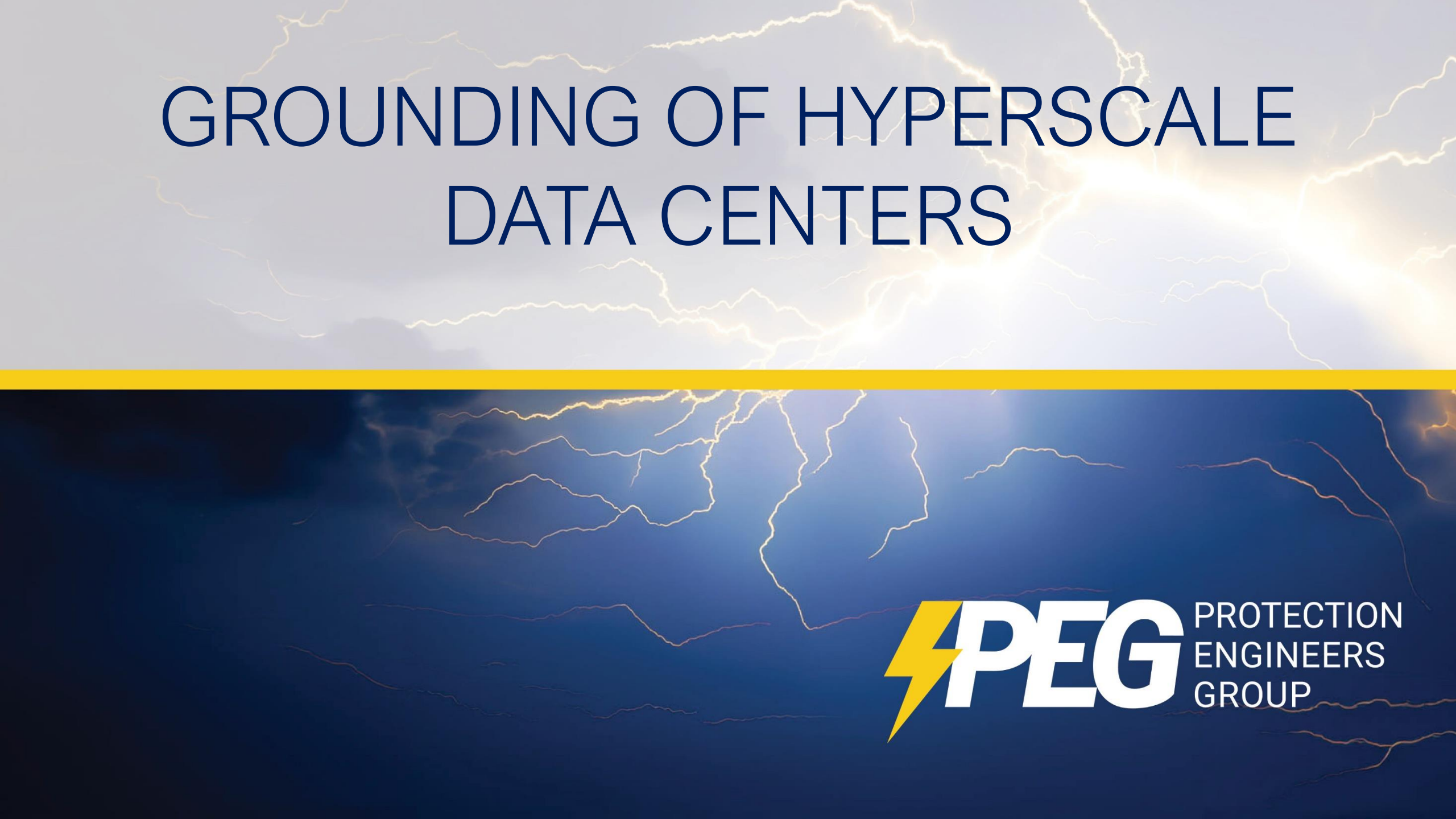
GROUNDING OF HYPERSCALE DATA CENTERS



Grounding System at Data Center

Contents

- Indoor grounding & Bonding
- Outdoor Ground Electrode
- High Voltage grounding
- Possible Renewable source grounding
- HVDC grounding
- Lightning Protection grounding
- Intersystem Bonding

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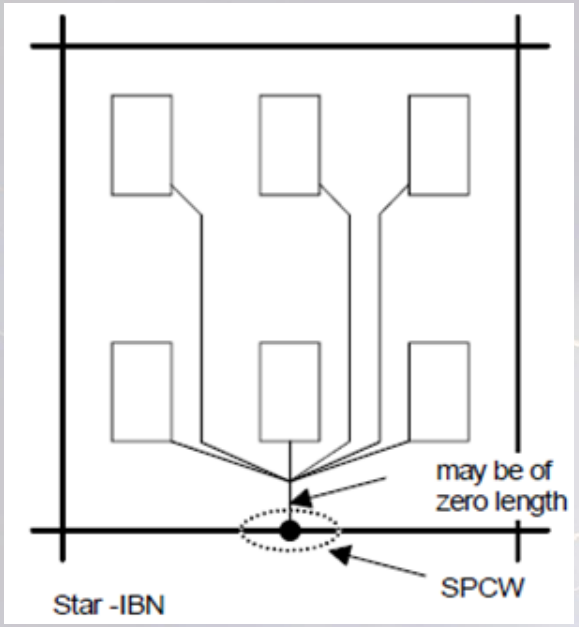
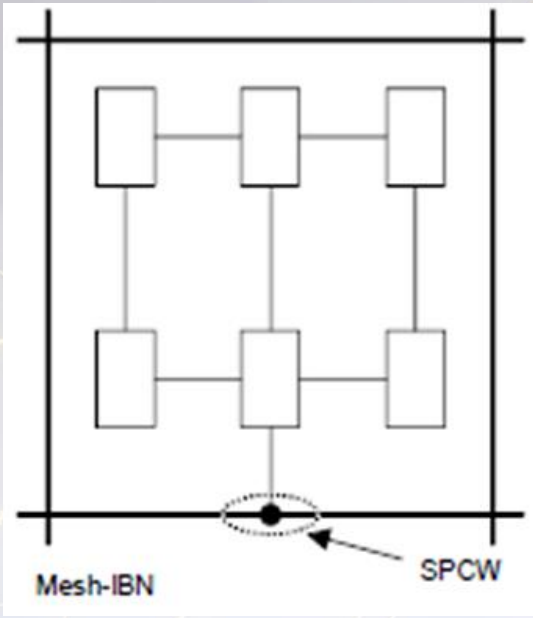
International Telecommunications Union

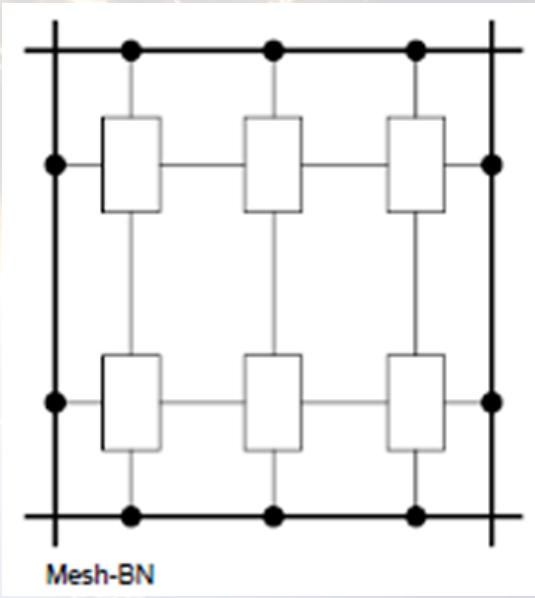
https://www.itu.int/ITU-T/recommendations/index.aspx?ser=K

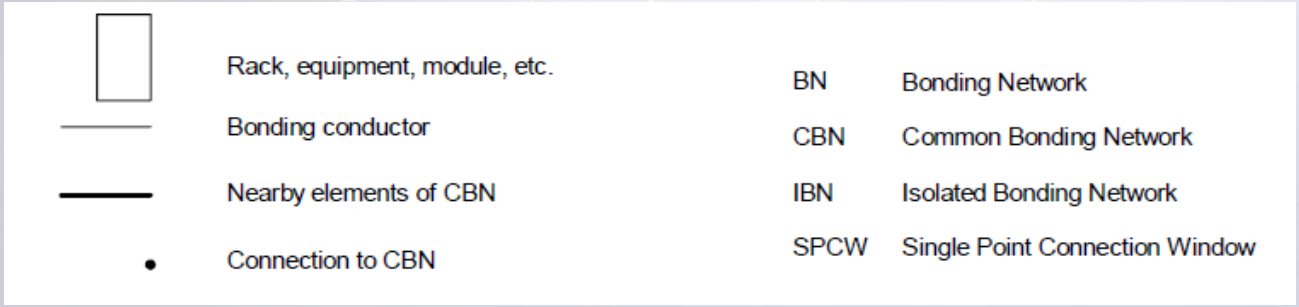
ITU was founded in Paris in 1865 as the International Telegraph Union. It took its present name in 1934, and in 1947 became a specialized agency of the United Nations.

