

Reyrolle
Protection
Devices

7SR157 Argus

Check and System Synchronising Relay

Energy Management

SIEMENS

Contents

Technical Manual Chapters

1. Description of Operation
2. Settings and Instruments
3. Performance Specification
4. Data Communications Definitions
5. Installation Guide
6. Commissioning and Maintenance
7. Applications Guide

7SR157

Check and System Synchronising Relay

Description of Operation

Document Release History

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2022/09	UPSU introduced
2016/11	E6 case IEC61850 models introduced
2014	First issue

Software Revision History

Date	Software Reference	Summary
2016/11	2436H80010R4e-2a	IEC61850 variants added
2014	2436H80010R2f-1a	First issue

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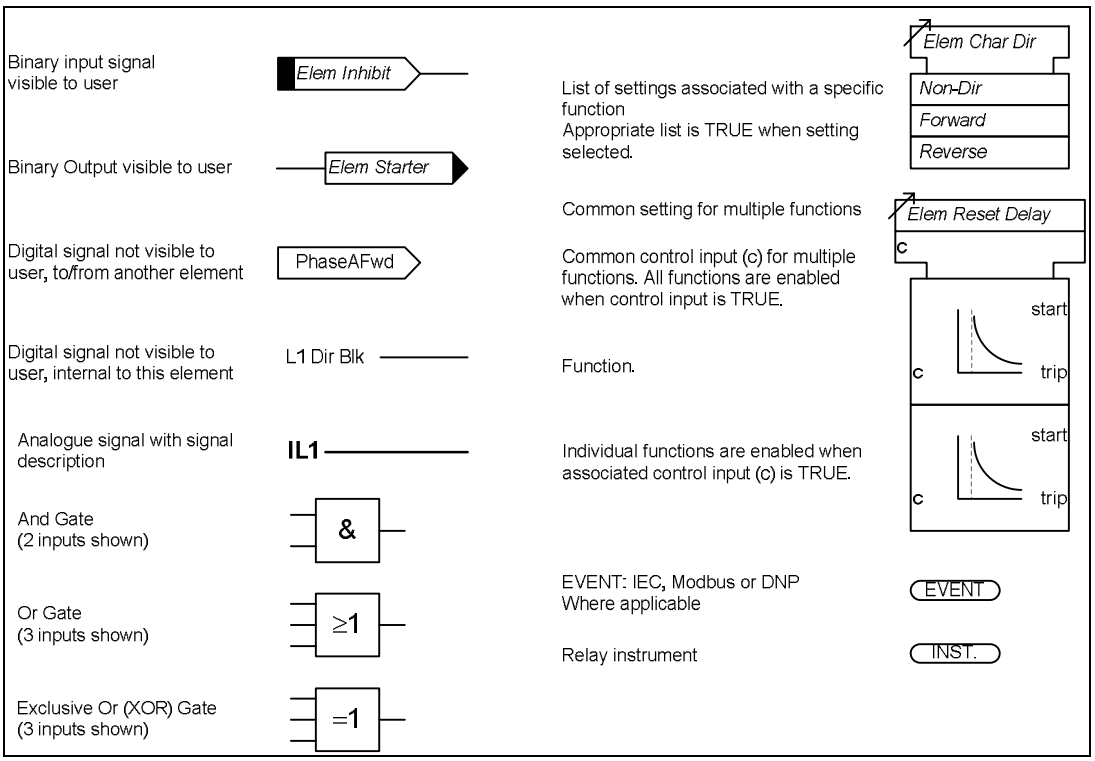
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Symbols and Nomenclature

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

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



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Section 1: Introduction

This manual is applicable to the following relays:

- 7SR157 Check and System Synchronising Relay

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

General Safety Precautions



External Resistors

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



Front Cover

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

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Table 1-1 7SR157 Ordering Options

	1	2	3	4	5	6	7		8	9	10	11	12		13	14	15	16
ORDER-No.:	7	S	R	1	5	7		-	5		A			-		C	A	0

Protection Product Family — 5

Voltage	5

Relay Type — 6

Check Synchronising	7

Case, I/O and Fascia — 7

2 VT, 3 Binary Inputs / 5 Binary Outputs, 10 LEDs	7
2 VT, 6 Binary Inputs / 8 Binary Outputs, 10 LEDs	8

Measuring input — 8

40-160V, 50/60Hz	5

Auxiliary voltage — 9

80 to 250 VDC / 115 VAC, binary input threshold 19 V DC	G
80 to 250 V DC, binary input threshold 88 V DC	H
24 to 60 V DC, binary input threshold 19 V DC	J
PSU Rated: 24-250V DC / 100-230V AC. Binary input threshold 19V DC (Rated: 24-250V DC)	M
PSU Rated: 24-250V DC / 100-230V AC. Binary input threshold 88V DC (Rated: 110-250V DC)	N

Spare — 10

	A

Communication Interface — 11

Standard version - included in all models, USB front port, RS485 rear port (E4 case) [1)]	1	2
Standard version - plus additional rear electrical Ethernet RJ45 (x2) (E6 Case) [1)]	7	7
Standard version - plus additional rear optical Ethernet duplex (x2) (E6 Case) [1)]	8	7

Protocol — 12

IEC 60870-5-103, Modbus RTU and DNP3 (user selectable setting)	2
IEC 60870-5-103, Modbus RTU, DNP3 and IEC 61850. (user selectable settings)	7

Front Cover — 13

Standard Version - No Push Buttons	1
Push Buttons - Down and right Arrows	2

Protection Function Packages — 14

Standard Version - 25 Check Synchronising	C

Additional Functionality — 15

No additional functionality	A

Spare — 16

	0

[1)] E4 case is standard, E6 case is required if IEC61850 option fitted

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The relay has 2 VT inputs:

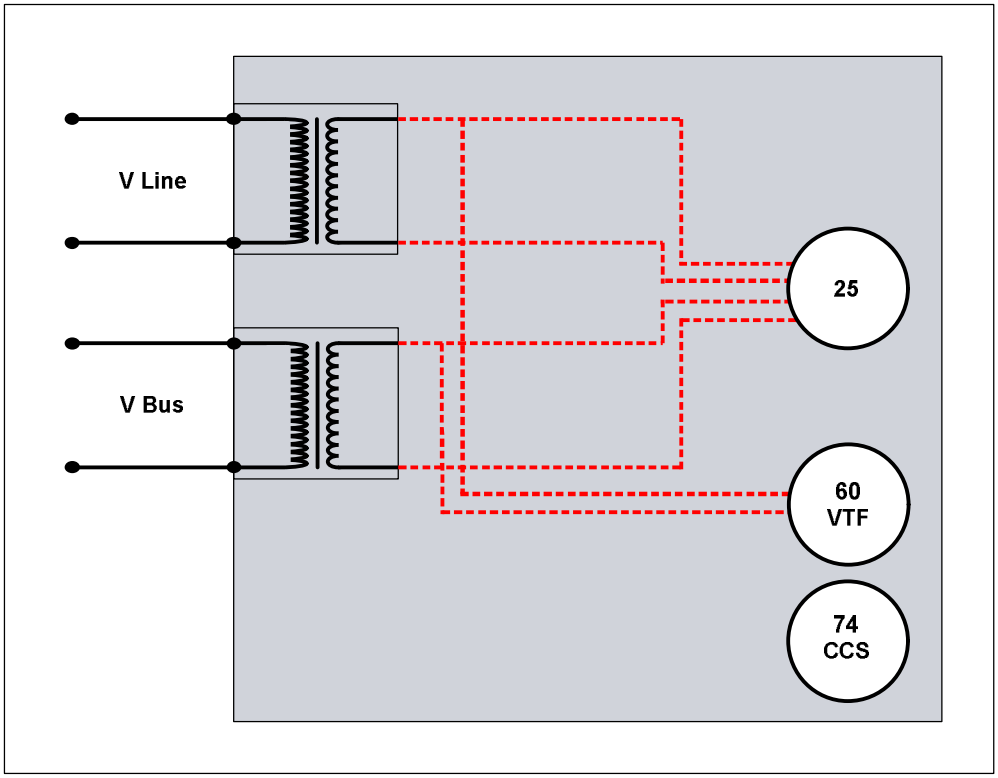
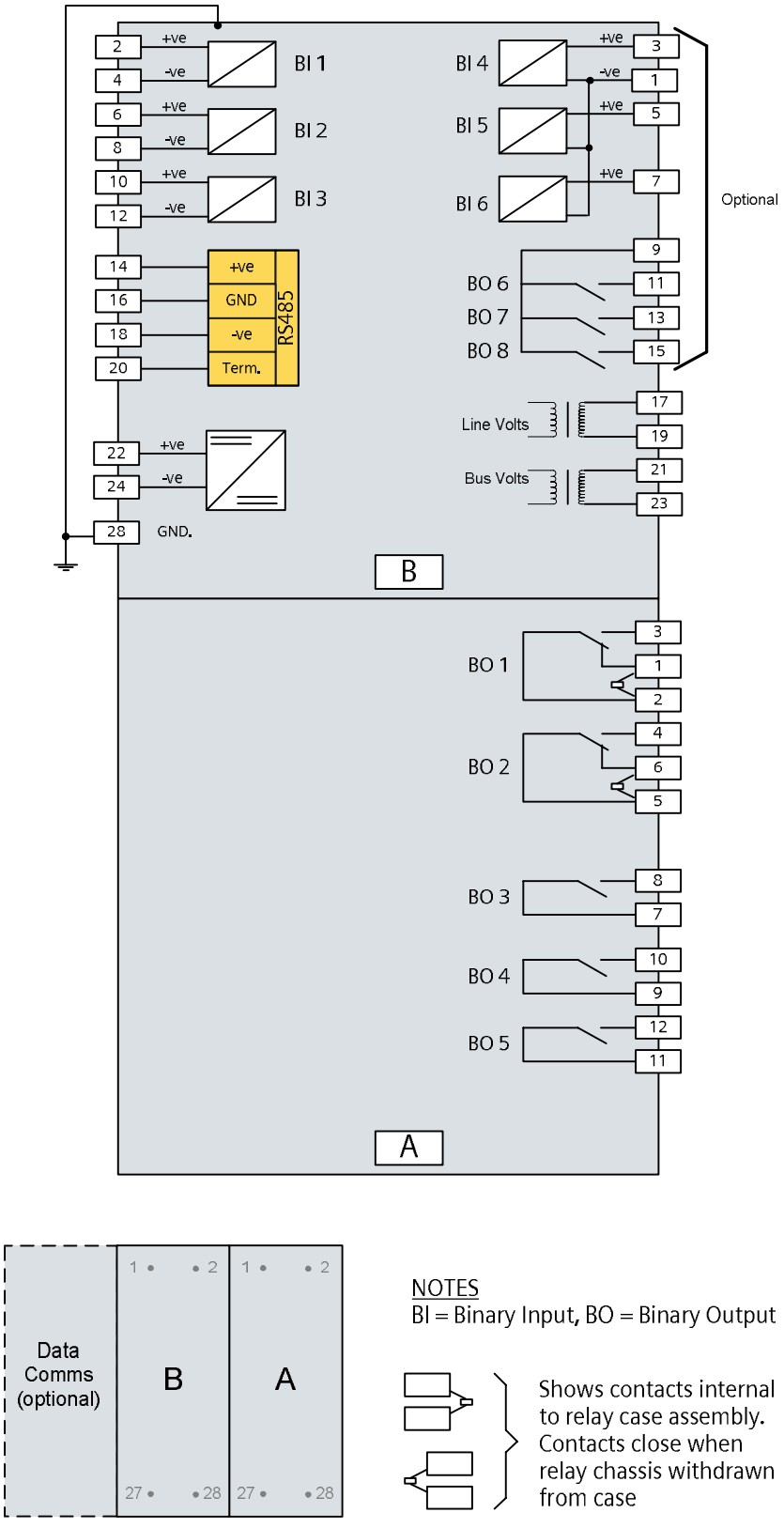


Figure 1-1 Protection Functions

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NOTES
BI = Binary Input, BO = Binary Output

Shows contacts internal to relay case assembly. Contacts close when relay chassis withdrawn from case

Figure 1-2 Connections Diagram for 7SR157 Relay

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Section 2: Hardware Description

2.1 General

The structure of the relay is based upon the Reyrolle Compact hardware platform. The relay is supplied in a size E4 or E6 case (where 1 x E = width of approx. 26mm). The hardware design provides commonality between products and components across the Reyrolle Compact range of relays.

Table 2-1 Summary of 7SR157 Relay Configurations

Relay	Voltage Inputs	Binary Inputs	Binary Outputs	LEDs
7SR1577	2	3	5	10
7SR1578	2	6	8	10

2.2 Case

The relays are housed in cases designed to fit directly into standard panel racks. The two case options have a width of 104mm (E4) and 156 mm (E6), both have a height of 177 mm (4U). The required panel depth is 216.5mm, with wiring clearance a total of 242 mm. 290mm depth clearance should be allowed to accommodate the bending radius of fibre optic data communications cables if fitted.

The complete relay assembly is withdrawable from the front of the case. Contacts in the case ensure that the normally closed contacts remain short-circuited when the relay is removed. To withdraw the relay, remove the plastic fascia cover by rotating the two securing pins and withdraw using the plastic handles. The relay should not be carried using these handles. The relay should only be held by the top and bottom plates and the user should not touch the exposed PCB's.



Figure 2-1 Relay shown withdrawn

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



Figure 2-2 Rear view of Relay (E6 Case with optional IEC61850 module)

Located at the top rear of the case is a screw clamp earthing point, this must be connected to terminal 28 and directly to the main panel earth.

See Chapter 5 (Installation Guide) for full details of panel cut-out and internal clearance requirements.

2.3 Front Cover

As standard the relay is supplied with a transparent front cover. The front cover is used to secure the relay assembly in the case and it is recommended that the cover is always fitted when the relay is in service.



Figure 2-3 Relay with standard transparent cover

If access is required to view the menus without removing the cover, an alternative transparent cover with push buttons may be ordered. With the cover in place the user will only have access to the ▼ and TEST/RESET► buttons, allowing all areas of the menu system to be viewed, but preventing setting changes and control actions. The only 'action' that is permitted is to reset the Fault Data display, latched binary outputs and LEDs by using the TEST/RESET ▸ button.

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Figure 2-4 Relay with transparent cover and push buttons

2.4 Power Supply Unit (PSU)

Ordering Option	Auxiliary Voltage	Binary Input Threshold
G	80V - 250V DC 110 / 115 V AC	19V DC
H	80V - 250V DC	88V DC
J	24V - 60V DC	19V DC
M	24V - 250V DC 100 - 230V AC	19V DC
N	24V - 250V DC 100 - 230V AC	88V DC

Relay PSU options allow the relay to be directly connected to dc system rated from 24V to 60V or 80 to 250V with the original options. The Universal PSU can be connected to dc systems rated from 24V to 250V and AC systems from 100V to 230V. The 80-250Vdc PSU can also be used with 110/115V AC supplies. For consistency and safety it is advised that AC connections to the auxiliary supply are made with the Live connection to the +ve terminal and Neutral connection to –ve. The high voltage PSU and the Universal PSU will operate normally for reversed polarity DC auxiliary voltages.

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

The PSU does not contain any fuses or user serviceable protection components. Typically the PSU is connected to the auxiliary supply via an external HRC fuse rated at 6A (BS88/IEC60259). Isolation links may also be installed in accordance with user requirements.

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2.5 Operator Interface/ Fascia

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



Figure 2-5 Relay with Transparent cover removed

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

Relay Information

Above the LCD two labels are provided, these provide the following information:

1) Product Information & Rating Label, containing

   MLFB ordering code, with hardware version suffix.

   Product name

   Rated frequency

   Auxiliary supply rating

   Voltage rating

   Binary input supply rating

   Serial number

2) Blank label for user defined information.



Figure 2-6 Close up of Relay Label

A template is available in Reydisp Evolution software to allow users to create and print customised labels.

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For safety reasons the following symbols are displayed on the fascia



Dielectric Test Voltage 2kV



Impulse Test Above 5kV



Caution: Refer to Equipment Documentation



Caution: Risk of Electric Shock

Liquid Crystal Display (LCD)

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

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

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

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

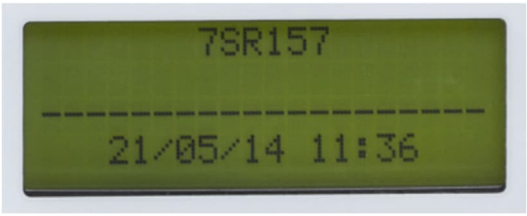


Figure 2-7 Close up of Relay Identifier

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LCD Indication

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

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

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

Standard Keys

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

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

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

'PROT. HEALTHY' LED

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

Indication LEDs

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

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

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

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

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

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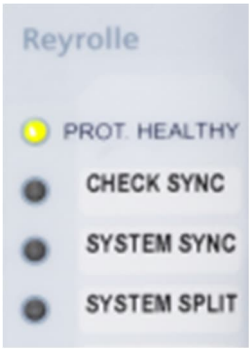


Figure 2-8 LED Indication Label (partial)

2.6 Voltage Inputs

The voltage inputs (***Line Nom Voltage*** and ***Bus Nom Voltage***) can be defined with a nominal rating between 40 – 160V.

Voltage is sampled at 32 samples per cycle (1600Hz for 50Hz and 1920Hz for 60Hz systems). Monitoring functions of the relay use fundamental frequency voltage measurement.

The waveform recorder samples and displays voltage input waveforms at 32 samples per cycle.

The appropriate VT connection and ratio is set in the CT/VT CONFIG menu.

2.7 Binary Inputs

The binary inputs are based upon opto-coupler technology and are operated from a suitably rated power supply.

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

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 20ms provides ac immunity. Each input can be programmed independently.

Each input may be logically inverted to facilitate integration of the relay within the user scheme. When inverted the relay indicates that the BI is energised when no voltage is applied. Inversion occurs before the PU & DO time delay, see Figure 2-9.

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

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.

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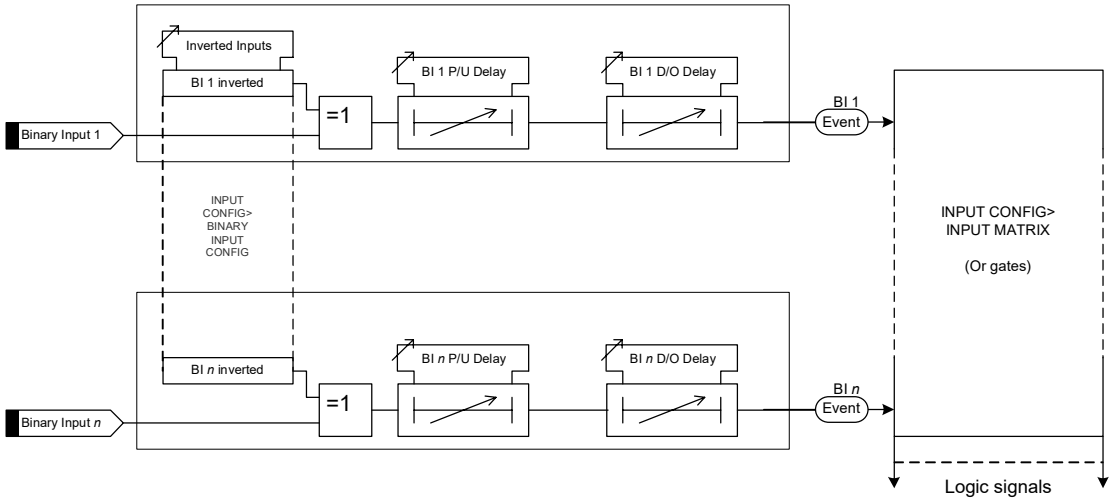


Figure 2-9 Binary Input Logic

2.8 Binary Outputs (Output Relays)

All outputs are fully user configurable and can be programmed to operate from any or all of the available functions.

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

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

The binary outputs can be used to operate the trip coils of the circuit breaker directly where the trip coil current does not exceed the 'make and carry' contact rating. The circuit breaker auxiliary contacts or other in-series auxiliary device must be used to break the trip coil current.

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

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

Notes on Pulsed Outputs

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

Notes on Self Reset Outputs

Self reset operation has a minimum reset time of 100ms

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

Notes on Hand Reset Outputs – 86 Lockout

Any binary output can be programmed to provide an 86 lockout function by selecting it to be hand reset. Hand reset outputs can be reset by either pressing the **TEST/RESET►** button, by energising a suitably programmed binary input, or, by sending an appropriate command over the data communications channel(s).

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

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Notes on General Pickup

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

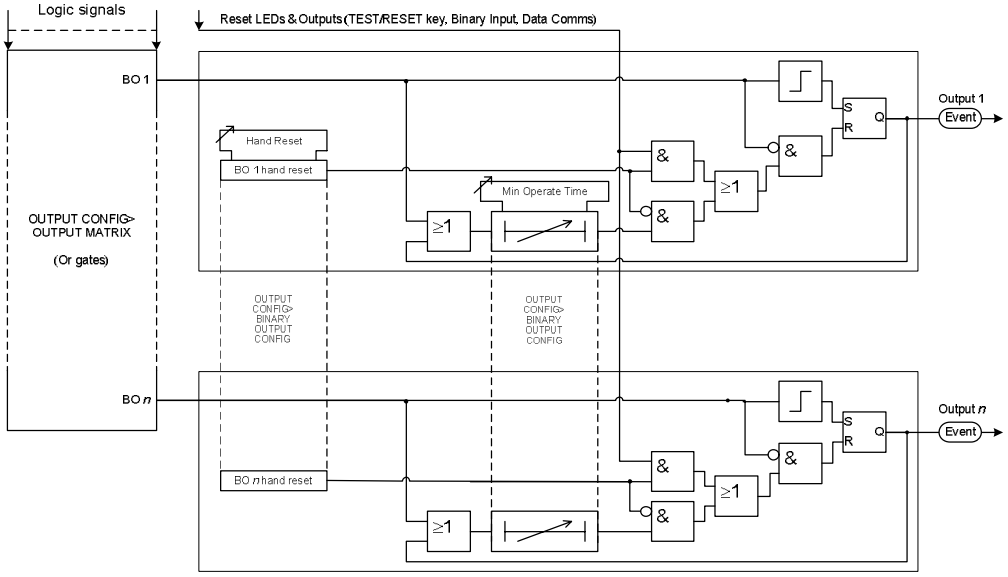


Figure 2-10 Binary Output Logic

2.9 Virtual Input/Outputs

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

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

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

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

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

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2.10 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 'Prot. 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 'Prot. Healthy' and flashing of the 'Prot. 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.

Figure 2.13 shows the events which are generated when the relay re-starts. The highlighted events show the cause of the re-start. The event which comes next shows the type of restart followed by the relay: Warm, Cold or Re-Start.

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

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

Figure 2-11 Unexpected Restarts Lockout Text

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

Once the Relay has failed in this manner, it is non-recoverable at site and must be returned to the manufacturer for repair.
A meter, Miscellaneous Meters>Unexpected Restarts, is provided to show how many Unexpected Restarts have occurred during the previous Unexpected Restart Period. This is resettable from the front fascia.

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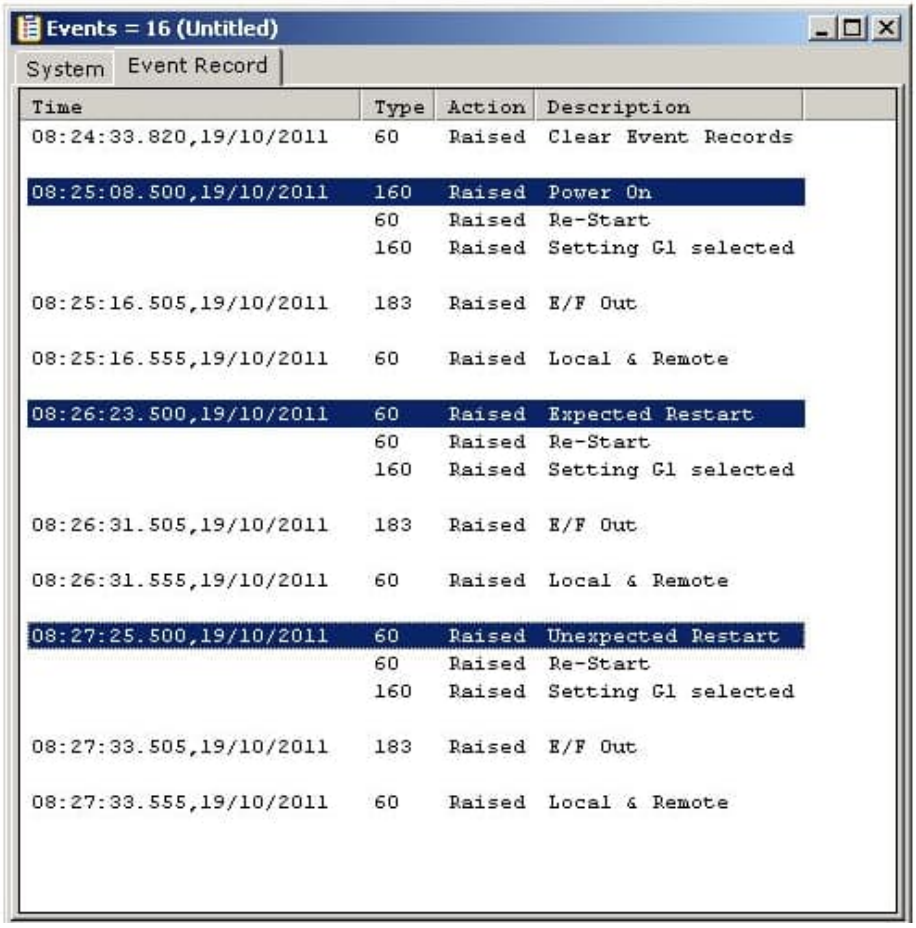


Figure 2-12 Start-up Events

2.10.1 Protection Healthy/Defective

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

A changeover or normally-closed (N/C) contact can be mapped via the binary output matrix to provide an external protection defective signal. When the protection relay is healthy, then the N/C contact is held open. When the auxiliary DC supply is not applied to the relay or a problem is detected within the relay then this output contact closes to provide external indication.

If the relay is withdrawn from the case, the case shorting contact will make across the N/C contacts to provide and external alarm.

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Section 3: Voltage Monitoring Functions

3.1 Voltage Levels (Live and Dead status)

The single phase voltage inputs can be connected to any phase to phase or phase to earth voltage transformer winding connection. The voltage is compared to the corresponding voltage from the other side of the circuit breaker. The live and dead voltage settings are set as a percentage of the nominal voltage setting (***Line Nom Voltage*** or ***Bus Nom Voltage***).

The relay provides two options for determining the live or dead status of the Line and Bus voltage inputs. The selection is made by changing the ***VT Level Mode*** in the VOLTAGE SETTING MENU. The two options are as follows:

3.1.1 VT Level Mode: 2 State

Voltage detectors determine the status of the line or bus. If the voltages on either the line or bus are below a set threshold level (***25 Dead Bus*** or ***25 Dead Line***) they can be considered to be 'dead'. If the voltages are within a range, usually around the nominal voltage, determined by (***25 Live Bus*** or ***25 Live Line***) settings, then they are classed as 'live'. Independent voltage detectors are provided for both line and bus.

In this mode, if a voltage is initially at or below the dead setting then it will be classed as dead until it has increased and reached the live setting. Similarly, if a voltage is live, it continues to be live until it has decreased and reached the dead setting. This effectively allows for variable amounts of hysteresis to be set. Figure 3-1 illustrates the voltage detector operation.

Note: the area between the dead and live zones is not indeterminate. When any voltage is applied to the relay it will ramp up the software RMS algorithm and always pass through the dead zone first.

Although a wide range is provided for live and dead voltage detector elements, the user must ensure that the live and dead zones do not overlap.

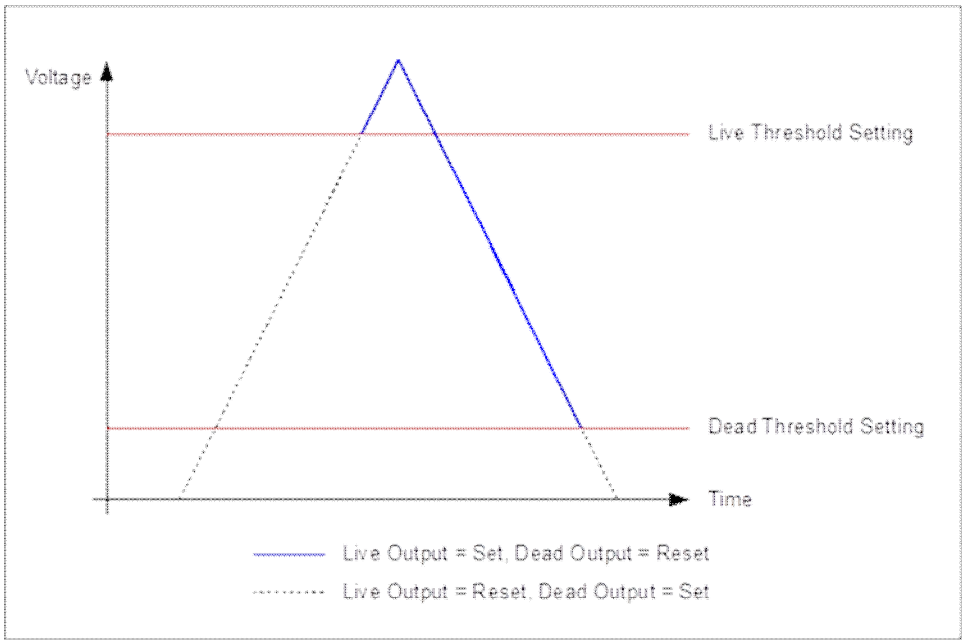


Figure 3-1 VT Level Mode: 2 State

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3.1.2 VT Level Mode: 3 State

In this mode, the Line or Bus Voltages are only classed as live when above the live threshold. When the voltage falls below the live threshold, the live output is RESET but the Dead output does not SET until the voltage falls below the Dead threshold. This is an indeterminate state, where both Live and Dead outputs have the same value; both are RESET.

This mode applies a 3% hysteresis setting to the drop off on both thresholds, to minimise 'chattering' of the element with frequency excursion.

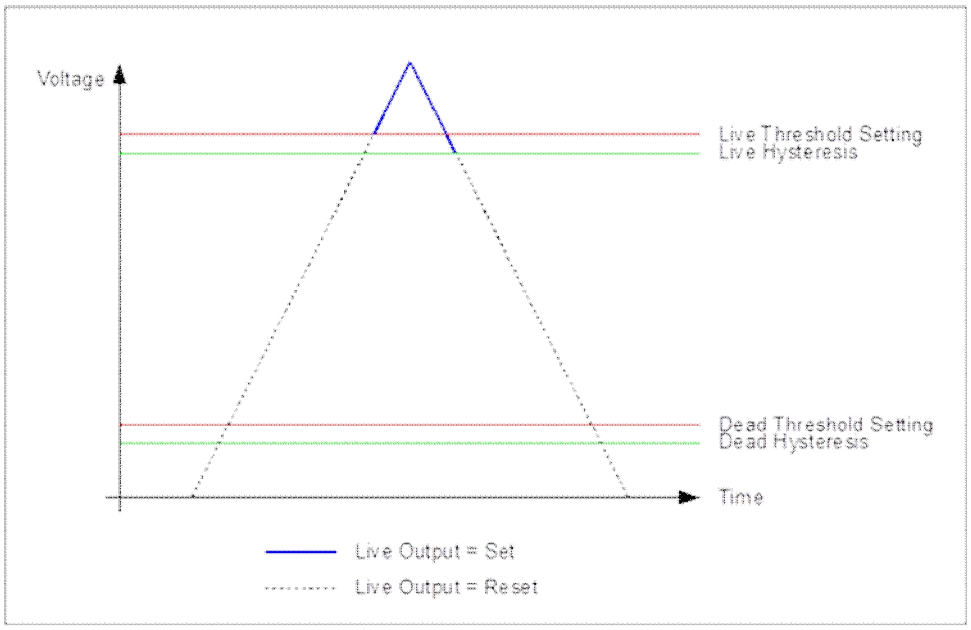


Figure 3-2 VT Level Mode: 3 State Live Output

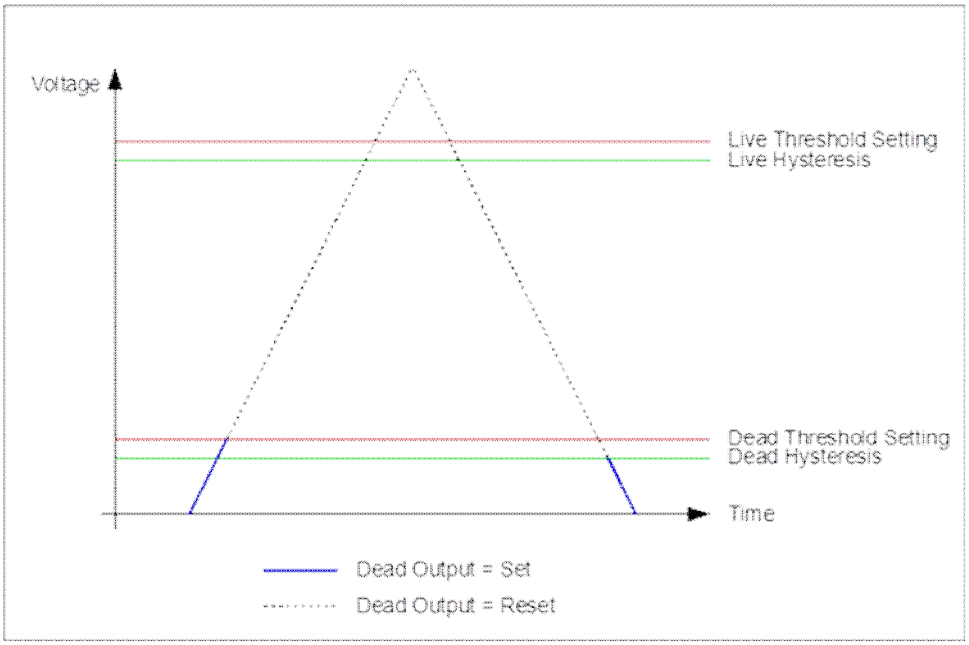


Figure 3-3 VT Level Mode: 3 State Dead Output

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3.3 Undervoltage Detector

There are two Undervoltage detector elements, one for the Line voltage and one for the Bus voltage. If enabled these elements can block a Check Synchronising, System Synchronising or Close On Zero operation.

The Line Undervoltage Detector and Bus Undervoltage Detector Enabled/Disabled selection is made by changing the ***25 Line U/V*** and ***25 Bus U/V*** in the VOLTAGE SETTING MENU.

The threshold settings (**25 Line Undervolts** and **25 Bus Undervolts**) are set as a percentage of the nominal voltage. The relay sets an Undervoltage output when the voltage is below the threshold setting. The line and bus voltages have independent Undervoltage outputs (**25 Line U/V** and **25 Bus U/V**).

There is 3% fixed hysteresis on the element drop off, to minimise 'chattering' of the element with frequency excursion.

3.4 Differential Voltage Detector

The Differential Voltage Detector Element monitors the difference between the secondary RMS Line Voltage and secondary RMS Bus Voltage. If enabled the element can block a Check Synchronising, System Synchronising or Close On Zero operation.

The Differential Voltage Detector Enabled/Disabled selection is made by changing the ***25 Voltage Diff*** in the VOLTAGE SETTING MENU.

The threshold setting ***25 Volt Differential*** is set as a percentage difference between the Line and Bus voltages. When the difference exceeds ***25 Volt Diff*** setting, **25 Diff Voltage** output is set.

