Grounding

So, what's a ground anyway?

Jerry Hogan

- Director of Engineering & Marketing - Solara Technical (E-VAR)
- BSEE from the University of Colorado
- MBA from the University of Chicago Booth School of Business.
- R&D, technical marketing in power electronics and systems at:
  - AT&T Bell Labs, Texas Instruments, Siemens, and Rockwell.
- Executive management at several smaller technical companies.
- Directly involved with power & power electronics for 40+ years.

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Solara Technical

Engineering Value Added Reseller providing vendor agnostic backup power solutions. We also consult on Lightning Mitigation and Grounding Issues.

Applications Include:

- Optical Networks
- Distributed Antenna Systems
- Microwave Radios (point-2-point, point-2-multi point)
- Variety of Telecom/Datacom Systems

YouTube

Solara Technical Sales

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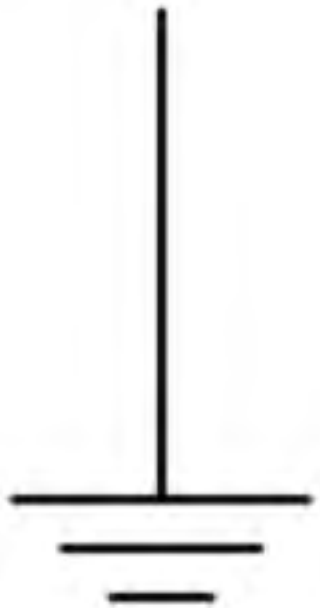
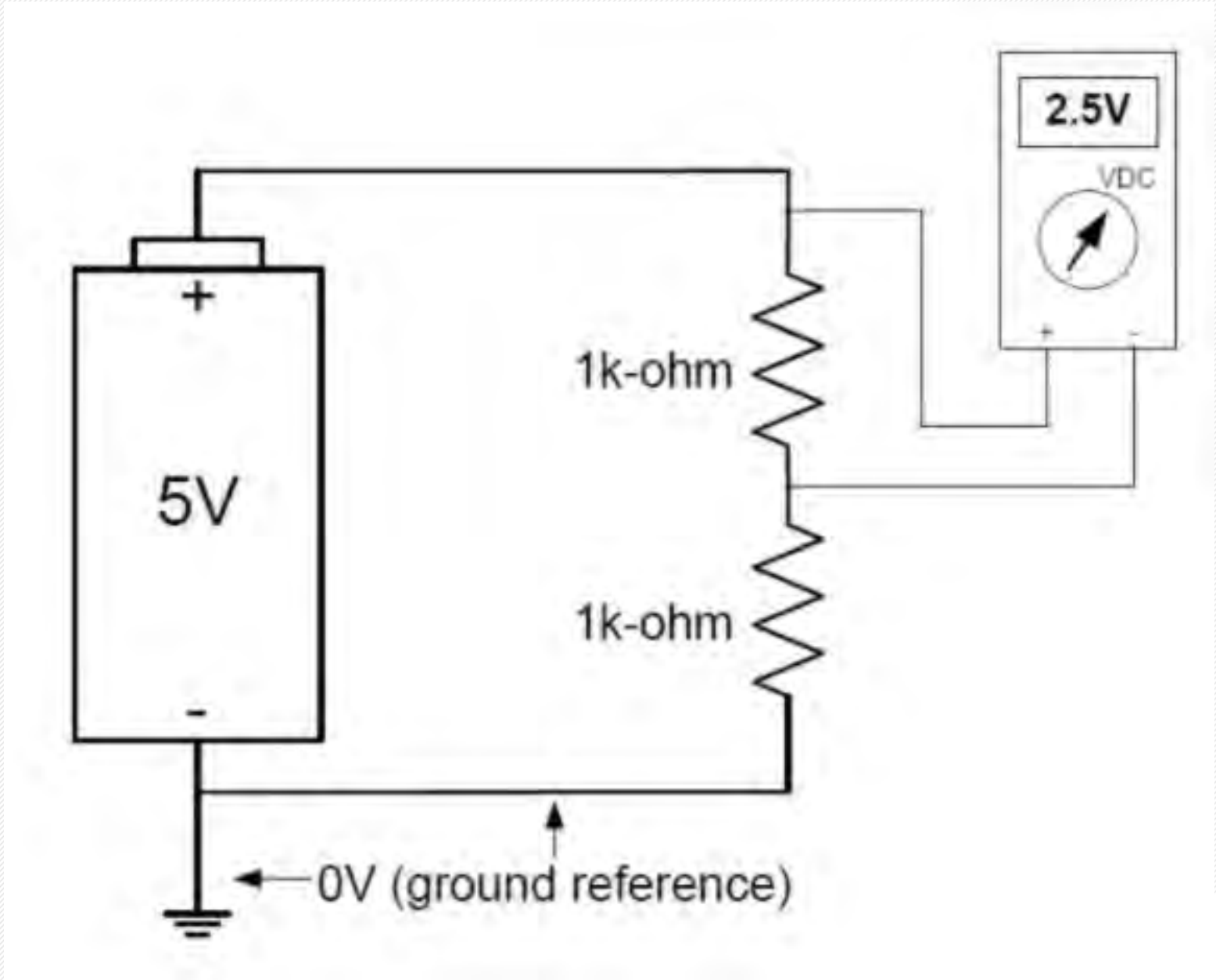
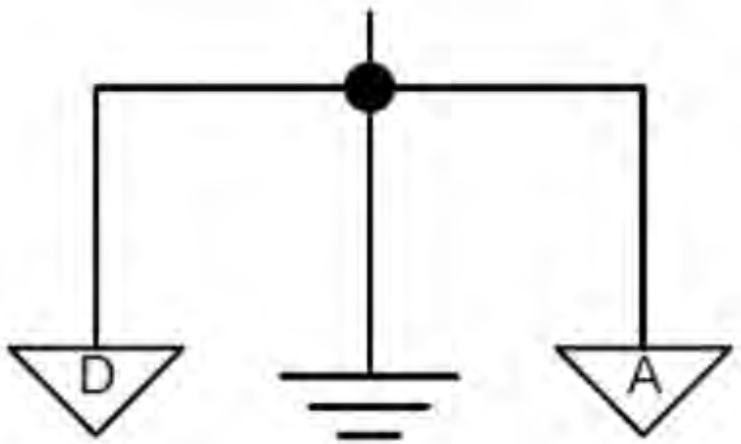
ground, general symbol / earth ground

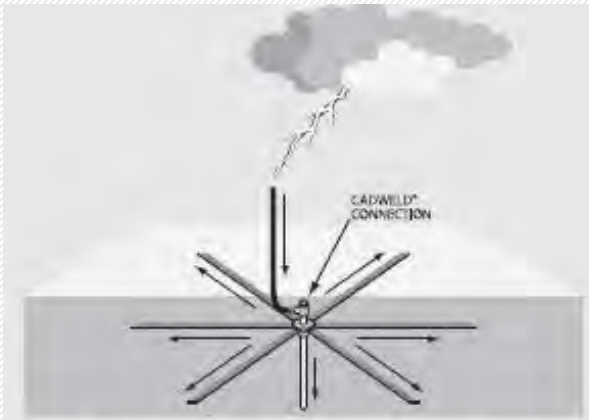



2.5V
VDC
+
-
1k-ohm
1k-ohm
5V
+
-
0V (ground reference)

