7SR242 Duobias

Multi-Function 2-Winding Transformer Protection Relay

Document Release History

This document is issue **2010/06**. The list of revisions up to and including this issue is:

2010/06	Additional Comms modules option of (RS485 + IRIG-B) and (RS232 + IRIG-B) and typographical revisions
2010/02	Document reformat due to rebrand
2010/02	Third issue. Software revision 2662H80001 R4c-3
2008/07	Second issue. Software revision 2662H80001R3d-2c.
2008/05	First issue

Software Revision History

2010/02	2662H80001 R4c-3	Revisions to: VT ratio settings, 87BD 1st bias slope limit setting increments, CB fail function, LED CONFIG menu, DATA STORAGE menu. Added: Open circuit detection (46BC), CONTROL MODE menu, Close circuit supervision (74CCS), Measured earth fault undercurrent (37G), Pulsed output contacts.
2008/07	2662H80001R3d-2c.	Demand metering. Optional DNP3.0 data comms.
2008/05	2662H80001R3-2b	First Release

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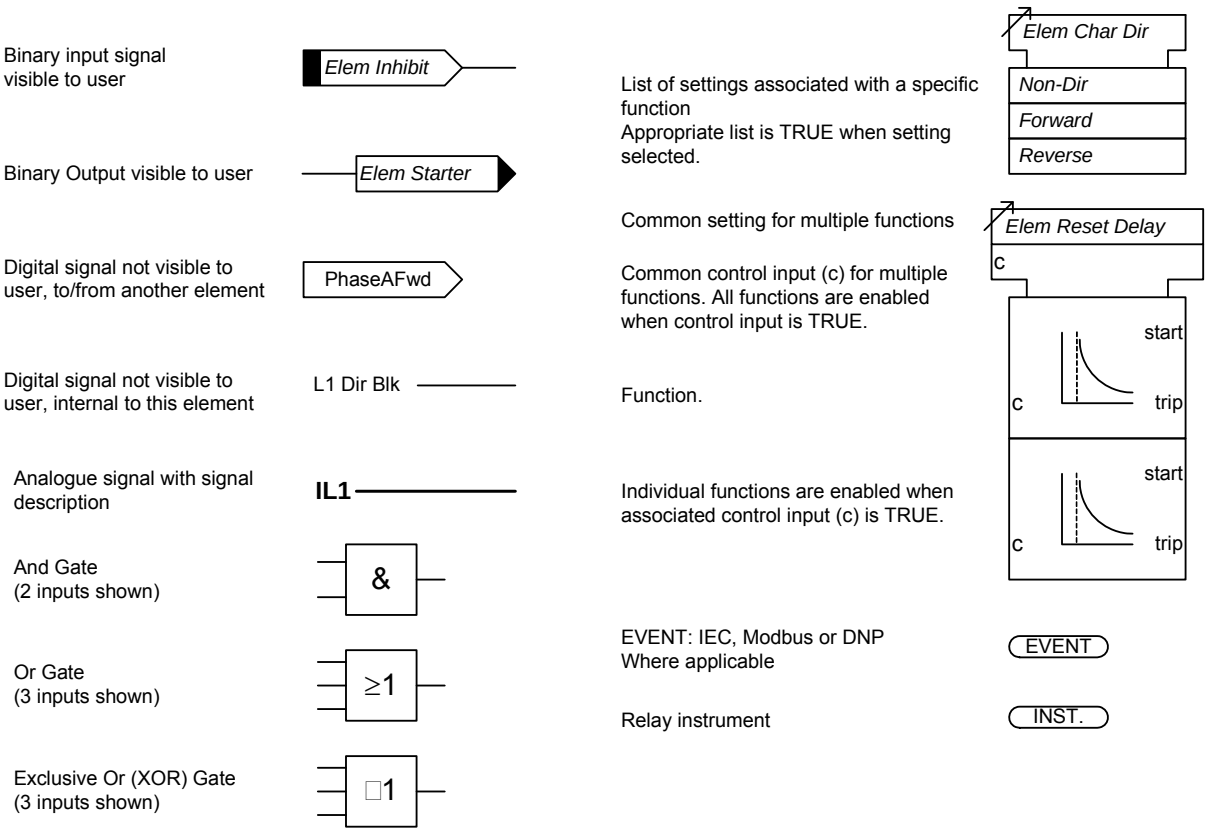
Symbols and Nomenclature

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

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



Section 1: Introduction

This manual is applicable to the following relays:

- **7SR242 Multi-Function 2-Winding Transformer Protection Relay**

The 7SR242 relay integrates the protection and control elements required to provide a complete transformer protection.

The 'Ordering Options' Tables summarise the features available in each model.

General Safety Precautions

Current Transformer Circuits

The secondary circuit of a live CT must not be open circuited. Non-observance of this precaution can result in injury to personnel or damage to equipment.

External Resistors

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

Fibre Optic Communication

Where fibre optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

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.

Table 1-1: 7SR242 Ordering Options

DUOBIAS-M — **7 S R 2 4 2 □ - 2 □ A □ □ - 0 □ A 0**

Multifunctional 2 winding transformer differential protection

Protection Product	
Transformer	4
Relay Type	
Differential (2 winding)	2
Case I/O and Fascia	
E8 case, 6 CT, 2 EF/REF CT, 1 VT, 9 Binary Inputs / 6 Binary Outputs, 16 LEDs	2
E10 case, 6 CT, 2 EF/REF CT, 1 VT, 19 Binary Inputs / 14 Binary Outputs, 24 LEDs	3
Measuring Input	
1/5 A, 63.5/110V, 50/60Hz	2
Auxiliary voltage	
30 to 220V DC, binary input threshold 19V DC	A
30 to 220V DC, binary input threshold 88V DC	B
Communication Interface	
Standard version – included in all models, USB front port, RS485 rear port	1
Standard version – plus additional rear F/O ST connectors (x2) and IRIG-B	2
Standard version – plus additional rear RS485 (x1) and IRIG-B	3
Standard version – plus additional rear RS232 (x1) and IRIG-B	4
Protocol	
IEC 60870-5-103 and Modbus RTU (user selectable setting)	1
IEC 60870-5-103 and Modbus RTU and DNP 3.0 (user selectable)	2
Protection Function Packages	
Option A: Standard version – Included in all models	A
- 81HBL2 Inrush Detector	
- 81HBL5 Overfluxing detector	
- 87BD Biased current differential	
- 87HS Current differential highest	
Programmable logic	
For each winding/circuit breaker	
- 50BF Circuit breaker fail	
- 64H High impedance REF	
- 74TCS/CCS Trip/close circuit supervision	
Option B: Standard version – plus	B
- 37/37G Undercurrent	
- 46BC Open circuit	
- 46NPS Negative phase sequence overcurrent	
- 49 Thermal overload	
- 50 Instantaneous phase fault overcurrent	
- 50G/50N Instantaneous earth fault	
- 51 Time delayed phase fault overcurrent	
- 51G/51N Time delayed earth fault	

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Option C:	Standard version - plus	**C**
- 24	Overfluxing	
- 27/59	Under/overvoltage	
- 59N	Neutral voltage displacement	
- 81	Under/overfrequency	
- 37/37G	Undercurrent	
- 46BC	Open circuit	
- 46NPS	Negative phase sequence overcurrent	
- 49	Thermal overload	
- 50	Instantaneous phase fault overcurrent	
- 50G/50N	Instantaneous earth fault	
- 51	Time delayed phase fault overcurrent	
- 51G/51N	Time delayed earth fault	

