

Electrical grounding techniques

from



Ground Resistance - Principles, Testing, Techniques & Applications

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Why Ground ?

There are a number of good reasons to ground but primary among them is to ensure personnel safety. The following agencies and organizations all have recommendations and / or standards for grounding, to ensure that personnel safety is being protected. The organizations that provide guidelines/rules for grounding are: The International Electrotechnical Commission (IEC), European Committee for Electrotechnical Standardization (CENELEC), Underwriters Laboratories (UL), National Fire Protection Association (NFPA), American National Standards Institute (ANSI), Mine Safety Health Administration (MSHA), Occupational Safety Health Administration (OSHA), Telecommunications Industry Standard (TIA) and others.

Good grounding is not only for the safety of personnel but to provide for the protection of plants and equipment. A good ground system will improve the reliability of equipment and reduce the likelihood of damage as a result of lightning or fault currents.

What is a ground and what does it do ?

The NEC, National Electrical Code defines a ground as: "a conducting connection, whether intentional or accidental between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth." When talking about grounding it is actually two different subjects, earth grounding and equipment grounding. Earth grounding is an intentional connection from a circuit conductor usually the neutral to a ground electrode placed in the earth. Equipment grounding is to ensure that operating equipment within a structure is properly grounded. These two grounding systems are required to be kept separate except for a connection between the two systems to prevent differences in potential from a possible flashover from a lightning strike. The purpose of a ground besides the protection of people plants and equipment is to provide a safe path for the dissipation of Fault Currents, Lightning Strikes, Static Discharges, EMI and RFI signals and Interference.

Ground resistance values

There is a good deal of confusion as to what constitutes a good ground and what the ground resistance value needs to be. Ideally a ground should be of zero ohms resistance. The NEC has stated that "A single electrode consisting of a rod, pipe, or plate which does not have a resistance to ground of 25 ohms or less shall be augmented by one additional electrode...". Once you have added the supplemental ground you have met the requirement for the NEC. This does not mean that the value of the ground now has to be 25 ohms or less. The ground resistance values objectives vary from industry to industry.

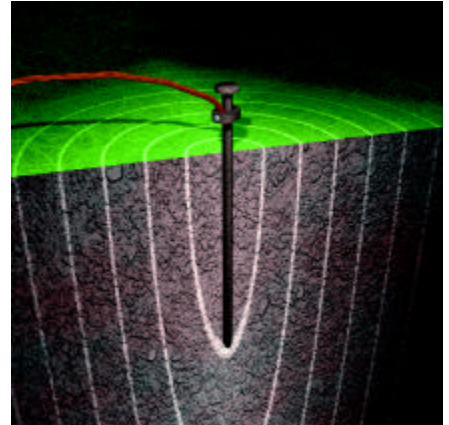
Telecommunications industry has often used 5 ohms or less as their value for grounding and bonding. The goal in ground resistance values is to achieve the lowest ground resistance value possible that makes sense economically and physically.

Ground Electrodes

consist of three basic components:

- ① ground conductor
- ② the connection/bonding of the conductor to the ground electrode
- ③ the ground electrode itself

Sphere of influence:

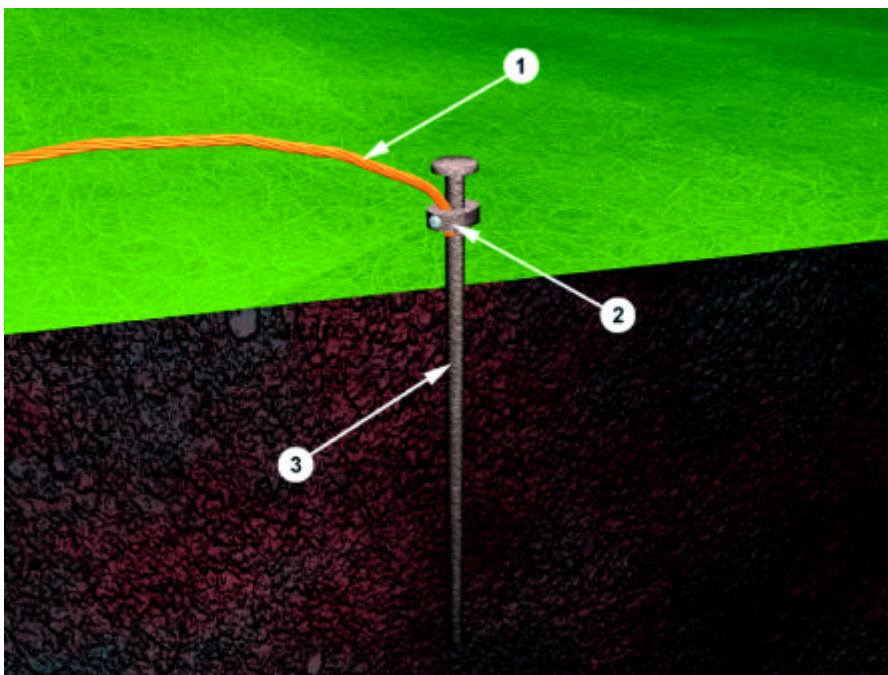


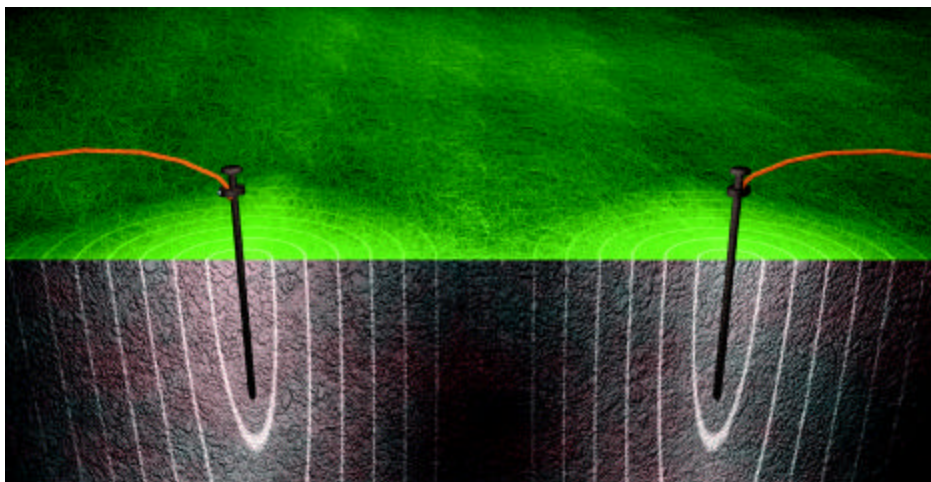
The resistance of a ground electrode has 3 basic components:

A) The resistance of the ground electrode itself and the connections to the electrode.

B) The contact resistance of the surrounding earth to the electrode.

C) The resistance of the surrounding body of earth around the ground electrode.





Multiple ground electrodes - Interaction

A) The resistance of the ground electrode and its connection is generally very low, ground rods are generally made of highly conductive/low resistance material such as copper or copper clad.

B) The contact resistance of the earth to the electrode: The Bureau of Standards has shown this resistance to be almost negligible providing that the ground electrode is free from paint, grease etc. and that the ground electrode is in firm contact with the earth.

