

MSCDN – MP1

Capacitor unbalance protection

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2010/02	Document reformat due to rebrand
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12/02/2003	R1 Revision History Added. First Issue.

Software Revision History

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1. Introduction

These commissioning recommendations apply to the testing, putting into service and subsequent maintenance of MSCDN-MP1 (**Modular II**) series integrated capacitor bank protection.

A software program called Reydisp Evolution is available for download from the www.siemens.com/energy website. This allows access to settings, waveform records and event records via relay communications with an IBM PC compatible computer.

Before starting the test procedures, the protection settings, the D.C. inputs, output relay configuration details must be available. This requires the following information: Capacitor Bank current rating, nominal Spill currents and the C.T. ratios. The Overall Differential protections setting must also have been determined using the calculated performance for stability and sensitivity.

It is recommended that use is made of all the tables provided so that a comprehensive record of the protection settings, as commissioned, is available for reference.

2. 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.

3. Sequence of Tests

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

When cabling and wiring is complete, a comprehensive check of all terminations for tightness and compliance with the approved diagrams must be carried out. This can then be followed by the insulation resistance tests, which if satisfactory allows the wiring to be energised by either the appropriate supply or test supplies. When injection tests are completed satisfactorily, all remaining systems can be functionally tested before the primary circuit is energised. Some circuits may require further tests, e.g synchronising before being put on load.

4. Test Equipment Required

Various test sets designed for protection testing can be used to test the relay providing these provide the required current source with sinusoidal waveform within practical limits.

Test currents of the following range are required:

Testing of the C1/C2 Unbalance elements requires a minimum of 2 sources to be applied simultaneously, however 3 sources may be connected in such a way as to make testing of this element easier.

Overall Differential	Both up to I_N
C1/C2 Unbalance Reference	up to $2.5 \times I_N$
C1/C2 Unbalance Spill	up to $2.5 \times I_N$
Phase Unbalance	up to $2.5 \times I_N$

Where I_N is the relay nominal current rating being used.

The basic test equipment for primary and secondary injection test is as follows:

- a) A digital test set capable of at least 2 x three phase current injection. The set must be capable of injecting at least 4 x the rated current on any of the relay inputs. For relay models with voltage inputs the amplifiers need to be reconfigured for voltage output.
- b) 1 - 500V insulation resistance test set.
- c) 1 – Digital Multimeter
- d) Laptop PC to drive the test set and the Reydisp Evolution relay software.
- e) 500volt Variac to measure CT magnetizing characteristics and inject the Restricted Earth Fault elements.
- f) Primary test leads and injection set.

Suitable primary injection connectors and secondary injection test plugs and leads and a suitable a.c supply may be required and must be suitable for the site concerned.

When making secondary injection tests ensure that the test circuit is earthed at one point only.

5. Insulation Resistance Test

Before commencing to inspect the wiring take the following precautions:

Isolate the auxiliary supplies
Remove the trip and inter-trip links

Check that the relay wiring is complete and that all terminal connections are tight and remove the C.T. earth link for the insulation resistance tests.

Measure the insulation resistance between each section of the wiring and the other sections connected together and to earth.

The sections comprise:

- a) C.T. secondary wiring connected to module AN1
- b) C.T. secondary wiring connected to module AN2
- c) C.T. secondary wiring connected to module AN3
- d) C.T. secondary wiring connected to module AN4
- e) D.C. wiring connected to PSU and I/O modules, excluding power supply wiring to the PSU Module.

Before testing the D.C. wiring to earth, apply test connections between suitable points to short circuit each status input and series resistor to avoid possible damage to the opto-coupler should the wiring be earthed.

- f) Test the power supply wiring to module PSU separately. Note that the D.C. +ve and D.C. -ve are each connected to earth by surge capacitors.

Record the results in Table 1 - Insulation Resistance Values.

Wiring Section	Resistance MegaOhms
AN1 C.T.'s to earth and other circuits	
AN2 C.T.'s to earth and other circuits	
AN3 C.T.'s to earth and other circuits	
AN4 C.T.'s to earth and other circuits	
D.C. Wiring to Earth and other circuits	
Power Supply wiring to earth	

Table 1 - Insulation Resistance Values

Insulation resistance values that are considered satisfactory must depend upon the amount of wiring involved. Generally, where a considerable amount of multi-core wiring is included, a reading of 2M ohms to 3M ohms is reasonable, For short lengths of wiring on a panel, higher readings should be expected. A reading of 1M ohm should not normally be considered satisfactory.

