary output (number)**: On
- **Virtual Input/Output (number)**: Vn

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).

![Sequence Diagram: Quick Logic PU/DO Timers (Counter Reset Mode Off)](image)

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

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

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.

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

1. Click Connect.

![Figure 6-1 Communication to Front USB Port](image)
2. Select **COM port** where the 7SR105 Rho Motor Protection Relay is connected.

![Port Selection in Connection Manager](image)

**Figure 6-3** Port Selection in Connection Manager

3. Select **System Information** icon.

![System Information Icon](image)

**Figure 6-4** System Information Icon

4. Confirm the connection establishment with the Reydisp.
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.

<table>
<thead>
<tr>
<th>Setting name</th>
<th>Range</th>
<th>Default</th>
<th>Setting</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Address</td>
<td>0 ... 254 (IEC60870-5-103)</td>
<td>0</td>
<td>1...</td>
<td>An address must be given to identify the relay. Each relay must have a unique address.</td>
</tr>
<tr>
<td></td>
<td>0 ... 247 (MODBUS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 ... 65534 (DNP3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COM1-RS485 Protocol</td>
<td>OFF, IEC60870-5-103, MODBUS-RTU, DNP3.0</td>
<td>IEC60870-5-103</td>
<td>As Required</td>
<td>Sets the protocol used to communicate on the RS485 connection.</td>
</tr>
<tr>
<td>COM1-RS485 Baud Rate</td>
<td>75 110 150 300 600 1200 2400 4800 9600 19200 38400</td>
<td>19200</td>
<td>As Required</td>
<td>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.</td>
</tr>
<tr>
<td>COM1-RS485 Parity</td>
<td>NONE, ODD, EVEN</td>
<td>EVEN</td>
<td>As Required</td>
<td>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.</td>
</tr>
<tr>
<td>COM1-RS485 Mode</td>
<td>Local, Remote, Local Or Remote</td>
<td>Remote</td>
<td>Remote</td>
<td>Selects whether the port is Local or Remote.</td>
</tr>
<tr>
<td>Setting name</td>
<td>Range</td>
<td>Default</td>
<td>Setting</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------</td>
<td>---------</td>
<td>-----------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Unsolicited Mode</td>
<td>DISABLED ENABLED</td>
<td>DISABLED</td>
<td>As Required</td>
<td>Setting is only visible when COM1 Protocol is set to DNP3</td>
</tr>
<tr>
<td>Destination Address</td>
<td>0 … 65534</td>
<td>0</td>
<td>As Required</td>
<td>Setting is only visible when COM1 Protocol is set to DNP3</td>
</tr>
</tbody>
</table>

![Diagram](image)

**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.
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.
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.
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>
<thead>
<tr>
<th>Table 6-1</th>
<th>Operation Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td>REMOTE MODE</td>
</tr>
<tr>
<td>Control</td>
<td>Enabled</td>
</tr>
<tr>
<td>Fascia (Control Mode)</td>
<td>Disabled</td>
</tr>
<tr>
<td>USB</td>
<td>Disabled</td>
</tr>
<tr>
<td>Binary Inputs</td>
<td>Setting Option</td>
</tr>
<tr>
<td>Binary Outputs</td>
<td>Enabled</td>
</tr>
</tbody>
</table>

**Reporting**

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>REMOTE MODE</th>
<th>LOCAL MODE</th>
<th>SERVICE MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>IEC</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>DNP</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>General Interrogation</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>IEC</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>DNP</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>MODBUS</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Enabled</td>
</tr>
</tbody>
</table>

**Changing of Settings**

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>REMOTE MODE</th>
<th>LOCAL MODE</th>
<th>SERVICE MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear Ports</td>
<td>Enabled</td>
<td>Disabled</td>
<td>Enabled</td>
</tr>
<tr>
<td>Fascia</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Enabled</td>
</tr>
<tr>
<td>USB</td>
<td>Disabled</td>
<td>Enabled</td>
<td>Enabled</td>
</tr>
</tbody>
</table>

**Historical Information**

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>REMOTE MODE</th>
<th>LOCAL MODE</th>
<th>SERVICE MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waveform Records</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Enabled</td>
</tr>
<tr>
<td>Event Records</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Enabled</td>
</tr>
<tr>
<td>Fault Information</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Enabled</td>
</tr>
<tr>
<td>Setting Information</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Enabled</td>
</tr>
</tbody>
</table>

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
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.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy (-10 °C to 60 °C)</td>
<td>±60 p.p.m</td>
</tr>
</tbody>
</table>

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.
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.
7SR105 Rho
Settings and Instruments

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Revision</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015/12</td>
<td>2437H80007 R4b-1a</td>
<td>First Release</td>
</tr>
<tr>
<td>2016/06</td>
<td>2437H80007 R4c-1b</td>
<td>Second Release</td>
</tr>
</tbody>
</table>

Software Revision History
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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,

![Menu Diagram]

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)
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 the settings document.

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

![Relay Identifier Screen](image)

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**
  - Used to navigate the menu structure.

- **READ UP**
  - Used to navigate the menu structure.

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

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

- **TEST/RESET**
  - This push-button is used to reset the fault indication on the fascia. When on the Relay Identifier screen it also acts as a lamp test button, when pressed all LEDs will momentarily light up to indicate their correct operation. It also moves the cursor right ► when navigating through menus and settings.
Figure 1.2-2 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/RESET buttons. The text description shown here is the default information. Depending upon the relay model you have, you may not have all of the meters shown.

<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| FAVOURITE METERS | 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 through 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 |
<p>| CURRENT METERS | 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 | Displays the 3 phase currents Primary RMS values |
| Ia | 0.00A |
| Ib | 0.00A |
| Ic | 0.00A |
| Secondary Current | Displays the 3 phase currents Secondary RMS values |
| Ia | 0.000A |
| Ib | 0.000A |
| Ic | 0.000A |
| Nom Current | Displays the 3 Phase currents Nominal RMS values &amp; phase angles with respect to PPS voltage. |
| Ia | 0.00xIn—&quot; |</p>
<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ib</td>
<td>Displays the 2 Earth currents Primary RMS values</td>
</tr>
<tr>
<td>Ic</td>
<td>Displays the 2 Earth currents Secondary RMS values</td>
</tr>
<tr>
<td>Pri Earth Current</td>
<td>Displays the 2 Earth currents Nominal RMS values &amp; phase angles.</td>
</tr>
<tr>
<td>Sec Earth Current</td>
<td>Displays the Current Sequence components Nominal RMS values &amp; phase angles with respect to PPS voltage.</td>
</tr>
<tr>
<td>Nom Earth Current</td>
<td>Displays the Current Sequence components Nominal RMS values &amp; phase angles with respect to PPS voltage.</td>
</tr>
<tr>
<td>I Seq Components</td>
<td>Displays the Last Trip Fault Current..</td>
</tr>
<tr>
<td>I Eq.</td>
<td>Displays the Last Trip Fault Current..</td>
</tr>
<tr>
<td>Pri Unbalance</td>
<td>Displays the Last Trip Fault Current..</td>
</tr>
<tr>
<td>THERMAL METERS</td>
<td>This is the sub-group that includes all the meters that are associated with Thermal functionality.</td>
</tr>
<tr>
<td>Thermal Capacity TC</td>
<td>Thermal Capacity TC</td>
</tr>
<tr>
<td>TC Used</td>
<td>0.00%</td>
</tr>
<tr>
<td>TC Available</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
### MOTOR METERS