Indoor grounding as Per ITU K.27[1]





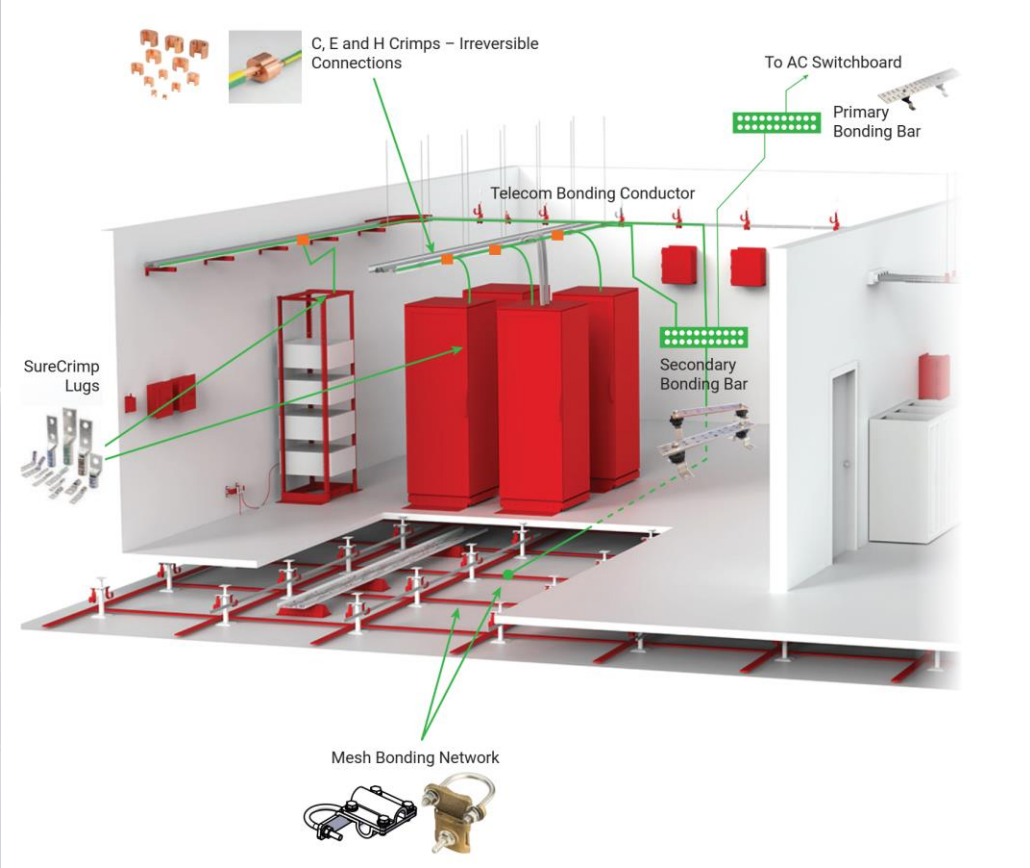




Star-IBN and Mesh-IBN

Star-IBN

- All indoor grounding connections end up at a single point
- <u>Via Spurs of Cables</u>
- One connection between indoor and outdoor grounding
- Modern DC

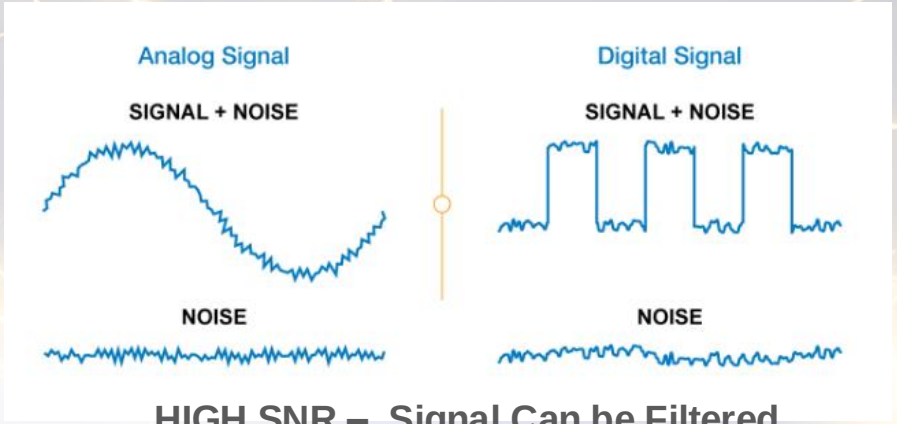


Mesh -IBN

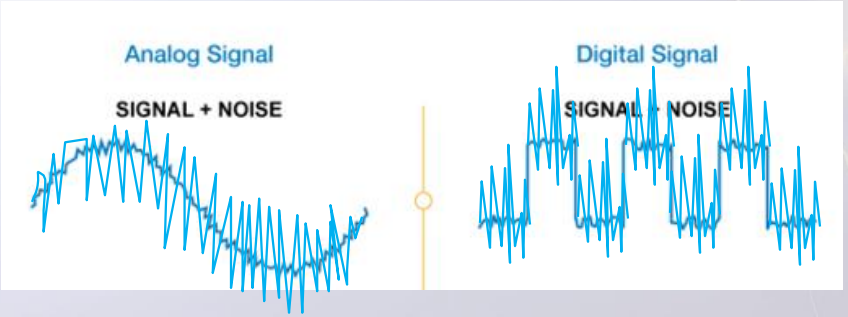
- All indoor grounding connections end up at a single point
- <u>Via Mesh Below Raised Floor</u>
- One connection between indoor and outdoor grounding
- Traditional DC

Noise in Communication Systems

- Noise, or interference, can be defined as undesirable electrical signals that distort an original (or desired) signal, or interfere with it. Good grounding reduces noise.
- When noise is high, the signal to noise SNR ratio is low. Bad!!
- When noise is low, the signal to noise ratio is good. GOOD
- The Bit Error Rate (BER) is the number of acceptable errors you are prepared to tolerate. This is typically a number between 0.1 (every 10th bit is bad!) and 0.000001 (Only one in a million is bad).
- This BER is closely linked to the Signal-to-Noise-Ratio (SNR) which is measured in decibels (dB).



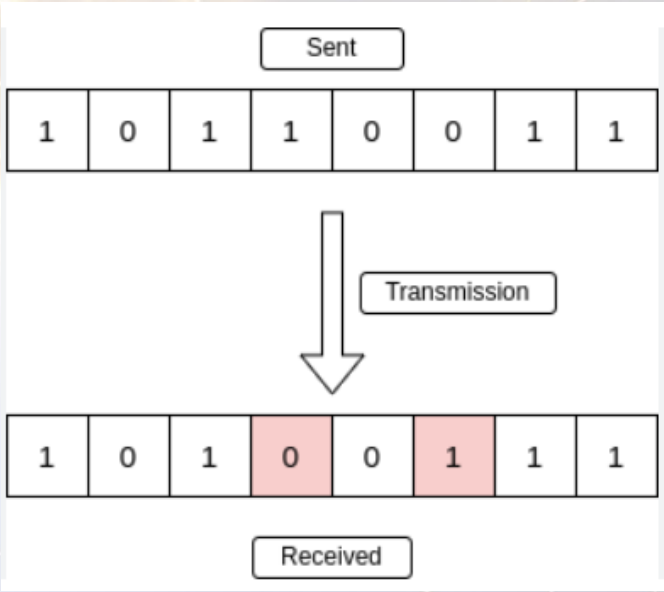
HIGH SNR – Signal Can be Filtered.
Low BER



