Grounding 101

Technical Bulletin

The service life of any piece of electronically controlled equipment is, to a large degree, determined by the quality of the electrical service that it receives power from. The number one complaint from electronics (commercial and residential) owners is downtime. The number one cause of downtime (other than user error, neglect, or abuse) is poor power quality. According to Utility Industry information, power quality is at an all-time low, and with deregulation rolling along, it's getting worse.

A low impedance ground is imperative to both surge protection designs and power quality. A regular check and upgrade (as needed) of grounding systems will reduce interference and line noise, improve power factors, reduce the risk of accidental electrocution, help decrease potentially damaging harmonics and improve the efficiency and durability of surge protection equipment. Since many electricians use the terms "bonding" and "grounding" interchangeably, for the purpose of this paper they will be defined in short, as follows:

- Ground/Grounding – Any direct conducting connection between an electrical circuit or equipment and earth
- Bond/Bonding – The permanent connection of metallic parts to form an electrically conductive path

An example would be an electrical service panel that is grounded while the telecommunications rack is bonded to the grounding system.

A primary concern that needs to be addressed when beginning any power quality survey is the need for a "complete" grounding and bonding system, between the electrical service entrance and remotely grounded buildings or equipment. If the remote ground runs back to the service entrance, it will be a relatively simple process to create a "single point ground" that will reference the initial utility company electrical ground back at the service entrance electrical meter.

Articles 100 and 250 of the NATIONAL ELECTRIC CODE (NEC) describe an acceptable ground as being rated at 25 Ohms of resistance or less, and requirements to achieve this. Optimum performance of surge protectors is achieved at 5 Ohms or below. Several manufacturers of electronic equipment also require 5 to 10 Ohms as a maximum resistance for their gear to work correctly. Failure to properly ground the metal parts of the electrical system to the earth can result in electric shock, fires and the destruction of expensive electronic equipment from lightning and high voltage line surges. We realize that in many areas of the country you may be starting with 350 ohms or more, instead. However, there are several preliminary tasks that we can perform to reduce that number to a more acceptable level.

The first (and most important) task to undertake is the actual measurement of resistance to ground at the service entrance meter's electrical ground, or of the soil itself. Several things can affect the actual resistance of the soil, including moisture content, quality and type of electrolytes, conductive objects, temperature, depth and spacing of the ground rods. This critical measurement can be accomplished in one of two ways… either by the use of a special "clamp-on" ground resistance measuring device (good for existing locations) or an earth resistance meter ("Megger") (preferred in new installations). Although the earth resistance meter is less expensive, it requires the use of multiple ground probes and leads from the tester with specific distance requirements between rods and measurements to be plotted on a nomograph in order to calculate the actual resistance of the ground.

Another issue with the Megger is that it comes in 3 and 4 terminal configurations. To test the actual resistivity of the soil itself, a four terminal model is required. The advantage of this method is that you are not connected to the electrical system during testing. An electrical line fault during testing can send high current to the grounding system. This could result in high current and voltage at the test leads and meter. Safety is a primary concern when working on "live" electrical systems. Always use proper protective equipment.

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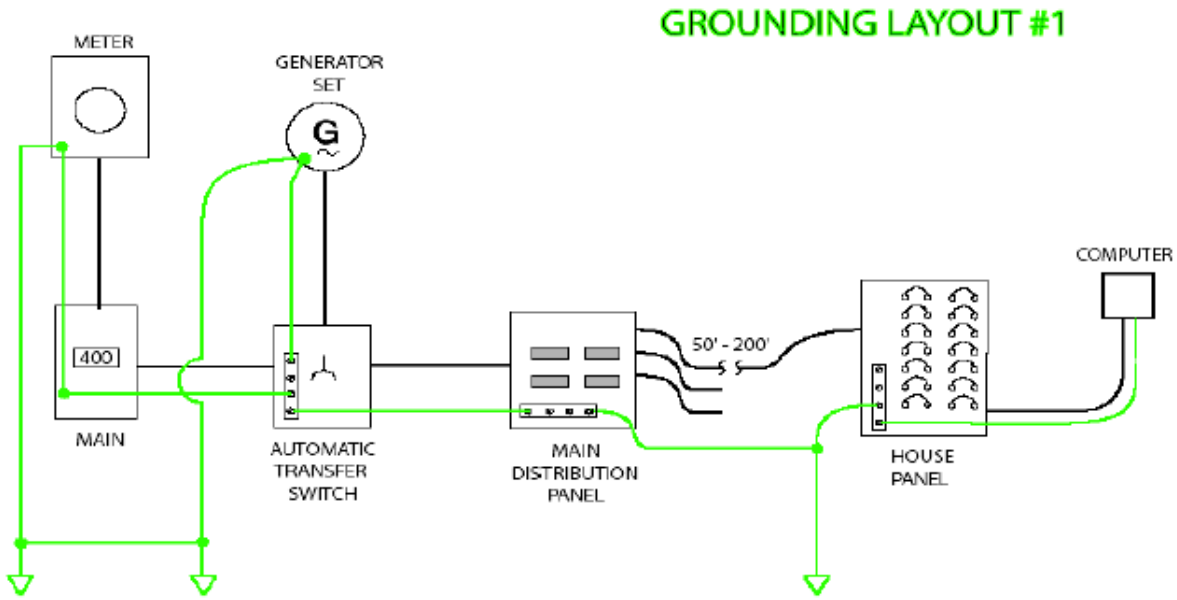
Remember, if you are in contact with the grounding system (particularly if the ground rod is disconnected) YOU become the ground for the system.

