MEGGER® DET2/2
Digital Earth Tester

User Guide

MEGGER®

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SAFETY WARNINGS

- Special precautions are necessary when 'live' earths may be encountered, and isolation switches and fuses are needed in this situation. See '**Operation - Earth Testing Safety Precautions**'.
- The earth spikes, test leads and their terminations **must not** be touched while the instrument is switched '**On**'.
- When working near high tension systems, rubber gloves and shoes should be worn.
- The *DET2/2* must be disconnected from any external circuit while its battery cells are being charged.
- A 12 V d.c. battery **must not** be used as an external supply while it is still **connected** to the vehicle.
- Replacement fuses **must** be of the correct type and rating
- Before charging the *DET2/2* battery ensure that the correct supply fuse is fitted and the voltage selector is set correctly.
- Warnings and precautions **must** be read and understood before the instrument is used. They must be observed during use.

NOTE

THE INSTRUMENT MUST ONLY BE USED BY SUITABLY TRAINED AND COMPETENT PERSONS.

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Symbols used on the instrument

⚠ Caution: Refer to accompanying notes.

⧈ Equipment protected throughout by Double Insulation (Class II)

CE Equipment complies with EU Directives

General Description

The **MEGGER®** *DET2/2* is a self contained compact portable instrument designed to measure earth electrode resistance and perform four terminal continuity tests. It may also make earth resistance tests which lead to the measurement of soil resistivity. Powered by internal rechargeable battery with an integral charger unit, the instrument design takes full advantage of microprocessor technology and features a large, clear liquid crystal display to provide digital readings. Terminals on the instrument provide an alternative power source connection to an external 12V battery, e.g. motor vehicle battery.

Display language can be selected from English, French, German, Portuguese or Spanish. A range of frequencies can be selected. *DET2/2* is auto ranging, and will indicate earth resistance in the range - 0,010 Ω to 19,99 kΩ, with a maximum resolution of 1 mΩ. The display warns of problems with the test conditions and also indicates low battery voltage. This enables the earth spikes to be re-positioned or instrument settings to be adjusted, to achieve optimum test conditions.

The red **TEST** push button is pressed to switch the instrument on, and then turned clockwise to hold it in the On position. To switch the instrument Off, the **TEST** button is turned anti - clockwise and released.

To suit prevailing lighting conditions, the **LCD** display can be adjusted by turning the contrast knob.

Four separate membrane switches (marked with ▲ or ▼) control the measurement function and are used to set the required language and test settings.

Test leads are not supplied with an instrument but form part of an earth testing field accessory kit which is available as an option. This kit also includes test spikes (electrodes) for making temporary earth spikes.

The instrument is housed in a robust and tough case moulded in ABS plastic. All the controls, the terminals and the **LCD** display are mounted on the front panel. *DET2/2* is splash proof, and suitable for outdoor use in most weather conditions.

Terminal '**C2**' ('**H**') is for the connection to the remote Current test spike.

Terminal '**P2**' ('**S**') is for the connection to the remote Potential test spike.

Terminal '**P1**' ('**ES'**) is for the Potential connection to the earth electrode to be tested.

Terminal '**C1**' ('**E'**) is for the Current connection to the earth electrode to be tested.

Applications

The installation of satisfactory earthing systems is an essential part of electricity supply, wiring safety and installation economics. It is also of great importance in many communications systems.

The primary application of the *DET2/2* is in the testing of earth electrodes, whether these take the form of a single electrode, multiple electrodes, mesh systems, earth plates or earth strips. All earthing arrangements should be tested immediately after installation and at periodic intervals thereafter.

Choice of electrode site

For an earth electrode system to perform satisfactorily it must always have a low total resistance to earth. This value will be influenced by the specific resistance of the surrounding soil. This in turn depends on the nature of the soil and its moisture content. Before sinking an electrode or electrode system it is often helpful to survey the surrounding area before choosing the final position for the electrode. It is possible with *DET2/2* to obtain the resistivity of the soil over an area and at different levels beneath the surface of the ground. These resistivity surveys may show whether any advantage is to be gained by driving electrodes to a greater depth, rather than increasing the cost by having to add further electrodes and associated cables, in order to obtain a specified total earth system resistance.

Earthing Systems Maintenance

After installation, checks may be made on an earthing system to see if there is any significant change in the resistance over a period of time or under different soil moisture conditions, (e.g. brought about by changing weather conditions or different seasons of the year). Such checks will indicate if the earth electrode resistance to earth has been exceeded by changing soil conditions or ageing of the system.

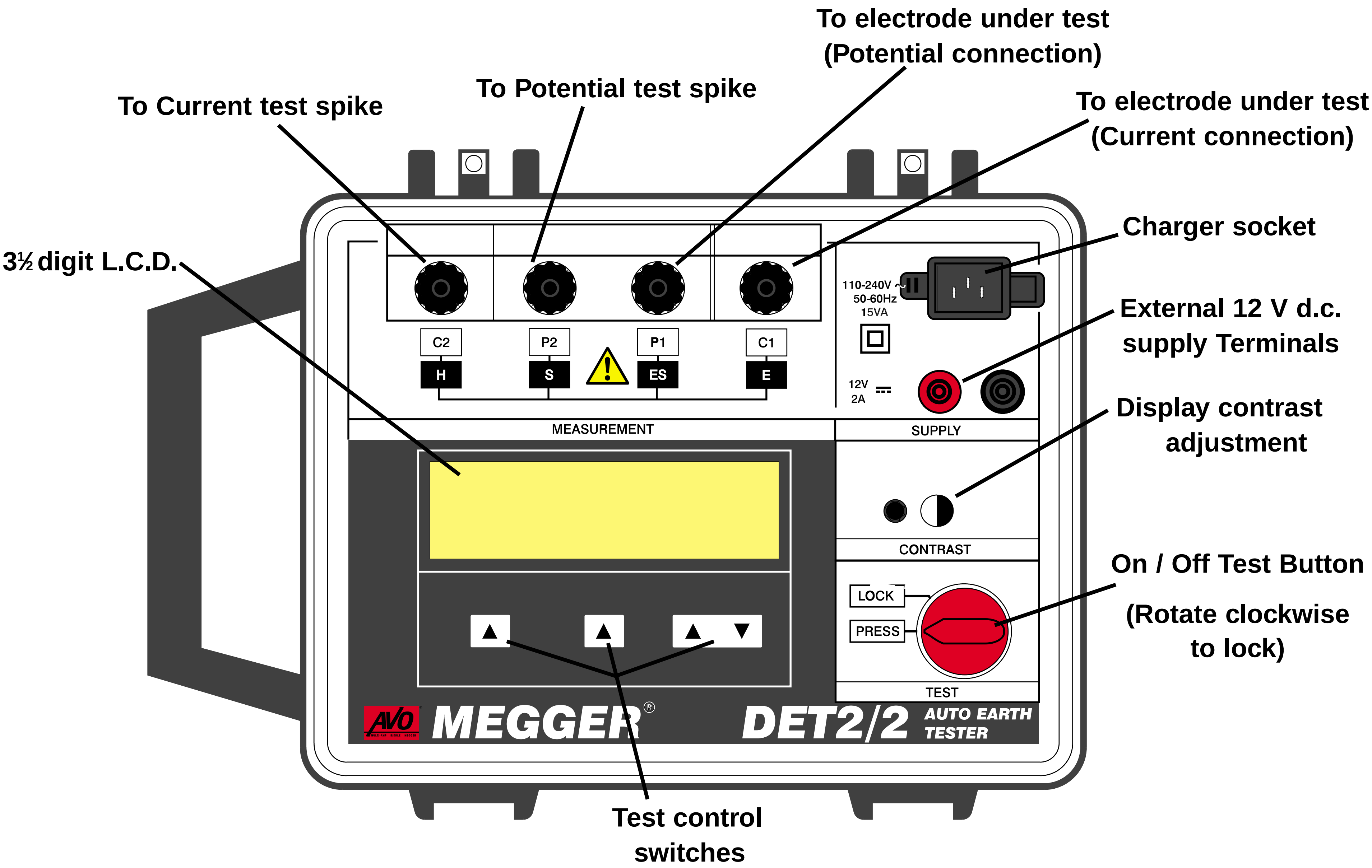
Other Applications

For archaeological and geological purposes, an investigation of soil structure and building remains can be carried out at varying measured depths, by the resistivity survey technique.

In all cases the accuracy of the instrument readings may be taken to be higher than the changes caused by natural variables in soil characteristics.

A further application is in continuity testing, for example checking the resistance of conductors used in an earthing circuit.

Features and Controls



Default Language Setting

Select and set the display language default as follows:

1. Press the left hand key ▲ and the **TEST** button together. Rotate the **TEST** button clockwise to the lock position. The language options are displayed.
2. Adjust the display contrast as necessary.
3. Using the centre ▲ key, scroll through the language options. When the required language is highlighted with a box surround, press the left hand ▲ key. The test frequency options are displayed.

Default Frequency Setting

Default test frequencies are available as follows:-

108 Hz - For use when testing with interference frequencies in the vicinity of 16 Hz.

128 Hz - For use when testing with interference frequencies in the vicinity of 50 Hz.

135 Hz -

150 Hz - For use when testing with interference frequencies in the vicinity of 60 Hz.

For each default value, the test frequency range can be incremented in 0,5 Hz steps from 105 Hz to 160 Hz; using the ▲ ▼ keys.

Select and set the default Frequency as follows:

1. Using the centre ▲ key, scroll through the Frequency options. When the required Frequency is highlighted with a box surround, press the left hand ▲ key. The Test and Calibration mode options are displayed. The message "**Please wait...**" is displayed.

Saving the Test Parameter settings

The settings made for Test current and filtering options, and the Frequency of the Test current may be saved for use in subsequent tests as follows:

1. After making the settings, press and hold the ▲ Scroll key during the measuring mode. The display lists the default selection.
2. Accept the settings and press the ▲ **Yes** key, or press the ▲ **No** key to cancel.

Once accepted, further tests may, if desired be carried out with different settings. The instrument will default to the saved settings if switched Off and back On again.

Setting up the Test spikes

For earth electrode testing and for earth resistivity surveying, the instrument’s test leads are connected to spikes inserted in the ground. The way the connections are made depends on the type of test being undertaken and details are given in ‘**Measuring Techniques**’.

Test spikes and long test leads are necessary for all types of earth testing and the optional earth testing field accessory kits contain the basic equipment. See ‘**Accessories**’.

1. Insert the **Current** test spike into the ground 30 to 50 metres away from the Earth electrode to to be tested.
2. Connect this spike to the instrument terminal '**C2**' (‘**H**’).
3. Insert the **Potential** test spike into the ground midway between the Current test spike and the Earth electrode, and in direct line with them both.
4. Connect this spike to the instrument terminal '**P2**' (‘**S**’).
5. When running the test leads out to each remote electrode, avoid laying the wires too close to each other.