There is 3% fixed hysteresis on the element drop off, to minimise 'chattering' of the element with frequency excursion.

3.5 Voltage Trim (Magnitude and Phase)

The relay incorporates a **Voltage Trim Magnitude** feature and a **Voltage Trim Angle** feature for both the line and bus voltages; these are found in the CT/VT CONFIG menu. They allow small adjustments to the input voltages and phase angles of the relay. The relay in service may not see exactly the expected nominal voltages in sevcie. This could be due to losses from cable lengths and joints and also due to small inaccuracies in the voltage transformers (VTs). Sometimes, interposing VTs are used to trim the voltages seen by the relay back to their nominal values. This feature does away with the need for interposing VTs because the relay can digitally adjust the incoming samples by a scaling factor back to their expected nominal values.

Each voltage input, V_{Line} and V_{Bus}, has an independent **Voltage Trim Magnitude** in the range of 0V to + 20.0V with a step size of 0.1V. Each also has an independent **Voltage Trim Angle** in the range of -45° to + 45° with a step size of 0.1°.

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Section 4: Control Functions

4.1 25 Check Sync

Check Synchronising is enabled via **25 Check Sync** in the CHECK SYNC MENU.

Check Synchronising sets **25 InSyncCS** and **25 Check Sync Close** outputs when the Line and Bus voltages are healthy and synchronised.

The phase angle tolerance between the Line and Bus voltages for being synchronised is set by ***25 Check Sync Angle*** setting. The synchronised conditions must be held for a minimum time of ***25 Check Sync Timer*** setting. An optional setting ***25 Check Sync Slip*** may be applied to limit Slip Frequency; this selection is made by changing the ***25 Check Sync Slip Freq*** setting.

Check Synchronising requires ***25 Voltage Check*** to be set. ***25 Voltage Check*** is an output derived from voltage logic, indicating that the line and bus voltages are healthy. Figure 4-1 illustrates the Voltage Check Function logic.

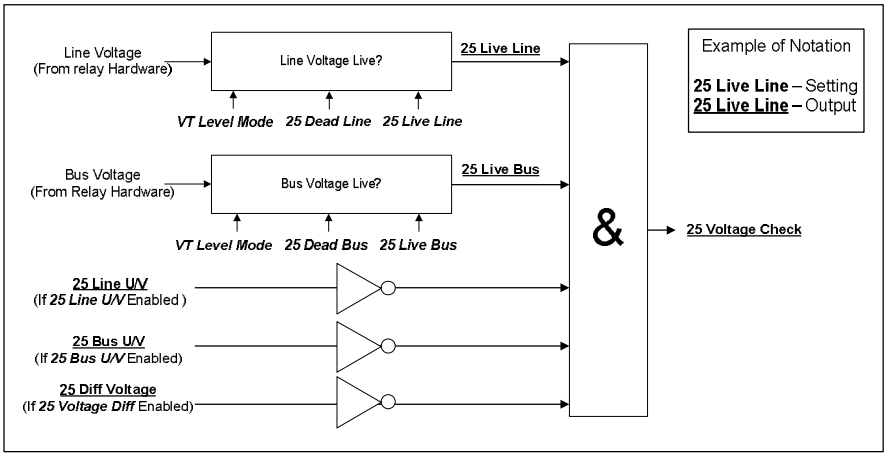


Figure 4-1 Voltage Check Function logic

The **25 Check Sync Close** output will stay on for a minimum time of 100ms and for the whole duration of the time that the check synchronizing conditions are met. Unlike **System Sync Close** and **Close On Zero Close**, which are pulsed outputs.

The Check Sync inhibit command, **Check Sync Inhibit** will inhibit a **25 Check Sync Close** output from being set. **Check Sync Inhibit** will not inhibit the **25 InSyncCS** or **25 CS In Progress** outputs from being set.

There are two modes of operation, Auto and Manual. The selection is made by changing ***25 Check Sync Enable*** in the CHECK SYNC MENU.

AUTO: **25 Check Sync Close** output is set when the Check synchronizing conditions are met.

MANUAL: **25 Check Sync Close** output is set when Check synchronizing conditions are met and a manual close command is received, via ***Start Check Sync*** input.

The **Reset 25 Sync** input resets the following outputs: **25 in Sync**, **25 InSyncCS**, **25 InSyncSS**, **25 InSyncCOZ**, **25 Check Sync Close**, **25 System Sync Close**, **25 COZ Close**, **25 CS In Progress**, **25 SS In Progress**, **25 COZ In Progress**.

For the relay to set the **25 Check Sync Close** output the following conditions have to be met:

- ***25 Check Sync Angle*** – the phase difference between the line and bus voltages has to be less than the ***25 Check Sync Angle*** setting value. Whilst within the limits the phase angle can be increasing or decreasing and the element will still issue a valid close signal.

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- ***25 Check Sync Timer*** – the phase angle and voltage blocking features have to be within their parameters for the duration of the slip timer setting. If either the phase angle or the voltage elements fall outside of their limits the slip timer is reset. If they subsequently come back in then the slip timer has to time out before a close output is given. (This ensures that a close output will not be given if there is a transient disturbance on the system due to e.g. some remote switching operations).
- ***25 Check Sync Slip*** [If enabled] – the frequency difference between line and bus voltages has to be less than the ***25 Check Sync Slip*** setting value.
- **25 Line Undervolts** [If enabled] – the line voltage has to be above the **25 Line Undervolts** setting value for an output to be given..
- **25 Bus Undervolts** [If enabled] – the bus voltage has to be above the **25 Bus Undervolts** setting value for an output to be given.
- **25 Volt Differential** [If enabled] – the percentage difference between the line and bus voltages has to be less than the **25 Volt Differential** setting value for an output to be given.

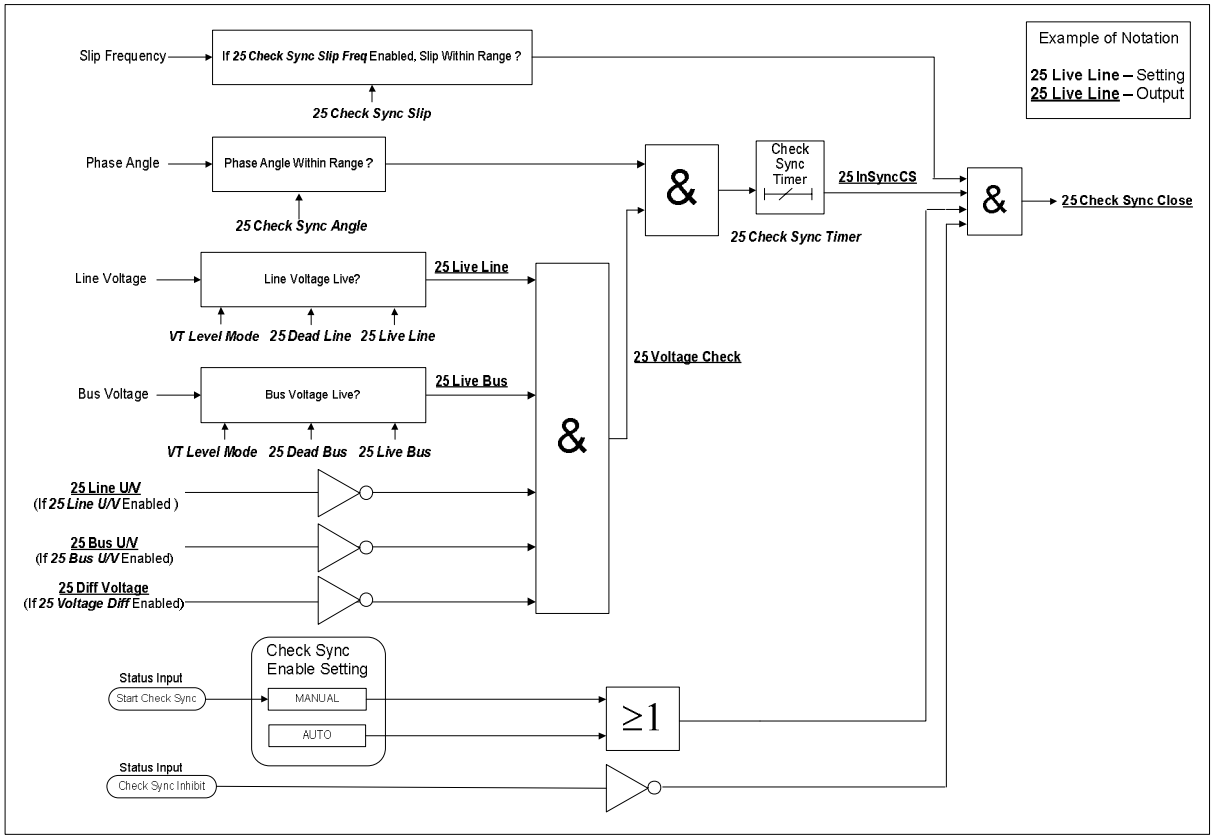


Figure 4-2 Check Sync Function logic

4.1.1 Close Guard

If manual closes are required to be carried out via an operator, the ***Close Guard*** feature can be enabled which provides an alarm message if the operator attempts to initiate a CB close before the relay issues a valid Check Sync Close signal.

The ***Close Guard*** Enabled/Disabled selection is made by changing the ***Close Guard*** in the CHECK SYNC MENU.

If enabled, the ***Close Guard*** feature will generate an alert message, indicating that a Check Sync Manual Close was not performed as Check synchronizing conditions were not met; a **Close Guard** output is set.

Close Guard alert is by default set to General Alarm 7 with the message ‘Close Guard Active’, which is also displayed on the relay LCD.

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4.2 25 System Split Detector

A system split occurs when the opening of a CB disconnects two separate sections of a grid network. Since the two grid sources are not coupled the frequencies can drift apart even though the independent control systems employ the same reference frequency. A small drift in frequency can lead to a major phase angle difference.

The System Split Detector Enabled/Disabled selection is made by changing the ***25 System Split Detector*** in the CHECK SYNC MENU.

When the phase angle difference or slip frequency exceeds a pre-set value the ***25 System Split Detector*** sets the **25 System Split** output, indicating the system is split. The ***25 System Split Timer*** holds the system split output on for a minimum time set by the timer setting value. This can be used when interfacing with delayed autoreclose (DAR) schemes. The delay can be adjusted by changing the ***25 System Split Timer*** in the CHECK SYNC MENU. The setting range is from 0 to 60000ms (setting step is 10ms).

The condition by which a system split is detected is made by changing the ***25 System Split Mode*** in the CHECK SYNC MENU. There are two options for this condition, Phase or Slip.

Phase: The phase angle difference between the Line and Bus voltages at which a system split is detected is set by changing the ***25 Split Angle*** in the CHECK SYNC MENU. The setting range is from 0 to 180° (setting step is 1°).

Note : the system split setting is effectively an absolute value and therefore a split will occur at the value regardless of the direction of the frequency slip e.g. if an angle of 170° is selected, then starting from 0°, a split will occur at either +170° or -170° (effectively +190°).

Slip: The frequency difference between the Line and Bus Voltages at which a system Split is detected is set by changing the ***25 Split Slip*** in the CHECK SYNC MENU. The setting range is from 0 to 2Hz° (setting step is 0.01Hz).

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4.3 25 System Sync

System Synchronising is enabled via **25 System Sync** and **25 Split Mode** set to SS (System Sync) in the SYSTEM SYNC MENU. The **25 Split Mode** setting allows the user to determine how the two parts of the network are reconnected after a split. The options for **25 Split Mode** are CS (Check Sync), SS (System Sync) and COZ (Close on Zero).

System Synchronising is triggered by a system split. After a split, System Sync will wait for Line and Bus voltages to realign, before setting **25 InSyncSS** and **25 System Sync Close** outputs.

System Synchronising requires **25 Voltage Check** and **25 System Split** outputs to be set. **25 Voltage Check** is an output derived from voltage logic, indicating that the line and bus voltages are healthy. Figure 4-1 illustrates the **25 Voltage Check** Function logic.

The phase angle tolerance between the Line and Bus voltages for being synchronised is set by the **25 System Sync Angle** setting in the SYSTEM SYNC MENU. The maximum frequency difference between the Line and Bus voltages is set by ***25 System Sync Slip***.

The synchronised conditions must be held for a minimum time of ***25 System Sync Timer*** setting before ***25*** **InSyncSS** and **25 System Sync Close** outputs are set.

The **25 System Sync Close** output is a pulsed output. The duration of the pulse can be set by adjusting the ***25 COZ Close Pulse*** setting.

The System Sync inhibit command, **System Sync Inhibit** will inhibit a **25 System Sync Close** output from being set. **System Sync Inhibit** will not inhibit the **25 InSyncSS** or **25 SS In Progress** outputs from being set.

There are three modes of operation: Auto and Manual and Lockout mode. The selection is made by changing the ***25 System Sync Enable*** setting.

AUTO: **25 System Sync Close** output is set when the System synchronizing conditions are met.

MANUAL: **25 System Sync Close** output is set when System synchronizing conditions are met and a manual close command is received, via ***Start System Sync*** input.

LOCKOUT: The ***System Split Lockout*** output is set when there is a ***25 System Split*** event.

The ***System Split Lockout*** is reset by any of the following:

- ***Reset Lockout Mode*** command (via Binary input or comms)
- Either the Line or Bus voltages become dead.
- The relay HMI ***Test/Reset*** key is pressed.

For the relay to issue a **25 System Sync Close** output the following conditions have to be met:

- **25 Line Undervolts** [If enabled] – the line voltage has to be above the **25 Line Undervolts** setting value for an output to be given.
- **25 Bus Undervolts** [If enabled] – the bus voltage has to be above the **25 Bus Undervolts** setting value for an output to be given.
- **25 Volt Differential** [If enabled] – the percentage difference between the line and bus voltages has to be less than the **25 Volt Differential** percentage for an output to be given.
- **25 System Sync Angle** – the phase difference between the line and bus voltages has to be less than **25 System Sync Angle** setting value and the phase angle has to be decreasing before the element will issue a valid close signal.
- **25 System Sync Slip** – the frequency difference between line and bus has to be less than the **25 System Sync Slip** setting value.
- **25 System Sync Timer** – the phase angle, slip frequency and voltage blocking features have to be within their parameters for the duration of the **25 System Sync Timer** setting. If either the phase angle, slip frequency or the voltage elements fall outside of their limits the **25 System Sync Timer** is reset. If they subsequently come back in then the **25 System Sync Timer** has to time out before a close output is given. (This ensures that a close output will not be given if there is a transient disturbance on the system due to e.g. some remote switching operations).

Figure 4-3 illustrates the System Sync Function logic.

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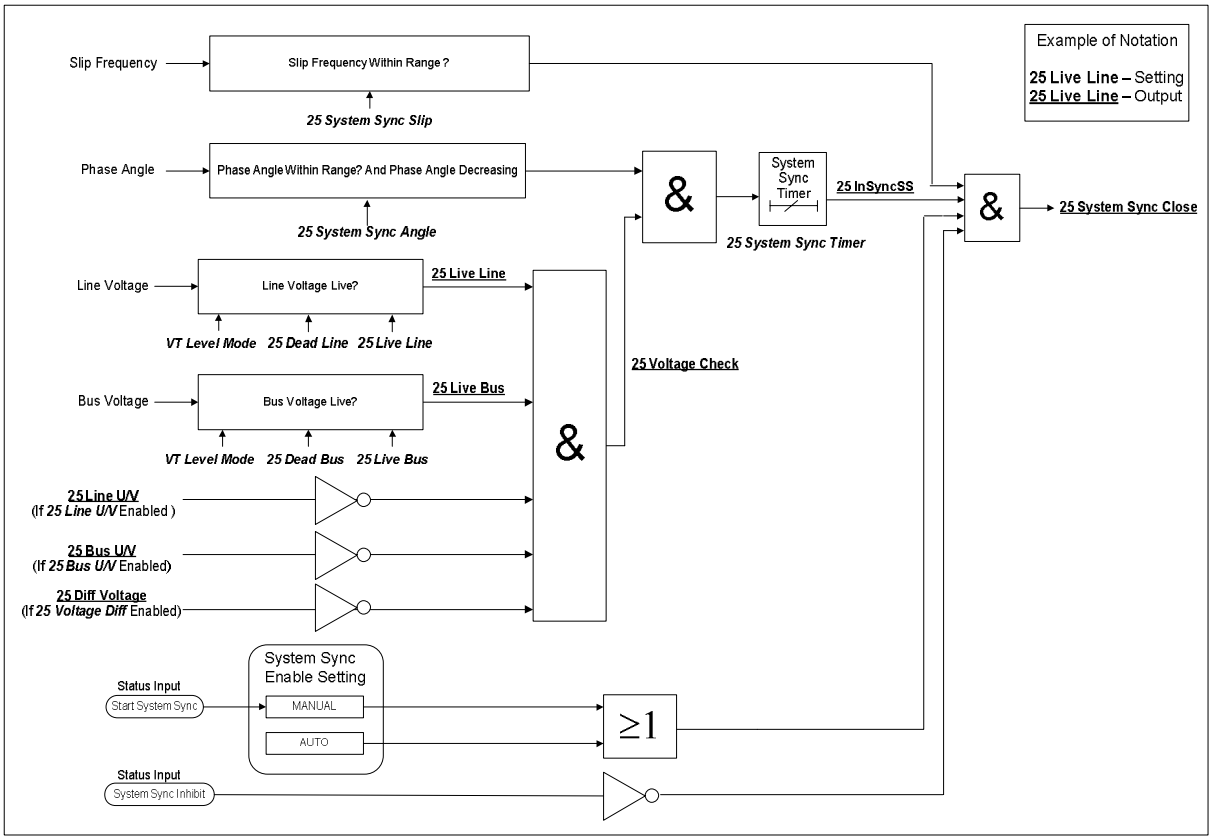


Figure 4-3 System Sync Function logic

4.4 25 Close On Zero

Close On Zero is part of the System Synchronising function. Close On Zero is enabled via ***25 System Sync*** and ***25 Split Mode*** set to COZ (Close On Zero).

If the ***25 Split Mode*** is set to COZ and a **25 System Split** occurs, a Close On Zero operation will be activated. Close On Zero differs from System Sync, by attempting issue a close output when phase angle is precisely zero. The phase angle, slip frequency and CB Close time delay are used to predict when zero phase angle will occur.

The slip frequency must be less than the ***25 COZ Slip Freq*** but greater than the ***25 Split Slip*** setting to avoid reversion to Check Synchronising conditions.

There are two modes of operation, Automatic and Manual. These modes require ***25 Split Mode*** set to Close On Zero. Modes are set via ***System Sync Enable***.
Automatic Mode – **COZ Close** output is set when Close On Zero conditions are met.
Manual Mode – **COZ Close** output is set when Close On Zero conditions are met, and a manual close command is received, via **Start System Sync** input.

System Sync Automatic and Manual modes apply, as well as **Start System Sync** manual close command. Close On Zero does have a separate inhibit command, **COZ Inhibit**. The COZ Inhibit input will inhibit a **COZ Close** output from being set but it will not inhibit the **InSyncCOZ** or **COZ In Progress** outputs from being set.

Figure 4-4 illustrates the Cloze on Zero Function logic.

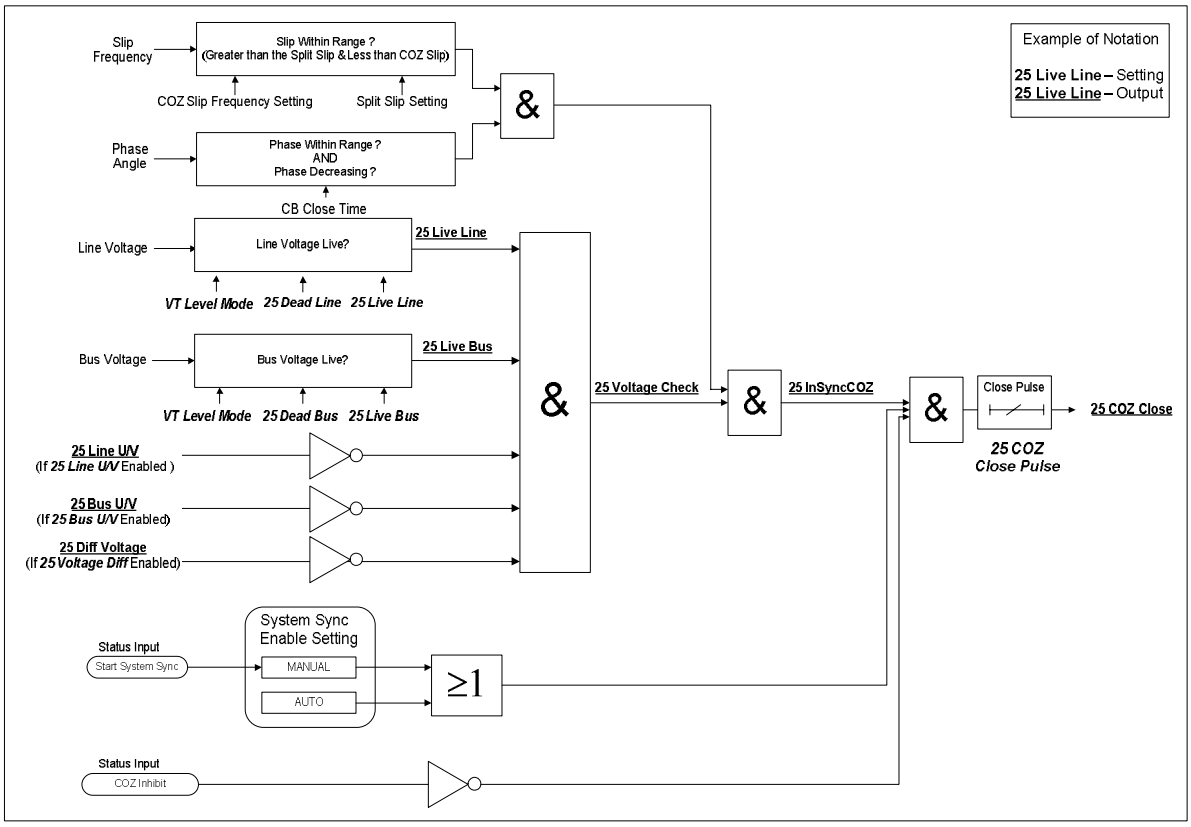


Figure 4-4 Close On Zero Function logic

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4.5 Synchronising Bypass

For switching operations, which involve connecting an uncharged line or bus to a live line or live bus, a means of bypassing the synchronising operation is required. This is achieved using the ***Sync Bypass*** setting, which is in the VOLTAGE SETTING MENU. The range of setting values for this are:

Setting	**Description**
DL AND LB	Dead Line AND Live Bus
LL AND DB	Live Line AND Dead Bus
DL AND DB	Dead Line AND Dead Bus
DL OR DB	Dead Line OR Dead Bus
DL XOR DB	Dead Line Exclusive OR Dead Bus

To bypass the synchronisation feature and issue a **Bypass Close** output, specific line and bus conditions have to be met and the **Sync Bypass** status input has to be energised. The **Bypass Close** output will stay on for the duration of the time that the **Sync Bypass** status input is energised and while the line and bus conditions are met.

Alarms can be generated from the following outputs:

LLLB (Live Line and Live Bus)
DLDB (Dead Line and Dead Bus)
LLDB (Live Line and Dead Bus)
DLLB (Dead Line and Live Bus)

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4.6 Quick Logic

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

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

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

Example Showing Use of Nomenclature

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

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

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

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

En Counter Reset Mode = **Single Shot**: The ***En Counter Reset Time*** is started only when the counter is first incremented (i.e. counter value = 1) and not for subsequent counter operations. Where ***En Counter Reset Time*** elapses and the count value has not reached its target the count value is reset to zero.

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

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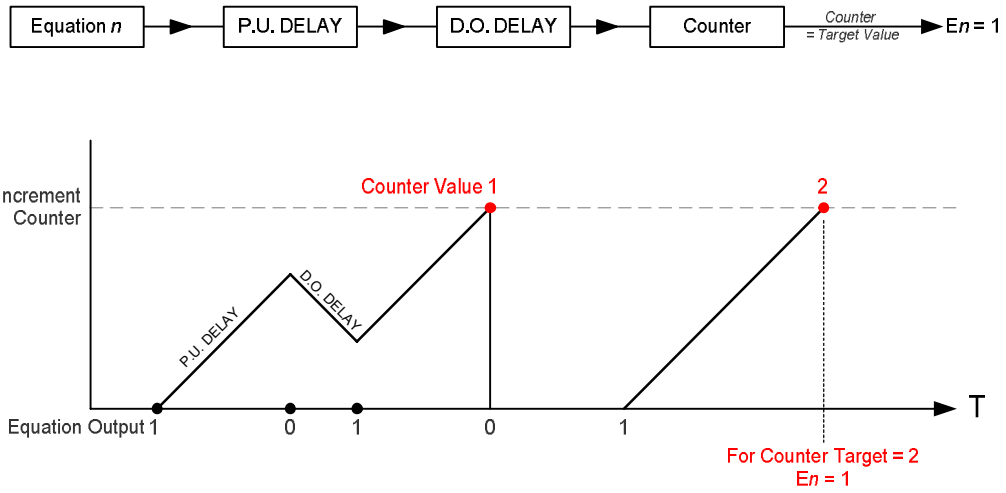


Figure 4-5 Sequence Diagram: Quick Logic PU/DO Timers (Counter Reset Mode Off)

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

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

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

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

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Section 5: Supervision Functions

5.1 VT Supervision (60 VTF)

When the circuit breaker is closed, both voltages should be either Live or Dead. If this is not true, a VT Fail output (**60VTS - Line** indicating the Line VT has failed or **60VTF-Bus** indicating the Bus VT has failed) is set. A time delay setting (***60VTF-Line Delay*** or ***60VTF-Bus Delay***) suppresses spurious operations during transient switching conditions. The status input **CB Closed** has to be set to allow the VT Supervision (60VTF) to operate.

Each VT Fail flag can be configured to Lockout ***Sync Bypass***, via the ***LO Bus VT Fail*** or ***LO Line VT Fail*** elements.

5.2 Demand Metering

The Demand Metering Calculates the maximum, minimum and mean values of Line and Bus voltages and displays it as instruments which can be read in the relay INSTRUMENTS MENU or via Reydisp.

The ***Data Log Period*** setting defines the time between data sampling. Up to 10080 samples are stored.

The ***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 ***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 the relay fascia, a binary input or communication command. After reset the update period and window are immediately restarted.

5.3 Close Circuit Supervision (74CCS)

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

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

The ***74CCS-n Delay*** setting prevents failure being incorrectly indicated during circuit breaker close 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 allows the user to realise several alternative monitoring schemes.

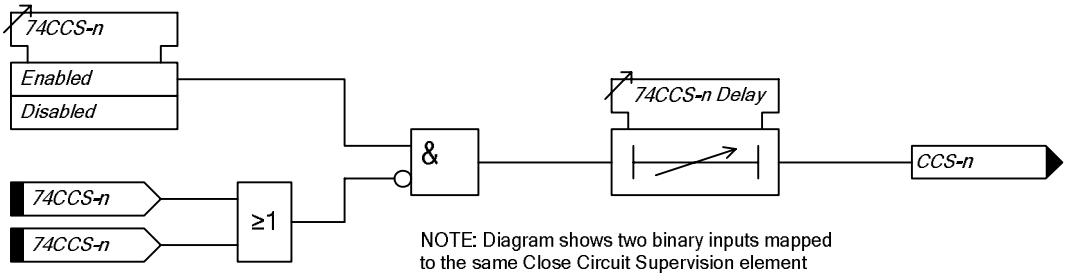


Figure 4-6 Logic Diagram: Close Circuit Supervision Feature (74CCS)

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Section 6: Other Features

6.1 Data Communications

Two serial 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.

Optionally, additional IEC61850 communication ports are available: -

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

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

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

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

For communication with the relay via a 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 IEC60870-5-103.

Data communications operation is described in detail in Section 4 of this manual.

6.2 IEC 61850 Communications

The relay can optionally be provided with IEC61850 comms.

IEC61850 is provided with an added EN100 communication module.

The following EN100 output alarms are provided:

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

For further details refer to the following publications:

Model Implementation Conformance Statement (MICS)

Protocol Implementation Conformance Statement (PICS)

Protocol Implementation Extra Information for Testing (PIXIT)

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6.3 Data Storage

6.3.1 General

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

6.3.2 Event Records

The event recorder feature allows the time tagging of any change of state (Event) in the relay. As an event occurs, the actual event condition is logged as a record along with a time and date stamp to a resolution of 1 millisecond. There is capacity for a maximum of 1000 event records that can be stored in the relay and when the event buffer is full any new record will over-write the oldest. Stored events can be erased using the DATA STORAGE>***Clear Events*** setting or from Reydisp.

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.

For a complete listing of events available in each model, refer to Technical Manual Section 4 'Data Communications Definitions'.

6.3.3 Waveform Records.

Relay waveform storage can be triggered either by user selected 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 illustrate 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 > ***Trigger Waveform*** setting.

In total the relay provides up to 10 seconds of waveform storage, this is user selectable to 1 x 10second, 2 x 5 second, 5 x 2 second or 10 x 1 second records. When the waveform recorder buffer is full any new waveform record will over-write the oldest. The most recent record is Waveform 1.

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

Waveforms are sampled at a rate of 1600Hz.

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

6.3.4 Fault Data Records

Up to ten fault records can be stored and displayed on the Fascia LCD. Fault records can be triggered by a suitably programmed binary input. The 7SR157 does not provide any protection or system fault detection functionality but will record data in the same format as other 7SR products fault records. 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 trigger, i.e. the Bus and Line voltage levels, LED indications, date and time. The ***Max Fault Rec. Time*** setting sets the time period from fault trigger during which the operation of any LEDs is recorded.

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

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

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

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

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

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

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

This function is set by the SYSTEM 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 SYSTEM 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 Instruments

Real-time data is available from the relay fascia in the ‘Instruments Mode’ or via the data communications interface.

The Primary values are calculated using the VT 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 Language Editor 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.

For a detailed description refer to Technical Manual Chapter 2 – Settings and Instruments.

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6.5 Operating Mode

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

The modes can be selected by the following methods:

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

Table 4-1 Operating Mode

OPERATION	REMOTE	LOCAL	OUT OF SERVICE
Control			
Rear Port	Enabled	Disabled	Disabled
USB	Disabled	Enabled	Disabled
Binary Inputs	Setting Option	Setting Option	Enabled
Binary Outputs	Enabled	Enabled	Disabled
Reporting			
Spontaneous			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
General Interrogation			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
MODBUS	Enabled	Enabled	Disabled
Changing of Settings			
Rear Port	Enabled	Disabled	Enabled
Fascia	Enabled	Enabled	Enabled
USB	Disabled	Enabled	Enabled
Historical Information			
Waveform Records	Enabled	Enabled	Enabled
Event Records	Enabled	Enabled	Enabled
Fault Information	Enabled	Enabled	Enabled
Setting Information	Enabled	Enabled	Enabled

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6.6 Real Time Clock

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

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

The default date is set at 01/01/2000 to deliberately indicate that 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.

6.6.1 Time Synchronisation – Data Communication Interface

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

6.6.2 Time Synchronisation – Binary Input

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

6.7 Settings Groups

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

It is possible to edit one group while the relay operates in accordance with settings from another 'active' group using the ***View/Edit Group*** setting.

Some settings are independent of the active group setting i.e. they apply to all settings groups. This is indicated on the top line of the relay LCD – where only the **Active Group No**. is identified. Where settings are group dependent this is indicated on the top line of the LCD by both the **Active Group No**. and the **View Group No**. being displayed.

A change of settings group can be achieved either locally at the relay fascia, remotely over the data comms channel(s) or via a binary input. When using a binary input an alternative settings group is selected only whilst the input is energised (***Select Grp Mode*: Level triggered**) or latches into the selected group after energisation of the input (***Select Grp Mode*: Edge triggered**).

Settings are stored in non-volatile memory.

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6.8 Password Feature

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

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

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

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

The Settings Password prevents unauthorised changes to settings from the front fascia or over the data comms channel(s). The Control Password prevents unauthorised operation of controls in the relay Control Menu from the front fascia. 7SR157 does not provide a Control Menu and therefore this password is not used.

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

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7SR157

Check and System Synchronising Relay

Settings and Instruments

Document Release History

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

2016/06	E6 case IEC61850 models introduced
2014	First Issue

Software Revision History

Date	Software Reference	Summary
2016/06	2436H80010R4e-2a	IEC61850 variants added
2014	2436H80010R2f-1a	First Release

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Section 1: Introduction

1.1 Relay Menus and Display

All 7SR1x relay fascias have similar appearance and support the same access keys. The basic menu structure consists of three 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 view the conditions that the relay is experiencing i.e. current, voltage etc.

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

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 shown below:

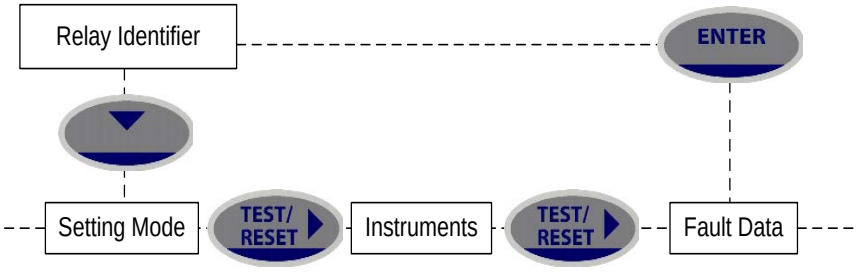


Figure 1-1 Menu System

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 Section 2.1.5.

1.1.1 LCD Contrast

To change the contrast on the LCD insert a flat bladed screwdriver into the screw head below the contrast symbol, turning the screw head left (anti-clockwise) lightens the contrast of the LCD and turning it right (clockwise) darkens the display.



Figure 1-2 Fascia Contrast symbol

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1.2 Operation Guide

1.2.1 User Interface Operation

The basic menu structure flow diagram is shown in Figure 1-1. This diagram shows the main modes of display: Settings Mode, Instrument Mode, and Fault Data Mode.

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

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

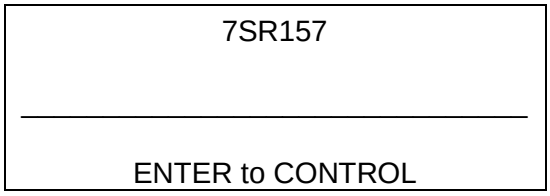


Figure 1-3 Relay Identifier Screen

On first boot-up of the relay, the LCD will display the relay identifier screen. On every subsequent power-on, whichever screen was last viewed will be displayed.

The push-buttons on the fascia are used to display and edit the relay settings via the LCD. They are also used 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 LEDs.

The five push-buttons have the following functions:

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

These are 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 move 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

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This push-button moves the cursor right ► when navigating through menus and settings. It is also used to reset the fault indication on the fascia e.g. lit LEDs. When on the relay identifier screen it can also act as an LED test button. When pressed, all programmable LEDs will momentarily light up to indicate their correct operation.

