7SG18 Solkor N

Numeric Differential Protection

Document Release History

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

2010/02	Document reformat due to rebrand

Software Revision History

Contents

1 Required Test Equipment

- 500V Insulation resistance test set.
- Variable single or three phase secondary injection current source rated at greater than 10A. The amplitude must be adjustable.
- Time interval meter.
- Primary injection equipment up to circuit rating.
- 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. status input rating. Additional equipment for testing the communications channel:
- Portable PC with Reydisp Evolution v4.02 (or later) installed, pair of ST type fibre optics, Sigma 4 RS232/FO converter and RS232 lead. Alternative is USB to RS232 converter.
- Test Plugs suitable for panel mounted test sockets.

It is recommended the facilities afforded by Reydisp Evolution Software be used for relay setting and commissioning. Relays can be programmed and final settings applied, then saved as a setting file, before altering the settings during commissioning. These can then be downloaded back into the relays before the circuit is put back into service. See Section 2 of this manual for equipment required.

Settings file can be compared using Reydisp Evolution Software. This is done by opening two settings files to be compared and then selecting [Relay] [File compare]. Any differences are highlighted in a different colour.

2 Inspection

Ensure that all connections are tight and in accordance with the relay wiring diagram and the scheme diagram. Check the relay is correctly programmed and the relay is fully inserted into the case. Refer to the Description of Operation for programming the relay.

3 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. Note the tripping and alarm contacts must be programmed correctly before any scheme tests are carried out. See the Relay Settings section of this manual for the default values and settings advice.

The relay features eight alternative settings groups. 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.

When using settings groups, it is important to remember that the relay need not necessarily be operating according to the settings currently displayed. There is an 'active settings group' on which the relay will operate, and a separate selection for 'edit/view settings group' which is visible on the display. The displayed Settings Group can be altered. This allows the settings in one group to be altered 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 differential setting of a pair of relays, at either end of the feeder must remain identical at all times.

Elsewhere in the settings menu, the settings can be altered in the different groups. Each Settings Group is indicated by the symbols G1, G2 etc. in the top left of the display. Some settings are common to all groups, but all the protection settings can be set to different values. It is important to set the differential settings identically on each pair of relays.

4 Precautions

Before testing commences the equipment should be isolated from the current transformers and the CT's short circuited in line with the local site and safety procedures. The tripping and alarm circuits should also be isolated where practical. Busbar CT's should be shorted where necessary, to avoid primary injection operating busbar protection.

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

5 Insulation Tests

Connect together all of the C.T. terminals and measure the insulation resistance between these terminals and all of the other relay terminals connected together and to earth.

Connect together the terminals of the DC auxiliary supply circuit and measure the insulation resistance between these terminals and all of the other relay terminals connected together and to earth.

Connect together the terminals of the DC status input circuits and measure the insulation resistance between these terminals and all of the other relay terminals connected together and to earth.

Connect together the terminals of the output relay circuits and measure the insulation resistance between these terminals and all of the other relay terminals connected together and to earth. Satisfactory values for the various readings depend upon the amount of wiring concerned. Where considerable multi-core wiring is involved a reading of 2.5 to 3.0 megohms can be considered satisfactory. For short lengths of wiring higher values can be expected. A value of 1.0 megohm or less should not be considered satisfactory and should be investigated for insulation damage.

Remove temporary connections.

6 Injection Tests

It is imperative that the relay differential settings and software revisions are identical at all times, for each pair of relays protecting the feeder. The Software Revision can be checked by pressing [TEST/RESET] and [CANCEL] pushbuttons simultaneously, when the relay is displaying its identifier at the top of the menu structure. The Revision information is scrolled across the LCD. The latest Software code revision is R5 to which relays may be upgraded, to improve sensitivity for feeders with significant charging current.

6.1 Secondary Injection Tests

Select the required relay configuration and settings for the application. Note that the relay may be connected as either a 1A or 5A rated device. The user should check this before commencing secondary testing.

Reydisp Evolution software can be used to prepare a setting file to download into the relay, prior to commissioning. It is often useful to download the file again, at the end of the tests prior to putting the circuit into service.

It is important that relay elements are tested individually, as spurious results may be recorded if more than one element operates from an injection. Some functional elements may need to be set to 'OFF' or some may need to have pickup and time delay settings to be increased, to avoid simultaneous operation of relay functions.

6.1.1 Current Differential

It is only necessary to test the relay operation at the settings to be used. Apply the settings to the relay in accordance to the requirements for the circuit and scheme.

The differential elements can be tested for accuracy of current magnitude comparison with the relays in three different configurations:

a) Normal - with healthy communications between relays
b) Loop Test Mode – Single relay test without communications
c) Line Test Mode – Single relay test with communications.

The relays at both ends of the feeder should be tested using **one** of these modes. The injection will test the relay accuracy at differential setting (I_s). The differential pickup level should be approximately the Phase Fault differential setting applied to the relays. The results can be recorded in **Table 1** of the Sample Test Record below.

