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NOISE CONTROL IN GROUND TESTING

Noise Control in Ground Testing

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A QUICK REVIEW IS IN ORDER: A ground test is the means by which a grounding electrode, that protects the electrical system by diverting fault currents to ground and fixes the voltage rating to a specified value, is tested for performance and its ability to keep the grounded electrical system running safely, efficiently, and to spec.

Grounding electrodes are typically buried metal objects; rods, interconnected arrays of rods, plates, grids, and various other designs aimed at putting a sufficient amount of metal in contact with the soil so as to safely and efficiently divert unwanted fault currents out of the electrical system and out of the protected facility. Upon construction, there is generally a ground resistance specification that is not to be exceeded. A performance test is run to assure that the system meets spec. Subsequently, maintenance tests should be run to assure that the system remains in spec, as grounding electrodes can deteriorate through corrosion, be damaged or destroyed in major fault clearance, or rise in resistance due to changes in the surrounding environment. So far, so good…

A ground test is typically performed as described in IEEE81, where a test current is established between the electrode under test and a remote metal probe driven at some distance in the soil. The ground tester typically applies a square wave test current so that it can recognize its own current apart from noise currents traveling in the soil. There are more than you might think! All sorts of sophisticated electronic equipment common in offices and factories chops up the utility sine wave in order to meet the requirements of their own circuitry. Much of this ends up on the grounding system as "noise". This can interfere with a ground test by unduly influencing or disturbing the readings.

Similarly, the ground tester senses voltage drop caused by resistance by means of a second measurement circuit and another long lead and probe. The two measurements…current and voltage drop…are combined through Ohm's Law to calculate the ground resistance, which appears on the display. The less resistance, the better. The procedure used…graphic or mathematical…determines the accuracy and reliability of the reading. But what are we actually measuring? The term that appears in the literature is "to remote earth". This means to the limits of the volume of soil around the electrode that actually determines its resistance. A measurement taken only a few feet from the electrode would be, understandably, quite low. But that would not be the resistance a fault current encounters as the electrode diverts it out of your system. Rather, there is a critical volume of soil around the electrode, beyond which

no further resistance is added. This limit is what is referred to as “remote earth”. It can be large or small, depending on size of electrode, soil type, prevailing weather and climate conditions, and other factors. But the accuracy and reliability of the measurement depend on it.

It can be seen, therefore, that getting a good ground resistance measurement can be a complicated and demanding operation. It’s not like hooking up a DMM! But modern features added to ground test meters have come a long way in effectively dealing with potential problems. One of the most useful developments is in noise mitigation. In the old days, noise mitigation consisted in judiciously guessing the midpoint of pointer swing. Then, useful suppression features were added; noise filtration, frequency adjustment, high current option. These went a long way to eliminating noise interference from the measurement, and in most normal testing environments, a quality instrument and trained operator would suffice. But there were still problem areas. Noise is one of the worst electrical problems in many applications and can be a formidable barrier to reliable results and acceptable performance. For good grounding, substations and heavy industry can provide daunting noise sources that make testing and evaluation difficult, deceptive and inconclusive. A valuable addition to the modern full-featured ground tester is the continuous graphic mode. With this function, the operator can view in real time, straight from the display, the amount, characteristics, and progress of noise interference in the measurement.

Your neighbor may be your biggest problem. It isn’t just the grounded electrical system under test that puts noise onto the test setup. Neighboring properties can be prime contributors, and they have the added disadvantage that you can’t turn off equipment to mitigate the source. An advanced instrument with a continuous graphical mode can effectively counter this problem by displaying the extent of background noise in real time against the measurement. With an old-style tester, a reading taken at any given time may or may not be affected by noise interference and the operator has no way of knowing except by judicious guesswork. Running the test continuously or repeatedly could be a help but often led to a series of different readings with no objective way of knowing which is correct. In worst case, a single test could be run at a bad time and produce a highly inaccurate reading with the operator accepting it as good.

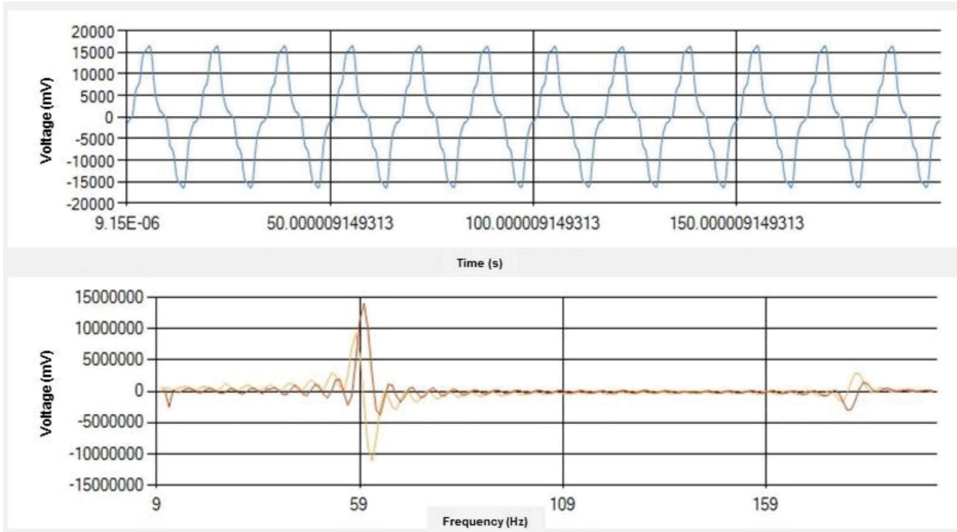

Fig 1: Typical noise spectrum in substations.

