



Earthing System Testing

**Off-Frequency
Low Current Injector
LCI 2058**

**Tuned Voltmeter
TVM 1058**



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Safety Warnings



Warning:

This equipment must only be used by qualified personnel. The operator must ensure that use of this device is in compliance with all local rules and regulations applicable to the situation.



High voltages can be exposed on the injector output terminals (up to 230 Vac). The injector output is isolated but hazards to personnel can still exist between terminals and if one terminal is connected to earth in any way.



Reliable and safe operation of this equipment requires that suitable transport and storage measures are taken. Under no circumstances should the device be exposed to extreme temperatures, forces, and/or moisture of any kind.

If for any reason the equipment is thought to have been exposed to extreme conditions, the equipment should be taken out of operation.



High voltages can also be exposed on the remote current injection probe during testing. The operator must ensure that correct measures are taken to prevent electric shock hazards to both workers and public at the remote injection site. This should include but not be limited to:

- The use of a competent supervisor and communication at the remote injection site.
- The use of barriers around the remote injection site.
- Regular maintenance of injection cables.



The operator should ensure that connection and operation of this equipment will not interfere with any nearby equipment (eg frame leakage protection or relays sensitive to earth currents).



The test procedures require that cables are sometimes run long distances in potentially busy areas (urban, industrial, and residential areas). The operator must take care in selecting and securing the cable routes so that no hazards are created by the presence of the cables. In particular the operator should:

- Ensure the cable is visible when placed across footpaths or other pedestrian areas.
- Avoid running cables across busy roads.
- Never run any cable across train tracks.

Qualified Personnel

Qualified personnel refers to workers that have undergone appropriate electrical and safety training relevant to operation of this device. This should include:

- A recognized first aid/life support training course.
- Electrical training pertaining to safety around mains voltage levels.
- Any necessary training required for works within the installation or area under test (e.g. site safety induction, entry approval certification etc)

1. Introduction

The Low Current Injector (LCI 2058) and Tuned Voltmeter (TVM 1058) provide a reliable method for comprehensive testing of earthing systems, particularly those with low impedance (< 2 ohms) or which are extensive or where noise is present.

Portable earth testers are often unsuitable for testing such earthing systems due to low test current and inadequate noise rejection.

The low current injection method injects a known current into the earth grid. The test current frequency is 58 Hz. This provides a very unique test condition and the 58 Hz signal can be easily identified during the tests. Combined with the use of 58 Hz tuned voltmeters (TVM 1058), the earth grid characteristics can be determined.

The LCI unit provides a constant current output. This is necessary for accurate testing and overcomes the phenomena of current variation due to the time varying resistance of the remote test probes (due to localised soil heating).

Auto shut-off is a safety feature that ensures the injected current immediately ceases should the injection circuit be interrupted.

The LCI output is galvanically isolated from the input supply.

In some cases it is impractical to use the LCI, for example where the injection is carried out using an existing power or transmission line running parallel to another line. In such cases the induced current in the test circuit may be excessive. Instead, a diesel generator operated at 58 Hz can be used in conjunction with tuned voltmeters (TVM 1058).

2. Applications

Injection testing enables comprehensive testing of earthing systems. Many important earthing system parameters can be measured, including impedance, touch, step, and transferred voltages, earth potential rise contours, current splits in overhead earth wires, OPGW and cable sheaths.

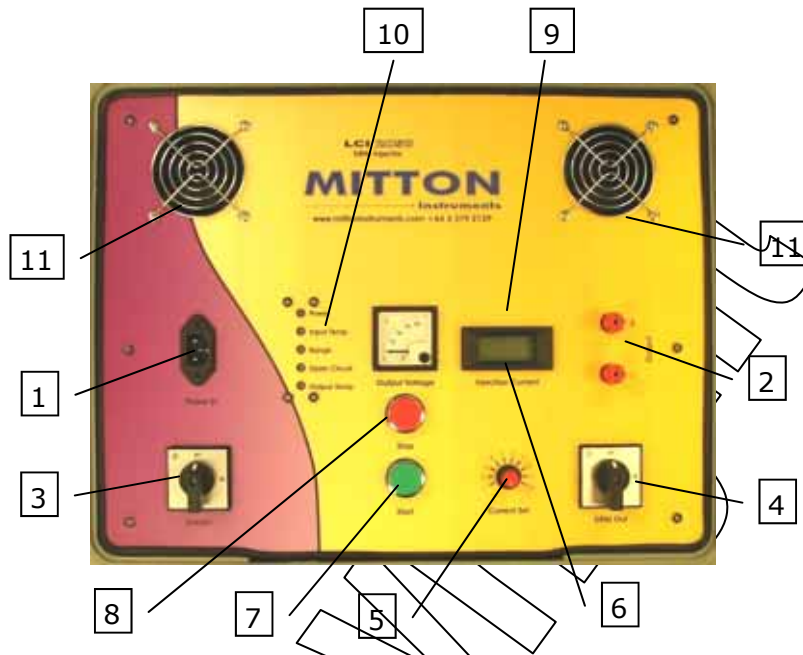
Injection testing is also suited to specific situations such as power stations or mining installations. Many sites require specific earthing measures for safety reasons and injection testing can confirm such issues.

