UNDERSTANDING
GROUND RESISTANCE TESTING

• Soil Resistivity • Ground Resistance • 3-Point Measurements
• 4-Point Measurements • Clamp-On Measurements

AEMC® INSTRUMENTS
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Understanding Ground Resistance Testing

A One Day Training Seminar

In today's rapidly changing world of technological advances, good grounding is more important than ever to prevent costly damage and downtime due to service interruptions and inoperative surge protection caused by poor grounds. Grounding systems offer protection from natural phenomenon such as lightning by channeling the lightning current to the ground, protecting personnel from injury and protecting system components from damage. In electric power systems with ground returns, grounds help ensure rapid operation of the protection relays by providing low resistance fault paths in the event of unexpected potentials due to faults. Low ground resistance is required to meet NEC®, OSHA and other electrical safety standards.

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Soil Resistivity

Effects of Soil Resistivity on Grounding Electrode Resistance

Soil resistivity is the key factor that determines what the resistance of a grounding electrode system will be, and to what depth it must be driven to obtain low ground resistance. The resistivity of the soil varies widely throughout the world and changes seasonally. Soil resistivity is determined largely by its content of electrolytes, which consist of moisture, minerals and dissolved salts. A dry soil has high resistivity if it contains no soluble salts. (Figure 1)

Note:The lower the soil resistivity value, the lower the grounding electrode resistance will be.

Soil	Resistivity (approx.), Ω-cm Min.	Average	Max.
Ashes, cinders, brine, waste	590	2370	7000
Clay, shale, gumbo, loam	340	4060	16,300
Same, with varying proportions of sand and gravel	1020	15,800	135,000
Gravel, sand, stones with little clay or loam	59,000	94,000	458,000

Figure 1

Factors Affecting Soil Resistivity

Two samples of soil, when thoroughly dried, may in fact become very good insulators having a resistivity in excess of 10^9Ω-cm. The resistivity of the soil sample is seen to change quite rapidly until approximately 20% or greater moisture content is reached. (Figure 2)

Moisture content % by weight	Resistivity Ω-cm Top soil	Sandy loam
0	$>10^9$	$>10^9$
2.5	250,000	150,000
5	165,000	43,000
10	53,000	18,500
15	19,000	10,500
20	12,000	6,300
30	6,400	4,200

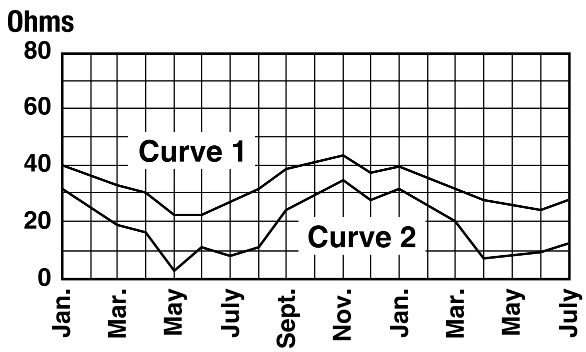
Figure 2

The resistivity of the soil is also influenced by temperature. Figure 3 shows the variation of the resistivity of sandy loam, containing 15.2% moisture, with temperature changes from 20° to -15°C. In this temperature range the resistivity is seen to vary from 7200 to 330,000Ω-cm.

Temperature °C	°F	Resistivity Ω-cm
20	68	7200
10	50	9900
0	32 (water)	13,800
0	32 (ice)	30,000
-5	23	79,000
-15	14	330,000

Figure 3

Because soil resistivity directly relates to moisture content and temperature, it is reasonable to assume that the resistance of any grounding system will vary throughout the different seasons of the year. Such variations are shown in Figure 4. Since both temperature and moisture content become more stable at greater distances below the surface of the earth, it follows that a grounding system, to be most effective at all times, should be constructed with the ground rod driven down a considerable distance below the surface of the earth. Best results are obtained if the ground rod reaches the water table.



Seasonal variation of earth resistance with an electrode of 3/4" pipe in rather stony clay soil. Depth of electrode in earth is 3 ft for Curve 1, and 10 ft for Curve 2

Figure 4

THE EFFECT OF SALT* CONTENT ON THE RESISTIVITY OF SOIL (Sandy loam, Moisture content, 15% by weight, Temperature, 17°C)	
Added Salt (% by weight of moisture)	Resistivity (Ω-cm)
0	10,700
0.1	1800
1.0	460
5	190
10	130
20	100

Figure 5

THE EFFECT OF TEMPERATURE ON THE RESISTIVITY OF SOIL CONTAINING SALT* (Sandy loam, 20% moisture. Salt 5% of weight of moisture)	
Temperature (Degrees C)	Resistivity (Ω-cms)
20	110
10	142
0	190
-5	312
-13	1440

Figure 6

*Such as copper sulfate, sodium carbonate, and others. Salts must be EPA or local ordinance approved prior to use.

In some locations, the resistivity of the earth is so high that low-resistance grounding can be obtained only at considerable expense and with an elaborate grounding system. In such situations, it may be economical to use a ground rod system of limited size and to reduce the ground resistivity by periodically increasing the soluble chemical content of the soil. Figure 5 shows the substantial reduction in resistivity of sandy loam brought about by an increase in chemical salt content.

Chemically treated soil is also subject to considerable variation of resistivity with temperature changes, as shown in Figure 6. If salt treatment is employed, it is necessary to use ground rods which will resist chemical corrosion.

Soil Resistivity Measurements
(4-Point Measurement)

Resistivity measurements are of two types; the 2-Point and the 4-Point method. The **2-Point method** is simply the resistance measured between two points. For most applications the most accurate is the **4-Point method** which is used in the Ground Tester Models 4610, 4620, 4630 or 6470. The 4-Point method (Figures 7 and 8), as the name implies, requires the insertion of four equally spaced and in-line electrodes into the test area.
A known current from a constant current generator is passed between the outer electrodes. The potential drop (a function of the resistance) is then measured across the two inner electrodes. The Models 4610, 4620, 4630 and 6470 are calibrated to read directly in ohms.
Where space or access to inserting rods is a problem, the Miller box may be used. The Schlumberger method is used mainly for geologic surveys.

NOTE:
To use feet instead of cm:
2π x (conversion from cm to ft) =
(2) (3.14) (12) (2.54) = 191.5

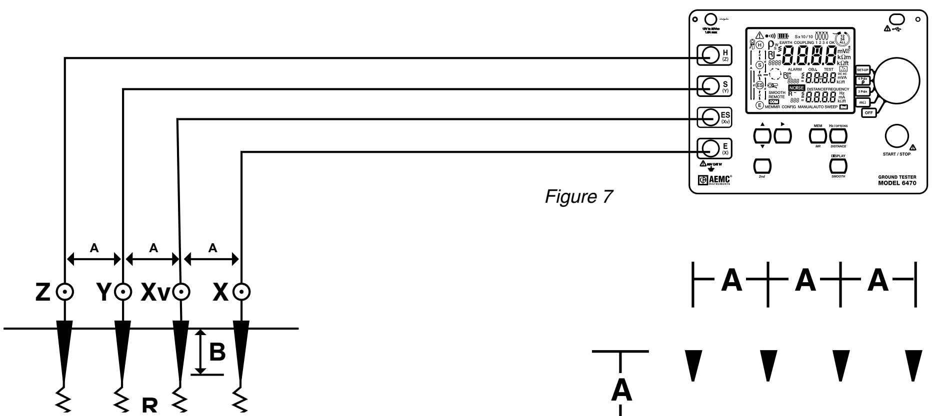


Figure 7

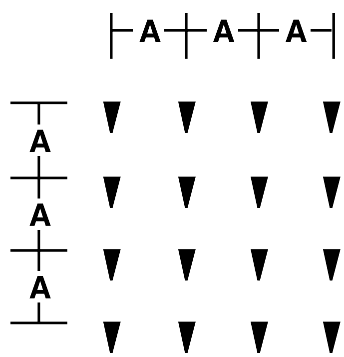


Figure 8

Where: A = distance between the electrodes in centimeters
B = electrode depth in centimeters
If A > 20 B, the formula becomes:

ρ = 2ϖ AR (with A in cm)
ρ = 191.5 AR (with A in ft)
ρ = Soil resistivity (Ω-cm)

The value to be used for ρ is the average resistivity of the ground at a depth equivalent to the distance "A" between two electrodes for all tests taken.

Given a sizable tract of land in which to determine the optimum soil resistivity some intuition is in order. Assuming that the objective is low resistivity, preference should be given to an area containing moist loam as opposed to a dry sandy area. Consideration must also be given to the depth at which resistivity is required.

Example
After inspection, the area investigated has been narrowed down to a plot of ground approximately 75 square feet ($7m^2$). Assume that you need to determine the resistivity at a depth of 15 ft (450cm). The distance "A" between the electrodes must then be equivalent to the depth at which average resistivity is to be determined (15 ft, or 450cm). Using the more simplified Wenner formula ($\rho = 2\varpi$ AR), the electrode depth must then be no more than 1/20th of the electrode spacing or 8⅞" (22.5cm).

Lay out the electrodes in a grid pattern and connect to the instrument as shown in Figure 8. Proceed as follows:

- Remove the shorting link between X and Xv (C1, P1)
- Connect all four auxiliary rods (Figure 7)

For example, if the reading is R = 15

ρ (resistivity) = 2ϖ x A x R
A (distance between electrodes) = 450cm
ρ = 6.28 x 15 x 450 = 42,390Ω-cm

Grounding Electrodes

The term "ground" is defined as a conducting connection by which a circuit or equipment is connected to the earth. The connection is used to establish and maintain as closely as possible the potential of the earth on the circuit or equipment connected to it. A "ground" consists of a grounding conductor, a bonding connector, its grounding electrode(s), and the soil in contact with the electrode.

"Grounds" have several protection applications. For natural phenomena such as lightning, grounds are used to discharge the system of current before personnel can be injured or system components damaged. For foreign potentials due to faults in electric power systems with ground returns, grounds help ensure rapid operation of the protection relays by providing low resistance fault current paths. This provides for the removal of the foreign potential as quickly as possible. The ground should drain the foreign potential before personnel are injured and the power or communications system is damaged.

Ideally, to maintain a reference potential for instrument safety, protect against static electricity, and limit the system to frame voltage for operator safety, a ground resistance should be zero ohms. In reality, as we describe further in the text, this value cannot be obtained.

Last but not least, low ground resistance is essential to meet NEC®, OSHA and other electrical safety standards.

Figure 9 illustrates a grounding rod. The resistance of the electrode has the following components:

(A) The resistance of the metal and that of the connection to it.
(B) The contact resistance of the surrounding earth to the electrode.
(C) The resistance in the surrounding earth to current flow or earth resistivity which is often the most significant factor.

More specifically:

(A) Grounding electrodes are usually made of a very conductive metal (copper or copper clad) with adequate cross sections so that the overall resistance is negligible.

(B) The National Institute of Standards and Technology has demonstrated that the resistance between the electrode and the surrounding earth is negligible if the electrode is free of paint, grease, or other coating, and if the earth is firmly packed.

(C) The only component remaining is the resistance of the surrounding earth. The electrode can be thought of as being surrounded by concentric shells of earth or soil, all of the same thickness. The closer the shell to the electrode, the smaller its surface; hence, the greater its resistance. The farther away the shells are from the electrode, the greater the surface of the shell; hence, the lower the resistance. Eventually, adding shells at a distance from the grounding electrode will no longer noticeably affect the overall earth resistance surrounding the electrode. The distance at which this effect occurs is referred to as the effective resistance area and is directly dependent on the depth of the grounding electrode.

