

Grounding Essentials for the Shack

Lightning Protection

AC Power Safety

RF “Grounding” (RF feedback - Tx)

RF Noise (RFI - Rcvr)

2014/2015

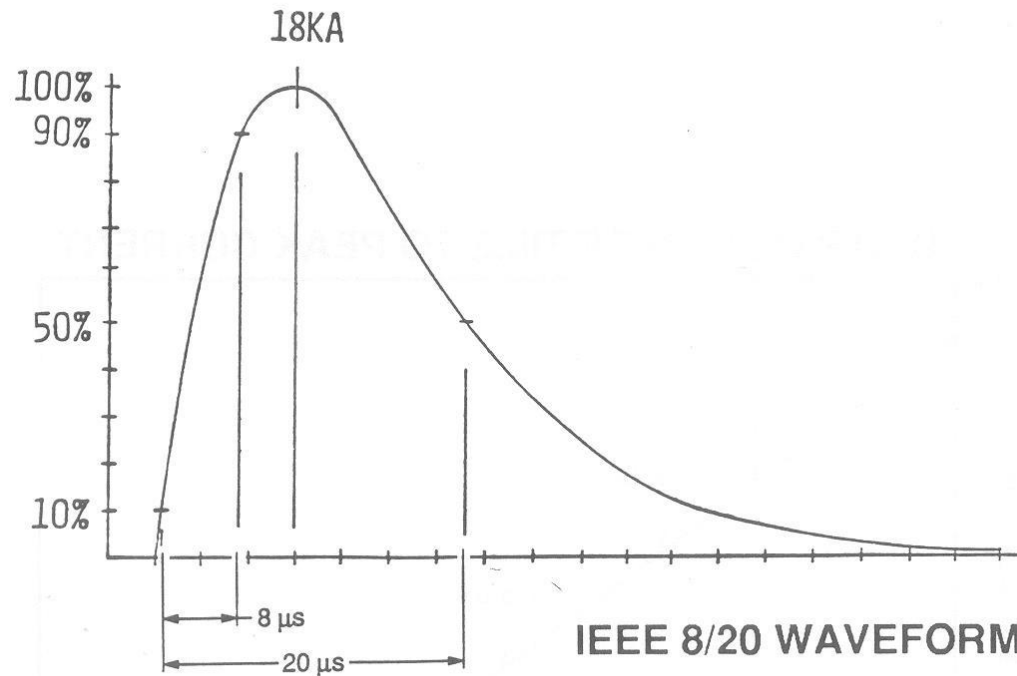
What is Lightning?

- 30-50 million volts
- 18,000 Amps

Xenon lights over Launch Pad 39A at Kennedy Space Center with a lightning strike seen to the left on August 24, 2009.



Lightning is a Pulse



- Average peak current is 18,000 Amps.
- Return strokes are approximately half the current.
- Three strokes are average per lightning strike.

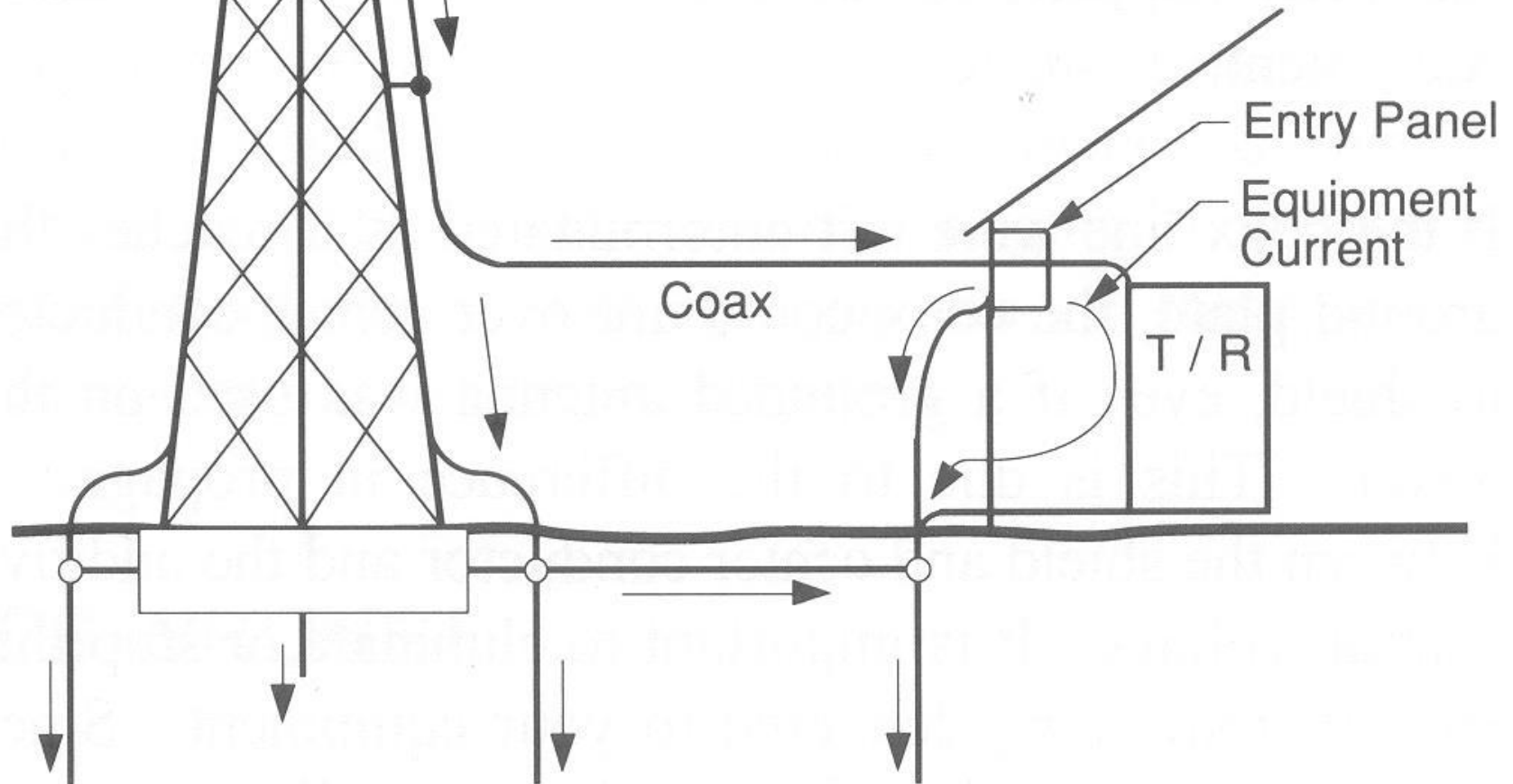
Avoid This

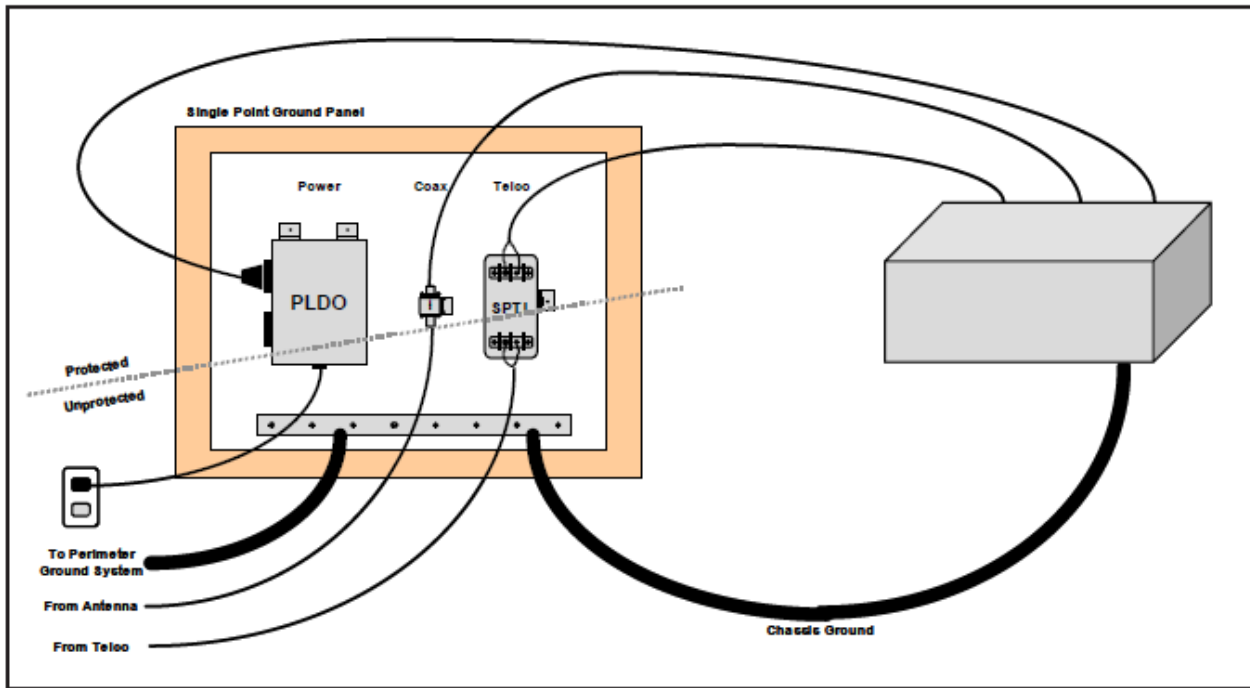


Inside and Outside the shack

- Single point ground
 - What is a Single Point Ground?
 - Why use a SPG?
 - Where to locate the SPG?
- Shack Grounding
 - AC Power Safety
 - RF feedback - transmitter
 - RF Noise (RFI) - Rcvr
- Grounding outside: “The Ground System”
 - Lightning Protection