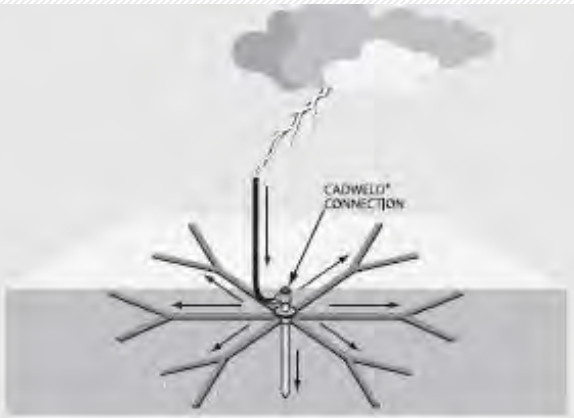


Chassis or frame ground

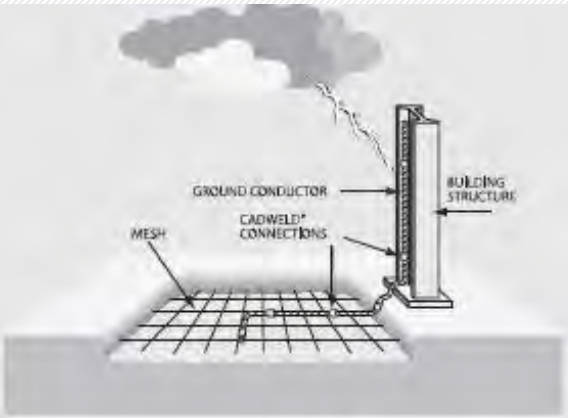
low-noise ground
or
functional earthing



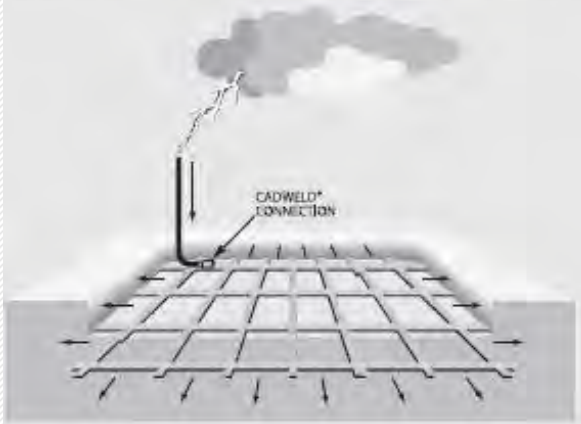
Radial Grounding, Single Radials



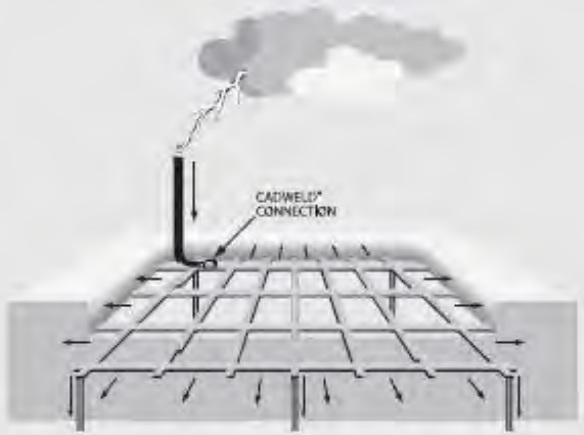
Radial Grounding, Multiple Radials



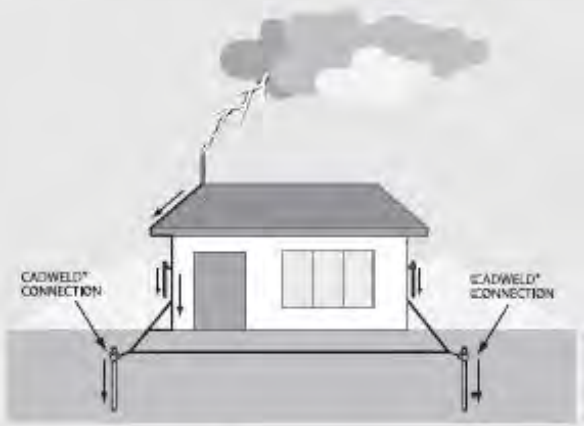
