Grounding Points

Single or Multi?

Use of unconventional hybrid energy sources, along with the increasing demand for uninterrupted power, is fueling unique power quality issues

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Perhaps no electrical engineering concept is as unclear, unexplained and misunderstood as grounding. Many of these misunderstandings result from methodologies and practices that have floated around the building design industry for years. In fact, some of these grounding approaches are even direct opposites.

But one argument that consistently arises among engineers is the issue of single-point vs. multi-point grounding—which is better? (For a general overview of grounding and why it is necessary, see “Ground Essentials,” p. 16).

Single-point grounding means exactly what its name implies. Electrical, telecommunications and IT systems are all grounded at a single point. In *multi-point grounding*, these systems are grounded at multiple points.

SINGLE-POINT

Figure 1 (p. 14) demonstrates a typical single-point grounding system, complete with power and telecommunications system grounds. The entire grounding network is taken back to building grounding at a common point. The *main electrical ground bar* (MEGB) is used as the hub of the grounding network to the building. The MEGB is bonded to the neutral bus of the switchgear, which in turn is bonded to the ground bus, cold water pipe, building steel, the switchgear enclosure and ground rod. This achieves *zero reference* (see "Grounding Essentials") and puts the entire building grounding system at building potential.

There are several advantages to using this single-point design. For example, if a phase-to-ground fault occurs at a piece of equipment along the electrical distribution system, a relatively controlled low-impedance path is provided back to the source. The fault current has limited routes back to the source and does not have the opportunity to diverge to multiple paths, creating parallel circuits. If multiple paths were introduced, the fault current would divide itself among the paths based on the impedance of the circuits.

Single-point grounding also limits the ground loops that occur when more than one conductive path exists between two points. If the electrical equipment is not only bonded to ground bars, as in Figure 1, but to various building steel columns—if available—and if the grounding potential is different in the building due to an electrical storm, on a multi-point grounding system, noise could circulate, cause error in equipment operation and become difficult to isolate.

If power for IT equipment is served from a separately derived source independent of the building ground system, noise might be generated on the system. This is a form of common mode noise, in which the power-source ground is referenced to a different point from the equipment ground. These stray currents—in other words, noise—can find their way onto grounded equipment, thus energizing the equipment.

WHEN LIGHTNING STRIKES

Another advantage of a single-point grounding system is its effectiveness at handling *ground potential rises*, which occur when a lightning storm passes over the building and causes electrical disruption. A lightning strike, or the elevation of a building's potential due to an electrical storm, can cause rises and falls of potential in the building grounding system. When electrical components are grounded at different points, each point can have different potentials from other nearby points, thus establishing equipment at different potentials.

In this situation, a common ground reference is essential, and a single-point system provides a predictable grounding method. The overall potential will rise due to the lighting strike, but each component will have the same potential because they are electrically tied to the building at the same point. The components' potential will uniformly rise and fall. This goes a long way in protecting electronic equipment from the effects of lightning, while keeping within NEC guidelines.

However, single-point grounding is not without its drawbacks. One disadvantage is that it relies on a common node—the MEGB—for a building grounding system. In these systems, particular concern must be given to properly made bonds between conductors and the bus, and correct installation of grounding conductors to minimize high frequency noise.

Another concern with single-point grounding is future testing and maintenance of equipment. It is difficult to isolate the MEGB for testing or modifications without affecting the equipment that uses the MEGB as a reference.

Finally, perhaps the most intriguing argument in the single- vs. multi-point debate concerns the ability to handle high frequencies—10 MHz or more. Modern digital computer devices often produce frequencies in the 100 MHz to 300 MHz range. At these frequencies, the argument for single-point grounding tends to break down, due to the length of the grounding conductors. When multiple pieces of electronic equipment are grouped together in one contiguous space, they are effective sources of unwanted electrical noise. The properties of the grounding conductor are such that at high frequencies, a conductor whose length is 1/4 wavelength (or multiples thereof) of an interfering frequency will become an efficient antenna. The rule of thumb developed by EIA/TIA and BICSI is to specify conductor lengths at no more than 1/20 wavelength of the highest frequency threat. Single-point grounding will usually fall short in this regard.