Earth Testing Safety Precautions

Electrode Isolation or Duplication
It is preferable that the earth electrode to be tested is first isolated from the circuit it is protecting, so that only the earth is measured and not the complete system. When this is done, the circuits and equipment must be de-energised. If however this is not possible, the earth electrode should be duplicated, so that when it is disconnected for test purposes, the other one provides the necessary circuit protection.

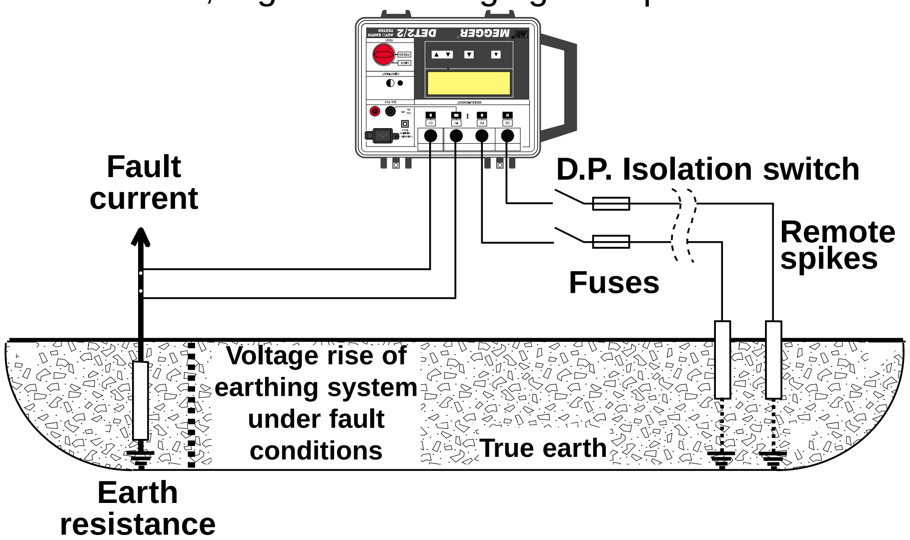
'Live' earth safety precautions
The *DET2/2* allows earth testing to be done at a relatively safe voltage using a maximum of a 50 V RMS square wave at a frequency of nominally 128 Hz. In use it is normally connected only to electrodes which are at earth potential.

A '**Live**' earth is one that carries current from the mains supply, or could do so under fault conditions.

When working around power stations or sub stations there is a danger that large potential gradients will occur across the ground in the event of a phase to earth fault. A wire which is connected to ground many metres away will then no longer be at the same potential as local ground, and in some cases could rise to above 1 kV. The following safety precautions are essential.

1. All persons involved **must** be trained and competent in isolation and safety procedures for the system to be worked on. They must be clearly instructed **not** to touch the earth electrode; test spikes; test leads, or their terminations if any 'Live' earths may be encountered. It is recommended that persons involved wear appropriate rubber gloves, rubber soled shoes, and stand on rubber mats.

2. The '**P2**' and '**C2**' terminals should be connected through a double pole isolation switch, the rating of which will cope with the maximum fault voltage and current. The isolation switch must be open whilst any personal contact is made with the remote test spikes, or the connecting leads, e.g. when changing their position.



A method of disconnection where fault conditions may occur.

⚠ Earth Testing Safety Precautions

If isolation switches cannot be used, the leads should be disconnected from the instrument before remote spikes and leads are handled. When the remote connections have been made, the final connections should be made to the instrument using insulated plugs, ensuring that the Operator takes adequate and appropriate precautions such as insulating mats, rubber gloves etc.

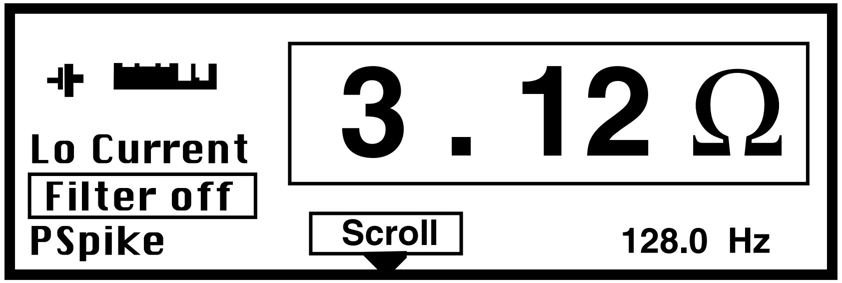
If a fault occurs while a test is being made the instrument may be damaged. Incorporating fuses (rated at 100 mA and able to cope with the maximum fault voltage) at the isolation switch will provide some protection for the instrument.

Caution: When working on live sites, **do not** use an external battery to power the instrument, as this would also **become live** under fault conditions.

General Testing Procedure

It is advisable that the battery of the *DET2/2* is fully charged before embarking on a test sequence. It can be extremely inconvenient if the battery becomes too low while a field test is in progress.

1. Firmly connect the instrument terminals to the respective earth electrode and test spikes. See ‘**Setting up the Test spikes**‘ and ‘**Measuring Techniques‘**.
2. Press and hold the **On/Off** push button, or rotate it to the **Lock** position.



3. If required, carry out a **Pspike** test to check continuity of the the Potential circuit.
4. The resistance value being measured is shown on the sub display after a few moments, when the “**Please wait...**” message has disappeared.

Test Condition Adjustments

If the sub display message states that a true measurement cannot be obtained, the test conditions can be altered to achieve optimum conditions for the test. One or more of the following may be used:-

Test current Frequency

Using the right hand ▲ or ▼ keys, increase or decrease the test current frequency range. See ‘**Initial Configuration and Spike set up**‘.

Lo Current /Hi Current

Using the centre ▲ key, scroll through the left hand options to select and highlight the ‘**Current**‘ option. Press the left hand ▲ key to toggle between ‘**Lo Current**‘ and ‘**Hi Current**‘. ‘**Hi Current**‘ assists to overcome problems caused by high current spike resistance. **Note:** Current circuit resistance is constantly monitored during a test. If too high, a message to this effect is displayed.

Filter

Using the centre ▲ key, scroll through the left hand options to select and highlight the ‘**Filter**‘ option.
Press the left hand s key to toggle between ‘**Filter off‘** and ‘**Filter on**‘. ‘**Filter on**‘ assists to reduce ‘noise‘ affecting the reading. The time taken to make a measurement increases significantly with ‘**Filter on**‘.

PSpike

Using the centre ▲ key, scroll through the left hand options to select and highlight the ‘**Pspike**‘ option. Press the left hand ▲ key to automatically carry out a resistance check of the of the Potential circuit. After a short pause, the result of this check is displayed on the sub panel. If appropriate, the '**Pspike**' label then changes to '**Retest**', giving the option to repeat the test after any alteration to spike position etc. has been made. Press the centre ▲ key, now labelled '**Measure**' to repeat the measurement.

Note: If for any reason a test is made with an open Potential circuit, the resultant test reading will be invalid. To confirm that connections are still in place and to check the validity of the test, a '**P spike'** check should be made before each test.

Auto Ranging

If the earth resistance being measured is low, but a high level of 'noise' is present, coupled with a high Current spike resistance, the instrument will automatically make a measurement with a lower precision. If successful, the resistance reading will be displayed with only 3 digits, the least significant digit being blanked out.

Greater precision can be obtained by:-

a) Reducing spike resistance (e.g. by wetting the ground, or by inserting the spikes deeper into the ground).

b) Toggling to '**Hi Current**' option.

c) Eliminating the 'noise' source if possible.

Display Messages

When appropriate, messages are displayed. The following message definitions are given:

"Please wait..."
"Please wait... zeroing"

This means that the instrument is making internal measurements and tests before displaying the resistance reading. The ▲ and ▼ keys remain active and measurement conditions may be adjusted before a reading is displayed. These messages may be repeatedly displayed if there is a high 'noise' level present, close to the frequency of the measurement, or if the Potential circuit is incorrectly connected.

"Open Circuit Current Terminals"

This means that the test current flowing is low, and implies that a resistance of >500 kΩ is present between the test terminals. If this message remains displayed when terminals '**C1'** and '**C2'** are shorted together, an internal fuse has ruptured, with the possibility of other internal damage having been caused. In this case, return the instrument, return the instrument to the manufacturer or an approved repair company. See '**Repair and Warranty**'.

"Check connections voltage terminals"

This message is displayed when the connections to the '**P1'** and '**P2'** connections are reversed. Check and correct as necessary.

“High current noise”
“High voltage noise”

These messages are displayed when the noise voltage present is greater than the acceptable level, causing the measurement to be invalid. Changing the test frequency will have no effect in this instance. If possible, eliminate the noise source, or reduce spike resistance (e.g. by wetting the ground, or by inserting the spikes deeper into the ground).

Further Display Messages

High level of interference or an instrument fault could cause the display of any of the following messages:

“Invalid current”

“Invalid voltage”

“Invalid current zero”

“Invalid voltage zero”

“Current zero too big”

“Voltage zero too big”

“Noisy current zero”

“Noisy voltage zero”

Incorrect connection of the potential terminals could cause an ‘**Invalid voltage**’ message.

Error Messages

Error messages may appear on the bottom line of the display in the event of a instrument or software fault, or due to the existence of adverse electrical conditions. If an error message appears, switch the *DET2/2* off, refer to ‘**Repair and Warranty**’ and return the instrument to the manufacturer or approved agent, giving details of the error message and the software edition.

“Calibration data retrieval error

Refer to handbook”

If calibration data stored in the instrument has been incorrectly retrieved, the above message is displayed (in English) when switching on. Switch the *DET2/2* off, refer to ’**Repair and Warranty**’ and return the instrument to the manufacturer or approved agent, giving details of the error message and the software edition.

“Setup data retrieval error”

Default language, frequency and current level are normally retrieved when the instrument is switched on.

If unsuccessful, the above message is displayed (in English) when switching on, with the option to **“Retry”** (try reading the data again) or **“Manual”** (manually set up the data again). If ‘**Retry**’ or ‘**Manual**’ is unsuccessful, switch the *DET2/2* off, refer to ’**Repair and Warranty**’ and return the instrument to the manufacturer or approved agent, giving details of the error message and the software edition.

Battery Charging

Battery capacity
The capacity of the battery is continuously monitored and displayed, adjacent to the battery symbol. The indicator segments will show fully charged, or recede as the battery is used, to indicate three quarters full, half full or quarter full. A warning message is displayed if the battery is unable to supply adequate test current.

Charging method
It is advisable that the battery is fully charged before embarking on a test sequence. Charging is carried out by external a.c. mains supply only. Charging commences automatically as soon as the supply is connected. Normal recharge time is 6 hours. Testing is inhibited during charging.