LOW SNR – Signal Distorted
Not possible to Filter, High BER

Noise in Communication Systems

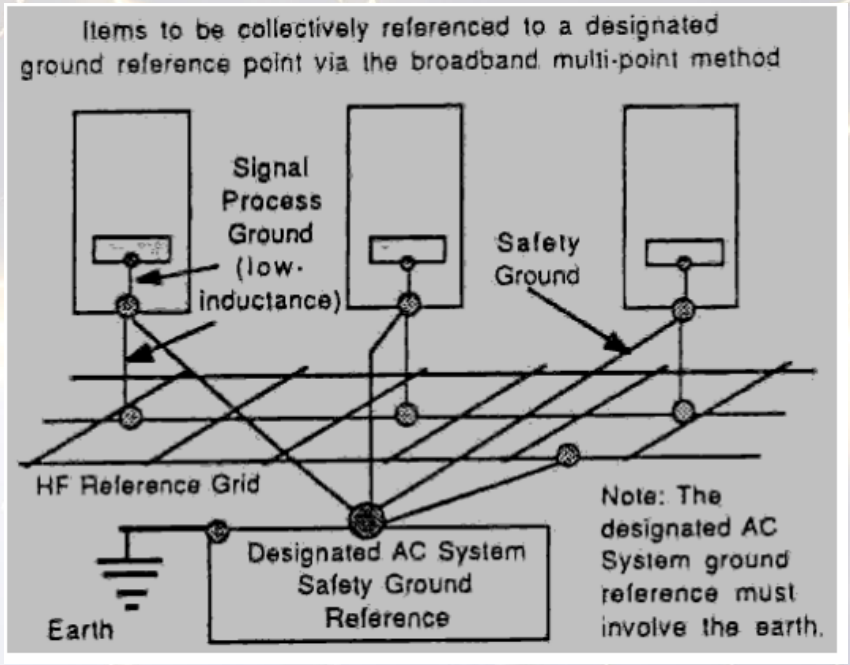
- Modern Digital Communication have error correction methods and techniques built in like Parity bit, Check Sum and Cyclic Redundancy Check - To achieve clean signal in the receive end
- But sender may have to re-transmit data to help fully recover it.
- So high BER can result in multiple re-transmission of same signal chewing up the available bandwidth reducing data speeds
- Where 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.



Effect of Noise on Digital Transmission

Legacy Data Centers

- 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.



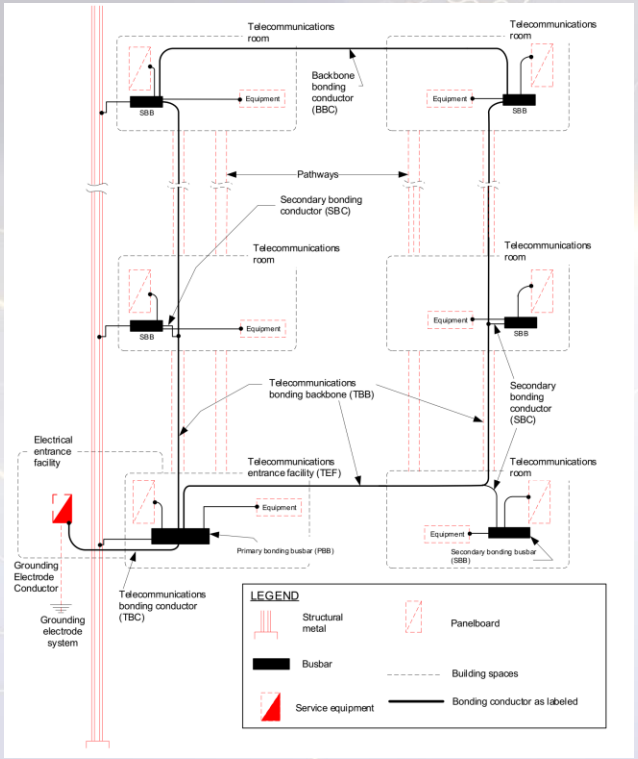
High-frequency grounding of electronic systems powered from building ac power system (IEEE 1100 2005) [2]

Modern Data Centers

- 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 balanced twisted pairs in ethernet communications where mutual coupling in the twisted pairs helps mitigate much of the data corruption due to noise.
- Furthermore, error correction techniques help detect and recover most of the lost data.
- Henceforth the importance of mesh bonded networks has diminished in modern data centers.

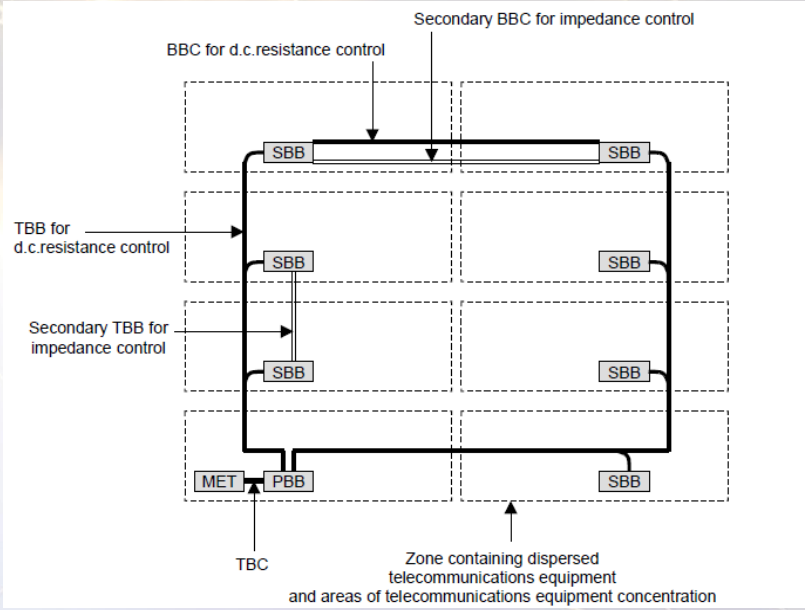
Star-IBN in TIA 607 E and IEC/AS30129 [3][6]

- Harmonized largely
- PBB – Primary Bonding Bar is Single Point Connection
- SBB – Secondary Bonding Bar for Distribution
- TIA 607 E shows CBN to Steel
- MET only in IEC/AS 30129
- Bonding each SBB to building steel is permitted and recommended in most countrie but IEC standard does not show this



Star-IBN in Large Building TIA 607 E

Star-IBN in Large Building AS/IEC30129



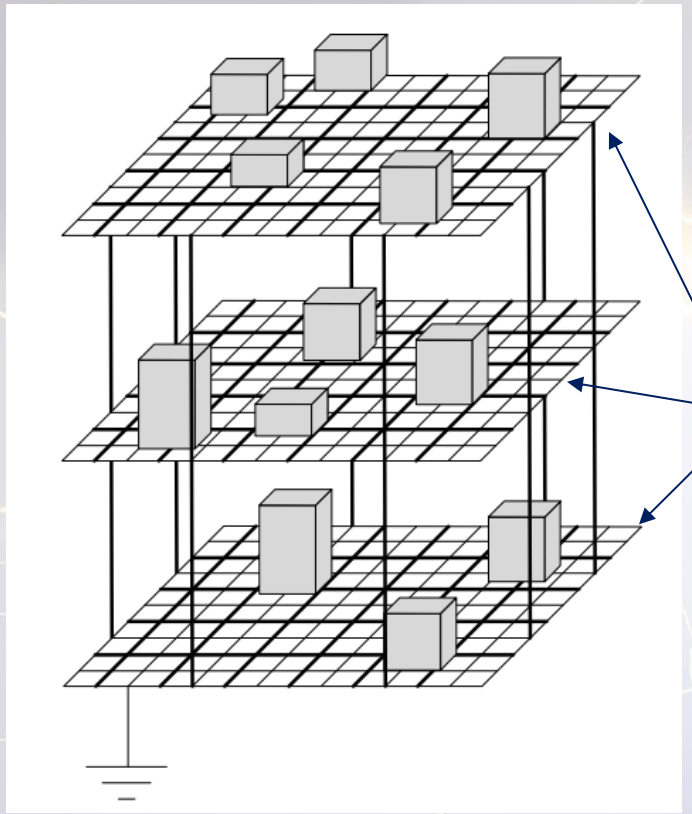
SBB – Secondary Bonding Busbar PBB - Primary Bonding Busbar

TBB - Telecommunications bonding backbone

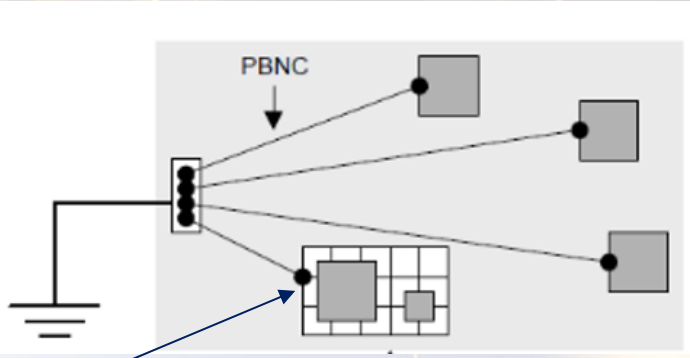
TBC - Telecommunications bonding conductor MET – Main grounding Terminal