C) The resistance of the surrounding earth: The ground electrode is surrounded by earth which is made up of concentric shells all having the same thickness. Those shells closest to the ground electrode have the smallest amount of area resulting in the greatest degree of resistance. Each subsequent shell incorporates a greater area resulting in lower resistance. This finally reaches a point where the additional shells offer little resistance to the ground surrounding the ground electrode.

The NEC specifies that the ground electrode shall be installed so that it is at least 2,4 m in length and in contact with the soil. There are 3 variables that affect the resistance of a ground electrode:

1. The ground itself
2. The length/depth of the ground electrode
3. Diameter of the ground electrode.

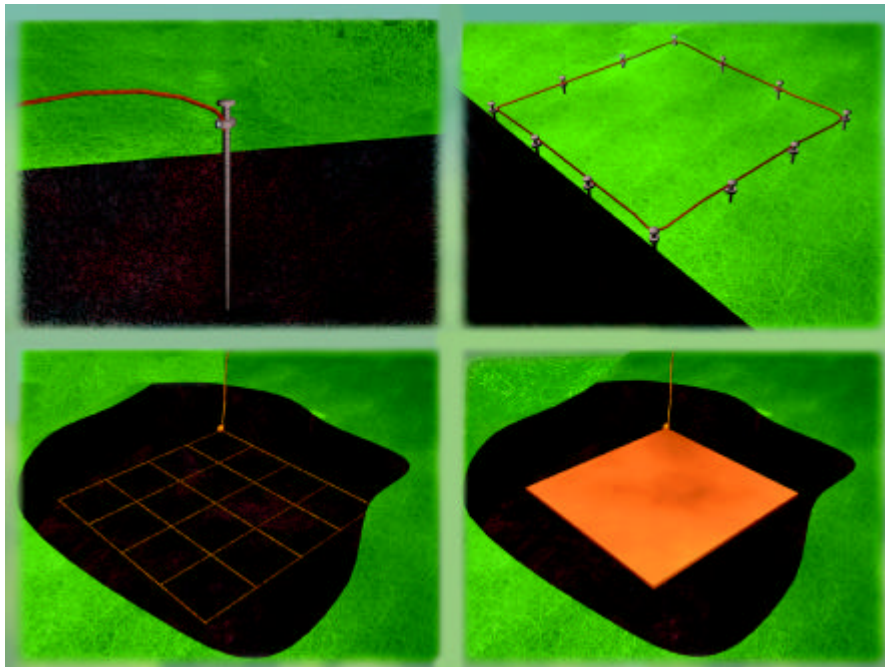
Increasing the diameter of the ground electrode has very little effect in lowering the resistance. For example you could double the diameter of a ground electrode and your resistance would only decrease by as much as 10 %.

One very effective way of lowering resistance is to drive ground electrodes deeper. Because the earth is in layers resistivity changes and varies considerably on the layer and the depth within that layer. Soil is not consistent in its resistivity but highly unpredictable. With that in mind it is of critical importance that when installing the ground electrode that it is below the frost line so that the resistance to ground will not be greatly increased by the freezing of the surrounding soil. Generally speaking by doubling the length of the ground electrode you can reduce the resistance level by an additional 40 %. There are occasions where it is physically impossible to drive ground rods deeper, areas that are composed of rock, granite etc. In these instances alternative methods such as grounding cement are a viable alternative.

To assist you in installing a ground rod that will meet your specific resistance requirements you can use the table of ground resistances on page 5. Remember this is to be used only as a rule of thumb, because soil is in layers and is rarely homogenous, so the resistance values will vary greatly.

Another system to lowering ground resistance is through the use of multiple ground electrodes. In this system more than one electrode is driven into the ground and connected in parallel to lower the resistance. Each ground electrode has its own sphere of influence and for additional electrodes to be effective the spacing of additional rods needs to be at least equal to the depth of the driven rod. Without proper spacing of the ground electrodes the spheres of influence will intersect and the lowering of the resistance will be minimal and of little value.

Types of Ground Systems



There are two types of grounding systems, simple and complex. Simple consist of a single ground electrode driven into the ground. The use of a single ground electrode is the most common form of grounding and can be found outside your home or place of business. Complex grounding systems consist of multiple ground rods connected, mesh or grid networks, ground plates and ground loops. These systems are typically installed at power generating substations, central offices and cellsites.

Ground Resistance Testing- Soil Resistivity

Why measure soil resistivity?

The reason for measuring soil resistivity when selecting a location for a sub-station or central office is to find a location that has the lowest possible resistance. Once a site has been selected, measuring the soil resistivity will give you the information necessary to design and build a ground field that will meet your ground resistance requirements.

There are a number of factors affecting soil resistivity, soil composition being one of them. Soil is rarely homogenous and the resistivity of the soil will vary geographically and at different depths.

The second factor affecting soil resistivity is moisture or the amount of water in the ground. Moisture content changes seasonally, varies according to the nature of the sub layers of earth and the depth of the permanent water table. The table on page 5 shows different types of soil and the affects that moisture has on their resistivity.

Since soil resistivity is so closely related to moisture and moisture is present in the soil we can logically assume that as moisture increases resistivity will decrease and vice versa.

As shown in the table there can be a change in resistivity from top to bottom by a factor of 50.

Ground Resistance Values

Soil resistivity depends on soil composition, moisture and temperature. It stands to reason that soil resistivity will vary through out the year in those areas of the country where seasonal changes bring about a change in the moisture and temperature content of the soil. For a grounding system to be effective it should be designed to withstand the worst possible conditions.

Since soil and water are generally more stable at deeper strata it is recommended that the ground rods be placed as deep as possible into the earth, the water table if possible. Ground rods should also be installed where there is a stable temperature i.e. below the frost line.

Caution! Soil that is low in resistivity is often highly corrosive because of the presence of water and salts, and this soil can eat away at ground rods and their connections. That is why it is highly recommended that grounds and ground fields be checked at least annually. Although resistance to ground will change seasonally and over time any increase of resistance >20% or more should be investigated and corrective action taken to lower the resistance.

The formula is as follows:

$$\rho = 2 \pi A R$$

Where: ρ = the average soil resistivity to depth A in ohm - cm

π = is the constant 3.1416

A = the distance between the electrodes in cm

R = the measured resistance value in ohms from the test instrument

The calculation of this measurement can be simplified by converting distance in cm to distance in feet giving you the following equation:

$$\rho = 191.5 A R$$

Where: ρ = the average soil resistivity to depth A in ohm - cm

A = the distance between electrodes in feet

R = the measured resistance value in ohms from the test instrument

Note: Divide ohm - centimeters by 100 to convert to meter - ohms.