6. Check of C.T. and Secondary Wiring Resistance

This test is to be applied to each of the Overall Differential protections.

Isolate the auxiliary supplies
Remove the trip and inter-trip links

Refer to the calculated performance data for the Overall Differential. This will give the maximum permissible lead resistance values.

Measure the resistance of the wiring between the relay equipment and the C.T.'s. The readings obtained should be recorded. These should be approximately equal to or less than the values used in the calculated settings for the Overall Differential elements.

Wiring Section	Resistance Ohms
AN1C1 (Overall Differential 1 Phase A)	
AN1C2 (Overall Differential 1 Phase B)	
AN1C3 (Overall Differential 1 Phase C)	
AN2C1 (Overall Differential 2 Phase A)	
AN2C2 (Overall Differential 2 Phase B)	
AN2C3 (Overall Differential 2 Phase C)	
AN1C4 (Ia Reference)	
AN2C4 (Ib Reference)	
AN3C4 (Ic Reference)	
AN3C1 (C1 Spill Phase A)	
AN3C2 (C1 Spill Phase B)	
AN3C3 (C1 Spill Phase C)	
AN4C1 (C2 Spill Phase A)	
AN4C2 (C2 Spill Phase B)	
AN4C3 (C2 Spill Phase C)	

Table 2 – Lead Resistance Values

7. Power Supply

Remove the relay front cover to give access to all the fascia push buttons. Relays are provided with a power supply suitable for one of the standard auxiliary supply ratings of 30V, 48V, 110V, 220V D.C. Ensure that the actual supply is the same as the relay rating as marked on the fascia. Ensure the polarity of the supply is correct before energising the relay. Note, the minimum recommended fuse rating of the supply is 6 A slow-blow or 12 A HRC fuse. Note that the relay D.C. status inputs are current rated.

With the relay energised the green LED will provide a steady illumination, all the red LEDs should be out. Operate the TEST/RESET button and check that all the red LEDs are illuminated while the push is depressed.

8. Programming the Relay

The relay can either be set using the fascia buttons or from a laptop PC running Reydisp Evolution. Due to the number of possible settings, it is recommended that the laptop method be used for speed and ease of commissioning.

8.1 Setting by Laptop

The relay is supplied with an RS232 port on the front of the fascia. This should be connected to a laptop using a 25 to 9 way RS232 cable. Reydisp Evolution should be installed – this will run on any MS Windows © operating system.

To access the relay communications port the Communications Settings in the relays must match the settings Communications settings selected in the Reydisp Evolution software.

To change the communications settings on the relay use the following procedure. On the relay fascia, keep tapping the \downarrow key until the COMMUNICATIONS MENU is displayed on the relay LCD. Press the TEST/RESET \Rightarrow once to bring up the STATION ADDRESS on the LCD. Press the ENTER button to alter the address to any desired number between 1 and 254. Set each relay to a unique number in the substation. The relays address and the relay address must be set identically. The relay address can be changed by tapping the \downarrow or \uparrow buttons. Press ENTER to register the selected number.

Continue to scroll down and set IEC 870 ON PORT to COM2 (front RS232 and bottom rear fibre ports are COMM 3 relay ports) and set AUTO DETECT to ON. The Auto Detect feature will automatically switch the active port to the front RS232 from the bottom rear fibre port when connection is made.

Ensure that the Communications baud rate and parity check settings on the Reydisp Evolution software running on laptop and Relay are the same. It is advisable to select the maximum baud rate on the relay and Reydisp Evolution, as this speeds up response times.

The communications setting can be changed in Reydisp Evolution by selecting: OPTIONS -> COMMUNICATIONS. This window displays the active part of the laptop. Select "OK" when changes are complete. Set the address on Reydisp Evolution to be the same as the relay station address.

Check the communications link by retrieving the relay settings (Relay->Settings->Get Settings)

Reydisp Evolutions allows off line generation of relay setting by saving the relay Settings File and then downloading it. This saves time and possibly sore fingers if the relay type is a more advance model with many protection functions.