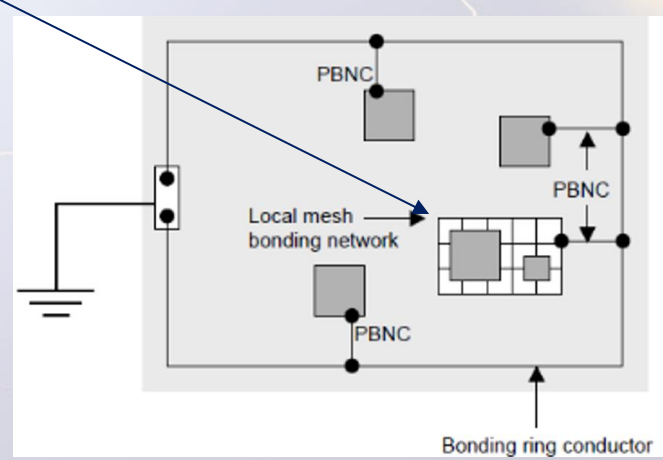
Mesh – IBN in TIA 607E and IEC/AS30129 [3][6]

- Coexist with Star-IBN
- Can be Local Mesh
- IEC/AS30129 - Spurs or Ring
- TIA 607 is almost always spurs
- MESH is either 4”x 26 guage or 50mmx0.4mm Tape or Used Pedestals Joined with#6AWG or 16 mm^2 bare wire
- Many Data Centers still designed with MESH-IBN



Mesh Bonded Network





Rack & Cable Tray Bonding in IEC 30129 and TIA 607-E [3][6]

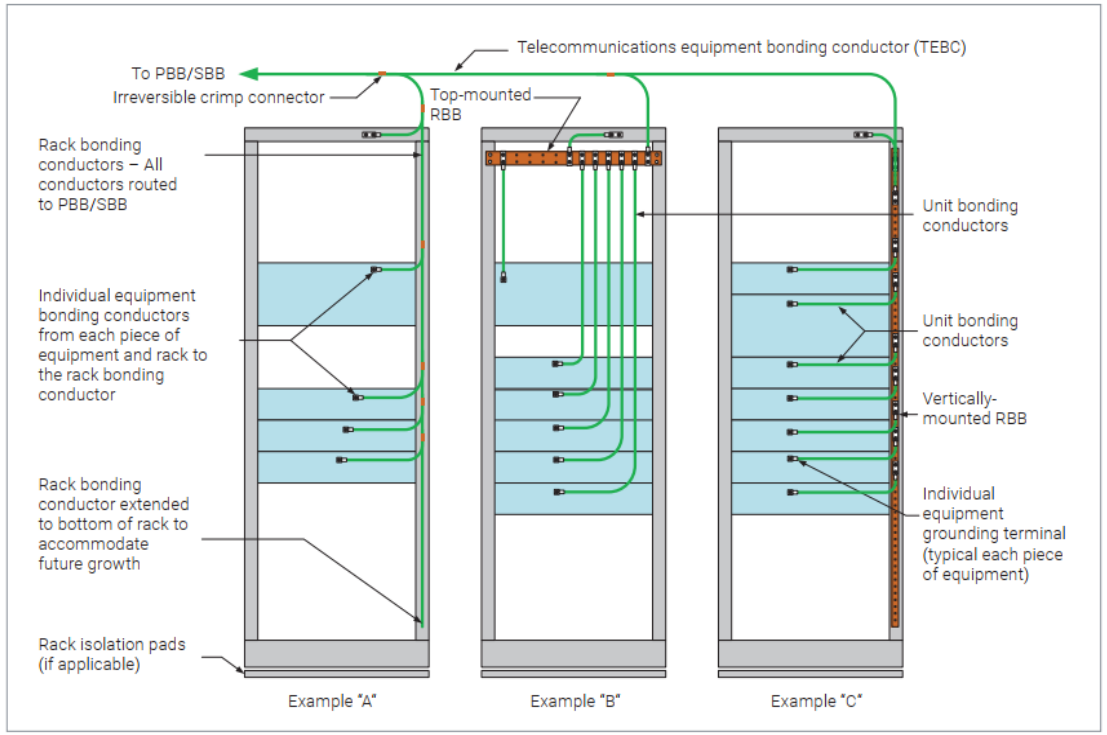


Figure 9: Equipment & Cabinet Bonding

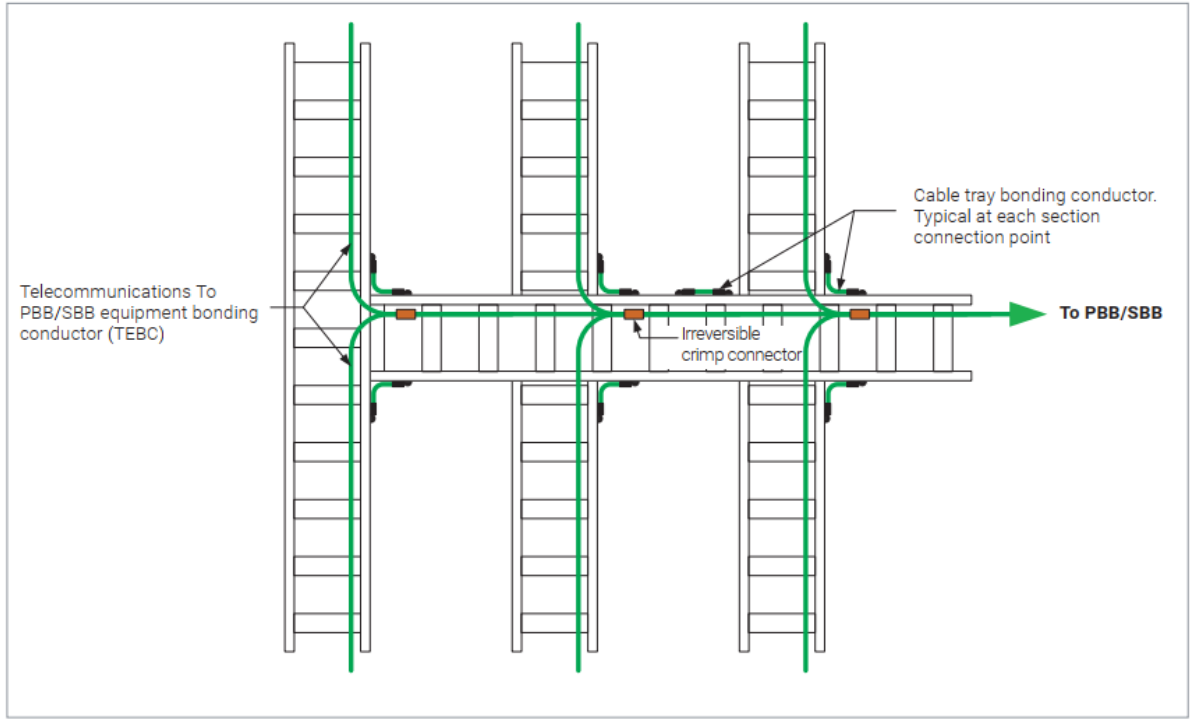
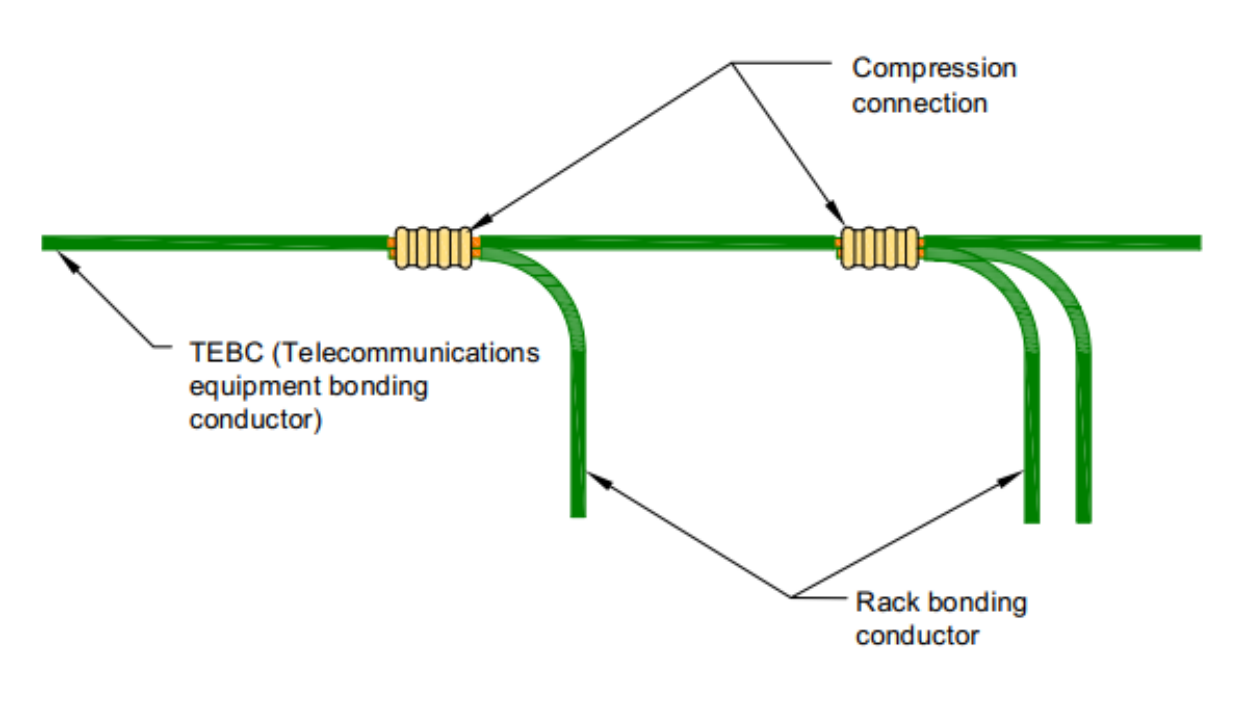


