July/August 2007

Volume 28, Number 4

advancing information transport systems

BICSI news

Solutions to Grounding Issues Confronting

Standards and methods manuals offer guidance for protection of equipment and personnel.

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Changing equipment requirements and inconsistencies between industry-recognized resources have made it difficult for designers to feel confident when specifying a network grounding system. Such industry resources include the *Telecommunications Distributions Methods Manual* (*TDMM*), 11th edition, ANSI *Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications* (J-STD-607-A) and IEEE 1100, *Powering and Grounding Sensitive Electronic Equipment*. This article offers a means of rationalizing the different design references and provides guidance on other grounding-related issues confronting network designers.

and Bonding
Network Designers

Telecommunications Bonding Backbone

One of the hottest topics in grounding today is the need for a telecommunications bonding backbone (TBB). According to J-STD-607-A, the TBB is the bonding conductor that runs from the telecommunications main grounding busbar (TMGB) and extends to the farthest telecommunications grounding busbar (TGB) in the building (see Figure 1).

The TMGB is intended to be located near the power service main panel board at the service entrance. One purpose of the TBB is to equalize potentials under steady-state and surge conditions, reducing electrical stress on networked equipment operating within adjacent floors. When multiple TBB runs exist within the same building, they are joined on the top floor and on every third floor in between with a conductor called a grounding equalizer (GE).

The *TDMM* states that TBB and GE conductors may not offer benefit beyond what is available from the power system grounding conductor due to the impedance that builds up over the length of the TBB and GE. The controversy surrounding the need for a TBB leaves the network designer in a precarious position.

While these issues likely will be discussed further in the standards bodies, it is noteworthy that the TIA committee (TR41.7.2) that drafted the original 607 standard discussed this subject. The TBB and GE components were incorporated and included within the succeeding J-STD-607-A standard. Pending further resolution by BICSI and TIA, some useful comments can be offered.

Figure 1. Telecommunications bonding backbone and grounding equalizer.