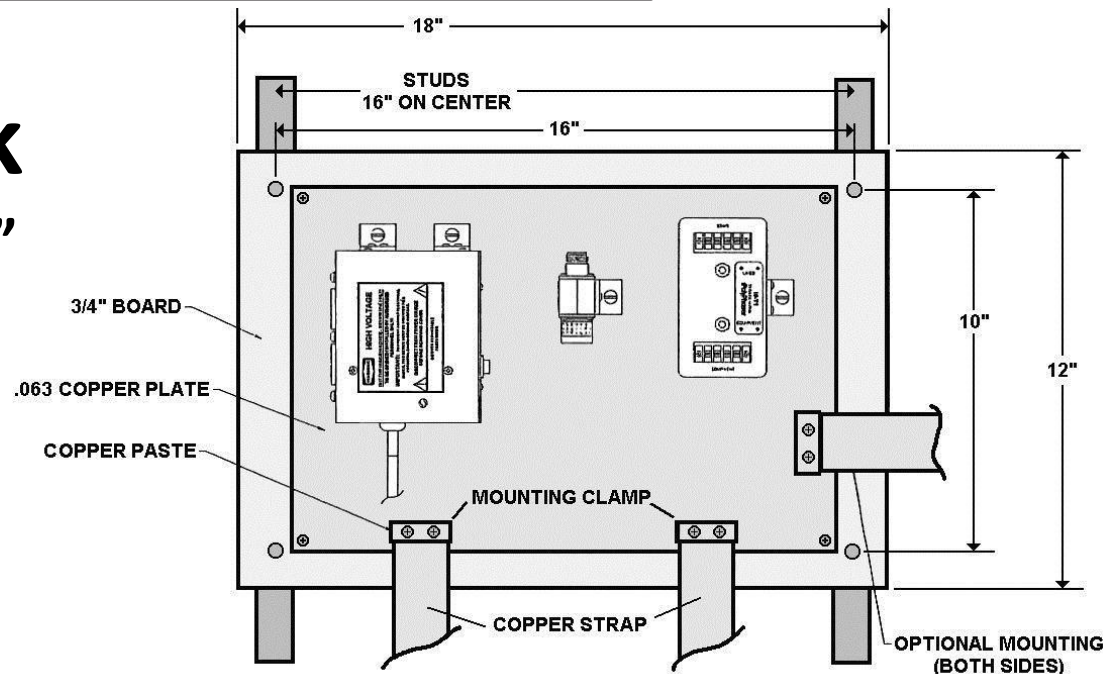
What's the Problem?





Inside the shack

"The Single Point Ground"



Comparison of conductors for ground systems inside and outside

www.georgiacopper.com

Quick Comparison Chart - Braid, Wire, Strap			
Quick Comparison Chart Braid, Wire, Strap	 COPPER BRAID	 COPPER WIRE	 COPPER STRAP
SUITABILITY FOR USE AS A DC CONDUCTOR	EXCELLENT	EXCELLENT	EXCELLENT
SUITABILITY FOR USE AS AN RF GROUND CONDUCTOR	GOOD	FAIR	EXCELLENT
SUITABILITY FOR USE AS A LIGHTNING GROUND CONDUCTOR	GOOD	GOOD	EXCELLENT
MECHANICAL FLEXIBILITY	EXCELLENT	MODERATE	MODERATE
SUITABLE FOR DIRECT BURIAL	NO	YES	YES
LONG-TERM DURABILITY OUTDOORS	FAIR	EXCELLENT	EXCELLENT
LARGE SURFACE AREA TO TAKE ADVANTAGE OF SKIN EFFECT	GOOD	POOR	EXCELLENT

Single Point Ground

- One connection (point) where all equipment is connected (grounded) together
 - equipment and every I/O line including AC power must have lightening protection devices
- The SPG is the best solution
 - For antenna cables at the point of entry.
 - Bulkhead installations
 - Direct grounding from the SPG to the “ground system” (ground rods)



Equipment Grounds in the Shack

- Ground everything to the SPG (panel or bulkhead) for a Good RF Ground

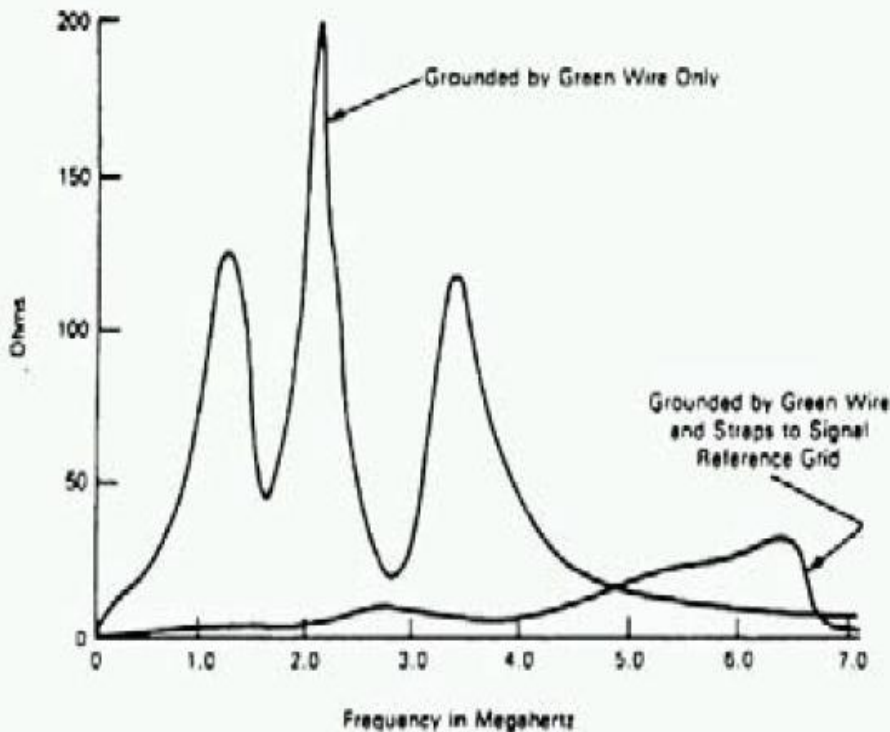
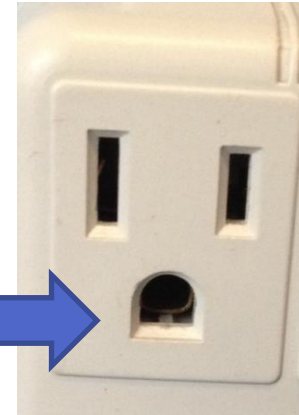
- SHORT path - very close to the station
- Use a big Ground Bus or Strap
- Use Low RF Impedance Leads (strap)