Equipotential Mesh Electrodes



Grid Electrodes



Grid with Ground Rods



Ring Electrode

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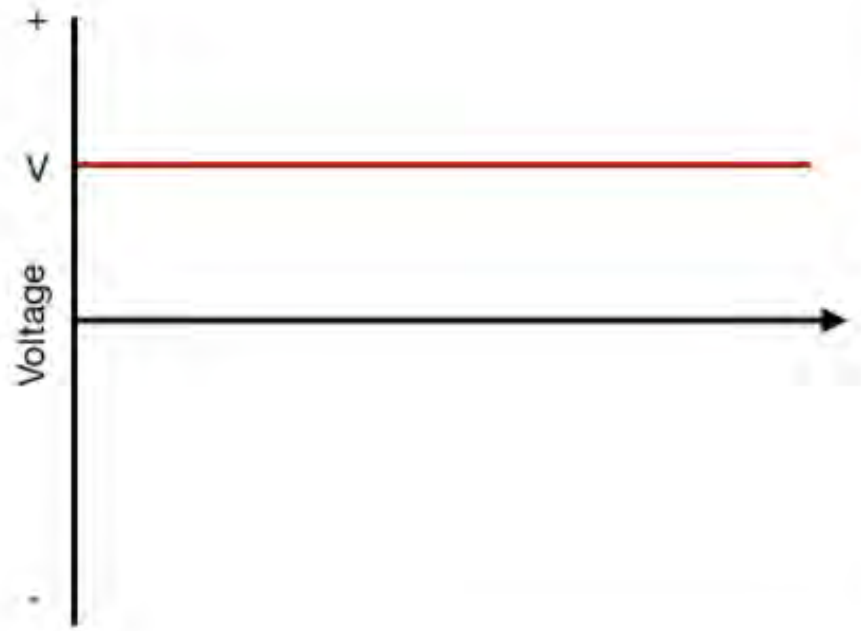
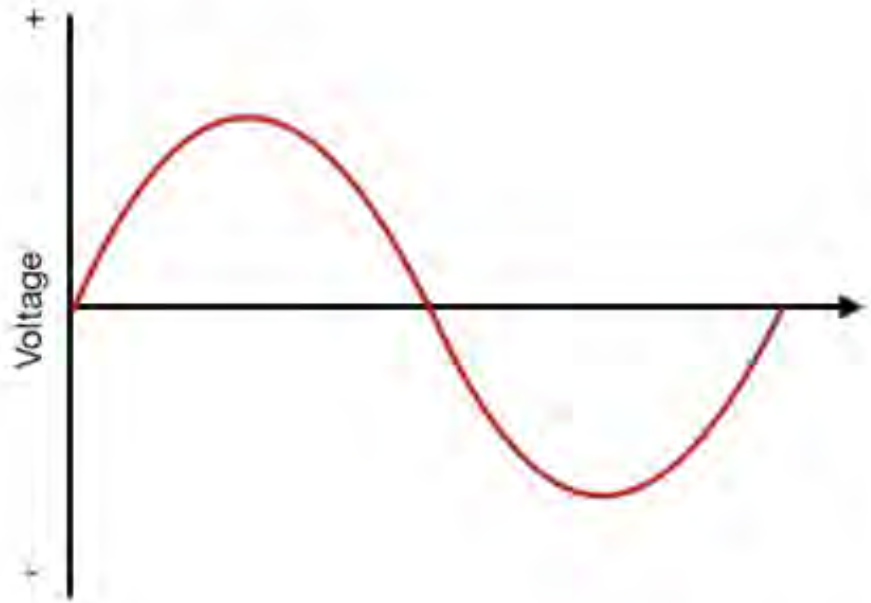
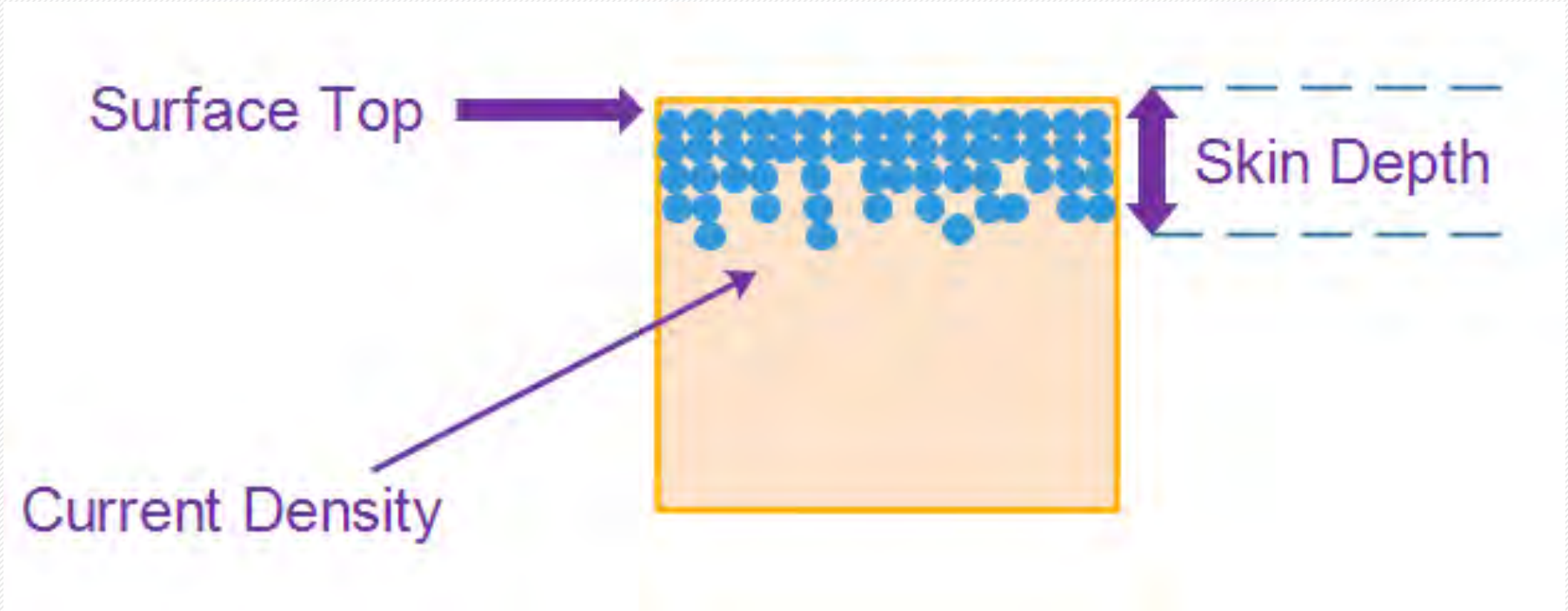
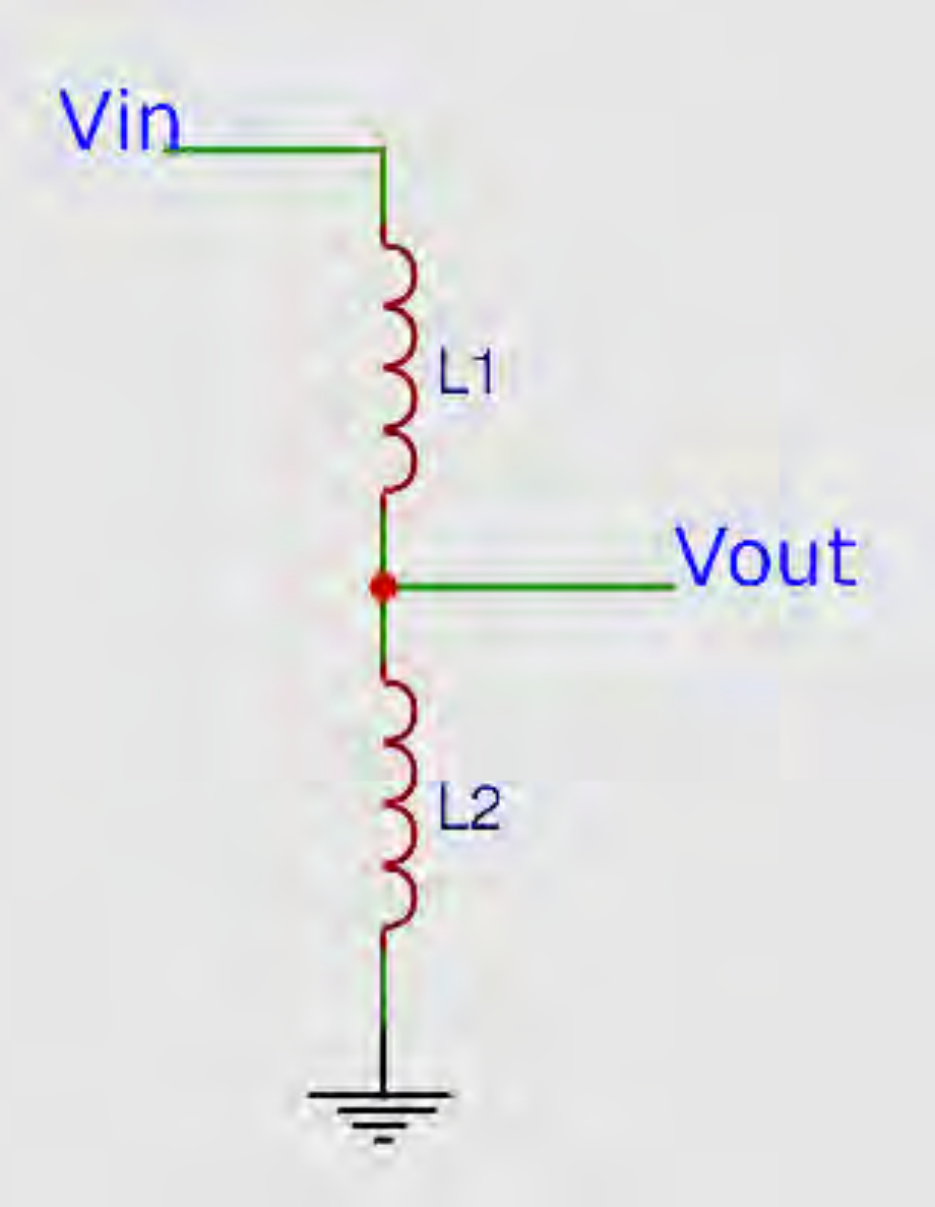
Audience Participation!

