Lightning Protection

by Doug Sharp, K2AD and John Maxwell, W0VG

Rocky Mountain Ham Radio University
March 13, 2021

Proper grounding practices for radio sites as well as shacks and radio equipment, why you need to ground and and what happens if you don't. This will be good for all levels of hams.

Lightning season is only a couple months away, so attending this class may save you lots of future grief.

What we will talk about today?

- Protection Theory
- What is a ground?
- Principals to protect your
  - Radio equipment
  - Station Accessories
  - Wireless IP equipment
- Products available

- Lots of questions and answers

Doug's First Law of Lightning Protection

- You must have a good ground for your station
- A really great ground!
- One (and only one) great master ground

- Don't cheap out on protection
- Inexpensive protectors are inexpensive.
- They are cheap for a reason.

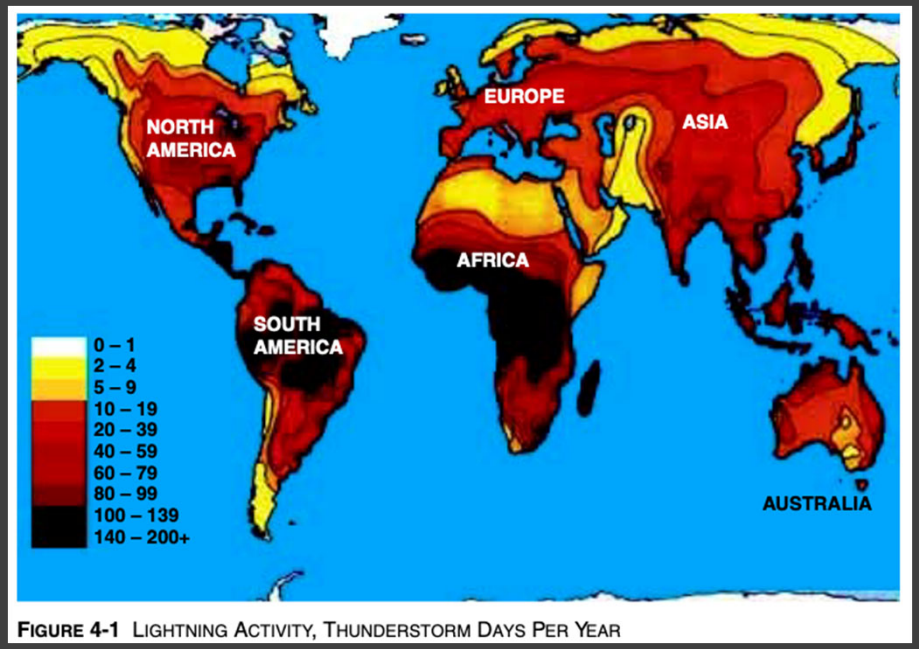


FIGURE 4-1 LIGHTNING ACTIVITY, THUNDERSTORM DAYS PER YEAR

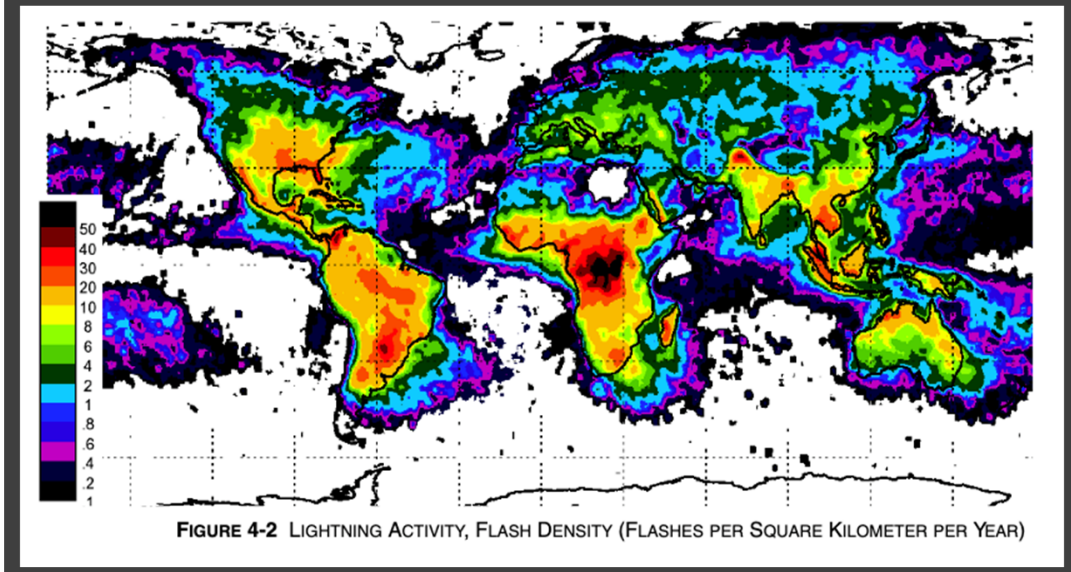


FIGURE 4-2 LIGHTNING ACTIVITY, FLASH DENSITY (FLASHES PER SQUARE KILOMETER PER YEAR)

Lightning Activity

- Serious lightning activity in Colorado
- From Standards and Guidelines for Communication Sites by Motorola Solutions

Reference Reading

Recommended Reading

"Lightning Protection for the Amateur Station" by Ron Block, KB2UYT

https://wrblock.com/StationProtection/Part-1.pdf QST June 2002

Lightning Protection for the Amateur Station

Part 1—Lightning protection can be a serious issue for amateurs. In the first of this three-part series, the author leads us through the process of developing a protection plan. Next: how to protect your equipment. The final part will cover the process of creating an effective ground system.

A three part article series

https://wrblock.com/StationProtection/Part-1.pdf

https://wrblock.com/StationProtection/Part-2.pdf

https://wrblock.com/StationProtection/Part-3.pdf

Recommended Reading

This is one of the Bibles of Commercial Communication Site Grounding

Most Public Safety radio sites being currently installed reference this publication

Google is your friend …
https://www.blm.gov/sites/blm.gov/files/Lands_ROW_Motorola_R56_2005_manual.pdf

MOTOROLA

STANDARDS AND GUIDELINES FOR COMMUNICATION SITES

68P81089E50-B
9/1/05 — UP

Fundamentals

Anatomy of a Lightning Strike

- A typical lightning strike is about 300 million Volts and about 30,000 Amps. (reference: The National Weather Service https://www.weather.gov/safety/lightning-power)
- All that energy is trying to find a path to ground
- We want to provide a path to ground that is not through our equipment
- Imagine a bird or squirrel on a high voltage wire
- Lightning seeks a low resistance and low inductance path to ground

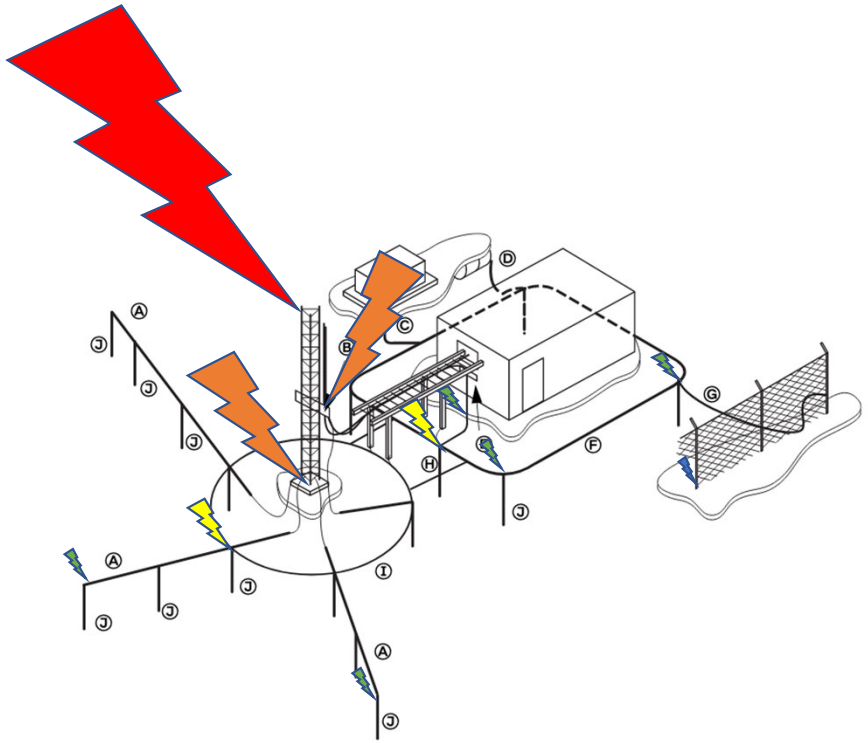
Divide and Conquer

As the lightning strike seeks a path to ground, we desire the voltage and current to decrease

What is the flow?