Note: Phase angle comparison cannot be tested by secondary injection. Refer to 6.2 – Primary Injection and load tests below.

a) Normal Connection

This test requires both relays to be powered up, settings applied and healthy communications channel. Inject single phase or three phase current into the current inputs of each relay in turn. Slowly increase the current until the TRIP LED (red) operates and record the pick-up current in **table 1** of the Sample Test Record at the end of his section. The remote relay will also operate on current differential as the relay can operate for a single end fed fault. Reduce the current and record the drop off level.

Check that all pick-up current levels are measured within 100% ± 10% for 1A rated inputs, and 100% ± 15% for 5A rated inputs, of the applied setting. Check that the reset levels are ≥95% of the measured pick-up value.

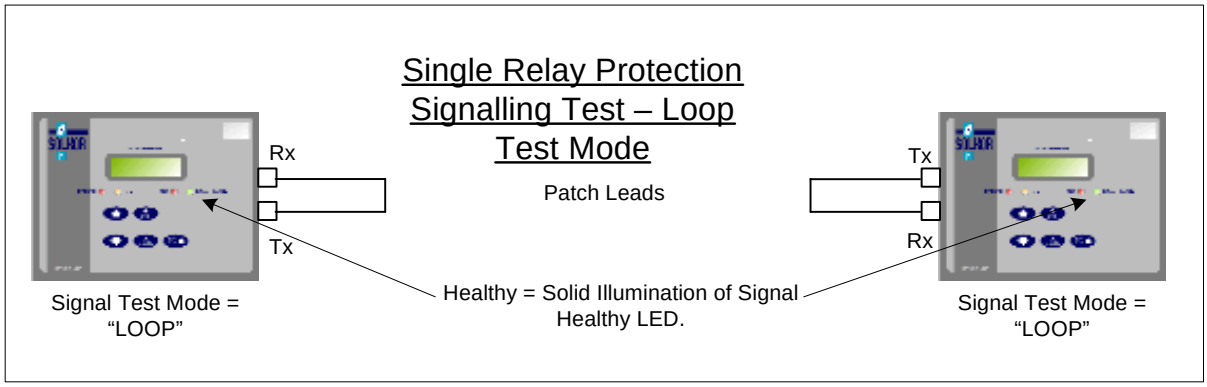
The stability of the differential protection system can only be checked when primary load current is applied, refer to item 6.3 below.

b) Loop Test Mode

A single relay can be tested on its own in this mode. To select this mode, press the [Down] arrow button on the relay until the PROTECTION SIGNALLING MENU appears, and select the Signal Test Mode to LOOP TEST using [ENTER] and [UP]/[DOWN] arrow keys.

The relay can be tested by connecting a single fibre optic between the Tx to the Rx ports on one relay. In this mode, the relay will test as a single end relay, as the received signal is ignored. Inject Current into the relay as above and record the pickup and drop-off values of current. Using this method it is only possible to check the P/F Differential Setting and perform a local end trip test.

The phase angle comparator cannot be tested using this method.



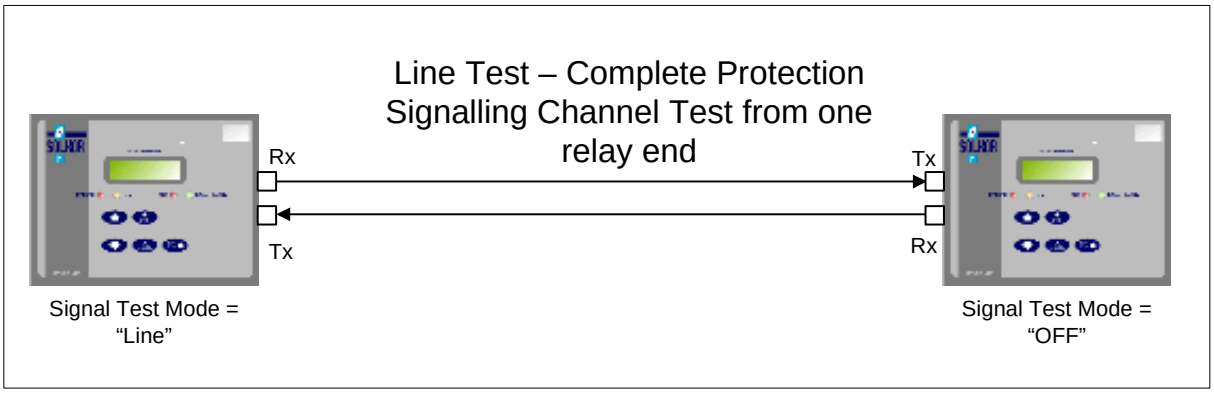
c) Line Test Mode

If the communications path exists and both relays are capable of being powered up, this method may be used. The whole communications channel can be checked from the Signal Healthy LED. It will be held illuminated if it is healthy. If an end to end communications problem exists, the Signal Healthy LED will flash constantly.