Additional Functionality

No Additional Functionality **A**

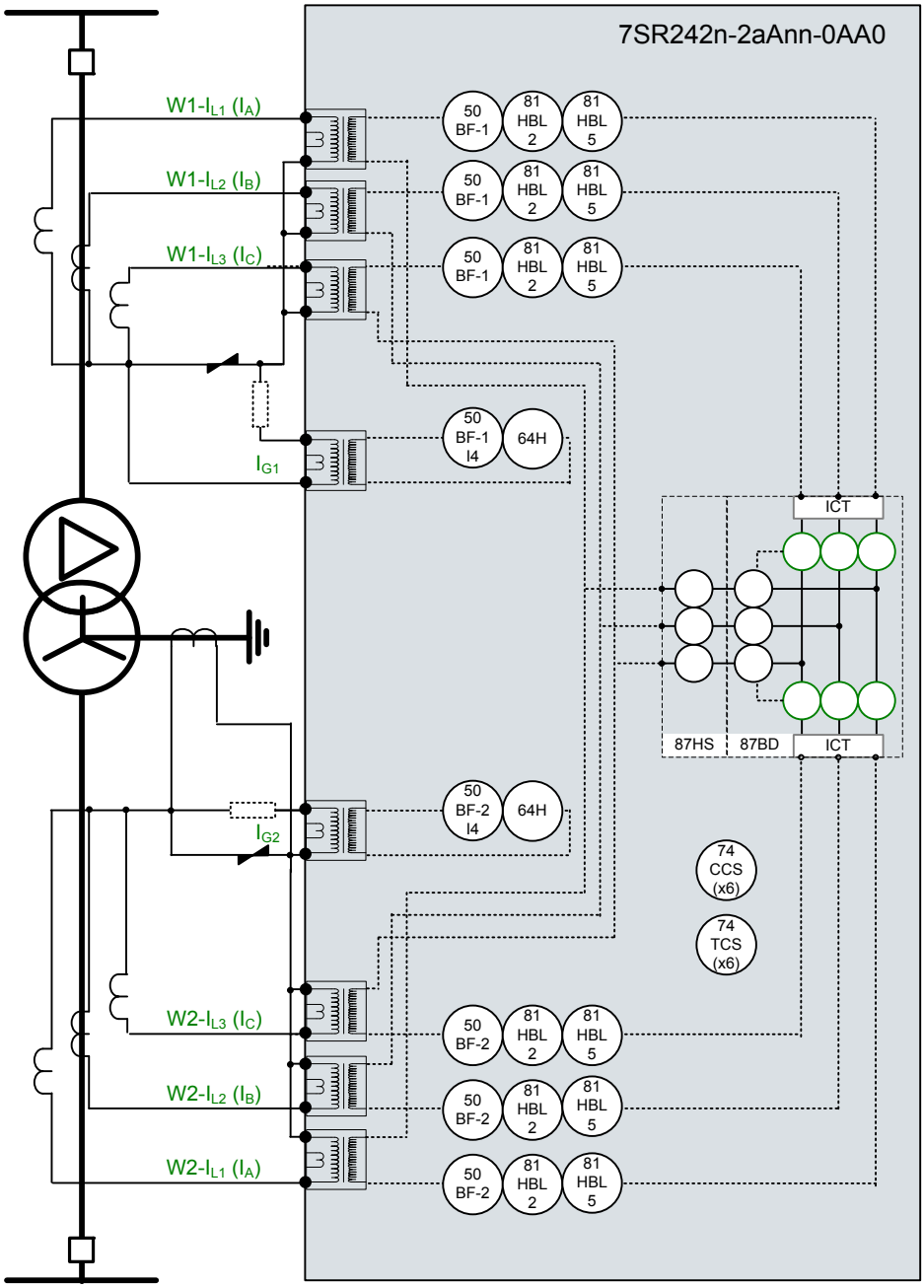

Figure 1-1 Functional Diagram: 7SR242n-2aAnn-0AA0 Relay

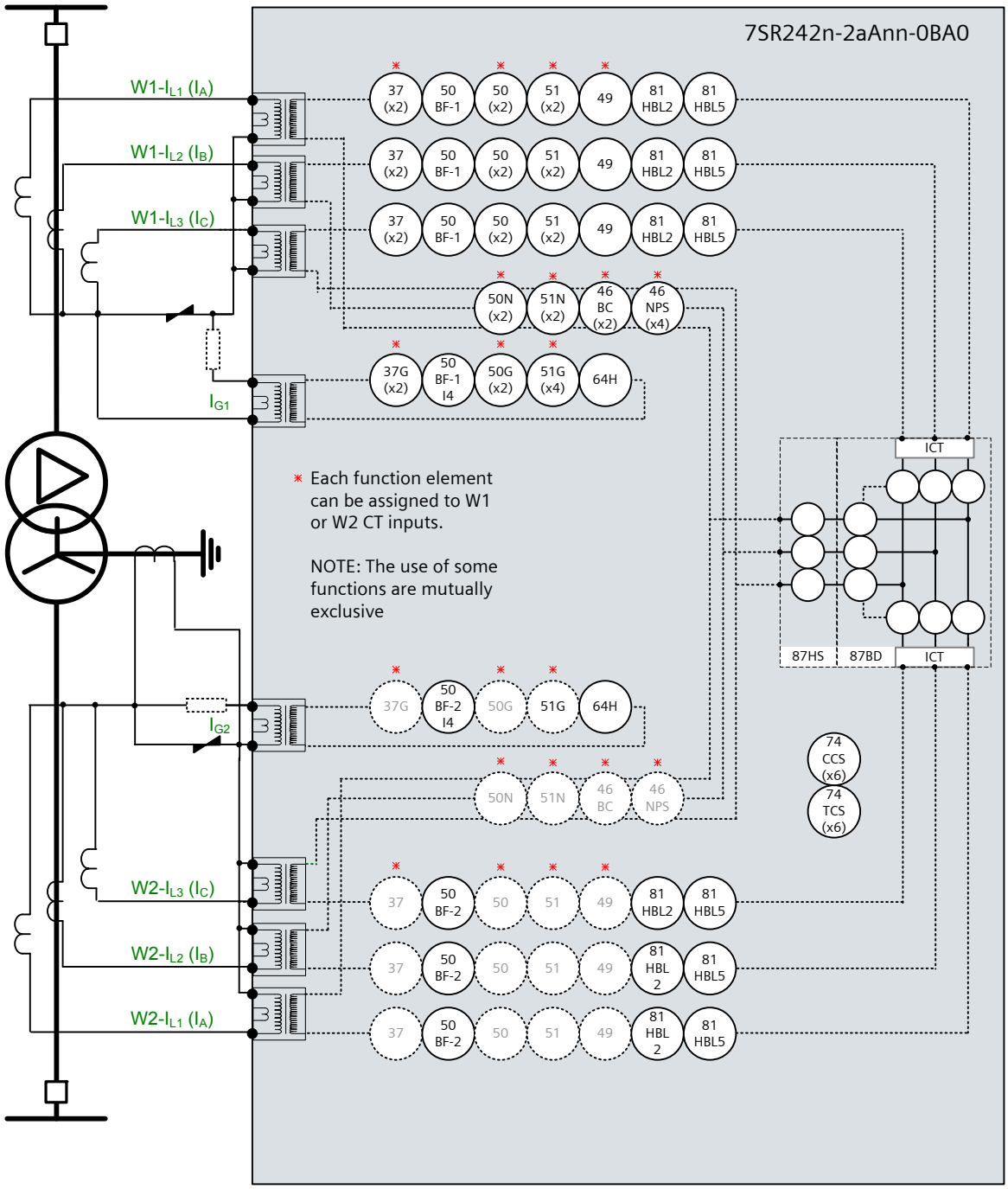

Figure 1-2 Functional Diagram: 7SR242n-2aAnn-0BA0 Relay

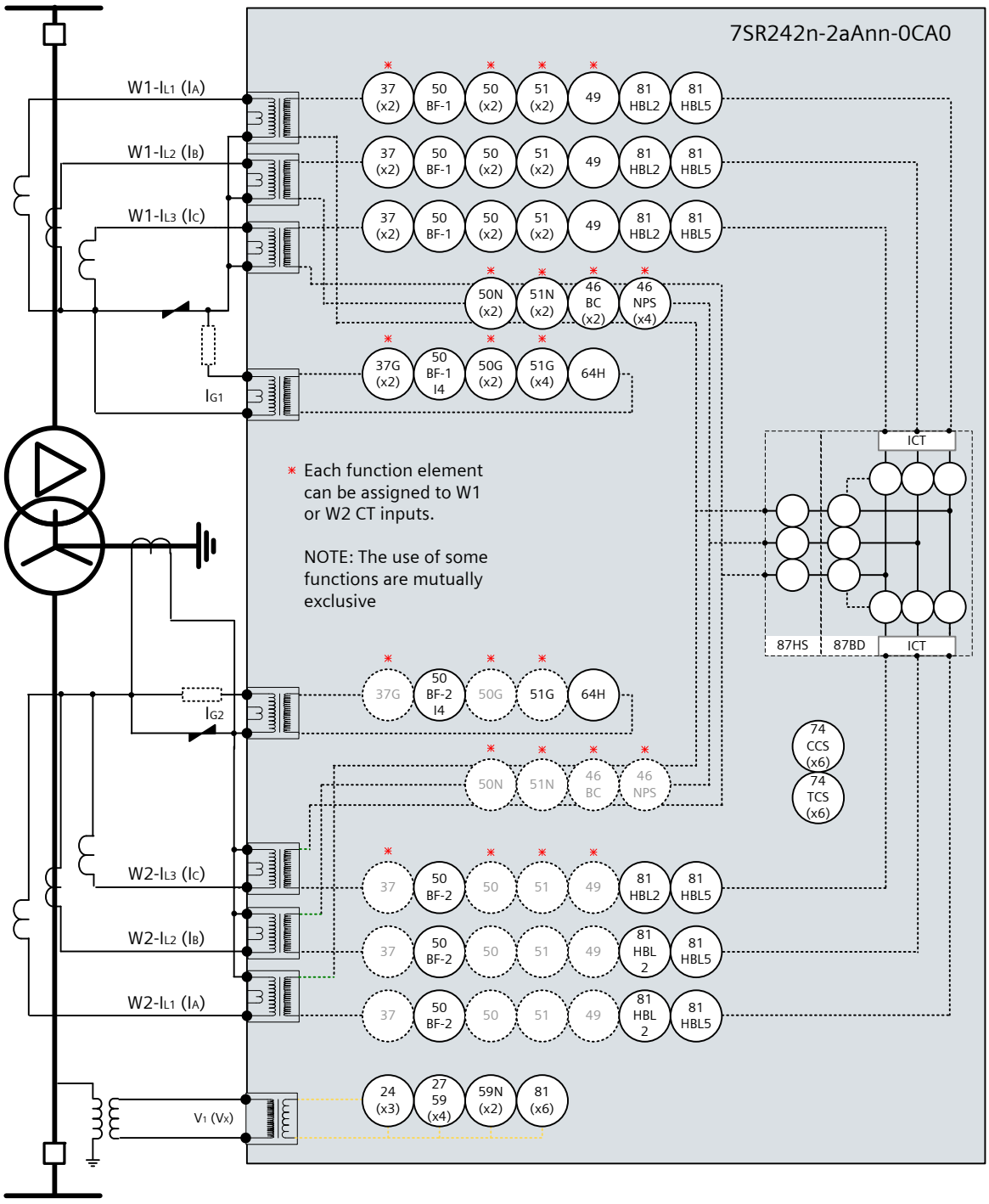

Figure 1-3 Functional Diagram: 7SR242n-2aAnn-0CA0 Relay

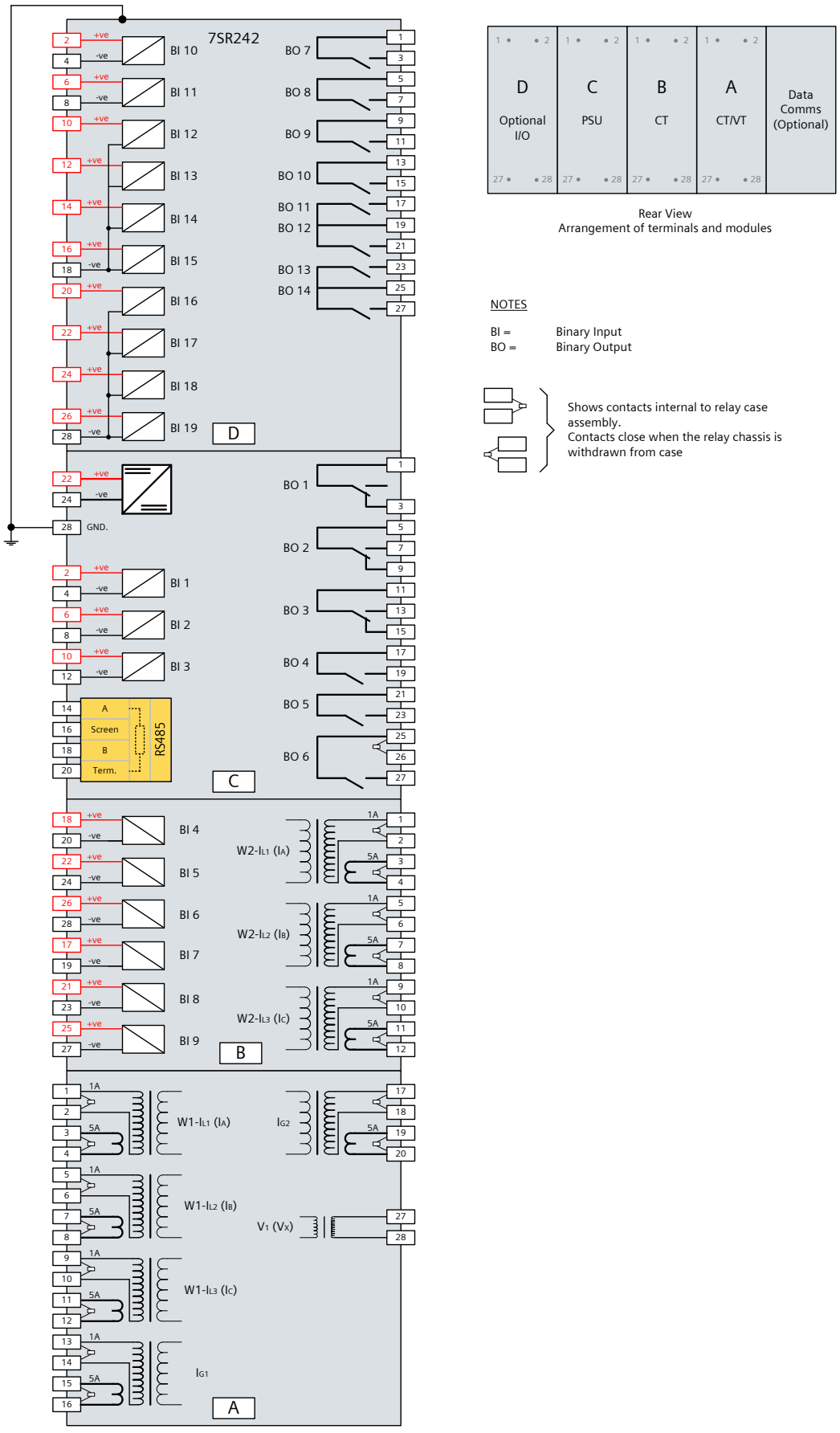

Figure 1-4 Connection Diagram: 7SR242 Relay

Section 2: Hardware Description

2.1 General

The structure of the relay is based upon the Multi-function hardware platform. The relays are supplied in either size E8 or size E10 cases (where 1 x E = width of approx. 26mm). The hardware design provides commonality between products and components across the Multi-function range of relays.

Table 2-1 Summary of 7SR24 Relay Configurations

Relay	Current Inputs	Voltage Inputs	Binary Inputs	Output Relays	LEDs	Case
7SR2422	8	1	9	6	16	E8
7SR2423	8	1	19	14	24	E10

Relays are assembled from the following modules:

1) Front Fascia with three fixed function LEDs and ordering options of configurable LEDs.
2) Processor module
3) Analogue Input module 'A': 3 x Current + 6 x Binary Inputs
4) Analogue Input module 'B': 5 x Current + 1 x Voltage.
5) Power Supply and basic Binary Input (BI) and Binary Output (BO).
6) Optional Binary Input/Output Module
7) Optional data comms module

2.2 Case

The relays are housed in cases designed to fit directly into standard panel racks. The two case options have widths of 208mm (E8) and 260 mm (E10), both have a height of 177 mm (4U). The required panel depth (with wiring clearance) is 242 mm. An additional 75 mm depth clearance should be allowed to accommodate the bending radius of fibre optic data communications cables if fitted.

The complete relay assembly is withdrawable from the front of the case. Contacts in the case ensure that the CT circuits remain short-circuited when the relay is removed.

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

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

2.3 Front Cover

With the transparent front cover in place the user 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. The only 'action' that is permitted is to reset the Fault Data display, latched binary outputs and LEDs by using the **TEST/RESET** ▸ button.

The front cover is used to secure the relay assembly in the case.

2.4 Power Supply Unit (PSU)

The relay PSU can be directly connected to any substation dc system rated from 30V dc to 220V dc.

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 then on.

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 2-1 7SR24 with 3 + 16 LEDs in E8 Case

NOTE: Pushbuttons on cover not shown

The fascia is an integral part of the relay. Handles are located at each side of the element to allow it to be withdrawn from the relay case.

Relay Information

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

1) Product name and order code.

2) Nominal current rating, rated frequency, voltage rating, auxiliary dc supply rating, binary input supply rating, configuration and serial number.

3) Blank label for user defined information.

A ‘template’ is available within the ‘Reydisp’ program to allow users to create and print customised LED label inserts.

The warning and information labels on the relay fascia provide the following information:

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 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. A setting within the “SYSTEM CONFIG” menu allows the timeout to be adjusted from 1 to 60 minutes and “Off” (backlight permanently on). After an hour the display is completely de-activated. 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.

‘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.

‘PICKUP’ LED

This yellow LED is illuminated to indicate that a user selectable function(s) has picked up. The LED will self reset after the initiating condition has been removed.

Functions are assigned to the PICKUP LED in the OUTPUT CONFIG>PICKUP CONFIG menu.

‘TRIP’ LED

This red LED is steadily illuminated to indicate that a user selectable function has operated to trip the circuit breaker. Functions are assigned to the ‘Trip’ LED using the OUTPUT CONFIG>Trip Contacts setting.

Operation of the LED is latched and 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).

Indication LEDs

Relays have either 8 or 16 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. . Each LED can be assigned two different colours dependent upon whether a Start/Pickup or Operate condition

initiates operation. The LED illumination colour is assigned in the OUTPUT CONFIG>LED CONFIG menu for both Pickup and Operate initiation.

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 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.

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, BO and function keys can be accessed and set by the user using these keys. Alternatively configuration/settings files can be loaded into the relay using 'ReyDisp'.

2.6 Current Inputs

In total eight current inputs are provided on the Analogue Input modules. Terminals are available for both 1A and 5A inputs. CT ratios are input by the user in the CT/VT CONFIG menu.

Current is sampled at 1600Hz for 50Hz systems and 1920Hz for 60Hz systems (32 samples per cycle).

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

2.7 Voltage Input

An optional voltage input is provided on the Analogue Input module 'A'.

VT ratios are input by the user in the CT/VT CONFIG menu.

Voltage is sampled at 1600Hz for 50Hz systems and 1920Hz for 60Hz systems (32 samples per cycle).

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

2.8 Binary inputs

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

Relays are fitted with 9 or 19 binary inputs (BI). The user can assign any binary input to any of the available functions (INPUT CONFIG > INPUT MATRIX).

The Power Supply module includes the relay basic I/O. The module includes 3 x BI.

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 d.c. is applied. Inversion occurs before the PU & DO time delay, see fig. 2.8-1.

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.

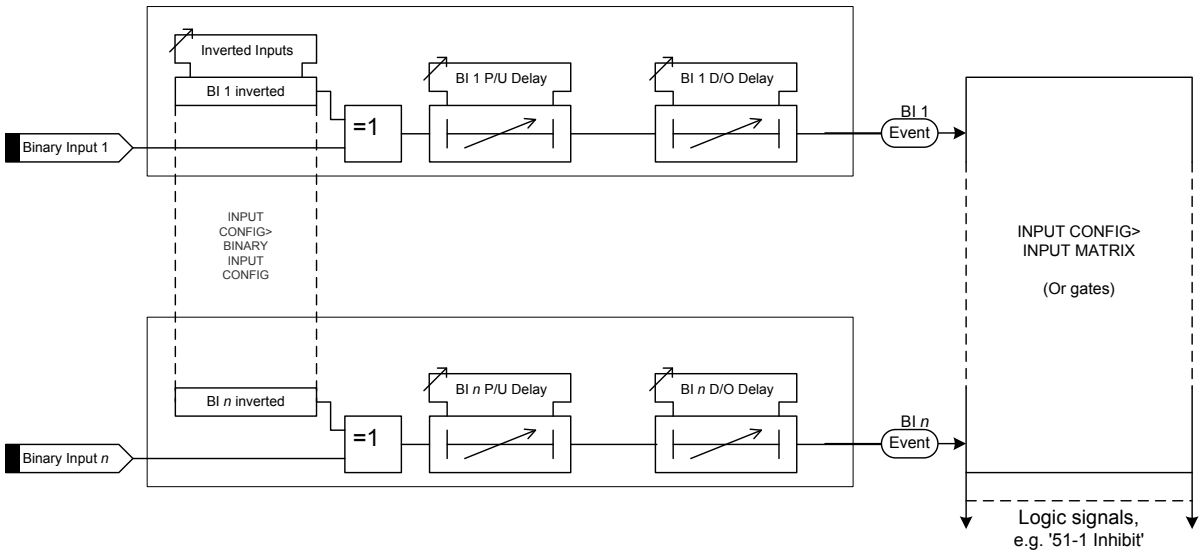

Figure 2-2 Binary Input Logic

2.9 Binary outputs (Output Relays)

Relays are fitted with 6 or 14 binary outputs. All outputs are fully user configurable and can be programmed to operate from any or all of the available functions.