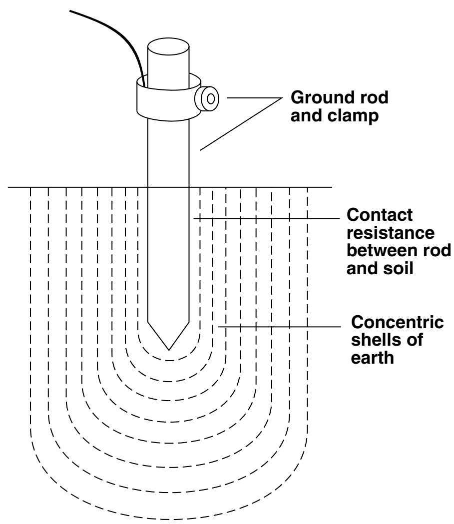


Figure 9

Effect of Grounding Electrode Size and Depth on Resistance

Size: Increasing the diameter of the rod does not significantly reduce its resistance. Doubling the diameter reduces resistance by less than 10%. (Figure 10)

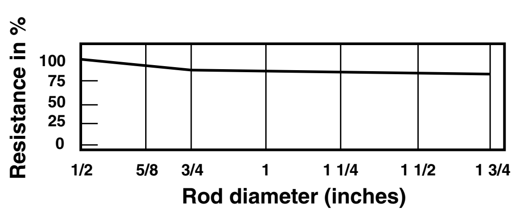
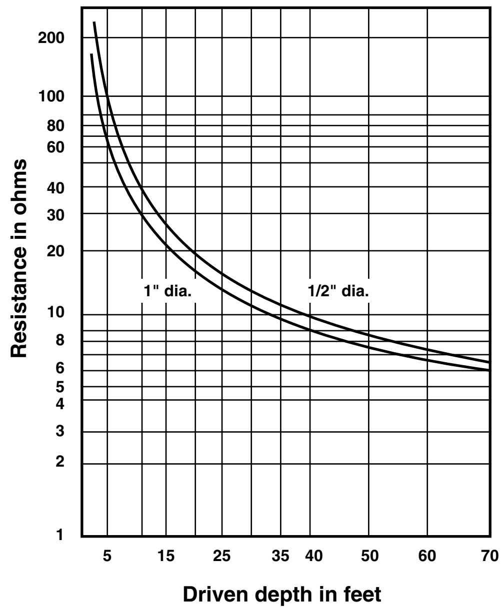


Figure 10

Depth: As a ground rod is driven deeper into the earth, its resistance is substantially reduced. In general, doubling the rod length reduces the
resistance by an additional 40% (Figure 11). The NEC (2008, 250.53 (G)) requires a minimum of 8 ft. (2.4m) in contact with the soil.
NEC (2008, 250.52 (A)(5)(b)) states that rod electrodes of stainless steel and copper or zinc coated steel shall be at least 15.87mm (5/8 in) diameter, unless listed and not less than 12.70mm (1/2 in) in diameter.



Ground resistance versus ground rod depth

Figure 11

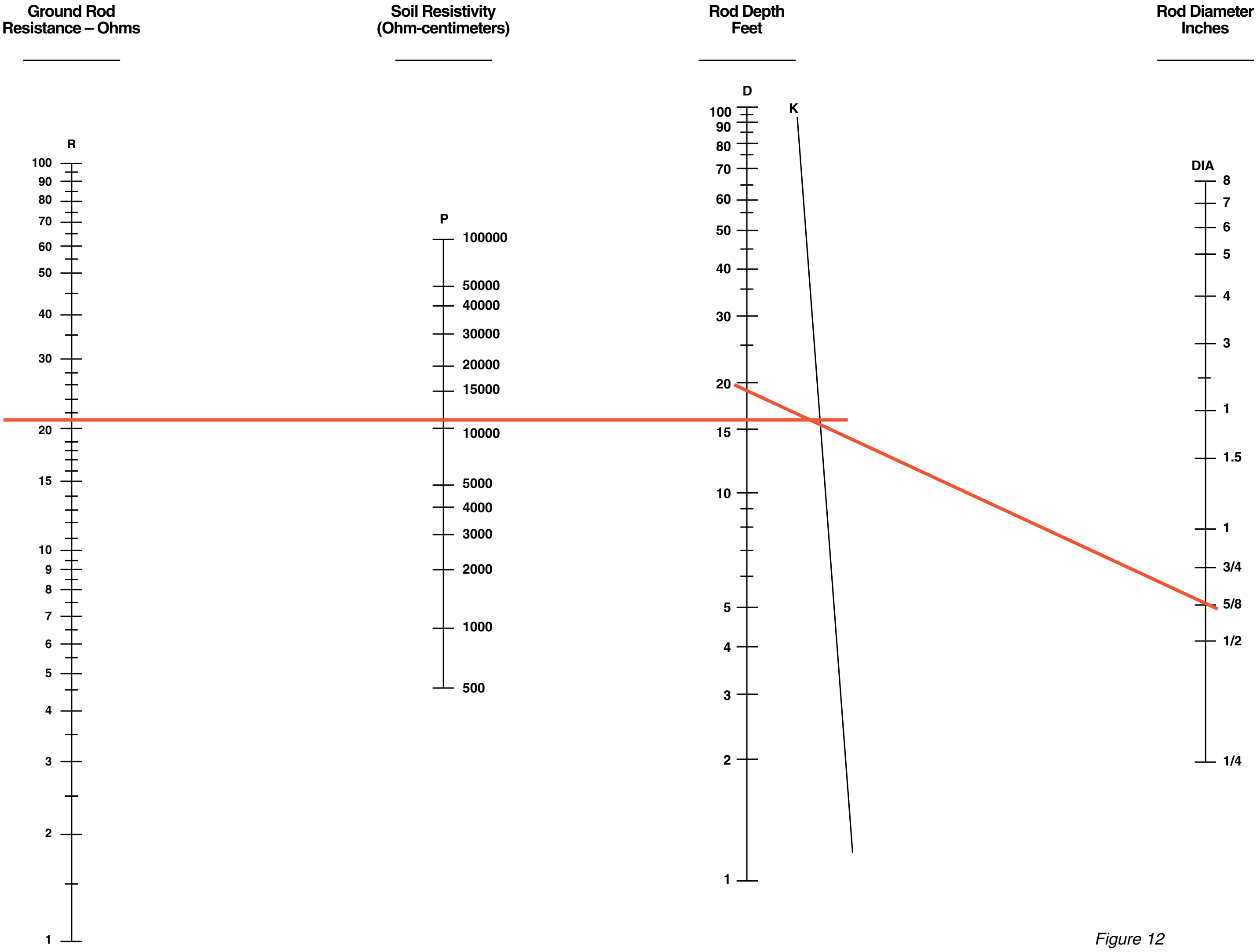


Figure 12

Grounding Nomograph

1. Select required resistance on R scale
2. Select apparent resistivity on P scale
3. Lay straightedge on R and P scale, and allow to intersect with K scale
4. Mark K scale point
5. Lay straightedge on K scale point & DIA scale, and allow to intersect with D scale
6. Point on D scale will be rod depth required for resistance on R scale

Ground Resistance Testing Principle
(Fall-of-Potential — 3-Point Measurement)

The potential difference between rods X and Y is measured by a voltmeter, and the current flow between rods X and Z is measured by an ammeter. (Note: X, Y and Z may be referred to as X, P and C or H, S or E in a 3-Point tester or C1, P2 and C2 in a 4-Point tester.) (Figure 13)

By Ohm's Law E = RI or R = E/I, we may obtain the grounding electrode resistance R.
If E = 20V and I = 1A, then

$$R = \frac{E}{I} = \frac{20}{1} = 20\Omega$$

This method requires the service neutral and any other grounding system be disconnected. It is not necessary to carry out all the measurements when using a ground tester. The ground tester will measure directly by generating its own current and displaying the resistance of the grounding electrode.

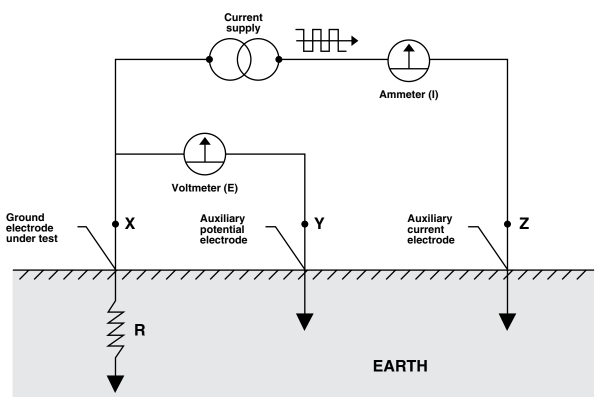


Figure 13

Position of the Auxiliary Electrodes on Measurements

The goal in precisely measuring the resistance to ground is to place the auxiliary current electrode Z far enough from the grounding electrode under test so that the auxiliary potential electrode Y will be outside of the effective resistance areas of both the grounding electrode and the auxiliary current electrode. The best way to find out if the auxiliary potential rod Y is outside the effective resistance areas is to move it between X and Z and to take a reading at each location (See Figure 16). If the auxiliary potential rod Y is in an effective resistance area (or in both if they overlap, as in Figure 14), by displacing it the readings taken will vary noticeably in value. Under these conditions, no exact value for the resistance to ground may be determined.

On the other hand, if the auxiliary potential rod Y is located outside of the effective resistance areas (Figure 15), as Y is moved back and forth the reading variation is minimal. The readings taken should be relatively close to each other, and are the best values for the resistance to ground of the grounding electrode X. The readings should be plotted to ensure that they lie in a "plateau" region as shown in Figure 15. The region is often referred to as the "62% area" (See page 11 for explanation).

Readings every 5-10% of the distance from x to z are suggested. The average of the closest three readings (user defined) would be considered the resistance between earth and the test point.

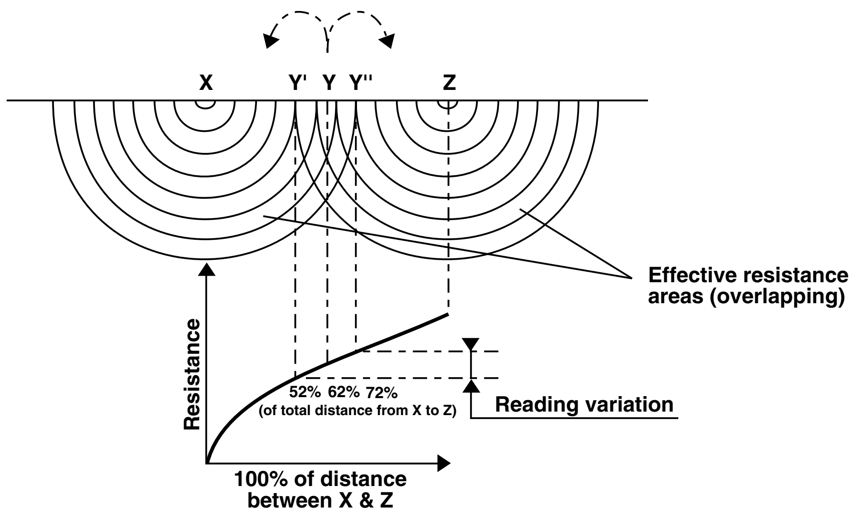


Figure 14

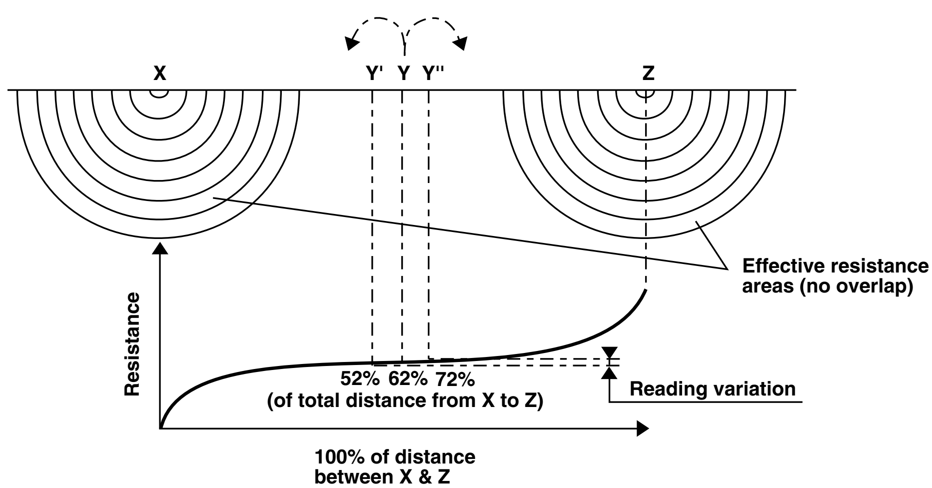


Figure 15

Measuring Resistance of Grounding Electrodes (62% Method)

The 62% method has been adopted after graphical consideration and after actual test. It is the most accurate method but is limited by the fact that *the ground tested is a single unit.*

This method applies only when all three electrodes are in a straight line and the ground is a *single* electrode, pipe, or plate, etc., as in Figure 16.

Consider Figure 17, which shows the effective resistance areas (concentric shells) of the grounding electrode X and of the auxiliary current electrode Z. The resistance areas overlap. If readings were taken by moving the auxiliary potential electrode Y towards either X or Z, the reading differentials would be great and one could not obtain a reading within a reasonable band of tolerance. The sensitive areas overlap and act constantly to increase resistance as Y is moved away from X.

Now consider Figure 18, where the X and Z electrodes are sufficiently spaced so that the areas of effective resistance do not overlap. If we plot the resistance measured we find that the measurements level off when Y is placed at 62% of the distance from X to Z, and that the readings on either side of the initial Y setting are most likely to be within the established tolerance band. This tolerance band is defined by the user and expressed as a percent of the initial reading: ±2%, ±5%, ±10%, etc.