Once an accurate measurement of resistance to ground has been calculated, we can perform a few tasks to help reduce resistance even further. Since geological features can vary greatly in different parts of the country, it will fall to the installing contractor to make the determination of how best to lower resistance to ground in his region. The recommended grounding conductor at the service entrance is specified by NEC based on the ampacity of the service.

1. Drive a new service entrance ground rod. Since it is impossible to know the exact length or current condition of the original ground rod, it may be prudent to install a new rod of suitable length and composition at the service entrance. Solid copper is the preferred material however, galvanized or copper clad may also be suitable if acceptable resistance levels are met.
2. Bond a new rod and the existing rod together. If the target ground resistance is not achieved by a new rod, drive a second rod and bond the two rods together by exothermic welding a piece of the grounding conductor between the two. The new rod should be approximately one rod length or more from the first rod. Multiple rods can be connected this way (See item #4 below). One additional rod will lower ground resistance by 40%. Two rods will result in a 60% reduction. Three rods will improve resistance by 66%.
3. Drive the rod deeper. Couple a new rod of equal length on top of the existing rod to effectively double the depth of the rod. Be sure to use rods of like type and a coupler matched to that type of rod. This will result in an approximate 40% reduction in ground resistance.
4. Create a “Ground Grid”. This procedure involves creating a grid of grounding electrodes, or rods, in close proximity (10 to 20 feet, or at least one rod length apart,) and welding or bonding the grounding conductor between the rods together. The entire grid is then backfilled with soil and compacted to complete the grid. Also, review NEC section 250-32(b) for more information.
5. Create a “Trench Ground” or “Ground Ring”. If your region provides a solid substrate such as bedrock immediately below a shallow layer of soil, it is possible to create a circular trench around the building (minimum 20 feet long) at least 30 inches deep utilizing a minimum of #2AWG bare copper conductor, lay in the grounding conductor, bond the two ends together to the ground rod, and then backfill the trench with soil. This allows maximum contact with the ground, yet need not be excessively deep to do the job.

A key element to the creation of a complete grounding system may involve making some fundamental adjustments to the routing of the grounding conductor if more than one ground can be referenced (campus environments, etc.). This will not be difficult or time consuming, but is very important in the system’s ability to reference the original equipment ground back at the service entrance utility service meter. The normal routing would be to bring the HOTS, the NEUTRAL and the GROUND wire into the remote electrical panel and terminate them to the appropriate busses. Then route the GROUND wire down to the house grounding electrode (ground rod). For our purposes, it is necessary to route the GROUND wire to the grounding electrode FIRST, and then up to the ground bus within the panel. This simple adjustment still follows NEC code, but provides an unobstructed pathway to divert surges to these ground rods while continuing to reference the service entrance ground. The fundamental result of this routing is the elimination of potential equipment damage from the ground loop created by multiple ground rods. It accomplishes this by allowing the electrical potential of the entire facility to rise and fall in a uniform manner, reducing the possibility of excessive current flow on the grounding system. Please note the diagram #1 for a sample layout.

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Finally, inspect and tighten all wiring terminations at the service entrance and at each of the remote panels, disconnects and equipment. It is surprising how over time these terminations can loosen. It can make a substantial difference in lowering resistance to ground if these connections are inspected for oxidation, cleaned up and tightened down on a regular basis.