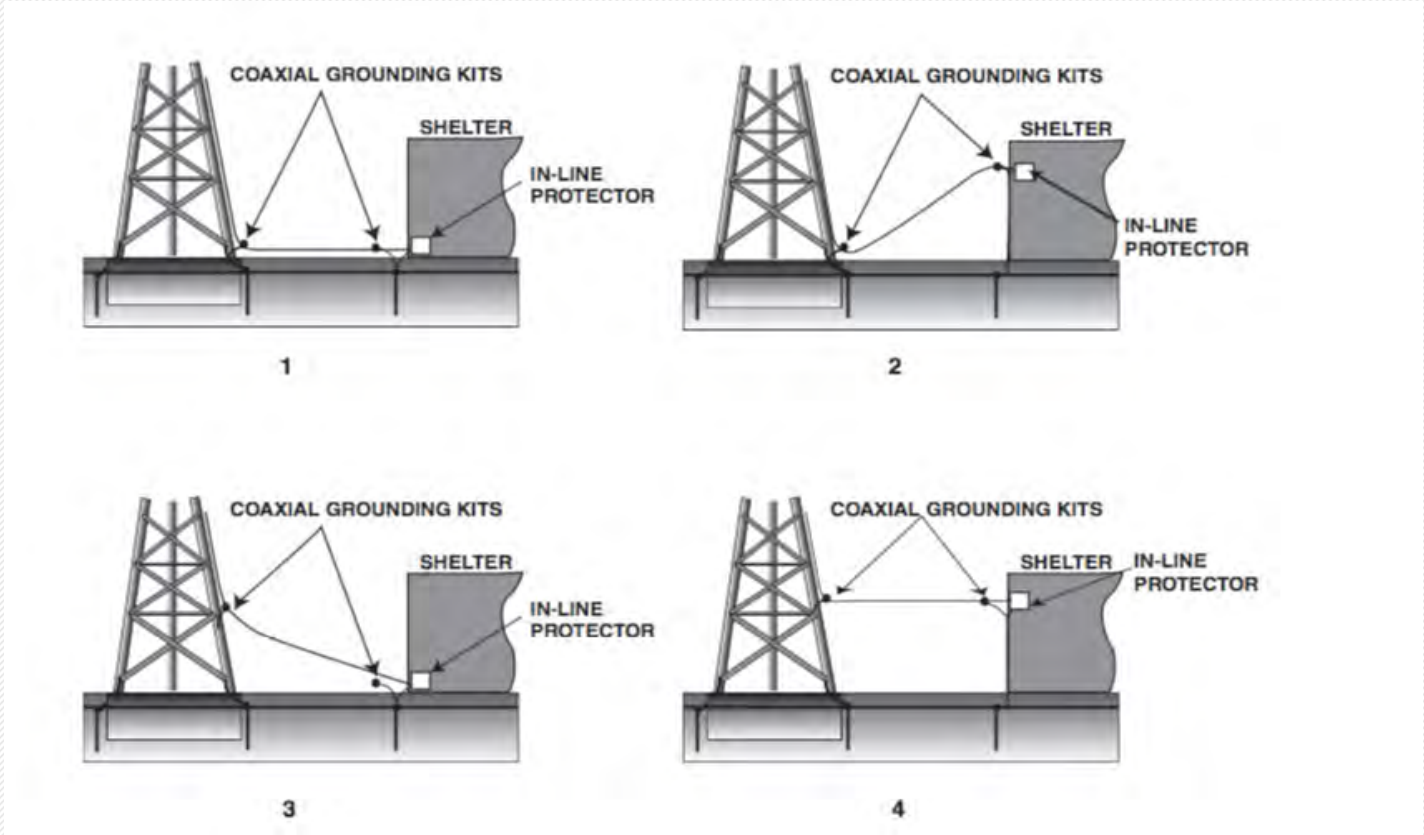
Direct Current	Alternating Current
	


Surface Top
Skin Depth
Current Density



Soil level

Cable paths make a *HUGE* difference!



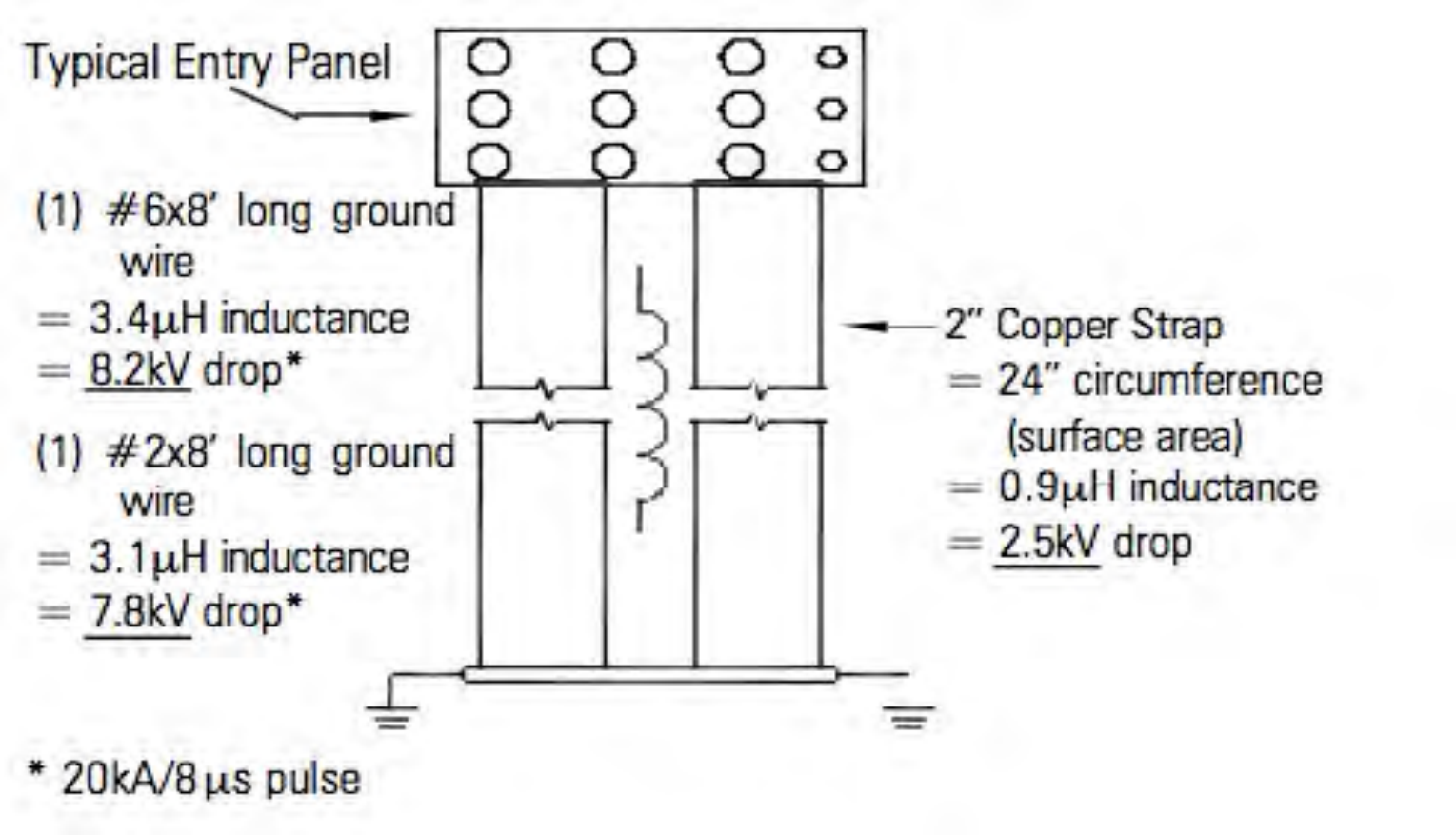
If the soil is a perfect ground, then reducing the distance from coax grounding kits to the soil-ground at the tower is the key!

