Reyrolle
Protection
Devices

7SR158 Argus

Voltage and Frequency Relay

Answers for energy.

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Contents

Technical Manual Chapters

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

7SR158

Voltage & Frequency Relay

Description of Operation

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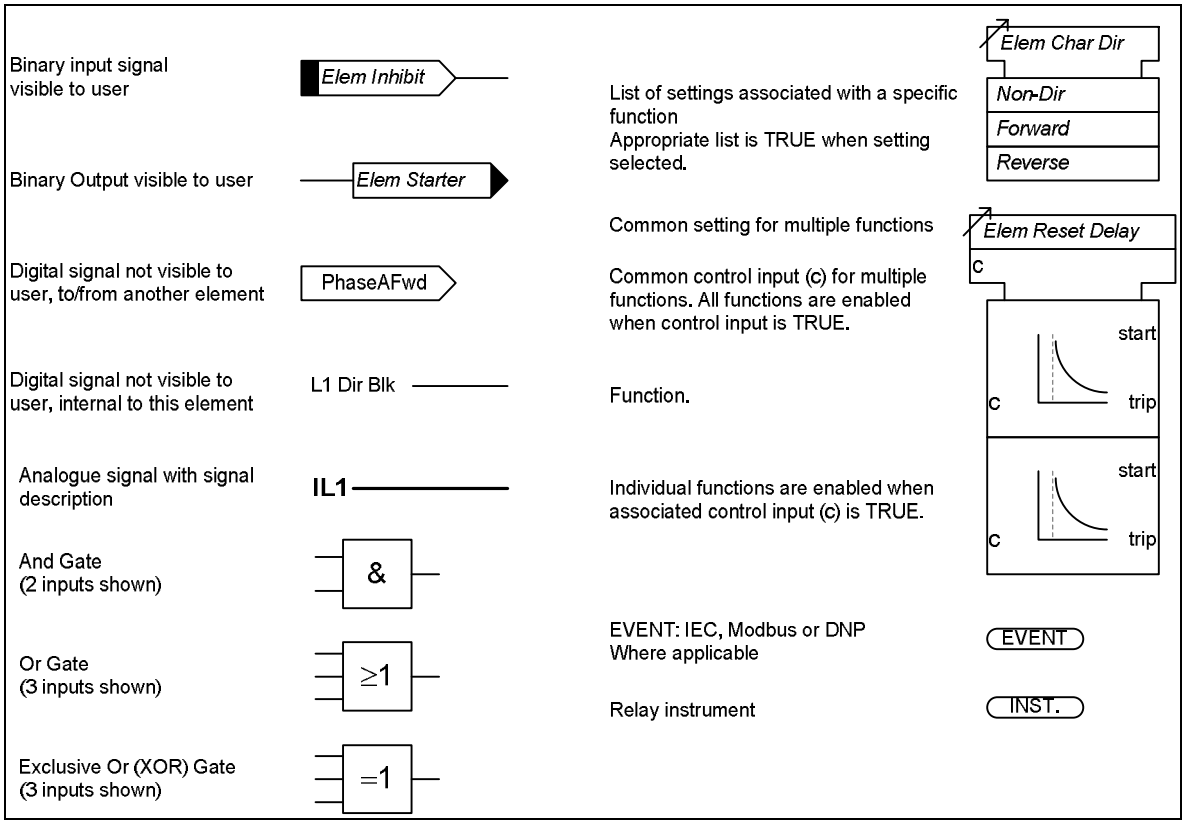
Symbols and Nomenclature

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

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



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Section 1: Introduction

This manual is applicable to the following relays:

- 7SR158 Voltage and Frequency 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 7SR158 Ordering Options

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

Protection Product Family (5)

Voltage	5

Relay Type (6)

Voltage & Frequency	8

Case, I/O and Fascia (7)

E4 case, 3 VT, 6 Binary Inputs / 8 Binary Outputs, 10 LEDs	7

Measuring input (8)

40 to 160 V, 50/60Hz	5

Auxiliary voltage (9)

80 to 250 V DC / 115 V AC, 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

Spare (10)

	A

Communication Interface (11)

Standard version - included in all models, USB front port, RS485 rear port	1

Protocol (12)

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

Front Cover (13)

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

Protection Function Packages (14)

For future development		A
For future development		B
Standard version		C
27/59	Under/overvoltage	
47	Negative phase sequence voltage	
59N	Neutral voltage displacement	
74T&C	Trip & Close circuit supervision	
81	Under/overfrequency	
Standard version - plus		D
78	Voltage Vector Shift	
81R	Rate of Change of Frequency	

Additional Functionality (15)

No additional functionality	A

Spare (16)

	0

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The relay has 3 VT inputs, configurable in one of three input modes via a setting:

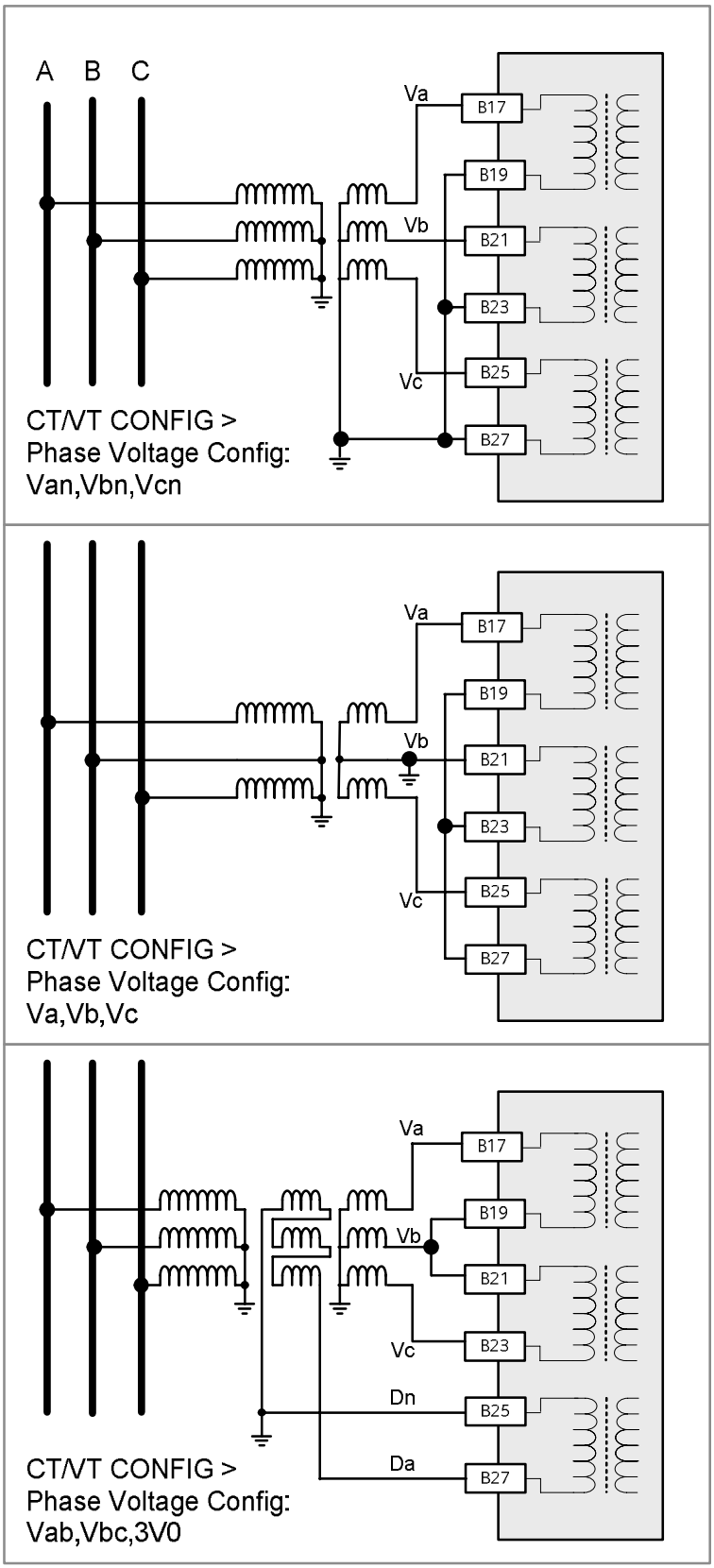
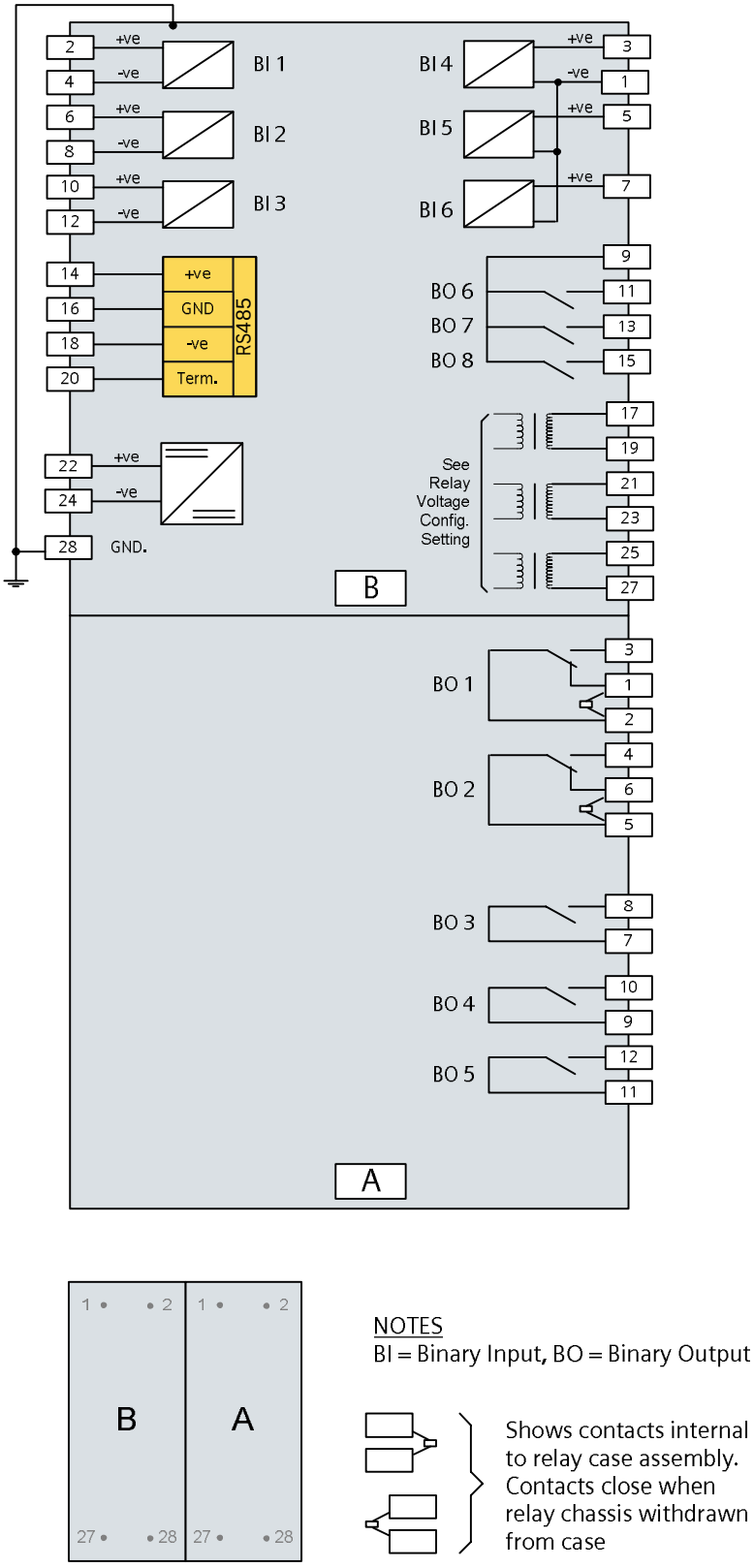


Figure 1-1 VT Connections



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 7SR158 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 relays are supplied in a size E4 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 7SR158 Relay Configurations

Relay	Voltage Inputs	Binary Inputs	Binary Outputs	LEDs
7SR158	3	6	8	10

2.2 Case

The relays are housed in cases designed to fit directly into standard panel racks. The case has a width of 104mm and a height of 177 mm (4U). The required panel depth (with wiring clearance) is 242 mm.

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

Figure 2-1 Relay shown withdrawn

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

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.

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 has access to the ▼ and TEST/RESET► buttons, allowing all areas of the menu system to be viewed, but preventing setting changes and control actions.

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The only 'action' that is permitted is to reset the Fault Data display, latched binary outputs and LEDs by using the TEST/RESET ▸ button.

Figure 2-4 Relay with transparent cover and push buttons

2.4 Power Supply Unit (PSU)

Relay PSU options allow the relay to be directly connected to dc system rated from 24V to 60V or 80 to 250V. The 80- 250Vdc PSU can also be used with 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 device 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.

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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

   Voltage rating

   Auxiliary supply 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 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

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.

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Standard Keys

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

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

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

'PROTECTION HEALTHY' LED

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

Indication LEDs

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

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

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

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

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

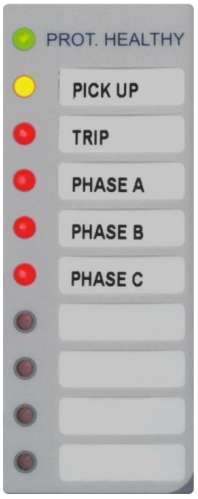

Figure 2-8 LED Indication Label

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2.6 Voltage Inputs

The voltage inputs 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). Protection and 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 opto-couplers 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 fig. 2.8-1.

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.

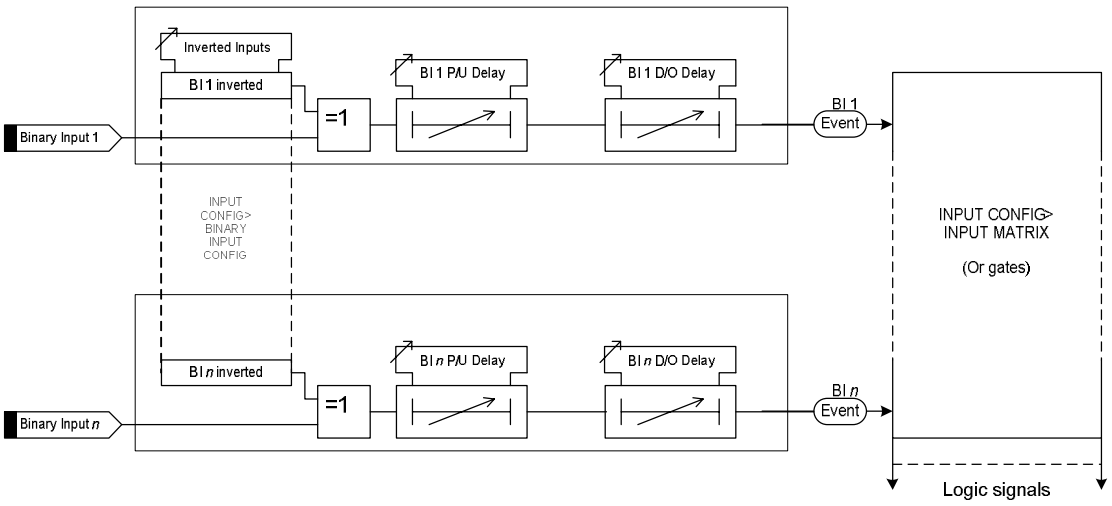

Figure 2-9 Binary Input Logic

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 'hand reset' and 'pulsed' then the output will be 'hand reset' only.

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

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

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

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

Contacts in the case ensure that the normally closed binary outputs remain short circuited when the relay is withdrawn from the case.

Notes on Self Reset Outputs

Outputs reset after the initiate condition is removed, they are subject to the user definable 'Minimum Operate Time' setting.

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

Notes on Pulsed Outputs

When operated, the output will reset after the user definable 'Minimum Operate Time' setting regardless of the initiating condition.

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.

Binary Output Test

The MAINTENANCE>OUTPUT MATRIX TEST menu includes a facility to test output relays from the relay fascia without the need for a secondary injection test set.

Binary outputs can also be energised from the Reydisp Evolution software package where PC facilities are available.

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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.

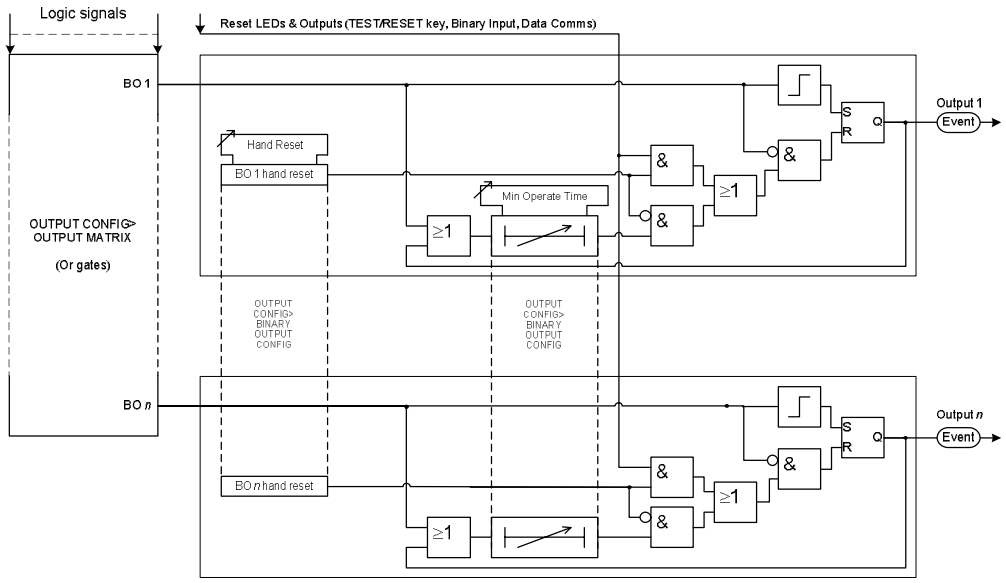

Figure 2-10 Binary Output Logic

2.9 Virtual Input/Outputs

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

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

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 'Protection Healthy' LED is illuminated.

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

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

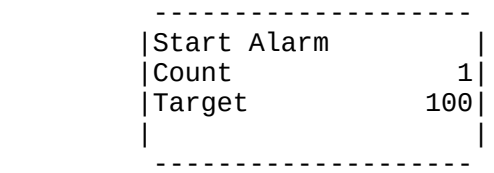

Figure 2-11 Start-up Counter Meter

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

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

1. **power-on starts**
2. **expected starts** (user initiated via comms)
3. **unexpected starts** (caused by the relay watchdog)

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

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

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

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

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

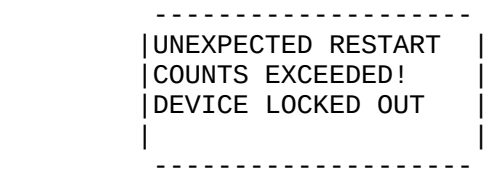

Figure 2-12 Unexpected Restarts Lockout Text

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

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

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

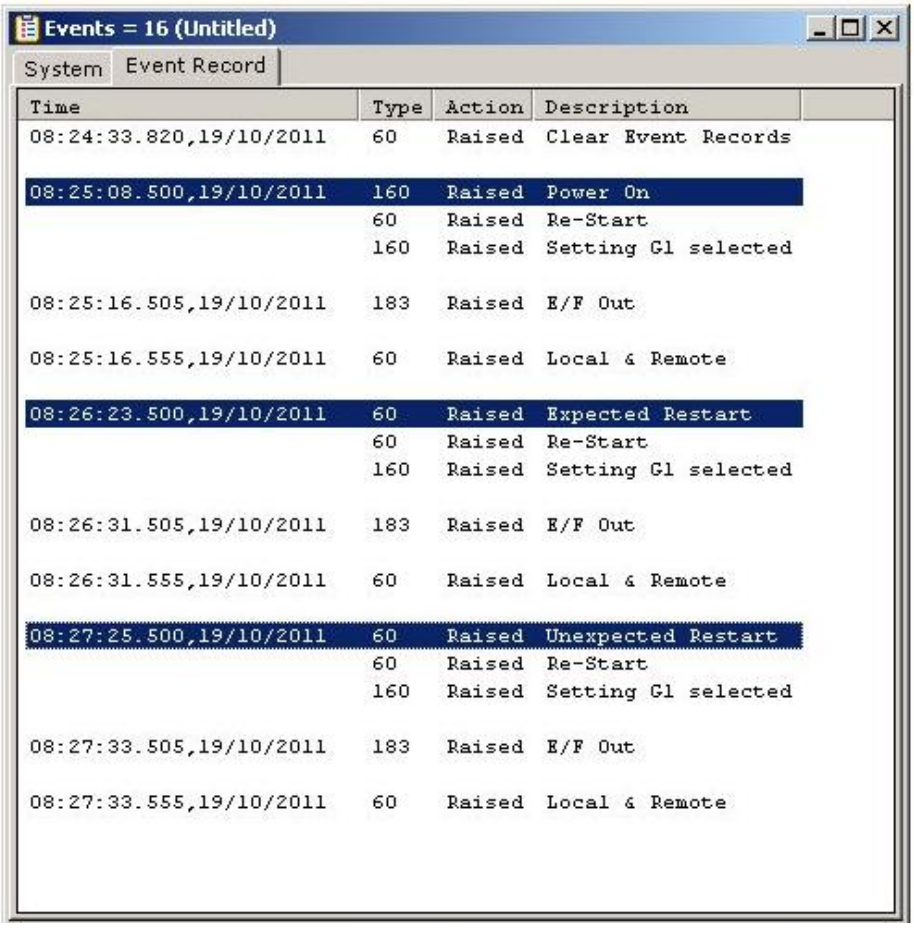

Figure 2-13 Start-up Events

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 Protection Healthy LED is turned on.

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

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

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

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Section 3: Protection Functions

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

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

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

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

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

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

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

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

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

Inhibit 27/59-n	A binary or virtual input.
27/59-n VTSInhibit	Operation of the VT Supervision function.
27/59-n U/V Guarded	Under voltage guard element.
User Inhibit	Reylogic (graphical logic)

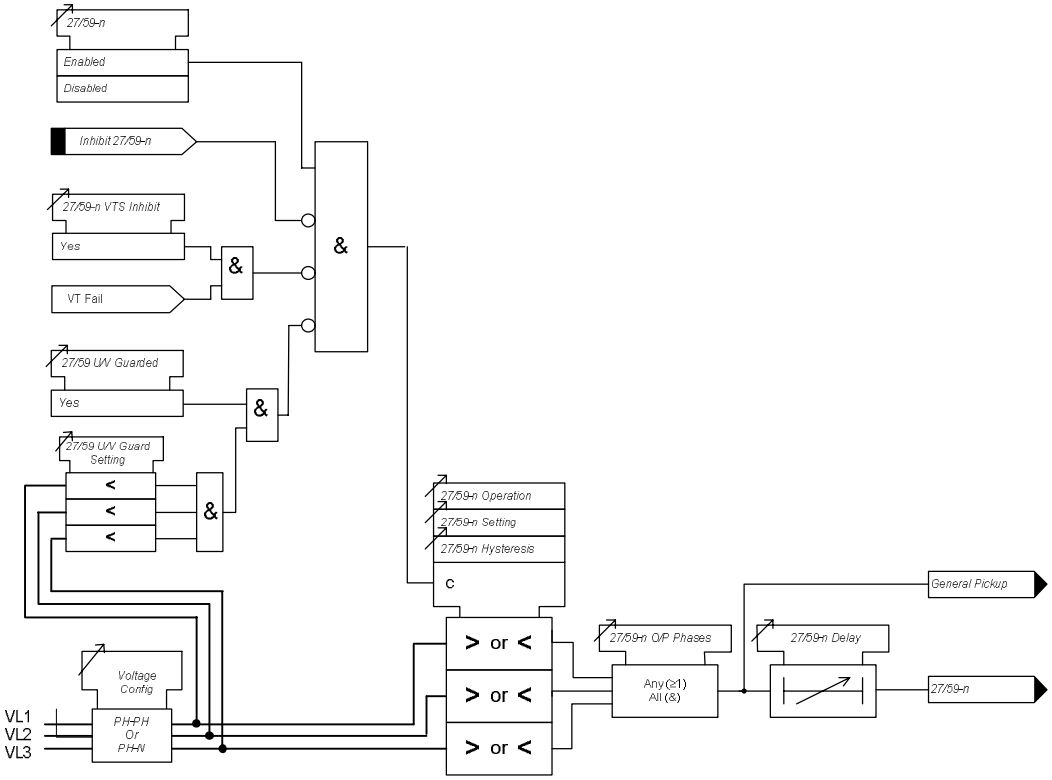

Figure 3-1 Logic Diagram: Under/Over Voltage Elements (27/59)

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3.2 Voltage Protection: Negative Phase Sequence Overvoltage (47)

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

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

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

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

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

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

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

Inhibit 47-n	A binary or virtual input.
47-n U/V Guarded	Under voltage guard element.
User Inhibit	Reylogic (graphical logic)

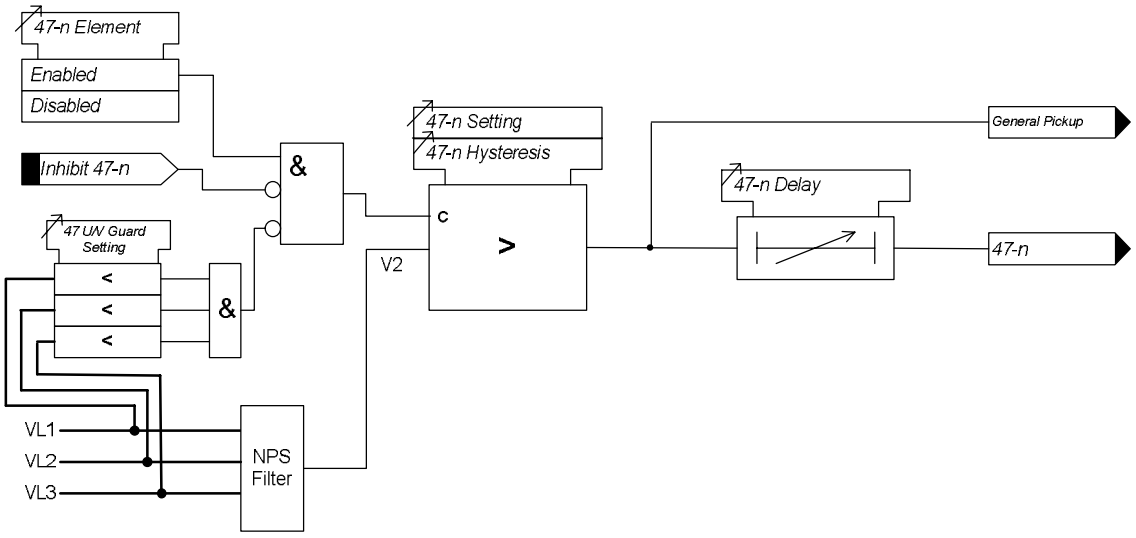

Figure 3-2 Logic Diagram: NPS Overvoltage Protection (47)

3.3 Voltage Protection: Neutral Overvoltage (59N)

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

The relay measures fundamental frequency residual voltage for this function. The relay can be connected to directly measure residual voltage (3V0 input) i.e. 'CT/VT CONFIG > Phase Voltage Config' setting = 'Vab,Vbc,3Vo'. Alternatively the value of residual voltage can be derived from the phase-neutral voltages i.e. 'CT/VT CONFIG > Phase Voltage Config' setting = 'Van,Vbn,Vcn'.