- **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

- **Max Temp Recorded Input Temp**: Displays the maximum temperature recorded
- **Temp1**
- **Temp2**
- **Temp3**
- **Temp4**
- **Temp5**
- **Temp6**

### MAINTENANCE METERS

- **CB Total Trips Count**: 0
- **CB Delta Trips Count**: 0
- **CB Wear Phase A**: 0.00MA*2s
- **CB Wear Phase B**: 0.00MA*2s
- **CB Wear Phase C**: 0.00MA*2s
- **CB Wear Remaining Phase A**: 0.00MA*2s
- **CB Wear Remaining Phase B**: 0.00MA*2s
- **CB Wear Remaining Phase C**: 0.00MA*2s
- **CB Trip Time Time**: 0.0ms
- **Flux Level**: Displays current measure of circuit breaker wear.
### General Alarm Meters

This is the sub-group that includes all the meters that are associated with the Binary inputs.

<table>
<thead>
<tr>
<th>General Alarms</th>
<th>Cleared</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARM 1</td>
<td></td>
</tr>
<tr>
<td>ALARM 2</td>
<td></td>
</tr>
<tr>
<td>ALARM 3</td>
<td></td>
</tr>
<tr>
<td>ALARM 4</td>
<td></td>
</tr>
<tr>
<td>ALARM 5</td>
<td></td>
</tr>
<tr>
<td>ALARM 6</td>
<td></td>
</tr>
</tbody>
</table>

### Demand Meters

This is the sub-group that includes all the meters that are associated with Demand. TEST/RESET ► allows access to this sub-group.

<table>
<thead>
<tr>
<th>I Phase A Demand</th>
<th>0.00A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>0.00A</td>
</tr>
<tr>
<td>Mean</td>
<td>0.00A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I Phase B Demand</th>
<th>0.00A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>0.00A</td>
</tr>
<tr>
<td>Mean</td>
<td>0.00A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I Phase C Demand</th>
<th>0.00A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>0.00A</td>
</tr>
<tr>
<td>Mean</td>
<td>0.00A</td>
</tr>
</tbody>
</table>

| Ig Demand        |       |

### Miscellaneous Meters

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.

<table>
<thead>
<tr>
<th>Start Alarm</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td></td>
</tr>
<tr>
<td>Target</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>DD/MM/YYYY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>HH:MM:SS</td>
</tr>
<tr>
<td>Waveform Recs</td>
<td>0</td>
</tr>
<tr>
<td>Fault Recs</td>
<td>0</td>
</tr>
<tr>
<td>Event Recs</td>
<td>0</td>
</tr>
<tr>
<td>Data Log Recs</td>
<td>0</td>
</tr>
<tr>
<td>Setting Group</td>
<td>1</td>
</tr>
</tbody>
</table>
### BINARY INPUT METERS

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.

<table>
<thead>
<tr>
<th>BI 1-6</th>
<th>---- --</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Displays the state of DC binary inputs 1 to 6 (The number of binary inputs may vary depending on model)</td>
</tr>
</tbody>
</table>

### BINARY OUTPUT METERS

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.

<table>
<thead>
<tr>
<th>BO 1-6</th>
<th>---- ----</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Displays the state of DC binary Outputs 1 to 6. (The number of binary outputs may vary depending on model)</td>
</tr>
</tbody>
</table>

### VIRTUAL METERS

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.

<table>
<thead>
<tr>
<th>V 1-8</th>
<th>---- ----</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Displays the state of Virtual Outputs 1 to 8 (The number of virtual inputs will vary depending on model)</td>
</tr>
</tbody>
</table>

### COMMUNICATION METERS

This is the sub-group that includes all the meters that are associated with Communications ports.

**TEST/RESET** allows access to this sub-group.

<table>
<thead>
<tr>
<th>COM1</th>
<th>COM2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Displays which com ports are currently active</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COM1 TRAFFIC</th>
<th>COM1 Tx</th>
<th>COM1 Rx Error</th>
<th>COM1 Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COM2 TRAFFIC</th>
<th>COM2 Tx</th>
<th>COM2 Rx Error</th>
<th>COM2 Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### QUICK LOGIC METERS

This is the sub-group that includes all the meters that are associated with QuickLogic Equations.

**TEST/RESET** allows access to this sub-group.

<table>
<thead>
<tr>
<th>E 1-4</th>
<th>----</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Displays traffic on Com1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EQN</th>
<th>TMR</th>
<th>CNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>0-0</td>
<td>0-1</td>
</tr>
<tr>
<td>E2</td>
<td>0-0</td>
<td>0-1</td>
</tr>
<tr>
<td>E3</td>
<td>0-0</td>
<td>0-1</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>E4 Equation</th>
<th>EQN</th>
<th>=0</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMR</td>
<td>0-0</td>
<td>=0</td>
</tr>
<tr>
<td>CNT</td>
<td>0-1</td>
<td>=0</td>
</tr>
</tbody>
</table>
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](image)

