# 7PG23 5B3

Restricted Earth Fault

## Document Release History

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

Pre release

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| 02/2010 | Document reformat due to rebrand |
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## Software Revision History

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# Contents

# 1. REQUIRED TEST EQUIPMENT

- A 1000V insulation resistance test set.
- A heavy current primary injection test transformer capable of providing 500A and an output of at least 5kVA.
- A variable ratio transformer suitable for controlling the input to the primary injection test transformer.
- Plug connections for voltage transformer and busbar orifices.
- An ammeter and a metering transformer to measure the output of the primary injection test transformer.
- Two multi-purpose instruments, e.g. Avometers.
- An ohmmeter.
- One or two variable ratio transformers for secondary injection tests.
- Resistors of suitable value to control the output of the variable ratio transformers.
- A suitable a.c. supply.

# 2. PRECAUTIONS

Before testing commences the equipment should be isolated from the current transformers and the CT's short circuited in line with local site procedures. During secondary injection tests, take care that the test circuit is earthed at one point only.

# 3. PROGRAMME OF TESTS

- General checks of connections.
- Insulation resistance tests.
- Pilot resistance tests.
- Current transformer ratio and polarity tests.
- Fault setting tests by primary injection.
- Tests using load current.
- Fault setting tests by secondary injection.
- Tripping and intertripping tests on circuit breakers, and operation tests on indicating devices.

# 4. TESTING OF CURRENT TRANSFORMERS MOUNTED IN POWER TRANSFORMER BUSHINGS

If the CTs associated with the earth fault protection are located in the power transformer bushings, it may not be possible to apply test connections between the CTs and the power transformer windings. If this is so, apply the test connections on another winding in order to short circuit the power transformer when making the primary injection tests. The injected primary current will be limited by the impedance of the power transformer; when making the CT polarity tests, check the spill current with the pilot connections normal and with them reversed. The connection which produces negligible spill current is correct.

As the injected primary current will normally be low in comparison with rated current of CTs make further tests using load current, as detailed in "Tests using load current" in order to verify as far as possible the conclusions reached during the primary injection tests.

# 5. GENERAL CHECK OF CONNECTIONS

Isolate the auxiliary supplies. Check that the wiring is complete and that the connections are tight.

# 6. INSULATION RESISTANCE TESTS

Isolate the auxiliary supplies. Remove the earth connections. Measure the insulation resistance at those points which will ensure that all the wiring, including the trip circuits and relays, is tested. Insulation resistance values which may be considered satisfactory depend on the amount of wiring involved. Where a considerable amount of multicore wiring is involved a reading of 2 or 3 megohms is reasonable, but for short lengths of wiring on a panel higher readings should be obtained. Normally a 1 megohm reading should not be considered satisfactory.

# 7. PILOT RESISTANCE TESTS

Isolate the auxiliary supplies. Using the test circuit shown in fig. 1 measure the resistance of the pilots between the relay tapping point and the CTs. These values should not exceed those values employed in the setting calculations. If the value obtained exceeds that given in the setting calculations, check the permissible pilot loop resistance using the equation:
R = V/I – Rct

# 8. CURRENT TRANSFORMER RATIO AND POLARITY

**TESTS**

If the protection does not include a neutral CT, ratio and polarity tests may be made with load current as described under "Tests Using Load Current". If the protection includes more than one set of line CTs or more than one neutral CT, ensure that the polarities of all CTs are checked relative to each other. Isolate the auxiliary supplies.

## 8.1. Ratio Test

Using the test circuit shown in fig. 2 inject a value of primary current equal to the rating of the CT primary. If this is more than can be obtained from the primary injection test transformer, inject the highest possible value.
Note that: Secondary current = Primary current / CT ratio

## 8.2. Polarity Test

Using the test circuit shown in fig. 3 inject a value of primary current equal to rating the CT primary. If this is more than can be obtained from the primary injection test transformer, inject the highest possible value. The current in the relay circuit should be negligible. Make the test on all phases.

# 9. FAULT SETTING TESTS BY PRIMARY INJECTION

Isolate the auxiliary supplies. Adjust the relay and the relay setting resistors to the recommended values given in the setting calculations. Using the test circuit shown in fig. 4 pass a current through one CT primary and increasing the current gradually, note the value at which the relay operates. This should approximate to the value given in the calculations.