Injection testing also allows identification of any transferred voltages, for example, onto farm fences, water and gas pipelines, telecommunications and railway signalling circuits etc. Injection test methods can also be used to measure induced voltages into other services in a transmission line right-of-way.

Another application is the testing of soil resistivity. The off-frequency low current injection method is preferable for soil testing where significant interference or large test distances prevent small portable earth testers from being used.



3. Injector Overview



Item Description:

1. Supply cable connector - 50 Hz (220 to 240 Vac)
2. Output terminals - 58 Hz constant current
3. Main switch
4. Output switch
5. Current level rotary knob (0 to 10 A)
6. 58 Hz Current level meter
7. Start button (green)
8. Stop button (red)
9. Output voltage level meter (0 to 200 Vrms)
10. Status LEDs (power, input circuitry temperature exceeded, out of range, open circuit, output circuitry temperature exceeded)
11. Cooling fan vents

Note: The injector will automatically remove the applied voltage if an open circuit is detected (ie break in the injection cable).

4. Basic Injector Operation

This section describes the basic operation of the injector unit. Refer to the test procedures in section 5 for detailed guidelines on selecting and setting up the injection circuit.

Setting Up the Injector:

1. Find a dry, level, indoor area to set-up the injector unit.
2. Ensure that both input and output switches are off and that the current control is set to minimum.
3. Insert the mains supply cord but leave the injector off.

Establishing the Injection Current:

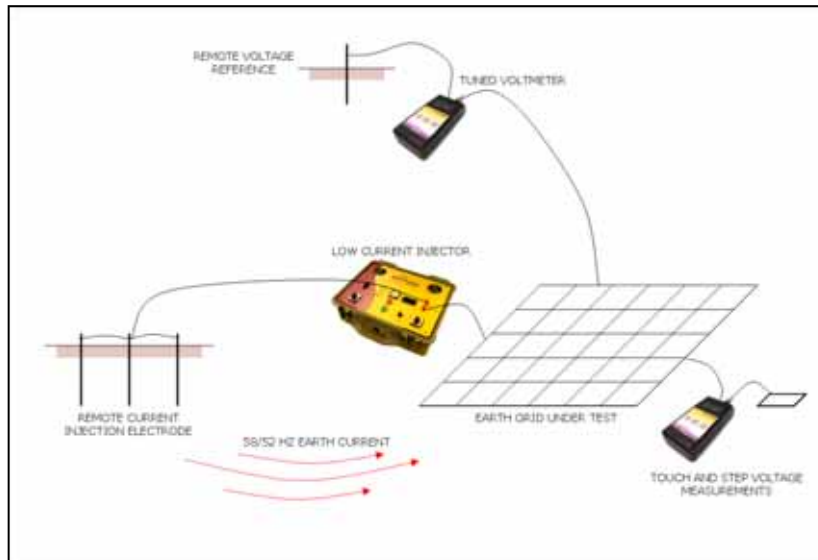
1. Complete the injection circuit as detailed in section 5.
2. If necessary, inform the remote probe supervisor that power is being applied to the injection circuit.
3. Switch on at the power supply socket.
4. Turn the input switch to 'on'.
5. Turn the output switch to 'on'.
6. Press and hold the green 'start' button.
7. While still holding the green button, turn the current control until the current meter panel indicates that current is flowing.
8. Once the current level is above approximately 1 A, release the green button.
9. Increase the current to the desired level.

If the current is $< 1A$ with the maximum voltage applied then the injection circuit impedance is too high (see section 5). Where possible, to enhance safety, use the minimum output voltage that provides sufficient test current.

To Stop the Current:

1. Press the stop button.
2. Turn both the input and output switches to 'off'.
3. Ensure that the injector has discharged before touching the output terminals.

5. Earthing System Test Procedure



This section details the basic test procedure as it relates to electrical installation earthing systems. Examples include:

- Power stations, high voltage and medium voltage substations
- Large industrial and urban substations
- Power system equipment earth grids

The basic test method begins by establishing a suitable current injection route and remote injection point. Once the injection current is flowing, a number of measurements can be made such as earthing system voltage rise, touch and step voltages and current splits between cable sheaths and other conductors.

The fundamental concept is to choose the injection circuit such that the largest amount of current returns to the earthing system under test through the soil. It is this current that will create the earthing system voltage rise and associated touch and step voltages.

5.1 The Current Injection Circuit

Minimum Distances

The most important part of the current injection method is establishing a suitable injection route and current injection point. The injection point must be far enough away from the earth grid under test so that the two are remote from each other. The minimum required distance depends mainly on the size of the earthing system under test and will vary in each situation. The following table gives a general guidelines.