2.1.2 Rear RS485 connection

![Figure 2.1-2 RS485 Connection to PC](image)
### 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Range</th>
<th>Default</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM1-RS485 Protocol</td>
<td>OFF, IEC60870-5-103, MODBUS-RTU, DNP3</td>
<td>IEC60870-5-103</td>
<td></td>
</tr>
<tr>
<td>COM1-RS485 Station Address</td>
<td>0, 1 ... 65533, 65534</td>
<td>0</td>
<td>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</td>
</tr>
<tr>
<td>COM1-RS485 Baud Rate</td>
<td>75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400</td>
<td>19200</td>
<td>19200</td>
</tr>
<tr>
<td>COM1-RS485 Parity</td>
<td>NONE, ODD, EVEN</td>
<td>EVEN</td>
<td>EVEN</td>
</tr>
<tr>
<td>COM1-RS485 Mode</td>
<td>Local, Remote, Local Or Remote</td>
<td>Remote</td>
<td>Remote</td>
</tr>
<tr>
<td>COM2-USB Protocol</td>
<td>OFF, DNP3, ASCII, MODBUS-RTU, IEC60870-5-103</td>
<td>IEC60870-5-103</td>
<td></td>
</tr>
<tr>
<td>COM2-USB Station Address</td>
<td>0, 1 ... 65533, 65534</td>
<td>0</td>
<td>Address given to relay to identify it for connection to the USB front port</td>
</tr>
<tr>
<td>COM2-USB Mode</td>
<td>Local, Remote, Local Or Remote</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>DNP3 Unsolicited Events</td>
<td>Disabled, Enabled</td>
<td>Disabled</td>
<td>Disabled</td>
</tr>
<tr>
<td>DNP3 Destination Address</td>
<td>0, 1 ... 65533, 65534</td>
<td>0</td>
<td>This setting is only visible when DNP3 Unsolicited Events is Enabled</td>
</tr>
<tr>
<td>DNP3 Application Timeout</td>
<td>5, 6 ... 299, 300</td>
<td>10s</td>
<td>10s</td>
</tr>
</tbody>
</table>
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.

![Connection Manager](image)

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.

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.
# 7SR105 Rho

Performance Specification

## Document Release History

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

<table>
<thead>
<tr>
<th>Year/Issue</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015/12</td>
<td>First Issue</td>
</tr>
<tr>
<td>2016/06</td>
<td>Second Issue</td>
</tr>
</tbody>
</table>

## Software Revision History

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<thead>
<tr>
<th>Year/Issue</th>
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</thead>
<tbody>
<tr>
<td>2015/12</td>
<td>2437H80007</td>
<td>First Release</td>
</tr>
<tr>
<td>2016/06</td>
<td>2437H80007</td>
<td>Second Release</td>
</tr>
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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** | **Motor Protection Relay** |
| **Case and LEDs** | Non Draw-out Polycarbonate case (Size 4 standard, Non Draw-out design), 10 LEDs |
| **Measuring Inputs** | 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 -50°C to +250°C |

| 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) |
### Table 1-3 Terminal Blocks with Push Buttons

<table>
<thead>
<tr>
<th>Current Inputs</th>
<th>12 position (Terminal X5), M4 Screw-type Barrier Terminal block suitable for 2.5 mm²/4 mm² cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary Supply</td>
<td>3 position (Terminal X3), M3 screw-type plug-in terminals suitable for 2.5 mm² cable</td>
</tr>
<tr>
<td>Rear Communication Port</td>
<td>4 position (Terminal X2), M2 screw-type plug-in terminals suitable for 1.5 mm² cable</td>
</tr>
<tr>
<td>Front Communication Port</td>
<td>USB, Type B</td>
</tr>
<tr>
<td>Binary Input</td>
<td>6 or 12 position (Terminal X1), M3 screw-type plug-in terminals suitable for 2.5 mm² cable</td>
</tr>
<tr>
<td>Binary Output</td>
<td>8 or 14 position (Terminal X4), M3 screw-type plug-in terminals suitable for 2.5 mm² cable</td>
</tr>
<tr>
<td>Temperature Inputs</td>
<td>18 position (Terminal X6, X7), M2 screw-type plug-in terminals suitable for 1.5 mm² shielded cable</td>
</tr>
</tbody>
</table>

### Table 1-4 Current Inputs

<table>
<thead>
<tr>
<th>Quantity</th>
<th>3 x Phase &amp; 1 x Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Current In</td>
<td>1 A/5 A</td>
</tr>
<tr>
<td>Measuring Range</td>
<td>80*In</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>± 1 % (typical) (≥ 0.1xIn to 3xIn)</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz (Range: 47.5 Hz to 52.5 Hz)</td>
</tr>
<tr>
<td>Thermal Withstand:</td>
<td>Continuous 10 s</td>
</tr>
<tr>
<td></td>
<td>1 s</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Burden @ In</td>
<td>≤ 0.3 VA per phase and earth for both 1 A and 5 A</td>
</tr>
</tbody>
</table>

### Table 1-5 Auxiliary Supply

<table>
<thead>
<tr>
<th>Rated Voltage</th>
<th>60 V - 240 V AC/DC, Tolerance – 20 % to +10 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable superimposed AC component</td>
<td>15 % of DC voltage</td>
</tr>
<tr>
<td>Typical Power consumption (DC)</td>
<td>&lt; 7 W</td>
</tr>
<tr>
<td>Typical Power consumption (AC)</td>
<td>&lt; 7 VA 0.5 PF</td>
</tr>
<tr>
<td>Max Interruption time (Collapse to Zero)</td>
<td>≤ 100 ms (110 V DC)</td>
</tr>
</tbody>
</table>
## Table 1-6: Auxiliary Supply

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>24 V - 60 V DC</td>
</tr>
<tr>
<td></td>
<td>Tolerance -20% to +10%</td>
</tr>
<tr>
<td>Allowable super imposed</td>
<td>15% of DC voltage</td>
</tr>
<tr>
<td>AC component</td>
<td></td>
</tr>
<tr>
<td>Typical Power</td>
<td>&lt; 7 W</td>
</tr>
<tr>
<td>consumption (DC)</td>
<td></td>
</tr>
<tr>
<td>Max Interruption time</td>
<td>20 ms (24 V DC)</td>
</tr>
<tr>
<td>(Collapse to Zero)</td>
<td></td>
</tr>
</tbody>
</table>

## Table 1-7: Binary Inputs

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>6</td>
</tr>
<tr>
<td>Operating Voltage*</td>
<td>19 V DC Range 24 V - 66 V DC</td>
</tr>
<tr>
<td></td>
<td>44 V AC/DC Range 44 V - 265 V</td>
</tr>
<tr>
<td></td>
<td>Range DC 44 V - 265 V DC</td>
</tr>
<tr>
<td></td>
<td>AC 36 V - 265 V AC</td>
</tr>
<tr>
<td>Maximum AC/DC current for operation</td>
<td>3.5 mA</td>
</tr>
<tr>
<td>Pick Up Delay</td>
<td>User selectable 0 to 14,400,000 ms (up to 4 hours)</td>
</tr>
<tr>
<td>Drop Off Delay</td>
<td>User selectable 0 to 14,400,000 ms (up to 4 hours)</td>
</tr>
</tbody>
</table>

*Refer to ordering information for more details.