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

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

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

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

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

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

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

Operation of the neutral overvoltage elements can be inhibited from:

Inhibit 59NIT	A binary or virtual input.
Inhibit59NDT	A binary or virtual input.
User Inhibit	Reylogic (graphical logic)

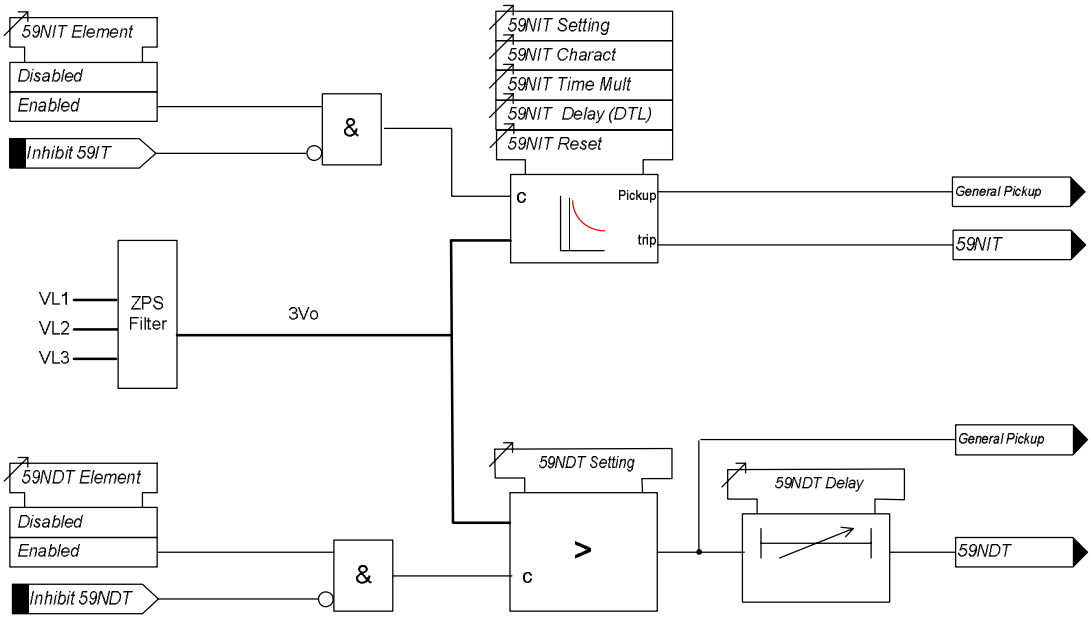

Figure 3-3 Logic Diagram: Neutral Overvoltage Element (59N)

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3.4 Voltage Protection: Vector Shift (78)

Voltage Vector Shift detects a phase 'jump' (vector shift) in all three system voltages over a half-cycle window. The function is used to detect 'islanding' or loss of connection between a generator and the main utility supply.. If the detected vector shift is greater than setting on all three measured voltages an output is issued. Operation of the element is instantaneous – the vector shift occurs once and then the voltage stabilises – so a delayed operation is not applicable. Phase detection by means of zero-crossing measurement is used to maximise speed of operation.

Two elements are provided ***78-1 & 78-2.***

All elements will be blocked if all phase voltages fall below the ***78 U/V Guard*** setting.

There is an absolute cut-off of vector shift measurement at 30°.

78-n Setting sets the pick-up phase shift angle for the element. The phase shift must be detected in all 3 phase-neutral voltages for the element to pick-up. This feature can be used when the 'CT/VT CONFIG > Phase Voltage Config' setting is selected to 'Van,Vbn,Vcn' or 'Vab,Vbc,3Vo'.

Operation of the elements is instantaneous.

Operation of the voltage vector shift elements can be inhibited from:

Inhibit 78-n	A binary or virtual input.
78 U/V Guard (Ph-N)	Under voltage guard element.
User Inhibit	Reylogic (graphical logic)

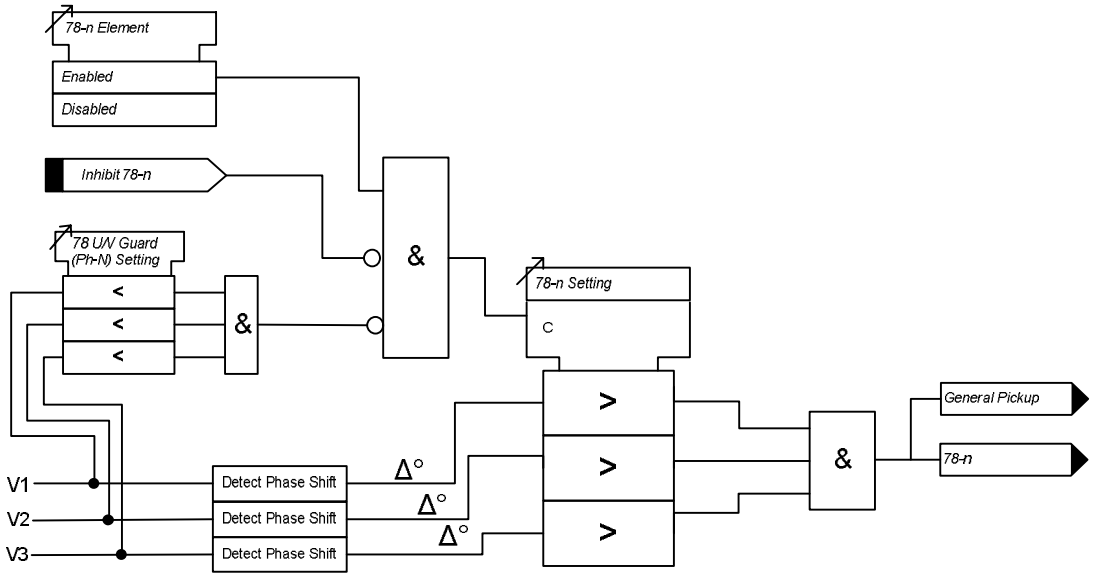

Figure 3-4 Logic Diagram: Vector Shift (78)

3.5 Voltage Protection: Under/Over Frequency (81)

Six under/over frequency elements are provided in the relay – ***81-1, 81-2, 81-3, 81-4, 81-5 & 81-6.***

All under/over frequency elements have a common ***Frequency Input Mode*** setting defining whether phase to phase **(Ph-Ph)** or phase to neutral **(Ph-N)** voltages are used. The frequency calculation is based on the highest input voltage derived from the voltage selection algorithm. The frequency of all VT inputs is monitored continually, switching between reference voltages is instantaneous.

All elements can be blocked if all phase voltages fall below the ***81 U/V Guard*** setting.

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

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

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

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

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

Inhibit 81-n	A binary or virtual input, or function key.
81-n U/V Guarded	Under voltage guard element.
User Inhibit	Reylogic (graphical logic)

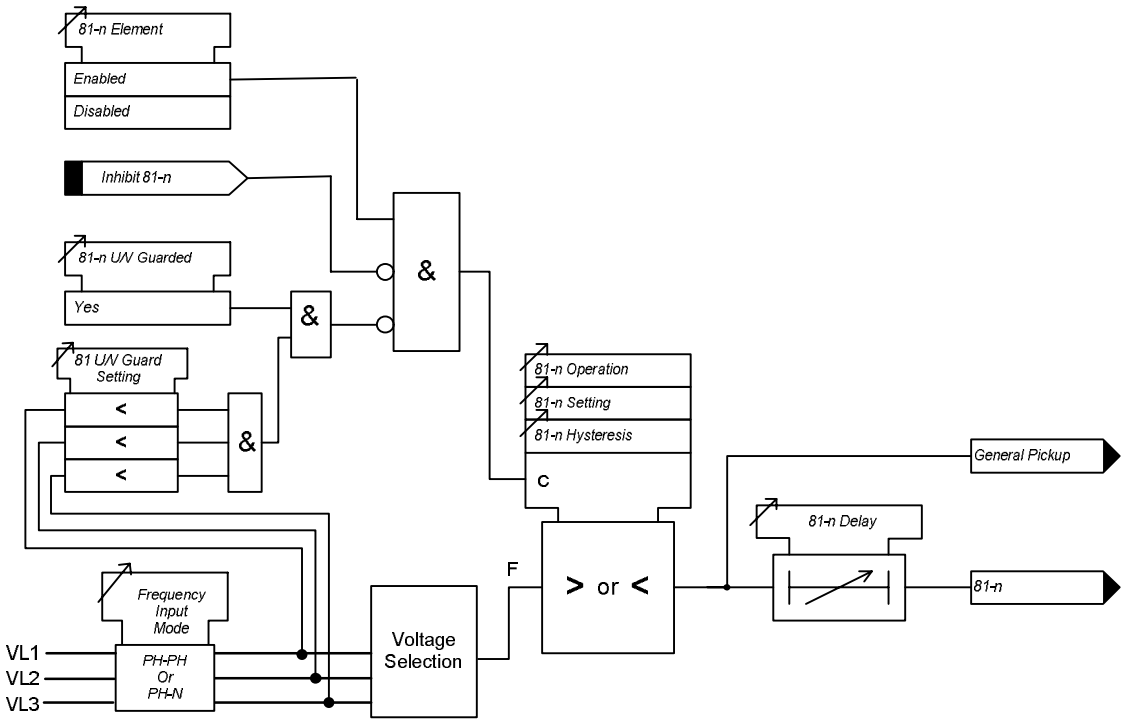

Figure 3-5 Logic Diagram: Under/Over Frequency Detector (81)

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3.6 Voltage Protection: Rate of Change of Frequency (81R)

Rate of Change of Frequency (ROCOF) is used to detect 'islanding' or loss of connection between a generator and the main utility supply.

Six elements are provided ***81R-1, 81R-2, 81R-3, 81R-4, 81R-5 & 81R-6.***

All ROCOF elements have a common ***ROCOF Input Mode*** setting defining whether phase to phase **(Ph-Ph)** or phase to neutral **(Ph-N)** voltages are used. The frequency calculation is based on the highest input voltage derived from the voltage selection algorithm. The frequency of all VT inputs is monitored continually, switching between reference voltages is instantaneous.

All elements will be blocked if all voltages fall below the ***81R U/V Guard*** setting.

81R-n Setting sets the pick-up frequency change for the element.

The direction of frequency change, Positive (increasing frequency), Negative (decreasing frequency) or Both, being looked for by the element is set by the ***81R-n Direction*** setting.

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

Operation of the voltage vector shift elements can be inhibited from:

Inhibit 81R-n	A binary or virtual input.
81R U/V Guard	Under voltage guard element.
User Inhibit	Reylogic (graphical logic)

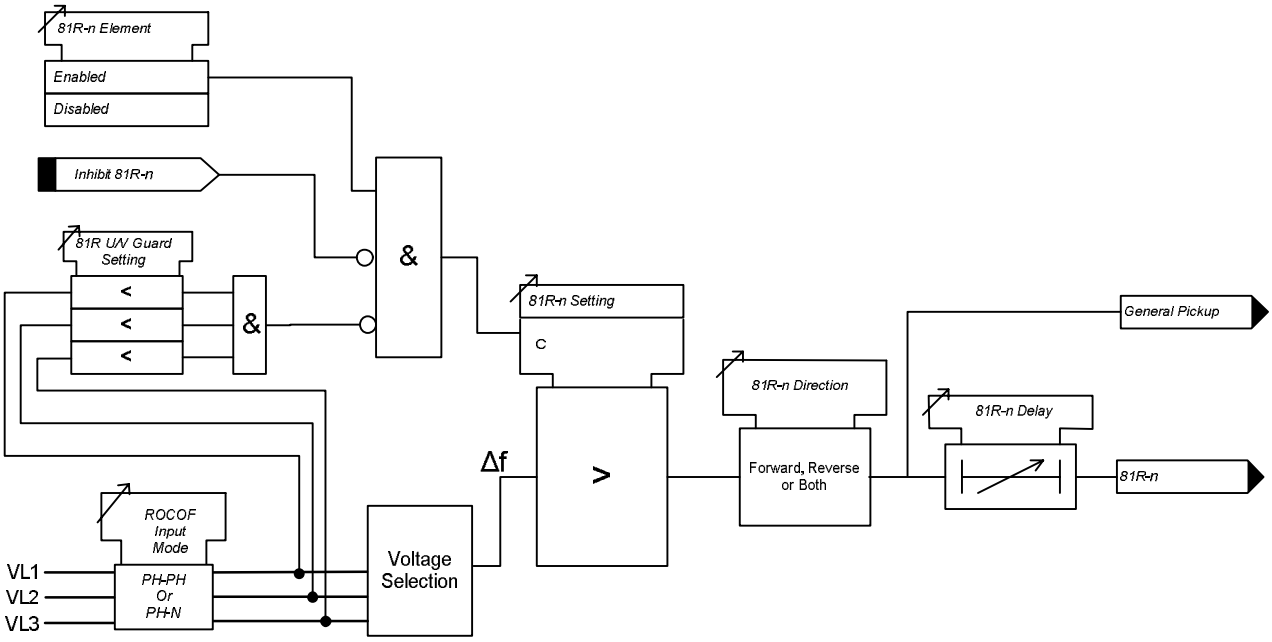

Figure 3-6 Logic Diagram: Rate of Change of Frequency (81R)

Section 4: Control & Logic Functions

4.1 Manual CB Control

Functionality is provided to allow a Relay to manually Open and Close its associated Circuit-Breaker (CB).

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

It should be noted that a CB Open initiated in this way is fundamentally different from a CB Trip initiated by a protection function. A CB Trip will initiate functionality such as fault data storage and operation counter.

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

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

Close CB Delay

Operation of the ***Close CB*** binary output can be delayed by the ***Close CB Delay*** setting. The status of this delay is displayed on the relay fascia as it decrements towards zero. Only when the delay reaches zero will the close command be issued and related functionality initiated.

Blocked Close Delay

The close command may be delayed for the duration that a ***Block Close CB*** signal is applied to a binary input. This can be used, for example, to delay CB closure until the CB energy has reached an acceptable level. The output ***Close CB Blocked*** indicates this condition.

Open CB Delay

Operation of the ***Open CB*** binary output can be delayed by the ***Open CB Delay*** setting. The status of this delay is displayed on the relay fascia as it decrements towards zero. Only when the delay reaches zero will the close command be issued and related functionality initiated.

CB Controls Latched

CB controls for manually closing and tripping can be latched for extra security.

With Reset operation, the control resets when the binary input drops off. This can lead to multiple control restarts due to bounce on the binary input signal.

With Latch operation, the close or trip sequence always continues to completion (or sequence failure) and bounce on the binary input is ignored.

Reset operation can be useful, however, as it allows a close or trip sequence to be aborted by dropping off the binary input signal.

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4.2 Circuit Breaker

Both 'CB Failed To Open' and 'CB Failed to Close' features are provided.

CB Travel Alarm

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

The CB should only ever be in 3 states:

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

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

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

CB Control Trip Time

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

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

Trip Time Alarm

The CB Trip Time meter displays the measured time between the trip being issued and the CB auxiliary contacts changing state. If this measured time exceeds the ***Trip Time Alarm*** time, a ***Trip Time Alarm*** output is issued.

Trip Time Adjust

This allows for the internal delays caused by the relay – especially the delay before a binary input operates – to be subtracted from the measured CB trip time. This gives a more accurate measurement of the time it took for the CB to actually trip.

Open CB Pulse

The duration of the CB open pulse is user settable to allow a range of CB's to be used. The ***Open CB Pulse*** must be long enough for the CB to physically open.

Close CB Pulse

The duration of the ***Close CB Pulse*** is settable to allow a range of Circuit-Breakers (CB's) to be used. The ***Close CB Pulse*** must be long enough for the CB to physically close.

The Close pulse will be terminated if any protection pick-up operates or a trip occurs. This is to prevent Close and Trip Command pulses existing simultaneously.

The output ***CB Successful Close*** confirms a successful CB Close operation.

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

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4.3 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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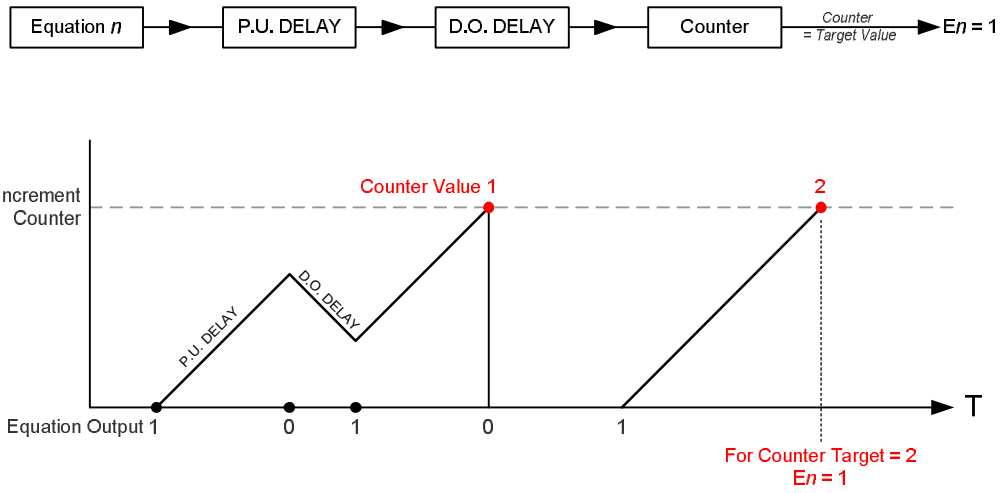

Figure 4-1 Sequence Diagram: Quick Logic PU/DO Timers (Counter Reset Mode Off)

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

This is a simple feature that allows the Relay to detect and report a tripping of the MCB protecting the measuring VT's. Operation of the ***MCB Failed*** binary input is reported by the ***VTS*** binary output.

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

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

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

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

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

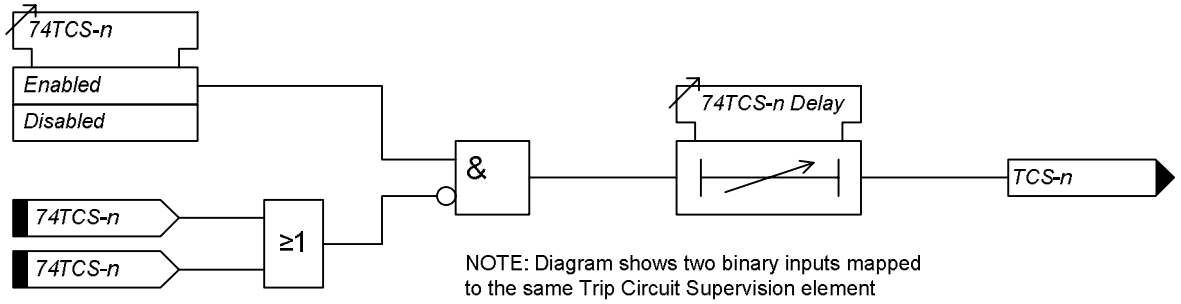

Figure 4-2 Logic Diagram: Trip Circuit Supervision Feature (74TCS)

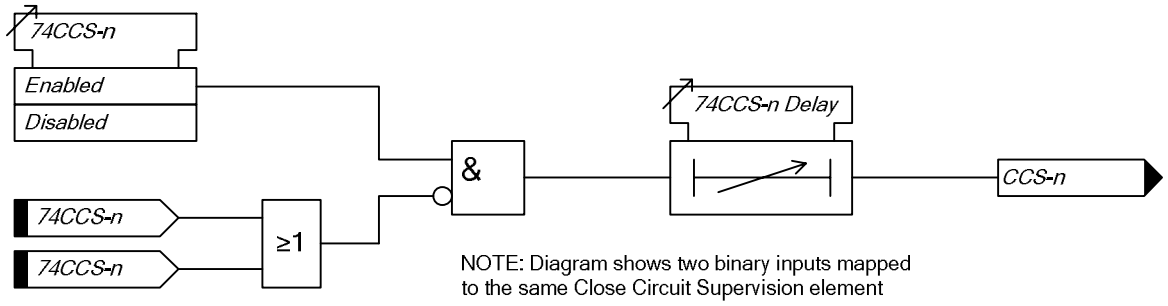

Figure 4-3 Logic Diagram: Close Circuit Supervision Feature (74CCS)

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Section 6: Other Features

6.1 Data Communications

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

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

Communication is compatible with Modbus-RTU, 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 Maintenance

6.2.1 Output Matrix Test

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

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

6.2.2 CB Counters

The following CB maintenance counters are provided:

CB Total Trip Count:	Increments on each trip command issued.
CB Delta Trip Count:	Additional counter which can be reset independently of the Total Trip Counter. This can be used, for example, for recording trip operations between visits to a substation.
CB Count to AR Block: (Only in Auto-reclose models)	Displays the number of CB trips experienced by the CB before the AR is blocked. When the target is reached the relay will only do 1 Delayed Trip to Lockout. An output is available to reset this value.
CB Frequent Ops Count	Logs the number of trip operations in a rolling window period of one hour. An output is available to reset this counter.

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

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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 Communication'.

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 comms 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/Waveform 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/Waveform Storage>***Clear Waveforms*** setting or from Reydisp.

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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 user selected relay operations or via a suitably programmed binary input. An output is provided to indicate when a new record has been stored.

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

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

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

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

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

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

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

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

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

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

> The 'A' symbol at the top-right position of the LCD indicates that new Events, Waveform Records or Fault Records are currently being held in volatile RAM and the archiving, to non-volatile flash disk storage, is being temporarily blocked.

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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 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.

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
Fascia (Control Mode)	Disabled	Enabled	Disabled
USB	Disabled	Enabled	Disabled
Binary Inputs	Setting Option	Setting Option	Enabled
Binary Outputs	Enabled	Enabled	Disabled
Reporting			
Spontaneous			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
General Interrogation			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
MODBUS	Enabled	Enabled	Disabled
Changing of Settings			
Rear 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 Control Mode

This mode provides convenient access to commonly used relay control and test functions. When any of the items listed in the control menu are selected control is initiated by pressing the ENTER key. The user is prompted to confirm the action, again by pressing the ENTER key, before the command is executed.

Note that a CB must be in a Closed state before an Open command will be accepted. And that a CB must be in an Open state before a Close command will be accepted. If not, the Relay reports that the requested command is 'Interlocked'.

Note also that switching a protection function IN / OUT via the Control Menu will not change that function's ENABLED / DISABLED setting. The Control Menu selection will over-ride the setting, however.

Control Mode commands are password protected using the Control Password function – see Section 6.9.

6.7 Real Time Clock

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

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

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

6.7.1 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.

6.7.2 Time Synchronisation – Binary Input

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

6.8 Settings Groups

The relay provides four groups of settings – Group number (Gn) 1 to 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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6.9 Password Feature

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

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

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

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

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

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

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7SR158

Voltage & Frequency Relay

Settings and Instruments

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Date	Software Reference	Summary
2013/11	2436H80011R2d-1a	First Release

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Section 1: Introduction

1.1 Relay Menus and Display

All relay fascias have the same appearance and support the same access keys. The basic menu structure is also the same in all products and consists of four main menus, these being,

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

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

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

Control Mode - allows the user to control external plant under the relays control for example the CB

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

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

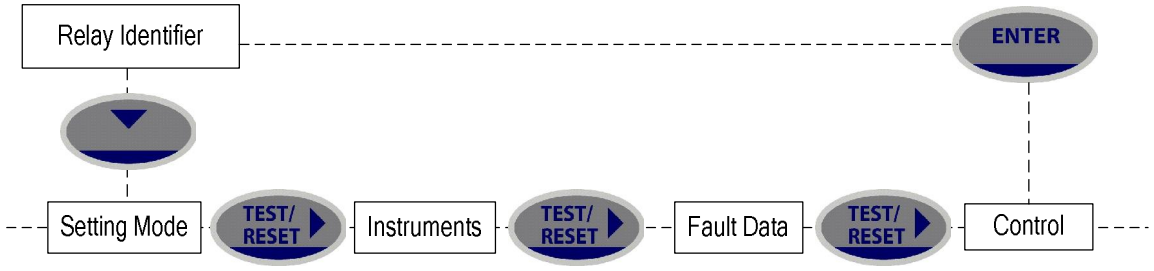

Figure 1.1-1 Menu

Pressing CANCEL returns to the Identifier screen

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

1.1.1 LCD Contrast

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

Figure 1.1-2 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 1.2-2. This diagram shows the main modes of display: Settings Mode, Instrument Mode, Fault Data Mode and Control Mode.

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

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

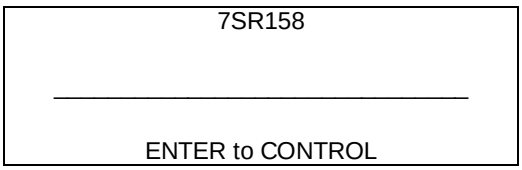

Figure 1.1-3 Relay Identifier Screen

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

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

The five push-buttons have the following functions:

READ DOWN **READ UP**

Used to navigate the menu structure.