Type and Size of Earthing System (m)	Minimum Separation (m)
Large substation - greater than 100 x 100	700
Medium substation - 20 x 20 to 100 x 100	300 to 700
Small substation - less than 20 x 20	300
Distribution transformer - less than 5 x 5	100

As a general rule the current injection point should be separated by at least 7 times the diagonal distance of the earthing system under test.

Earth grid modelling software (such as CDEGS™ from Safe Engineering Services Ltd) can be used to calculate the minimum separation distance for large complicated sites. The earth potential rise is modelled to determine at what distance the EPR approaches zero, this is the minimum distance required for testing.

Injection Route

In most situations there are usually a number of possible current injection routes. It may not be feasible to run a dedicated test cable from a substation located in a busy urban area. In such situations it may be more suitable to use one phase of an out-of-service distribution line, earthed at a nearby substation, to create the injection circuit.

5.1 The Current Injection Circuit (continued)

Note that induction from a nearby in-service circuit may be significant and can overload the injector. In such cases it may be preferable to use a suitably rated diesel genset operating at 58 Hz.

A standard 1.5 to 2.5 mm² copper single core conductor is suitable for the current injection cable. The following should be noted when selecting a cable:

- The cable should have a tough protective sheathing (TPS) for physical protection.
- The cable insulation should be in good condition to adequately insulate the conductor from the ground.
- The conductor should be rated for a minimum 10 A in air.

Care should also be taken when running cables in busy urban areas. Where possible, running cables across busy roads should be avoided (see safety warnings at beginning of manual).

Injection Electrode

The next step is to find or create a current injection electrode at the remote site. To establish sufficient current (>1 A), the total injection circuit loop impedance must be less than 200 Ω . This can usually be achieved using several copper clad rods driven 1 - 2 m deep (or more), bonded together and covered. Moist or swampy locations are most suitable. In some situations (stony, sandy or volcanic areas) this value may be difficult to achieve. Alternative remote electrodes could include:

- Transmission tower foundations. There must be no overhead earth wire (OHEW).
- Water pipe or gas well test bore.
- A nearby substation earth grid.
- Metallic rods laid in a river.

5.1 The Current Injection Circuit (continued)

In some cases a combination of the above may be required to achieve sufficient injection current. For example a number of driven rods could be bonded to a nearby transmission tower footing to lower the combined resistance. To further reduce the resistance, water can be added to the electrode. In hot climates the water will have to be continually added otherwise the soil will dry out and the injector may not be able to sustain the current.

Where an out-of-service distribution line is used, a remote substation provides an excellent low resistance injection electrode. The injection line is simply bonded to the earth grid at the remote substation using an earth switch or portable earths. Care must be taken to ensure that the current injection circuit is connected such that it does not interfere with any of the substation equipment (eg frame leakage protection).

A nearby substation may not be suitable if there is any return electrical connection to the earthing system under test. This can arise in a number of ways such as through OHEWs or LV distribution network neutrals. This must be thoroughly investigated before any injection circuit of this type is considered.

Establishing the Injection Current

Before starting the injector ensure that the injection cable and electrode have been set up correctly and that all safety checks have been completed (see warnings section at the beginning of this manual).

Measure the loop impedance of the injection circuit with a 4 terminal earth tester or similar. The impedance must be less than about 200 Ω to ensure injector operation.

Check for induced current by temporarily connecting the current injection cable to the earth grid under test. Measure the induced current using a standard clip-on meter.

5.1 The Current Injection Circuit (continued)

If the induced current exceeds approximately 5 A then the injection circuit is not suitable. Refer to earlier in this section for guidelines on selecting an appropriate injection circuit.

To start the injector follow the instructions given in section 4 of this manual.

Once established, the injector will maintain a constant current level by adjusting the applied voltage. The current should be set such that the applied voltage is not at maximum. This will allow the injector to increase the voltage and maintain a constant test current if the injection circuit impedance increases (drying out of injection electrode etc).

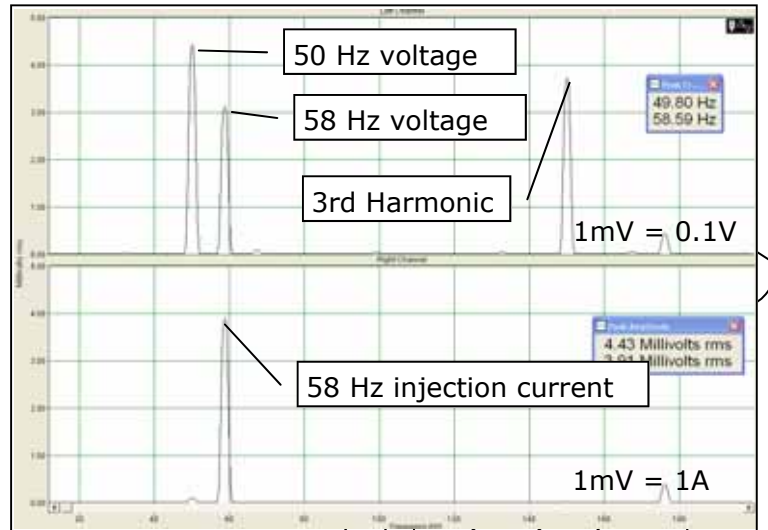
5.2 Earthing System Voltage Rise Measurement

With the injection current flowing, the earthing system voltage rise can be measured. The voltage rise is measured with respect to remote earth (ie zero volts). To achieve this, a cable must physically be run a large distance away from the earthing system to provide a remote earth voltage reference.

