7SR242 Duobias

Multi-Function 2-Winding Transformer Protection Relay

Document Release History

This document is issue **2010/02**. The list of revisions up to and including this issue is:

2010/06	Defect Report Form revised
2010/02	Document reformat due to rebrand
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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.
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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) Prove 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. Fused test leads should not be used where the measurement of a current transformer (C.T.) secondary current is involved, the failure or blowing of an instrument fuse or the operation of an instrument cut-out could cause the secondary winding of the C.T. to become an open circuit.

Open circuit secondary windings on energised current transformers are a hazard that can produce high voltages dangerous to personnel and damaging to equipment, test procedures must be devised so as to eliminate this risk.

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/or equipment.

When all cabling and wiring is completed, 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 station supply or test supply.

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. A typical example of this Site Test Sheet is included.

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

1.2.3 Test Equipment

Required test equipment is:

Secondary injection equipment with integral time interval meter

Primary injection equipment

A d.c. supply with nominal voltage within the working range of the relay's d.c. auxiliary supply rating

A d.c. supply with nominal voltage within the working range of the relay's d.c. binary input rating

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:

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

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.

1.2.4 Precautions

Before electrical testing commences the equipment should be isolated from the current and voltage transformers. The current transformers should be short-circuited in line with the local site procedure. 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.

Check that the nominal secondary current rating of the current and voltage transformers has been correctly set in the System Config menu of the relay.

1.2.5 Applying Settings

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

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

The relay features multiple settings groups, 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.

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

For all high current tests it must be ensured that the test equipment has the required rating and stability and that the relay is not stressed beyond its thermal limit.

1.3.3 Primary Injection Tests

Primary injection tests are essential to check the ratio and polarity of the current transformers as well as the secondary wiring. Primary injection testing of the 87BD Biased Differential protection is recommended to avoid relay operation during first energisation of the transformer if incorrect values are applied to the *ICT Connection* protection setting.

Note. If the current transformers associated with the protection are located in power transformer bushings it may not be possible to apply test connections between the current transformer and the power transformer windings. Primary injection is needed however, to verify the polarity of the CTs. In these circumstances primary current must be injected through the associated power transformer winding. It may be necessary to short circuit another winding in order to allow current to flow. During these primary injection tests the injected current is likely to be small due to the impedance of the transformer.

Phase current transformer polarities and connections can be checked by examination of the relay Current Meters and Differential Meters in the Instruments Menu when the protected plant is carrying load but Earth Fault CT polarity can only be checked during primary injection.

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.

1.4 AC Energising Quantities

Voltage and current 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 Current								Applied Voltage
	W1-I_A	W1-I_B	W1-I_C	I_{G1}	W2-I_A	W2-I_B	W2-I_C	I_{G2}	$V_1(V_X)$
Secondary									
Primary									

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

	ZPS	NPS
Current		

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 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 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 energisation and closure of the output contacts. Similarly, to measure the drop-off delay, map to an output relay that has a normally closed contact, time the interval between binary de-energisation and closure of the output contacts.

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						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						

1.6 Binary Outputs

A minimum of six output relays are provided. Two of these have change over contacts, BO2 & BO3, one has a normally closed contact, BO1 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)
1NC		
2NO		
2NC		
3NO		
3NC		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

1.7 Relay Case Shorting Contacts

CT inputs and terminals C25-C26 (Relay Withdrawn Alarm) 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.

CT Shorting contacts checked	
Relay Withdrawn Alarm Checked	

Section 2: Protection Functions

This section details the procedures for testing each protection function of the 7SR24 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.

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	Biased Differential	Differential Highset	Phase Overcurrent	Derived E/F	Measured E/F	Restricted E/F	Open Circuit	NPS Overcurrent	Undercurrent	Thermal	U/O voltage	Neutral Overvoltage	U/O Frequency	Overfluxing	CB Fail	Trip cct Supervision	Inrush Detector	Overfluxing Detector
Biased Diff.		O	O	O	O	O	O	O	O	O					O			
Diff. Highset	O		O	O	O	O	O	O							O			
Phase OC	O	O		O	O		O	O	O	O					O			
Derived E/F	O	O	O		O	O	O	O	O	O					O			
Measured E/F	O	O	O	O		O	O	O	O	O					O			
Restricted E/F	O	O	O	O	O		O	O	O	O					O			
Open Circuit	O	O		O	O				O	O					O			
NPS OC	O	O		O	O	O			O	O					O			
Undercurrent	O		O	O	O	O	O	O							O			
Thermal	O		O	O	O	O	O	O							O			
U/O voltage												O	O	O	O			
Neutral OV											O			O	O			
U/O Frequency											O				O			
Overfluxing											O	O			O			
CB Fail	O	O	O	O	O	O	O	O	O	O	O	O	O	O				
74TCS/74CCS																		
Inrush Detector																		
O/fluxing Detector																		

The General Pickup LED can be used to assess operation of functions during testing if other functions are disabled or if the setting allocating General Pickup is temporarily modified.

Particular care should be taken when testing overcurrent functions that the thermal rating of the current inputs is not exceeded.

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.

An example ‘Test Sheet’ summary document is included at the end of this Guide.

2.1 Biased Differential (87BD, 87HS)

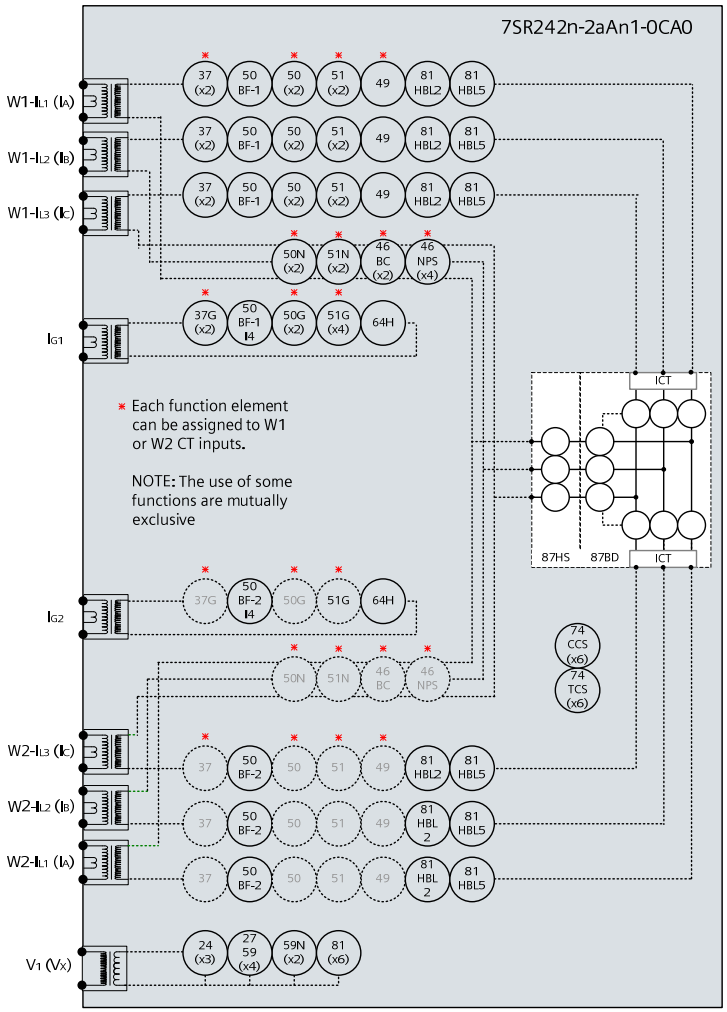

Figure 2-1 Biased Differential

Voltage Inputs:	None
Current Inputs:	W1-I_{L1} (I_A),W1-I_{L2} (I_B),W1-I_{L3} (I_C), and W2-I_{L1} (I_A),W2-I_{L2} (I_B),W2-I_{L3} (I_C),
Disable:	46, 49, 50, 51, 50N, 51N, 50BF,
Map Pickup LED:	87BD, 87HS - Self Reset

The differential elements are subjected to CT multipliers, Vector Group Compensation and Zero Sequence filters when applied to power transformers. The complexity of these features can cause confusion during testing and lead to incorrect relay settings being applied. It is recommended that the accuracy of the differential elements are tested by secondary injection with simplified differential settings applied to avoid ambiguity before reinstating the required site settings which can be tested more thoroughly by primary injection followed by final checking with the protected transformer on load.

2.1.1 Secondary Injection Testing

The settings used for Secondary Injection test purposes should be:

W1 ICT Multiplier	1x	W1 ICT
Connection	Yy0,0deg	W2 ICT
Multiplier	1x	W2 ICT
Connection	Yy0,0deg	

Secondary testing of the bias characteristic will be greatly simplified by the use of automated numeric protection test equipment such as the Omicron CMC256. This equipment can be programmed using setting which match those of the relay to test for accuracy over the whole operating range and give a clear easy to use graphical display of relay performance against the specified characteristic.

The relay characteristic can however be tested manually by recording a sequence of operating points for increasing levels of Restrain current. This can be achieved phase by phase using a single current source such as a Variac with two independently variable current limiting resistors as shown in figure 2-2 or from two independent single or three phase current sources. When two separate sources are used the phase of the two sinusoidal supplies must be the same and the Restrain and Operate currents must be calculated from the sum and difference of the two currents.

During manual testing the Operate and Restrain currents can be monitored on the relay in the Differential Meters in the Instruments menu.

For manual testing, the bias slope is usually checked for Restrain current up to 250% of nominal current. For testing above this level the continuous current rating of the relay inputs is likely to be exceeded, equipment or test procedure should be arranged in such a way that the short term thermal withstand of the relay current inputs is not exceeded during testing.