At each ground point we desire a low resistance and low inductance path to ground

The ground ring and ground radials also provide a capacitive couple to ground

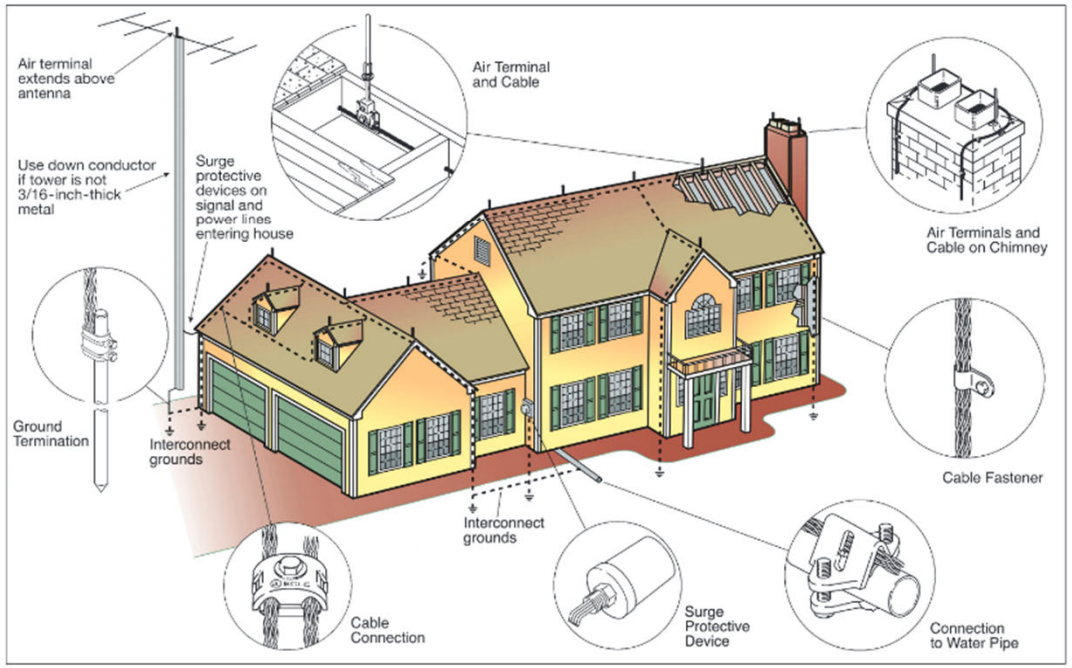


A: Grounding Radials
B. Tower Ground Bus Bar and Down Conductor
C. Generator Grounding Conductor
D. Buried Fuel Tank Grounding Conductor
E. External Ground Bus Bar
F. Shelter Ground Ring
G. Fence Grounding Conductor
H. Ground Ring Bonding Conductors (2 minimum)
I. Tower Ground Ring
J. Earthing Electrodes (Ground Rods)

A typical home station

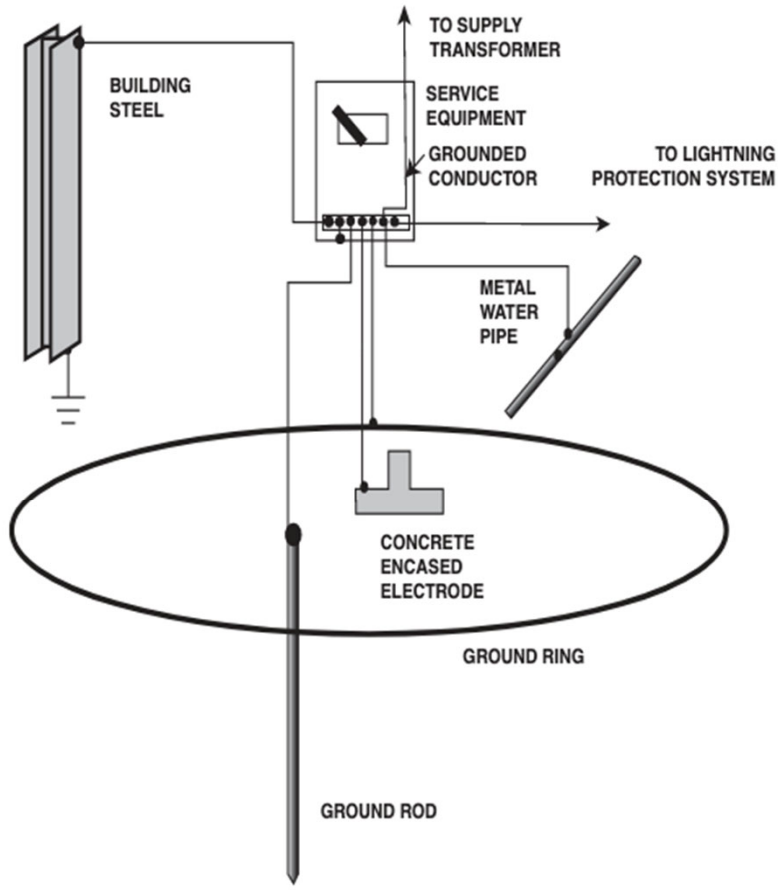
- Big tower!
- Adequate ground?
- Interconnected grounds?
- Single point or master ground?

- Is your equipment the connection between grounds?
- Or is your equipment the bird on a high voltage wire?



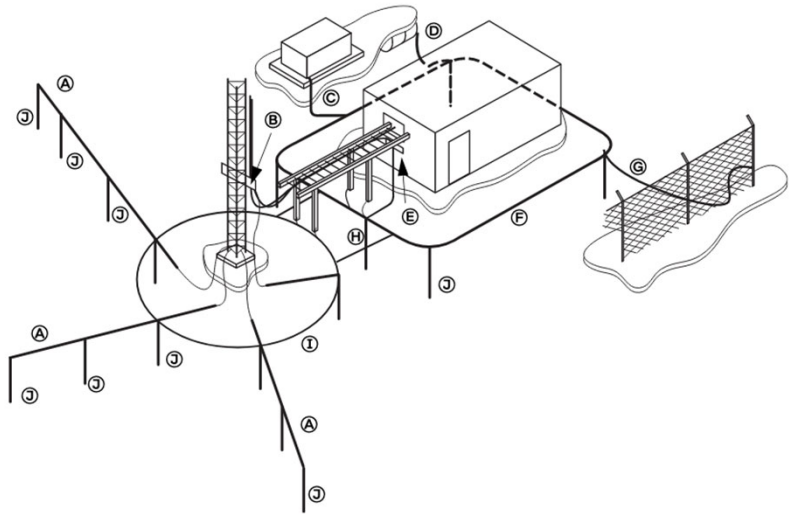
Typical Residential Lightning Protection System

Single Point Ground (simple)



4-3 COMMON GROUNDING EXAMPLE

Typical Commercial Site Ground System



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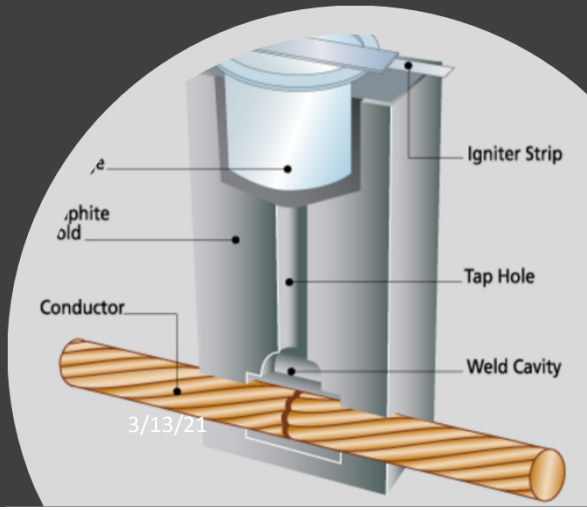
I. Tower Ground Ring
J. Earthing Electrodes (Ground Rods)

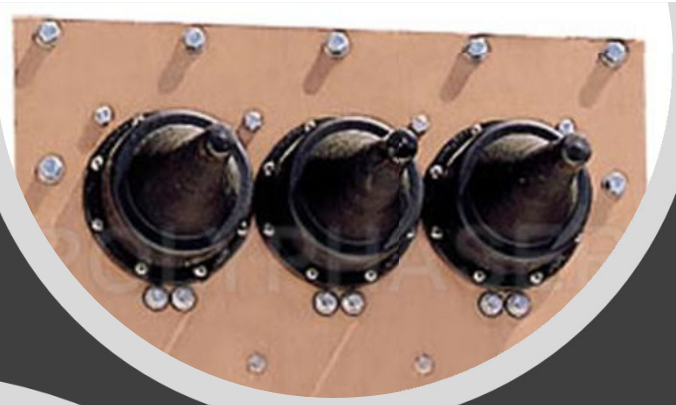
Exothermic Connections

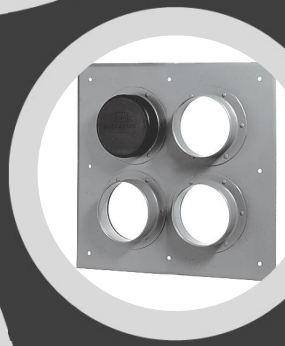
- Anything outside needs a weatherproof ground