The Power Supply module includes the relay basic I/O. The module includes six binary outputs each fitted with 1 contact – providing in total 1 x normally closed (NC), 2 x change-over (CO) and 3 x normally open (NO) contacts.

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'. Where an output is programmed to be 'hand reset' and 'pulsed' then the output will be 'hand reset' only.

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

CB1 and CB2 'Trip Contacts' are assigned in the OUTPUT CONFIG>BINARY OUTPUT CONFIG menu. Operation of a 'Trip Contact' will actuate the 'Trip Alert' screen where enabled and will initiate both fault record storage and CB Fail protection where enabled.

When the relay is withdrawn from the case all normally closed contacts will be open circuited. This should be considered in the design of the control and protection circuitry.

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

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.

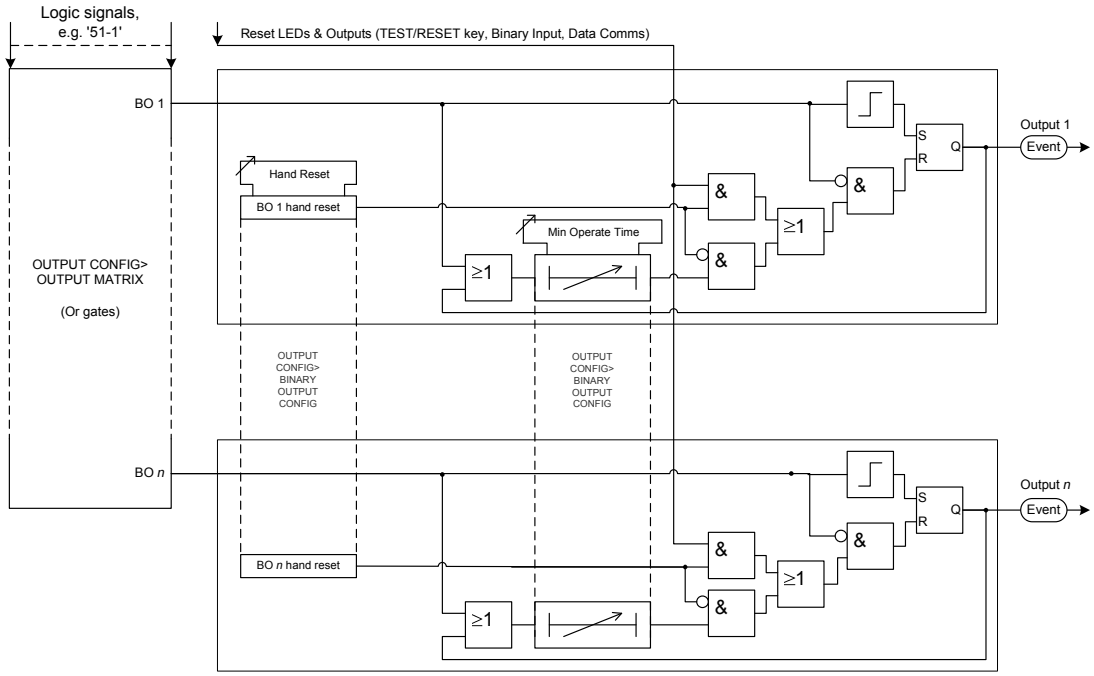

Figure 2-3 Binary Output Logic

2.10 Virtual Input/Outputs

The relays have 16 virtual input/outputs, these are internal logic states. Virtual I/O is assigned in the same way as physical Binary Inputs and Binary Outputs. Virtual I/O is mapped from within the INPUT CONFIG > INPUT MATRIX and OUTPUT CONFIG > OUTPUT MATRIX menus.

The status of virtual I/O is not stored during power loss.

2.11 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, also an event will be generated and stored. 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.

2.11.1 Protection Healthy/Defective

A normally open contact can be used to signal protection healthy. When the relay has DC supply and it has successfully passed its self-checking procedure then the Protection Healthy contacts are made.

A normally closed contact is used to signal protection defective. When the DC supply is not applied to the relay or a problem is detected within the relay then this output is de-energised and the normally closed contacts make to provide an external alarm.

An alarm can be provided if the relay is withdrawn from the case. A contact is provided in the case at positions 25-26 of the PSU module, this contact closes when the relay is withdrawn.

Section 3: Protection Functions

3.1 Current Protection: Differential Protection

Comprises both biased differential and high-set differential elements.

The fundamental frequency current is measured with the line CT inputs. These line currents are both multiplied and vector corrected before being applied to the current differential elements.

3.1.1 ICT

The ***Wn ICT Multiplier*** setting is applied to the line currents – the CT secondary currents. The multiplier is used to correct any CT ratio mismatch so that ideally nominal current (ICT_{OUT} = 1A) is applied to the biased differential algorithm.

The ***Wn ICT Connection*** setting applies the correct vector compensation to the current applied to the differential algorithm.

The nominal current ratio of the virtual interposing CT is 1:1. Note that where Yd settings are applied some current distributions will result in a √3 multiplying factor being applied. See 'Applications Guide'.

3.1.2 Overall Biased Differential (87BD)

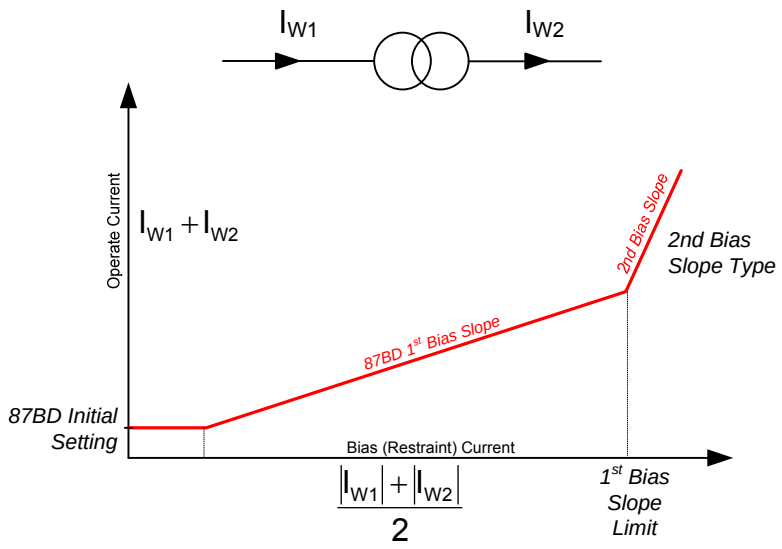

Figure 3-1 Biased Differential Characteristic

Figure 3.1-1 illustrates the biased differential characteristic. Within the relay the fundamental frequency RMS line currents are modified by the ***ICT Multiplier*** and ***ICT Connection*** settings (see 3.1.1) before being applied to the biased differential elements. The biased differential elements calculate the operate current for each phase from the vector sum of winding 1 and winding 2 currents i.e. $I_{OPERATE} = I_{W1} + I_{W2}$. The bias (or restraint) current is calculated from the total current of winding 1 and winding 2 currents i.e. $I_{RESTRAIN} = \frac{|I_{W1}| + |I_{W2}|}{2}$.

The ***87BD Initial*** setting defines the minimum differential current required to operate the relay.

The ***87BD 1st Bias Slope*** setting is used to ensure protection stability in the presence of steady state errors e.g. the effects of an on-load tap changer.

The ***87BD 1st Bias Slope Limit*** setting defines the border between the 1st and 2nd bias slopes.

87BD 2nd Bias Slope Type setting allows the user to select the preferred characteristic shape i.e. **Line** or **Curve**.

The ***87BD 2nd Bias Slope*** setting is applied when ***87BD 2nd Bias Slope Type*** **= Line.** This setting is used to modify the sensitivity of the differential algorithm at higher current levels.

The output of ***87BD Delay*** can be mapped to relay outputs.

Operation of the biased differential elements can be inhibited from:

Inhibit 87BD	A binary or virtual input.
87BD Inrush Action: **Inhibit**	Operation of the inrush current detector
87BD Overfluxing Action: **Inhibit**	Operation of the overfluxing detector

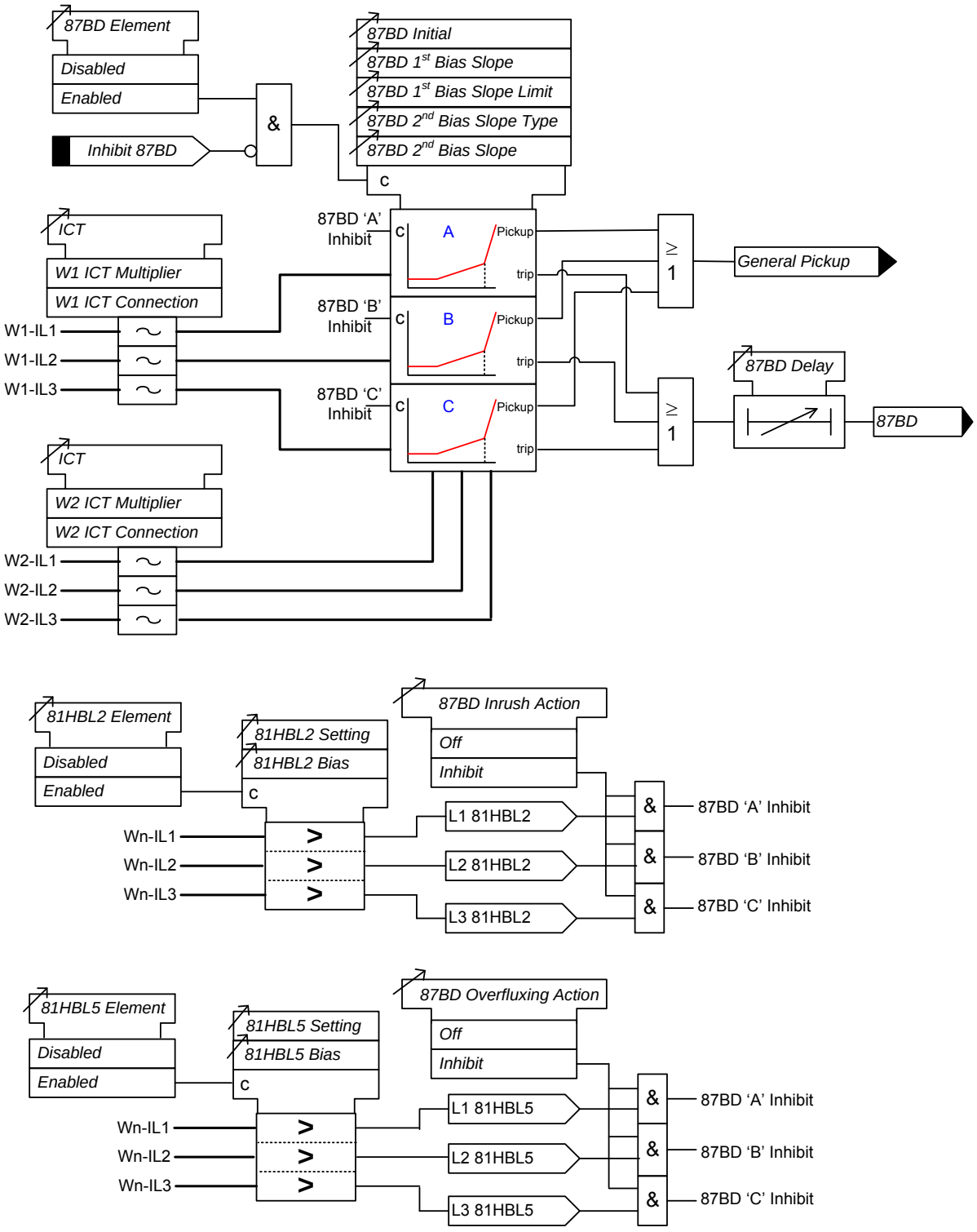

Figure 3-2 Functional Diagram for Biased Current Differential Protection

3.1.3 87HS

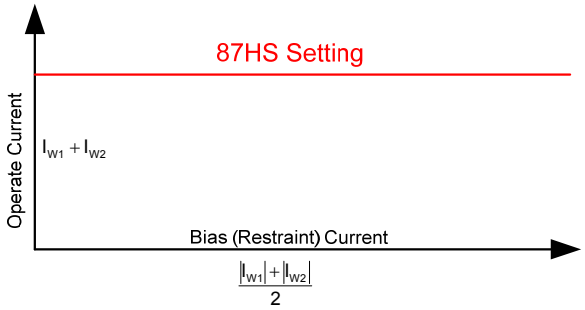

Figure 3-3 Differential Highset Characteristic

Figure 3.1-3 illustrates the differential highset characteristic. Within the relay the fundamental frequency RMS line currents are modified by the ***ICT Multiplier*** and ***ICT Connection*** settings (see 3.1.1) before being applied to the differential highset elements. The differential highset elements calculate the operate current for each phase from the vector sum of winding 1 and winding 2 currents i.e. $I_{OPERATE} = I_{W1} + I_{W2}$.

87HS Setting defines the differential current required to operate the element. The output of ***87HS Delay*** can be mapped to relay outputs.