Connect relays at either end to the communications channel.

Set the relay required to be tested into LINE TEST mode, in the PROTECTION SIGNALLING MENU. Only one relay must be put in LINE TEST MODE at a time, as this enables a complete test of the signal path from one end of the feeder.

The relay in LINE TEST MODE can now be tested as in the LOOP TEST MODE, i.e. injection will simulate a single end fed fault. The pickup and drop-off accuracy of the differential elements of the relay in LINE TEST can performed in a similar way to the Loop test above. Only the relay injected will operate.



6.1.2 IDMTL/DTLOver Current and Earth Fault Pick-up and Reset

This test checks the accuracy of the pick-up and drop-off levels of the settings applied.

Inject single phase current into one of the current inputs. Slowly increase the current until the I>Is LED (yellow) operates and record the pick-up current in **Table 2** of the Sample Test Record. Reduce the current until the LED goes out, and record this as the reset level. Repeat this test for each current input.

Check that all pick-up current levels are measured within 105% ± 4% of the applied setting. Check that the reset levels are ≥95% of the measured pick-up value.

Note: Depending upon the applied settings a trip could occur if the current is on for longer than the relay operating time. This may be undesirable while measuring pick-up and reset levels. The fault trigger setting (in the data storage menu) can be used to disable trip indication temporarily during this test. Alternatively the Low and High Set elements can be temporarily turned off, in order to prevent unwanted instantaneous operations.

6.1.3 Overcurrent and Earth Fault IDMTL/DTL Timing Characteristics

This test checks the accuracy of the time delay characteristic (IDMTL/DTL) applied. Select the relay current setting, characteristic and time multiplier setting as required, and then inject a level of current which is a multiple of the relay setting.

The correct output contact must be programmed for the phase fault and earth fault elements. A time interval meter must be connected to the correct terminals. The timer should be started by the source and stopped by the trip contacts. Each current input should be tested. A secondary injection timing test circuit is illustrated in **Figure 1**.

The table below shows theoretical values for each characteristic curve with a time multiplier of 1.0. Record the actual results in **Table 3** of the Sample Test Record and check that the measured times lie within ±5% of the theoretical ones.

Curve	2X Is	5 X Is	10 X Is	20 X Is
NI	10.03	4.28	2.97	2.27
EI	26.67	3.33	0.81	0.20
VI	13.50	3.38	1.50	0.71
LTI	120.00	30.0	13.33	6.32
DTL	*	*	*	*

Timing characteristic (Time in seconds) *User setting

A specific operate times at set multiple of pickup, can be calculated using the IDMTL equations found in Section 2- Performance Specification.

6.1.4 Overcurrent and Earth Fault Lowset and HighSets – (DTL or Instantaneous Elements)

Two highsets and one lowset are available and any one of these instantaneous/DTL characteristics may be required depending on the application. The following tests should be applied to the functions in use.

The low/high set under test should be programmed to operate an output contact. That contact can then be monitored to detect operation of the protection.

Programme the current setting for the low/high set characteristic to the required level, and set its time delay to 0.00 sec. Inject a level of current below the setting of the relay, then increase the current until the output contact operates. Record the pick-up level of these elements in **Table 4, 5 or 6** and confirm that in each case it occurs within ±5% of the applied setting.

For high levels of current the thermal limit of the relay must not be exceeded. Refer to the performance specification for the relay which defines the thermal limits.

To test the operating time, a current of 5 times setting should be applied and the required time delay set on the relay. Output contacts for the high/low set must be programmed and a time interval meter connected to the correct terminals.

The timer should be started by the source and stopped by the High/Low set contacts. Each phase should be tested. For testing above this level then care must be taken to ensure that the test equipment has the required rating and stability and the relay is not stressed beyond its thermal limit.

Record the results in **Tables 7, 8 and 9** and confirm that the measured delays are within ±5% of the set values.

6.1.5 Circuit Breaker Fail (CBF)

The CBF feature works by looking at the reset of the protection element(s) that have operated, allocated fault triggers to distinguish between alarm and trip outputs and an optional level detector on each of the relay poles. The level detector check may also be switched off.

Internally Initiated CBF
The 2-stage internal circuit breaker failure feature should be tested if it is being used, otherwise the CBF time delay 1 & 2 should be set to OFF. If only one of the stages is to be used then only CBF delay 1 need be tested.

In order to test both stages of the CBF feature then the two CBF delays should be programmed to operate output contacts other than the main trip output. They should also be programmed with their appropriate delays.

CBF delay 1 starts timing out when the main trip output operates and a protection element remains operated, indicating a fault current is still flowing. After timing out, it generates a trip output of its own and also initiates CBF delay 2 which subsequently generates a final trip output.

Note both Phase and Earth CBF Level detectors must be set to allow them to be incorporated into the CBF logic.

Connect the main trip output to start a time interval meter. Connect the output from CBF delay 1 to stop both the timer and the current source. Inject current of 2x setting into any pole and record the first CBF time delay in **Table 10**.