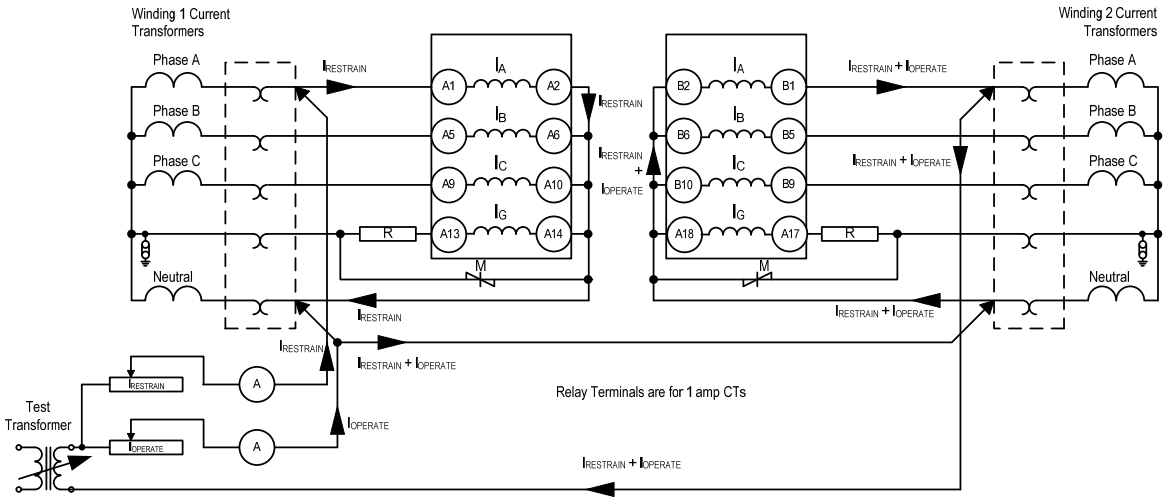

Figure 2-2 Secondary Injection using a Variac

2.1.1.1 Results for testing 87BD with a Variac

87BD INITIAL SETTING	87BD 1ST BIAS SLOPE SETTING	BIAS CURRENT (X I_N) MEASURED ON AMMETER A1				
		0.00	1.00	1.50	2.00	2.50
		Operate Current Measured on Ammeter A2				
0.10	0.10	0.10	0.11	0.16	0.21	0.26
0.20	0.20	0.20	0.22	0.33	0.44	0.56
0.30	0.30	0.30	0.35	0.53	0.71	0.88
0.40	0.40	0.40	0.50	0.75	1.00	1.25
0.50	0.50	0.50	0.67	1.00	1.33	1.67
0.50	0.60	0.50	0.86	1.29	1.71	2.14
0.50	0.70	0.50	1.08	1.62	2.15	2.69
Selected Settings		Test Results				
		0.00	1.00	1.50	2.00	2.50
Phase A Pickup						
Phase B Pickup						
Phase C Pickup						

2.1.1.2 Results for testing 87BD with 2 current sources

87BD INITIAL SETTING	87BD 1ST BIAS SLOPE SETTING	W1 CURRENT (x I_N)				
		0.00	1.00	1.50	2.00	2.50
		W2 Current (x I_n)				
0.10	0.10	0.1	1.11	1.66	2.21	2.76
0.20	0.20	0.2	1.22	1.83	2.44	3.06
0.30	0.30	0.3	1.35	2.03	2.71	3.38
0.40	0.40	0.4	1.5	2.25	3.0	3.75
0.50	0.50	0.5	1.67	2.5	3.33	4.17
0.50	0.60	0.5	1.86	2.79	3.71	4.64
0.50	0.70	0.5	2.08	3.12	4.15	5.19
Selected Settings		Test Results				
		0.00	1.00	1.50	2.00	2.50
Phase A Pickup						
Phase B Pickup						
Phase C Pickup						

2.1.1.3 **Differential Highset 87HS**

Differential Highset can be tested by single phase secondary current injection. 87HS settings will usually be higher than the continuous thermal rating of the relay current inputs and equipment or test procedure should be arranged in such a way that the short term thermal withstand of the relay current inputs is not exceeded during testing. 50% of relay setting current can be injected into each of the 2 winding inputs simultaneously to achieve a differential current level of 100% if test current is limited by test equipment capacity.

The settings used for Secondary Injection test purposes should be:

W1 ICT Multiplier	1x
W1 ICT Connection	Yy0,0deg
W2 ICT Multiplier	1x
W2 ICT Connection	Yy0,0deg

These settings ensure a 1:1 ratio between the injected current and the relay setting. Note that operation of the element can be achieved at a lower level of current if a higher ICT multiplier setting is applied.

During testing the Operate current can be monitored on the relay in the Instruments menu.

2.1.2 Primary Injection Testing

Primary injection is recommended to prove the relay connections, CT polarity and settings before putting the protection scheme into service. Primary injection is essential to fully prove the connections of the Biased Differential and REF protections. To provide a useful test the relay should have the final site specific settings applied for primary injection tests.

WARNING!

It is important before carrying out any primary injection to ensure appropriate CTs are shorted to avoid operation of mesh corner or busbar type unit protection. If the injected primary current is large enough, the bus zones protection may operate.

Sufficient primary current to prove the connections and settings is required so that a minimum secondary current of about 10mA rms circulates in the relay inputs. This is difficult to achieve using high current primary injection equipment due to the relatively high impedance of the transformer windings. An alternative method is to apply 415 LVAC to one side of the transformer with a short circuit applied to the other side. The external three-phase primary short is usually applied to the HV side so that the LVAC supply is connected to the winding with lowest impedance which will result in a higher current level. The test current that will be produced can be predicted based on the impedance of the transformer and the applied test voltage. The primary test current is injected through all of the biased differential CT's on the LV side.

Injection of 3 phase current in this way will simulate balanced load conditions, or through fault. During injection, check that the W1 and W2 relay currents are in anti-phase by examination of the relay 'Differential Meters' in 'Instruments Mode'. Check each phase in turn, ensuring that the phase angle for 'W1 Relay' is in anti-phase with 'W2 Relay'.

When the transformer is eventually energised and carrying load current, the above examination of the W1 and W2 relay current phase angle should be re-checked for anti-phase to ensure that the correct *ICT Connection* settings are applied to the differential protection.

It should be noted that checking of Vector Grouping by phase alignment between W1 and W2 by 3 phase primary injection or on-load will highlight phase cross-over or connection polarity but will not show incorrect application of zero sequence filters.

2.1.3 Phase Overcurrent (50, 51)

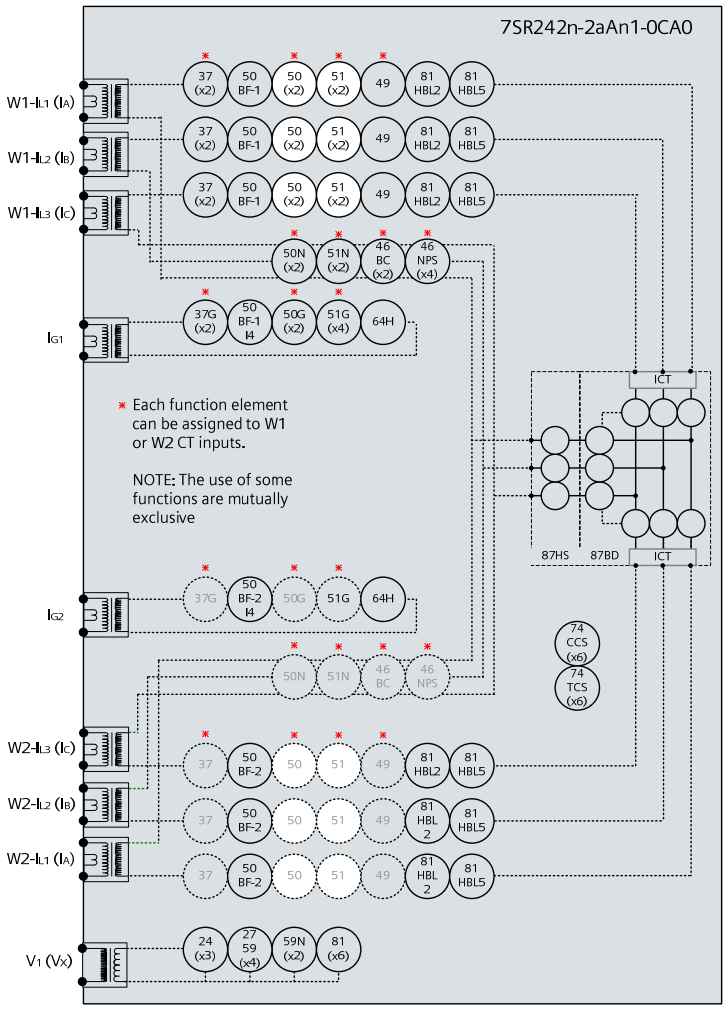

Figure 2-3 Phase Overcurrent

Voltage Inputs:	None
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C),
Disable:	46, 49, 50BF, 87BD, 87HS
Map Pickup LED:	51-n/50-n - Self Reset

Other protection functions may overlap with these functions during testing, it may be useful to disable some functions to avoid ambiguity.

These elements can be allocated to W1 or W2 current inputs by relay settings, ensure that current is injected on the correct input.

Particular care should be taken when testing overcurrent functions that the thermal rating of the current inputs is not exceeded.

2.1.4 Definite Time Overcurrent (50)

If DTL setting is small, gradually increase current 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

Phase	Dir.	Is (Amps)	DTL (sec)	P.U. Current Amps	Operate Time 2 x Is	NOTES
$I_{L1}(I_A)$						
$I_{L2}(I_B)$						
$I_{L3}(I_C)$						

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

2.1.5 Inverse Time Overcurrent (51)

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 current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x setting current and record operating time.

Compare to calculated values for operating times

P.U. D.O. & TIMING TESTS	Ph.	Dir	Char. (NI EI VI LTI, DTL)	Is (A)	TM	Operate Current		Operate Time		NOTES
						P.U. (Amps)	D.O. (Amps)	2 x Is (sec)	5 x Is (sec)	
	$I_{L1}(I_A)$									
	$I_{L2}(I_B)$									
	$I_{L3}(I_C)$									

Calculated Timing values in seconds for TM =1.0

Curve	2 xIs	5 xIs
IEC-NI	10.03	4.28
IEC-VI	13.50	3.38
IEC-EI	26.67	3.33
IEC-LTI	120.00	30.00
ANSI-MI	3.80	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.30

Note that the operate time may be subject to the **Minimum op time** setting for the element and/or may have a **Follower DTL** applied.

2.1.5.1 Element Blocking

The Phase Overcurrent elements can be blocked by Binary Input Inhibit and Inrush Detector operation. This functionality should be checked.

Element	BI Inhibits	Inrush Detector
51-1		
51-2		
50-1		
50-2		

2.1.5.2 ANSI Reset

If the element is configured as an ANSI characteristic, it may have an ANSI (decaying) reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and Time multiplier (TM) = 1.0. The reset curve characteristic type and TM is defined by the operating characteristic.

Curve	Fully operated to reset with Zero current applied & TM=1 (secs)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50% of the previous value. Ensure that the second operate time (c) is 50% of the first (a) operate time.