Figure 10: Typical Arrangement of Cable Tray Bonding and TEBC connections

Bonds between TEBC and Racks [3][6]

- Both the IEC and TIA Standard require the connection to the main ground wire called TEBC to be compression or irreversible connections



Outdoor Grounding - TIA 607 E Standard [6]

- Outdoor Grounding has generally been missing in normative parts of data center standards
- Recent version of TIA 607 E has outdoor grounding added to normative part.
- Essentially it sets target resistance of 25 ohms for ordinary data installations and 5 ohms for critical data centers.

8 EXTERNAL GROUNDING

8.1 Grounding resistance

8.1.1 Minimum requirements

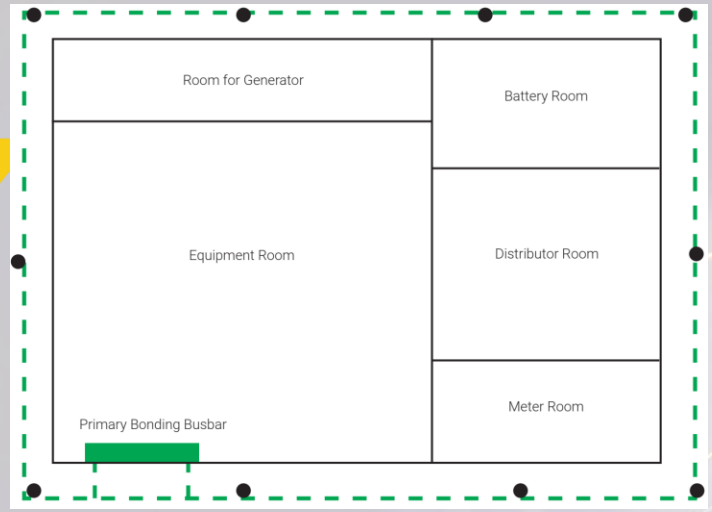
The requirements of this clause are met by the use of an NFPA 70 compliant grounding electrode system.

The grounding electrode system shall be designed to have a resistance of 25 ohms or less for a single grounding electrode. If 25 ohms cannot be achieved or maintained throughout the year with a single grounding electrode, then the grounding electrode shall be augmented by at least one additional grounding electrode. One should take into account the soil resistance due to seasonal fluctuations. It is recommended to use two grounding electrodes as the minimum installation, even if 25 ohms is achieved with a single grounding electrode.

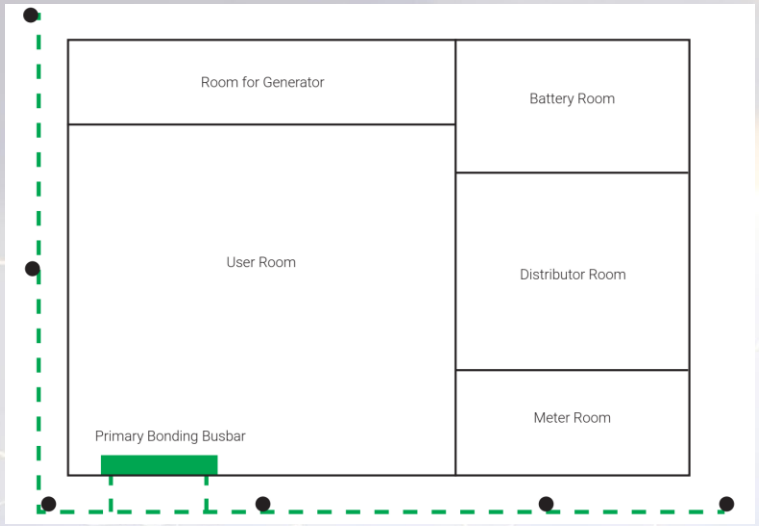
8.1.2 Enhanced requirements

The grounding electrode system for sites that are critical in nature (e.g., public safety facilities, military installations, data centers, web hosting facilities, central offices) shall be designed to have a resistance of 5 ohms or less. The grounding electrode system design should take into account seasonal fluctuations such as moisture and temperature.