Connect the CBF delay 1 output to start the time interval meter. Connect the output from CBF delay 2 to stop both the timer and the current source. Inject current of 2x setting into any pole and record the second CBF time delay.

Check that the measured delays are within ±5% of the set values.

External Initiated CBF
The 2-stage external circuit breaker failure feature should be tested if required by the application. If only one of the stages is to be used then only one of the DTL elements (used as the CBF 1 detector) need be tested.

In order to test both stages of the CBF feature then the two DTL elements used should be programmed to operate output contacts other than the main trip output. They should also be programmed with their appropriate delays.

CBF delay 1 DTL element is initiated by voltage being applied to its assigned status input to allow the DTL element to measure and time out. After timing out, it generates a trip output of its own. The second DTL element used for CBF delay 2 is usually set to the same current pickup and inhibited by the same status input, but has a longer time delay applied and separate trip output(s) allocated.

Connect the main trip output to start a time interval meter. Connect the output from CBF delay 1 to stop both the timer and the current source. Inject current of 2x setting into any pole and record the first CBF time delay in **Table 11**. The inverted status input used to block operation of the DTL elements must be energised to allow the DTL elements to operate.
Connect the DTL (CBF) delay 1 output to start the time interval meter. Connect the output from DTL (CBF) delay 2 to stop both the timer and the current source. Inject current of 2x setting into any pole and record the second CBF time delay.

Check that the measured delays are within±5% of the set values.

The pickup and drop-off of the CBF level detectors may be tested by operating the element with a ramp up or down of the injected current.

6.1.6 Status Inputs

The operation of the status input(s) can be monitored on the ‘status input’ display when in Instruments Mode. Apply the required supply voltage to the status input and check for correct operation. Repeat for the other status inputs if the expanded relay with 9 status inputs is ordered.

Depending on the application, the status inputs may be programmed to perform a number of functions, and these may need to be tested individually. Such functions are alarms and waveform recording from other external protection devices, such as Buchholz.

Status inputs may be inverted to allow testing without applying and energising voltage.

See **Table 12** to record test results.

6.1.7 Output Relays

All relay models have seven output relays, three of which have change-over contacts; the remaining four have normally open contacts. Each contact can be tested individually by the trip test feature or they can be checked during commissioning by testing the feature to which they are assigned. See **Table 13** to record test results.

6.2 Primary Injection Tests

Primary injection tests are important, to check the ratio and polarity of the current transformers as well as the secondary wiring. Alternatively on load tests may be conducted to speed to up test procedure.

Use the circuit shown in **Figure 2** to check the current transformer ratio and the c.t. phase to earth connections. Inject a current of sufficient magnitude for the relay ammeters to display. These values should be compared with the ammeters connected in series with the relay.

The secondary current is: $Is = \frac{\text{Primary current}}{\text{C. T. ratio}}$

Use the circuit shown in **Fig. 3** to check the current transformer ratio and the C.T. phase to phase connections.

Record the results in **Table 14**.

6.3 End to end Signalling

Healthy end to end signalling will illuminate the SIGNAL HEALTHY LED permanently. A flashing LED indicates a fault in the end to end signalling.

The SIGNAL HEALTHY LED of both relays should be checked, as they are independent of each other.

The relays monitor the incoming received signal for noise or interruption. Differential protection is blocked if the signal to noise ratio exceeds a set value or the channel is lost.

The state of the signal healthy LED can be recorded in **Table 15**.

6.4 On-Load Tests

The phase angle comparator must be tested using load current. The test undertaken (Test 1 or Test 2) is depending upon the level of load current flowing in the feeder at the time of the test. The level of load current can be checked via the restraint current measurement in the Instruments mode. The levels of load, restraint and differential currents should be recorded in **Table 16**. One of the following tests should be performed to test the phase angle comparator. Which of these two tests to do, will depend upon the restraint (feeder load) current flowing at the time of the test:

(i) **Test 1** – If restraint current is greater than the P/F Differential Setting /2
(ii) **Test 2** - If the load current is less than P/F Differential Setting /2

The test procedure is as follows:

Close both circuit breakers at either end of the feeder to permit load current to flow. Both relays should be stable and the “Signal Healthy” LED on both relays should be permanently illuminated, i.e. not flashing.

Test 1 – Where Load Current is High

This test applies when the load current is high enough to ensure that the restraint current is higher than half of “P/F Differential” setting. The restraint current is the average of the load current measured at each end. Since these two values are normally the same (eg, unless there are significant values of in-zone capacitance current or load current of a small auxiliary power transformer in the protected zone), then the restraint current will equal the load current.

If this load current is higher than half the P/F Differential current setting there is sufficient current to ensure the phase angle comparator is not blocked.

The load current at the local end and the remote end can both be read from either relay using the Instrument display. This allows the restraint current to be established.