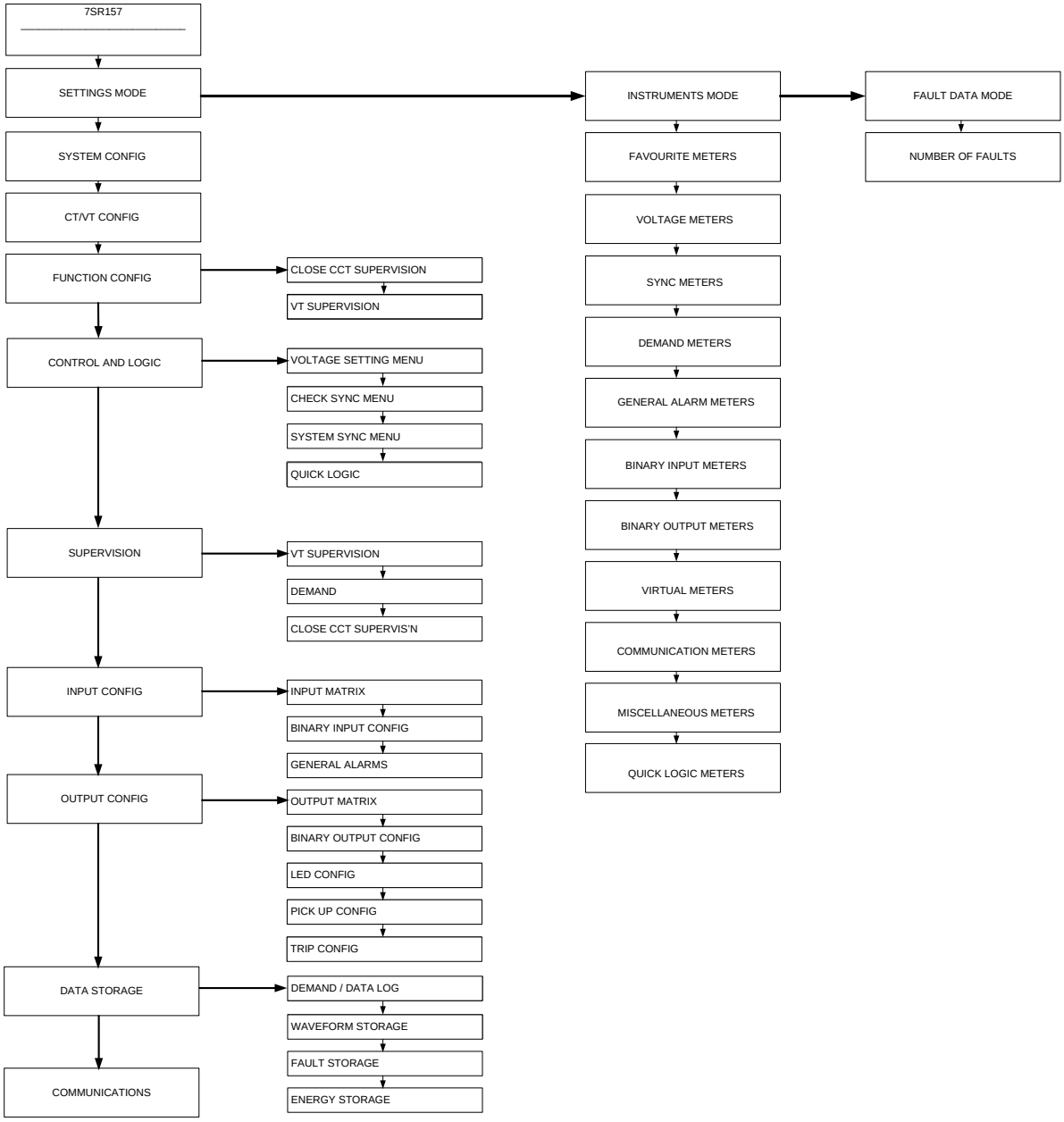


Figure 1-4 Menu Structure

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1.3 Setting Mode

The Settings Mode is reached by pressing the READ DOWN ▼ button from the relay identifier screen. Pressing the READ DOWN ▼ button again 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 setting change is effective immediately unless any protection element is operating, in which case the change becomes effective when no elements are operating.

Configuration and inspection of communications protocol data objects, text used for display in international languages, graphical user logic and programming of user specific custom protection characteristics is not possible from the fascia and pc based tools must be used if required.

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1.4 Instruments Mode

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

Instrument	Description
FAVOURITE METERS →to view	This allows the user to view his previously constructed list of 'favourite meters' by pressing TEST/RESET ► button and the READ DOWN button to scroll though the meters added to this sub-group. To construct a sub-group of favourite meters: first go to the desired meter then press ENTER. This will cause a message to appear on the LCD 'Add To Favourites YES'. Pressing ENTER again will add this to the FAVOURITE METERS Sub-menu. To remove a meter from the FAVOURITE METERS sub-menu go to the meter in the FAVOURITE METERS sub-menu or at its Primary location and press ENTER. The message 'Remove From Favourites YES' will appear. Press ENTER again and this meter will be removed from the FAVOURITE METERS sub-group.
VOLTAGE METERS →to view	This sub-group includes all the meters that are associated with Voltage. TEST/RESET ► allows access to this sub-group.
Prim Voltage VLine 0.00V VBus 0.00V	Displays the Primary RMS value of the Line and Bus voltage.
Sec Voltage VLine 0.00V VBus 0.00V	Displays the Secondary RMS value of the Line and Bus voltage.
SYNC METERS →to view	This sub-group includes all the meters that are associated with Synchronising. TEST/RESET ► allows access to this sub-group.
Line Volts 0.0V Bus Volts 0.0V Line Freq 0.000Hz Bus Freq 0.000Hz	Displays the Secondary RMS value of the Line and Bus Voltage and the Line and Bus frequency.
Phase Diff 0.0Deg Voltage Diff 0.0V Slip Freq 0.000Hz	Displays the phase difference in degrees between the Line voltage and the Bus voltage. Displays the voltage difference between the secondary RMS Line voltage and the secondary RMS Bus voltage. Displays the slip frequency (rate at which the frequency of the Line and Bus voltages are changing).
Sync Status & Mode ChckSync, SysSync, DL DB, LL DB, DL LB, LL LB, CS, SS, COZ, LO, No Seq	Displays an overview of the enabled Synchronising method and the status of the Line and Bus Voltages.
Phase CS IN, CS OUT, SS IN, SS OUT	Displays the CS and SS status relative to the system phase difference.
Slip CS IN, CS OUT, SS IN, SS OUT	Displays the CS and SS status relative to the system slip frequency.
Line/Bus Status DL, DB, LL, LB	Displays Line and Bus status information.
Volt Blocking L-U/V, B-U/V or Volt-Diff	Displays the status of voltage blocking elements.
DEMAND METERS →to view	This sub-group includes all the meters that are associated with DEMAND. TEST/RESET ► allows access to this sub-group

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Instrument	Description
V Line Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Line Voltage Max, Min and Mean demand values.
V Bus Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Bus Voltage Max, Min and Mean demand values.
GENERAL ALARM METERS →to view	This sub-group includes all the meters that are associated with the Binary inputs. Pressing TEST/RESET ► allows access to this sub-group.
General Alarms ALARM 1 Cleared	Displays the status of General Alarm 1.
General Alarms ALARM 2 Cleared	Displays the status of General Alarm 2.
General Alarms ALARM 3 Cleared	Displays the status of General Alarm 3.
General Alarms ALARM 4 Cleared	Displays the status of General Alarm 4.
General Alarms ALARM 5 Cleared	Displays the status of General Alarm 5.
General Alarms ALARM 6 Cleared	Displays the status of General Alarm 6.
General Alarms Close Guard Cleared	Displays the status of the Close Guard.
BINARY INPUT METERS →to view	This sub-group includes all the meters that are associated with the Binary inputs. TEST/RESET ► allows access to this sub-group.
BI 1-6 ---- --	Displays the status of Binary Inputs 1 to 6 (The number of Binary Inputs may vary depending on model).
BINARY OUTPUT METERS →to view	This sub-group includes all the meters that are associated with the Binary Outputs. TEST/RESET ► allows access to this sub-group.
BO 1-8 ---- ----	Displays the status of Binary Outputs 1 to 8. (The number of Binary Outputs may vary depending on model).
VIRTUAL METERS →to view	This sub-group shows the status of the Virtual I/O in the relay. TEST/RESET ► allows access to this sub-group.
V 1-8 ---- ----	Displays the status of Virtual I/O 1 to 8 (The number of virtual inputs will vary depending on model).
COMMUNICATION METERS →to view	This sub-group includes all the meters that are associated with Communications ports TEST/RESET ► allows access to this sub-group
COM1 RX TX COM2 RX TX	Displays which com ports are currently active by displaying RX and TX (Receive and Transmit) information.
COM1 TRAFFIC COM1 Tx 0 COM1 Rx Error 0 COM1 Rx 0	Displays data traffic on Communications Port 1. The accumulated numbers of received, transmitted and erroneous bytes are displayed. Pressing TEST/RESET ► can reset the meter.
COM2 TRAFFIC COM2 Tx 0 COM2 Rx Error 0 COM2 Rx 0	Displays data traffic on Communications Port 2. The accumulated numbers of received, transmitted and erroneous bytes are displayed. Pressing TEST/RESET ► can reset the meter.
EN100 INFORMATION	Displays EN100 information

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Instrument			Description
Version : EN100 Version Info Part# BF1111111111			
Network Config Mac 00000000 IP 000.000.000.000 NM 255.255.255.000			Displays EN100 network information
Gateway: 000.000.000.000 EN100 NTP info: EN100 Link ½ status info: EN100 Rx/Tx Count			Displays further EN100 61850 information
En100 Rx/Tx Error En100 Rx/Tx 10s CPU Load % EN100 Info Meters : 1-n			Displays further EN100 61850 information
MISCELLANEOUS METERS →to view			This sub-group includes information such as: relay time and date, and the amount of fault, waveform and event records stored in the relay. TEST/RESET ► allows access to this sub-group
Date Time Waveform Recs Fault Recs		01/01/2000 22:41:44 0 0	This meter displays the date and time and the number of Waveform and Fault records stored in the relay.
Event Recs Data Log Recs Setting Group		0 0 1	This meter displays the number of Event and Data Log records stored in the relay along with which Setting Group is currently active.
QUICK LOGIC METERS →to view			This sub-group includes all the meters that are associated with QuickLogic Equations. TEST/RESET ► allows access to this sub-group.
E 1-4		----	Displays which Equation(s) are currently in use.
E1 Equation EQN TMR CNT	 0-0 0-1	 =0 =0 =0	EQN = 0 or 1. This shows the current state of the Equation (True or False). TMR 0-0 indicates current status and target value for the timer. CNT 0-0 indicates current status and target value for the counter.
E2 Equation EQN TMR CNT	 0-0 0-1	 =0 =0 =0	EQN = 0 or 1. This shows the current state of the Equation (True or False). TMR 0-0 indicates current status and target value for the timer. CNT 0-0 indicates current status and target value for the counter.
E3 Equation EQN TMR CNT	 0-0 0-1	 =0 =0 =0	EQN = 0 or 1. This shows the current state of the Equation (True or False). TMR 0-0 indicates current status and target value for the timer. CNT 0-0 indicates current status and target value for the counter.
E4 Equation EQN TMR CNT	 0-0 0-1	 =0 =0 =0	EQN = 0 or 1. This shows the current state of the Equation (True or False). TMR 0-0 indicates current status and target value for the timer. CNT 0-0 indicates current status and target value for the counter.

1.5 Fault Data Mode

The Fault Data Mode sub menu lists the time and date of the previous 10 triggered records. The stored data about each 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.

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Section 2: Setting & Configuring the Relay Using Reydisp Evolution

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

Reydisp Evolution Software, which requires a PC with at least Microsoft Window XP (with Service Pack 3) installed. The latest versions of Reydisp are available as a free for download from our website.

Programming of graphical user logic requires the use of the Reydisp Manager software which is supplied with online instructions and help and is not documented here.

2.1 Physical Connection

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

2.1.1 Front USB connection

To connect your PC locally via the front USB port.

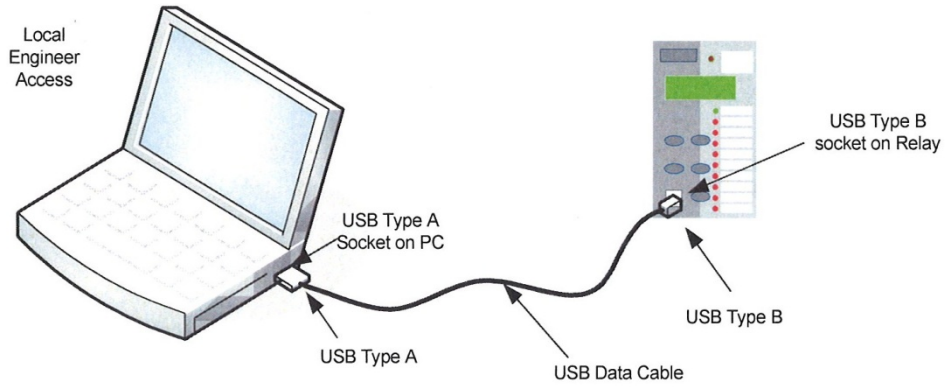


Figure 2-1 USB connection to PC

2.1.2 Rear RS485 connection

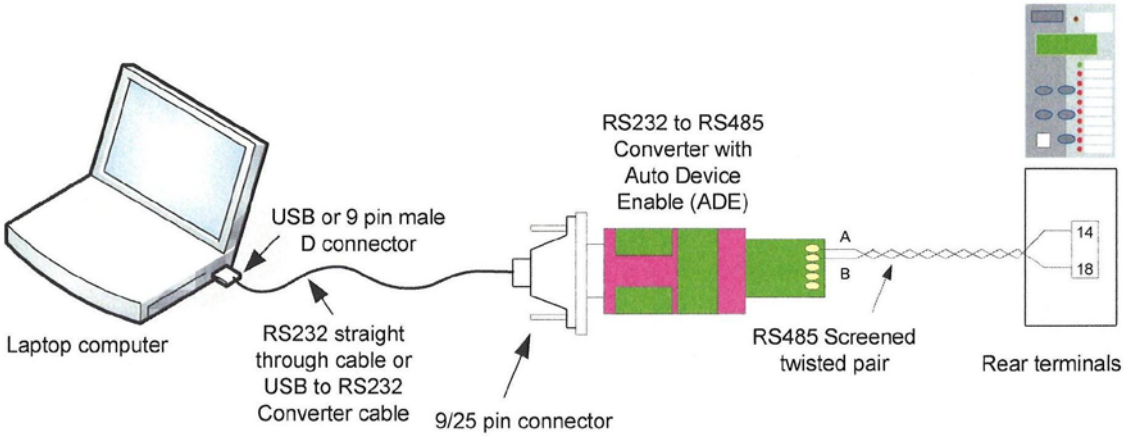


Figure 2-2 RS485 connection to PC

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2.1.3 Optional Rear EN100 Ethernet Module (COM3)

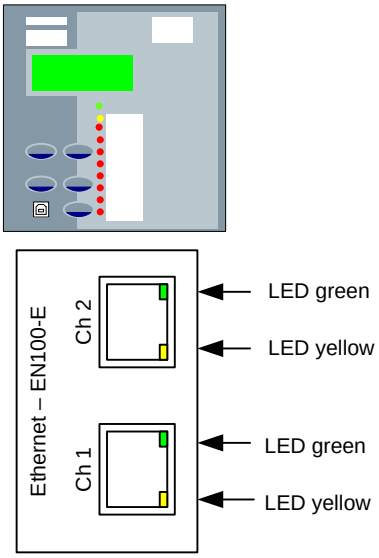
The optional ethernet interface is primarily provided for support of IEC 61850 protocol. Support for IEC 870-5-103 is also provided over this interface to allow connection with Reydisp Evolution and Reydisp Manager software for interrogation, editing and download of relay settings and other data. Ordering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

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

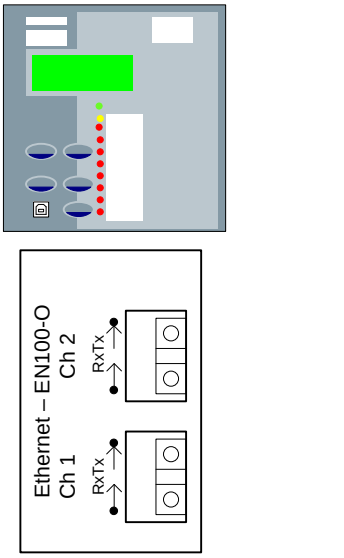
If this setting is set to Off, access to relay data using Reydisp Evolution and Reydisp Manager software via the Ethernet interface is not available.

Connections to the optional EN100 ethernet module are made on the rear side of the relay.

Connections are made to either RJ45 sockets (electrical) or Duplex LC (fibre optic) connectors.



EN100 Module – RJ45 Interface



EN100 Module – Duplex-LC Interface

Green LED (Physical Link)
Off – No link
On – Link present

Yellow LED (Activity)
Off – No traffic
On/flashing - Traffic

Figure 2.1-3 EN100 Ethernet Module

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2.1.4 Configuring Relay Data Communication

Navigate to the COMMUNICATIONS menu and alter the settings for the communication port you are intending to use on the relay. Reydisp software uses the 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, if COM2-USB Protocol setting is set to IEC60870-5-103.

COM1-RS485 Port and COM2-USB Port

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

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2.1.5 Connecting to the Relay for setting via Reydisp

When Reydisp software is running all available communication ports will automatically be detected.

On the start-page tool bar, open up the sub-menu ‘File’ and select ‘Connect’. The ‘Connection Manager’ window will display all available communication ports. With the preferred port highlighted select the ‘Properties’ option and ensure the baud rate and parity match that selected in the relay settings. Select ‘Connect’ to initiate the relay-PC connection.

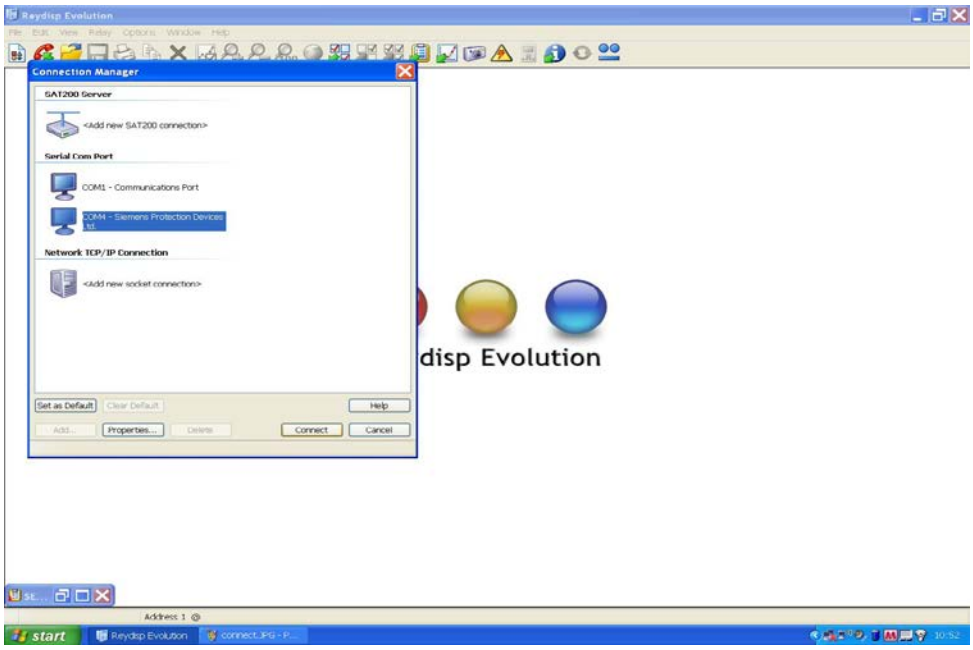


Figure 2-4 PC Communications Port Selection

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

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2.1.6 Configuring the user texts using Reydisp Language Editor

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

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

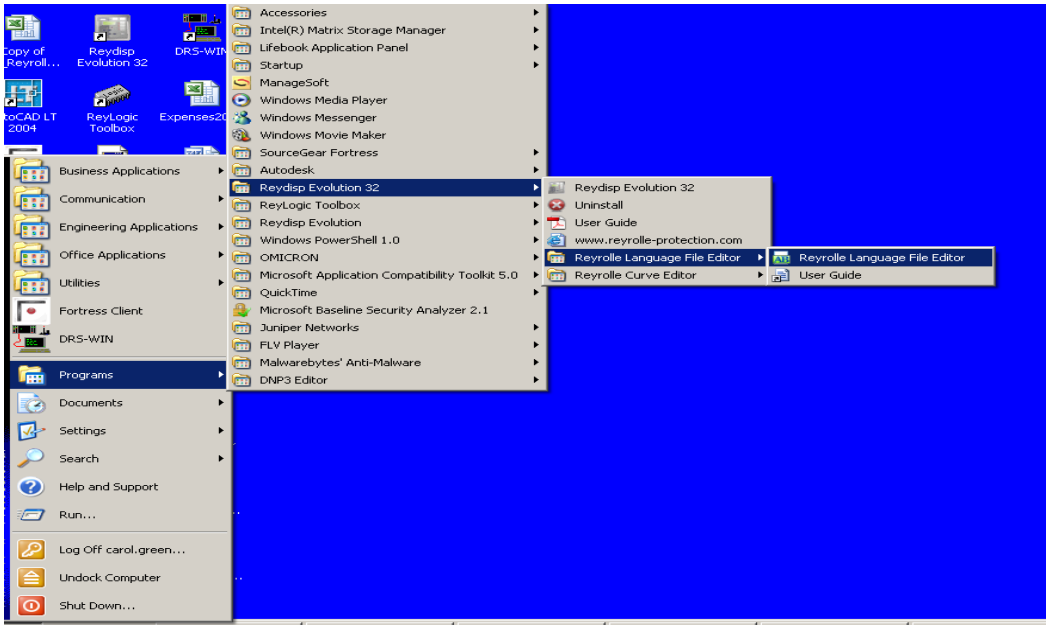


Figure 2-5 PC Language File Editor

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

The communication properties in the software and on the relay must be set and the relay must be restarted after the file is installed. To activate the language file it must be selected in the relay configuration menu. The 'Original' file is the file labelled 'ENGLISH' and the new file will be displayed using the file name allocated by the user.

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

Please refer to the Language Editor Manual for further guidance.

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7SR157

Check and System Synchronising Relay

Performance Specification

Document Release History

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

2023/02	UKCA compliance added 1.1.1
2022/09	UPSU added and IEC standard references updated. 88V BI min v aligned to 0.5x max IEC 60255-1 125V battery voltage 1.2.4.
2016/06	E6 case IEC61850 models introduced
2014	First issue

Software Revision History

Date	Software Reference	Summary
2016/06	2436H80010R4e-2a	IEC61850 variants added
2014	2436H80010R2f-1a	First Release

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Section 1: Common Functions

1.1 General

1.1.1 CE and UKCA Conformity

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

1.1.2 Reference

This product complies with IEC 60255-1, IEC 60255-26, IEC 60255-27, IEC 60255-12, IEC61000-4-8

and ENATS 48-5

and withdrawn standards IEC 60255-3, IEC 60255-6, IEC60255-11,

1.1.2.1 Accuracy Reference Conditions

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

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

1.1.3 Dimensions

Parameter	Value
E4 case width	103.5 mm
E6 case width	155.5 mm
Height	177.0 mm
Depth behind panel, including clearance for: - Wiring Fibre Optic Ethernet enclosure Depth below Ethernet variant for cables	 241.5 mm 286.5 mm 261.5 mm 75 mm
Projection (from front of panel)	31.0 mm

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

1.1.4 Weights

Parameter		Value
Net weight	7SR157, E4 Case	2.7 kg
	7SR157, E6 case	3.65.kg

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1.2 Energising Quantities

1.2.1 Auxiliary Power Supply

IEC60255-11 & EATS 48-4

Nominal Operating Range		Absolute Range*	Comments
Vaux	24 to 60 VDC	18 to 72 VDC	Low voltage PSU suitable for 24VDC, 30VDC,48VDC and 60VDC systems
	80 to 250 VDC (115 VAC 50/60Hz)	64 to 300 VDC (92 to 138 V rms AC 47.5-52.5/57-63Hz)	High Voltage PSU suitable for 115VAC, 110VDC and 220VDC systems.
	24 to 250 VDC (100 to 230 VAC 50/60Hz)	19.2 to 275 VDC 80 – 253VAC	Universal PSU (UPSU) suitable for 24 - 250 Volts DC and 100 - 230 Volts AC systems

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

1.2.1.1 Burden

Battery loading can be estimated from the following maximum figures (LV and HV PSU):

Attribute		Watts					VA
Voltage		24V	30V	48V	110V	220V	115V AC rms 50/60Hz
Quiescent Relay (inc.'PROT HEALTHY' LED)		3.7			3.6		9
Backlight		1.3					3.2
LED - Red or Green)	Each led	0.03					0.05
LED – Yellow	Each led	0.06					0.1
Binary Output	Each output	0.35					0.7
Optional IEC 61850 Comms Interface		2.5					5.5

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

Attribute	Watts (DC)						
Voltage	24	48	60	110	125	220	250
Quiescent Relay (inc. 'PROT HEALTHY' LED)	3.8	3.5	3.4	3.3	3.2	3.0	3.0
Backlight	1.4	1.3	1.2	1.2	1.2	1.1	1.1
Per LED – (Red or Green)	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Per LED – Yellow	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Per Binary Output	0.4	0.35	0.35	0.35	0.35	0.3	0.3
Optional IEC 61850 Comms Interface	2.7	2.6	2.5	2.5	2.5	2.5	2.5

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AC supply loading

Attribute	VA (RMS)					
Voltage	100	110	115	120	200	230
Quiescent Relay (inc. 'PROT HEALTHY' LED)	7.5	7.5	7.5	7.5	8	9
Backlight	2	2	2	2	2.1	2.1
Per LED – (Red or Green)	0.06	0.06	0.06	0.06	0.06	0.06
Per LED – Yellow	0.10	0.10	0.10	0.10	0.10	0.10
Per Binary Output	0.6	0.6	0.6	0.6	0.7	0.7
Optional IEC 61850 Comms Interface	5	5	5	5	5.5	5.5

1.2.1.2 Operational Features

Attribute	**Value**	**Comments**
0% Dip Withstand Period	50ms	
Dip Immunity Acquisition Period	5minutes	Typical time after switch on to attain claimed immunity to dips
NOTE: Dips in supply that fall below the minimum voltage for a period greater than the 0% Dip With stand Period will invoke a relay reset.		
During conditions of auxiliary input voltage variations which are not described (1) in section 1.2.1 and 1.4.3.1, relays with HV or LV PSU modules may enter a safety protection mode where a power supply shutdown occurs. This condition is designed to protect the power supply from damage as well as prevent internal relay faults from developing into dangerous situations. Once the relay has entered this safety mode, it may be necessary to reduce the auxiliary input voltage to zero volts for up to 30 seconds before re-application of the auxiliary supply will cause the relay to power up and operate normally. (1) Using fuses as on/off switches or allowing batteries to run at very low cell voltages for extended periods and then attempting to re-charge, are examples of such auxiliary supply conditions.		

1.2.2 AC Analogue Voltage

Attribute	**Nominal**	**Operating Range**
Vn	40 to 160 Vrms	0 to 200 Vrms
Fn	50, 60Hz	47.5 to 52.5Hz and 57.0 to 63.0Hz

1.2.2.1 Burden

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

1.2.2.2 Thermal Withstand

Attribute	**Value**
Overvoltage Withstand (Continuous)	300 Vrms

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1.2.3 Binary (Digital) Outputs

Contact rating to IEC 60255-0-2

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

1.2.4 Binary (Digital) Inputs

DC operation ENATS48-4

	Type (maximum threshold)	**Nominal Voltage**	**Minimum threshold**	**Maximum withstand**
V_{BI}	19 VDC	24, 48, 60 110, 220 V DC	17 VDC	320 VDC
	88 VDC	110, 220 V DC	68.75 VDC	320 VDC

AC operation

Nominal		**Operating Range**
V_{BI}	19 VDC	92 to 138 V_{RMS} AC

1.2.4.1 DC Performance

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

* The binary inputs have a low minimum operate current and can be set for high speed operation. To achieve immunity from AC interference, a BI pick-up delay of typically one-cycle can be applied. This setting is applied by default.

1.2.4.2 AC Performance

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

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

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1.3 Functional performance

1.3.1 Instrumentation

	Instrument Value	Reference	Typical accuracy
V	Voltage	0.1 x Vn ≤ V ≤ 1.2 x Vn	± 1 % Vn
F	Frequency	F = 47.5 to 52.5Hz @ 50Hz and 57 to 63Hz @60Hz	± 10mHz

1.3.2 Data Communication

1.3.2.1 USB 2.0 Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	USB-Type B

1.3.2.2 RS485 Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	4mm Ring Crimp

1.3.2.3 Fibre Optic Ethernet Data Communication Interface (IEC 61850 Option)

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

1.3.2.4 Electrical Ethernet Data Communication Interface (IEC 61850 Option)

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

1.3.3 Real Time Clock

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

Attribute	Value
Accuracy (-10 to +55°C)	± 3.5 ppm (no auxiliary supply connected)
	± 100 ppm (auxiliary supply connected)

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1.4 Environmental Performance

1.4.1 General

1.4.1.1 Temperature

IEC 60255-1 & IEC 60068-2-1/2

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

1.4.1.2 Humidity

IEC 60255-1 & IEC 60068-2-78

Type	**Level**
Operational test	56 days at 40 °C and 93 % relative humidity

1.4.1.3 Impulse (Transient Overvoltage)

IEC 60255-27

IEC 60255-5 (withdrawn)

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

1.4.1.4 Dielectric Insulation

IEC 60255-27

IEC 60255-5 (withdrawn)

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

1.4.1.5 Installation Category

IEC 60255-27

Type	Level
Installation Category (Overvoltage Category)	Class III

1.4.1.6 Pollution

IEC 60255-27

Level
Pollution Degree 2

1.4.1.7 IP Ratings

IEC60529

Type		**Level**
Installed with cover on	Front	IP 51
	Rear Enclosure (case)	IP 20
Installed with cover removed	Front	IP 20
	Rear Enclosure (case)	IP 20
Rear wiring terminal access	IEC 60255-27:2014 (5.1.5.2.6)	IP 10

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1.4.2 Emissions

IEC 60255-26

IEC 60255-25 (withdrawn)

1.4.2.1 Radiated Emissions: Enclosure

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

1.4.2.2 Radiated Emissions: Conducted

IEC 60255-26 & CISPR 22

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

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1.4.3 Immunity

1.4.3.1 Auxiliary Supply Variation

IEC 60255-26, IEC 60255-27, EATS 48-5, IEC 60255-11 (withdrawn)

EN/IEC 61000-4-11, EN/IEC 61000-4-29, EN/IEC 61000-4-17

Type of Phenomena	Standard	Test Specifications	Duration	Declared Operation
Voltage Dips (DC auxiliary supply)	IEC 60255-26 IEC 61000-4-11 IEC 61000-4-29	0% RV	50ms (Claimed)	Normal Operation[1]
		40% RV	200ms	Normal operation[1] except where Dip falls below the relay minimum voltage then Relay Restart[2]
		70% RV	500ms	Normal operation[1] except where Dip falls below the relay minimum voltage then Relay Restart[2]
Voltage Dips (AC auxiliary supply)		0% RV	2.5/3 cycles @50/60Hz (claimed)	Normal Operation[1]
		40% RV	10/12 cycles @50/60Hz	Normal Operation[1]
		70% RV	25/30 cycles @50/60Hz	Normal Operation[1]
Voltage Interruptions (DC auxiliary supply)		0% RV	5s	Relay Reset[2]
Voltage Interruptions (AC auxiliary supply)		0% RV	250/300 cycles @50/60Hz	Relay Reset[2]
Alternating Component In DC (Ripple) (DC auxiliary supply)	IEC 60255-26 IEC 61000-4-17	15% max and min RV	Continuous	Normal operation[1]
Gradual Shut-down/ Start-up (DC auxiliary supply)	IEC 60255-26	Max & min RV to 0V	60s	Relay Reset
		0V	5minutes	Relay Off
		0V to min & max RV	60s	Relay Restart[2]
Reversal of DC Power Supply polarity		Max reversed RV	1minute	24-60 V Dc models: No operation 80-250 V DC, 115 V AC models: Normal Operation[1] Universal PSU models Normal Operation[1]

Key:

RV = Residual Voltage Test Value. Two conditions: (a) Range voltage low-20% and

(b) Range voltage high +20%

[1] No effect on relay performance.

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

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1.4.3.2 Slow Damped Oscillatory Wave (High Frequency Disturbance)

IEC 60255-26 & IEC 61000-4-18

IEC 60255-22-1 (withdrawn)

Type	Level	Variation
Case, Aux Power & I/O common (longitudinal) mode	2.5 kV	≤ 10%
Case, Aux Power & I/O Series (transverse) mode	1.0 kV	
RS485 Metallic Comms	1.0kV	No data loss

1.4.3.3 Electrostatic Discharge

IEC 60255-26 & IEC 61000-4-2

IEC 60255-22-2 (withdrawn)

Type	Level	Variation
Air discharge	Level III, 8.0 kV	≤ 5%

1.4.3.4 Radiated Immunity

IEC 60255-26 & IEC 61000-4-3

IEC 60255-22-3 2 (withdrawn)

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

1.4.3.5 Fast Transients

IEC 60255-26

Type		Level
5/50 ns 5 kHz repetitive	Analog inputs, Aux Power & I/O	4kV
	RS485 communications port	2kV

1.4.3.6 Surge Immunity

IEC 60255-26 & IEC 61000-4-5

IEC 60255-22-5 (withdrawn)

Type	Level	Variation
Analog Inputs Line to Earth	4.0 kV	≤ 10%
Case, Aux Power & I/O Line to Earth	2.0 kV	
Analog Inputs Line to Line	1.0 kV	
Case, Aux Power & I/O Line to Line	1.0 kV*	
RS485 Comms port Line to Earth	1.0 kV	No data loss

* Note 45ms pick up delay applied to binary inputs

1.4.3.7 Conducted Radio Frequency Interference

IEC 60255-22-6

Type	Level
0.15 to 80 MHz	10 V
Spot Frequencies 27 MHz & 68 MHz	10 V

1.4.3.8 Magnetic Field with Power Frequency

IEC 61000-4-8 Level 5

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

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1.4.3.9 Power Frequency Immunity

IEC 60255-26 & IEC 61000-4-16

IEC 60255-22-7 (withdrawn)

Type		Level
Binary Inputs	Common mode (min operate time delay 0ms)	300 V
	Differential mode (min operate time delay 10ms)	150 V

1.4.4 Mechanical

1.4.4.1 Vibration (Sinusoidal)

IEC 60255-27 & IEC 60255-21-1 Class I

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

1.4.4.2 Shock and Bump

IEC 60255-27 & IEC 60255-21-2 Class I

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

1.4.4.3 Seismic

IEC 60255-27 & IEC 60255-21-3 Class I

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

1.4.4.4 Mechanical Classification

Type	Level
Durability	> 10^6 operations

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Section 2: Control & Logic Functions

2.1 Voltage Settings (Live and Dead Status)

2.1.1 Live and Dead Status

2.1.1.1 Reference

Parameter	Value
Line Nom Voltage	40, 40.1... 160 V
Bus Nom Voltage	40, 40.1... 160 V
System Frequency	50/60 Hz
25 Live Line	0, 1... 150%
25 Dead Line	0, 1... 150%
25 Live Line	0, 1... 150%
25 Dead Line	0, 1... 150%

2.1.1.2 Operate and Reset Level

	Attribute		Value
$V_{live,act}$	Live operate level		100% V_{live}, ± 1% V_n
	Live reset level		$V_{dead,act}$, ± 1% V_n
	Live Hysteresis level		$V_{live,act}$ - 3% V_n
$V_{dead,act}$	Dead operate level		100% V_{dead}, ± 1% V_n
	Dead reset level		$V_{live,act}$, ± 1% V_n
	Dead Hysteresis level		$V_{dead,act}$ - 3% V_n
	Repeatability		± 1%
	Variation	-10°C to +55°C	≤ 5%
		f_{nom} ± 5%	≤ 1%

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2.1.2 Line and Bus Undervolts Element

2.1.2.1 Reference

Parameter	Value
Line Nom Voltage	40, 40.1... 160 V
Bus Nom Voltage	40, 40.1... 160 V
System Frequency	50/60 Hz
25 Line Undervolts	0, 1... 150%
25 Bus Undervolts	0, 1... 150%

2.1.2.2 Operate and Reset Level

	Attribute		Value
V_{line}	Operate level		100% Vsl, ± 1% V_n
	Reset level		≤ V_{line} + 3%
V_{bus}	Operate level		100% Vsb, ± 1% V_n
	Reset level		≤ V_{bus} + 3%
	Repeatability		± 1%
	Variation	-10 °C to +55 °C	≤ 5%
		f_{nom} ± 5%	≤ 1%

2.1.3 Volts Differential Element

2.1.3.1 Reference

	Parameter	Value
V_{nom}	Line Nom Voltage	40, 40.1... 160 V
V_{nom}	Bus Nom Voltage	40, 40.1... 160 V
f_n	System Frequency	50/60 Hz
V_{diff}	25 Volt Differential	0, 1... 100%

2.1.3.2 Operate and Reset Level

	Attribute	Value
V_{op}	Operate level	100% V_{diff}, ± 2 % V_n or ± 0.5 V
	Reset level	≥ V_{op} – 3%
	Repeatability	± 2%

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2.2 Check Synchronising

2.2.1 Reference

Parameter	Value
Line Nom Voltage	40, 40.1... 160 V
Bus Nom Voltage	40, 40.1... 160 V
System Frequency	50/60 Hz
25 Check Sync Angle	0 – 90º
25 Check Sync Slip	0 – 2Hz
25 Check Sync Timer	0-100s
25 Split Slip	0 – 2Hz
25 System Split Timer	0 – 60s

2.2.2 25 Check Sync Angle Difference

	Attribute	Value
θ_{op}	Operate angle	θ_{diff}, ± 1º
	Reset angle	θ_{op}, ± 1º
	Repeatability	± 1º

2.2.3 25 Check Sync Slip Frequency

	Attribute	Value
f_{op}	Operate frequency	f_{slip}, ± 10mHz
	Reset frequency	f_{op}, - 10mHz
	Repeatability	± 10mHz

Note: minimum synchronising time following restoration of voltage from a dead condition is 320ms.