www.dxengineering.com

AC Power Ground

NOT RF GROUND



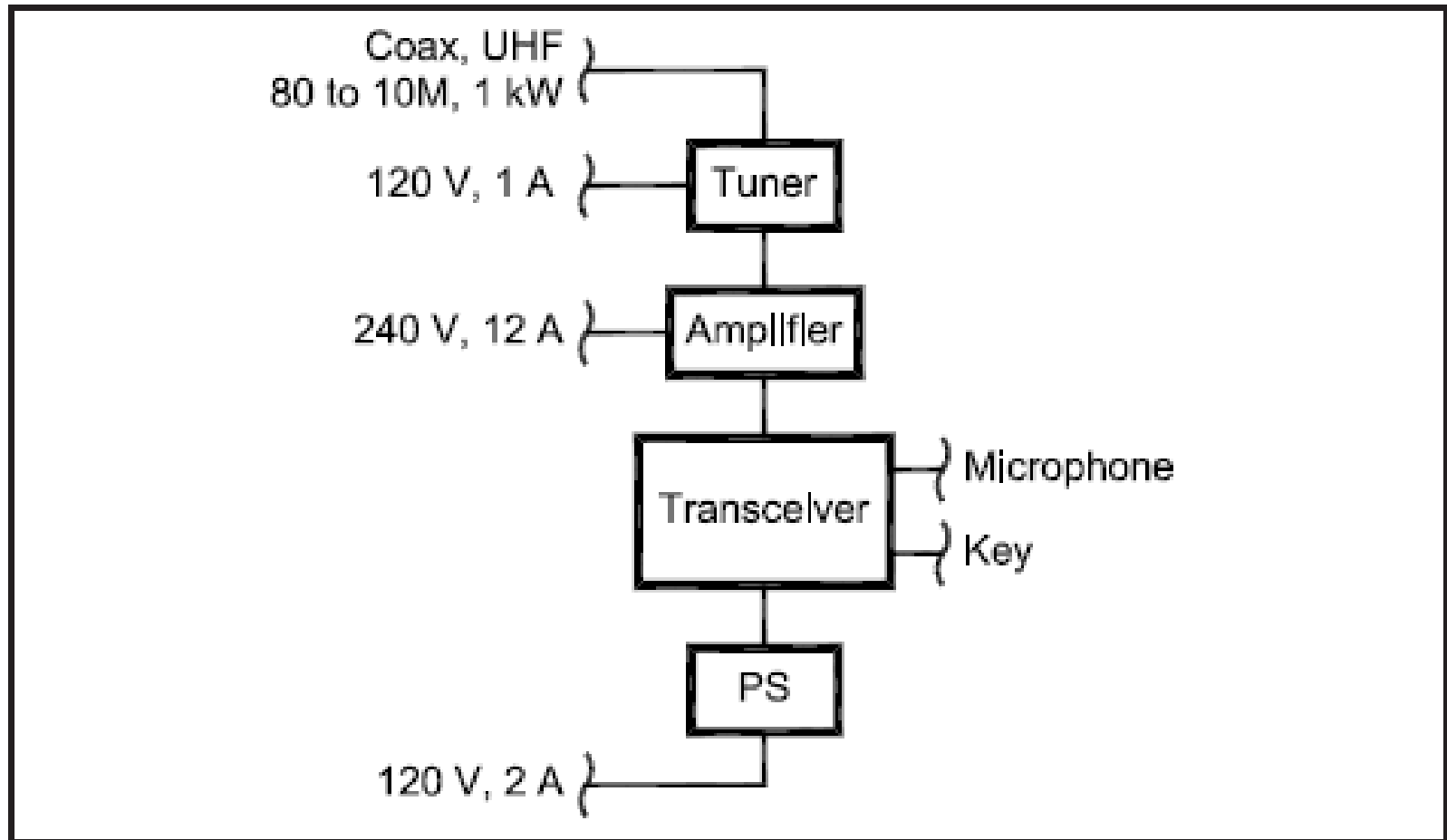
Power Protection Ground
(3rd prong) is NOT RF
Ground.

Impedance of AC “green wire”
ground vs. SPG (copper strap to
ground rods)

*

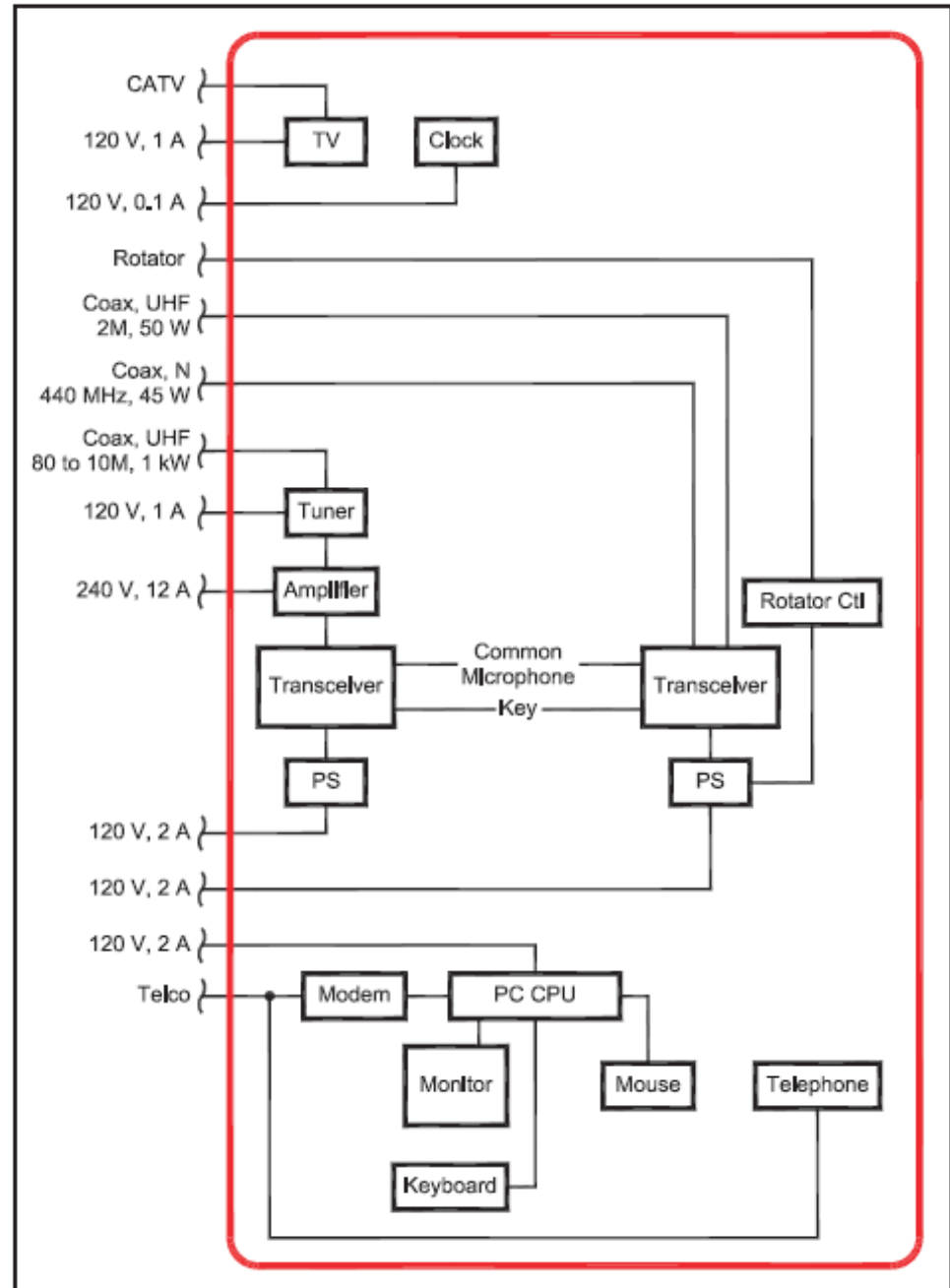
Typical Amateur Station

Think “electrical island”

