1621 Earth Ground Tester

Addendum to Users Manual

Earth Ground Resistance

Earth ground resistance consists of:

- resistance of the connecting lead to the earth ground electrode
- resistance of the earth ground electrode, earthing rod, earthing plate, earthing strip, mesh earth electrode, and similar
- dissipation resistance (the resistance between the earth ground electrode and soil potential)

The resistances of the connecting lead and earth ground electrode are negligible (after correct dimensioning), so the earth ground resistance consists primarily of the dissipation resistance.

To determine the exact earth ground conditions, an accurate measurement of the dissipation resistance is required. Because dissipation resistance is dependent on soil resistivity and the shape of the earth ground electrode, a metrological check must be made even if the position of the earth ground electrode and the condition of the soil are known.

When redesigning an earth ground system (for example, for lightning protection), the resistance can be calculated using Table 1. As a basis for this calculation, the soil resistivity of the location where the earth ground electrode is to be installed must be known. See “Soil Resistivity.”

Table 1. Earth Ground Resistance Calculation

Soil Type	Soil Resistivity (ρE)	Earth Ground Resistance Ω					
		Earth Ground Rod Depth in meters [1]			Earth Ground Strip Length in meters [1]		
	Ωm	3 m (9 ft)	6 m (20 ft)	10 m (33 ft)	5 m (16 ft)	10 m (33 ft)	20 m (66 ft)
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
Moist sandy soil	300	66	33	20	80	40	20
Dry sandy soil	1000	330	165	100	400	200	100
Concrete 1 : 5 [2]	400				160	80	40
Moist gravel	500	160	80	48	200	100	50
Dry gravel	1000	330	165	100	400	200	100
Stony gravel	30000	1000	500	300	1200	600	300
Rock	10^7	-	-	-	-	-	-

[1] All values in the table are in meters except where specifically noted

[2] For 1 : 7 concrete mixtures, increase value 24 %

Soil Resistivity

Soil resistivity (ρE) is the resistance measured between two opposing surfaces of a cube of soil, with a lateral length of 1 meter. Soil resistivity is measured in ohms-meters (Ωm). See Figure 1.

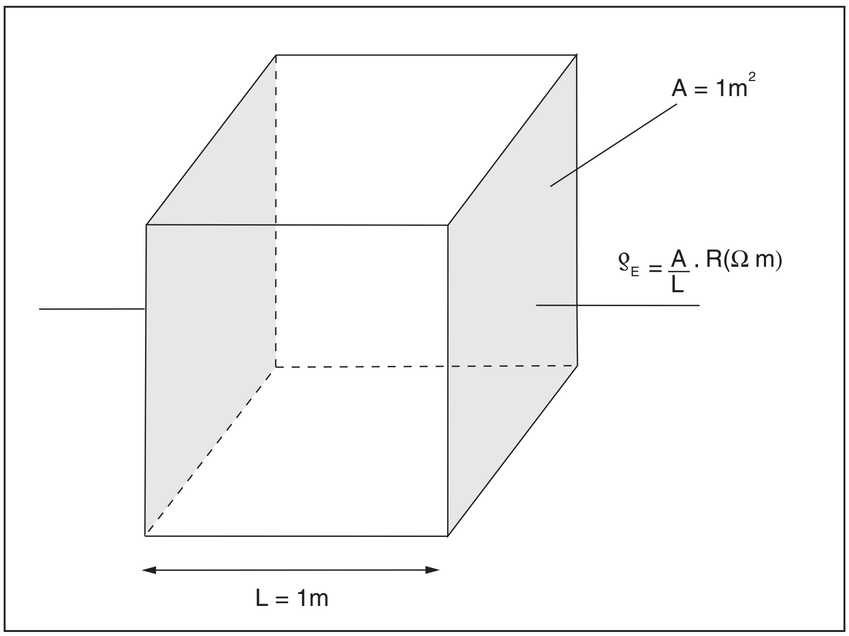

Figure 1. Soil Resistivity

Soil resistivity primarily depends on soil type (like farming soil, dry sand, moist sand, concrete, gravel), although seasonal changes can also influence resistivity. Dry soil has a higher resistivity than moist soil, and frozen ground has a higher resistivity than dry, warm sand. See Figure 2 for examples of how resistivity can change over the course of a year.