To download a Settings File On the laptop, select Relay->Settings->Send All Settings. Confirm the action and the program will inform whether the settings have been successfully entered into the relay. It is worth doing a few spot checks on the setting to be confident the correct setting are installed.

8.2 Setting via Relay Fascia

The relay can be set from the fascia by utilising the \uparrow , \downarrow , \Rightarrow and ENTER buttons. Settings can be selected with the arrow buttons. Pressing ENTER when the setting to change is found will make the setting flash. This allows the \uparrow and \downarrow buttons to be used to alter the setting. Once the desired setting is selected the ENTER pushbutton MUST be pressed for the relay to active the selected setting. The setting will now stop flashing indicating this value will be utilised by the relay software.

The menu structure is shown in the "Description of Operation " section of this manual.

9. Secondary Injection Tests

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

We recommend the use of an Omicron Test Set Type CMA156. The Omicron set should be connected in accordance with the manufacturer's instructions.

By default all protection elements are disabled, however if this is not the case, then disable all protection and alarm elements.

9.1 Accuracy of Measurement

Inject all of the current inputs with nominal current in turn, and record the following currents measured by the relay in Table 3 – Accuracy of Measurement.

Tap \downarrow to select: -

e.g. Diff1 Currents
0.00 0.00 0.00 x I_n

Use \downarrow and \uparrow to select the current measured by each of the inputs injected: -

e.g. Diff2 Currents
0.00 0.00 0.00 x I_n

If the relay measurement is within tolerance proceed to 9.2 below. If any of the measurements are outside the stated tolerance ($\pm 5\%$) the relay must be sent back to the Quality Assurance Department for investigation.

Meter	A	B	C
Diff1 Currents	A xIn	B xIn	C xIn
Diff2 Currents	A xIn	B xIn	C xIn
Reference Currents	A xIn	B xIn	C xIn
C1 Ia Spill	xIn	Angle	
C1 Ib Spill	xIn	Angle	
C1 Ic Spill	xIn	Angle	
C2 Ia Spill	xIn	Angle	
C2 Ib Spill	xIn	Angle	
C2 Ic Spill	xIn	Angle	
Residual Current	xIn		

Table 3 – Accuracy of Measurement

9.2 Checking the Overall Differential 1 Elements

When testing the Overall Differential 1 Element the Differential 1 Currents can be displayed on the LCD by changing to INSTRUMENTS mode and scrolling down to [Diff1 Currents]. Generally 87/50-1-1 is used for tripping with no time delay applied and 87/501-2 is used for CT supervision (broken CT connection) and is therefore set very low but with a 10 second time delay.

Connect a single phase current source to Phase A, see Table below :-

Phase	Unit	Connection	
		Start	Finish
A	AN1C1	17	18
B	AN1C2	21	22
C	AN1C3	25	26

Modify the following settings :-

Setting Description	Setting Value
87/50-1-1 Element	Enabled
87/50-1-1 Delay	0.1

Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
87/50-1-1 Setting	0.05		
87/50-1-1 Setting	0.10		
87/50-1-1 Setting	0.50		
87/50-1-1 Setting	0.90		

Table 4 – 87/50-1-1 Element PU/DO

Record the results and verify the accuracy complies with performance stated in the Performance Specification.

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Repeat Tests for connections to Phase B and C.

Modify the following settings :-

Setting Description	Setting Value
87/50-1-1 Element	Disabled
87/50-1-2 Element	Enabled
87/50-1-2 Delay	0.1

Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
87/50-1-2 Setting	0.05		
87/50-1-2 Setting	0.10		
87/50-1-2 Setting	0.50		
87/50-1-2 Setting	0.90		

Table 5 – 87/50-1-2 Element PU/DO

Record the results and verify the accuracy complies with performance stated in the Performance Specification.

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Repeat Tests for connections to Phase B and C.

9.3 Checking the Overall Differential 2 Elements

When testing the Overall Differential 2 Element the Differential 2 Currents can be displayed on the LCD by changing to INSTRUMENTS mode and scrolling down to [Diff2 Currents].