Operate time (expected)	Reset time (calculated)	Operate time (measured)	50% Reset Time (calculated)	50% operate time (calculated)	50% operate time (measured)
		First test (c)			Second Test (c)

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

2.2 Derived Earth fault (50N,51N)

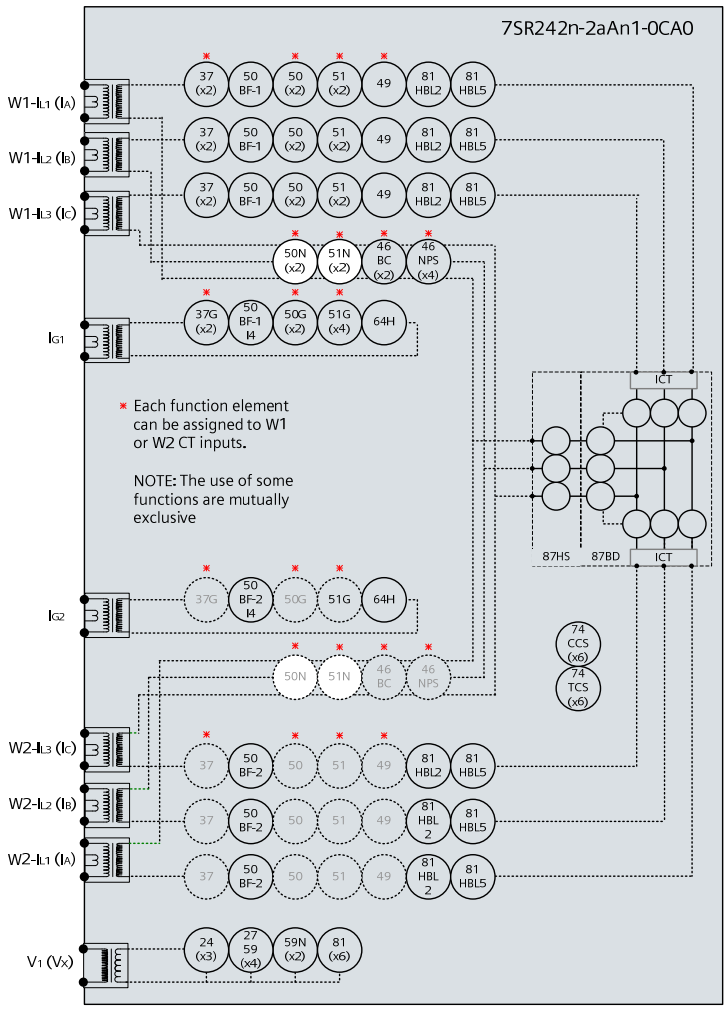

Figure 2-4 Measured Earth Fault

Voltage Inputs:	None
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C),
Disable:	50BF, 50, 51, 49, 37
Map Pickup LED:	51N-n/50N-n - Self Reset

Other protection functions may overlap with these functions during testing, it may be useful to disable some functions to avoid ambiguity. Measured EF & Restricted EF protections can be Enabled/Disabled individually or as groups in the 'Function Config' menu.

These elements can be allocated to W1 or W2 current inputs by relay settings, ensure that current is injected on the correct input.

Derived EF elements can be separated from Measured EF by secondary injection of current through the phase input circuit only.

2.2.1 Definite Time Overcurrent (50N)

If DTL setting is small, gradually increase current 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

Input	Is (Amps)	DTL (sec)	P.U. Current Amps	Operate Time 2 x Is	NOTES

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

2.2.2 Inverse Time Overcurrent (51N)

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 current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x setting current and record operating time.

Compare to calculated values for operating times

P.U. D.O. & TIMING TESTS	Input	Char. (NI EI VI LTI, DTL)	Is (A)	T.M.	Operate Current	Operate Time	NOTES		
					P.U. (Amps)	D.O. (Amps)	2 x Is (sec)	5 x Is (sec)	

Calculated Timing values in seconds for TM =1.0

Curve	2 xIs	5 xIs
IEC-NI	10.03	4.28
IEC-VI	13.50	3.38
IEC-EI	26.67	3.33
IEC-LTI	120.00	30.00
ANSI-MI	3.80	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.30

Note that the operate time may be subject to the *Minimum op time* setting for the element and/or may have a *Follower DTL* applied.

2.2.2.1 Element Blocking

The Measured Earth Fault elements can be blocked by Binary Input Inhibit, VT Supervision and Inrush Detector operation. The Characteristic can be made non-directional by VT Supervision. This functionality should be checked.

Element	BI Inhibits	Inrush Detector
51N-1		
51N-2		
51N-3		
51N-4		
50N-1		
50N-2		
50N-3		
50N-4		

2.2.3 ANSI Reset

If the element is configured as an ANSI characteristic, it may have a reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and TM = 1.0. The reset curve characteristic type and TM is defined by the operating characteristic.

Curve	Fully operated to reset with Zero current applied & TM=1 (secs)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50% of the previous value. Ensure that the second operate time (c) is 50% of the first (a) operate time.

Operate time (expected)	Reset time (calculated)	Operate time (measured)	50% Reset Time (calculated)	50% operate time (calculated)	50% operate time (measured)
		First test (c)			Second Test (c)

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

2.3 Measured Earth fault (50G, 51G)

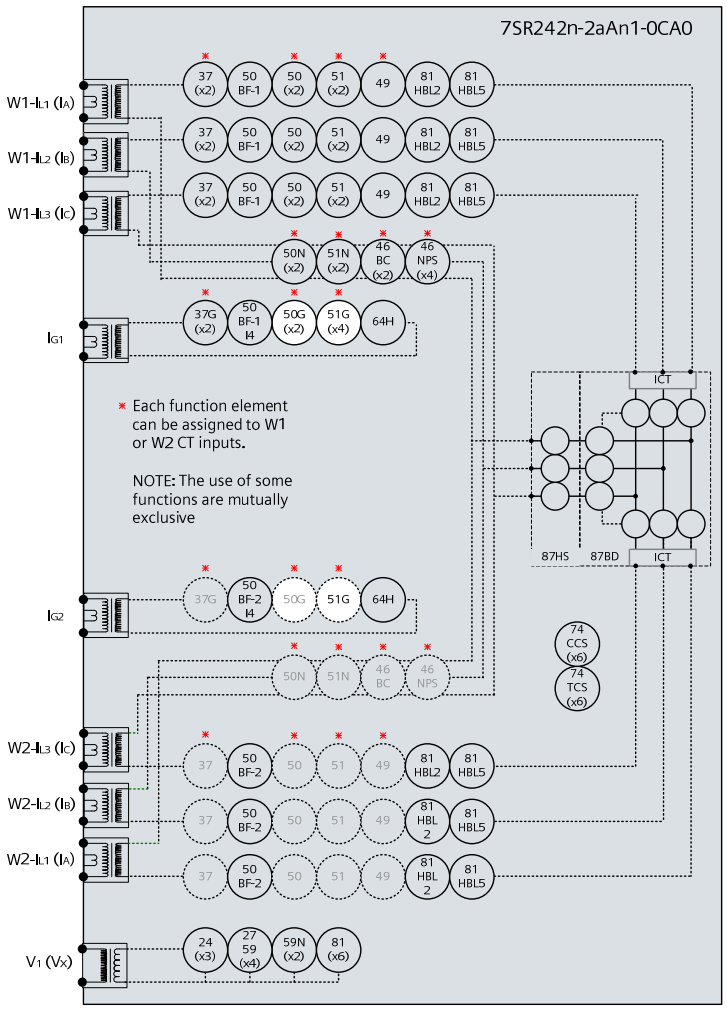

Figure 2-5 Measured Earth Fault

Voltage Inputs:	None
Current Inputs:	I_{G1} , I_{G2}
Disable:	50BF, 64H
Map Pickup LED:	51G-n/50G-n - Self Reset

Other protection functions may overlap with these functions during testing, it may be useful to disable some functions to avoid ambiguity. Derived EF, Measured EF & Restricted EF protections can be Enabled/Disabled individually or as groups in the 'Function Config' menu.

These elements can be allocated to I_{G1} or I_{G2} current inputs by relay settings, ensure that current is injected on the correct input.

Measured EF elements can be separated from Derived EF by secondary injection of current through the I_{G1} or I_{G2} input circuit only.

2.3.1 Definite Time Overcurrent (50G)

If DTL setting is small, gradually increase current 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

Input	Is (Amps)	DTL (sec)	P.U. Current Amps	Operate Time 2 x Is	NOTES
I_{G1}					

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

2.3.2 Inverse Time Overcurrent (51G)

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 current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x setting current and record operating time.

Compare to calculated values for operating times

P.U. D.O. & TIMING TESTS	Input	Char. (NI EI VI LTI, DTL)	Is (A)	T.M.	Operate Current		Operate Time		NOTES
					P.U. (Amps)	D.O. (Amps)	2 x Is (sec)	5 x Is (sec)	
	I_{G1}								

Calculated Timing values in seconds for TM =1.0

Curve	2 xIs	5 xIs
IEC-NI	10.03	4.28
IEC-VI	13.50	3.38
IEC-EI	26.67	3.33
IEC-LTI	120.00	30.00
ANSI-MI	3.80	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.30

Note that the operate time may be subject to the *Minimum op time* setting for the element and/or may have a *Follower DTL* applied.

2.3.2.1 Element Blocking

The Measured Earth Fault elements can be blocked by Binary Input Inhibit, VT Supervision and Inrush Detector operation. The Characteristic can be made non-directional by VT Supervision. This functionality should be checked.

Element	BI Inhibits	Inrush Detector
51G-1		
51G-2		
51G-3		
51G-4		
50G-1		
50G-2		
50G-3		
50G-4		

2.3.3 ANSI Reset

If the element is configured as an ANSI characteristic, it may have a reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and TM = 1.0. The reset curve characteristic type and TM is defined by the operating characteristic.

Curve	Fully operated to reset with Zero current applied & TM=1 (secs)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50% of the previous value. Ensure that the second operate time (c) is 50% of the first (a) operate time.