## Table 1-8: Binary Outputs

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>6</td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>Voltage Free</td>
</tr>
<tr>
<td>Operating Mode</td>
<td>User selectable - Self or Hand/Electrical Reset or pulsed</td>
</tr>
<tr>
<td>Operating Time from energizing Binary Input</td>
<td>&lt; 20 ms</td>
</tr>
<tr>
<td>Making Capacity:</td>
<td></td>
</tr>
<tr>
<td>Carry continuously</td>
<td></td>
</tr>
<tr>
<td>Make and carry (L/R ≤ 40 ms and V ≤ 300 V)</td>
<td>5 A AC or DC</td>
</tr>
<tr>
<td></td>
<td>20 A AC or DC for 0.5 s</td>
</tr>
<tr>
<td></td>
<td>30 A AC or DC for 0.5 s</td>
</tr>
<tr>
<td>Breaking Capacity (≤ 5 A and ≤ 300 V):</td>
<td></td>
</tr>
<tr>
<td>AC Resistive</td>
<td>1250 VA</td>
</tr>
<tr>
<td>AC Inductive</td>
<td>250 VA at p.f. ≤ 0.4</td>
</tr>
<tr>
<td>DC Resistive</td>
<td>75 W</td>
</tr>
<tr>
<td>DC Inductive</td>
<td>30 W at L/R ≤ 40 ms</td>
</tr>
<tr>
<td></td>
<td>50 W at L/R ≤ 10 ms</td>
</tr>
</tbody>
</table>
### Table 1-9 Temperature Inputs

<table>
<thead>
<tr>
<th>Number</th>
<th>6</th>
</tr>
</thead>
</table>
| 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

<table>
<thead>
<tr>
<th>Quantity</th>
<th>1 No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical connection</td>
<td>RS485, 2 wire electrical</td>
</tr>
</tbody>
</table>
| Protocol Support | MODBUS RTU,  
  IEC 60870-5-103,  
  DNP 3.0 |
| Rate | Data Transfer rate:  
  2400 - 38400 bps |

### Table 1-11 Front Communication Port

<table>
<thead>
<tr>
<th>Quantity</th>
<th>1 No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical connection</td>
<td>USB, Type B</td>
</tr>
</tbody>
</table>

### 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) |
1.3 Environmental Performance

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

<table>
<thead>
<tr>
<th>Type Test</th>
<th>Reference</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| 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>
<thead>
<tr>
<th>Type Test</th>
<th>Reference</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| 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 |
<table>
<thead>
<tr>
<th>Type Test</th>
<th>Reference</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Frequency Disturbance</td>
<td>IEC 60255-26</td>
<td>• Common-mode test voltage: 2.5 kV&lt;br&gt;• Differential test voltage: 1.0 kV&lt;br&gt;• Test duration: 2 s&lt;br&gt;• Source impedance: 200 Ω</td>
</tr>
<tr>
<td>Electrostatic Discharge</td>
<td>IEC 60255-26</td>
<td>• 8 kV air discharge</td>
</tr>
<tr>
<td>Electrical Fast Transient or Burst*</td>
<td>IEC 60255-26, Zone A</td>
<td>Test severity Amplitude:&lt;br&gt;Power ports: 4 kV, burst frequency 5 kHz&lt;br&gt;Other ports: 4 kV, burst frequency 5 kHz</td>
</tr>
<tr>
<td>Surge Immunity*</td>
<td>IEC 60255-26, Zone A</td>
<td>Time to half-value: 1.2/50 μs&lt;br&gt;• Amplitude: 4 kV between all groups and case earth (CM)&lt;br&gt;• Amplitude: 2 kV between terminals of each group (DM)</td>
</tr>
<tr>
<td>Radiated Immunity*</td>
<td>IEC 60255-26</td>
<td>Test field strength, frequency band 80 MHz to 1000 MHz and 1400 MHz to 2700 MHz:&lt;br&gt;10 V/m, Test using AM: 1 kHz/80 %</td>
</tr>
<tr>
<td>Conducted Radio Frequency Interference</td>
<td>IEC 60255-26, Class III</td>
<td>0.15 MHz to 80 MHz 10 V</td>
</tr>
<tr>
<td>Power Frequency Magnetic Field</td>
<td>IEC 60255-26</td>
<td>30 A/m applied continuously, 300 A/m applied for 3 s</td>
</tr>
<tr>
<td>Conducted Emissions</td>
<td>IEC 60255-26, CISPR 22, Class A</td>
<td>0.15 MHz - 0.5 MHz, 79dB μV (quasi peak)&lt;br&gt;66 dB μ V (average)&lt;br&gt;0.5 MHz - 30 MHz, 73dB μ V (quasi peak)&lt;br&gt;60 dB μV (average)</td>
</tr>
<tr>
<td>Radiated Emissions</td>
<td>IEC 60255-26, CISPR 11, Class A</td>
<td>30 MHz - 230 MHz, 40 dB μ V/m at 10 m measurement distance&lt;br&gt;230 MHz - 1 GHz, 47 dB μ V/m at 10 m measurement distance</td>
</tr>
<tr>
<td>Thermal &amp; Burden</td>
<td>IEC 60255-27 and IEC 60255-1</td>
<td><strong>Thermal:</strong>&lt;br&gt;1 A CT:&lt;br&gt;4 A continuous&lt;br&gt;30 A for 10 s&lt;br&gt;100 A for 1 s&lt;br&gt;5 A CT:&lt;br&gt;20 A Continuous&lt;br&gt;150 A for 10 s&lt;br&gt;500 A for 1s&lt;br&gt;<strong>Burden:</strong> ≤ 0.3 VA for 1 A and 5 A CT</td>
</tr>
</tbody>
</table>
**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°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

<table>
<thead>
<tr>
<th>Type Test</th>
<th>Reference</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| 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)

<table>
<thead>
<tr>
<th>Type Test</th>
<th>Reference</th>
<th>Parameters</th>
<th>Declared Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Dips (AC auxiliary supply) RV = 230 V AC</td>
<td>IEC 60255-26</td>
<td>0% RV at 1000 ms Normal Operation¹</td>
<td></td>
</tr>
<tr>
<td>40% RV at 200 ms Normal Operation¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70% RV at 500 ms Normal Operation¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage Dips (DC auxiliary supply) RV = 110 V DC</td>
<td>IEC 60255-26</td>
<td>0% RV at 100 ms Normal Operation¹</td>
<td></td>
</tr>
<tr>
<td>40% RV at 200 ms Normal Operation¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70% RV at 500 ms Normal Operation¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage Dips (DC auxiliary supply) RV = 48 V DC</td>
<td>IEC 60255-26</td>
<td>0% RV at 20 ms Normal Operation¹</td>
<td></td>
</tr>
<tr>
<td>40% RV at 200 ms Normal Operation¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70% RV at 500 ms Normal Operation¹</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 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)

| IEC 60255-26 | 0% RV at 5 s | Normal Operation$^2$

**RV** = 48 V/220 V DC  
**RV** = 230 V AC

### Alternating component in DC (Ripple)

| 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

### Environmental Test

<table>
<thead>
<tr>
<th>Type Test</th>
<th>Reference</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| Climatic Environmental Test            | IEC 60068-2-1, IEC 60068-2-2, IEC60255-1 | Operating Temperature -10°C to +60°C  
|                                        |                                    | Storage Range - 25°C to +70°C |
| Humidity                               | IEC 60068-2-30, IEC 60068-2-78, IEC60255-1 | Damp heat test, Cyclic  
|                                        |                                    | 4 days at 40°C and 93% relative humidity  
|                                        |                                    | Damp heat test, Steady state  
|                                        |                                    | 4 days at 95% RH, +40°C |