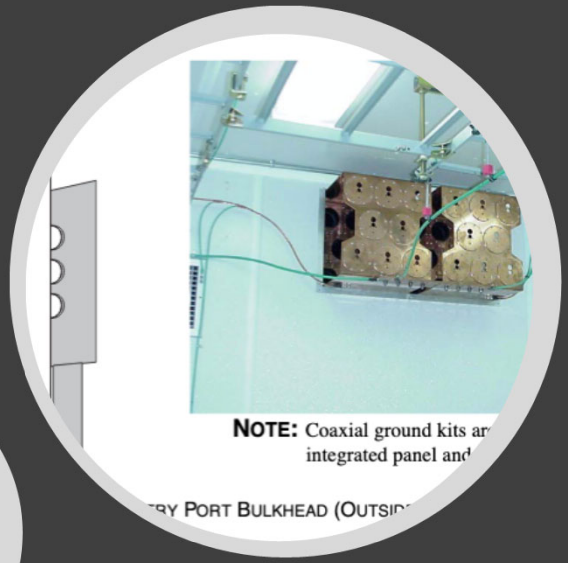
- Exothermic is best
- Clamp is OK
- Inspect for corrosion on a regular basis

- My Pick: CAD Weld / Ultraweld
- Multiple brands available

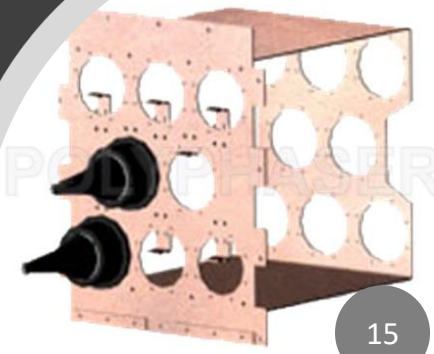




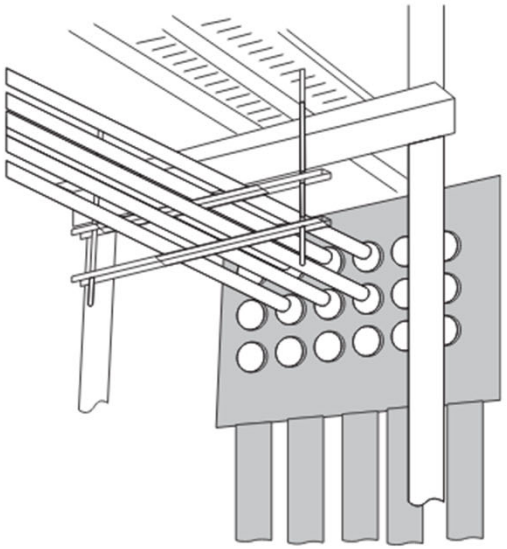


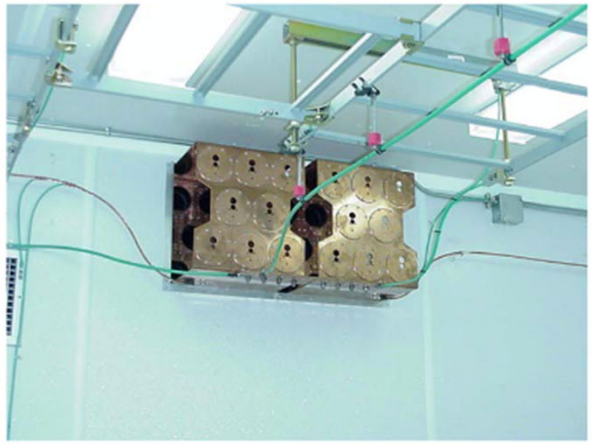

NOTE: Coaxial ground kits ar
integrated panel and
RY PORT BULKHEAD (OUTSI

Entry Panel



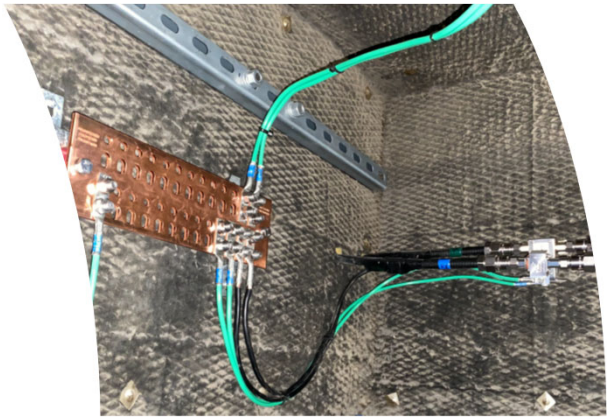
Entry Panel



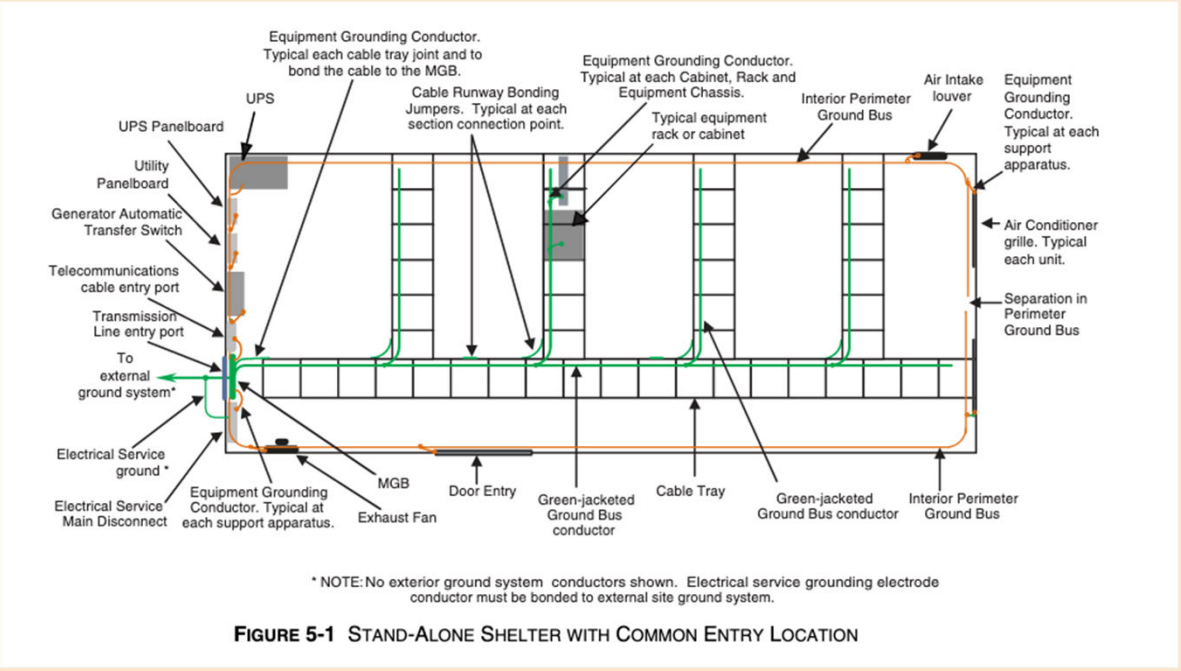


NOTE: Coaxial ground kits are located within the integrated panel and are not shown.

FIGURE 5-7 INTEGRATED CABLE ENTRY PORT BULKHEAD (OUTSIDE AND INSIDE VIEWS)



Inside the Repeater Shelter (or inside your shack)



* NOTE: No exterior ground system conductors shown. Electrical service grounding electrode conductor must be bonded to external site ground system.