For example, you have decided to install 3 m ground rods as part of your grounding system. To measure the soil resistivity at a depth of 3 m requires that the spacing between the test electrodes is 3 m. The depth that the test electrodes is to be driven is A/20. To measure the soil resistivity start the GEO and read the resistance value in ohms. Now if your resistance reading is 100 ohms the soil resistivity for one cubic meter would be:

$$\rho = 2 \times \pi \times 3 \times 100$$

$$\rho = 1885 \Omega \text{m}$$

Soil Resistivity

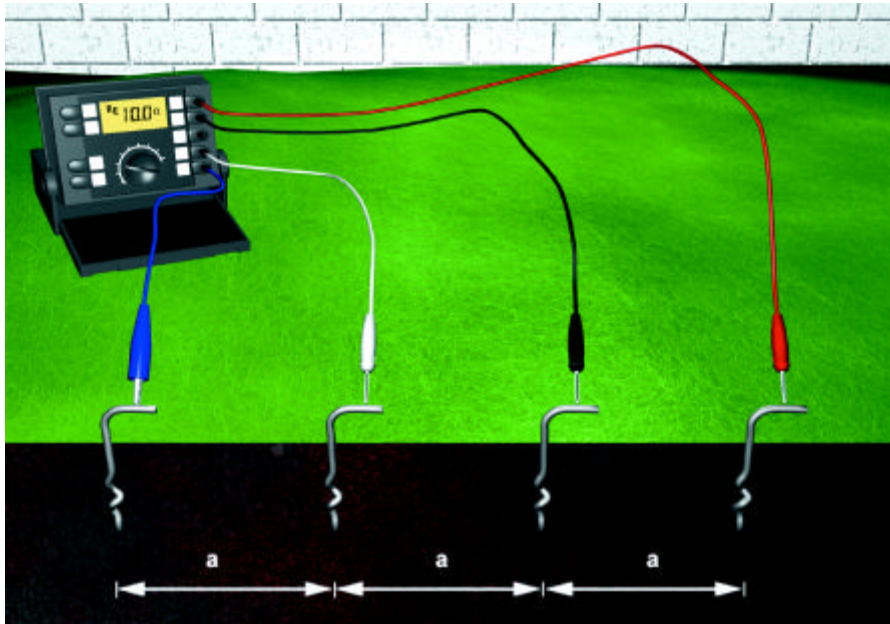
Measuring Soil Resistivity 4 - Pole Method

The measuring procedure described below uses the universally accepted Wenner method developed by Dr. Frank Wenner of the US Bureau of Standards in 1915. (F. Wenner, A Method of Measuring Earth Resistivity; Bull, National Bureau of Standards, Bull 12(4) 258, p. 478-496; 1915/16.

Type of Soil	Soil resistivity R_E $\Omega \text{ m}$	Earthing resistance (Ω)					
		Earthing rod m depth			Earthing strip m		
		3	6	10	5	10	20
Moist humus soil, moor soil, swamp	30	10	5	3	12	6	3
Farming soil loamy and clay soils	100	33	17	10	40	20	10
Sandy clay soil	150	50	25	15	60	30	15
Moisty sandy soi	300	66	33	20	80	40	20
Dry sand soil	1000	330	165	100	400	200	100
Concrete 1: 5	400	-	-	-	160	80	40
Moist gravel	500	160	80	48	200	100	50
Dry gravel	1000	330	165	100	400	200	100
Stoney soil	30,000	1000	500	300	1200	600	300
Rock	10^7	-	-	-	-	-	-

Soil Resistivity Testing

To test soil resistivity connect the ground tester as indicated.



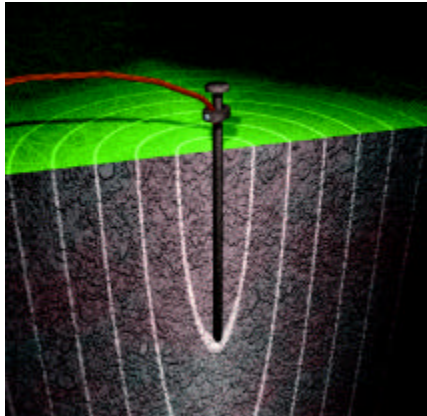
The ground stakes are positioned in a straight line equidistant from one another and at a distance between one another reflecting the depth to be measured. The ground stakes should be screwed in no deeper than $\frac{1}{3}$ the distance from one another. A known fixed current is generated by the GEO between the two outer ground stakes and a drop in potential (which is a result of the resistance) is then measured automatically between the two inner ground stakes. The GEO then displays this resistance value in ohms.

Because measurement results are often distorted and invalidated by underground pieces of metal, underground aquifers etc. additional measurements in which the stakes axis is turned 90 degrees is always recommended. By changing the depth and distance several times a profile is produced that can determine a suitable ground resistance system.

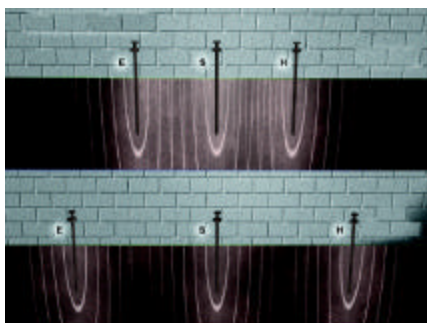
Soil resistivity measurements are often corrupted and/or prevented by the existence of ground currents and their harmonics. To prevent this from occurring the GEO uses an Automatic Frequency Control System (AFC), that automatically selects the testing frequency with the least amount of noise enabling you to get a clear reading.

Stake Setting

To achieve the highest degree of accuracy when performing a 3 - Pole ground resistance it is essential that the probe is placed outside the sphere of influence of the ground electrode under test and the auxiliary earth.



If you do not get outside the sphere of influence the effective areas of resistance will overlap and invalidate any measurements that you are taking.



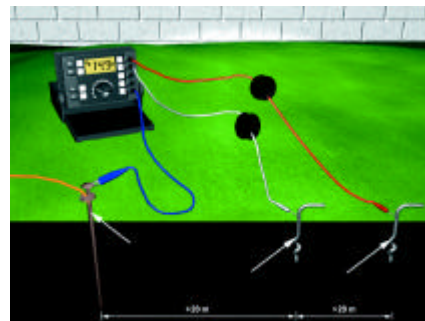
The following table is a guideline for setting probe (S/P2) and auxiliary ground (H/C2).

Approximate distance to auxiliary probes using the 62% method (in m)		
Depth of electrode under test C1/E	Distance to probe P2/S	Distance to auxiliary probe C2/H
2	15	25
3	20	30
6	25	40
10	30	50

To test the accuracy of the results and to ensure that the ground stakes are outside the 'spheres of influence' reposition ground stake P2 / S 3 ft in either direction and take a fresh measurement. If the measured value remains fairly constant the distance between the ground stakes is sufficient. If there is a significant change in the reading (30 %) you need to increase the distance between the ground rod under test and P2/S and C2/H until the measured values remain fairly constant when repositioning the P2/S ground stake.

3 - Pole Fall of Potential Testing for Complex Ground Systems

The 3 - pole fall of potential method is used to measure the dissipation capability of a single ground electrode, ground grids, foundation grounds and other grounding systems.



The potential difference is measured with a voltmeter and the current flow by an ammeter internally by the GEO. Using Ohm's law:

$$R = E/I \text{ we can calculate } R$$

Connect the ground tester as shown in the picture below. Press START, and read out the RE, (resistance) value. This is the actual value of the ground electrode under test. If this ground electrode is in parallel or series with other ground rods the RE value is the total value of all resistances.

Often the driving of a single ground rod into the earth does not result in a resistance reading low enough or desired, this is especially true in substations and central offices where resistances of < 3 ohms are required. In this case the guidelines for setting your auxiliary ground stakes may not get you outside the sphere of the influence. Take the maximum distance of the ground field either straight line or diagonal and the spacing for the first reference stake to be twice the distance. The table can be utilized as a guide for setting reference stakes for complex ground systems.

Ground resistance measurements are often corrupted and / or prevented by the existence of ground currents and their harmonics.

To prevent this from occurring the GEO uses an Automatic Frequency Control System (AFC), that automatically selects the testing frequency with the least amount of noise enabling you to get a clear reading.