### Product Safety Test

<table>
<thead>
<tr>
<th>Type Test</th>
<th>Reference</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearances and Creepage Distances</td>
<td>IEC/EN 60255-27: Edition 2: 2013-10</td>
<td>Clearances and creepage distances between external circuits mutual and to the enclosure</td>
<td>≥ 4 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For Unit Rear side</td>
<td>IP20</td>
</tr>
<tr>
<td>AC Dielectric Voltage</td>
<td>IEC/EN 60255-27: Edition 2: 2013-10</td>
<td>Test voltage (AC): 2 kV</td>
<td>After test, the relay should be operative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Test frequency: 50 Hz</td>
<td>(Reinforced Insulation with communication circuit)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Test duration: 1 min</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------------------------</td>
<td>--------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Protective Bonding Resistance</strong></td>
<td>IEC/EN 60255-27: Edition 2: 2013-10</td>
<td>Test voltage: &lt; 12V AC/DC Test duration: 1 min Bonding resistance &lt; 0.1 Ohm</td>
<td></td>
</tr>
<tr>
<td><strong>Protective Bonding Continuity</strong></td>
<td>IEC/EN 60255-27: Edition 2: 2013-10</td>
<td>Accessible conductive parts should be bonded with the protective conductor terminal Low current continuity test</td>
<td></td>
</tr>
<tr>
<td>Terminals</td>
<td>Class UL 94 V-0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminal Mounting</td>
<td>Class UL 94 V-0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wiring (CT)</td>
<td>(N)2GFAF (VDE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Components mounting</td>
<td>Class UL 94 V-0</td>
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<td></td>
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<tr>
<td>Enclosure</td>
<td>Class UL 94 V-0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCB</td>
<td>Class UL 94 V-0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCD</td>
<td>Class UL 94 V-0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Single Fault Condition</strong></td>
<td>IEC/EN 60255-27: Edition 2: 2013-10</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td><strong>Marking and Documentation</strong></td>
<td>IEC 61010-1 : 2010</td>
<td>Clause No. 5 Clause No. 6 Clause No. 7</td>
<td></td>
</tr>
<tr>
<td><strong>Protection against electric shock</strong></td>
<td>Clause No. 5</td>
<td></td>
<td></td>
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<tr>
<td><strong>Protection against mechanical hazard</strong></td>
<td>Clause No. 7</td>
<td></td>
<td></td>
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<tr>
<td>Resistance to mechanical stresses</td>
<td>Clause No. 8</td>
<td>-</td>
<td></td>
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<tr>
<td>----------------------------------------------------</td>
<td>---------------</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Protection against the spread of fire</td>
<td>Clause No. 9</td>
<td>-</td>
<td></td>
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<td>Equipment temperature limits and resistance to heat</td>
<td>Clause No. 10</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Protection against liberated gases and substances, explosion and implosion</td>
<td>Clause No. 13</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Components and sub assemblies</td>
<td>Clause No. 14</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>HAZARDS resulting from application</td>
<td>Clause No. 16</td>
<td>-</td>
<td></td>
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<tr>
<td>Risk Assessment</td>
<td>Clause No. 17</td>
<td>-</td>
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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

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Elements</td>
<td>4</td>
</tr>
<tr>
<td>Setting Range $I_s$</td>
<td>0.05 to 10 $x$ In</td>
</tr>
<tr>
<td>Time Delay</td>
<td>0.00 to 14400 s</td>
</tr>
<tr>
<td>Operate Level</td>
<td>100 $% I_s$ ±5 $%$ or ±1 $% x$In</td>
</tr>
<tr>
<td>Operate time</td>
<td></td>
</tr>
<tr>
<td>$2 x I_s$</td>
<td>35 ms ± 10 ms,</td>
</tr>
<tr>
<td>$5 x I_s$</td>
<td>25 ms ± 10 ms</td>
</tr>
<tr>
<td>Operate time following delay</td>
<td>$t_{basic} + t_d$, ±1 $%$ or ±10 ms</td>
</tr>
<tr>
<td>Controlled by</td>
<td>Stopped, No acceleration, Running, None</td>
</tr>
<tr>
<td>Disengaging time</td>
<td>&lt; 50 ms</td>
</tr>
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Table 1-20 37 Undercurrent

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Elements</td>
<td>2</td>
</tr>
<tr>
<td>$U/C$ Guard</td>
<td>0.05 to 5.0 $x$ In</td>
</tr>
<tr>
<td>Setting Range $I_s$</td>
<td>0.05 to 5.0 $x$ In</td>
</tr>
<tr>
<td>Operate Level</td>
<td>100 $% I_s$ ±5 $%$ or ±1 $% x$In</td>
</tr>
<tr>
<td>Delay Setting $t_d$</td>
<td>0 to 14400 s</td>
</tr>
<tr>
<td>Basic Operate Time:</td>
<td></td>
</tr>
<tr>
<td>$0.5 x I_s$</td>
<td>35 ms ± 20 ms</td>
</tr>
<tr>
<td>Operate time following delay</td>
<td>$t_{basic} + t_d$, ±1 $%$ or ±10 ms</td>
</tr>
<tr>
<td>Overshoot Time</td>
<td>&lt; 40 ms</td>
</tr>
<tr>
<td>Inhibited by</td>
<td>Binary or Virtual Input</td>
</tr>
<tr>
<td>Disengaging time</td>
<td>&lt; 60 ms</td>
</tr>
</tbody>
</table>
### Table 1-21 46 Phase Unbalance Protection

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

### Table 1-22 48/66 Start Protection

<table>
<thead>
<tr>
<th>Max. No. of Starts</th>
<th>OFF, 1 to 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Starts Period</td>
<td>1 to 60 minutes</td>
</tr>
<tr>
<td>Start Inhibit Delay</td>
<td>1 to 60 minutes</td>
</tr>
<tr>
<td>Time Between Starts</td>
<td>OFF, 1 to 60 minutes</td>
</tr>
</tbody>
</table>