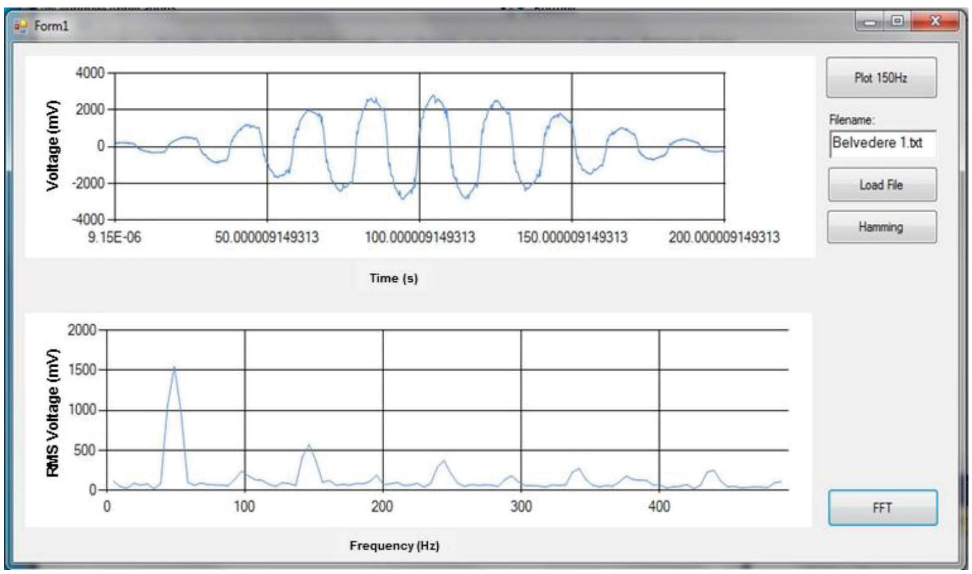

Fig 2: Average sites suffer from far less noise.

Two typical examples are shown in Fig. 1 from one of the most prevalent problem areas, utility substations. Taken with an oscilloscope, the top graphic shows a regular fluctuation of as much as 30 volts in regular intervals. This is beyond the tolerance level of many common ground testers. Undetected, it would cause destabilization of the reading and possibly promote the acceptance of a highly influenced measurement as a valid reading. The bottom graphic of interference versus frequency shows a pronounced spike at 60 Hz. An instrument of a quality tech level would have a frequency adjustment feature, so that the operator would not have to accept a reading that may have inadvertently been left on 60 Hz. In Fig. 2 it is shown that a less electrically active site, in this case a church, can still have a burst of noise activity, around 4 volts for about 2 minutes, and again at 60 Hz, with additional harmonics at less intensity. A fairly common tester of good quality would be expected to have tolerance for this level, and so a graphic mode wouldn’t necessarily be required. Fig. 3 was taken from a tester with full noise defeating features. Even smoothed out, the graph is far from the flat line you would expect from a perfectly quiet test area. But it shows that the destabilization of the anticipated flat line over

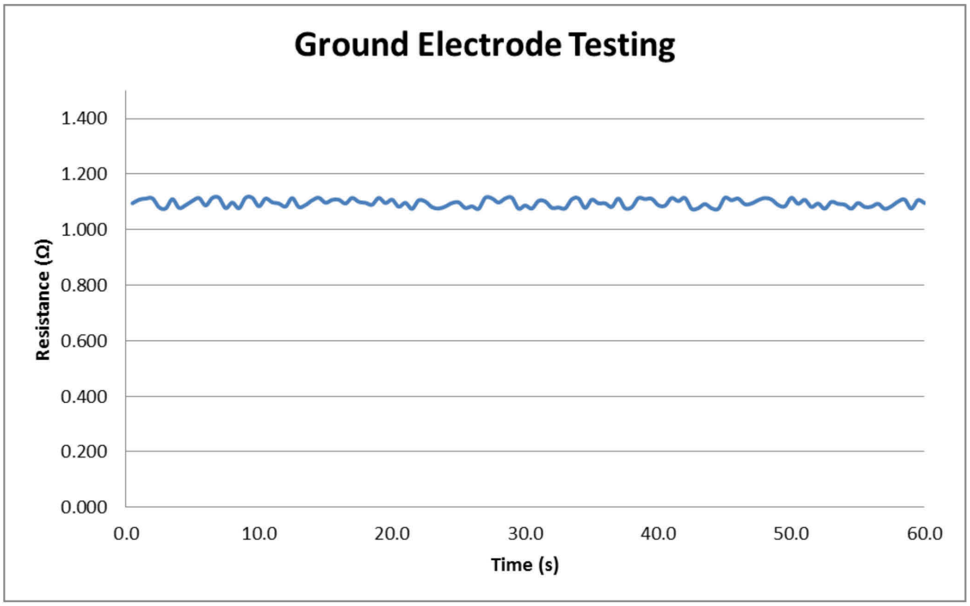

Fig 3: Noise suppression features can smooth noisy graphics to readable levels.