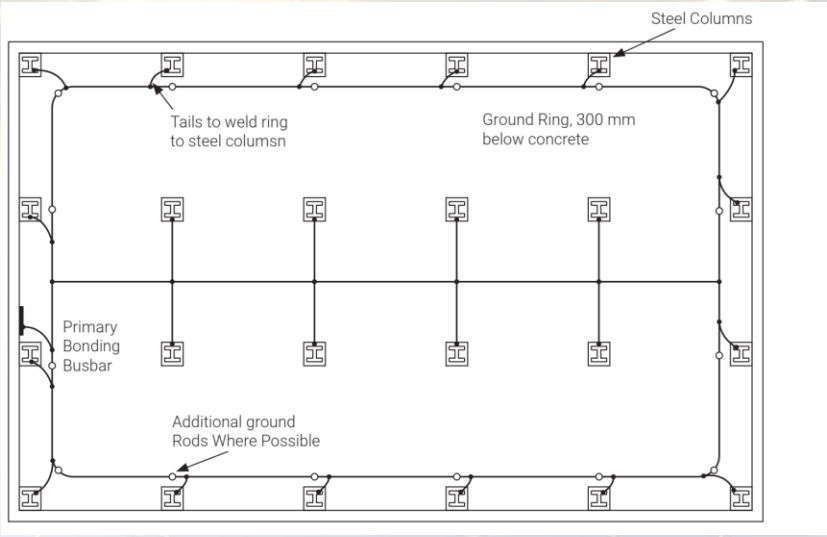
Outdoor Grounding – Layout



METHOD 1

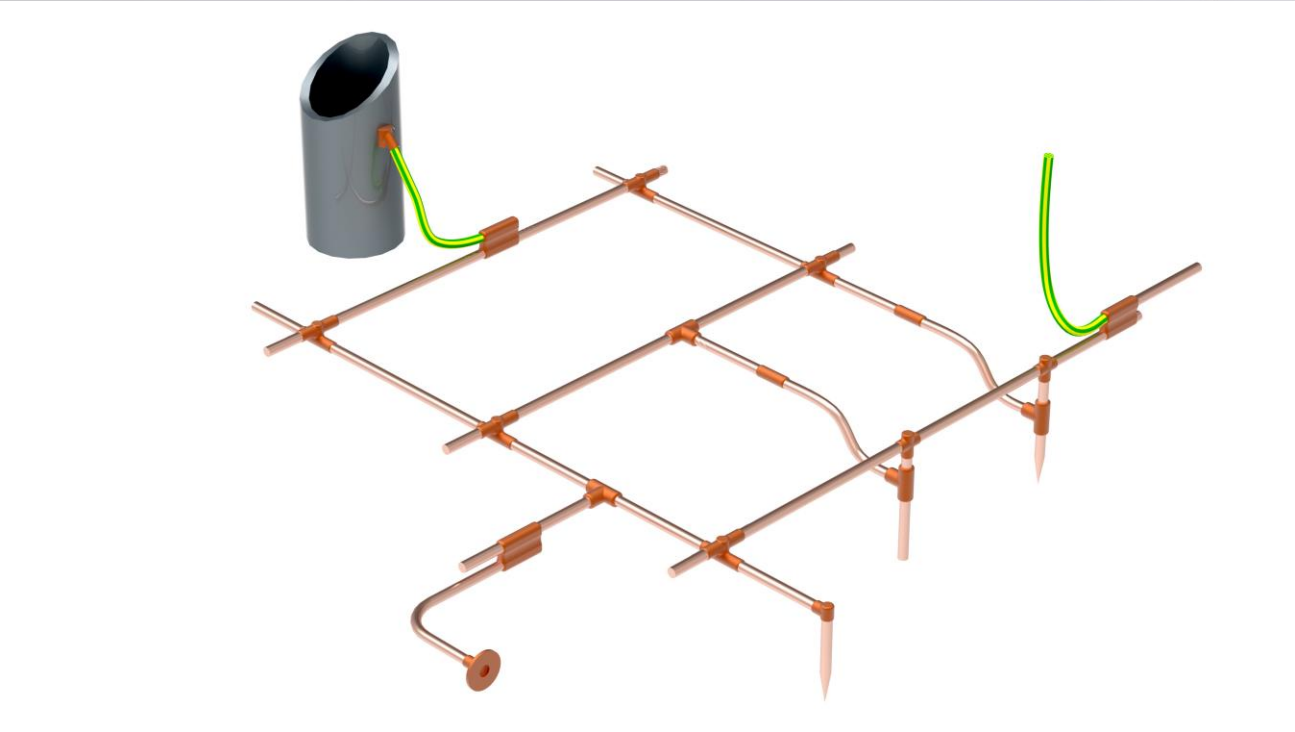


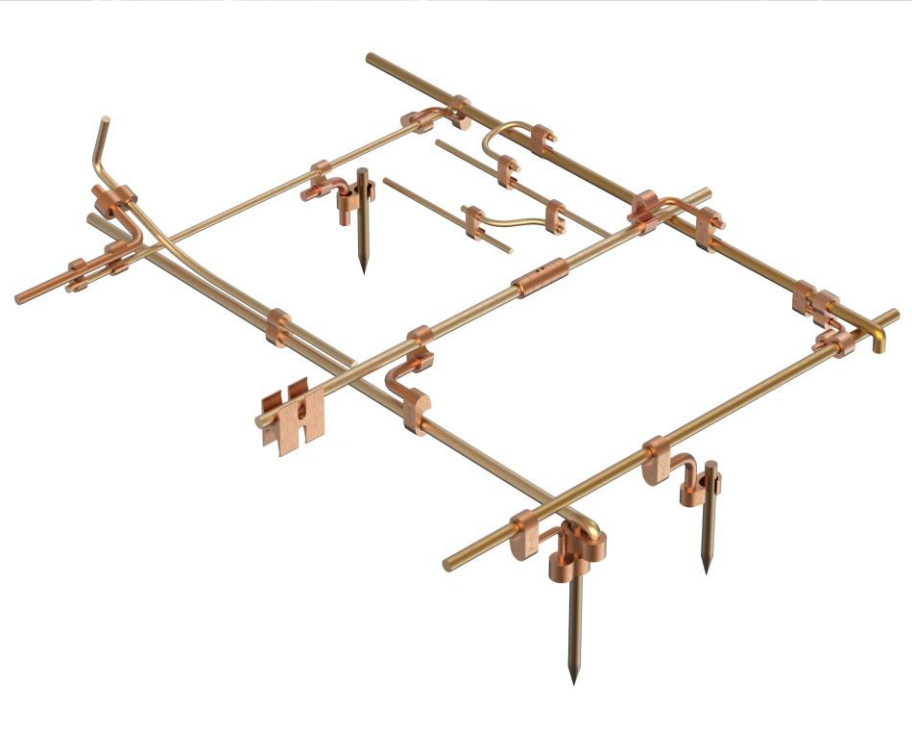
METHOD 2



METHOD 3

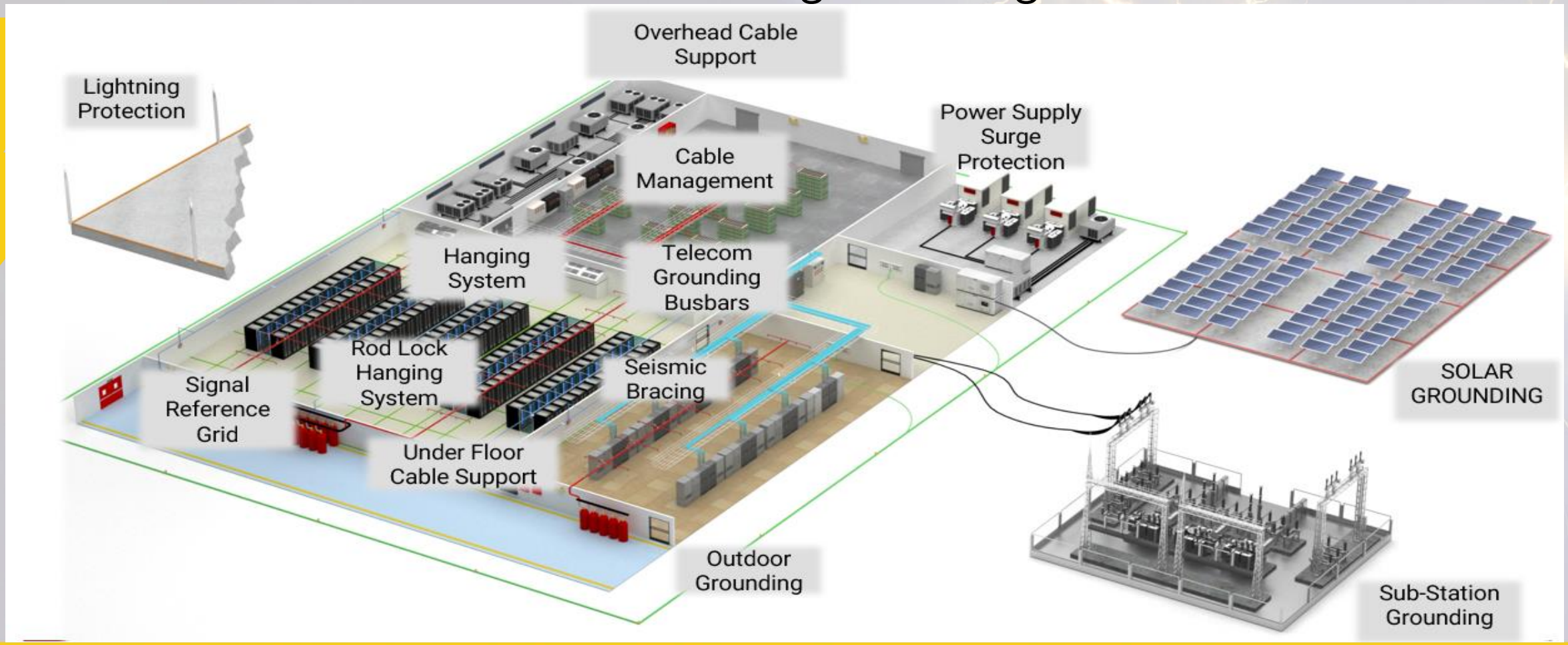
Outdoor grounding – Connections





Lightning Protection Grounding

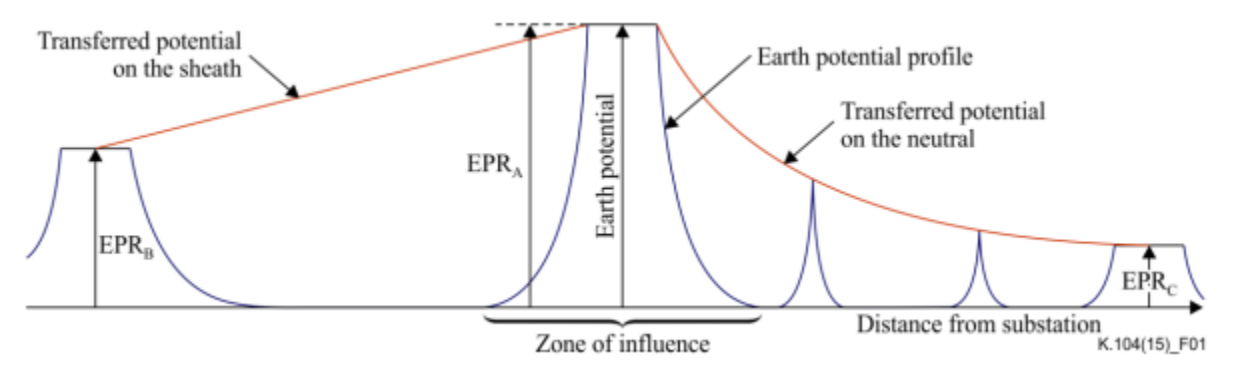
Renewable and Sub-Station grounding



How GPR Can Transfer to a Nearby Facility

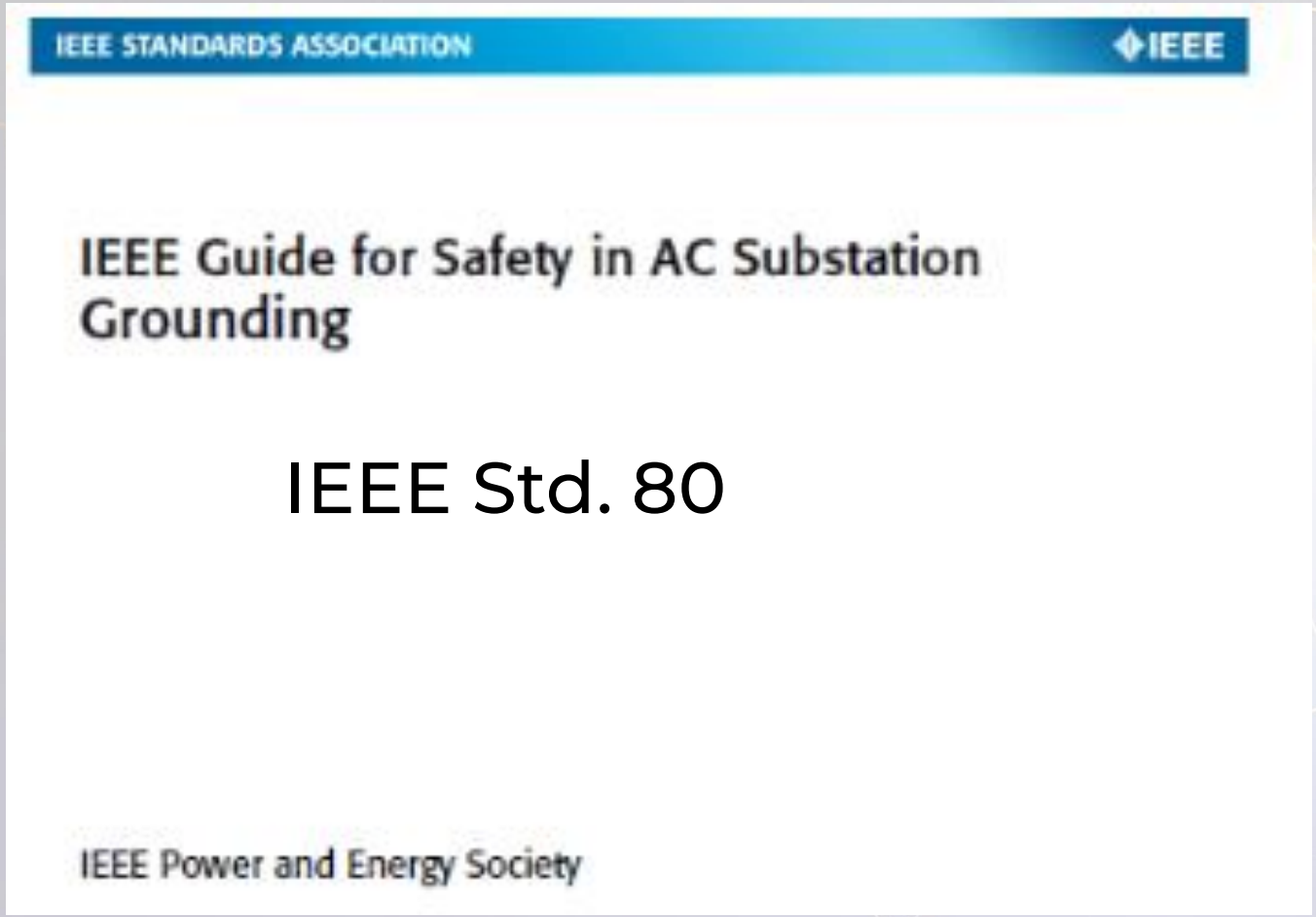
Two ways that GPR appears at a data center facility

- The telecommunications facility may be in the GPR/EPR zone of the HV/MV Substation occurring due to ground faults in electric power systems
- Ground/ground potential rise (GPR/EPR), can also be transferred by metallic transfer to the telecommunication plant occurring due to ground faults in electric power systems, as the site will inevitable powered by the HV/MV Network
- Both the methods of GPR/EPR Transfer above can cause damage to telecommunication plants and endanger people working in the plants



EPR and Transferred Potential [10]

Key Standards for EPR & Step & Touch Voltage [11][12][13][14]