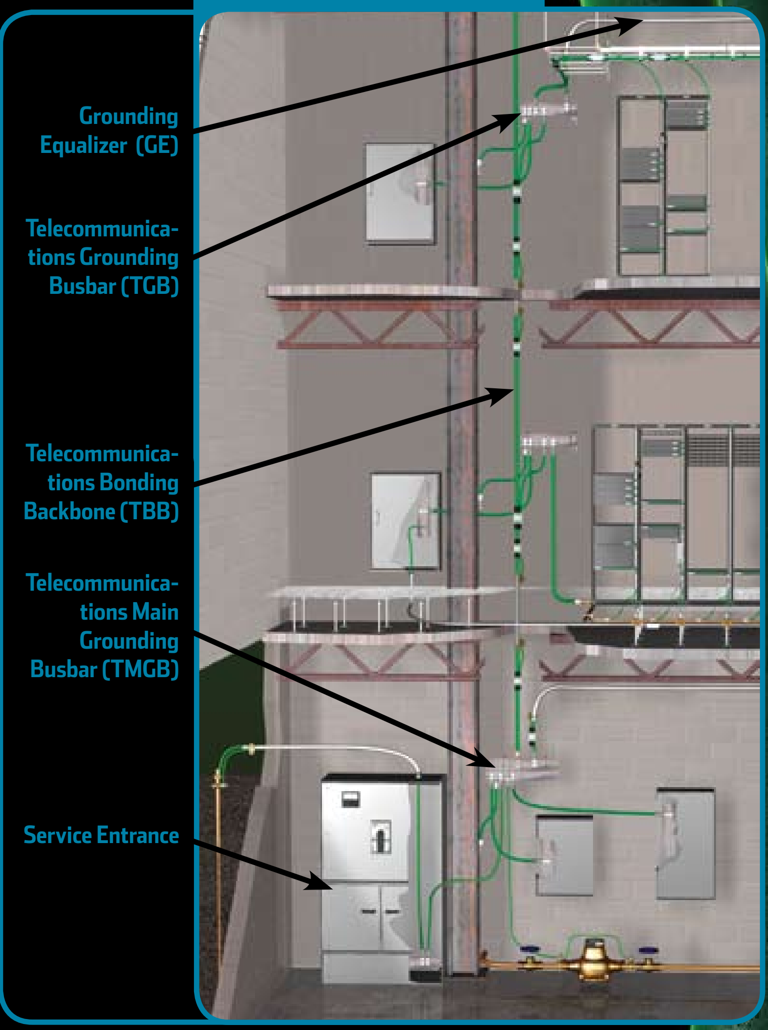
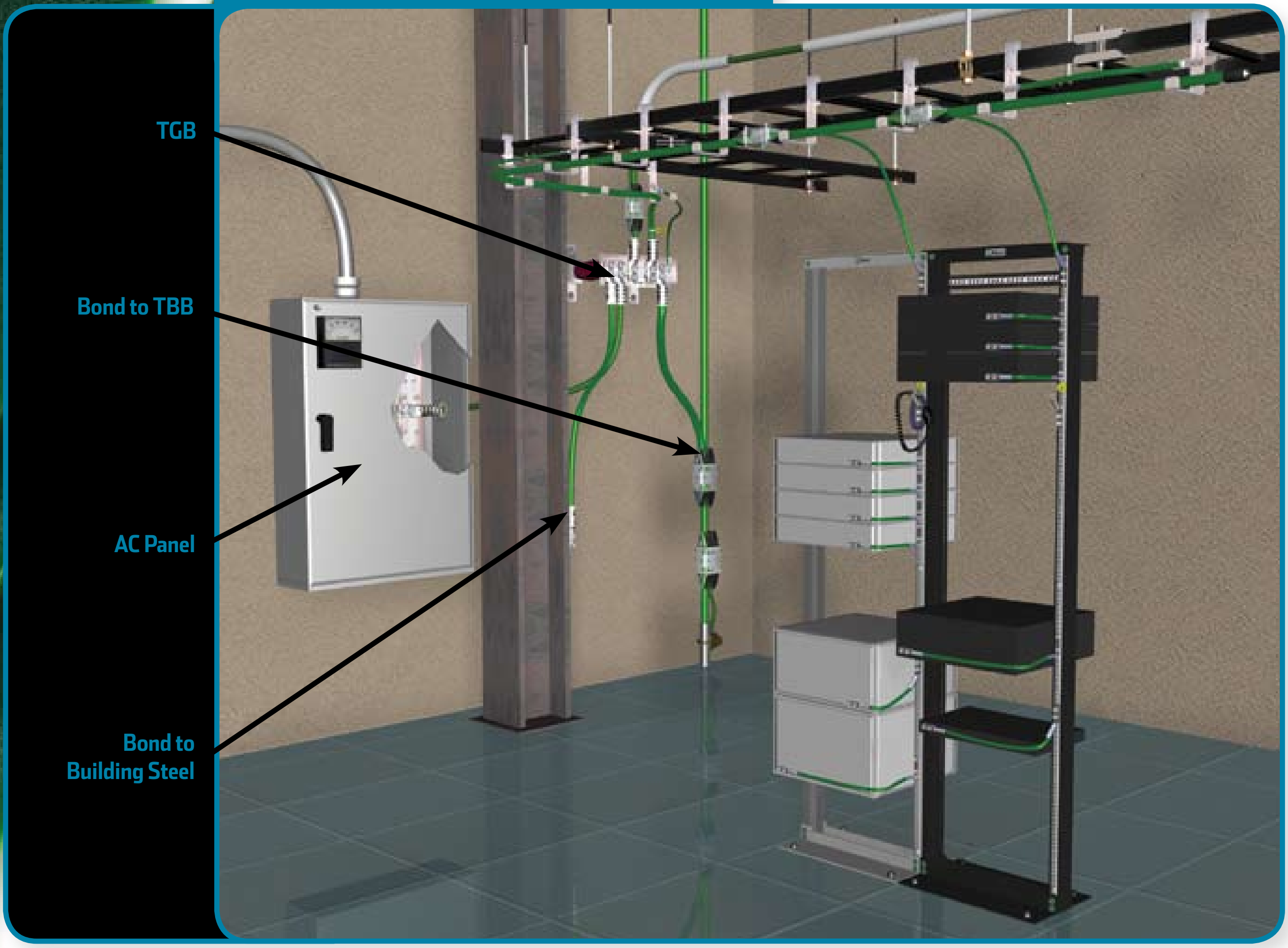


Figure 2. TGB with bonds to the ac panel, building steel and TBB.