The voltage will be at the test frequency (58 Hz) and so must be measured using a specifically tuned voltmeter such as the TVM 1058 (see section 9 for accessories) or a spectrum analyser. This is important as there will generally be a significant amount of power frequency (and harmonic) noise on the earthing system and in the test cables. As an example, a typical spectrum analyser plot (for a 50 Hz power system) is shown below illustrating the large amount of power frequency noise present on the earthing system.

The injected current (58 Hz in this case) is shown in the bottom trace. The top trace shows the 58 Hz voltage rise and the background 50 Hz noise.

5.2 Earthing System Voltage Rise Measurement (cont.)



Minimum Distances

As for the current injection cable, the voltage measurement cable must be at least a certain distance away from the earthing system under test. The earth potential rise (EPR) due to earth currents will fall away from the earthing system and extends out further for larger sites. As a general rule the voltage reference point should be separated by at least 10 times the diagonal distance of the earthing system under test.

Voltage Reference Methods

There are a two possible methods for providing the remote earth reference such as:

- A dedicated cable as described above. This can be a light weight, small cross sectional area conductor as the voltage measurement uses a high impedance circuit.
- A spare telecommunications circuit. These circuits often run large distances and can be easily earthed at the remote end.

5.2 Earthing System Voltage Rise Measurement (cont.)

Where possible, the voltage reference cable should be run at 90 degrees to the current injection cable route. This will minimise any induced 58 Hz voltage arising from the injection current.

In many cases it is not practical to have the current and voltage cables run perpendicular to each other from a site (due to road restrictions, railway tracks etc). In such cases it is suitable to run the cables at angles greater than or less than 90 degrees. If this is not feasible either then the cables can be run in parallel but only if the earthing system impedance is greater than approx 1Ω (the cables must be separated by at least 10 m). For low impedance systems the induced voltage can be of similar magnitude to the actual earthing system voltage rise. This will cause significant errors in the measurement. Software such as CDEGS™ can be used to assist with determination of these errors.

Voltage Measurement Electrode

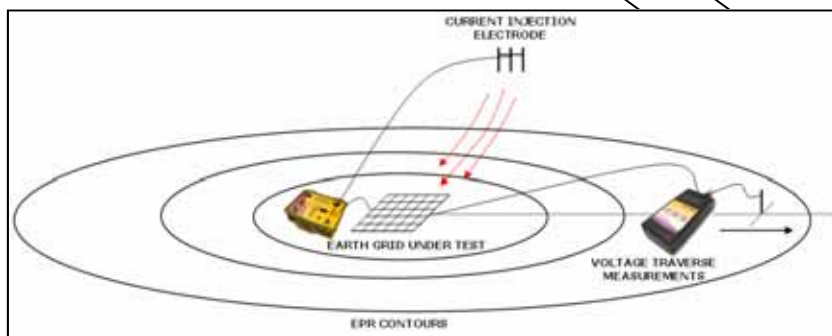
To provide a voltage reference the voltage cable is earthed at the remote end. Voltmeter measurements are by nature high impedance. This means that the voltage cable can be earthed using a small driven rod or even a firmly inserted screwdriver.

The voltage cable should be earthed away from any equipment that may be conducting any of the 58 Hz test current to earth. Some examples include distribution transformers, cable termination driven earths etc. The earthing systems of these items may be bonded back to the earthing system under test through a network of cable screens and LV neutrals. If so, there will be an EPR area around the equipment earthing system that could give an incorrect measurement.

Preferable earthing points include large open areas such as parks and paddocks. If the area is heavily built up then a telecommunications circuit or similar may be the best option.

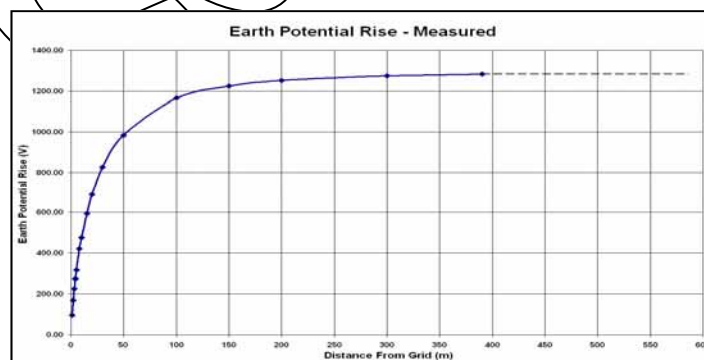
5.3 EPR Traverse Measurements

The LCI 2058 can be used to determine the EPR contour locations of an earthing system. With the test current flowing, the voltage rise measurement process is repeated at a number of positions extending out from the earthing system as shown below. This can be repeated in several directions for a more complete picture of the EPR contours.