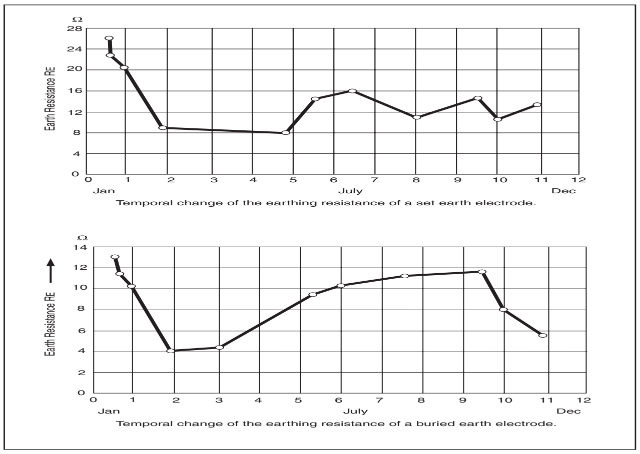

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Figure 2. Examples of Temporal Changes to Resistivity

Measuring Method

The current-voltage measuring method is demonstrated in Figure 3.

In Figure 3, ac generator G directs current I to earth ground electrode E (earth ground electrode resistance R_E) and auxiliary earth electrode H (auxiliary earth electrode resistance R_H).

Voltage U_E drops on earth ground resistance R_E (U_E proportional to R_E). This voltage is measured by probe S. With a 3-wire circuit, instrument sockets E and ES are connected to each other, so the voltage drop of the cable between socket E and the earth ground electrode is not measured. (In a 4-wire circuit, a separate cable connects socket ES to the earth ground electrode.) Because the voltage measuring circuit is high impedance, the influence of probe resistance R_S is negligible. Therefore, the earth ground resistance is calculated as:

$$R_E = U_{MEAS} / I$$

and is independent of the resistance of the auxiliary earth electrode R_H.

AC generator G runs at a frequency between 70 and 140 Hz. It must be within 5 Hz of one of the nominal frequencies of 16-2/3, 50 or 60 Hz and their harmonic waves. A frequency selective filter is inserted and adjusted to the generator frequency.

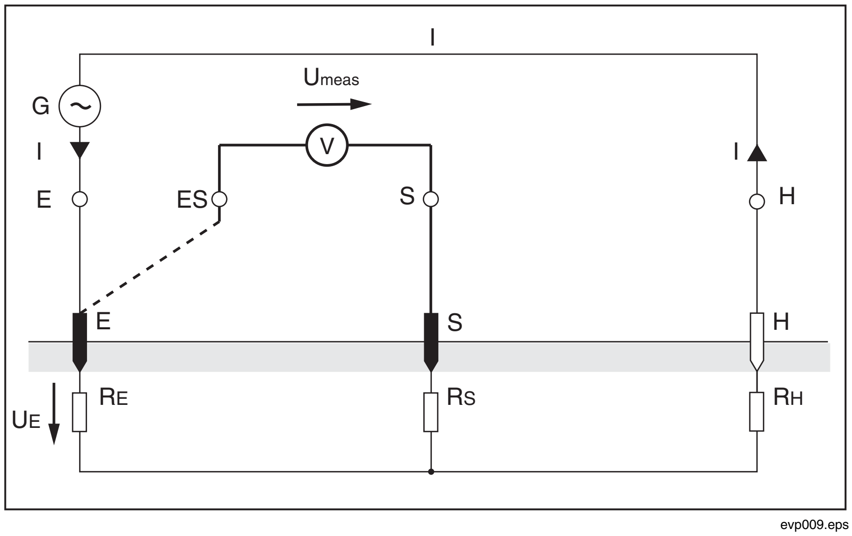

Figure 3. Current Voltage Measuring Method

Potential Gradient Area

When electric current flows through an earth ground electrode, the area around the electrode develops what is called the "potential gradient area." When selecting a location to insert the probe into the ground, you will need to determine the size of this potential gradient area because you must place the probe outside this area. Placing the probe inside the area will lead to inaccurate resistance measurements.

The size of the potential gradient area is determined by soil resistivity. Soils with high resistivity (bad conductivity) have larger diameters, typically 30 to 60 m (100 to 200 ft); soils with a low resistance (good conductivity) have comparatively small diameters, typically 10 to 15 m (33 to 50 ft).

As you increase the distance between the probe and earth ground electrode, the voltage measured between the earth ground electrode and probe decreases. When the probe is at a distance where the voltage no longer changes, the voltage has leveled to earth potential ΦE and the probe is outside the potential gradient area. See Figure 4.

Measuring the probe and auxiliary earth electrode resistances helps to determine the size of the potential gradient area. Because low resistances result in smaller potential gradient areas (and vice versa), you must take into account that soil with good conductivity (low resistance) results in a steep voltage shape, and therefore a higher step voltage. If necessary, check the potential of such systems.