Connect a single phase current source to Phase A, see Table below :-

Phase	Unit	Connection	
		Start	Finish
A	AN2C1	17	18
B	AN2C2	21	22
C	AN2C3	25	26

Modify the following settings :-

Setting Description	Setting Value
87/50-2-1 Element	Enabled
87/50-2-1 Delay	0.1

Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
87/50-2-1 Setting	0.05		
87/50-2-1 Setting	0.10		
87/50-2-1 Setting	0.50		
87/50-2-1 Setting	0.90		

Table 6 – 87/50-2-1 Element PU/DO

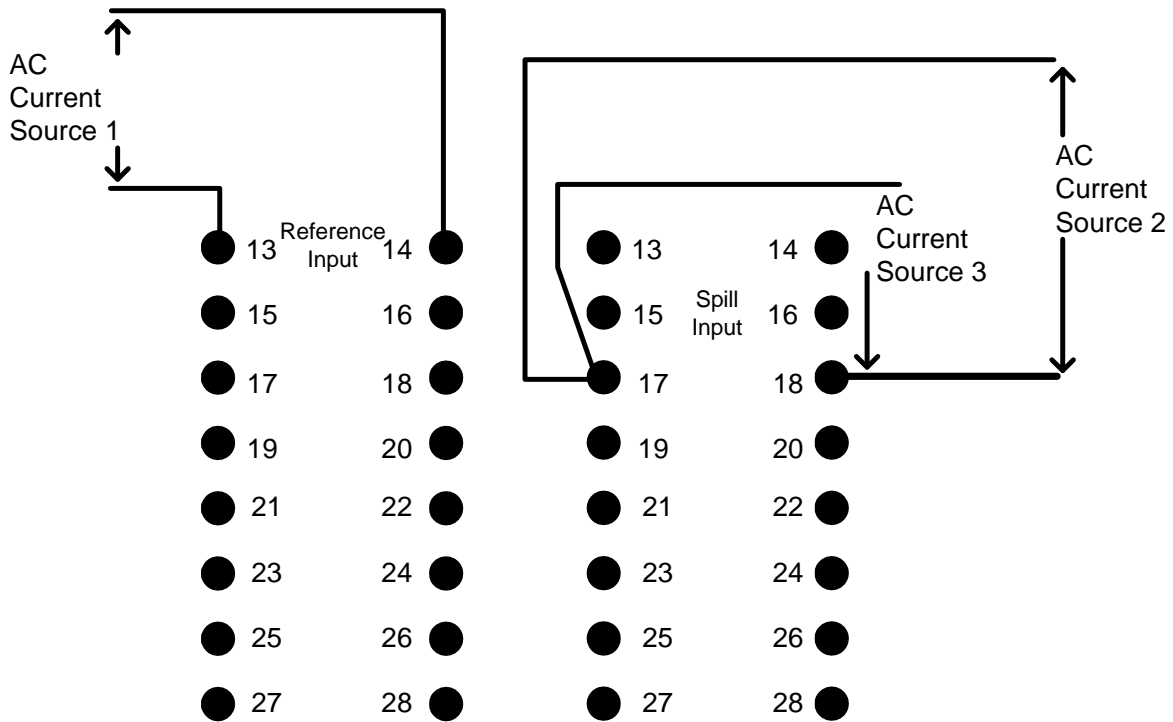
Record the results and verify the accuracy complies with performance stated in the Performance Specification.

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Repeat Tests for connections to Phase B and C.

Modify the following settings :-

Setting Description	Setting Value
87/50-2-1 Element	Disabled
87/50-2-2 Element	Enabled
87/50-2-2 Delay	0.1



Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
87/50-2-2 Setting	0.05		
87/50-2-2 Setting	0.10		
87/50-2-2 Setting	0.50		
87/50-2-2 Setting	0.90		

Table 7 – 87/50-2-2 Element PU/DO

Record the results and verify the accuracy complies with performance stated in the Performance Specification.

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Repeat Tests for connections to Phase B and C.

9.4 C1 Unbalance (C1 50-2 Element)

With Reference to the connection diagram and table below :-

Figure 1 – C1 Unbalance Test Connection Diagram

Phase	Reference			Spill		
	Unit	Start	Finish	Unit	Start	Finish
A	AN1C4	13	14	AN3C1	17	18
B	AN2C4	13	14	AN3C2	21	22
C	AN3C4	13	14	AN3C3	25	26

Note:- Current Sources 1, 2 and 3 must be synchronised

Connect the current sources as described for Phase A.