Operation of the highset differential elements can be inhibited from:

Inhibit 87HS	A binary or virtual input.
87HS Inrush Action: **Inhibit**	Operation of the inrush current detector
87HS Overfluxing Action: **Inhibit**	Operation of the overfluxing detector

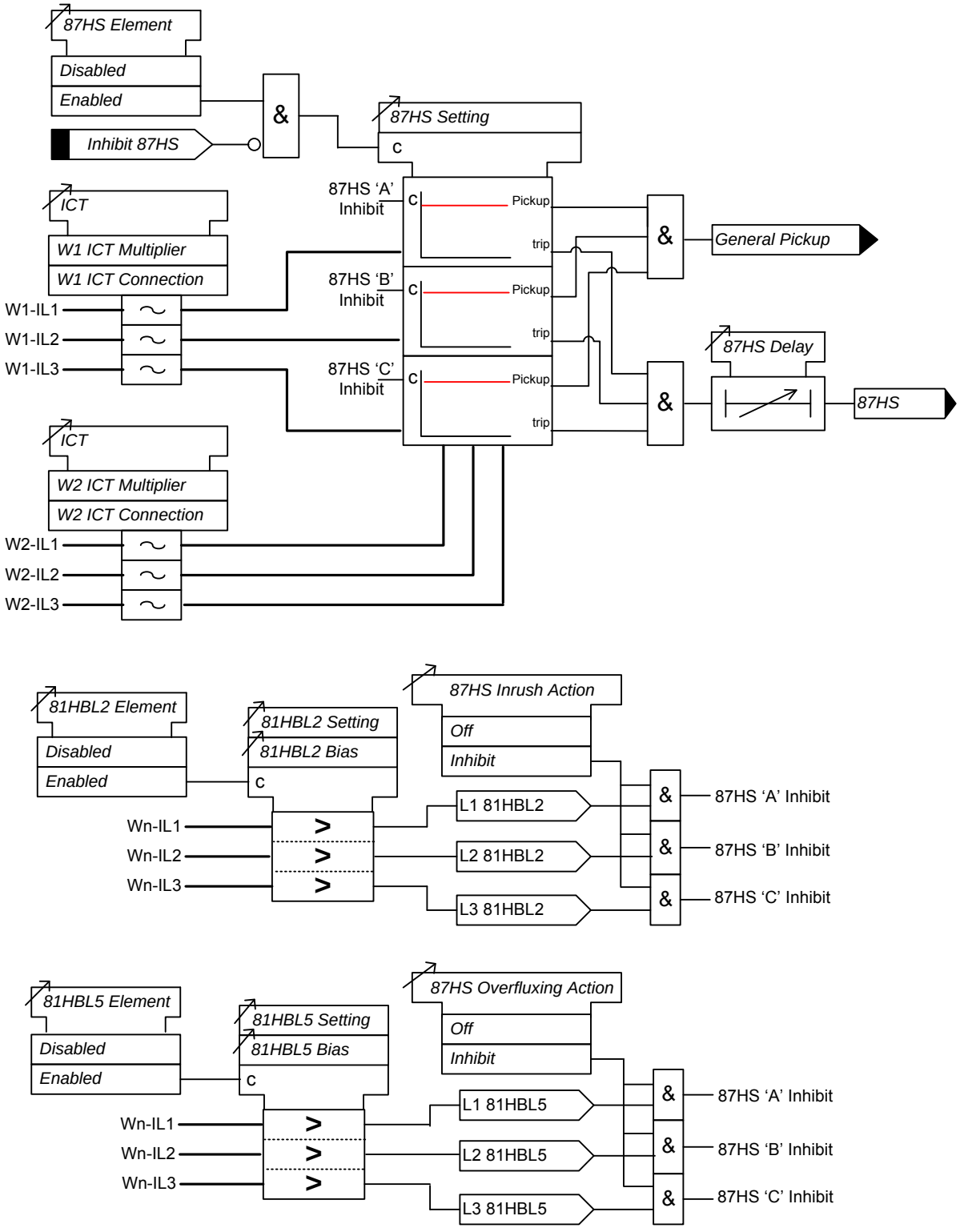

Figure 3-4 Logic Diagram: High Set Current Differential Protection

3.2 Current Protection: Phase Overcurrent (51, 50)

The optional phase overcurrent elements have a common setting to measure either fundamental frequency RMS or True RMS current:

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

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

3.2.1 Instantaneous Overcurrent Protection (50)

Optionally two instantaneous overcurrent elements are provided, each can be selected to either winding 1 or winding 2.

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

Operation of the instantaneous overcurrent elements can be inhibited from:

Inhibit 50-n	A binary or virtual input.
50-n Inrush Action: **Inhibit**	Operation of the inrush detector function.

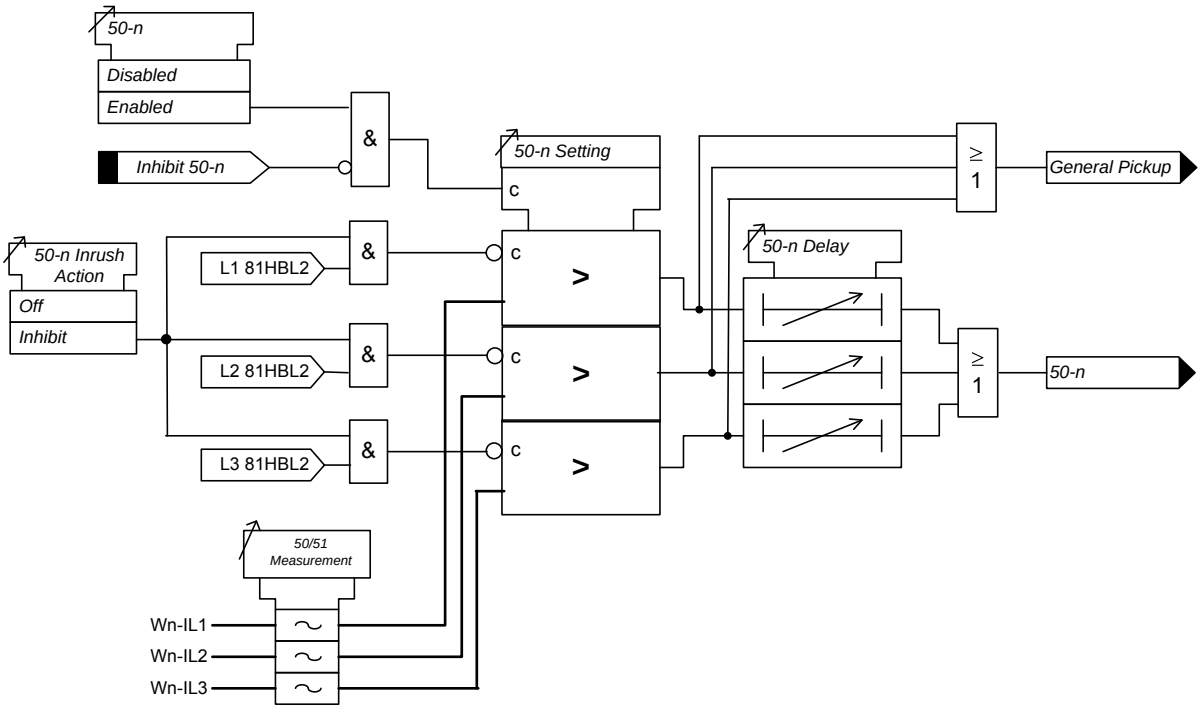

Figure 3-5 Logic Diagram: Instantaneous Over-current Element

3.2.2 Time Delayed Overcurrent Protection (51)

Optionally two time delayed overcurrent elements are provided, each can be selected to either winding 1 or winding 2.

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

A number of shaped characteristics are provided. An inverse definite minimum time (IDMT) characteristic is selected from IEC, ANSI or user defined curves using ***51-n Char***. A time multiplier is applied to the characteristic curves using the ***51-n Time Mult*** setting. Alternatively, a definite time lag delay (DTL) can be chosen using ***51-n Char***. When Delay (DTL) is selected the time multiplier is not applied and the ***51-n Delay (DTL)*** setting is used instead. The full list of operating curves is given in Chapter 2 – 'Settings, Configuration and Instruments Guide'. Operating curve characteristics are illustrated in Chapter 3 – 'Performance Specification'.

The ***51-n Reset*** setting can apply a **definite time delayed** reset**,** or when configured as an ANSI characteristic an **ANSI (DECAYING)** reset. If ANSI (DECAYING) reset is selected for an IEC characteristic, the reset will be instantaneous. The reset mode is significant where the characteristic has reset before issuing a trip output – see 'Applications Guide'.

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

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

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

Inhibit 51-n	A binary or virtual input.
51-n Inrush Action: **Inhibit**	Operation of the inrush detector function.

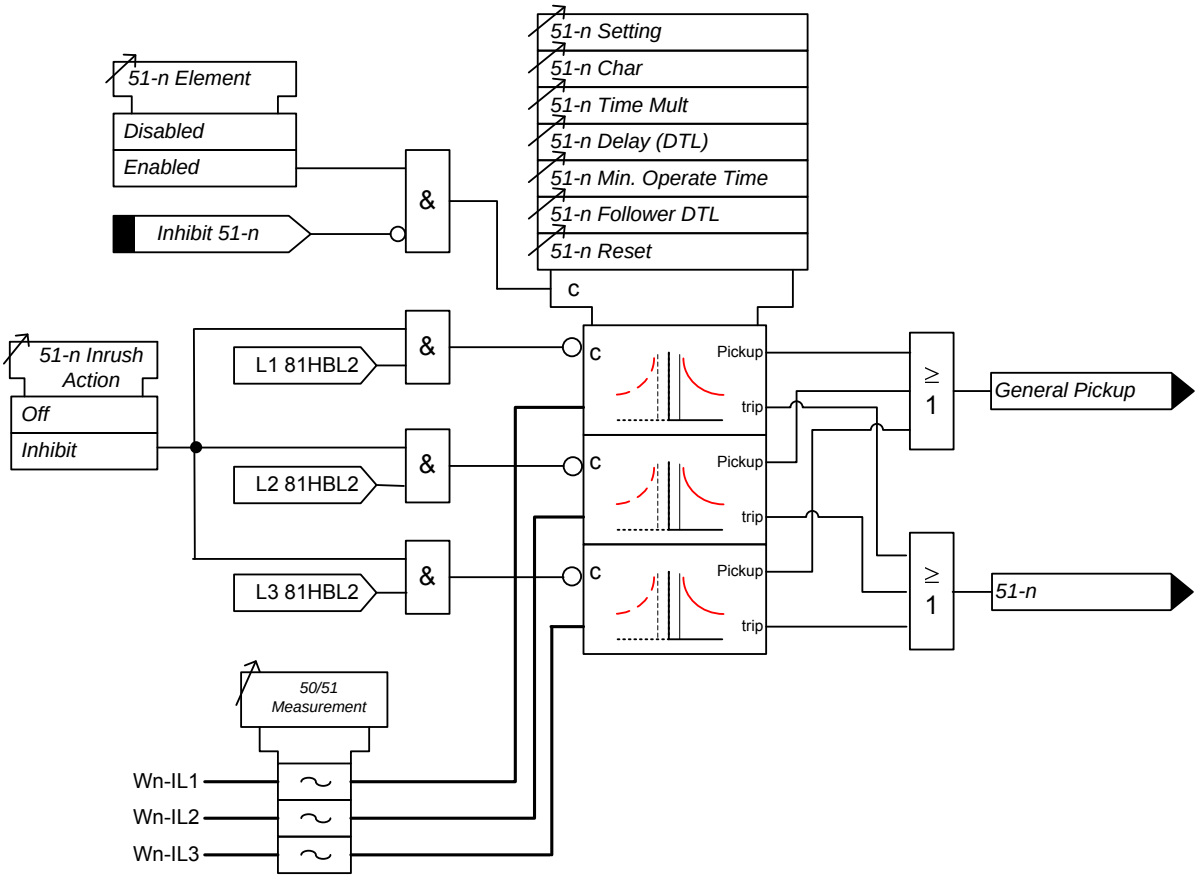

Figure 3-6 Logic Diagram: Time Delayed Overcurrent Element

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

The earth current is derived by calculating the sum of the measured line currents. These optional elements utilise RMS current values of the fundamental frequency (50 or 60Hz).

3.3.1 Instantaneous Derived Earth Fault Protection (50N)

Optionally two instantaneous derived earth fault elements are provided, each can be selected to either winding 1 or winding 2.

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

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

Inhibit 50N-nt	A binary or virtual input.
50N-n Inrush Action: **Inhibit**	Operation of the inrush detector function.

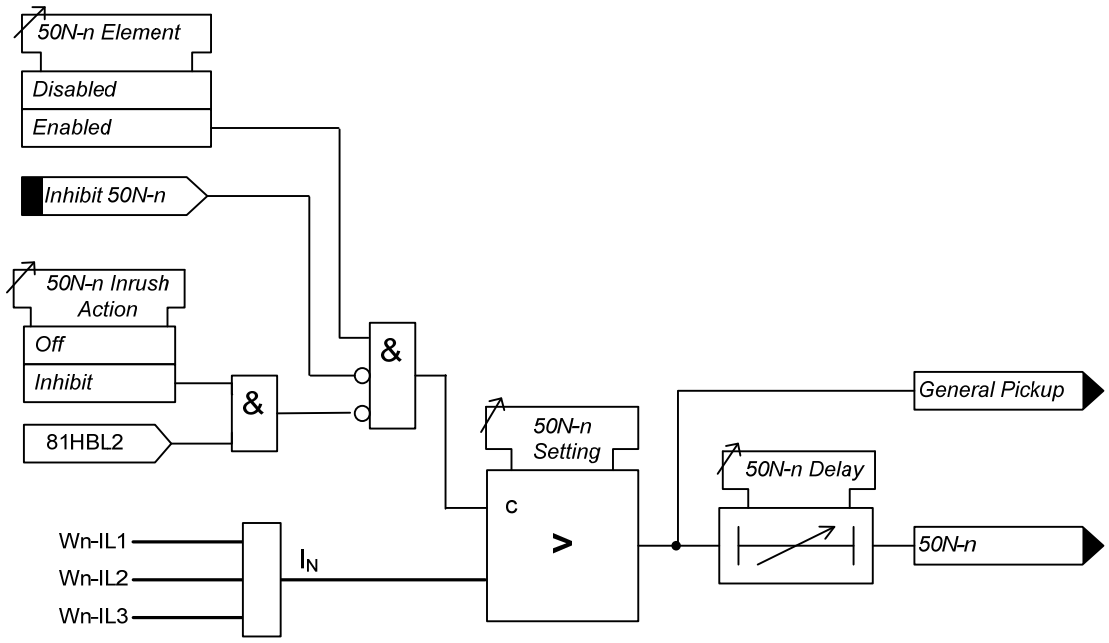

Figure 3-7 Logic Diagram: Instantaneous Derived Earth Fault Element

3.3.2 Time Delayed Derived Earth Fault Protection (51N)

Optionally two time delayed derived earth fault elements are provided, each can be selected to either winding 1 or winding 2.

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

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

The ***51N-n Reset*** setting can apply a **definite time delayed** or **ANSI (DECAYING)** reset. The reset mode is significant where the characteristic has reset before issuing a trip output – see 'Applications Guide'.

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

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

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

Inhibit 51N-n	A binary or virtual input.
51N-n Inrush Action: **Inhibit**	Operation of the inrush detector function.

