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Indoor Grounding of Data Centers to IEC30129 and TIA607-E Standards

Whitepaper

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Abstract—The indoor grounding system at a data center has been an evolving discipline from its inception in the early days where almost all data centers had a raised floor construction. Today raised floor designs are less common and more thought is needed in the design of indoor grounding systems. Standards IEC 30129 and AS 30129 Telecommunications Bonding Networks for Buildings and Other Structures and Standard TIA607-E Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises provide guidance on the design and installation of the indoor grounding systems suited for the modern datacenter. This paper will discuss the design requirements and common installation practices for the implementation of a good grounding system that would follow these guidelines. It will also discuss how the data center indoor grounding system is interfaced with other grounding systems like the low voltage or the LV ground, the high voltage or the HV grounding system, the DC Power grounding system and grounding system for any adjacent renewable energy source like photovoltaics. The key reasons for the design and installation of the grounding system are:

- *Noise and Transient Control*
- *Fault-current mitigation*
- *Equipment protection*
- *Protection of people*
- *Signal reference*
- *Reducing effects of ground loops*

INTRODUCTION

The indoor grounding system for a data center is critical to the operation of the facility. The traditional data center was constructed as a raised floor design but in modern data centers this type of construction is becoming less common. The raised floor system provided a mechanism for cooling by pumping cold air via floor opening into equipment racks. In modern data centers which don't have raised floor, hot and cold air containment system, liquid cooling, liquid to air cooling, inrow cooling and in-rack cooling has become more dominant. The space below the raised floor in traditional data centers was also used for cabling and a mesh bonded network or MBN for grounding. With the decline of raised floor data centers, the existence and requirements of MBN has diminished.

MBN is defined as "a bonding network to which all associated equipment (e.g. cabinets, frames, racks, trays, pathways) are connected using a bonding grid, which is connected to multiple points on the common bonding network."
Refer STANDARD TIA-607D Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises. [1]

Standards have emerged or modified now to allow a indoor grounding systems to be constructed using the Star Isolated Bonded Networks IBN method or Star-IBN. Star-IBN has been used for a much longer time in telecommunications rooms, usually powered by 48 VDC power systems. Isolated bonding network or IBN is defined in Standard ITU K.27 Bonding Configurations and Earthing Inside a Telecommunications Building as a bonding network that has a single point of connection ("SPC") to either the common bonding network or another isolated bonding network. All IBNs considered here will have a connection to earth via the SPC [2]. Standards TIA 607 and Standard IEC-30129 both have provisions whereby MBN and Star-IBN can co-exist at the same facility.

HISTORY OF MESH BONDING NETWORKS BONDING

In early computer or data rooms, there was a need for very strong signal reference so that data would not become corrupted during peer to peer communications. This signal reference was provided by the mesh bonding network, MBN or the signal reference grid SRG. Most of the data was transmitted via copper conductors and in some communication methods, the signal wires were not balanced or were not a twisted pair.

Standard IEEE 1100-999 Recommended Practice for Powering and Grounding Electronic Equipment has a large section in Chapter 4 that explains this need in early computer rooms. There is very good analysis of how ground bonding conductors behave at high frequencies in this standard.

Noise, or interference, can be defined as undesirable electrical signals that distort an original (or desired) signal, or interfere with it. Good indoor and outdoor grounding reduces noise and when noise level is high, the signal to noise SNR ratio is low. The Bit Error Rate (BER) is the number of acceptable errors the data equipment can tolerate. This is typically a number between 0.1 (considered bad) and 0.000001 (considered very good).

This BER is closely linked to the Signal-to-Noise-Ratio (SNR) which is measured in decibels (dB). Modern digital communication protocols and modulation techniques haveerror correction methods and techniques built in like parity bit, check sum and cyclic redundancy check to achieve clean signal in the receive end. However when these error correction techniques are used, the sending equipment may have to retransmit data to help fully recover it. Hence high BER can result in multiple re-transmission of same signal chewing up the available bandwidth and reducing data speeds. When noise is very high, the error correction techniques may not work. Grounding, bonding and shielding systems contribute significantly towards controlling these noise levels and minimize interference.

While noise level in a data center is still a consideration, the need for a strong signal reference provided by traditional mesh bonding networks is less important in a modern data center. This is because peer to peer communications is either via optical fiber communication which is not susceptible to noise or twisted pairs in ethernet communications where mutual coupling in the twisted pairs helps mitigates much of the data corruption due to noise. Furthermore error correction techniques discussed above help detect and recover most of the lost data. Henceforth the importance is mesh bonded networks has diminished in modern data centers.