# 10. TESTS USING LOAD CURRENT

If it is not practical to perform the ratio and polarity tests by primary current injection as described previously, the ratio and polarity tests of the line CTs and a check of relay operation can be made using load current. The test is applicable to earth fault protection which does not include neutral CTs. Isolate the auxiliary supplies.

## 10.1. Ratio Test

Connect an ammeter across the relay circuit and disconnect the relay. Short circuit and disconnect two CTs. Note that: Secondary current = Primary current / CT ratio

## 10.2. Polarity Test

Restore the CT connections and note the ammeter reading, this should be negligible.

## 10.3. Check of Relay Operation

Reconnect the relay and disconnect the ammeter. Short circuit and disconnect one CT. If the load exceeds the fault setting of the protection, check that the relay operates.

# 11. FAULT SETTING TESTS BY SECONDARY INJECTION

Isolate the auxiliary supplies. Using the test circuit shown in fig. 5 inject a current and, increasing it gradually, note the value at which operation occurs. This should be equal to:
Primary fault setting / CT ratio

# 12. TRIPPING TESTS AND INTERTRIPPING TESTS ON CIRCUIT BREAKERS AND OPERATION TESTS ON INDICATING DEVICES

Check that the auxiliary supplies are connected. Operate the earth fault relay and check that the circuit breakers operate only when the appropriate resistors are selected and that the indicators operate correctly.

# 13. CHECK OF ATTRACTED ARMATURE ELEMENT

To enable the attracted armature element to be checked and tested the following is required:

- 0.15mm (0.006") Shim, 0.4mm (0.016") Shim, 1.0mm (0.039") Shim or Rod; 1.65mm (0.065") Shim or Rod, 2.4mm (0.095") Shim or Rod
- 0 to 15g Pressure Gauge
- Contact Pliers or Stroking Tool
- Set of BA Spanners
- Small Screw-driver
- Variable A.C. Supply

The shims can be obtained on precision metric feeler gauges, typically M & W Set No. 390M.

## 13.1. Mechanical Checks

The location of the components is shown in fig. 6.

### 13.1.1. Armature

Ensure that there is not excessive end play on the armature by a gentle movement in the horizontal directions. Ensure that the residual screw in the armature has full travel onto the core face in the operated position and that the armature fully engages on the back stop in the reset position.

### 13.1.2. Armature Gap

Ensure that the armature gap is free from dust or swarf and clean, if necessary, with a soft brush or a wooden spatula.

### 13.1.3. Contact Stack

Check that the contact stack clamp nut is tight.

### 13.1.4. Contacts

If contacts require cleaning they should be washed with a suitable substance using a soft brush, then polished with chamois leather mounted on a spatula. If pitting has occurred, then they should be burnished smooth and cleaned again to ensure the removal of any grit. It is not advisable to use abrasive paper. Care must be taken to avoid bending the contact fingers. All make contacts should make and all break contacts should break simultaneously and have a good wiping action and follow through.

### 13.1.5. Commissioning

The following check is to be made before the element is put into service. To check minimum armature travel after contact touch (i.e. contact follow through) insert a 0.25mm shim between the residual screw on the armature and the face of the core, see fig. 7. Close the armature onto the shim and ensure that the contacts are closed. If the armature travel after contact touch (i.e. contact follow through) is less than the minimum 0.25mm see resetting recommendations.

### 13.1.6. During Service

To check minimum armature travel after contact (i.e. contact follow through) insert a 0.15mm shim between the residual screw on the armature and the face of the core, see fig. 8. Close the armature onto the shim and ensure that the contacts are closed. If the armature travel after contact touch (i.e. contact follow through) is less than the minimum 0.15mm see resetting recommendations.

### 13.1.7. Flag Indicator

Check that the flag falls just prior to the make contact touching, or, if break contacts only are fitted, just after the break contact opens.

## 13.2. Recommendations for Re-setting

If the relay does not comply with above then the following points should be checked and the relay adjusted as necessary.

### 13.2.1. Armature

The end plate on the armature is controlled by the armature keep. Adjustment is made by slacking the keep fixing screw and slightly moving the keep horizontally forward or backward. Retighten the keep screw after any adjustment.

### 13.2.2. Armature Gap

The armature gap is measured using a 2.4mm (0.095") shim or rod approximately 1.6mm (1/16") in from the bottom edge of the core face, see fig. 8. Adjustment is made by the back stop screw which is sealed after adjustment during manufacture. If it is re-adjusted on site we recommend that it’s re-sealed with a suitable lacquer.