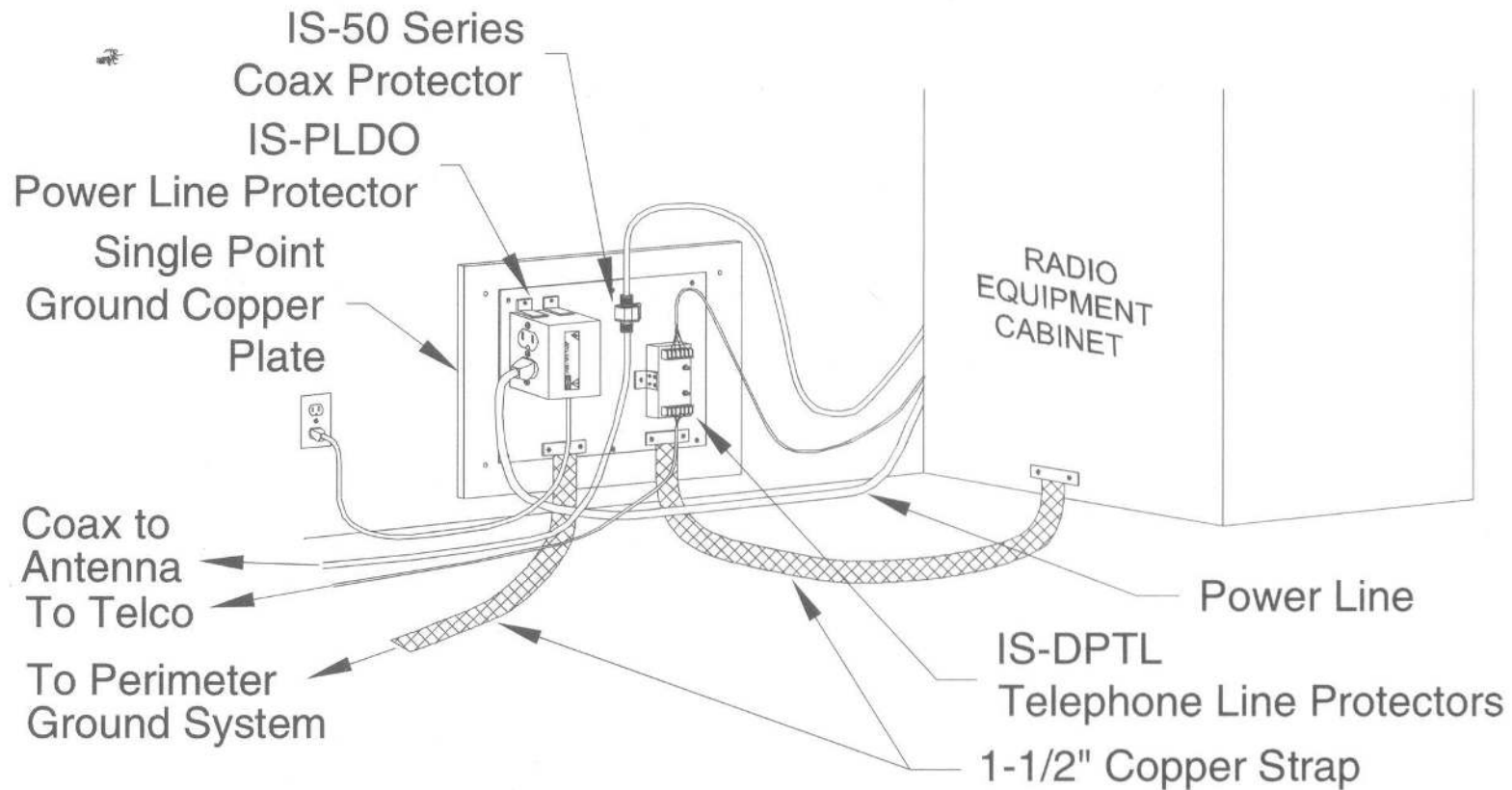


More complex station layout

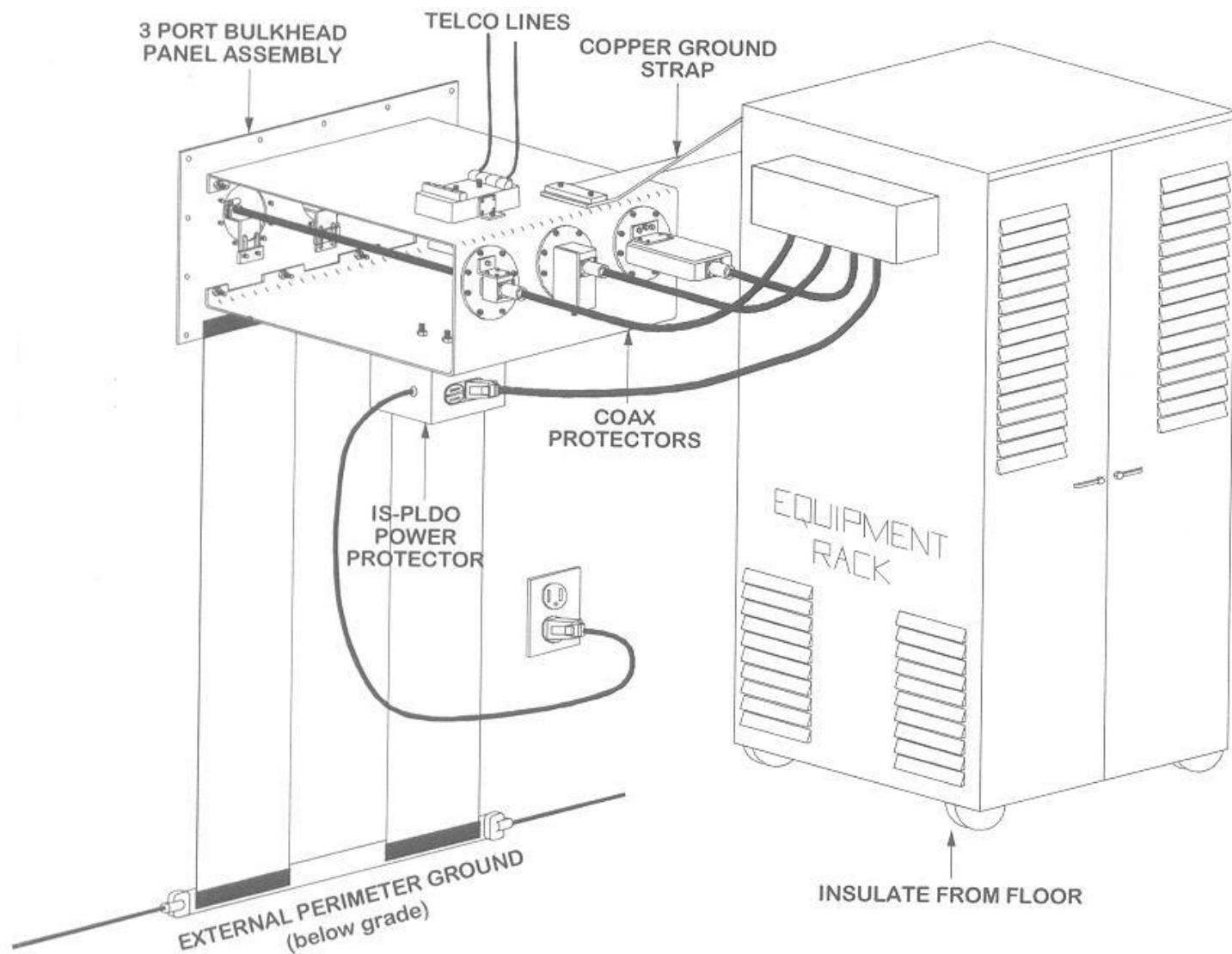
All equipment needs to be treated as an “electrical island,” with each piece tied to ground and every line protected, all at the single point ground panel or bulkhead.