Battery charging requires a supply voltage of 100 V to 130 V a.c., or 200 V to 260 V, 50 - 60 Hz. Connection to a voltage from 130 V to 200 V will not cause harm, but will not charge the battery, and the message "**Power Supply too low**" will be displayed. Charging time will be extended if either the power supply voltage drops too low during the charge period or if the battery has been excessively discharged. Charge the battery as follows:

1. Switch the **Test** switch to Off.
2. Remove any connections to the 4 mm external supply sockets.
3. Disconnect and remove the test leads.
4. Connect the mains supply to the IEC 320 connector on the top right of the instrument. Confirm that the message "**Charging On**" is displayed. Progressive and accumulated charging times are displayed.

```
Charging On

Time on charge : 0.0  hour
Normal charge time : 6.0 hours
```

5. When fully charged, the charging current will automatically reduce to "**Trickle Charge**". Charging will automatically stop after a period of 24 hours.

Note: The battery will be prevented from charging if an external battery is connected to the 4 mm sockets during the charging process. An external connected battery **cannot** be charged via the instrument.

Battery Charging

Battery Charging Power cord plug

If the power cord plug is not suitable for your type of socket, do not use an adaptor. You should use a suitable alternative power cord, or if necessary, change the plug by cutting the disconnected cord and fitting a suitable plug.

The colour code of the cord is:-

Earth (Ground)	**-**	**Yellow/Green**
Neutral	**-**	**Blue**
Phase(Line)	**-**	**Brown**

If using a fused plug, a 3 amp fuse to BS 1362 should be fitted.

Note: A plug severed from the power cord should be destroyed, as a plug with bare connections is hazardous in a live socket outlet.

Battery Charging Notes

1) **Do Not** leave battery in a totally discharged state. If the instrument is idle for long periods, recharge the battery at least every 6 months. (More frequently if the storage temperature is >40 °C).
2) Battery charging should be carried out in a dry environment and at temperatures in the range 0 °C to 40°C.
3) When charging the battery indoors, the area should be well ventilated.

FALL-OF-POTENTIAL METHOD

This is the basic method for measuring the resistance of earth electrode systems. However, it may only be practical on small, single earth electrodes because of limitation on the size of area available to perform the tests.

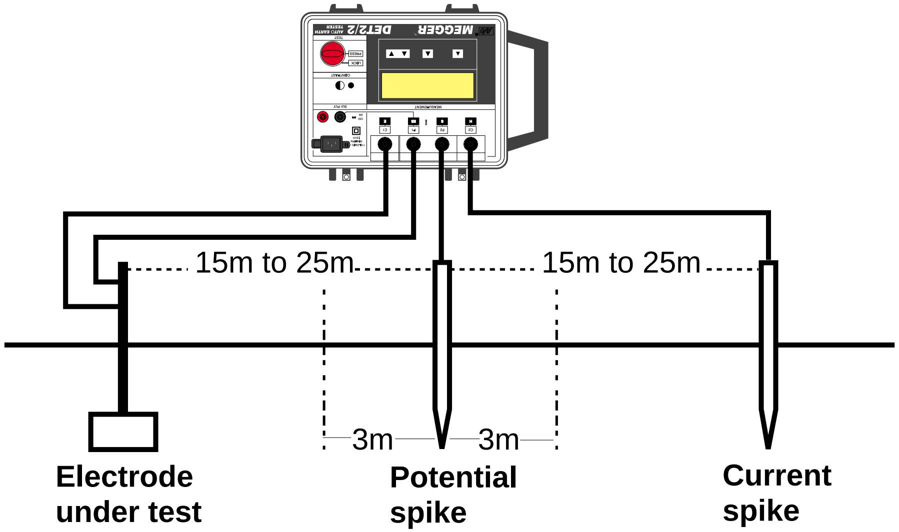
Insert the Current test spike into the ground some 30 to 50 metres away from the earth electrode to be tested. Firmly connect this spike to the instrument terminal '**C2**'.

Insert the Potential test spike into the ground midway between the Current test spike and the earth electrode. Firmly connect this spike to the instrument terminal '**P2**'.

Note:- It is important that the Current spike, the Potential spike and the earth electrode are all in a straight line. Also when running the test leads out to each remote spike, it is preferable not to lay the wires close to each other in order to minimise the effect of mutual inductance.

Firmly connect the '**C1**' and the '**P1**' instrument terminals to the earth electrode as shown.

Operate the instrument as explained in '**Basic Test Procedure**', and note the resistance obtained.



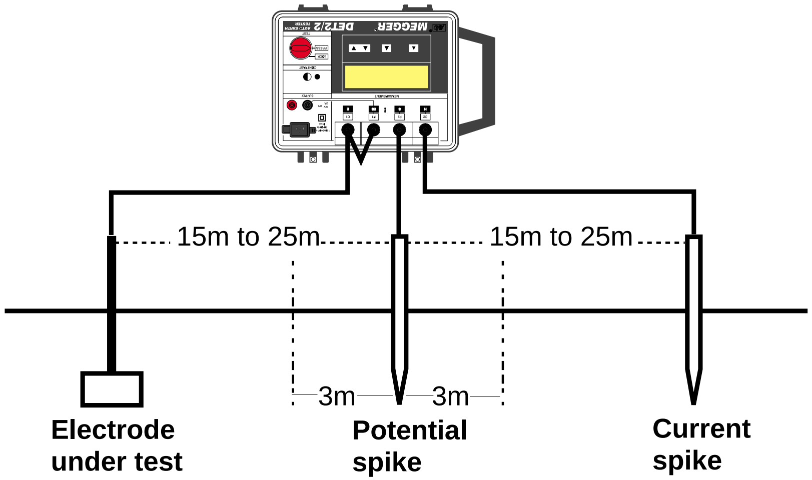
Fall-of-Potential method connections.

Move the potential spike 3 metres further away from the earth electrode and make a second resistance measurement. Then move the potential spike 3 metres nearer the electrode (than the original position) and make a third resistance measurement. If the three resistance readings agree with each other, within the required accuracy, then their average may be taken as the resistance to earth of the electrode. If the readings disagree beyond the required accuracy then an alternative method should be used e.g. the 61,8% Rule or the Slope Method etc.

Fall-of-Potential Method with Short 'E' Lead

Another way of making connections to the earth electrode is to connect to the earth electrode using only one single connection to the ‘**C1**’ terminal. This should **only** be done if the test lead can be kept short because its resistance will be included in the measurement.

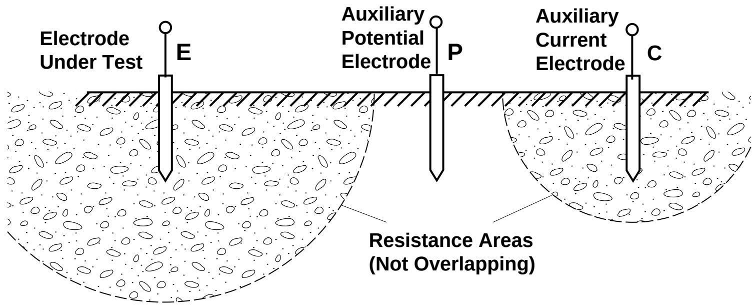
Note:- Earth electrode test lead resistance can be determined separately. First remove it from the the electrode and connect to the '**C2**' and '**P2**' terminals. Press the **Test** push button. The lead resistance can then be deducted from the earth resistance measurements. This procedure is not, of course, necessary if the '**C1**' and '**P1**' terminals are connected by separate test leads.



Fall-of-Potential method using a single lead to the earth electrode.

THE 61,8% RULE

To obtain an accurate reading using the Fall-of-Potential method the current spike must be correctly sited in relation to the earth electrode. Since both possess ‘resistance areas’, the Current spike must be sufficiently remote to prevent these areas overlapping. Furthermore, the Potential spike must be between these areas. If these requirements are not met, the Fall-of-Potential method may give unsatisfactory results.

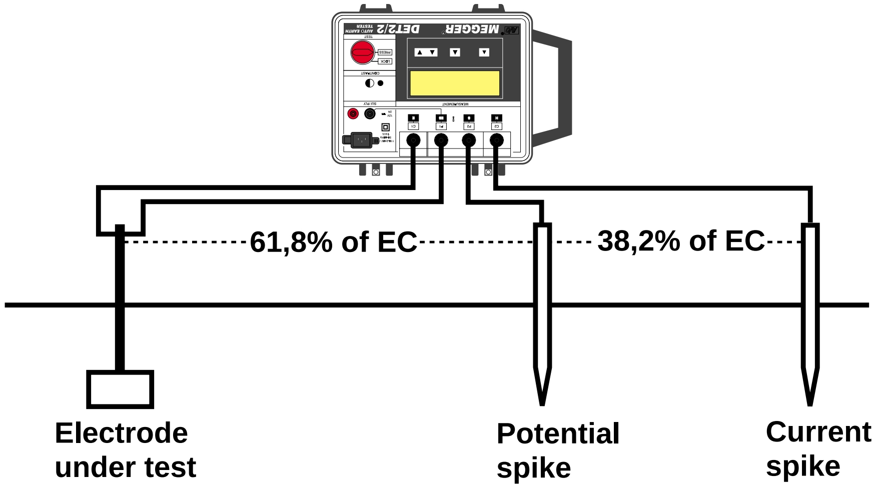


Resistance areas associated with an earth electrode and current spike.

Theoretically, both the Current and Potential spikes should be at an infinite distance from the earth electrode. However, by graphical considerations and by actual test it can be demonstrated that:-

The ‘**true**’ resistance of the earth electrode is equal to the measured value of resistance when the Potential spike is positioned 61,8% of the distance between the earth electrode and the Current spike, away from the earth electrode.

This is the 61,8% Rule and strictly applies only when the earth electrode and Current and Potential spikes lie in a straight line, when the soil is homogeneous and when the earth electrode has a small resistance area that can be approximated by a hemisphere. Bearing these limitations in mind this method can be used, with care, on small earth electrode systems consisting of a single rod or plate etc. and on medium systems with several rods.



Connections for the 61,8% Rule.

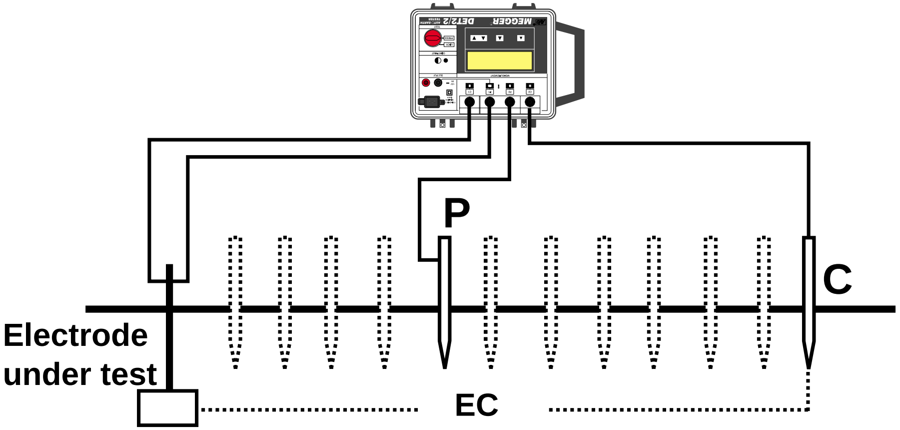
For most purposes the Current spike should be 30 metres to 50 metres from the centre of the earth electrode under test. The Potential spike should be inserted in the ground 61,8% of this distance, between and in a straight line with, the Current spike and the earth electrode. The distance is measured from the earth electrode. If the earth electrode system is of medium size containing several rods, then these distances must be increased. The following table gives a range of distances that agree with the rule. In the first column '**Maximum dimension**' is the maximum distance across the earth electrode system to be measured.