HISTORY OF STAR ISOLATED BONDING

In the telecommunication industry (–48 VDC Powered) the noise mitigation using twisted pair balance signal wires has been used from early days of telegraphs and plain old telephone lines. This was a necessity from the beginning as telephone lines run in the streets were subject to noise being induced by various sources including power lines.

Hence the need for strong signal reference grid in the telephone exchanges was significantly less than in early computer room. While excessive noise of lines would still be a problem, much of this would be mitigated by mutual coupling in twisted pair balanced phone wires. Subsequently star isolated bonded networks have been an incumbent practice in telecommunications networks for a long time. The advantage that Star IBN offers is tight control of ground or earth loops minimizing risk of equipment damage from disturbances like lightning surges. Due to the gradual disappearance of raised floor systems and lesser need for a strong signal reference in data centers, there is convergence of data center standards towards Star IBN systems as well.

TIA 607 GENERIC TELECOMMUNICATIONS BONDING AND GROUNDING FOR CUSTOMER PREMISES

The purpose of this Standard is to enable and encourage the planning, design, and installation of generic telecommunications bonding and grounding systems within premises with or without prior knowledge of the telecommunications systems that will subsequently be installed[1]. While primarily intended to provide direction for the design of new buildings, this Standard may be used for existing building renovations or retrofit treatment.
This standard is for customer premises grounding. It is generally used for the grounding and bonding of computer and data rooms and large data centres. They may be used by carriers in some datacentre and other applications. Figure 1 below is taken from TIA607-D Standard[1].

The Primary Bonding Bar (PBB) is the a single point connection window and usually at the basement of a building. The PBB serves as the dedicated extension of the building grounding electrode system for the telecommunications infrastructure. The PBB also serves as the central attachment point for the Telecommunication Bonding Backbone TBB(s) and equipment.

Bonding conductor for telecommunications (BCT) bonds the PBB to the service equipment (power) ground [1].

Telecommunications bonding backbone (TBB) is a conductor that interconnects all Secondary Bonding Bars (SBB) with the PBB. The intended function of a TBB is to reduce or equalize potential differences. A TBB is not intended to serve as the only conductor providing a ground fault current return path. The TBB originates at the PBB extends throughout the building using the telecommunications backbone pathways, and connects to the SBBs in distributors [1]. SBB is the grounding connection point for telecommunications systems and equipment in the area served by a distributor [1].

Each computer room shall contain a SBB (or PBB when specified in the design) and should also contain a supplementary bonding network that is bonded to the SBB or PBB. This supplementary bonding network may be in a form as identified in Figure 2 below but is typically a mesh-bonding network (mesh-BN) [1].