Single Point Ground in the Shack



Example of Single Point Ground
without Bulkhead

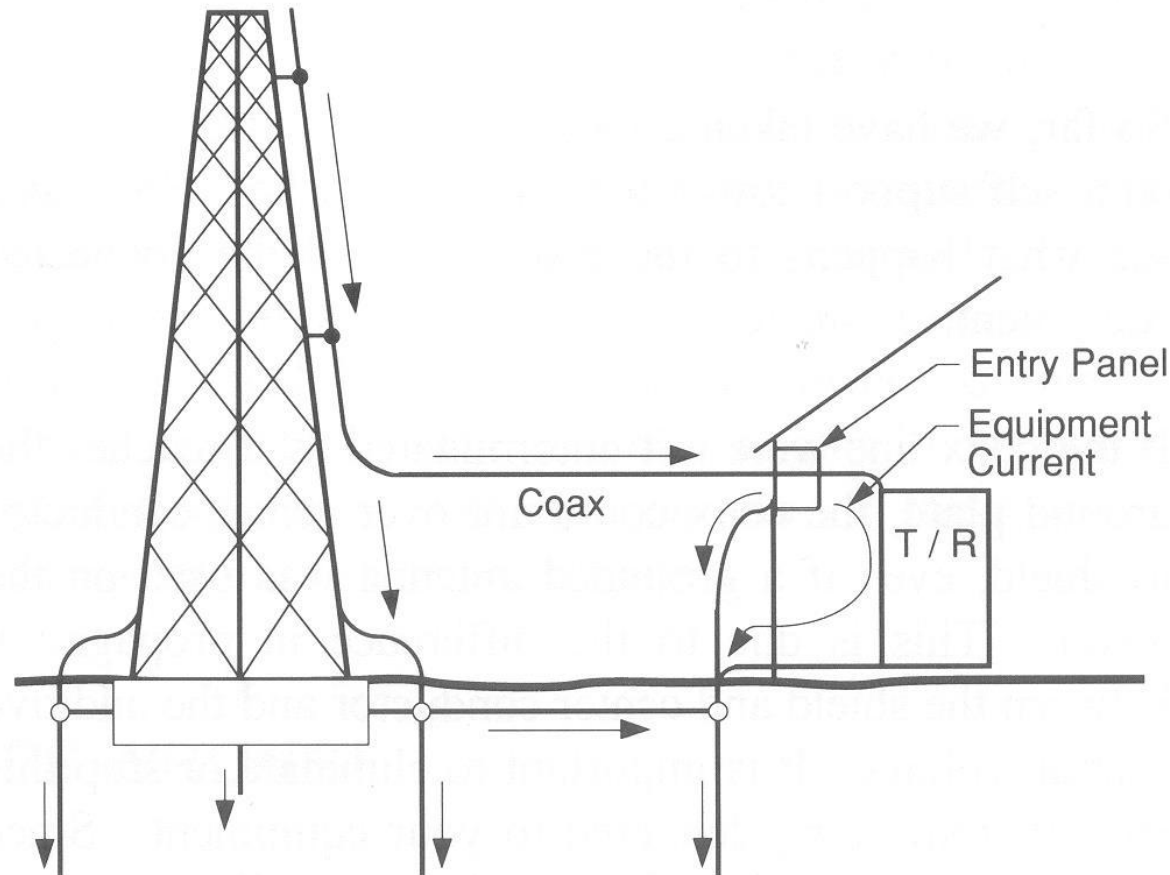


Bulkhead Single Point Ground

Tying the Single Point Ground (Bulkhead Panel) to Earth

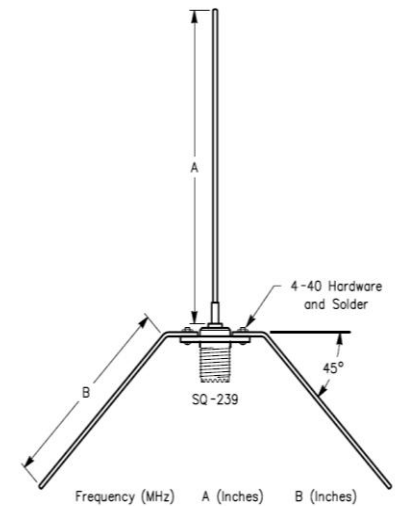
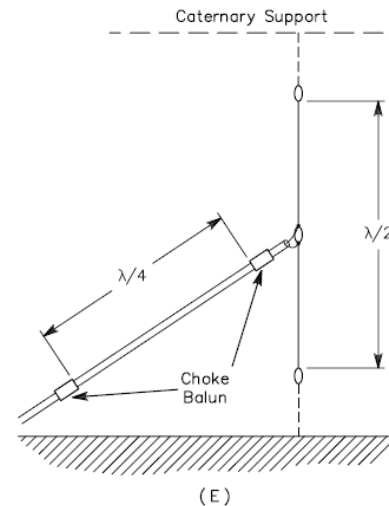
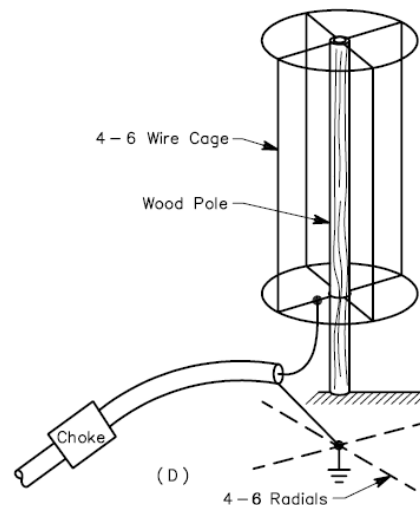
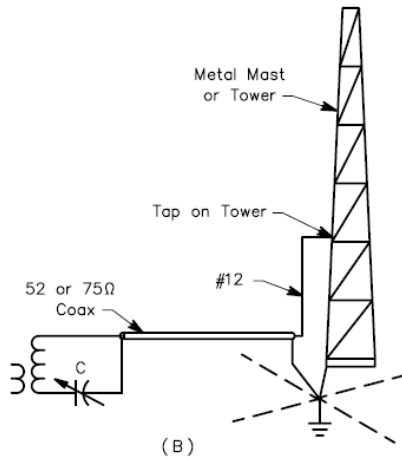
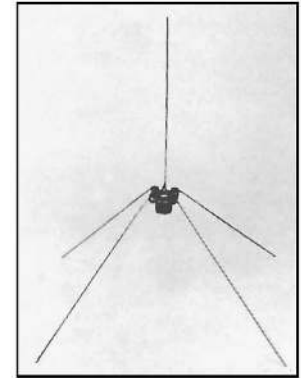
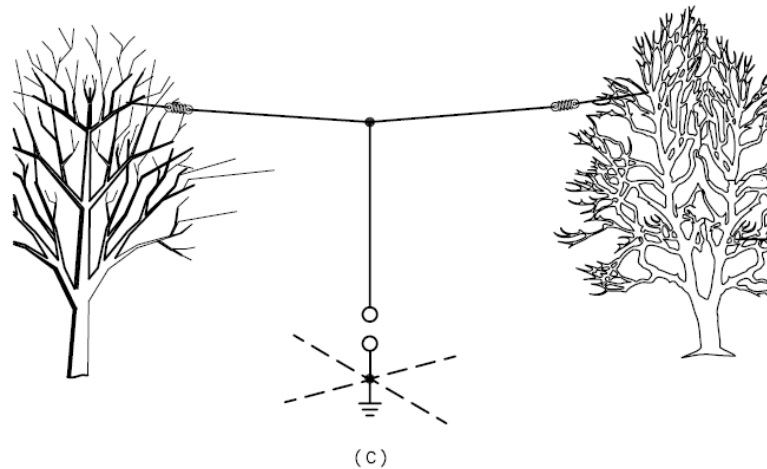
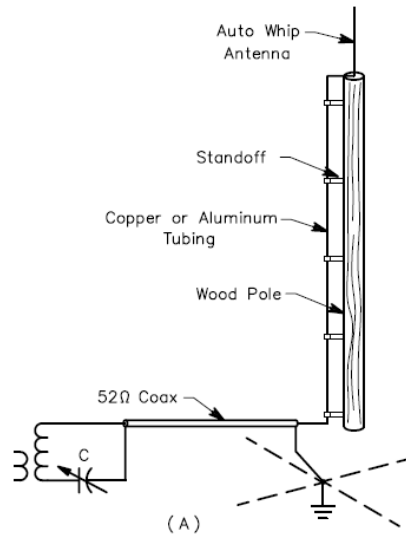
- Short run of Strap or braid.
- Earth Ground is a System
 - Ground system design
 - Ground Rods
 - Conductors and Connections
 - Current flow in the ground

Can you spot the danger with this?

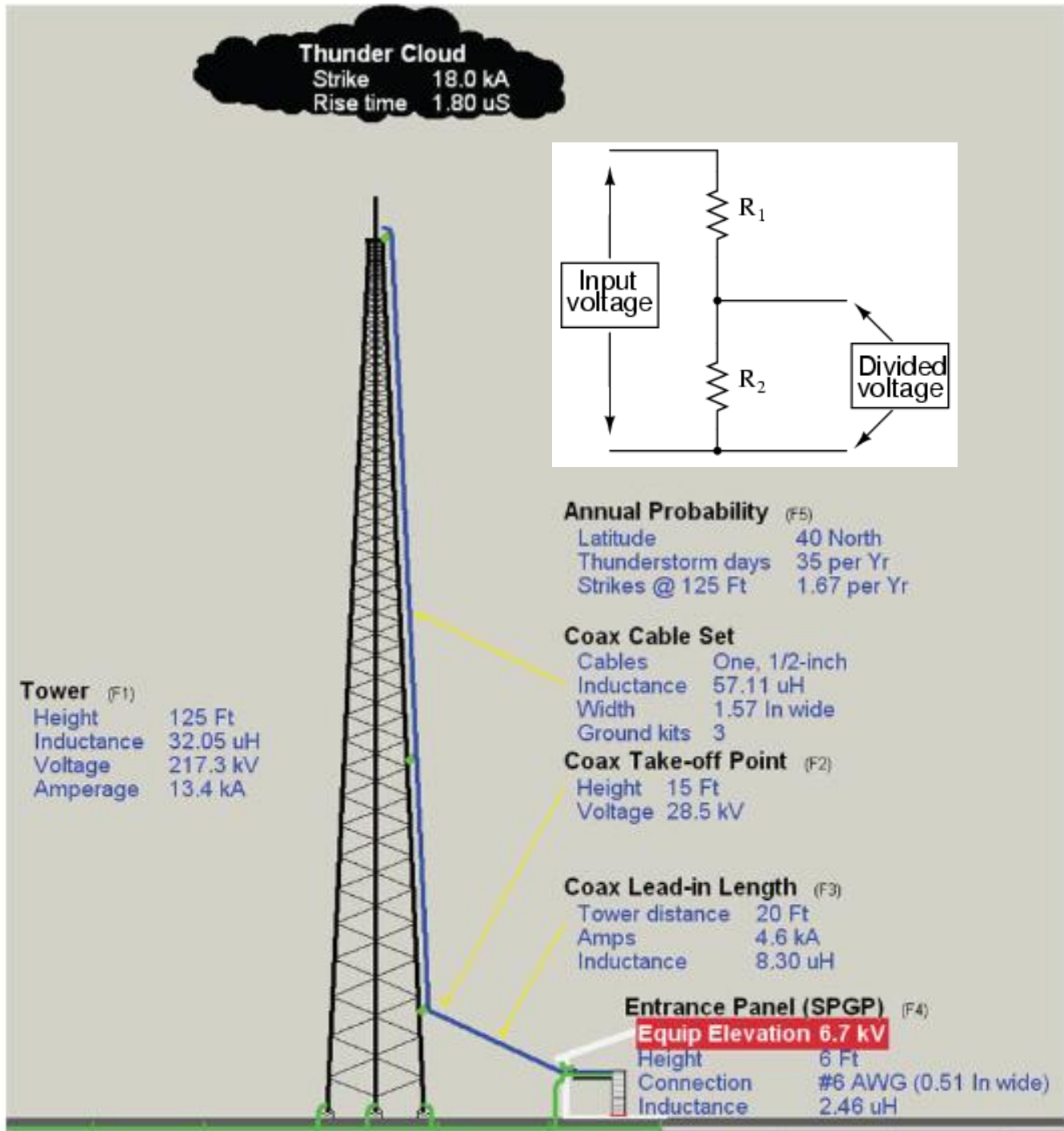


Grounding equipment at bottom creates a loop and surge current can traverse the equipment rack, hiccupping or destroying the equipment.

