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# Earth Ground Measurements

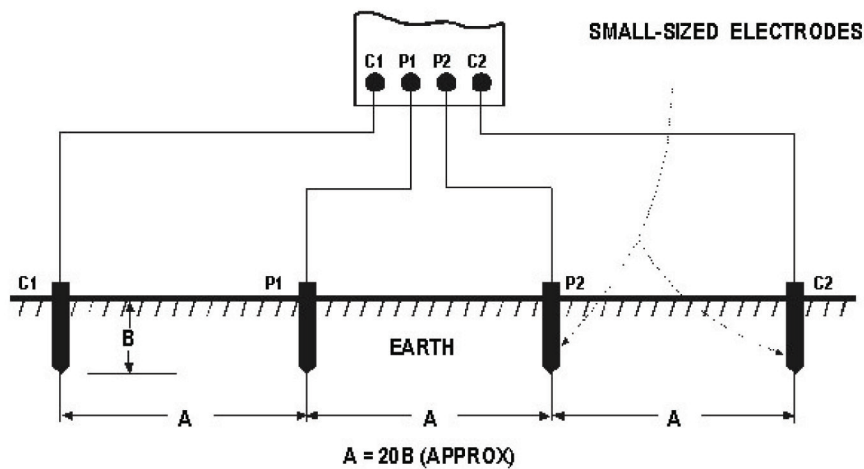
Technical Note

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## Earth Ground Measurements

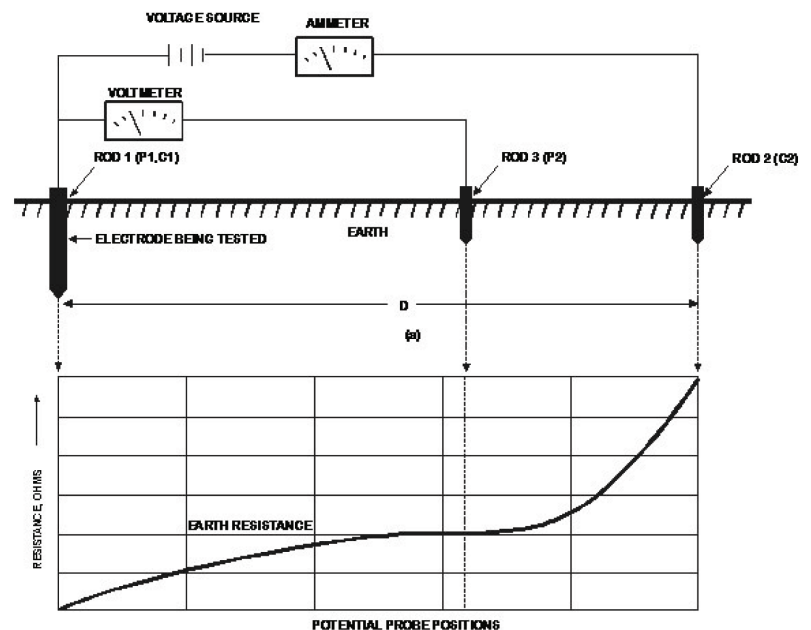
Any properly applied lightning protection device is only as effective as the ground system attached to it! Ground resistance (impedance) is usually measured using the 3-stake fall of potential method. Theoretically, the final measurement achieved on the completed ground system is the same resistance (impedance) to any other ground system on earth. A good ground system measurement would be between 5 and 10 Ohms. A well designed 5 Ohm ground system is usually considered optimal for a lightning ground system.

A 4-stake resistivity measurement should be done ahead of the actual ground system installation. This procedure tells the engineer which areas within the system's geographic confines have the most conductive soil and at what depth this occurs. The results will be expressed as resistance (in Ohms - cm/m) and will determine the ground system's final design.



After the ground system is designed and constructed using the 4-stake resistivity measurement results, its performance can be verified by using the 3-stake fall of potential measurement below.

The ground system's final 3 stake fall of potential ground resistance reading is the impedance of the system measured with approximately 100 to 300 Hz source potential. The obvious concern of this measurement is how well the ground system will handle electric utility ground faults. There must be enough current flow in to the earth to trip the applicable ac circuit breaker during a ground fault. Unfortunately, there is yet no way we can directly relate this 100 Hz measurement to the energy/frequency distribution range of a lightning event. Information gathered



by PolyPhaser Corporation indicates that a properly designed 5 ohm ground system is the low frequency impedance measurement representing an impedance at higher frequencies that usually works well for lightning.

There are additional ways to reduce the ground measurement at low frequencies. Additional buried conductive surface area and chemically treating the soil are possibilities. With very small sites, a chemical ground rod activated by rain water or a water drip system, attached to the end of a 1½ inch [33.1 mm] copper strap used as a radial from the tower base, is a good alternative. Two to four chemical ground rods and radials extending out from the tower base and connected to the fence line should reduce the low frequency ground measurement and enhance the lightning handling capabilities as well. The galvanized fence posts at small sites could be extended in length with added below ground section used as additional grounding surface area interconnected with the tower ground loop / chemical ground rod system. Connect all fence posts together with a below ground conductor. Some consideration need be given to the mixing of galvanized and copper grounding components. It is always “trade-off” between a lower resistance and better transient response vs. long term corrosion effects. However, consider the fence posts are there and are indirectly a part of the ground system already.

When a single long “ground well” is used in rock or poor conductivity top soil, the series inductance of the top section of pipe “chokes off” current flow to the more conductive lower section causing rapid local ground potential rise (GPR). Outbound currents from this higher potential can cause damage to circuitry bridging both potentials.

From a practical point of view, grounding specifications at ac power line frequencies must be met using the fall of potential method. But to be effective as a lightning ground, the ground system must also be designed for a rapid response in the RF range between 10-100 kHz. This usually means large surface area low inductance conductors connected to multiple ground radials with ground rods along their length.

Very high potential differences can occur from “point a to point b” on the same ground system due to the ground system/earth’s combined impedance at the strike’s higher frequencies (Ground Potential Rise - GPR).

## Recommended Ground System Layout

