Outdoor Cabinet Protection Through Better Grounds and Bonding

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Electrical Protection of Communications Networks

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atis

Outdoor Cabinet Protection Through Better Grounds and Bonding

- Risks from Bad Grounds and Bonding
- Potential Costs of Bad Grounds
- Accepted Practices for Telecom Grounding and Bonding
- Issues found in Equipment cabinets
- Standards Controlling Installations

Risks from Bad Grounds and Bonding

Extreme danger to personnel from accidental shock (Lightning, Contact Voltage and Stray Current)

High risks of equipment degradation and failure (ESD, EMP surges)

Data corruption and transmission errors due to interference, especially with wireless connections

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Extreme Danger From Lightning

Not Just your equipment is at risk - Every state has recorded at least one lightning related fatality in the last 10 years

Contact Voltage and Stray Current

"Contact voltage has occurred on city streets when energized wires accidentally came in contact with manholes, metal sidewalk plates, light poles, and service boxes."

https://www.ecmweb.com/content/can-stray-voltages-kill

Poor grounding and bonding practices are killing people, animals and equipment

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Causes for Bad Grounds and Bonds

- **Poor Designs** – Engineers not following industry specification standards
- **Poor Quality at Cabinet Manufacturer** – Not following designs, making bad part substitution decisions, and lack of training in production.
- **Poor work by Field Technicians** – Lack of training or available time causing short cuts during maintenance or add on’s.
- **Natural Causes** - Weather and Humidity causing corroded and eroded parts. Contact voltage and stray current is the result
- **Human Factor** – Copper theft causes loss of grounding system integrity.

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Industry Cost of Bad Grounds and Bonding

Telecom Enterprise estimates the cost of downtime as $11,000 per minute, per server. This represents the revenue that's lost as a result of service level agreements (SLAs) with customers (mostly high-value, enterprise users). If each server is down for 526 minutes per year, that's an annual cost of **$5,780,000** per server.

https://www.lightreading.com/data-center/data-center-infrastructure/whats-the-real-cost-of-network-downtime/a/d-id/710595

World's largest mobile networks, including AT&T, NTT Docomo, Sprint Nextel, T-Mobile USA and Verizon Wireless indicate that down time are costing the world's mobile operators around **$15 billion** a year, or an average of **1.5 percent** of their annual revenues.

http://www.heavyreading.com/spit/details.asp?sku_id=3144&skuitem_itemid=1545&promo_code=&aff_code= &next_url=%2Fsearch%2Easp%3F

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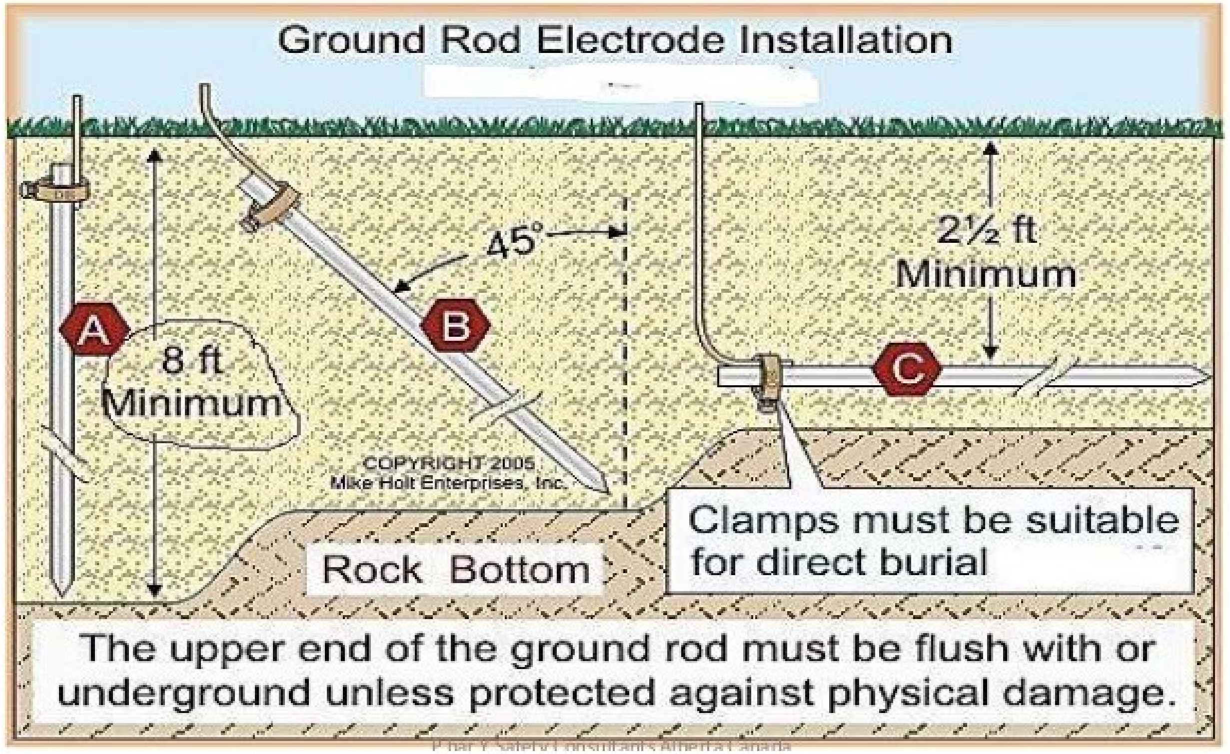
What is Grounding?



NEC Article 250

Grounding refers to intentionally or accidently connecting any conductor to earth (the grounded conductor)

GROUNDING (EARTHING) CONDUCTORS

Grounding (earthing) conductors are the conductors used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or grounding electrode system. These conductors may connect grounding electrodes together, form buried ground rings, and connect objects to the grounding electrode system. See BS 7430:1998, clause 3.17 and NFPA 70-2005, Article 100 for additional information.

GENERAL SPECIFICATIONS

General specifications for grounding (earthing) conductors are listed below.

- Unless otherwise stated, all below-ground, or partially below-ground, external grounding electrode system conductors **shall** be 35 mm^2 csa (#2 AWG) or coarser, bare, solid, tinned or un-tinned, copper conductors (ANSI T1.313-2003 and ANSI T1.334-2002, section 5.3). For areas highly prone to lightning, and/or military installations, larger conductors, such as 50 mm^2 csa (#1/0 AWG) or coarser, should be considered (MIL-HDBK-419A); stranded conductors may be used in this application. Tinned conductors are recommended for stranded conductors.
- Solid, bare, tinned, copper conductors should be used to help minimize galvanic corrosion between tower legs and other parts of the grounding electrode system (ANSI T1.313-2003, section 10.7). See "Dissimilar Metals and Corrosion Control" on page 4-34.