FIGURE 5-1 STAND-ALONE SHELTER WITH COMMON ENTRY LOCATION

- All grounds inside the building connect to a single point
- Note: Orange wire “ring”
- Note: Green wire stubs
- Lightning must not travel to ground through the equipment

Proper Rack Grounding

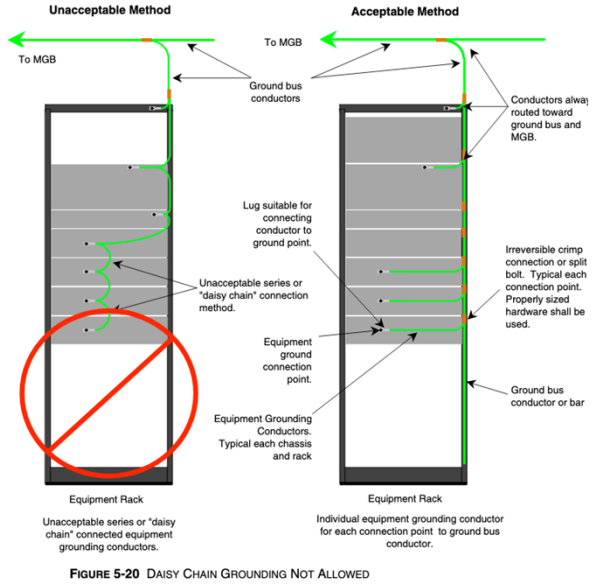
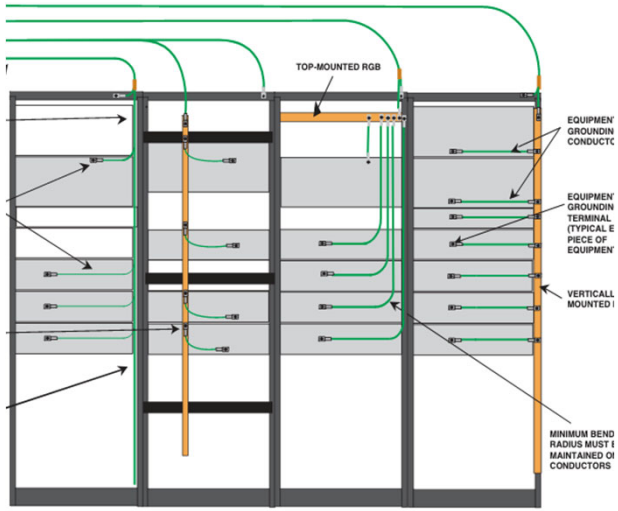


FIGURE 5-20 DAISY CHAIN GROUNDING NOT ALLOWED



GURE 5-17 ACCEPTABLE METHODS FOR BONDING FROM THE EQUIPMENT TO THE MG

- Don't daisy chain grounds within your rack
- Everything connects back to the Master Ground
- Note: Rack cabinet mounted rails
- Equipment grounds connect to mounted rails
- Rack rails are not connected to ground at bottom of rack (and might also be insulated from the floor)

Conductor Bends

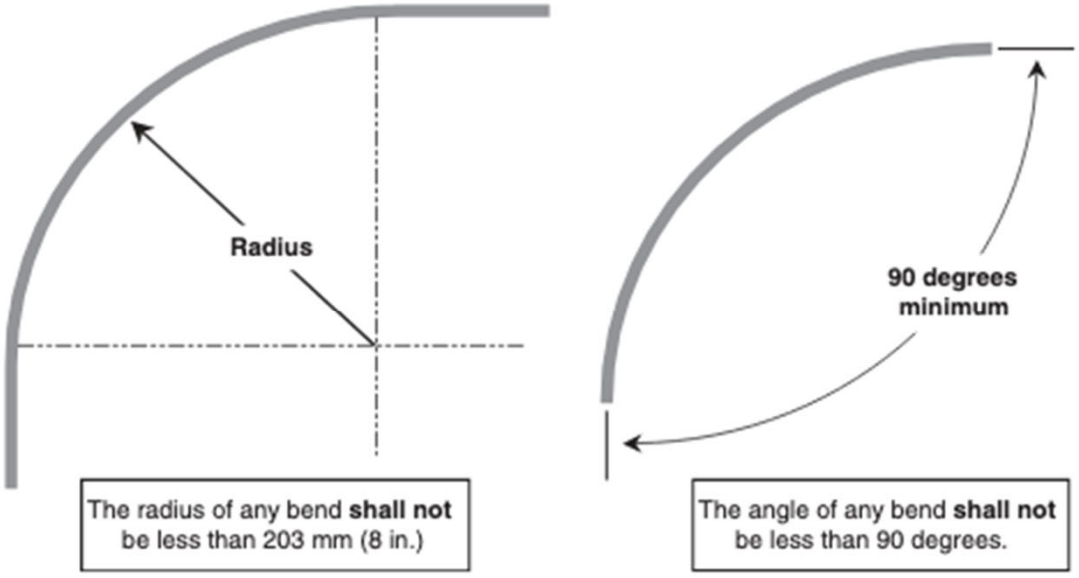


FIGURE 5-13 ACCEPTABLE GROUND CONDUCTOR BENDING


Implementing

From
"Lightning Protection for the Amateur Station" by Ron Block, KB2UYT

- Figure 5 shows a typical amateur station

- Figure 6 shows "the box" Anything going in or out of "the box" must have protection

- There must be a single master ground to "the box"
- Otherwise things will go boom

QST June 2002

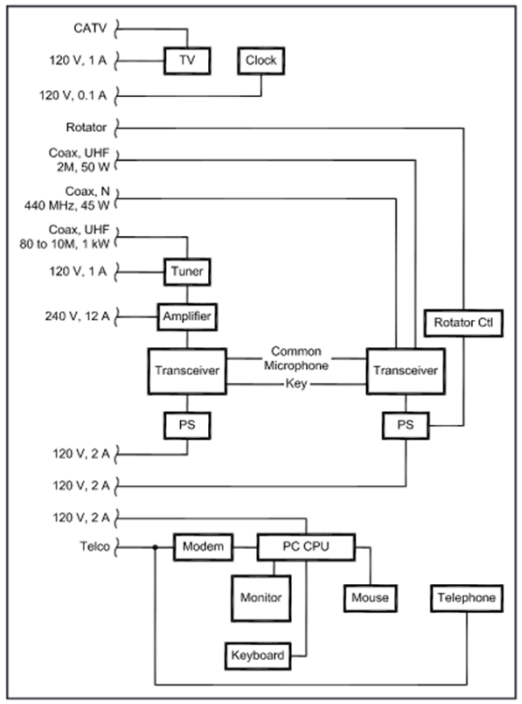


Figure 5—Block diagram of a typical more-complex radio station.

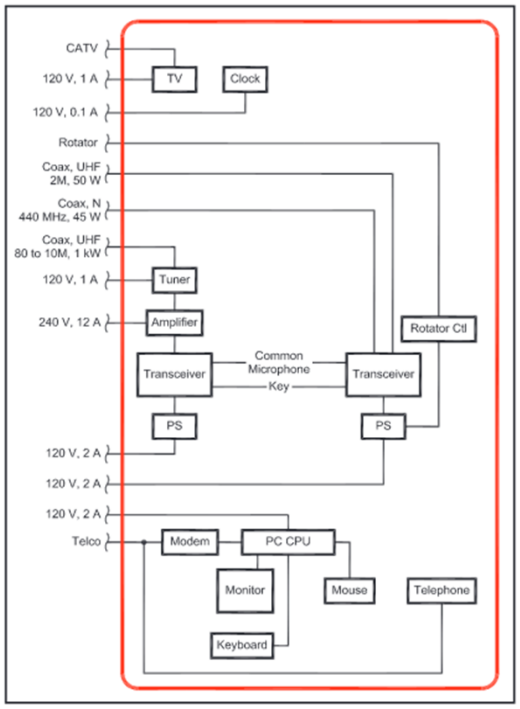
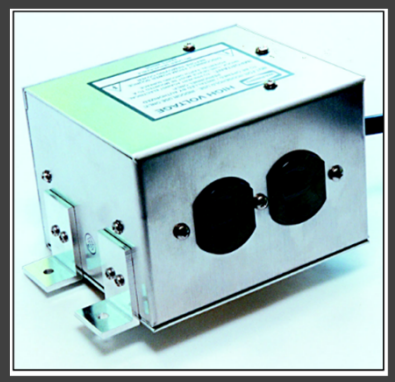
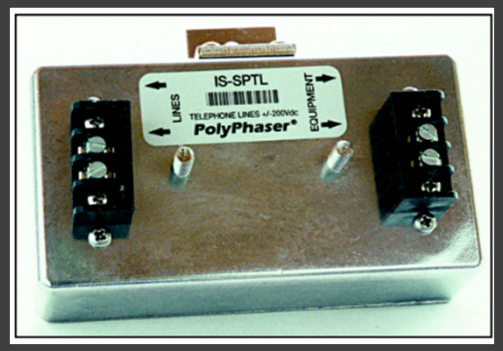
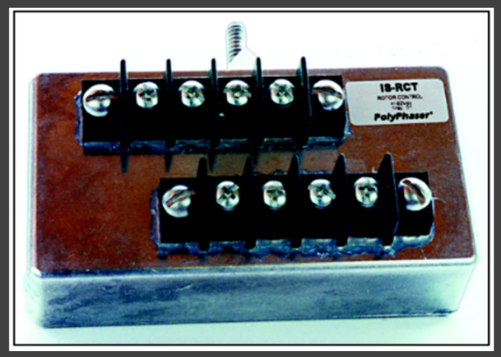


Figure 6—Lines that penetrate the circle are the radio station I/O circuits that must be protected.