2.2.4 25 Split Angle Detector

	Attribute	Value
θ_{op}	Operate angle	θ_{split}, ± 1°

2.2.5 25 Split Slip Frequency Detector

	Attribute	Value
f_{op}	Operate frequency	f_{slip}, ± 10mHz
	Reset frequency	f_{op}, - 10mHz
	Repeatability	± 10mHz

2.2.6 25 Check Sync Timer

	Attribute		Value
	Accuracy		± 1% or ± 20ms
	Repeatability		± 1% or ± 20ms
	Variation	-10°C to +55°C	≤ 5%
		f_{nom} ± 5 %	≤ 5%

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2.3 System Synchronising

2.3.1 Reference

Parameter	Value
Line Nom Voltage	40, 40.1... 160 V
Bus Nom Voltage	40, 40.1... 160 V
System Frequency	50/60 Hz
25 System Sync Angle	0 – 90º
25 COZ Slip Freq	0 – 2Hz
25 System Sync Slip	0 – 2Hz
25 System Sync Timer	0-100s
25 SS Close Pulse	0-60s
25 COZ Close Pulse	0-60s

2.3.2 25 System Sync Angle Difference

	Attribute	Value
θ_{op}	Operate angle	θ_{diff}, ± 1º
	Reset angle	θ_{op}, ± 1º
	Repeatability	± 1º

2.3.3 25 System Sync Slip Frequency

	Attribute	Value
f_{op}	Operate frequency	f_{slip}, ± 10mHz
	Reset frequency	f_{op}, - 10mHz
	Repeatability	± 10mHz

Note: minimum synchronising time following restoration of voltage from a dead condition is 320ms.

2.3.4 25 Close on Zero Slip Frequency

	Parameter	Value
f_{coz}	Operate frequency	f_{slip}, ± 10mHz
	Reset frequency	f_{op}, - 10mHz
	Repeatability	± 10mHz

2.3.5 25 System Sync Timer

	Attribute		Value
	Accuracy		± 1% or ± 20ms
	Repeatability		± 1% or ± 20ms
	Variation	-10°C to +55°C	≤ 5%
		f_{nom} ± 5%	≤ 5%

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Section 3: Supervision

3.1 74CCS Close Circuit Supervision

3.1.1 Reference

	Parameter	Value
t_d	Delay setting	0, 0.02…60 s

3.1.2 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		25ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1% or ± 20ms
	Repeatability		± 1% or ± 20ms
	Variation	-10°C to +55°C	≤ 5%
		f_{nom} ± 5%	≤ 5%

3.2 60 VTF VT Failure

3.2.1 Reference

	Parameter	Value
t_d	Delay setting	0, 0.1…100 s

3.2.2 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time		63 ms, ± 10ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 20ms
	Repeatability		± 1% or ±20ms
	Variation	-10°C to +55°C	≤ 5%
		f_{nom} ± 5%	≤ 5%

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7SR157

Check and System Synchronising Relay

7SR157x-5xA[178][27]-xCA0

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1. Introduction

This section describes how to use the Communication Interface with a control system or interrogating computer.

The interface is compatible with control and automation systems using industry standard communications protocols ***DNP3*** , ***IEC 60870-5-103*** , ***IEC 61850*** and ***MODBUS-RTU***. Note, not all protocols are available on all devices.

Reydisp Evolution or Reydisp Manager Software is available, for computers running Microsoft Windows™, to connect to devices to provide operational information, post-fault analysis, setting interrogation and editing facilities etc. Configuration software can be downloaded from our website http://www.siemens.com/energy.

This section specifies connection details and lists the information available through the individual protocols.

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2. Physical Connection
2.1 Introduction

The relay provides one “Front” USB communication interface (Com2) located on the fascia and one RS485 (Com1) located on the “Rear” as standard.

A detailed description of the ports is given below.

COM1-RS485: This port can be used for IEC60870-5-103, MODBUS-RTU or DNP3 communications to a substation SCADA or integrated control system or for engineer remote access. This port can also be used for connection to Reydisp software.

COM2-USB: This port is used for IEC60870-5-103 (default setting) communication with the Reydisp software.

An ASCII protocol is also available through this port, the main use of this protocol is to allow the Relay firmware to be updated via the front connection.

MODBUS-RTU or the optional DNP3 protocols are also available.

COM3-LAN: When the Ethernet module is fitted, in addition to IEC61850 a LAN connection is provided to allow the Reydisp software to connect to the Relay via the network. This port only supports the IEC60870-5-103 protocol.

Any or all serial ports can be mapped to the IEC60870-5-103, DNP3 or MODBUS-RTU protocol at any one time, protocols available will depend upon relay model. The optional ethernet port uses IEC 61850 protocol and can also provide an IEC 60870-5-103 protocol connection to Reydisp. Any port not required can be disabled by setting its protocol to OFF.

When connecting to Reydisp Evolution software the protocol for the relevant port should be set to IEC60870-5-103.

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2.2 USB Interface (COM2)

The USB communication port is connected using a standard USB cable with a type B connection to the relay and type A to the PC.

The PC will require a suitable USB driver to be installed; this will be carried out automatically when the Reydisp software is installed. When the Reydisp software is running with the USB cable connected to a device an additional connection is shown. Connections to these devices are not shown when they are not connected.

The USB communication interface on the relay is labelled Com 2 and its associated settings are located in the Data communications menu. When connecting to Reydisp using this connection the default settings can be used without the need to first change any settings.

Access to the communication settings for the USB port is only available from the relay front fascia via the key pad setting menu COMMUNICATIONS MENU.

Setting Name	Range/Options	Default	Setting	Notes
COM2-USB Protocol	OFF IEC60870-5-103 MODBUS-RTU ASCII DNP3	IEC60870-5-103		Reydisp software requires IEC60870-5-103.
COM2-USB Station Address	0 - 254 for IEC60870-5-103 1 - 247 for Modbus RTU 0 - 65534 for DNP3.0	0		An address within the range of the relevant protocol must be given to identify the relay. Each relay in a network must have a unique address.
COM2-USB Mode	Local Local or Remote Remote	Local		Refer to Appendix 1, page 57, for further explanation

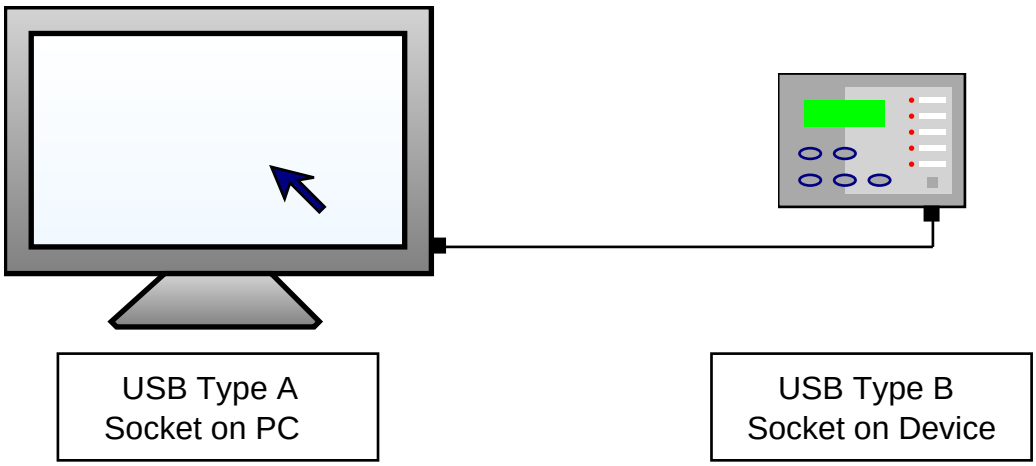


Fig. 2-1 Communication to Front USB Port

2.3 RS485 Interface (COM1)

The 2-wire RS485 communication port is located on the rear of the relay and can be connected using a suitable RS485 120 Ohm screened twisted pair cable.

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The RS485 electrical connection can be used in a single or multi-drop configuration. The RS485 master must support and use the Auto Device Enable (ADE) feature. The last device in the connection must be terminated correctly in accordance with the master device driving the connection. This can be done via the internal 120 ohm terminating resistor, which can be connected between 14 (A) and 18 (B) by fitting an external wire loop between terminals 18 and 20 on the power supply module.

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

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

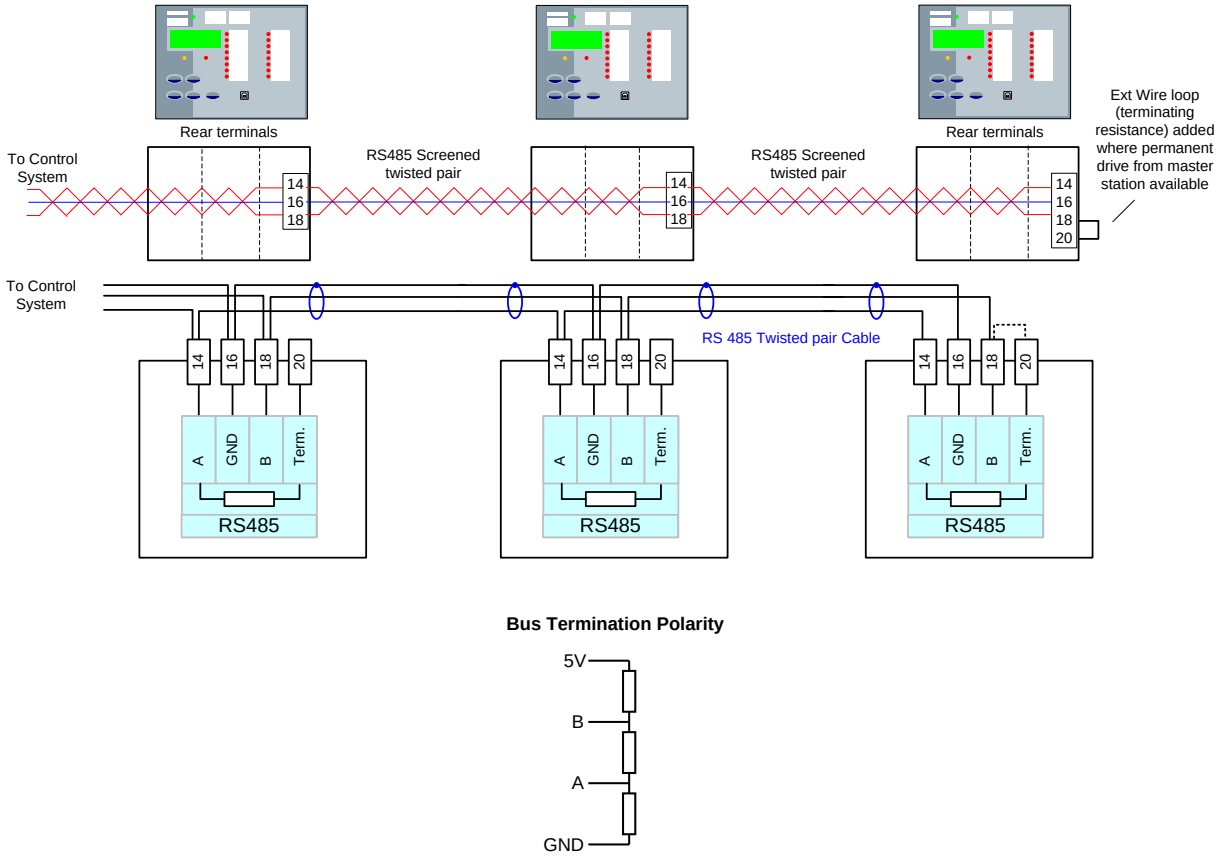
The maximum number of relays that can be connected to the bus is 64.

The RS485 data comms link will be broken for that particular relay element if it is withdrawn from the case but the chain of communication to the other relays is maintained.

The following settings, on the COMMUNICATIONS MENU, must be configured when using the RS485 interface.

Setting Name	Range/Options	Default	Setting	Notes
COM1-RS485 Protocol	OFF IEC60870-5-103 MODBUS-RTU DNP3	IEC60870-5-103		The protocol used to communicate on the standard RS485 connection.
COM1-RS485 Station Address	0 - 254 for IEC60870-5-103 1 - 247 for Modbus RTU 0 - 65534 for DNP3.0	0		An address within the range of the relevant protocol must be given to identify the relay. Each relay in a network must have a unique address.
COM1-RS485 Baud Rate	75 110 150 300 600 1200 2400 4800 9600 19200 38400	19200		The baud rate set on all of the relays connected to the control system must be the same as the one set on the master device.
COM1-RS485 Parity	NONE ODD EVEN	EVEN		The parity set on all of the relays connected to the control system must be the same and in accordance with the master device.
COM1-RS485 Mode	Local Local or Remote Remote	Remote		Refer to Appendix 1, page 57, for further explanation

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Bus Termination Polarity

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

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3. IEC 60870-5-103 Definitions

3.1 Introduction

This section describes the IEC 60870-5-103 protocol implementation in the relays. This protocol is used for the communication with Reydisp software and can also be used for communication with a suitable control system. The control system or local PC acts as the master in the system with the relay operating as a slave responding to the master's commands. The implementation provides event information, time synchronising, commands and measurands and also supports the transfer of disturbance records.

This protocol can be set to use any or all of the relays hardware interfaces (USB, Fibre Optic, RS232, RS485 and Ethernet) where fitted and is the standard protocol used by the USB port. The relay can communicate simultaneously on all ports regardless of protocol used.

The Station Address of the port being used must be set to a suitable address within the range 0 - 254 to enable communication. This can be set by the **Communications Menu : COM *n-xxxxx* Station Address** setting.

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3.2 Cause of Transmission

The cause of transmission (COT) column of the "Information Number and Function" table lists possible causes of transmission for these frames. The following abbreviations are used:

Abbreviation	Description
SE	spontaneous event
T	test mode
GI	general interrogation
Loc	local operation
Rem	remote operation
Ack	command acknowledge
Nak	Negative command acknowledge

Note: Events listing a GI cause of transmission can be raised and cleared; other events are raised only.

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3.3 Application Service Data Unit (ASDU) Type

The Application Service Data Unit (ASDU) column of the "Information Number and Function" table lists the possible ASDUs returned for a point.

ASDU #	Description
1	Time tagged message (monitor direction)
2	Time tagged message (relative time) (monitor direction)
3.1	Measurands I
4	Time-tagged measurands with relative time
5	Identification message
6	Time synchronisation
7	General Interrogation Initialization
9	Measurands II
20	General command

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3.4 Point List

The following sub-sections contain tables listing the data points available via the IEC60870-5-103 protocol.

The information shown below is the default configuration. This can be modified using the Communications Configuration Editor tool, refer section 9 for details.

The information shown below is the default configuration. This can be modified using the Communications Configuration Editor tool, refer section 9 for details.

3.4.1 Event Function (FUN) & Information (INF) Numbers

The following Event EVT and INF numbers apply to this device.

FUN	INF	Description	ASDU	COT
60	4	Remote Mode	1	SE, GI
			20	Ack, Nak
60	5	Out Of Service Mode	1	SE, GI
			20	Ack, Nak
60	6	Local Mode	1	SE, GI
			20	Ack, Nak
60	7	Local & Remote	1	SE, GI
			20	Ack, Nak
60	12	Control Received	1	SE
60	13	Command Received	1	SE
60	128	Cold Start	1	SE
60	129	Warm Start	1	SE
60	130	Re-Start	1	SE
60	131	Expected Restart	1	SE, GI
60	132	Unexpected Restart	1	SE, GI
60	135	Trigger Storage	1	SE
60	136	Clear Waveform Records	1	SE
60	137	Clear Fault Records	1	SE
60	138	Clear Event Records	1	SE
60	140	Demand metering reset	1	SE
			20	Ack, Nak
60	170	General Alarm 1	1	SE, GI
60	171	General Alarm 2	1	SE, GI
60	172	General Alarm 3	1	SE, GI
60	173	General Alarm 4	1	SE, GI
60	174	General Alarm 5	1	SE, GI
60	175	General Alarm 6	1	SE, GI
60	176	General Alarm 7	1	SE, GI
60	182	Quick Logic E1	1	SE, GI
60	183	Quick Logic E2	1	SE, GI
60	184	Quick Logic E3	1	SE, GI
60	185	Quick Logic E4	1	SE, GI
70	5	Binary Input 5	1	SE, GI
70	6	Binary Input 6	1	SE, GI
75	1	Virtual Input 1	1	SE, GI
75	2	Virtual Input 2	1	SE, GI

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FUN	INF	Description	ASDU	COT
75	3	Virtual Input 3	1	SE, GI
75	4	Virtual Input 4	1	SE, GI
75	5	Virtual Input 5	1	SE, GI
75	6	Virtual Input 6	1	SE, GI
75	7	Virtual Input 7	1	SE, GI
75	8	Virtual Input 8	1	SE, GI
80	1	Binary Output 1	1	SE, GI
			20	Ack, Nak
80	2	Binary Output 2	1	SE, GI
			20	Ack, Nak
80	3	Binary Output 3	1	SE, GI
			20	Ack, Nak
80	4	Binary Output 4	1	SE, GI
			20	Ack, Nak
80	5	Binary Output 5	1	SE, GI
			20	Ack, Nak
80	6	Binary Output 6	1	SE, GI
			20	Ack, Nak
80	7	Binary Output 7	1	SE, GI
			20	Ack, Nak
80	8	Binary Output 8	1	SE, GI
			20	Ack, Nak
90	1	LED 1	1	SE, GI
90	2	LED 2	1	SE, GI
90	3	LED 3	1	SE, GI
90	4	LED 4	1	SE, GI
90	5	LED 5	1	SE, GI
90	6	LED 6	1	SE, GI
90	7	LED 7	1	SE, GI
90	8	LED 8	1	SE, GI
90	9	LED 9	1	SE, GI
91	1	LED PU 1	1	SE, GI
91	2	LED PU 2	1	SE, GI
91	3	LED PU 3	1	SE, GI
91	4	LED PU 4	1	SE, GI
91	5	LED PU 5	1	SE, GI
91	6	LED PU 6	1	SE, GI
91	7	LED PU 7	1	SE, GI
91	8	LED PU 8	1	SE, GI
91	9	LED PU 9	1	SE, GI
160	2	Reset FCB	5	SE
160	3	Reset CU	5	SE
160	4	Start/Restart	5	SE
160	5	Power On	1	SE, GI
160	19	LED Reset	1	SE
			20	Ack, Nak
160	22	Settings changed	1	SE
160	23	Setting G1 selected	1	SE, GI

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FUN	INF	Description	ASDU	COT
			20	Ack, Nak
160	24	Setting G2 selected	1	SE, GI
			20	Ack, Nak
160	25	Setting G3 selected	1	SE, GI
			20	Ack, Nak
160	26	Setting G4 selected	1	SE, GI
			20	Ack, Nak
160	27	Binary Input 1	1	SE, GI
160	28	Binary Input 2	1	SE, GI
160	29	Binary Input 3	1	SE, GI
160	30	Binary Input 4	1	SE, GI
160	38	VT Fuse Failure	1	SE, GI
160	68	General Trip	2	SE
160	84	General Start/Pick-up	2	SE, GI
183	164	Close Circuit Fail 1	2	SE, GI
183	165	Close Circuit Fail 2	2	SE, GI
183	166	Close Circuit Fail 3	2	SE, GI
183	167	Close Circuit Fail	2	SE, GI
183	198	25 Check Sync	1	SE, GI
183	199	25 System Sync	1	SE, GI
183	200	25 Close On Zero	1	SE, GI
183	201	25 System Split	1	SE, GI
183	202	25 Live Line	1	SE, GI
183	203	25 Live Bus	1	SE, GI
183	204	25 Line U/V	1	SE, GI
183	205	25 Bus U/V	1	SE, GI
183	206	25 Voltage Dif >	1	SE, GI
183	207	25 CS Slip Freq >	1	SE, GI
183	208	25 SS Slip Freq >	1	SE, GI
183	209	25 COZ Slip Freq >	1	SE, GI
183	210	25 In Sync	1	SE, GI
183	211	25 CS In Progress	1	SE, GI
183	212	25 SS In Progress	1	SE, GI
183	213	25 COZ In Progress	1	SE, GI
183	214	25 System Split LO	1	SE, GI
183	215	60VTF-Bus	1	SE, GI
200	150	User SP Command 1	1	SE, GI
			20	Ack, Nak
200	151	User SP Command 2	1	SE, GI
			20	Ack, Nak
200	152	User SP Command 3	1	SE, GI
			20	Ack, Nak
200	153	User SP Command 4	1	SE, GI
			20	Ack, Nak
200	154	User SP Command 5	1	SE, GI
			20	Ack, Nak
200	155	User SP Command 6	1	SE, GI
			20	Ack, Nak
200	156	User SP Command 7	1	SE, GI

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FUN	INF	Description	ASDU	COT
			20	Ack, Nak
200	157	User SP Command 8	1	SE, GI
			20	Ack, Nak
200	158	User DP Command 1	1	SE
			20	Ack, Nak
200	159	User DP Command 2	1	SE
			20	Ack, Nak
200	160	User DP Command 3	1	SE
			20	Ack, Nak
200	161	User DP Command 4	1	SE
			20	Ack, Nak
200	162	User DP Command 5	1	SE
			20	Ack, Nak
200	163	User DP Command 6	1	SE
			20	Ack, Nak
200	164	User DP Command 7	1	SE
			20	Ack, Nak
200	165	User DP Command 8	1	SE
			20	Ack, Nak
255	0	General Interrogation (GI) Initiation	7	Init. GI
255	0	General Interrogation (GI) End	8	End of GI
255	0	Time Synchronisation	6	Time Synch.

3.4.2 Measurands

The following Measurand EVT and INF numbers apply to this device.

FUN	INF	Description	ASDU	COT
185	240	Measurand $V_{Line,Bus}$, $F_{Line,Bus}$, $CS_{Phase\ Diff}$, $V_{Measured\ Diff}$, F_{Slip} --- V_{Line} (1.2x) (Window 0%) V_{Bus} (1.2x) (Window 0%) F_{Line} (1.2x) (Window 0%) F_{Bus} (1.2x) (Window 0%) CheckSync Phase Diff (1.2x) (Window 0%) $V_{Measured\ Diff}$ (1.2x) (Window 0%) F_{Slip} (1.2x) (Window 0%)	9	Cyclic - Refresh rate 5 seconds or value change greater than Window x %.

3.4.3 Disturbance Recorder Actual Channel (ACC) Numbers

The following Disturbance Recorder channel numbers apply to this device.

FUN	ACC	Description
182	12	VLine
182	13	VBus

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4. MODBUS Definitions

4.1 Introduction

This section describes the MODBUS-RTU protocol implementation in the relays. This protocol is used for communication with a suitable control system.

This protocol can be set to use any or all of the relays hardware interfaces (USB, Fibre Optic, RS232 and RS485) where fitted. The relay can communicate simultaneously on all ports regardless of protocol used.

The Station Address of the port being used must be set to a suitable address within the range 1 - 247 to enable communication. This can be set by the **Communications Menu : COM *n-xxxxx* Station Address** setting.

Communication via MODBUS over Ethernet requires external devices. Please refer to the documents ***TCPIP Catalogue Sheet*** and ***TCPIP Interface Technical Guidance Notes*** for more information.

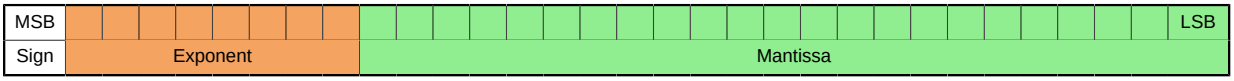
Definitions with shaded area are not available on all relay models.

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4.2 MODBUS Register Data Types

4.2.1 FLOAT_IEEE_754

The float data type conforms to the IEEE 754 floating point definition. This specifies that 32 bits of data will be formatted as a sign bit in the most significant bit (MSB) followed by an 8 bit exponent then a 23 bit mantissa, down to the least significant bit (LSB).



FLOAT_IEEE_754 IN DETAIL

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

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

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

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

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

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

This calculates out as:

Sign = +1

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

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

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

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

FLOAT_IEEE_754 & MODBUS

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

Address	Value
30001	4974

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Address	Value
30002	2400

On reception these two registers should be interpreted in the correct order as IEEE754 floating point representation.

4.2.2 FP_32BITS_3DP

The FP_32BITS_3DP is a 32 bit integer fixed point value, containing 3 decimal places of information. It is used to send a real value to 3 decimal places as an integer. For example, if the value in a device is 123.456 it will be sent as 123456. As it is an integer, negative numbers are sent as 2's complement.

FP_32BITS_3DP & MODBUS

In this MODBUS implementation the 32 bit value is stored in 2 16 registers in Big-Endian format. As an example, if we take the hex representation of 123456, we have 1E240h. Assume this is stored in the registers 30001 and 30002, it would look as follows:

Address	Value
30001	1
30002	E240

On reception these two registers should be interpreted in the correct order as a 32 bit integer.

4.2.3 UINT32

The UINT32 is a signed 32 bit integer. As it is an integer, negative numbers are sent as 2's complement.

UINT32 & MODBUS

In this MODBUS implementation the 32 bit value is stored in 2 16 bit registers in Big-Endian format. As an example, if we take the hex representation of -123456, in 2's complement, we have FFFE1DC0h. Assume this is stored in the registers 30001 and 30002, it would look as follows:

Address	Value
30001	FFFE
30002	1DC0

On reception these two registers should be interpreted in the correct order as a 32 bit integer.

4.2.4 UINT16

The UINT16 is a signed 16 bit integer. As it is an integer, negative numbers are sent as 2's complement.

UINT16 & MODBUS

In this MODBUS implementation the 16 bit value is stored in a 16 bit register in Big-Endian format. As an example, if we take the hex representation of 5678 we have 162Eh. Assume this is stored in the register 30001, it would look as follows:

Address	Value
30001	162E

On reception this register should be interpreted as a 16 bit integer.

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Truncation

Calculations are performed as 32 bit. The 16 bit value is the lowest 16 bits of the 32 bit value. Therefore, when values overflow the returned value is the lowest 16 bits of the calculated value. For Example, if the value is 85400 = 14D98h, the value returned would be the lowest 16 bits = 4D98h which equals 19864.

4.2.5 EVENT

MODBUS does not define a method for extracting events; therefore a private method has been defined based on that defined by IEC60870-5-103.

The EVENT register contains the earliest event record available. The event record is 8 registers (16 bytes) of information, whose format is described below. When this record has been read it will be replaced by the next available record. Event records must be read completely; therefore the quantity value must be set to 8 before reading. Failing to do this will result in an exception code 2. If no event record is present the exception code 2 will be returned. The EVENT register should be polled regularly by the master for events.

The EVENTCOUNT register can be checked periodically to determine how many events are stored.

The format of the event record is defined by the zero byte. It signifies the type of record which is used to decode the event information. The zero byte can be one of the following.

Format

The format of the event record is defined by the zero byte. It signifies the type of record which is used to decode the event information. The zero byte can be one of the following.

Type	Description
1	Event
2	Event with Relative Time
4	Measurand Event with Relative Time

The following table describes the fields in the event record.

Key	Description
FUN	Function Type, as defined for IEC870-5-103.
INF	Information Number, as defined for IEC870-5-103.
DPI	Measurand Event with Relative Time, values 1 = OFF, 2 = ON.
ms L	Time Stamp Milliseconds low byte.
ms H	Time Stamp Milliseconds high byte.
Mi	Time Stamp Minutes (MSB = invalid, time not set > 23 hours).
Ho	Time Stamp Hours (MSB = Summer time flag).
RT L	Relative Time low byte.
RT H	Relative Time high byte.
F# L	Fault Number low byte.
F# H	Fault Number high byte.
Meas	Measurand format R32.23, sent least significant byte first.

The following tables show the fields in the different event records as they are returned.

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	1	0	FUN	INF	DPI	0	0	0	0	0	0	0	ms L	ms H	Mi	Ho

Event Type 1 Format.

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Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	2	0	FUN	INF	DPI	RT L	RT H	F# L	F# H	0	0	0	ms L	ms H	Mi	Ho

Event Type 2 Format.

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Content	4	0	FUN	INF	Meas				0	0	0	0	ms L	ms H	Mi	Ho

Event Type 4 Format.

4.2.6 EVENTCOUNT

The EVENTCOUNT register contains the current number of events in the relay's event buffer.

On reception this register should be interpreted as a 16 bit integer.

4.2.7 TIME_METER

The TIME_METER register contains the device's time. The time must be read or written in one step; therefore the quantity should be 4 registers. Failing to do this will result in an exception code 2. The time format is 8 bytes as follows.

The following table describes the fields in the time.

Key	Description
ms L	Time Stamp Milliseconds low byte.
ms H	Time Stamp Milliseconds high byte.
Mi	Time Stamp Minutes (MSB = invalid, time not set > 23 hours).
Ho	Time Stamp Hours (MSB = Summer time flag).
Da	Time Stamp Days.
Mo	Time Stamp Months.
Ye L	Time Stamp Years low byte.
Ye H	Time Stamp Years high byte (Not Used).

The following table shows the fields in the time as they are returned.

Byte	0	1	2	3	4	5	6	7
Content	ms L	ms H	Mi	Ho	Da	Mo	Ye L	Ye H

Time Format.

4.2.8 STR32 & STR64

4.2.9 BITSTRING

A Bit-String (or Bit-Array) is a method of compactly storing a number of bits of data. In this instance we store up to 16 bit values, for example the states of binary inputs, in a single 16 bit register. The first bit value is stored in the Least Significant Bit (LSB) of the register. The 16th value would be in the Most Significant Bit (MSB). Bit values can only be zero or one. Any unused bits will be set to zero.

BITSTRING & MODBUS

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In this MODBUS implementation the 16 bit value is stored in a 16 bit register in Big-Endian format. As an example, assume bits 1, 3, 9 and 12 are set. The binary representation of this would be 0000100100000101_2 giving a hex representation of 0905h. Assume this is stored in the register 30001, it would look as follows:

Address	Value
30001	0905

On reception this register should be interpreted as a 16 bit integer.

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4.3 Point List

The information shown below is the default configuration. This can be modified using the Communications Configuration Editor tool, refer section 9 for details.