Normal Grounding (Earthing) conductors shall be #2 or larger

Areas prone to high lightning risks conductors should be 1/0

Grounding Electrode (Earthing) system

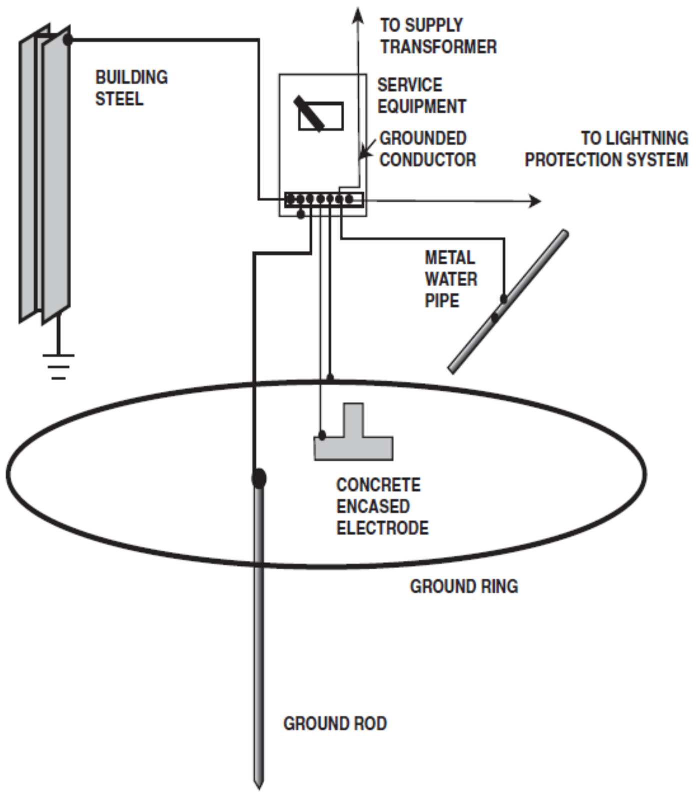
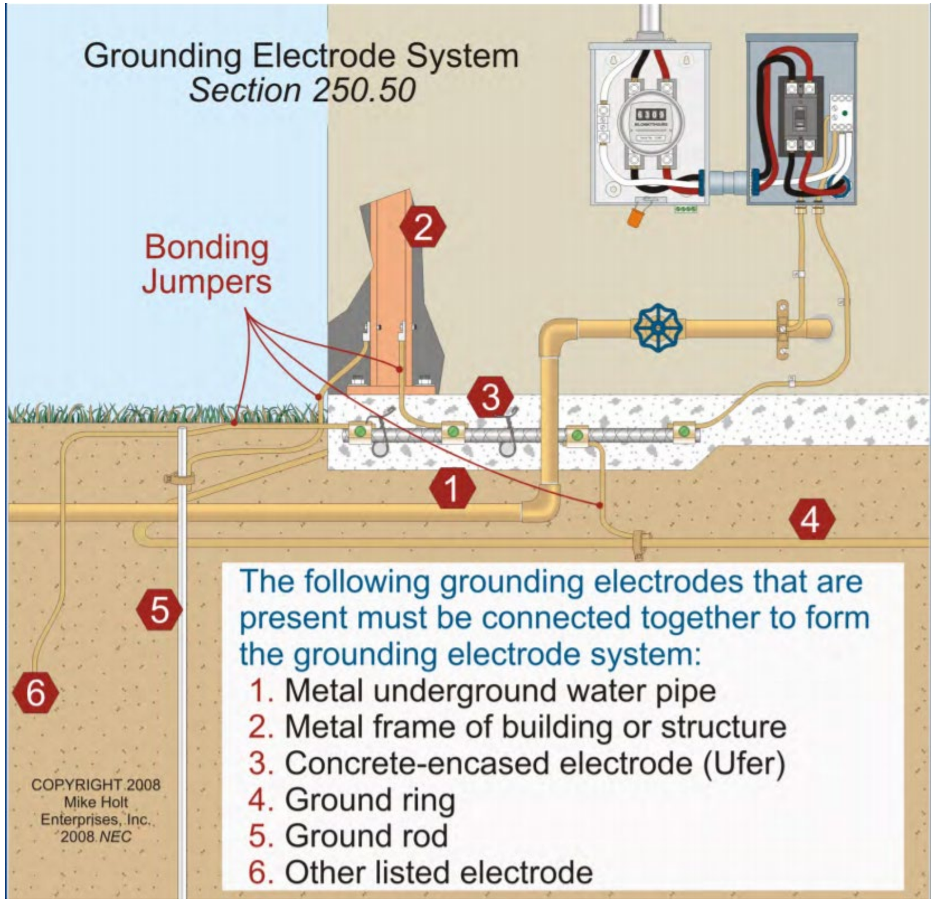


FIGURE 4-3 COMMON GROUNDING EXAMPLE

- <25 ohms for NEC Code –good for personnel safety… bad for equipment safety.
- <5 ohms for most electronic cabinets like Telecom and ITS
- All Grounding should be brought back to the Master Ground Bar to avoid Ground Loops
- 2 AWG minimum to Ground Rod or Water Pipe, all other ground conductors should be no less than 6 AWG wire

Grounding Electrode (Earthing) system



A **grounding electrode system** includes using multiple grounding electrodes or other buried metal items

For Telecom the earthing system selected is directly reflective of type of installation (Brick & Mortar, Shelter, Equipment Cabinet, Below Grade vaults and now light poles for microcell 5G