Operate time (expected)	Reset time (calculated)	Operate time (measured)	50% Reset Time (calculated)	50% operate time (calculated)	50% operate time (measured)
		First test (c)			Second Test (c)

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

2.4 Restricted Earth fault (64H)

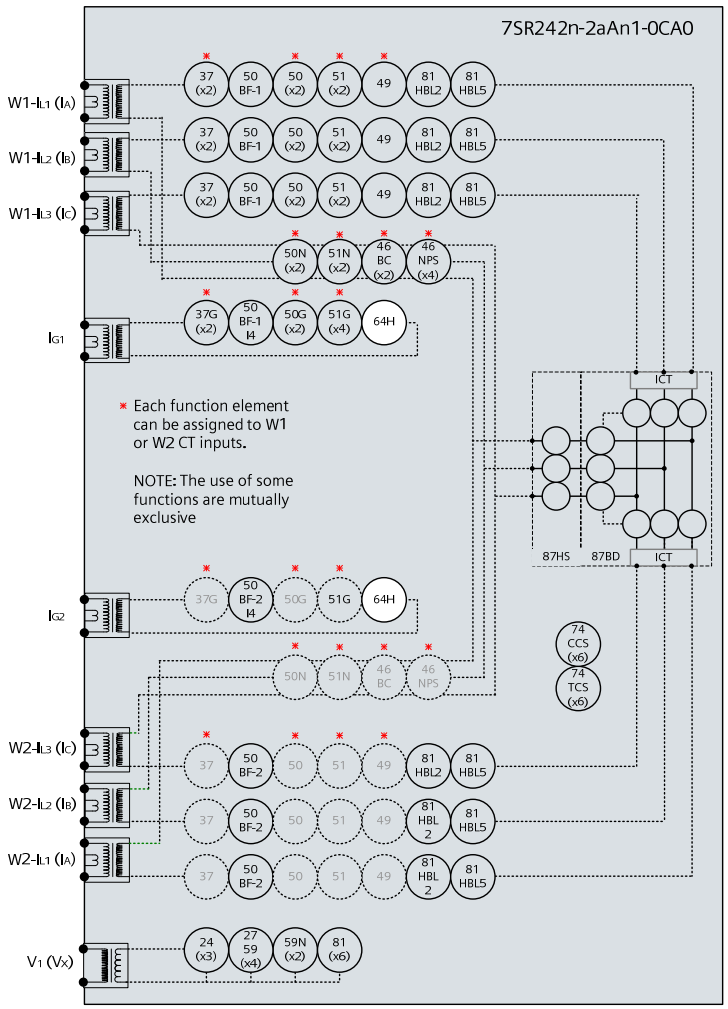

Figure 2-6 Restricted Earth Fault

Voltage Inputs:	n/a
Current Inputs:	I_{G1} , I_{G2}
Disable:	50G, 51G, 50BF
Map Pickup LED:	64H-n - Self Reset

The external stabilising resistor value should be measured and compared to that specified in the settings data. Both values should be recorded.

Element	Settings Data: R_{STAB} Value	R_{STAB} Measured
64H-1		
64H-2		

The relatively high value of stabilising resistance R_{STAB} will often interfere with secondary current injection when using a digital test set. It is normal practice in these cases to short circuit the resistor to allow testing, the shorting link should be removed after testing.

These elements can be enabled for the I_{G1} or I_{G2} current inputs by relay settings, ensure that current is injected on the correct input.

Since the DTL setting is generally small the pick-up setting can be tested by gradually increasing current until element operates. The relay should be disconnected from the current transformers for this test.

Apply 2x setting current if possible and record operating time

	Is (Amps)	DTL (sec)	P.U. Current Amps	Operate Time 2 x Is	NOTES
64H-1					
64H-2					

It is also desirable to check the operating voltage achieved with the setting resistor and all parallel CTs connected but de-energised. A higher capacity test set will be required for this test. Adequate current must be supplied to provide the magnetising current of all connected CTs. Precautions should be taken to ensure that no personnel are at risk of contact with any of the energised secondary wiring during the test.

	Settings Data: Voltage Setting (V_S)	**V_S Measured**	**Settings Data: Operate Current (I_{OP})**	**I_{OP} Measured**
64H-1				
64H-2				

To complete testing of the REF requires primary injection through the phase and residual (REF) CT in series to simulate an out of zone fault and ensure stability of the relay. The test can then be repeated with the REF CT secondary connections reversed to prove operation.

2.4.1.1 Element Blocking

The Restricted Earth Fault element can be blocked by Binary Input Inhibit. Where applied this functionality should be checked.

Element	**BI Inhibits**	**Checked**
64H-1		
64H-2		

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

Check that any shorting links are removed after testing.

2.5 Open Circuit (46BC)

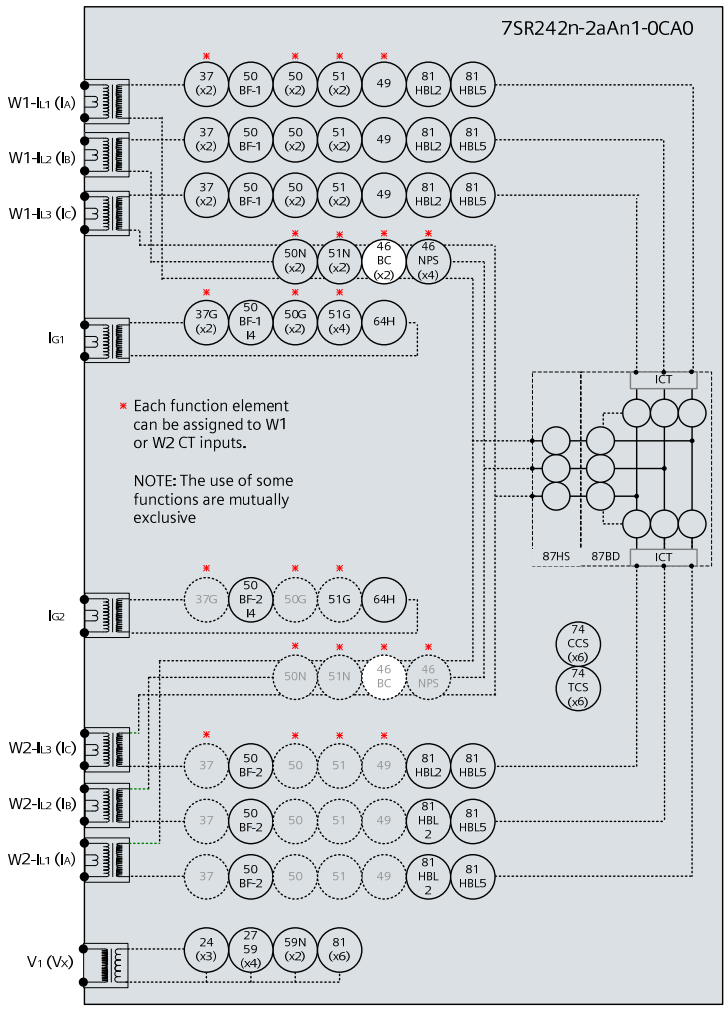

Figure 2-7 Open Circuit

Voltage Inputs:	n/a
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C),
Disable:	51N, 46IT, 46DT
Map Pickup LED:	46BC - Self Reset

This function uses the ratio of NPS current to PPS current to detect an open circuit . These quantities can be produced directly from many advanced test sets but with limited equipment the following approach can be applied.

Apply 3P balanced current with normal phase rotation direction. This current will consist of PPS alone, no NPS or ZPS.

Increase 1 phase current magnitude in isolation to produce NPS. The single phase unbalance current will contain equal quantities of ZPS, NPS and PPS. The NPS component will be 1/3 of the unbalance current and the total PPS component will be value of the original balanced 3P current plus 1/3 of the additional unbalance current. i.e. as the single phase unbalance current increases, the ratio of NPS to PPS will also increase. The levels of each sequence component current can be monitored in the ***Current Meters*** in ***Instruments Mode***.

Inject 1A of balanced current. Gradually increase imbalance current, operating level should be as follows:

46BC Setting	1P unbalance current (% of 3P current)
20%	75%
25%	100%
30%	129%
35%	161%
40%	200%

46BC Setting	3P balanced current (A)	1P unbalance current (A)	Measured Unbalance current
46BC-1			
46BC-2			

Apply 1A 1P unbalance current without 3P balanced current. Measure 46BC operating time.

46BC Delay setting	Measured
46BC-1	
46BC-2	

2.5.1.1 Element Blocking

Elements can be blocked by operation of a Binary Input Inhibit or by operation of the 46BC-n U/I Guard element. This functionality should be checked.

Element	**BI Inhibits**	**U/I Guard**	**NOTES**
46BC-1			
46BC-2			

2.6 Negative Phase Sequence Overcurrent (46NPS)

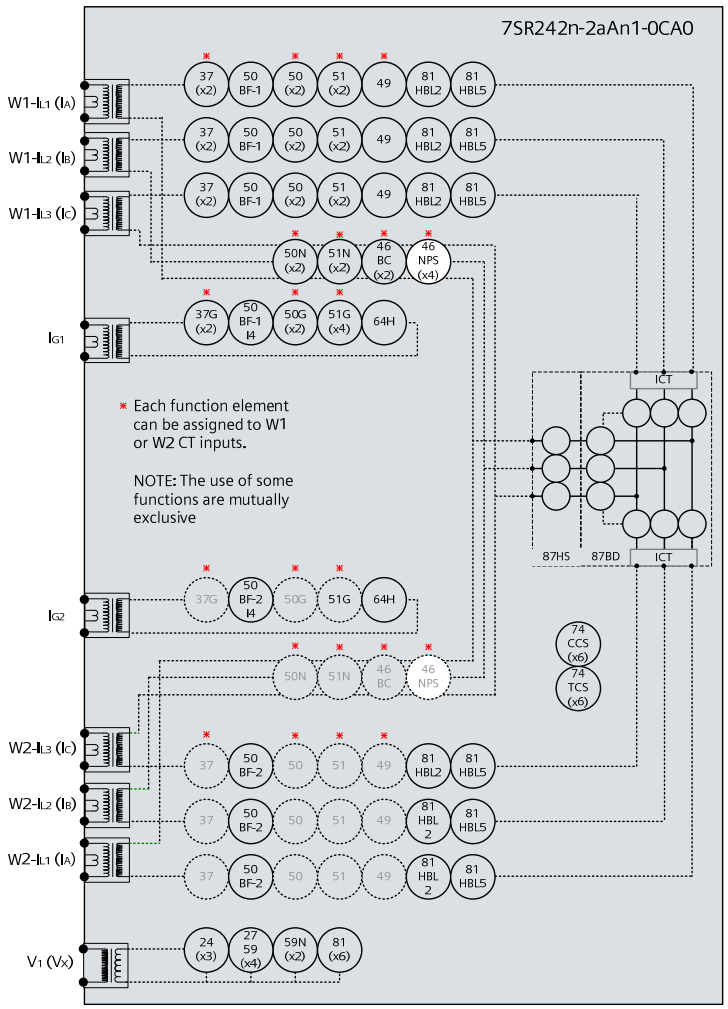

Figure 2-8 Negative Phase Sequence Overcurrent

Voltage Inputs:	n/a
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C),
Disable:	50, 51, 50BF, 87BD
Map Pickup LED:	46IT/46DT - 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. The Thermal withstand limitations of the current inputs, stated in the Performance Specification should always be observed throughout testing.

These elements can be allocated to W1 or W2 current inputs by relay settings, ensure that current is injected on the correct input.