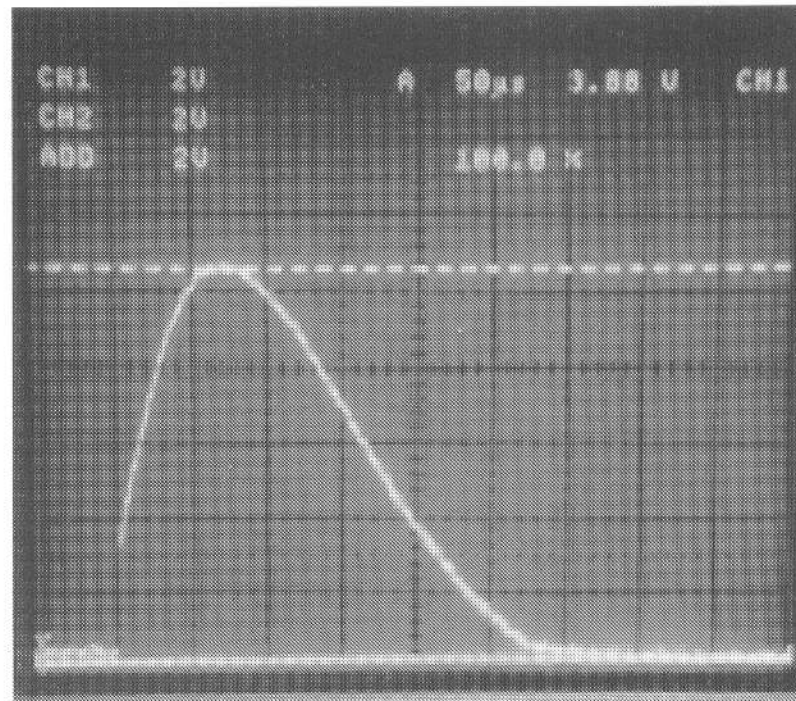
How would you install lightning protection for your antennas?



Coax (and towers) provide a path for the strike to earth and act as a transmission line.

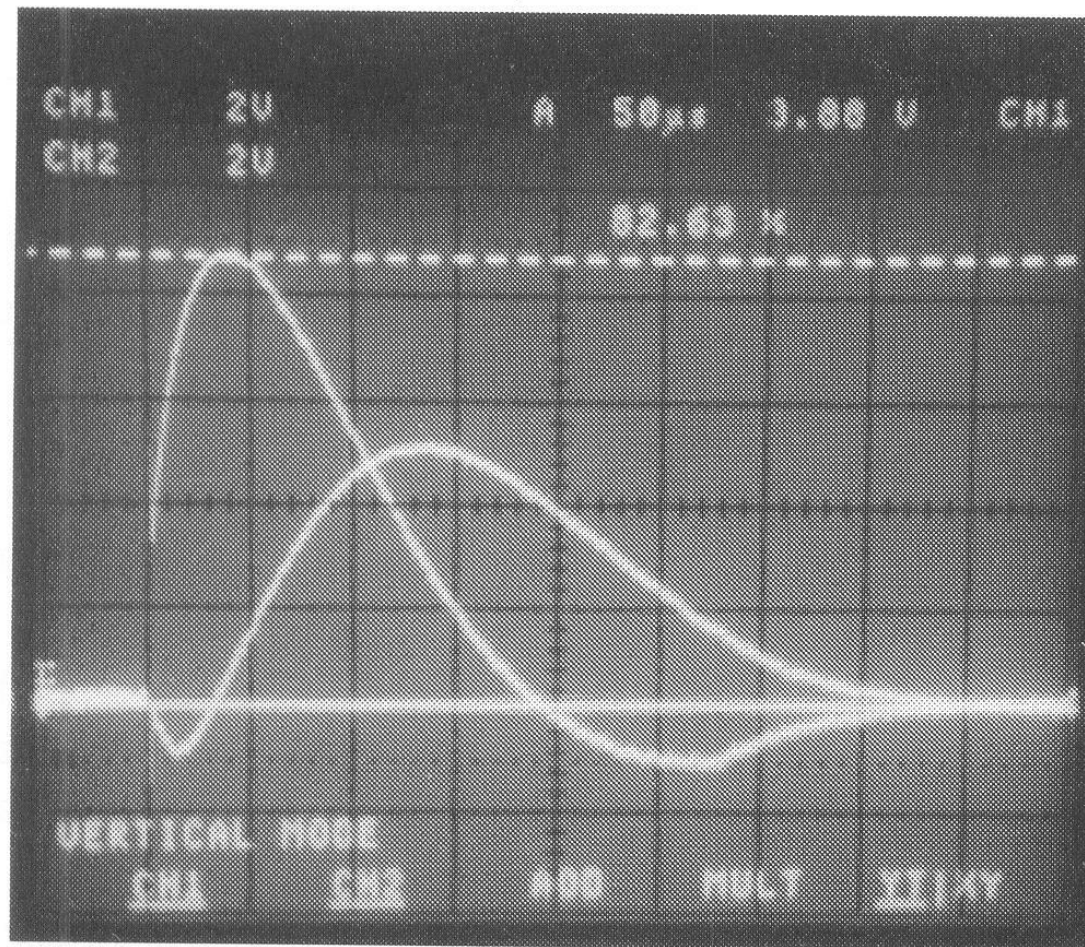


Why the Antenna Feed Line Needs Lightning Protection



The above pulse was used on a 51-foot long 1/2-inch hard line. One end was shorted to simulate a shunt-fed antenna, while the other end went to separate .01 ohm current viewing resistors.

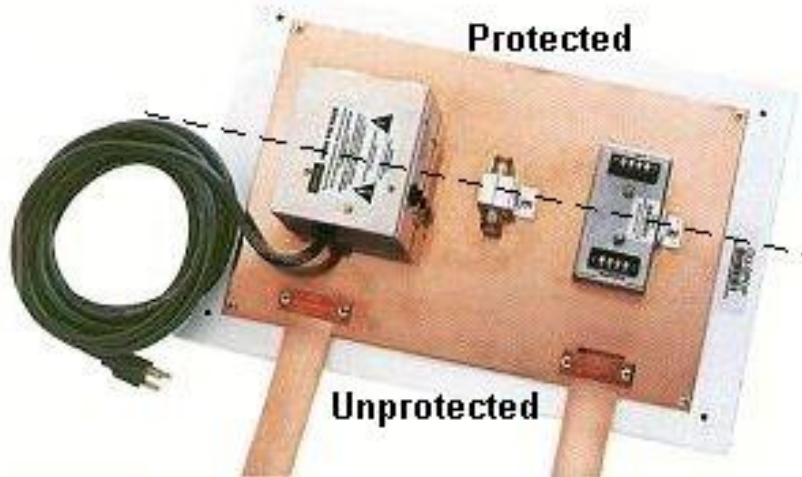
NOTE: This pulse is the algebraic summation and its peak 1050 Amps is referenced to 100%.



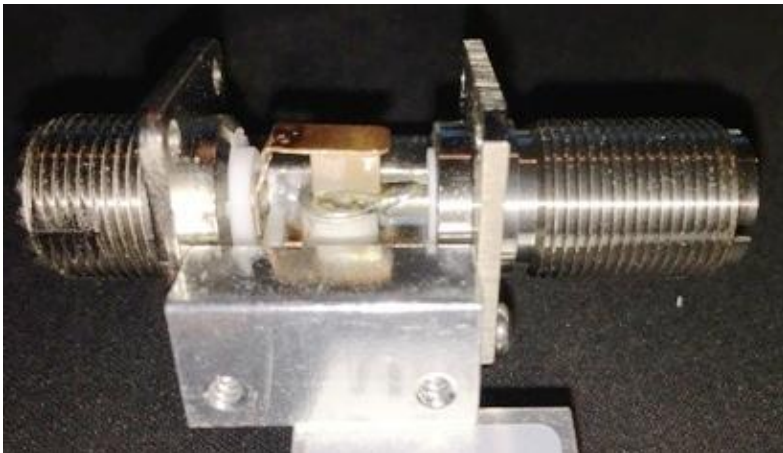
SHIELD

The voltage across each .01 resistor. Here the shield has 82.63% relative to the total pulse.

Typical Coax Lightning Protector



Throughput Energy is less than 10mj
For a pulse 8-20us long @ 6kV & 3kA.
Gas tube turn on voltage is in the range of
500-600 volts for the 2kW size protector.