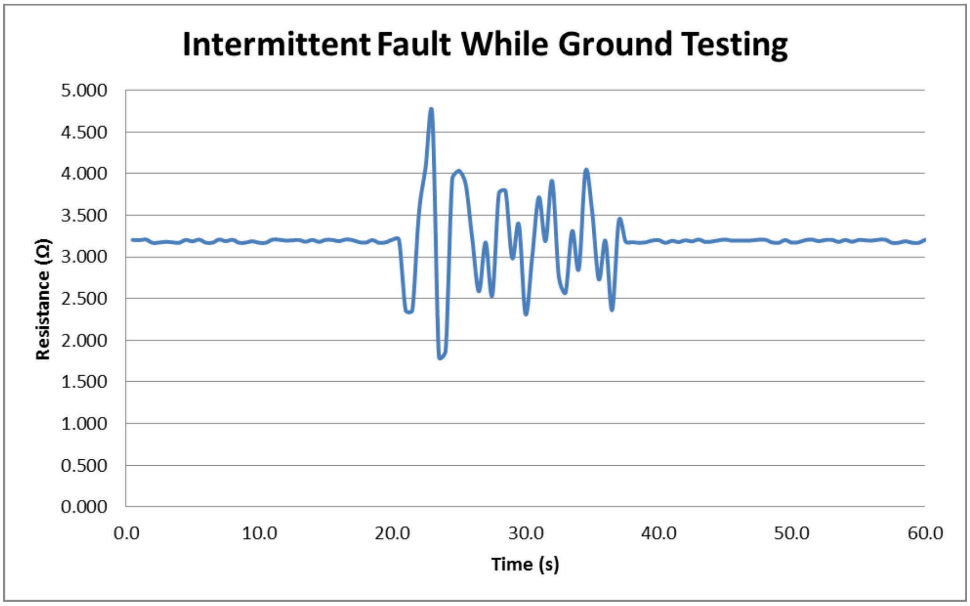

Fig 4: Electrical events can have pronounced effects on unfiltered measurements.

an interval of a minute has been reduced to only hundredths of a volt, effectively eliminating ambient noise which could be reflected in jumping digits on a less developed tester's display. Fig. 4 indicates the pronounced effect of a discrete electrical event occurring on the system while the test is in progress. It could be startup of a heavy piece of equipment drawing current. Once again, a ground test reading taken right at that time could be negatively influenced. Without a graphic mode feature on the tester, the operator could be taken unaware.

If you've detected noise interference, what can be done about it? The most long-standing remedy is simply to try to get away from it. Move the leads and probes. Position the current probe as far from any electrical source as possible. Especially, try to get at right angles. If you suspect the noise is being generated by some longitudinal source, like a power line, try to cross it at a right angle or as close to that as possible. Whatever you do, don't run parallel! The first electronic corrective feature is to adjust the frequency of the test signal. This option was not available in early testers and many still do not offer it. But quality testers have steadily expanded the capability, now to even half-Hertz intervals over a wide range. Furthermore, a top-of-line instrument will include an input bandpass filter to perform an auto scan and find the quietest frequency. The operator is left with the option of manual selection or accepting the tester's choice.

Finally, as we've indicated, if the tester has a graphic mode, the results can be analyzed over time for stability and repeatability. This ability makes an objective determination of result acceptance, removing all guesswork and operator influence on test results, and provides an objective factor against third party discussion. Let's take a look at how this capability can help in a practical example. A substation was surrounded by heavy industry and active railroad tracks. The electrical maintenance program called for bi-annual shutdown and testing. This included the grounding system, a critical and indispensable part of substation function. Time is money and with the station shut down, testing had to be completed in two to three days. But even shut down, noise proved a problem for the grid testing. It emanated from the adjacent properties.

Routine procedure called for five tests to be made with reasonable agreement and then averaged. Standard ground testers without augmented noise capabilities, however, frequently produced such lack of agreement as to be unacceptable. An advanced model, however, dealt with the problem efficiently and effectively. Switching on graphic mode readily identified the problem and eliminated guesswork and trial-and-error. Filtering and high current functions then empowered the tester to extract meaningful results despite the presence of noise. Testing could proceed without interruption and on schedule.

Do you need an advanced tester complete with graphic mode? Not necessarily. Size of the electrode is a determining factor. Smaller systems consisting of a limited number of rods can generally be tested with a standard-quality instrument. Electrodes falling within industry-standard 5 – 10 Ω range generally can be tested. But large electrodes with exceptionally low resistance requirements, especially if in high resistivity soil that doesn't mitigate noise well, can be prohibitively difficult to test reliably in the absence of state-of-the-art features and functions. ❑