Ground Resistance Testing Existing Systems 'Selective' Clamp-on

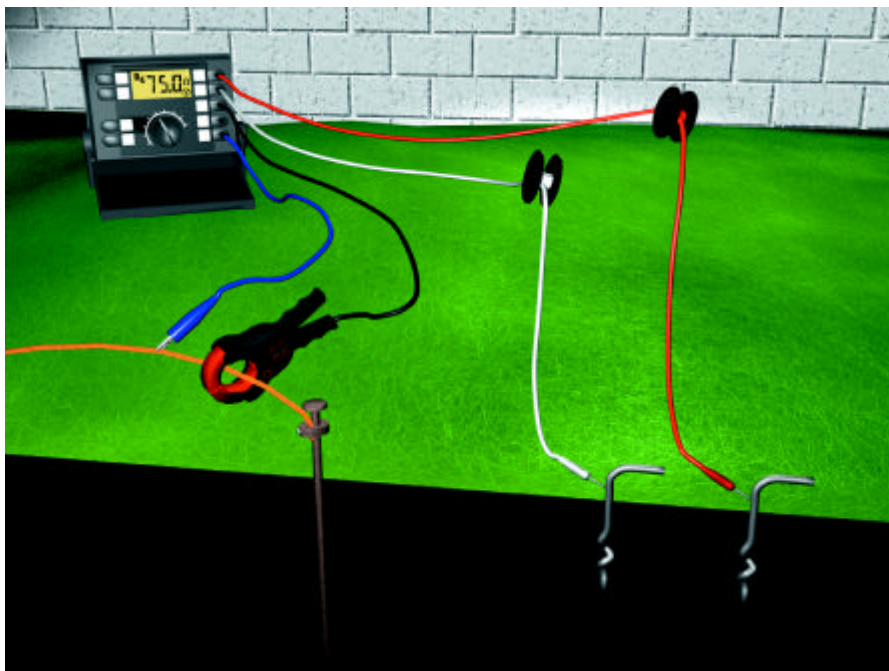
NO DISCONNECTION REQUIRED!

This unique exclusive LEM method has been created to measure resistances of individual ground electrodes in all types of grounded systems including ground grids and wired meshes as are common in substations, high voltage pylons with ground cabling, and commercial settings with multiple grounds. By using a specialized clamp-on current transformer the effects of parallel resistances are

Diameter of Ground Grid, or Field in m	Distance to Probe P2/S in m	Distance to Probe C2/H in m
20	30	50
25	50	80
30	70	100
50	100	170
70	130	200

eliminated from the measuring process and therefore do not influence the measuring results. A special rectification method is used to isolate or 'digitally filter' out other currents to significantly increase accuracy. As with the standard 3-Pole Fall of Potential testing the rules / guidelines for the setting of ground stakes apply for both simple and complex grounds.

The "Ground Under Test" does not have to be disconnected!



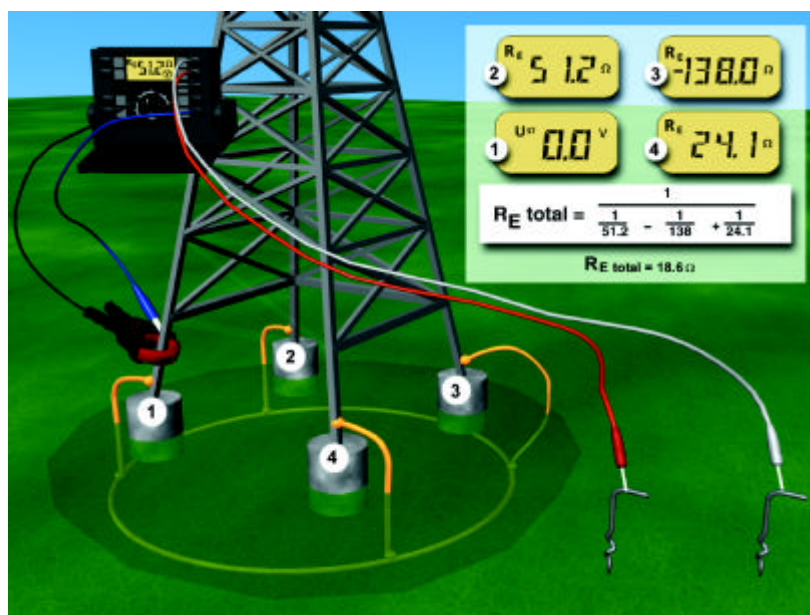
Connect the ground tester as shown in the picture above. Press START, and read out the RE value. This is the actual value of the ground electrode under test.

To test the accuracy of the results and to ensure that the ground stakes are outside the 'spheres of influence' reposition ground stake P2/S 1 m in either direction and take a new measurement. If the measured value remains fairly constant the distance between the ground stakes is sufficient. If there is a significant change in the reading (30 %) you need to increase the distance between the ground rod under test and P2/S and C2/H until the measured values remain fairly constant when repositioning the P2/S ground stake 1 m or so.

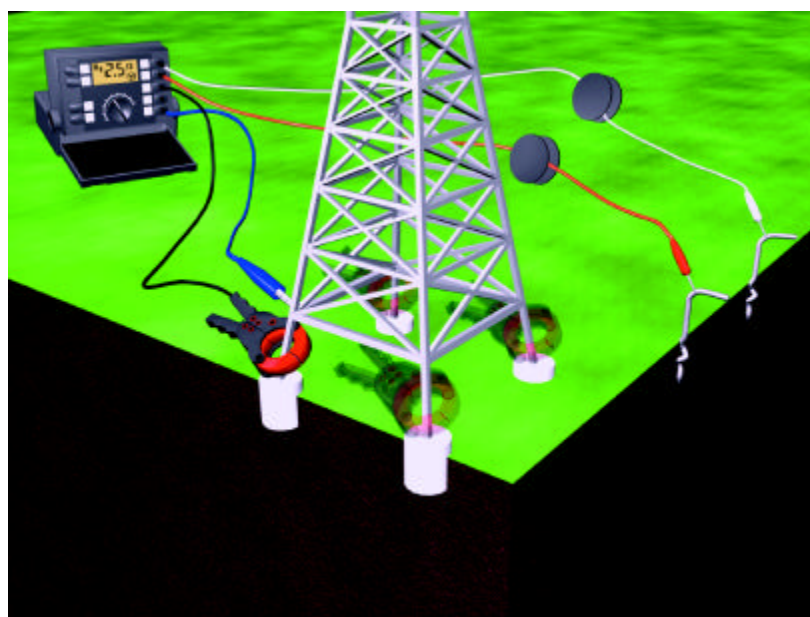
Ground resistance measurements are often corrupted and or prevented by the existence of ground currents and their harmonics. To prevent this from occurring the **UNILAP GEO** uses an Automatic Frequency Control System (AFC), that automatically selects the testing frequency with the least amount of noise enabling you to get a clear and accurate reading.

'Selective' Measuring of High Voltage Transmission Towers

Testing individual ground electrode resistances of high voltage transmission towers with overhead ground or static wire requires that these wires be disconnected. If a tower has more than one ground at it's base, these must also be disconnected one by one and tested. The **UNILAP GEO X** with the 31 cm diameter clamp-on current transformer can measure the individual resistances of each leg without disconnecting any ground leads or overhead static/ground wires.



From the picture above we can see that the total resistance of an individual tower is the parallel sum of all grounds. The tower has 4 individual grounds you must measure all 4, generating the individual resistance and then calculate according to the formula above.