Ham Grade Surge Arrestors

- PolyPhaser makes excellent arrestors
- A variety of RF arrestors
  - Most typical connectors available
  - Varied frequency range and power handling
- Telephone line and rotor available
- AC power (120VAC and 220VAC)

From the ARRL Handbook

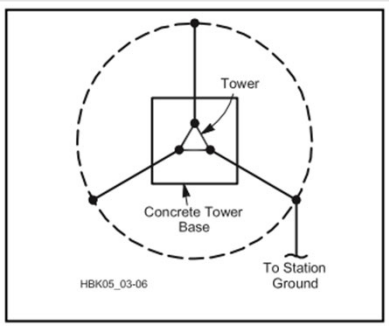


Fig 28.8 — Schematic of a properly grounded tower. A bonding conductor connects each tower leg to a ground rod and a buried (1 foot deep) bare, tinned copper ring (dashed line), which is also connected to the station ground and then to the ac safety ground. Locate ground rods on the ring, as close as possible to their respective tower legs. All connectors should be compatible with the tower and conductor materials to prevent corrosion. See text for conductor sizes and details of lightning and voltage transient protection.

Suppliers of Lightning Protection Equipment

For current vendor contact information, use your favorite Internet search tool.

- Alpha Delta Communications: Coax lightning arrestors, coax switches with surge protectors.
- The Wireman: copper wire up to #4 AWG, 2-inch flat copper strap, 8-ft copper clad ground rods and 1 × ¼-inch buss bar.
- ERICO International Corporation: CadWeld bonding system and lightning protection equipment.
- Harger Lightning & Grounding: lightning protection components.
- Industrial Communication Engineers, Ltd (ICE): Coax lightning arrestors.
- PolyPhaser Corporation: Many lightning protection products for feed lines, towers, equipment, and so on.
- Zero Surge Inc: Power line surge protector.

- Short section in ARRL Handbook on Lightning Protection
- Sample vendors suggested

Ground Kit

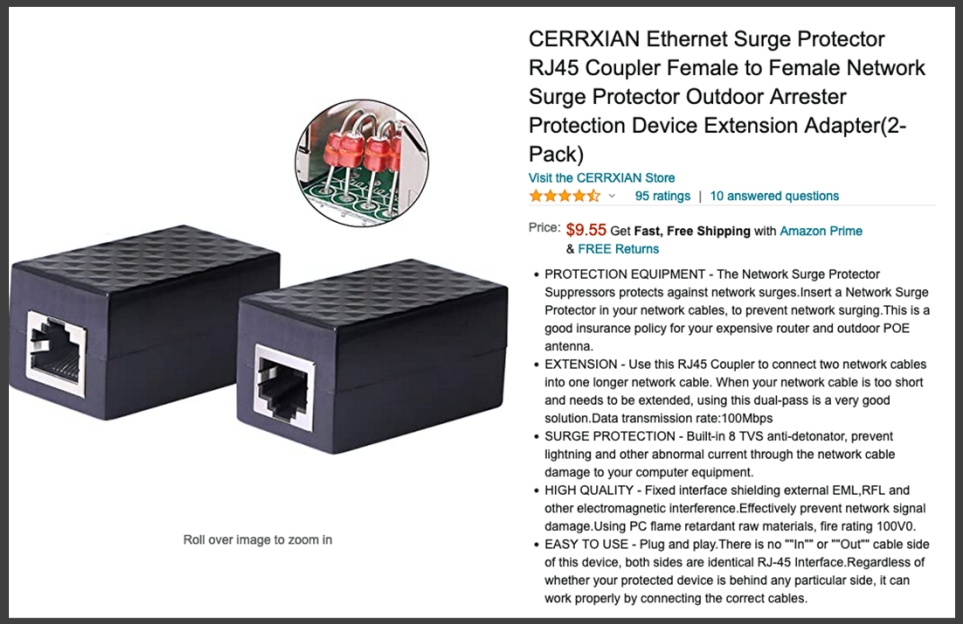
- Can be used on Hardline or Coaxial Cable
- Best: Install on Top, Middle and Bottom of coax run on tower
- Minimum: Install at bottom of tower

Surge Suppression of Ethernet Cables

- Ethernet is challenging to suppress surges, it's very low signal potential and surges can be of massive potential
- Ethernet is on a CAT5/6/7/8 cable on wire 1,2,3 & 6

- Ethernet surge suppressors are not expensive devices and can be used if cable is susceptible to an outside force.
- If the cable runs outside, use shielded cable.

- Surge Arrestors in your shack or repeater shelter protect your switch and router
- Surge Arrestors mounted at the microwave dish protects the tower mounted electronics



Basic Surge Protector

Surge Suppression of Ethernet Cables with PoE

- Power over Ethernet adds more challenging issues.
- Power is superimposed on the same cable as the ethernet signals.
- Ethernet is on wire 1, 2, 3 & 6
- DC power is on 4,5 & 7,8

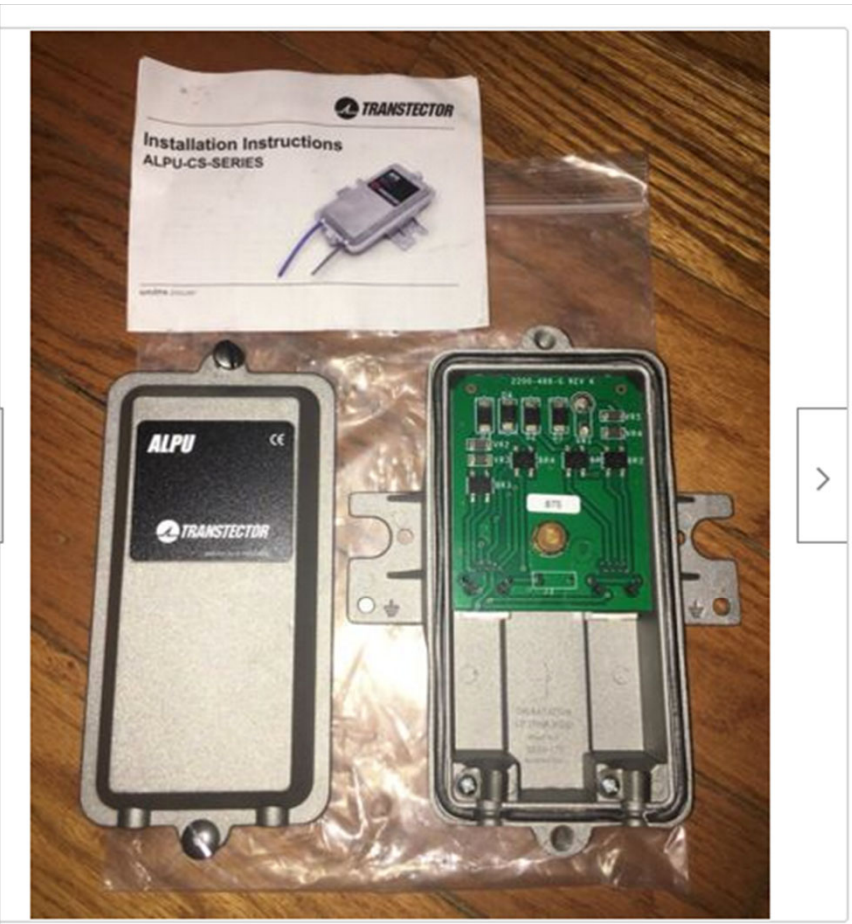
- PoE is used to run all manner of devices, cameras, microwave radios, certain equipment with a single cable feed.

- Info on Power over Ethernet (PoE)

https://www.bb-elec.com/Learning-Center/All-White-Papers/Ethernet/Power-over-Ethernet-PoE.aspx

Lightning Protection at RMHAM "In the Beginning"

- Because we're sticking these surge susceptible devices on large lightning attractors, we need to use proper surge devices and grounding for these exterior locations
- Use only shielded CAT 5 and ground the drain at the bottom
  - Benefits: lowers radiated noise (Ethernet clock tears up VHF)
  - Lowers ground potential rise from near misses and static
- High quality surge suppressors should be used any time POE is installed outside.
- These are the devices we started using many years ago and they are quite good devices. They work very well and are a very trusted manufacturer.



$ Have one to sell? Sell now

Lightning Protection at RMHAM Microwave sites

- This is the good stuff
- Used at RMHAM Microwave sites
- Extremely robust
- Can be expensive … unless you can find some on eBay

Ubiquiti Ethernet Surge Arrestor

- Ubiquiti ETH-SP-G2 is a nice surge arrestor for the money
- Small, easy to install, outdoor rated

- Our recommendation is to place one at the top of the tower, and one in the shelter.
- Make sure to ground both properly!
- This doubles the cost, but saves equipment

- Maxwell's Law - The combination of shielded, grounded ethernet cable, high quality surge suppressors and a sufficient grounding system along with low impedance connections from the surge suppressor, cable shield to the ground makes a great combination.