Since it is not possible to know how a building will be configured throughout its existence or to accurately predict the grounding needs of future information technology equipment (ITE), good network grounding design in a new facility includes TBBs and GEs.

When the designer encounters an existing building without a telecommunications grounding and bonding infrastructure, careful consideration is required, including the economic costs of the installation. Where feasible, the J-STD-607-A infrastructure should be installed. Where not feasible, a prudent approach is necessary (recognizing that compromises to recommended practices are to be accepted). If networked equipment will operate on consecutive floors, especially if that network will utilize copper cabling, the ability of the equipment to survive a major surge is enhanced by the existence of a TBB. However, if permanent gaps in the multistory structure effectively segregate the network nodes or if the associated data links are decoupled with optical fiber cabling, the primary value of a TBB for that associated vertical section may be reduced. Further, if the telecommunications rooms (TRs) are decoupled, either because the ITE does not communicate between those TRs or because the communications medium is unarmored optical fiber cabling, the primary value of a GE may be reduced.

Within the telecommunications space—which per TIA could be any area of the building that houses ITE, cable terminations and cross-connect cabling—the *TDMM* and J-STD-607-A are in agreement. Here, there should be a TGB, which should always be bonded to the local electrical panel, accessible building steel and the TBB and GE, if present (see Figure 2). A TGB must be installed by a qualified electrician due to the need for a bond to the service panel. Once in place, the TGB offers an accessible place to consolidate bonding conductors and provides a visually verifiable installation.

At a minimum, the designer should require that a TGB be present in each telecommunications space. The TGB must always be bonded to the local electrical panel and accessible building steel (for safety reasons).

Mesh Common Bonding Network vs. Signal Reference Grid

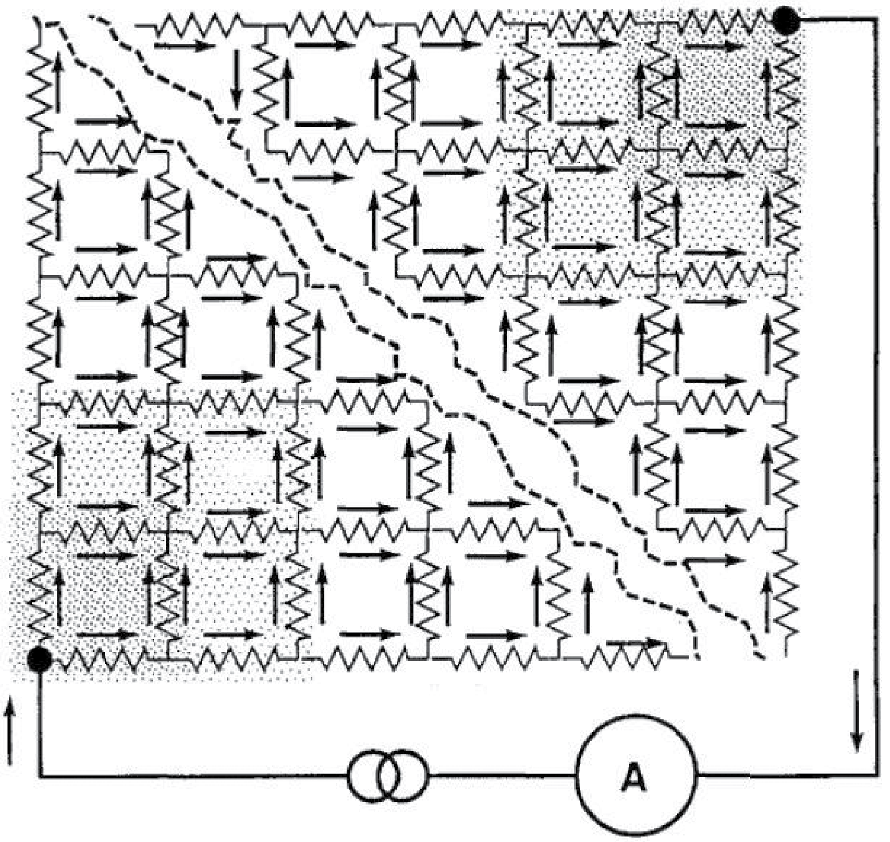


Figure 3. Top view of electrical schematic of an MCBN. Adapted from IEEE 1100, 2005, Figure 4-68. Current density is greatest as shading increases. Density becomes constant across plane after its equipotential line is crossed.