4.3.1 Coils (Read Write Binary values)

Address	Description
00001	Binary Output 1
00002	Binary Output 2
00003	Binary Output 3
00004	Binary Output 4
00005	Binary Output 5
00006	Binary Output 6
00007	Binary Output 7
00008	Binary Output 8
00101	Setting G1 selected
00102	Setting G2 selected
00103	Setting G3 selected
00104	Setting G4 selected
00155	Remote Mode
00156	Out Of Service Mode
00157	Local Mode
00158	Local & Remote
00200	User SP Command 1
00201	User SP Command 2
00202	User SP Command 3
00203	User SP Command 4
00204	User SP Command 5
00205	User SP Command 6
00206	User SP Command 7
00207	User SP Command 8
00208	User DP Command 1
00209	User DP Command 2
00210	User DP Command 3
00211	User DP Command 4
00212	User DP Command 5
00213	User DP Command 6
00214	User DP Command 7
00215	User DP Command 8

4.3.2 Inputs (Read Only Binary values)

Address	Description
10001	Binary Input 1
10002	Binary Input 2
10003	Binary Input 3
10004	Binary Input 4

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Address	Description
10005	Binary Input 5
10006	Binary Input 6
10102	Remote Mode
10103	Out Of Service Mode
10104	Local Mode
10105	Local & Remote
10115	General Start/Pick-up
10116	VT Fuse Failure
10283	Close Circuit Fail 1
10284	Close Circuit Fail 2
10285	Close Circuit Fail 3
10286	Close Circuit Fail
10290	General Alarm 1
10291	General Alarm 2
10292	General Alarm 3
10293	General Alarm 4
10294	General Alarm 5
10295	General Alarm 6
10296	General Alarm 7
10302	Quick Logic E1
10303	Quick Logic E2
10304	Quick Logic E3
10305	Quick Logic E4
10352	25 System Split
10353	25 Live Line
10354	25 Live Bus
10355	25 Line U/V
10356	25 Bus U/V
10357	25 Voltage Dif >
10358	25 CS Slip Freq >
10359	25 SS Slip Freq >
10360	25 COZ Slip Freq >
10361	25 In Sync
10362	25 CS In Progress
10363	25 SS In Progress
10364	25 COZ In Progress
10365	25 System Split LO
10366	60VTF-Bus
10501	Virtual Input 1
10502	Virtual Input 2
10503	Virtual Input 3
10504	Virtual Input 4
10505	Virtual Input 5
10506	Virtual Input 6
10507	Virtual Input 7
10508	Virtual Input 8
10601	LED 1
10602	LED 2
10603	LED 3

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Address	Description
10604	LED 4
10605	LED 5
10606	LED 6
10607	LED 7
10608	LED 8
10609	LED 9
10701	LED PU 1
10702	LED PU 2
10703	LED PU 3
10704	LED PU 4
10705	LED PU 5
10706	LED PU 6
10707	LED PU 7
10708	LED PU 8
10709	LED PU 9
10800	Cold Start
10801	Warm Start
10802	Re-Start
10803	Power On
10804	Expected Restart
10805	Unexpected Restart
10900	User SP Command 1
10901	User SP Command 2
10902	User SP Command 3
10903	User SP Command 4
10904	User SP Command 5
10905	User SP Command 6
10906	User SP Command 7
10907	User SP Command 8
10908	User DP Command 1
10909	User DP Command 2
10910	User DP Command 3
10911	User DP Command 4
10912	User DP Command 5
10913	User DP Command 6
10914	User DP Command 7
10915	User DP Command 8

4.3.3 Input Registers (Read Only Registers)

Address	Description	Format	Mult	Description
30001	Event Count	EVENTCOUNT	0.000000	Events Counter
30002	Event	EVENT	0.000000	8 Registers
30060	Frequency	FP_32BITS_3DP	1.000000	Frequency Hz
30167	Fault Records	UINT16	1.000000	Fault Records
30168	Event Records	UINT16	1.000000	Event Records
30169	Waveform Records	UINT16	1.000000	Waveform Records

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Address	Description	Format	Mult	Description
30293	Bus Freq	FP_32BITS_3DP	1.000000	Vx Frequency
30295	Phase Diff	FP_32BITS_3DP	1.000000	25 Phase Diff
30297	Slip Freq	FP_32BITS_3DP	1.000000	25 Slip Freq
30299	Voltage Diff	FP_32BITS_3DP	1.000000	25 Voltage Diff
30341	LED1-n	BITSTRING	0.000000	Led 1-16 status
30342	LED1-n	BITSTRING	0.000000	Led 17-32 status
30343	INP1-n	BITSTRING	0.000000	Input 1-16 status
30344	INP1-n	BITSTRING	0.000000	Input 17-32 status
30345	OUT1-n	BITSTRING	0.000000	Output 1-16 status
30346	OUT1-n	BITSTRING	0.000000	Output 17-32 status
30347	VRT1-n	BITSTRING	0.000000	Virtual 1-16 status
30348	VRT1-n	BITSTRING	0.000000	Virtual 17-32 status
30349	EQN1-n	BITSTRING	0.000000	Equation 1-16 status
30350	EQN1-n	BITSTRING	0.000000	Equation 17-32 status
30392	Active Setting Group	UINT16	1.000000	Active Setting Group
30470	V Line Primary	FP_32BITS_3DP	1.000000	V Line Primary V
30472	V Bus Primary	FP_32BITS_3DP	1.000000	V Bus Primary V
30474	V Line Secondary	FP_32BITS_3DP	1.000000	V Line Secondary V
30476	V Bus Secondary	FP_32BITS_3DP	1.000000	V Bus Secondary V
30478	V Line Max	FP_32BITS_3DP	1.000000	V Line Max Demand V
30480	V Bus Max	FP_32BITS_3DP	1.000000	V Bus Max Demand V

4.3.4 Holding Registers (Read Write Registers)

Address	Description	Format	Mult	Description
40001	Time	TIME_METER	0.000000	Time
40060	Frequency	FP_32BITS_3DP	1.000000	Frequency Hz
40167	Fault Records	UINT16	1.000000	Fault Records
40168	Event Records	UINT16	1.000000	Event Records
40169	Waveform Records	UINT16	1.000000	Waveform Records
40293	Bus Freq	FP_32BITS_3DP	1.000000	Vx Frequency
40295	Phase Diff	FP_32BITS_3DP	1.000000	25 Phase Diff
40297	Slip Freq	FP_32BITS_3DP	1.000000	25 Slip Freq
40299	Voltage Diff	FP_32BITS_3DP	1.000000	25 Voltage Diff
40341	LED1-n	BITSTRING	0.000000	Led 1-16 status
40342	LED1-n	BITSTRING	0.000000	Led 17-32 status
40343	INP1-n	BITSTRING	0.000000	Input 1-16 status
40344	INP1-n	BITSTRING	0.000000	Input 17-32 status
40345	OUT1-n	BITSTRING	0.000000	Output 1-16 status
40346	OUT1-n	BITSTRING	0.000000	Output 17-32 status
40347	VRT1-n	BITSTRING	0.000000	Virtual 1-16 status
40348	VRT1-n	BITSTRING	0.000000	Virtual 17-32 status
40349	EQN1-n	BITSTRING	0.000000	Equation 1-16 status
40350	EQN1-n	BITSTRING	0.000000	Equation 17-32 status
40368	Active Setting Group	UINT16	1.000000	Active Setting Group
40401	Event Count	EVENTCOUNT	0.000000	Events Counter
40402	Event	EVENT	0.000000	8 Registers

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5. DNP3 Definitions

5.1 Device Profile

The following table provides a “Device Profile Document” in the standard format defined in the DNP 3.0 Subset Definitions Document. While it is referred to in the DNP 3.0 Subset Definitions as a “Document,” it is in fact a table, and only a component of a total interoperability guide. The table, in combination with the Implementation Table provided in Section 5.2 (beginning on page 32), and the Point List Tables provided in Section 5.3 (beginning on page 38), should provide a complete configuration/interoperability guide for communicating with a device implementing the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library.

<table>
<tr><td colspan="2">DNP V3.0
DEVICE PROFILE DOCUMENT
(Also see the DNP 3.0 Implementation Table in Section 5.2, beginning on page 32).</td></tr>
<tr><td colspan="2">Vendor Name: Siemens Protection Devices Ltd.</td></tr>
<tr><td colspan="2">Device Name: 7SR157, using the Triangle MicroWorks, Inc. DNP3 Slave Source Code Library, Version 3.</td></tr>
<tr><td>Highest DNP Level Supported:
For Requests: Level 3
For Responses: Level 3</td><td>Device Function:
☐ Master
☒ Slave</td></tr>
<tr><td colspan="2">Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

For static (non-change-event) object requests, request qualifier codes 07 and 08 (limited quantity), and 17 and 28 (index) are supported. Static object requests sent with qualifiers 07, or 08, will be responded with qualifiers 00 or 01.

Output Event Object 11 is supported.</td></tr>
<tr><td>Maximum Data Link Frame Size (octets):
Transmitted: 256
Received: 256</td><td>Maximum Application Fragment Size (octets):
Transmitted: 2048
Received: 2048</td></tr>
<tr><td>Maximum Data Link Re-tries:
☐ None
☐ Fixed (3)
☒ Configurable from 0 to 65535 (Default 3)</td><td>Maximum Application Layer Re-tries:
☒ None
☐ Configurable</td></tr>
<tr><td colspan="2">Requires Data Link Layer Confirmation:
☐ Never
☐ Always
☐ Sometimes
☒ Configurable as: Never, Only for multi-frame messages, or Always</td></tr>
<tr><td colspan="2">Requires Application Layer Confirmation:
☐ Never
☐ Always
☒ When reporting Event Data (Slave devices only)
☒ When sending multi-fragment responses (Slave devices only)
☐ Sometimes
☐ Configurable as: “Only when reporting event data”, or “When reporting event data or multi-fragment messages.”</td></tr>
<tr><td colspan="2">Timeouts while waiting for:
Data Link Confirm: ☐ None ☐ Fixed at ____ ☐ Variable ☒ Configurable (2sec)
Complete Appl. Fragment: ☒ None ☐ Fixed at ____ ☐ Variable ☐ Configurable
Application Confirm: ☐ None ☐ Fixed at ____ ☐ Variable ☒ Configurable (10sec)
Complete Appl. Response: ☒ None ☐ Fixed at ____ ☐ Variable ☐ Configurable
Others:
Transmission Delay, (Configurable, default 0 sec)
Select/Operate Arm Timeout, (Configurable, default 5 sec)
Need Time Interval, (Configurable, default 30 minutes)</td></tr>
</table>

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DNP V3.0
DEVICE PROFILE DOCUMENT
(Also see the DNP 3.0 Implementation Table in Section 5.2, beginning on page 32).

Unsolicited Notification Delay, (Configurable, default 5 seconds)
Unsolicited Response Retry Delay, (Configurable (between 3 - 9), default 5 seconds)
Unsolicited Offline Interval, (Configurable, default 30 seconds)
Binary Change Event Scan Period, (Polled, Not Applicable)
Double Bit Change Event Scan Period, (Polled - Not Applicable)
Analog Change Event Scan Period, (Polled - Not Applicable)
Counter Change Event Scan Period, (Polled - Not Applicable)
Frozen Counter Change Event Scan Period, (Polled - Not Applicable)
String Change Event Scan Period, (Unsupported - Not Applicable)
Virtual Terminal Event Scan Period, (Unsupported - Not Applicable)

Sends/Executes Control Operations:

WRITE Binary Outputs	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
DIRECT OPERATE	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
DIRECT OPERATE - NO ACK	☐ Never	☒ **Always**	☐ Sometimes	☐ Configurable
Count > 1	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Pulse Off	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Latch On	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Latch Off	☐ Never	☐ Always	☒ **Sometimes**	☐ Configurable
Queue	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ **Never**	☐ Always	☐ Sometimes	☐ Configurable

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

Reports Binary Input Change Events when no specific variation requested:
- ☐ Never
- ☐ Only time-tagged
- ☐ Only non-time-tagged
- ☒ **Configurable to send one or the other**

Reports time-tagged Binary Input Change Events when no specific variation requested:
- ☐ Never
- ☐ Binary Input Change With Time
- ☐ Binary Input Change With Relative Time
- ☒ **Configurable**

Sends Unsolicited Responses:
- ☐ Never
- ☒ **Configurable**
- ☐ Only certain objects
- ☐ Sometimes (attach explanation)
- ☒ **ENABLE/DISABLE UNSOLICITED Function codes supported**

Sends Static Data in Unsolicited Responses:
- ☒ **Never**
- ☐ When Device Restarts
- ☐ When Status Flags Change

No other options are permitted.

Default Counter Object/Variation:
- ☐ No Counters Reported
- ☒ **Configurable**
- ☐ Default Object
  Default Variation: _____
- ☒ **Point-by-point list attached**

Counters Roll Over at:
- ☐ No Counters Reported
- ☐ Configurable (attach explanation)
- ☐ 16 Bits
- ☒ **32 Bits**
- ☐ Other Value: _____
- ☒ **Point-by-point list attached**

Sends Multi-Fragment Responses:
- ☒ **Yes**
- ☐ No
- ☐ Configurable

Sequential File Transfer Support:

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DNP V3.0 DEVICE PROFILE DOCUMENT (Also see the DNP 3.0 Implementation Table in Section 5.2, beginning on page 32).		
File Transfer Support	☐ Yes	☒ **No**
Append File Mode	☐ Yes	☒ **No**
Custom Status Code Strings	☐ Yes	☒ **No**
Permissions Field	☐ Yes	☒ **No**
File Events Assigned to Class	☐ Yes	☒ **No**
File Events Send Immediately	☐ Yes	☒ **No**
Multiple Blocks in a Fragment	☐ Yes	☒ **No**
Max Number of Files Open	**0**	

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5.2 Implementation Table

The following table identifies which object variations, function codes, and qualifiers the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library supports in both request messages and in response messages. For static (non-change-event) objects, requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. Requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28. For change-event objects, qualifiers 17 or 28 are always responded.

In the table below, text shaded as 00, 01 (start stop) indicates Subset Level 3 functionality (beyond Subset Level 2).

In the table below, text shaded as 07, 08 (limited qty) indicates functionality beyond Subset Level 3.

OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
1	0	Binary Input - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
1	1	Binary Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
1	2 (default - see note 1)	Binary Input with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
2	0	Binary Input Change - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
2	1	Binary Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	2 (default - see note 1)	Binary Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
2	3	Binary Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
3	0	Double Bit Input - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
3	1 (default - see note 1)	Double Bit Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 1)
3	2	Double Bit Input with Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 1)
4	0	Double Bit Input Change - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
4	1	Double Bit Input Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
4	2	Double Bit Input Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
4	3 (default - see note 1)	Double Bit Input Change with Relative Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
10	0	Binary Output - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		

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OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
10	1	Binary Output	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
			2 (write)	00, 01 (start-stop)		
10	2 (default - see note 1)	Binary Output Status	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
11	0	Binary Output Change - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
11	1	Binary Output Change without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
11	2 (default - see note 1)	Binary Output Change with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
12	0	Control Relay Output Block	22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
12	1	Control Relay Output Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	17, 28 (index)	129 (response)	echo of request
12	2	Pattern Control Block	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	7 (limited quantity)	129 (response)	echo of request
12	3	Pattern Mask	3 (select) 4 (operate) 5 (direct op) 6 (dir. op, noack)	00, 01 (start-stop)	129 (response)	echo of request
13	0	Binary Output Command Event - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
13	1 (default - see note 1)	Binary Output Command Event without Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
13	2	Binary Output Command Event with Time	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
20	0	Binary Counter - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
			7 (freeze) 8 (freeze noack) 9 (freeze clear) 10 (frz. cl. noack)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty)		
20	1	32-Bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
20	2	16-Bit Binary Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
20	3	32-Bit Delta Counter (with Flag)				
20	4	16-Bit Delta Counter (with Flag)				
20	5 (default see note 1)	32-Bit Binary Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)

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OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
20	6	16-Bit Binary Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
20	7	32-Bit Delta Counter (without Flag)				
20	8	16-Bit Delta Counter (without Flag)				
21	0	Frozen Counter - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
21	1	32-Bit Frozen Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
21	2	16-Bit Frozen Counter (with Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
21	3	32-Bit Frozen Delta Counter (with Flag)				
21	4	16-Bit Frozen Delta Counter (with Flag)				
21	5	32-Bit Frozen Counter (without Time Of Freeze)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
21	6	16-Bit Frozen Counter (without Time Of Freeze)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
21	7	32-Bit Frozen Delta Counter (with Time Of Freeze)				
21	8	16-Bit Frozen Delta Counter (with Time Of Freeze)				
21	9 (default - see note 1)	32-Bit Frozen Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
21	10	16-Bit Frozen Counter (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
21	11	32-Bit Frozen Delta Counter (without Flag)				
21	12	16-Bit Frozen Delta Counter (without Flag)				
22	0	Counter Change Event - Any Variation	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
22	1 (default - see note 1)	32-Bit Counter Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	2	16-Bit Counter Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	3	32-Bit Delta Counter Change Event (without Time)				
22	4	16-Bit Delta Counter Change Event (without Time)				
22	5	32-Bit Counter Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
22	6	16-Bit Counter Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130	17, 28 (index)

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OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
					(unsol. resp)	
22	7	32-Bit Delta Counter Change Event (with Time)				
22	8	16-Bit Delta Counter Change Event (with Time)				
23	0	Frozen Counter Event (Variation 0 is used to request default variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
23	1 (default - see note 1)	32-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
23	2	16-Bit Frozen Counter Event	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response)	17, 28 (index)
23	3	32-Bit Frozen Delta Counter Event				
23	4	16-Bit Frozen Delta Counter Event				
23	5	32-Bit Frozen Counter Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
23	6	32-Bit Frozen Counter Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
23	7	32-Bit Frozen Delta Counter Event (with Time)				
23	8	16-Bit Frozen Delta Counter Event (with Time)				
30	0	Analog Input - Any Variation	1 (read) 22 (assign class)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
30	1	32-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
30	2 (default - see note 1)	16-Bit Analog Input	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
30	3	32-Bit Analog Input (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
30	4	16-Bit Analog Input (without Flag)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
30	5	short floating point	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
30	6	long floating point	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
31	0	Frozen Analog Input - Any Variation				
31	1	32-Bit Frozen Analog Input				
31	2	16-Bit Frozen Analog Input				
31	3	32-Bit Frozen Analog Input (with Time of freeze)				
31	4	16-Bit Frozen Analog Input (with Time of freeze)				
31	5	32-Bit Frozen Analog Input (without Flag)				
31	6	16-Bit Frozen Analog Input (without Flag)				

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OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
32	0	Analog Change Event - Any Variation)	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
32	1	32Bit-Analog Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	2	16Bit-Analog Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	3	32Bit-Analog Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	4 (default - see note 1)	16Bit-Analog Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	5	short floating point Analog Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	6	long floating point Analog Change Event (without Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	7	short floating point Analog Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
32	8	long floating point Analog Change Event (with Time)	1 (read)	06 (no range, or all) 07, 08 (limited qty)	129 (response) 130 (unsol. resp)	17, 28 (index)
33	0	Frozen Analog Event - Any Variation				
33	1	32-Bit Frozen Analog Event (without Time)				
33	2	16-Bit Frozen Analog Event (without Time)				
33	3	32-Bit Frozen Analog Event (with Time)				
33	4	16-Bit Frozen Analog Event (with Time)				
33	5	Short Floating Point Frozen Analog Event				
33	6	Long Floating Point Frozen Analog Event				
33	7	Extended Floating Point Frozen Analog Event				
34	0	Analog Input Deadband (Variation 0 is used to request default variation)	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)		
34	1	16 bit Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
34	2 (default - see note 1)	32 bit Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty) 17, 27, 28 (index)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
34	3	Short Floating Point Analog Input Deadband	1 (read)	00, 01 (start-stop) 06 (no range, or all) 07, 08 (limited qty)	129 (response)	00, 01 (start-stop) 17, 28 (index - see note 2)

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OBJECT			REQUEST (Library will parse)		RESPONSE (Library will respond with)	
Object Number	**Variation**	**Description**	**Function Codes (dec)**	**Qualifier Codes (hex)**	**Function Codes (dec)**	**Qualifier Codes (hex)**
				17, 27, 28 (index)		
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
50	0	Time and Date				
50	1 (default - see note 1)	Time and Date	1 (read)	07, 08 (limited qty)	129 (response)	07 (limited qty = 1)
			2 (write)	00, 01 (start-stop) 07, 08 (limited qty) 17, 27, 28 (index)		
50	3	Time and Date Last Recorded Time	2 (write)	07 (limited qty)		
51	1	Time and Date CTO			129 (response) 130 (unsol. resp)	(limited qty = 1)
51	2	Unsynchronized Time and Date CTO			129 (response) 130 (unsol. resp)	(limited qty = 1)
52	1	Time Delay Coarse			129 (response)	(limited qty = 1)
52	2	Time Delay Fine			129 (response)	(limited qty = 1)
60	0	Not Defined				
60	1	Class 0 Data	1 (read)	06 (no range, or all)		
60	2	Class 1 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
60	3	Class 2 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
60	4	Class 3 Data	1 (read)	06 (no range, or all) 07, 08 (limited qty)		
			20 (enbl. unsol.) 21 (dab. unsol.) 22 (assign class)	06 (no range, or all)		
80	1	Internal Indications	1 (read)	00, 01 (start-stop)	129 (response)	00, 01 (start-stop)
			2 (write)(see note 3)	00 (start-stop) index=7		
		No Object (function code only)	13 (cold restart)			
		No Object (function code only)	14 (warm restart)			
		No Object (function code only)	23 (delay meas.)			
		No Object (function code only)	24 (record current time)			

Note 1: A Default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans. Default variations are configurable; however, default settings for the configuration parameters are indicated in the table above.

Note 2: For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. (For change-event objects, qualifiers 17 or 28 are always responded.)

Note 3: Writes of Internal Indications are only supported for index 7 (Restart IIN1-7).

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5.3 Point List

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

This protocol can be set to use any or all of the relays hardware interfaces (USB, Fibre Optic, RS232 and RS485) where fitted. The relay can communicate simultaneously on all ports regardless of protocol used.

The Station Address of the port being used must be set to a suitable address within the range 0 - 65534 to enable communication. This can be set by the **Communications Menu : COM *n-xxxxx* Station Address** setting.

Communication via DNP3 over Ethernet requires external devices. Please refer to the documents ***TCPIP Catalogue Sheet*** and ***TCPIP Interface Technical Guidance Notes*** for more information.

The information shown below is the default configuration. This can be modified using the Communications Configuration Editor tool, refer section 9 for details.

5.3.1 Binary Input Points

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

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

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

Binary Input Points
Static (Steady-State) Object Number: **1 (Packed Format)**
Change Event Object Number: **1 (w/o Time)**
Static Variation reported when variation 0 requested: **1 (Binary Input w/o status)**
or **2 (Binary Input with status)**
Change Event Variation reported when variation 0 requested: **1 (Binary Input Change w/o Time)**
or **2 (Binary Input Change with Absolute Time)**
or **3 (Binary Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
1	Binary Input 1	0,2	2	2
2	Binary Input 2	0,2	2	2
3	Binary Input 3	0,2	2	2
4	Binary Input 4	0,2	2	2
5	Binary Input 5	0,2	2	2
6	Binary Input 6	0,2	2	2
35	Remote Mode	0,2	2	2
36	Out Of Service Mode	0,2	2	2
37	Local Mode	0,2	2	2
38	Local & Remote	0,2	2	2
45	General Start/Pick-up	0,2	2	2
46	VT Fuse Failure	0,2	2	2
207	Close Circuit Fail 1	0,2	2	2
208	Close Circuit Fail 2	0,2	2	2
209	Close Circuit Fail 3	0,2	2	2
210	Close Circuit Fail	0,2	2	2
225	General Alarm 1	0,2	2	2
226	General Alarm 2	0,2	2	2
227	General Alarm 3	0,2	2	2
228	General Alarm 4	0,2	2	2

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Binary Input Points
Static (Steady-State) Object Number: **1 (Packed Format)**
Change Event Object Number: **1 (w/o Time)**
Static Variation reported when variation 0 requested: **1 (Binary Input w/o status)**
or **2 (Binary Input with status)**
Change Event Variation reported when variation 0 requested: **1 (Binary Input Change w/o Time)**
or **2 (Binary Input Change with Absolute Time)**
or **3 (Binary Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
229	General Alarm 5	0,2	2	2
230	General Alarm 6	0,2	2	2
231	General Alarm 7	0,2	2	2
237	Quick Logic E1	0,2	2	2
238	Quick Logic E2	0,2	2	2
239	Quick Logic E3	0,2	2	2
240	Quick Logic E4	0,2	2	2
387	25 System Split	0,2	2	2
388	25 Live Line	0,2	2	2
389	25 Live Bus	0,2	2	2
390	25 Line U/V	0,2	2	2
391	25 Bus U/V	0,2	2	2
392	25 Voltage Dif >	0,2	2	2
393	25 CS Slip Freq >	0,2	2	2
394	25 SS Slip Freq >	0,2	2	2
395	25 COZ Slip Freq >	0,2	2	2
396	25 In Sync	0,2	2	2
397	25 CS In Progress	0,2	2	2
398	25 SS In Progress	0,2	2	2
399	25 COZ In Progress	0,2	2	2
400	25 System Split LO	0,2	2	2
401	60VTF-Bus	0,2	2	2
411	Setting G1 selected	0,2	2	2
412	Setting G2 selected	0,2	2	2
413	Setting G3 selected	0,2	2	2
414	Setting G4 selected	0,2	2	2
501	Virtual Input 1	0,2	2	2
502	Virtual Input 2	0,2	2	2
503	Virtual Input 3	0,2	2	2
504	Virtual Input 4	0,2	2	2
505	Virtual Input 5	0,2	2	2
506	Virtual Input 6	0,2	2	2
507	Virtual Input 7	0,2	2	2
508	Virtual Input 8	0,2	2	2
601	LED 1	0,2	2	2
602	LED 2	0,2	2	2
603	LED 3	0,2	2	2
604	LED 4	0,2	2	2
605	LED 5	0,2	2	2
606	LED 6	0,2	2	2
607	LED 7	0,2	2	2

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Binary Input Points
Static (Steady-State) Object Number: **1 (Packed Format)**
Change Event Object Number: **1 (w/o Time)**
Static Variation reported when variation 0 requested: **1 (Binary Input w/o status)**
or **2 (Binary Input with status)**
Change Event Variation reported when variation 0 requested: **1 (Binary Input Change w/o Time)**
or **2 (Binary Input Change with Absolute Time)**
or **3 (Binary Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
608	LED 8	0,2	2	2
609	LED 9	0,2	2	2
701	LED PU 1	0,2	2	2
702	LED PU 2	0,2	2	2
703	LED PU 3	0,2	2	2
704	LED PU 4	0,2	2	2
705	LED PU 5	0,2	2	2
706	LED PU 6	0,2	2	2
707	LED PU 7	0,2	2	2
708	LED PU 8	0,2	2	2
709	LED PU 9	0,2	2	2
801	Binary Output 1	0,2	2	2
802	Binary Output 2	0,2	2	2
803	Binary Output 3	0,2	2	2
804	Binary Output 4	0,2	2	2
805	Binary Output 5	0,2	2	2
806	Binary Output 6	0,2	2	2
807	Binary Output 7	0,2	2	2
808	Binary Output 8	0,2	2	2
871	Cold Start	0,2	2	2
872	Warm Start	0,2	2	2
873	Re-Start	0,2	2	2
874	Power On	0,2	2	2
875	Expected Restart	0,2	2	2
876	Unexpected Restart	0,2	2	2
900	User SP Command 1	0,2	2	2
901	User SP Command 2	0,2	2	2
902	User SP Command 3	0,2	2	2
903	User SP Command 4	0,2	2	2
904	User SP Command 5	0,2	2	2
905	User SP Command 6	0,2	2	2
906	User SP Command 7	0,2	2	2
907	User SP Command 8	0,2	2	2

5.3.2 Double Bit Input Points

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

Double bit inputs are by default returned in a class zero interrogation.

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

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Double Bit Input Points
Static (Steady-State) Object Number: **3**
Change Event Object Number: **4**
Static Variation reported when variation 0 requested: **1 (Double Bit Input w/o status)**
or **2 (Double Bit Input with status)**
Change Event Variation reported when variation 0 requested: **1 (Double Bit Input Change w/o Time)**
or **2 (Double Bit Input Change with Absolute Time)**
or **3 (Double Bit Input Change with Relative Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 3	Default Variation Event Object 4
10	User DP Command 1	0,2	1	3
11	User DP Command 2	0,2	1	3
12	User DP Command 3	0,2	1	3
13	User DP Command 4	0,2	1	3
14	User DP Command 5	0,2	1	3
15	User DP Command 6	0,2	1	3
16	User DP Command 7	0,2	1	3
17	User DP Command 8	0,2	1	3

5.3.3 Binary Output Status Points and Control Relay Output Blocks

The following table lists both the Binary Output Status Points (Object 10) and the Control Relay Output Blocks (Object 12).

While Binary Output Status Points are included here for completeness, they are not often polled by DNP 3.0 Masters. Binary Output Status points are not recommended to be included in class 0 polls.

As an alternative, it is recommended that “actual” status values of Control Relay Output Block points be looped around and mapped as Binary Inputs. (The “actual” status value, as opposed to the “commanded” status value, is the value of the actuated control. For example, a DNP control command may be blocked through hardware or software mechanisms; in this case, the actual status value would indicate the control failed because of the blocking. Looping Control Relay Output Block actual status values as Binary Inputs has several advantages:

- it allows actual statuses to be included in class 0 polls,
- it allows change event reporting of the actual statuses, which is a more efficient and time-accurate method of communicating control values,
- and it allows reporting of time-based information associated with controls, including any delays before controls are actuated, and any durations if the controls are pulsed.

The default select/control buffer size is large enough to hold 10 of the largest select requests possible.

Binary outputs are by default **NOT** returned in a class zero interrogation.

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

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Binary Output Status Points
Static (Steady-State) Object Number: **10**
Change Event Object Number: **11**
Control Relay Output Blocks (CROB) Object Number: **12**
Binary Output Command Event Object Number: **13**
Static Variation reported when variation 0 requested: **1 (Binary Output w/o status)**
or **2 (Binary Output with status)**
Change Event Variation reported when variation 0 requested: **1 (Binary Output Event w/o Time)**
or **2 (Binary Output Event with Time)**
Command Event Variation reported when variation 0 requested: **1 (Command Status w/o Time)**
or **2 (Command Status with Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
1	RL 1	0	2	2	0	1	Pulse On Latch On Close	Pulse On
2	RL 2	0	2	2	0	1	Pulse On Latch On Close	Pulse On
3	RL 3	0	2	2	0	1	Pulse On Latch On Close	Pulse On
4	RL 4	0	2	2	0	1	Pulse On Latch On Close	Pulse On
5	RL 5	0	2	2	0	1	Pulse On Latch On Close	Pulse On
6	RL 6	0	2	2	0	1	Pulse On Latch On Close	Pulse On
7	RL 7	0	2	2	0	1	Pulse On Latch On Close	Pulse On
8	RL 8	0	2	2	0	1	Pulse On Latch On Close	Pulse On
33	LED reset, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
34	Settings Group 1	0	2	2	0	1	Pulse On Latch On Close	Latch On
35	Settings Group 2	0	2	2	0	1	Pulse On Latch On Close	Latch On
36	Settings Group 3	0	2	2	0	1	Pulse On Latch On Close	Latch On
37	Settings Group 4	0	2	2	0	1	Pulse On Latch On Close	Latch On
59	Demand metering reset, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
88	Remote mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On

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Binary Output Status Points
Static (Steady-State) Object Number: **10**
Change Event Object Number: **11**
Control Relay Output Blocks (CROB) Object Number: **12**
Binary Output Command Event Object Number: **13**
Static Variation reported when variation 0 requested: **1 (Binary Output w/o status)**
or **2 (Binary Output with status)**
Change Event Variation reported when variation 0 requested: **1 (Binary Output Event w/o Time)**
or **2 (Binary Output Event with Time)**
Command Event Variation reported when variation 0 requested: **1 (Command Status w/o Time)**
or **2 (Command Status with Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
89	Service mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On
90	Local mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On
91	Local & Remote	0	2	2	0	1	Pulse On Latch On Close	Pulse On
99	User SP Command 1.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
100	User SP Command 2.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
101	User SP Command 3.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
102	User SP Command 4.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
103	User SP Command 5.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
104	User SP Command 6.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
105	User SP Command 7.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
106	User SP Command 8.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
107	User DP Command 1.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
108	User DP Command 2.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off

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Binary Output Status Points
Static (Steady-State) Object Number: **10**
Change Event Object Number: **11**
Control Relay Output Blocks (CROB) Object Number: **12**
Binary Output Command Event Object Number: **13**
Static Variation reported when variation 0 requested: **1 (Binary Output w/o status)**
or **2 (Binary Output with status)**
Change Event Variation reported when variation 0 requested: **1 (Binary Output Event w/o Time)**
or **2 (Binary Output Event with Time)**
Command Event Variation reported when variation 0 requested: **1 (Command Status w/o Time)**
or **2 (Command Status with Time)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
109	User DP Command 3.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
110	User DP Command 4.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
111	User DP Command 5.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
112	User DP Command 6.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
113	User DP Command 7.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off
114	User DP Command 8.	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off

5.3.4 Counters

The following table lists both Binary Counters (Object 20) and Frozen Counters (Object 21). When a freeze function is performed on a Binary Counter point, the frozen value is available in the corresponding Frozen Counter point. The default Binary Counter and Frozen Counter event buffer sizes are set to 30.

The “Default Deadband,” and the “Default Change Event Assigned Class” columns are used to represent the absolute amount by which the point must change before a Counter change event will be generated, and once generated in which class poll (1, 2, 3, or none) will the change event be reported.

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The default counter event buffer size is set 30. The counter event mode is set to Most Recent, only most recent event for each point is stored.

Counters are by default returned in a class zero interrogation.

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

Counters
Static (Steady-State) Object Number: **20**
Change Event Object Number: **22**
Static Variation reported when variation 0 requested: **1 (32-Bit Counter with Flag)**
or **2 (16-Bit Counter with Flag)**
or **5 (32-Bit Counter w/o Flag)**
or **6 (16-Bit Counter w/o Flag)**
Change Event Variation reported when variation 0 requested: **1 (32-Bit Counter Event with Flag)**
or **2 (16-Bit Counter Event with Flag)**
or **5 (32-Bit Counter Event with Flag and Time)**
or **6 (16-Bit Counter Event with Flag and Time)**
Frozen Counters
Static (Steady-State) Object Number: **21**
Change Event Object Number: **23**
Static Variation reported when variation 0 requested: **1 (32-Bit Frozen Counter with Flag)**
or **2 (16-Bit Frozen Counter with Flag)**
or **5 (32-Bit Frozen Counter with Flag and Time)**
or **6 (16-Bit Frozen Counter with Flag and Time)**
or **9 (32-Bit Frozen Counter w/o Flag)**
or **10 (16-Bit Frozen Counter w/o Flag)**
Change Event Variation reported when variation 0 requested: **1 (32-Bit Frozen Counter Event with Flag)**
or **2 (16-Bit Frozen Counter Event with Flag)**
or **5 (32-Bit Frozen Counter Event with Flag and Time)**
or **6 (16-Bit Frozen Counter Event with Flag and Time)**

		Counter						Frozen Counter		
Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 20	Default Variation Event Object 22	Deadband	Is Resettable	IsFreezable	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 21	Default Variation Event Object 23
0	Waveform Records	0,3	5	1	1		✔	0,2	9	1
1	Fault Records	0,3	5	1	1		✔	0,2	9	1
2	Event Records	0,3	5	1	1		✔	0,2	9	1
3	Data Log Records	0,3	5	1	1		✔	0,2	9	1
7	Active Setting Group	0,3	5	1	1		✔	0,2	9	1
21	E1 Counter	0,3	5	1	1		✔	0,2	9	1
22	E2 Counter	0,3	5	1	1		✔	0,2	9	1
23	E3 Counter	0,3	5	1	1		✔	0,2	9	1
24	E4 Counter	0,3	5	1	1		✔	0,2	9	1

5.3.5 Analog Inputs

The following table lists Analog Inputs (Object 30). It is important to note that 16-bit and 32-bit variations of Analog Inputs, Analog Output Control Blocks, and Analog Output Statuses are transmitted through DNP as signed numbers.

The “Default Deadband,” and the “Default Change Event Assigned Class” columns are used to represent the absolute amount by which the point must change before an Analog change event will be generated, and once generated in which class poll (1, 2, 3, or none) will the change event be reported.

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

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

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

Analog Inputs
Static (Steady-State) Object Number: **30**
Change Event Object Number: **32**
Analog Input Deadband: **34**
Static Variation reported when variation 0 requested: **1 (32-Bit Analog Input with Flag)**
or **2 (16-Bit Analog Input with Flag)**
or **3 (32-Bit Analog Input w/o Flag)**
or **4 (16-Bit Analog Input w/o Flag)**
or **5 (Single Precision, floating point Analog Input with Flag)**
Change Event Variation reported when variation 0 requested: **1 (32-Bit Analog Change Event w/o Time)**
or **2 (16-Bit Analog Input w/o Time)**
or **3 (32-Bit Analog Input with Time)**
or **4 (16-Bit Analog Input with Time)**
or **5 (Single Precision, floating point Analog Input w/o Time)**
or **7 (Single Precision, floating point Analog Input with Time)**
Analog Input Reporting Deadband Variation reported when variation 0 requested: **1 (16-Bit)**
or **2 (32-Bit)**
or **3 (Single Precision, floating point)**

Point Index	Description	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 30	Default Variation Event Object 32	Default Multiplier	Default Deadband
0	Frequency	0,3	2	4	100.000	1.000
95	Active Setting Group	0,3	2	4	1.000	1.000
162	Phase Diff	0,3	2	4	100.000	1.000
163	Slip Freq	0,3	2	4	100.000	1.000
164	Voltage Diff	0,3	2	4	100.000	1.000
331	V Line Primary	0,3	2	4	0.010	100.000
332	V Bus Primary	0,3	2	4	0.010	100.000
333	V Line Secondary	0,3	2	4	10.000	1.000
334	V Bus Secondary	0,3	2	4	10.000	1.000
335	V Line Max	0,3	2	4	0.010	100.000
336	V Bus Max	0,3	2	4	0.010	100.000

5.4 Additional Settings

The following relay settings are provided for configuration of the DNP 3.0 implementation when available and are common to all ports using this protocol.

Setting Name	Range/Options	Default	Setting	Notes
Unsolicited Mode	DISABLED, ENABLED	DISABLED	As Required	Setting is only visible when any port Protocol is set to DNP3.
Destination Address	0 - 65534	0	As Required	Setting is only visible when DNP3 Unsolicited Events set to Enabled.
DNP3 Application Timeout	5, 6 ... 299, 300	10s	As Required	Setting is only visible when any port Protocol is set to DNP3.

