Figure 1. Two-hole compression lug required by J-STD-607-A.

Bonding and Grounding Strategies for the Telecommunications Room

By Tom Turner

By location, the lion's share of grounding and bonding opportunities for telecommunications installers exist in telecommunications rooms (TR). While a number of industry standards exist to help guide installers of telecommunications grounding systems, such as IEEE Std. 1100, TIA-942, J-STD-607-A, the forthcoming NECA/BICSI 607, and design manuals like the BICSI *Telecommunications Distribution Methods Manual* (TDMM), confusion still exists. This article walks through a typical telecommunications room installation and discusses recommended practices for installing a telecommunications grounding and bonding system that is reliable, standards' compliant, and professional in appearance.

The key to deploying a system that meets these objectives is by understanding how to apply the information found in the different documents. At every step this article touches on bonding and grounding challenges typically encountered by low-voltage installers, what the standards say, the purpose behind making different

Below: Figure 2. Common bonding connections in the telecommunications closet space include (a) split bolt on cable basket, (b) jumper on ladder rack, (c) HTAP on TBB, and (d) auxiliary cable brackets on ladder rack.

CHECKING YOUR WORK

A telecommunications bonding system runs parallel to the AC power bonding system. Attempting to measure the resistance of any bond will actually result in the measurement of all electrical paths available, making it difficult to measure the resistance of any single bonding connection. As such, it is important to combine a visual inspection with measurements when verifying an installation. An inspection should include the following steps:

Check for excessive currents on the conductors bonded to the TGB. Using a clamp-on ammeter check to be sure AC RMS currents are between 0.0 A and 1.0 A and DC currents are between 0.0 A and 0.5 A.

COMPLETE VISUAL VERIFICATION OF THE BONDING AND GROUNDING SYSTEM:

- Confirm bond between AC panel board and TGB
- Verify continuity within racks/cabinets
- Look for two-hole compression lugs on racks/cabinets and on busbars
- Ensure that ESD wrist strap docking stations are convenient
- Confirm that equipment is bonded to the rack/cabinet
- Perform two-point continuity checks between surfaces where a bond is desired.

bonding connections, and how to install those connections.

THE TGB: WHERE ELECTRICIANS END AND INSTALLERS BEGIN

We start at the point where the electrician's work ends – bonding the electrical power panel (i.e., the panel board) to the telecommunications grounding busbar (TGB). If this bond does not exist, an electrical potential may develop between the AC power system ground and the telecommunications ground. This potential difference allows current to flow that can cause harm to both people and equipment.

By the time the low-voltage installer begins putting in the telecommunications room grounding system, a licensed electrician should have installed this critical bond. Therefore, as a first step before installing the rest of the system, the installer must verify that the bond between the panel board and the TGB exists and is functional. When properly installed, one end of the conductor terminates on the TGB with a two-hole compression lug and the other end terminates directly to the panel board area. The conductor should have a green color to indicate its use for grounding purposes. Ensure that this bond exists before installing the telecommunications grounding system.

BONDS RUNNING FROM THE TGB

The next step to installing the grounding system is to complete all the other required bonds to the TGB per J-STD-607-A and IEEE Std. 1100. These include the following bonds: accessible building steel, any metallic raceways or ladder racks used for routing telecommunications cabling, and the telecommunications bonding backbone (TBB).

Because of their convenience, it is not unusual to see one-hole lugs bonded to busbars in telecommunications spaces. However, one-hole lugs can twist if the conductor is bumped, causing the bolted connection that bonds them to the mating surface to loosen. If this connection becomes loose, it can create a high resistance that may prevent the telecommunications grounding system from functioning as intended. It is estimated that as many as ten percent of one-hole tongue lugs used on telecommunications grounding busbars are loose.

J-STD-607-A requires that connections to the TGB be made with compression connectors having two-hole tongues (see Figure 1). Anti-oxidant should also be applied to the mating surface between all lugs and their mounting surface, regardless of whether the mounting surface is a busbar or something else.

The choice of bonding hardware can also affect the long-term integrity of the bond. The forthcoming BICSI 607 standard will likely require the use of flat washers on both sides of the busbar (for load distribution) along with one belleville (i.e. conical) washer to ensure that the connection remains tight. Also, to minimize corrosion from material incompatibilities, the use of stainless steel or silicon bronze hardware also will likely be required.

Several options exist for bonding conductors to building steel. One option is to use a flange-type bonding connector, which bolts onto building steel and provides a mounting pad on which to attach a two-hole compression lug. Another option is to drill holes in the building steel and bolt a two-hole lug directly to the steel. A #6 AWG conductor should be used to make this bond in most telecommunications spaces (per J-STD-607-A). The exception occurs in the computer room of a data center, where TIA-942 requires mating a #4 AWG conductor to each steel column.