### 13.2.3. Residual Gap

Measure the residual gap by inserting a 0.15mm (0.006") shim between the top of the core face and the adjustment with the armature closed, see fig. 9. The gap is adjusted by the residual screw. The shim should be slotted or have a hole in it to clear the residual screw and should be a sliding fit up to, but not beyond, the top edge of the core face.

### 13.2.4. Contacts

The contacts should be approximately horizontal with yoke. The position of the contacts is adjusted by the tappet arm screw which is screwed into position and retained by a lock nut. This adjustment should not normally be altered on site. The contact gap should be 2.4mm (0.095") and is adjusted by moving the fixed contact relative to the moving contact. To ensure that the contacts make simultaneously we recommend that the bottom right hand contact is set to the correct dimension, then set all similar contacts so that they make simultaneously with this contact. Ensure that the armature has the required minimum travel after contact touch by inserting a 0.4mm

(0.016") shim between the residual screw on the armature and the core, with the armature closed see fig. 7. All make contacts should be closed.

## 13.3. Contact Control Force

Ensure that there is sufficient control force to return the armature positively on to the back stop screw and that the operation occurs at the minimum specified voltage or setting. The control force is applied by the moving spring steel strip of the make contacts and adjusted by stroking the spring steel strip with contact pliers or a contact stroking tool. Do not kink these strips. The pressure should be evenly distributed to ensure that all contacts in the same layer are horizontally in line as shown in fig. 10.

### 13.3.1. Flag Indicator

Check that the flag falls just prior to the make contacts touching. Adjustment to the hand reset flag is made by the 10BA adjusting screw, see fig. 11. Ensure that the flag mechanism does not prevent the armature from fully returning to the back stop.

### 13.3.2. Electrical Checks

Check that the relay operates at its setting as stated below and fully resets when the supply is switched off. The test supply should consist of a 240V a.c. supply from a Variac with a 6kW, 10W, fixed resistor and ammeter in series.