Ubiquiti ETH-SP-G2 Surge Suppressor/Protector

Brand: Ubiquiti Networks

354 ratings | 20 answered questions

Price: $25.69 & FREE Returns

Color	White
Brand	Ubiquiti Networks
Data Transfer Rate	1 Gigabits Per Second

About this item

- Weight (Approximate): 1.10 lb

Compare with similar items

New (18) from $13.99 & FREE Shipping

www.balticnetworks.com
$10.90 single quantity

Example: Squaw Mountain - We lost two radios within two years before we started grounding the drain on each microwave radio. Once we grounded the drain and started using the high-end surge suppressors, the problem went away!

RMHAM Firestone Microwave Hub

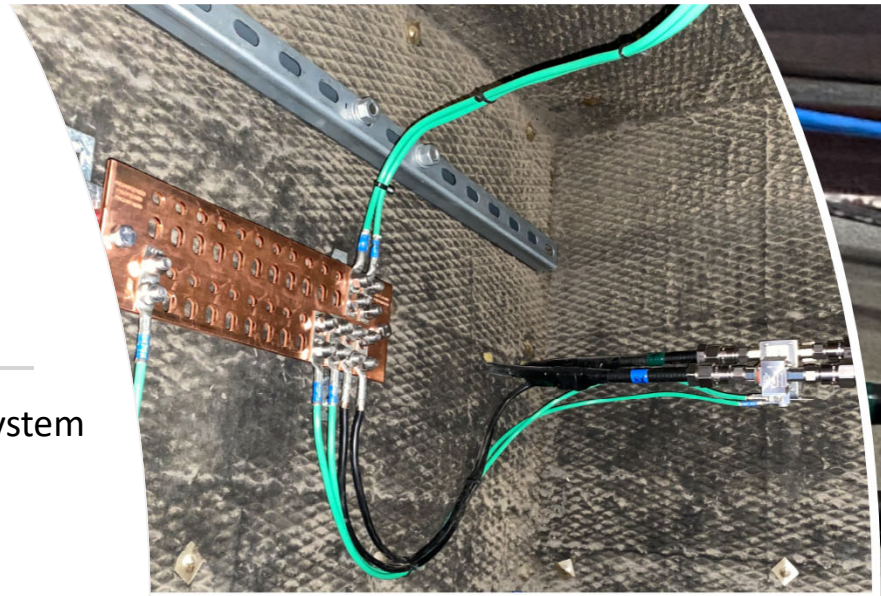
- RMHAM Microwave Hub linking
  - Horsetooth Mountain – North
  - Horsetooth Mountain – South
  - Lee Hill
  - Eldorado Mountain
  - Lookout Mountain
- Each dish antenna has a tower mounted microwave radio and Ubiquiti surge arrestor
- So far … knock on wood … no lightning induced failures

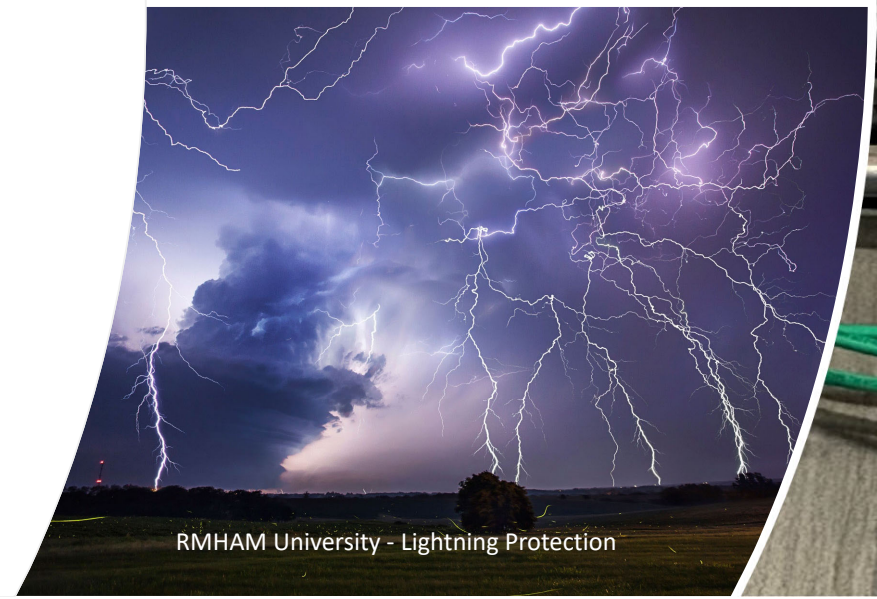
Case Studies and Discussion

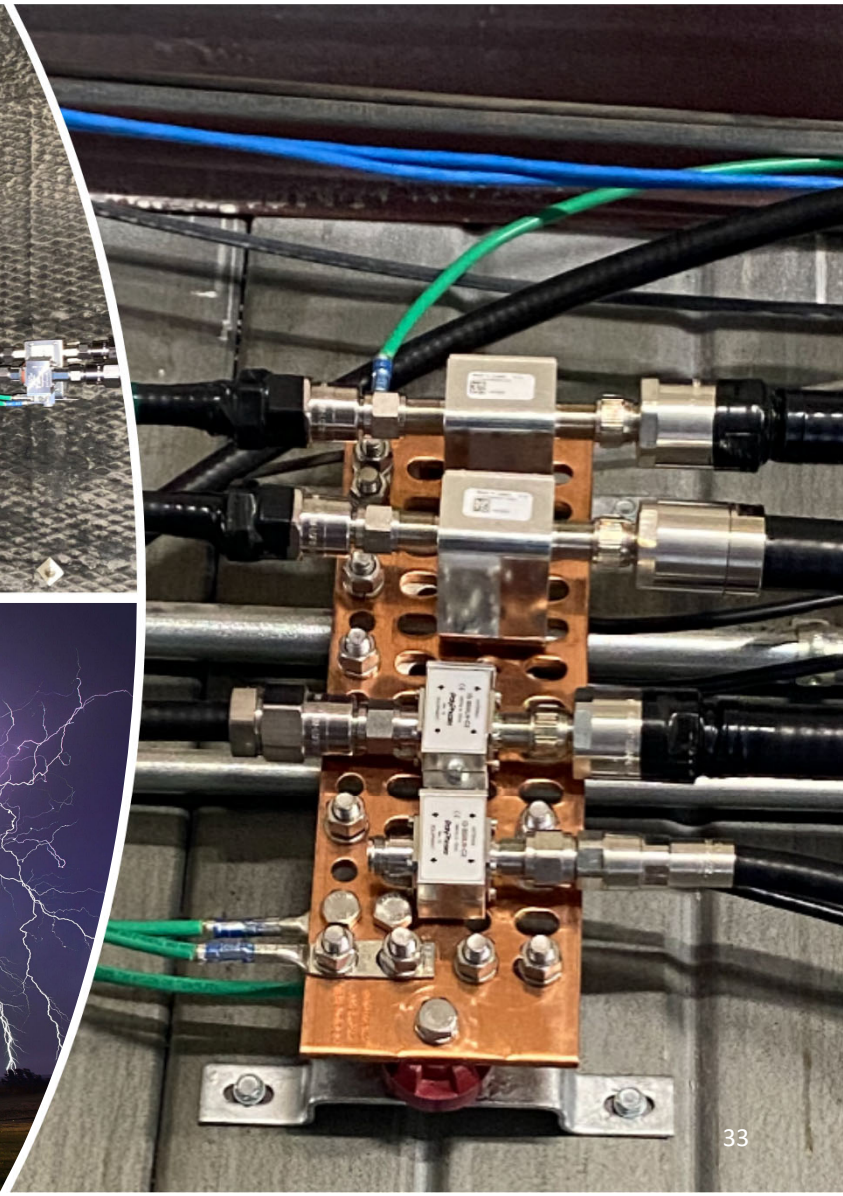
Site Study #1 – Commercial UHF Trunked Radio System