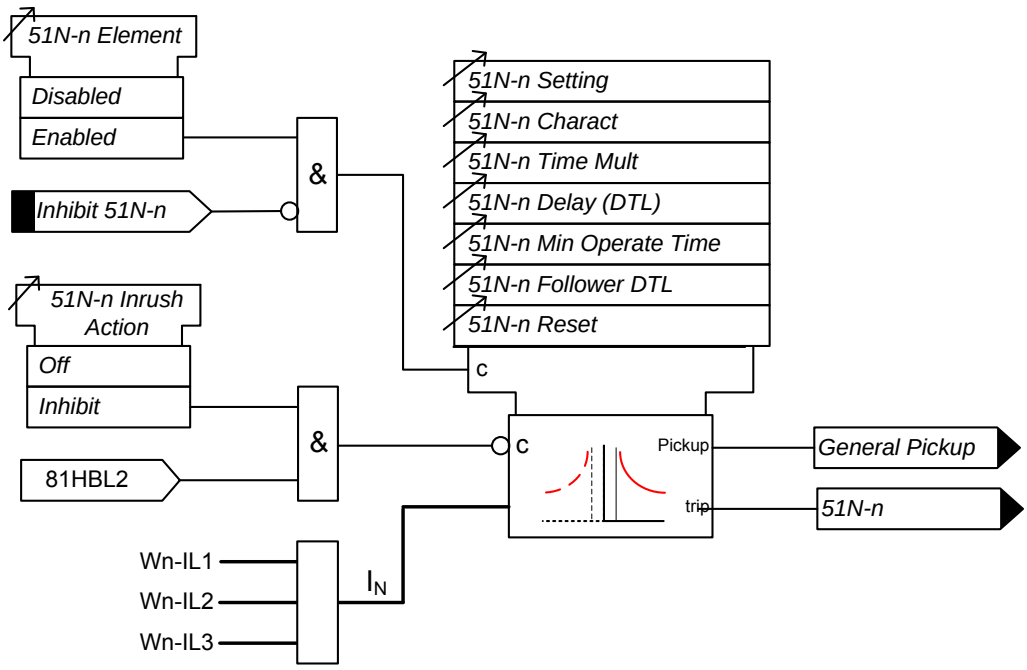

Figure 3-8 Logic Diagram: Derived Time Delayed Earth Fault Protection

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

The earth current is measured directly via dedicated current analogue inputs. These optional elements utilise either RMS or Fundamental current values as defined by the ***51G/50G Measurement*** setting (MEASURED E/F menu).

3.4.1 Instantaneous Measured Earth Fault Protection (50G)

Optionally two instantaneous measured earth fault elements are provided, each can be selected to either winding 1 or winding 2.

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

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

Inhibit 50G-n	A binary or virtual input.
50G-n Inrush Action: **Inhibit**	Operation of the inrush detector function.

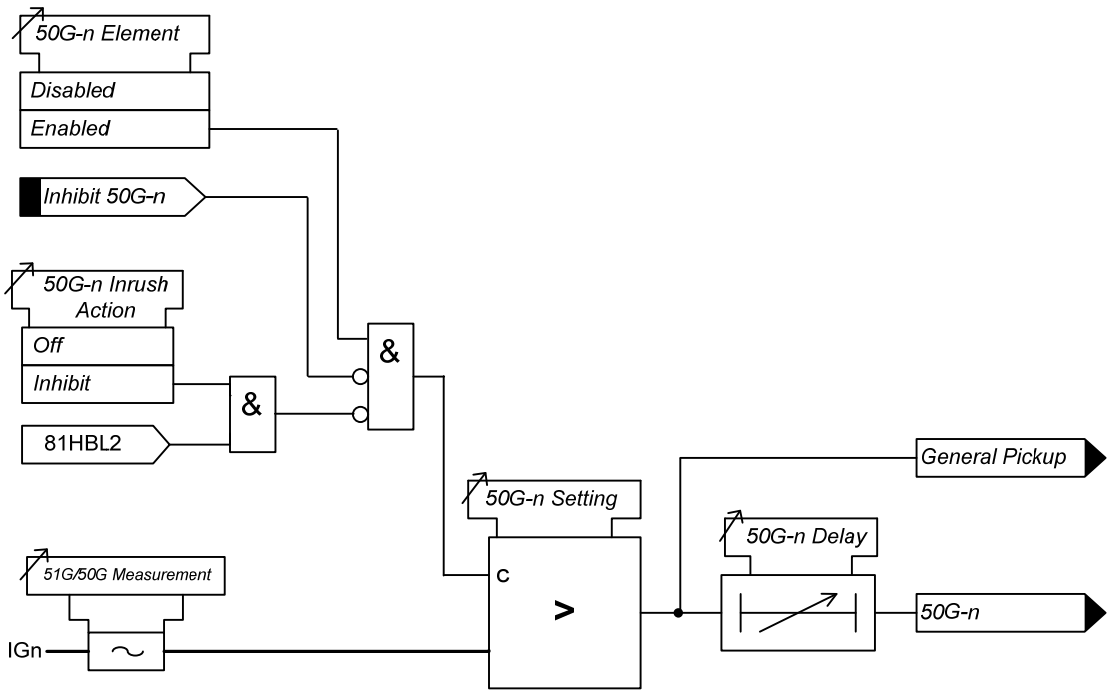

Figure 3-9 Logic Diagram: Measured Instantaneous Earth-fault Element

3.4.2 Time Delayed Measured Earth Fault Protection (51G)

Optionally two time delayed measured earth fault elements are provided, each can be selected to either winding 1 or winding 2.

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

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

The ***51G-n Reset*** setting can apply a **definite time delayed** or **ANSI (DECAYING)** reset. The reset mode is significant where the characteristic has reset before issuing a trip output – see 'Applications Guide'.

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

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

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

Inhibit 51G-n	A binary or virtual input.
51G-n Inrush Action: **Inhibit**	Operation of the inrush detector function.

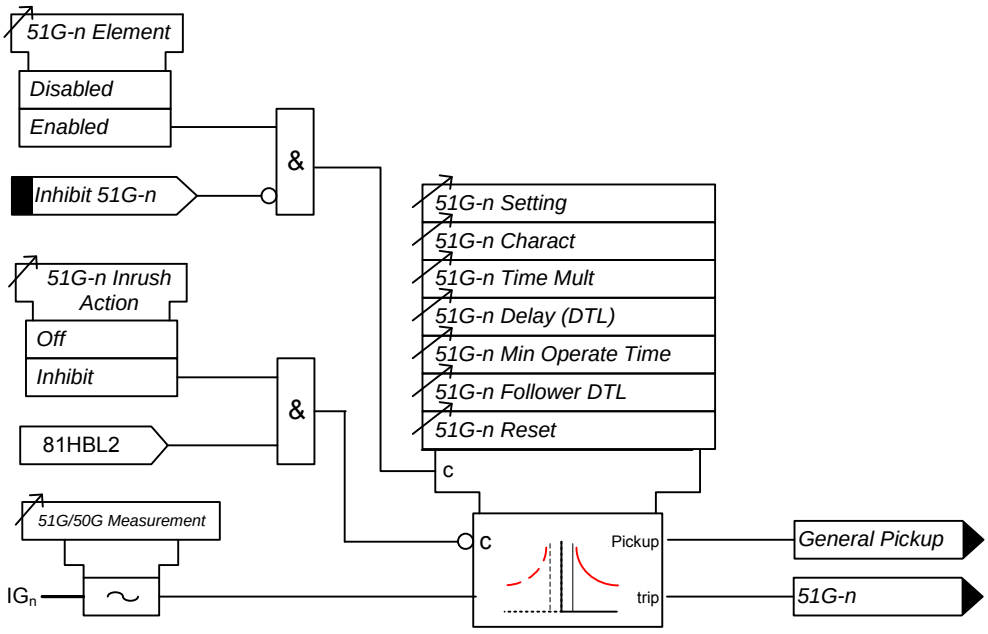

Figure 3-10 Logic Diagram: Time Delayed Measured Earth Fault Element (51G)

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

Two high impedance restricted earth fault elements are provided, one for each transformer winding

The relay utilises fundamental current measurement values for this function.

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

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

An external series stabilising resistor and a parallel connected voltage limiting non-linear resistor are used with this function. See 'Applications Guide' for advice in specifying suitable component values.

Operation of the high impedance element can be inhibited from:

Inhibit 64H A binary or virtual input.

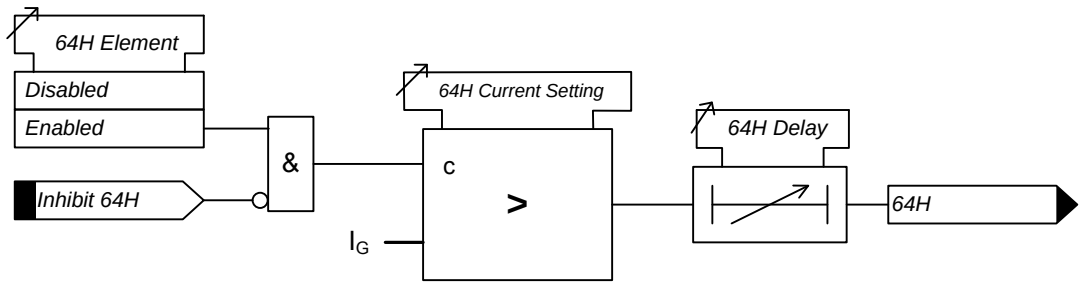

Figure 3-11 Logic Diagram: High Impedance REF (64H)

3.6 Open Circuit (46BC)

Optionally two open circuit elements are provided, each can be selected to either winding 1 or winding 2.

The element calculates the ratio of NPS to PPS currents. Where the NPS:PPS current ratio is above ***46BC Setting*** an output is given after the ***46BC Delay***.

The Open Circuit function can be inhibited from

Inhibit 46BC A binary or virtual input .

Gn 46BC-n U/I Guarded Operation of the undercurrent guard function.

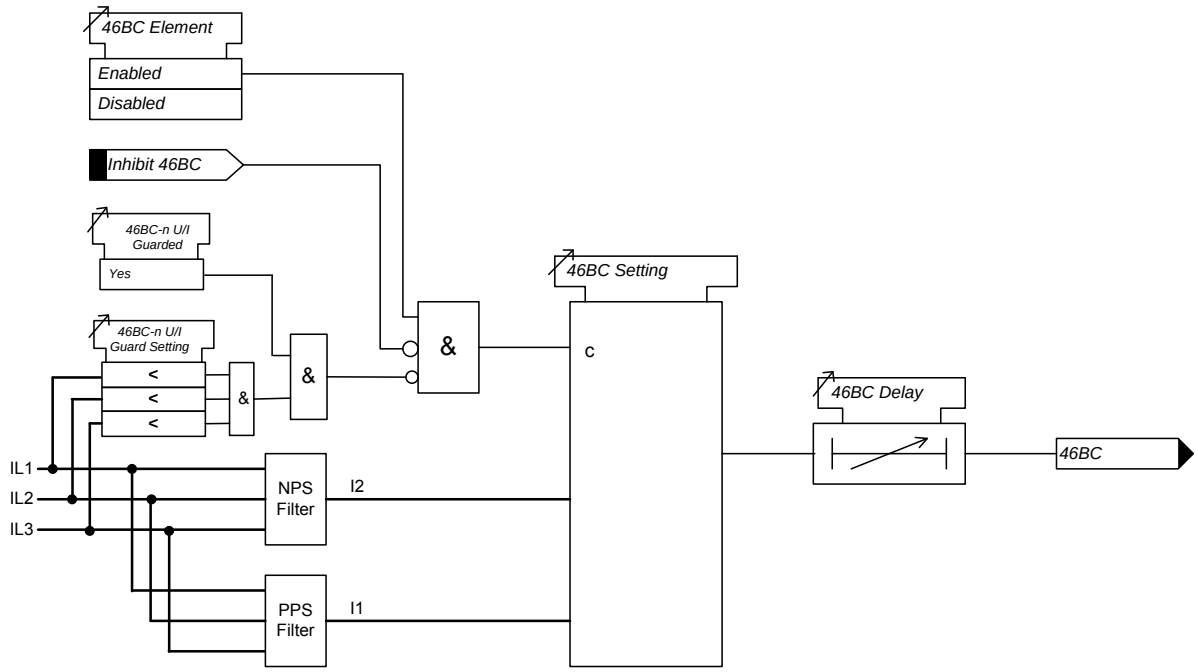

Figure 3-12 Logic Diagram: Open Circuit Function (46BC)

3.7 Current Protection: Negative Phase Sequence Overcurrent (46NPS)

Optionally four NPS current elements are provided – 2 x 46IT and 2 x 46DT. Each element can be selected to either winding 1 or winding 2.

The 46IT elements can be configured to be either definite time lag (DTL) or inverse definite minimum time (IDMT),

46IT Setting sets the pick-up current level for the element.

A number of shaped characteristics are provided. An inverse definite minimum time (IDMT) characteristic is selected from IEC and ANSI curves using ***46IT Char***. A time multiplier is applied to the characteristic curves using the ***46IT Time Mult*** setting. Alternatively, a definite time lag delay (DTL) can be chosen using ***46ITChar***. When Delay (DTL) is selected the time multiplier is not applied and the ***46IT Delay (DTL)*** setting is used instead.

The ***46IT Reset*** setting can apply a, **definite time delayed** or **ANSI (DECAYING)** reset.

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

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

Inhibit 46IT	A binary or virtual input.
Inhibit 46DT	A binary or virtual input.