[Click to Enlarge Image](#)



Email This
to a Friend



Ask a Tech Question
About This Item

PolyPhaser Coaxial Lightning Protectors IS-50UX-C0

Coaxial Lightning Protector, Flange Mount,
1.5-700MHz, HF 2kW, VHF 375W, DC Block,
UHF Female, 50 ohms, Each

Availability: In Stock
Estimated Ship Date: Today

Want your order tomorrow, November 13?

Order in the next **2 hrs 13 mins** and
select Next Day Air in checkout. [Details](#)

Would you rather pick it up at Summit Racing Equipment
in Tallmadge OH? | [Select](#)

Price: **\$61.95**

ADD TO CART

Quantity

[Add to Wishlist](#)
[Add to Compare](#)

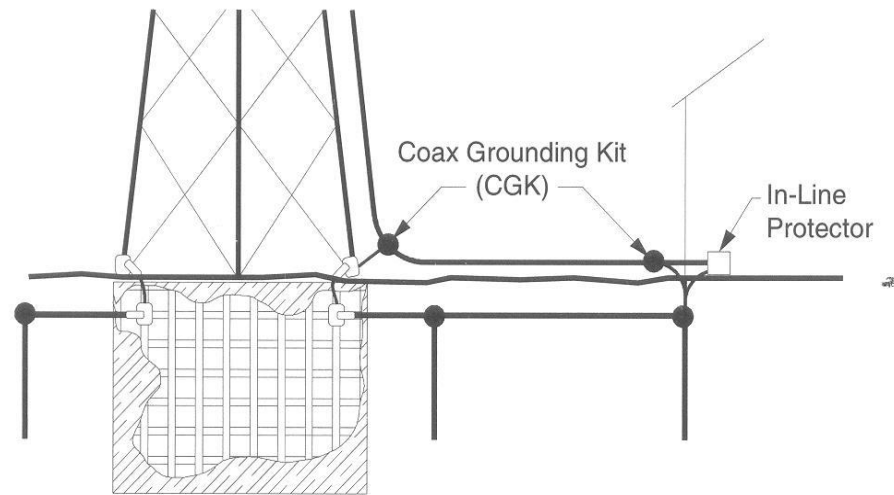
[Overview](#) | [Documentation](#) | [Suggested Parts](#) | [Show All](#)

Brand: [PolyPhaser](#)
Manufacturer's Part Number: IS-50UX-C0
Part Type: [Coaxial Lightning Protectors](#)
Product Line: [PolyPhaser Coaxial Lightning Protectors](#)
DXE Part Number: PPR-IS-50UX-C0

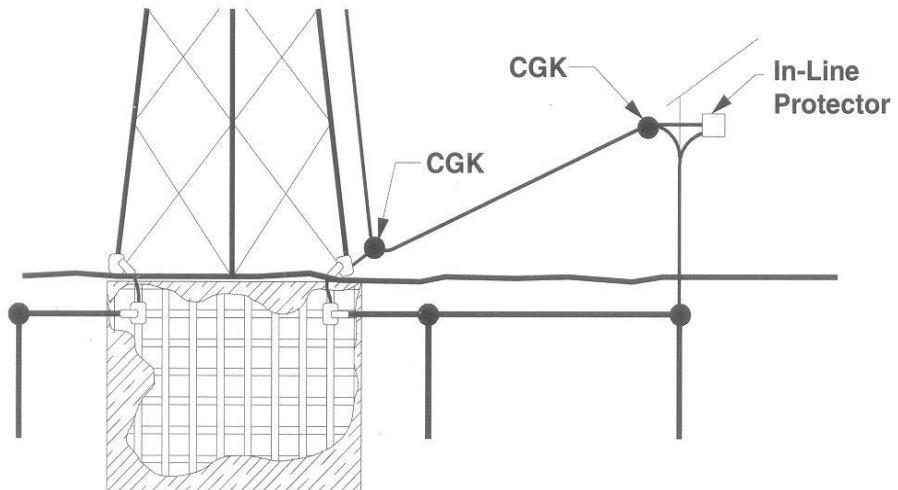
Protector Type: DC block
Protector Equipment Connector: UHF female, SO-239
Protector Antenna Connector: UHF female, SO-239
Protector Mount: Flange
Protector Power Rating: 2,000 W
Quantity: Sold individually.

Voltage divider analysis

The “Best” solution is when the coax from tower or simple dipole is tied to the earth ground at the lowest possible point to allow the smallest amount of voltage (potential) entering the building.

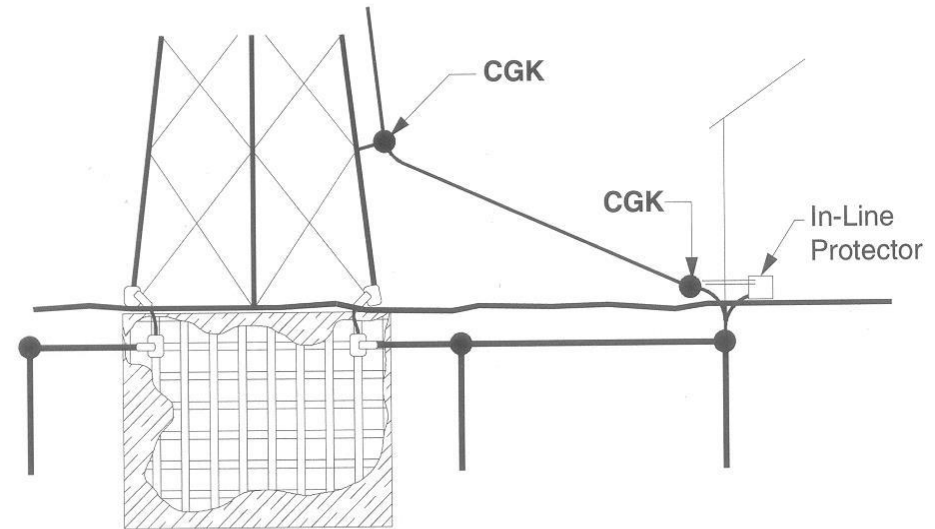


BEST



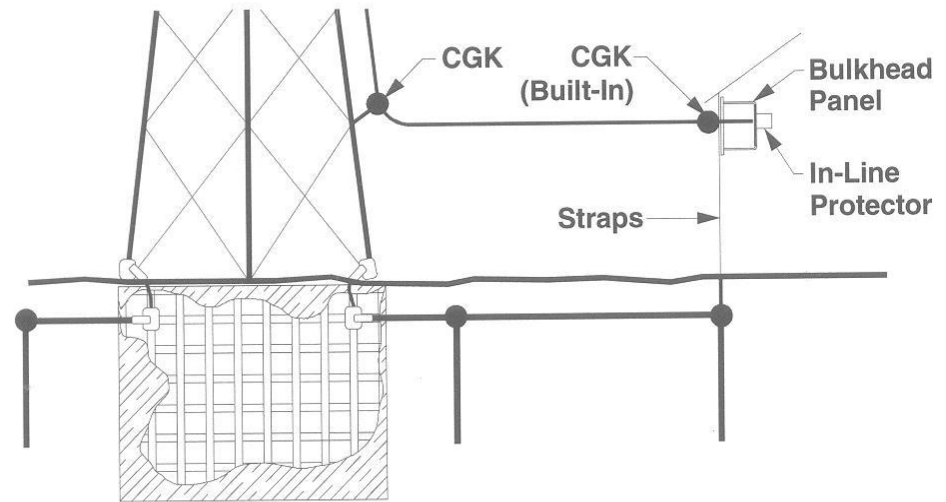
GOOD

The best solution is for the coax from tower or simple dipole to be tied to the earth ground at the lowest possible point to allow the smallest amount of voltage (potential) entering the building.