The earth potential rise will fall away quickly close to the earthing system and will flatten out as the distance increases. Therefore close in the measurements should be taken at small intervals increasing to larger steps further out. A suggested measurement plan starting from the edge of the earthing system is 1m, 2m, 3m, 4m, 5m, 8m, 10m, 15m, 20m, 30m, 50m, 100m, 150m, 200m, 300m, 400m etc.

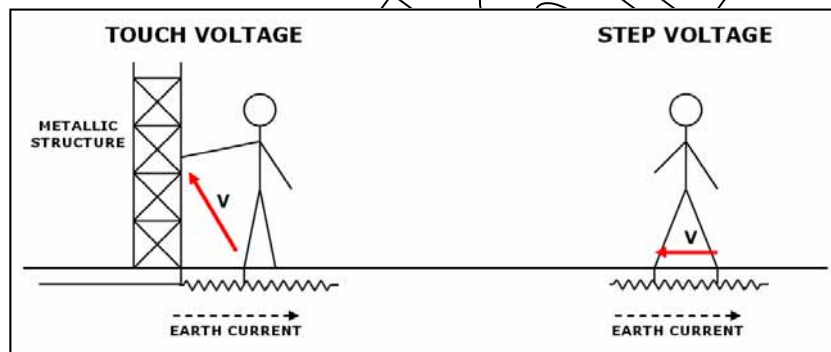
The traverse measurements can then be plotted with respect to the earthing system (see section 6 for analysis details)



5.4 Touch and Step Voltage Measurements

The LCI is ideal for enabling measurement of touch and step voltages around an earthing system. The injection current will cause voltages to arise around the site that represent, on a smaller scale, the actual touch and step voltages likely to be encountered during a real fault.

When current flows through the earth, voltage differences will appear along the path of the current. Current flows out from an earthing system in all directions so touch and step voltages can appear all around the site. The basic touch and step voltage situations are shown below:



To measure these voltages a tuned voltmeter is required such as the TVM 1058 (see section 8). This can be used in conjunction with flat aluminium plates to simulate the electrical contact of a human foot (see below).

One large plate (402 cm²) is used for touch voltage measurements to simulate the contact of two feet in parallel. Two smaller plates (each 201 cm²) are used for step voltages. Refer to section 7 of IEEE80:2000 for further details.



5.4 Touch and Step Voltage Measurements (continued)

Some common touch voltage locations include substation primary plant, support stands, junction boxes, fences, water taps, metallic doors, disconnecter handles, bonded items such as nearby domestic water pipes and any other metallic items that may be touched.



Step Voltage



Touch Voltage

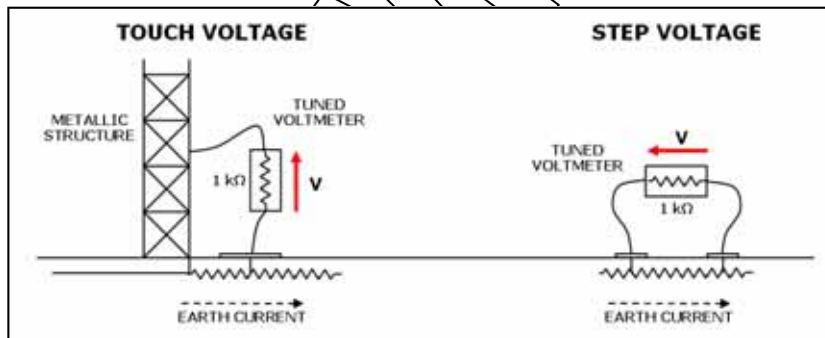
The tolerable touch and step voltage limits are lower where there is a low resistivity surface material such as concrete or natural ground. On these surfaces the contact resistance of the foot is low and shock currents can be high. On high resistivity surfaces such as asphalt and crushed rock the contact resistance is high therefore larger voltages can be tolerated.

The measured touch and step voltages must be scaled up to represent a real fault situation. The scaled voltages can then be compared to the tolerable limits as calculated using guidelines given in IEEE80:2000 (see section 6 for details).

5.4 Touch and Step Voltage Measurements (continued)

The touch and step voltages measured by the tuned voltmeter are prospective or open circuit values (these voltages are also calculated by earthing software packages). This means that the voltage will reduce when the touch or step voltage circuit is 'loaded'. How much the voltage drops depends on the contact resistance of the persons hands and feet. For high resistivity surfaces such as asphalt or crushed rock the loaded voltage will be much lower than the prospective value. This shows there will be less voltage across the person and subsequently less shock current.

The human body will 'load' the circuit with approximately 1 k Ω hand to hand or hand to foot (see IEC60479:1994). To simulate this effect the TVM 1058 tuned voltmeter has a 'Low Z' button that applies a 1 k Ω load to the measurement circuit as shown below. In this way both the prospective and loaded measurements can be taken without making any circuit adjustments.