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

2.6.1 Definite Time NPS Overcurrent (46DT)

If DTL setting is small, gradually increase current 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

Phase	Is (Amps)	DTL (sec)	P.U. Current Amps	Operate Time 2 x Is	NOTES
NPS					

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

2.6.2 Inverse Time NPS Overcurrent (46IT)

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 current until Pickup LED operates.

Apply 2x setting current and record operating time,

Apply 5x setting current and record operating time.

Compare to calculated values for operating times

	Ph.	Char. (NI EI VI LTI, DTL)	Is (A)	TM	Operate Current		Operate Time		NOTES
					P.U. (Amps)	D.O. (Amps)	2 x Is (sec)	5 x Is (sec)	
P.U. D.O. & TIMING TESTS	NPS								

Calculated Timing values in seconds for TM =1.0

Curve	2 xIs	5 xIs
IEC-NI	10.03	4.28
IEC-VI	13.50	3.38
IEC-EI	26.67	3.33
IEC-LTI	120.00	30.00
ANSI-MI	3.80	1.69
ANSI-VI	7.03	1.31
ANSI-EI	9.52	1.30

Note that the operate time may be subject to the *Minimum op time* setting for the element and/or may have a *Follower DTL* applied.

2.6.2.1 ANSI Reset

If the element is configured as an ANSI characteristic, it may have a reset delay applied. If ANSI reset is selected for an IEC characteristic element, the reset will be instantaneous.

ANSI reset times from operated condition to fully reset are as follows for zero applied current and TM = 1.0. The reset curve characteristic type and TM is defined by the operating characteristic.

Curve	Fully operated to reset with Zero current applied & TM=1 (secs)
ANSI-MI	4.85
ANSI-VI	21.6
ANSI-EI	29.1

Apply current in the following sequence, a) 2x setting for a time to ensure element operation, b) Zero current for the reset time above (xTM), c) 2x setting for a time to ensure element operation. Check that the second operation (c) is similar to the first (a) and in line with the expected operate time for the element at this current level.

Repeat the test with the reset time (b) reduced to 50% of the previous value. Ensure that the second operate time (c) is 50% of the first (a) operate time.

Operate time (expected)	Reset time (calculated)	Operate time (measured)	50% Reset Time (calculated)	50% operate time (calculated)	50% operate time (measured)
		First test (c)			Second Test (c)

2.6.2.2 **Element Blocking**

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

Element	BI Inhibits
46IT	
46DT	

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

When testing is complete reinstate any of the disabled functions.

2.7 Undercurrent (37, 37G)

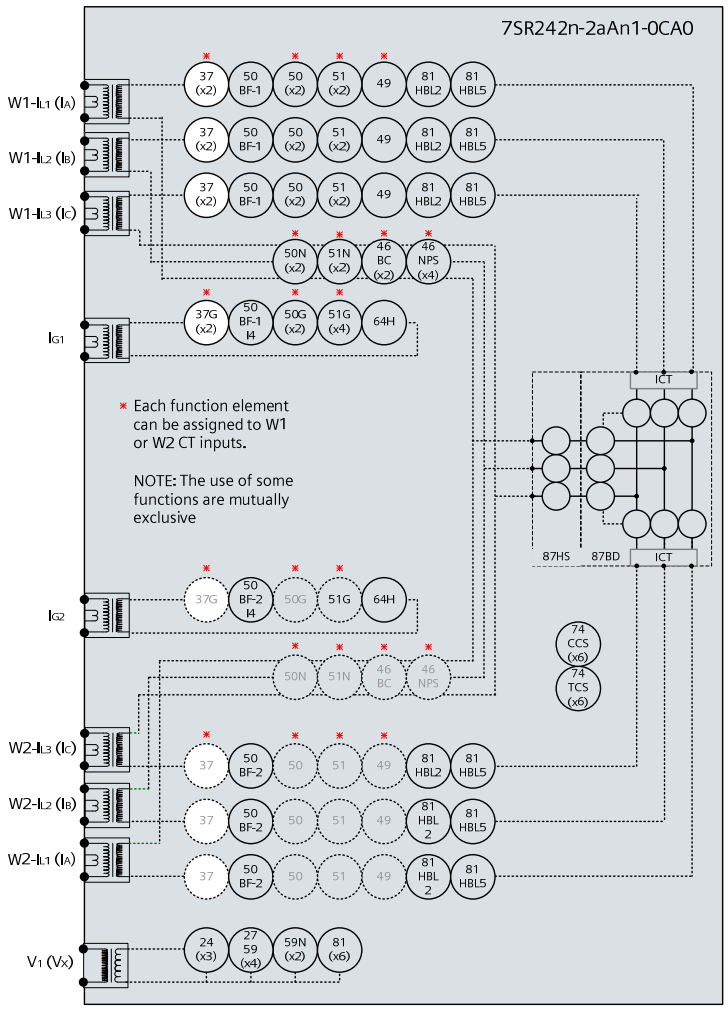

Figure 2-9 Undercurrent

Voltage Inputs:	n/a
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), I_{G1} or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C), I_{G2}
Disable:	50N, 51N, 51G, 46, 87BD
Map Pickup LED:	37-n, 37G-n - Self Reset

2.7.1 37-n Elements

If two Undercurrent 37 elements are used with different settings, it is convenient to test the element with the lowest setting first. The higher setting element can then be tested without interference from the other element.

These elements can be allocated to W1 or W2 current inputs by relay settings, ensure that current is injected on the correct input.

Apply 3P balanced current at a level above the 37-n setting until the element resets.

If DTL setting is small, gradually reduce any each phase current in turn until element operates.

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

Testing of these elements phase by phase may cause inadvertent operation of the 46 NPS Overcurrent elements.

Apply 0.5x setting current and record operating time

Phase	Is (Amps)	DTL (sec)	P.U. Current Amps	Operate Time 0.5 x Is	NOTES
Wn-I_{L1}(I_A)					
Wn-I_{L2}(I_B)					
Wn-I_{L3}(I_C)					
Wn-I_{L1}(I_A)					
Wn-I_{L2}(I_B)					
Wn-I_{L3}(I_C)					

Elements can be blocked by operation of a Binary Input Inhibit or by operation of the 37-n U/I Guard element.
This functionality should be checked.

Element	BI Inhibits	U/I Guard	NOTES
37-1			
37-2			

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

2.7.2 37G-n Elements

Apply current to the I_{Gn} input at a level above the 37G-n setting until the element resets.
If DTL setting is small, gradually reduce current until element operates.
If DTL is large apply 1.1x setting, check for no operation, apply 0.9x setting, check operation
Apply 0.5x setting current and record operating time

Phase	Is (Amps)	DTL (sec)	P.U. Current Amps	Operate Time 0.5 x Is	NOTES
I_G					
I_G					

Elements can be blocked by operation of a Binary Input Inhibit.
This functionality should be checked.

Element	BI Inhibits	NOTES
37G-1		
37G-2		

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

2.8 Thermal Overload (49)

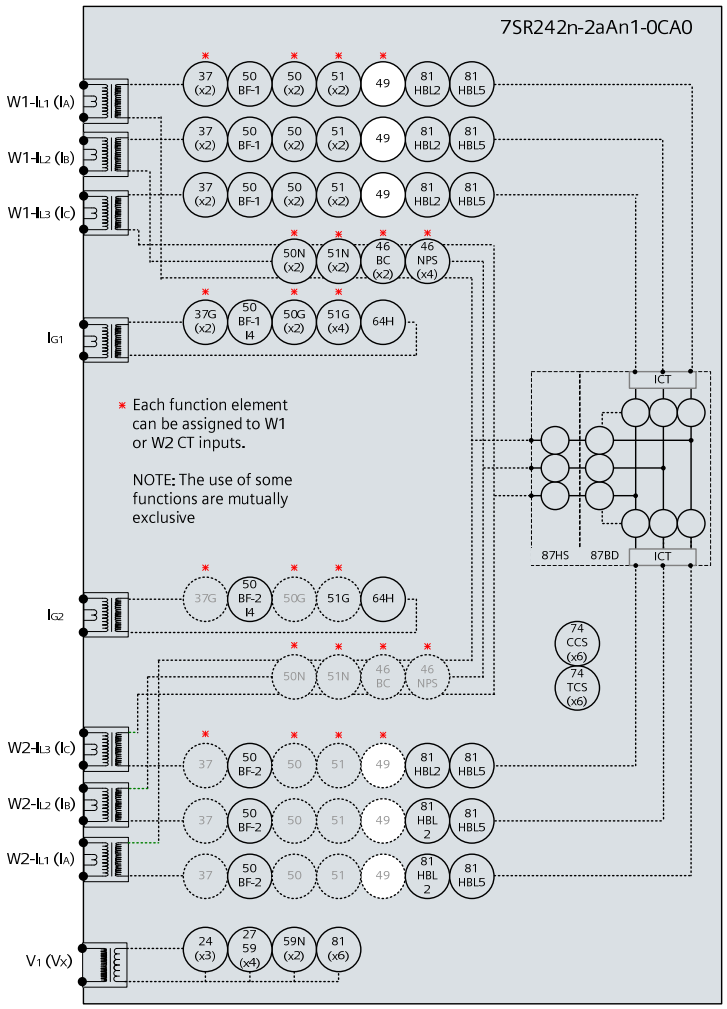

Figure 2-10 Thermal Overload

Voltage Inputs:	n/a
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C),
Disable:	51, 50, 37, 46NPS, 50CBF, 87BD
Map Pickup LED:	49 Alarm

The current can be applied from a 3P balanced supply or phase by phase from a 1P supply. Alternatively the 3 phase current inputs can be connected in series and injected simultaneously from a single 1P source.

This elements can be allocated to W1 or W2 current inputs by relay settings, ensure that current is injected on the correct input.

The Thermal Overload Setting and Time Constant Setting can be considered together to calculate the operating time for a particular applied current.

The following table lists operate times for a range of Time Constant Settings for an applied current of 2x the Thermal Overload setting. Ensure that the thermal rating of the relay is not exceeded during this test.

Time Constant (mins)	Operate Time (sec)
1	17.3
2	34.5
3	51.8
4	69
5	86.3
10	173
15	259
20	345
25	432
30	51.8
50	863
100	1726

The Thermal State must be in the fully reset condition in order to measure the operate time correctly. This can be achieved by setting change in the Thermal protection settings menu or by pressing the Test/Reset button when the Thermal Meter is shown in the Instruments Mode.
Reset the thermal State then apply 2x the Overload Setting current.

Calculated Operate Time (s)	Measured Operate Time (s)

If the Thermal Overload Capacity Alarm is used, this can be tested by monitoring the Thermal Capacity in the instruments menu. If the Thermal time constant is longer than a few minutes, this can be assessed during the timing test above. If the Time Constant is less than a few minutes, a lower multiple of current will be required such that the rate of capacity increase is slowed to allow monitoring of the instrument to be accurate.