Maximum dimension in metres	Distance to Potential spike in metres from centre of earth system	Distance to Current spike in metres from centre of earth system
5	62	100
10	93	150
20	124	200

For greater accuracy an average reading can be calculated by moving the current spike, say 10 metres, towards and then away from its first position and making further resistance measurements. (Remember that the Potential spike must also be moved in accordance with the 61,8% Rule). The average of the three readings can then be calculated.

THE SLOPE METHOD

This method is more applicable to larger earth electrode systems or where the position of the centre of the earthing system is not known or inaccessible (e.g. if the system is beneath the floor of a building). The Slope method can also be used if the area available for siting the earth electrodes is restricted. It can be tried if the previous methods prove unsatisfactory and generally yields results of greater accuracy than those methods.

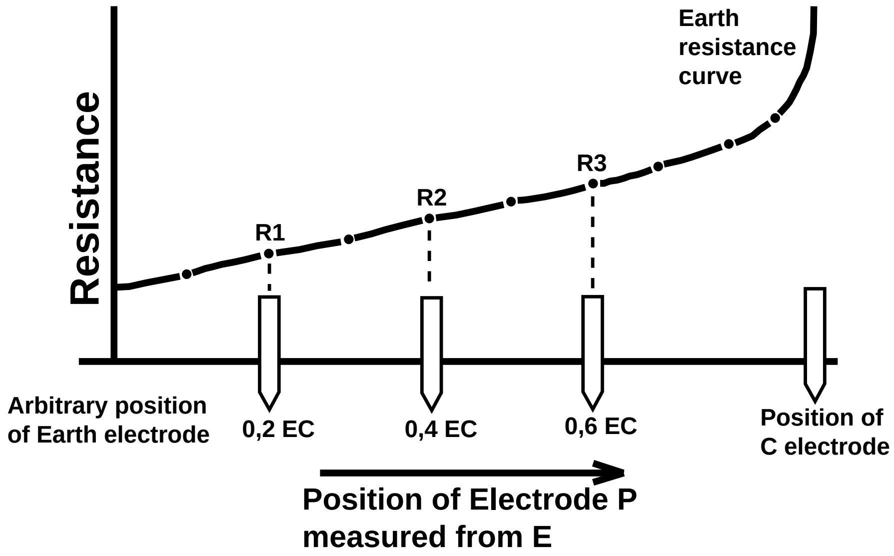


Connections for the Slope method

The equipment is set up as shown. The remote Current spike is placed 50 metres or more from the earth electrode system to be measured and connected to the '**C2**' terminal. The Potential spike is inserted at a number of positions consecutively, between the earth system and the Current spike, and connected to the '**P2**' terminal. The test spikes and the earth system should all be in a straight line.

The '**C1**' and '**P1**' terminals are connected separately to some point on the earth electrode system.

The earth resistance is measured at each separate position of the Potential spike and the resistance curve is plotted from the results. At least six readings are needed. Drawing the curve will show up any incorrect points which may be either rechecked or ignored.



Example Resistance curve from Slope method tests.

Suppose the distance from the earth electrode system to the current spike is **EC**. From the curve equivalent resistance readings to Potential positions 0,2**EC**, 0,4**EC** and 0,6 **EC** can be found. These are called R1, R2 and R3 respectively.

Calculate the slope coefficient μ, where

$$\mu = \frac{(R3-R2)}{(R2-R1)}$$

which is a measure of the change of slope of the earth resistance curve.

From the table commencing on page 36 obtain the value of P_t **/ Ec** for this value of **μ**.

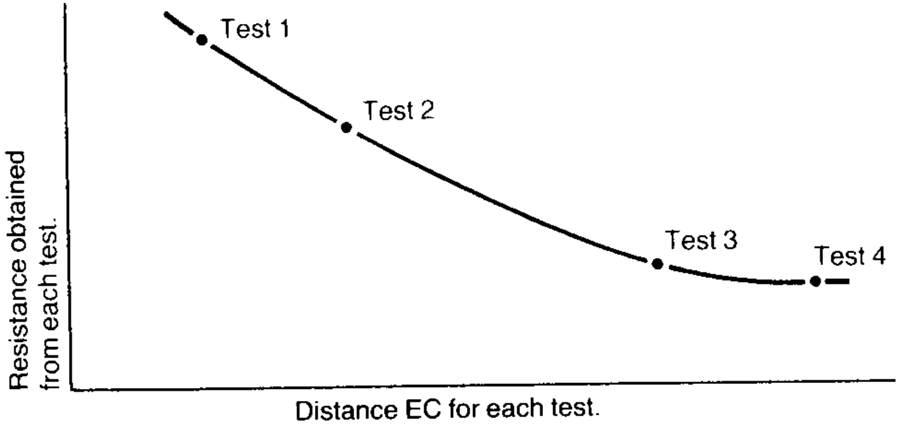
P_t is the distance to the Potential electrode at the position where the '**true'** resistance would be measured.

Multiply the value of P_t **/ Ec** by **Ec** to obtain the distance P_t.

From the curve read off the value of resistance that corresponds to this value of P_t. The value obtained is the earth electrode system's resistance.

Note:- (i) If the value of **μ** obtained is not covered in the table then the current spike will have to be moved further away from the earthing system.

(ii) If it is necessary, further sets of test results can be obtained with different values of **EC**, or different directions of the line of **EC**. From the results obtained of the resistance for various values of the distance **EC.**



Example of possible results from several Slope method tests.

This shows how the resistance is decreasing as the distance chosen for **EC** is increased.

The curve indicates that the distances chosen for **EC** in tests (1) and (2) were not large enough, and that those chosen in tests (3) and (4) were preferable because they would give the more correct value of the earth resistance.

(iii) It is unreasonable to expect a total accuracy of more than 5%. This will usually be adequate, bearing in mind that this sort of variation occurs with varying soil moisture conditions or non-homogeneous soils.

METHOD USING A ‘DEAD’ EARTH

The techniques using test spikes explained earlier are the preferred methods of earth testing. In congested areas it may not be possible to find suitable sites for the test spikes, nor sufficient space to run the test leads. In such cases a low resistance conductive water main may be available. This is referred to as a ‘dead’ earth.

Great care must be taken before deciding to adopt this method and its use is not to be encouraged. Before employing this method, the user must be quite sure that no part of the ‘dead‘ earth installation contains plastic or other non-metallic materials.

1) Short together terminals ‘**P1**’ and ‘**C1**’.

2) Short together terminals ‘**P2**’ and ‘**C2**’.

2) Firmly connect a test lead to ‘**C1‘** and **’P1**‘ and the other test lead to ‘**P2**‘ and ‘**C2**‘.

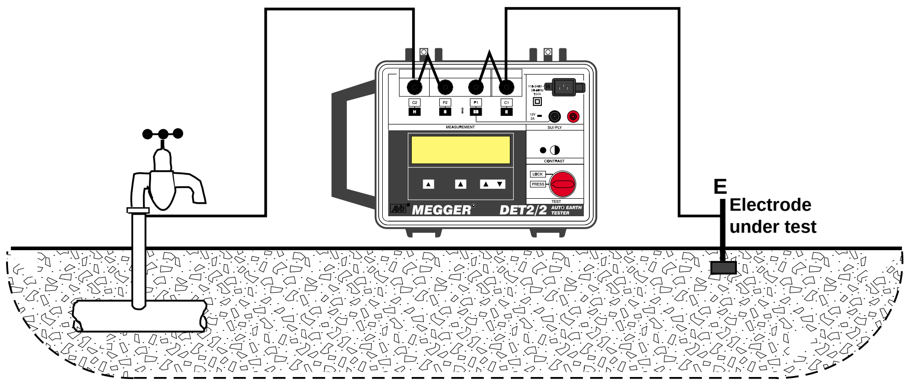
3) Firmly connect the free ends of the test leads to the ‘dead’ earth, and to the electrode under test.

4) Press the **Test** push, and take a reading in the normal way.

This test will give give the combined resistance to earth of the two earths in series. If that of the ‘dead‘ earth is negligible then the reading may be taken as that of the electrode under test .

The resistance of the two test leads can be found by firmly joining their free ends together, pressing the **Test** push and taking the reading in the usual way. Test lead resistance can then be subtracted from the original reading, to obtain the combined resistance of the earth electrode and the ‘dead’ earth.

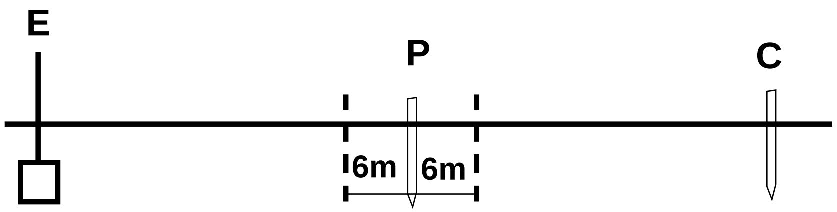
In congested urban areas, the Star-Delta method is the preferable. This method is explained along with other methods referred to, in ‘**Getting Down to Earth**’ (see ‘**Accessories**‘ - **Publications**).



‘Dead’ earth testing

BS7671(16th Edition wiring regulations) requirements

Regulation 713-11 of BS7671 specifies that the resistance of earth electrodes must be measured. The accompanying Guidance Notes describe a method of test that is very similar to the Fall-of-Potential method. If the maximum deviation from the average of the three readings is better than 5% then the average can be taken as the earth electrode resistance. If the deviation exceeds 5% then the current spike should be moved further away from the electrodes and the tests repeated.



Test spike positions for BS7671 testing

Other Methods

There are other methods of earth electrode testing among which are the Four Potential, Intersecting Curves and Star Delta methods. **AVO INTERNATIONAL** publications explain these test methods and give other helpful information about earth testing. See '**Accessories**' - **Publications.**

Determining 'Touch' Potential

'**Touch**' potential is the potential difference a person would experience across his body if he were, for example, standing on the ground outside the earthed perimeter fence of a substation and touching the fence at the time a fault occurred.

Firmly connect the instrument as follows:-

1) Terminal '**C1**' to the substation earth.