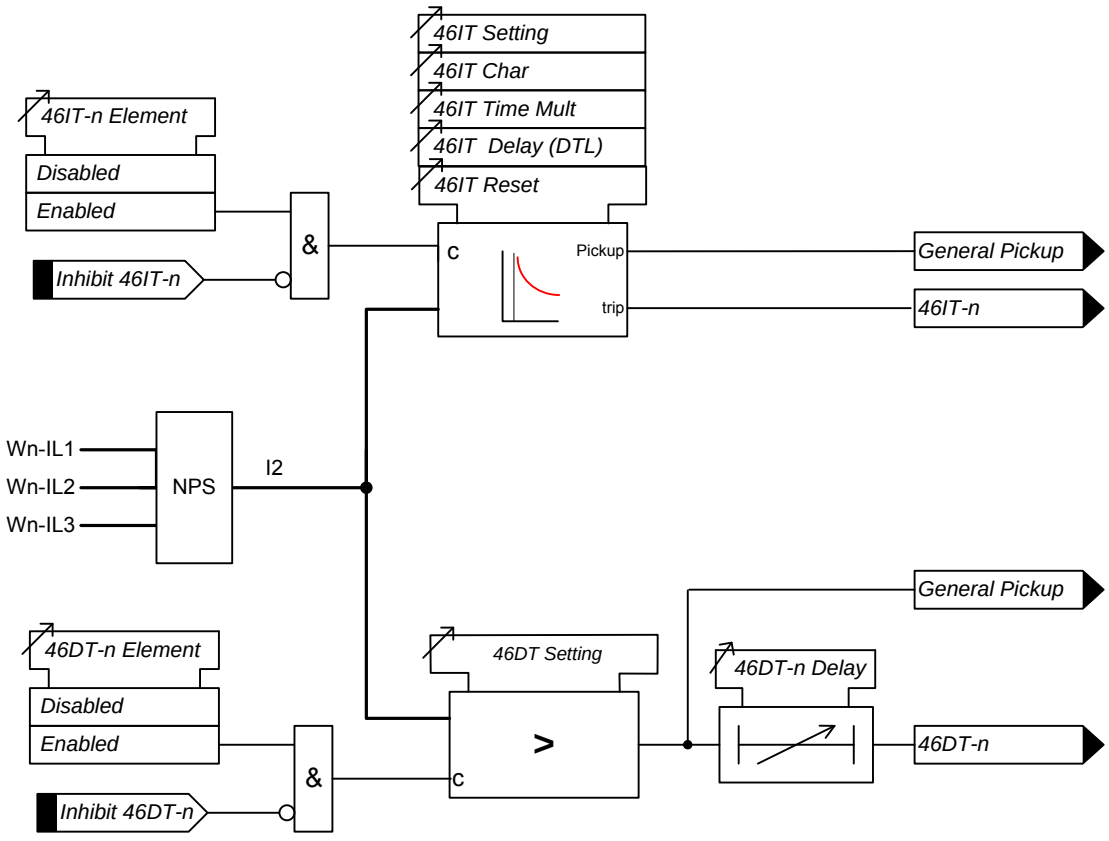

Figure 3-13 Logic Diagram: Negative Phase Sequence Overcurrent (46NPS)

3.8 Current Protection: Under-Current (37, 37G)

Optionally two under-current elements are provided for both line and measured earth current, each can be selected to either winding 1 or winding 2.

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

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

Inhibit 37-n	A binary or virtual input.
Gn 37-n U/I Guarded	Operation of the undercurrent guard function.
Inhibit 37G-n	A binary or virtual input.

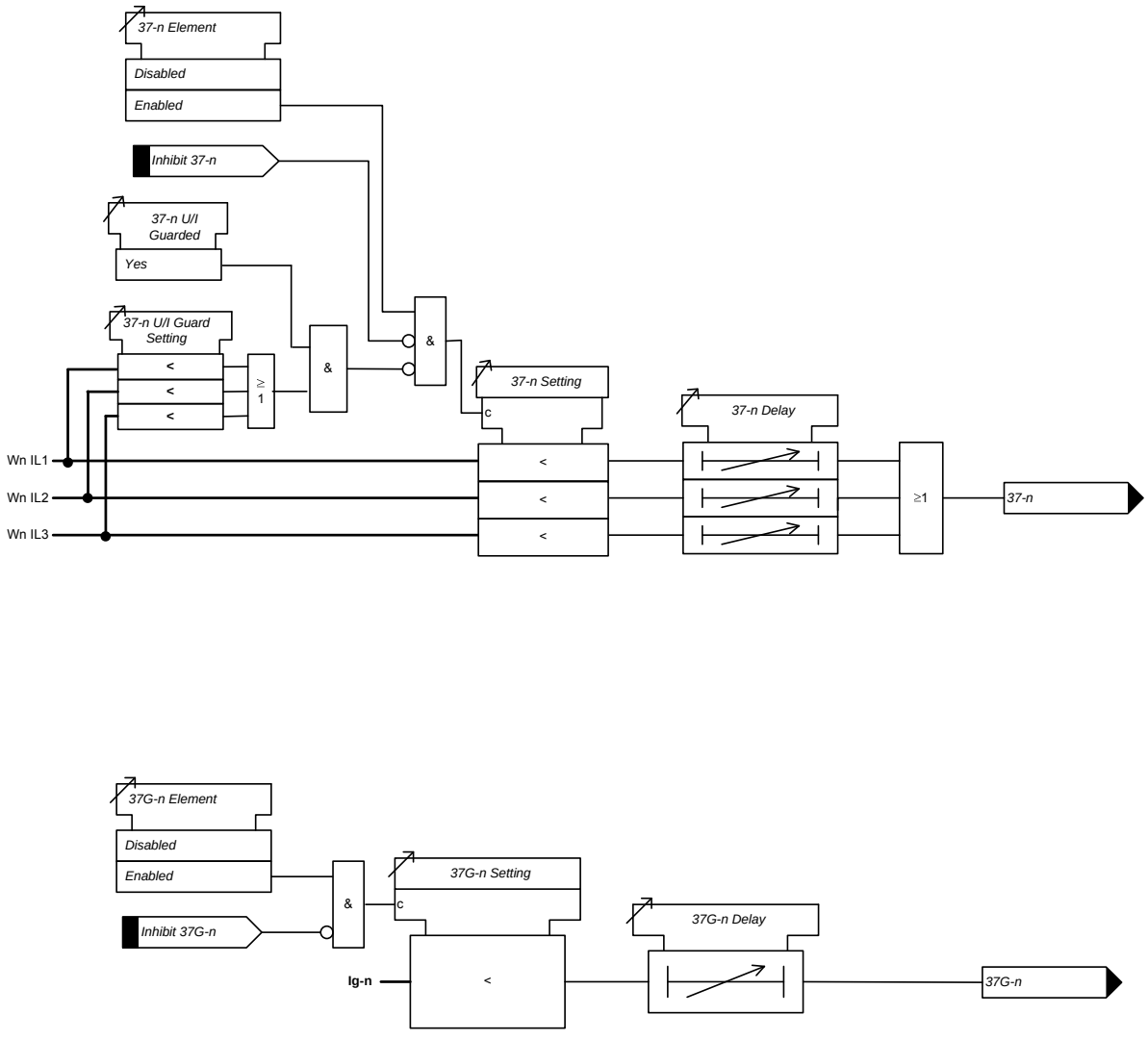

Figure 3-14 Logic Diagram: Undercurrent Detector (37, 37G)

3.9 Current Protection: Thermal Overload (49)

Optionally a phase segregated thermal overload element is provided, this can be selected to either winding 1 or winding 2. The thermal state is calculated using the measured True RMS current.

Should the current rise above the ***49 Overload Setting*** for a defined time an output signal will be initiated.

Operate Time (t):-

$$t = \tau \times \ln\left\{\frac{I^2 - I_P^2}{I^2 - (k \times I_B)^2}\right\}$$

Where

T = Time in minutes

τ = ***49 Time Constant*** setting (minutes)

In = Log Natural

I = measured current

I_P = Previous steady state current level

k = Constant

I_B = Basic current, typically the same as In

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

Additionally, an alarm can be given if the thermal state of the system exceeds a specified percentage of the protected equipment's thermal capacity ***49 Capacity Alarm*** setting.

For the heating curve:

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

Where: θ = thermal state at time t

I = measured thermal current

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

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

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

Where: θ_F = final thermal state before disconnection of device

49 Overload Setting I_θ is expressed as a multiple of the relay nominal current and is equivalent to the factor $k.I_B$ as defined in the IEC255-8 thermal operating characteristics. It is the value of current above which 100% of thermal capacity will be reached after a period of time and it is therefore normally set slightly above the full load current of the protected device.

The thermal state may be reset from the fascia or externally via a binary input.

Thermal overload protection can be inhibited from:

Inhibit 49 A binary or virtual input.

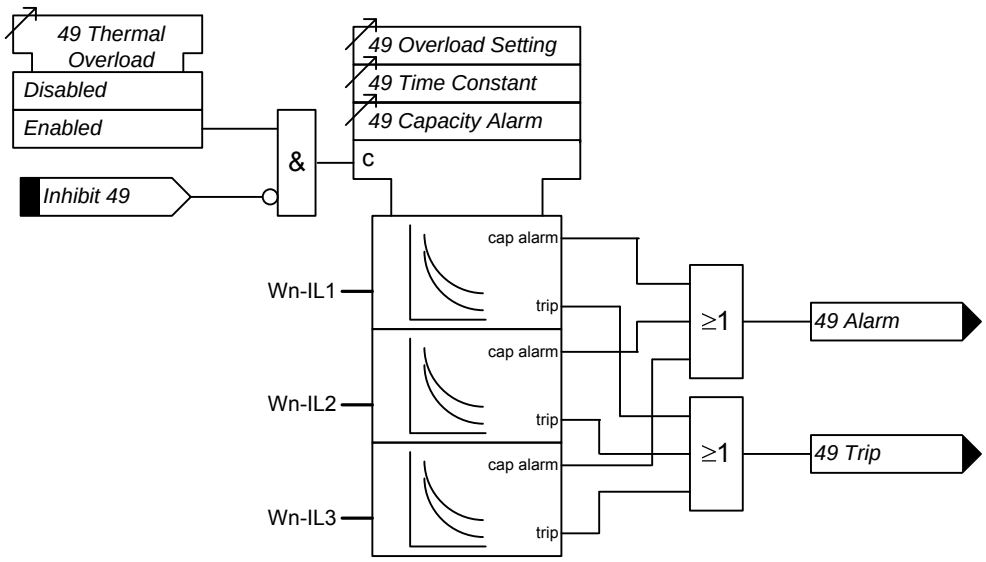

Figure 3-15 Logic Diagram: Thermal Overload Protection (49)

3.10 Voltage Protection: Over Fluxing (24)

Optionally, three over fluxing elements are provided – 2 x 24DT and 1 x 24IT Char elements.

The 24DT Elements have a DTL characteristic. ***24DT Setting*** sets the pick-up level and ***24DT Delay*** the follower time delay. An output is given if the Volts/Hertz ratio is above setting for the duration of the delay. The ***24DT-n Hysteresis*** setting allows the user to vary the pick-up/drop-off ratio for the element.

The 24IT Element has a user definable shape.

24Xn Point Setting sets the over fluxing (V/f) level for up to 7 user definable points.

24Yn Point Setting sets the operate time for each of the defined points.

The ***24IT Reset*** setting can apply a, **definite time delayed** reset.

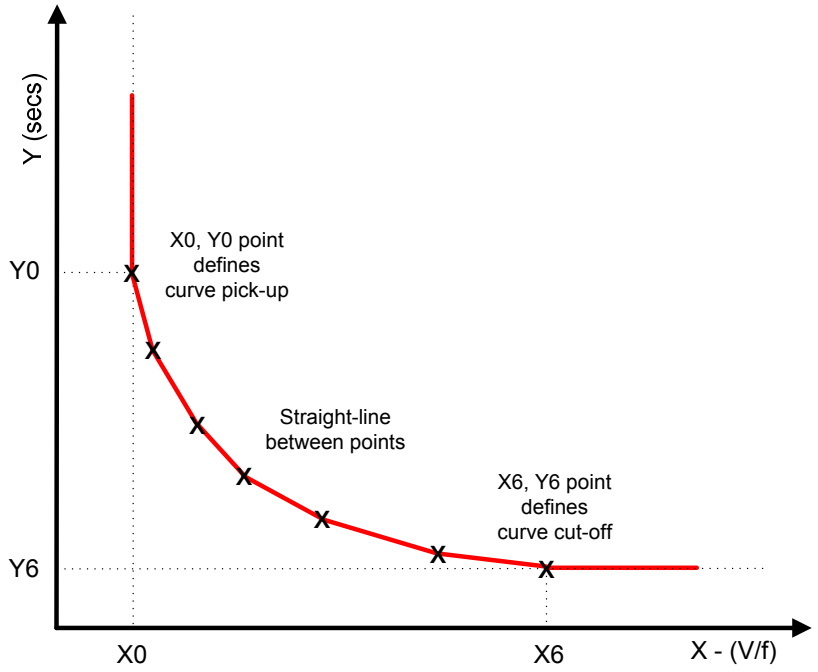

Figure 3-16 Inverse Over-fluxing Characteristic (24IT)

Operation of the over fluxing elements can be inhibited from:

Inhibit 24IT	A binary or virtual input.
Inhibit 24DT-n	A binary or virtual input.

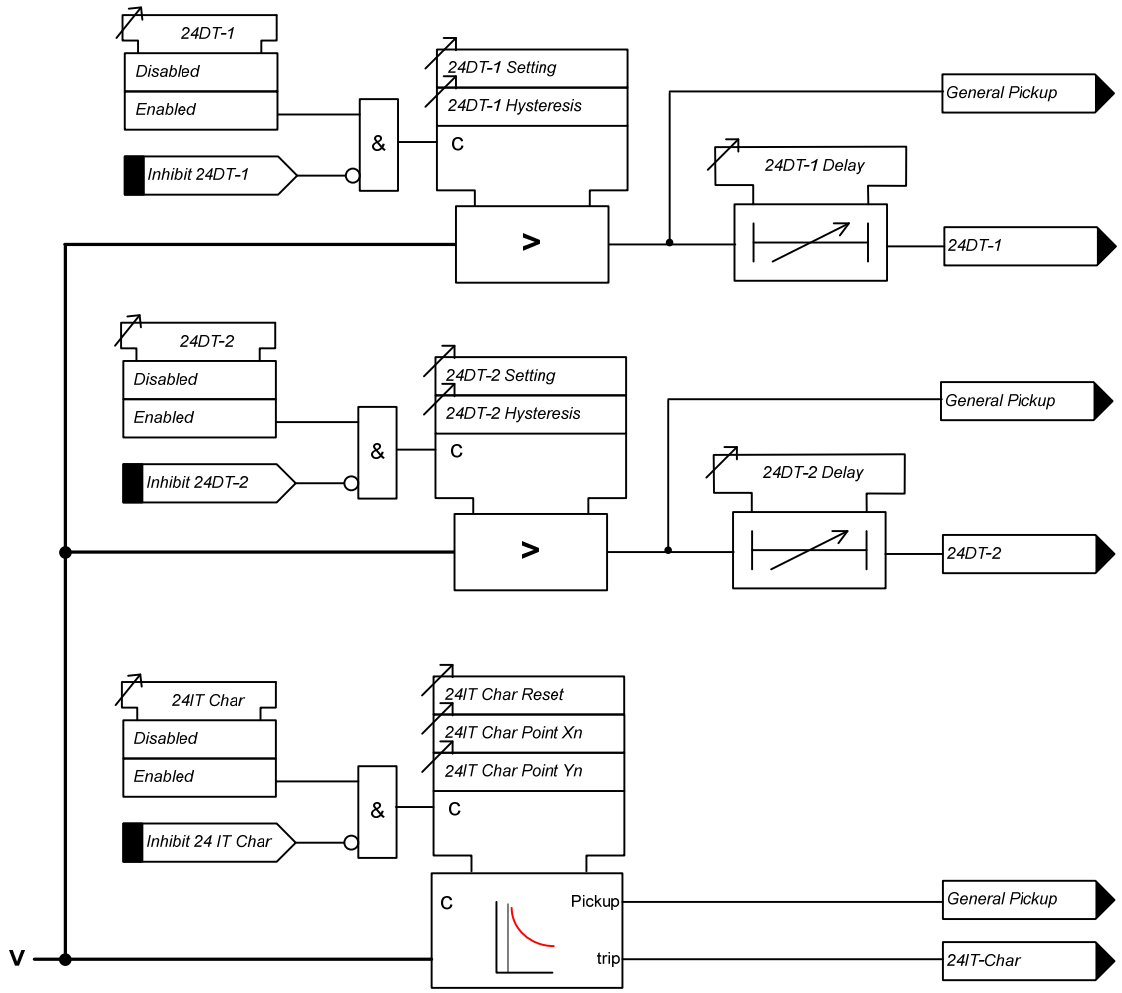

Figure 3-17 Logic Diagram: Overfluxing Elements (24)

3.11 Voltage Protection: Under/Over Voltage (27/59)

Optionally four under/over voltage elements are provided.