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6. Not Applicable

This section intentionally left blank.

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7. IEC61850 Protocol Support

7.1 Introduction

The relay can optionally be provided with IEC61850 comms.

For further details refer to the following publications:

- Model Implementation Conformance Statement (MICS)
- Protocol Implementation Conformance Statement (PICS)
- Protocol Implementation Extra Information for Testing (PIXIT)

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8. Serial Modems

8.1 Introduction

The communications interface has been designed to allow data transfer via modems. A suitable Modem can be connected directly to the Relay's serial interface, for example RS232, RS485 or fibre-optic port where fitted.

8.2 Connecting a Modem to the Relay(s)

RS232C defines devices as being either Data Terminal Equipment (DTE) e.g. computers, or data Communications Equipment (DCE), e.g. modems, where one is designed to be connected to the other.

The optional RS232 port of the Relay is wired as a DTE device and can therefore be connected directly to a Modem.

The 7XV5652 RS232 fibre-optic converter is wired as a DCE device, the same as a Modem. Where two DCE devices e.g. the modem and the fibre-optic converter are being connected together a null terminal connector is required which switches various control lines. The fibre-optic converter is then connected to the relay Network Tx to Relay Rx and Network Rx to Relay Tx.

8.3 Setting the Remote Modem

The exact settings of the modem are dependent on the type of modem. Although most modems support the basic Hayes “AT” command format, different manufacturers use different commands for the same functions. In addition, some modems use DIP switches to set parameters, others are entirely software configured.

Before applying settings, the modem's factory default settings should be applied, to ensure it is in a known state.

Several factors must be considered to allow remote dialling to the relays. The first is that the modem at the remote end must be configured as auto answer. This will allow it to initiate communications with the relays. Next, the user should set the data configuration at the local port, i.e. baud rate and parity, so that communication will be at the same rate and format as that set on the relay and the error correction is disabled.

Auto-answer usually requires two parameters to be set. The auto-answer setting should be switched on and the number of rings after which it will answer. The Data Terminal Ready (DTR) settings should be forced on. This tells the modem that the device connected to it is ready to receive data.

The parameters of the modem's RS232C port are set to match those set on the relay, set baud rate and parity to be the same as the settings on the relay and number of data bits to be 8 and stop bits 1. Note, although the device may be able to communicate with the modem at, for example, 19200 bps, the modem may only be able to transmit over the telephone lines at 14400 bps. Therefore, a baud rate setting on which the modem can transmit should be chosen. In the above example, a baud rate of 9600 should be chosen.

As the modems are required to be transparent, simply passing on the data sent from the controller to the device and vice versa, error correction and buffering is turned off.

Finally, the settings selected for configuration should be stored in the modem's memory for power on defaults.

8.4 Connecting to the Remote Modem

Once the remote modem has been configured correctly, it should be possible to make connection to the relay.

Where a “dial-up” modem system is installed the settings on the remote modem are fixed so the local modem should negotiate with it on connection, choosing suitable matching settings. Where this is not possible the local modem should be set with settings equivalent to those of the remote modem as described above.

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9. Configuration

The data points and control features which are possible within the relay is fixed and can be transmitted over the communication channel(s) protocols in the default format described earlier in this document. The default data transmitted is not always directly compatible with the needs of the substation control system and will require some tailoring; this can be done by the user with the Reydisp software Communications Editor tool.

The Communications Editor is provided to allow its users to configure the Communication Protocol's Files in Reyrolle brand Relays manufactured by Siemens Protection Devices Limited (SPDL).

The editor supports configuring DNP3, IEC60870-5-103, IEC60870-5-101 and MODBUS protocols.

The editor allows configuration files to be retrieved from the relay, edited, and then uploaded back to the relay. Files may also be saved to and loaded from disc to work offline. The protocols will be stored in a Reyrolle Protection Device Comms file (RPDC), which will be stored locally, so that the editor can be used when the relay is not connected.

DNP3

The tool will allow:

- Data Points to be enabled or disabled.
- Changing the point numbers for the Binary Inputs, Double Bit Inputs, Binary Outputs, Counters and Analogue Inputs.
- Changing their assigned class and static and event variants.
- Specifying inclusion in a Class 0 poll.
- Setting Binary points to be inverted before transmission.
- Setting the Control Relay Output Block (CROB) commands that can be used with a Binary Output (Object 12).
- Specifying a dead-band outside which Analogue Events will be generated.
- Specifying a multiplier that will be applied to an analogue value before transmission.
- Configuring a Counter's respective Frozen Counter.

IEC60870-5-103

The tool will allow:

- Data Points to be enabled or disabled.
- Changing the point numbers Function Type (FUN) and Information (INF), returned by each point.
- Changing the text returned to Reydisp for display in its event viewer.

MODBUS

Note, as MODBUS points are polled they do not need to be enabled or disabled.

The tool will allow:

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- Changing the Addresses for the Coils, Inputs and Registers.
- Changing the format of the instrument returned in a register, e.g. 16 or 32 bit.
- Specifying a multiplier that will be applied to an analogue value before transmission.

The user can check if the relay contains user configured communication files via a meter in the relay menus. Pressing the Enter and down arrow buttons on the fascia, then scrolling down, the number of files stored in the relay is displayed. The file name can also be viewed by pressing the Cancel and Test/Reset buttons together when in the relay Instruments menu. The user must ensure when naming the file, they use a unique file name including the version number.

Please refer to the Communications Editor User Guide for further guidance.

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10. Glossary

Baud Rate
Data transmission speed.

Bit
The smallest measure of computer data.

Bits Per Second (bps)
Measurement of data transmission speed.

Data Bits
A number of bits containing the data. Sent after the start bit.

Data Echo
When connecting relays in an optical ring architecture, the data must be passed from one relay to the next, therefore when connecting in this method all relays must have the Data Echo ON.

EN100
Siemens' Ethernet communications module supporting IEC61850, available in optical and electrical versions.

Ethernet
A computer networking technology.

Full-Duplex Asynchronous Communications
Communications in two directions simultaneously.

Half-Duplex Asynchronous Communications
Communications in two directions, but only one at a time.

Hayes “AT”
Modem command set developed by Hayes Microcomputer products, Inc.

LAN
Local Area Network. A computer network covering a small geographic area.

LC
Fibre optic connector type designed by Lucent Technologies, Inc.

Line Idle
Determines when the device is not communicating if the idle state transmits light.

Modem
MOdulator / DEModulator device for connecting computer equipment to a telephone line.

Parity
Method of error checking by counting the value of the bits in a sequence, and adding a parity bit to make the outcome, for example, even.

Parity Bit
Bit used for implementing parity checking. Sent after the data bits.

RS232C
Serial Communications Standard. Electronic Industries Association Recommended Standard Number 232, Revision C.

RS485
Serial Communications Standard. Electronic Industries Association Recommended Standard Number 485.

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Start Bit
Bit (logical 0) sent to signify the start of a byte during data transmission.

Stop Bit
Bit (logical 1) sent to signify the end.

USB
Universal Serial Bus standard for the transfer of data.

WAN
Wide Area Network. A computer network covering a large geographic area.

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Appendix 1

The operating mode of the device is set via the setting, or through a command sent to a communications port. There are four options; **Local**, **Remote**, **Local or Remote** and **Service**.

The following table illustrates whether a function is Enabled (✔) or Disabled (✘) in each mode.

Function	Operation Mode		
	Local	Remote	Service
Control			
Com1	✔ when Com1-Mode = Local	✔ when Com1-Mode = Remote	✘
Com2 (USB)	✔ when Com2-Mode = Local	✔ when Com2-Mode = Remote	✘
Fascia (Control Mode)	✔	✘	✘
Binary Input (n)	✔ when BI (n) Mode = Local	✔ when BI (n) Mode = Remote	✔
Binary Outputs	✔	✔	✘
Reporting			
Spontaneous			
IEC	✔	✔	✘
DNP3	✔	✔	✘
General Interrogation			
IEC	✔	✔	✘
DNP3	✔	✔	✘
MODBUS	✔	✔	✔
Change Settings			
Com1	✔ when Com1-Mode = Local	✔ when Com1-Mode = Remote	✔
Com2 (USB)	✔ when Com2-Mode = Local	✔ when Com2-Mode = Remote	✔
Fascia	✔	✔	✔
Historical Information			
Waveform Records	✔	✔	✔
Event Records	✔	✔	✔
Fault Information	✔	✔	✔
Setting Information	✔	✔	✔

Fig. A1 Operating Mode Table

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Template Revision 16.

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7SR157

Check and System Synchronising Relay

Installation Guide

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

2023/02	Symbols list added page 5
2018/07	Addition of Disposal information
2016/11	E6 case IEC61850 models introduced
2014	First Issue

Software Revision History

Date	Software Reference	Summary
2016/11	2436H80010R4e-2a	IEC61850 variants added
2014	2436H80010R2f-1a	First Release

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Section 1: Installation

1.1 Packaging

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

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

1.2 Unpacking, Storage and Handling

On receipt remove the relay from the container in which it was received and inspect it for obvious damage. It is recommended that the relay not be removed from its case.

If damage has been sustained a claim should be immediately be made against the carrier, also inform Siemens Protection Devices Limited, and the nearest Siemens agent.

When not required for immediate use, Relays should be stored in their original packaging. The place of storage should be dry and free from dust. It should also not exceed the storage temperature and humidity limits of the relay, given in the Performance Specification of this manual.

The relay contains static sensitive devices, which are susceptible to damage due to static discharge. The relay's electronic circuits are protected from damage by static discharge when the relay is housed in its case.

The relay element should not be withdrawn or reinserted into the relay case while auxiliary voltage is present.

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

1.3 Selection of Used Symbols on the Device

No.	Symbol	Description
1		Direct current, IEC 60417, 5031
2		Alternating current, IEC 60417, 5032
3		Direct and alternating current, IEC 60417, 5033
4		Earth (ground) terminal, IEC 60417, 5017
5		Protective conductor terminal, IEC 60417, 5019
6		Caution, risk of electric shock
7		Caution, risk of danger, ISO 7000, 0434
8		Guideline 2002/96/EC for electrical and electronic devices
9	EAC	Guideline for the Eurasian market
10		AC 2 kV insulation test of reset coil, trip coil, and output contacts
11		5 kV impulse voltage test (type test) in compliance with class III

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12		ESD-sensitive devices
13		CE marking
14		Mandatory conformity mark for electronics and electrotechnical products in Morocco
15		South Korea KC certification for electrical and electronic products
16		United Kingdom (UK) conformity-assessed marking
17		TSI chassis earth (ground) symbol, IEC 60417, 5020

1.4 Recommended Mounting Position

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

The relay should be mounted to allow the operator the best access to the relay functions.

1.5 Wiring

The product should be wired according to the scheme requirements, with reference to the appropriate wiring diagram.

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

1.6 Earthing

Terminal 28 of the PSU (Power Supply Unit) should be solidly earthed by a direct connection to the panel earth. The relay case earth stud connection should be connected to terminal 28 of the PSU.

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

1.7 Ancillary Equipment

The relay can be interrogated locally or remotely. For local interrogation a portable PC with a minimum of MS Windows XP (with SP3 installed) and Reydisp Evolution software can be used. This uses USB port (Com 2) situated on front of the relay.

The latest version of Reydisp is available as a free for download from our website.

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1.8 Disposal

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

1.8.1 ENVIRONMENTAL PROTECTION HINTS

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

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



The crossed-out wheelie bin on the products, packaging and/or accompanying documents means that used electrical and electronic products and batteries must not be mixed with normal household waste.
According to national legislation, penalties may be charged for incorrect disposal of such waste.

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

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

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

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

REACH/RoHS Declaration

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

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

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

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

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Section 2: Equipment Operating Conditions

2.1 External Resistors



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

2.2 Front Cover



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

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Section 3: Dimension and Panel Fixings

3.1 Relay Dimensions and Weight

Relays are supplied in the modular size E4 case.
The following drawing gives panel cut-out and mounting details:

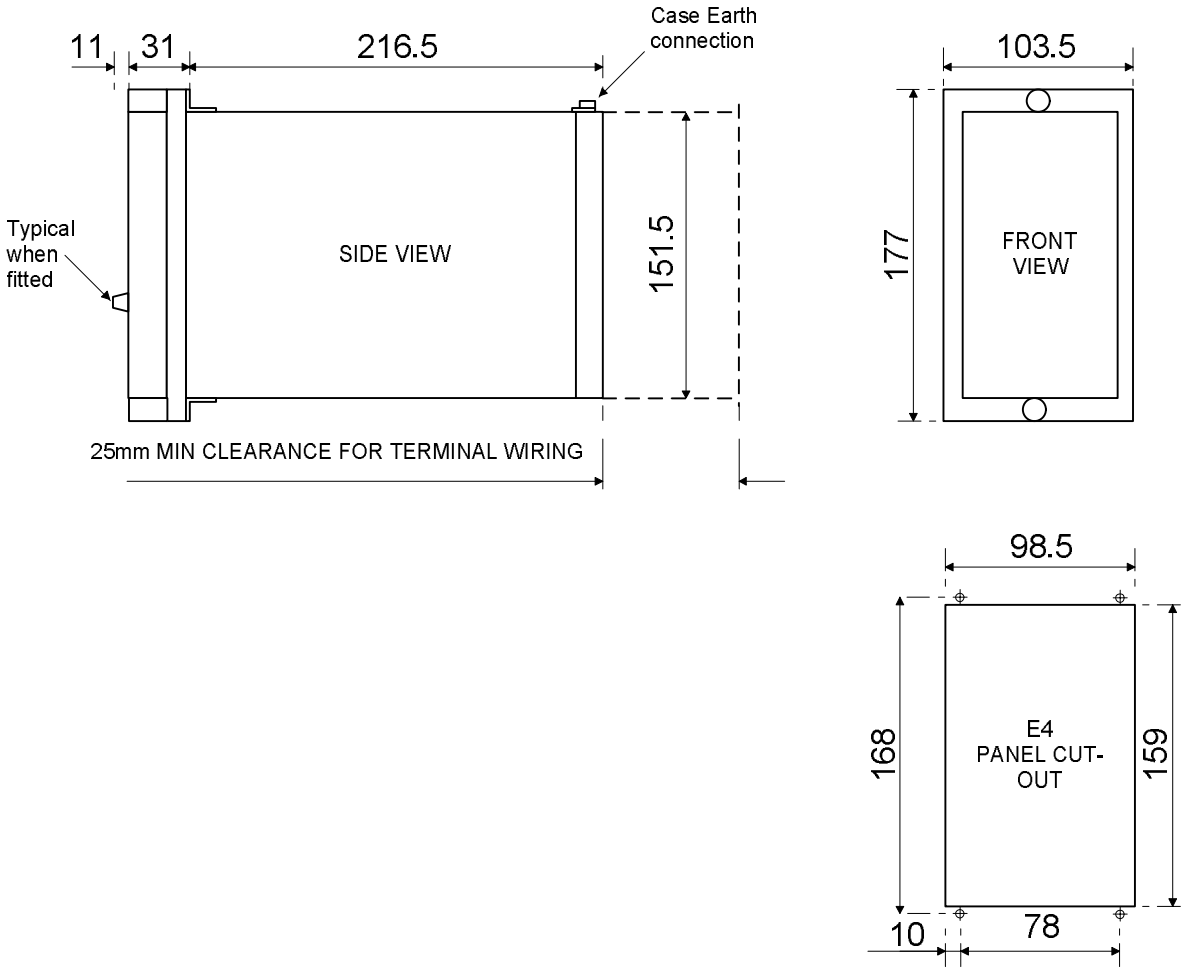
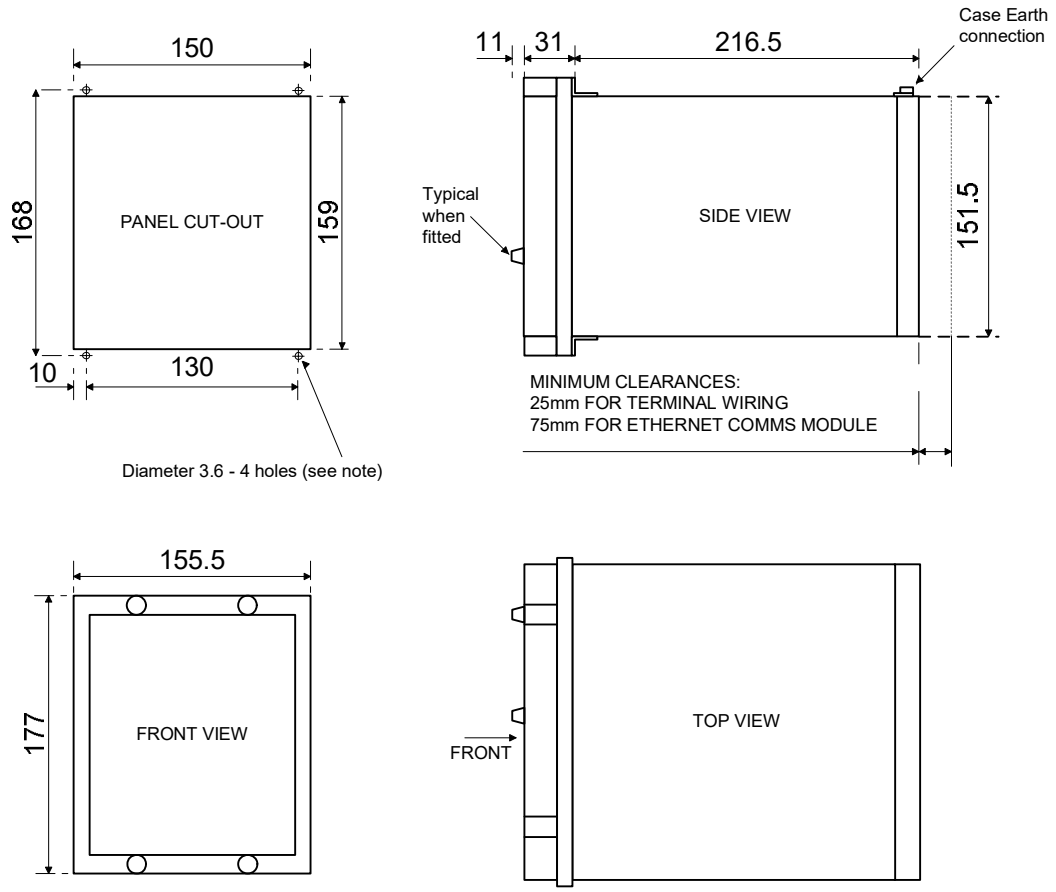


Figure 3-1 Dimensions and Panel Drilling for Size E4 Epsilon Case



NOTE:
THE 3.6 HOLES ARE FOR M4 THREAD FORMING (TRILOBULAR) SCREWS. THESE ARE SUPPLIED AS STANDARD AND ARE SUITABLE FOR USE IN FERROUS / ALUMINIUM PANELS 1.6mm THICK AND ABOVE. FOR OTHER PANELS, HOLES TO BE M4 CLEARANCE (TYPICALLY 4.5 DIAMETER) AND RELAYS MOUNTED USING M4 MACHINE SCREWS, NUTS AND LOCKWASHERS (SUPPLIED IN PANEL FIXING KIT).

Figure 3-2 Dimensions and Panel Drilling for Size E6 Epsilon Case

Hardware Model	Net Weight Kg
7SR157 E4 Case	2.7
7SR157 E6 Case	3.65

Additional Transport packaging: add 0.4kg

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3.2 Fixings

3.2.1 CRIMPS

Ring tongued crimps with 90˚ bend are recommended.

3.2.2 PANEL FIXINGS

Typical mounting screw kit per Relay comprises:

- 4 off M4x10mm Screws
- 4 off M4 Nuts
- 4 off M4 Lock Washer

Typical rear terminal block fixing kit (1kit per terminal block fitted to relay) comprises:

- 28 off M4, 8mm Screws
- 28 off M4 Lock Washer

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Section 4: Rear Terminal Drawings

4.1 E4 Case



Figure 4-1 E4 Case viewed from rear



Figure 4-2 E6 Case viewed from rear

Notes

1) Recommended terminations are pre-insulated and must be crimped using approved tooling.

2) RS485 (Block B Terminals: 14, 16, 18, 20) - connection to this communication facility is by screened, twisted pair cable. On site when wiring other facilities, ensure that these terminals are not obscured by other wiring runs. Cable should be RS485 compliant.

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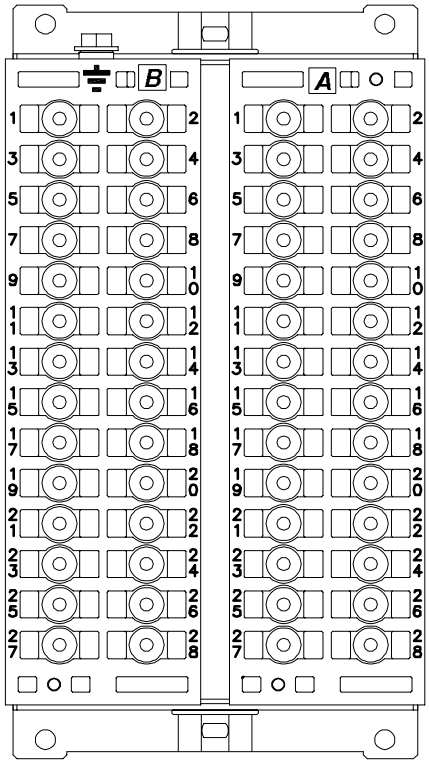


Figure 4-3 E4 Case Terminal Arrangement viewed from rear

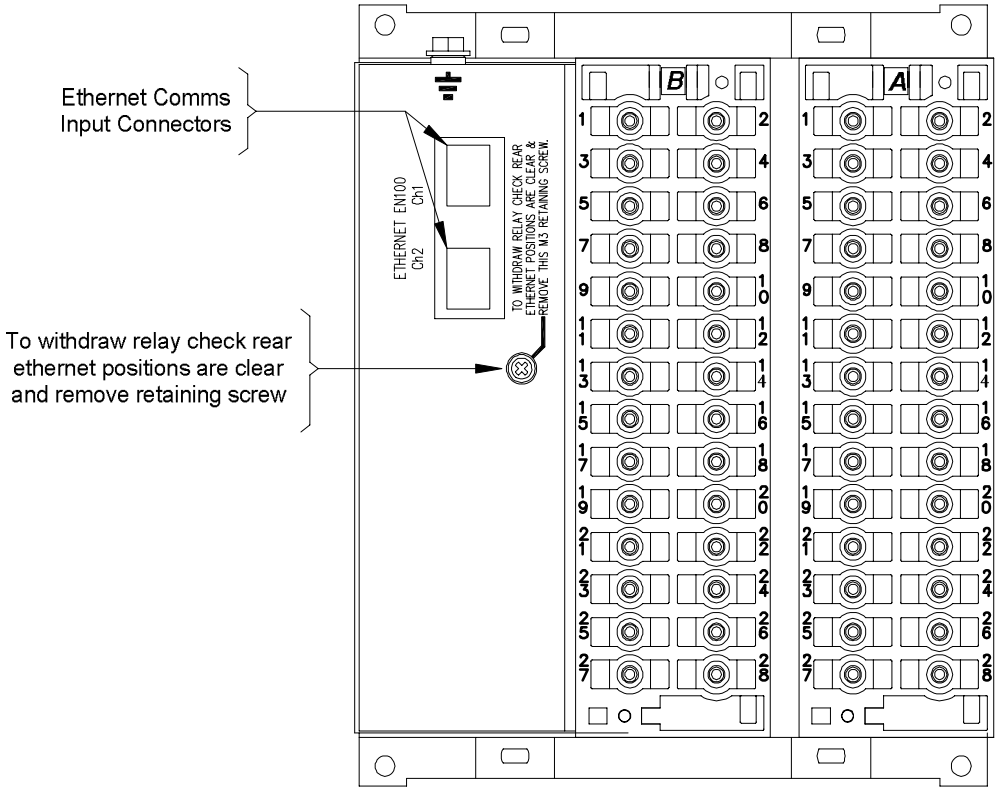


Figure 4-4 E6 Case Terminal Arrangement viewed from rear

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Section 5: Connection/Wiring/Diagrams

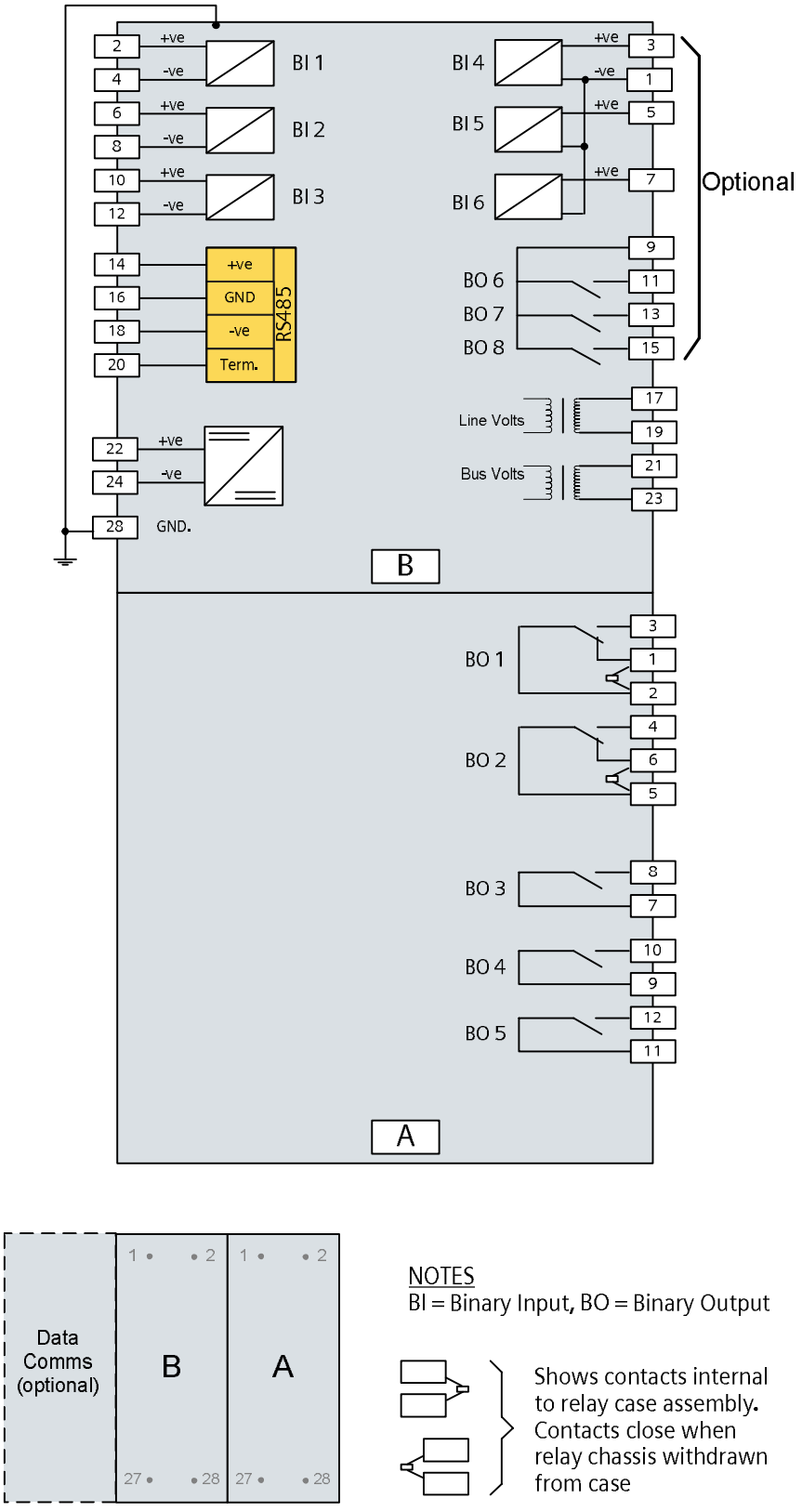
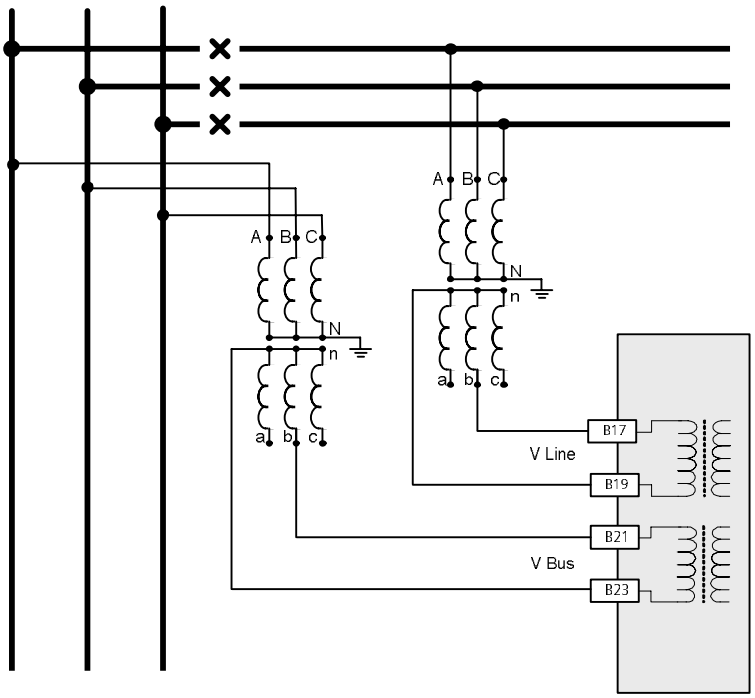
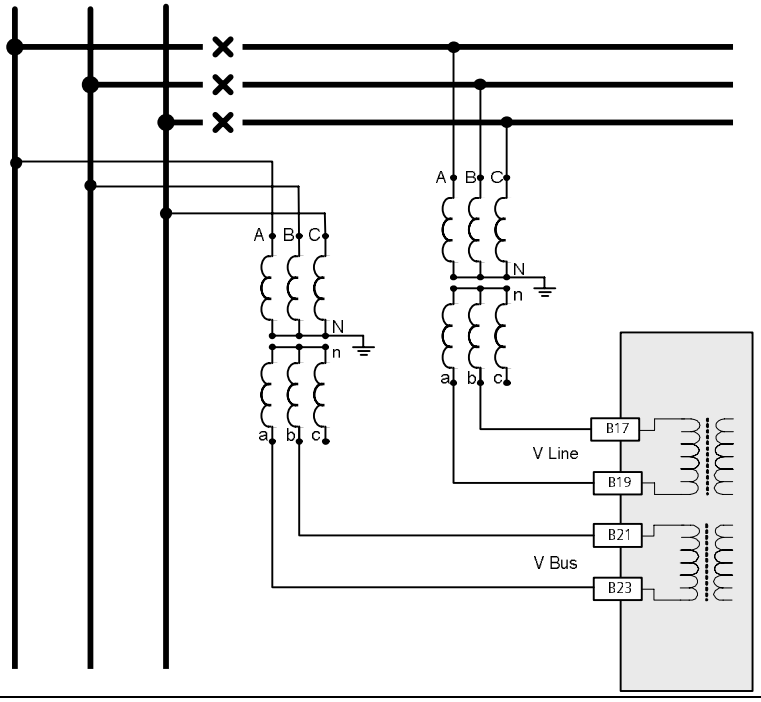


Figure 5-1 7SR157 Connection diagram

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5.1 Voltage Transformer Configurations

Relay Voltage Configuration	Description	Connection
Vbn line, Vbn bus,	25 Check Sync, 60 VTF	
Vab line, Vab bus,	25 Check Sync, 60 VTF	

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Section 6: Data Communications Connections

6.1 RS485 Connection

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

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

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

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

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

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

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

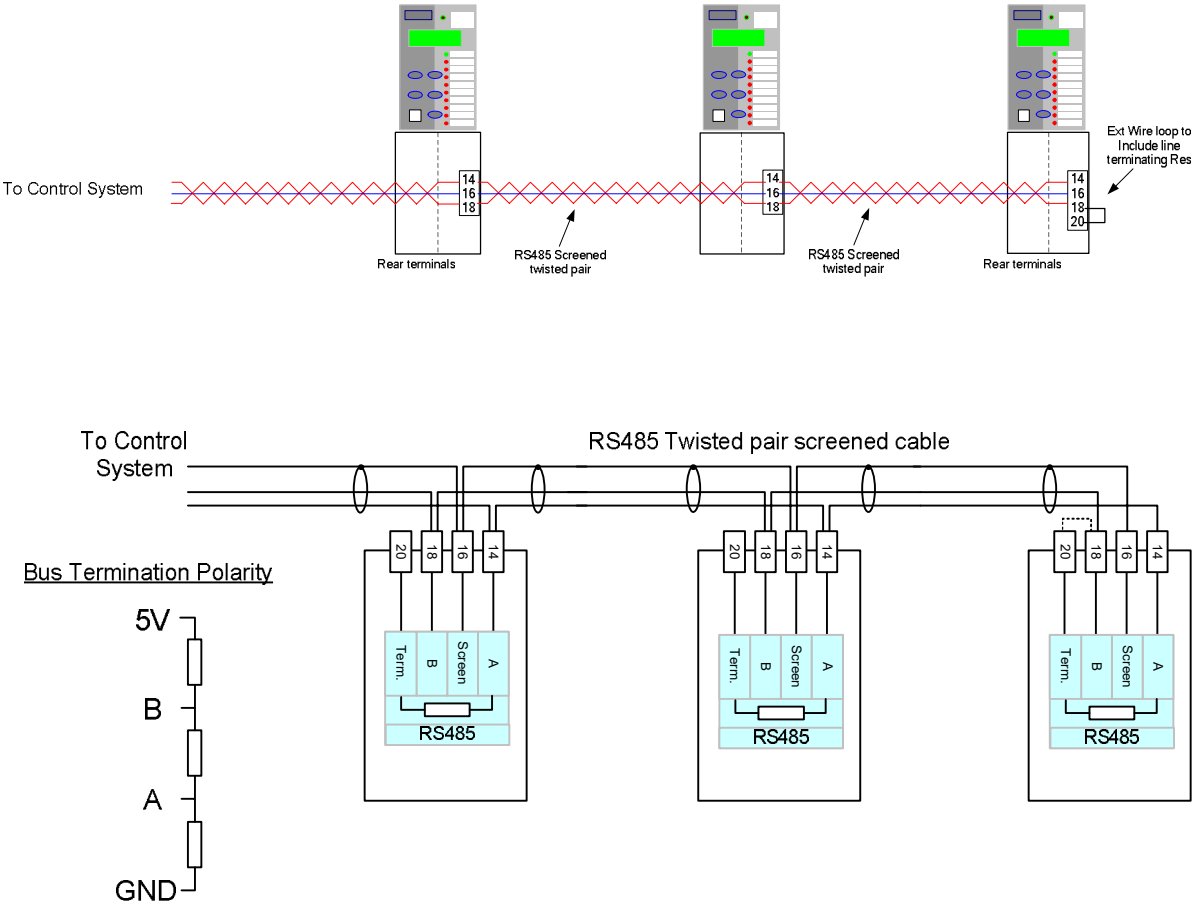


Figure 6-1 RS485 Data Communications connections between relays

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6.2 Additional (Optional) Ethernet Connection for IEC 61850

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

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

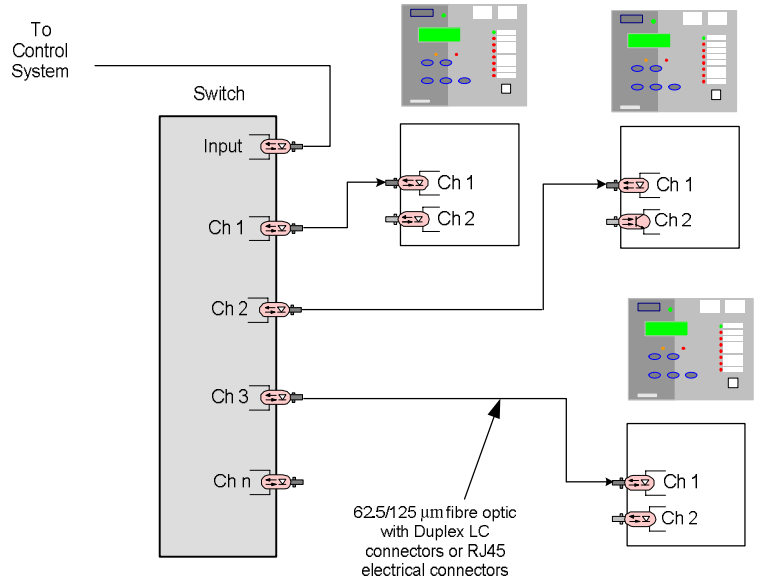


Figure: 6.2-1 Ethernet connection for IEC 61850 (star connection)

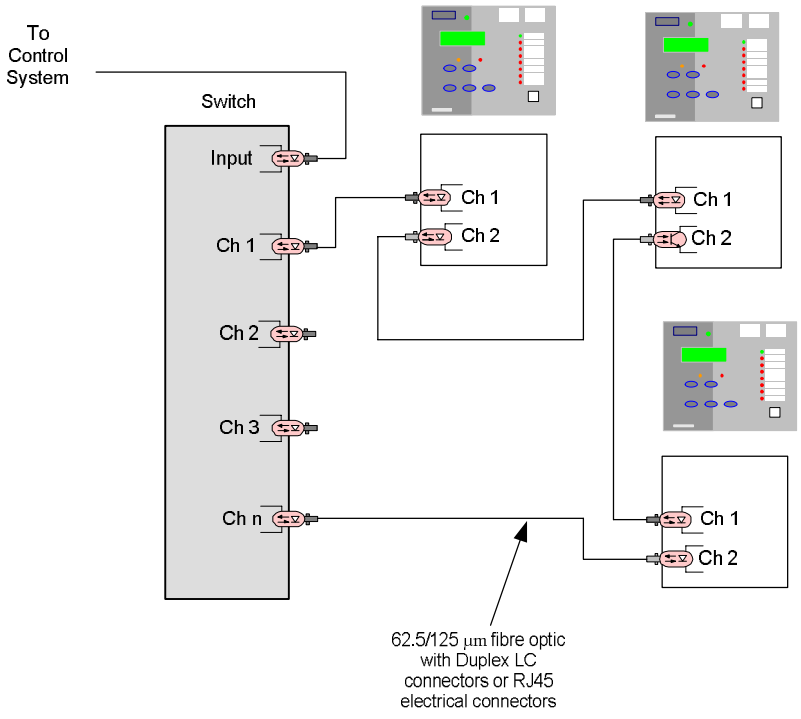


Figure: 6.2-2 Ethernet connection for IEC 61850 (ring connection)

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6.3 Ethernet Network Redundancy IEC 61850

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

All 7SR157 IEC61850 variants are delivered with the EN100+ (Plus) module and firmware 4.27 or later. The earlier EN100 (standard) modules are not used in the 7SR157.

