Equipment and System Grounding for Power Quality

Power Quality Two-Pager A product of the EPRI Power Quality Program

Here is a classic question taken from the stack of "old jokes": If all an aircraft's equipment should be and are actually grounded, where is the ground when the plane is up in the air? This may seem like a trivia-type question, but it emphasizes the importance and sometimes complexity of wiring and grounding to assure proper functioning of electrical and electronic equipment and systems.

From years of EPRI PQ investigations, we have discovered that as much as 80% of power quality problems may actually result from inadequate wiring or grounding on the customer's premises or from interactions between on-site loads sharing a joint connection. Thus, the most common solution to potential power quality problems will require attention to wiring and grounding as well as sometimes to a load's placement in a specific troublesome location in the building or on the factory floor.

Numerous, relatively quick yet effective solutions can be considered when reviewing a troubled location at a customer's site. However, after receiving a power quality–related complaint from a customer, utility technical personnel should not rush in to install power conditioning equipment or any other power protection solution until all information has been gathered, including noted effects throughout the system. The list of potential disruptions on a customer site (residential, commercial, and industrial alike) can be lengthy; therefore, the first rescue usually is to check adequacy of wiring and grounding.

Most utility customers assume that having equipment and/or system connected following National Electrical Code (NEC) standards should be sufficient to guarantee uninterruptible operations. Definitely, adhering to NEC protocols is a must for all installations of electric and electronic equipment. However, we need to be aware of another fact: NEC standards are mainly focused on safe installations, not on system reliability or power quality. The fundamental purpose of equipment grounding is to provide equipment and personnel safety; the secondary purpose is to enhance equipment and system performance. This emphasis on safety first and performance second has been documented in a number of EPRI PQ publications, some of which are referenced at the end of this document.

In other words, as has been documented in a number of PQ case studies investigated by the EPRI PQ team, having the installation of equipment fully comply with NEC rules and standards does not guarantee adequate support for proper operation of sensitive electronic-based loads.

First, let's see where affected equipment has been connected. In most cases, the new piece of equipment—usually full of electronic and microelectronic components—is connected to existing building wiring, where sometimes an old "ground" is lost or broken. Thus, the primary response in such case is a thorough check of wiring and grounding, fixing missing or broken connections (i.e., reviewing system ground).

The logical place to begin a grounding investigation is at the electric utility service entrance. On a factory floor, machines are usually supplied with three-phase service classified as "four-wire grounded" or "three-wire ungrounded." Make no mistake about these notions: both grounded and ungrounded electrical systems are required to be connected to earth via a building grounding electrode system. This practice is usually referred to as "grounding" for safety and allows a check of the present condition of the grounding (e.g., whether the electrode conductor is working or is damaged with rust and not providing any effective contact). In past publications by the EPRI PQ program, we have documented that both grounded and ungrounded building electrical services require a grounding electrode conductor to reference the electrical power system to the building grounding electrode system.

While checking for proper wiring and grounding at a customer's facility, another solution can be to reconnect sensitive equipment by use of an individual branch circuit (also known as a dedicated line) to minimize electromagnetic and electrostatic interference, thus improving overall power quality. This approach is enhancing performance of sensitive loads. Although NEC standards allow the use of conduits for grounding, the customer should be advised not to rely solely on conduit ground connection to avoid interaction coming from differences in ground voltage potentials between different equipment.

In summary, when investigating wiring and grounding the following are important:

- Let's make sure the subject installation is in compliance with NEC standards.
- Check if wiring is properly upgraded to accommodate the higher power consumption from an expansion of customer operations.
- Since differences in voltage between individual system components can disrupt operation, let's check if equipment is working on proper electrical potential (i.e., on the same voltage levels).
- Obtain and review any available recent data on upgraded wiring or if transformer's voltage taps have been properly adjusted.

References

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