Ground Rod Installations

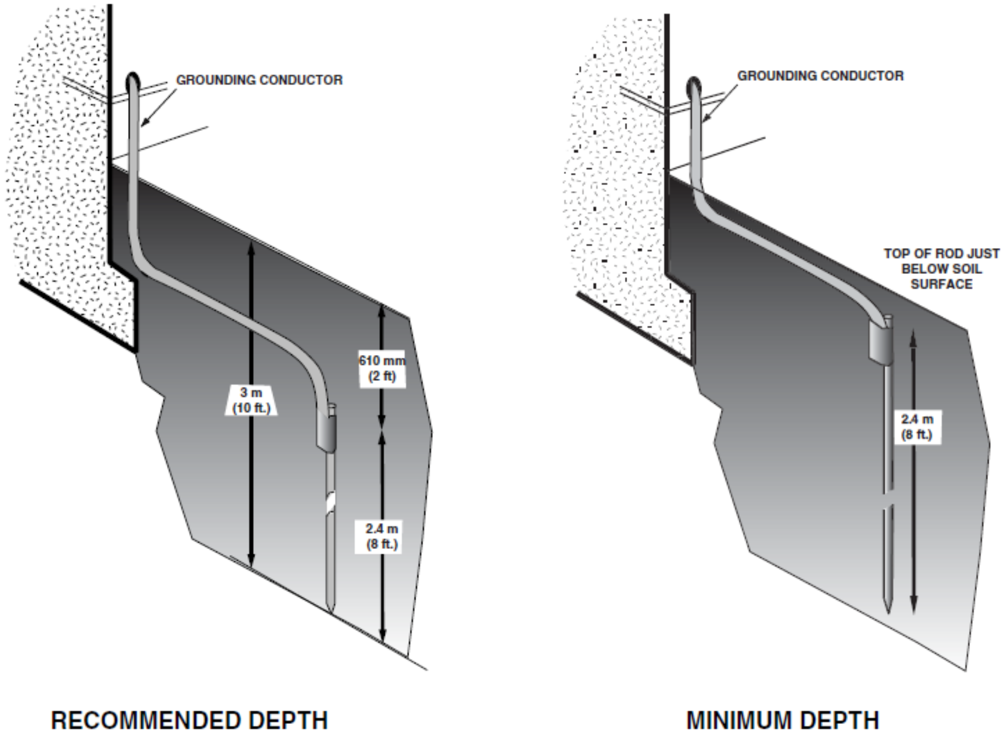


FIGURE 4-8 TYPICAL SINGLE GROUND ROD INSTALLATION

Ground Rod should be 2’ below grade and at least 8’ long

Ground Rods should be spaced no closer than the length of rod

Bending And Routing Grounding (Earthing) Conductors

Grounding (earthing) conductors **shall** be run in a direct manner with no sharp bends or narrow loops (ANSI T1.313-2003, section 11.3, and ANSI T1.334-2002, section 13.4). Sharp bends and/or narrow loops increase the impedance and may produce flash points (also see NFPA 780-2004, section 4.9.5). The following requirements apply when installing grounding system conductors:

- Sharp bends **shall** be avoided (ANSI T1.334-2002, section 13.4).
- Grounding conductors **shall** be run as short, straight, and smoothly as possible, with the fewest possible number of bends and curves (ANSI T1.313-2003, section 11.3; ANSI T1.334-2002, section 13.4; and NFPA 70-2005, Articles 800.100, 810.21, and 820.100).
- A minimum bending radius of 203 mm (8 in.) **shall** be maintained, applicable to grounding conductors of all sizes (ANSI T1.313-2003, section 11.3; MIL-STD-188-124B; and NFPA 780-2004, section 4.9.5). A diagonal run is preferable to a bend even though it does not follow the contour or run parallel to the supporting structure. See Figure 4-22.
- All bends and curves **shall** be made toward the ground location (grounding electrode system or ground bar).

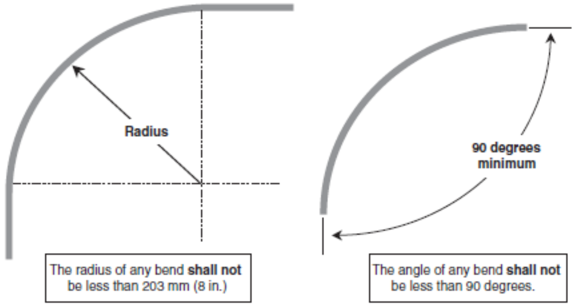


Figure 4-22 Minimum Bending Radius For Grounding Conductors

- All Ground connections should be as short and straight as possible
- Minimum bend radius is 8”
- All surge protection ground wires follow these same rules

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Types of Grounding and Bonding

In the United States the term “Grounding” can mean many different things, depending on the electrical applications. As engineers its important to use the correct terms

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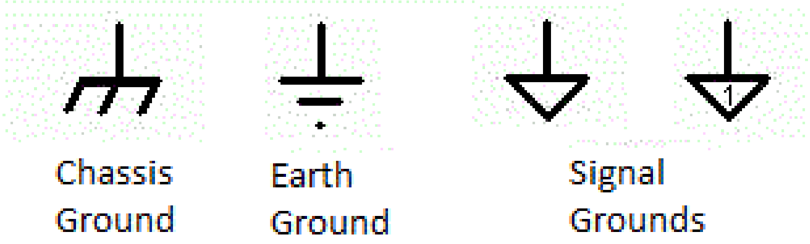
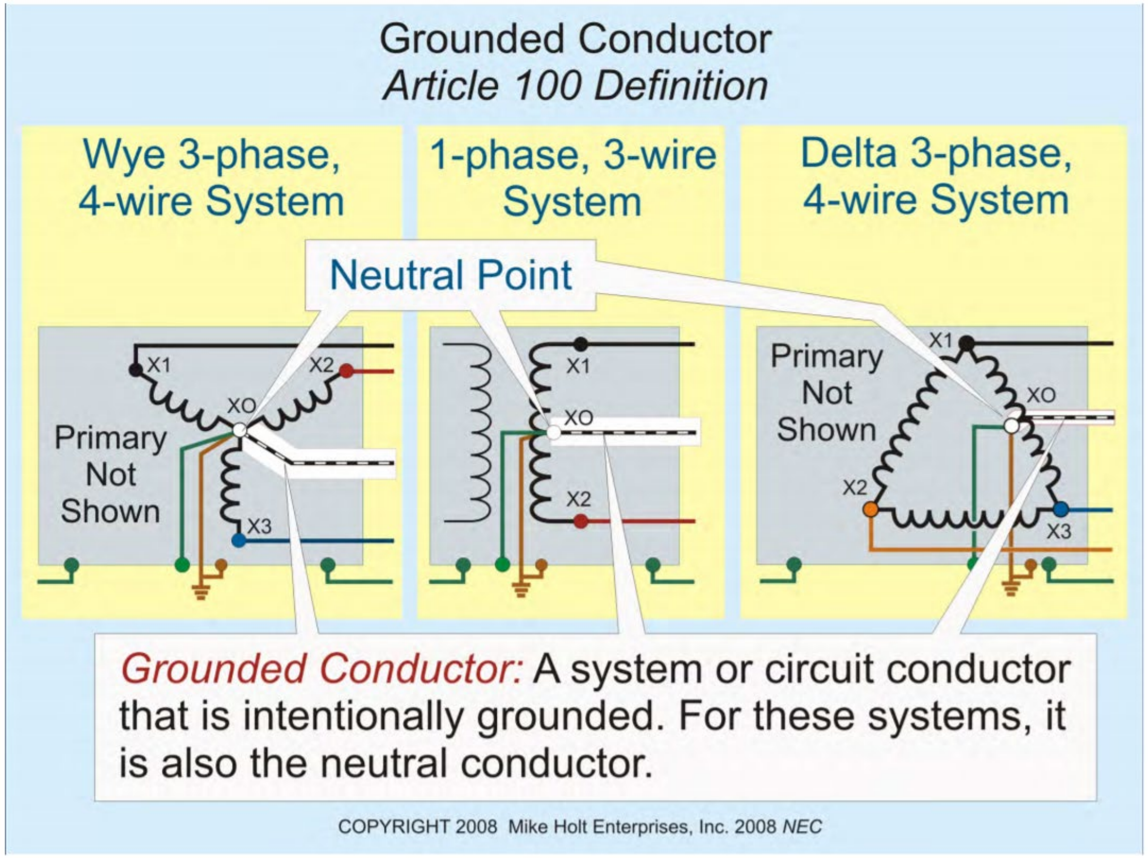
- Grounding Electrode (Earthing) system
- Equipment Grounding (Bonding)
- Lightning Protection Systems (which includes SPD and arrestors)
- Signal Reference grounding systems