Two very different Entry Panels

$

$$$

Entry Panel Inductance:



1,000V of potential/one foot of round conductor above ground.

Copper strap? 300V/foot for 2" width copper strap. 3.3X better.

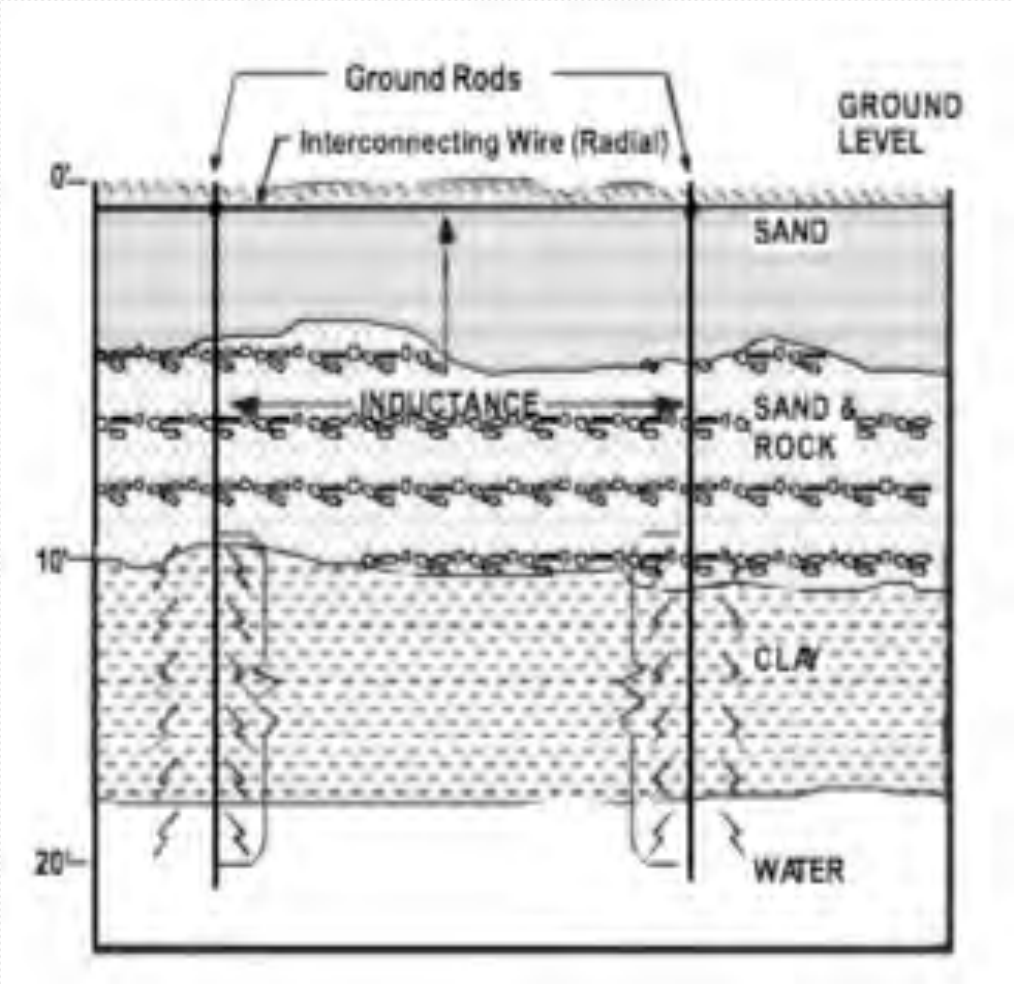
Voltages @ Entry Panel (20kA, 8uS pulse)

6,000V for 6 feet

1800V/6 conductors =
300V for 6'or 1/20th

(Again, assume for now that the soil is a perfect ground.)

But Soil is not a perfect conductor. Untreated soil is a very poor conductor with high inductance.



Now this is a low inductance ground!

THANK YOU

Grounding Essentials

Importance of grounding in wireless networks

John E Hargrove PE TX
Evergreen Technology Solutions LLC
Buna Texas

EVERGREEN
TECHNOLOGY SOLUTIONS, LLC

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Overview of Grounding

Several Crucial Purposes:
Lightning Protection
Electrical Safety
Reduce Electrical Noise And Interference
Compliance with Regulations
Equipment Protection
Low impedance path to earth ground

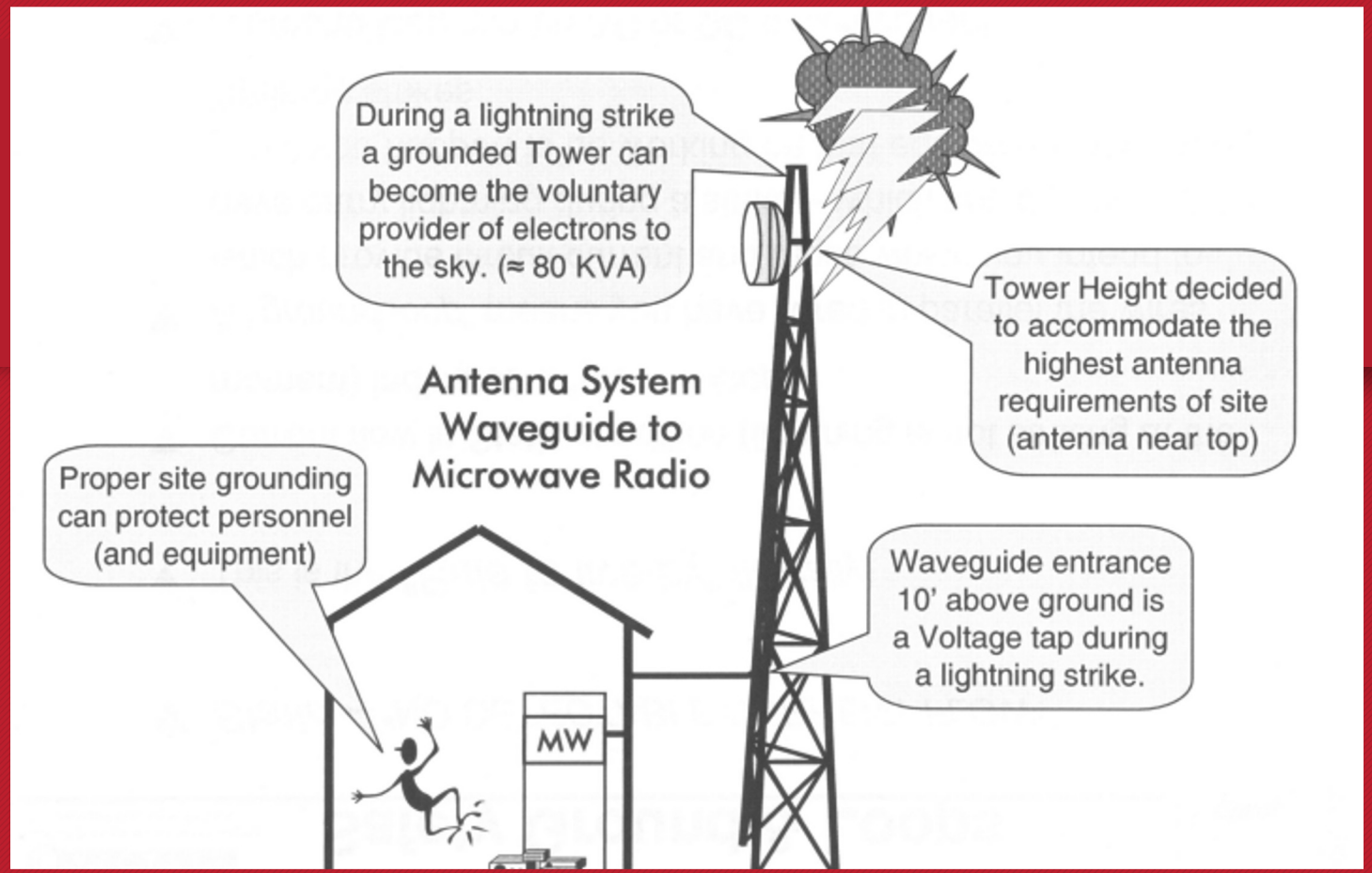
Towers and Grounding

Low impedance path to earth ground
(Low inductance path is what the high frequency energy follows)