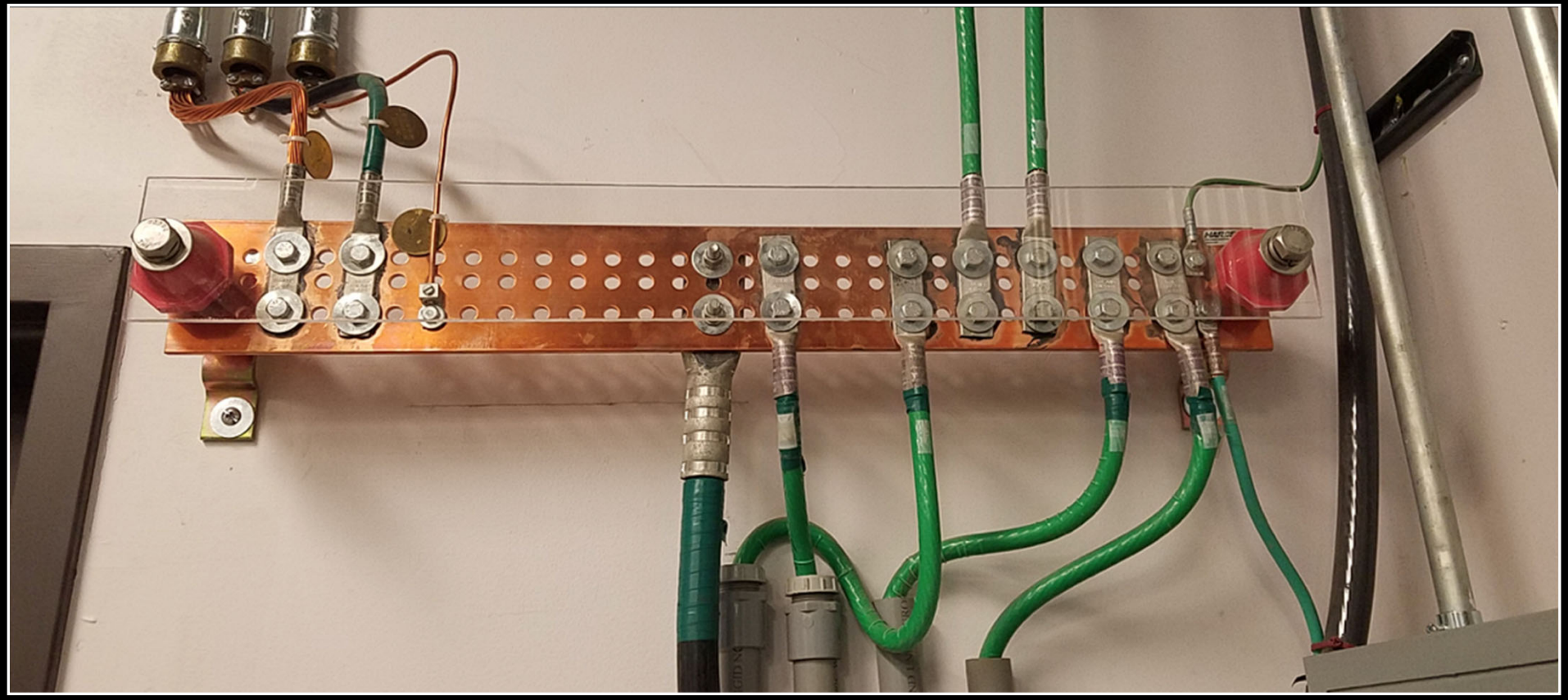
- UHF Trunked Repeater System
- Six channels per site
- TX antenna
- RX antenna
- Each with Polyphaser
- Single point ground

- So far, no failures





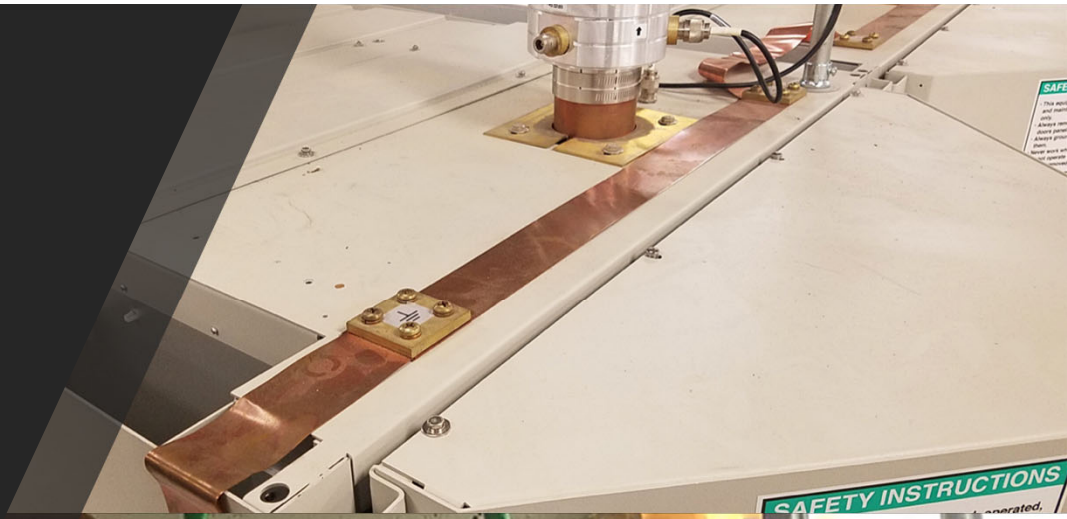


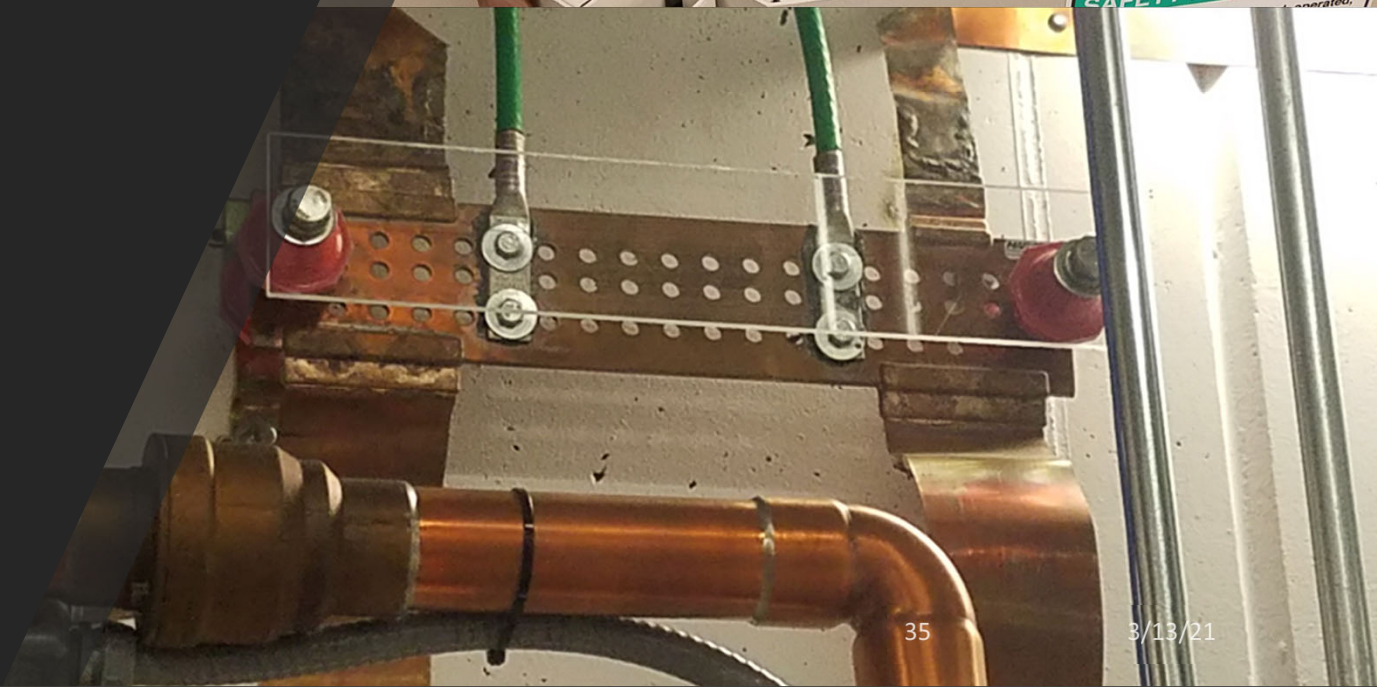


Case Study #2 - Lookout Mountain Broadcast site

Lookout Mountain

- R56 Compliant Ground Bus
- Double hole lugs
- Proper size ground wire
- Copper strap for lowest inductance