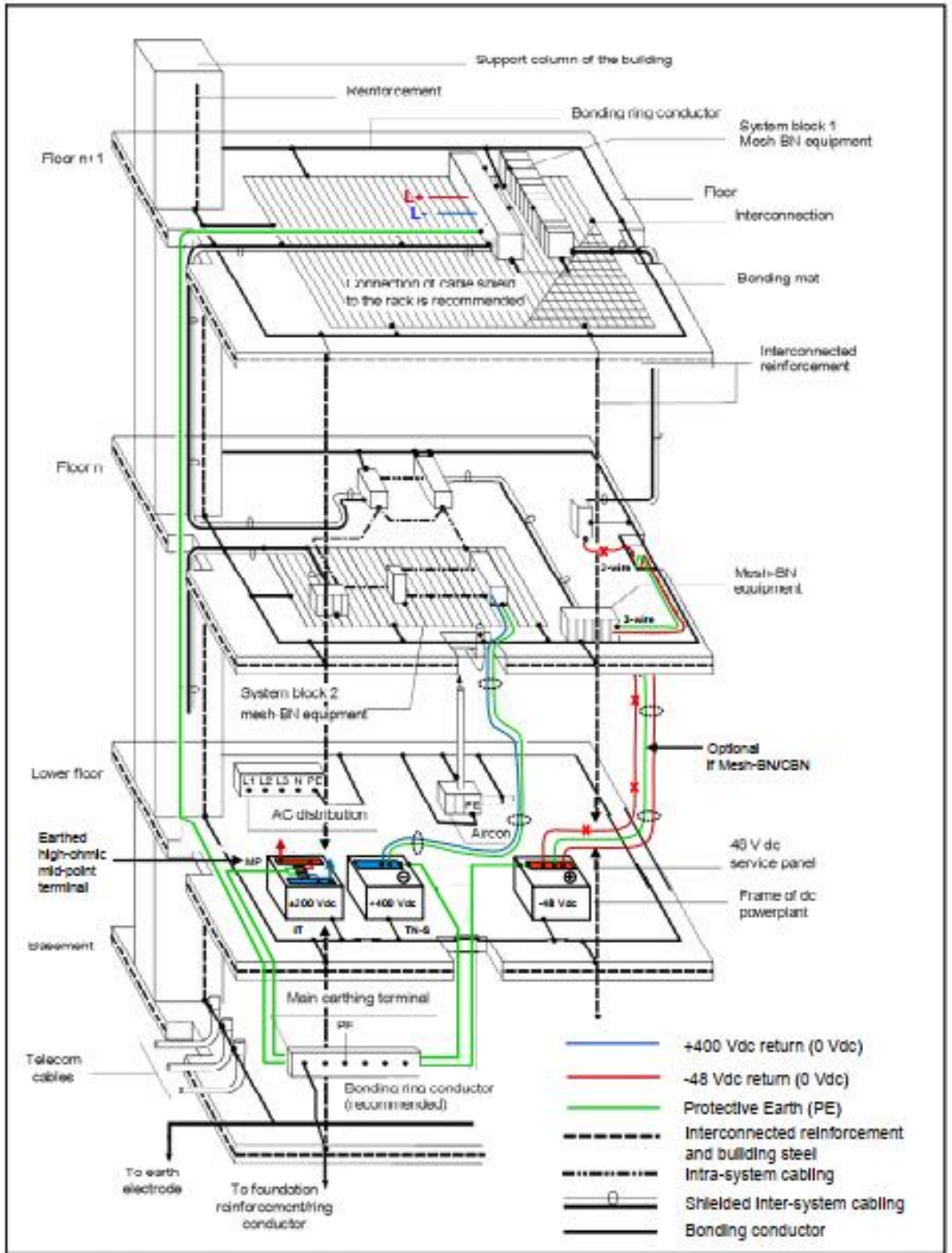


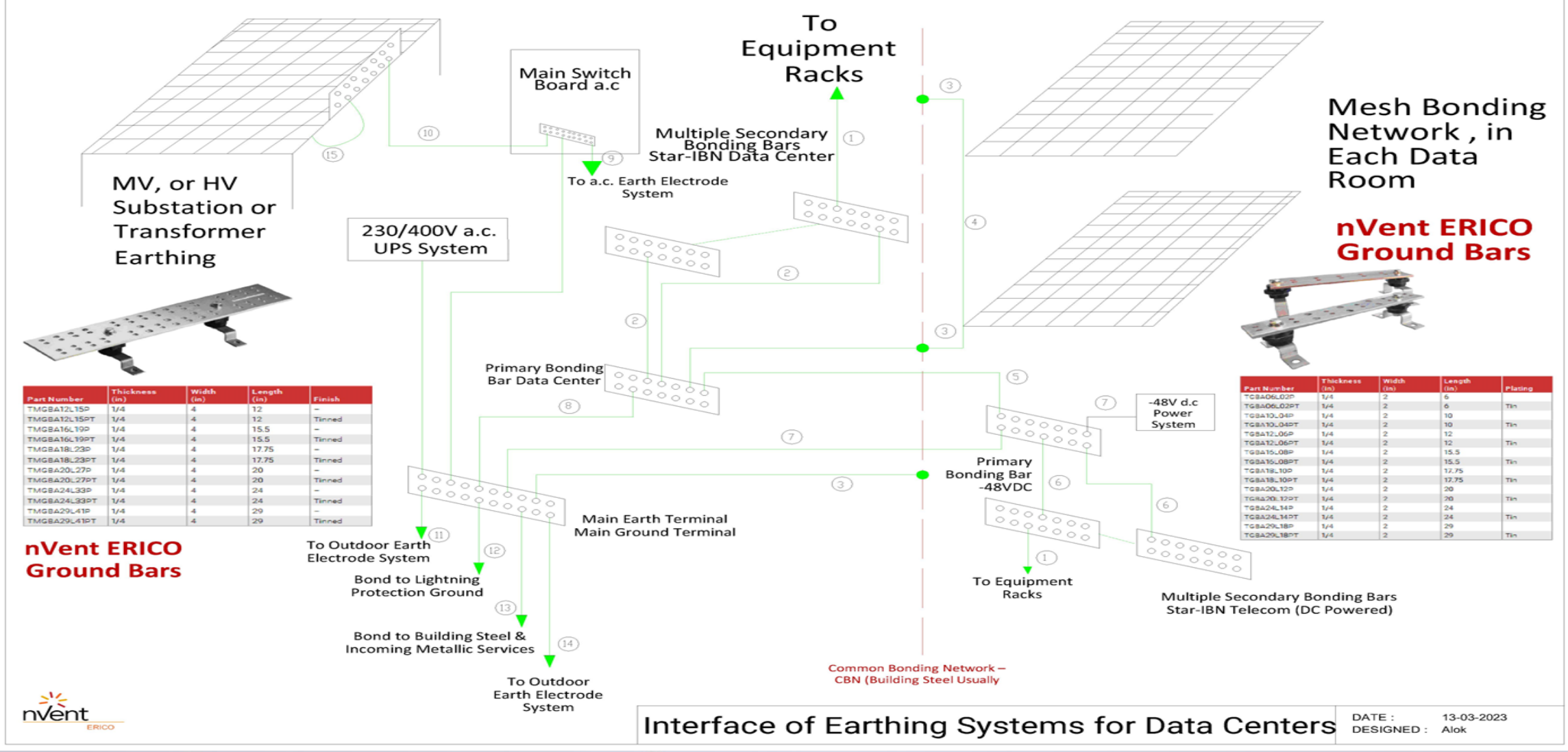
HVDC grounding – 400VDC (Not Really HV)

ETSI EN 301 605 V1.1.1 (2013-10)

General requirements

- The grounding and bonding arrangements for 400 VDC in the 2013 document are intended to be implemented on new sites as well as on existing sites.
- The grounding and bonding arrangements for 400 VDC are intended to co-exist with the grounding and bonding arrangements valid for -48 VDC and for ICT equipment powered by 230 VAC, without any adverse effects on safety and continuity of service.
- Bonding configurations can be addressed at a building level (Star-IBN) , at an installation level (Star-IBN and MESH Bonding Network (MESH-BN)





Part Number	Thickness (in)	Width (in)	Length (in)	Finish
TMGBA12L15P	1/4	4	12	–
TMGBA12L15PT	1/4	4	12	Tinned
TMGBA16L19P	1/4	4	15.5	–
TMGBA16L19PT	1/4	4	15.5	Tinned
TMGBA18L23P	1/4	4	17.75	–
TMGBA18L23PT	1/4	4	17.75	Tinned
TMGBA20L27P	1/4	4	20	–
TMGBA20L27PT	1/4	4	20	Tinned
TMGBA24L33P	1/4	4	24	–
TMGBA24L33PT	1/4	4	24	Tinned
TMGBA29L41P	1/4	4	29	–
TMGBA29L41PT	1/4	4	29	Tinned

Part Number	Thickness (in)	Width (in)	Length (in)	Plating
TGBA06L02P	1/4	2	6	
TGBA06L02PT	1/4	2	6	Tin
TGBA10L04P	1/4	2	10	
TGBA10L04PT	1/4	2	10	Tin
TGBA12L06P	1/4	2	12	
TGBA12L06PT	1/4	2	12	Tin
TGBA15L08P	1/4	2	15.5	
TGBA15L08PT	1/4	2	15.5	Tin
TGBA18L10P	1/4	2	17.75	
TGBA18L10PT	1/4	2	17.75	Tin
TGBA20L12P	1/4	2	20	
TGBA20L12PT	1/4	2	20	Tin
TGBA24L14P	1/4	2	24	
TGBA24L14PT	1/4	2	24	Tin
TGBA29L18P	1/4	2	29	
TGBA29L18PT	1/4	2	29	Tin

Interface of Earthing Systems for Data Centers

DATE : 13-03-2023
DESIGNED : Alok

nVent ERICO

PEG PROTECTION ENGINEERS GROUP

Summary

- Indoor grounding & Bonding
  - Mesh IBN and Star IBN systems both exist in data centers today. Mesh- IBN is legacy system used for strong signal reference . These system can also co-exist.
- Outdoor Ground Electrode
  - Generally, has not been part of standards but notably added to normative part of TIA 607 E
- High Voltage grounding
  - This will exist at all data center installations and designs will be covered by other substation standards. EPR Zones that data center equipment is placed in has to be given added considerations
- Possible Renewable source grounding
  - More Data Centers will be built at renewable energy generation at site and the grounding of this facilities has to be coordinated with data center and HV grounding
- HVDC grounding
  - Fairly uncommon in USA.
- Lightning Protection grounding
  - This is covered by AS1768 Standard. Electrode system will almost always be same as that for data center outdoor grounding
- Intersystem Bonding
  - Generally, not well covered by standards because each standard is built on a certain voltage system. But this is a critical part of the grounding design

References

[1] ITU K.27 – Bonding configurations and grounding inside a telecommunication building

[2] IEEE 1100 2055 – IEEE Recommended Practice for Powering and Grounding Electronic Equipment

[3] IEC/AS30129 2018 ; Current Information technology - Telecommunications bonding networks for buildings and other structures

[4] ETSI EN 300 253 “Environmental Engineering (EE); grounding and Bonding Configuration Inside Telecommunications Centres”

[5] Rohit Narayan Method for the Design of Lightning Protection, Noise Control And Grounding System at a Telecom Facility INTELEC 2014,Copyright IEEE

[6] STANDARD TIA 607 C/D/E Generic Telecommunications Bonding and Grounding (grounding) for Customer Premises

[7] Standard NECA/BICSI 607 2011 Telecommunications Bonding and Grounding Planning and Installation Methods forCommercial Buildings

[8] Rohit Narayan, Mesh Bonded vs Isolated Bonded grounding Network for Indoor Grounding, INTELEC 2017,Copyright IEEE

[9] Rohit Narayan, Indoor Grounding of Data Centers to IEC30129 and TIA607D Standards, INTELEC 2024,Copyright IEEE

[10] ITU K.104 SERIES K: PROTECTION AGAINST INTERFERENCE Method for identifying the transfer potential of the ground potential rise from high or medium voltage networks to the grounding system or neutral of low voltage networks

[11] AS 2067:2016[Current] Substations and high voltage installations exceeding 1 kV a.c.

[12] IEEE 80-2013 - IEEE Guide for Safety in AC Substation Grounding

[13] AS/NZS 3835.1:2006[Pending Revision] ground potential rise — Protection of telecommunications network users, personnel and plant, Part 1: Code of practice

[14] AS/NZS 3835.2:2006[Pending Revision] ground potential rise — Protection of telecommunications network users, personnel and plant, Part 2: Application guide

THANK YOU