ENTER

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

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

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

CANCEL

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

TEST/RESET

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

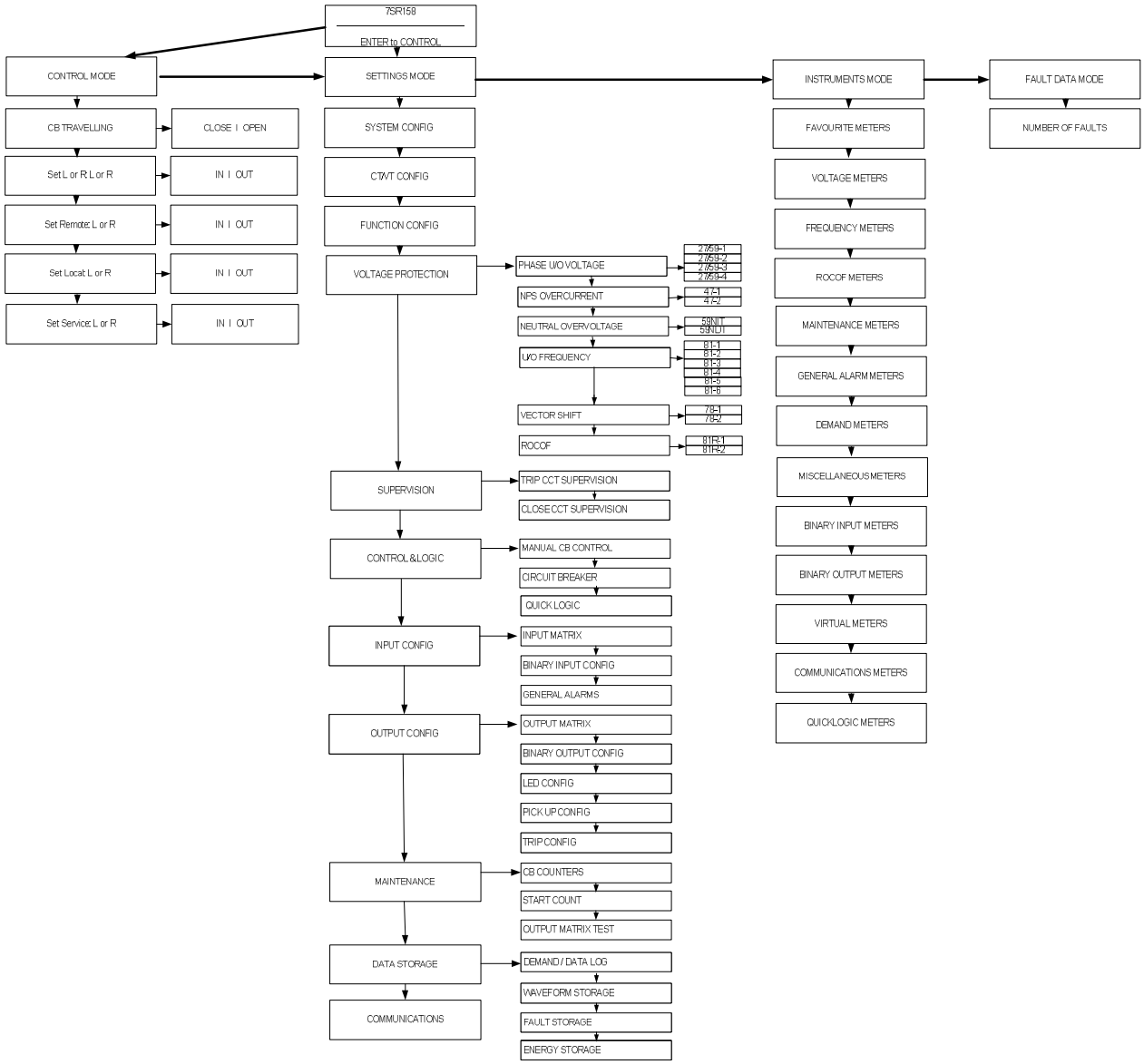

Figure 1.1-4 Menu Structure

1.3 Setting Mode

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

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

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

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

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

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

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

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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 that meter each in the FAVOURITE METERS sub-menu or at its Primary location press ENTER and the message 'Remove From Favourites' will appear press ENTER again and this meter will be removed from the FAVOURITE METERS sub-group
VOLTAGE METERS →to view		This is the sub-group that includes all the meters that are associated with Voltage TEST/RESET ► allows access to this sub-group
Prim Ph-Ph Voltage		Displays the Phase to Phase Voltage Primary RMS values
Vab	0.00kV	
Vbc	0.00kV	
Vca	0.00kV	
Sec Ph-Ph Voltage		Displays the Phase to Phase Voltage Secondary RMS values & Angles with respect to PPS voltage.
Vab	0.00V	
Vbc	0.00V	
Vca	0.00V	
Nominal Ph-Ph Voltage		Displays the Phase to Phase Voltage Nominal RMS values
Vab	0.00V ---^{o}	
Vbc	0.00V ---^{o}	
Vca	0.00V ---^{o}	
Prim Ph-N Voltage		Displays the Phase to Neutral Voltage Primary RMS values
Va	0.00kV	
Vb	0.00kV	
Vc	0.00kV	
Sec Ph-N Voltage		Displays the Phase to Neutral Voltage Secondary RMS values & Angles with respect to PPS voltage.
Va	0.00V	
Vb	0.00V	
Vc	0.00V	
Nom Ph-N Voltage		Displays the Phase to Neutral Voltage Nominal RMS values
Va	0.00V ----^{o}	
Vb	0.00V ----^{o}	
Vc	0.00V ----^{o}	
V Seq Components		Displays the Voltage Sequence components Nominal RMS values & phase angles with respect to PPS voltage.
Vzps	0.00V ----^{o}	
Vpps	0.00V ----^{o}	
Vnps	0.00V ----^{o}	
Calc Earth Voltage		Displays the calculated Earth voltage both primary and secondary which also shows the secondary angle
Pri	0.00V	
Sec	0.00V ----^{o}	
Last Trip Voltage		Displays the Phase to Neutral Voltage Nominal RMS values from Last Trip
Va	0.00V	
Vb	0.00V	
Vc	0.00V	

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Instrument		Description
FREQUENCY METERS →to view		This is the sub-group that includes all the meters that are associated with Frequency. TEST/RESET ► allows access to this sub-group.
Frequency Last Trip	0.000Hz 0.000Hz	Displays the frequency of the last trip
VECTOR SHIFT METERS →to view		This is the sub-group that includes all the meters that are associated with Vector Shift. TEST/RESET ► allows access to this sub-group.
78 Last Trip	Va Vb Vc	Displays the phase shift
ROCOF METERS →to view		This is the sub-group that includes all the meters that are associated with the Rate of Change of Frequency (ROCOF) protection
81R ROCOF Fine Coarse Direction	 0.000Hz/s 0.000Hz/s None	ROCOF < 2 x setting, measurement more accurate but takes longer to update ROCOF ≥ 2 x Setting, measurement more coarse but also faster
81R ROCOF Last Trip Fine Coarse	 0.000Hz/s 0.000Hz/s	Displays the ROCOF values from Last Trip
MAINTENANCE METERS →to view		This is the sub-group that includes all the meters that are associated with Maintenance TEST/RESET ► allows access to this sub-group
CB Total Trips Count Target	 0 100	Displays the number of CB trips experienced by the CB
CB Delta Trips Count Target	 0 100	Displays the number of CB trips experienced by the CB
CB Trip Time Time	 0.0ms	Displays the circuit breaker trip time to open time. Measured from CB auxiliary contacts.
GENERAL ALARM METERS →to view		This is the sub-group that includes all the meters that are associated with the Binary inputs TEST/RESET ► allows access to this sub-group
General Alarms ALARM 1	 Cleared	Displays the state of General Alarm
General Alarms ALARM 2	 Cleared	
General Alarms ALARM 3	 Cleared	
General Alarms ALARM 4	 Cleared	
General Alarms ALARM 5	 Cleared	
General Alarms ALARM 6	 Cleared	
DEMAND METERS →to view		This is the sub-group that includes all the meters that are associated with DEMAND. TEST/RESET ► allows access to this sub-group
V Phase A Demand Max Min Mean	 0.00V 0.00V 0.00V	Displays the Voltage demand based on Va.
V Phase B Demand Max Min Mean	 0.00V 0.00V 0.00V	Displays the Voltage demand based on Vb.

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Instrument	Description
V Phase C Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vc.
V Phase AB Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vab.
V Phase BC Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vbc.
V Phase CA Demand Max 0.00V Min 0.00V Mean 0.00V	Displays the Voltage demand based on Vca.
Frequency Demand Max 0.000Hz Min 0.000Hz Mean 0.000Hz	Displays the Frequency demand.
MISCELLANEOUS METERS →to view	This is the sub-group that includes indication such as the relays time and date, the amount of fault and waveform records stored in the relay TEST/RESET ► allows access to this sub-group
Start Alarm Count 0 Target 100	Count of configurable type of Relay starts
Date 01/01/2000 Time 22:41:44 Waveform Recs 0 Fault Recs 0	This meter displays the date and time and the number of Fault records and Event records stored in the relay
Event Recs 0 Data Log Recs 0 Setting Group 1	
BINARY INPUT METERS →to view	This is the sub-group that includes all the meters that are associated with the Binary inputs TEST/RESET ► allows access to this sub-group
BI 1-6 ---- --	Displays the state of DC binary inputs 1 to 6 (The number of binary inputs may vary depending on model)
BINARY OUTPUT METERS →to view	This is the sub-group that includes all the meters that are associated with the Binary Outputs TEST/RESET ► allows access to this sub-group
BO 1-8 ---- ----	Displays the state of DC binary Outputs 1 to 8. (The number of binary outputs may vary depending on model)
VIRTUAL METERS →to view	This is the sub-group that shows the state of the virtual status inputs in the relay TEST/RESET ► allows access to this sub-group
V 1-8 ---- ----	Displays the state of Virtual Outputs 1 to 8 (The number of virtual inputs will vary depending on model)
COMMUNICATION METERS →to view	This is the sub-group that includes all the meters that are associated with Communications ports TEST/RESET ► allows access to this sub-group
COM1 X COM2	Displays which com ports are currently active
COM1 TRAFFIC COM1 Tx1 0 COM1 Rx1 Error 0 COM1 Rx1 0	Displays data traffic on Communications Port 1

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

1.5 Fault Data Mode

The Fault Data Mode sub menu lists the time and date of the previous 10 protection operations. The stored data about each fault can be viewed by pressing the TEST/RESET► button. Each record contains data on the operated elements, analogue values and LED flag states at the time of the fault. The data is viewed by scrolling down using the ▼ button.

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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:-

PC with Reydisp Evolution Version 7.1.5.6 or later Installed. (This can be downloaded from our website and found under the submenu 'Software') This software requires windows 2000-service pack 4 or above, or windows XP with service pack 2 or above and Microsoft.NET framework for tools.

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.

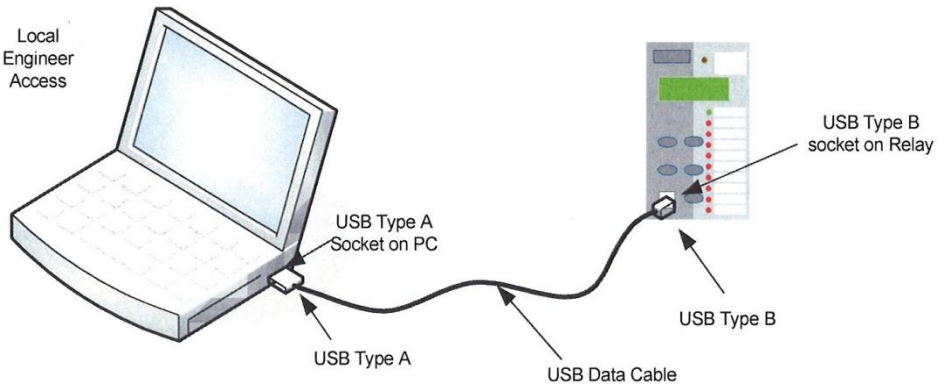

Figure 2.1-1 USB connection to PC

2.1.2 Rear RS485 connection

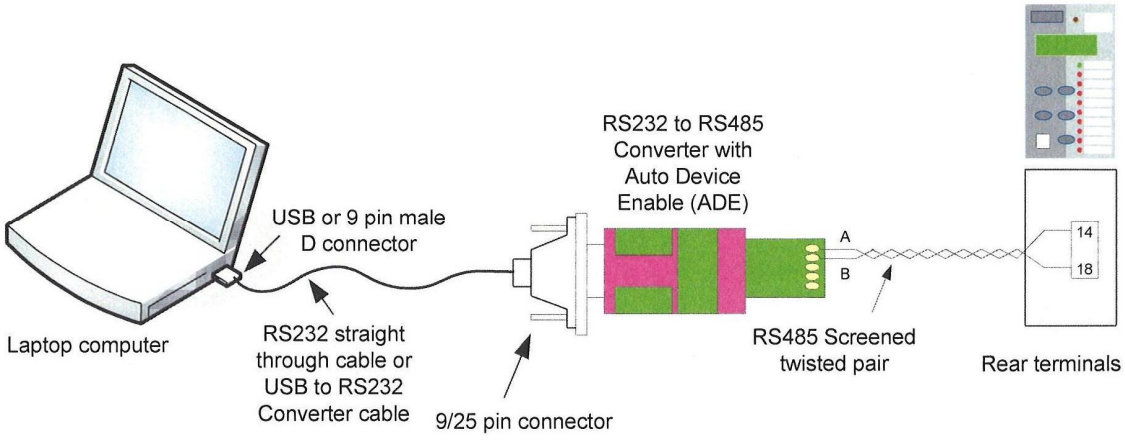

Figure 2.1-2 RS485 connection to PC

2.1.3 Configuring Relay Data Communication

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

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

COM1-RS485 Port and COM2-USB Port

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

2.1.4 Connecting to the Relay for setting via Reydisp

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

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

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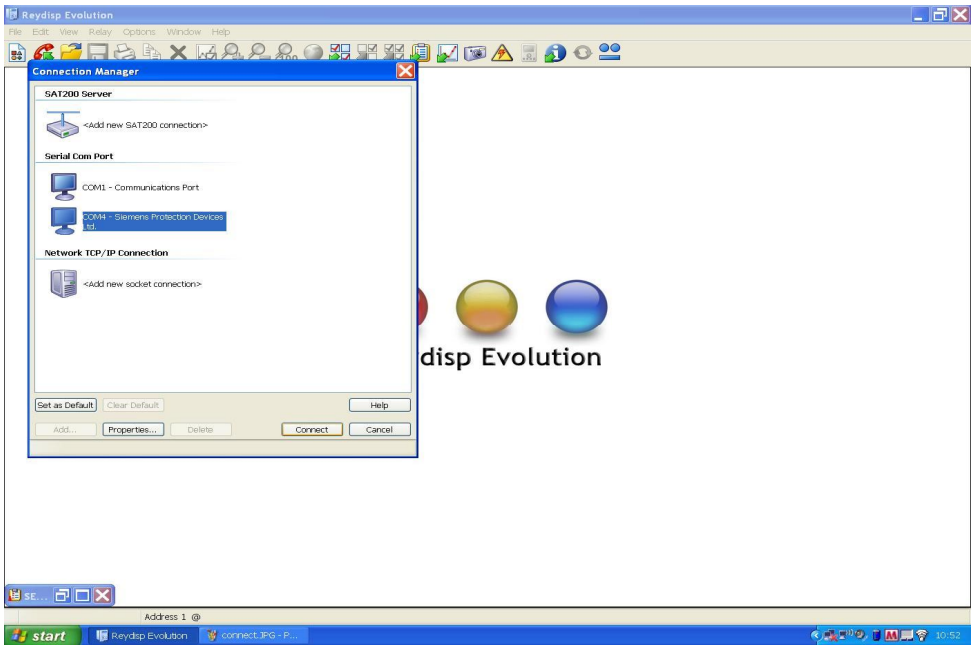

Figure 2.1-3 PC Comm Port Selection

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

2.1.5 Configuring the user texts using Reydisp Language Editor

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

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

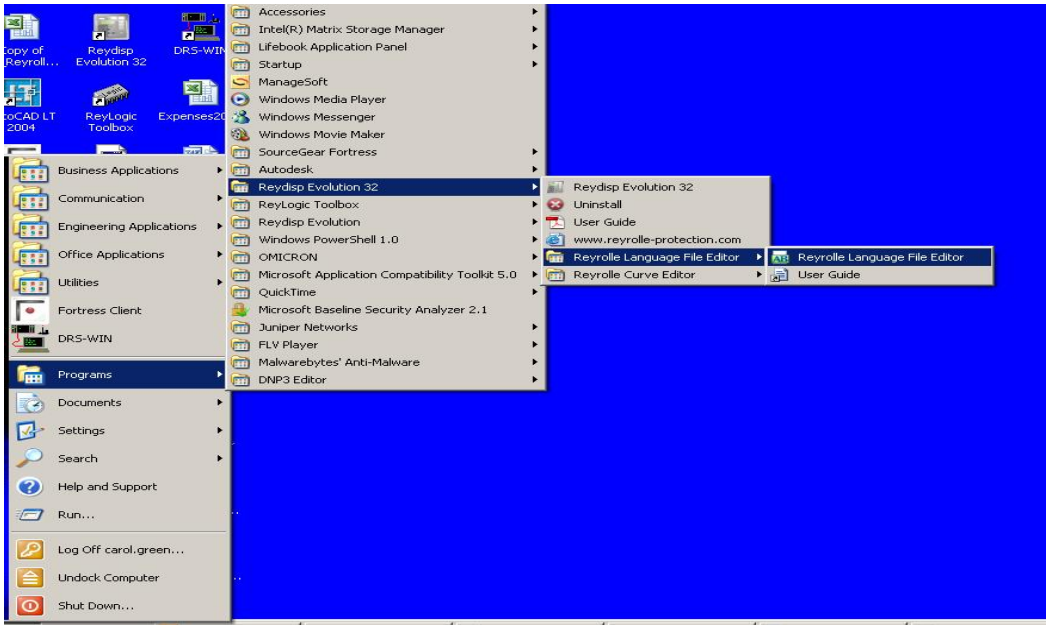

Figure 2.1-4 PC Language File Editor

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

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

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

Please refer to the Language Editor Manual for further guidance.

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7SR158

Voltage & Frequency Relay

Performance Specification

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Section 1: Common Functions

1.1 General

1.1.1 CE Conformity

CE This product is CE compliant to relevant EU directives.

1.1.2 Reference

This product complies with IEC 60255-3 and IEC 60255-6.

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	103.5 mm	103.5 mm
Height		177 mm
Depth behind panel (including clearance for wiring and fibre)		241.5 mm
Projection (from front of panel)		31 mm

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

1.1.4 Weights

Parameter		Value
Net weight	7SR158, E4 case	2.7 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
V_{aux}	24 to 60 VDC	18 to 72 VDC	Low voltage PSU suitable for 24VDC, 30VDC,48VDC and 60VDC systems
	80 to 250 VDC	64 to 300 VDC	High Voltage PSU suitable for 115VAC, 110VDC and 220VDC systems.
	115 VAC 50/60Hz	92 to 138 V rms AC 47.5-52.5/57-63Hz	High Voltage PSU suitable for 115VAC, 110VDC and 220VDC systems.

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

1.2.1.1 Burden

Attribute		Value
24V DC	Minimum	3.9 W
	User Access (back light)	5.3 W
	Maximum	8.0W
60V DC	Minimum	3.9W
	User Access (back light)	5.2 W
	Maximum	7.3W
80V DC	Minimum	4.0W
	User Access (back light)	5.5W
	Maximum	6.5W
250V DC	Minimum	4.2W
	User Access (back light)	5.4W
	Maximum	7.5W
115V AC	Minimum	9VA 0.5PF approx.
	User Access (back light)	10VA 0.5PF approx.
	Maximum	15VA 0.5PF approx.

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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 1.4.3.1, the relay may enter a safety protection mode where a power supply shutdown occurs. This condition is designed to protect the power supply from damage as well as prevent internal relay faults from developing into dangerous situations. Once the relay has entered this safety mode, it may be necessary to reduce the auxiliary input voltage to zero volts for up to 30 seconds before re-application of the auxiliary supply will cause the relay to power up and operate normally. (1) Using fuses as on/off switches or allowing batteries to run at very low cell voltages for extended periods and then attempting to re-charge them are examples of such auxiliary supply conditions.		

1.2.2 AC Analogue Voltage

Attribute	**Nominal**	**Operating Range**
Vn	40 to 160 Vrms	0 to 200 Vrms
fn	50, 60Hz	47.5 to 52.5Hz and 57 to 63Hz

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 EATS48-4

Nominal		Operating Range
V_{BI}	19 VDC	17 to 320 VDC
	88 VDC	74 to 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 may be set for high speed operation. Where a binary input is both used to influence a control function (e.g. provide a tripping function) and it is considered to be susceptible to mal-operation due to capacitive currents, the external circuitry can be modified to provide immunity to such disturbances.

To comply with EATS 48-4, classes ESI 1 and ESI 2, external components / BI pick-up delays are required as shown in fig. 1-1.

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

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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.

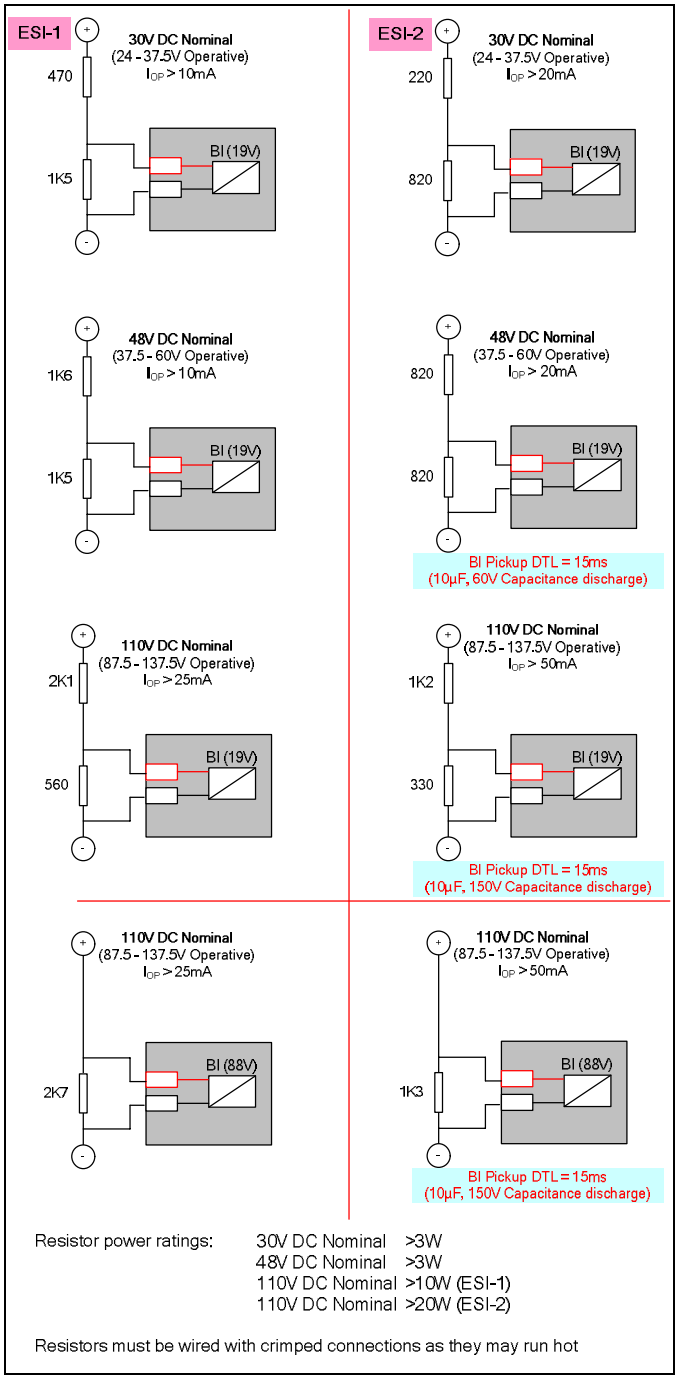

Figure 1.2-1 Binary Input Configurations Providing Compliance with EATS 48-4 Classes ESI 1 and ESI 2

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1.3 Functional performance

1.3.1 Instrumentation

	Instrument Value	Reference	Typical accuracy
V	Voltage	V ≥ 0.8 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

1.3.3 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 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 60068-2-78

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

1.4.1.3 Transient Overvoltage

IEC 60255-5

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 Insulation

IEC 60255-5

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 IP Ratings

IEC60529

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

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1.4.2 Emissions

IEC 60255-25

1.4.2.1 Radiated Radio Frequency

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 Conducted Radio Frequency

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 60255-11

Type of Phenomena	Test Specifications	Duration	Declared Operation
Voltage Dips (DC auxiliary supply)	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)	15% max and min RV	Continuous	Normal operation[1]
Gradual Shut-down/ Start-up (DC auxiliary supply)	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]

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 High Frequency Disturbance

IEC 60255-22-1

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 60255-22-2 Class IV

Type	Level	Variation
Contact discharge	8.0 kV	≤ 5 %

1.4.3.4 Radiated Immunity

IEC 60255-22-3 Class III

Type		Level	Variation
80 MHz to 1000 MHz	Sweep	10 V/m	≤ 5 %
1.4GHz to 2.7GHz	Sweep		
80,160,380,450,900,1850,2150 MHz	Spot		

1.4.3.5 Electrical Fast Transient / Burst Immunity

IEC 60255-22-4 Class A (2002)

Type	Level	Variation
Case, Aux Power & I/O	4.0 kV	≤ 10 %
RS485 Metallic Comms	2.0 kV	No data loss

1.4.3.6 Surge Immunity

IEC 60255-22-5, IEC 61000-4-5

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

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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	

1.4.4 Mechanical

1.4.4.1 Vibration (Sinusoidal)

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 60255-21-2 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 60255-21-3 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

Section 2: Protection Functions

2.1 27/59 Under/Over Voltage

2.1.1 Reference

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

2.1.2 Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		100 % *Vs*, ± 1 % or ±0.25V
	Reset level	Overvoltage	= (100 % - *hyst*) *x* $V_{op,}$ ± 1 % or ± 0.25V
		Undervoltage	= (100 % + *hyst*) *x* V_{op} ± 1 % or ± 0.25V
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.1.3 Operate and Reset Time

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

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2.2 47 Negative Phase Sequence Voltage