Positive operation of the phase angle comparator can be checked as follows and this test could provide an on-load trip test:

With the relays connected normally and load current flowing the relay should be stable and minimum differential current displayed on the instruments.

Reversing the CT connections will cause the relays to become unstable and they will issue a trip signal. High levels of differential current can be observed on the instruments.

➢ The “CT Reversal” setting in the relay’s “CB Maintenance” setting menu is employed to swing the current vector on one relay by 180° and thus operate the phase angle comparator function.

➢ Use the [ENTER], [⇩] and [⇧] pushbuttons or Reydisp Evolution to change the “CT Reversal” setting from “OFF” to “ON”.

Note: When the [ENTER] pushbutton is pressed to initiate the CT reversal of 180°, the trip output will be initiated immediately! CT reversal can then be turned back to the OFF setting. See **Table 17** to record test results.

Often this test is conducted to operate the trip relay only, without tripping the feeder, by removal of the CB Trip - Fuse and Link. For this test, the relay will be in permanent trip state. The relay does not accept setting changes when in the tripped state, as the relay trip operation takes priority over implementing setting changes. To revert the relay to its normal state, change the CT reversal setting(s) to normal and select “Update Changed Setting” in the Relay Menu of Reydisp Evolution. Then remove the relay supply by extracting either its supply fuse or link, to power the relay down. Immediately after the LCD powers down, power the relay up by re-inserting the fuse or link. The setting change will then be implemented to and the CT reversal removed (set to OFF) to allow the relay to reset.

Test 2 – Where Load Current is Low

This test applies when the restraint current is below the P/F differential settings /2. At this level of load current the Phase angle comparator is blocked and as a result the relays will remain stable.

The phase comparator will be blocked if the restraint current (which is approximately equal to the load current for on-load testing) is less than half of the “P/F Differential” setting.

The connections are correct if the relay indicates an increase in differential current when the CT reversal applied to one relay only. The CT Reversal Setting is found in the CB Maintenance Menu. In this state, the differential current should be approximately double the restraint current. The differential current should increase significantly when CT reversal is implemented. Check the differential and restraint currents for all three phases.

The CT Reversal” is implemented as described in Test No 1 above. See **Table 18** to record test results. The CT reversal should then be de-selected.

If load current levels measured by the relay are very low then settings may have to be altered to allow the increase in differential currents to be registered, when the CT reversal is applied. An angle measurement cut-off is applied at the following levels if either the Local or Remote current is less than the following levels:

P/F Differential Setting Selected	Secondary Current Required to activate CT Reversal	
	Relay 1 Ampere Rated Inputs used (mA)	Relay 5 Ampere Rated Inputs used (mA)
0.10 x In	13	60
0.15 x In	15	70
0.20 x In	16	75
0.25 x In	20	95
0.30 x In	21	113
0.35 x In	29	136
0.40 x In	30	137
0.45 x In	35	158
0.50 x In	40	172

If load levels are very low set both relays to the minimum P/F Differential of 0.1 x In. As indicated above the minimum levels are 13mA for 1A and 60mA for 5A terminals. If 5A CT’s are used and the secondary current is below 60mA, the check for an increase in differential current may be carried out by temporarily connecting the 5A CT wiring to the 1A relay input terminals.

Test Waveform Records

The Reydisp Evolution software program can be employed to trigger waveform storage to provide a record of these tests. A snapshot of the load current can be taken for both of the above tests and in the case of Test No 1 the trip record can also be taken.

Waveform storage can be triggered either by the trip initiation (i.e. Test No 1) or by energising a status input which has been programmed to trigger a waveform record (i.e. Test No 2). These records can be used as part of the protection commissioning report for the relay under test. When the relay is balanced the phase angle difference on each phase, as displayed on the waveform record should be 8 ±2.

7 Trip And Intertrip Tests

The relays have settings to allow:
1. A local trip test or
2. An intertrip test of both relays

7.1 Local Trip Test

This can be activated through the fascia pushbuttons on the Reydisp Evolution Software. Select the [CB Maintenance Menu] and scroll down into O/P test. Select the output relays used to initiate circuit breaker tripping on pressing the enter pushbutton to activate the setting the relay will wait 10 secs before the closing the selected output contacts. This 10 secs delay is used to allow personnel to vacate the vicinity of the CB before it opens.

7.2 Manual Intertrip Test

Either a simulated internal intertrip or external intertrip can be simulated by selection of settings. Again the [ENTER] pushbutton to activate this setting will initiate this test.

Record the Trip and Intertrip Test results in **Table 19.**

Note: These tests do not require any current in the relay.

8 Putting Into Service

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

Remove all test connections.

Where possible, the relay settings should be down-loaded to a computer and a printout of the settings produced. This should then be compared against the required settings. The Reydisp Evolution Software can compare settings files automatically. To do this open the two settings files for comparison and select [Relay] [Compare Settings]. Select one file to compare to the other and select [Compare]. Differences are highlighted in colour.

It is important that the correct settings group is active if more than one group has been programmed.

Replace all fuses and links.