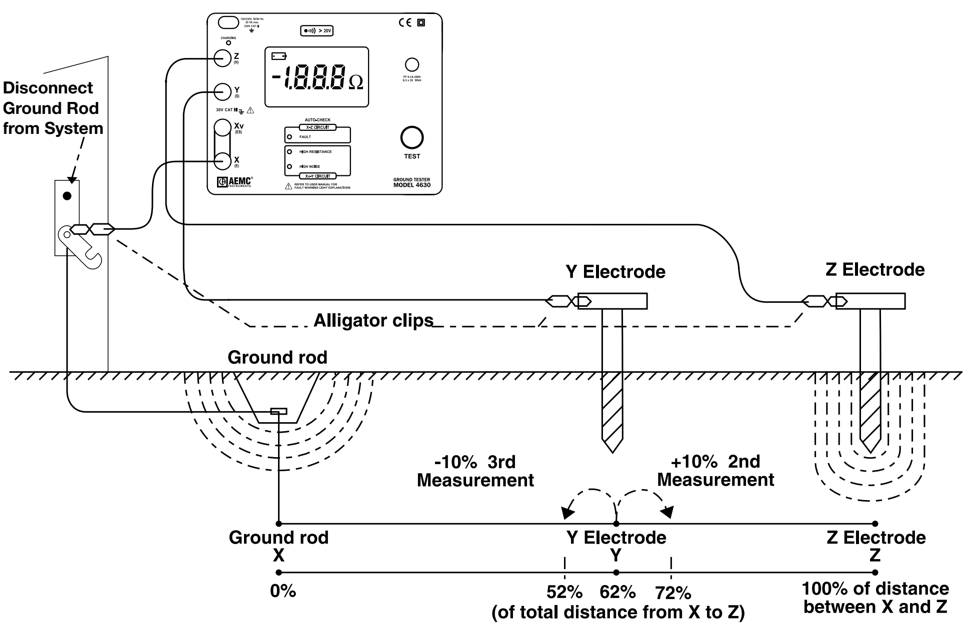


Figure 16

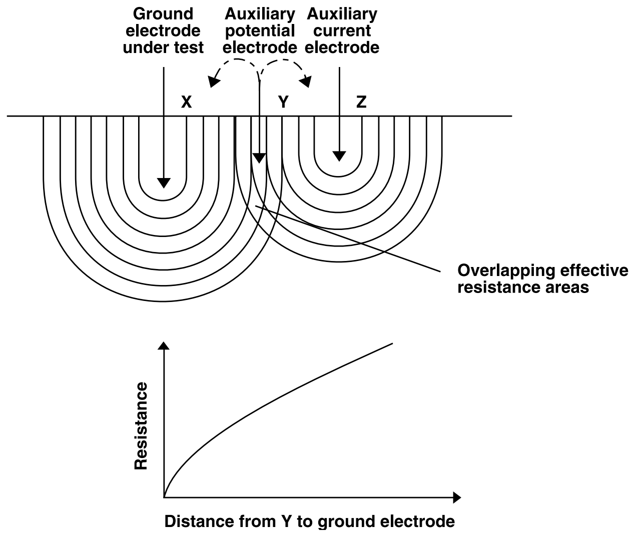


Figure 17

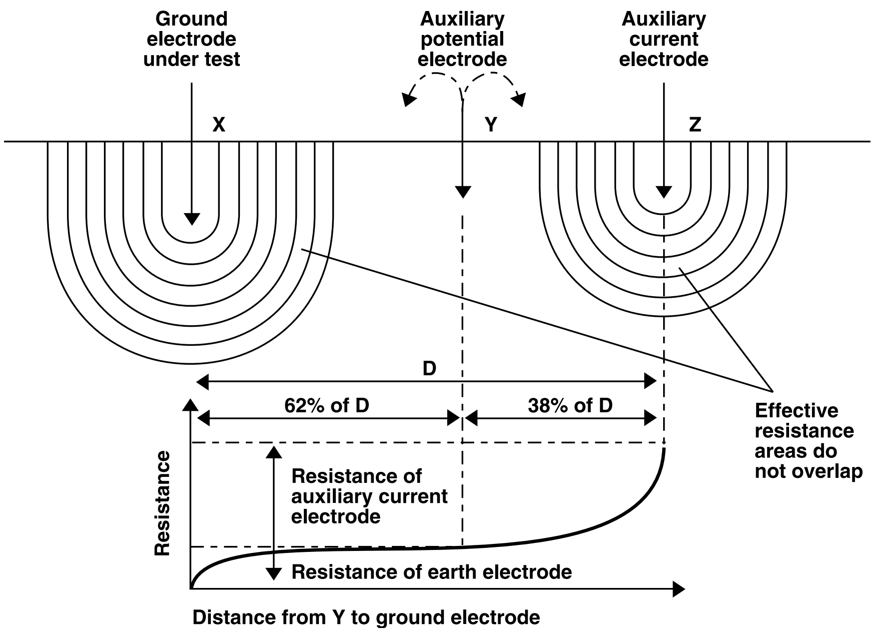


Figure 18

Auxiliary Electrode Spacing

No definite distance between X and Z can be given, since this distance is relative to the diameter of the electrode tested, its length, the homogeneity of the soil tested, and particularly, the effective resistance areas. However, an approximate distance may be determined from the following chart which is given for a homogeneous soil and an electrode of 1" in diameter. (For a diameter of ½", reduce the distance by 10%; for a diameter of 2" increase the distance by 10%; for a diameter of ⅜", reduce the distance by 8%.)

Approximate distance to auxiliary electrodes using the 62% method		
Depth Driven	**Distance to Y**	**Distance to Z**
6 ft	45 ft	72 ft
8 ft	50 ft	80 ft
10 ft	55 ft	88 ft
12 ft	60 ft	96 ft
18 ft	71 ft	115 ft
20 ft	74 ft	120 ft
30 ft	86 ft	140 ft

Multiple Rod Spacing

Parallel multiple electrodes yield lower resistance to ground than a single electrode. High-capacity installations require low grounding resistance. Multiple rods are used to provide this resistance.

A second rod does not provide a total resistance of half that of a single rod unless the two are several rod lengths apart. To achieve the grounding resistance place multiple rods one rod length apart in a line, circle, hollow triangle, or square. The equivalent resistance can be calculated by dividing by the number of rods and multiplying by the factor X (shown below). Additional considerations regarding step and touch potentials should be addressed by the geometry.

Placing additional rods within the periphery of a shape will not reduce the grounding resistance below that of the peripheral rods alone.

Multiplying Factors for Multiple Rods	
Number of Rods	**X**
2	1.16
3	1.29
4	1.36
8	1.68
12	1.80
16	1.92
20	2.00
24	2.16

Multiple Electrode System

A single driven grounding electrode is an economical and simple means of making a good ground system. But sometimes a single rod will not provide sufficient low resistance, and several grounding electrodes will be driven and connected in parallel by a cable. Very often when two, three or four grounding electrodes are being used, they are driven in a straight line; when four or more are being used, a hollow square configuration is used and the grounding electrodes are still connected in parallel and are equally spaced (Figure 19).

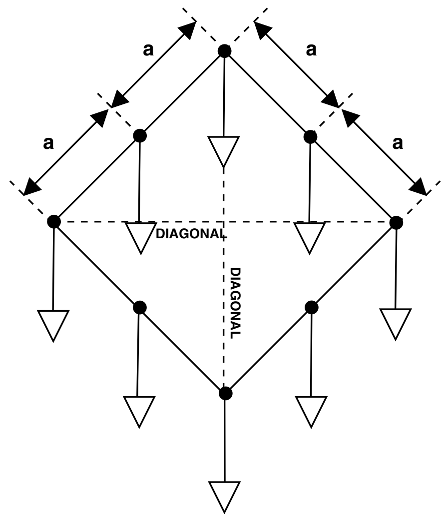


Figure 19

In multiple electrode systems, the 62% method electrode spacing may no longer be applied directly. The distance of the auxiliary electrodes is now based on the maximum grid distance (i.e. in a square, the diagonal; in a line, the total length. For example, a square having a side of 20 ft will have a diagonal of approximately 28 ft). Three readings, minimum, are still required for proper testing.

	Multiple Electrode System	
Max Grid Distance	Distance to Y	Distance to Z
6 ft	78 ft	125 ft
8 ft	87 ft	140 ft
10 ft	100 ft	160 ft
12 ft	105 ft	170 ft
14 ft	118 ft	190 ft
16 ft	124 ft	200 ft
18 ft	130 ft	210 ft
20 ft	136 ft	220 ft
30 ft	161 ft	260 ft
40 ft	186 ft	300 ft
50 ft	211 ft	340 ft
60 ft	230 ft	370 ft
80 ft	273 ft	440 ft
100 ft	310 ft	500 ft
120 ft	341 ft	550 ft
140 ft	372 ft	600 ft
160 ft	390 ft	630 ft
180 ft	434 ft	700 ft
200 ft	453 ft	730 ft

Tech Tips

Excessive Noise

Excessive noise may interfere with testing because of the long leads used to perform a Fall-of-Potential test. A voltmeter can be utilized to identify this problem. Connect the “X”, “Y” and “Z” cables to the auxiliary electrodes as for a standard ground resistance test. Use the voltmeter to test the voltage across terminals “X” and “Z ” (See Figure 20).

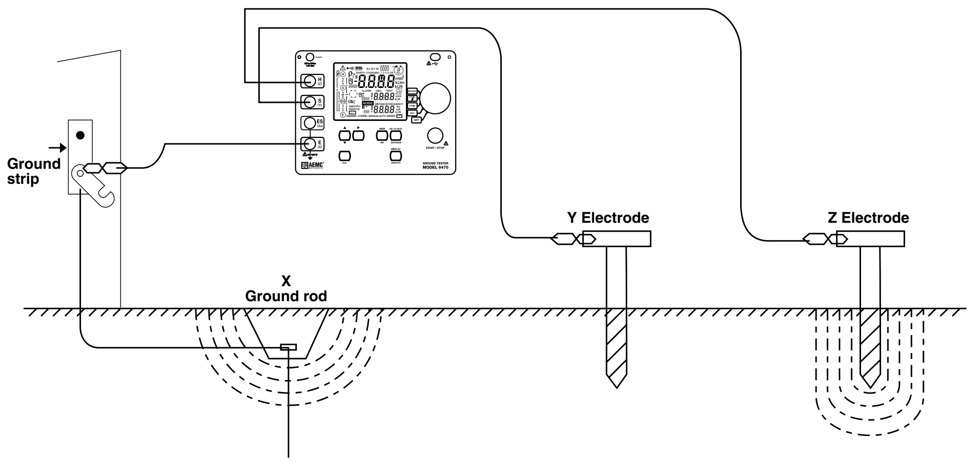


Figure 20

The voltage reading should be within stray voltage tolerances acceptable
to your ground tester. If the voltage exceeds this value, try the following techniques:

A) Braid the auxiliary cables together. This often has the effect of canceling out the common mode voltages between these two conductors. (Figure 21)

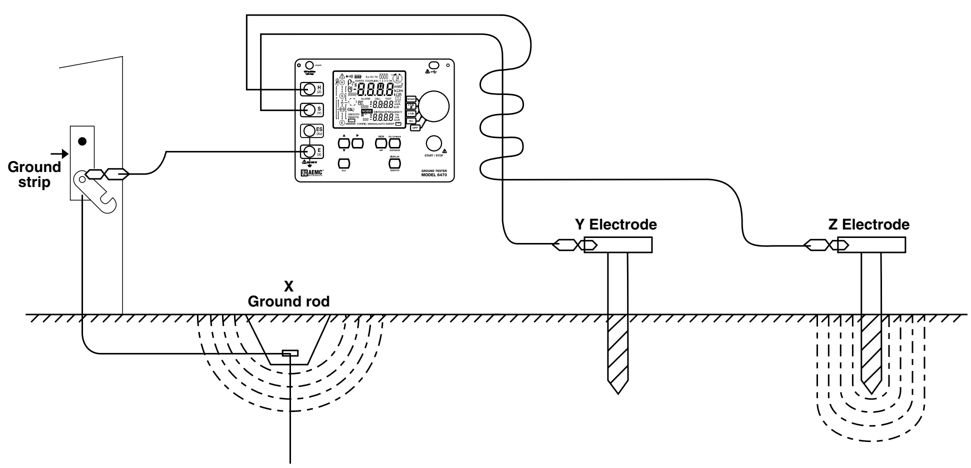


Figure 21

B) If the previous method fails, try changing the alignment of the auxiliary cables so that they are not parallel to power lines above or below the ground. (Figure 22)