The loaded value provides an indication of the voltage that is likely to appear across the human body. This should not be used to rule out voltage hazards as the contact resistance can vary greatly with weather conditions. On a wet day the loaded voltage could be much higher (and more hazardous) than on a dry day. The most consistent method is to use the prospective measurement as this provides an upper limit on the voltage across the human body.

5.4 Touch and Step Voltage Measurements (continued)

The loaded value is only used to confirm voltage hazards identified by the prospective value. If the loaded value is high then the surface resistivity is low and therefore the hazard may be significant. It is important to first wet the ground underneath the footplate.

5.5 Current Splits Measurements

The current injection method can be used to determine the effect of secondary earthing such as cables screens and overhead earth wires (OHEWs). The test current in these secondary paths can be detected using a tuned voltmeter in conjunction with a clip-on current transformer. A flexible CT (eg LEMFLEX™) is most suited to this.



Measurement of 58 Hz current in 11 kV cable screen.

Only current at the test frequency will be detected because any power system frequency signals will be filtered out by the voltmeter. This technique identifies the amount of current that is likely to flow through the secondary paths during a real earth fault (see section 6 for analysis details). This can be useful for earthing conductor sizing purposes. There may be phase angles present and more accurate readings should be carried out with a dual channel spectrum analyzer.

6. Earthing System Measurement Analysis

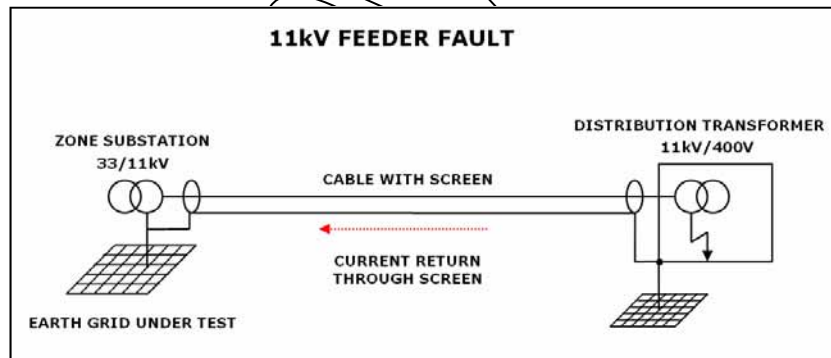
The earthing system impedance is simply calculated by:

$$Z_{\text{System}} = \text{ESVR}_{\text{Test}} / I_{\text{Test}}$$

$\text{ESVR}_{\text{Test}}$ (Earthing System Voltage Rise) is the measured earthing system voltage rise.

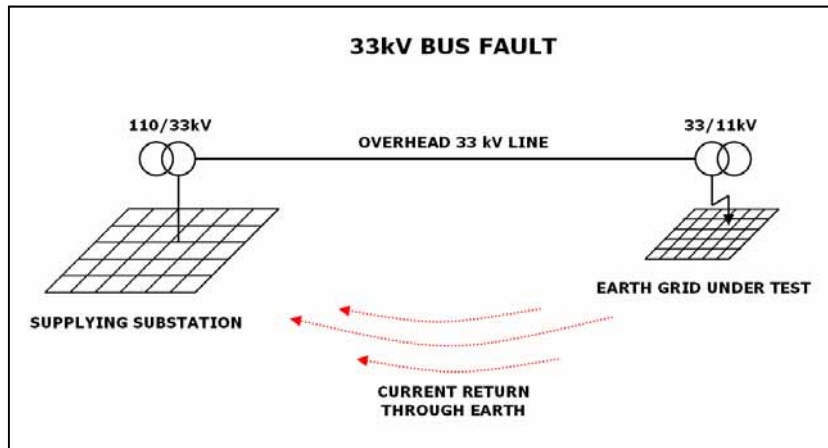
The next step is to relate the voltage and current measurements to a real fault situation. First the worst case earth fault current must be calculated. In terms of EPR the worst case is the fault that results in the largest amount of current flowing into the earthing system under test.

As an example an earth fault on an 11 kV feeder from a 33/11 kV zone substation may have a fault level of 12 kA. However if the feeder is an underground cable then most of the current will return to the zone substation transformer through the cable screen (if bonded to the earth grid). In this case there will be little or no earth potential rise around the zone substation (see below).



Alternatively, at the same zone substation a 33 kV bus earth fault may have a fault level of 6 kA. If the 33 kV bus is supplied by incoming overhead lines (with no neutral) then all of the current will return to the supplying substation through the earth. This will result in the greatest earth potential rise around the zone substation even though the fault level is much less than the 11 kV feeder fault level.

6. Earthing System Measurement Analysis (continued)



Once the worst case fault current is determined the measurement scaling factor can be calculated. The current injection method accurately simulates a real fault situation therefore the measurements can be directly scaled up. The scaling factor is simply the ratio of the test current to the worst case fault current:

$$\text{Scaling Factor } SF = I_{\text{Fault}} / I_{\text{Test}}$$

This factor can be used to scale up the measured earthing system voltage rise, EPR traverse voltages, touch and step voltages, and the cable screen currents.