MULTI-POINT

Unlike single-point, the multi-point system does not trace a singular path back to building. Many existing buildings use multi-point grounding by bonding the same pieces of electrical equipment to ground bars, building steel, cold water pipes or other electrodes. One could say that multi-point grounding often uses a "more the merrier" approach.

Figure 2 (p. 14) represents a multi-point building grounding system in which ground bars in each electrical and telecom closet are bonded to building steel and to the main ground bar. Both BICSI and EIA/TIA are proponents of multi-point grounding. The EIA/TIA J-STD-607-A standard introduces the concept of *grounding equalizers* for telecommunications grounding. These are meant to equalize potentials among ground system components. In the end, the goal of all multi-point grounding is the same—to provide multiple paths for ground currents to flow and to equalize potentials throughout the building grounding system. And it can be argued that multi-point grounding achieves more effective safety than single-point grounding.

When it comes to implementation of grounding systems, one way that multi-point grounding is applied effectively is the use of *signal reference grids*. Commonly used in raised-floor applications in which many pieces of electronic and computer equipment are located in the same room, an SRG is basically a network of interconnected ground conductors located beneath the raised floor. The equipment in the room is bonded to it via conductive straps. In essence, the SRG acts as an equipotential plane to which the equipment is referenced. Charge can be easily dissipated to the grid from one or more pieces of equipment, keeping the equipment at the same potential.

The SRG can also be bonded to building steel or other conductive paths within close proximity. Sensitive digital equipment can be effectively bonded to the SRG at multiple points, offering greater flexibility in equipment layouts because equipment can be grounded at any location in the room. This practice can minimize equipment damage by limiting the potential differences between pieces of equipment. But more importantly, it can minimize *touch potential*.

Touch potential is the difference in voltage between an energized piece of equipment and the feet of any person who touches the equipment. A person who touches the equipment can receive a harmful or even fatal electric shock. When charge accumulates on the equipment enclosure—due to static electricity, lightning storms or other reasons—it can be dispersed to the SRG, greatly reducing the risk of touch potential.

Another major difference between the two types of systems is that where single-point grounding eliminates ground loops, multi-point systems may facilitate them. If the building grounding system relies on multiple grounding paths and numerous connections to building steel, stray currents may be allowed to flow through the building steel footings, then through the electrical system, and finally, back down to earth. Multiple connections provide opportunities for stray currents to wreak havoc on electrical, telecommunications and IT systems. If the power and telecom grounding systems are intermingled, a fault or stray current on one system could locate a path to the other and have adverse effects.

Figure 1

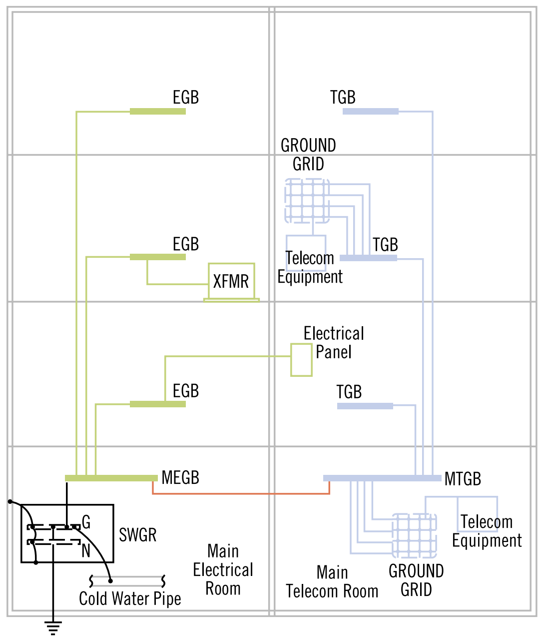
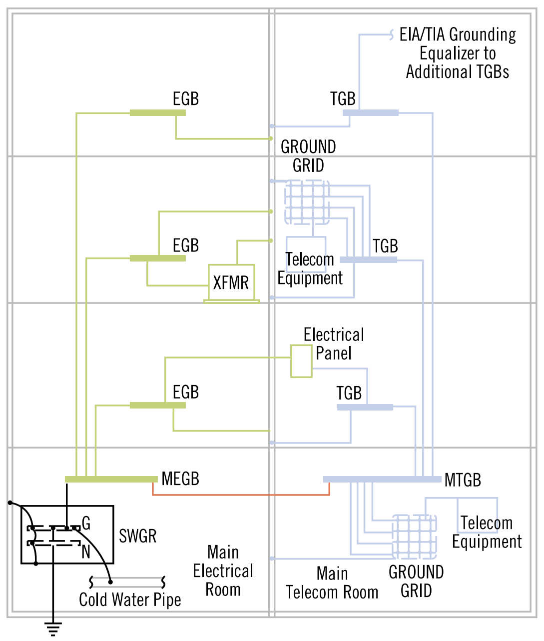