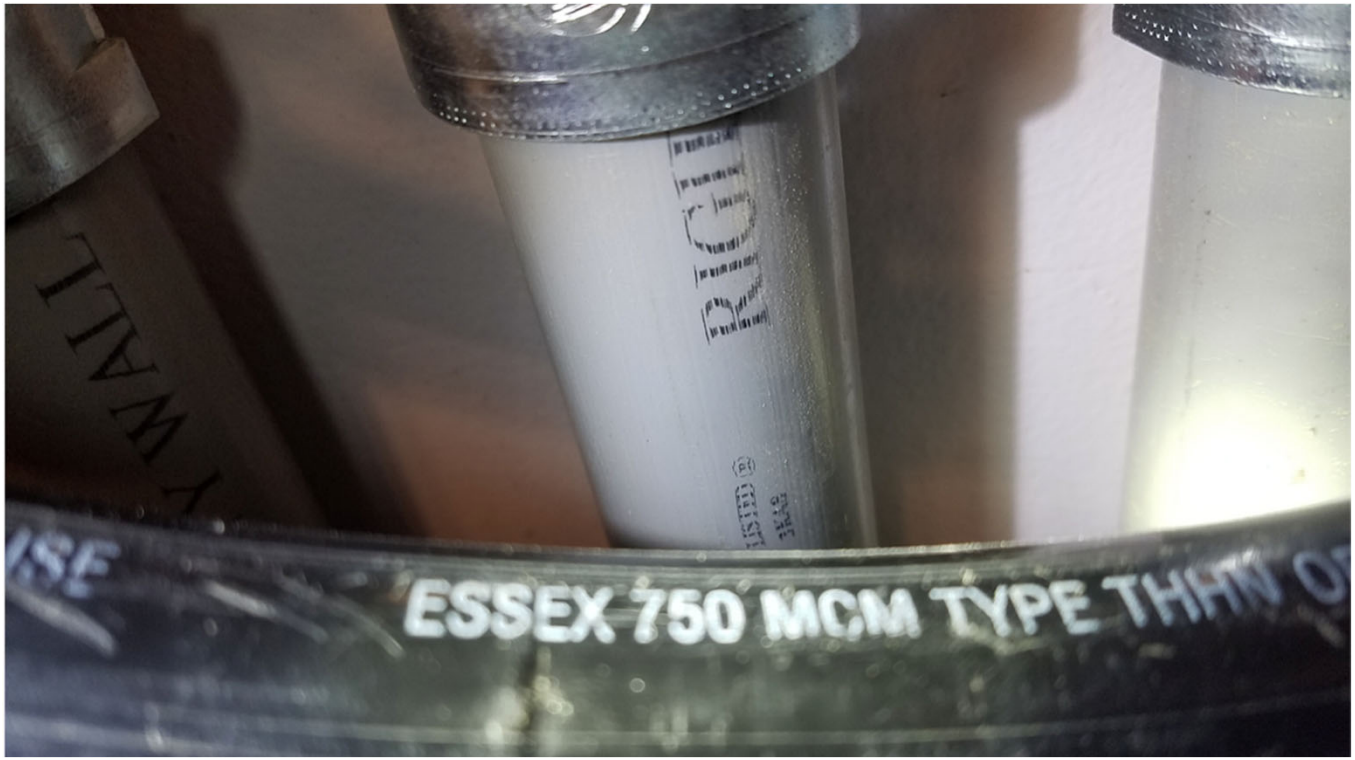
Study #3 – Public Safety P25 Trunked Site

- A work in progress when this photo was taken
- Customer specification is R56 compliant
- Entry Master Ground mounted on wall with connected
  - Building ring
  - Electrical mains
  - Antennas
  - Microwave


Questions?


Rocky Mountain
Ham Radio

Backup Slides


ESSEX 750 MCM TYPE THHN

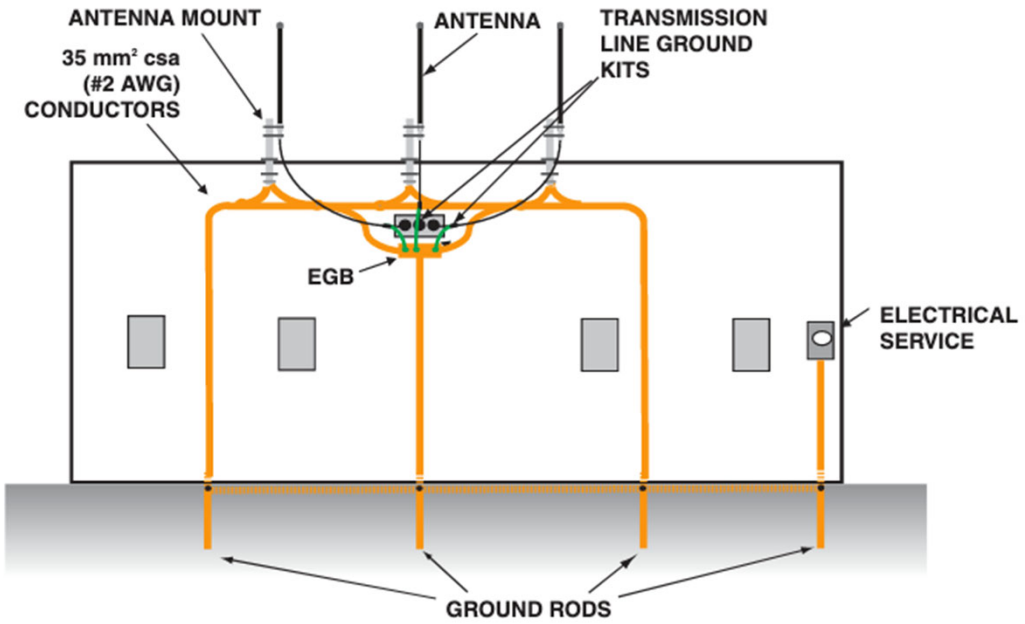
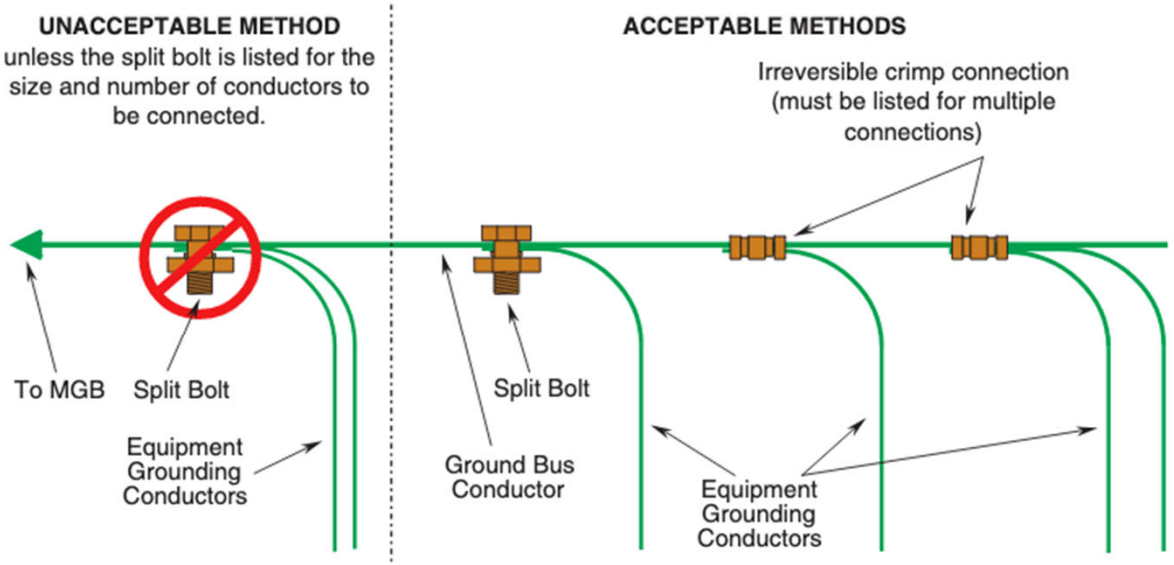


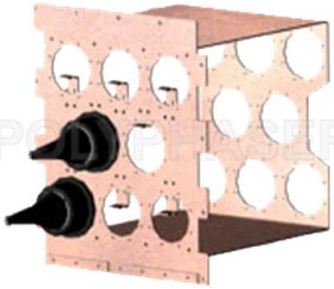
FIGURE 4-56 GROUNDING OF MULTIPLE SIDE-MOUNTED ANTENNAS

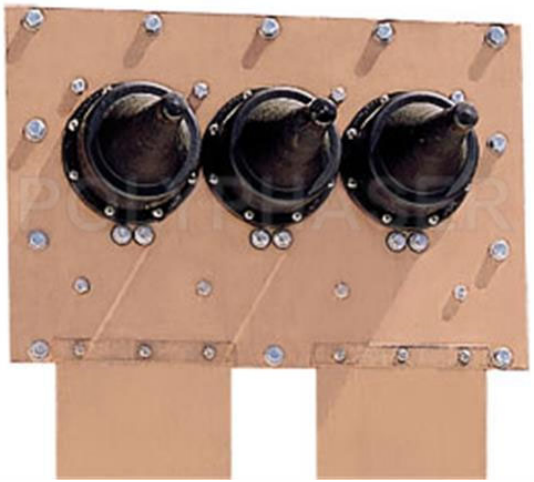


NOTE: Route all conductors toward the MGB.

FIGURE 5-25 BONDING TO GROUND BUS CONDUCTOR

Entry Panel





A Cable Entrance Panel

The basic concept with transient protection is to make sure that all the radio and other equipment is tied together and "moves together" in the presence of a transient voltage. It's not so important that the shack be at "ground" potential, but, rather, that everything is at the *same* potential. For fast rise-time transients such as the individual strokes that make up a lightning strike, even a short wire has enough inductance that the voltage drop along the wire is significant, so whether you are on the ground floor, or the 10th floor of a building, your shack is "far" from Earth potential.