Modify the following Settings :-

Menu	Setting Description	Setting Value
C1 UNBALANCE MENU	C1 50-2 Element	Enabled
C1 UNBALANCE MENU	C1 50-2 Delay	0.1

Using Table 4 – 87/50-1-1 Element PU/DO apply the necessary settings and determine the PU and DO of the element.

Settings				Current Sources						
CAPACITOR CONFIG MENU	C1 UNBALANCE MENU			Source 1		Source 2		Source 3		
Reference	Spill	Angle	C1 50-1 Setting	Magnitude	Angle	Magnitude	Angle	PU	DO	Angle
1.0	0.50	0	0.20	1.0	0	0.50	0			0
0.8	0.20	90	0.10	0.8	0	0.20	90			90
0.7	0.10	180	0.10	0.7	0	0.10	180			180
0.6	0.05	-90	0.05	0.6	0	0.05	-90			-90

Table 8 - C1 50-1 Unbalance Tests

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Return all settings to their original configuration.

Repeat for Phases B and C.

Return all settings to their default values.

9.5 C2 Unbalance (C2 50-2 Element)

With Reference to the connection diagram and table below :-



Figure 2 – C2 Unbalance Test Connection Diagram

Phase	Reference			Spill		
	Unit	Start	Finish	Unit	Start	Finish
A	AN1C4	13	14	AN3C1	17	18
B	AN2C4	13	14	AN3C2	21	22
C	AN3C4	13	14	AN3C3	25	26

Note:- Current Sources 1, 2 and 3 must be synchronised

Connect the current sources as described for Phase A.

Modify the following Settings :-

Menu	Setting Description	Setting Value
C2 UNBALANCE MENU	C2 50-2 Element	Enabled
C2 UNBALANCE MENU	C2 50-2 Delay	0.1

Using Table 9 - C2 50-1Unbalance Tests apply the necessary settings and determine the PU and DO of the element.

Settings				Current Sources							
CAPACITOR CONFIG MENU	C2 UNBALANCE MENU			Source 1		Source 2		Source 3			
	Reference	Spill	Angle	C2 50-1 Setting	Magnitude	Angle	Magnitude	Angle	PU	DO	Angle
	1.0	0.50	0	0.20	1.0	0	0.50	0			0
	0.8	0.20	90	0.10	0.8	0	0.20	90			90
	0.7	0.10	180	0.10	0.7	0	0.10	180			180
	0.6	0.05	-90	0.05	0.6	0	0.05	-90			-90

Table 9 - C2 50-1Unbalance Tests

Verify the correct operation of the Trip Relays RL4, RL5 and the LED indication.

Return all settings to their original configuration.

Repeat for Phases B and C.

Return all settings to their default values.

9.6 Phase Unbalance (50n Element)

Connect the relay as shown below :-

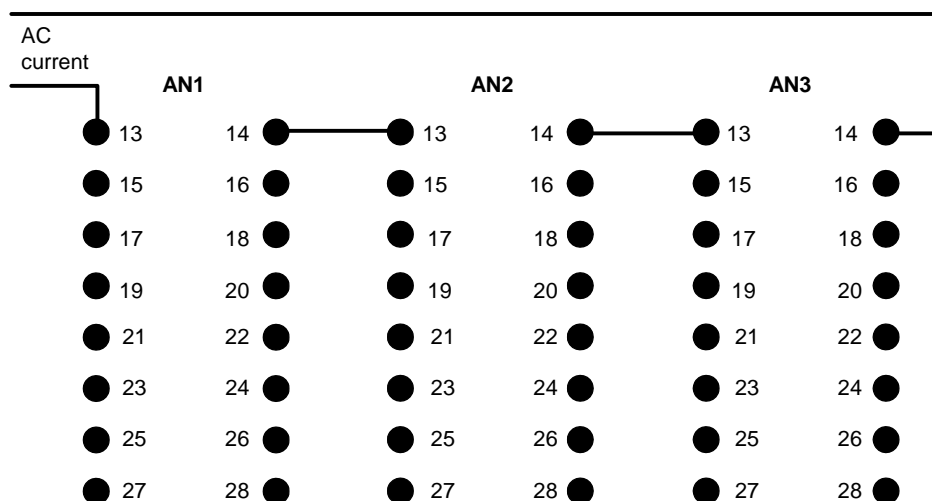


Figure 3 – Phase Unbalance Test Connection Diagram

Modify the following Settings :-

Menu	Setting Description	Setting Value
PHASE UNBALANCE MENU	50N Element	Enabled
PHASE UNBALANCE MENU	50N Delay	0.1

Modify the operate setting and determine the PU and DO at each setting :-

Setting Description	Setting Value	PU	DO
50N Setting	0.60		
50N Setting	0.90		
50N Setting	1.20		
50N Setting	1.50		

Note:- Since the applied 3 phase currents are in phase then the PU and DO levels will be approximately a third of the setting value.