Earthing System Voltage Rise

The ESVR during a worst case earth fault is given by:

$$\text{ESVR} = \text{ESVR}_{\text{Test}} \times SF$$

The scaled voltage rise indicates what voltage the earthing system will be at for the duration of a real fault.

6. Earthing System Measurement Analysis (continued)

EPR Traverse Measurements

The measured EPR traverse values give the voltage difference between the earthing system and the ground at the test point. Traditionally, EPR values are given as the voltage rise of the ground above absolute zero volts. This means that the traverse measurements must be converted to the correct format.

First of all the traverse measurements must be scaled up to the real fault situation. This can be achieved by multiplying each measurement by the scaling factor SF.

For each traverse measurement:

$$V_{EPR\text{Scaled}} = V_{EPR\text{Test}} \times SF$$

The next step is to calculate the maximum earthing system voltage rise as shown in the previous section. This value signifies the voltage rise of the earthing system above absolute zero volts and is used as a reference for the traverse calculations. The real fault earthing system voltage rise is:

$$ESVR = ESVR_{\text{Test}} \times SF$$

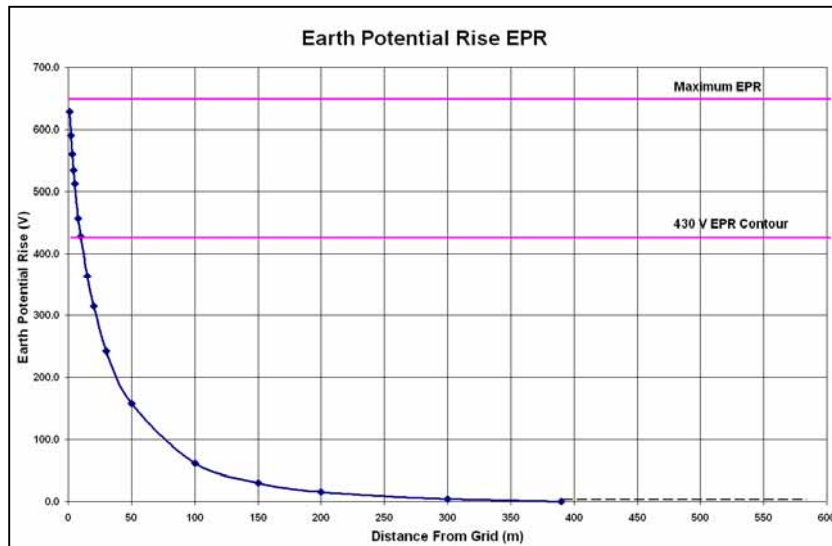
Finally the actual EPR values are given by subtracting the scaled measured EPR values from the maximum earthing system voltage rise:

For each scaled traverse measurement:

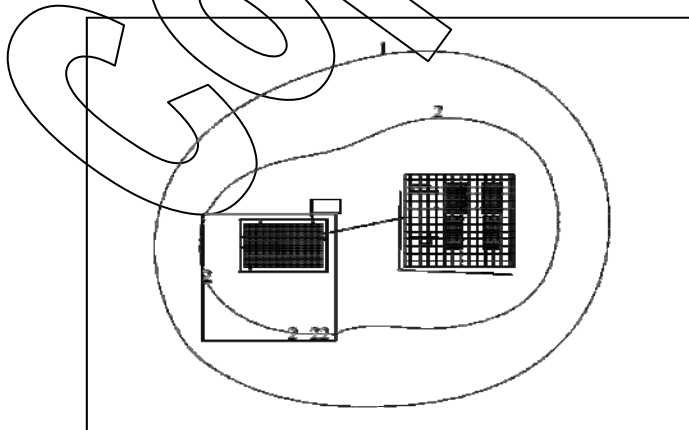
$$V_{EPR} = ESVR - V_{EPR\text{Scaled}}$$

These calculated values can then be plotted to give the actual EPR voltage traverse for a real earth fault (see diagram below). The location of EPR contours of interest (eg 430 V contour) can be determined from the plot. If more than one traverse was completed then the process is just repeated for each set of measurements.

6. Earthing System Measurement Analysis (continued)



The measured EPR values can be combined with earth grid modelling software such as CDEGS™ to provide an overall picture of the earthing system EPR. CDEGS™ can be used to create an EPR contour plot based on the earthing system shape and soil characteristics. The EPR contours can be adjusted to match the EPR locations from the test results. An example plot is shown below.



6. Earthing System Measurement Analysis (continued)

Touch and Step Voltage Measurements

The measured touch and step voltages are simply scaled up by the scaling factor (see beginning of section 6). The voltages can then be compared to the tolerable voltage limits as calculated according to IEEE80:2000 or similar standards.