2.2.1 Reference

	Parameter	Value
Vs	Setting	1, 1.5… 90V
Hyst.	Hysteresis	0, 0.1… 80%
t_d	Delay setting	0.00, 0.01…20.00, 20.10… 100, 101… 1000, 1010… 10000, 10100… 14400 s

2.2.2 Operate and Reset Level

	Attribute		Value
V_{op}	Operate level		100 % *Vs*, ± 2 % or ± 0.5 V
	Reset level		(100%-Hyst.) x V_{op} ± 1% or ± 0.25V
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.2.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0V to 2.0 *xVs*, 80 ms, ± 20ms
		0V to 10 *xVs*, 70ms, ± 20ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 2 % or ± 20ms
	Repeatability	± 1 % or ± 20ms
	Overshoot time	< 40 ms
	Disengaging time	< 90 ms

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2.3 59N Neutral Voltage Displacement

2.3.1 Reference (59NDT)

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

2.3.2 Operate and Reset Level (59NDT)

	Attribute		Value
V_{op}	Operate level		100 % *Vs*, ± 2 % or ± 0.5 V
	Reset level		≥ 95 % V_{op} or ± 0.5 V
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.3.3 Operate and Reset Time (59NDT)

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

2.3.4 Reference (59NIT)

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

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2.3.5 Operate and Reset Level (59NIT)

	Attribute		Value
V_{op}	Operate level		100 % *Vs*, ± 2 % or ± 0.5 V
	Reset level		≥ 95 % V_{op} or ± 0.5 V
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

2.3.6 Operate and Reset Time (59NIT)

	Attribute		Value
t_{basic}	Starter operate time		65 ms, ± 20ms
$3V_o$	Applied Current (for Operate-Time) DTL		10 x Vs
t_{op}	Operate time	char = IDMTL	$t_{op} = \frac{M}{\left[\frac{3V0}{Vs}\right] - 1}$, ± 5 % or ± 65 ms
		char = DTL	t_d, ± 1 % or ± 40ms
	Reset Time	char = IDMTL	t_{res}, ± 5 % or ± 65ms
		char = DTL	t_{res}, ± 1 % or ± 40ms
	Repeatability		± 1 % or ± 20ms
	Overshoot time		< 40 ms
	Disengaging time		< 100 ms

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2.4 78 Vector Shift

2.4.1 Reference

	Parameter	Value
VS_s	78 Setting	2.0, 2.5 ... 30 °
F_{nom}	Nominal Frequency	50 Hz or 60 Hz

2.4.2 Operate Level

	Attribute	Value
VS_{op}	Operate Level	VS_s, ± 2°

2.4.3 Operate Time

	Attribute	Value
t_{basic}	Basic operate time	≤ 40 ms

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2.5 81 Under/Over Frequency

2.5.1 Reference

	Parameter	Value
F_s	Setting	43, 43.01… 68 Hz
Hyst	Hysteresis setting	0, 0.1… 2%
t_d	Delay setting	0.00, 0.01… 20.0, 20.1… 100.0, 101.…1000, 1010 … 10000 , 10100 … 14400 s

2.5.2 Operate and Reset Level

	Attribute		Value
F_{op}	Operate level		100 % F_s, ± 10mHz
	Reset level	Overfrequency	(100 % - *hyst*) $xF_{op,}$ ± 10mHz
		Underfrequency	(100 % + *hyst*) $xF_{op,}$ ± 10mHz
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %

2.5.3 Operate and Reset Time

	Attribute		Value
t_{basic}	Element basic operate time (for ROCOF between 0.1 and 5.0 Hz/sec)	overfrequency	Typically < 110ms
			Maximum < 150ms
		underfrequency	Typically < 110ms
			Maximum < 150ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability		± 1 % or ± 10ms
	Disengaging time		< 100 ms

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2.6 81R Rate-of-Change-of-Frequency (df/dt)

2.6.1 Reference

	Parameter	Value
R_s	Setting	0.050, 0.075 …10.0 Hz/s
t_d	Delay setting	0, 0.01 … 20, 20.1 ... 100, 101 ... 1000, 1010 ... 10000,10100 ... 100000, 101000 ... 864000s
F_{nom}	Nominal Frequency	50 Hz or 60 Hz

2.6.2 Operate Level

	Attribute		Value
R_{op}	Operate Level		R_s, ± 50 mHz/s (Fnom ± 3Hz)
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %

2.6.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time (for ROCOF > 1.3x setting)	Typically < 215 ms
		Maximum < 300 ms
	Element basic operate time (for ROCOF > 2x setting)	Typically < 185 ms
		Maximum < 200 ms
t_{op}	Operate time following delay	t_{basic} + t_d, ± 1 % or ± 10 ms
	Repeatability	± 1 % or ± 10 ms

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Section 3: Supervision Functions

3.1 74TCS & 74CCS Trip & 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		30ms ± 10ms
t_{op}	Operate time following delay		t_{basic} + t_d, ± 1 % or ± 10ms
	Repeatability		± 1 % or ± 10ms
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} ± 5 %	≤ 5 %

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7SR158

7SR1587-5xA12-xDA0

Document Release History

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

Date	Description
2013/09	First Issue

Software Revision History

FW#	Date	Aricle Number	Description
	2013/09	2436H80011R2d-1a	First Issue

Note the column ***FW#*** above contains a reference to the firmware revision. This reference is used within this document where features have been added to the firmware and are available from a particular revision, or are specific to certain revisions.

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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*** 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.

Any or all serial ports can be mapped to the IEC60870-5-103, DNP3 or MODBUS-RTU protocol at any one time, protocols available will depend upon relay model. Any port not required can be disabled by setting its protocol to OFF.

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

Siemens Protection Devices Limited (SPDL) can provide a range of interface devices, please refer to product portfolio catalogue.

Full details of the interface devices can be found by referring to the website www.siemens.com/energy.

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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 65, for further explanation

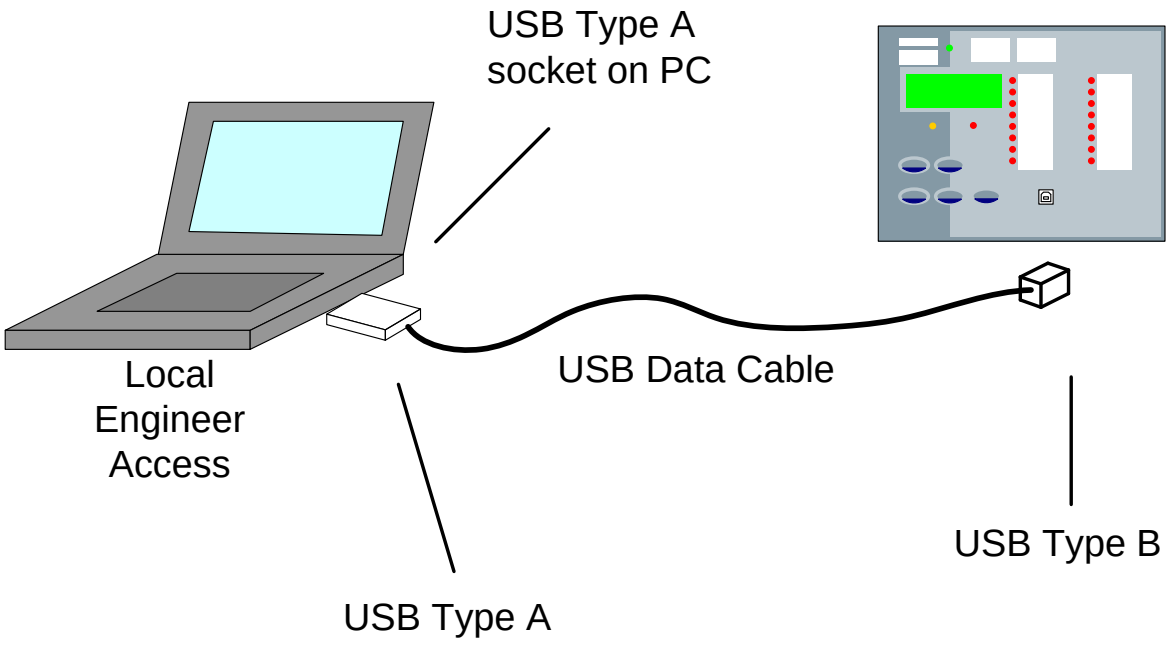

Fig. 2-1 Communication to Front USB Port

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2.3 RS485 Interface (COM1)

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

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

The 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 65, for further explanation

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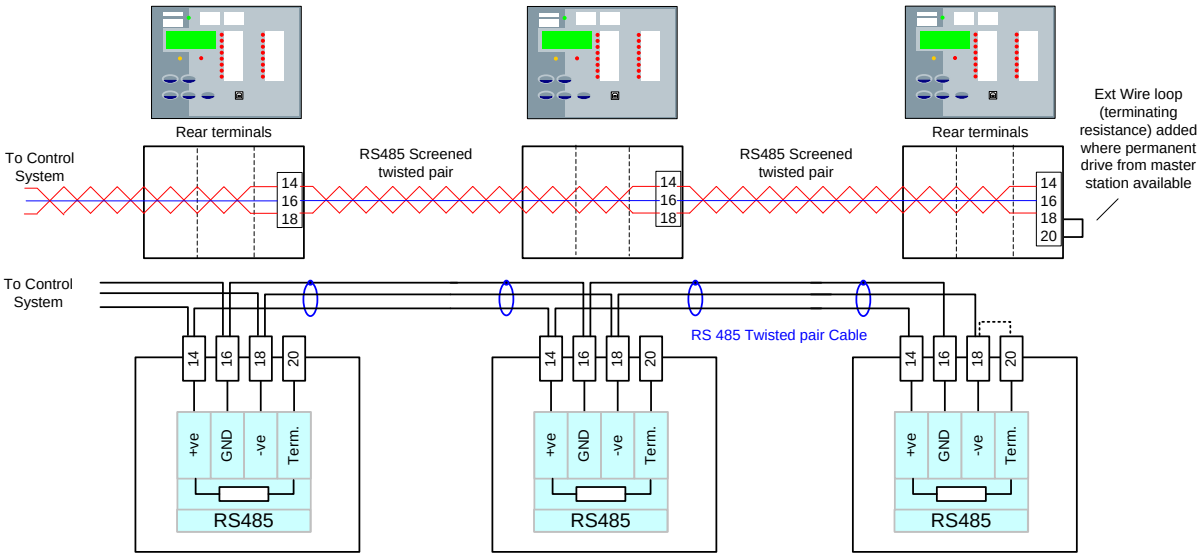

Fig. 2-2 Communication to Multiple Devices using RS485 (Standard Port)

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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) 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.

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

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

FW#	FUN	INF	Description	ASDU	COT
	60	4	Remote Mode	1	SE, GI
				20	Ack, Nak
	60	5	Out Of Service Mode	1	SE, GI
				20	Ack, Nak
	60	6	Local Mode	1	SE, GI
				20	Ack, Nak
	60	7	Local & Remote	1	SE, GI
				20	Ack, Nak
	60	12	Control Received	1	SE
	60	13	Command Received	1	SE
	60	128	Cold Start	1	SE
	60	129	Warm Start	1	SE
	60	130	Re-Start	1	SE
	60	131	Expected Restart	1	SE, GI
	60	132	Unexpected Restart	1	SE, GI
	60	133	Reset Start Count	1	SE
				20	Ack, Nak
	60	135	Trigger Storage	1	SE
	60	136	Clear Waveform Records	1	SE
	60	137	Clear Fault Records	1	SE
	60	138	Clear Event Records	1	SE
	60	140	Demand metering reset	1	SE
				20	Ack, Nak
	60	170	General Alarm 1	1	SE, GI
	60	171	General Alarm 2	1	SE, GI
	60	172	General Alarm 3	1	SE, GI
	60	173	General Alarm 4	1	SE, GI
	60	174	General Alarm 5	1	SE, GI
	60	175	General Alarm 6	1	SE, GI
	60	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

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FW#	FUN	INF	Description	ASDU	COT
	75	1	Virtual Input 1	1	SE, GI
	75	2	Virtual Input 2	1	SE, GI
	75	3	Virtual Input 3	1	SE, GI
	75	4	Virtual Input 4	1	SE, GI
	75	5	Virtual Input 5	1	SE, GI
	75	6	Virtual Input 6	1	SE, GI
	75	7	Virtual Input 7	1	SE, GI
	75	8	Virtual Input 8	1	SE, GI
	80	1	Binary Output 1	1	SE, GI
				20	Ack, Nak
	80	2	Binary Output 2	1	SE, GI
				20	Ack, Nak
	80	3	Binary Output 3	1	SE, GI
				20	Ack, Nak
	80	4	Binary Output 4	1	SE, GI
				20	Ack, Nak
	80	5	Binary Output 5	1	SE, GI
				20	Ack, Nak
	80	6	Binary Output 6	1	SE, GI
				20	Ack, Nak
	80	7	Binary Output 7	1	SE, GI
				20	Ack, Nak
	80	8	Binary Output 8	1	SE, GI
				20	Ack, Nak
	90	1	LED 1	1	SE, GI
	90	2	LED 2	1	SE, GI
	90	3	LED 3	1	SE, GI
	90	4	LED 4	1	SE, GI
	90	5	LED 5	1	SE, GI
	90	6	LED 6	1	SE, GI
	90	7	LED 7	1	SE, GI
	90	8	LED 8	1	SE, GI
	90	9	LED 9	1	SE, GI
	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

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FW#	FUN	INF	Description	ASDU	COT
	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
				20	Ack, Nak
	160	24	Setting G2 selected	1	SE, GI
				20	Ack, Nak
	160	25	Setting G3 selected	1	SE, GI
				20	Ack, Nak
	160	26	Setting G4 selected	1	SE, GI
				20	Ack, Nak
	160	27	Binary Input 1	1	SE, GI
	160	28	Binary Input 2	1	SE, GI
	160	29	Binary Input 3	1	SE, GI
	160	30	Binary Input 4	1	SE, GI
	160	36	Trip Circuit Fail	1	SE, GI
	160	38	VT Fuse Failure	1	SE, GI
	160	68	General Trip	2	SE
	160	84	General Start/Pick-up	2	SE, GI
	183	60	47-1	2	SE, GI
	183	61	47-2	2	SE, GI
	183	81	27/59-1	2	SE, GI
	183	82	27/59-2	2	SE, GI
	183	83	27/59-3	2	SE, GI
	183	84	27/59-4	2	SE, GI
	183	85	59NIT	2	SE, GI
	183	86	59NDT	2	SE, GI
	183	90	81-1	2	SE, GI
	183	91	81-2	2	SE, GI
	183	92	81-3	2	SE, GI
	183	93	81-4	2	SE, GI
	183	94	81-5	2	SE, GI
	183	95	81-6	2	SE, GI
	183	101	Trip Circuit Fail 1	2	SE, GI
	183	102	Trip Circuit Fail 2	2	SE, GI
	183	103	Trip Circuit Fail 3	2	SE, GI
	183	114	Close CB Failed	1	SE
	183	115	Open CB Failed	1	SE
	183	118	Successful Close	1	SE
	183	123	CB Total Trip Count	1	SE, GI
	183	124	CB Delta Trip Count	1	SE, GI
	183	126	Reset CB Total Trip Count	1	SE
				20	Ack, Nak
	183	127	Reset CB Delta Trip Count	1	SE

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FW#	FUN	INF	Description	ASDU	COT
				20	Ack, Nak
	183	163	Trip Time Alarm	1	SE
	183	164	Close Circuit Fail 1	2	SE, GI
	183	165	Close Circuit Fail 2	2	SE, GI
	183	166	Close Circuit Fail 3	2	SE, GI
	183	167	Close Circuit Fail	2	SE, GI
	183	181	CB Total Trip Count	4	SE
	183	182	CB Delta Trip Count	4	SE
	183	245	Va Fault Voltage	4	SE
	183	246	Vb Fault Voltage	4	SE
	183	247	Vc Fault Voltage	4	SE
	185	37	27/59 PhA	2	SE, GI
	185	38	27/59 PhB	2	SE, GI
	185	39	27/59 PhC	2	SE, GI
	185	133	78-1	2	SE, GI
	185	134	78-2	2	SE, GI
	185	135	81R-1	2	SE, GI
	185	136	81R-2	2	SE, GI
	185	137	81R-3	2	SE, GI
	185	138	81R-4	2	SE, GI
	185	139	81R-5	2	SE, GI
	185	140	81R-6	2	SE, GI
	200	1	CB 1	1	SE
				20	Ack, Nak
	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
				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

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FW#	FUN	INF	Description	ASDU	COT
				20	Ack, Nak
	200	161	User DP Command 4	1	SE
				20	Ack, Nak
	200	162	User DP Command 5	1	SE
				20	Ack, Nak
	200	163	User DP Command 6	1	SE
				20	Ack, Nak
	200	164	User DP Command 7	1	SE
				20	Ack, Nak
	200	165	User DP Command 8	1	SE
				20	Ack, Nak
	200	255	Blocked By Interlocking	1	SE, GI
	255	0	General Interrogation (GI) Initiation	7	Init. GI
	255	0	General Interrogation (GI) End	8	End of GI
	255	0	Time Synchronisation	6	Time Synch.

3.4.2 Measurands

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

FW#	FUN	INF	Description	ASDU	COT
	183	148	Measurand $V_{L1-2,L2-3,L3-1,}$ $V_{L1,2,3,}$ F --- V_{L1-2} (1.2x) (Window 1%) V_{L2-3} (1.2x) (Window 1%) V_{L3-1} (1.2x) (Window 1%) V_{L1} (1.2x) (Window 1%) V_{L2} (1.2x) (Window 1%) V_{L3} (1.2x) (Window 1%) F (1.2x) (Window 0.1%)	9	Cyclic - Refresh rate 5 seconds or value change greater than Window x %.
	183	236	Measurand V $Max_{1,2,3,}$ VPh $Max_{1,2,3}$ --- V Max_1 (1.2x) (Window 1%) V Max_2 (1.2x) (Window 1%) V Max_3 (1.2x) (Window 1%) VPh Max_1 (1.2x) (Window 1%) VPh Max_2 (1.2x) (Window 1%) VPh Max_3 (1.2x) (Window 1%)	9	Cyclic - Refresh rate 5 seconds or value change greater than Window x %.

3.4.3 Disturbance Recorder Actual Channel (ACC) Numbers

The following Disturbance Recorder channel numbers apply to this device.

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FW#	FUN	ACC	Description
	182	1	V1
	182	2	V2
	182	3	V3

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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). 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.

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Address	Value
30001	4974
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:

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Address	Value
30001	162E

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

Truncation

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

4.2.5 EVENT

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

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

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

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

Format

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

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

The following table describes the fields in the event record.

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

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Key	Description
F# L	Fault Number low byte.
F# H	Fault Number high byte.
Meas	Measurand format R32.23, sent least significant byte first.

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

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

Event Type 1 Format.

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

Event Type 2 Format.

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

Event Type 4 Format.

4.2.6 EVENTCOUNT

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

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

4.2.7 TIME_METER

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

The following table describes the fields in the time.

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

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

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

Time Format.

4.2.8 STR32 & STR64

4.2.9 BITSTRING

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

BITSTRING & MODBUS

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

Address	Value
30001	0905

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

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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)

FW#	Address	Name
	00001	Binary Output 1
	00002	Binary Output 2
	00003	Binary Output 3
	00004	Binary Output 4
	00005	Binary Output 5
	00006	Binary Output 6
	00007	Binary Output 7
	00008	Binary Output 8
	00101	Setting G1 selected
	00102	Setting G2 selected
	00103	Setting G3 selected
	00104	Setting G4 selected
	00109	CB 1
	00155	Remote Mode
	00156	Out Of Service Mode
	00157	Local Mode
	00158	Local & Remote
	00165	Reset Start Count
	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)

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FW#	Address	Name
	10001	Binary Input 1
	10002	Binary Input 2
	10003	Binary Input 3
	10004	Binary Input 4
	10005	Binary Input 5
	10006	Binary Input 6
	10102	Remote Mode
	10103	Out Of Service Mode
	10104	Local Mode
	10105	Local & Remote
	10111	Trip Circuit Fail
	10115	General Start/Pick-up
	10116	VT Fuse Failure
	10152	47-1
	10153	47-2
	10155	27/59-1
	10156	27/59-2
	10157	27/59-3
	10158	27/59-4
	10159	59NIT
	10160	59NDT
	10161	81-1
	10162	81-2
	10163	81-3
	10164	81-4
	10165	81-5
	10166	81-6
	10177	CB Total Trip Count
	10178	CB Delta Trip Count
	10211	Trip Circuit Fail 1
	10212	Trip Circuit Fail 2
	10213	Trip Circuit Fail 3
	10214	CB Total Trip Count
	10215	CB Delta Trip Count
	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

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FW#	Address	Name
	10302	Quick Logic E1
	10303	Quick Logic E2
	10304	Quick Logic E3
	10305	Quick Logic E4
	10401	27/59 PhA
	10402	27/59 PhB
	10403	27/59 PhC
	10501	Virtual Input 1
	10502	Virtual Input 2
	10503	Virtual Input 3
	10504	Virtual Input 4
	10505	Virtual Input 5
	10506	Virtual Input 6
	10507	Virtual Input 7
	10508	Virtual Input 8
	10601	LED 1
	10602	LED 2
	10603	LED 3
	10604	LED 4
	10605	LED 5
	10606	LED 6
	10607	LED 7
	10608	LED 8
	10609	LED 9
	10701	LED PU 1
	10702	LED PU 2
	10703	LED PU 3
	10704	LED PU 4
	10705	LED PU 5
	10706	LED PU 6
	10707	LED PU 7
	10708	LED PU 8
	10709	LED PU 9
	10800	Cold Start
	10801	Warm Start
	10802	Re-Start
	10803	Power On
	10804	Expected Restart
	10805	Unexpected Restart
	10806	Reset Start Count
	10900	User SP Command 1
	10901	User SP Command 2
	10902	User SP Command 3
	10903	User SP Command 4
	10904	User SP Command 5

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FW#	Address	Name
	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
	10984	81R-1
	10985	81R-2
	10986	81R-3
	10987	81R-4
	10988	81R-5
	10989	81R-6

4.3.3 Input Registers (Read Only Registers)

FW#	Address	Name	Format	Mult	Description
	30001	Event Count	EVENTCOUNT	0.000000	Events Counter
	30002	Event	EVENT	0.000000	8 Registers
	30010	Vab Primary	FP_32BITS_3DP	1.000000	Vab V
	30012	Vbc Primary	FP_32BITS_3DP	1.000000	Vbc V
	30014	Vca Primary	FP_32BITS_3DP	1.000000	Vca V
	30016	Va Primary	FP_32BITS_3DP	1.000000	Va V
	30018	Vb Primary	FP_32BITS_3DP	1.000000	Vb V
	30020	Vc Primary	FP_32BITS_3DP	1.000000	Vc V
	30022	Va Secondary	FP_32BITS_3DP	1.000000	Va V
	30024	Vb Secondary	FP_32BITS_3DP	1.000000	Vb V
	30026	Vc Secondary	FP_32BITS_3DP	1.000000	Vc V
	30034	Vab Nominal	FP_32BITS_3DP	1.000000	Vab Degrees
	30036	Vbc Nominal	FP_32BITS_3DP	1.000000	Vbc Degrees
	30038	Vca Nominal	FP_32BITS_3DP	1.000000	Vca Degrees
	30040	Va Nominal	FP_32BITS_3DP	1.000000	Va Degrees
	30042	Vb Nominal	FP_32BITS_3DP	1.000000	Vb Degrees
	30044	Vc Nominal	FP_32BITS_3DP	1.000000	Vc Degrees
	30048	Vzps	FP_32BITS_3DP	1.000000	Vzps V
	30050	Vpps	FP_32BITS_3DP	1.000000	Vpps V
	30052	Vnps	FP_32BITS_3DP	1.000000	Vnps V
	30054	Vzps	FP_32BITS_3DP	1.000000	Vzps Degrees
	30056	Vpps	FP_32BITS_3DP	1.000000	Vpps Degrees
	30058	Vnps	FP_32BITS_3DP	1.000000	Vnps Degrees

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FW#	Address	Name	Format	Mult	Description
	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
	30170	Vab Secondary	FP_32BITS_3DP	1.000000	Vab V
	30172	Vbc Secondary	FP_32BITS_3DP	1.000000	Vbc V
	30174	Vca Secondary	FP_32BITS_3DP	1.000000	Vca V
	30176	Vn Primary	FP_32BITS_3DP	1.000000	Vn V
	30178	Vn Secondary	FP_32BITS_3DP	1.000000	Vn V
	30180	Vn Secondary	FP_32BITS_3DP	1.000000	Vn Degrees
	30241	CB Total Trip Count	UINT32	1.000000	CB Total Trip Count
	30243	CB Delta Trip Count	UINT32	1.000000	CB Delta Trip Count
	30307	Va Last Trip	FP_32BITS_3DP	1.000000	Va Fault
	30309	Vb Last Trip	FP_32BITS_3DP	1.000000	Vb Fault
	30311	Vc Last Trip	FP_32BITS_3DP	1.000000	Vc Fault
	30319	V Phase A Max	FP_32BITS_3DP	1.000000	Va Max Demand
	30321	V Phase B Max	FP_32BITS_3DP	1.000000	Vb Max Demand
	30323	V Phase C Max	FP_32BITS_3DP	1.000000	Vc Max Demand
	30325	V Phase AB Max	FP_32BITS_3DP	1.000000	Vab Max Demand
	30327	V Phase BC Max	FP_32BITS_3DP	1.000000	Vbc Max Demand
	30329	V Phase CA Max	FP_32BITS_3DP	1.000000	Vca Max Demand
	30341	LED1-n	BITSTRING	0.000000	Led 1-16 status
	30342	LED1-n	BITSTRING	0.000000	Led 17-32 status
	30343	INP1-n	BITSTRING	0.000000	Input 1-16 status
	30344	INP1-n	BITSTRING	0.000000	Input 17-32 status
	30345	OUT1-n	BITSTRING	0.000000	Output 1-16 status
	30346	OUT1-n	BITSTRING	0.000000	Output 17-32 status
	30347	VRT1-n	BITSTRING	0.000000	Virtual 1-16 status
	30348	VRT1-n	BITSTRING	0.000000	Virtual 17-32 status
	30349	EQN1-n	BITSTRING	0.000000	Equation 1-16 status
	30350	EQN1-n	BITSTRING	0.000000	Equation 17-32 status
	30380	StartCount	FP_32BITS_3DP	1.000000	Start Count
	30382	Start Count Target	FP_32BITS_3DP	1.000000	Start Count Target
	30390	Freq Last Trip	FP_32BITS_3DP	1.000000	Freq Last Trip
	30392	Active Setting Group	UINT16	1.000000	Active Setting Group
	30400	Frequency Max	FP_32BITS_3DP	1.000000	Frequency Max

4.3.4 Holding Registers (Read Write Registers)

FW#	Address	Name	Format	Mult	Description
	40001	Time	TIME_METER	0.000000	Time

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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 36), and the Point List Tables provided in Section 5.3 (beginning on page 43), should provide a complete configuration/interoperability guide for communicating with a device implementing the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library.