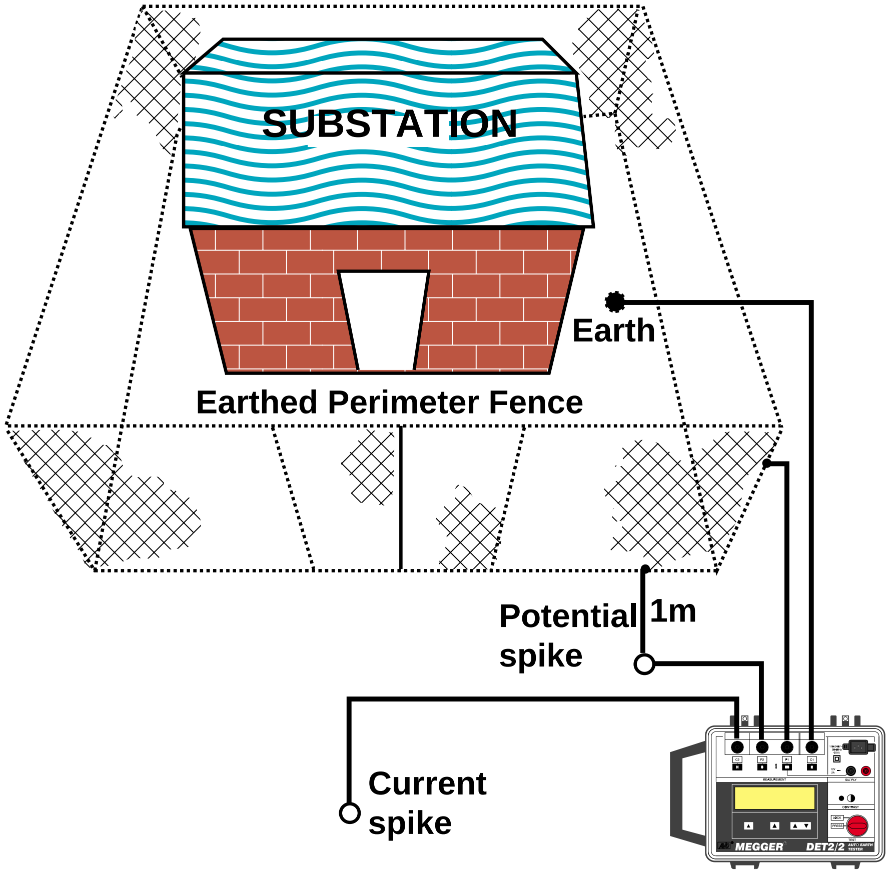
2) Terminal '**C2**' to the Current spike inserted in the ground some distance away.

3) Terminal '**P1**' to the structure being tested e.g. the perimeter fence.

4) Terminal '**P2**' to the Potential spike inserted in the ground 1 metre away from the perimeter fence adjacent to the point where a person might stand.

5) Press the **Test** push, and take a reading in the normal way. This is the effective resistance between the point of test on the fence and the Potential spike as seen by the test current.

The maximum value of the current that would flow in the earth when a fault to earth occurred at the substation must be known. The maximum fault current has to be calculated from the parameters associated with the substation ratings involved. From Ohms Law (V = I x R), the Touch potential can be calculated.



Determining 'Touch' potential.

Determining 'Step' potential

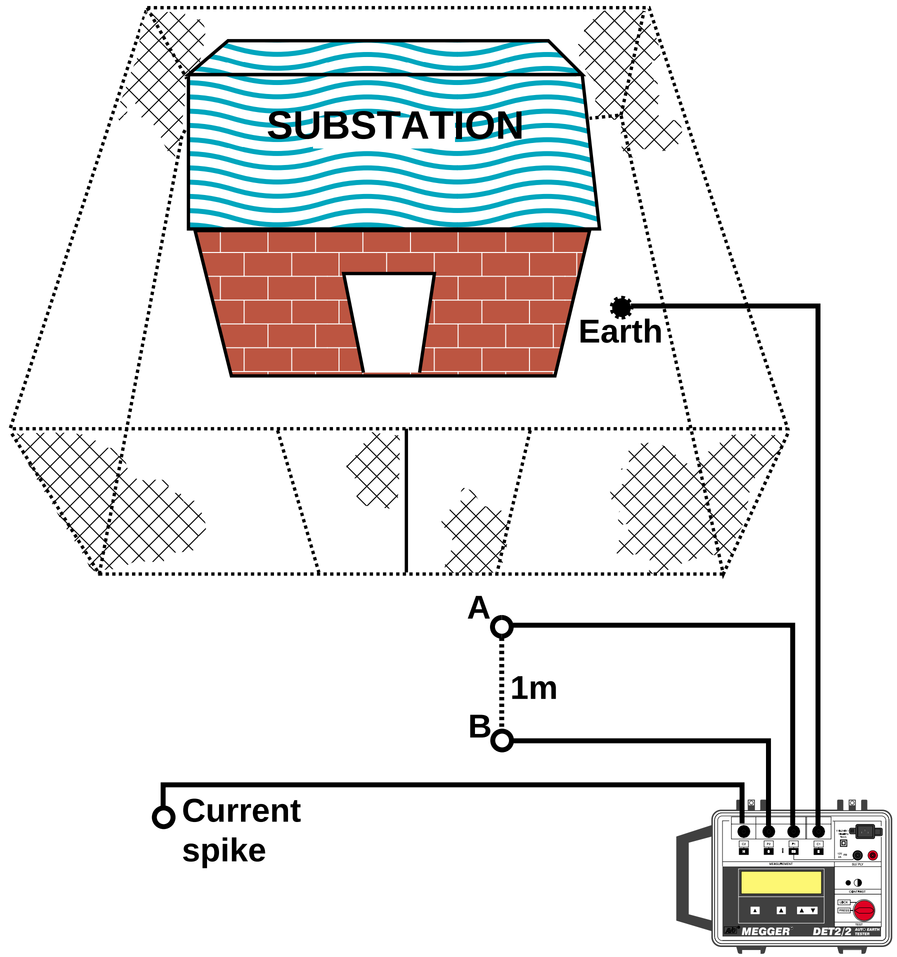
'**Step**' potential is the potential difference a person would experience between his feet as he walked across the ground in which a fault current was flowing.

Firmly connect the instrument as follows :-

1) Terminal '**C1**' to the substation earth.
2) Terminal '**C2**' to the Current spike inserted in the ground some distance away.
3) Firmly connect the '**P1**' and '**P2**' terminals to test spikes inserted in the ground 1 metre apart, (or the length of a step) at positions A and B respectively. A is nearest to the substation earth.
4) Press the **Test** push, and take a reading in the normal way.

Record the resistance indicated. This is the effective resistance across the positions **A** and **B**, as seen by the test current.

The maximum value of the current that would flow in the earth when a fault to earth occurred at the substation must again be known. From Ohms Law the 'Step potential' can be calculated.



Determining 'Step' potential

Typical variations in soil resistivity

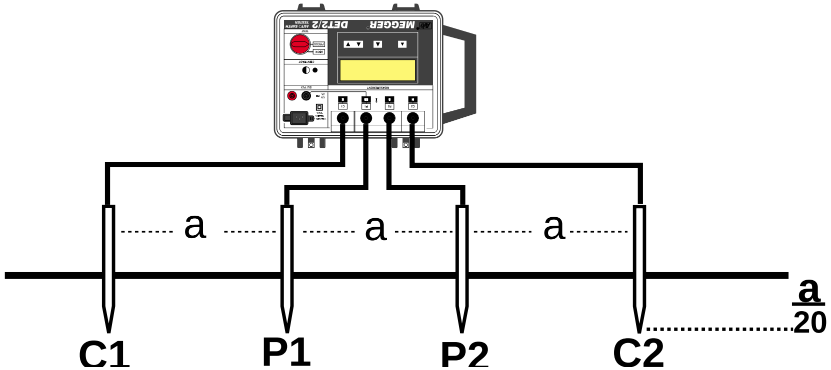
The resistance to earth of an earth electrode is influenced by the resistivity of the surrounding soil. The resistivity depends upon the nature of the soil and its moisture content and can vary enormously as seen in the table below:-

Material	Specific resistance in Ω-cms	Information source
Ashes	350	Higgs
Coke	20 - 800	
Peat	4500 - 20000	
Garden earth - 50% moisture	1400	Ruppel
Garden earth - 20% moisture	4800	Ruppel
Clay soil - 40% moisture	770	Ruppel
Clay soil - 20% moisture	3300	
London clay	400 - 2000	
Very dry clay	5000 - 15000	
Sand - 90% moisture	13000	Ruppel
Sand - normal moisture	300000 - 800000	
Chalk	5000 - 15000	
Consolidated Sedimentary rocks	1000 - 50000	Broughton Edge & Laby

Because it is impossible to forecast the resistivity of the soil with any degree of accuracy it is important to measure the resistance of an earth electrode when it is first laid down and thereafter at periodic intervals. Before sinking an electrode into the ground for a new installation it is often advantageous to make a preliminary survey of the soil resistivity of the surrounding site. This will enable decisions to be made on the best position for the electrode(s) and to decide whether any advantage can be gained by driving rods to a greater depth. Such a survey may produce considerable savings in electrode and installation costs incurred trying to achieve a required resistance.

Line Traverse

The most common method of measuring soil resistivity is often referred to as the line traverse. Four test spikes are inserted into the ground in a straight line at equal distances '**a**' and to a depth of not more than 1/20 of '**a**'. The instrument is connected to the test spikes as shown.



Soil resistivity measurement.

The instrument is operated and the measurement made in the normal way. The resistivity may be calculated from the formula given opposite or from the nomogram overleaf. This is the average soil resistivity to a depth '**a**'.

The four test spikes are then re-positioned for further tests along a different line. If both the spacing '**a**' and the depth **a/20** are maintained, a directly comparable reading will be obtained each time, and thus regions of lowest resistivity can be located over a given area (at the constant depth '**a**').

Re-spacing the test spikes at separations '**b**', '**c**', '**d**', etc will yield results from which a profile of the resistivity at new depths **b/20, c/20, d/20**,etc.can be obtained.

If the same line for the test spikes is maintained, but the separation of them is progressively widened, resistivity values at various depths can be obtained. By this means depth surveys may be made.

More details can be found in the AVO **INTERNATIONAL** publications. See '**Accessories**'.