Power System Types

Grounded Conductor – aka "Neutral" used in 120/240; 120/208; 240 High Leg and 277/480V application. Ground wire is ran for electrical safety

240V and 480V Delta usually has no neutral wire pulled and motor or rectifier uses a balanced 3 phase power with ground providing electrical safety



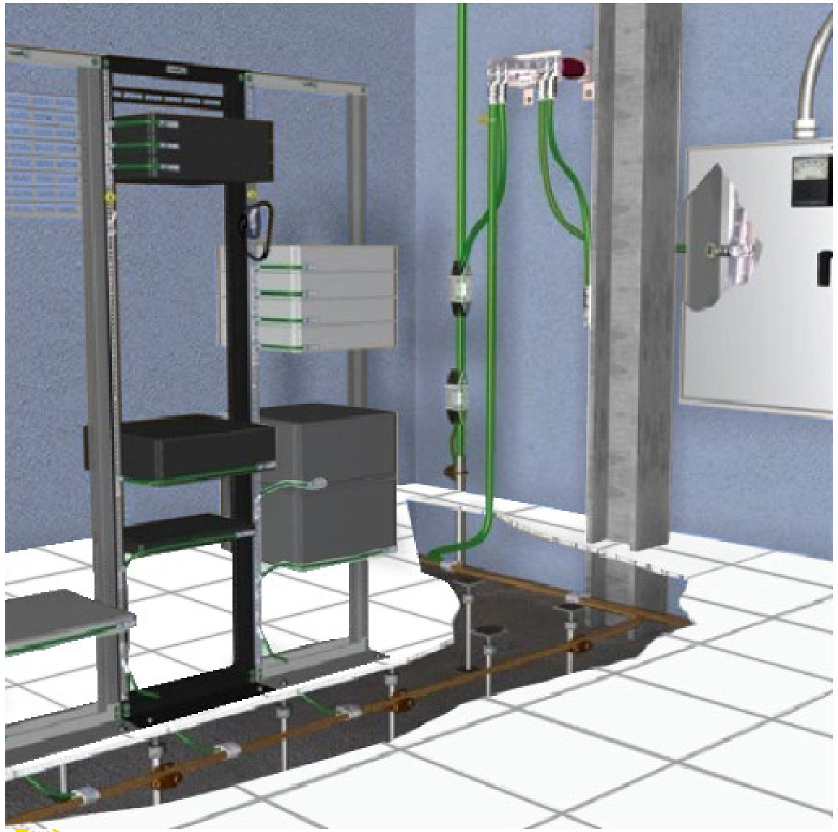
NEC Article 100

A Bonding System

Bonding or Bonded: means that metallic parts are permanently *joined* so as to assure that they form a reliably continuous electrical path NEC Article 100

Bonding electrical components together makes certain that all of the joined items are at the same electrical potential (that is, that current will not flow from one to the other).

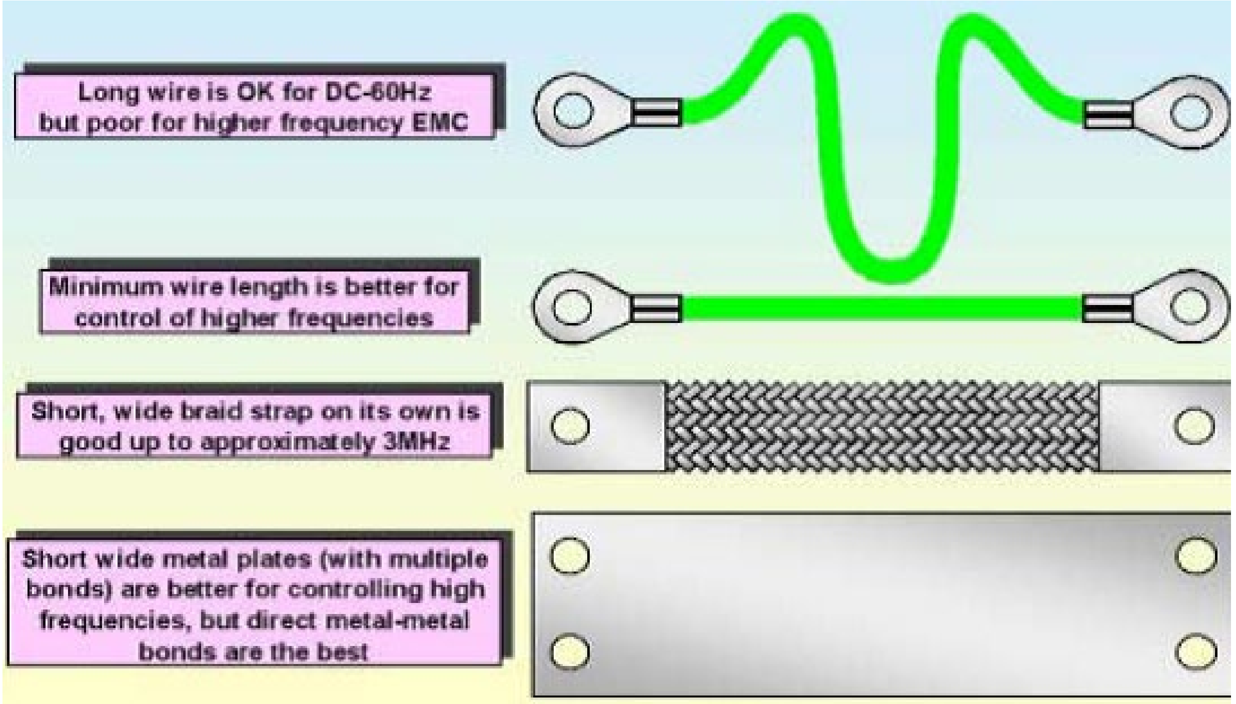
Single Point Grounding and Bonding Concept