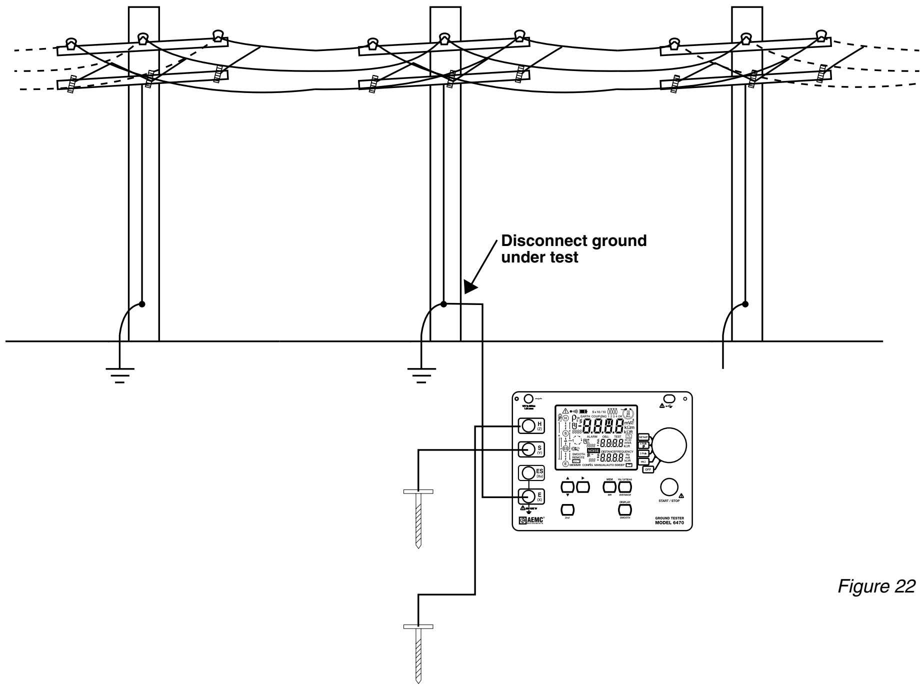


Figure 22

C) If a satisfactory low voltage value is still not obtained, the use of shielded cables may be required. The shield acts to protect the inner conductor by capturing the voltage and draining it to ground. (Figure 23)

1. Float the shields at the auxiliary electrodes
2. Connect all three shields together at (but not to) the instrument
3. Solidly ground the remaining shield to the ground under test

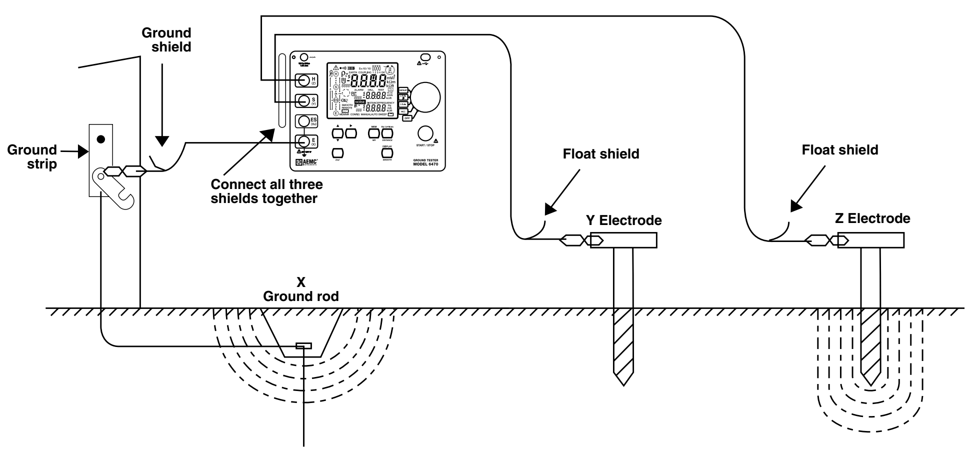


Figure 23

Excessive Auxiliary Rod Resistance

The inherent function of a Fall-of-Potential ground tester is to input a constant current into the earth and measure the voltage drop by means of auxiliary electrodes. Excessive resistance of one or both auxiliary electrodes can inhibit this function. This is caused by high soil resistivity or poor contact between the auxiliary electrode and the surrounding dirt (Figure 24).

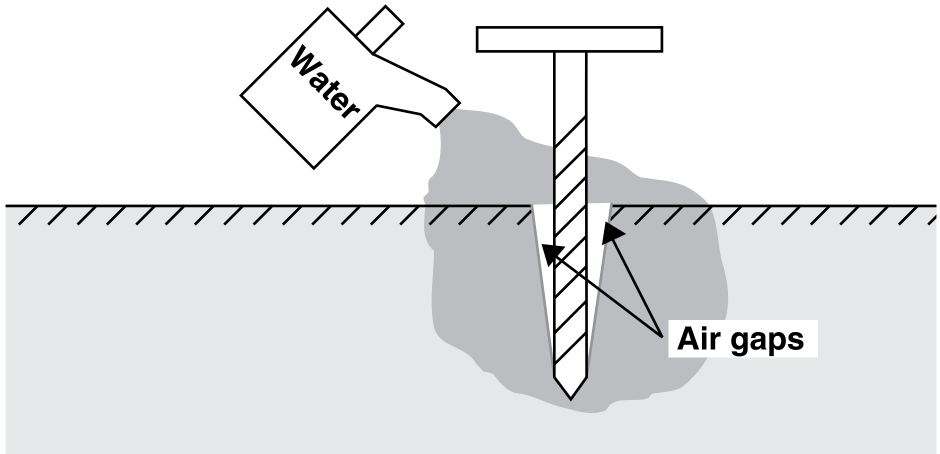


Figure 24

To ensure good contact with the earth, stamp down the soil directly around the auxiliary electrode to remove air gaps formed when inserting the rod.
If soil resistivity is the problem, pour water around the auxiliary electrodes. This reduces the auxiliary electrode's contact resistance without affecting the measurement.

Asphalt or Concrete Mat

Sometimes a test must be performed on a ground rod that is surrounded by a tar or concrete mat, where auxiliary electrodes cannot be driven easily. In such cases, metal screens and water can be used to replace auxiliary electrodes, as shown in Figure 25.

Place the screens on the floor the same distance from the ground rod under test as you would auxiliary electrodes in a standard fall-of-potential test. Pour water on the screens and allow it to soak in. These screens will now perform the same function as would driven auxiliary electrodes.

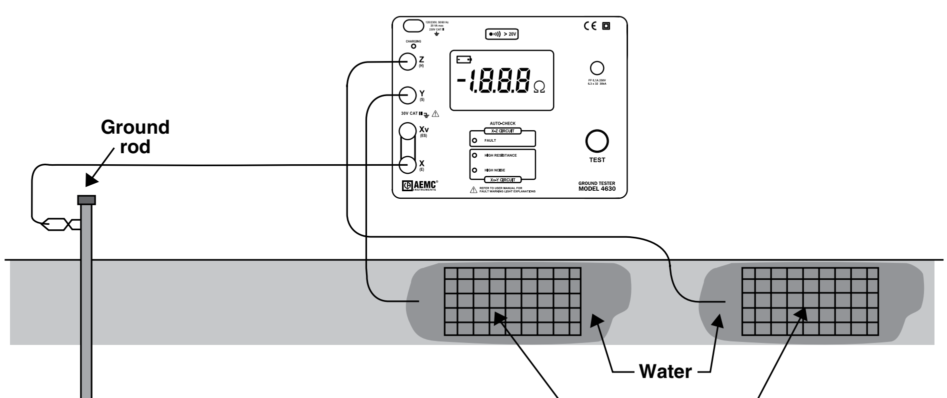


Figure 25

Clamp-on Ground Resistance Measurement
(Models 3711 & 3731)

This measurement method is innovative and quite unique. It offers the ability to measure the resistance without disconnecting the ground. This type of measurement also offers the advantage of including the bonding to ground and the overall grounding connection resistances.
This method requires connection of utility neutral or another grounding system so that the signal goes out to the other system and returns to the test point through the earth.

Principle of Operation

Usually, a common distribution line grounded system can be simulated as a simple basic circuit as shown in Figure 26 or an equivalent circuit, shown in Figure 30. If voltage E is applied to any measured grounding point Rx through a special transformer, current I flows through the circuit, thereby establishing the following equation.

$$E/I = Rx + \frac{1}{\sum_{k=1}^{n} \frac{1}{Rk}} \quad \textit{where, usually} \quad Rx \gg \frac{1}{\sum_{k=1}^{n} \frac{1}{Rk}}$$

Therefore, E/I = Rx is established. If I is detected with E kept constant, measured grounding point resistance can be obtained. Refer again to Figures 26 and 27. Current is fed to a special transformer via a power amplifier from a 2.4kHz constant voltage oscillator. This current is detected by a detection CT. Only the 2.4kHz signal frequency is amplified by a filter amplifier. This occurs before the A/D conversion and after synchronous rectification. It is then displayed on the LCD.

The filter amplifier is used tocut off both earth current at commercial frequency and high-frequency noise. Voltage is detected by coils wound around the injection CT which is then amplified, rectified, and compared by a level comparator. If the clamp is not closed properly, an “open jaw” annunciator appears on the LCD.

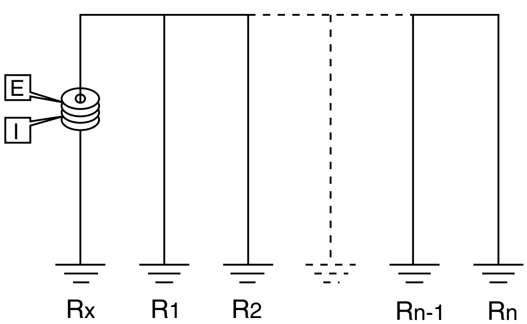


Figure 26

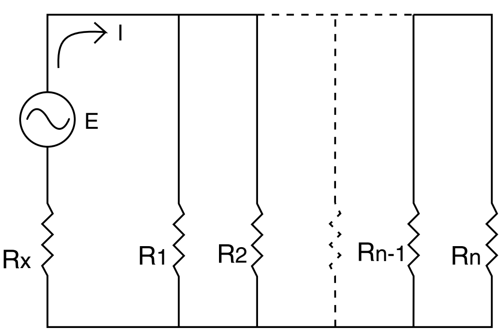


Figure 27

Examples: Typical In-Field Measurements

Pole Mounted Transformer

Remove any molding covering the ground conductor, and provide sufficient room for the Model 3711 & 3731 jaws, which must be able to close easily around the conductor. The jaws can be placed around the ground rod itself. **Note:** The clamp must be placed so that the jaws are in an electrical path from the system neutral or ground wire to the ground rod or rods as the circuit provides.

Select the current range "A." Clamp onto the ground conductor and measure the ground current. The maximum current range is 30A. If the ground current exceeds 5A, ground resistance measurements are not possible. *Do not proceed further with the measurement.* Instead, remove the clamp-on tester from the circuit, noting the location for maintenance, and continue to the next test location.

After noting the ground current, select the ground resistance range "Ω" and measure the resistance directly. The reading you measure with the Model 3711 & 3731 indicates the resistance not just of the rod, but also of the connection to the system neutral and all bonding connections between the neutral and the rod.

Note that in Figure 28 there is both a butt plate and a ground rod. In this type of circuit, the instrument must be placed above the bond so that both grounds are included in the test. For future reference note the date, ohms reading, current reading and point number. Replace any molding you may have removed from the conductor.

Note: A high reading indicates one or more of the following:

A) Poor ground rod

B) Open ground conductor

C) High resistance bonds on the rod or splices on the conductor; watch for buried split bolts, clamps and hammer-on connections

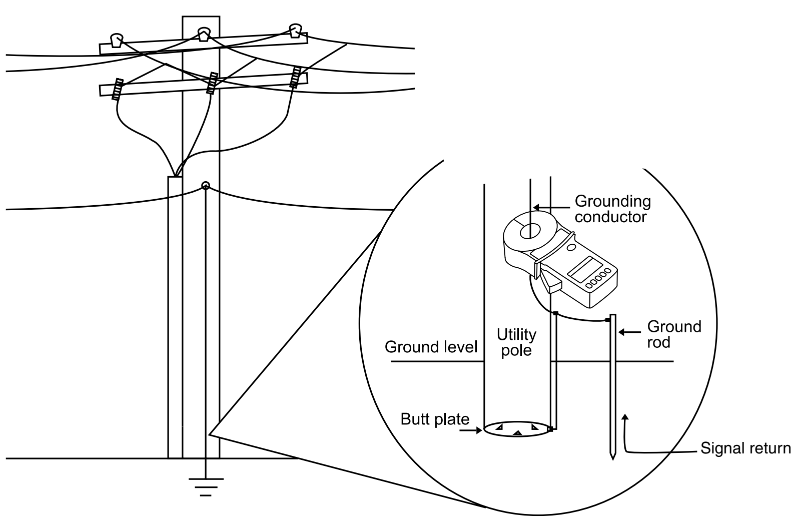


Figure 28

Service Entrance or Meter

Follow basically the same procedure as in the first example. Notice that Figure 29 shows the possibility of multiple ground rods, and in Figure 30 the ground rods have been replaced with a water pipe ground. You may also have both types acting as a ground. In these cases, it is necessary to make the measurements between the service neutral and both grounded points.