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

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

Table 1: EN100 Redundancy availability

6.3.1 RSTP – Rapid Spanning Tree Protocol

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

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

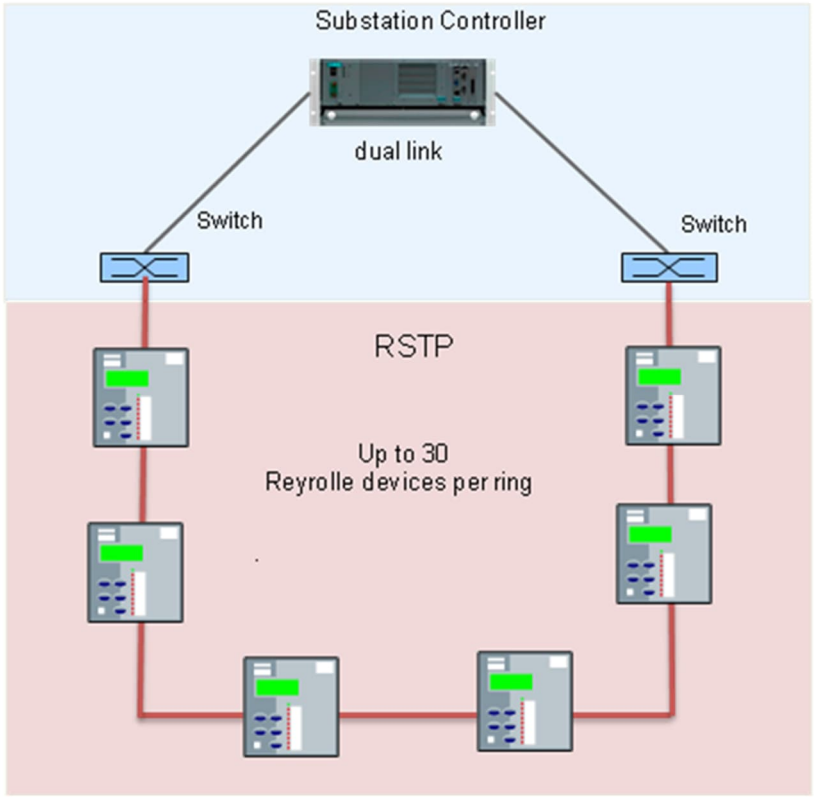


Figure: 6.3-1 RSTP Ethernet Network Ring Configuration

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6.3.2 PRP – PARALLEL REDUNDANCY PROTOCOL

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

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

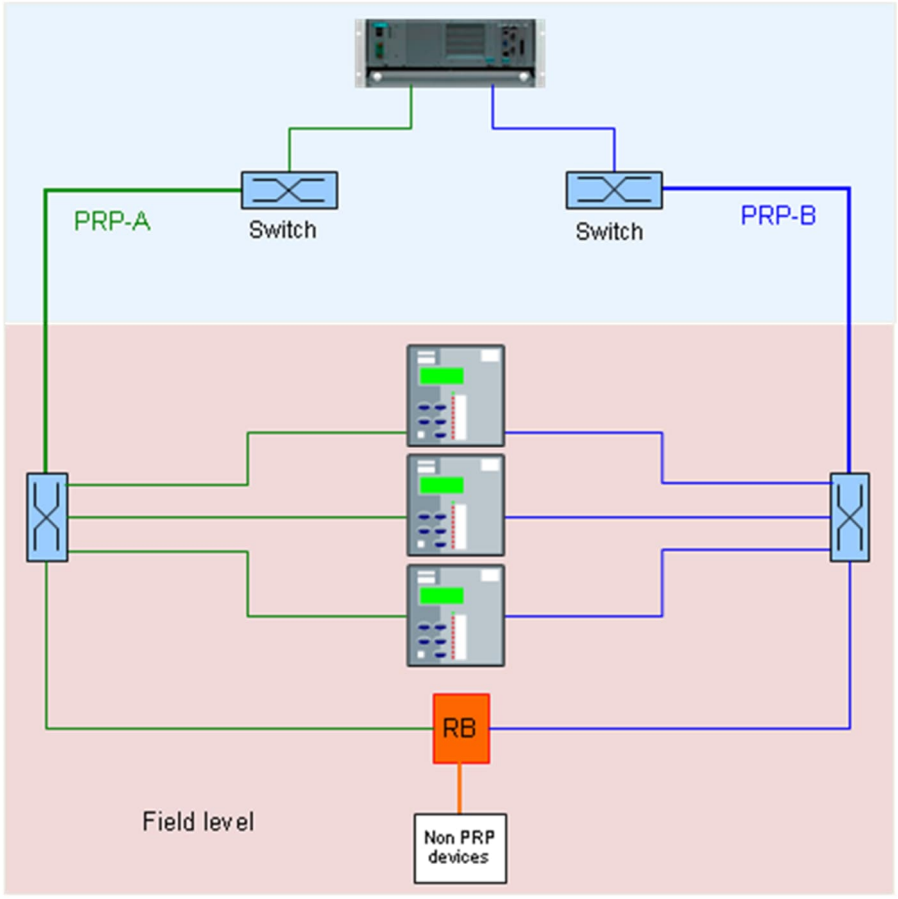


Figure: 6.3-2 PRP Ethernet Network Configuration

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6.3.3 HSR – HIGH AVAILABILITY SEAMLESS REDUNDANCY PROTOCOL

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

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

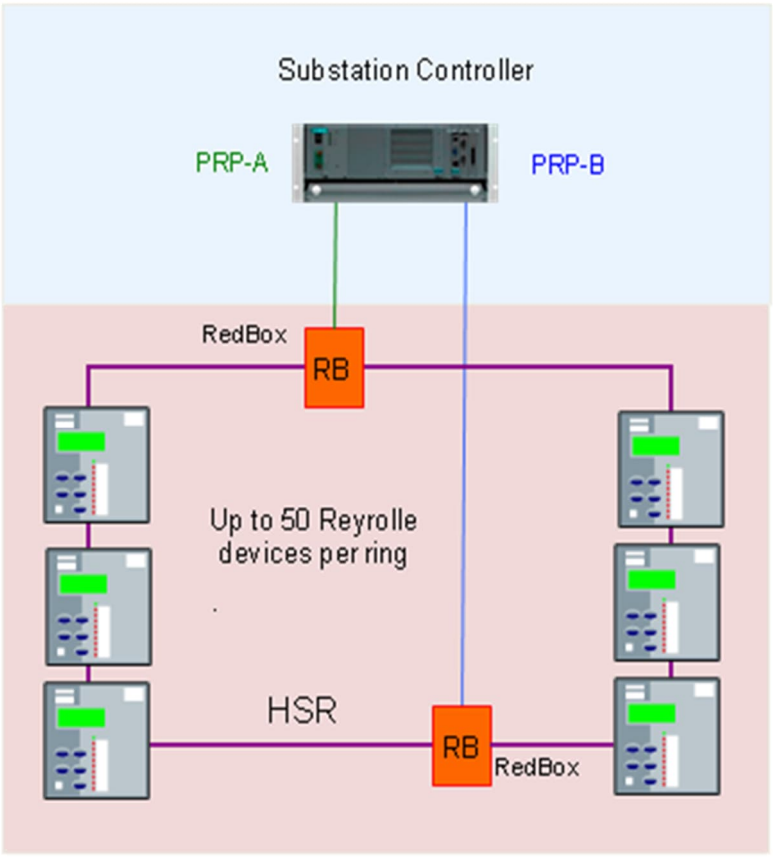


Figure: 6.3-3 HSR Ethernet Network Ring Configuration

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7SR157

Check and System Synchronising Relay

Commissioning and Maintenance Guide

Document Release History

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2016/10	Software revision removed from front page
2014	First Issue

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Section 1: Common Functions

1.1 Overview

Commissioning tests are carried out to prove:

a) Equipment has not been damaged in transit.

b) Equipment has been correctly connected and installed.

c) Characteristics of the control and settings which are based on calculations.

d) Confirm that settings have been correctly applied.

e) To obtain a set of test results for future reference.

1.2 Before Testing

1.2.1 Safety

The commissioning and maintenance of this equipment should only be carried out by skilled personnel trained in relay maintenance and capable of observing all the safety precautions and regulations appropriate to this type of equipment and also the associated primary plant.

Ensure that all test equipment and leads have been correctly maintained and are in good condition. It is recommended that all power supplies to test equipment be connected via a Residual Current Device (RCD), which should be located as close to the supply source as possible.

The choice of test instrument and test leads must be appropriate to the application. Fused instrument leads should be used when measurements of power sources are involved, since the selection of an inappropriate range on a multi-range instrument could lead to a dangerous flashover.

1.2.2 Sequence of Tests

If other equipment is to be tested at the same time, then such testing must be co-ordinated to avoid danger to personnel and equipment.

When cabling and wiring is complete, a comprehensive check of all terminations for tightness and compliance with the approved diagrams must be carried out. This can then be followed by the insulation resistance tests, which if satisfactory, allows the wiring to be energised by either the appropriate supply or test supplies.

When primary injection tests are completed satisfactorily, all remaining systems can be functionally tested before the primary circuit is energised. Some circuits may require further tests before being put on load.

Protection relay testing will require access to the protection system wiring diagrams, relay configuration information and protection settings. The following sequence of tests is loosely based on the arrangement of the relay menu structure. A test log based on the actual tests completed should be recorded for each relay tested.

The Description of Operation section of this manual provides detailed information regarding the operation of each function of the relay.

1.2.3 Test Equipment

Required test equipment is:

1. Automated Secondary injection test set with integral time interval meter.
2. Primary injection equipment.
3. A power source with nominal voltage within the working range of the relay's auxiliary supply rating.
4. A power source with nominal voltage within the working range of the relay’s binary input rating.

The secondary injection equipment should be appropriate to the protection functions to be tested. Additional equipment for general tests and for testing the communications channel is:

5. Portable PC with appropriate interface equipment.
6. Printer to operate from the above PC (Optional).

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1.2.4 Use of PC to facilitate testing

The functions of Reydisp Evolution (see Section 2: Settings and Instruments) can be used during the commissioning tests to assist with test procedures or to provide documentation recording the test and test parameters. One method is to clear both the waveform and event records before each test is started. Then, after the test upload from the relay, the settings, events and waveform files generated can then be saved off to retain a comprehensive record of that test.

Relay settings files can be prepared on the PC (offline) or on the relay before testing commences. These settings should be saved for reference and compared with the settings at the end of testing. This is to check that errors have not been introduced during testing and that any temporary changes to settings to suit the test process are returned to the required service state.

A copy of the Relay Settings as a Rich Text Format (.rtf) file, suitable for printing or for record purposes can be produced from Reydisp as follows: from the *File* menu select *Save As,* change the file type to *Export Default/Actual Setting (.RTF)* and input a suitable filename.

When testing is completed, the event and waveform records should be cleared and the settings file checked to ensure that the required in-service settings are being applied.

1.2.5 Precautions

Before electrical testing commences the equipment should be isolated from the voltage transformers. The tripping and alarm circuits should also be isolated where practical. The provision and use of secondary injection test sockets on the panel simplifies the isolation and test procedure.

Ensure that the correct auxiliary supply voltage and polarity is applied. See the relevant scheme diagrams for the relay connections.

1.2.6 Applying Settings

The relay settings for the particular application should be applied before any secondary testing occurs. If they are not available then the relay has default settings that can be used for pre-commissioning tests. See the Relay Settings section of this manual for the default settings.

Note that the tripping and alarm contacts for any function must be programmed correctly before any scheme tests are carried out.

The relay features multiple settings groups, of which only one is active at a time. In applications where more than one settings group is to be used it may be necessary to test the relay in more than one configuration.

Note: one group may be used as a Test group to hold test-only settings that can be used for regular maintenance testing. This eliminates the need for the Test Engineer to interfere with the actual in-service settings in the normally active group. This Test group may also be used for functional testing, where it is necessary to disable or change settings to facilitate testing.

When using settings groups it is important to remember that the relay need not necessarily be operating according to the settings that are currently being displayed. There is an ‘active settings group’ on which the relay operates and an ‘edit/view settings group’ which is visible on the display and which can be altered. This allows the settings in one group to be altered from the relay fascia while the protection continues to operate on a different unaffected group. The ‘Active Settings Group’ and the ‘Edit Settings Group’ are selected in the ‘System Configuration Menu’.

The currently Active Group and the group currently Viewed are shown at the top of the display in the Settings display screen. If the View Group is not shown at the top of the display, this indicates that the setting is common to all groups. CT/VT ratio, I/O mapping and other settings which are directly related to hardware are common to all groups.

If the relay is allowed to trip during testing then the instruments display will be interrupted and replaced by the Trip Alert screen which displays fault data information. If this normal operation interferes with testing then this function can be temporarily disabled for the duration of testing by use of the Trip Alert Enabled/Disabled setting in the System Config Menu.

After applying a settings change to the relay, which may involve a change to the indication and output contacts, the **TEST/RESET** key should be pressed to ensure any existing indication and output is correctly cleared.

1.3 Tests

1.3.1 Inspection

Ensure that all connections are tight and correct to the relay wiring diagram and the scheme diagram. Record any deviations. Check that the relay is correctly programmed and that it is fully inserted into the case. Refer to Section 2: Settings and Instruments for information on programming the relay.

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1.3.2 Secondary Injection Tests

Select the required relay configuration and settings for the application.

Isolate the auxiliary D.C. supplies for alarm and tripping from the relay and remove the trip and intertrip links.

Carry out injection tests for each relay function, as described in this document

1.3.3 Primary Injection Tests

Primary injection tests are essential to check the ratio and polarity of the transformers as well as the secondary wiring.

1.3.4 Putting into Service

After tests have been performed satisfactorily the relay should be put back into service as follows:-

Remove all test connections.

Replace all secondary circuit fuses and links, or close miniature circuit breaker (MCB).

Ensure the Protection Healthy LED is on, steady, and that all LED indications are correct. If necessary press **CANCEL** until the Relay Identifier screen is displayed, then press **TEST/RESET** to reset the indication LEDs.

The relay meters should be checked in Instruments Mode with the relay on load.

The relay settings should be downloaded to a computer and a printout of the settings produced. The installed settings should then be compared against the required settings supplied before testing began. Automated setting comparison can be carried out by Reydisp using the *Compare Settings Groups* function in the *Edit* menu. Any modified settings will be clearly highlighted.

1.4 AC Analogue Energising Quantities

Voltage measurement for each input channel is displayed in the Instrumentation Mode sub-menus. Each input should be checked for correct connection and measurement accuracy by single phase secondary injection at nominal levels. Ensure that the correct instrument, displays the applied signal within limits of the Performance Specification.

		Applied Sec Volts (Vrms)	**Tolerance**	
V Line	Secondary			
	Primary			Line VT Ratio:
V Bus	Secondary			
	Primary			Bus VT Ratio:

Note: Instrument tolerance is: ± 1 % Vn (0.1 x Vn ≤ V ≤ 1.2 x Vn).

1.5 Binary Inputs

The operation of the Binary Input(s) can be monitored on the Binary Input Meters display shown in Instruments Mode. Apply the required voltage onto each binary input in turn and check for correct operation. Depending on the application, each binary input may be programmed to perform a specific function. Each binary should be checked to prove that it's mapping and functionality is as set as part of the Scheme Operation tests.

Where the pick-up timers associated with a binary input are set for DC operation, these delays should be checked either as part of the scheme logic or individually. To check a binary pick-up time delay, temporarily map the binary input to an output relay that has a normally-open contact. This can be achieved in the Output Matrix sub-menu by utilising the *BI n Operated* settings. Use an external timer to measure the interval between Binary Input energisation and closure of the output contacts. Similarly, to measure the drop-off delay, map the Binary Input to an output relay that has a normally-closed contact; time the interval between binary input de-energisation and closure of the output contacts.

The timers are also used to ensure correct operation of Binary Inputs from AC voltage energisation. If a delayed pickup is required, this must be provided by additional Quick Logic configuration. An example is shown in Chapter 7 – Applications Guide.

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Note. The time measured will include an additional delay, typically less than 20ms, due to the response time of the binary input hardware, software processing time and the operate time of the output relay.

BI	Tested	DO Delay	Measured	PU Delay	Measured	Notes (method of initiation)
1						
2						
3						
4						
5						
6						

1.6 Binary Outputs

Either 5 or 8 Binary Output relays are provided, depending upon ordering option. Two of these, BO1 & BO2, have change-over contacts and the remainder have normally open contacts.

Care should be observed with regard to connected devices when forcing contacts to operate for test purposes. Short duration energisation can cause contact failure due to exceeding the break capacity when connected to inductive load such as electrically reset trip relays.

Close each Binary Outputs in turn using the Reydisp Evolution PC programme. This function will energise each output for its set minimum operate time. This time is specified in the Output Config\Binary Output Config sub menu for each output relay and may be set to too short a time to register with a continuity tester. It should therefore be increased to a time suitable for the actual test equipment used.

An alternative method of energising an Binary Output relay permanently, so that wiring can be checked, is to temporarily map the relay being tested to the 'Protection Healthy' signal. As this signal is permanently energised, the particular mapped relay will be permanently held energised. Normally-open contacts will close and, for BO1 and BO2, normally-closed contacts will open.

BO	Checked	Notes (method of test)
1NO		
1NC		
2NO		
2NC		
3		
4		
5		
6		
7		
8		

1.7 Relay Case Shorting Contacts

The terminals of normally closed contacts of Binary outputs 1 & 2 are fitted with case mounted shorting contacts which provide a closed contact when the relay is withdrawn from the case. The operation of these contacts should be checked.

Binary Output 1 terminals 1 & 2 Alarm Checked?	
Binary Output 2 terminals 5 & 6 Alarm Checked?	

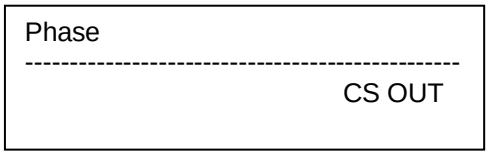
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Section 2: Control Functions

2.1 Phase Angle Tests

The Phase Angle detector algorithm, which is used for both Check and System Sync elements, is best tested using a portable relay test set.

Disable ***25 System Sync***. Enable ***25 Check Sync*** and set the ***25 Check Sync Angle*** to a practical value such as 20°. Apply nominal volts to both the Line and Bus input terminals of the relay and adjust the phase angle between the two voltages to a value greater than ***25 Check Sync Angle***. Using the INSTRUMENTS MODE \ SYNC METERS, scroll down to the Phase screen display:



Slowly decrease the phase angle difference between the Line and Bus voltages and note the value where Phase displays CS In; this is the pick-up value. Slowly increase the phase angle difference and check the drop-off value where Phase displays CS Out. Record the values in the table below. Repeat this test having effectively reversed the angles between Line and Bus.

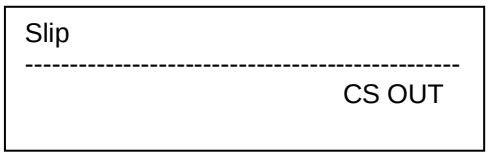
The results should fall within the claims made in the relevant sections of: Chapter 3 - Performance Specification.

	Positive angle		**Negative angle**	
25 Check Sync Angle (°)	**Pick Up (°)**	**Drop Off (°)**	**Pick Up (°)**	**Drop Off (°)**

2.2 Slip Frequency Tests

The Slip Frequency detector algorithm, which is used for both Check and System Sync elements, is more difficult to test as it requires variable frequency sources. A portable relay test set with fixed and variable frequency voltage source output is essential for this.

Disable ***25 System Sync*** and ***25 System Split Detector***. Enable both the ***25 Check Sync*** and ***25 Check Sync Slip Freq*** functions. Set ***25 Check Sync Slip*** to a practical value such as 0.05Hz. Apply nominal volts to both the Line and Bus input terminals of the relay, and adjust the frequency difference between the two to a value greater than the ***25 Check Sync Slip*** setting value. Using the INSTRUMENTS MODE \ SYNC METERS, scroll down to the Slip screen display:



Slowly reduce the frequency difference until the element picks up. Slip should now display CS In. Gradually increase the slip until the element drops off as indicated by CS Out. Repeat this test having effectively reversed the direction of slip between Line and Bus.

The results should fall within the claims made in the relevant sections of: Chapter 3 - Performance Specification.

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	Positive Slip		Negative Slip	
25 Check Sync Slip Freq (Hz)	**Pick Up (Hz)**	**Drop Off (Hz)**	**Pick Up (Hz)**	**Drop Off (Hz)**

2.3 Timer Tests

The timers, ***25 Check Sync Timer*** and ***25 System Sync Timer*** are difficult to test without specialist test equipment and test software. There are two recommended methods:

1. Using an automated secondary injection test set with a software package able to record timing shots, apply out of phase nominal volts to both the Line and Bus input terminals of the relay. Change the phase angle between the two voltages to a value less than ***25 Check Sync Angle.*** The relay will issue a close only after the ***25 Check Sync Timer*** has timed out. A binary output from the relay mapped to **25 Check Sync Close** can be used to provide the stop signal for the automated secondary injection test set.

Note, that the timing shot recorded will be greater than the ***25 Check Sync Timer*** setting. This is due to a delay on the operation of the binary outputs of the relay, a set up delay in the logic of the relay and delays to the input of the automated secondary injection test set. A way to determine the total length of these delays is to set the ***25 Check Sync Timer*** to 0.00s and record the delay time. This delay time should then be subtracted from the time recorded when the ***25 Check Sync Timer*** is greater than 0.00s.

2. Using Reydisp Evolution software the event records will give accurate times for all of the timing events within the relay.

Set the ***25 Check Sync Timer*** to 0.00s. Apply in phase nominal volts to both the Line and Bus input terminals of the relay. Wait for the ***25 Check Sync Timer*** to time out and a **25 Check Sync Close** output to be raised.

Change the ***25 Check Sync Timer*** to a value greater than 0.00s, for example 1.00s.

The following events were extracted from a relay with the ***Check Sync Timer*** initially set to 0.00s. It can be seen that there is a 0.32s delay time between the in-phase nominal volts being applied to the relay and **25 Check Sync** being raised. The settings are then changed to give a ***Check Sync Timer*** value of 1.00s. It can be seen that there is a 1.33s recorded time between the in-phase nominal volts being applied to the relay and **25 Check Sync** being raised. This shows that the actual time is 1.01s.

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The results should fall within the claims made in the relevant sections of: Chapter 3 - Performance Specification.

00:28:30.170,22/01/2000	183	Raised	25 Live Line
	183	Raised	25 Live Bus
	183	Cleared	25 Line U/V
	183	Cleared	25 Bus U/V
00:28:30.200,22/01/2000	183	Raised	25 CS In Progress
00:28:30.520,22/01/2000	80	Raised	Binary Output 3
	90	Raised	LED 1
	183	Raised	25 In Sync
	183	Raised	25 Check Sync
	60	Raised	Trigger Storage
00:28:44.875,22/01/2000	160	Raised	Settings changed
00:28:52.375,22/01/2000	183	Raised	25 Live Line
	183	Raised	25 Live Bus
	183	Cleared	25 Line U/V
	183	Cleared	25 Bus U/V
00:28:52.395,22/01/2000	183	Raised	25 CS In Progress
00:28:53.725,22/01/2000	80	Raised	Binary Output 3
	90	Raised	LED 1
	183	Raised	25 In Sync
	183	Raised	25 Check Sync
	60	Raised	Trigger Storage

25 Check Sync Timer Setting (sec)	**Recorded Delay Time (sec)**	**Recorded Time (sec)**	**Actual Time [Recorded Time – Recorded Delay Time] (sec)**
25 System Sync Timer Setting (sec)			

Repeat the test for a range of ***Check and System Sync Timer*** settings.

2.4 Voltage Level Detector Tests

To check the pick-up and drop-off levels for both ***VT Level Modes*** (***2 State*** and ***3 State***):

Apply nominal voltage to both the Line and Bus input terminals of the relay. Examine the Line/Bus Status instrument (found in the SYNC METERS instrument) and check for operation of the elements as shown below:

```
Line/Bus Status
------------------------------------------------
                                          DL,DB
```

Individually ramp up and down the Line and Bus voltages to values above and below the ***25 Dead Line***, ***25 Live Line***, ***25 Dead Bus*** and ***25 Dead Bus*** settings.

All results should fall within the claims made in the relevant sections of: Chapter 3 - Performance Specification.

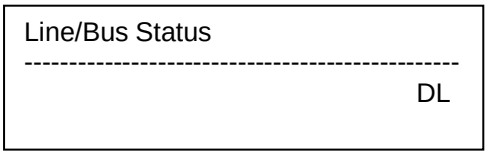
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	Live Level			Dead Level		
2 State Mode	25 Live Line (%)	Pick Up (%)	Drop Off (%)	25 Dead Line (%)	Pick Up (%)	Drop Off (%)
Line						
	25 Live Bus (%)	Pick Up (%)	Drop Off (%)	25 Dead Bus (%)	Pick Up (%)	Drop Off (%)
Bus						

3 State Mode	25 Live Line (%)	Pick Up (%)	Drop Off (%)	25 Dead Line (%)	Pick Up (%)	Drop Off (%)
Line						
	25 Live Bus (%)	Pick Up (%)	Drop Off (%)	25 Dead Bus (%)	Pick Up (%)	Drop Off (%)
Bus						

Notes:

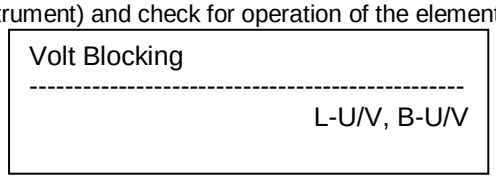
1. ***VT Level Mode** 3 State* has 3% hysteresis on drop-off.
2. For ***VT Level Mode** 3 State,* an example screen showing a Dead Line and indeterminate Bus state is shown below. See Chapter 1 – Description of Operation for a full description of this mode.



2.5 Undervoltage Detector Tests

To check the pick-up and drop-off levels for both ***25 Bus Undervolts*** and ***25 Line Undervolts*** blocking elements:

Apply nominal volts to both the Line and Bus input terminals of the relay. Examine the Volt Blocking instrument (found in the SYNC METERS instrument) and check for operation of the element as shown below:



Individually ramp up and down the Line and Bus voltages to values above and below the ***25 Bus Undervolts*** and ***25 Bus Undervolts*** settings and record the results
All results should fall within the claims made in the relevant sections of: Chapter 3 - Performance Specification.

	Setting (%)	**Pick Up (%)**	**Drop Off (%)**
25 Line Undervolts			
25 Bus Undervolts			

Note: ***25 Bus Undervolts*** and ***25 Line Undervolts*** have 3% hysteresis on drop-off.

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Section 3: Control & Logic Functions

3.1 Quick Logic

If this functionality is used, the logic equations may interfere with testing of other control functions in the relay. The function of the Quick Logic equations should be tested conjunctively with connected plant or by simulation to assess suitability and check for correct operation on an individual basis with tests specifically devised to suit the particular application.

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Section 4: Testing and Maintenance

The relays are maintenance free, with no user serviceable parts.

4.1 Periodic Tests

During the life of the relay, it should be checked for operation during the normal maintenance period for the site on which the product is installed. It is recommended the following tests are carried out:

1. Visual inspection of the metering display.
2. Operation of output contacts.
3. Secondary injection of each element.

4.2 Maintenance

Relay failure will be indicated by the Protection Healthy LED being off or flashing. A message may also be displayed on the LCD. In the event of failure, Siemens Protection Devices Ltd. (or one of its agents), should be contacted.

The relay should be returned as a complete unit. No attempt should be made to disassemble the unit to isolate and return only the damaged sub-assembly. It may however be convenient to fit the withdrawable relay to the outer case from a spare relay, to avoid the disturbance of relay panel wiring, for return to Siemens Protection Devices Ltd. The withdrawn relay should never be transported without the protection of the outer case.

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4.3 Troubleshooting

Observation	Action
Relay does not power up.	Check that the correct auxiliary AC or DC voltage is applied and that the polarity is correct.
Relay won't accept the password.	The Password being entered is wrong. Enter correct password. If correct password has been forgotten, note down the Numeric Code which is displayed at the Change Password screen e.g. Active G1 ---------- Setting Password Code = 340701675 To retrieve the password, communicate this code to a Siemens Protection Devices Ltd. representative.
Protection Healthy LED flashes	General failure. Contact a Siemens Protection Devices Ltd. representative.
LCD screen flashes continuously.	The LCD has many possible error messages which when displayed will flash continuously. These indicate various processor card faults. General failure. Contact a Siemens Protection Devices Ltd. representative.
Backlight is on but no text can be seen.	Adjust the contrast.
Scrolling text messages are unreadable.	Adjust the contrast.
Relay displays one instrument after another with no user intervention.	This is normal operation, default instruments are enabled. Remove all instruments from the default list and only add those that are required. (See Section 2: Settings and Instruments of this manual).
Cannot communicate with the relay.	Check that all of the communications settings match those used by Reydisp Evolution. Check that all cables, modems and fibre-optic cables work correctly. Ensure that IEC60870-5-103 is specified for the connected port (COM1 or COM2).
Relays will not communicate in a ring network.	Check that all relays are powered up. Check that all relays have unique addresses.
Binary Inputs do not work.	Check that the correct DC voltage is applied and that the polarity is correct. Check that the Binary Input settings such as the pick-up and drop-off delays and the Inverted Input function are correctly set.
Relay instrument displays show small currents or voltages even though the system is dead.	This is normal. The relay is displaying calculation noise. This will not affect any accuracy claims for the relay.

If the above checklist does not help in correcting the problem please contact the local Siemens office or contact PTD 24hr Customer Support: Tel: +49 180 524 7000. Fax: +49 180 524 2471 or email: support.energy@siemens.com.

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7SR157

Check and System Synchronising Relay

Applications Guide

Document Release History

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2016/10	Software revision removed from front page
2014	First issue

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Section 1: Introduction

The 7SR157 is a combined check and system synchronising relay which can automatically select check or system synchronise, as appropriate, from measurements of the relative phase angles between the line and bus voltages. The relay will prevent closure of the circuit breaker if the phase angle, slip frequency or the voltage magnitudes of the incoming and running voltages fall outside prescribed limits.

If these calculated quantities are within the relays' setting limits the relay will issue an output which can be used to close the circuit breaker directly or in conjunction with an autoreclose scheme. Both the check and system synchronise functions have independent settings and blocking features. The relay also includes split system detection with a variable time delay, which can be used for blocking purposes within delayed autoreclose (DAR) schemes.

Synchronising bypass logic is provided to connect a dead line or bus to a live line or bus. For manual synchronising the relay includes a circuit breaker close guard feature which is used to alarm if the control switch is being held closed during a synchronising operation. This feature is implemented using internal logic and removes the need for an external guard relay.

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Section 2: Control Functions

2.1 Synchronising Enable Modes

The 7SR157 relay has been designed to conform to NGTS 3.7.7 and therefore must be able to be set up as a check synchronising relay, for applications such as manually bringing a generator online and also as a check and system synchronising relay for applications where two power systems are to be connected. The following examples show various ways that the relay can be enabled for these different applications.

The ***25 Check Sync*** and ***25 System Sync*** functions each have independent enable modes. If the requirement is for the relay to be used as a check for manually synchronising a generator for example, then ***25 System Sync*** is not required.

1. Set ***25 Check Sync Enable*** to **MANUAL** (or **AUTO**)

   Set ***25 System Sync Enable*** to **Disabled**

   Set ***25 Close On Zero*** to **Disabled**

Setting the ***25 System Sync Enable*** to **Disabled** and the ***25 Close On Zero*** to **Disabled** will ensure that the relay will only give a **25 Check Sync Close output**. The relay will continue to issue a **25 Check Sync Close output** if the power system conditions fall within the relay setting parameters.

If the requirement is for a check and system synchronising scheme where a lockout of the relay is required if the system splits, then:

2. Set ***25 Check Sync Enable*** to **MANUAL** (or **AUTO**)

   Set ***25 System Split Detector*** to **Enabled**

   Set ***25 System Split Mode*** to **Phase**

   Set ***25 Split Angle*** to a suitable angle e.g. **170°**

   Set ***System Sync Enable*** to **LOCKOUT**

   Set ***25 Close On Zero*** to **Disabled**

This will ensure that if the power system splits the relay will not go into system synchronising mode but revert to lockout mode. The relay will at this point issue a **System Split Lockout** output.