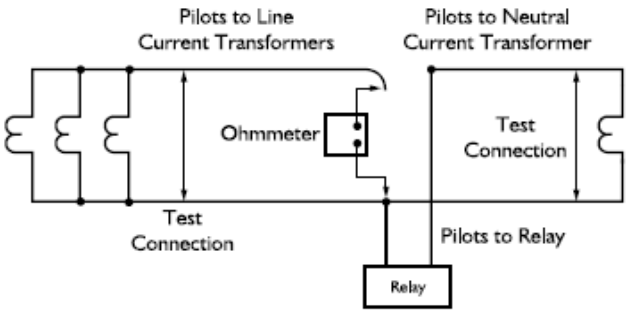


**Figure 1 Pilot-Resistance Test-Circuit**

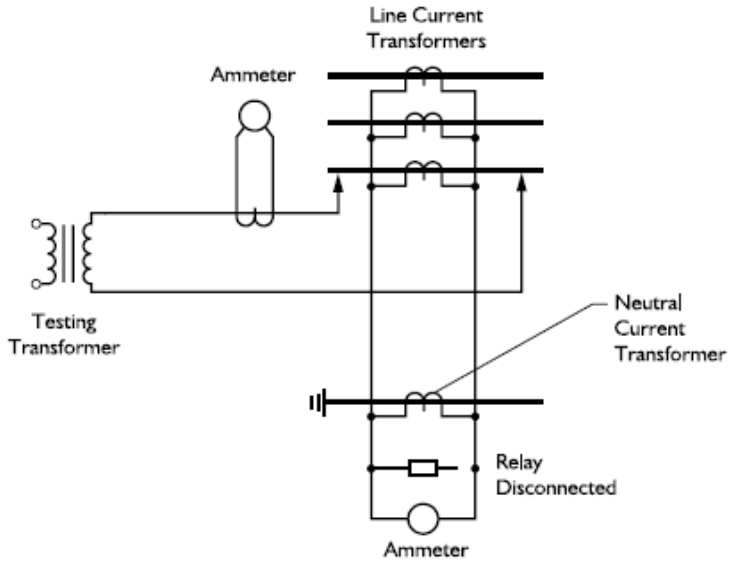


**Figure 2 Current-Transformer Ratio Test-Circuit**

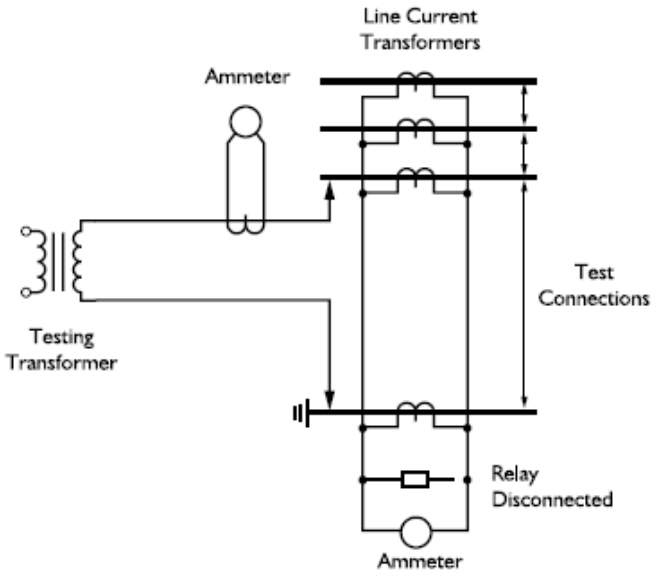


**Figure 3 Current-Transformer Polarity Test-Circuit**

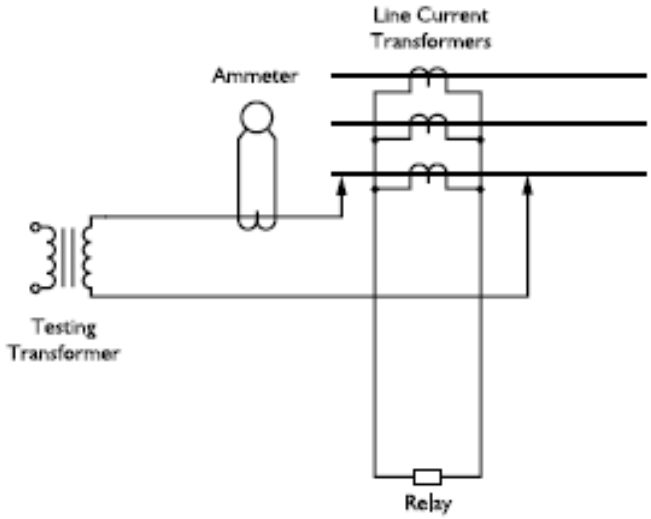


**Figure 4 Circuit for Fault-Setting Test by Primary Injection**

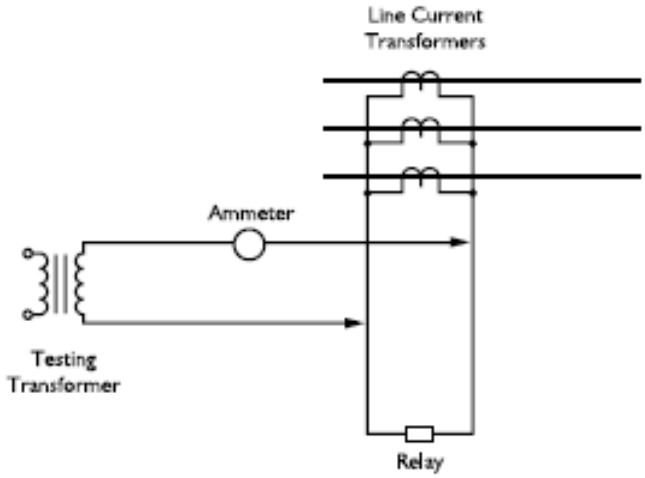


**Figure 5 Circuit for Fault-Setting Tests by Secondary Injection**

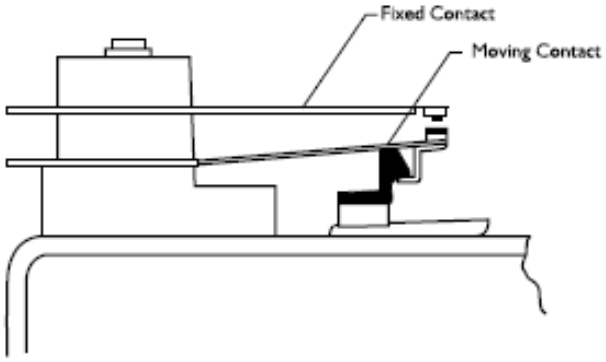