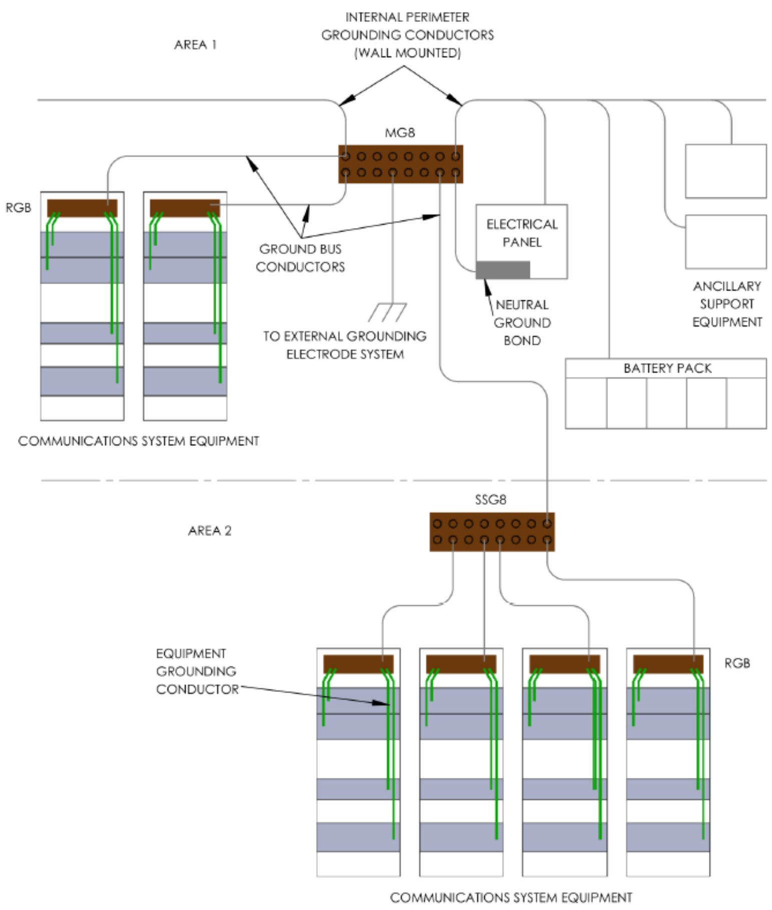
- Minimizes any differences of potential that may develop between electrical devices
- A single point grounding concept must have all communication, support equipment, power systems (AC and DC), surge protection and any other conductive material in the equipment space bonded together to a single bonding point called the Main Ground Bar (MGB)
- Ground Conductor Connections should be as short as possible

Bonding Conductors

Bonding Conductors are wires or bus that connect electrical equipment or racks to the closest Ground Bar



Single Point Grounding Concept for a facility or shelter



Each piece of equipment ground is connected to the rack grounding conductor which feeds back to the rack bus bar (RGB) – NO DAISY CHAINING

Multiple Racks can be bonded to a single sub system Ground Bus Bar (SSGB) to save cable clutter and lower impedance

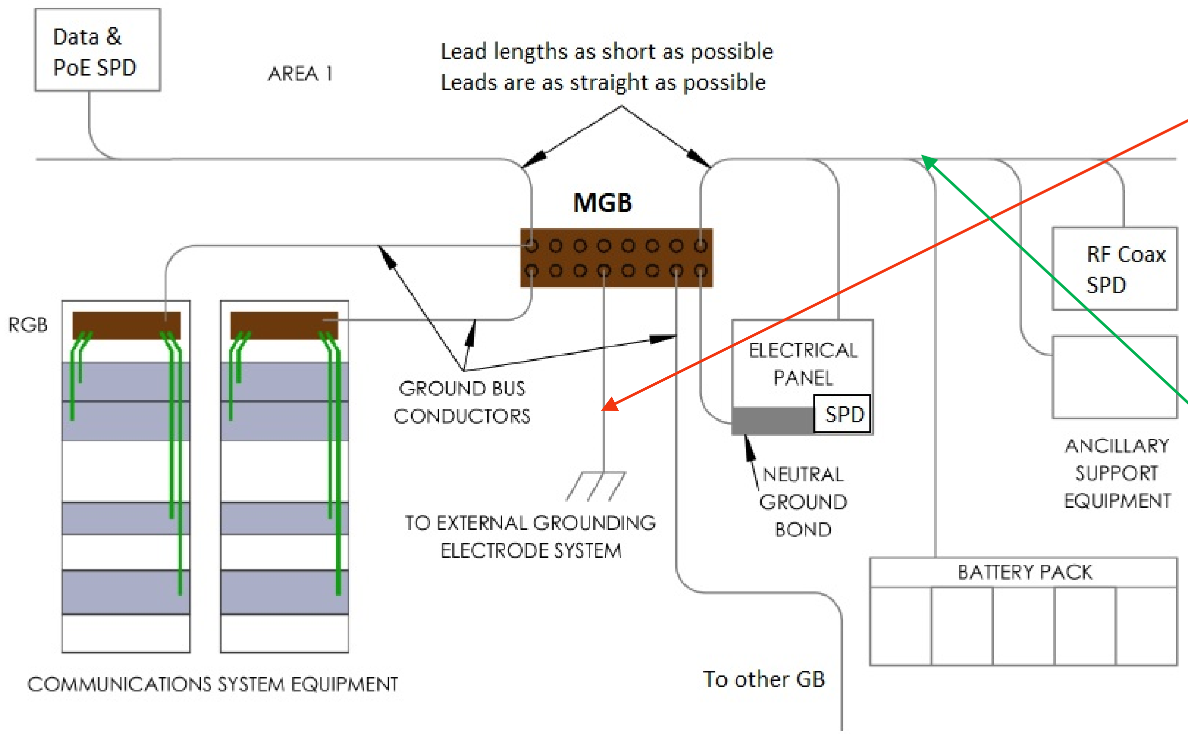
All grounds connect to the MGB including all power sources and communication equipment

As ground wires are consolidated on multiple ground bus bars, the ground bus conductors MUST increase in size to be able to safely handle multiple faults

All ground conductors from surge protection devices should be as short as possible

Refer to Motorola R-56 & IEEE 1100

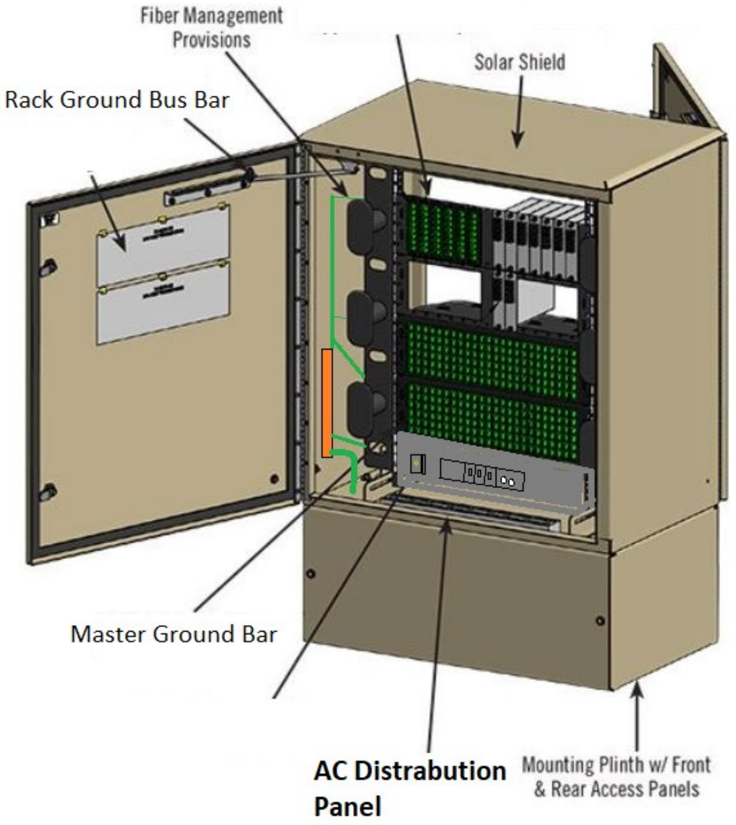
Ground and Bonding Inside An Equipment Cabinet