Capacity Alarm Setting	Measured

2.8.1.1 Element Blocking

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

Element	BI Inhibits
49	

2.9 Under/Over Voltage (27/59)

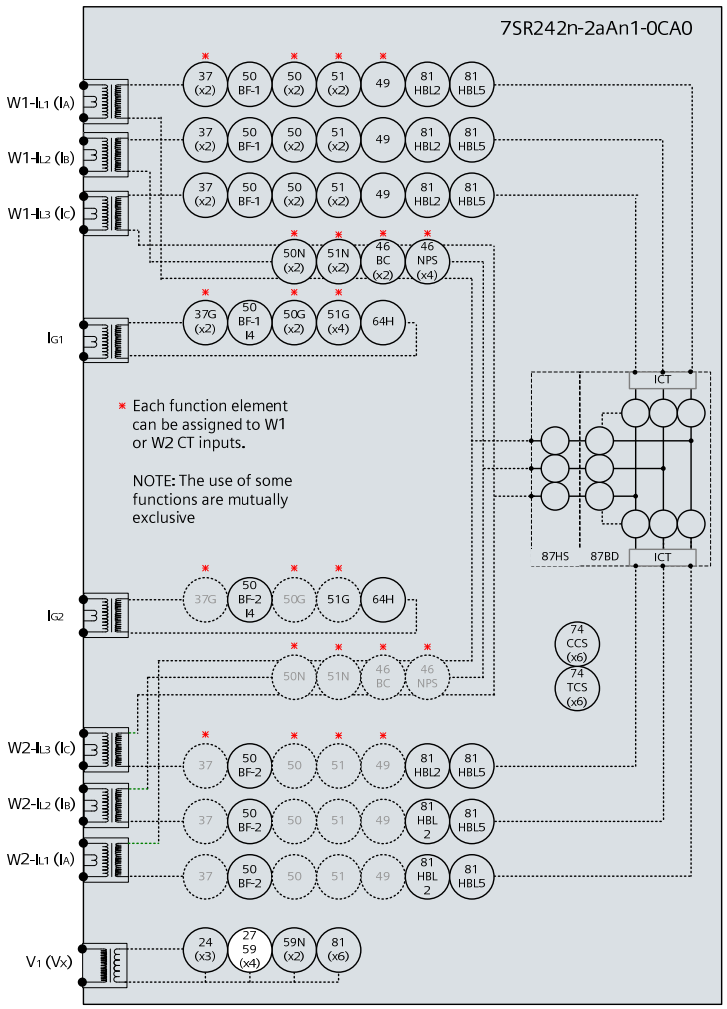

Figure 2-11 Phase Under/Over Voltage

Voltage Inputs:	V_1 (V_X)
Current Inputs:	n/a apply zero current to stabilize other functions
Disable:	59N
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. Current inputs are not required to stabilise the relay during voltage element testing.

If the DTL is short, starting from nominal voltage, slowly decrease the applied 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 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%

When testing is complete reinstate any of the disabled functions.

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	NOTES
$V_1(V_X)$										

2.9.1.1 Element Blocking

The NPS Overcurrent elements can be blocked by Binary Input Inhibit and VT Supervision. This functionality should be checked.

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

When testing is complete reinstate any of the disabled functions.

2.9.2 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).

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

2.10 Neutral Over Voltage (59N)

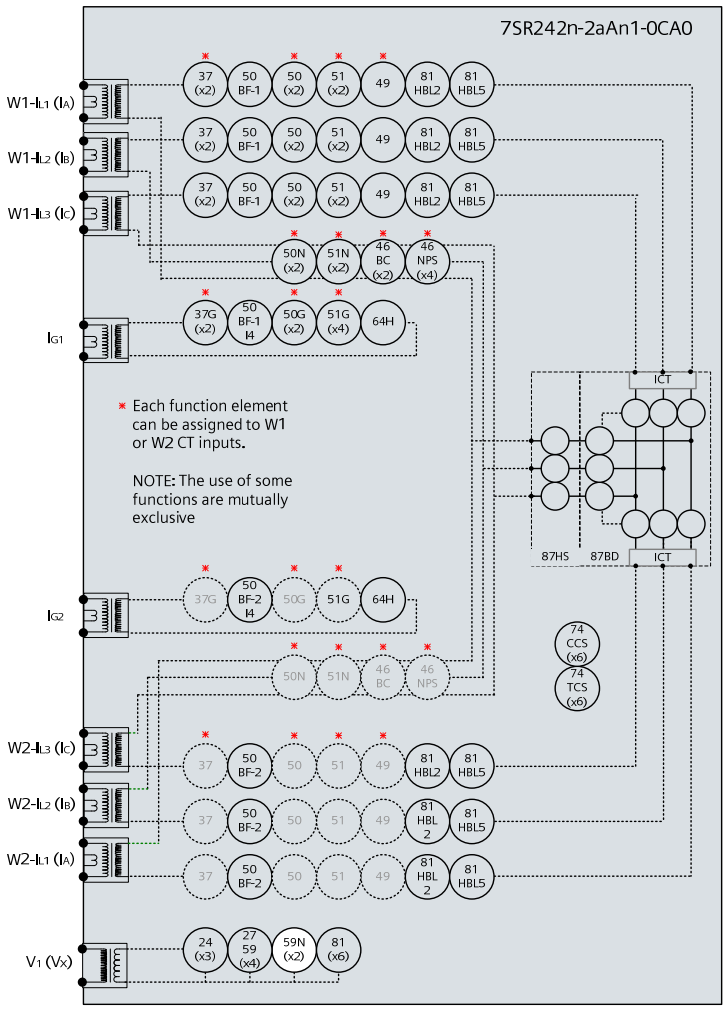

Figure 2-12 Neutral Overvoltage

Voltage Inputs:	V_1 (V_X)
Current Inputs:	n/a apply zero current to stabilize other functions
Disable:	27/59
Map Pickup LED:	59N-n - Self Reset

2.10.1 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	Vs (Volts)	DTL (sec)	P.U. Current Volts	Operate Time 2 x Vs	NOTES
$V_1(V_X)$					

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

2.10.2 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:

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

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

Ph.	Vs (V)	TM	Operate Voltage		Operate Time		NOTES
			P.U. (Volts)	D.O. (Volts)	2 x Vs (sec)	x Vs (sec)	
$V_1(V_X)$							

2.10.2.1 Element Blocking

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

Element	BI Inhibits
59NIT	
59NDT	

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

When testing is complete reinstate any of the disabled functions.

2.11 Under/Over Frequency (81)

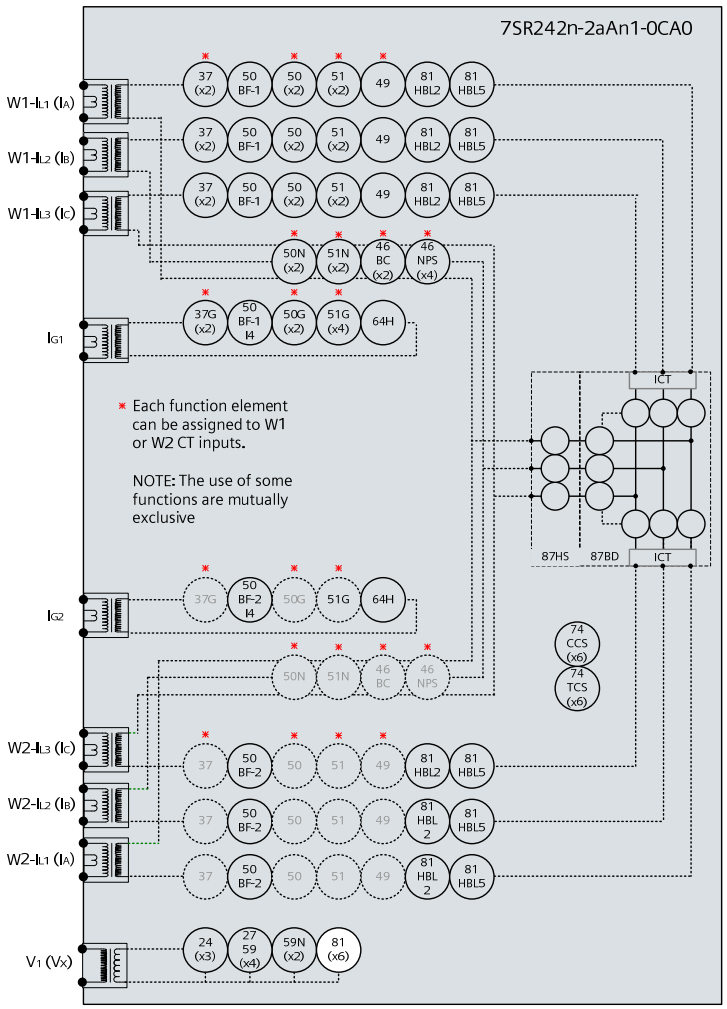

Figure 2-13 Under/Over Frequency

Voltage Inputs:	V_1 (V_X)
Current Inputs:	n/a apply zero current to stabilize other functions
Disable:	
Map Pickup LED:	81-n - Self Reset

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.

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

2.11.1.1 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	

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

When testing is complete reinstate any of the disabled functions.

2.12 Overfluxing (24)

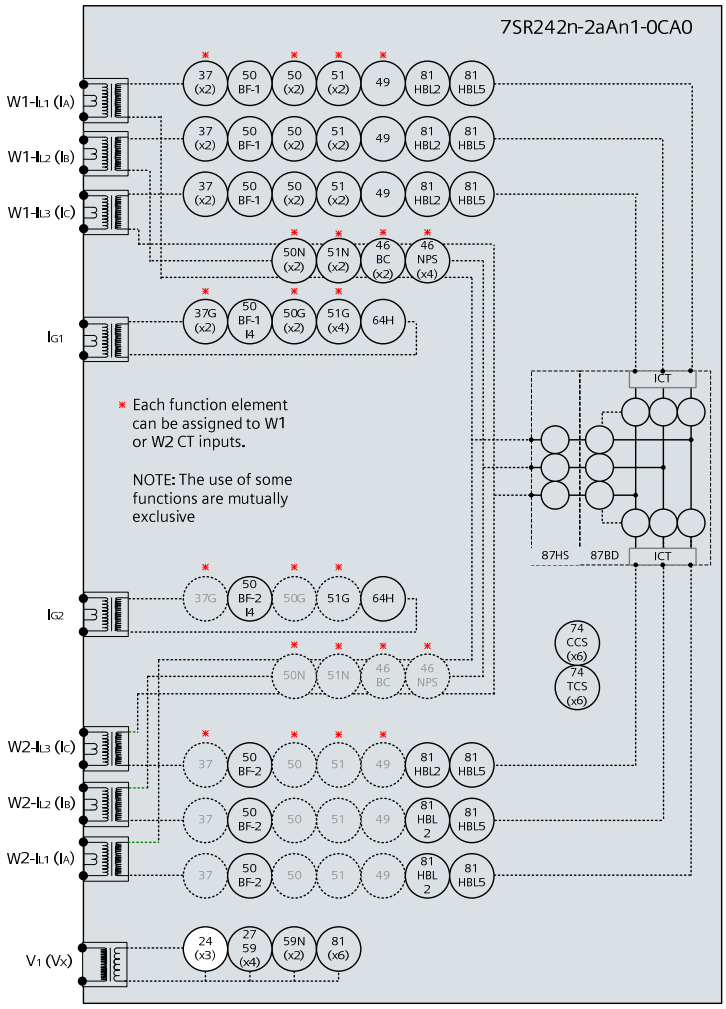

Figure 2-14 Under/Over Frequency

The settings are set in terms of V/f based on multiple of nominal voltage and frequency. Application of a voltage of nominal voltage and frequency represents 1.0.