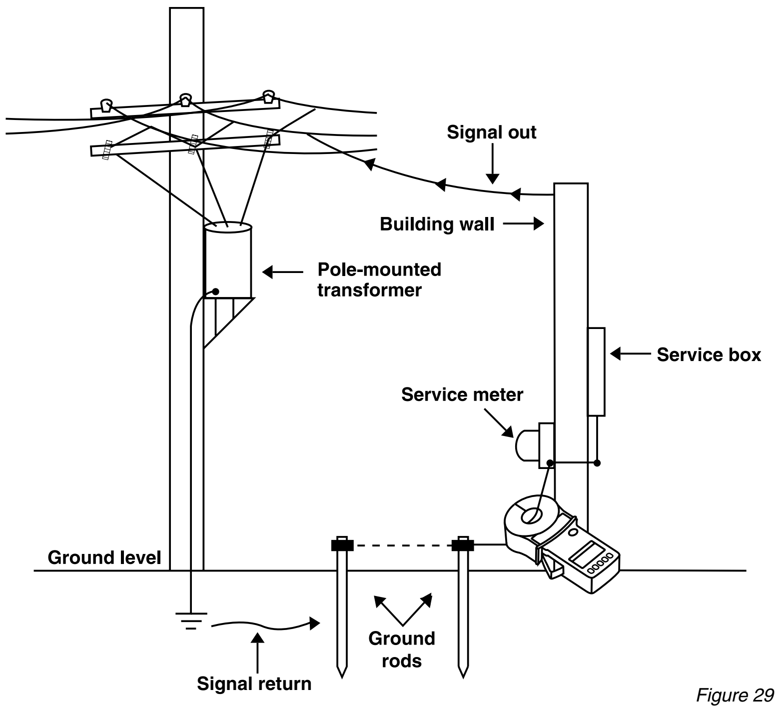


Figure 29

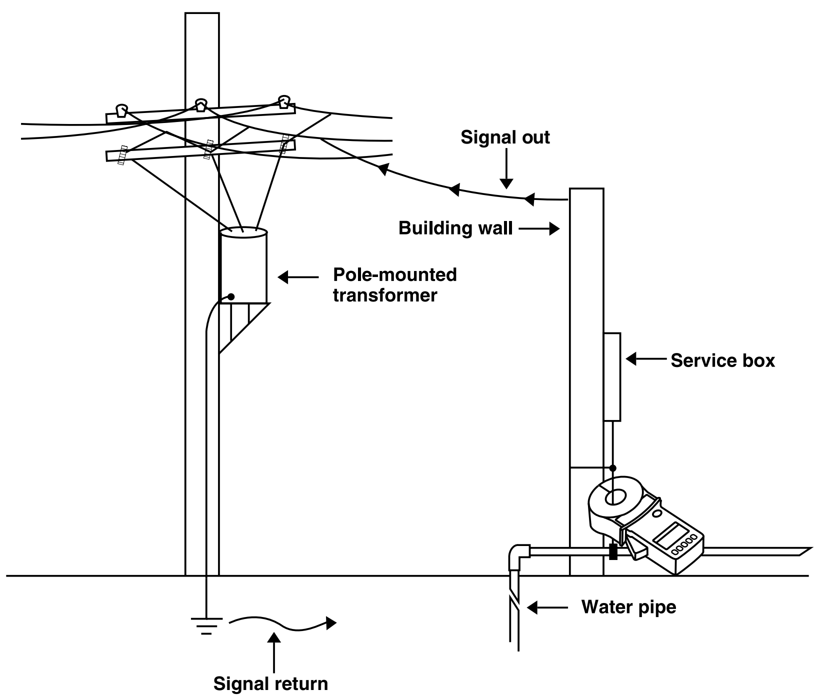


Figure 30

Pad Mounted Transformer

Note: Never open transformer enclosures. They are the property of the electrical utility. This test is for high voltage experts only.

Observe all safety requirements, since dangerously high voltage is present. Locate and number all rods (usually only a single rod is present). If the ground rods are inside the enclosure, refer to Figure 31 and if they are outside the enclosure, refer to Figure 32. If a single rod is found within the enclosure, the measurement should be taken on the conductor just before the bond on the ground rod. Often, more than one ground conductor is tied to this clamp, looping back to the enclosure or neutral.

In many cases, the best reading can be obtained by clamping the Models 3711 & 3731 onto the ground rod itself, below the point when the ground conductors are attached to the rod, so that you are measuring the ground circuit. Care must be taken to find a conductor with only one return path to the neutral.

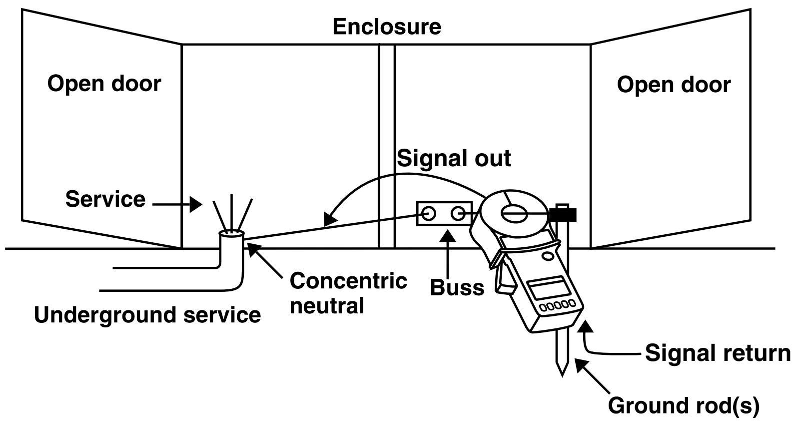


Figure 31

Telecommunications

The clamp-on ground tester developed by AEMC® and discussed in the previous chapter has revolutionized the ability of power companies to measure their ground resistance values. This same proven instrument and technology can be applied to telephone industries to aid in detecting grounding and bonding problems. As equipment operates at lower voltages, the system's ability to remove any man made or natural over potentials becomes even more critical. The traditional Fall-of-Potential tester proved to be labor intensive and left much to interpretation. Even more important, the clamp-on ground test method allows the user to make this necessary reading without the risky business of removing the ground under test from service.

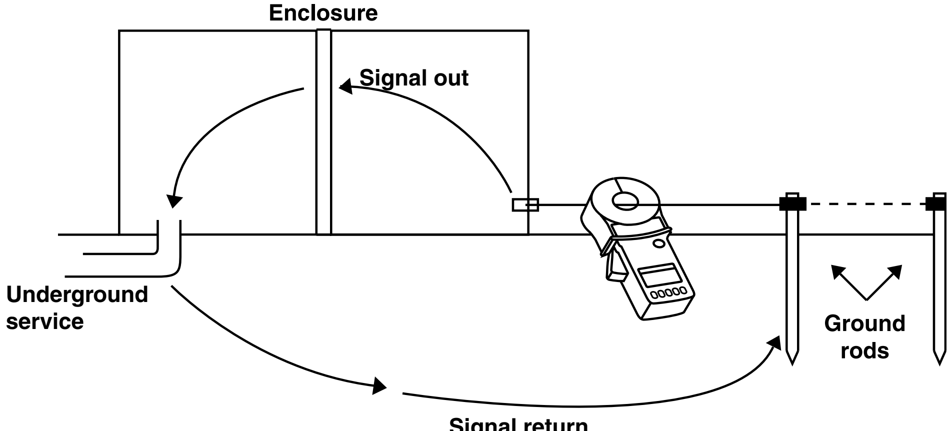


Figure 32

In many applications, the ground consists of bonding the two Utilities together to avoid any difference of potentials that could be dangerous to equipment and personnel alike. The clamp-on "Ohm meter" can be used to test these important bonds.

Here are some of the solutions and clamp-on procedures that have applications to the telephone industry.

Telephone Cabinets and Enclosures

Grounding plays a very important role in the maintenance of sensitive equipment in telephone cabinets and enclosures. In order to protect this equipment, a low resistance path must be maintained in order for any overvoltage potentials to conduct safely to earth. This resistance test is performed by clamping a ground tester, Models 3711 and 3731, around the driven ground rod, below any common telephone and power company bond connections.

To avoid any high voltage potentials between the telephone and power companies, a low resistance bond is established. Bonding integrity is performed by clamping around the No. 6 copper wire between the master ground bar (MGB) and the power company's multigrounded neutral (MGN). The resistance value displayed on the tester will also include loose or poorly landed terminations that may have degraded over time.

Additionally, the clamp-on ground tester can be used as a True RMS ammeter.

Pedestal Grounds

All cable sheaths are bonded to a ground bar inside each pedestal.
This ground bar is connected to earth by means of a driven ground rod.
The ground rod resistance can be found by using the instrument clamped around the ground rod or the No. 6 cable connecting these two points. (Figure 33)

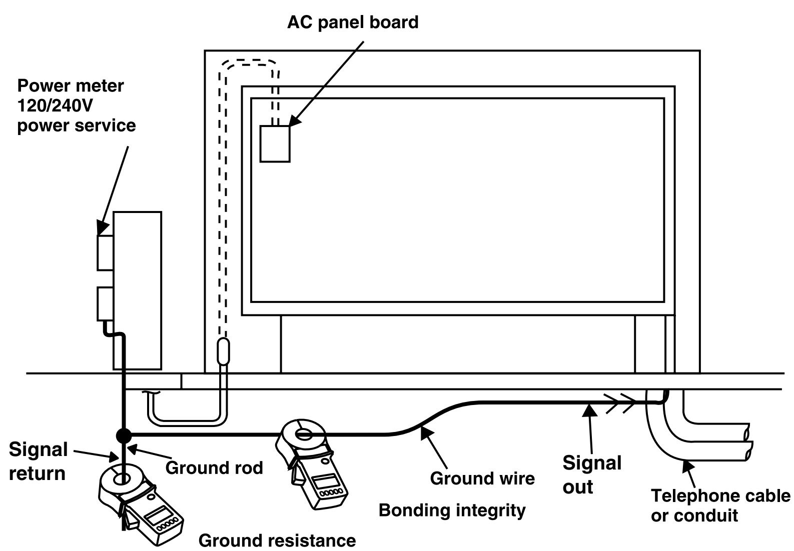


Figure 33

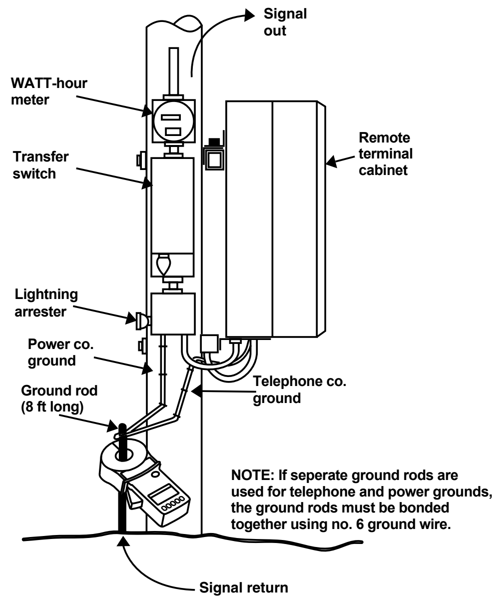


Figure 34

Cable Shield Bonds to MGN

The cable shields in a buried or above ground telephone enclosure may be grounded by means of the power company's multigrounded neutral. The clamp-on ground tester can be utilized to ensure that this connection has been successfully terminated. The low resistance return path for the instrument to make this measurement will be from this bond wire under test to the MGN back through all other bonds up and/or down stream (theory of parallel resistance).

The clamp-on ground tester also is a True RMS ammeter.