- #2 AWG from MGB to ground rod
- No 90-degree bends and bend radius of less than 8"
- Ground wires should be as short and straight as possible
- All ground wires should flow towards MGB

Master Ground Bar is most critical component in every cabinet
<u>THOUGHT ABOUT THE LEAST</u>

Single Point Grounding Concept for a cabinet



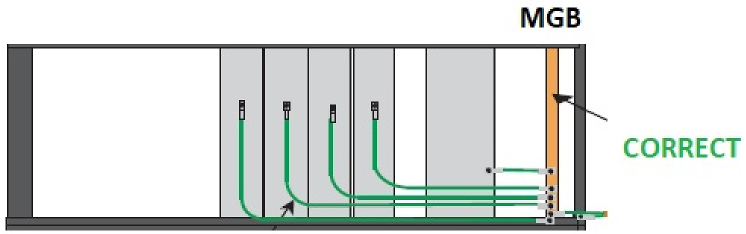
- MGB should be mounted as low as possible in the cabinet (shorter lead to Ground Electrodes)
- Surge protection should always be discharged directly to MGB using dedicated cable/wire.
- Equipment mounting plates should be not be used as a ground bus without isolation from Cabinet Chassis.
- RF Surge protection can discharge to a Sub System Bus Bar(SSB) (not connected to chassis) with a single ground conductor that feeds back towards the MSG.
- DIN Rails used as equipment ground should not be connected to the chassis and wired grounded

Ground and Bonding Inside Of The Cabinet

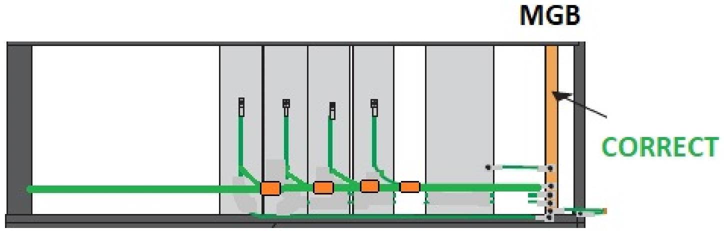
- All ground conductors should connect directly to the MGB including all power sources and communication equipment. Avoid DAISY CHAINING ground conductors.

- All equipment and enclosure should individually bond to the MGB or connected to a dedicated ground conductor

- Equipment Ground leads to MGB should be no less than 12 AWG or smaller than the largest gage wire connected to the electronic equipment



Each piece of equipment should be individually cabled back to MGB



If equipment is connected to a rack ground cable, wire connection should always point towards the direction of the MGB

Daisy Chaining your grounds causes equipment risks to transients surges and EMI Noise issues