Testing is simplified by applying nominal frequency and increasing voltage only, such that the operating level is simply the setting multiplied by *Nominal Voltage*.

2.12.1 definite time (24DT)

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

If DTL is large apply 0.95x setting, check for no operation, apply 1.05x setting, check operation

Apply 0.9x voltage, increase to 1.1x setting and record operating time

Setting (xVn)	Setting (volts)	Hysteresis (%)	Calculated D.O. (volts)	DTL Setting (sec)	P.U. Volts	D.O. Volts	Operate Time	NOTES

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

2.12.2 inverse time (24IT)

The inverse V/f element should be tested at each of the points specified by settings that constitute the overall inverse characteristics.

Setting (xVn)	Setting (volts)	Hysteresis (%)	Calculated D.O. (volts)	DTL Setting (sec)	P.U. Volts	D.O. Volts	Operate Time	NOTES
X0				Y0				

Setting (xVn)	Setting (volts)	DTL Setting (sec)	Operate Time	NOTES
X1		Y1		
X2		Y2		
X3		Y3		
X4		Y4		
X5		Y5		
X6		Y6		

Section 3: Supervision Functions

3.1 CB Fail (50BF)

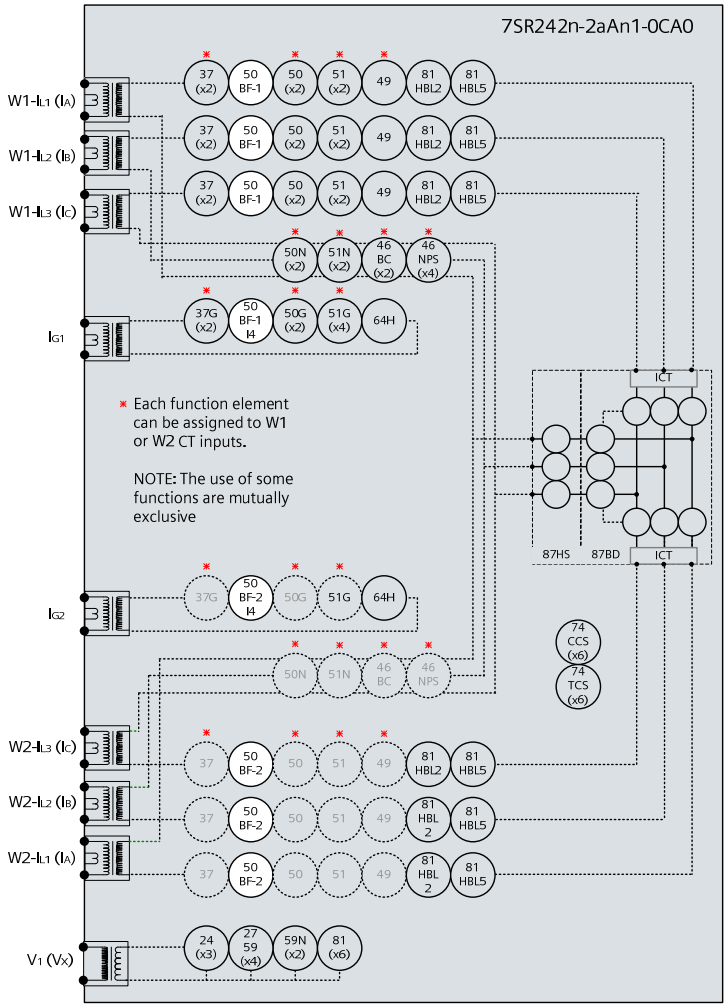

Figure 3-1 CB Fail

Voltage Inputs:	n/a
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), I_{G1} or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C), I_{G2}
Disable:	
Map Pickup LED:	50BF-n-n - Self Reset

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

A binary output mapped as **Trip Contact** in the OUTPUT CONFIG>BINARY OUTPUT CONFIG menu,

or

A binary input mapped as **50BF Ext Trip** in the INPUT CONFIG>INPUT MATRIX menu.

Or

A binary input mapped as **50BF Mech Trip** in the INPUT CONFIG>INPUT MATRIX menu.

These elements are operated from W1 and W2 current inputs, ensure that current is injected on the correct input for the element being tested.

Apply a trip condition by injection of current to cause operation of a suitable protection element. Allow current to continue after the trip at a level of 110% of the *50BF Setting* current level on any phase. Measure the time for operation of *50BF-1 Delay* and *50BF-2 Delay.* Repeat the sequence with the 50BF CB Faulty input energised and ensure the 50BF-1 and 50BF-2 outputs operate without delay, by-passing the timer delay settings.

Repeat the sequence with current at 90% of the *50BF Setting* current level after the element trip and check for no CB Fail operation.

Repeat the sequence by injecting the current to I4 and using the *50BF-I4 Setting.*

Setting (xIn)	**Test Current**	50BF-1 Delay……	50BF-2 Delay…….
50BF-1	(110%)…….		
	(90%)……..	No Operation □	No Operation □
	50BF CB Faulty	Operation No Delay □	Operation No Delay □
50BF-1-I4	(110%)…….		
	(90%)……..	No Operation □	No Operation □
	50BF CB Faulty	Operation No Delay □	Operation No Delay □
50BF-2	(110%)…….		
	(90%)……..	No Operation □	No Operation □
	50BF CB Faulty	Operation No Delay □	Operation No Delay □
50BF-2-I4	(110%)…….		
	(90%)……..	No Operation □	No Operation □
	50BF CB Faulty	Operation No Delay □	Operation No Delay □

If the circuit breaker can also receive a trip signal from a protection function where there is no increase in current, this trip input should be mapped to **50BF Mech Trip** in the INPUT CONFIG>INPUT MATRIX menu.

Initiate this binary input and simulate the circuit breaker remaining closed by ensuring the CB Closed binary Input is energised and ensure operation of the 50BF-1 and 50BF-2 outputs after their programmed delays.

Mech Trip		50BF-1 Delay……	50BF-2 Delay…….
50BF-1	CB Closed		
	CB Open	No Operation □	No Operation □
50BF-2	CB Closed		
	CB Open	No Operation □	No Operation □

3.1.1.1 Element Blocking

The CB Fail function can be blocked by Binary Input Inhibit. This functionality should be checked.

Element	BI Inhibits	NOTES
50BF-1		
50BF-2		

3.2 Trip/Close Circuit Supervision (74TCS, 74CCS)

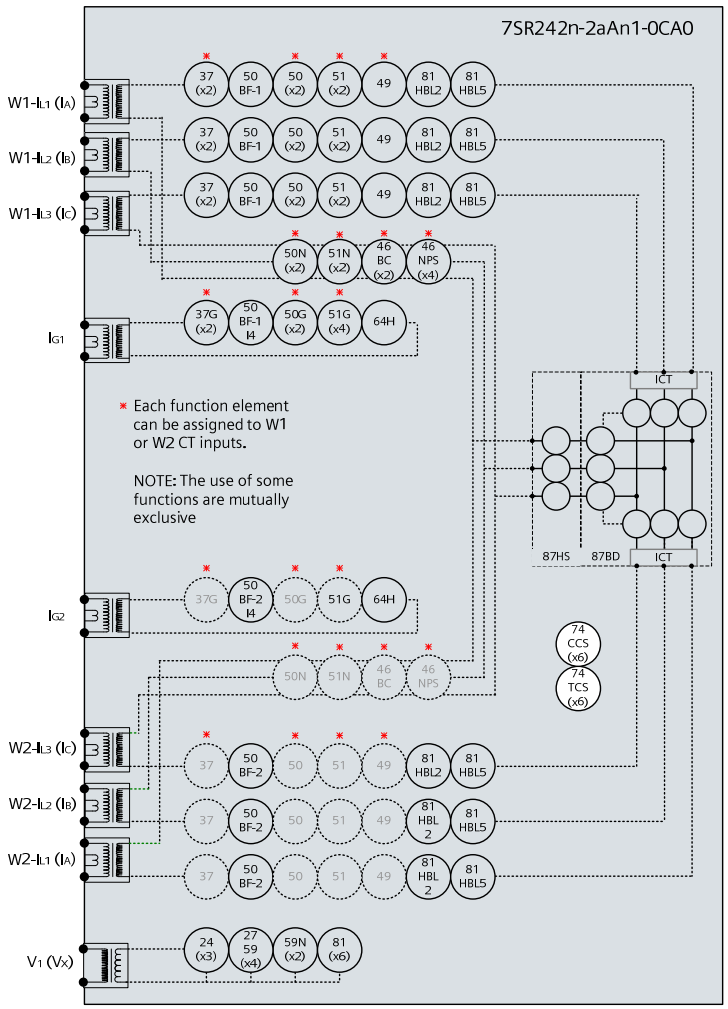

Figure 3-2 Trip Circuit Supervision

Voltage Inputs: n/a

Current Inputs: n/a

Disable:

Map Pickup LED: 74TCS-n/74CCS-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**