Ground Resistance Testing Existing Systems - 'Stakeless'

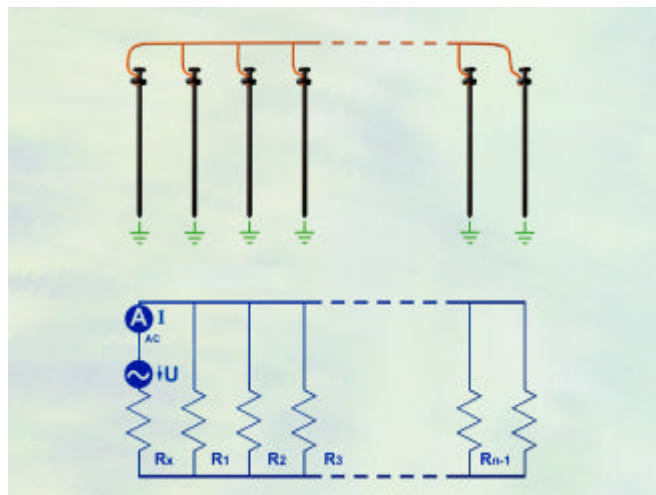
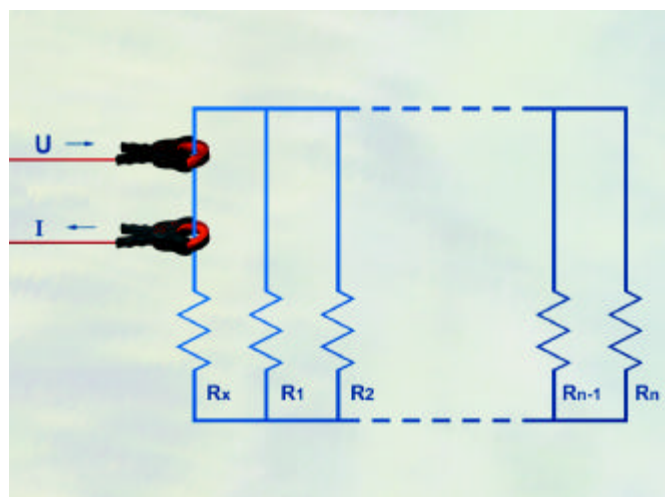
The **UNILAP GEO X** measures individual ground resistances in multi-grounded systems using two clamp-on current transformers, eliminating the dangerous and time consuming activity of disconnecting parallel grounds as well as the process of finding suitable locations for auxiliary ground stakes.

How it Works...

The **GEO X** works on the principle that in parallel / multigrounded systems the net resistance of all ground paths will be extremely low as compared to any single path (the one under test).

So the net resistance of all the parallel return path resistances ($R_1...R_n$) is effectively zero. It is reasonable to assume any resistance measured must be associated with the individual path to ground the clamp is around (R_x).

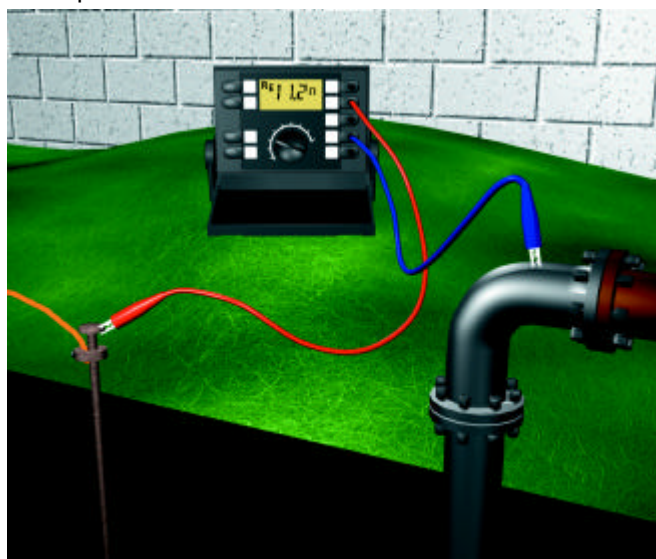
The first current transformer induces a voltage in the circuit while the second current transformer measures the actual current flowing allowing the **GEO X** to calculate the resistance of the ground path after synchronous rectification of current and voltage.



Clamp-on technology only measures individual ground rod resistances in parallel to earth grounding systems. If the ground system is not straight parallel to earth then you will either have an open circuit or be measuring ground loop resistance.

Ground Resistance Testing 2 - Pole

In situations where the driving of ground stakes is neither practical or possible the **GEO** does give you the ability to do 2 - pole ground resistance/continuity measurements. To perform this test requires a good known ground such as an all metal water pipe. The water pipe should be extensive enough and be metallic throughout without any insulating couplings or flanges. Unlike many testers the **GEO** performs this test with relatively high voltage AC with up to 250 mA of current.



Ground Impedance Measurements

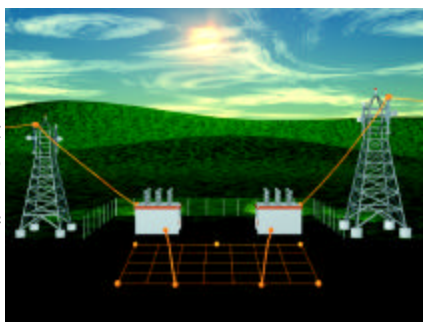
When attempting to calculate possible short circuit currents in power plants and other high voltage/current situations, determining the complex grounding impedance is important since both inductivity and resistivity are present. Because inductivity and resistivity are known in most cases actual impedance can be determined using a complex computation. Since impedance is frequency dependent, **GEO** uses a 55 Hz signal for this calculation to be close to mains as possible without corrupting the measurement. Accurate direct measurements of grounding impedance are possible.

Power utilities testing high voltage transmission lines are interested in two things. The ground resistance in case of a lightning strike and the impedance of the entire system in case of a short circuit on a specific point in the line. Short circuit in this case means an active wire breaks loose and touches the metal grid of a tower.

Measuring Ground Resistance at Substations

The first measurement to be taken is a "Stakeless" measurement. Use the **GEO X** to clamp around all grounding connections.

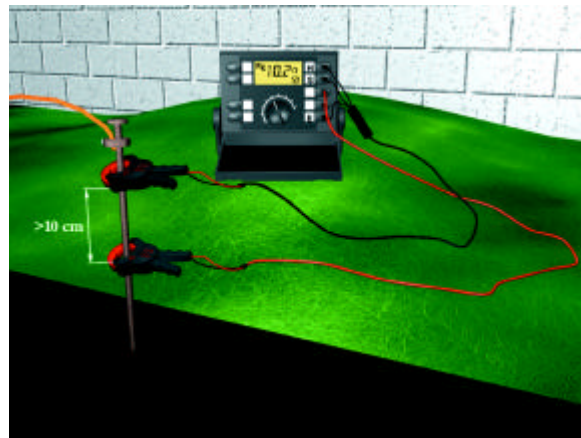
There are 3 separate types of ground measurements that are necessary to conduct when doing a grounding audit of a substation.



First determine the nature of the ground system, i.e. mat, rods, water system, combination etc. Substations generally consist of high voltage transmission towers and transformers that are connected and grounded to a ground grid.