Figure 2



Grounding Essentials

Electrical system grounding has three distinct purposes: to cause the operation of overcurrent protection devices in the event of a fault condition; to provide zero reference for the building electrical system; and to equalize potential differences in the system.

The National Electric Code (NFPA 70) stipulates that grounding must occur at the building (premises wiring system) service entrance and at each separately derived source—in most cases, a transformer. At the service entrance, the ground and neutral are bonded together; then, the grounding conductor is taken from the neutral bus to ground rod(s), switchgear enclosure, building steel, an underground cold water pipe or other available electrodes (NEC 250.30, 250.52).

Creating a neutral-to-ground bond at the service entrance creates a line-to-ground voltage reference for the electrical system. This zero reference establishes a convenient frame of reference for line-to-ground voltage measurements. The neutral-to-ground bond also creates an effective grounding system and minimizing the voltage to ground and can limit overvoltage stresses on conductors to electrical equipment. This allows for intended equipment performance by isolating potential fault.

Grounding at each separately derived system is also of benefit under a fault condition, because electrons emanating from a source—transformer, generator or inverters—will attempt to return to the source. Under a phase-to-ground fault condition, the current will travel back along the ground wire or ground path—such as conduits and equipment enclosures—to the source. The source will provide current on the phase conductor(s) to meet the requirements of the short, thus causing the overcurrent device to trip. The purpose of the ground wire in this case is to provide a low impedance path back to the source.

Note that the ground wire is not returning the current to ground. In this sense, "ground wire" is a bit of a misnomer. Many times, this is called an "equipment" or "safety" ground, the latter being the most appropriate term, because it is meant to provide personnel safety by isolating the fault in the system.

In many mission-critical applications, IT equipment operation is the main thrust of design. But an often-overlooked aspect of data center reliability is the grounding system design and the need to provide an equipotential grounding system. If the electrical and IT equipment are not properly grounded, there is a latent possibility for transients, EMI, RFI and static electricity affecting proper operation of the equipment. When noise is generated on the power source or in the enclosure housings, electronic equipment can have its data corrupted. Even though IT equipment may appear to be functioning properly, there may be data errors or in extreme cases catastrophic failures.

In the multi-point vs. single-point debate, both sides are able to offer substantial evidence to support their cause. There are also detriments to each design strategy.

In general, each accomplishes specific goals while complying with NEC guidelines. However, the designer can't always implementing just one strategy while completing dismissing the other. The design application and building needs are factors instrumental in selecting the best solution. The answer to the question, "which is better, single or multipoint grounding?" is not as clear-cut as the strategies themselves. More often than not, effective building grounding systems will implement both strategies. An electrically complex building with intricate power and IT components should rely on a "hybrid" system.

BEST OF TWO SYSTEMS

Single-point grounding should be utilized as the backbone of the building grounding system. Provide a main ground bar to act a common distribution point for ground risers and connections. Tie the MEGB to the ground bus of the main switchgear and then go to the building from there. Separate ground bars for power and telecommunications should be utilized in each closet, while providing a single path back to the source (transformers). Tie telecommunication and IT grounding systems to the power grounding system and final connection at the MEGB.

Multi-point grounding should be used almost as a grounding subsystem for data centers and computer rooms filled with high-frequency electronic equipment, where the benefits of multi-point grounding can be efficiently achieved with SRGs.

It is crucial, however, that this multi-point subsystem be tied to the single-point building grounding system. It should not be thought of as a separate grounding system. This type of hybrid system will work in most applications.

This is the first of a two-part article. The second part, which will appear in the Summer (June) issue, shows how this hybrid design can create a reliable and effective system for building components. Exact design of an SRG will be discussed. END