IEEE80:2000 calculates limits for touch and step voltages based on limiting body currents to safe levels defined by C.F. Dalziel ("Dangerous electric currents" 1946). For a 50 kg person (public areas) the safe body current limit is given by:

$$I_{50\text{kg}} = 0.116/\sqrt{t}$$

Where t is the duration of the fault.

For a 70 kg person (i.e. restricted access areas) the safe body current limit is given by:

$$I_{70\text{kg}} = 0.157/\sqrt{t}$$

IEEE80 looks at the series impedance of the shock circuit and calculates a tolerable voltage limit corresponding to these currents. The shock circuit includes the contact resistance of the feet (and hands for touch voltages) and the body impedance (about 1 k Ω):

$$V_{\text{Limit}50\text{kg}} = I_{50\text{kg}} \times (R_{\text{Feet}} + R_{\text{Body}})$$

$$V_{\text{Limit}70\text{kg}} = I_{70\text{kg}} \times (R_{\text{Feet}} + R_{\text{Body}})$$

The contact resistance of a foot is found to be proportional to the ground surface resistivity and is given by:

$$R_{\text{Foot}} = 3\rho$$

Where ρ = resistivity of the ground surface ($\Omega\text{-m}$)

6. Earthing System Measurement Analysis (continued)

For touch voltages there are two feet in parallel so the contact resistance is given by:

$$R_{\text{Feet}} = 1.5\rho$$

For step voltages there are two feet in series so the contact resistance is given by:

$$R_{\text{Feet}} = 6\rho$$

Therefore the following formulas are given for calculating the tolerable touch and step voltage limits.

50 kg person (public areas):

Touch:

$$V_{\text{Limit50kg}} = (0.116/\sqrt{t}) \times (1.5\rho + 1,000)$$

Step:

$$V_{\text{Limit50kg}} = (0.116/\sqrt{t}) \times (6\rho + 1,000)$$

70 kg person (restricted access areas):

Touch:

$$V_{\text{Limit70kg}} = (0.157/\sqrt{t}) \times (1.5\rho + 1,000)$$

Step:

$$V_{\text{Limit70kg}} = (0.157/\sqrt{t}) \times (6\rho + 1,000)$$

The 6ρ term in the formula for step voltages indicates why step voltage hazards are unlikely on high resistivity surfaces.

For loaded measurements the tolerable voltage limits are simply given by:

$$V_{\text{Loaded50kg}} = (0.116/\sqrt{t}) \times 1,000$$

$$V_{\text{Loaded70kg}} = (0.157/\sqrt{t}) \times 1,000$$

7. LCI 2058 Technical Specifications

Power Supply	220-240 V ac 50 Hz (mains or generator)
Output Voltage	0 - 200 V
Output Current	1 - 10 A constant current
Output Signal	58 Hz square wave
Protection	Auto shutdown on open circuit
Housing	Robust Pelican case
Weight	15 kg

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8. TVM 1058 Tuned Voltmeter

8.1 Introduction



The TVM 1058 tuned voltmeter is specifically designed for use with the LCI 2058 injector unit to detect 58 Hz voltage under very noisy conditions. The TVM can also be used with a diesel generator when it is impractical to use the LCI 2058 unit because of induction.

In many instances, the residual 50 Hz or harmonic voltages on the earthing system or induced in the test cables may be many times the 58 Hz test signal level. The TVM is able to filter out unwanted frequencies. This means very low levels of test voltage may be identified anywhere on the site under test, even where the background signal level is high.

The TVM has a high input impedance to ensure accurate reading of prospective touch, step and transferred voltages. It also has a switchable low input impedance (1 k Ω) to simulate a person's body impedance.

8.2 Equipment Overview



Item Description:

1. On/off switch
2. Filter off button: Depress to bypass 58 Hz filtering, meter acts as a true RMS voltmeter.
3. Load button: Depress to apply 1k Ω load in parallel with input.
4. 3 1/2 digit LCD display
5. 4mm input sockets



Warning:
Meter input voltages must not exceed 200 V.

8.3 Basic Meter Operation

In normal operation the meter displays the filtered 58 Hz voltage. By pressing the 'FILTER OFF' button the meter will display a true RMS measurement of the input signal.

A 1 k Ω load can be applied across the input by pressing the 'LOW Z' button. This provides an indication of the voltage that would appear if the circuit was 'loaded' with the typical impedance of a human body (see section 5.4).

8.4 TVM 1058 Technical Specifications:

Power Supply	4 x AA
Ranges (auto)	0 - 1.999 V 0 - 19.99 V 0 - 199.9 V
Accuracy	$\pm 0.1\%$ FSD ± 2 counts
Frequency	58 Hz ± 1 Hz
Sensitivity	5 mV
Input Impedance	1 M Ω / 1 k Ω
Noise Rejection	> 70 dB ($> 3,000:1$)
Display	LCD 3½ Digit
Battery Life	40 hours (approx.)
Weight	200 g
Dimensions	195 x 100 x 40 mm (H x W x D)

9. Maintenance and Repair

Please refer all enquiries to:

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