DNP V3.0
DEVICE PROFILE DOCUMENT
(Also see the DNP 3.0 Implementation Table in Section 5.2, beginning on page 36).

Vendor Name: **Siemens Protection Devices Ltd.**

Device Name: **7SR158, using the Triangle MicroWorks, Inc. DNP3 Slave Source Code Library, Version 3.**

Highest DNP Level Supported:	Device Function:
For Requests: **Level 3** For Responses: **Level 3**	☐ Master ☒ **Slave**

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

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

Output Event Object 11 is supported.

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted: **256** Received: **256**	Transmitted: **2048** Received: **2048**

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
☐ None ☐ Fixed (3) ☒ **Configurable from 0 to 65535 (Default 3)**	☒ **None** ☐ Configurable

Requires Data Link Layer Confirmation:
- ☐ Never
- ☐ Always
- ☐ Sometimes
- ☒ **Configurable as: Never, Only for multi-frame messages, or Always**

Requires Application Layer Confirmation:
- ☐ Never
- ☐ Always
- ☒ **When reporting Event Data (Slave devices only)**
- ☒ **When sending multi-fragment responses (Slave devices only)**
- ☐ Sometimes
- ☐ Configurable as: “Only when reporting event data”, or “When reporting event data or multi-fragment messages.”

Timeouts while waiting:

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:

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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 36).

Transmission Delay, (Configurable, default 0 sec)
Select/Operate Arm Timeout, (Configurable, default 5 sec)
Need Time Interval, (Configurable, default 30 minutes)
Unsolicited Notification Delay, (Configurable, default 5 seconds)
Unsolicited Response Retry Delay, (Configurable (between 3 - 9), default 5 seconds)
Unsolicited Offline Interval, (Configurable, default 30 seconds)
Binary Change Event Scan Period, (Polled, Not Applicable)
Double Bit Change Event Scan Period, (Polled - Not Applicable)
Analog Change Event Scan Period, (Polled - Not Applicable)
Counter Change Event Scan Period, (Polled - Not Applicable)
Frozen Counter Change Event Scan Period, (Polled - Not Applicable)
String Change Event Scan Period, (Unsupported - Not Applicable)
Virtual Terminal Event Scan Period, (Unsupported - Not Applicable)

Sends/Executes Control Operations:

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: _____

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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 36).

	☒ **Point-by-point list attached**

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

Sequential File Transfer Support:

File Transfer Support	☐ Yes	☒ **No**
Append File Mode	☐ Yes	☒ **No**
Custom Status Code Strings	☐ Yes	☒ **No**
Permissions Field	☐ Yes	☒ **No**
File Events Assigned to Class	☐ Yes	☒ **No**
File Events Send Immediately	☐ Yes	☒ **No**
Multiple Blocks in a Fragment	☐ Yes	☒ **No**
Max Number of Files Open	**0**	

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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)

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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	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)		
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)

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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	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)
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)

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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)**
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 (unsol. resp)	17, 28 (index)
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)	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)		
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)				
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				

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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)**
		(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) 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)		
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.)	06 (no range, or all)		

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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)**
			22 (assign class)			
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). 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)**

FW#	Point Index	Name (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
	41	Trip Circuit Fail	0,2	2	2
	45	General Start/Pick-up	0,2	2	2
	46	VT Fuse Failure	0,2	2	2
	67	47-1	0,2	2	2
	68	47-2	0,2	2	2
	70	27/59-1	0,2	2	2
	71	27/59-2	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)**

FW#	Point Index	Name (Description)	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
	72	27/59-3	0,2	2	2
	73	27/59-4	0,2	2	2
	74	59NIT	0,2	2	2
	75	59NDT	0,2	2	2
	76	81-1	0,2	2	2
	77	81-2	0,2	2	2
	78	81-3	0,2	2	2
	79	81-4	0,2	2	2
	84	81-5	0,2	2	2
	85	81-6	0,2	2	2
	126	Trip Circuit Fail 1	0,2	2	2
	127	Trip Circuit Fail 2	0,2	2	2
	128	Trip Circuit Fail 3	0,2	2	2
	129	CB Total Trip Count	0,2	2	2
	130	CB Delta Trip Count	0,2	2	2
	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
	229	General Alarm 5	0,2	2	2
	230	General Alarm 6	0,2	2	2
	237	Quick Logic E1	0,2	2	2
	238	Quick Logic E2	0,2	2	2
	239	Quick Logic E3	0,2	2	2
	240	Quick Logic E4	0,2	2	2
	302	27/59 PhA	0,2	2	2
	303	27/59 PhB	0,2	2	2
	304	27/59 PhC	0,2	2	2
	411	Setting G1 selected	0,2	2	2
	412	Setting G2 selected	0,2	2	2
	413	Setting G3 selected	0,2	2	2
	414	Setting G4 selected	0,2	2	2
	427	CB 1	0,2	2	2
	501	Virtual Input 1	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)**

FW#	Point Index	Name (Description)	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
	502	Virtual Input 2	0,2	2	2
	503	Virtual Input 3	0,2	2	2
	504	Virtual Input 4	0,2	2	2
	505	Virtual Input 5	0,2	2	2
	506	Virtual Input 6	0,2	2	2
	507	Virtual Input 7	0,2	2	2
	508	Virtual Input 8	0,2	2	2
	601	LED 1	0,2	2	2
	602	LED 2	0,2	2	2
	603	LED 3	0,2	2	2
	604	LED 4	0,2	2	2
	605	LED 5	0,2	2	2
	606	LED 6	0,2	2	2
	607	LED 7	0,2	2	2
	608	LED 8	0,2	2	2
	609	LED 9	0,2	2	2
	701	LED PU 1	0,2	2	2
	702	LED PU 2	0,2	2	2
	703	LED PU 3	0,2	2	2
	704	LED PU 4	0,2	2	2
	705	LED PU 5	0,2	2	2
	706	LED PU 6	0,2	2	2
	707	LED PU 7	0,2	2	2
	708	LED PU 8	0,2	2	2
	709	LED PU 9	0,2	2	2
	801	Binary Output 1	0,2	2	2
	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

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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)**

FW#	Point Index	Name (Description)	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 1	Default Variation Event Object 2
	876	Unexpected Restart	0,2	2	2
	877	Reset Start Count	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
	972	78-1	0,2	2	2
	973	78-2	0,2	2	2
	974	81R-1	0,2	2	2
	975	81R-2	0,2	2	2
	976	81R-3	0,2	2	2
	977	81R-4	0,2	2	2
	978	81R-5	0,2	2	2
	979	81R-6	0,2	2	2

5.3.2 Double Bit Input Points

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

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

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

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

FW#	Point Index	Name (Description)	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 3	Default Variation Event Object 4
	0	CB 1	0,2	1	3
	10	User DP Command 1	0,2	1	3
	11	User DP Command 2	0,2	1	3
	12	User DP Command 3	0,2	1	3

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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)**

FW#	Point Index	Name (Description)	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 3	Default Variation Event Object 4
	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. It is recommended that Binary Output Status points represent the most recent DNP “commanded” value for the corresponding Control Relay Output Block (CROB) point. Because many, if not most, Control Relay Output Block points are controlled through pulse mechanisms, the value of the output status may in fact be meaningless. 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)**

FW#	Point Index	Name (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

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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)**

FW#	Point Index	Name (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
	48	Reset CB Total Trip Count, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	49	Reset CB Delta Trip Count, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	54	CB 1	0	2	2	0	1	Pulse On Pulse Off Latch On Latch Off Close Trip	Pulse On Pulse Off Latch On Latch Off
	59	Demand metering reset, write only location.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	88	Remote mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	89	Service mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	90	Local mode	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	91	Local & Remote	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	98	Reset Start Count (Action)	0	2	2	0	1	Pulse On Latch On Close	Pulse On Latch On
	99	User SP Command 1.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	100	User SP Command 2.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	101	User SP Command 3.	0	2	2	0	1	Pulse On Latch On Close	Pulse On
	102	User SP Command 4.	0	2	2	0	1	Pulse On Latch On Close	Pulse On

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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)**

FW#	Point Index	Name (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
	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
	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	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)**

FW#	Point Index	Name (Description)	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 10	Default Variation Event Object 11	Default Command Event Object 13 Assigned Class (1, 2, 3 or none)	Default Variation Command Event Object 13	CROB Supported Operations	Default CROB Operations
								Latch On Latch Off Close Trip	
	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.

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.

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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		
FW#	Point Index	Name (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
	4	Number User Files	0,3	5	1	1		✔	0,2	9	1
	5	StartCount	0,3	5	1	1	✔	✔	0,2	9	1
	6	Start Count Target	0,3	5	1	1		✔	0,2	9	1
	7	Active Setting Group	0,3	5	1	1		✔	0,2	9	1
	11	CB Total Trip Count	0,3	5	1	1	✔	✔	0,2	9	1
	16	CB Delta Trip Count	0,3	5	1	1	✔	✔	0,2	9	1
	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.

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

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

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

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

FW#	Point Index	Name (Description)	Default Change Event Assigned Class (1, 2, 3 or none)	Default Variation Static Object 30	Default Variation Event Object 32	Default Multiplier	Default Deadband
	0	Frequency	0,3	2	4	100.000	1.000
	1	Vab Primary	0,3	2	4	0.010	100.000
	2	Vbc Primary	0,3	2	4	0.010	100.000
	3	Vca Primary	0,3	2	4	0.010	100.000
	4	Va Primary	0,3	2	4	0.010	100.000
	5	Vb Primary	0,3	2	4	0.010	100.000
	6	Vc Primary	0,3	2	4	0.010	100.000
	7	Va Secondary	0,3	2	4	10.000	1.000
	8	Vb Secondary	0,3	2	4	10.000	1.000
	9	Vc Secondary	0,3	2	4	10.000	1.000
	21	Vzps	0,3	2	4	10.000	1.000
	22	Vpps	0,3	2	4	10.000	1.000
	23	Vnps	0,3	2	4	10.000	1.000
	95	Active Setting Group	0,3	2	4	1.000	1.000
	99	Vab Secondary	0,3	2	4	10.000	1.000
	100	Vbc Secondary	0,3	2	4	10.000	1.000
	101	Vca Secondary	0,3	2	4	10.000	1.000
	102	Vn Primary	0,3	2	4	0.010	100.000
	103	Vn Secondary	0,3	2	4	10.000	1.000
	135	CB Total Trip Count	0,3	1	3	1.000	1.000
	136	CB Delta Trip Count	0,3	1	3	1.000	1.000
	168	Va Last Trip	0,3	1	3	1.000	Disabled
	169	Vb Last Trip	0,3	1	3	1.000	Disabled
	170	Vc Last Trip	0,3	1	3	1.000	Disabled

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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)**

FW#	Point Index	Name (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
	174	V Phase A Max	0,3	2	4	0.010	100.000
	175	V Phase B Max	0,3	2	4	0.010	100.000
	176	V Phase C Max	0,3	2	4	0.010	100.000
	177	V Phase AB Max	0,3	2	4	0.010	100.000
	178	V Phase BC Max	0,3	2	4	0.010	100.000
	179	V Phase CA Max	0,3	2	4	0.010	100.000
	192	Freq Last Trip	0,3	5	7	1.000	1.000
	196	Frequency Max	0,3	2	4	100.000	1.000

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

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8. 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 RS232, RS485 or to fibre-optic port. An additional interface, for example a Sigma unit, may be required to connect to the fibre-optic port.

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 Sigma 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 aboveexample, 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.

When using a Sigma converter without an external power supply, if possible the Data Carrier Detect (DCD) line on the Modem should be forced on, as this will be used to power the Sigma unit.

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.

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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

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

The tool will allow:

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

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

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

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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.

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

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

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

USB
Universal Serial Bus standard for the transfer of data.

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

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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	✘
Com3	✔ when Com3-Mode = Local	✔ when Com3-Mode = Remote	✘
Com4	✔ when Com4-Mode = Local	✔ when Com4-Mode = Remote	✘
Fascia (Control Mode)	✔	✘	✘
Function Key (n)	✔	✔ when F Key(n) Mode = Remote	✘
Binary Input (n)	✔ when BI (n) Mode = Local	✔ when BI (n) Mode = Remote	✔
Binary Outputs	✔	✔	✘
Reporting			
Spontaneous			
IEC	✔	✔	✘
DNP3	✔	✔	✘
General Interrogation			
IEC	✔	✔	✘
DNP3	✔	✔	✘
MODBUS	✔	✔	✔
Change Settings			
Com1	✔ when Com1-Mode = Local	✔ when Com1-Mode = Remote	✔
Com2 (USB)	✔ when Com2-Mode = Local	✔ when Com2-Mode = Remote	✔
Com3	✔ when Com3-Mode = Local	✔ when Com3-Mode = Remote	✔
Com4	✔ when Com4-Mode = Local	✔ when Com4-Mode = Remote	✔
Fascia	✔	✔	✔
Historical Information			
Waveform Records	✔	✔	✔
Event Records	✔	✔	✔
Fault Information	✔	✔	✔
Setting Information	✔	✔	✔

Fig. A1 Operating Mode Table

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Template Revision 5.

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7SR158

Voltage & Frequency Relay

Installation Guide

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

1.3 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 on the circuit breaker (or protection panel) to allow the operator the best access to the relay functions

1.4 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.

1.5 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.

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1.6 Ancillary Equipment

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

1.7 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.

The relays and protection systems manufactured under the Reyrolle brand currently do not come within the scope of either the European WEEE or RoHS directives as they are equipment making up a fixed installation.

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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: Dimensions and Panel Fixings

3.1 Relay Dimensions and Weight

Relays are supplied in the modular size E4

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

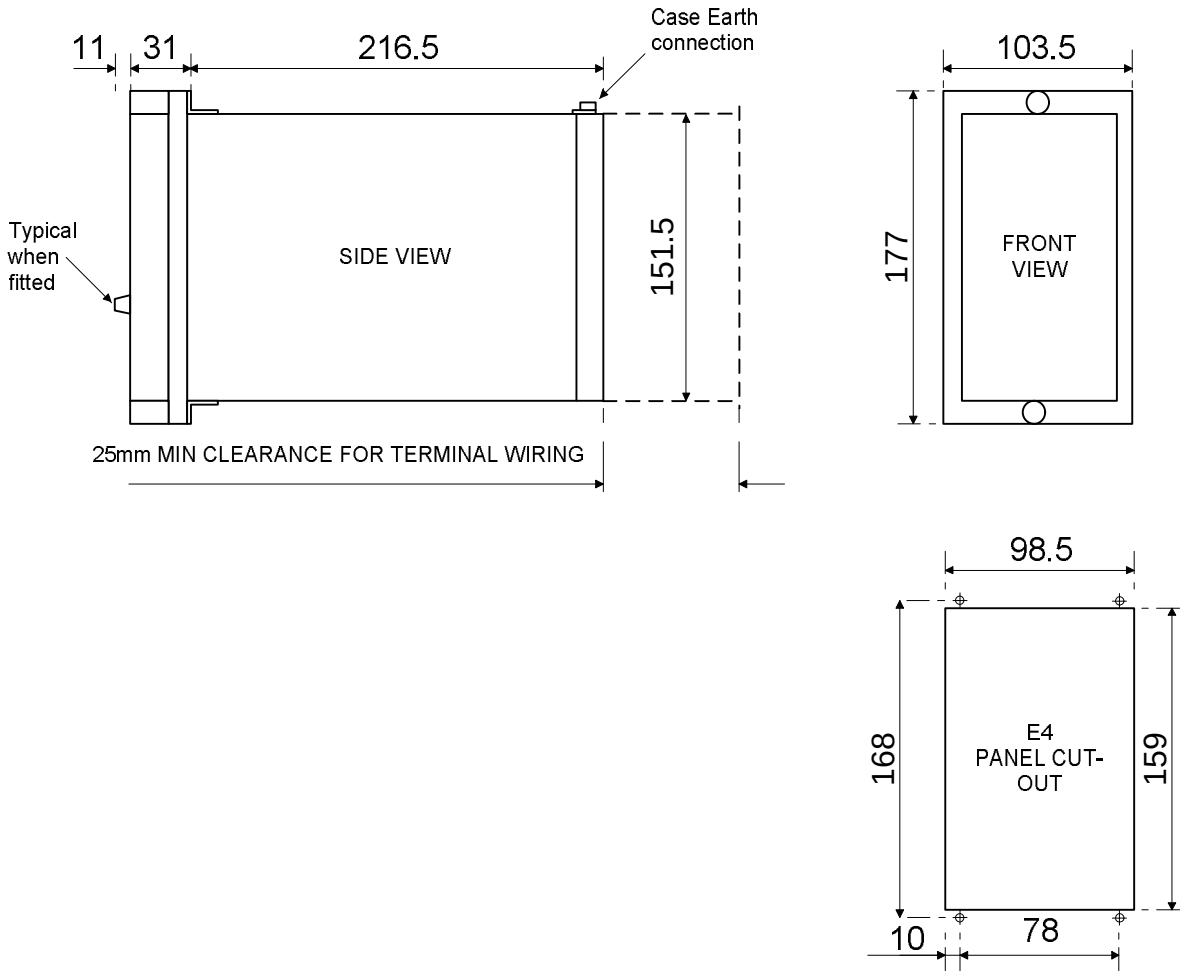

Figure 3.1-1 Overall Dimensions and Panel Drilling for Size E4 Epsilon Case

Hardware Model	Net Weight Kg
7SR158	2.7

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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

Consists of 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) consists of:

28 off M4, 8mm Screws

28 off M4 Lock Washer

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Section 4: Rear Terminal Drawings

4.1 E4 Case

Figure 4.1-1 E4 Case viewed from rear

Notes

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

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

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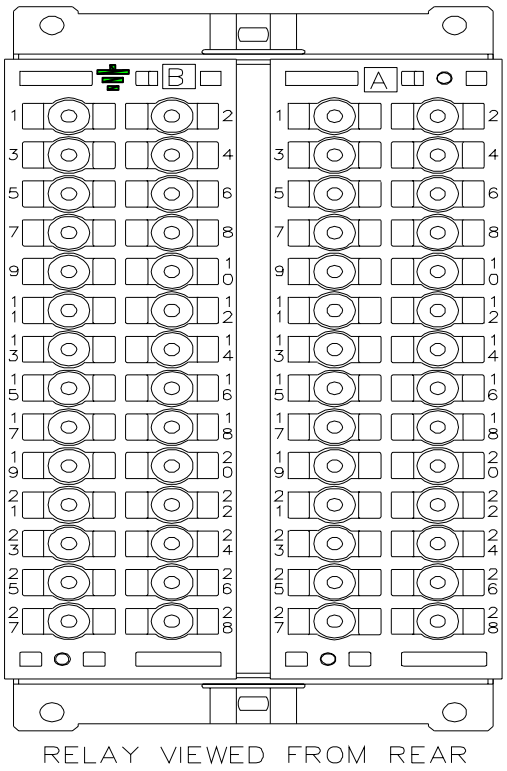

Figure 4.1-2 E4 Case Terminal Arrangement viewed from rear

Section 5: Connection/Wiring/Diagrams

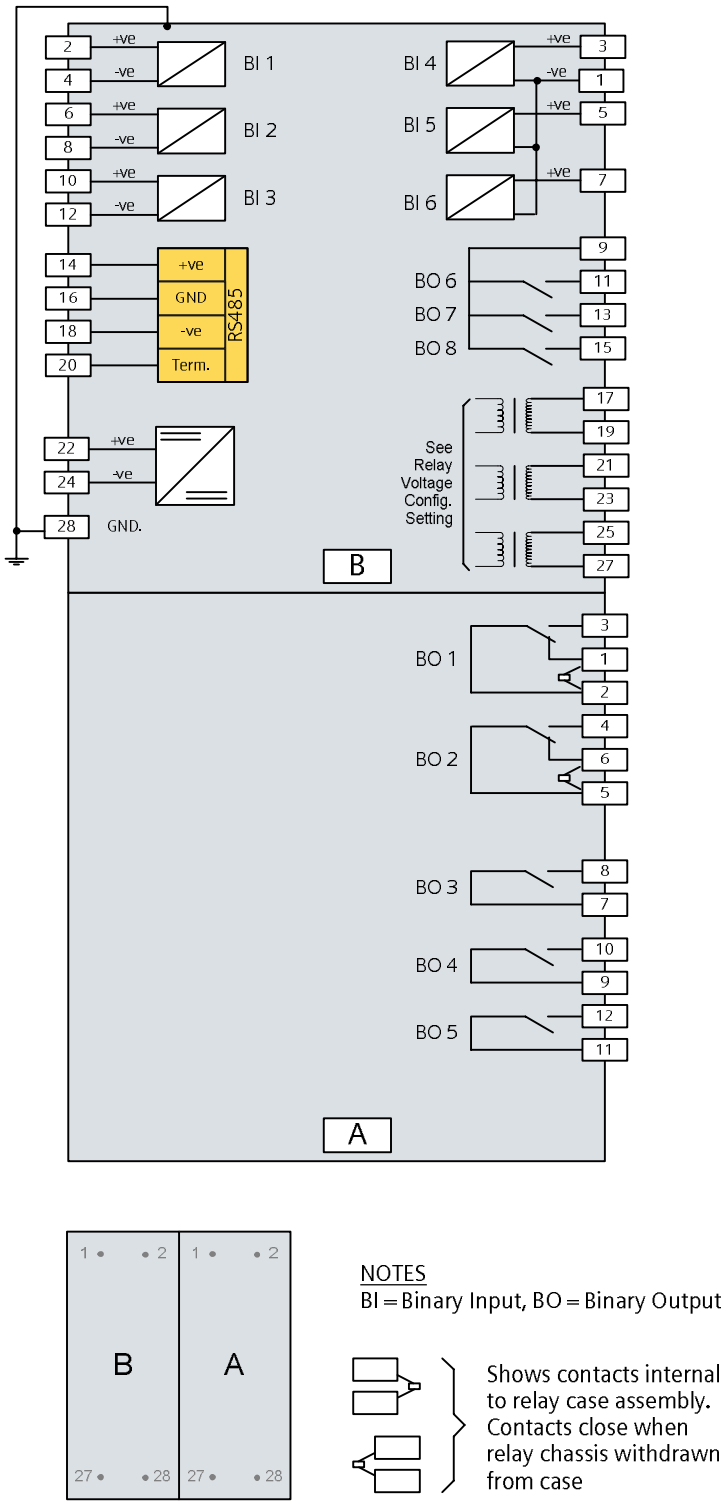

Figure 4.1-3 7SR158 Connection Diagram

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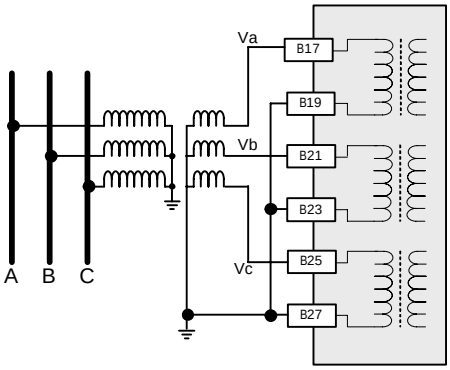
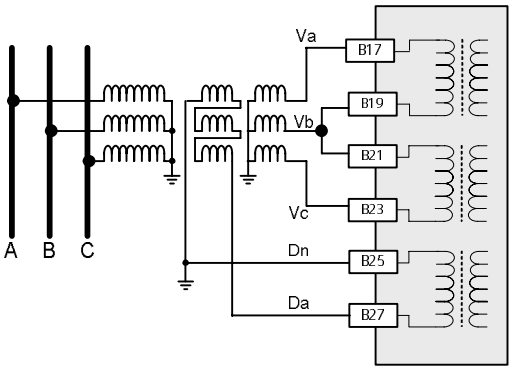
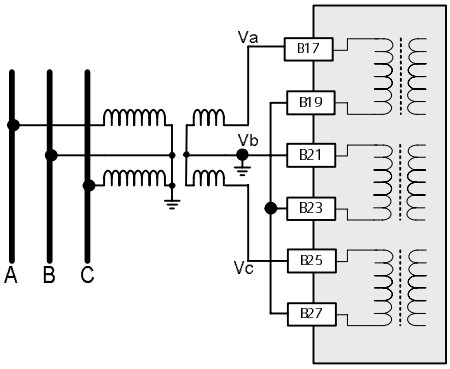
5.1 Voltage Transformer Configurations

Relay Voltage Configuration Setting	Description	Connection
Van, Vbn, Vcn	27/59, 47, 59N, 78, 81, 81R Phase – Neutral Phase – Phase Calculated NPS ZPS	
Vab, Vbc, 3Vo	27/59, 47, 59N, 78, 81, 81R Phase – Neutral Phase – Phase Calculated NPS ZPS	
Va, Vb, Vc	27/59, 47, 78, 81, 81R Phase – Neutral Phase – Phase Calculated NPS No ZPS available	

Section 6: Data Comms Connections

6.1 RS485 Connection

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

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

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

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

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

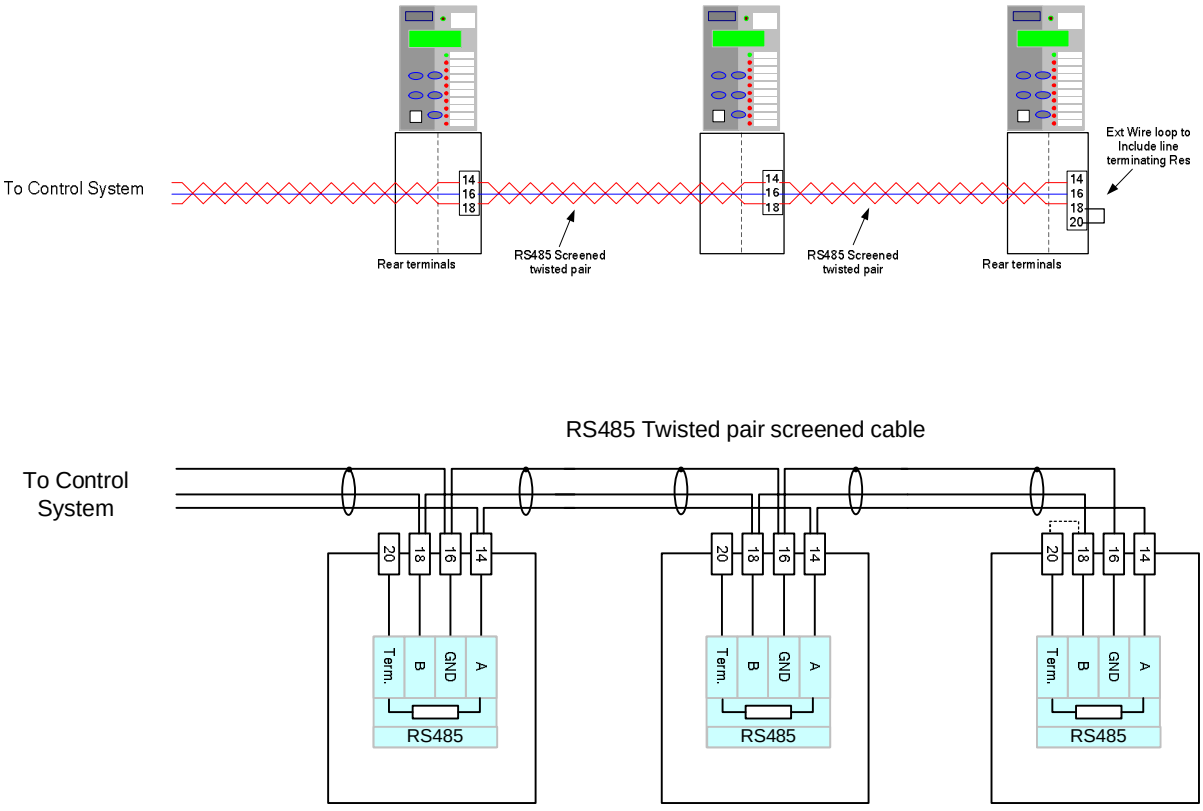


Figure 6.1-1 RS485 Data Comms Connections Between Relays

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7SR158

Voltage & Frequency Relay

Commissioning and Maintenance Guide

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Software Revision History

Date	Software Reference	Summary
2013/11	2436H80011R2d-1a	First Release

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Section 1: **Common Functions**

1.1 Overview

Commissioning tests are carried out to prove:

a) Equipment has not been damaged in transit.

b) Equipment has been correctly connected and installed.