The relay utilises fundamental voltage measurement values for this function.

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.

Voltage elements are blocked if the measured voltage falls below the ***27/59 U/V Guard*** setting.

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 U/V Guarded	Under voltage guard element.

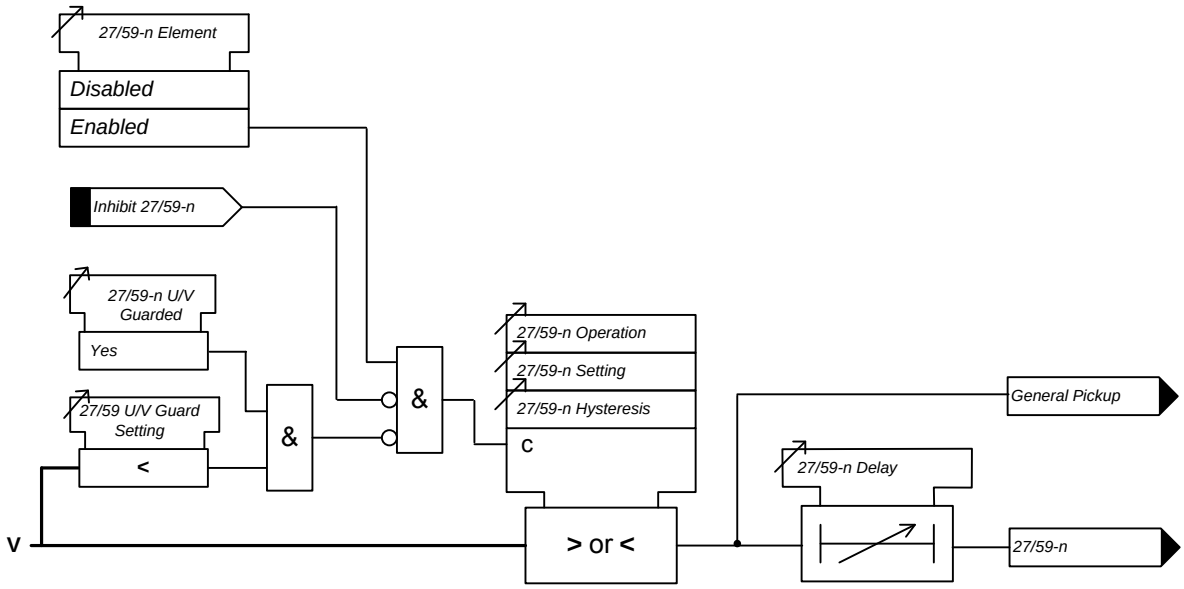

Figure 3-18 Logic Diagram: Under/Over Voltage Elements (27/59)

3.12 Voltage Protection: Neutral Overvoltage (59N)

Optionally two Neutral Overvoltage (or Neutral Voltage Displacement) elements are provided.

One of the elements can be configured to be either definite time lag (DTL) or inverse definite minimum time (IDMT),

59NIT Setting sets the pick-up voltage level ($3V_0$) 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):

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

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 second element has a DTL characteristic. ***59NDT Setting*** sets the pick-up voltage ($3V_0$) 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.

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

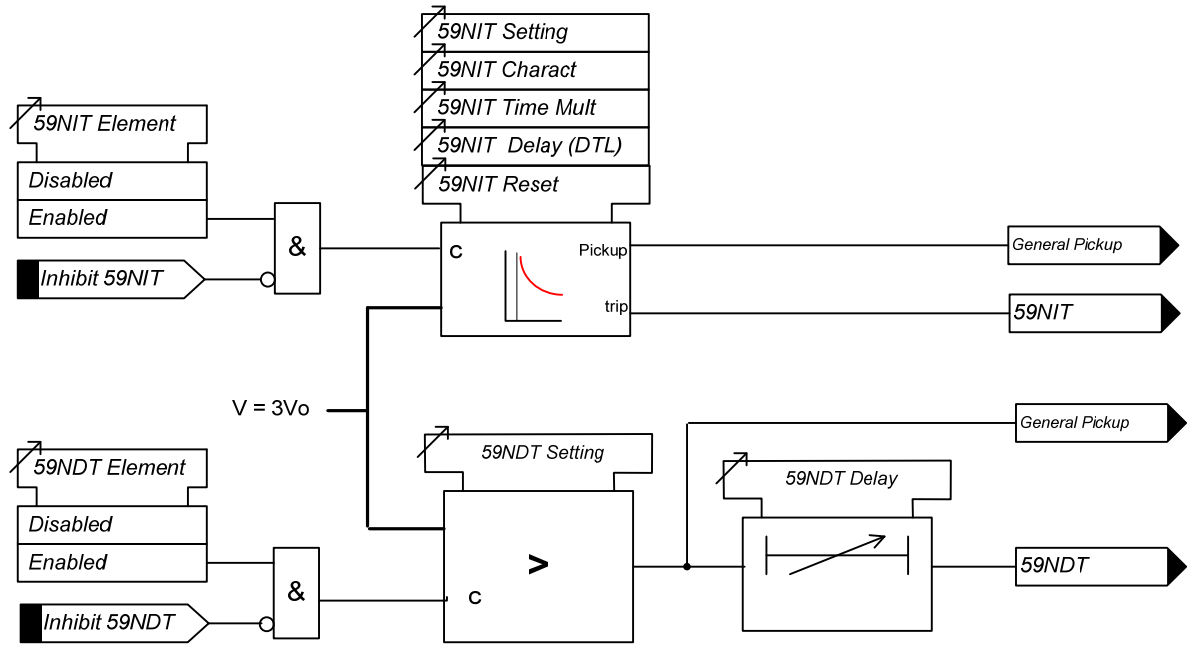

Figure 3-19 Logic Diagram: Neutral Overvoltage Element

3.13 Voltage Protection: Under/Over Frequency (81)

Optionally six under/over frequency elements are provided.

Frequency elements are blocked if the measured voltage falls 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 frequency 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.
81-n U/V Guarded	Under voltage guard element.

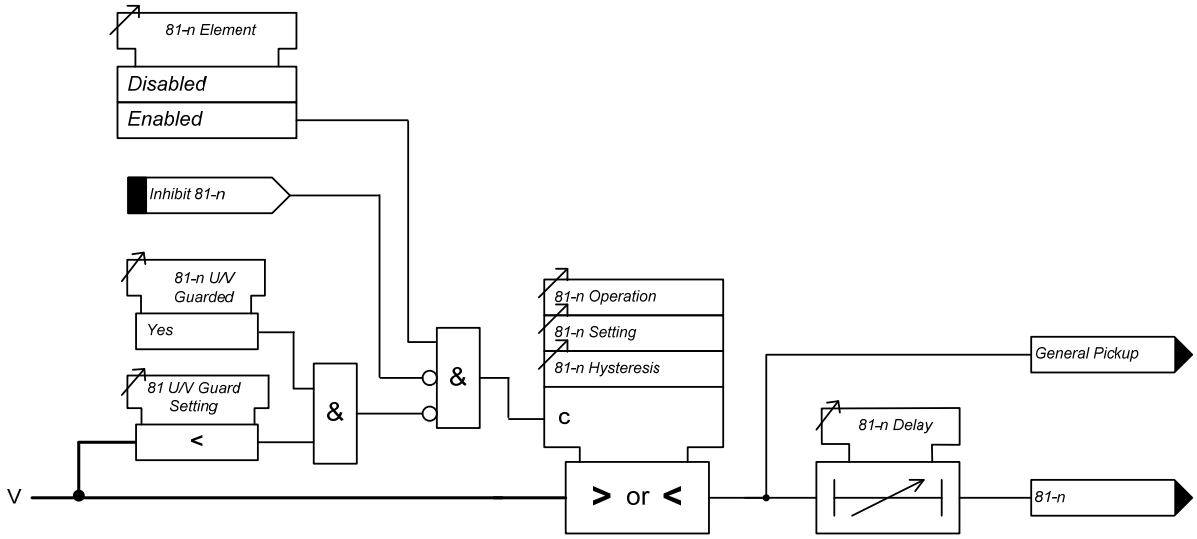

Figure 3-20 Logic Diagram: Under/Over Frequency Detector (81)

Section 4: Control & Logic Functions

4.1 Quick Logic

The 'Quick Logic' feature allows the user to input up to 16 logic equations (E1 to E16) in text format. Equations can be entered using Reydisp or at the relay fascia.

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

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

Example Showing Use of Nomenclature

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

Equation 1 = ((Binary Input 1 XOR Function Key 1) AND NOT Binary Output 2)

OR

LED 1

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

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.

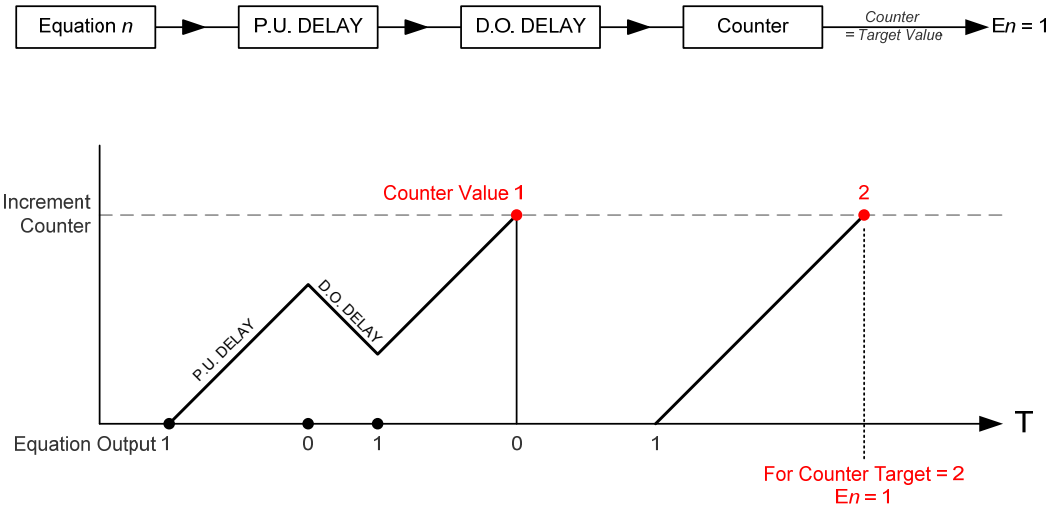

Figure 4-1 Sequence Diagram showing PU/DO Timers in Quick Logic (Counter Reset Mode Off)

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.

Section 5: Supervision Functions

5.1 Circuit Breaker Failure (50BF)

Two CB Fail elements are provided – one element per winding.

Each circuit breaker fail function has two time delayed outputs that can be used for combinations of re-tripping or back-tripping. CB Fail outputs are given after elapse of the ***50BF-n-1 Delay*** or ***50BF-n-2 Delay*** settings. The two timers run concurrently.

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

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

A binary or virtual input assigned to **50BF-n Ext Trip** (MENU: INPUT CONFIG\INPUT MATRIX\50BF Ext Trip).

A binary or virtual input assigned to **50BF-n Mech Trip** (MENU: INPUT CONFIG\INPUT MATRIX\ 50BF-n Mech Trip).

CB Fail outputs will be issued providing any of the 3 phase currents are above the ***50BF-n Setting*** or the current in the fourth CT is above ***50BF-n-I4*** for longer than the ***50BF-n-n Delay*** setting, or for a mechanical protection trip the circuit breaker is still closed when the ***50BF-n-n Delay*** setting has expired – indicating that the fault has not been cleared.

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

If the ***50BF-n CB Faulty*** input (MENU: INPUT CONFIG\INPUT MATRIX\CB Faulty) is energised when a CB trip is given the time delays ***50BF-n-n Delay*** will be by-passed and the output given immediately.

Operation of the CB Fail elements can be inhibited from:

Inhibit 50BF-n A binary or virtual input.