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Cabinet Grounding System

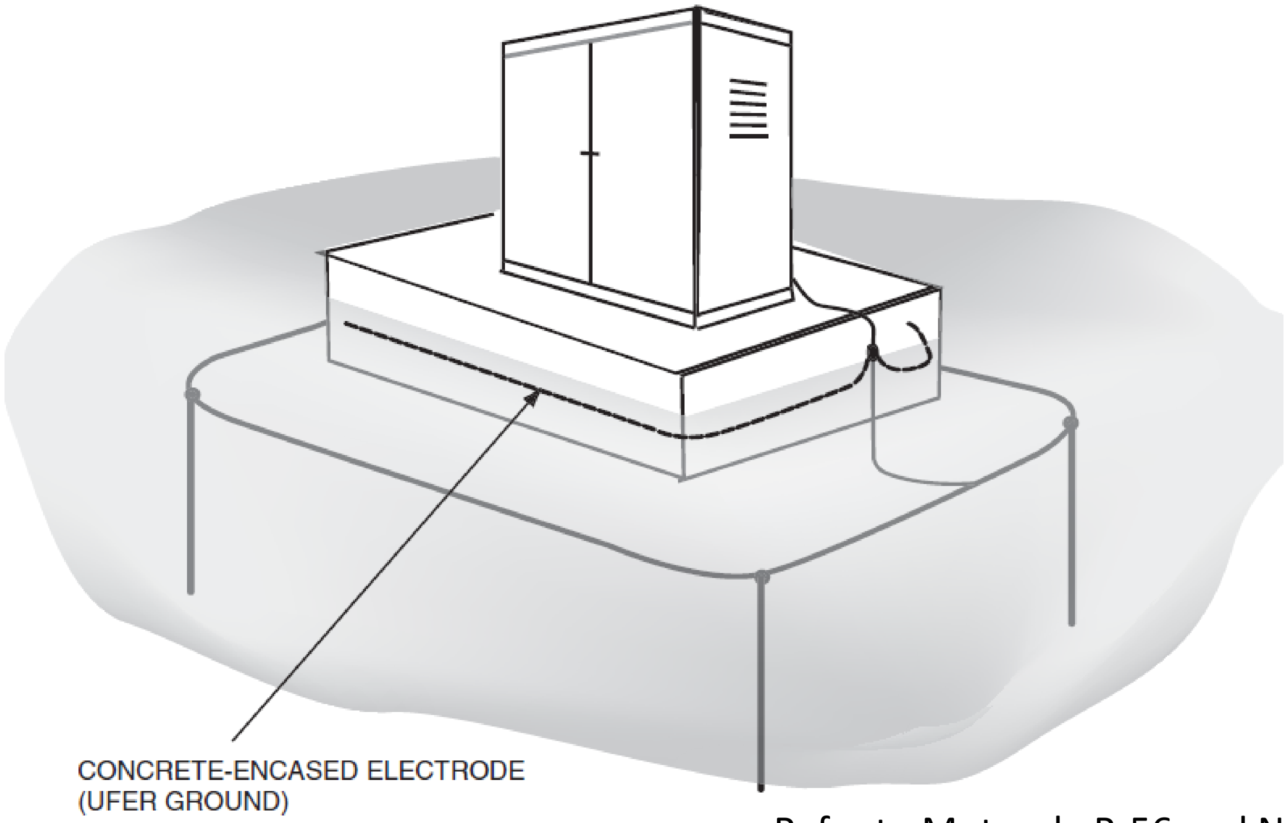

FIGURE 4-41 CABINET GROUNDING SYSTEM

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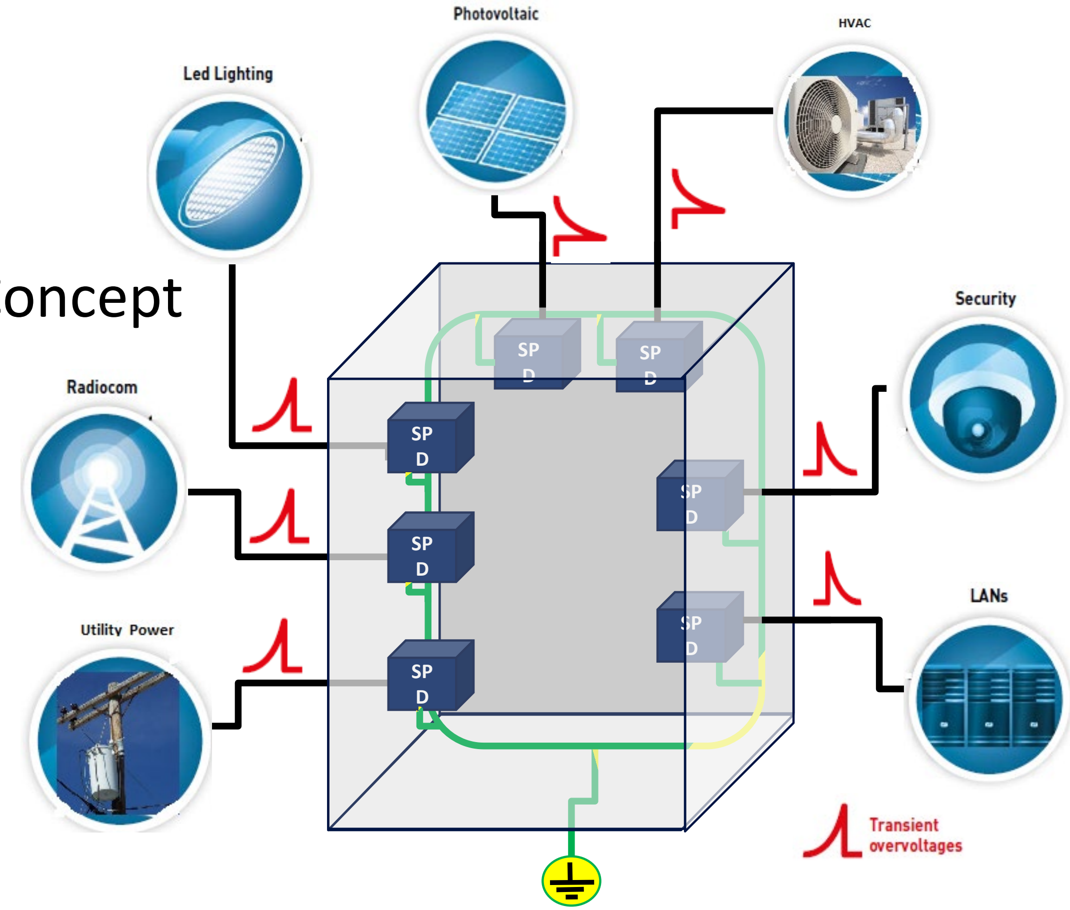
- If a single Ground Rod doesn’t get you to 5 ohms or less, consider putting in multiple ground rods or even a Halo System.
- Rods should be spaced no less than 8’ -10’ (depending on rod length) from each other.

Refer to Motorola R-56 and NEC 250.1

Surge Protection and Risks

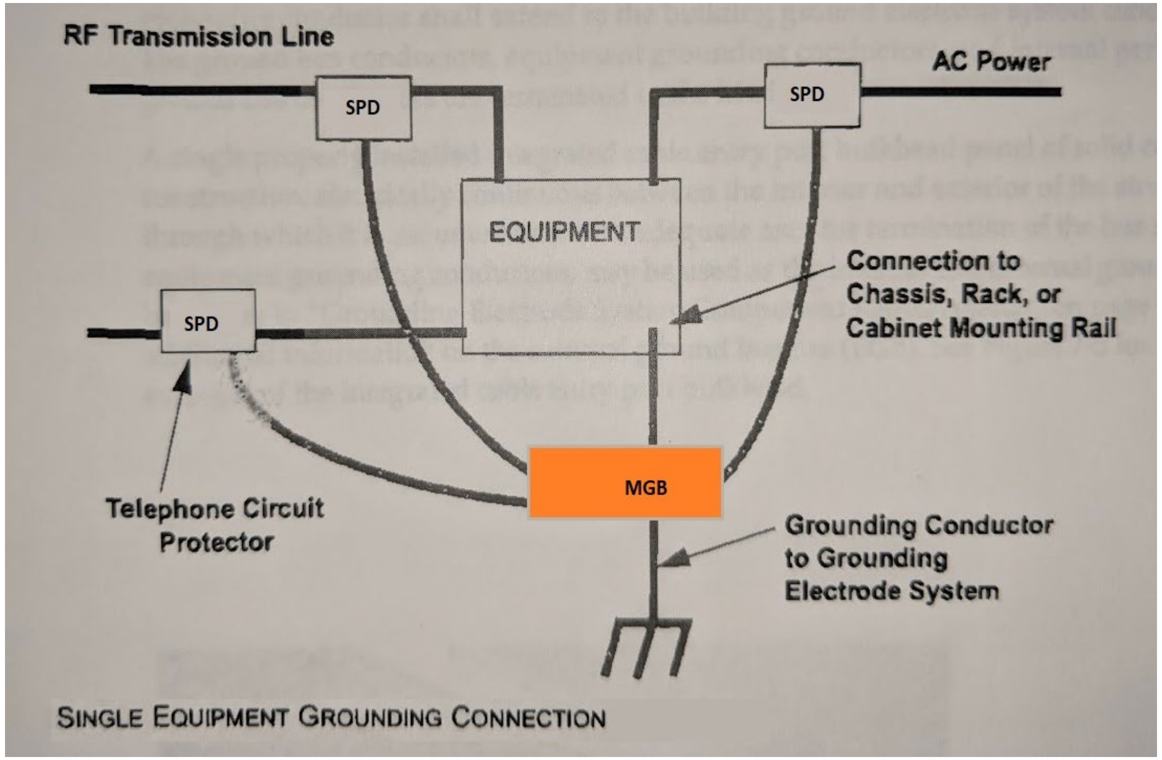
The "BOX" Concept



When looking at your equipment cabinet, recognize that every single metal object that pierces the metal enclosure brings in transient and EMI risks to the inside of the equipment cabinet.

Surge protection is normally used to remove high risk transients from the system – But only if the Grounding and Bonding is done correctly

Lightning Protection Systems For Cabinets



- Good Grounds and Bonding practices ensures the surge protector has the lowest impedance paths to earth ground.
- Existing industry testing standards by NEMA, IEEE, NEC and UL insure that the surge protector is strong enough for the application.

Lightning Protection Systems For Cabinets

AC, DC, Coax, RF and Data/PoE and Fiber Sheaths are all points to be considered during the cabinet design.

No matter which manufacturer is selected, the protectors are only as good as the ground and bonding its connected to.