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

d) Confirm that settings have been correctly applied.

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

1.2 Before Testing

1.2.1 Safety

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

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. All functions are not available in all devices, please refer the ‘Description of Operation’ section to establish your function set.

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1.2.3 Test Equipment

Required test equipment is:

1. Secondary injection equipment with integral time interval meter
2. Primary injection equipment
3. A power source with nominal voltage within the working range of the relay's auxiliary supply rating.
4. A power source with nominal voltage within the working range of the relay's binary input rating.
5. Other equipment as appropriate to the protection being commissioned – this will be specified in the product specific documentation.

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

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

1.2.4 Use of PC to facilitate testing

The functions of Reydisp Evolution (see 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 as a result of application of the test. These can then be saved off to retain a comprehensive record of that test.

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

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

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

1.2.5 Precautions

Before electrical testing commences the equipment should be isolated from the 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.

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

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

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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.

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 m.c.b.

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

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

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

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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 Voltage…….			
Measured	**V_A/V_{AB}**	**V_B/V_{BC}**	**V_C/V_{CB}**	**Tolerance**
Secondary				
Primary				

Apply 3 phase balanced Voltage at nominal levels and ensure that the measured Zero Phase Sequence and Negative Phase Sequence quantities are approximately zero.

Measured	**ZPS**	**NPS**
Voltage		

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 supply voltage onto each binary input in turn and check for correct operation. Depending on the application, each binary input may be programmed to perform a specific function; each binary should be checked to prove that its mapping and functionality is as set as part of the Scheme Operation tests.

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

For AC operation of binary inputs, these timers are used to ensure correct operation from AC voltage and if a delayed pickup is required this must be provided by additional quicklogic configuration. An example is shown in Chapter 7 – Applications Guide.

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						

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1.6 Binary Outputs

Eight binary output relays are provided. 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 output relay in turn from the Reydisp Evolution PC programme, Relay – Control - Close output relay. This function will energise the output for its minimum operate time. This time is specified in the Output Config - Binary Output Config menu for each output relay and may be too short to measure with a continuity tester.

An alternative method of energising an output permanently so that wiring can be checked is to temporarily map the relay being tested to the 'Protection Healthy' signal in the Output Matrix, as this signal is permanently energised the mapped relay will be held energised, normally open contacts will be closed and vice versa.

BO	Checked	Notes (method of test)
1NO		
1NC		
2NO		
2NC		
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: **Protection Functions**

This section details the procedures for testing each protection function of the relay. These tests are carried out to verify the accuracy of the protection pick-ups and time delays at setting and to confirm correct operation of any associated input and output functionality.

The exact model type must be checked to confirm the functions available.

Guidance for calculating test input quantities is given in the relevant test description where required. In many cases it may be necessary to disable some functions during the testing of other functions, this prevents any ambiguity caused by the operation of multiple functions from one set of input quantities. The 'Function Config' Menu provides a convenient high level point at which all elements of a particular function can be Enabled/Disabled to suit testing. The 'Config' tab in 'Reydisp Evolution' can be used to 'Enable/Disable' individual elements. Note that this screen disables functions by applying setting changes to the relay and that any changes must be sent to the relay to take effect and settings must be returned to their correct value after testing.

The table below indicates functions where function conflicts may occur during testing, consideration should be given to disabling functions to avoid interference.

Function Under Test	Phase U/O voltage	NPS Overvoltage	Neutral Voltage Displacement	VT Supervision	Trip / Close Circuit Supervision	U/O Frequency	Voltage Vector Shift	Rate-of-Change-of-Frequency
Phase U/O voltage		O	O	O				
NPS Overvoltage	O		O					
Neutral Voltage Displacement	O	O						
VT Supervision								
Trip / Close Circuit Supervision								
U/O Frequency							O	O
Voltage Vector Shift						O		O
Rate-of-Change-of-Frequency						O	O	

Any LED can be assigned to be a General Pickup LED in the Output Matrix menu and used to assess operation of functions during testing if other functions are disabled or if the setting allocating General Pickup is temporarily modified.

It should be considered that where several overlapping elements are used simultaneously, the overall protection operate time may be dependent on the operation of different individual elements at the various levels of applied current or voltage. The resulting composite characteristic may be tested by enabling all of the relevant applicable elements or the element operations can be separated or disabled and tested individually.

All relay settings should be checked before testing begins. It is recommended that the relay settings are extracted from the relay using Reydisp Evolution software and a copy of these settings is stored for reference during and after testing. It may be necessary to disable some protection functions during the testing of other functions to allow unambiguous results to be obtained.

Care must be taken to reset or re-enable any settings that have been temporarily altered during the testing before the relay can be put into service. At the end of testing the relay settings should be compared to the file extracted at the start to ensure that errors have not been introduced.

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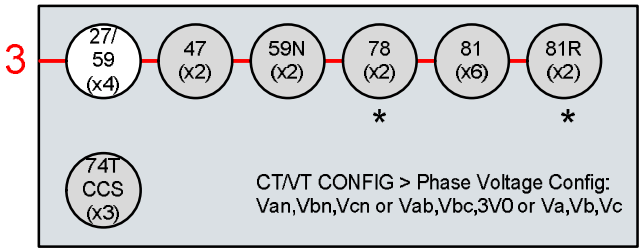
2.1 Over/Under Voltage

2.1.1 Phase Under/Over Voltage (27/59)



Voltage Inputs:	'Van,Vbn,Vcn' or 'Vab,Vbc,3V0' or 'Va,Vb,Vc'.
Disable:	47, 59N, 60VTS
Map Pickup LED:	27/59-n - Self Reset

Where more than one Undervoltage (27) elements are being used with different settings, it is convenient to test the elements with the lowest settings first. The elements with higher settings can then be tested without disabling the lower settings.

Note that if the voltage is reduced below the 27UVG setting, the function may be blocked.

If the 'O/P Phases' is set to 'All', the voltage on all phases must be reduced simultaneously. Otherwise the 3 phases should be tested individually. If the DTL is short, starting from nominal voltage, slowly decrease the applied 3P or VL1 test voltage until the Pickup LED (temporarily mapped) is lit. Record the operate voltage. The LED should light at setting Volts +/-5%. Slowly increase the input voltage until the LED extinguishes. Record the reset voltage to check the 'Hysteresis' setting. If the DTL is long, the operate level should be checked by applying a voltage of 90% of setting voltage. Check Hysteresis by resetting the element to the operate level setting plus the hysteresis setting.

Connect the relevant output contact(s) to stop the test set. Step the applied voltage to a level below the setting. The test set should be stopped at the operate time setting +/-5%

Test inputs VL2 and VL3 by repeating the above if necessary.

Where more than one overvoltage (59) elements are being used with different settings, it is convenient to test the elements with the highest settings first. The elements with lower settings can then be tested without disabling the higher settings.

If the 'O/P Phases' is set to 'All', the voltage on all phases must be increased simultaneously. Otherwise the 3 phases should be tested individually. If the DTL setting is short, starting from nominal voltage, slowly increase the applied 3P or VL1 test voltage until the Pickup LED (temporarily mapped) is lit. The LED should light at setting Volts +/-5% Decrease the input voltage to nominal Volts and the LED will extinguish. Record the reset voltage to check the 'Hysteresis' setting. If the DTL setting is long, the operate level can be checked by applying 100% of setting to cause operation followed by setting minus the Hysteresis setting to cause reset.

Connect the relevant output contact(s) to stop the test set. Step the applied voltage to a level above the setting. The test set should be stopped at the operate time setting +/-5%

Test inputs VL2 and VL3 by repeating the above if necessary.

Phase	27/59 setting (Volts)	U/O	DTL (sec)	Hyst.	D.O. (calculated)	P.U. Volts	D.O Volts	Op. Time @ 2x Vs (OV) @ 0.5x Vs (UV)	UV Guard	Tolerance
$V_1(V_A)$										
$V_2(V_B)$										
$V_3(V_C)$										

Check correct indication, trip output, alarm contacts, waveform record.

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2.1.1.1 Element Blocking

The Under/Over Voltage elements can be blocked by Binary Input Inhibit and VT Supervision. This functionality should be checked.

Element	BI Inhibits	VT Supervision
27/59-1		
27/59-2		
27/59-3		
27/59-4		

When testing is complete reinstate any of the disabled functions.

2.1.2 **Undervoltage Guard (27/59UVG)**

If any 27 Undervoltage element is set to be inhibited by the 27 Undervoltage Guard element, this function should be tested.

Connect the test voltage inputs to suit the installation wiring diagram utilising any test socket facilities available. It may be useful to temporarily map an LED as 'General Pickup' to assist during testing. 27UVG operation will reset the General Pickup if no other element is operated. This LED should not be set as 'Hand Reset' in the Output matrix.

Starting from nominal voltage, apply a step decrease to the applied voltage to a level below the 27 Undervoltage setting but above the 27UVG setting such that an Undervoltage element operation occurs. Slowly reduce the applied voltage until the 27 Undervoltage element resets, this can be detected by the General Pickup LED reset if no other element is operated (this includes any Undervoltage element which is not UV Guarded).

	Vs (Volts)	Tolerance	V element Used for test	Blocked Volts	NOTES
UVG					

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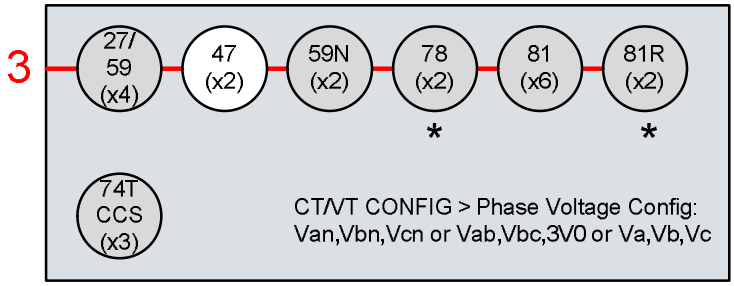
2.1.3 NPS Overvoltage (47)



Voltage Inputs:	'Van,Vbn,Vcn' or 'Vab,Vbc,3V0' or 'Va,Vb,Vc'.
Disable:	27/59, 59N
Map Pickup LED:	47-n - Self Reset

Where two NPS elements are being used with different settings, it is convenient to test the elements with the highest settings first. The elements with lower settings can then be tested without disabling the lower settings.

NPS Overvoltage can be tested using a normal 3P balanced source. Two phase voltage connections should be reversed so that the applied balanced 3P voltage is all Negative Phase Sequence.

If the 47-n delay is small, gradually increased the applied balanced 3P voltage until element operates.

If DTL is large apply 0.9x setting, check for no operation, apply 1.1x setting, check operation

Apply 2x setting current if possible and record operating time.

	Setting (Volts)	Delay (sec)	Hyst.	P.U. (Volts)	D.O (Volts)	Op. Time @ 2x Vs	Tolerance
NPS							

Check correct indication, trip output, alarm contacts, waveform record.

2.1.3.1 Element Blocking

The NPS Overvoltage element can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
47-1	
47-2	

When testing is complete reinstate any of the disabled functions.

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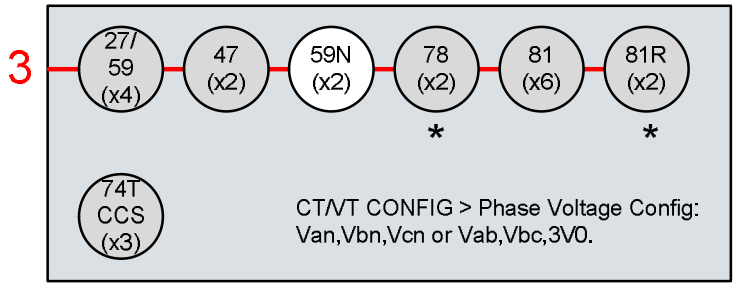
2.1.4 Neutral Overvoltage (59N)



Voltage Inputs:	'Van,Vbn,Vcn' or 'Vab,Vbc,3V0'.
Disable:	27/59, 47
Map Pickup LED:	59N-n - Self Reset

The voltage source for the Neutral Overvoltage 59N function is Vn, calculated from the applied 3 phase voltage inputs. To test, apply test voltage to one phase input.

2.1.4.1 Definite Time (59NDT)

If DTL setting is small, gradually increase single phase voltage until element operates.

If DTL is large apply 0.9x setting, check for no operation, apply 1.1x setting, check operation

Apply 2x setting voltage if possible and record operating time.

Phase	Seting (Volts)	Delay (sec)	P.U. Current (Volts)	Operate Time @ 2 x Vs	Tolerance
E					

Check correct indication, trip output, alarm contacts, waveform record.

2.1.4.2 Inverse Time (59NIT)

It will be advantageous to map the function being tested to temporarily drive the relevant Pickup output in the *Pickup Config* sub-menu in the *Output Config* menu as this will allow the Pick-up led to operate for the function.

Gradually increase voltage until Pickup LED operates.

Apply 2x setting voltage and record operating time.

Apply a higher multiple of setting voltage and record operating time.

Compare to calculated values for operating times from:

$$t_{op}(\text{sec}) = M\left[\frac{1}{\left[\frac{Vn}{Vs}\right]-1}\right]$$

Where M = Time multiplier and Vn/Vs = multiple of setting.

Phase	Setting (Volts)	TM	Operate Voltage			Operate Time		
			P.U. (Volts)	D.O. (Volts)	Tolerance	@ 2 x Vs (sec)	@ - x Vs (sec)	Tolerance
E								

Check correct indication, trip output, alarm contacts, waveform record.

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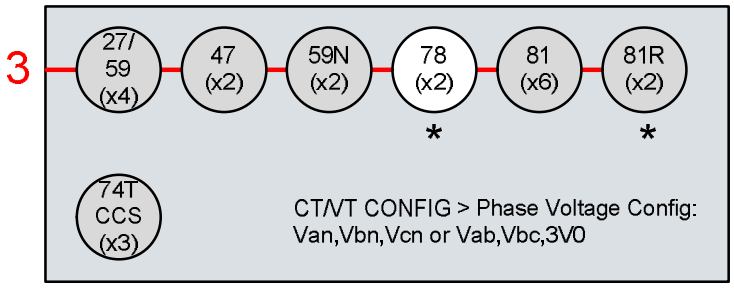
2.1.4.3 Element Blocking

The Neutral Overvoltage elements can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
59NIT	
59NDT	

When testing is complete reinstate any of the disabled functions.

2.1.5 Vector Shift (78)



Voltage Inputs:	'Van,Vbn,Vcn' or 'Vab,Vbc,3V0'.
Disable:	81, 81R
Map Pickup LED:	78-n - Self Reset

Vector shift is a 3-phase protection and therefore test voltages must be applied to all VT inputs. Elements with the highest pick-up setting should be tested first. The elements with lower pick-up settings can then be tested without the need to disable the elements already tested.

To test operation of the 78 elements, it is necessary to step change the phase 'jump' in the voltage waveform. The size of the jump is increased with each with test step until the element operates. Being instantaneous, there should be no difference between the element picking-up and operating. Therefore the 78-n output contact can be used for both pick-up and timing measurements.

Voltage Vector Shift (°)	P.U. Phase Step (°)	Operate Time (sec)	UV Guard	NOTES

The applied voltage must be above the ***78 UV Guard (Ph-N0 Setting*** in the ***Vector Shift*** menu for the element to operate.

This setting can be tested by applying the test voltage at a level below the ***78 U/V Guard Setting*** at a vector shift in the operate range. Increase the voltage until the relay operates.

UVG Setting (Volts)	Vector Shift element Used for test	Blocked Vector Shift (D.O.)	Unblocked Vector Shift (P.U.)	NOTES

Check correct indication, trip output, alarm contacts, waveform record.

2.1.5.1 Element Blocking

The vector shift elements can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
78-1	
78-2	

When testing is complete reinstate any of the disabled functions.

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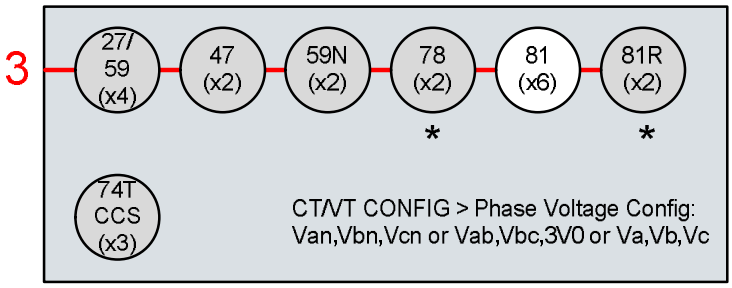
2.2 Under/Over Frequency

2.2.1 Phase Under/Over Frequency (81)



Voltage Inputs:	'Van,Vbn,Vcn' or 'Vab,Vbc,3V0' or 'Va,Vb,Vc'.
Disable:	78, 81R
Map Pickup LED:	81-n - Self Reset

This function can be tested by application of 1P or 3P voltage. For Over-frequency, the elements with the highest setting should be tested first and for Under-frequency the elements with the lowest settings should be tested first. The elements with other settings can then be tested without need to disable the elements already tested. Note that the relay is designed to track the gradual changes in power system frequency and that sudden step changes in frequency during testing do not reflect normal system operation. Normal 'instantaneous' operation of the frequency element is 140-175ms in line with the Performance Specification. Application of sudden step changes to frequency can add additional delay which can produce misleading test results.

Gradually increase/decrease applied voltage frequency until 81-n operation occurs. Elements set for more extreme frequency fluctuation should be tested first with lesser elements disabled.

If the 81-n Delay setting is long it will be advantageous to map the function to temporarily drive the relevant Pickup output in the *Pickup Config* sub-menu in the *Output Config* menu as this will allow the Pick-up led to operate for the function. If the delay setting is short the operation of the element can be easily checked directly.

The frequency should then be gradually decreased / increased until the element resets. The reset frequency can be used to check the Hysteresis setting.

If the element is set as ***81-n U/V Guarded***, The applied voltage must be above the ***81 UV Guard*** **Setting** in the ***U/O Frequency*** menu.

Apply setting frequency +0.5Hz for Over-frequency or -0.5Hz for Under-frequency and record operating time.

Starting with the element in the operated condition, gradually increase or decrease the applied voltage until the element resets. Measure the reset voltage level to check the ***81 Hysteresis*** setting.

Freq (Hertz)	U/O	Delay (sec)	Hyst.	D.O. (calc.)	P.U. Freq (Hertz)	D.O. Freq. (Hertz)	Operate Time @ +/- 0.5Hz	UV Guard	NOTES

If the element is set as ***81-nU/V Guarded*****,** this setting can be tested by applying the test voltage at a level below the ***81 U/V Guard Setting*** at a frequency in the operate range. Increase the voltage until the relay operates.

UVG Setting (Volts)	Freq element Used for test	Blocked Volts (D.O.)	Unblocked Volts (P.U.)	NOTES

Check correct indication, trip output, alarm contacts, waveform record.

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2.2.1.1 Element Blocking

The U/O Frequency elements can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
81-1	
81-2	
81-3	
81-4	
81-5	
81-6	

When testing is complete reinstate any of the disabled functions.

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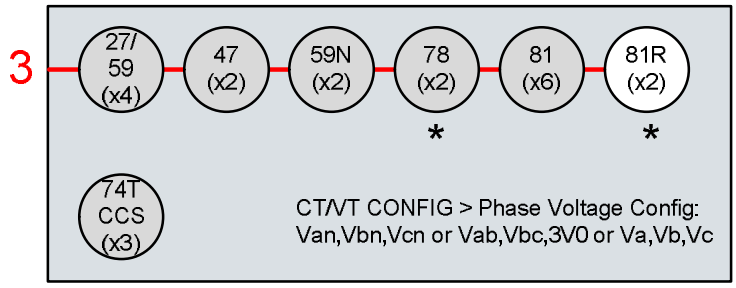
2.2.2 Rate of Change of Frequency (81R)



Voltage Inputs:	'Van,Vbn,Vcn' or 'Vab,Vbc,3V0' or 'Va,Vb,Vc'.
Disable:	78, 81
Map Pickup LED:	81R-n - Self Reset

This function can be tested by application of 1P or 3P voltage. Elements with the highest ROCOF pick-up setting should be tested first. The elements with lower pick-up settings can then be tested without need to disable the elements already tested.

Gradually increase/decrease applied voltage frequency gradient until 81R-n operation occurs. If the 81R-n Delay setting is long it will be advantageous to map the function to temporarily drive the relevant Pickup output in the *Pickup Config* sub-menu in the *Output Config* menu as this will allow the Pick-up led to operate for the function. If the delay setting is short the operation of the element can be easily checked directly.

The frequency gradient should then be gradually decreased / increased until the element resets.

Apply voltage frequency gradient at twice setting level and record operating time.

ROCOF (Hertz/s)	Dir	Delay (sec)	P.U. ROCOF (Hertz/s)	D.O. ROCOF (Hertz/s)	Operate Time @ 2 x setting	NOTES

The applied voltage must be above the ***81R UV Guard Setting*** in the ***ROCOF*** menu for the element to operate.

This setting can be tested by applying the test voltage at a level below the ***81R U/V Guard Setting*** at a ROCOF in the operate range. Increase the voltage until the relay operates.

UVG Setting (Volts)	ROCOF element Used for test	Blocked ROCOF (D.O.)	Unblocked ROCOF (P.U.)	NOTES

Check correct indication, trip output, alarm contacts, waveform record.

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2.2.2.1 Element Blocking

The ROCOF elements can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits
81R-1	
81R-2	
81R-3	
81R-4	
81R-5	
81R-6	

When testing is complete reinstate any of the disabled functions.

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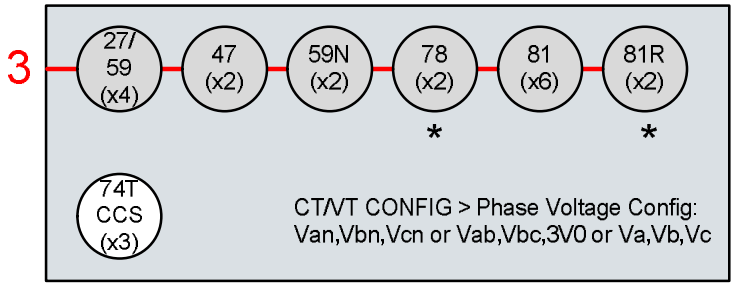
Section 3: **Supervision Functions**

3.1 Trip/Close Circuit Supervision (74T/CCS)



Voltage Inputs:	n/a
Disable:	n/a
Map Pickup LED:	74TCS-n - Self Reset

The T/CCS-n Delay can be initiated by applying an inversion to the relevant status input and measured by monitoring of the alarm output.

TCS-n Delay setting	**Measured**
CCS-n Delay setting	**Measured**

Section 4: **Control & Logic Functions**

4.1 Quick Logic

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

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Section 5: **Testing and Maintenance**

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

5.1 Periodic Tests

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

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

5.2 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 – see defect report sheet in section 5.3.