Methods for bonding conductors to metallic raceways depend on the type of raceway deployed. For cable baskets, split bolt connectors can be used to attach bonding conductors; if the cable basket is made of galvanized steel, use tin plated split bolts to minimize corrosion. For ladder racks, if sections of the ladder rack are not joined with hardware that creates a bond, two options exist for creating electrical continuity. The first is to use an auxiliary cable bracket that is designed to bond ladder rack sections together without drilling holes in the ladder rack. The second is to drill two holes in the ladder rack on each side of the splice that joins sections together and then bolt a jumper wire to the holes (see Figure 2).

Finally, a telecommunications bonding backbone, or TBB, is a conductor that is used to equalize potentials between telecommunications spaces. Because the BICSI *TDMM* makes the installation of this conductor optional, engineers may choose not to specify it so a TBB may not be present in every installation. When specified, the TBB should be run as a continuous conductor from the telecommunications main grounding busbar (TMGB) to the furthest TGB in the building. At each TBB, use a compression HTAP connector to bond a jumper wire to the TBB, and bond the other end of the jumper to the TGB with a two-hole compression lug and the appropriate bonding hardware (as previously described).

BONDING CABINETS AND RACKS

Once all bonds from TGB to building steel, raceways, and TBB have been made, the TR is ready for racks and cabinets to be deployed and bonded to the TGB. This process can be broken into two smaller steps: (1) ensuring electrical continuity within rack and cabinet units, and (2) bonding these units to the busbar.

When assembling and installing racks and cabinets, TIA-942 and the upcoming BICSI 607 require the installer to verify that electrical continuity exists between all structural members. The paint used on racks and cabinets acts as an electrical insulator, preventing the flow of electricity from one section of the rack or cabinet to another. Therefore, attaching a grounding jumper from the rack to the TGB may not actually ground the entire rack, which results in a safety hazard.

Racks and cabinets are available that are fully bonded upon arrival from the manufacturer. Other rack designs contain provisions to create electrical continuity via grounding washers as the units are assembled in the field (see Figure 3). Otherwise, it is important to use paint-piercing hardware tested for its ability to create an electrical bond as the rack or cabinet is being assembled or, a last option is to scrape the paint between the mating components.

After the rack is assembled, install electrostatic discharge (ESD) wrist strap ports approximately forty-eight inches above the floor in racks that house active equipment, such as switches. Having such ports available allows people who service that equipment to have a convenient place to plug in their ESD protection wrist straps, thus protecting the equipment from damage while it is being worked upon (see Figure 4).

Different options exist for how to bond racks to the busbar (see Figure 5). Which method is chosen often depends upon the size and configuration of the installation. In TRs with about a half-dozen racks or less, the most convenient method of bonding the racks to the busbar is to run a jumper, known as a telecommunications equipment bonding conductor (TEBC) directly from each rack to the TGB.

In larger installations, the number of lug mounting locations on the busbar and the management of the grounding cables present a more complicated bonding situation. Under these circumstances the installer should run a continuous TEBC from the TGB down each row of racks, making a bond from the TEBC to each rack. These jumpers should be bonded to the TEBC using compression HTAP connectors, and bonded to the rack using a two-hole compression lug. The use of this lug at the rack is quite important, as this is a series circuit (where only one connection is made between rack and TEBC) and a two-hole compression lug will maintain the reliability of the connection at the same level as connections to the TGB. Compression connectors are required by many grounding standards and specifications because the connector barrel will not loosen from the conductor over time.

Figure 3. Grounding washers can be used to create electrical continuity in racks and cabinets. In this photo a bolt and washer is removed, showing paint removal from the contact area (bottom right).

Figure 4. ESD wrist straps and ports enhance equipment protection.

The conductors used in bonding the racks to the TGB should be insulated with an all-green jacket or a green jacket having a distinctive yellow stripe to visually indicate them as being used for grounding purposes. In most telecommunications closets, use of a #6 AWG TEBC will be sufficient due to the limited length required within a closet space. When bonding the conductor to the rack, it is important to remove insulating paint from the mating surface to complete the connection. For this purpose, most installers prefer to use thread-forming screws that remove paint from the thread holes as they are installed, or to use suitable bonding hardware for cage nut rail applications. It is also acceptable to simply