All conductors in and out of a cabinet should have good surge protection protecting each wire

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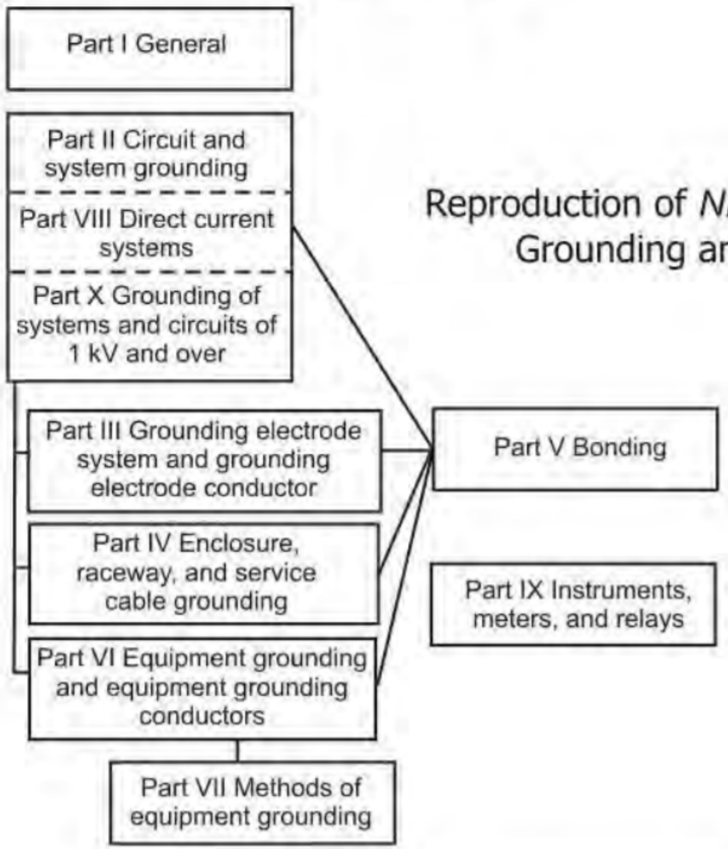
NEC 250



Reproduction of *NEC* Figure 250.1 Grounding and Bonding

(1) What systems, circuits and electronic equipment require grounding or should not being grounded.
(2) Circuit conductors needing grounding on grounded systems.
(3) Location of grounded systems
(4) Type and size of grounding and bonding conductors
(5) Methods of grounding and bonding
(6) Conditions when isolation and insulation can be used instead of grounding

Good Standards for Designing Communication Equipment

Alliance for Telecommunications Industry Solutions ATIS

ATIS is a technical planning and standards development organization that is committed to rapidly developing and promoting technical and operations standards for the communications and related information technologies industry worldwide using a pragmatic, flexible and open approach. Over 1,200 participants from more than 400 communications companies are active in ATIS' 22 industry committees, and its Incubator Solutions Program. www.atis.org

J-STD-607-A-2002, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications is jointly developed by TIA/EIA and ATIS' technical committee T1E1. This document is available on the ATIS Document Center at www.atis.org.

Adhering to the grounding principles outlined in J-STD-607-A helps ensure that telecommunications equipment and systems operate reliably. As stated in J-STD-607-A, the preferred means of connecting conductors to busbars is by using two-hole irreversible compression lugs listed by a nationally recognized testing laboratory (NRTL) such as UL. *PANDUIT® PAN-LUG™* Copper Compression Connectors meet these requirements, in all of the barrel sizes specified by the 607 standard.

Telecommunications Industry Association TIA

The Telecommunications Industry Association is a leading U.S. non-profit trade association serving the communications and information technology industry. TIA represents providers of communications and information technology products and services for the global marketplace through its core competencies in standards development.

ANSI/TIA-942 Draft 5.0a – Telecommunications Infrastructure Standard for Data Centers

TIA-942 states that electrical continuity is required throughout the rack materials. Adhering to these principles protects network equipment and maintains system performance. *PANDUIT® STRUCTUREDGROUND™* System for Data Center Grounding meets TIA-942 requirements by incorporating an all-copper grounding path. Paint piercing grounding washers ensure metal to metal contact of rack members and two-hole compression lugs for a permanent and reliable connection.

The Institute of Electrical and Electronics Engineers, Inc. (IEEE)

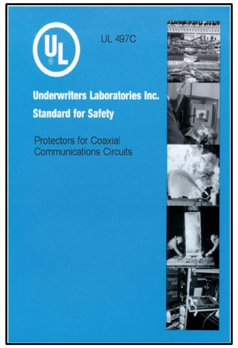
The IEEE promotes the engineering process of creating, developing, integrating, sharing, and applying knowledge about electro and information technologies and sciences for the benefit of humanity and the profession.

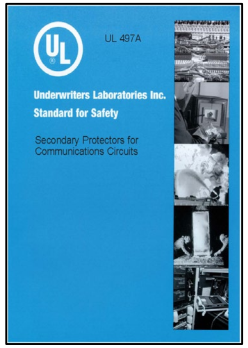
IEEE Std 1100-1999 (IEEE Emerald Book) – IEEE Recommended Practice for Powering and Grounding Electronic Equipment

The main objective of the Emerald Book is to provide a consensus of recommended practices to address electronic equipment performance issues while maintaining a safe installation, as specified in the National Electrical Code® (NEC®) (NFPA 70-1999) and recognized testing laboratories' standards.

ATIS	TIA
IEEE 1100	NEC Article 100 & 250
UL /CSA	Motorola R-56

Good Standards for Controlling the designs for SPD





1. NEMA Surge Protection Institute: http://www.nemasurge.org/surge-damage/

2. IEEE Standard C62.41.1 – 2002 (Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits)

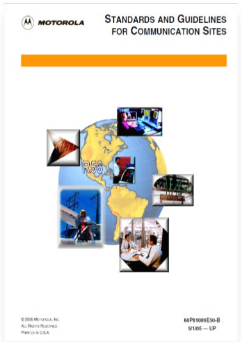
3. IEEE Standard 1100 – 2005 (Recommended Practice for Powering and Grounding Electronic Equipment)

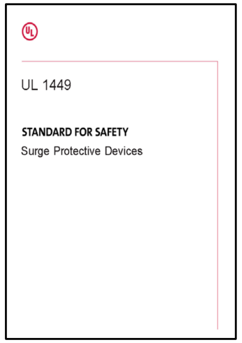
4. UL1449 4th Edition – Surge Protective Devices

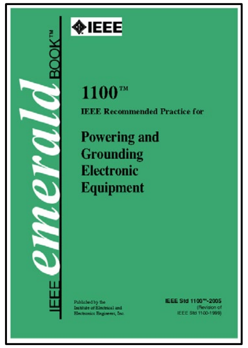
5. UL497B – Secondary Surge Protectors

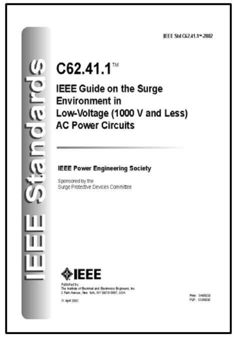
6. UL497E – Antenna Lead-In Conductors

7. MOTOROLA R-56 Standards and Guidelines For Communications Sites









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Thank You – QUESTIONS?

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