**Figure 6 Type B61 Contact Stack as used on 5B3 Relay**

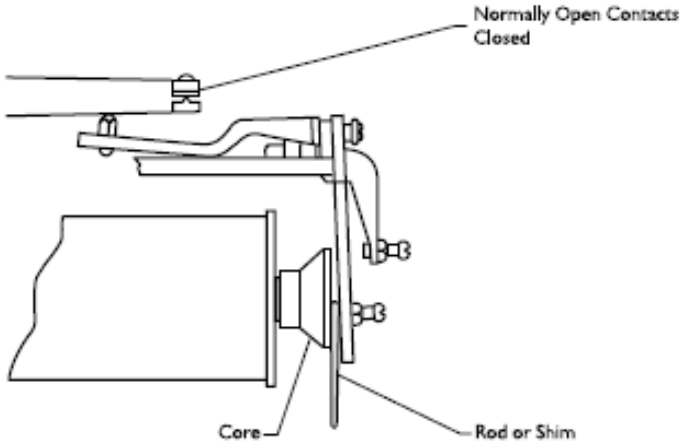


**Figure 7 Checking Remaining Armature Travel at Contact Touch**

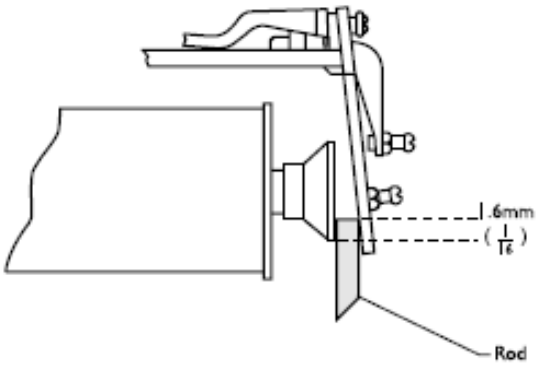


**Figure 8 Armature Gap Setting**

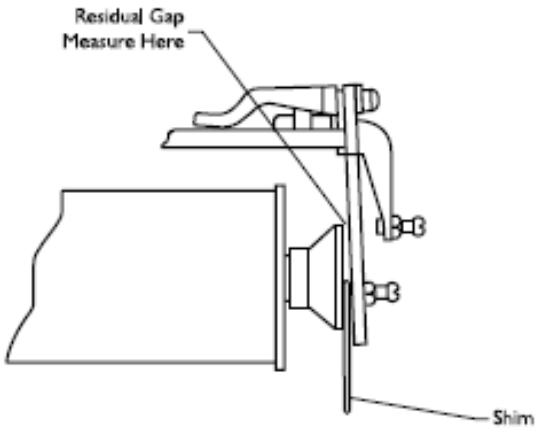


**Figure 9 Residual Gap Setting**

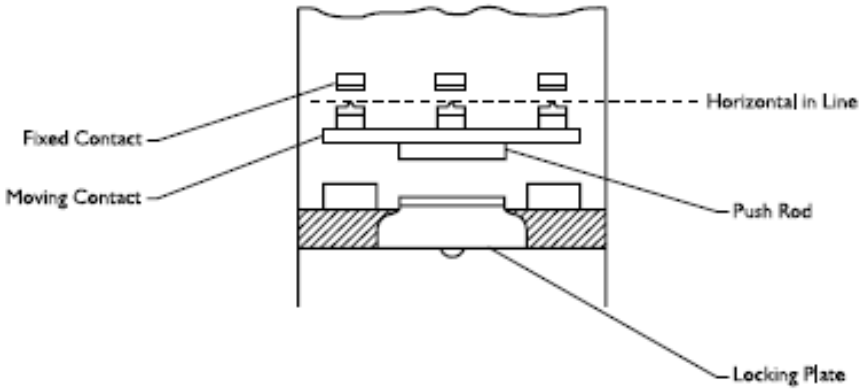


**Figure 10 Setting of Contact Control Force**

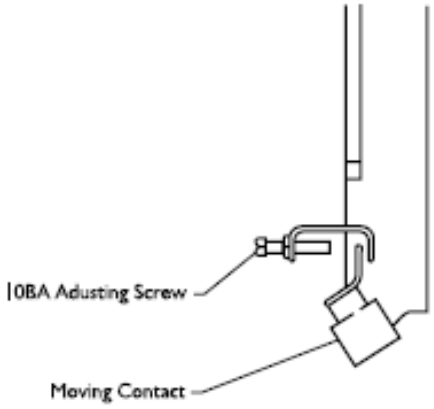


**Figure 11 Flag Mechanism**