9 Sample Test Records

RECORD OF COMMISSIONING TESTS RESULTS

Substation Name:

Feeder Name:

Date Tested:

INSULATION TEST RESULTS **M Ohms**

Between Relay a.c. current inputs and earth	
Between Relay power supply terminals and earth	
Between Relay status inputs and earth	
Between Relay output contacts and earth	

SECONDARY INJECTION TESTS

Differential Protection

Substation Name - end A:

Mode of Test : Normal/ Loop Test/Line Test (delete where appropriate)

Substation Name - end B:

Mode of Test : Normal/ Loop Test/Line Test (delete where appropriate)

Level of Restraint current = $I_S/2$

Differential Current

Current Input	P/F differential Setting	Measured Pick-up	*Pick-up Error(±10% of 100% Max)	Measured Reset	Reset (≥95% of pick-up)
Phase A					
Phase B					
Phase C					

Table 1 – Differential Pick-up/Reset Results

*This accuracy tolerance is for 1A rated inputs used on both relays. Note the pickup error for 5A inputs or where 1A and 5A inputs are used is 15%.
Table 1. Differential Pick-up/Reset Results

Overcurrent and Earth Fault Protection

Current Input	Pick-up Setting	Measured Pick-up	Pick-up Error (±4% of 105%)	Measured Reset	Reset (≥95%) of pick-up)
Phase A					
Phase B					
Phase C					
E/F					

Table 2 - Characteristic Pick-up/Reset Results

Current Input	Characteristic (NI, VI, EI, LTI, DTL)	2xIs		5xIs		10xIs		20xIs	
		Delay	Error (±5%)	Delay	Error (±5%)	Delay	Error (±5%)	Delay	Error (±5%)
Phase A									
Phase B									

Phase C									
E/F									

Table 3 - Timing Characteristic Results

Current Input	Lowset Setting	Measured Pick-up	Error (±5% setting)
Phase A			
Phase B			
Phase C			
E/F			

Table 4 - Lowset Setting Results

Current Input	Highset 1 Setting	Measured Pick-up	Error (±5% of setting)
Phase A			
Phase B			
Phase C			
E/F			

Table 5 - Highset 1 Setting Results

Current Input	Highset 2 Setting	Measured Pick-up	Error (±5% of setting)
Phase A			
Phase B			
Phase C			
E/F			

Table 6 - Highset 2 Setting Results

Current Input	Lowset Delay Setting	Measured Delay	Error (±5% of setting)
Phase A			
Phase B			
Phase C			
E/F			

Table 7 - Lowset Timing Results

Current Input	Highset 1 Delay Setting	Measured Delay	Error (±5% of setting)
Phase A			
Phase B			
Phase C			
E/F			

Table 8 - Highset 1 Timing Results

Current Input	Highset 2 Delay Setting	Measured Delay	Error (±5% of setting)
Phase A			
Phase B			
Phase C			
E/F			

Table 9 - Highset 2 Timing Results

CBF Delay	Delay Setting	Measured Delay	Error (±5% of setting)
Delay 1			
Delay 2			

Table 10 - Circuit Breaker Fault Timing Results

CBF Delay	Delay Setting	Measured Delay	Error (±5% of setting)
Delay 1			
Delay 2			

Table 11 – External Circuit Breaker fault Timing Results

CBF Level Detectors	PU Setting	PU Measured	Error (±5% of setting)
Phase A			
Phase B			
Phase C			
E/F			

Table 12 – External Circuit Breaker fault Timing Results

Status Inputs

S/I No	1	2*	3*	4*	5*	6*	7*	8*	9*
Tested OK (✓)									

Table 13 – Status Input Test Results * - Applicable Yes/No

Output Relays

Relay Reference	RL1	RL2	RL3	RL4	RL5	RL6	RL7
Operation Confirmed (✓)							

Table 14 – Output Contact Test Results

Primary Injection

Phase Injected	Primary Current	Secondary Current			
		A	B	C	N
A-B				Nil	Nil
B-C		Nil			Nil
B-E		Nil		Nil	

Table 15 – Primary Injection Results

Signal Healthy LED Indication

Green LED illuminated constantly	Signal Healthy	
Green LED flashing	Signal unhealthy	

Table 16 – Protection Signalling Test Results

If Signal unhealthy, investigate protection signalling path.

On Load Tests

Substation A -
Substation B -

Instruments Display

Phase	Measured Load Current ($x I_N$) (Sec Amps)	Restraint Current displayed by relay at Substation A (Sec Amps)	Restraint current displayed by relay at Substation B (Sec Amps)	Differential Current Displayed S/S end A (Sec Amps)	Differential Current displayed S/S end B (Sec Amps)
A					
B					
C					

Table 17 – Record of Load, Restraint and Differential Currents

The differential current shown on the instruments display should be less than 15% of the local and remote restraint currents.

If the calculated restraint current is less than the P/F Bias Setting /2, proceed to Test 2. If the restraint current is greater than the P/F Bias Setting /2, proceed to Test 1.