Record the results and verify the accuracy is 5%.

Verify the correct operation of the Output Relay RL6 and the LED indication.

Return all settings to their default values.

10. Primary Injection Tests

Primary injection tests are required to prove the CT ratio and secondary connections to the relay. A polarity test is required for this relay, but only in respect of the phase relationship between the Phase Reference inputs and the corresponding C1 and C2 Spill inputs.

Reference Currents	A xIn	B xIn	C xIn
C1 Ia Spill	xIn	Angle	
C1 Ib Spill	xIn	Angle	
C1 Ic Spill	xIn	Angle	
C2 Ia Spill	xIn	Angle	
C2 Ib Spill	xIn	Angle	
C2 Ic Spill	xIn	Angle	

Table 10 – Primary Injection Test Results

Inject using a primary injection test set and record and verify the expected levels on the instruments on the relay, the Reference Currents and corresponding Spill current will be in phase when the Spill Angle is zero.

11. Fault Setting Tests

Fault setting tests use primary injection testing to verify the protection settings, they can conveniently be combined with the current transformer ratio and polarity tests in section 10.1.

Isolate the auxiliary d.c. supplies for trip and alarm, remove the Trip and Intertrip links. Use the test circuit shown in Fig 8. Inject primary current and record the values at which the relay operates. Relay operation is indicated by LEDs 2,3 and 4. Check the operation of all the output relays selected for this function, i.e. HV Trip, LV Trip and alarm(s) functions.

The LEDs that operate for the phase-to-phase injection will depend on the vector group compensation setting. e.g.

11.1 Overall Differential 1 & 2 Protections

Isolate the auxiliary d.c. supplies for trip and alarm and remove the Trip and Intertrip links.

Check that the setting resistor is the correct ohmic value, also that the correct Overall Differential 1 & 2 settings are selected.

Measure the primary current for operation of the 87/50-X-1 and 87/50-X-2 elements and record the value obtained.

12. Tripping and Intertripping Tests

Re-connect the auxiliary d.c. supplies for trip and alarm operations and insert the Trip and InterTrip links.

Simulate the operation of each external contact that initiates a status input and in each case check that appropriate LED illuminates and that the correct tripping, intertripping and alarm initiation occurs.

Disconnect the d.c. power supply to the relay and check for correct PROTECTION INOPERATIVE alarm. Operate all protection and alarm elements in turn by primary or secondary injection and check that the correct tripping and indication occurs.

13. Tests Using Load Currents

Isolate the auxiliary d.c. supplies for the trip and alarm functions.

Ensure that the relay is set the assigned settings for the capacitor bank installation.

Energise the Capacitor Bank.

Utilising the INSTRUMENT Displays verify the correct meter readings for each of the instruments, paying attention to the following :-

- Ensure all primary current displays are correct, thus verifying CT Ratio settings are correct.
- Ensure all secondary current displays are correct, thus verifying CT input settings are correct.
- Verify that there is minimal Diff1 Currents and Diff2 Currents displayed, thus verifying that the Overall Differential circuit is balanced.
- Verify that the Reference and Spill Currents correspond to those calculated for the capacitor bank.
- Verify that there is minimal C1 and C2 Operate Currents, thus verifying the C1 and C2 Unbalance settings.
- Verify that there is minimal Residual Current, thus verifying the Capacitor Bank is phase balanced.

14. Putting in to Service

Ensure that: The trip supply is connected.
All the RED LEDs are off
The GREEN LED is ON steady.

Ensure that all earth links, trip links and inter-trip links are in their normal operational positions.

Operate the Cancel PUSH BUTTON

Check that the LCD displays the screen below , or the 'Relay Identifier' set in the SYSTEM CONFIG MENU.

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Replace the cover. The above reading will remain for approximately 1 hour then the screen will go blank.