3.3 Magnetising Inrush Detector (81HBL2)

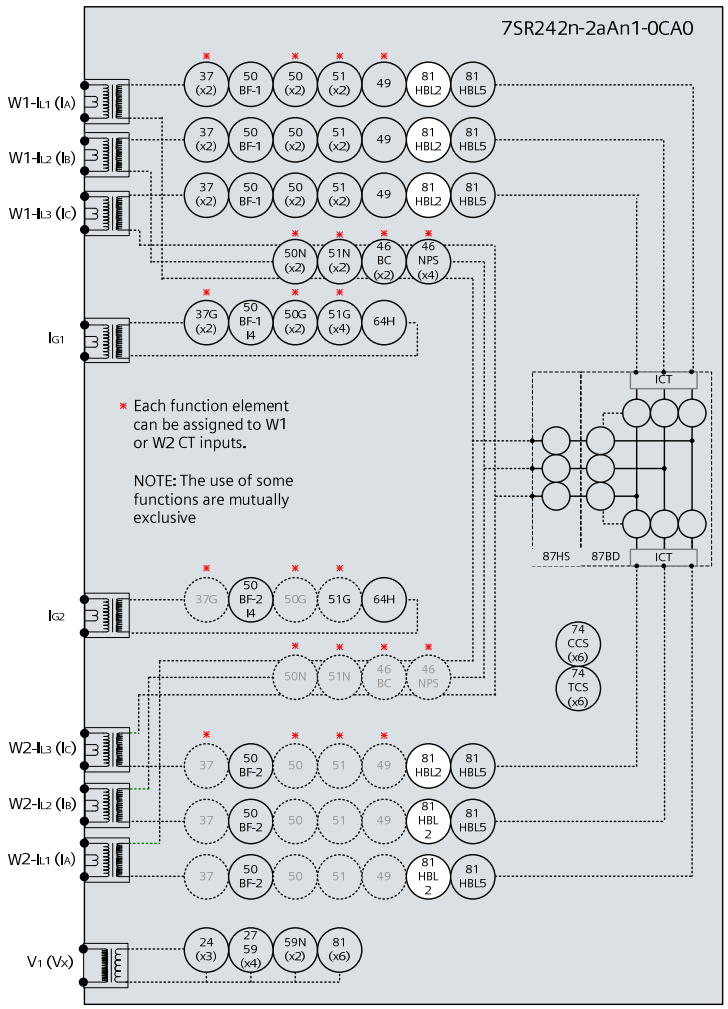

Figure 3-3 Magnetising Inrush Detector

Voltage Inputs:	n/a
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C)
Disable:	
Map Pickup LED:	

Logical operation of the harmonic blocking can be tested by injection of 2nd harmonic current (at 100Hz for 50Hz relay) to cause operation of the blocking signals. Note that injection of any level of 2nd harmonic alone on a current input will cause the block to be raised if the Cross or Phase blocking method is used since the harmonic content on this input is 100%, i.e. greater than setting. Full wave rectified current contains mostly 2nd harmonic and is the traditional method to generate it without advanced equipment.

If the Cross or Sum Blocking methods are used, fundamental frequency current can be injected into the other winding simultaneously to operate protection elements if required to test the blocking operation. Care should be taken that the thermal limits of the relay are not exceeded during these tests.

More advanced test equipment is required, with the facility to combine harmonic and fundamental frequencies of current, to test the accuracy of setting for current level of the blocking element. Note that the *81HBL2 Setting* is set as a fraction of the total current. e.g. 0.25A at 100Hz combined with 1A at 50Hz gives a 2nd harmonic content of 0.2 i.e. (0.25/(0.25+1.0)).

A compromise test can be made by the use of a diode to generate a half-wave rectified waveform from a sinusoidal source. The half-wave rectified current will contain a combination of fundamental and harmonic currents. The rectified waveform contains even harmonics higher than 2nd but the relationship between the 2nd harmonic current content, the fundamental component and the total RMS current is as shown below. Note that some protection elements can be set to operate on the RMS current or the Fundamental current and the applied values are different when non-sinusoidal waveforms are applied. The Inrush Detector setting is based on the ratio of 2nd harmonic to fundamental. This method is not suitable for use with constant current generating test sets such as modern digital equipment.

	Full Sine RMS	Rectified RMS Current	Fundamental component	2nd Harmonic component	2nd/Fundamental
Half Wave Rectified	1.0	0.5	0.5	0.212	0.424

Assuming that the *Gn 81HBL2 Setting* is less than 40%, inject half-wave rectified current at an RMS or Fundamental component level above the element setting to prove that the block is applied and the element is stable. Care should be taken that the thermal limits of the relay are not exceeded during these tests.

3.4 Overfluxing Detector (81HBL5)

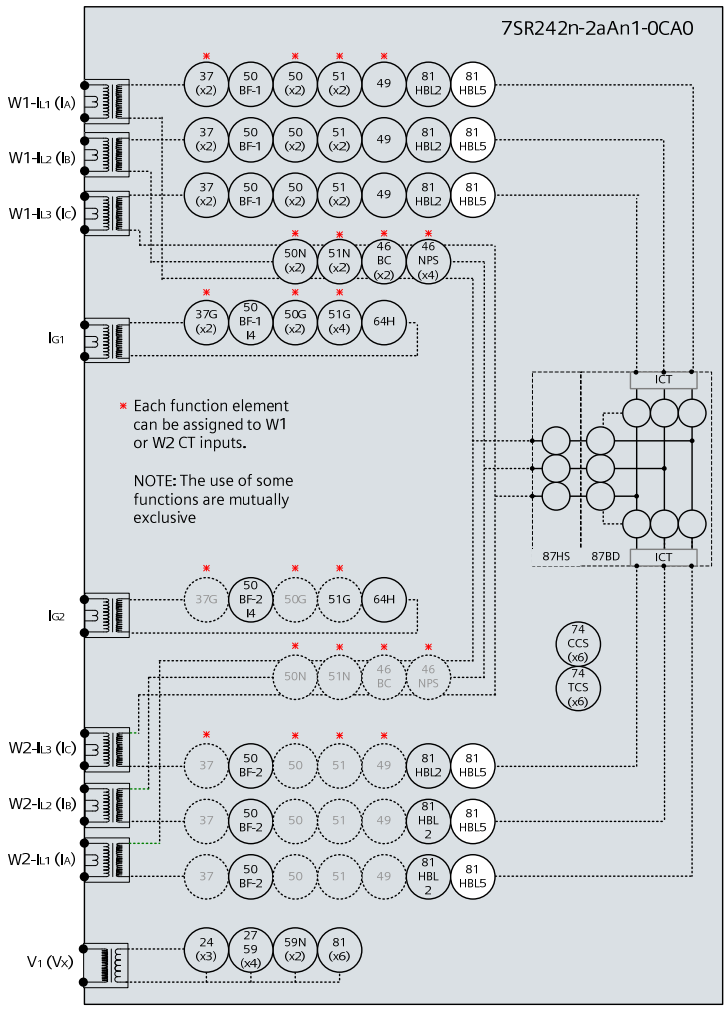

Figure 3-4 Magnetising Inrush Detector

Voltage Inputs:	n/a
Current Inputs:	W1-I_{L1} (I_A), W1-I_{L2} (I_B), W1-I_{L3} (I_C), or W2-I_{L1} (I_A), W2-I_{L2} (I_B), W2-I_{L3} (I_C)
Disable:	
Map Pickup LED:	

Logical operation of the harmonic blocking can be tested by injection of 5th harmonic current (at 250Hz for 50Hz relay) to cause operation of the blocking signals. Note that injection of any level of 5th harmonic alone on a current input will cause the block to be raised since the harmonic content on this input is 100%, i.e. greater than setting.

Fundamental frequency current can be injected into the other winding simultaneously to operate the 87BD or 87HS protection elements if required to test the blocking operation. Care should be taken that the thermal limits of the relay are not exceeded during these tests.

More advanced test equipment is required, with the facility to combine harmonic and fundamental frequencies of current, to test the level of the blocking element. Note that the *81HBL5 Setting* is set as a fraction of the total current. e.g. 0.25A at 250Hz combined with 1A at 50Hz gives a 5th harmonic content of 0.2 i.e. (0.25/(0.25+1.0)).

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.

Section 5: Testing and Maintenance

7SR24 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:-

1. Visual inspection of the metering display
2. Operation of output contacts
3. 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 the nearest Siemens office) 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 dismantle 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 withdrawable relay should never be transported without the protection of the outer case.

5.3 Troubleshooting

Table 5-1 Troubleshooting Guide

Observation	Action
Relay does not power up.	Check that the correct auxiliary 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).

Observation	Action
Cannot communicate with the relay.	Check that all of the communications settings match those used by ReyDisp Evolution. Check that the Tx and Rx fibre-optic cables are connected correctly. (Tx –> Rx and Rx –> Tx). Check that all cables, modems and fibre-optic cables work correctly. Ensure that IEC 60870-5-103 is specified for the connected port (COM1, COM2, COM3 or COM4).
Relays will not communicate in a ring network.	Check that the Data Echo setting on all relays is set to ON. 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.

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 5247000,

Fax: +49 180 524 2471,

e-mail: support.energy@siemens.com.

5.4 Defect Report Form

Form sheet for repairs and returned goods (fields marked with * are mandatory fields)

Sender:

*** Name, first name:**	Complete phone number (incl. country code):	Complete fax number (incl. country code):
Email address:	*** Org-ID and GBK reference:**	*** AWV:**

*** Order-/ reference-no (choosing at least 1 option):**

Order-no for repair:	order-/ delivery note-no for return of commission failure:	Beginning order-no for credit note demand:

Information concerning the product and its use:

*** Order Code (MLFB):**	Firmware version: V		*** Serial number:**
* Customer:	Product was in use approximately since:	Station/project:	Hotline Input no.:
Customer original purchase order number:	Delivery note number with position number:	Manufacturer:	

*** Type of order (choosing at least 1 option):**

☐ Repair	☐ Return of commission failure	☐ Credit Note
☐ Upgrade / Modification to …	☐ Warranty repair	☐ Quotation (not repair V4 and current products! See prices in PMD)
	☐ For collection	

Type of failure:

☐ Device or module does not start up	☐ Mechanical problem	☐ Overload	
☐ Sporadic failure	☐ Knock sensitive	☐ Transport damage	
☐ Permanent failure	☐ Temperature caused failure	☐ Failure after ca	☐ hrs in use
☐ Repeated breakdown	☐ Failure after firmware update		

Error description:

☐ Display message:
(use separated sheet for more info)

☐ Active LED messages:

☐ Faulty Interface(s), which? ☐ Wrong measured value(s), which? ☐ Faulty input(s)/output(s), which?

***Detailed error description** (please refer to other error reports or documentation if possible):

*** Shall a firmware update be made during repair or mechanical upgrade of protective relays? (choosing at least 1 option)**

☐ Yes, to most recent version ☐ No ☐ Yes, actual parameters must be reusable

repair report:

☐ Yes, standard report (free of charge) ☐ Yes, detailed report (charge: 400EUR)

Shipping address of the repaired/upgraded product:

Company, department

Name, first name

Street, number

Postcode, city, country

Date, Signature

E D EA MF TCC 6 release from 11/2009

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