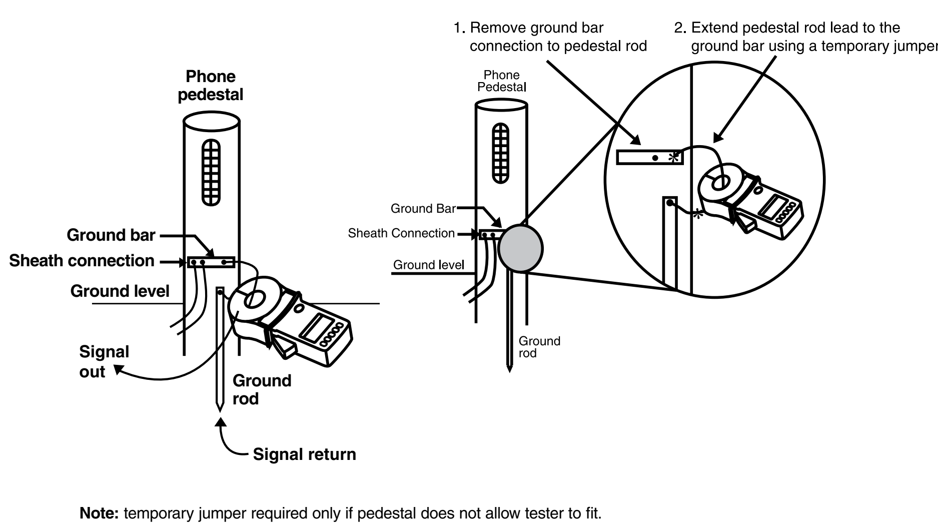


Figure 35

References

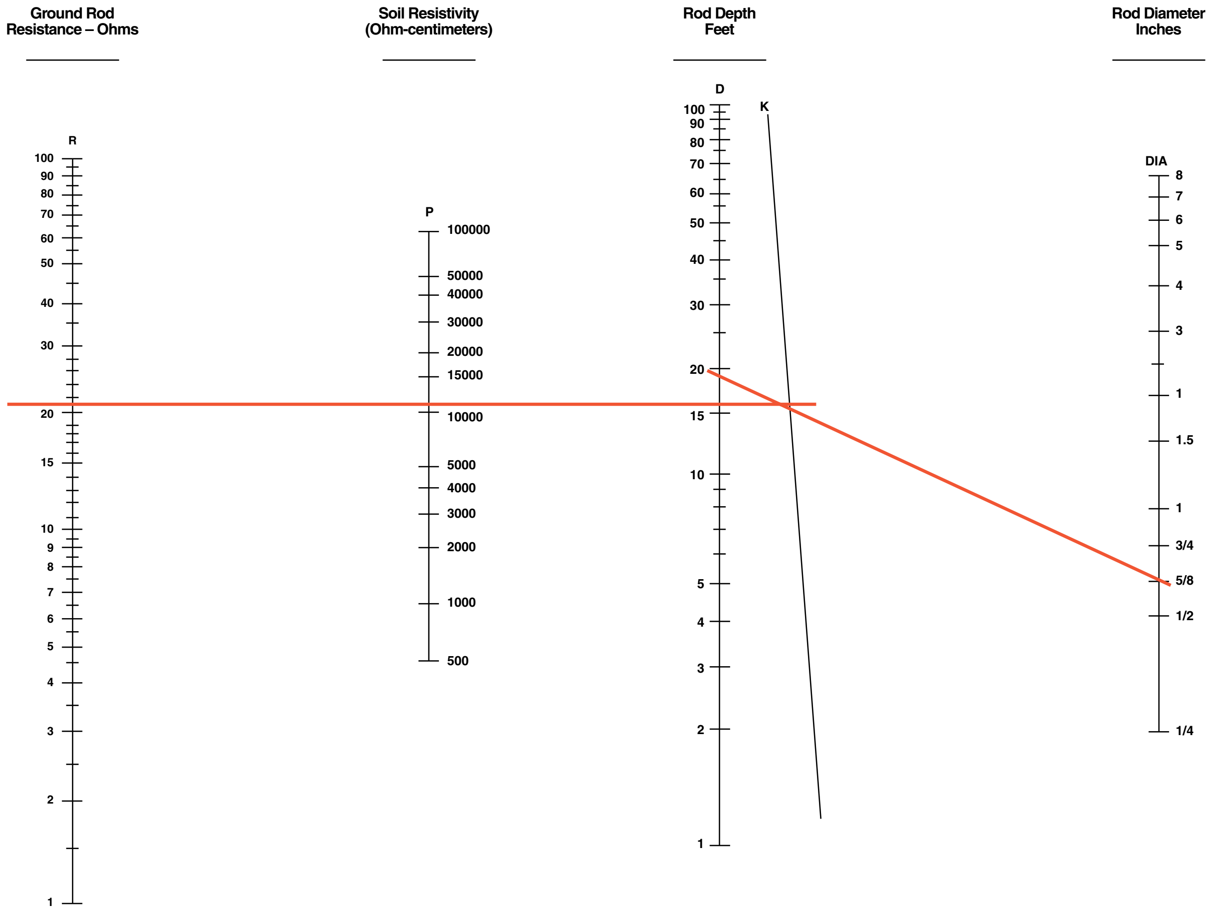
IEEE Std 81-1983
— *EEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of Ground Systems*

IEEE Std 142-1991
— *IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems*

Blackburn/American Electric Co.
Memphis, TN 38119
— *A Modern Approach to Grounding Systems*

NEC 2008
— NFPA

Grounding Nomograph



Represents example of a 20Ω, 20 ft ground rod

1. Select required resistance on R scale
2. Select apparent resistivity on P scale
3. Lay straightedge on R and P scale, and allow to intersect with K scale
4. Mark K scale point
5. Lay straightedge on K scale point and DIA scale, and allow to intersect with D scale
6. Point on D scale will be the rod depth required for resistance on R scale

Fall-of-Potential Plot

Instrument Mfr. ____________

Model ____________

Serial # ____________

Name of Operator ____________________________

Location ____________________ Date ____________

Ground System Type: Single Rod ☐ Rod Depth ____________ ft

Multiple Rods (Grid) ☐ Longest Diagonal Dimension ________ ft

Z Electrode Distance ____________________________ ft

	Voltage Electrode (Y) distance from Ground Rod under Test (X)	Measured Resistance
%	FEET	OHMS
100	______	______
90	______	______
80	______	______
72	______	______
70	______	______
62	______	______
60	______	______
52	______	______
50	______	______
40	______	______
30	______	______
20	______	______
10	______	______
0	______	______

Resistance Scale: ☐ 50 ☐ 100

Multiplier: ☐ x1 ☐ x10

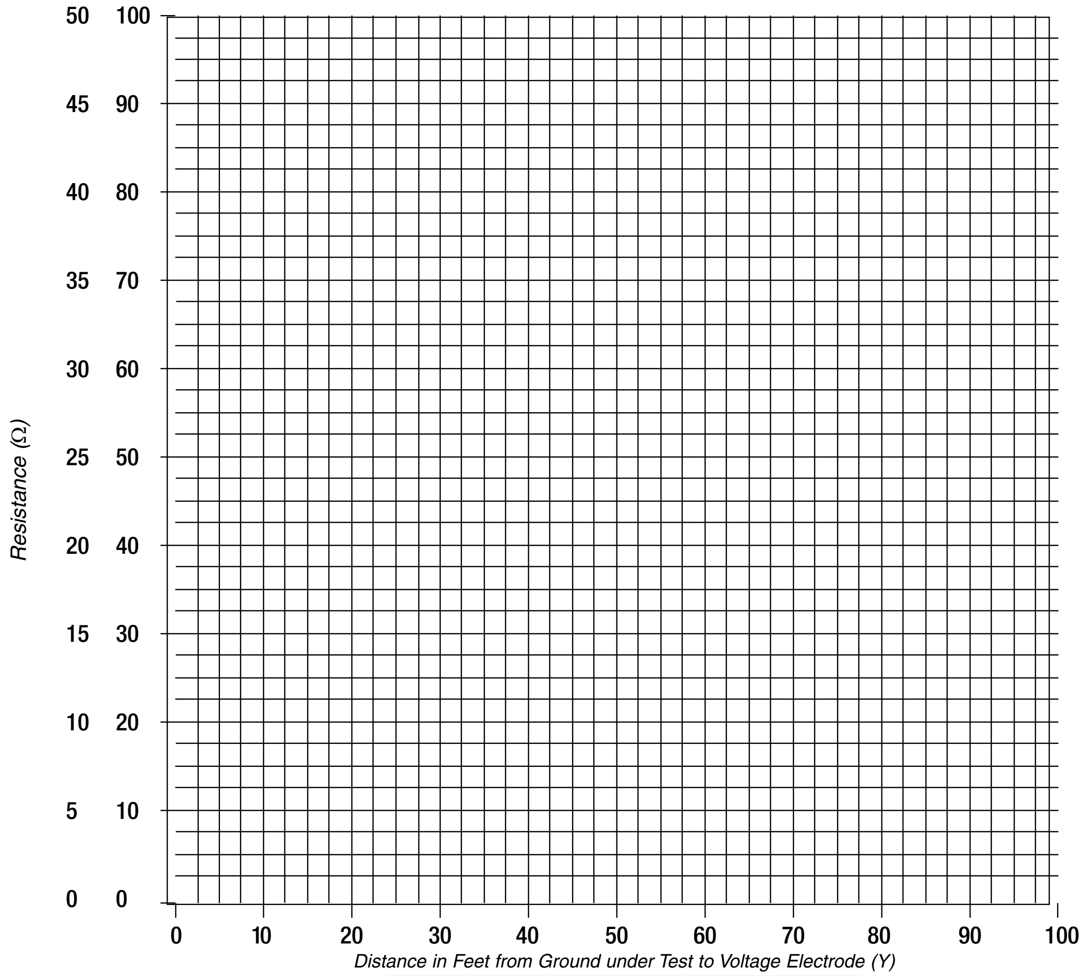
Test Conditions

Temp: __________ Soil: ☐ Moist ☐ Dry

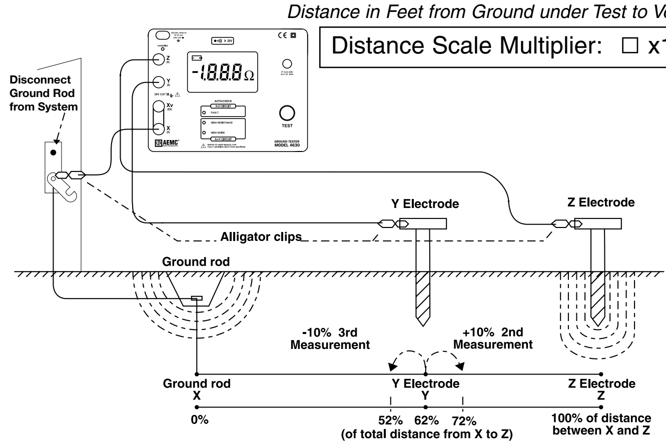
Soil Type

☐ Loam ☐ Sand & Gravel ☐ Shale ☐ Clay ☐ Limestone

☐ Sandstone ☐ Granite ☐ Slate ☐ Other ____________



Distance Scale Multiplier: ☐ x1 ☐ x10



AEMC® INSTRUMENTS

Multi-Function Ground Resistance Tester Model 6472

NEW!

Model 6472

SPECIFICATIONS	
MODEL	**6472**
ELECTRICAL	
3-Point Measurement	
Range (Auto-Ranging)	0.09Ω to 99.9kΩ
Resolution	0.01Ω to 100Ω
Test Voltage	Nominal 16 or 32VRMS user selectable
Resistance Measurement Frequency	41 to 5078Hz user selectable or automatic selection
Test Current	Up to 250mA
Accuracy	±2% of Reading + 1ct @ 128Hz
Soil Resistivity 4-Point Measurement	
Test Method	Wenner or Schlumberger selectable with automatic calculation of test results in Ω-meters, Ω-cm or Ω-feet
Range (Auto-Ranging)	0.01 to 99.99kΩ; ρ Max: 999kΩm (display in kΩft is not possible)
Resolution	0.01 to 100Ω
Test Voltage	16 or 32V user selectable
Frequency	From 41 to 128Hz selectable
External Voltage Measurement	
Range (Auto-Ranging)	0.1 to 65.0VAC/DC – DC to 440Hz
Accuracy	±2% of Reading + 1cts
Resistance Measurement (Bond Testing)	
Measurement Type	2-Pole (with lead resistance compensation) or 4-Pole (Kelvin sensing) user selectable
Range (Auto-Ranging)	2-Pole 0.01Ω to 99.9kΩ; 4-Pole 0.001Ω to 99.99kΩ
Accuracy	±2% of Reading + 2cts
Test Voltage	16VDC (+, - or auto polarity)
Test Current	Up to 250mA max
Data Storage	
Memory Capacity	512 test results
Communication	Optically Isolated USB
Power Source	9.6V rechargeable battery pack
Recharging Source	110/220 50/60Hz external charger with 18VDC, 1.9A output or 12V vehicle power

Features

- 2- and 4-Wire Bond Resistance/Continuity Measurement (DC Resistance) with automatic polarity reversal
- 3-Point Fall-of-Potential measurement with manual or automatic frequency selection
- 4-Point soil resistivity measurement with automatic calculation of Rho (ρ) and user selection of the Wenner or Schlumberger test method
- 3-Point earth coupling measurement
- Measures Ground Resistance using the 2 clamp method (selective ground testing)
- Measures Ground Impedance at frequencies up to 5kHz to test lightning strike protection
- Manual and automatic frequency scan from 40 to 5078Hz for optimum test accuracy in electrically noisy environments
- Selectable test voltage of 16 or 32V up to 250mA of test current
- Auto-off power management
- Automatic recognition of all electrode connections and their resistance value
- Stores up to 512 complete test results
- Optically isolated USB communication
- Remote set up and operation of all measurements using DataView® software
- Automatic report generation including the fall of potential plot
- Rechargeable NiMH batteries from wall charger or vehicle power
- Rugged dustproof and rainproof field case
- Includes DataView® software for data storage, real-time display, analysis, report generation and system configuration

Description

The Model 6472 measures from 0.01 to 99.99kΩ and is auto-ranging, automatically seeking out the optimum measurement range, test frequency and test current.

Easy-to-use – Simply connect the leads, select test mode, press Start and read the results. Up to 512 test results can be stored in internal memory for recall to the display or downloaded to a PC via DataView® software.

The large LCD is easy-to-read and indicates ground electrode resistance, test voltage, current and frequency as well as individual electrode resistance, battery status and more.

The Model 6472 is Cat IV rated to 50V and is over voltage protected to more than 250VAC against accidental live connection to live circuits. The voltage is also displayed on screen. In the event of a system fault, the Model 6472 can withstand 250VAC.