Tower Surface Inductance lower impedance than…anything else on the tower

Bonding and testing important

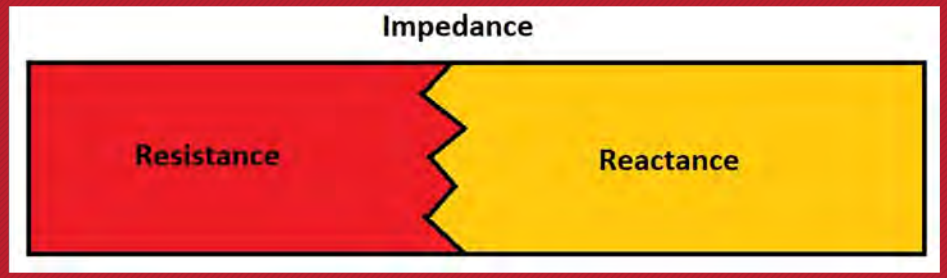
Towers and Grounding



The Difference Between Resistance and Impedance

Resistance is a measure of the opposition to the flow of direct current (DC) through a conductor.

Impedance accounts for both the energy dissipated as heat (resistance) and the energy stored and later released by the circuit elements (reactance)



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Towers and Grounding

This is poor

Towers and Grounding

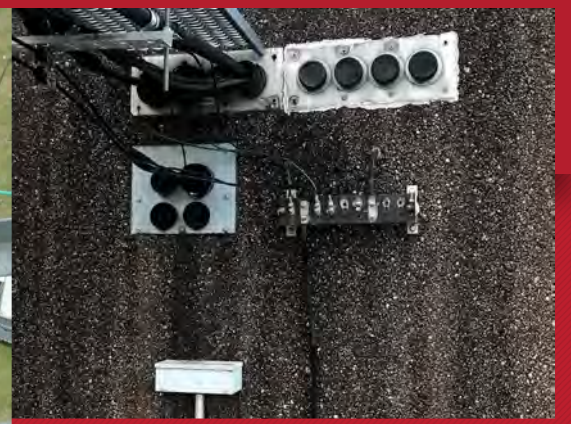
This is better

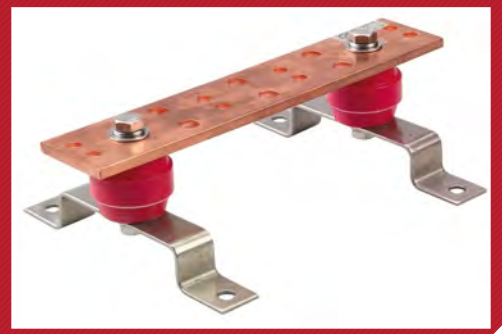
Towers and Grounding

Mechanical Compression
Hydraulically bonds at a molecular level.

Towers and Grounding

Tower Top - middle and bottom





Overview of NEC Code Requirements

Excerpts

Article 800 - Communications Circuits

Grounding Busbar (TGB)

Grounding Electrode System: ensure a common grounding reference point

Bonding (Article 250): Bonding is the process of creating electrical continuity and conductivity between metallic parts of an electrical installation

Customer Premises Equipment (CPE) Grounding

CPE must be grounded to the premises' grounding electrode system

Grounding conductors should be of the type and size specified by the NEC

The grounding of CPE must also adhere to the manufacturer's installation instructions

Care must be taken to avoid creating ground loops

RJ45 Shielded Grounding for POE Cable Systems

The shield of the RJ45 connector must be properly terminated to ensure it effectively grounds the cable.

Use of Grounded Patch Panels and Equipment Racks

Consistency in Grounding Practices.

Bonding and Earth Grounds

Earth grounding refers to the connection of electrical systems to the earth itself. The primary purpose of earth grounding is to protect people from electric shock, stabilize voltage levels within the system, and provide a path for electrical current to dissipate into the earth in the event of a fault.

Earth grounding is typically achieved by driving grounding rods into the soil and connecting these rods to the electrical system with grounding conductors.

Practical Considerations and Case Studies

Tower site inside an electrical substation

- Multiyear problem - loss of 100K of equipment over two years
- applied single point ground system, removed loops, improved bonding, measure earth ground

Stand alone tower site

- Iron ore ground in a dry desert climate
- Installed ground leads (4 inch copper straps) out to multiple chemical ground rods 50 foot length