Test 1 – Phase Comparison Test – medium to high feeder load current

P/F Differential Setting (Sec Amps)			
Restraint Current (Sec Amps)			
CT Reversal – OFF	No trip	–	Yes/No
***CT Reversal – ON	Relay Trip	–	Yes/No
CT Reversal – OFF	Relay Reset	–	Yes/No
Waveform record obtained			Yes/No

Table 18 – Comparator test results with feeder load current > P/f Bias Setting /2

***Note, for correct operation, when the CT reversal is activated both relays operate.

Test 2 – Phase Comparison trip Blocked – low feeder load current

P/F Differential Setting (Sec Amps)			
Restraint Current (Sec Amps)			
CT Reversal – OFF	No trip	–	Yes/No
*CT Reversal – ON	Relay Trip	–	Yes/No
CT Reversal – OFF	Relay Reset	–	Yes/No
Waveform record obtained (eg from status input initiation)			Yes/No

Table 19 – Comparator tests with feeder load current< P/F Bias Setting/2.

*Note for correct operation, when setting the CT reversal to 'ON' the relay should NOT trip.

Manual Trip and Intertrip Tests

Internal iTrip (✓ - OK)			
External iTrip 1 (✓ - OK)			
External iTrip 2 (✓ - OK)			
Trip Test	**Output Contacts Tested->**		**(✓ - ok)**

Table 20 – Record of Manual Trip and Inter-trip tests

Test Result - Approval Signatures

The above Results are a true reflection of the test measurements taken, and the protections scheme is considered fit for service.

Witnessing Engineer: **Date:**

Company:

