

Engineer's Notebook

Large ground systems are important in protecting the electricity supply network. They ensure that fault current will enable protective devices to operate correctly. A system must have a low ground resistance to reduce the potentially dangerous, excessive voltages that develop during a fault.

In order to get a ground resistance that's low enough, large ground systems consist of many interconnected rods or of a large earth mat. Test techniques used on large systems to obtain valid readings are different from those used on a small single electrode (e.g., a residential ground), which is simple to test.

Fall of Potential Testing

For single-electrode grounds, current test spikes are fairly close (typically 30 to 60 ft) to the electrode under test. You can usually find a flat portion of the ground resistance curve that is close to the resistance of the electrode.

Testing several points or plotting a curve helps define the area around the electrode. You should always check the results by using a different direction or a longer distance to the test spikes. This helps eliminate errors caused by nearby buried conductors and other parts of the electrical system.

The Slope Method

The slope method lets you measure a large ground system without finding the flat portion of the characteristic curve. This can reduce the test distances, and the electrical center of the ground system is not required. Calculations are minimal, and you can easily check the result.

Take readings at 20%, 40%, and 60% to the current spike distance. The differences between these readings are used to fit to a model of the resistance characteristic. The coefficient of slope, is calculated from: $= (R_{60} - R_{40}) / (R_{40} - R_{20})$. Using a table of values vs. "actual distance" published in some user guides, you can retest this value to see if it fits the model.

Again, it is best to check the results by plotting the full characteristic and repeating the test using a different direction for the test spikes or a greater distance to the electrode.

Large Ground Systems

The physically large areas used by ground systems result in large "resistance areas" and great distances to the test spikes. This typically gives a ground resistance of less than 0.5Ω, allowing a good path for the large prospective fault current.

The distance to the electrode should be ten times the maximum dimension of the ground system. For one 6-ft electrode, this is not usually a problem, with a remote test spike at 60 ft. But it may be impractical for a substation with a 300-ft-square ground mat. A current electrode is required approximately 3,000 ft from the site. In cases like this, you can use a technique such as the slope method. This reduces the length of cable runs and is less likely to overlap with other local ground systems that might interfere with results.

Increase the Resolution

When measuring resistances of less than 1Ω in large ground systems, you need high-resolution readings for accurate measurements. A unit with 1 mΩ resolution—such as the MEGGER DET2/2—is appropriate. If you're using the fall of

Testing Large Ground Systems



potential or the slope method, small differences between low readings are significant. The extra digit of resolution makes these readings more accurate and compatible with standard reference tables.

Noise Interference

When induced noise is present, you need high noise-interference rejection to take readings, since a small signal has to be retrieved from a much larger total signal.

To remove the effect of noise, a frequency of 128 Hz is often used. This is close enough to line frequency to give results that can be used to make ground-fault current calculations. It avoids harmonics of the standard line frequencies to allow filtering of the test signal. A filter can remove the 50 or 60 Hz interference from the total signal.

Many ground testers only reject noise of a single frequency. This is usually inadequate, as electrical networks contain noise that consists of the frequency of the supply and its harmonics, high-frequency noise from switching, and induced signals from other sources. In some ground testers, this interference can cause significant measurement errors. These errors are not apparent to the user, since such instruments neither reject the noise nor trigger a high-noise annunciator.

With transient electrical noise—e.g., a train passing during testing of a railway system—testing can be delayed until the noise diminishes. However, in most cases background noise cannot be removed, so a suitable instrument is needed.

The MEGGER DET2/2's filtering system rejects more noise than other available earth testers. Adjustable test frequency and selectable levels of noise filtering also help remove stray noise. Its high current range increases the test-signal strength in relation to the noise. But, in extreme cases, you may still have to delay testing until the noise decreases.

CONCLUSIONS

The latest generation of digital instruments greatly simplifies ground-system testing. However, care is still needed in interpreting the results. Error indicators can alert you to misconnected leads or conditions that might cause an invalid reading, but taking one reading is not sufficient to measure the resistance of any ground system. Repeating the test using a different direction or distance can eliminate errors from hidden differences in the soil and confirm the initial results.

When selecting a ground tester, make sure that the resolution and accuracy are suitable for the application. Instrument errors can lead to unnecessary expense in the design or maintenance of ground systems or, worse still, unsafe installations.