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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5.3 Troubleshooting

Observation	Action
Relay does not power up.	Check that the correct auxiliary AC or DC voltage is applied and that the polarity is correct.
Relay won't accept the password.	The Password being entered is wrong. Enter correct password. If correct password has been forgotten, note down the Numeric Code which is displayed at the Change Password screen e.g. Change password = 1234567 To retrieve the password, communicate this code to a Siemens Protection Devices Ltd. representative.
Protection Healthy LED flashes	General failure. Contact a Siemens Protection Devices Ltd. representative.
LCD screen flashes continuously.	The LCD has many possible error messages which when displayed will flash continuously. These indicate various processor card faults. General failure. Contact a Siemens Protection Devices Ltd. representative.
Backlight is on but no text can be seen.	Adjust the contrast.
Scrolling text messages are unreadable.	Adjust the contrast.
Relay displays one instrument after another with no user intervention.	This is normal operation, default instruments are enabled. Remove all instruments from the default list and only add those that are required. (See Section 2: Settings and Instruments).
Cannot communicate with the relay.	Check that all of the communications settings match those used by Reydisp Evolution. Check that all cables, modems and fibre-optic cables work correctly. Ensure that IEC 60870-5-103 is specified for the connected port (COM1 or COM2).
Relays will not communicate in a ring network.	Check that all relays are powered up. Check that all relays have unique addresses.
Status inputs do not work.	Check that the correct DC voltage is applied and that the polarity is correct. Check that the status input settings such as the pick-up and drop-off timers and the status inversion function are correctly set.
Relay instrument displays show small currents or voltages even though the system is dead.	This is normal. The relay is displaying calculation noise. This will not affect any accuracy claims for the relay.

Table 2-1 Troubleshooting Guide

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

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7SR158

Voltage & Frequency Relay

Applications Guide

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2013/11	First issue

Software Revision History

Date	Software Reference	Summary
2013/11	2436H80011R2d-1a	First Release

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Section 1: Introduction

The 7SR158 relay can be applied for all voltage and frequency functions. The relay is used to provide under-frequency load shedding. The 'Rate of Change of Frequency' or 'Vector Shift' functions can be used to detect loss of connection between a distributed generator and the main utility supply ('Loss of Mains' or Islanding').

1.1 Loss of Mains (LoM)

Where the electrical connection between Distributed generation (DG), such as a Wind Farm, combined heat & power system, etc. and the electricity supply system is broken (Loss-of-Mains), it is usual for the embedded generation to be physically disconnected from the system by means of tripping interconnecting Circuit-Breakers (CB's). The DG must not be allowed to supply a part of the network once it has become electrically isolated from the main grid supply.

In some cases the disconnected generation may be allowed to continue in operation to feed local loads – as an 'islanded' system. However the islanding may have adverse safety and operational implications for both the Generator Operator and Utility Provider and it is then a requirement to disconnect from both the electricity system and local loads when LoM occurs. Following restoration of the electricity system, the embedded generation must then be safely re-synchronised with the system before the connection is restored.

Restoring the electrical network with the distributed generation still connected can lead to CB damage and voltage disturbances. The LoM detection must therefore be fast enough to ensure that the electricity supply is not restored – for example by auto-reclosure – before the embedded generation is disconnected.

At the same time, the embedded generation must remain connected – the LoM protection must remain stable - during normal operating conditions, such as voltage depression.

Vector Shift (78) and 'Rate-of-Change –of-Frequency' (81R) monitoring is used to detect loss of mains. The method applicable to a particular system depends largely on the generator's inertia (ability to resist change). For smaller generators, perhaps up to 250kV, vector shift will be most applicable. These small machines are not usually able to tolerate sudden changes in load and so react in an abnormal manner by phase 'jumping'. Larger generators are more able to resist sudden changes in load, their slower reaction resulting in a gradual rolling-off of the frequency. This makes ROCOF more applicable. These are just general guidelines, however, and a complete LOM protection provides both elements.

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Section 2: Protection Functions

2.1 Under/Over Voltage Protection (27/59)

Each under and over voltage element has a variable hysteresis setting which allows the user to adjust the pick-up/drop-off ratio of the element. Where for example the '27/59-n Hysteresis' setting is set at 2% for over-voltage operation then a pick-up setting of 100V would have a drop-off value of 98V.

When using the variable hysteresis, care has to be taken to ensure that with under-voltage elements, the reset level of the element is not set to a value higher than that at which the system rated voltage is expected to operate. Conversely, the level of hysteresis set for an over-voltage element should not be set below that at which the system rated voltage is expected to run.

2.1.1 Under-Voltage

During normal system operating conditions regulating equipment such as transformer On Load Tap Changers (OLTC) and generator Automatic Voltage Regulators (AVR) ensure that the system runs within acceptable voltage limits. Power system under-voltages on may occur due to system faults, increase in system loading or a non-energized power system e.g. loss of an incoming transformer.

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

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

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

2.1.2 Over-Voltage

System over-voltages can damage component insulation. Excessive voltage may occur for sudden loss of load, a tap changer run-away condition, generator AVR equipment malfunctions or reactive compensation control malfunctions.

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

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

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

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

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2.2 Negative Phase Sequence Overvoltage (47)

Unbalanced voltage on a 3-phase network results as a consequence of unbalanced load current causing unequal voltage drops in network impedances. The unbalanced load current could be the result of single phase open circuits (isolator failures, broken conductors etc.) or because of loads generating harmonics (e.g. thyristor drives). Unbalanced voltage generated at a busbar has the knock-on

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

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

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

2.3 Neutral Overvoltage (59N)

The three phases of a balanced healthy system summate to zero. When a single-phase earth fault occurs the system balance is upset and a residual/neutral voltage is produced. Neutral Over-Voltage protection, sometimes referred to as Neutral Voltage Displacement (NVD) protection, is used to detect an earth fault where little or no earth current flows.

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

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

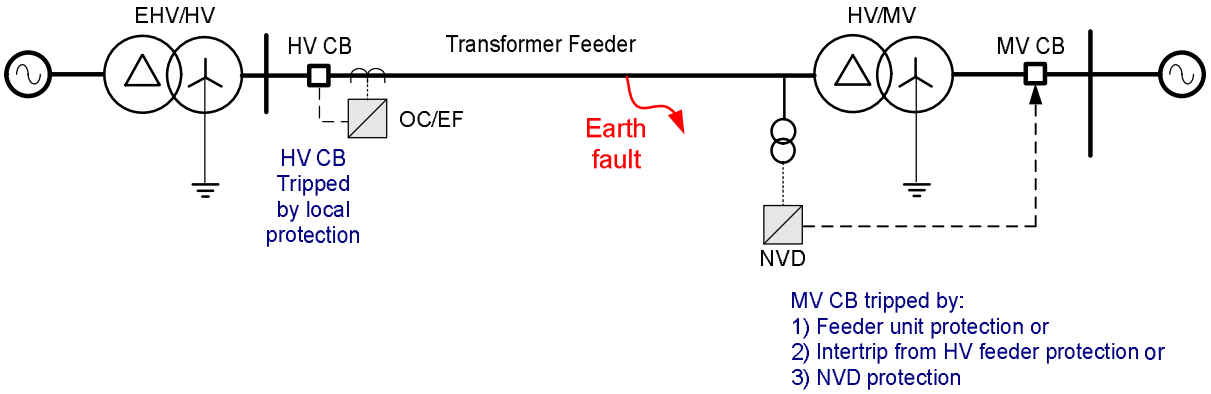

Figure 2.3-1 Neutral Overvoltage Application

The neutral voltage ($3V_0$) can be measured directly or derived from the phase-neutral voltages - see Figure 2.3-2.

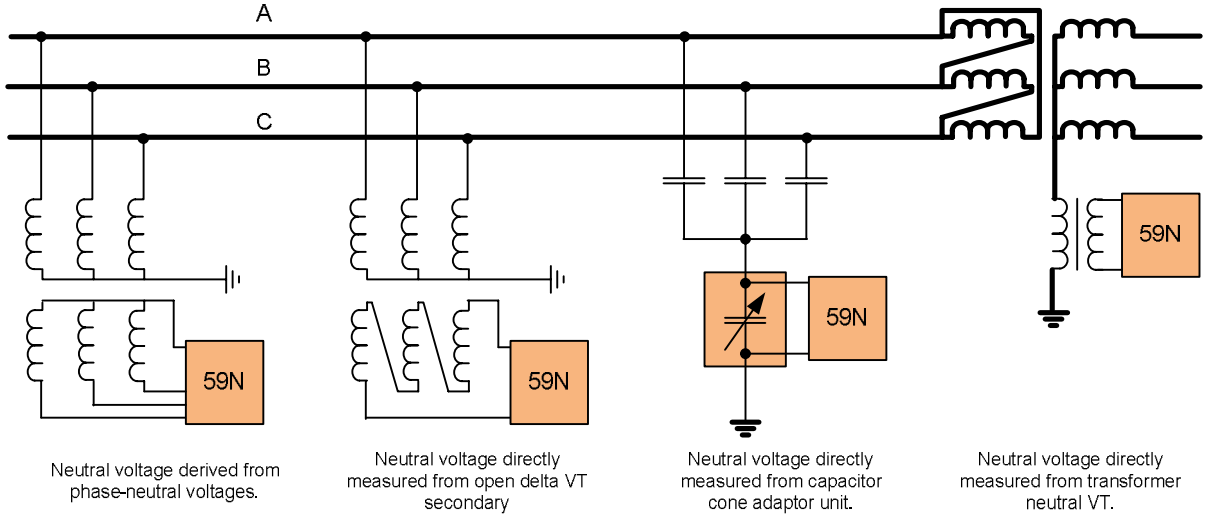

Figure 2.3-2 Neutral Overvoltage Protection Connections

2.3.1 Application with Capacitor Cone Units

Capacitor cones are used to provide a neutral voltage output where conventional VTs are too large or too expensive. A capacitor cone adaptor unit (type 7XG21) is used with the 7SR158 to enable the relay input to be calibrated for a range of capacitor cone values such that protection settings and instruments can be scaled to the primary NVD value - see Figure 2.3-2.

2.3.2 Derived Neutral Voltage

Neutral voltage can be derived from the three phase to neutral voltages – the relay will derive neutral voltage when the 'CT/VT CONFIG' setting is selected to 'Van,Vbn,Vcn'. Note with this method the NVD protection may mal-operate during a VT Fail condition.

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2.4 Vector Shift (78)

When a Generator is connected to an electricity supply system, the Generator will respond to any transitory changes in load to keep both voltage and frequency levels as close to constant as possible. When a LoM event occurs, however, the Generator is unable to respond instantaneously to the sudden, large-scale change in load and an instantaneous shift in the phase of the Generator voltage can result (Voltage Vector Shift). The sudden change in load causes a sudden change in cycle length. The cycle length becomes shorter or longer depending on whether the newly formed island has a surplus or shortage of generation.

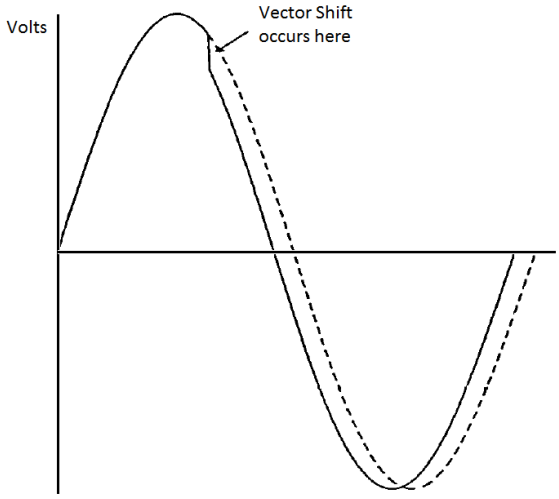

Figure 2.4-1 Vector Shift

This vector shift can be in either direction depending on whether load increases or decreases. Where the DG capacity is insufficient to supply the local load and power is supplemented from the mains then a LoM event will cause the DG load to increase.

With an increase in load, the voltage would tend to 'jump back'; as in Figure 2.4-1. This would occur when a trip on the mains network has left the distributed generation to try and supply the whole of the downstream load. This would be the usual condition leading to a LOM tripping.

Alternatively, if the local generation is supplying both a local load and the mains network – such as happens with some industrial systems, disconnection from the mains network would create an islanding condition in which there may be an excess of electrical supply and the voltage would tend to 'jump forward'.

There is an obvious link between the 78 element and the 81R (Rate-of-Change-of-Frequency) element. However the equivalent vector shift seen for expected ROCOF levels should not result in operation of the 78 element:

The highest 81R pick-up setting is 10 Hz/s

This equates to a ROCOF of 0.1 Hz over the 10ms measuring interval

Giving an equivalent vector shift of (360° / 50 Hz) x 0.1 Hz = 0.72°

At 60Hz system frequency, the equivalent is 0.5° vector shift at maximum ROCOF setting

Attempting to differentiate between the two elements at inordinately high levels of ROCOF would impose a delay on the operation of the 78 element and so this is considered acceptable. Momentary changes in phase can occur due to load switching operations. These can be as great as 5° and must be allowed for in the setting of the 78 pick-up setting. A setting of 6° is recommended by the G.59 standard for connection of distributed generation to an electricity supply system, and settings of 8° to 12° are typical.

When the exported power to the mains network is very low, there is a risk that the drop in load will be insufficient to cause a vector shift. Or will cause a vector shift of limited extent. Generally it is required that exported power will be of the order of 10-20% of total power generated before a LOM will always be detected.

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2.5 Under/Over Frequency (81)

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

Loss of generating capacity, or loss of mains supply (under-frequency): If the governors and other regulating equipment cannot respond to correct the balance, a sustained under-frequency condition may lead to a system collapse.

Loss of load – excess generation (over-frequency): The generator speeds will increase causing a proportional frequency rise. This may be unacceptable to industrial loads, for example, where the running speeds of synchronous motors will be affected.

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

The relay has six under/over frequency elements.

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

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

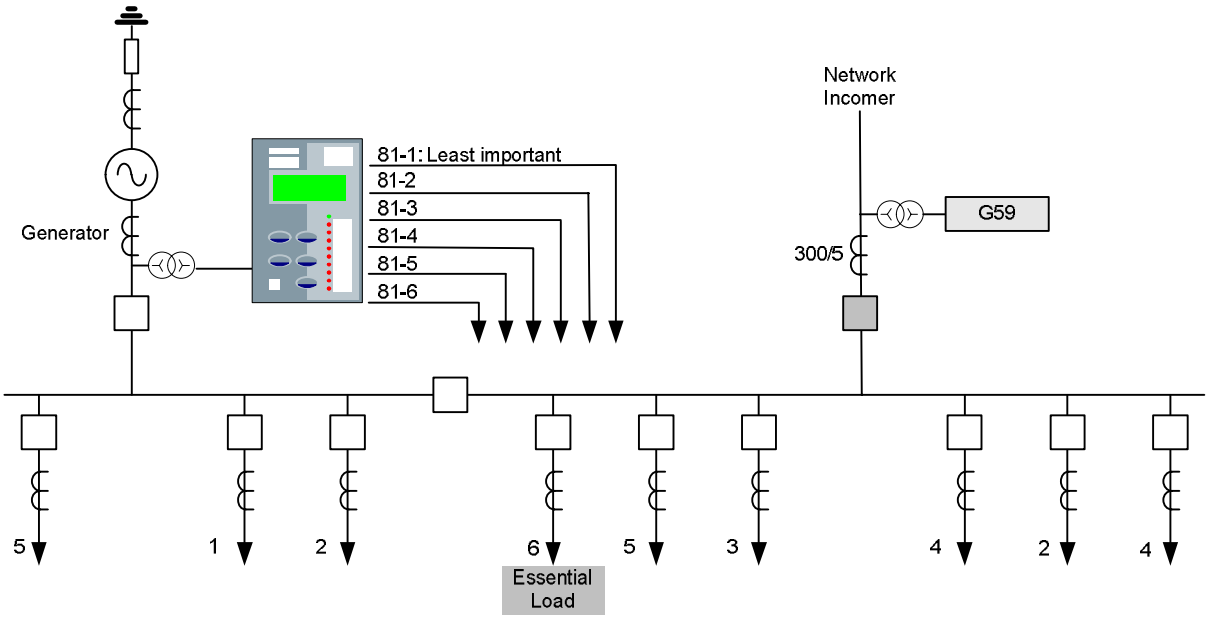

Figure 2.5-1 Load Shedding Scheme Using Under-Frequency Elements

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2.6 Rate-of-Change-of-Frequency (81R)

For some applications, operation of 81 (Under/Over-Frequency) elements can take an unacceptably long time. e.g. where the frequency changes gradually and so takes time to reach the Under or Over-Frequency pick-up level; after which the element delay to trip will then begin. For such applications it may be more desirable to use an 81R Rate of Change of Frequency (ROCOF) element.

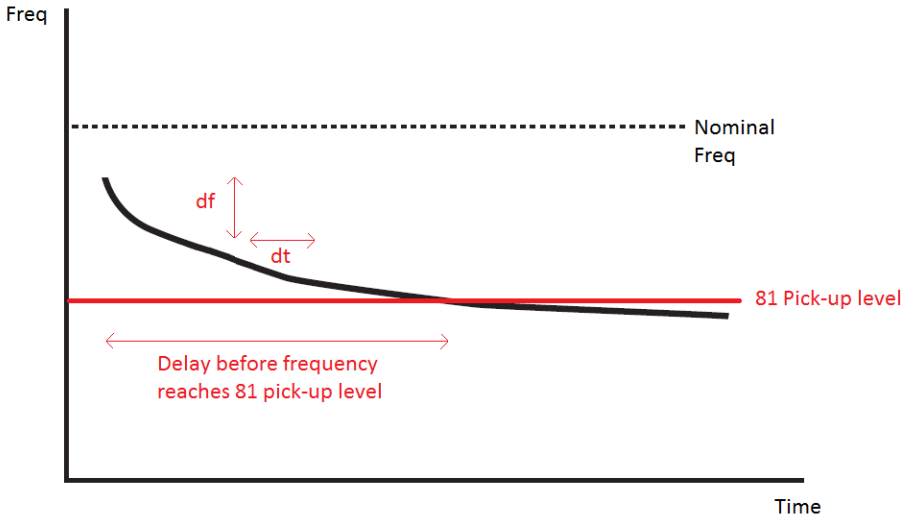

Figure 2.6-1 Use of ROCOF elements

ROCOF is applied to both load shedding and loss-of-mains (LOM) detection. In both instances, it may be necessary to have fast tripping times. For load shedding it may be necessary to restore voltage and frequency levels to regulated levels within a regulated timeframe. For LOM, it may be necessary to disconnect a source of generation before the mains network is restored e.g. by auto-reclosure thereby avoiding synchronising problems.

Where load has reduced, creating an excess of generated power, frequency will rise and a positive df/dt curve will result. This would be the case where a local load has become 'islanded' and the local generation is higher than that required to supply it. Reductions in 'downstream' load levels, caused by switching or tripping events, should not be sufficient to cause the 81R elements to operate since the connection to the mains supply will ensure voltage and frequency regulation and the effect on the local generation should not be great.

If the User is concerned about vector shifts below 3°, then the delay setting should used to delay operation of the 81R element. A delay of 300ms will ensure that the 81R element will not operate for a vector shift of any size.

2.6.1 Loss of Mains (LOM)

ROCOF's of up to 0.1 Hz/s can be expected on power networks due to normal system operations. The G.59 standard, defining the requirements for connecting significant distributed generation to a mains supply, therefore recommends an 81R pick-up setting of 0.125 Hz/s. However frequency does not decay in a linear manner and for this reason it is inadvisable to set the 81R element to be too fast; a short period of rapid decay may be uncharacteristic of the system condition but sufficient to trip off the element. Not allowing for this complex decay characteristic is one of the main reasons that 81R protection has gained a reputation for being unstable. At such a low level of 81R pick-up as 0.125 Hz/s, a delay in the order of 300ms is recommended.

The second 81R element can be set to a higher pick-up level, but with a corresponding reduction in operate time.

2.6.2 Load Shedding

Frequency broadly decays in an exponential curve during a load shedding situation, eventually stabilising at a reduced level. However predicting the rate of decay is a complex issue; the most significant factors being the scale of the overload and the amount of inertia (resistance to change) in the network. A number of operational conditions will have an effect and these will rarely be constant over a number of load shedding events. For this reason a detailed knowledge of the system is essential for arriving at suitable settings.

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Where other protection elements are used as part of the Load Shedding scheme – such as 27 (under-voltage) or 81 (under-frequency) – it is advisable that the 81R elements are set so that they contribute to the overall scheme coverage. Operate times should be long enough so that any previous loading shedding event has had an opportunity to take effect; there will be a delay between a load shedding command being sent and the resulting reduction in load during which frequency may continue to fall. A delay of 300ms to 400ms will be sufficient to allow for all cases.

In particular it must be remembered that automatic load-shedding represents a highly unusual system condition and can be viewed as an emergency, last-ditch measure. For this reason it should never be set too sensitively or too fast-acting, inadvertent loss of load having a potentially catastrophic effect on the power network.

The provision of programmable logic in the Relays means that Protection features can be easily configured to provide quite complex control functionality. For example, following a load shedding event, an 81 Under/Over Frequency element can be configured to provide load restoration once the frequency has recovered for a minimum duration. With the order of load restoration being defined in sequential logic.

Alternatively, to improve stability, an 81 element can be used as a starter for the 81R elements. In this case the 81R elements could be inhibited until the frequency varies by an abnormal amount; as indicated by the picking-up of the 81 element.

Where a high rate of frequency change has been detected – indicating a large generated power to load imbalance, it may be preferable to shed two or more load groups at the same time without waiting for the relative under-frequency levels to be reached.

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Section 3: Control Functions

3.1 Quick Logic Applications

3.1.1 Auto-Changeover Scheme Example

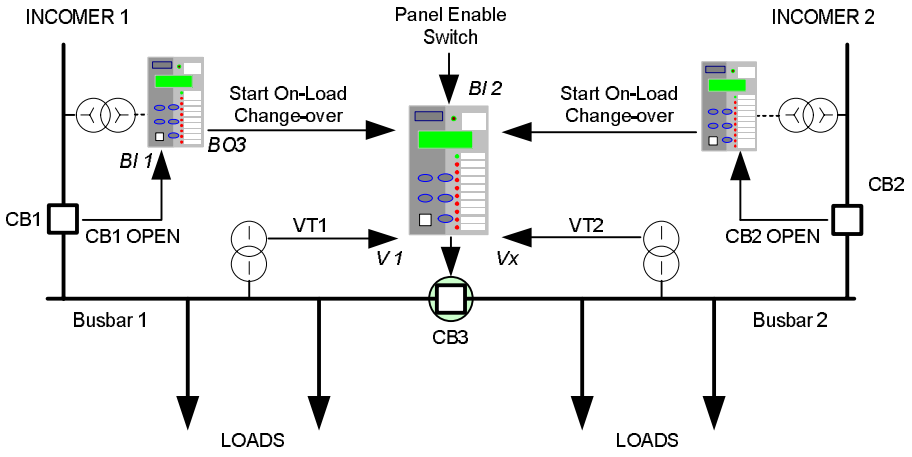

Figure 3.1-1 Quick Logic Example

The MV installation illustrated above is fed from two incomers. To limit the substation fault level the busbar is run with CB3 open. When a fault occurs on one of the incomers it is isolated by the circuit protection. To re-supply the disconnected loads from the remaining incomer CB3 is closed.

If the line fault occurs on incomer 1 it must be confirmed that CB 1 has opened before CB3 can be closed. The relay on incomer 1 confirms that a trip has been issued to CB1 (e.g. Binary Output 2), that CB 1 has opened (e.g. Binary Input 1) and that no current flows in the circuit (e.g. 37-1 = Virtual 1):

Incomer 1 Relay is Configured:

CB1 Open auxiliary switch wired to BI 1

Trip output to CB1 = BO 2

OUTPUT CONFIG>OUTPUT MATRIX: ***37-1*** = **V1**

OUTPUT CONFIG>OUTPUT MATRIX: ***E1*** = **BO3**

CONTROL & LOGIC>QUICK LOGIC: ***E1*** = **O2.I1.V1**

The output from Incomer 1 (Binary Output 3) relay is input to the relay on CB 3 (Binary Input 1). A panel switch may be used to enable the On-Load Change-over scheme (Binary Input 2). Before Closing CB3 a check may be made that there is no voltage on busbar 1 (27/59-1 = Virtual 1). CB 3 is closed from Binary Output 3.

CB3 Relay is Configured:

Panel switch (ON-Load Change-over Enabled) wired to BI2

OUTPUT CONFIG>OUTPUT MATRIX: ***27/59-1*** = **V1**

OUTPUT CONFIG>OUTPUT MATRIX: ***E1*** = **BO3**

CONTROL & LOGIC>QUICK LOGIC: ***E1*** = **I1.I2.V1**

If required a time delay can be added to the output using the CONTROL & LOGIC > QUICK LOGIC: ***E1 Pickup Delay*** setting.

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Section 4: Supervision Functions

4.1 Trip/Close Circuit Supervision (74T/CCS)

Binary Inputs may be used to monitor the integrity of the CB trip and close circuit wiring. A small current flows through the B.I. and the circuit. This current operates the B.I. 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 B.I. drops off and if it is user programmed to operate one of the output relays, this can provide a remote alarm. In addition, an LED on the relay can be programmed to operate. A user text label can be used to define the operated LED e.g. "Trip CCT Fail".

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

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

4.1.1 Trip Circuit Supervision Connections

The following circuits are derived from UK ENA S15 standard schemes H5, H6 and H7.

For compliance with this standard:

> Where more than one device is used to trip the CB then connections should be looped between the tripping contacts. To ensure that all wiring is monitored the binary input must be at the end of the looped wiring.
>
> Resistors must be continuously rated and where possible should be of wire-wound construction.