Calculation of resistivity

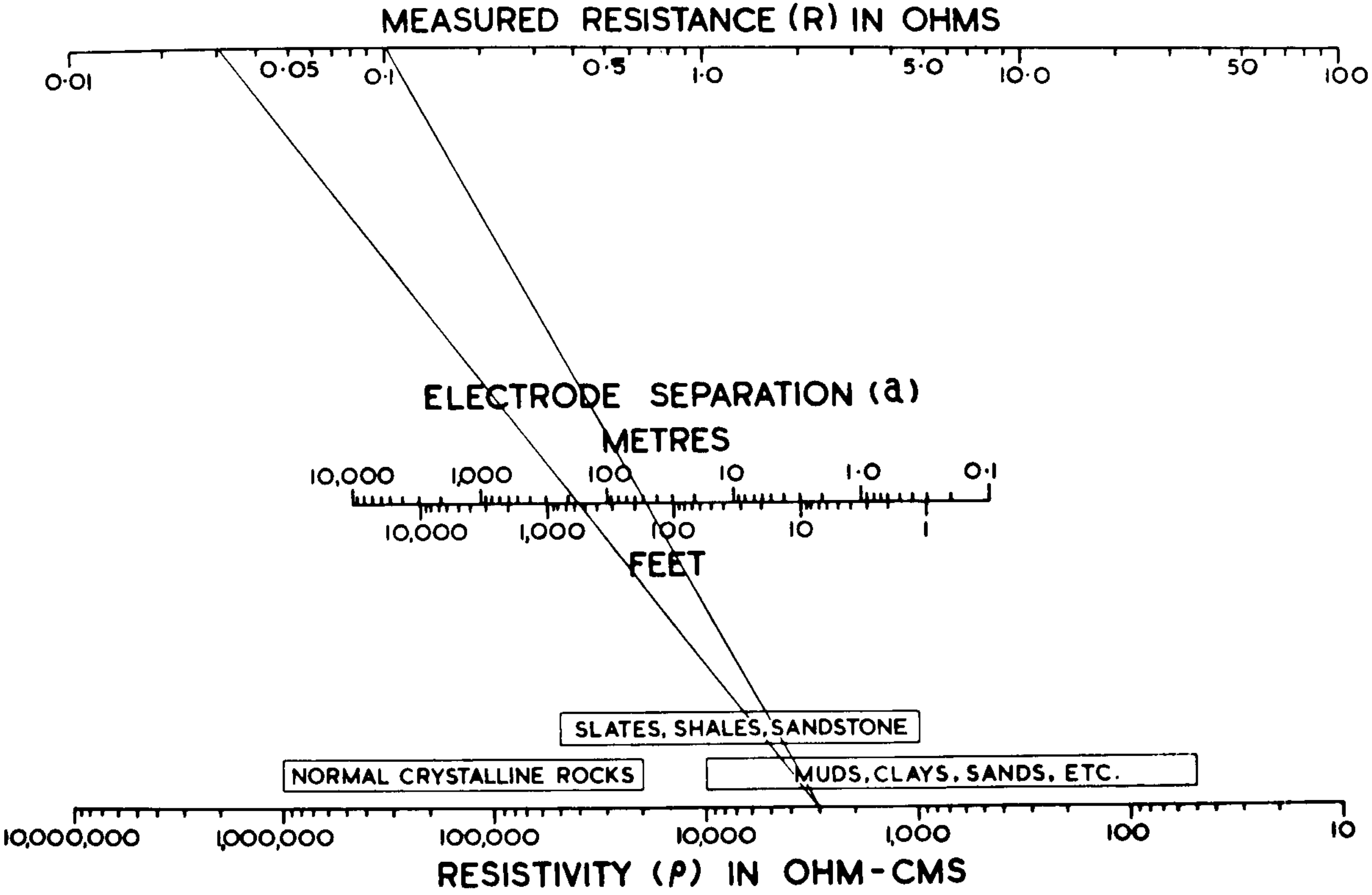
Assuming that the tests were carried out in homogeneous soil the resistivity is given by the formula:-

$$\rho = 2\pi aR$$

where '**R'** is the resistance measured in ohms, '**a'** is the test spike spacing in metres and 'ρ' is the resistivity in ohm-metres.

For non-homogeneous soils the formula will give an apparent resistivity which is very approximately the average value to a depth equal to the test spike spacing '**a**'.

Measuring Techniques - Measuring Soil Resistivity



Resistivity calculation Nomogram

Measuring Techniques - Continuity Testing

DET 2/2 can be used to measure metallic resistances of low inductance or capacitance. To test the continuity of conduit or other earth conductors the instrument can be connected as shown. Ensure that the circuit is de-energised, before connecting the instrument for measurement.

Note:- Due to the inherent high accuracy of the instrument and the low continuity resistance to be measured, contact resistance between the test lead clips and the conduit becomes a factor in the measured value. Contact resistance should therefore be kept as low as possible.

1) Firmly short together terminals ‘**P2’** and **‘C2’**.

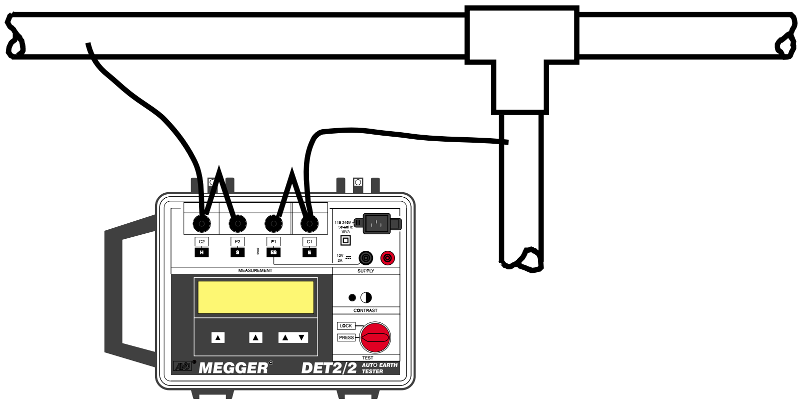
2) Firmly short together terminals ‘**P1’** and **‘C1’**.

3) Firmly connect a test lead to ‘**P2** and **C2**’,and the other test lead to ‘**P1**’ and ‘**C1**’.

4) Firmly connect the free ends of the test leads across the isolated circuit under test.

5) Press the **Test** push, and take a reading in the normal way.

The resistance of the two test leads can be found by firmly joining their free ends together, pressing the **Test** push and taking the reading in the usual way. Test lead resistance can then be subtracted from the original reading, to give a ‘true’ value of continuity resistance.



Continuity testing.

Specification

Earth Resistance Ranges: 0,010 Ω to 19,99 kΩ (Auto-ranging) 1 mΩ resolution

Accuracy (23°C ±2°C): ±0,5% of reading ±2 digits. Service error ±5% of reading ±2 digits ±10 m Ω (meets VDE service error over 50 mΩ)

Test Frequency: 105 Hz to 160 Hz reversing d.c. (50 Hz environments default to 128 Hz, 60 Hz environments default to 150 Hz). Set in steps of 0,5 Hz

Test Current: 50 mA max. (selectable high and low levels)

Max Output Voltage: < 50 V r.m.s.

Interference: Typically 40 V pk to pk (50 Hz, 60 Hz, sinusoidal nature)

Max. Current spike (Loop) Resistance:

Range (R_E)	High current (R_p)	Low current (R_c)
0,010 Ω - 0,499 Ω	5 kΩ	1 kΩ
0,500 Ω - 1,999 Ω	5 kΩ	3 kΩ
2,000 Ω - 19,99 Ω	10 kΩ	5 kΩ
20,000 Ω - 199,9 Ω	50 kΩ	20 kΩ
200, 0 Ω - upwards	50 kΩ	50 kΩ

Max. Potential Spike Resistance:

Range (R_E)	High current (R_p)		Low current (R_p)	
	(R_{p1})	(R_{p2})	(R_{p1})	(R_{p2})
0,010 Ω - 0,499 Ω	1 kΩ	10 kΩ	1 kΩ	10 kΩ
0,500 Ω - 1,999 Ω	1 kΩ	20 kΩ	1 kΩ	10 kΩ
2,000 Ω - 19,99 Ω	1 kΩ	20 kΩ	1 kΩ	10 kΩ
20,000 Ω - 199,9 Ω	200 x R_E	20 kΩ	200 x R_E	20 kΩ
200, 0 Ω - upwards	50 kΩ total		50 kΩ total	

Display:	Alpha numeric LCD (130 mm x 35 mm) giving test information and a large (20 mm) 3½ digitLCD, maximum reading 1999
Instrument Protection:	Meets the general requirements of IP54
Temperature Effect:	<±0,1%/°C over the temperature range -10°C to +40°C
Temperature Range:	Operating: -10°C to +40 °C Storage: -20°C to +60°C
Humidity:	Operating: 90% RH max. at 40°C
Flash Test:	3 kV a.c.
Voltage Withstand:	In the event of a system fault the instrument will withstand 240 V a.c. applied between any two terminals.
Compliance with Standards:	BS 7430 (1992) BS7671 (1992) NFC 15-100 VDE 0413 Part 7 (1982) IEC364
Power Supply:	(i) Internal rechargeable sealed lead acid cells 12 V nominal, 2,6 Ah capacity. Battery voltage range over which basic accuracy is maintained, 11,0 V to 13,5 V.
Battery life:	Typically 5 Hours continuous use
Battery charging time:	6 hours max. (from completely exhausted).
Charging supply required:	100 V to 130 V or 200 V to 260 V a.c. 50 Hz/60 Hz.
Power consumption:	25 VA

Specification

Note: When the battery is charging, fast transients can cause the display to go blank. This will not normally affect the charging operation.

(ii) External 12 V d.c. source

Fuses (Non replaceable):

Mains supply protection:	200 mA (T) ceramic HBC 20 mm x 5 mm to IEC 127/3
Battery protection:	2 A (T) ceramic HBC 20 mm x 5 mm to IEC 127/3
Battery in-line protection:	3,15 A (T) ceramic HBC 20 mm x 5 mm IEC 127/3
External 12 V supply protection:	2 A (T) ceramic HBC 20 mm x 5 mm IEC 127/3
Output current protection:	80 mA (F) glass 20 mm x 5 mm

Fuse (Replaceable):

Mains power cord fused plug:	3 Amp fuse to BS 1362

Safety: Meets the requirements for safety to IEC 1010-1 1995) EN61010-1 (1995).

E.M.C: In accordance with IEC61326 including amendment No.1

Dimensions: 344 mm x 245 mm x 158 mm

Weight: 5 kg

Cleaning: Wipe the disconnected instrument with a clean cloth dampened with soapy water or Isopropyl Alcohol (IPA).

VDE 0413 part 7 specification stipulates that these instructions should contain a table or diagram showing the maximum value which the instrument must indicate in certain conditions. An earth test being performed on any electrode system would normally be carried out to a particular specification. Therefore, even at the iworst accuracy of the instrument, the reading is never above the limiting value required by the particular specification in question.

The table overleaf shows the maximum reading which shall be indicated by the instrument (at its maximum error) to ensure that the maximum value of the earth resistance given in the relevant earth electrode test specification is met.

Note: The decimal point position in the Maximum Resistance value column is correct for resistance readings < 2 Ω. For the 2 Ω to 20 Ω column and the > 20 Ω column, the decimal point should be moved accordingly. For maximum readings in excess of 200 Ω use the right hand column and adjust the decimal point accordingly.