Follow the rules / guidelines for stake setting to ensure that the measurement is accurate and has not been influenced by the effects of the grid. Reposition P2/S a yard or so and take a new measurement. If there is a deviation >30 % of measured value, reposition both P2 and C2 further from the ground under test and repeat. This value should then be recorded. These measurements should be repeated at least annually to detect any change within the ground grid.

After having completed the 3-Pole test for the entire grid we to measure individual ground rods and their connections in the grid using the selective clamp-on method. We measure each connection separately without having to disconnect. The purpose of the selective clamp on is to ensure that the resistances within the grid are fairly uniform.

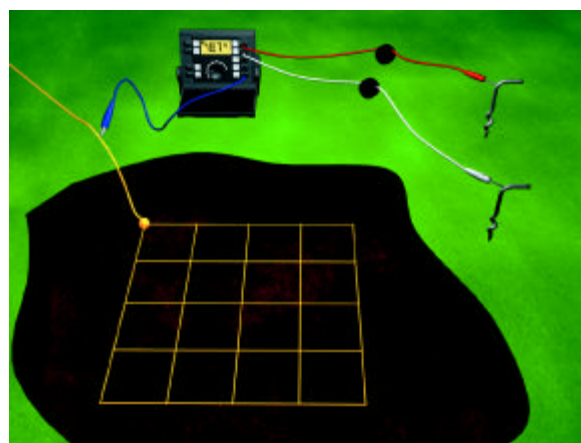


A measurement that showed a great deviation to the other measurements is probably indicative of a problem that should be investigated.

To conduct a selective clamp-on test, keep in mind that the spacing requirements for the reference stakes are the same as with a standard fall of potential test. Make sure that you leave enough slack in your leads so you can move easily from connection to connection. The results of this test should be recorded and the test repeated at least annually.

Approximate distance to auxiliary probes using the 62% method in m

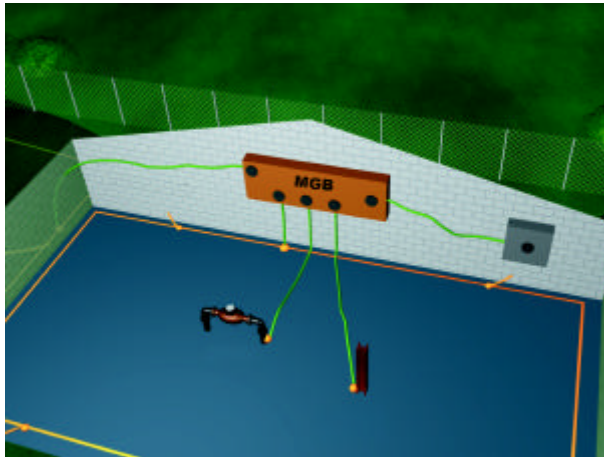
Depth of electrode	Distance to probe C1/E	Distance to auxilliary probe C2/H
2	15	25
3	20	30
6	25	40
10	30	50





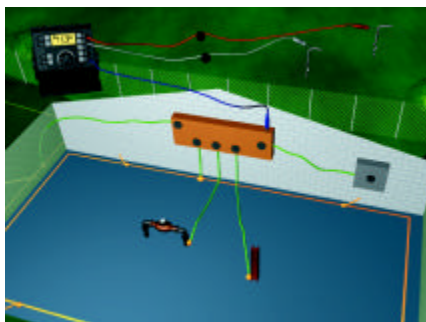
Measuring Ground Resistance At Central Offices ...

1 When conducting a grounding audit of a central office there are 3 or 4 different measurements required. First locate the MGB (Master Ground Bar) within the central office to determine the type of ground. The MGB will have a ground lead going to the MGN (Multi-Grounded Neutral) or incoming service, a separate ground lead from the MGB to the ground field, another ground lead from the MGB connected to the water pipe and a ground lead connected to structural or building steel. The first measurement to take is stakeless measurement of all the



individual grounds coming off of the MGB. The purpose is to ensure that all the grounds are connected especially the MGN. It is important to note that you are not measuring the individual resistance rather the loop resistance of what you are clamped around. Connect the **GEO X** and measure the loop resistance of the MGN, the ground field the water pipe and the building steel.

2 The second measurement is the 3-pole fall of potential of the entire ground system. Connect to the MGB as illustrated below, keeping in mind the requirements for the setting of the reference ground stakes. To get to remote earth many phone companies utilize unused cable pairs going out



by as much as a mile.

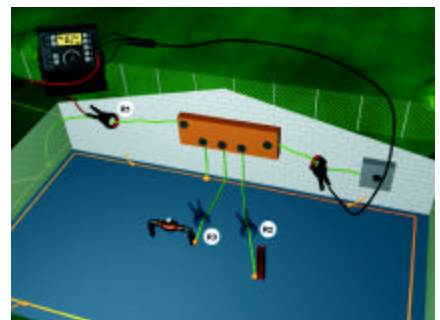
Record the measurement and this test should be repeated at least annually.

3 Now we measure the individual resistances of the groundsystem using the Selective clamp-on capability of the **GEO X**. Connect the **GEO X** as shown below. Measure the resistance of the MGN, the value is the resistance of that particular leg of the MGB. Then measure the ground field, this reading is actual resistance value of the Central Office Ground Field, now move on to the water pipe and then repeat for the resistance of the building steel. You can easily verify the accuracy of these measurements through Ohm's law. The resistance of the individual legs when calculated should equal the resistance of the entire system given.

This is the most accurate way to measure a central office in that it gives you the individual resistances and their actual behavior in a series ground. Disconnect the various legs of the MGB and measure the resistance. Now measure the individual resistances.

Measurements would be accurate but would not show how the system behaves as a network, because in real life in the event of a lightning strike or fault current everything is connected. To prove this out you can measure each leg separately disconnected via the 3-pole method and record each measurement. Using Ohm's law again these measurements should be equal to the resistance of the entire system. From the calculations you will see that you are from 20 - 30 % off the total RE value. The final way to measure the resistances of the various legs of the MGB is the 'Selective Stakeless Method'. It works similar to the Stakeless Method but it differs in the way we use the two separate CT's. We clamp the inducing voltage CT around the cable going to the MGB, and since the MGB is connected to the incoming power which is straight parallel to earth system we have achieved that requirement.

Take the sensing CT and clamp it around the ground cable leading out to the ground field (see below). When we measure the resistance this is the actual resistance of the ground field plus the parallel path of the MGB which because it should be very low ohmically should have no real effect on the measured reading. This process can be repeated for the other legs of the Ground Bar i.e. water pipe and structural steel. To measure the MGB via the Stakeless Selective method



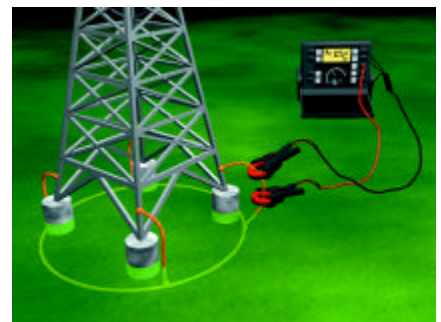
clamp the inducing CT around the lead going to the water pipe as the water pipe should have very low resistance, your reading will be for the MGN only.