If the requirement is for a check and system synchronising scheme where system synchronising is required if the system splits, then:

3. Set ***25 Check Sync Enable*** to **MANUAL** (or **AUTO**)

   Set ***25 System Split Detector*** to **Enabled**

   Set ***25 System Split Mode*** to **Phase**

   Set ***25 Split Angle*** to a suitable angle e.g. **170°**

   Set **25 Split Mode** to **SS**

   Set ***System Sync Enable*** to **MANUAL** (or **AUTO**)

   Set ***25 Close On Zero*** to **Disabled**

This will ensure that if the power system splits the relay will system synchronise.

It should be noted that at any time during a synchronising sequence, the relay can be inhibited from operation using the **Check Sync Inhibit** or **System Sync Inhibit** command from the control system.

Note: the relay settings groups could be used to switch between the different modes of the relay. The relay could be set up to be a check synchroniser in settings Group 1 and a check and system synchronising relay in settings Group 2. The group selection and thus the actual relay mode of operation could then be changed remotely using a status input signal or a communications command from a control system.

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2.2 Manual Synchronising

In applications where the relay is used for manual synchronising of e.g. generators, a close guard feature can be used to ensure that the operator uses the relay as a check for synchronism but does not give all the responsibility for the close to the relay. Previously this functionality has been achieved using external auxiliary guard relays to prevent the operator from pre-closing the switch and waiting for the relay to issue its close signal. This can now be achieved without the external guard elements but by using a status input and internal logic.

To use the close guard feature:

- Set ***25 Check Sync Enable*** to **MANUAL**
- ***Close Guard*** is set to **ON**

When the ***Start Check Sync*** status input is received, internal logic will only allow the relay to issue a close if the system conditions are in; the relay will display in the events that this close was initiated by the close guard function.

2.3 Typical Voltage Settings

2.3.1 Rated Voltage Setting – V.T. Connection

The 7SR157 relay can be connected either single-phase (e.g. phase-neutral of a 3 phase V.T.) or phase-phase (e.g. of Vee connected or 3 phase V.T.). The same VT connections must be employed for both ***Line Nom Voltage*** and ***Bus Nom Voltage***.

V.T. ratings for secondary connections are normally either 100V or 110V for phase-phase connection, with the associated phase-neutral ratings being 57.7V and 63.5V respectively. A nominal voltage range, which can be set between 40.0 – 160.0V, is available for both the Line and Bus.

2.3.2 Undervoltage Detector Settings

The relay undervoltage blocking elements, if enabled, can be used to block a close operation if either the line (incoming) or bus (running) voltages fall below a certain percentage of rated voltage. Typically, the undervoltage elements are set somewhere between 80% and 90% of rating.

Note : when using the undervoltage elements care should be taken to ensure that the reset of the element occurs at below the expected minimum operating voltage of the system. The undervoltage elements reset at <103% of the operate level. If the system is expected to run at less than the rated voltage, the undervoltage element reset level must be set to operate at a value below this plus a discrimination margin.

e.g. - for a phase to neutral connection nominally at 63.5 Vrms but which can run as low as 59 Vrms, the undervoltage setting should be set no higher than 59 V – 1 V (margin) = 58V / 103% = 56.31V (the actual setting would have to be 56.5V). This is equivalent to approximately 89% of rated voltage. If the setting is set higher than this then the element may never reset and will continuously block.

2.3.3 Differential Voltage Detector Settings

A differential voltage detector is incorporated and this, if enabled, blocks the synchronising function if the difference between the measured voltages is greater than the setting. This is used to prevent closing of the circuit breaker with a large voltage differential between the line (incoming) or bus (running) voltages, which could overstress the electrical systems. Typically, the differential voltage element is set below 10% of rated voltage.

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2.4 Synchronising Bypass Logic

The relay Dead and Live voltage monitors are used along with corresponding internal logic to bypass the synchronising operation of the relay. Typically, anywhere above 80% to 90% of rating can be classed as a live line or live bus. The dead voltage monitors should be set to somewhere above the expected level of induced voltages on the line or bus. It should be noted that a dead line or dead bus can have a considerable potential induced onto it from a parallel line or via capacitance across open breaker contacts. This potential can be as high as 30% of rated voltage.

The ***Sync Bypass*** logic (found in VOLTAGE SETTING MENU) can be enabled, if required, to provide Dead Line and Live Bus closing, Live Line and Dead Bus closing, Dead Line and Dead Bus closing, Dead Line or Dead Bus closing and Dead Line xor Dead Bus closing. A truth table showing the close logic for all of the possible combinations is shown in Table 1.

		Sync Bypass Setting				
		DL & LB	**LL & DB**	**DL & DB**	**DL or DB**	**DL xor DB**
Line Status	**Bus Status**	**Allow Close**	**Allow Close**	**Allow Close**	**Allow Close**	**Allow Close**
Dead	Dead	No	No	Yes	Yes	No
Dead	Live	Yes	No	No	Yes	Yes
Live	Dead	No	Yes	No	Yes	Yes
Live	Live	No	No	No	No	No

Table 1 - Bypass Close Logic

2.5 Slip Frequency and Phase Angle Relationship

Slip frequency is defined as the difference between two frequencies. Where a slip frequency exists between two separate systems, during a 'slip' cycle the two voltage vectors will be in anti-phase at one point in time. The phase angle difference will vary between being in phase and anti-phase. The 7SR157 relays can be set to measure slip frequency in two ways. One way is to measure the two system frequencies directly and calculate the difference. Another way is to measure the phase difference between the two systems and check that the phase angle change in a defined time period is less than a predetermined value. If F1 and F2 represent the frequencies of two systems then it can be shown that for check synchronising operation:

$$\Delta F = F1 - F2 = \frac{1}{Td} \times \frac{\theta}{180°}$$

where Td = time delay setting (***25 Check Sync Timer***) and θ = phase angle setting (***25 Check Sync Angle***).

For system synchronising operation the following formula is used because in this mode the relay will only issue a close signal if the phase angle is decreasing in value. It will not issue a close if the phase angle is increasing in value.

$$\Delta F = F1 - F2 = \frac{1}{Td} \times \frac{\theta}{360°}$$

where Td = time delay setting (***25 System Sync Timer***) and θ = phase angle setting (***25 System Sync Angle***).

The 7SR157 relay has both a frequency measuring element and phase detector and so can be set up to measure slip either directly or by the phase detector plus timer method. Use of either method is perfectly valid, as is use of both at the same time.

Note : if using both the slip frequency detector and the phase angle plus slip timer for a particular scheme then care has to be taken in setting selection. It is possible to set the relay up with an incorrect slip timer setting which will prevent the relay from issuing a valid close signal e.g. a system with a high rate of slip which is within the allowable slip frequency limit, could be set up with too long a slip timer setting. This would mean that the incoming vector could pass through the valid close window too quickly and not allow the slip timer to time out and give a valid output.

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2.6 Check Synchronising Settings

The check synchronising operation of the relay is used mainly in switching operations which link two parts of a system which are weakly tied via other paths elsewhere in the system. In this synchronous system there should be no frequency difference across the breaker but significant differences in phase angle and voltage magnitude may exist due to the transmission line characteristics such as its length and type of loading.

For ***25 Check Sync*** operation the relay should be set to the maximum phase angle and maximum voltage difference which still permit the circuit breaker to close without causing large disturbances to the system. For most systems the ***25 Check Sync Angle*** can be set between 20° and 30°. There should not be any slip frequency but a setting of 50mHz is typically applied as a check against loss of synchronism. Table 2 shows some possible check synchronising settings when using the ***25 Check Sync Angle*** plus ***25 Check Sync Timer*** method. This shows a range of ***25 Check Sync Angle*** and the required ***25 Check Sync Timer*** settings to achieve a slip frequency limit of 50mHz. Note that due to the step resolution of the timer, an exact 50mHz slip limit is not always achievable when using this method.

25 Check Sync Angle (θ°)	25 Check Sync Timer settings (sec)	Slip Frequency Limit (mHz)
± 10°	1.11	50.05
± 15°	1.66	50.20
± 20°	2.22	50.05
± 25°	2.77	50.14
± 30°	3.33	50.05
± 35°	3.88	50.11
± 40°	4.44	50.05
± 45°	5.00	50.00

Table 2 - Typical Check Synchronising Settings

Alternatively, if the ***25 Check Sync Slip Freq*** detector is ***Enabled*** and the ***25 Check Sync Timer*** set to *0.00s*, a setting of 50mHz could be applied to the ***25 Check Sync Slip*** directly to achieve the same ends.

Note: in check synchronising mode the valid phase difference window for closing is actually twice the ***25 Check Sync Angle*** setting value because the valid Check Sync close can be given when the phase angle is either decreasing or increasing. It should also be noted that the **Check Sync Close** output will stay on for a minimum of 100ms and for the whole duration of the time that the close parameters are met.

2.7 System Synchronising Settings

The system synchronising operation of the relay can automatically start if the two systems become asynchronous i.e. there are no ties between the two systems and one system is effectively 'islanded'. If this situation occurs the frequencies will slip past each other and may cause the phase angle to come into the system split limits. The system split detector can be set anywhere from 90° to 175° and is typically set to 170°. This will start system synchronising automatically if ***System Sync Enable*** has been set to AUTO.

When there are high rates of slip between the two systems greater care is needed when closing the breaker and for this reason the ***25 system Sync*** mode has independent settings from the ***25 Check Sync*** mode. The allowable phase angle close window is usually set much narrower than for check synchronising operation. Also, the close decision from the relay is only given in the case of the phase angle decreasing. It will not issue a close if the phase angle is increasing in value. Typically the slip frequency will be set to a limit of 250mHz or less and the phase angle to 10° or 15°. Table 3 shows some possible system synchronising settings for limits of 100mHz and 250mHz using the timer method. Note that due to the step resolution of the timer, an exact 100mHz or 250mHz slip limit is not always achievable.

25 System Sync Angle (θ°)	25 System Sync Timer settings (sec)	Slip Frequency Limit (mHz)
± 10°	0.27	102.88
± 15°	0.42	99.21
± 10°	0.11	252.53
± 15°	0.17	245.10

Table 3 - Typical System Synchronising Settings

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Alternatively, if the ***25 System Sync Timer*** is set to 0.00s, settings of 100mHz or 250mHz could be applied to the ***25 System Sync Slip*** directly to achieve the same ends.

Note: the **System Sync Close** output pulse is on for a minimum of 100ms, but can be extended if necessary by using the ***25 SS Close Pulse*** setting.

2.8 Example Setting Calculations for 25 Check Sync Timer

In Check Synchronising operation the relay will issue a **25 Check Sync Close** output if the system conditions are such that the phase angle and/or slip frequency are within limits. There is a possibility, however, that a **25 Check Sync Close** could be issued at a point where the phase angle is approaching the ***25 Check Sync Angle***, say +20°, and the slip frequency is at the ***25 Check Sync Slip*** value. The consequence of this is that due to the inherent closing time of the CB the actual CB close occurs outside of the ***25 Check Sync Angle***. The angle overshoot being dependent on the actual slip frequency and the total CB closing delay.

The total delays involved in this process include the main software timing loop which issues the close command, the output relay time to pick up and the actual breaker closing time delays. To reduce the risk of a late closure it is common practice to set the ***25 Check Sync Timer*** time delay to typically 10x the CB closing time. This will ensure that the CB will close no later than 1.2x the actual ***25 Check Sync Angle*** setting of the relay e.g. ± 24° for a ± 20° setting. This is explained further below:

The change in phase angle between two waveforms is directly related to the frequency difference, or slip, between them. The change in phase angle $\Delta\theta$ for a system with 1Hz slip is 360° in 1 second. Thus,

Change in phase angle $\Delta\theta = (\text{Slip} \times 360)$ °/sec.

The distance the phasor can travel during the breaker close time can therefore be given by:

$\Delta\theta = (\text{Slip} \times 360 \times t_{CB})$ - where t_{CB} is the breaker close time in seconds.

Using the equation given in Section 2.5 for check synchronising:

$\text{Slip} = \frac{1}{\text{Td}} \times \frac{\theta}{180°}$ - substituting this into $\Delta\theta = (\text{Slip} \times 360 \times t_{CB})$ gives the following:

$\Delta\theta = \frac{1}{\text{Td}} \times \frac{\theta}{180°} \times 360° \times t_{CB}$ - which gives $\Delta\theta = 2 \times \theta \times \frac{t_{CB}}{\text{Td}}$

It was stated that the ***25 Check Sync Timer*** setting Td should be set to 10x the breaker closing time t_{CB}.

Substituting for this in the above equation gives:

$\Delta\theta = \frac{(2 \times \theta)}{10}$ or $\Delta\theta = 0.2 \times \theta$

Thus for a ***25 Check Sync Timer*** setting (Td) of 10x breaker closing time (t_{CB}) the actual change in ***25 Check Sync Angle*** will be 20% of the ***25 Check Sync Angle*** setting. The maximum closing angle will be 120% of ***25 Check Sync Angle*** setting.

In practice, however, the relay operating times need to be taken into consideration. A typical example now follows:

- Maximum allowed phase angle for closure = 30°
- Circuit breaker closure time = 150ms
- Maximum relay delays: Software timing loop + Output relay delays = 5ms + 7ms = 12ms

Therefore ***25 Check Sync Timer*** time delay should be set to 10x (150ms + 12ms) = 1.62sec.

The ***25 Check Sync Angle*** setting should be set to 80% of the maximum allowable closing angle, which is 24°.

If the relay was to issue a close right on the boundary of 24° then the breaker will not close outside of 30°.

With an angle of 24° and a ***25 Check Sync Timer*** delay (Td) of 1.62 sec, using the equation from Section 2.5, the maximum allowable slip is therefore:

24 / (1.62 x 180) = 83mHz. If the relay were to issue a **25 Check Sync Close** on the boundary, the phase angle traversed in the 160ms total delay time is given by,

$\Delta\theta = (\text{Slip} \times 360) \times (t_{CB} + t_{RELAY})$ = 0.083 x 360 x 0.16 = 4.80°.

Therefore the CB will close at 24° + 4.80° = 28.80°.

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Section 3: Supervision Functions

3.1 Close Circuit Supervision (74CCS)

Binary Inputs may be used to monitor the integrity of the CB close circuit wiring. A small current flows through the BI and the circuit. This current operates the BI confirming the integrity of the auxiliary supply, CB coil, auxiliary switch, C.B. secondary isolating contacts and associated wiring. If monitoring current flow ceases the BI drops off and if it is user programmed to operate one of the Binary Outputs, 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. “Close CCT Fail”.

The relevant Binary Input is mapped to **74CCS-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, which is found in the SUPERVISION>CLOSE CIRCUIT SUPERVISION menu.

To provide an alarm output, a normally-open Binary Output is mapped to **74CCS-n**.

3.1.1 Close Circuit Supervision Connections

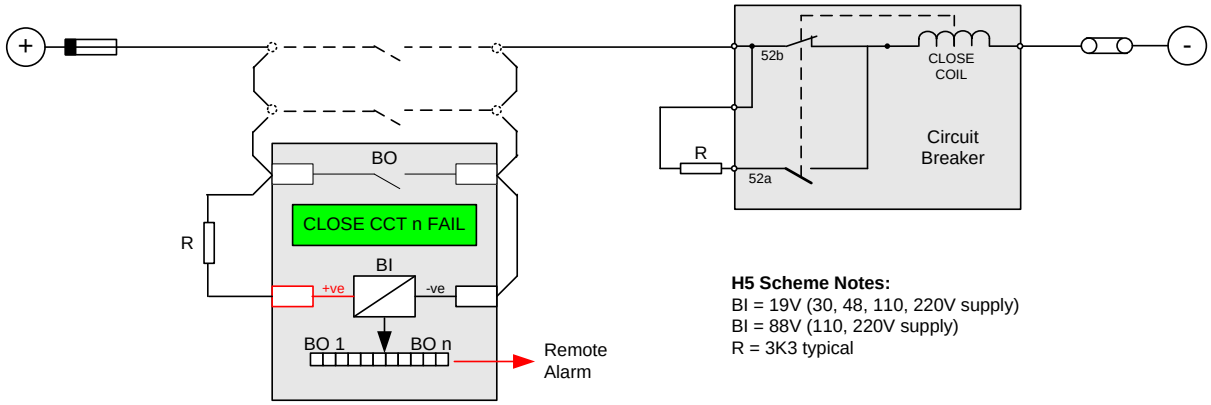


Figure 3-1 Close Circuit Supervision Scheme

Section 4: Common Functions

4.1 Binary Inputs

Each Binary Input (BI) can be programmed to operate one or more of the relay functions e.g. inhibits for elements, close-circuit supervision status and plant status signals etc. A common use of BI is to provide indication of alarm or fault conditions. They can also be mapped directly to LEDs and for triggering waveform storage and operate Binary Outputs directly.

4.1.1 The Effects of Capacitance Current

The BI have a low minimum operate current and may be set for instantaneous operation. Consideration should be given to the likelihood of mal-operation due to capacitance current. Capacitance current can flow through the BI for example if an earth fault occurs on the dc circuits associated with the relay. The BI will be less likely to mal-operate if they:

1 Have both the positive and negative auxiliary supplies switched (double-pole switched).

2 Do not have extensive external wiring associated with them e.g. if the wiring is confined to the relay room.

4.1.2 AC Rejection

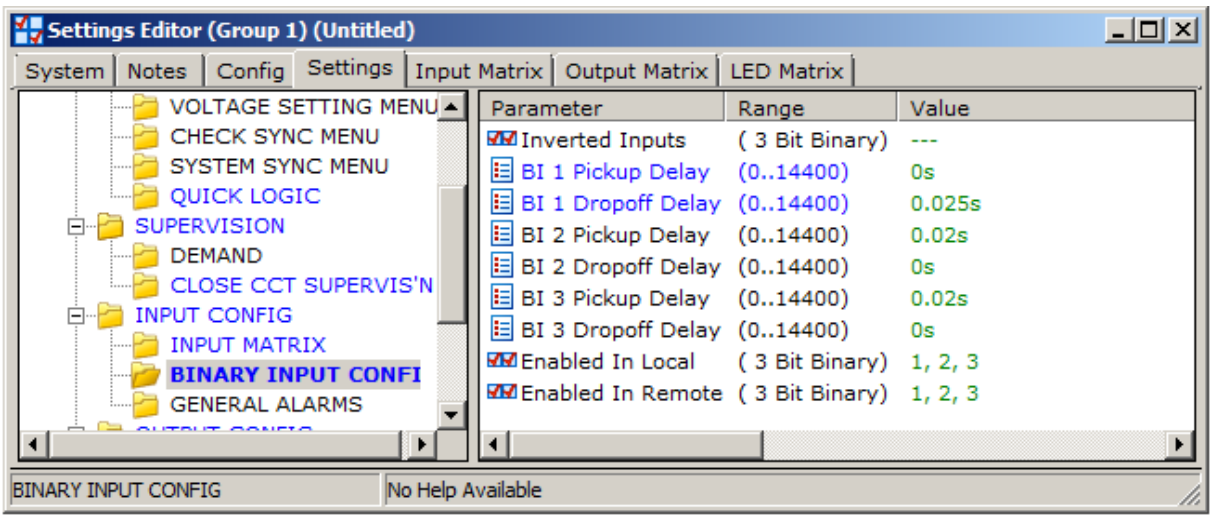
The default pick-up time delay of 20ms provides immunity to ac current for dc applications e.g. induced from cross site wiring.

BI can be configured for intentional operation from an ac supply by setting pickup and drop-off timers for each individual BI: set pick-up to 0ms and drop-off to 25ms. If the wiring for ac operation of BI is more than 10 metres in length, then screened twisted pair cable should be used.

If additional pick-up or drop-off time delays are required by the scheme logic, then this functionality can be achieved by programmable logic within the device. An example:

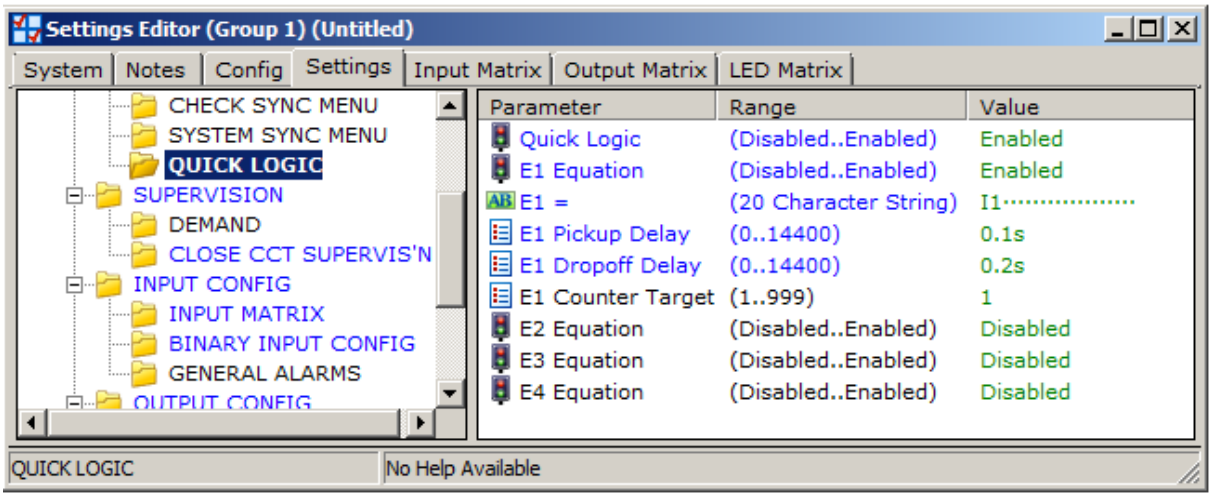
An ac supply operated BI is required to operate the System Sync inhibit function, but also include a 100ms minimum pick-up delay and 200ms minimum drop-off delay.

1) Set BI 1 for ac operation:

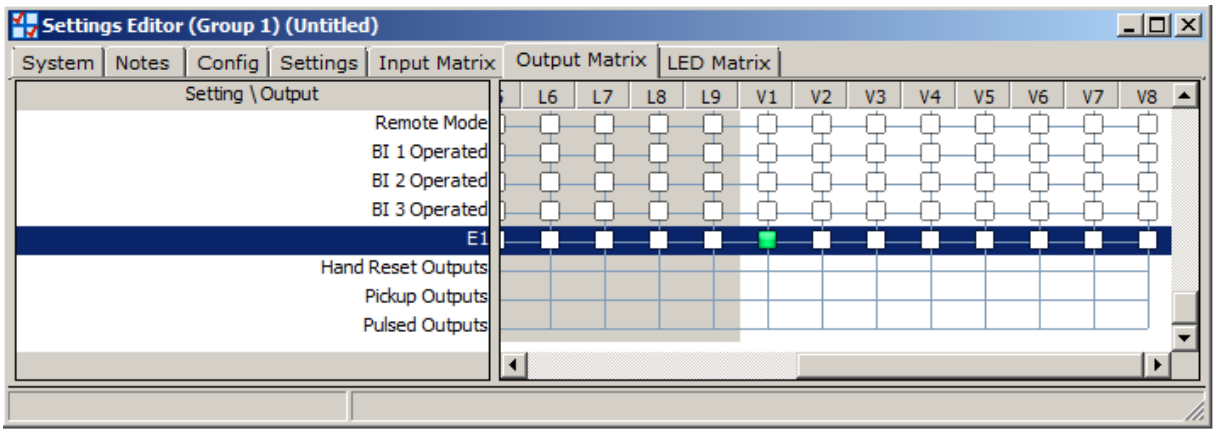


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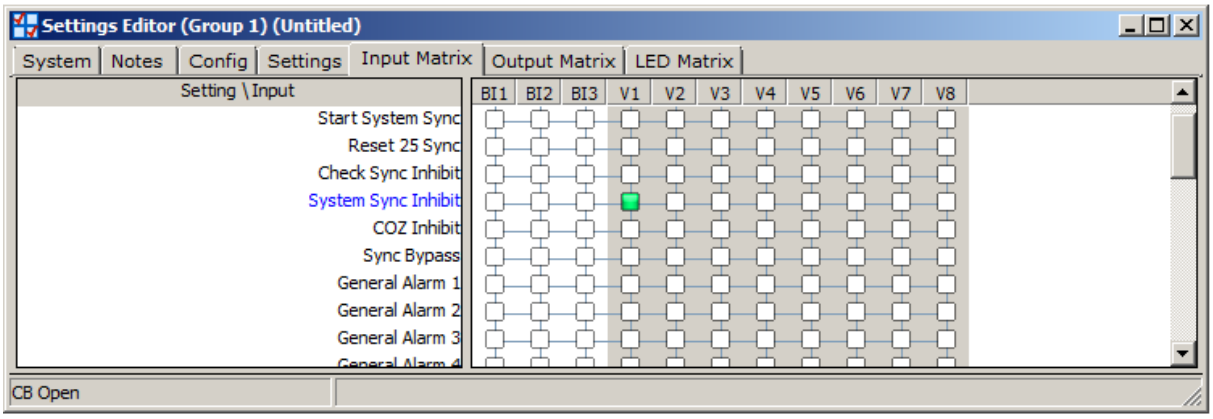
2) Set Quick Logic equation E1 to operate from BI 1 and apply required delays:



3) Set equation E1 to operate virtual I/O V1 in the Output Matrix:



4) Set virtual I/O V1 to operate the System Sync inhibit in the Input Matrix:



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4.1.3 Use of Binary Inputs in control and tripping circuits

Where a BI is used to as part of a dc control function, for example tripping or closing a circuit breaker, it may be desirable to provide an enhanced level of immunity to prevent maloperation due to induced voltages.

This is most important where cross-site cabling is involved, as this is susceptible to induced voltages and will contribute to capacitive discharge currents under dc system earth fault conditions.

One method of enhancing the immunity of the BI is to switch both positive and negative connections; however this is often not possible or desirable.

Where a higher battery voltage is available, an 88V BI will give an added measure of immunity, compared to the 19V BI, due to its higher minimum pickup voltage.

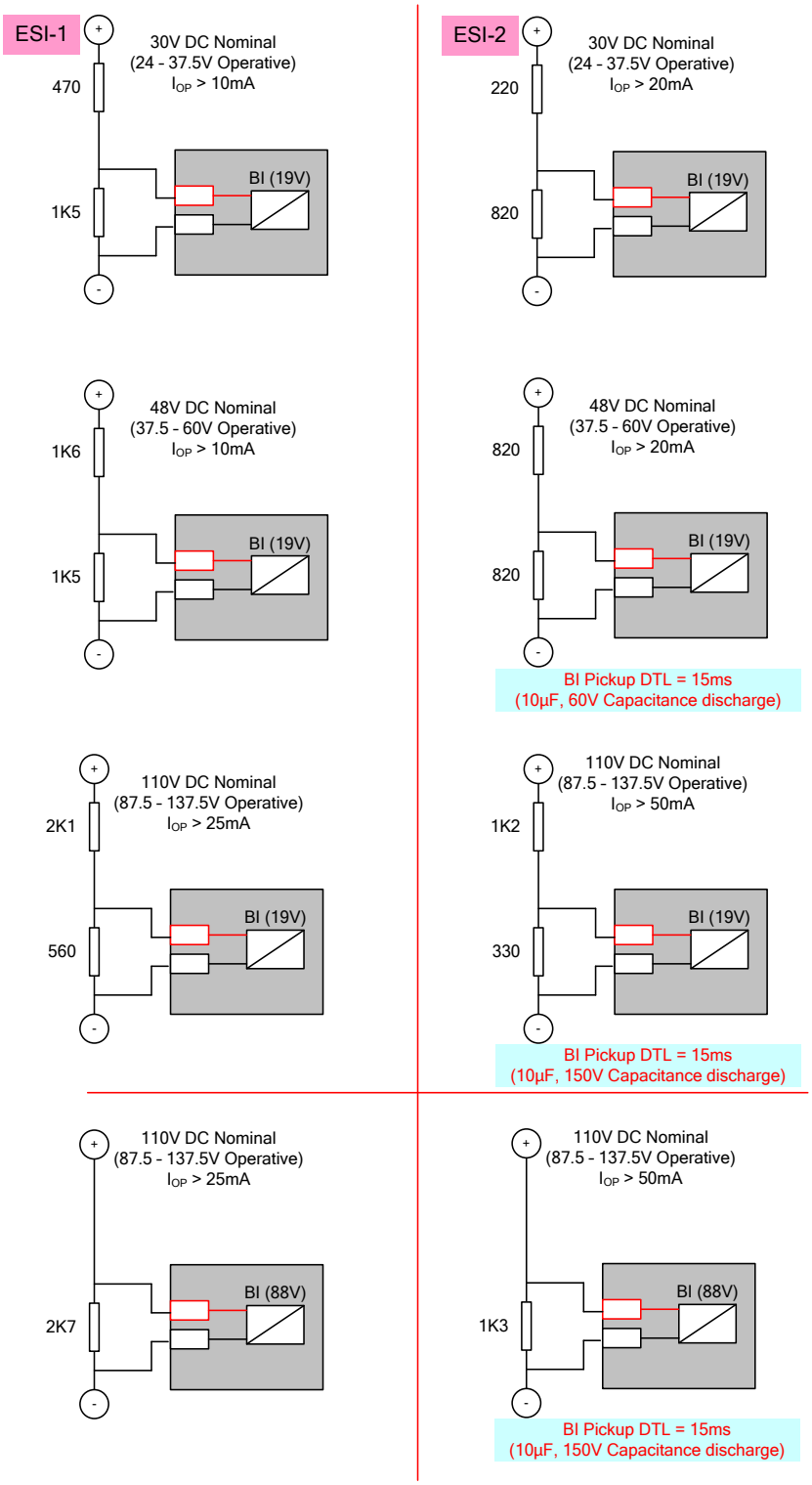
As a guide to suitable degrees of enhanced immunity, we have adopted the parameters laid down in U.K. standard EATS 48-4. This standard identifies two levels of immunity:

- Category ESI 1 may be adopted for connections which do not include significant wiring runs or cabling outside the relay enclosure.
- Category ESI 2 should be used for connections which include significant wiring runs or cabling outside the relay enclosure. This category also gives immunity to capacitive discharge currents.

Figure 4-1 show the external resistors which should be fitted to allow the BI to comply with either of the above categories. Fitting these components will raise the current required to operate the BI, and hence makes it less susceptible to maloperation.

Where required, the minimum pickup delay for the BI is stated on the diagram.

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Resistor power ratings:	30V DC Nominal	>3W
	48V DC Nominal	>3W
	110V DC Nominal	>10W (ESI- 1)
	110V DC Nominal	>20W (ESI-2)

Resistors must be wired with crimped connections as they may run hot

Figure 4-1 Example BI configurations with compliance to EATS 48-4 Classes ESI 1 and ESI2

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4.2 Binary Outputs

Binary Outputs (BO) are mapped to output functions in the OUTPUT MATRIX menu. All are Trip rated and each can be defined as Self or Hand-Reset. Self-reset contacts are applicable to most protection applications. Hand-reset contacts are used where the output must remain active until the user expressly clears it e.g. in a control scheme where the output must remain active until some external feature has correctly processed it.

4.3 LEDs

LEDs are mapped to functions in the OUTPUT MATRIX menu. They can be used to display the status of virtually all of the different internal functions of the synchronising relay e.g. Line/Bus status, CS In Progress, System Split etc.

Each LED can be defined as Self or Hand-reset and this is set in the LED CONFIG menu. Hand-reset LEDs are used where the user is required to expressly acknowledge the change in status. Self-reset LEDs are used to display features which routinely change state, such as Circuit-Breaker open or close.

The status of Hand-reset LEDs is retained in capacitor-backed memory in the event of supply loss.

Each LED can be assigned as red, yellow or green in colour. There are two methods for doing this: -

1) In the LED Matrix tab: to assign the LED as a red colour select a box on the red row. To assign the LED as a green colour select a box on the green row. To assign the LED as a yellow colour, select boxes on both the red and green rows.

   NB: If there are no boxes selected the LED will not illuminate.

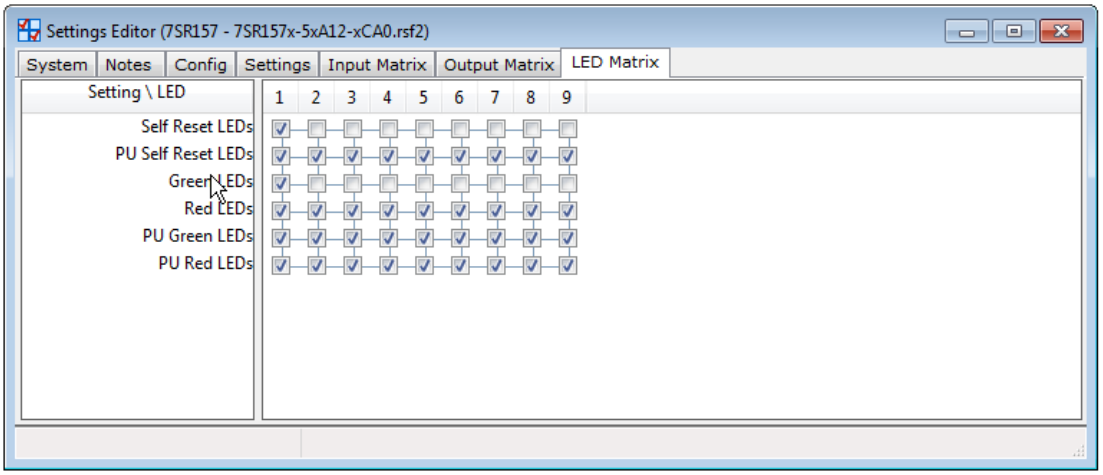


Figure 4-2 LED configuration via the LED Matrix tab

2) In the settings tab, OUTPUT CONFIG\LED CONFIG menu: to assign the required LED as a particular colour, either red or green, type the LED number in the appropriate row. To assign the required LED as a yellow colour, type the LED number in both red and green rows.

   NB: If a LED number is not assigned that particular LED will not illuminate.

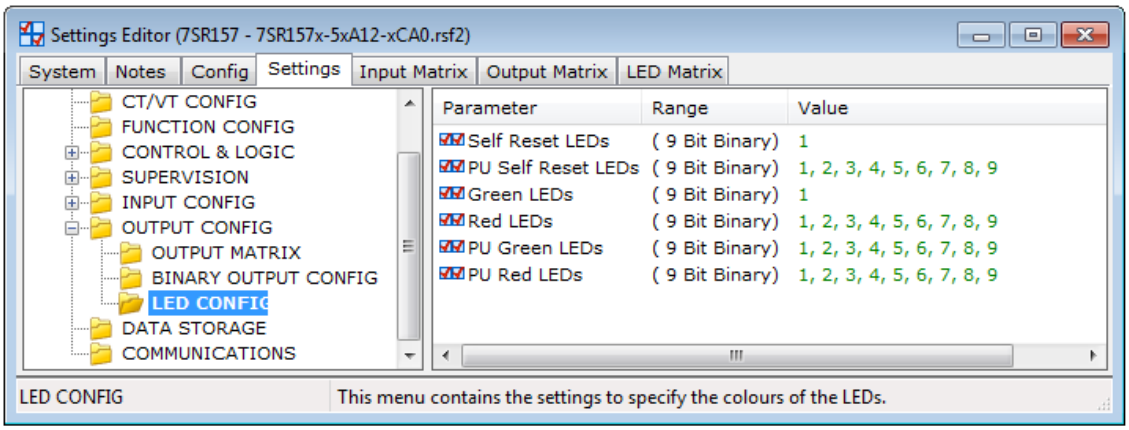


Figure 4-3 LED configuration via the Settings \ OUTPUT CONFIG \ LED CONFIG menu

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