The table gives the maximum reading that would be allowed for a known maximum resistance value, assuming the instrument is used as specified.

If a maximum resistance is known, this value is found from the left hand column. The maximum reading to be given by the instrument is found by reading across to the appropriate of the three right hand columns, depending upon the range of the value to be measured.

For example If 10 Ω is the value of the maximum resistance, since this is less than 20 Ω, the centre column of the three right hand columns is used. This shows that a reading of less than 9,49 Ω will ensure that, allowing for instrument tolerances, the measured resistance will be less than 10 Ω.

A maximum value may be given to a measurement by using the table in reverse. For example, a reading of 1,545 Ω would give a maximum limit to the resistance value of between 1,600 Ω and 1,650 Ω. Interpolation can be used to increase the accuracy if required.

Note: This table can only be used for readings from a *DET2/2*.

Specification

Maximum Resistance Value Ω	Maximum Reading		
	< 2 Ω	2 Ω to 20 Ω	> 20 Ω
0,050	0,036	-	-
0,100	0,083	-	-
0,150	0,131	-	-
0,200	0,179	1,88	18,8
0,250	0,226	2,35	23,6
0,300	0,274	2,83	28,3
0,350	0,321	3,30	33,1
0,400	0,369	3,78	37,9
0,450	0,417	4,26	42,6
0,500	0,464	4,73	47,4
0,550	0,512	5,21	52,1
0,600	0,560	5,68	56,9
0,650	0,607	6,16	61,7
0,700	0,655	6,64	66,4
0,750	0,702	7,11	71,2
0,800	0,750	7,59	76,0
0,850	0,798	8,07	80,7
0,900	0,845	8,54	85,5
0,950	0,983	9,02	90,2
1,000	0,940	9,49	95,0
1,050	0,988	9,97	99,8

Maximum Resistance Value Ω	Maximum Reading		
	< 2 Ω	2 Ω to 20 Ω	> 20 Ω
1,100	1,036	10,45	104,5
1,150	1,083	10,92	109,3
1,200	1,131	11,40	114,0
1,250	1,179	11,88	118,8
1,300	1,226	12,35	123,6
1,350	1,274	12,83	128,3
1,400	1,321	13,30	133,1
1,450	1,369	13,78	137,9
1,500	1,417	14,26	142,6
1,550	1,464	14,73	147,4
1,600	1,512	15,21	152,1
1,650	1,560	15,69	156,9
1,700	1,607	16,16	161,7
1,750	1,655	16,64	166,4
1,800	1,702	17,11	171,2
1,850	1,750	17,59	176,0
1,900	1,798	18,07	180,7
1,950	1,845	18,54	185,4
2,000	1,893	19,02	190,2
2,050	1,940	19,50	195,0
21,00	1,988	19,97	199,8

Accessories

SUPPLIED	Part Number
User Guide	6171-428
Battery charging Power cord	

OPTIONAL

Publications
'Getting Down to Earth' — AVTM25-TA

Four Terminal Earth Testing kit — 6310 - 755
Carrying bag containing:-
Club hammer, 4 x spikes, 3m (x2) cable
and 30m, 50m of cable on winders.

Four Terminal Compact Earth Testing kit — 6210 - 161
Compact carrying bag containing:-
4 x push in spikes, 3m, 15m, 30,
and 50m of cable on cable tidy.

Three Terminal Compact Earth Testing Kit — 6210 - 160
Compact carrying bag containing:-
3 x push spikes, 3m, 15m and 30m
of cable on a cable tidy.

U.S. OPTIONS	Cat. Number
Standard Accessory kit Canvas case containing:- 2 x 20 in rods, leads (25,50 &100 ft)	250579
Deluxe Accessory kit Padded case to hold instrument, 2 x 20 in rods, leads (25,50 &100 ft)	250581
Soil Resistivity kit Padded case to hold instrument, 4 x 20 in rods and test leads (4 x 50ft)	250586

Chart for use with the Slope Method

Values of $P_{t / EC}$ for Values of **μ**

μ	0	1	2	3	4	5	6	7	8	9
0.40	0.6432	0.6431	0.6429	0.6428	0.6426	0.6425	0.6423	0.6422	0.6420	0.642
0.41	0.6418	0.6417	0.6415	0.6414	0.6412	0.6411	0.641	0.6408	0.6407	0.6405
0.42	0.6404	0.6403	0.6401	0.64	0.6398	0.6397	0.6395	0.6394	0.6393	0.6391
0.43	0.639	0.6388	0.6387	0.6385	0.6384	0.6383	0.6381	0.638	0.6378	0.6377
0.44	0.6375	0.6374	0.6372	0.6371	0.637	0.6368	0.6367	0.6365	0.6364	0.6362
0.45	0.6361	0.6359	0.6358	0.6357	0.6355	0.6354	0.6352	0.6351	0.6349	0.6348
0.46	0.6346	0.6345	0.6344	0.6342	0.6341	0.6339	0.6338	0.6336	0.6335	0.6333
0.47	0.6332	0.633	0.6329	0.6328	0.6326	0.6325	0.6323	0.6322	0.632	0.6319
0.48	0.6317	0.6316	0.6314	0.6313	0.6311	0.631	0.6308	0.6307	0.6306	0.6304
0.49	0.6303	0.6301	0.63	0.6298	0.6297	0.6295	0.6294	0.6292	0.6291	0.6289
0.50	0.6288	0.6286	0.6285	0.6283	0.6282	0.628	0.6279	0.6277	0.6276	0.6274
0.51	0.6273	0.6271	0.627	0.6268	0.6267	0.6266	0.6264	0.6263	0.6261	0.626
0.52	0.6258	0.6257	0.6255	0.6254	0.6252	0.6251	0.6249	0.6248	0.6246	0.6245
0.53	0.6243	0.6242	0.624	0.6239	0.6237	0.6235	0.6234	0.6232	0.6231	0.6229
0.54	0.6228	0.6226	0.6225	0.6223	0.6222	0.622	0.6219	0.6217	0.6216	0.6214
0.55	0.6213	0.6211	0.621	0.6208	0.6207	0.6205	0.6204	0.6202	0.6201	0.6199
0.56	0.6198	0.6196	0.6194	0.6193	0.6191	0.619	0.6188	0.6187	0.6185	0.6184
0.57	0.6182	0.6181	0.6179	0.6178	0.6176	0.6174	0.6173	0.6171	0.617	0.6168
0.58	0.6167	0.6165	0.6164	0.6162	0.6161	0.6159	0.6157	0.6156	0.6154	0.6153
0.59	0.6151	0.615	0.6148	0.6147	0.6145	0.6143	0.6142	0.614	0.6139	0.6137
0.60	0.6136	0.6134	0.6133	0.6131	0.6129	0.6128	0.6126	0.6125	0.6123	0.6122
0.61	0.612	0.6118	0.6117	0.6115	0.6114	0.6112	0.6111	0.6109	0.6107	0.6106
0.62	0.6104	0.6103	0.6101	0.6099	0.6098	0.6096	0.6095	0.6093	0.6092	0.609
0.63	0.6088	0.6087	0.6085	0.6084	0.6082	0.608	0.6079	0.6077	0.6076	0.6074

μ	0	1	2	3	4	5	6	7	8	9
0.64	0.6072	0.6071	0.6069	0.6068	0.6066	0.6064	0.6063	0.6061	0.606	0.6058
0.65	0.6056	0.6055	0.6053	0.6052	0.605	0.6048	0.6047	0.6045	0.6043	0.6042
0.66	0.604	0.6039	0.6037	0.6035	0.6034	0.6032	0.6031	0.6029	0.6027	0.6026
0.67	0.6024	0.6022	0.6021	0.6019	0.6017	0.6016	0.6014	0.6013	0.6011	0.6009
0.68	0.6008	0.6006	0.6004	0.6003	0.6001	0.5999	0.5998	0.5996	0.5994	0.5993
0.69	0.5991	0.599	0.5988	0.5986	0.5985	0.5983	0.5981	0.598	0.5978	0.5976
0.70	0.5975	0.5973	0.5971	0.597	0.5968	0.5966	0.5965	0.5963	0.5961	0.596
0.71	0.5958	0.5956	0.5955	0.5953	0.5951	0.595	0.5948	0.5946	0.5945	0.5943
0.72	0.5941	0.594	0.5938	0.5936	0.5934	0.5933	0.5931	0.5929	0.5928	0.5926
0.73	0.5924	0.5923	0.5921	0.5919	0.5918	0.5916	0.5914	0.5912	0.5911	0.5909
0.74	0.5907	0.5906	0.5904	0.5902	0.5901	0.5899	0.5897	0.5895	0.5894	0.5892
0.75	0.589	0.5889	0.5887	0.5885	0.5883	0.5882	0.588	0.5878	0.5876	0.5875
0.76	0.5873	0.5871	0.587	0.5868	0.5866	0.5864	0.5863	0.5861	0.5859	0.5857
0.77	0.5856	0.5854	0.5852	0.585	0.5849	0.5847	0.5845	0.5843	0.5842	0.584
0.78	0.5838	0.5836	0.5835	0.5833	0.5831	0.5829	0.5828	0.5826	0.5824	0.5822
0.79	0.5821	0.5819	0.5817	0.5815	0.5813	0.5812	0.581	0.5808	0.5806	0.5805
0.80	0.5803	0.5801	0.5799	0.5797	0.5796	0.5794	0.5792	0.579	0.5789	0.5787
0.81	0.5785	0.5783	0.5781	0.578	0.5778	0.5776	0.5774	0.5772	0.5771	0.5769
0.82	0.5767	0.5765	0.5763	0.5762	0.576	0.5758	0.5756	0.5754	0.5752	0.5751
0.83	0.5749	0.5747	0.5745	0.5743	0.5742	0.574	0.5738	0.5736	0.5734	0.5732
0.84	0.5731	0.5729	0.5727	0.5725	0.5723	0.5721	0.572	0.5718	0.5716	0.5714
0.85	0.5712	0.571	0.5708	0.5707	0.5705	0.5703	0.5701	0.5699	0.5697	0.5695
0.86	0.5694	0.5692	0.569	0.5688	0.5686	0.5684	0.5682	0.568	0.5679	0.5677
0.87	0.5675	0.5673	0.5671	0.5669	0.5667	0.5665	0.5664	0.5662	0.566	0.5658
0.88	0.5656	0.5654	0.5652	0.565	0.5648	0.5646	0.5645	0.5643	0.5641	0.5639
0.89	0.5637	0.5635	0.5633	0.5631	0.5629	0.5627	0.5625	0.5624	0.5622	0.562

Chart for use with the Slope Method (continued)

