Proper wiring and good grounds can eliminate many power quality problems. Also important is the bonding to the ground system. Testing grounds and bonding should be an active part of any power quality troubleshooting strategy. One effective time-saving method is to use a clamp-on ground tester. This technique employs a hand-held test instrument that has a transmitter and receiver built into a split core head. This construction allows the instrument to clamp onto the rod or ground under test (see Figure 1).

To verify the grounding resistance, the operator simply clamps the sensor around the connection at the ground rod and reads the resistance on the display of the instrument. It is that simple. This method offers several distinct advantages over the commonly used fall-of-potential method. First, you do not have to disconnect the ground rod from the system, which eliminates a potential safety hazard. Secondly, no auxiliary rods need to be driven which saves time and money. Thirdly, this test method includes the bonding and overall connecting resistance, which is not available with other methods. An additional benefit is the ability to measure leakage current flowing through the grounding system.

Usually, a common distribution line grounded system can be simulated as a simple basic circuit as shown in Figure 2 or an equivalent circuit, shown in Figure 3. If voltage $E$ is applied to any measured grounding pole $R_x$ through a special transformer, current $I$ flows through the circuit, thereby establishing the following equation:

$$E/R = R_x + \frac{1}{\sum_{k=1}^{n} \frac{1}{R_k}}$$

where, usually $R_x \gg \frac{1}{\sum_{k=1}^{n} \frac{1}{R_k}}$ (1)

When $R_x$ is much greater than the effective resistance of a significant number of other ground rods in parallel, $E/I = R_x$ is established. If $I$ is detected with $E$ kept constant, measured grounding pole resistance can be obtained. Refer again to Figures 2 and 3. Current is fed to a special transformer via a power amplifier from a constant voltage oscillator. The current is detected and displayed on the LCD.

A filter amplifier is used to cut off earth current at both 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.
Typical In-Field Measurements

Pole-Mounted Transfer

Remove any molding covering the ground conductor and provide sufficient room for the clamp-on ground tester 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.

Clamp onto the ground conductor and measure the ground current. If the ground current exceeds five amperes, ground resistance measurements should not be made.

Note the ground current and measure the resistance directly. The reading you measure with the clamp-on ground resistance tester 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 4 there is 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. 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 butts, clamps, and hammered-on connections

Service Entrance or Meter

Follow basically the same procedure as in the previous example. Notice that Figure 5 shows the possibility of multiple ground rods, and in Figure 6 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.

Pad-Mounted Transformer

Note: Don’t open transformer enclosures. They may be 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 a single rod is present). If the ground rods are inside the enclosure, refer to Figure 7, and if they are outside 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 tester onto the rod itself, below the point where ground conductors are attached to the rod, so that you are
measuring the ground rod resistance to earth. Care must be taken to find a conductor with only one return path to the neutral.

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 ohmmeter 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.

Telecommunications

The clamp-on ground tester discussed in this article 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. Since communications equipment typically operates at lower voltages than power system equipment, the grounding system's ability to remove a man-made or natural overpotential becomes even more critical. The traditional fall-of-potential testers proved to be labor intensive and left a lot of interpretation to the person making the test. 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.

Editor's Note: It must be remembered that the location of the clamp is critical in determining the desired ground impedance. Placed in the wrong position, it will give false low readings. Also remember that, to measure the contribution of one ground rod in a ground grid accurately, there must be many other ground rods attached to the system.

Network Interface Device (NID) with a Protector Block

The typical customer connection is achieved with the tip and ring drop cable pair. In order to protect against an over-voltage situation on the telephone wires, a protector block is installed inside the NID. This protector has two internal devices that conduct only when unwanted overvoltages are present. In order for the protector to function properly, it must have a low resistance path for any fault to conduct to earth. This bonding and ground resistance potential can be verified by using the clamp-on ground resistance tester. Simply take a short piece of wire and temporarily jumper the tip side (CO ground) to the ground connector protector block (see Figure 10). By clamping around this jumper wire, you will now test the ground resistance potential including all terminations at this location. The return signal path required for the clamp-on tester to make this measurement would be the CO ground.
These examples depict just a few of the applications where a clamp-on ground tester can save both time and money and provide accurate ground resistance test results as part of an overall power quality testing strategy.

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