... at Cellular Sites/Microwave and Radio Towers

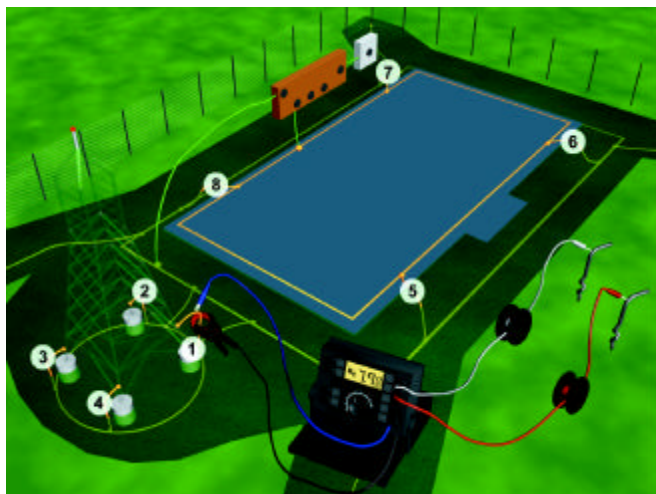
There are 3 measurements required when conducting an audit at a cell site, microwave or radio tower. At most locations there is a 3 legged tower with each leg individually grounded. These grounds are then connected with a copper cable. Next to the tower is the Cell site building housing all the transmission equipment. Inside the building there is a halo ground and a MGB with the halo ground connected to the MGB. The cell site building is grounded at all 4 corners connected to the MGB via a copper cable the 4 corners are also interconnected via copper wire. There is also a connection between the building ground ring and the tower ground ring.



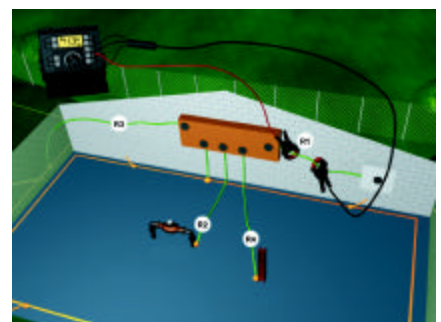
1 The first measurement Stakeless measurement of the individual legs of the tower and the 4 corners of the building. This is not a true ground resistance measurement because of the network ground. This is mainly a continuity test to verify that we are grounded and do have an electrical connection and can pass current.



3 Finally we measure the individual grounds through the selective clamp-on method. This will verify the integrity of the individual grounds and their connections and that the grounding potential is fairly uniform throughout. Measure the resistance of each leg of the tower and all 4 corners of the building. If any of the measurements show a greater degree of variability than the other ones, the reason for this should be determined.



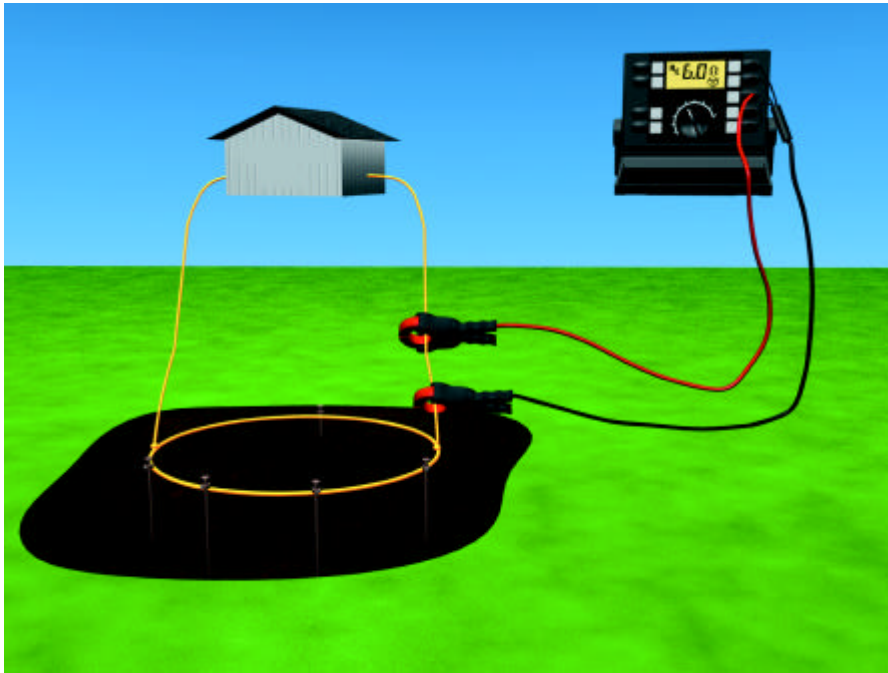
2 Afterwards we measure the resistance of the entire system via the 3-pole method. Keep in mind the rules for stake setting. This measurement should be recorded and measurements should take place at least semi-annually.



M

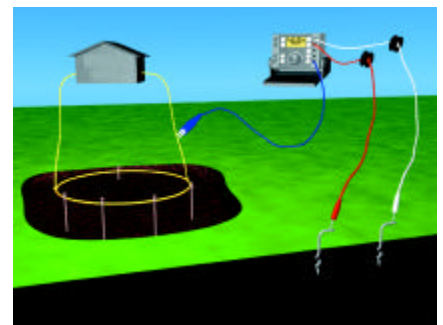
easuring Ground Resistance at Remote Switching Sites ...

There are 3 key measurements when conducting tests at remote switching sites also known as slick sites, digital line concentrators and probably more. The remote site is generally grounded at either end of the cabinet and then will have a series of ground stakes around the cabinet connected by copper wire.

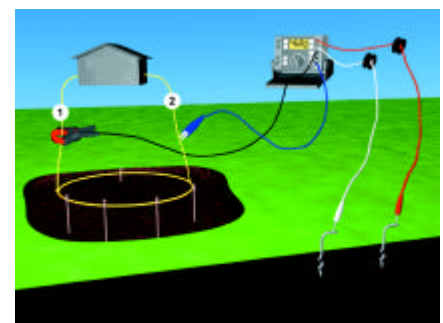


1 We first want to verify that the grounds from the remote switching site is connected, and we do this by the 'Stakeless' method. In this application we are not measuring individual ground resistance but measuring loop resistance to verify that we are connected and capable of passing current.

2 The second measurement to be taken is the 3-pole of the entire ground system. Connect to any of the grounds as illustrated below. Keep in mind the requirements for the setting of the reference ground stakes. This measurement should be recorded and measurements should take place at least semi-annually.



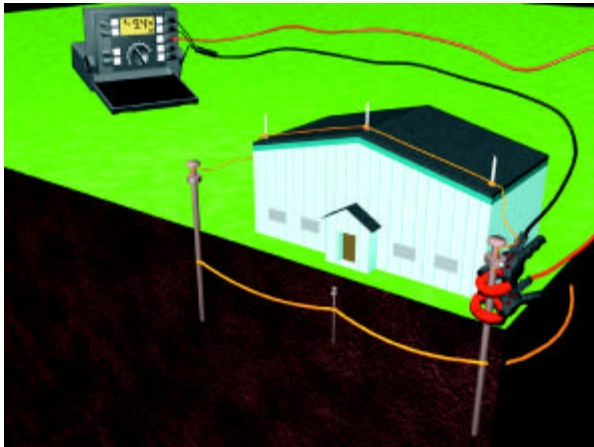
3 Finally measure the individual grounds by selective clamp-on method. This will verify the integrity of the individual grounds and their connections and that the grounding potential is fairly uniform throughout. Do a selective test measurement at both ends of the remote site.