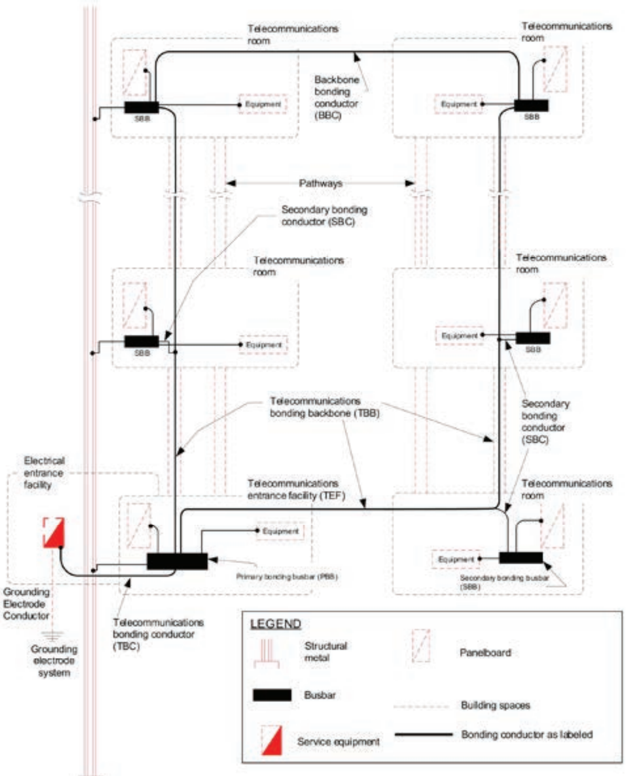


Fig 1: General Arrangement in TIA 607-E

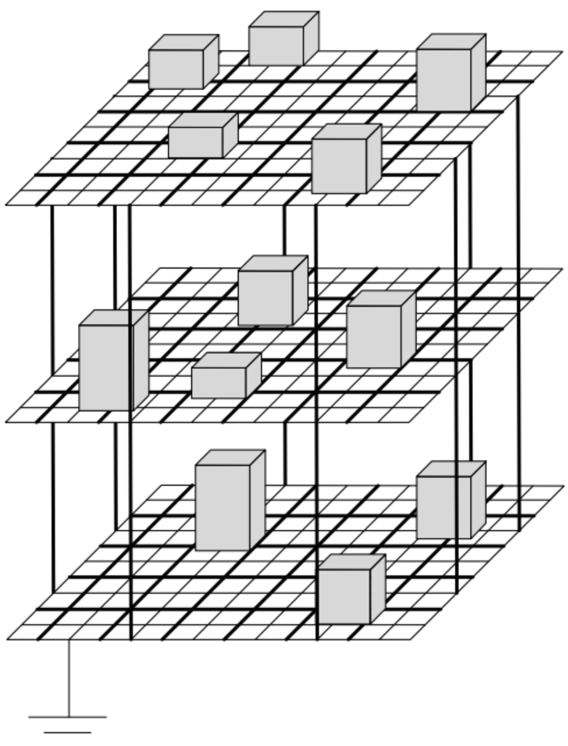


Fig. 2. Mesh Bonding Network

The supplementary bonding system or MBN stipulated in last paragraph was the primary method of indoor grounding in early standards but in this version it is not a "shall be" requirement.

If the mesh is constructed from flat conductors, the mesh should be prefabricated of minimum of 0.4 mm (0.0159 in; 26 gauge) x 50.8 mm (2 in) wide copper strips with all crossings and joined sections properly welded [1]. Where the mesh is constructed from standard, bare round wire, the conductors shall be a minimum sized conductor of No.6 AWG (16 mm^2) stranded copper conductors joined together via proper welding, brazing, listed compression connectors, or listed grounding clamps at each of the crossing points. [1] If the mesh is constructed using the access-floor pedestals, the flooring system must be electrically continuous and must be bonded together every 4 to 6 pedestals in each direction using a minimum sized conductor of No. 6 AWG stranded copper conductors and listed pedestal grounding clamps [1].

IEC30129 INFORMATION TECHNOLOGY: TELECOMMUNICATIONS BONDING NETWORKS FOR BUILDINGS AND OTHER STRUCTURES

The IEC 30129 is a recent standard in comparison to TIA 607. Similar to Standard TIA 607D it provides star IBN as the prime method for indoor grounding. The example below in figure 3 shows the layout of the Star-IBN system in a large building. It must be noted that as a contrast to TIA 607D, the bonds from the star-IBN to the building is not shown. The terminology for Primary Bonding Bar PBB and Secondary Bonding Bar SBB is now harmonized between IEC 30129 and TIA 607D. In IEC30129 there is an added ground bar, Main Earth Terminal or MET. [18]

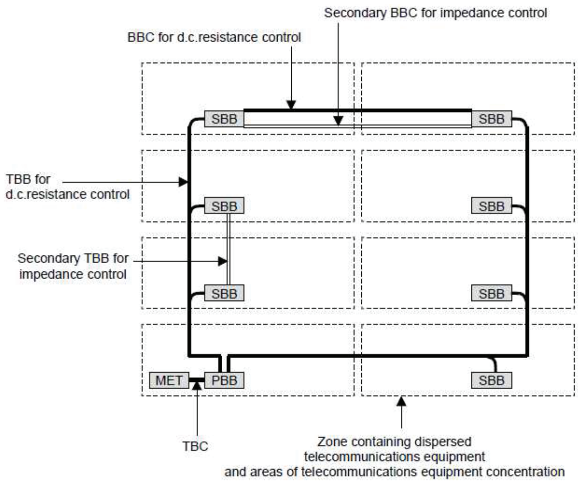


Fig. 3. Star-IBN in Large Building IEC 30129

SBB – Secondary Bonding Busbar

PBB – Primary Bonding Busbar

TBB – Telecommunications bonding backbone

TBC – Telecommunications bonding conductor

MET – Main Earthing Terminal

The IEC 30129 standard recognizes that where the telecommunications equipment is served by the Star-IBN the following problems may result where the cables lengths are long or the items of equipment are some distance from each other [3]