### Table 1-23 49 Thermal Protection

<table>
<thead>
<tr>
<th>Setting Range Itheta</th>
<th>0.1 to 3.0 x ln</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS Weighting Factor (K)</td>
<td>0.1 to 10.0 Δ 0.1</td>
</tr>
<tr>
<td>TauH Heating Constant</td>
<td>0.5 to 1000 mins, Δ 0.5 mins</td>
</tr>
<tr>
<td>TauS Starting Constant</td>
<td>0.005 to 1.0 x TauH, Δ 0.005</td>
</tr>
<tr>
<td>TauC Cooling Constant</td>
<td>1 to 100 x TauH, Δ 1</td>
</tr>
<tr>
<td>Hot/cold ratio</td>
<td>OFF, 1 to 100 %, Δ 1 %</td>
</tr>
<tr>
<td>Operate Level</td>
<td>100 % Is, ±5 % or ±1 % x ln</td>
</tr>
<tr>
<td>Operate time</td>
<td>$t = \tau \times \ln \left( \frac{I_{\theta 0}}{I_{\theta}} \right)$</td>
</tr>
<tr>
<td></td>
<td>±5 % or ±100 ms</td>
</tr>
<tr>
<td></td>
<td>(Itheta = 0.3 to 3 x ln)</td>
</tr>
<tr>
<td></td>
<td>(1.2 to 20 x Itheta)</td>
</tr>
<tr>
<td></td>
<td>User defined</td>
</tr>
<tr>
<td>Capacity Alarm Level</td>
<td>Disabled, 50,51…100 %</td>
</tr>
<tr>
<td>Load Alarm Level</td>
<td>OFF, 0.5 to 1.0 x Itheta, Δ 0.05</td>
</tr>
<tr>
<td>Thermal restart inhibit</td>
<td>20 to 100 %, Δ 1 %</td>
</tr>
<tr>
<td>Inhibited by</td>
<td>Binary or Virtual Input</td>
</tr>
</tbody>
</table>
### Table 1-24  50 Instantaneous & DTL OC&EF

<table>
<thead>
<tr>
<th>Operation</th>
<th>Non directional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements</td>
<td>Phase, Derived Earth, Measured Earth</td>
</tr>
<tr>
<td>Setting Range $I_e$ (50/50N)</td>
<td>0.05, 0.06... 50 x ln</td>
</tr>
<tr>
<td>Setting Range $I_e$ (50G)</td>
<td>0.01, 0.011,.... 5 x ln</td>
</tr>
<tr>
<td>Time Delay</td>
<td>0.00... 14400 s</td>
</tr>
<tr>
<td>Operate Level $I_{op}$</td>
<td>100 % $I_s$, ±5 % or ±1 % x ln</td>
</tr>
<tr>
<td>Reset level</td>
<td>≥ 95 % $I_{op}$</td>
</tr>
<tr>
<td>Reset level (50G)</td>
<td>≥ 95 % $I_{op}$ or $I_{op}$ - 0.1 % ln</td>
</tr>
<tr>
<td>Operate time:</td>
<td></td>
</tr>
<tr>
<td>50, 50G</td>
<td>0 to 2x $I_s$ – 35 ms, ±10 ms,</td>
</tr>
<tr>
<td>50N</td>
<td>0 to 5x $I_s$ – 25 ms, ±10 ms,</td>
</tr>
<tr>
<td>Operate time following delay</td>
<td>$t_{basic} + t_d$, ±1 % or ±10 ms</td>
</tr>
</tbody>
</table>

Inhibited by

- Binary or Virtual Input
- Inrush detector

Disengaging time (50G) < 50 ms

### Table 1-25  51 Time Delayed OC&EF

<table>
<thead>
<tr>
<th>Operation</th>
<th>Non directional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elements</td>
<td>Phase, Derived Earth, Measured Earth</td>
</tr>
<tr>
<td>Characteristic</td>
<td>IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL</td>
</tr>
<tr>
<td>Setting Range $I_e$ (51/51N)</td>
<td>0.05, 0.06... 4 x ln</td>
</tr>
<tr>
<td>Setting Range $I_e$ (51G)</td>
<td>0.01, 0.011,...0.5 x ln</td>
</tr>
<tr>
<td>Time Multiplier</td>
<td>0.01, 0.015,...1.6, 1.7,...5, 6...100</td>
</tr>
<tr>
<td>Time Delay</td>
<td>0, 0.01... 20 s</td>
</tr>
<tr>
<td>Operate Level</td>
<td>105 % $I_s$, ±4 % or ±1 % x ln</td>
</tr>
</tbody>
</table>

Minimum Operate time

- **IEC**
  
  \[
  I_{op} = \frac{K}{[\frac{I_s}{I_{op}}] - 1} \times T_m
  \]

- **ANSI**
  
  \[
  I_{op} = \left[\frac{K}{\frac{I_s}{I_{op}} - 1}\right] \times T_m
  \]

  ± 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
### Table 1-26  50 BF Circuit Breaker Fail

<table>
<thead>
<tr>
<th>Operation</th>
<th>Current check - Phase and Measured Earth with independent settings Mechanical Trip CB Faulty Monitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting Range ( I_s )</td>
<td>0.05, 0.055...2.0 ( x ) ( I_n )</td>
</tr>
<tr>
<td>Setting Range ( I_s )</td>
<td>0.01, 0.015...2.0 ( x ) ( I_n )</td>
</tr>
<tr>
<td>2 Stage Time Delays</td>
<td>Timer 1 20...60000 ms</td>
</tr>
<tr>
<td></td>
<td>Timer 2 20...60000 ms</td>
</tr>
<tr>
<td>Operate Level</td>
<td>100 % ( I_s ), ±5 % or ±1 % ( x ) ( I_n )</td>
</tr>
<tr>
<td>Disengaging time</td>
<td>&lt; 20 ms</td>
</tr>
<tr>
<td>Operate time following delay</td>
<td>( T_{cbf} ) ±1 % or ±20 ms</td>
</tr>
<tr>
<td>Triggered by</td>
<td>Any function mapped as trip contact</td>
</tr>
<tr>
<td>Inhibited by</td>
<td>Binary/Virtual Input</td>
</tr>
<tr>
<td>Timer By pass</td>
<td>Yes, 50BF CB Faulty Input</td>
</tr>
</tbody>
</table>