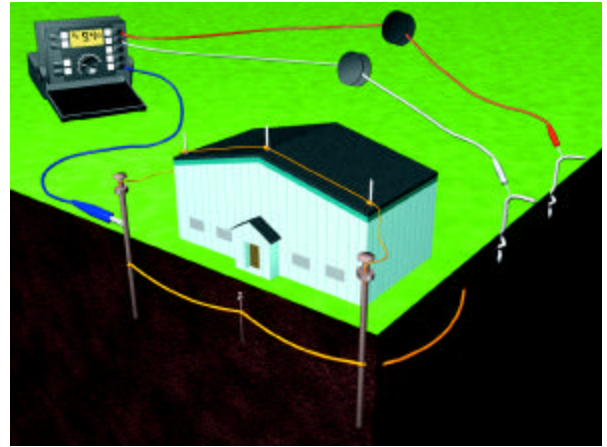
... and for Lightning Protection Commercial / Industrial

There are 3 ground resistance measurements required when conducting an audit of a lightning/fault current protection system. Most lightning fault current protection systems follow the design of having all 4 corners of the building grounded and these are usually connected via a copper cable. Depending on the size of the building and the resistance value that was tried to be obtained number of ground rods will vary.

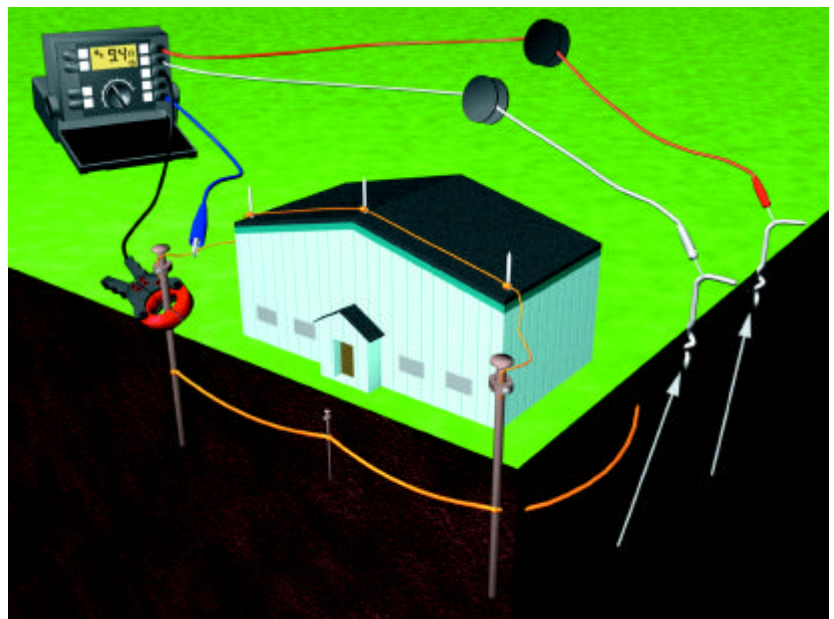
1 The first measurement to be taken is a Stakeless measurement of the building (shown below). This is not a true ground resistance measurement because of the network ground. This is mainly a continuity test to verify that we are grounded and do have an electrical connection and can pass current.



2 After we have completed the "Stakeless" check of the building we will then want to measure the resistance of the entire system via the 3-pole method. Keep in mind the rules for stake setting. This measurement should be recorded and measurements should take place at least semi-annually.



3 Finally we measure the individual grounds by the selective clamp-on method. This will verify the integrity of the individual grounds and their connections and that the grounding potential is fairly uniform throughout. Measure the resistance of all 4 corners of the building. If any of the measurements shows a greater degree of variability than any of the others it should be investigated.



Ground Testing Instruments

Universal ground testing instruments for testing installations and lightning protection. All instruments operate with a battery, have automatic an switch-off, a display illumination, adjustable limits, and display probe and auxiliary earth resistances. Auto-ranging and parasitic current suppression provide reliable measuring results. For standard 3-pole measurements, many additional special functions are available.



UNILAP GEO X

Ground tester for measurements on single grounds or multi-loop systems without breaking into the circuits.

- Selective ground measurements without influence from parallel grounds,
- stakeless ground
- measurements for quick testing, measurements of the specific ground resistance
- Ground impedance of high voltage towers.

- 2-pole and 4-pole resistance measurements with DC (>200 mA)
- 2-pole resistance measurements with AC
- Measured value output via interface (to printer or PC)
- Storage or direct printout of the values via optional DOCU-PACK (RS232 interface required)
- Logging of measured values via optional Windows® software WinGEO

UNILAP GEO

3-pole measurement and additional 2-pole resistance measurements with AC.

WinGEO

Application software for PCs using Windows®, Windows® 95, Windows® NT.

Suited for UNILAP GEO X (with RS232 interface or DOCU-PACK), measured data acquisition, remote control, logging, SETUP, DIAGNOSE.

Technical Data	Handy GEO	SATURN GEO	UNILAP GEO	UNILAP GEO X
Measuring range	2000 Ω , 6%	300 kΩ , 2%	300 kΩ , 2%	300 kΩ , 2%
Resolution	10 mΩ	1 mΩ	1 mΩ	1 mΩ
Measuring voltage	<25 V	20/48 V	20/48 V	20/48 V
Test current max.	>50 mA	250 mA	250 mA	250 mA
Frequency	128Hz	55...128Hz, auto	55...128Hz, auto	55...128Hz, auto
4-pole	-	ü	ü	ü
2-pole	ü	ü	ü	ü
3-pole	ü	ü	ü	ü
Selektive	-	-	-	ü
Stakeless meas.	-	-	-	ü
Accessories				
RS232 interface	ü	-	-	ü
Software	WinVIEW	-	-	WinGEO
DOCU-PACK	-	-	-	ü

Ground Testing Instruments

SATURN GEO

Universal earth tester

- 4-pole ground measurement
- 3-pole ground measurement
- 2-pole resistance measurements
- Resistance measurements with AC
- Specific earth resistance
- Digital display
- Earth impedance of high voltage pylons

Extremely rugged housing thanks to protective cover and carrying strap.



Handy GEO

Small, handy ground tester

- 3-pole ground measurement
- 2-pole resistance measurements
- Digital display, bar graph

Logging of the measured values via an optional RS 232 interface and PC software WinVIEW or directly via a printer.

Designation	Order No.
Handy GEO base instrument	A 1885 03110
Handy GEO incl. ground measuring kit + 2 ground stakes, 2 cable reels (25m, 50m), carrying case	A 1885 03111
Handy GEO base instrument + RS 232 interface and PC-software WinVIEW	A 1885 03112
Ground measuring kit 2 stakes, 2 reels (25m, 50m), case	A 6030 03100
SATURN GEO without accessories	A 1885 06411
UNILAP GEO without accessories	A 1885 06110
UNILAP GEO incl. ground measuring set: 4 ground stakes, 2 cable reels (25 m), 1 cable ree (50 m), case	A 1885 06111
UNILAP GEO X incl. ground measuring set	A 1885 06211
UNILAP GEO X incl. ground measuring set and RS232	A 1885 06212
UNILAP GEO X incl. ground measuring set and stakeless kit	A 1885 06213
UNILAP GEO X with ground measuring set and DOCU-PACK	A 1885 06215
WinGEO PC software for UNILAP GEO X with RS232/DOCU-PACK	A 1885 00172
12 1/2" split core transformer	A 6805 06211
Earth/Ground measuring kit: 2 stakes, 2 reels (25m, 50m) in carrying case	A 6045 10301



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