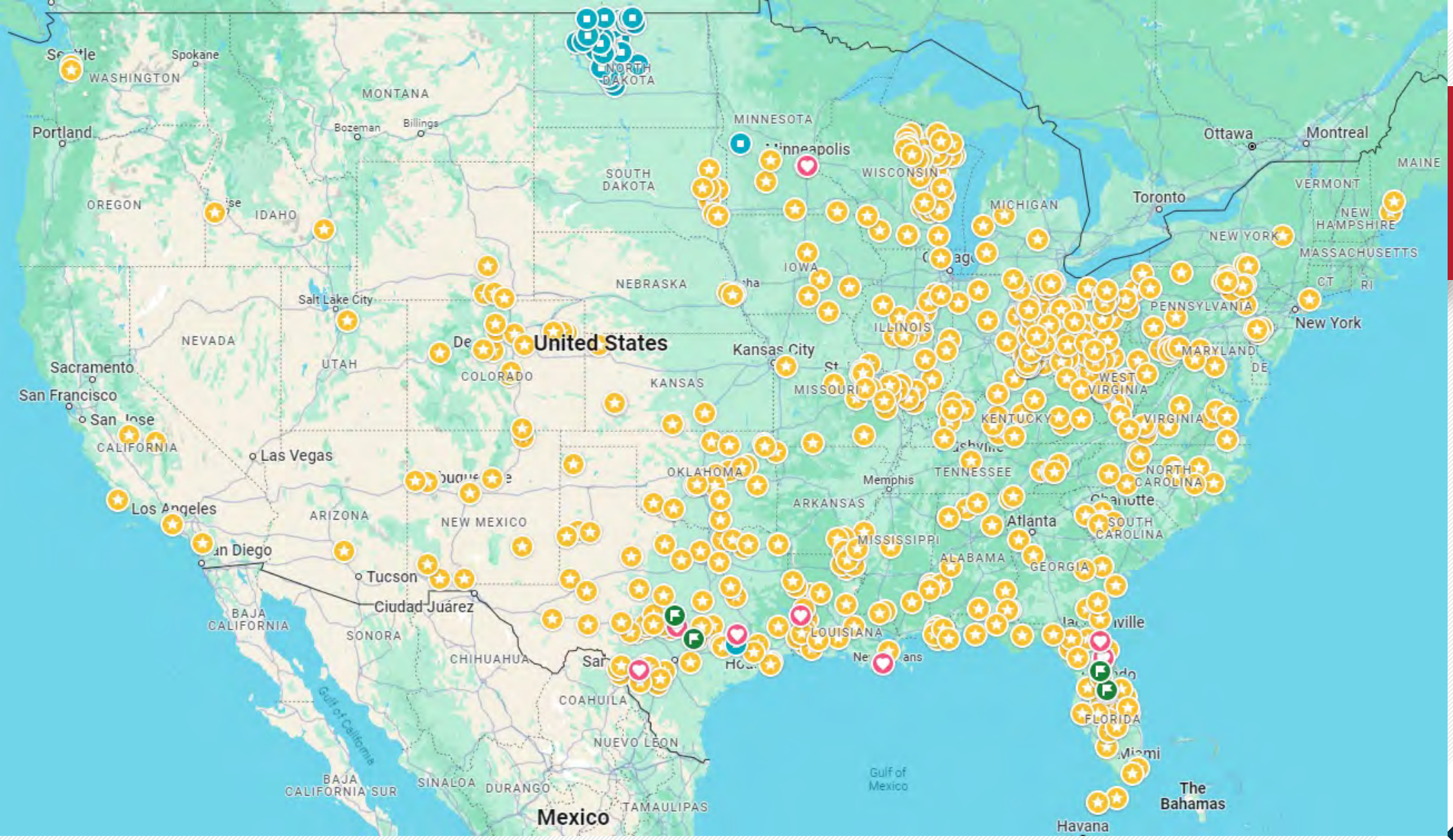
Conclusions

Keep it simple
Single Point ground for tower sites
Smooth NOT sharp bend in all bonding conductors
Keep bonding conductors short as possible
Measure earth ohms at the ground rods and bus bars and major bonding straps

THANK YOU

Personal and Business Introduction

- Jeff Little
- CEO
- Above Wireless LLC
- Troy, Ohio
- 24 years of experience



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Importance of Grounding

- Mark Roberts

Importance of Grounding

- Daniel Park

Importance of Grounding

- Spencer Fuller

Standards and Regulations

- NEC (National Electrical Code) - NFPA 70
- ANSI/TIA-607-D
- ANSI/TIA-222

Tower Ground Ring Conductor:

- Should be an uninsulated tinned or untinned copper conductor, minimum 2 AWG, buried at least 0.75 m (2.5 ft) or below the frost line, whichever is deeper, and installed at least 0.6 m (2 ft) away from the tower base.

Ground Rods and Potential Equalization:

Ground rods used should be at least 3 m (10 ft) in length and 16 mm (0.625 in) nominal in diameter. The spacing between any two ground rods should be at least the sum of their driven lengths for maximum effectiveness.

Use of Tinned Conductors:

Radial conductors should be a minimum of 2 AWG, uninsulated, tinned or untinned copper conductor, with tinned conductors recommended for their corrosion resistance.

Bonding Busbars:

•The external bonding busbar, which connects the antenna transmission lines and other telecommunications cables at the point of entry to a building, should use 2 AWG or larger uninsulated solid or stranded tinned or untinned copper conductor.

Materials/Tools Overview

Grounding Rod

5/8 x 10ft

Costs 25-35 each

#2 Tinned Wire

2 AWG

Costs $1.80-$4.15 per ft

Cadweld Exothermic Welding Deluxe Kit

- Costs $1,728.46
- Costs Per Shot $8-$11

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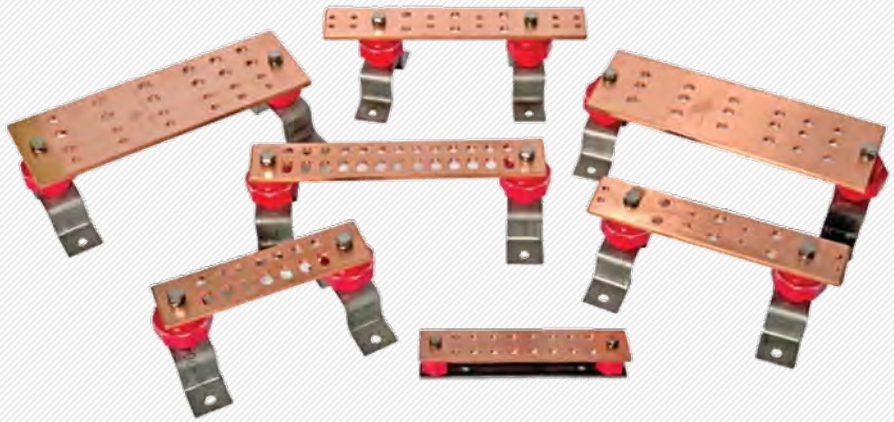
Lugs

- Izzy 2 Hole Lug
- Costs $1-$3 Each

Buss Bars

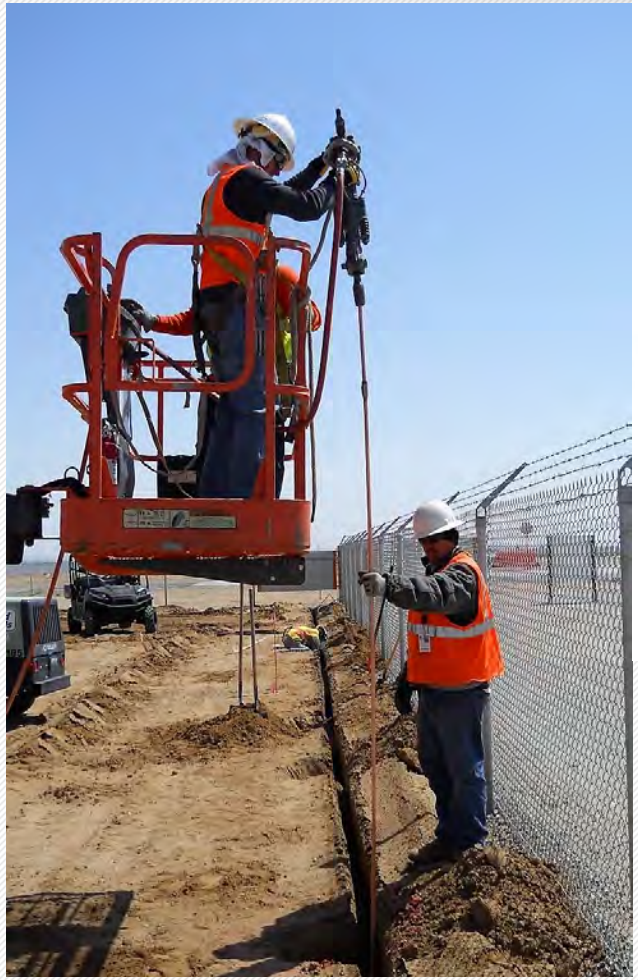


- Costs $17-$53 Each

- Costs $0.77-$2.30 per ft

Ground Rod Installation Methods

- Sledgehammer
- Electric hammer drill



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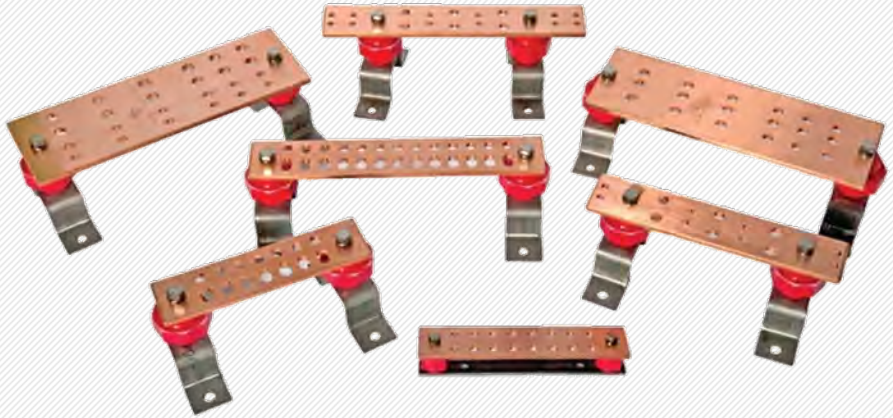
Tower Bonding