Additional features of the Model 6472 include; manual and automatic test frequency selection from 40 to 5078Hz; user selectable 3 or 4-Pole Fall of Potential or 4-Pole Soil Resistivity test methods and user selectable 2-Wire or 4-Wire Bond Resistance test method.

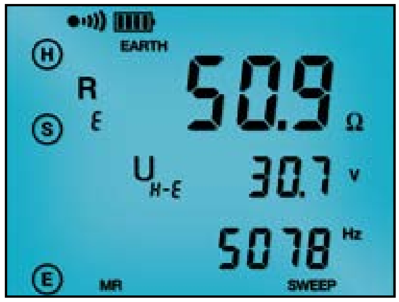
The Model 6472 is powered by 9.6V, 3.5 Ah NiMH rechargeable batteries. An external recharger powered from 120/230V, 50/60Hz is included and provides for testing while recharging. The Model 6472 can also be vehicle powered from an optional 12V battery adapter. (Cat. #2135.42)

Large Display!

4-Point Bond Test

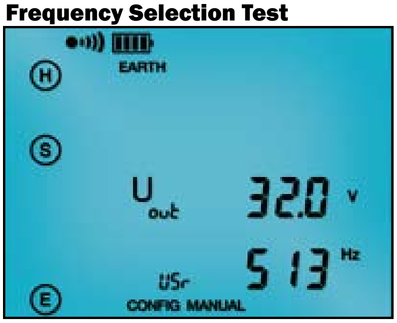
The 4-Point Bond test displaying lead connections, bond resistance test results, test voltage and current.

3-Point Fall-of-Potential Test



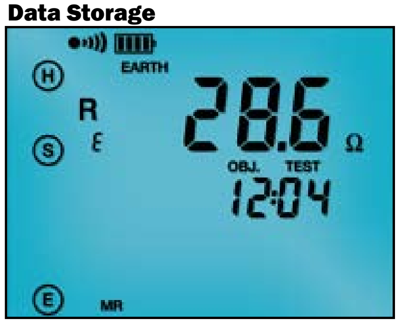
The 3-Point Fall-of-Potential test displaying test lead connection, grounding electrode resistance, test voltage and frequency.

Frequency Selection Test



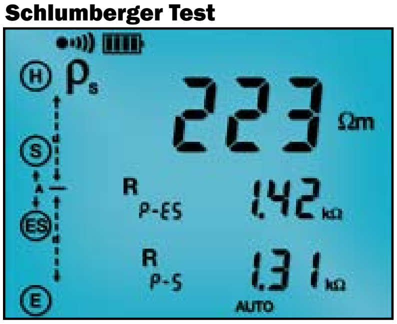
The Frequency selection screen displays selected test frequency and voltage for the test as well as lead connection.

Data Storage



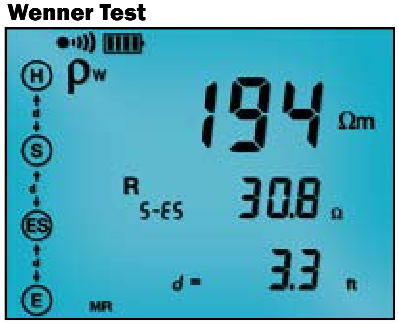
Memory Recall displays test results stored at a specific memory location.

Schlumberger Test



The Schlumberger test displays test lead connection, soil resistivity (ρ) test results, test electrode resistance and more.

Wenner Test



The Wenner test displays test lead connection, soil resistivity (ρ) test results, electrode spacing and resistance.

NOTE: More information for each test is available by scrolling through the displays.

Current Probe accessory options

(For use in two probe and selective ground testing methods)

AC Current Probe
Model MN82
Catalog #2135.71

AC Current Probe
Model SR182
Catalog #2135.72

DataView® Software for Model 6472

DataView® is included with the Model 6472.

- Configure all functions and parameters from your PC
- Display and analyze real-time data on your PC
- Customize views, templates and reports to your exact needs
- Create and store a complete library of configurations that can be uploaded to the Model 6472 as needed
- Zoom in and out and pan through sections of the graph to analyze the data
- Download, display and analyze recorded data
- Print reports using standard or custom templates you design

Includes meter, rechargeable NiMH batteries, optical USB cable, power adapter 110/240V with power cord 115V US, two 500 ft color-coded leads on spools (red/blue), two 100 ft color-coded leads (hand-tied, green/black), one 30 ft lead (green), four T-shaped auxiliary ground electrodes, set of five spaded lugs, one 100 ft AEMC® tape measure, DataView® software, ground tester workbook CD, carrying bag for meter, carrying bag for kit, product warranty and registration card and a user manual.
Catalog #2135.54

CATALOG NO.	DESCRIPTION	PRICE	NIST CALIBRATION
2135.51	Ground Resistance Tester Model 6472 (2-Point, 3-Point, 4-Point, Bond Test, Digital, Rechargeable Battery, DataView® software)	$3,795.00	$94.00
2135.52	Ground Resistance Tester Model 6472 Kit – 150 ft (Model 6472 and Catalog #2135.35)	$4,195.00	$99.00
2135.53	Ground Resistance Tester Model 6472 Kit – 300 ft (Model 6472 and Catalog #2135.36)	$4,295.00	$99.00
2135.54	Ground Resistance Tester Model 6472 Kit – 500 ft (Model 6472 and Catalog #2135.37)	$4,395.00	$99.00
Accessories (Optional)	**Reference to page 21 for Model 6472 Kits Catalog #2135.35, #2135.36 & #2135.37**		
2135.71*	AC Current Probe Model MN82 for use with Model 6472	$ 299.00	–
2135.72*	AC Current Probe Model SR182 for use with Model 6472	$ 369.00	–

**2 probes required for two clamp testing method.*

Multi-Function Ground Resistance Tester Model 6470

Measure ground resistance, soil resistivity and bonding resistance with one instrument!

Model 6470

Features

- 3- and 4-Point measurement with manual or automatic frequency selection (even during measurement) from 40 up to 500Hz
- Automatic calculation of Soil Resistivity Ωcm
- Selectable test voltage of 16 or 32V with up to 250mA
- Automatic frequency scan for optimum test frequency in noisy environments
- Automatic measurement of auxiliary electrodes resistance
- Soil resistivity measurement using Wenner or Schlumberger test method
- 2- and 4-Point DC resistance measurement with automatic polarity change (Bonding test function)
- Auto-off power management
- Automatic recognition of all electrode connections and their resistance value
- Memory stores up to 512 test results
- USB communication
- Remote operation of all measurement functions using DataView® software
- Automatic report generation through computer or serial printer
- Rechargeable NiMH battery pack
- Rugged dustproof and rainproof field case - IP54 in closed position
- IEC 61557 part 4 and part 5 compliance
- Includes DataView® software for data storage, real-time display, analysis report generation and system configuration

SPECIFICATIONS

MODEL	6470
ELECTRICAL	
3-Point Measurement	
Range (Auto-Ranging)	0.01 to 99.99kΩ
Resolution	0.01 to 100Ω
Test Voltage	16 or 32V selectable
Resistance Measurement Frequency	40 to 513Hz selectable or automatic selection
Test Current	Up to 250mA
Accuracy	±2% of Reading + 1ct
Soil Resistivity 4-Point Measurement	
Test Method	Wenner or Schlumberger selectable with automatic calculation of test results displayed in Ω-meters or Ω-feet
Range (Auto-Ranging)	0.01 to 99.99kΩ
Resolution	0.01 to 100Ω
Test Voltage	16 or 32V selectable
Frequency	73, 91.5, 101, 110 or 128Hz selectable
External Voltage Measurement	
Range (Auto-Ranging)	0.1 to 65.0VAC/DC – DC to 450Hz
Accuracy	2% of Reading + 2cts
Resistance Measurement (Bond Testing)	
Measurement Type	2-Point or 4-Point user selectable
Range (Auto-Ranging)	2-Point 0.01 to 99.9kΩ; 4-Point 0.001 to 99.99kΩ
Accuracy	±2% of Reading + 2cts
Test Voltage	16VDC
Test Current	200mA max
Data Storage	
Memory Capacity	512 test results
Communication	Optically isolated USB
Power Source	9.6V NiMH rechargeable battery pack
Recharging Source	110/120 50/60Hz external charge with 18VDC, 1.9A output or 12VDC vehicle power

Model 6470 includes meter, NiMH batteries, optical USB cable, DataView® software, external battery charger, power cord 110/240V (line) and user manual.

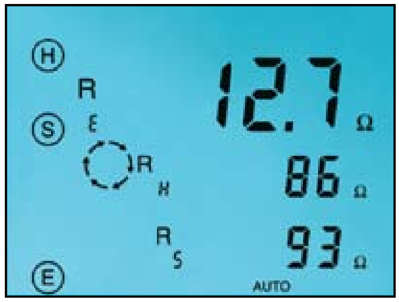
AEMC® INSTRUMENTS

Large Display!

4-Point Bond Test

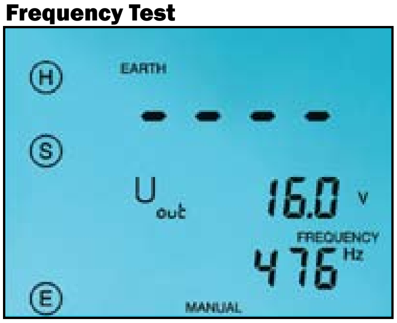
The 4-Point Bond test shows lead connections, bond resistance test results, test voltage and current.

3-Point Fall-of-Potential Test



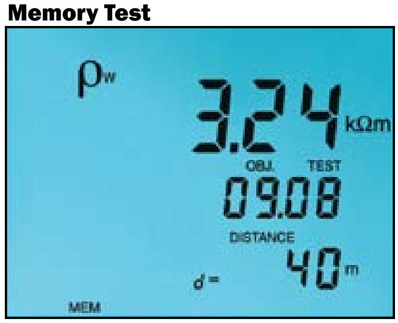
The 3-Point Fall-of-Potential test displays test lead connection, grounding rod resistance and test electrode resistances.

Frequency Test



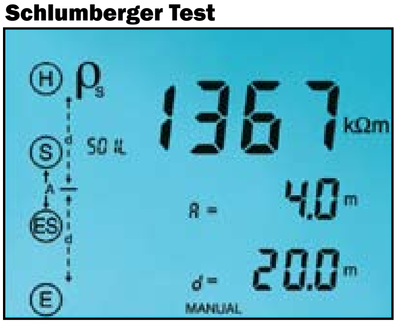
The Frequency selection screen displays selected test frequency and voltage for the test as well as lead connection.

Memory Test



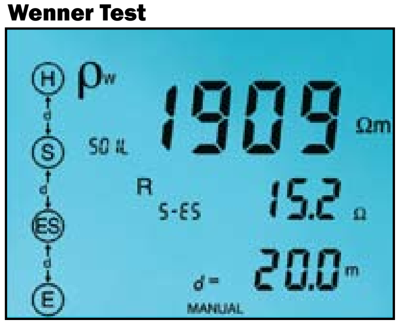
Displays test results stored at a specific memory location as well as the test function.

Schlumberger Test



The Schlumberger test displays test lead connection, soil resistivity (ρ) test results and electrode spacing.

Wenner Test



The Wenner test displays test lead connection, soil resistivity (ρ) test results, electrode spacing and resistance.

DataView® Software for Model 6470

DataView® is included with the Model 6470.