Many data center designers give little thought to the network of conductors that run between the TGB and the equipment. As a matter of practice, many designers specify a signal reference grid (SRG). While people sometimes call any conductor configuration under the access floor an SRG, in a data center an SRG historically refers to a grid of conductors spaced 0.6 meters (2 ft) apart, forming a 90-degree intersection that is usually located at each access floor pedestal. Such a conductor configuration was described by Federal Information Processing Standards (FIPS) PUB 94, *Guideline on Electrical Power for ADP Installation*, in 1983 and later in different versions of IEEE 1100.

SRGs were originally developed to facilitate data communications by reducing the ground potential difference between networked equipment that used unbalanced communications circuits (e.g., RS-232). Modern data equipment typically uses Ethernet, which takes advantage of balanced and isolated signaling circuits, creating virtual immunity to ground potential differences.

In addition to the elimination of signal reference, modern circuits communicate at much higher frequencies than SRGs were designed to operate. IEEE 1100 states that the SRG operates at frequencies up to 30 megahertz (MHz). These frequencies are well below the range at which modern networks operate. Even category 5 operates at up to 100 MHz, while the newer category 6a operates at frequencies up to 500 MHz. Attempting to create a high-frequency grid for modern networks would be prohibitively expensive and impractical due to radiation as the dominant mode past 30 MHz. It also would offer little benefit due to the immunity present within the signaling circuits.

While the role of the bonding network has diminished in terms of facilitating data communications via a common signal reference, reasons for installing a supplemental bonding network—also known in this article as a mesh common bonding network (MCBN)—are that such a network:

- Helps to equalize voltage across metal structures within the room, which minimizes currents on these structures.
- Facilitates static charge equalization.
- Serves to enhance the other electrical protection schemes used within the data center (including serving as a supplemental safety path should the green wire ground become compromised).

When constructed as a grid, the supplemental bonding network acts as a current divider, decreasing the current density as it progressively moves through greater area on the MCBN (see Figure 3). However, the point at which the surge is applied to the MCBN is beset with the full force of that current. Thus, it is important that the connectors used in the construction of the MCBN be tested for their ability to handle ground currents.

In order to maximize the benefits of an MCBN, the following needs to be specified by the designer:

- At a minimum, use #6 AWG round wire per TIA-942, *Telecommunications Infrastructure Standard for Data Centers*.
- Run aisle ground wires under each lineup of racks and cabinets. It is not important to maintain 0.6 m (2 ft) spacing of the conductors. What is important is that the MCBN conductors are conveniently accessible for bonding the jumpers that run to racks and cabinets.
- To facilitate equalization and comply with the recommendations of TIA-942, construct the network as a grid, crossing the aisle grounding conductors at least every 3 m (10 ft).
- Grounding connectors that bond the conductors to one another and to the access floor pedestal must be Underwriters Laboratories Inc.® (UL®) Listed for grounding (UL 467, *Grounding and Bonding Equipment*).
- Bond each rack or cabinet directly to the MCBN at least once with a #6 AWG conductor. Use permanent compression HTAP connectors to bond to the MCBN and a two-hole compression lug to create a permanent bond to the rack and cabinet.

Bonding Requirements Within Racks and Cabinets

Because paint acts as an electrical insulator, a rack with a grounding jumper that bonds to the MCBN may not actually be grounded. Care must be taken to ensure that continuity exists between the structural rack members so that current can flow from any location on the rack to the MCBN jumper. TIA-942 was the first standard to deal directly with this issue, although the European Committee for Electrotechnical Standardization (CENELEC) dealt with the more general issue of requiring the creation of continuity between conductive paths when in 2000 it adopted EN 50310, *Application of Equipotential Bonding and Earthing in Buildings with Information Technology Equipment*. Bonding frame members ensures that racks and cabinets are at the same potential as their surroundings, which improves equipment and personnel safety. Not all installers understand this requirement, so designers still need to specify that provisions shall be made to fully bond racks and cabinets. Acceptable bonding means include using welded frames, scraping paint between mating components and assembling the structure with paint-piercing hardware tested for its ability to create an electrical bond.