Commissioning Engineer: **Date:**

Company

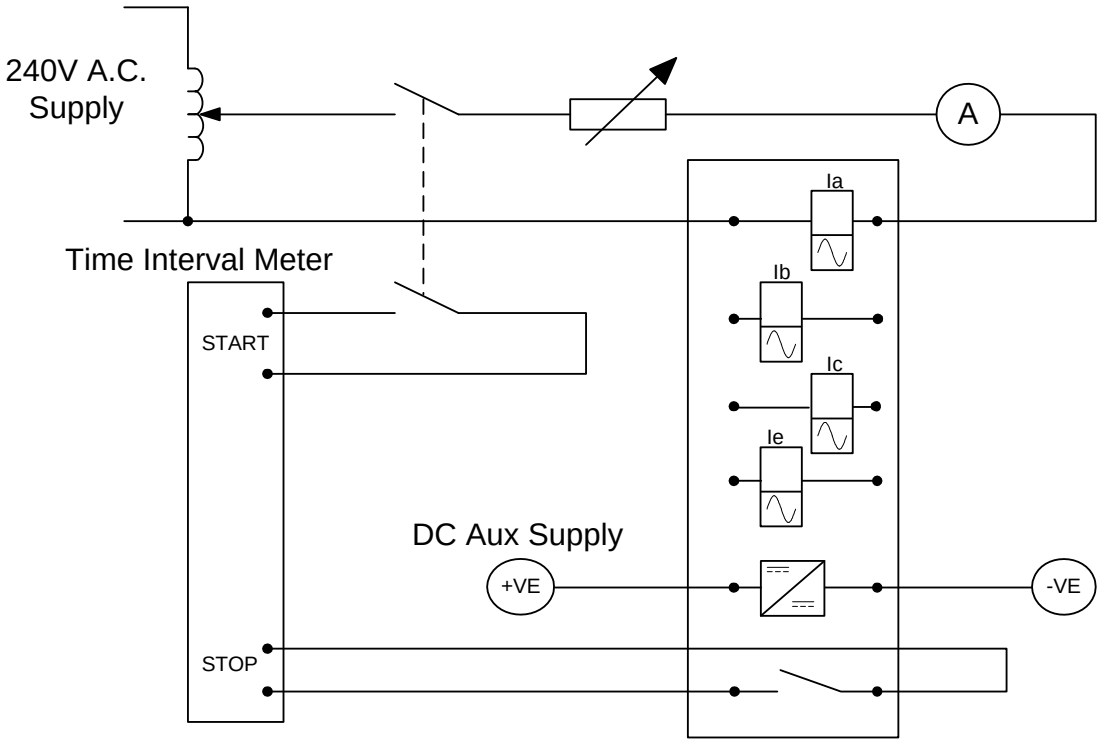


Figure 1 - Secondary Injection Test Circuit

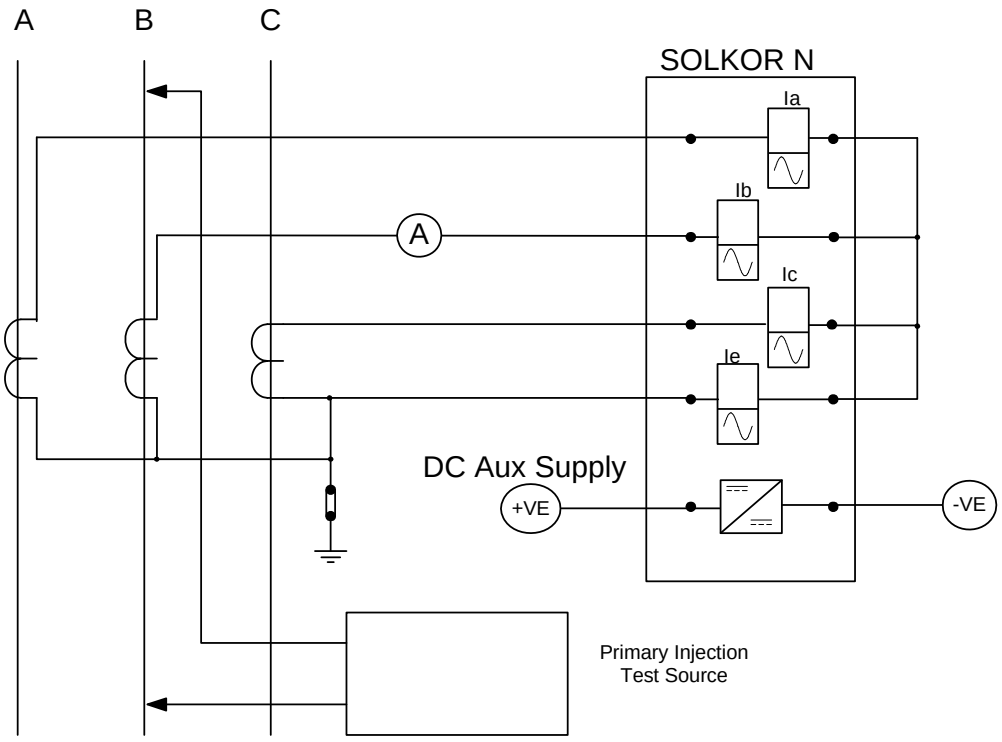


Figure 2 - Phase to Earth Primary Injection Test Circuit

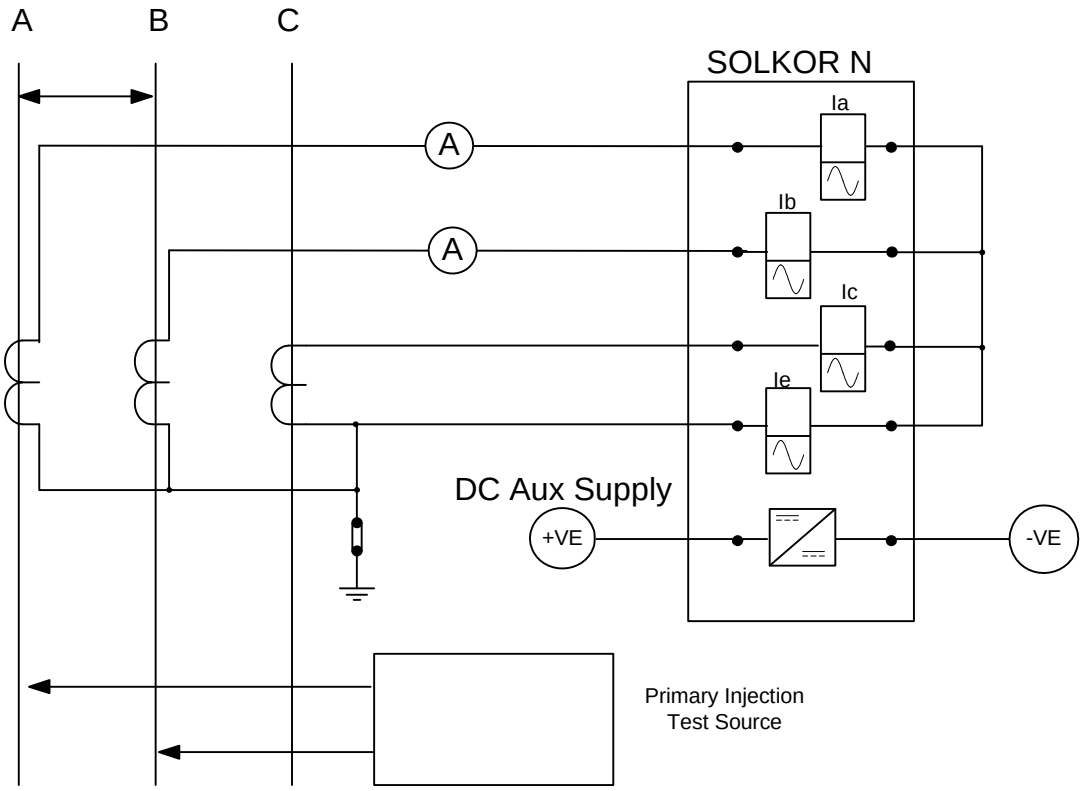


Figure 3 - Phase to Phase Primary Injection Test Circuit