To use the correct voltage drop from the earth ground resistance (the resistance between the earth ground electrode and the soil potential ΦE), ensure the probe is placed outside the potential gradient areas of the earth ground electrode and the auxiliary earth electrode. Further, it is advisable to repeat each measurement with repositioned probes, and only regard a measurement as successful and accurate if several subsequent measurements result in the same value.

A distance of 20 m (64 ft) between the earth ground electrode and auxiliary electrode, and a distance of 20 m (64 ft) between the auxiliary electrode and probe, is normally sufficient.

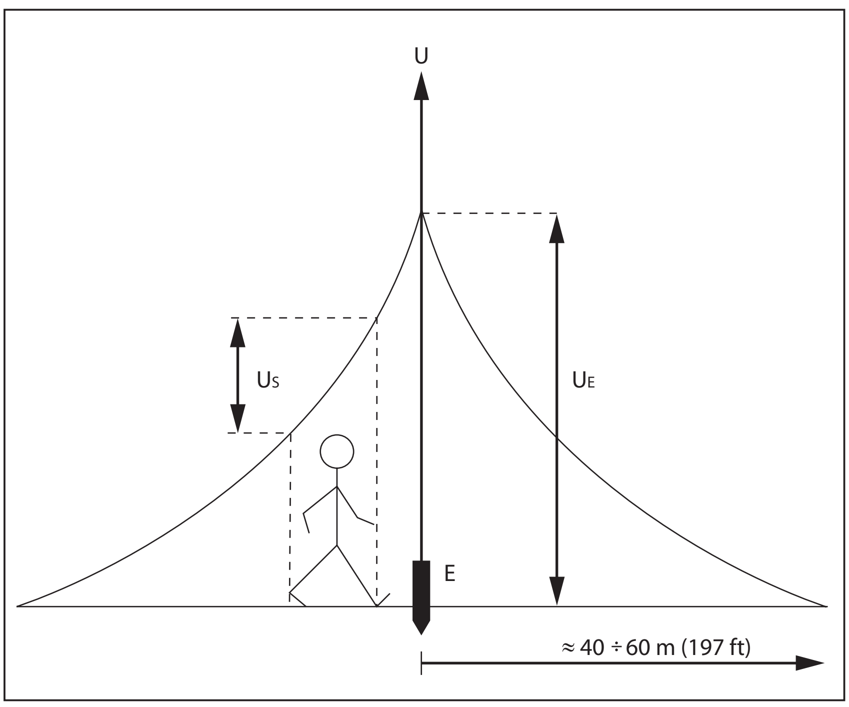

Figure 4. Potential Gradient Area

Demonstration of Potential Gradient Area's Influence on Measurements

This section demonstrates how placing a probe inside the potential gradient area of an earth ground electrode leads to incorrect measurements. As shown in Figure 5, probes S1, S2 and S4 are positioned inside the potential gradient area, and probe S3 is positioned outside the potential gradient area.

Probes S1 and S2 deliver voltages (US1 and US2) that are too low, which means the earth ground resistance is too low. Probe S4 delivers a voltage (US4) that is too high, which means the earth ground resistance is too high. Only probe S3 delivers an unaltered voltage (US3) between the earth ground electrode and soil potential ΦE.

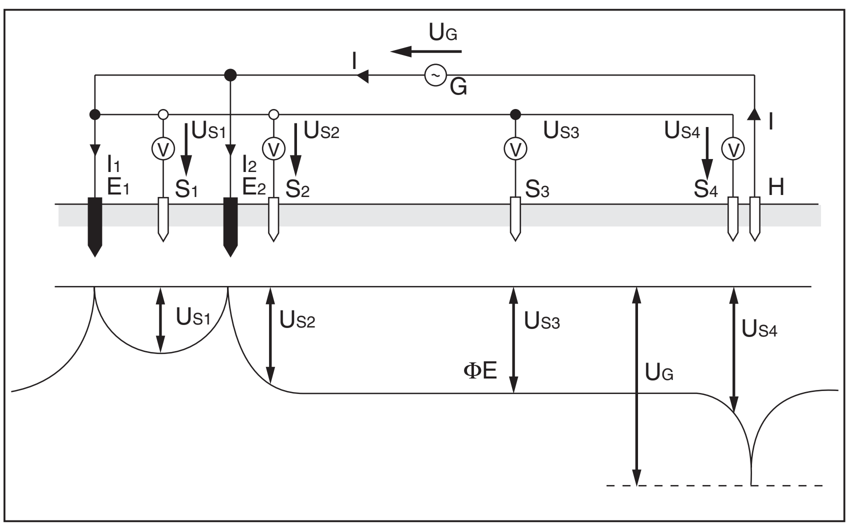

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Figure 5. Demonstration of Potential Gradient Area's Influence on Measurements