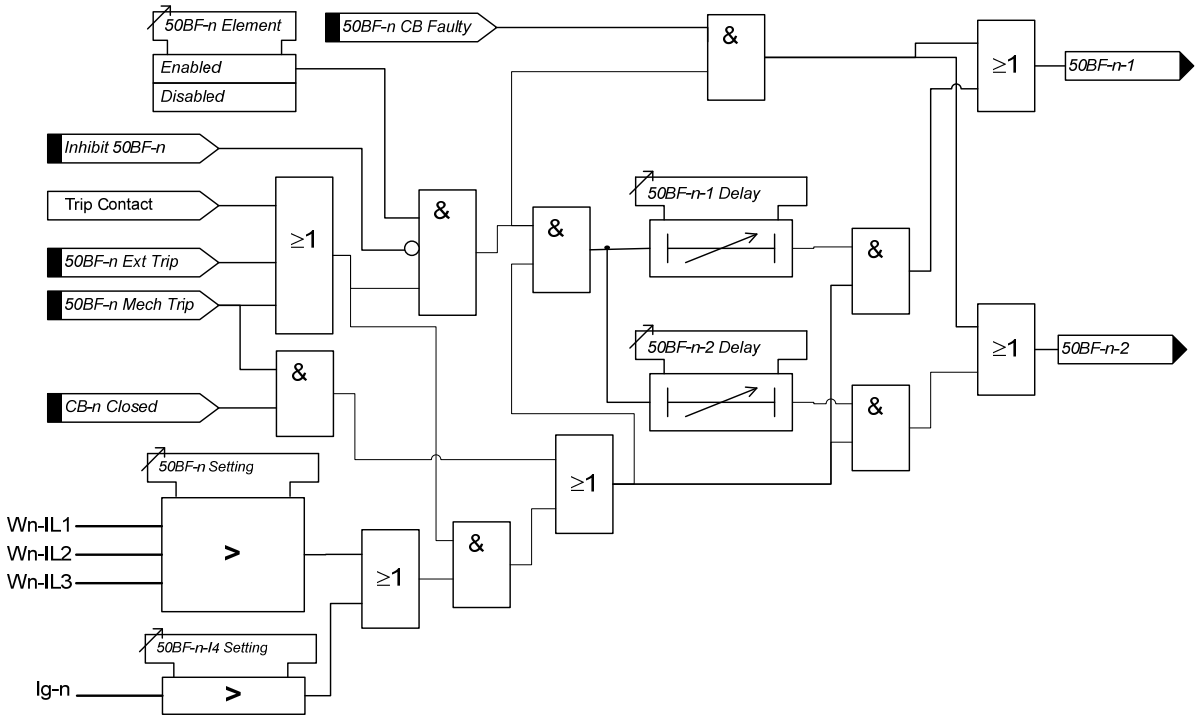

Figure 5-1 Logic Diagram: Circuit Breaker Fail Protection (50BF)

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

The relay provides six trip and six close circuit supervision elements, all elements are identical in operation and independent from each other allowing 6 trip and 6 close circuits to be monitored.

One or more binary inputs can be mapped to ***74TCS-n/74CCS-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*** or ***74CCS-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 Circuit Supervision element (e.g. 74TCS-n) allows the user to realise several alternative monitoring schemes – see 'Applications Guide'.

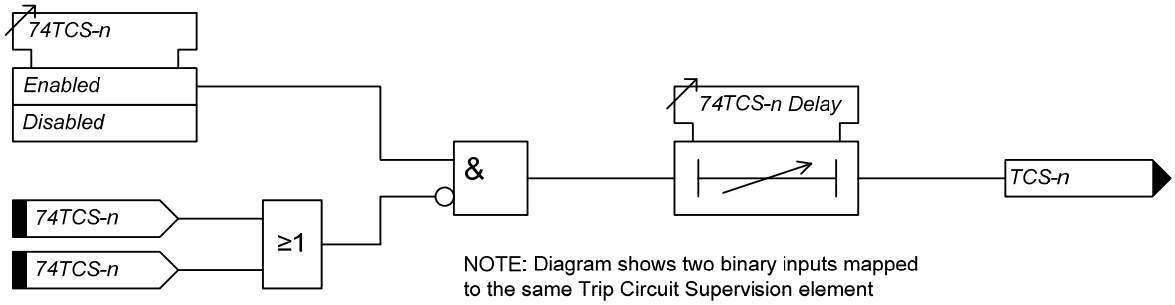

Figure 5-2 Logic Diagram: Trip Circuit Supervision Feature (74TCS)

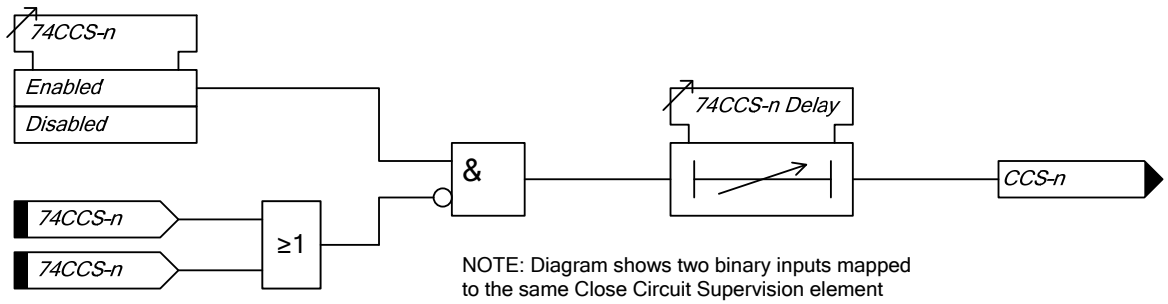

Figure 5-3 Logic Diagram: Close Circuit Supervision Feature (74CCS)

5.3 Inrush Detector (81HBL2)

Inrush detector elements monitor the line currents.

The inrush detector can be used to block the operation of selected elements during transformer magnetising inrush conditions.

The ***81HBL2 Bias*** setting allows the user to select between **Phase**, **Sum** and **Cross** methods of measurement:

Phase Each phase is inhibited separately.

Sum With this method the square root of the sum of the squares of the second harmonic in each phase is compared to each operate current individually.

Cross All phases are inhibited when any phase detects an inrush condition.

An output is given where the measured ratio of second harmonic to fundamental current component content is above the **81HBL2** setting.

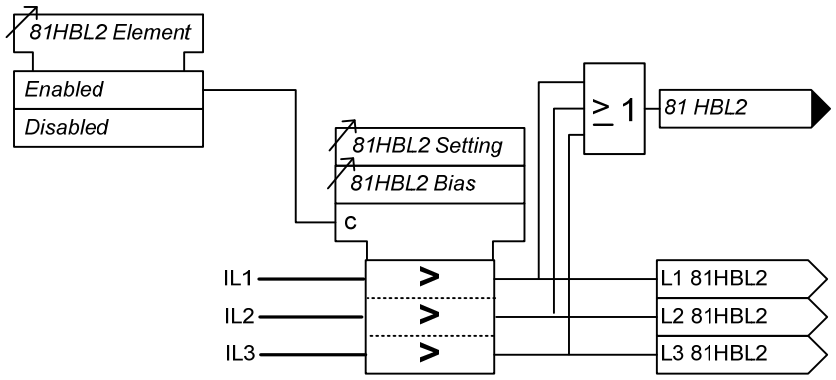

Figure 5-4 Logic Diagram: Inrush Detector Feature (81HBL2)

5.4 OverFluxing Detector (81HBL5)

Overfluxing detector elements monitor the line currents.

The over fluxing detector can be used to block the operation of differential protection (87BD/ 87HS) elements.

The ***81HBL5 Bias*** setting allows the user to select between **Phase**, **Sum** and **Cross** methods of measurement:

Phase Each phase is inhibited separately

Sum The inrush current from each phase is summated and compared to each operate current individually

Cross All phases are inhibited when any phase detects an inrush condition

An output is given where the measured fifth harmonic component content is above the **81HBL5** setting.

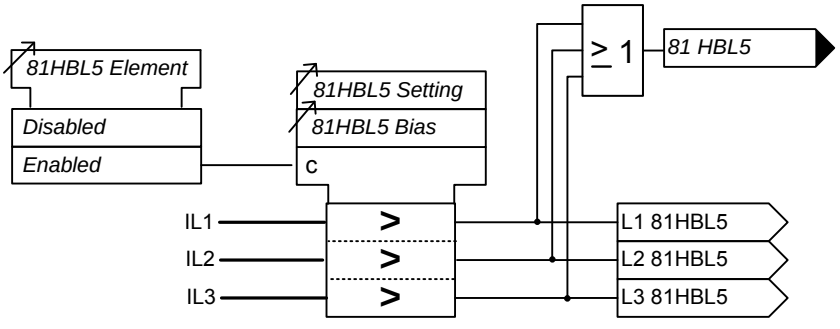

Figure 5-5 Logic Diagram: Overfluxing Detector Feature (81HBL5)

5.5 Demand

Maximum, minimum and mean values of line currents and voltage (where applicable) are available as instruments which can be read in the relay INSTRUMENTS MENU or via Reydisp.

The **DATA STORAGE > DEMAND DATA LOG >** ***Data Log Period*** setting is used to define the time/duration after which the instrument is updated. The updated value indicates the maximum, minimum and mean values for the defined period.

The ***Gn Demand Window*** setting defines the maximum period of time over which the demand values are valid. A new set of demand values is established after expiry of the set time.

The ***Gn Demand Window Type*** can be set to **FIXED, PEAK or ROLLING**.

When set to **FIXED** the maximum, minimum and mean values demand statistics are calculated over fixed Window duration. At the end of each window the internal statistics are reset and a new window is started.

When set to **PEAK** the maximum and minimum values within the ***Demand Window*** time setting is recorded.

When set to **ROLLING** the maximum, minimum and mean values demand statistics are calculated over a moving Window duration. The internal statistics
are updated when the window advances every ***Updated Period***.

The statistics can be reset from a binary input or communication command, after a reset the update period and window are immediately restarted.

Section 6: Other Features

6.1 Data Communications

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

Optionally, additional communication ports are available: -

2 x fibre optic with ST connectors (COM3 and COM4) and 1x IRIG-B

1 x RS485 (COM3) and 1x IRIG-B

1 x RS232 (COM3) and 1 x IRIG-B

Communication is compatible with Modbus-RTU, IEC60870-5-103 FT 1.2 and optionally DNP3.0 transmission and application standards.

Communication with the relay from a personal computer (PC) is facilitated by the REYDISP EVOLUTION software package. The program allows the transfer of relay settings, waveform records, event records, fault data records, Instruments/meters and control functions. REYDISP EVOLUTION is compatible with IEC60870-5-103.

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

6.2 Maintenance

6.2.1 Output Matrix Test

The feature is available from the Relay fascia and allows the user to operate binary outputs or LEDs assigned to relay functions.

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

6.2.2 CB Counters

Four CB trip counters are provided:

CB1 Total Trip Count:	Increments on each trip command issued.
CB1 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.
CB2 Total Trip Count	As CB1
CB2 Delta Trip Count:	As CB1

The status of each counter can be viewed in the INSTRUMENTS mode.

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

6.2.3 I^2t CB Wear

CB1 and CB2 wear counters are also provided:

I^2t CB1 Wear:	Provides an estimate of contact wear and maintenance requirements. The algorithm works on a per phase basis, measuring the arcing current during faults. The I_2t value at

the time of trip is added to the previously stored value and an alarm is given when any one of the three phase running counts exceeds the set ***Alarm limit*** . The t value is the time between CB contacts separation when an arc is formed, ***Separation Time,*** and the CB ***Clearance time***.

I^2t CB2 Wear: As CB1

The status of each counter can be viewed in the INSTRUMENTS mode.

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

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.

Waveform records, fault records and event records are backed up in non-volatile memory and are permanently stored even in the event of loss of auxiliary d.c. supply voltage.

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 5000 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.

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.

All events can be uploaded over the data communications channel(s) and can be displayed in the 'ReyDisp Evolution' package in chronological order, allowing the sequence of events to be viewed. Events are also made available spontaneously to an IEC 60870-5-103 or Modbus RTU compliant control system.

For a complete listing of events available in each model, refer to Technical Manual Chapter 4 'Data Comms'.

6.3.3 Waveform Records.

Relay waveform storage can be triggered from:

- User selected relay operations, this requires the relevant OUTPUT CONFIG>B.O. CONFIG>***Trip Contacts*** setting to be assigned.
- The relay fascia.
- A suitably programmed binary input.
- The data comms channel(s).

Stored analogue and digital waveforms illustrate the system and relay conditions at the time of trigger.

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

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

Waveforms are sampled at a rate of 1600Hz.

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

6.3.4 Fault Records

Up to ten fault records can be stored and displayed on the Fascia LCD.

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.

To achieve accurate instrumentation values for the fault records when testing, ensure a drop off delay is applied to the test set so that the injected quantities remain on for a short duration, typically 20ms, after the relay has issued the trip output. This extended period of injection simulates the behaviour of the power system where faulted conditions are present until CB operation.

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

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

The SYSTEM CONFIG > ***Trip Alert*** = **Disabled** setting allows the above to be switched off e.g. during commissioning tests.

6.3.5 Demand/Data Log

The Data log feature can be used to build trend and demand records.

Up to 10,080 values for each phase current (W1 and W2) and voltage (where fitted) analogue are recorded. Each recorded value consists of the mean value of the sampled data over the ***Data Log Period***.

Stored Data Log records are retrieved using Reydisp.

6.4 Metering

The metering feature provides real-time data available from the relay fascia in the ‘Instruments Mode’ or via the data communications interface.

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>***RELAY MODE*** setting, a Binary Input or Command

Table 6-1 Operation Mode

OPERATION	REMOTE MODE	LOCAL MODE	SERVICE MODE
Control			
Rear Ports	Enabled	Disabled	Disabled
Fascia (Control Mode)	Disabled	Enabled	Disabled
USB	Disabled	Enabled	Disabled
Binary Inputs	Setting Option	Setting Option	Enabled
Binary Outputs	Enabled	Enabled	Disabled
Reporting			
Spontaneous			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
General Interrogation			
IEC	Enabled	Enabled	Disabled
DNP	Enabled	Enabled	Disabled
MODBUS	Enabled	Enabled	Disabled
Changing of Settings			
Rear Ports	Enabled	Disabled	Enabled
Fascia	Enabled	Enabled	Enabled
USB	Disabled	Enabled	Enabled
Historical Information			
Waveform Records	Enabled	Enabled	Enabled
Event Records	Enabled	Enabled	Enabled
Fault Information	Enabled	Enabled	Enabled
Setting Information	Enabled	Enabled	Enabled

6.6 Control Mode

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

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

6.7 Real Time Clock

The relay stores the time and date. The time and date are maintained while the relay is de-energised by a back up storage capacitor.

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.

Time and date can be set either via the relay fascia using appropriate commands in the System Config menu or via:

6.7.1 Time Synchronisation – Data Comms

Where the data comms channel(s) is connected to a dedicated substation automation system the relay can be time synchronised using the relevant command within IEC 60870-5-103 or optional DNP3.0 protocols. The time can also be synchronised from 'Reydisp Evolution' which utilises the communications support software.

6.7.2 Time Synchronisation – Binary Input

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

6.7.3 Time Synchronisation – IRIG-B (Optional)

A BNC connector on the relay rear provides an isolated IRIG-B time synchronisation port. The IRIG-B input expects a modulated 3-6 Volt signal and provides time synchronisation to the nearest millisecond.

6.8 Settings Groups

The relay provides eight groups of settings – Group number (Gn) 1 to 8. At any one time only one group of settings can be 'active' – SYSTEM CONFIG>***Active Group*** setting.

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

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

A change of settings group can be achieved 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**).

6.9 Password Feature

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

The programmable password feature enables the user to enter a 4 character alpha numeric code to secure access to the relay functions. The relay is supplied with the passwords set to **NONE**, i.e. the password feature is disabled. The password must be entered twice as a security measure against 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.