Further, it is important to note the grounding requirements for the ITE. Many switches and servers come with locations for grounding jumpers, and the manufacturers of the equipment expect that those grounding pads will be used. The opposite end of the bonding jumper can be bolted directly to the rack mounting rail with thread-forming screws or studs for cage nut rails, preferably onto a grounding strip that guarantees a minimum current-carrying capability, so long as continuity has been established throughout the rack.

Figure 4. Electrostatic discharge wrist strap and wrist strap port.

The network grounding system designer also needs to consider electrostatic discharge (ESD) protection. As equipment runs hotter, more static energy is being generated in data centers. Even though many computer room air conditioners (CRACs) are set at 50 percent relative humidity (RH), data centers are developing hot spots where the humidity can be significantly less. At the 2006 High-Density Computing Symposium hosted by The Uptime Institute, Bob Sullivan presented findings that dipping below 30 percent RH produced a measurable change in the rate of ESD-related equipment damage.

While electrostatic dissipative flooring is recommended for data centers, it should not be the only solution that designers rely upon for protection from static charges. First, polishing the floor with the wrong wax can defeat the antistatic properties of the tiles. Further, it is possible to isolate oneself from the floor by wearing shoes with soles made of an insulating material, especially when RH is low. The largest issue is that service technicians simply ignore ESD protection. As such, designers should make electrostatic discharge wrist straps and wrist strap ports available and convenient for people who work around equipment (see Figure 4).

Equipment found in data networks is rated to IEC 61000-4-2, *Electromagnetic Compatibility (EMC)—Part 4-2: Testing and Measurement Techniques—Electrostatic*

Figure 5. Bonded data center

Discharge Immunity Test, which guarantees ESD immunity to potentials of up to 15 kilovolts (kV). This means that ITE can withstand a static electricity discharge of 15 kV directly to the chassis or data ports without creating data errors or damage. TIA TSB-153, *Static Discharge Between LAN and Data Terminal Equipment*, states that data cables can develop charges with potentials in the tens of thousands of volts from moving air. Wearing a wrist strap plugged into a port that is bonded to the rack guarantees that the data cable jacket is equalized with the rack before plugging the cable into the equipment.

While 15 kV of immunity is available when the chassis is closed, the level of immunity inside the open chassis can be surprisingly low. The Electrostatic Discharge Association, in its *Fundamentals of Electrostatic Discharge, Part One—An Introduction to ESD*, shows that a number of the basic components found on circuit boards can be damaged by less than 2,000 volts (V) of static discharge. By comparison, FIPS PUB 94 states that, "Few subjects can feel a discharge of less than 3,000 to 4,000 V from their own charged bodies…." In short, people can damage equipment without realizing it. For this reason, it is imperative that people who work inside equipment chassis, such as those who perform hot swaps and reconfigurations, wear ESD wrist straps. Making wrist straps and wrist strap ports convenient helps guarantee that people will take proper precautions when working around sensitive electronics.

A drawing of a data center that demonstrates the bonding recommendations in this article is shown in Figure 5.

Conclusion

The world of grounding and bonding has undergone significant changes in recent years. While the standards committees and methods manuals are not in complete agreement, their concepts can be rationalized to deliver a bonding system that offers improved protection of network equipment and personnel.

When specifying the network grounding system, it is important to clearly state the needs of the system. Because of disagreements in the documents that guide industry and changes in the needs of the ITE itself, many people are confused or unaware of how to construct the best grounding and bonding system. Until these issues are formally resolved by the industry documents, a prudent approach is advised.

By following the recommendations in this article, network designers can be confident that the systems they specify support the given applications. ■

Related Industry Activities

ANSI J-STD-607-A is entering a TIA review cycle to commence no later than the fall of 2007. Ongoing BICSI standards committees on Grounding and on Data Centers are continuing related investigations. Several contributors serve on both TIA and BICSI standards committees. BICSI is also convening a task force to investigate grounding application issues between the *TDMM* and related industry standards.

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