Grounding Tower Equipment



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Grounding Tower Equipment

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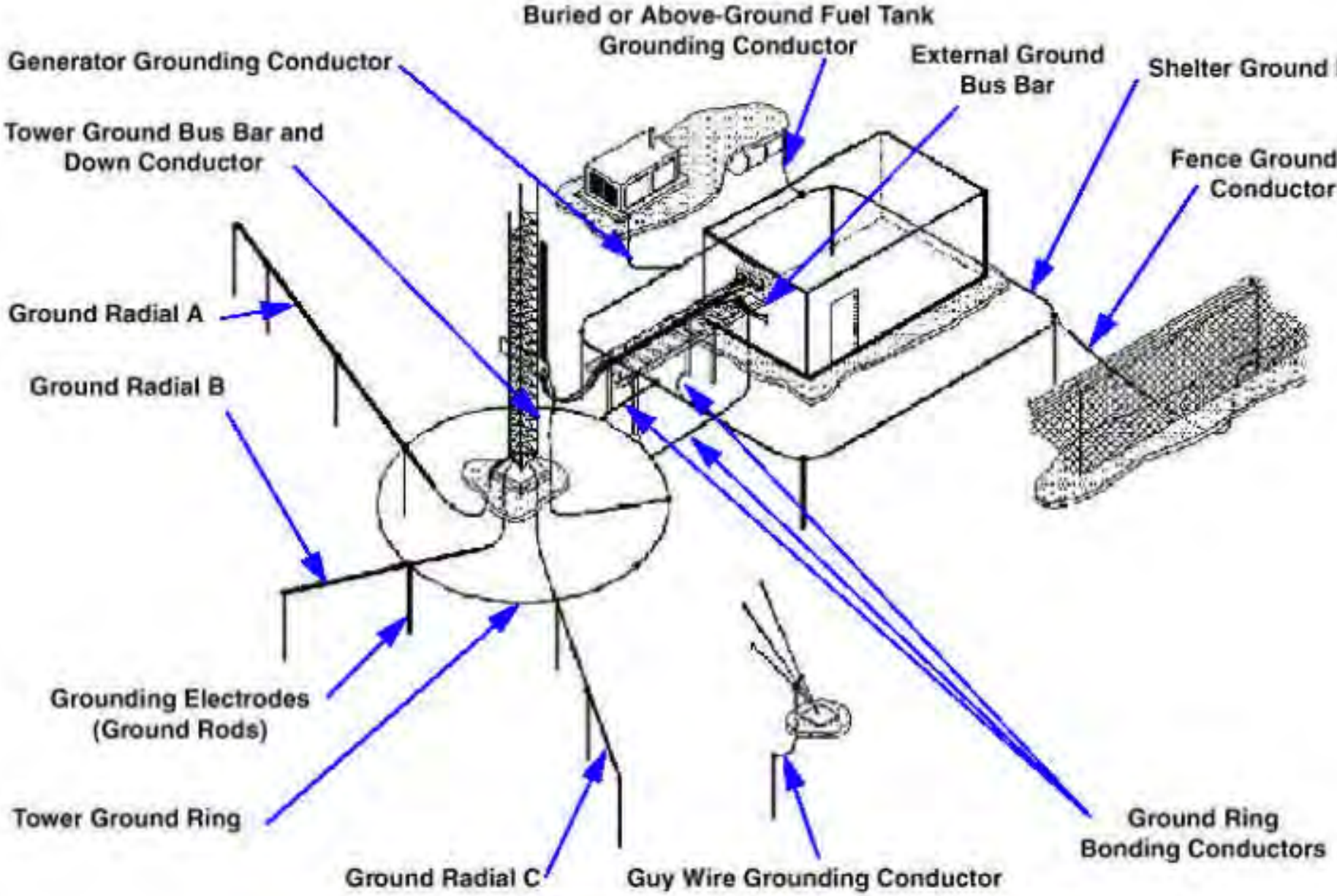

FIGURE 6-1 TYPICAL TYPE B EXTERNAL GROUNDING ELECTRODE SYSTEM

Ground Ring Specs

10.4.1 Materials

Grounding rod-type electrodes (also referred to as ground rods) shall be 5/8 in. [16 mm] minimum diameter, 10 ft. [3 m] minimum length, stainless steel, copper, copper clad steel, or zinc coated steel.

Ground wires shall be a minimum #2 AWG or larger solid bare tinned copper conductor. Ground wires larger than #2 shall be permitted to utilize stranded tinned copper conductor.

Ground Ring Specs

10.4.2 Grounding System Configuration

The grounding system shall consist of rod-type electrodes and ground wires (including rings and radials specified in 10.4.2.1 and 10.4.2.2) installed below the frost depth but not less than 30 in [760 mm] below grade.

Rod-type electrodes shall be installed vertically below grade. The number of ground rods installed shall be in accordance with 10.4.2.1. When site conditions do not allow for a vertical installation, battering the electrodes away from the base of the structure as close as possible to vertical shall be considered acceptable when the minimum depth below grade is maintained.

Ground wires connected to the structure shall continuously flow down or away from the structure with bends not less than 90 degrees. The minimum bend radius shall be 12 in. [300 mm].

No portion of the grounding system shall pass through or be connected to a concrete foundation.

Ground Ring Specs

10.4.2.1 Ground Rods and Ground Wire Radials

For tubular pole structures and pinned base latticed structures, one ground rod and one ground wire radial shall be installed on each side of the structure foundation with a separation of 180 degrees (+/- 30 degrees).

Structures with height less than 40 ft [12 m] require a single ground rod and ground wire radial only.

For all other structures, one ground rod and one ground wire radial shall be installed for each leg.

One ground rod shall be installed at each guy anchor for guyed masts and connected to the guy anchor with a ground wire.

Each ground rod shall be connected to a ground wire radial installed around the base of the structure. The ground wire radials shall project outward from the base of the structure for a minimum length of 25 ft [7.6 m] per radial. Each ground wire radial shall be connected to the base of the structure and be directed away from the base of the structure. Ground radials are not required for ground rods installed at guy anchors for guyed masts.

When site conditions do not allow for a straight line radial, the ground wire for any radial shall be permitted to deviate from a straight line using one or more 120 degree minimum bends with a 12 in. [300 mm] minimum bend radius.

Testing

$1,591.25

$2,205

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TIA 607 2.2

2.2 Grounding resistance minimum requirements (subclause 8.1.2)

Subclause 8.1.2 shall be modified as follows:

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 ~~10 ohms or less, preferably~~ 5 ohms or less. The grounding electrode system design should take into account seasonal fluctuations such as moisture and temperature.

Recommended Reading

- TIA-222-I
- ANSI/TIA-607-D
- NEC (National Electrical Code)

Summary

CHATGPT Joke

- Why did the telecommunications tower refuse to play cards with the lightning?

CHATGPT Joke

- Because it was afraid of getting a shock even though it knew it was well-grounded!