### Table 1-27  Temperature Inputs

<table>
<thead>
<tr>
<th>Temperature input type</th>
<th>Cu10 (0.00427), Ni100 (0.00618), Pt100 (0.00385), Ni120 (0.00672), Pt250 (0.00385), Ni250 (0.00618), and Pt1000 (0.00385)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature input type</td>
<td>(Temperature Coefficient Resistance based on DIN/IEC 60751 standard)</td>
</tr>
<tr>
<td>Temperature input Alarm</td>
<td>0, 1, 2...250°C</td>
</tr>
<tr>
<td>Temperature input Trip</td>
<td>0, 1, 2...250°C</td>
</tr>
<tr>
<td>Operate value</td>
<td>100 % ( T_{set} ), ±2 % or ±2°C, For Cu10: ±2 % or ±5°C</td>
</tr>
<tr>
<td>Response time</td>
<td>&lt; 3 s</td>
</tr>
<tr>
<td>Sensing current</td>
<td>&lt; 0.5 mA</td>
</tr>
<tr>
<td>Maximum lead resistance</td>
<td>25 ( \Omega )/lead</td>
</tr>
<tr>
<td></td>
<td>For Cu10: 2.5 ( \Omega )/lead</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Number of supervisable circuits</th>
<th>3 x Trip and 3 x Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of BI's Required</td>
<td>1 or 2 per function</td>
</tr>
</tbody>
</table>

### Table 1-29  50BCL Break Capacity Limit

<table>
<thead>
<tr>
<th>Setting</th>
<th>1.0, 1.5...50 ( x ) ( I_n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate level</td>
<td>100 % ( I_s ), ±5 % or ±1 % ( I_n )</td>
</tr>
<tr>
<td>Reset level</td>
<td>≥ 95 % ( I_{op} )</td>
</tr>
<tr>
<td>Element basic operate time</td>
<td>0 to 2 ( x ) Is: 20 ms or ±10 ms</td>
</tr>
<tr>
<td></td>
<td>0 to 5 ( x ) Is: 15 ms or ±10 ms</td>
</tr>
</tbody>
</table>
### Table 1-30 46PH REV Phase Reversal

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPS to PPS ratio</td>
<td>20…100 %</td>
</tr>
<tr>
<td>Delay setting</td>
<td>0…14400 s</td>
</tr>
<tr>
<td>Operate level</td>
<td>100 % I_s ± 5 %</td>
</tr>
<tr>
<td>Reset level</td>
<td>&gt;85 % I_op</td>
</tr>
<tr>
<td>Basic operate time</td>
<td>1x In to 0 A</td>
</tr>
<tr>
<td></td>
<td>60 ms</td>
</tr>
<tr>
<td>Operate time</td>
<td>( t_f + t_{\text{basic}} \pm 1 % ) or ( ± 20 ) ms</td>
</tr>
</tbody>
</table>

### Table 1-31 Control Functions

<table>
<thead>
<tr>
<th>Option</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>Start/Stop</td>
</tr>
<tr>
<td>EF</td>
<td>IN/OUT</td>
</tr>
<tr>
<td>Relay Mode</td>
<td>Local/Remote/Local or Remote/Out of service</td>
</tr>
<tr>
<td>Reset</td>
<td>LED’s &amp; O/P’s (Test/Reset key)</td>
</tr>
</tbody>
</table>

### Table 1-32 CB Maintenance

<table>
<thead>
<tr>
<th>Option</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip Counter</td>
<td>Total &amp; Delta 0…10000</td>
</tr>
<tr>
<td>( I^2 t ) Alarm</td>
<td>10…100000</td>
</tr>
</tbody>
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**7SR105 Rho**
Data Communications Definitions

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

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7SR105 Rho
Installation Guide

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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 mm² (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.
Table 1-1  Recommended Terminal Lugs Specifications with Control Push Buttons

<table>
<thead>
<tr>
<th>Terminal Blocks</th>
<th>Type/Cable Specifications</th>
<th>Manufacturer/Part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Inputs (Terminal X5)</td>
<td>Ring type lug/2.5 mm² or 4 mm² control cable</td>
<td>Dowell’s/RS007 or equivalent</td>
</tr>
<tr>
<td>Auxiliary Supply (Terminal X3)</td>
<td>Pin type lug/1.5 mm²/2.5 mm² control cable</td>
<td>Dowell’s/CP9/CP1 or equivalent</td>
</tr>
<tr>
<td>Rear Communication Port (Terminal X2)</td>
<td>Pin type lug/1.5 mm² control cable</td>
<td>Dowell’s/CP9 or equivalent</td>
</tr>
<tr>
<td>Front Communication Port</td>
<td>USB, Type B</td>
<td>Tyco/974329-1 or equivalent</td>
</tr>
<tr>
<td>Binary Input (Terminal X1)</td>
<td>Pin type lug/1.5 mm²/2.5 mm² control cable</td>
<td>Dowell’s/CP9/CP1 or equivalent</td>
</tr>
<tr>
<td>Temperature Inputs (Terminal X6, X7)</td>
<td>Pin type lug/1.5 mm² shielded cable</td>
<td>Dowell’s/CP9 or equivalent</td>
</tr>
<tr>
<td>Binary Output (Terminal X4)</td>
<td>Pin type lug/1.5 mm²/2.5 mm² control cable</td>
<td>Dowell’s/CP9/CP1 or equivalent</td>
</tr>
<tr>
<td>Earth Connections</td>
<td>Ring type lug/2.5 mm² or 4 mm² control cable</td>
<td>Dowell’s/RS007 or equivalent</td>
</tr>
</tbody>
</table>

Figure 1-2  Panel cut-out
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.

![Temperature input connection diagram](image)

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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## Section 1: Commissioning and Maintenance Guide

### 1.1 Troubleshooting

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

<table>
<thead>
<tr>
<th>Observation</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relay does not power up</td>
<td>Check the correct auxiliary AC or DC voltage is applied and the polarity is correct.</td>
</tr>
<tr>
<td>Relay won't accept the password</td>
<td>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.</td>
</tr>
<tr>
<td>Protection Healthy LED flashes</td>
<td>General failure. Contact a Siemens Limited representative.</td>
</tr>
<tr>
<td>LCD screen flashes continuously</td>
<td>The LCD displays multiple error messages by flashing continuously. These indicate the various processor card faults. General failure. Contact a Siemens Limited representative.</td>
</tr>
<tr>
<td>Relay displays one instrument after another with no user intervention</td>
<td>This is normal operation, the default instruments are enabled. Remove all instruments from the default list and add only the instruments that are required.</td>
</tr>
<tr>
<td>Cannot communicate with the relay</td>
<td>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).</td>
</tr>
<tr>
<td>Relays will not communicate in a ring network</td>
<td>Check that all relays are powered up. Check that all relays have unique addresses.</td>
</tr>
<tr>
<td>Status inputs do not work</td>
<td>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.</td>
</tr>
<tr>
<td>Relay instrument displays show small currents or voltages even though the system is dead</td>
<td>This is normal. The relay is displaying calculation noise. This will not affect any accuracy claims for the relay.</td>
</tr>
<tr>
<td>Temperature input meter displays the open and short indications</td>
<td>Check the wiring of temperature inputs as per the connection diagram.</td>
</tr>
<tr>
<td>Temperature inputs are displaying OPEN and SHORT indication in the Instrument mode</td>
<td>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.</td>
</tr>
</tbody>
</table>
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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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.
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](image)