μ	0	1	2	3	4	5	6	7	8	9
0.90	0.5618	0.5616	0.5614	0.5612	0.561	0.5608	0.5606	0.5604	0.5602	0.56
0.91	0.5598	0.5596	0.5595	0.5593	0.5591	0.5589	0.5587	0.5585	0.5583	0.5581
0.92	0.5579	0.5577	0.5575	0.5573	0.5571	0.5569	0.5567	0.5565	0.5563	0.5561
0.93	0.5559	0.5557	0.5555	0.5553	0.5551	0.5549	0.5547	0.5545	0.5543	0.5541
0.94	0.5539	0.5537	0.5535	0.5533	0.5531	0.5529	0.5527	0.5525	0.5523	0.5521
0.95	0.5519	0.5517	0.5515	0.5513	0.5511	0.5509	0.5507	0.5505	0.5503	0.5501
0.96	0.5499	0.5497	0.5495	0.5493	0.5491	0.5489	0.5487	0.5485	0.5483	0.5481
0.97	0.5479	0.5476	0.5474	0.5472	0.547	0.5468	0.5466	0.5464	0.5462	0.546
0.98	0.5458	0.5456	0.5454	0.5452	0.545	0.5447	0.5445	0.5443	0.5441	0.5439
0.99	0.5437	0.5435	0.5433	0.5431	0.5429	0.5427	0.5424	0.5422	0.542	0.5418
1.00	0.5416	0.5414	0.5412	0.541	0.5408	0.5405	0.5403	0.5401	0.5399	0.5397
1.01	0.5395	0.5393	0.539	0.5388	0.5386	0.5384	0.5382	0.538	0.5378	0.5375
1.02	0.5373	0.5371	0.5369	0.5367	0.5365	0.5362	0.536	0.5358	0.5356	0.5354
1.03	0.5352	0.5349	0.5347	0.5345	0.5343	0.5341	0.5338	0.5336	0.5334	0.5332
1.04	0.533	0.5327	0.5325	0.5323	0.5321	0.5319	0.5316	0.5314	0.5312	0.531
1.05	0.5307	0.5305	0.5303	0.5301	0.5298	0.5296	0.5294	0.5292	0.529	0.5287
1.06	0.5285	0.5283	0.5281	0.5278	0.5276	0.5274	0.5271	0.5269	0.5267	0.5265
1.07	0.5262	0.526	0.5258	0.5256	0.5253	0.5251	0.5249	0.5246	0.5244	0.5242
1.08	0.5239	0.5237	0.5235	0.5233	0.523	0.5228	0.5226	0.5223	0.5221	0.5219
1.09	0.5216	0.5214	0.5212	0.5209	0.5207	0.5205	0.5202	0.52	0.5197	0.5195
1.10	0.5193	0.519	0.5188	0.5186	0.5183	0.5181	0.5179	0.5176	0.5174	0.5171
1.11	0.5169	0.5167	0.5164	0.5162	0.5159	0.5157	0.5155	0.5152	0.515	0.5147
1.12	0.5145	0.5143	0.514	0.5138	0.5135	0.5133	0.513	0.5128	0.5126	0.5123
1.13	0.5121	0.5118	0.5116	0.5113	0.5111	0.5108	0.5106	0.5103	0.5101	0.5099
1.14	0.5096	0.5094	0.5091	0.5089	0.5086	0.5084	0.5081	0.5079	0.5076	0.5074
1.15	0.5071	0.5069	0.5066	0.5064	0.5061	0.5059	0.5056	0.5053	0.5051	0.5048

μ	0	1	2	3	4	5	6	7	8	9
1.16	0.5046	0.5043	0.5041	0.5038	0.5036	0.5033	0.5031	0.5028	0.5025	0.5023
1.17	0.502	0.5018	0.5015	0.5013	0.501	0.5007	0.5005	0.5002	0.5	0.4997
1.18	0.4994	0.4992	0.4989	0.4987	0.4984	0.4981	0.4979	0.4976	0.4973	0.4971
1.19	0.4968	0.4965	0.4963	0.496	0.4957	0.4955	0.4952	0.4949	0.4947	0.4944
1.20	0.4941	0.4939	0.4936	0.4933	0.4931	0.4928	0.4925	0.4923	0.492	0.4917
1.21	0.4914	0.4912	0.4909	0.4906	0.4903	0.4901	0.4898	0.4895	0.4892	0.489
1.22	0.4887	0.4884	0.4881	0.4879	0.4876	0.4873	0.487	0.4868	0.4865	0.4862
1.23	0.4859	0.4856	0.4854	0.4851	0.4848	0.4845	0.4842	0.4839	0.4837	0.4834
1.24	0.4831	0.4828	0.4825	0.4822	0.4819	0.4817	0.4814	0.4811	0.4808	0.4805
1.25	0.4802	0.4799	0.4796	0.4794	0.4791	0.4788	0.4785	0.4782	0.4779	0.4776
1.26	0.4773	0.477	0.4767	0.4764	0.4761	0.4758	0.4755	0.4752	0.475	0.4747
1.27	0.4744	0.4741	0.4738	0.4735	0.4732	0.4729	0.4726	0.4723	0.472	0.4717
1.28	0.4714	0.4711	0.4707	0.4704	0.4701	0.4698	0.4695	0.4692	0.4689	0.4686
1.29	0.4683	0.468	0.4677	0.4674	0.4671	0.4668	0.4664	0.4661	0.4658	0.4655
1.30	0.4652	0.4649	0.4646	0.4643	0.4639	0.4636	0.4633	0.463	0.4627	0.4624
1.31	0.462	0.4617	0.4614	0.4611	0.4608	0.4604	0.4601	0.4598	0.4595	0.4592
1.32	0.4588	0.4585	0.4582	0.4579	0.4575	0.4572	0.4569	0.4566	0.4562	0.4559
1.33	0.4556	0.4552	0.4549	0.4546	0.4542	0.4539	0.4536	0.4532	0.4529	0.4526
1.34	0.4522	0.4519	0.4516	0.4512	0.4509	0.4506	0.4502	0.4499	0.4495	0.4492
1.35	0.4489	0.4485	0.4482	0.4478	0.4475	0.4471	0.4468	0.4464	0.4461	0.4458
1.36	0.4454	0.4451	0.4447	0.4444	0.444	0.4437	0.4433	0.443	0.4426	0.4422
1.37	0.4419	0.4415	0.4412	0.4408	0.4405	0.4401	0.4398	0.4394	0.439	0.4387
1.38	0.4383	0.4379	0.4376	0.4372	0.4369	0.4365	0.4361	0.4358	0.4354	0.435
1.39	0.4347	0.4343	0.4339	0.4335	0.4332	0.4328	0.4324	0.4321	0.4317	0.4313
1.40	0.4309	0.4306	0.4302	0.4298	0.4294	0.429	0.4287	0.4283	0.4279	0.4275
1.41	0.4271	0.4267	0.4264	0.426	0.4256	0.4252	0.4248	0.4244	0.424	0.4236

Chart for use with the Slope Method (continued)

μ	0	1	2	3	4	5	6	7	8	9
1.42	0.4232	0.4228	0.4225	0.4221	0.4217	0.4213	0.4209	0.4205	0.4201	0.4197
1.43	0.4193	0.4189	0.4185	0.4181	0.4177	0.4173	0.4168	0.4164	0.416	0.4156
1.44	0.4152	0.4148	0.4144	0.414	0.4136	0.4131	0.4127	0.4123	0.4119	0.4115
1.45	0.4111	0.4106	0.4102	0.4098	0.4094	0.409	0.4085	0.4081	0.4077	0.4072
1.46	0.4068	0.4064	0.406	0.4055	0.4051	0.4047	0.4042	0.4038	0.4034	0.4029
1.47	0.4025	0.402	0.4016	0.4012	0.4007	0.4003	0.3998	0.3994	0.3989	0.3985
1.48	0.398	0.3976	0.3971	0.3967	0.3962	0.3958	0.3953	0.3949	0.3944	0.3939
1.49	0.3935	0.393	0.3925	0.3921	0.3916	0.3912	0.3907	0.3902	0.3897	0.3893
1.50	0.3888	0.3883	0.3878	0.3874	0.3869	0.3864	0.3859	0.3855	0.385	0.3845
1.51	0.384	0.3835	0.383	0.3825	0.3821	0.3816	0.3811	0.3806	0.3801	0.3796
1.52	0.3791	0.3786	0.3781	0.3776	0.3771	0.3766	0.3761	0.3756	0.3751	0.3745
1.53	0.374	0.3735	0.373	0.3725	0.372	0.3715	0.3709	0.3704	0.3699	0.3694
1.54	0.3688	0.3683	0.3678	0.3673	0.3667	0.3662	0.3657	0.3651	0.3646	0.364
1.55	0.3635	0.363	0.3624	0.3619	0.3613	0.3608	0.3602	0.3597	0.3591	0.3586
1.56	0.358	0.3574	0.3569	0.3563	0.3558	0.3552	0.3546	0.354	0.3535	0.3529
1.57	0.3523	0.3518	0.3512	0.3506	0.35	0.3494	0.3488	0.3483	0.3477	0.3471
1.58	0.3465	0.3459	0.3453	0.3447	0.3441	0.3435	0.3429	0.3423	0.3417	0.3411
1.59	0.3405	0.3399	0.3392	0.3386	0.338	0.3374	0.3368	0.3361	0.3355	0.3349

Repair and Warranty

The instrument circuit contains static sensitive devices, and care must be taken in handling the printed circuit board. If the protection of an instrument has been impaired it should not be used, and be sent for repair by suitably trained and qualified personnel. The protection is likely to be impaired if, for example, the instrument shows visible damage, fails to perform the intended measurements, has been subjected to prolonged storage under unfavourable conditions, or has been exposed to severe transport stresses.

New Instruments are Guaranteed for 1 Year from the Date of Purchase by the User.

Note: Any unauthorized prior repair or adjustment will automatically invalidate the Warranty.

Instrument Repair and Spare Parts

For service requirements for *MEGGER*® Instruments contact

AVO INTERNATIONAL or	**AVO INTERNATIONAL**
Archcliffe Road	Valley Forge Corporate Center
Dover	2621 Van Buren Avenue
Kent CT17 9EN	Norristown
England	PA 19403 U.S.A.
Tel: +44 (0)1304 502243	Tel: +1 (610) 676-8579
Fax: +44 (0)1304 207342	Fax: +1 (610) 676-8625

or an approved repair company.

Approved Repair Companies

A number of independent instrument repair companies have been approved for repair work on most *MEGGER*® instruments, using genuine *MEGGER*® spare parts. Consult the Appointed Distributor/Agent regarding spare parts, repair facilities and advice on the best course of action to take.

Returning an Instrument for Repair

If returning an instrument to the manufacturer for repair, it should be sent, freight pre-paid, to the appropriate address. A copy of the Invoice and of the packing note should be sent simultaneously by airmail to expedite clearance through Customs. A repair estimate showing freight return and other charges will be submitted to the sender, if required, before work on the instrument commences.

AVO INTERNATIONAL

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This instrument is manufactured in the United Kingdom.
The company reserves the right to change the specification or design without prior notice.

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