1) a high common impedance between equipment particularly at high frequencies

2) potential large ground loops

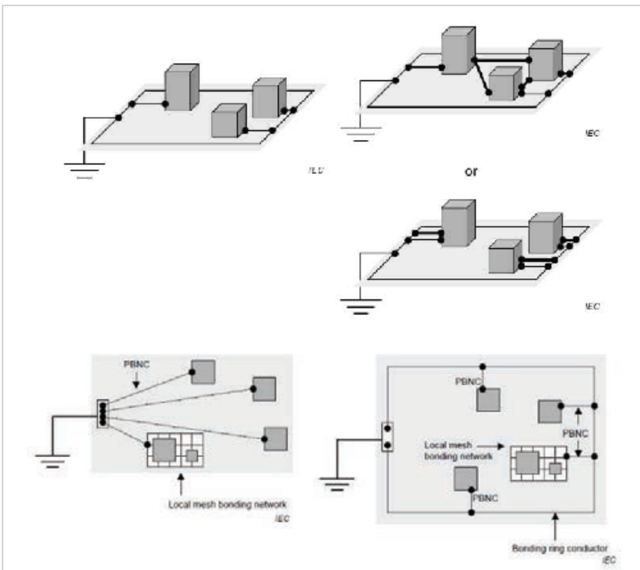
In addition to the Star-IBN the IEC30129 also allows the use of additional bonding and localized MESH-BN, compliment the star-IBN in order to reduce the above problems.[3]

INTERFACE OF MULTIPLE GROUNDING SYSTEMS

One area of grounding and bonding that is extremely important from a safety and performance point of view, is the interface of multiple grounding systems at a data center or a telecommunications facilities.

This interface of various earthing systems is not covered well in standards. One reason for this shortcoming is that most electrical standards cover a particular voltage systems and do not extend beyond that system. However the grounding system of various power systems coexisting at one facility always overlap. There may additionally be country or state specific rules that restrict how various grounding systems are interfaced.

Figure 5 is an example of a good inter-system bonding at a facility where medium voltage, low voltage, communications systems and extra low voltage and HVDC systems all co-exist. This intersystem bonding will be simpler at facility that only have medium and low voltage systems. An example of a good inter system bonding method for this type of facility is shown in Figure 6.



Fig, 4. Additional Bonding and Localized Mesh Networks IEC 30129

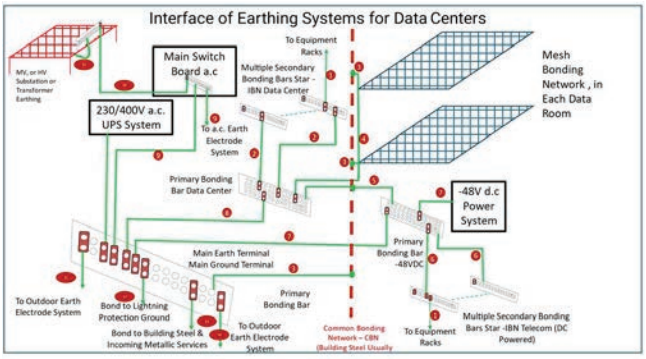


Fig. 5. Interface of Grounding or Earthing Systems at a Data Center (Multiple power systems)

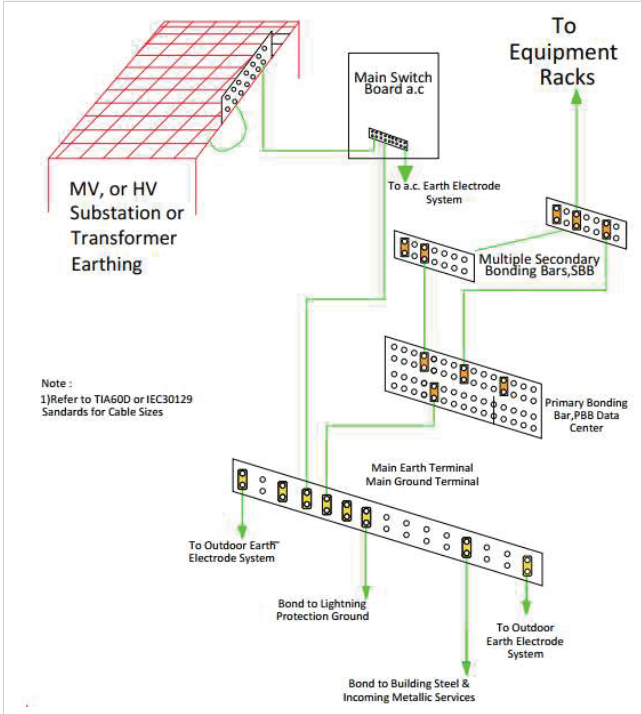
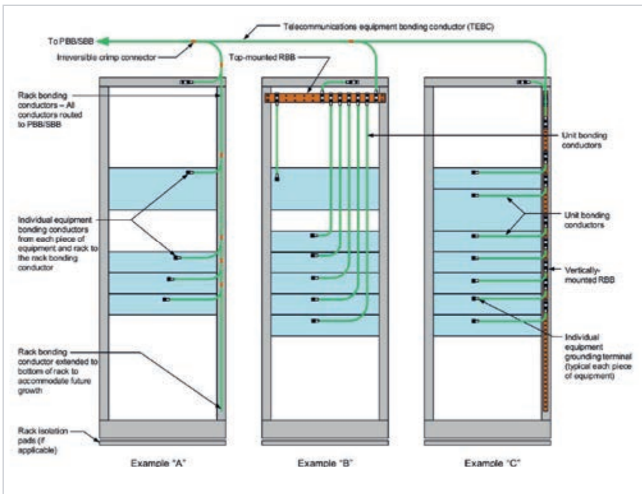