- Configure all functions and parameters from your PC
- Display and analyze real-time data on your PC
- Customize views, templates and reports to your exact needs
- Create and store a complete library of configurations that can be uploaded to the Model 6470 as needed
- Zoom in and out and pan through sections of the graph to analyze the data
- Download, display and analyze recorded data
- Print reports using standard or custom templates you design

AUTOMATIC REPORT GENERATION

Multi-Function Ground Resistance Tester Model 6470 Kit (500 ft) includes meter, NiMH batteries, optical USB cable, DataView® software, external battery charger, power cord 110/240V (line), one 30 ft green wire, one each 500 ft red and blue wire, one each 100 ft black and green wire, set of five spaded lugs, four auxiliary ground electrodes, tape measure, carrying case and user manual. Catalog #2135.04

CATALOG NO.	DESCRIPTION	PRICE	NIST CALIBRATION
2135.01	Ground Resistance Tester Model 6470 (2-Point, 3-Point, 4-Point, Bond Test, Digital, Rechargeable Battery, DataView® software)	$2,250.00	$94.00
2135.02	Ground Resistance Tester Model 6470 Kit – 150 ft (Model 6470 and Catalog #2135.35)	$2,649.00	$99.00
2135.03	Ground Resistance Tester Model 6470 Kit – 300 ft (Model 6470 and Catalog #2135.36)	$2,749.00	$99.00
2135.04	Ground Resistance Tester Model 6470 Kit – 500 ft (Model 6470 and Catalog #2135.37)	$2,849.00	$99.00
Accessories (Optional)			
2135.35	Test Kit for 3-Point testing (includes two 150 ft color-coded leads on spools (red/blue), one 30 ft lead (green), two 14.5" T-shaped auxiliary ground electrodes, set of five spaded lugs, 100 ft tape measure and soft carrying bag)	$ 449.00	–
2135.36	Test Kit for 4-Point testing (includes two 300 ft color-coded leads on spools (red/blue), two 100 ft color-coded leads (hand-tied green/black), four 14.5" T-shaped auxiliary ground electrodes, set of five spaded lugs, 100 ft tape measure and soft carrying bag)	$ 549.00	–
2135.37	Test Kit for 4-Point testing (includes two 500 ft color-coded leads on spools (red/blue), two 100 ft color-coded leads (hand-tied green/black), one 30 ft lead (green), four 14.5" T-shaped auxiliary ground electrodes, set of five spaded lugs, 100 ft tape measure and soft carrying bag)	$ 649.00	–
2135.38	Ground Test Kit for 3-Point testing (Supplemental for 4-Point testing – includes two 100 ft color-coded leads (hand-tied green/black), one 30 ft lead (green), two 14.5" T-shaped auxiliary ground electrodes and soft carrying bag)	$ 249.00	–

Ground Resistance Tester Models 4620 & 4630

Model 4630

Features

- Measures soil resistivity (4-Point)
- Measures ground resistance (2- and 3-Point) Fall-of-Potential method
- Step voltage tests and touch potential measurements
- Auto-Ranging: automatically selects the optimum resistance range and test current
- Designed to reject high levels of noise and interference
- Extremely simple to operate: connect - press - read
- LED on faceplate informs operator of high input noise, high auxiliary rod resistance and fault connections
- Large easy-to-read backlit display
- Battery powered (Model 4620)
- AC powered with rechargeable NiMH battery pack (Model 4630)
- Rugged dustproof and rainproof field case
- Can also be used for continuity tests on bonding
- Color-coded terminals

Test Kit for 3-Point testing includes two 150 ft color-coded leads on spools (red and blue), one 30 ft lead (green), two 14.5" T-shaped auxiliary ground electrodes, one set of five spaded lugs, 100 ft tape measurer and carrying bag.
Catalog #2135.35

Test Kit for 4-Point testing includes two 300 ft color-coded leads on spools (red and blue), two 100 ft color-coded leads (green and black), four 14.5" T-shaped auxiliary ground electrodes, one set of five spaded lugs, 100 ft tape measurer and carrying bag.
Catalog #2135.36

Test Kit for 4-Point testing includes two 500 ft color-coded leads on spools (red and blue), two 100 ft color-coded leads (green and black), one 30 ft lead (green), four 14.5" T-shaped auxiliary ground electrodes, one set of five spaded lugs, 100 ft tape measurer and carrying bag. Catalog #2135.37

See page 23 for Ground Testing kit images.

SPECIFICATIONS

MODELS	4620		4630
ELECTRICAL			
Range	20Ω	200Ω	2000Ω
Measurement Range	0.00 to 19.99Ω	20.0 to 199.9Ω	200 to 1999Ω
Resolution	10mΩ	100mΩ	1Ω
Open Voltage	≤42V peak	≤42V peak	≤42V peak
Resistance Measurement Frequency	128Hz square wave	128Hz square wave	128Hz square wave
Test Current	10mA	1mA	0.1mA
Accuracy	±2% of Reading ± 1ct	±2% of Reading ± 1ct	±2% of Reading ± 3ct
Auxiliary Electrode Influence Max Res. in Current Circuit Max Res. in Voltage Circuit	 3kΩ 50kΩ	 30kΩ 50kΩ	 50kΩ 50kΩ
Response Time	Approximately four to eight seconds for a stabilized measurement		
Withstanding Voltage	250VAC or 100VDC		
Power Source	Eight C cell batteries; Alkaline recommended		120/230V 50/60Hz Rechargeable 9.6V, 3.5 Ah NiMH battery pack
Battery Life	>2000 15-second measurements; LO BAT indication on LCD		
Fuse Protection	0.1A, >250V, 0.25 x 1.25"; 30kA Interrupt Capacity		

CATALOG NO.	DESCRIPTION	PRICE	NIST CALIBRATION
2130.43	Ground Resistance Tester Model 4620 (Digital, 4-Point, Battery Powered)	$1,265.00	$ 94.00
2130.44	Ground Resistance Tester Model 4630 (Digital, 4-Point, Rechargeable Battery)	$1,795.00	$ 94.00
2135.19	Ground Resistance Tester Model 4620 Kit – 150 ft (Model 4620 and Catalog #2135.35)	$1,669.00	$105.00
2135.20	Ground Resistance Tester Model 4620 Kit – 300 ft (Model 4620 and Catalog #2135.36)	$1,769.00	$105.00
2135.21	Ground Resistance Tester Model 4620 Kit – 500 ft (Model 4620 and Catalog #2135.37)	$1,869.00	$105.00
2135.22	Ground Resistance Tester Model 4630 Kit – 150 ft (Model 4630 and Catalog #2135.35)	$2,199.00	$105.00
2135.23	Ground Resistance Tester Model 4630 Kit – 300 ft (Model 4630 and Catalog #2135.36)	$2,299.00	$105.00
2135.24	Ground Resistance Tester Model 4630 Kit – 500 ft (Model 4630 and Catalog #2135.37)	$2,399.00	$105.00
Accessories (Optional)			
2130.60	Tape Measure (100 ft)	$ 34.95	–
2135.35	Test Kit for 3-Point testing – 150 ft (see descriptions above for details)	$ 449.00	–
2135.36	Test Kit for 4-Point testing – 300 ft (see descriptions above for details)	$ 549.00	–
2135.37	Test Kit for 4-Point testing – 500 ft (see descriptions above for details)	$ 649.00	–
2135.38	Ground Test Kit for 3-Point testing (Supplemental for 4-Point testing – includes two 100 ft color-coded leads, one 30 ft lead (green), two 14.5" T-shaped auxiliary ground electrodes and soft carrying bag) (see descriptions above)	$ 249.00	–
2130.59	Calibration checker – 25Ω for Models 3620, 3640, 4500, 4610, 4620 and 4630	$ 54.95	–

Ground Resistance Tester Models 3620, 3640 & 4610

Features

- Measures soil resistivity (4-Point) (Model 4610)
- Measures ground resistance (2- and 3-Point) Fall-of-Potential method
- Large analog display (Model 3620)
- Large LCD digital display (Models 3640 and 4610)
- Designed to reject high levels of noise and interference
- Auto-Ranging: automatically selects the optimum range (Models 3640 and 4610)
- Battery powered
- Extremely simple to operate: connect - press- read
- Error indicator lights
- Rugged dustproof and rainproof case
- Color-coded terminals and lead identification

Model 4610

All individual units include soft carrying case and user manual.

See page 22 for Ground Testing kit descriptions.

Catalog #2135.35

Catalog #2135.36

Catalog #2135.37

SPECIFICATIONS

MODELS	3620	3640		4610
Types of Measurements	2- and 3-Point	2- and 3-Point		2-, 3-, and 4-Point
Display	Analog	Digital		Digital
Soil Resistivity Test	No	No		Yes
Measurement Ranges	0.5 to 1000Ω	20Ω: 0.00 to 19.99Ω	200Ω: 20.0 to 199Ω	2000Ω: 200 to 1999Ω
Resolution	–	10mΩ	100mΩ	1Ω
Test Current	10mA	10mA	1mA	0.1mA
Open Voltage	≤24V peak	≤42V peak		
Operating Frequency	128Hz square wave			
Accuracy	±5% of Reading + 0.1% scale length	±2% of Reading ± 1ct		±3% of Reading ± 3cts
Interference	All models reject high levels of interference voltage (DC, 50 to 60Hz, harmonics)			
Power Source	Eight 1.5V AA batteries			
Battery Life	Approx. 1680 15-second measurements	Approx. 1800 15-second measurements		
Low Battery Indication	Yes			
Fuse Protection	High breaking capacity, 0.1A, >250V			

CATALOG NO.	DESCRIPTION	PRICE	NIST CALIBRATION
2114.90	Ground Resistance Tester Model 3620 (Analog, 3-Point)	$ 759.00	$ 94.00
2114.92	Ground Resistance Tester Model 3640 (Digital, 3-Point)	$ 795.00	$ 94.00
2114.94	Ground Resistance Tester Model 4610 (Digital, 4-Point)	$1,045.00	$ 94.00
2135.10	Ground Resistance Tester Model 3620 Kit – 150 ft (Model 3620 and Catalog #2135.35)	$1,159.00	$105.00
2135.11	Ground Resistance Tester Model 3620 Kit – 300 ft (Model 3620 and Catalog #2135.36)	$1,259.00	$105.00
2135.12	Ground Resistance Tester Model 3620 Kit – 500 ft (Model 3620 and Catalog #2135.37)	$1,359.00	$105.00
2135.13	Ground Resistance Tester Model 3640 Kit – 150 ft (Model 3640 and Catalog #2135.35)	$1,175.00	$105.00
2135.14	Ground Resistance Tester Model 3640 Kit – 300 ft (Model 3640 and Catalog #2135.36)	$1,275.00	$105.00
2135.15	Ground Resistance Tester Model 3640 Kit – 500 ft (Model 3640 and Catalog #2135.37)	$1,375.00	$105.00
2135.16	Ground Resistance Tester Model 4610 Kit – 150 ft (Model 4610 and Catalog #2135.35)	$1,449.00	$105.00
2135.17	Ground Resistance Tester Model 4610 Kit – 300 ft (Model 4610 and Catalog #2135.36)	$1,549.00	$105.00
2135.18	Ground Resistance Tester Model 4610 Kit – 500 ft (Model 4610 and Catalog #2135.37)	$1,649.00	$105.00
2130.59	Calibration checker – 25Ω for Models 3620, 3640, 4500, 4610, 4620 and 4630	$ 54.95	–

Clamp-On Ground Resistance Tester Models 3711 & 3731

Model 3731
US Patent No. 362,639

Features

- Simple and fast clamp-on operation - no leads, no auxiliary rods or spacing requirements
- Direct reading of ground resistance from 0.1 to 1200Ω
- Direct reading of continuity and ground loop resistance
- Direct reading of ground leakage or phase current from 1mA to 30Arms
- Jaw design with large 1.25" (32mm) window - accommodates up to 1000kcmil cables
- Auto-Off for power management
- Alarm function with adjustable set point and buzzer for quick field checks (Model 3731)
- Memory function to store 99 field measurements for later retrieval and analysis (Model 3731)
- Rugged Lexan® head and body construction resists breakage
- Alarm settings and stored memory information saved during shutdown (Model 3731)
- Designed to EN 61010-1, Cat. III safety standards
- Patented design

SPECIFICATIONS

MODELS	3711 & 3731		
ELECTRICAL			
Ground Resistance	**Measurement Range**	**Resolution**	**Accuracy (% of Reading)**
	0.1 to 1.0Ω	0.01Ω	±(2% ± 0.02Ω)
	1.0 to 50.00Ω	0.1Ω	±(1.5% ± 0.1Ω)
Auto-Ranging 0.01 to 1200Ω	50.0 to 100.0Ω	0.5Ω	±(2.0% ± 0.5Ω)
	100 to 200Ω	1Ω	±(3.0% ± 1Ω)
	200 to 400Ω	5Ω	±(6% ± 5Ω)
	400 to 600Ω	10Ω	±(10% ± 10Ω)
	600 to 1200Ω	50Ω	25% of Reading ±50Ω
Current Measurement	1 to 299mA	1mA	±(2.5% + 2mA)
Auto-Ranging	0.300 to 2.999A	0.001A	±(2.5% + 2mA)
1mA to 30.00Arms	3.00 to 29.99A	0.01A	±(2.5% + 20mA)
Resistance Measurement Frequency	2403Hz		
Current Measurement Frequency	47 to 800Hz		
Current Overload	OL displayed above 29.99Arms		
Power Source	9V Alkaline battery; Battery life: Eight hours or approximately 1000 measurements of 30 seconds		

FEATURES & FUNCTIONS

MODELS	3711	3731
Ohms Range	✓	✓
Arms Range	✓	✓
Hold Function	✓	✓
Self Test	✓	✓
Auto-Off	✓	✓
Battery Life Indicator	✓	✓
Noise Indicator	✓	✓
Open Jaw Indicator	✓	✓
Closed Loop Indicator	✓	✓
Multi-Tone Beeper	✓	✓
Alarm Function	–	✓
Memory (Logging)	–	✓

Models 3711 and 3731 include calibration loop, battery, hard carrying case and user manual.

CATALOG NO.	DESCRIPTION	PRICE	NIST CALIBRATION
2117.60	Ground Resistance Tester Model 3711 (Clamp-On)	$1,545.00	$ 98.00
2117.61	Ground Resistance Tester Model 3731 (Clamp-On with memory and alarm)	$1,745.00	$ 98.00

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