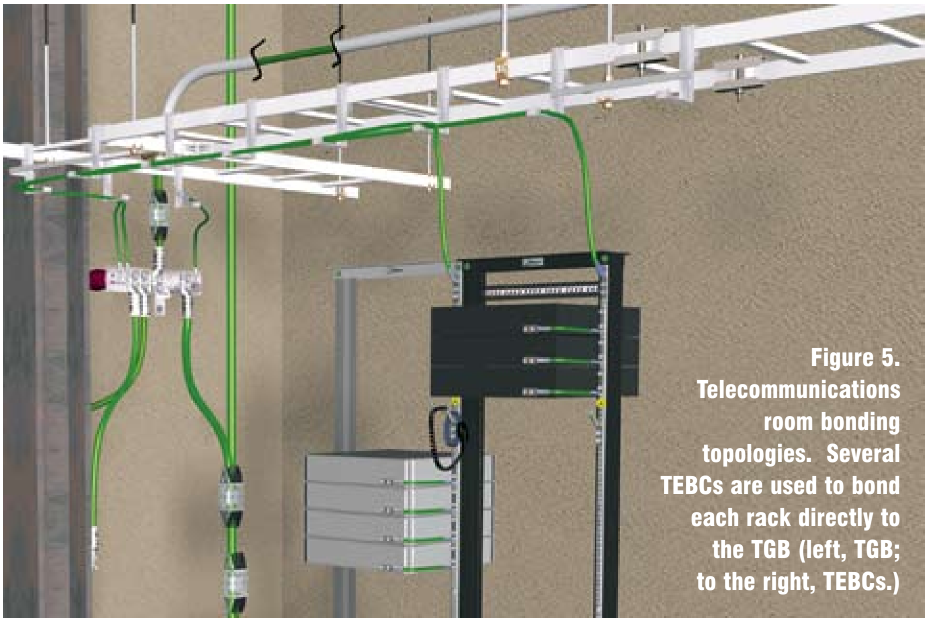

Figure 5. Telecommunications room bonding topologies. Several TEBCs are used to bond each rack directly to the TGB (left, TGB; to the right, TEBCs.)

scrape the paint off the rack in the area that the lug will bond, but is more time and labor intensive than using thread-forming screws.

BONDING EQUIPMENT TO RACKS

The final step for an installer is to bond active equipment (such as switches and servers) to the rack or cabinet as it is installed. The forthcoming BICSI 607 standard will likely contain the following statement when it is officially adopted:

"Grounding through the equipment AC (alternating current) power cord does not meet the intent of this standard. It is intended that the AC power ground path and the telecommunications ground path offer redundant and specific ground paths for the equipment. While the AC-powered equipment typically has a power cord that contains a ground wire, the integrity of this path to ground cannot be easily verified. Rather than relying on the AC power cord ground wire, it is desirable that equipment be grounded in a verifiable manner as described in this Standard."

The best strategy to meet the intent of this statement is to use a discreet jumper wire that bonds from a lug mounting pad (if provided by the manufacturer) on the active equipment and terminates via a two-hole compression lug at a busbar or vertical grounding strip attached to one of the rack's equipment mounting rails. The busbar or vertical grounding strip should be used to provide a visually verifiable, all-copper grounding path.

When equipment does not provide a lug-mounting pad, the next best option is to bond the equipment mounting flanges directly to the rack rails. If the equipment mounting flanges are painted or covered in a non-conductive coating, bonding screws can be used to make this bond (i.e. thread-forming screws with serrations under the head of the screw will remove coatings from the surface to which they are mounted).

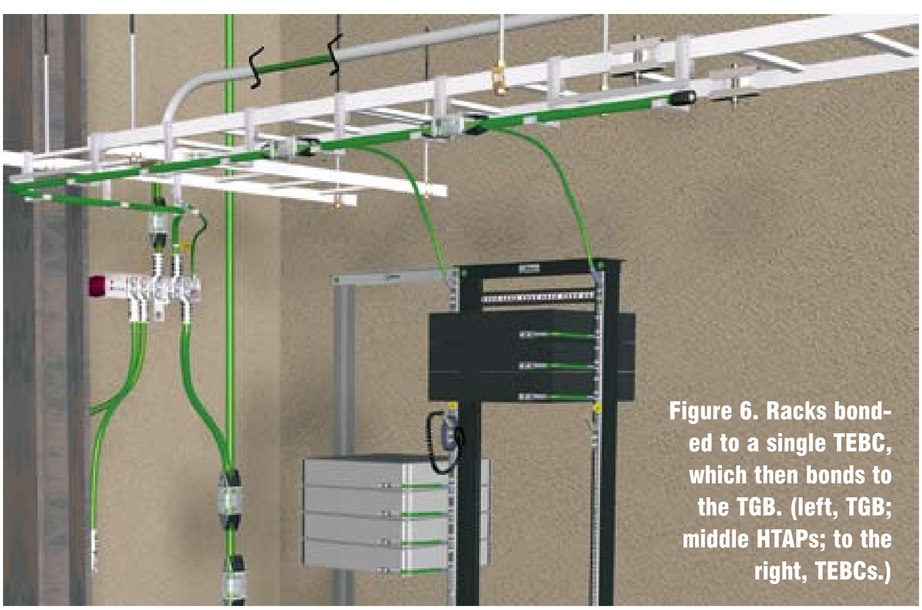

Figure 6. Racks bonded to a single TEBC, which then bonds to the TGB. (left, TGB; middle HTAPs; to the right, TEBCs.)

CONCLUSION

The deployment of a reliable bonding and grounding system to support uptime goals has never been more critical. Once the AC power ground has been bonded to the TGB, installers can follow these basic steps in common TR spaces include the following:

- Verify that the AC panel board is bonded to the TGB.
- Bond the TGB to the telecommunications grounding and bonding infrastructure.
- Create continuity within racks and cabinets.
- Bond the racks and cabinets to the TGB.
- Bond the equipment to the racks.

When these steps are followed, the result is a robust grounding and bonding system, satisfying the intent of the standards and professional in appearance. ■

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