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:

**Motor Rating Plate or Data Sheet Information**

Where available:
- Rated output kW
- Rated Voltage kV
- Rated Frequency Hz
- Rated Power Factor
- Rated Efficiency % (95% default)
- Service Factor
- Stall Withstand Time Cold/Hot secs
- Starting Method
- Locked Rotor Current A primary
- Permitted starts cold/hot
- Start Time @ 100% Voltage
- Max. Starts Per Hour
- Min. Time Between Starts
- Control Device

**CT and VT Connection Details**

- CT turns ratio (T)
- VT Ratio and connection

**Nominate Basic Thermal Settings**

- NPS Weighting
- Thermal Overload Setting (49 Itheta)
- Motor Start Current (x Itheta)
- Motor Stop Current (x Itheta)

**Calculate Thermal Protection Settings**

- Overload: OL protection settings, alarms and inhibits
- Stall protection settings
- Start protection settings
- Current Unbalance protection settings

**Enable and Set Other Protections as Required**

*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 protection

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 (Iθ).

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 (Iθ).

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.
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](image)

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.
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 \( \tau_{auC} / \tau_{auH} \) 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 60 x.

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](image)

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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 I\text{\texttheta} 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)

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)
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 I2, and short time capability based on a constant, K, where $K = (I_2)^2 \cdot t$.

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.

### 2.2Setting Example - Thermal Protection

![Motor Circuit Diagram](image)

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:

\[
\frac{\text{Motor FLC}}{\text{CT Ratio}} = \frac{86.3 \times 1}{100} = 0.86A \quad (= 0.86 \times \text{In})
\]

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

\[
5 \times 0.86 = 4.3A \quad (= 4.3 \times \text{In})
\]
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 I_{\text{theta}} 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, 'I_{\text{theta}} Thermal Overload' should be set to 0.90 x I_n.

Gn 49 Motor Start Type
The default setting '% I_{\text{theta}}' can be used.

Gn 49 Motor Start Current
The default value (1.5 x I_{\text{theta}}) 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 I_{\text{theta}}).

Gn 49 Motor Stop Type
The default setting '% I_{\text{theta}}' can be used.

Gn 49 Motor Stop Current
Use default setting, 0.1 x I_{\text{theta}}.

Thermal Protection – Overload Settings

Gn 49 Characteristic
The following settings can be based on 'IEC' characteristic

Heating Time Constant $T_{\text{HEAT}}$
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.

\[ 5 \times \text{F.L.C.} = 5 \times 0.86 = 4.3A \]
\[ 4.3/I_{\text{theta}} = 4.3/0.9 = 4.8 I_\theta \]
The $\tau_H$ value can be calculated from:
As the safe stall time from cold (CSST) is 11 seconds, the TauH value could be set to 4 minutes e.g.

$$\text{tauH} = \frac{t}{\ln \left( \frac{I^2 - I_0^2}{I_f^2 - I_0^2} \right)} = \frac{8/60}{\ln \left( \frac{4.3^2}{4.3^2 - 0.9^2} \right)} = 2.96 \text{ minutes}$$  

(see Figure 2.1-3.)

The safe stall time from hot (HSST) i.e. 7 seconds gives a $T_{\text{HEAT}}$ 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 $T_{\text{START}}$

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

### Cooling Time Constant $T_{\text{COOL}}$

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:

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

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

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

### 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 $I_{\text{theta}}$.

### 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 should be between 20-30%.
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**

![Graph](image)

**Figure 2.2-2 Summary of Thermal Settings**

Thermal overload (I\_theta) = 0.9 x I_n
Heating Constant Tau_H = 4 minutes
Starting Constant Tau_S = 1
Cooling Constant Tau_C = 10
H/C = 64%
49 Capacity Alarm Setting = 95%
Load Alarm Setting = 1.0 x I\_theta

**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’.
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.

![Diagram of motor with PF correction capacitors](image)

### 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.
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](image)

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 ensuring 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.
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](image)

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.
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 ISTOP.

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.
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:

\[
\frac{\text{MotorFLC}}{\text{CT Ratio}} = \frac{86.3 \times 1}{100} = 0.864 (= 0.86 \times \text{In})
\]

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 CTs 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.
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
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.
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.

![Logic Diagram: Trip Circuit Supervision Feature (74TCS)](image1)

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

![Logic Diagram: Close Circuit Supervision Feature (74CCS)](image2)

**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.
Scheme 1 (Basic)

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)

Scheme 2 provides continuous Trip Circuit Supervision of trip coil with the circuit breaker Open or Closed. It does not provide pre-closing supervision of the connections and links between the tripping contacts and the circuit breaker and may not therefore be suitable for some circuits which include an isolating link.
Scheme 3 (Comprehensive)

Figure 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.
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](image)

**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.

<table>
<thead>
<tr>
<th>Stage 1 (Retrip)</th>
<th></th>
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<tbody>
<tr>
<td>Trip Relay operate time</td>
<td>10ms</td>
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<tr>
<td>7SR105 or 7SR17 Disengaging Time</td>
<td>50ms</td>
</tr>
<tr>
<td>CB Trip time</td>
<td>80ms</td>
</tr>
<tr>
<td>Safety Margin</td>
<td>60ms</td>
</tr>
<tr>
<td>50BF-1 Delay</td>
<td>200ms</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 2 (Back Trip)</th>
<th></th>
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<tbody>
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<td>First BF Time Delay</td>
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<tr>
<td>Trip Relay operate time</td>
<td>10ms</td>
</tr>
<tr>
<td>7SR105 or 7SR17 Disengaging Time</td>
<td>50ms</td>
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<tr>
<td>CB Trip time</td>
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<tr>
<td>Margin</td>
<td>60ms</td>
</tr>
<tr>
<td>50BF-2 Delay</td>
<td>400ms</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Pt100</th>
<th>Pt250</th>
<th>Pt1000</th>
<th>Ni100</th>
<th>Ni120</th>
<th>Ni250</th>
<th>Cu10</th>
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<td>842.706</td>
<td>81.931</td>
<td>92.752</td>
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<td>204.053</td>
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<td>91.730</td>
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<td>95</td>
<td>100</td>
<td>105</td>
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</tr>
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</table>
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.
Section 6: Application Examples

6.1 FUNCTION AND CONNECTION DIAGRAMS

Figure 6.1-1 7SR105 Rho Function Diagrams
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