Scheme 1 (Basic)

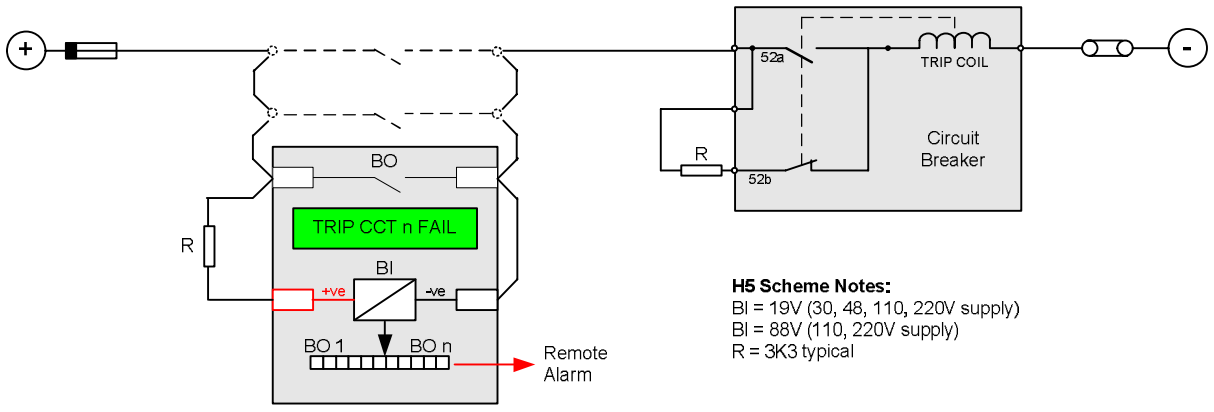

Figure 4.1-1 Trip Circuit Supervision Scheme 1 (H5)

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

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

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Scheme 2 (Intermediate)

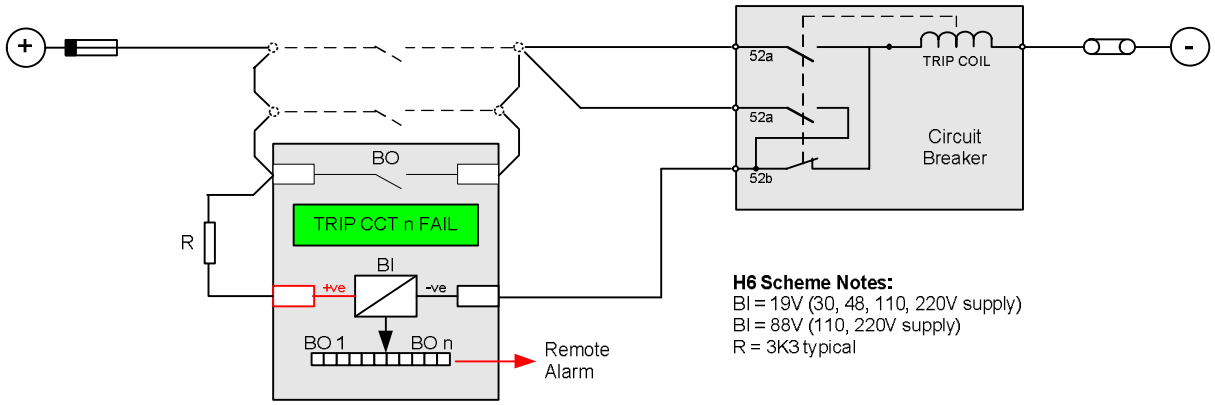

Figure 4.1-2 Trip Circuit Supervision Scheme 2 (H6)

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

Scheme 3 (Comprehensive)

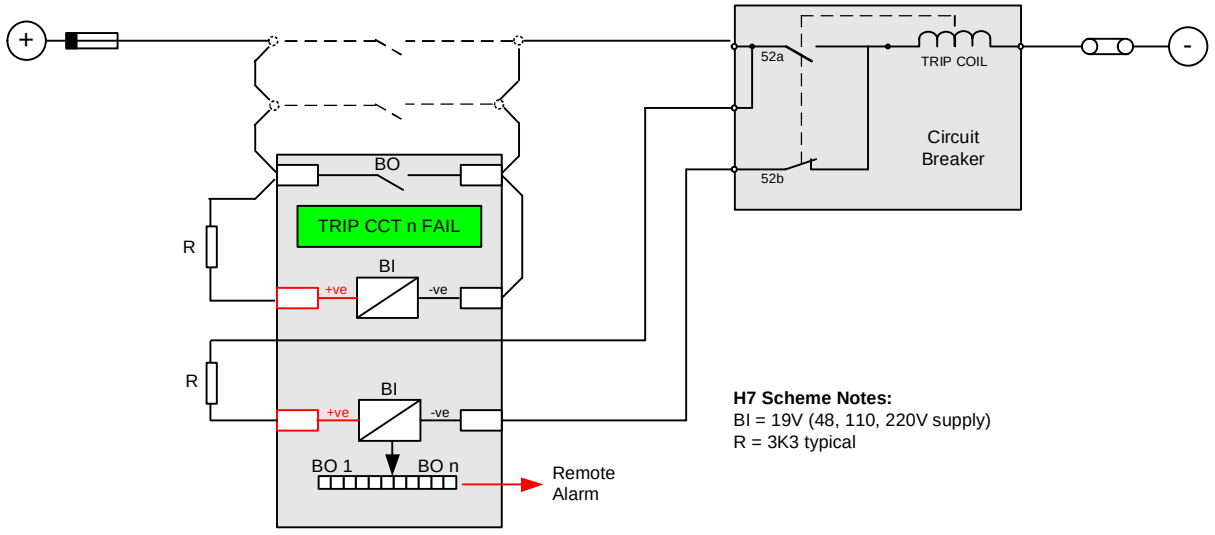

Figure 4.1-3 Trip Circuit Supervision Scheme 3 (H7)

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

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4.1.2 Close Circuit Supervision Connections

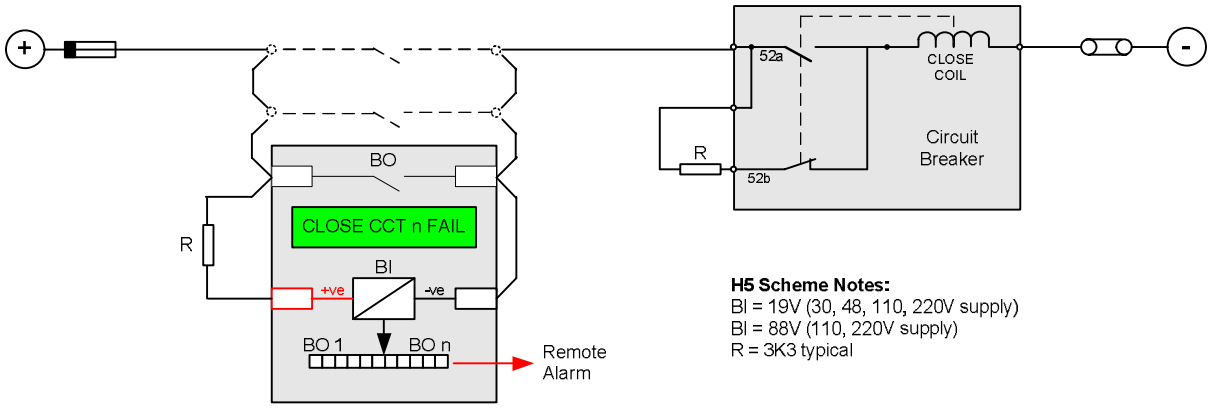

Figure 4.1-4 Close Circuit Supervision Scheme

Close circuit supervision with the circuit breaker Open or Closed.

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4.2 Circuit-Breaker Maintenance

The Relay provides Total, Delta and Frequent CB Operation Counters along with an I^2t Counter to estimate the amount of wear and tear experienced by a Circuit-Breaker. Alarm can be provided once set levels have been exceeded.

Typically estimates obtained from previous circuit-breaker maintenance schedules or manufacturers data sheets are used for setting these alarm levels. The relay instrumentation provides the current values of these counters.

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Section 5: Common Functions

5.1 Binary Inputs

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

5.1.1 Alarm and Tripping Inputs

A common use of binary inputs is to provide indication of alarm or fault conditions e.g. transformer Buchholz Gas or Buchholz Surge conditions. The Binary Inputs are mapped to LED(s), waveform storage trigger and binary outputs. Note that transformer outputs which require high speed tripping, such as a Buchholz Surge, should be wired to a binary input to provide LED indication and also have a parallel connection wired to directly trip the circuit via a blocking diode.

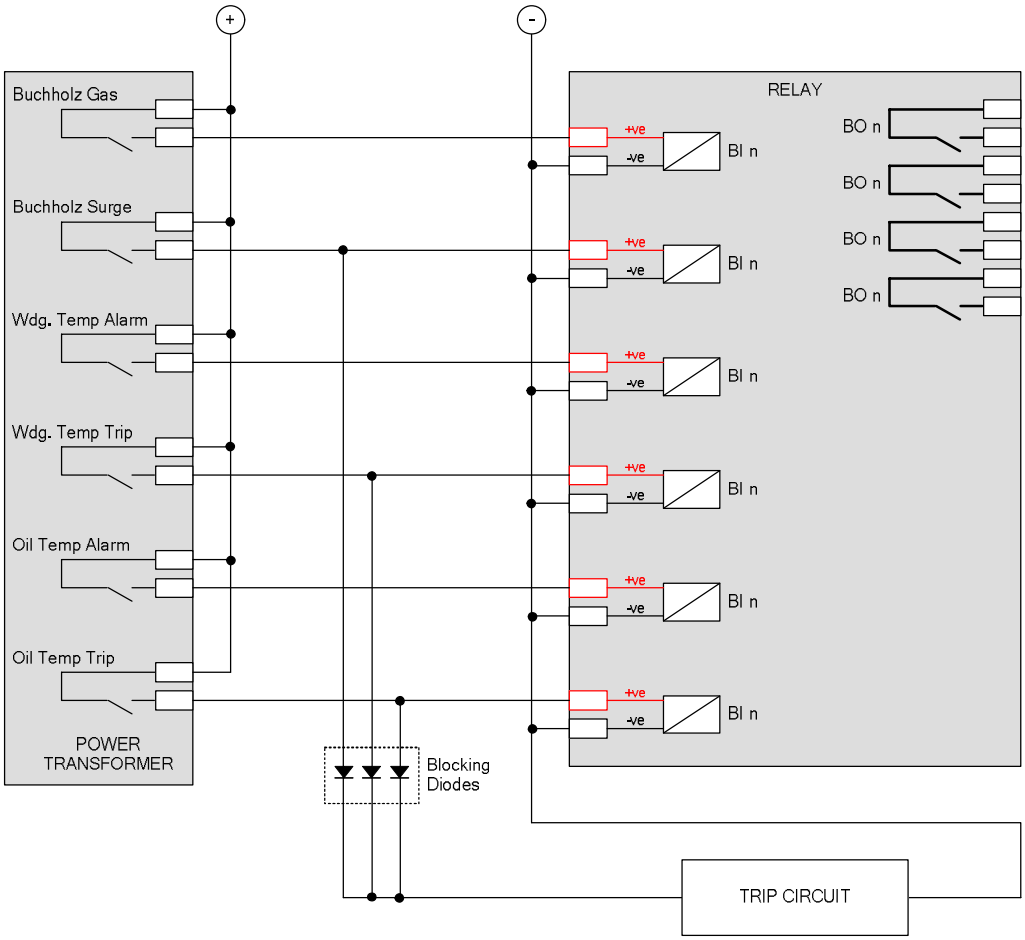

Figure 5.1-1 Example of Transformer Alarm and Trip Wiring

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5.1.2 The Effects of Capacitance Current

The binary inputs have a low minimum operate current and may be set for instantaneous operation. Consideration should be given to the likelihood of mal-operation due to capacitance current. Capacitance current can flow through the BI for example if an earth fault occurs on the dc circuits associated with the relay. The binary inputs will be less likely to mal-operate if they:

1 Have both the positive and negative switched (double-pole switched).

2 Do not have extensive external wiring associated with them e.g. if the wiring is confined to the relay room.

Where a binary input is both used to influence a control function (e.g. provide a tripping function) and it is considered to be susceptible to mal-operation the external circuitry can be modified to provide immunity to such disturbances, see figure 1.2-2.

5.1.3 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.

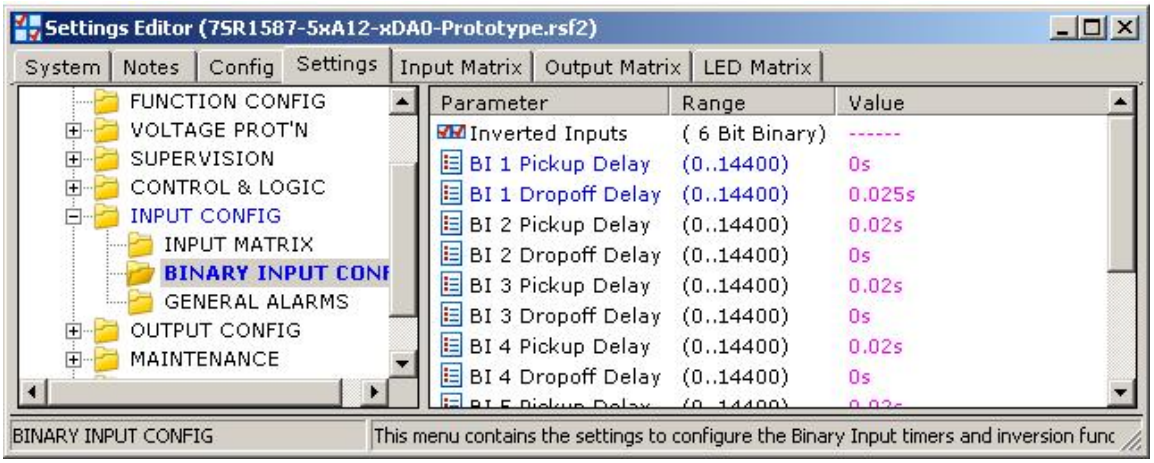
Binary inputs can be configured for intentional operation from an ac power supply by setting pickup and drop-off timers for each binary input; 0ms PU and 25ms DO. If wiring to AC operate binary inputs is required to have a total length of more than 10 metres, screened twisted pair cable should be used.

If additional pickup or drop-off time delays are required by the scheme logic, this functionality can be achieved by programmable logic within the device.

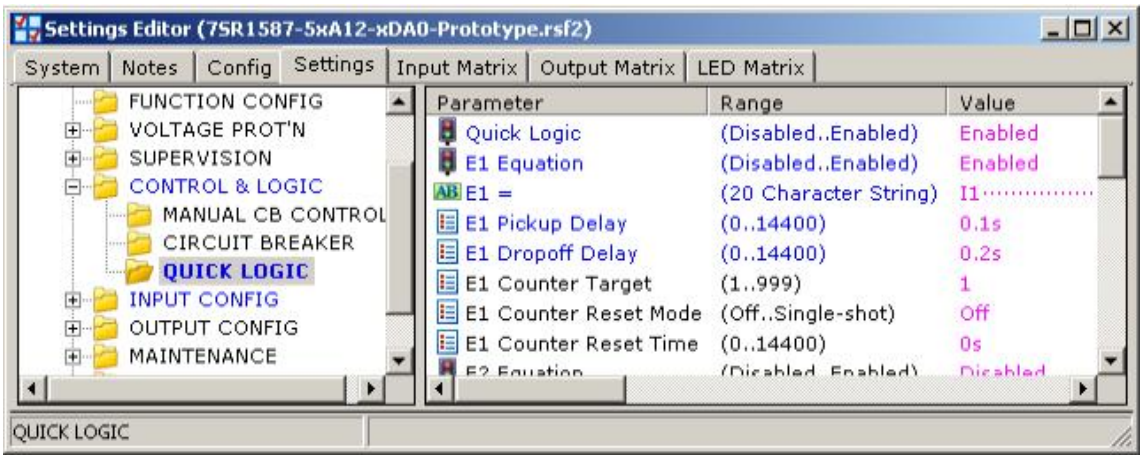
Example.

An AC operated Binary input is required to inhibit the 27/59-1 protection element with 100ms minimum pickup delay and 200ms minimum drop-off delay.

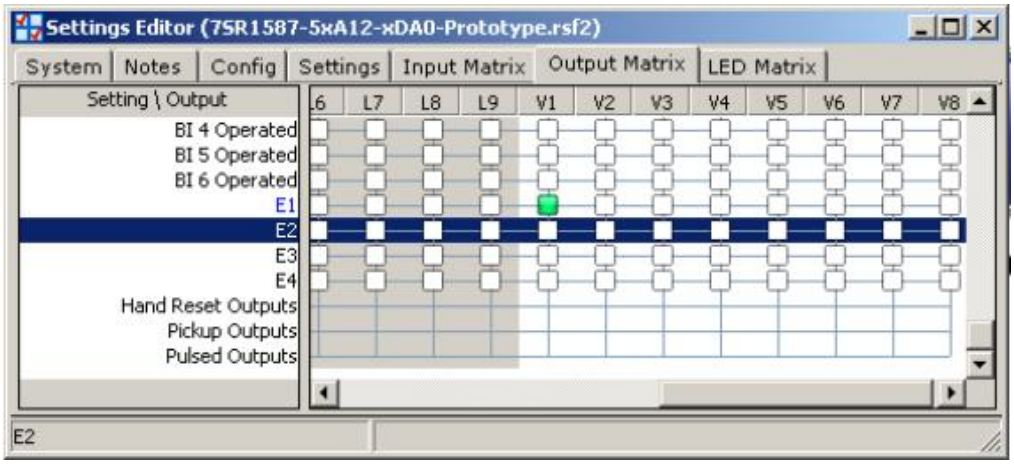
1) Set Binary Input 1 for AC operation:



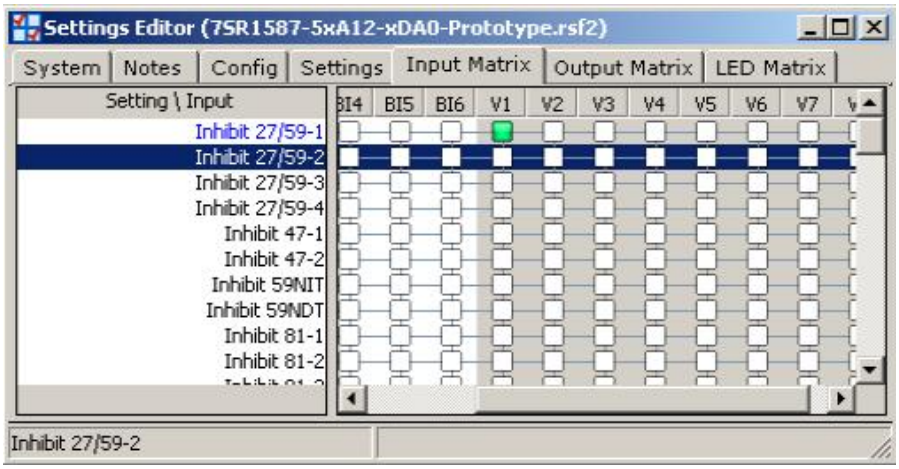
2) Set quicklogic equation E1 to operate from Binary Input 1 and apply required delays:



3) Set equation E1 to operate virtual I/O V1 in the Output Matrix:



4) Set virtual I/O V1 to operate Inhibit 27/59-1 in the Input Matrix:



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5.1.4 Use of Binary Inputs in control and tripping circuits

Where a binary input is used to as part of a dc control function, for example tripping or closing a circuit breaker, it may be desirable to provide an enhanced level of immunity to prevent 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 binary input is to switch both positive and negative connections; however this is often not possible or desirable.

Where the battery voltage allows its use, the 88V binary input will give an added measure of immunity, compared to the 19V binary input, 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.

The following diagrams show the external resistors which should be fitted to allow the binary input to comply with either of the above categories.

Fitting these components will raise the current required to operate the binary input, and hence makes it less susceptible to maloperation.

Where required, the minimum pickup delay for the binary input is stated on the diagram.

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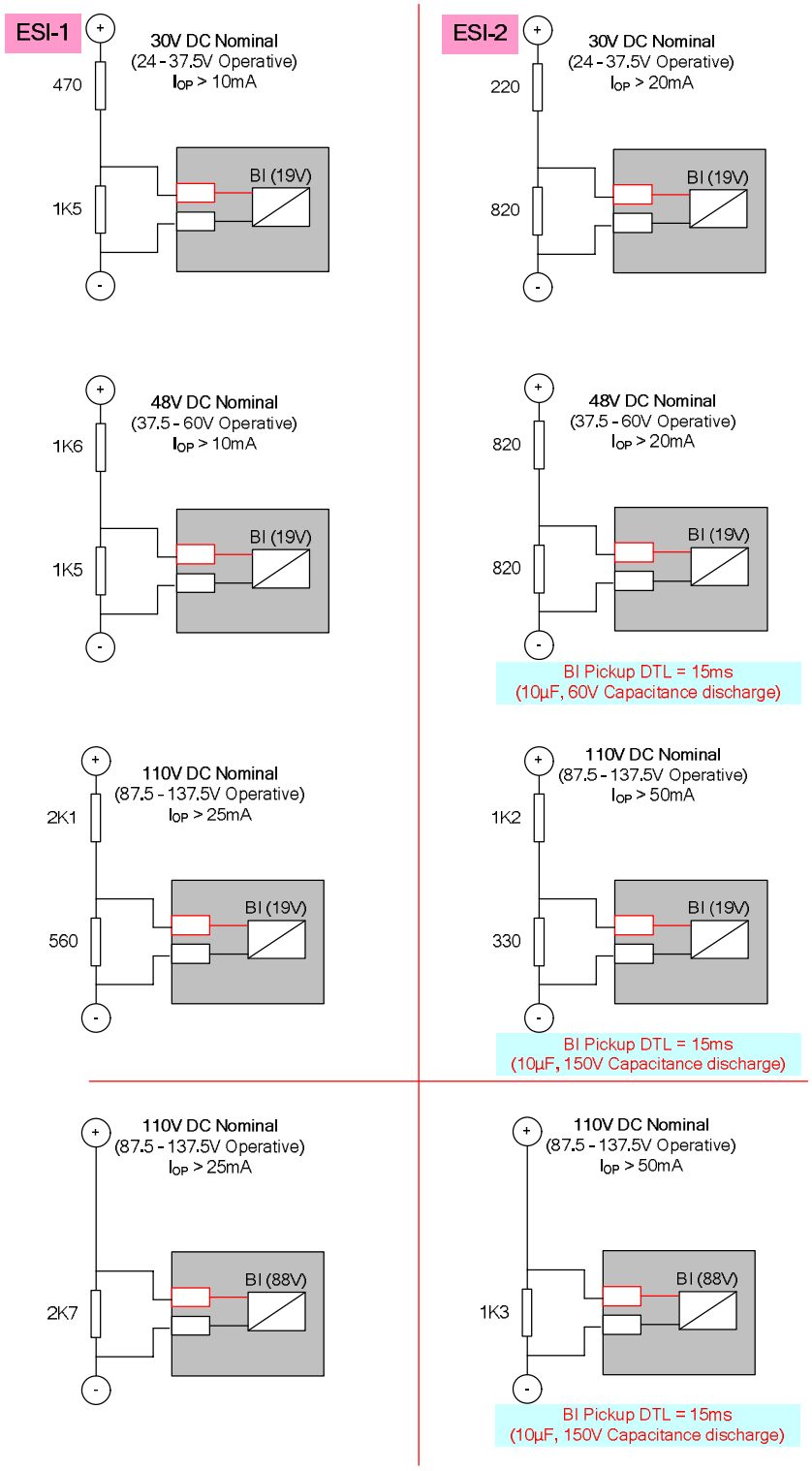

Resistor power ratings:

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 5.1-2 Example Binary Input Configurations Providing Compliance with EATS 48-4 Classes ESI 1 and ESI2

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5.2 Binary Outputs

Binary Outputs are mapped to output functions by means of settings. These could be used to bring out such digital signals as trips, a general pick-up, plant control signals etc.

All Binary Outputs are Trip rated

Each can be defined as Self or Hand Reset. Self-reset contacts are applicable to most protection applications. Hand-reset contacts are used where the output must remain active until the user expressly clears it e.g. in a control scheme where the output must remain active until some external feature has correctly processed it.

Notes on Self Reset Outputs:

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

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5.3 LED's

In the Output Configuration menu LED's can be mapped to output functions by means of settings. These could be used to display such digital signals as trips, a general pick-up, plant control signals etc.

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

The status of hand reset LEDs is retained in capacitor-backed memory in the event of supply loss.

Each LED can be assigned as red, yellow or green in colour. There are two methods for doing this: -

1) In the LED Matrix tab, to assign the LED as a red colour select a box on the red row. To assign the LED as a green colour select a box on the green row. To assign the LED as a yellow colour, select boxes on both the red and green rows.

   NB: If there are no boxes selected the LED will not illuminate.

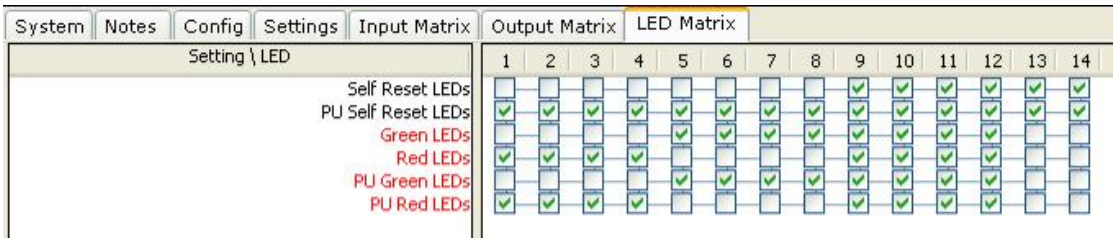

Figure 5.3-1 LED configuration via the LED Matrix tab

2) In the OUTPUT CONFIG\LED CONFIG menu in the Settings tab, to assign the required LED as a particular colour, either red or green, type the LED number in the appropriate row. To assign the required LED as a yellow colour, type the LED number in both red and green rows.

   NB: If a LED number is not assigned that particular LED will not illuminate.

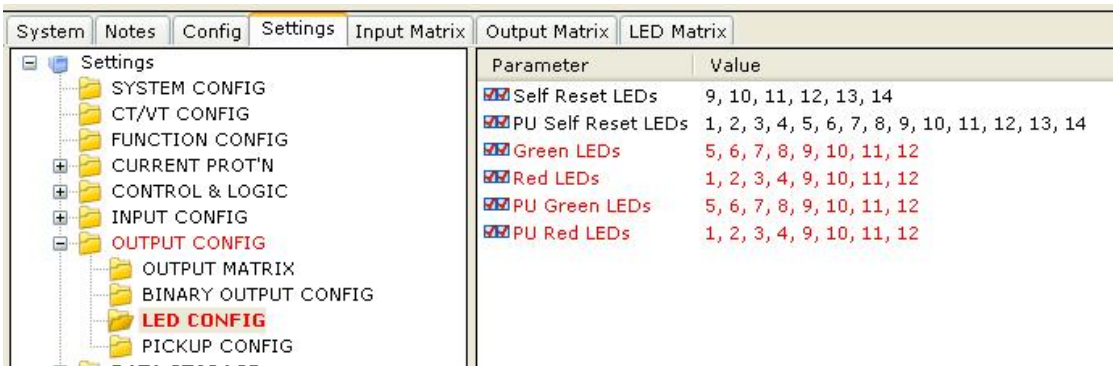

Figure 5.3-2 LED configuration via the Settings \ OUTPUT CONFIG \ LED CONFIG menu

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