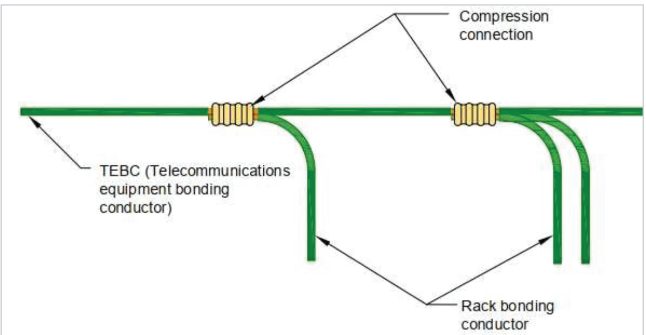
Fig. 6. Interface of Grounding or Earthing Systems at a Data Center (One Power System)

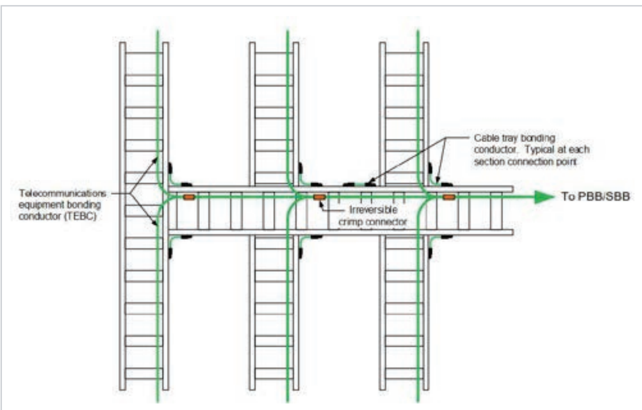
RACK, CABINET AND CABLE TRAY BONDING

The equipment and the cabinets are connected to the indoor grounding system via the Telecommunication Equipment Bonding Conductor (TEBC) using one of the three methods shown in Figure7. This methods is identical in TIA607C and IEC 30129. The TEBC is run on cable trays as shown below. All joints of cable trays shall be bonded across with a short wire as shown. All connections shall be irreversible crimp conductor. The typical arrangement of cable tray bonding and TEBC connections is shown in Figure 7 [18].

The bend radius on the TEBC shall not be less than 200 mm. The angle bend of any grounding conductors shall not be less than 90 degrees. Smaller bends radius may be permitted on grounding wires at cabinet level. However sharp bends shall be avoided where possible [18].







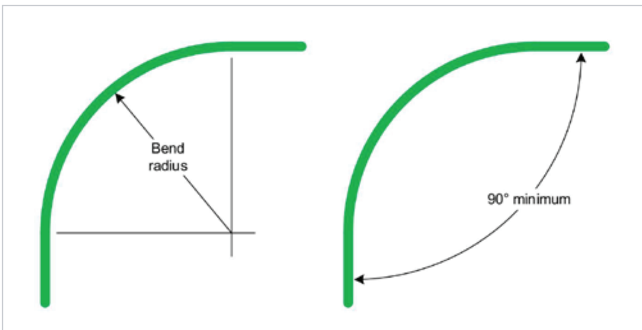


Fig. 7. Rack, Cabinet and Cable Tray Bonding TIA 607-E

CONCLUSION

There is strong harmonization between standards TIA 607D and IEC30129 for indoor grounding systems of data centers. Both standards acknowledge the prime system for indoor grounding should be star-IBN system. However there is provision to superimpose mesh bonded networks, MBN with the IBN at facilities where there is MBN.

REFERENCES

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