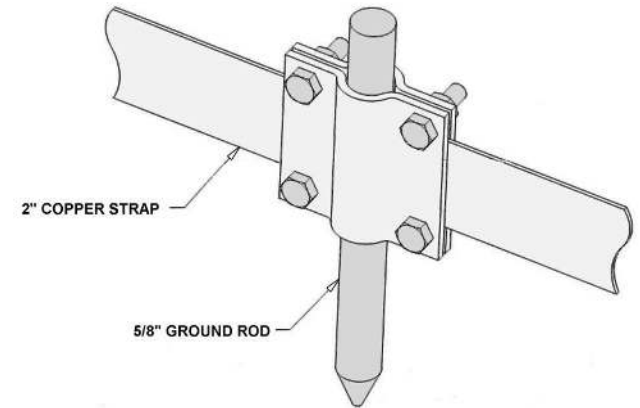
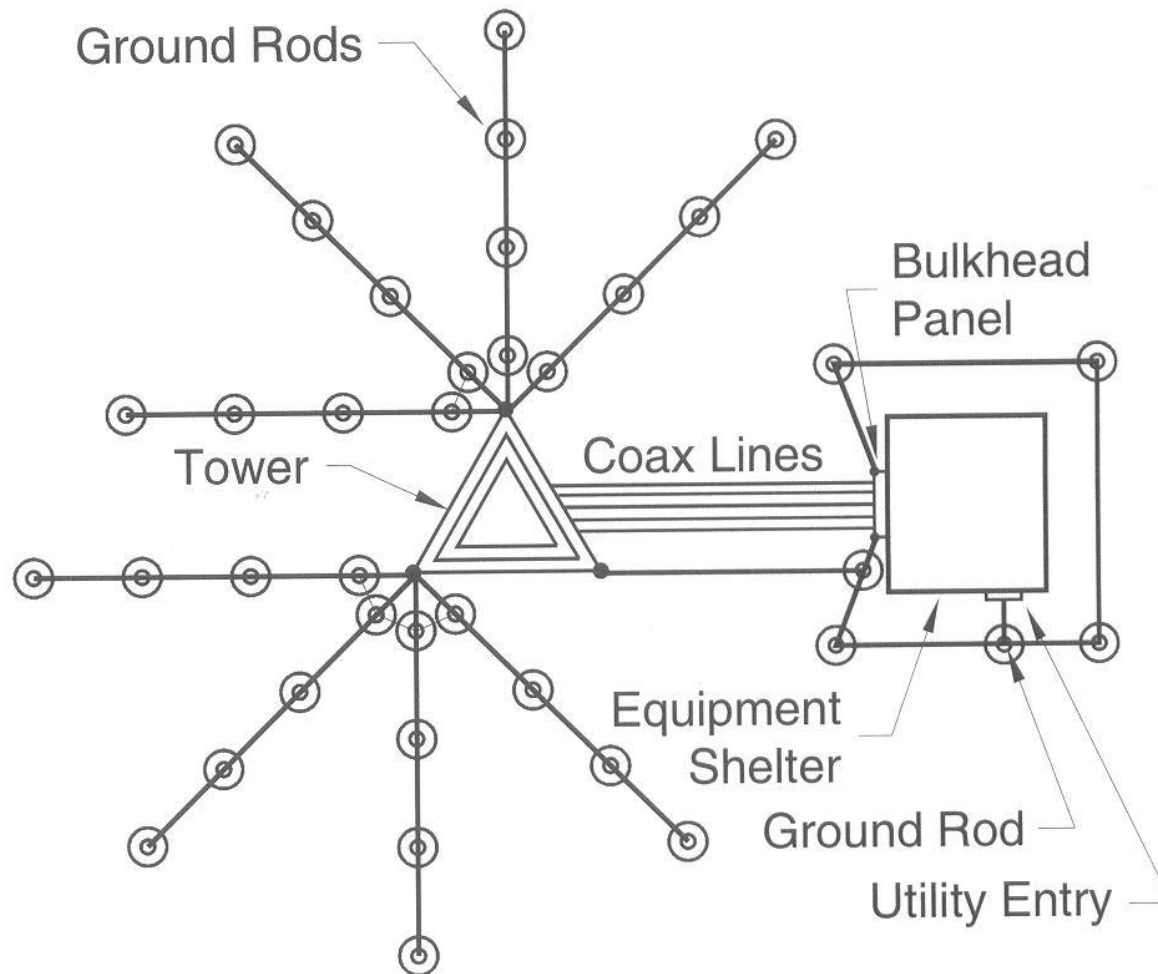
OK

Thinking of the antenna when hit, it could have 100kV at the top and decreases in voltage as one moves down the tower. The tower acts like a voltage divider where the cable take-off is a tap on the divider.



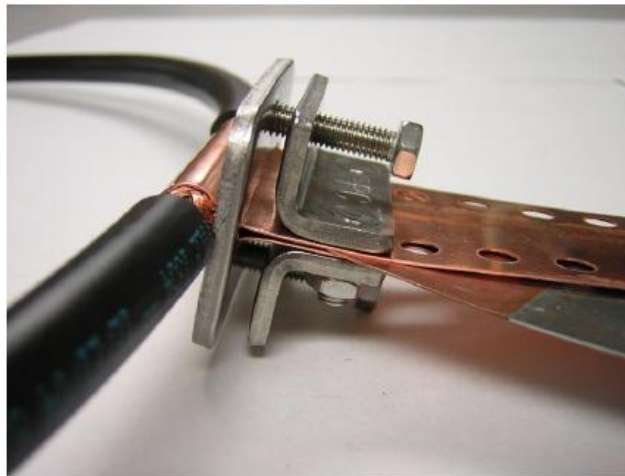
ACCEPTABLE

The commercial earth ground "System"



Mechanical connections

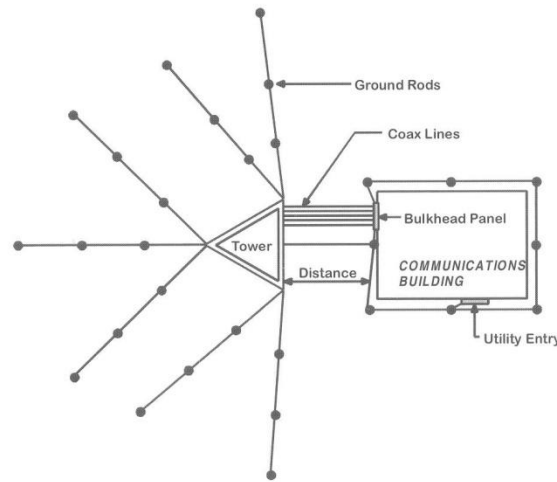
- Bonding coax to the tower
- In-ground strap to gnd rod



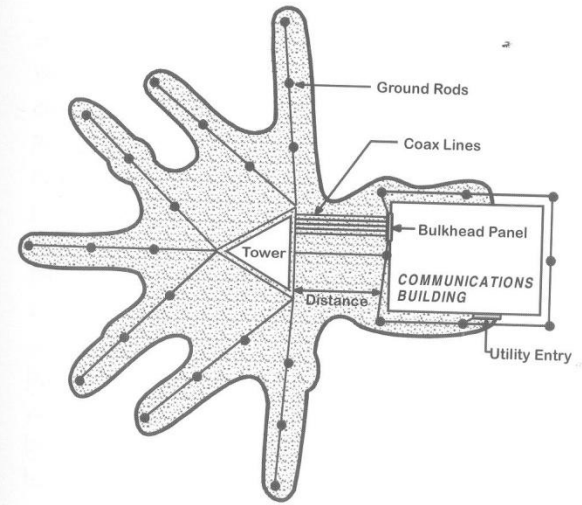
How the strike dissipates in the earth.

Important points:

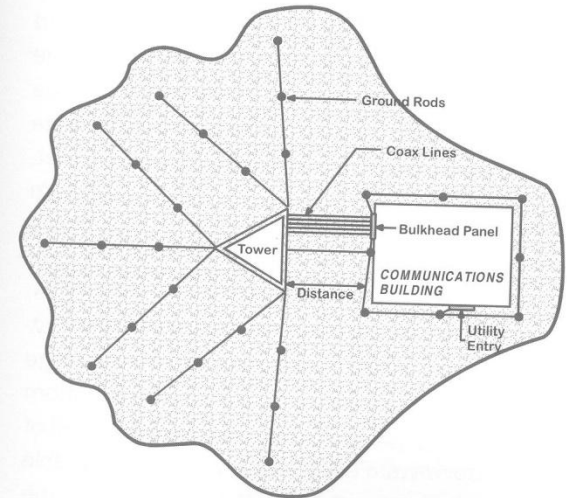
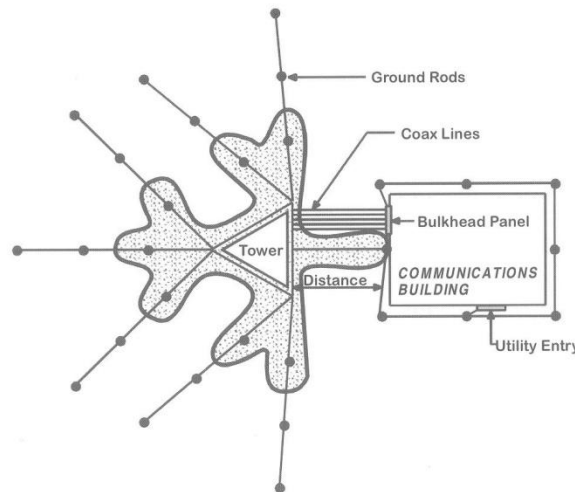
- 8' copper clad Ground Rods are typical
- Rod spacing is twice their depth
- Copper strap or heavy gauge wire
- Conductive paste at every joint
- Ground system must be tied to Utility grounds outside.
- Perimeter ground is important. Even a "U" shaped loop is effective.
- Rods should be pounded in for greatest conductivity to earth.



Recommended site grounding system about to be hit by lightning.



As it spreads, it loses energy due to the spreading and I-R losses.



Bulkhead Panel Inside



All inside connections can be removed from the SPG panel to isolate the station.

MOVs are used on all control lines and the solar panel feed line.

Lightning protectors are used on all coax lines.

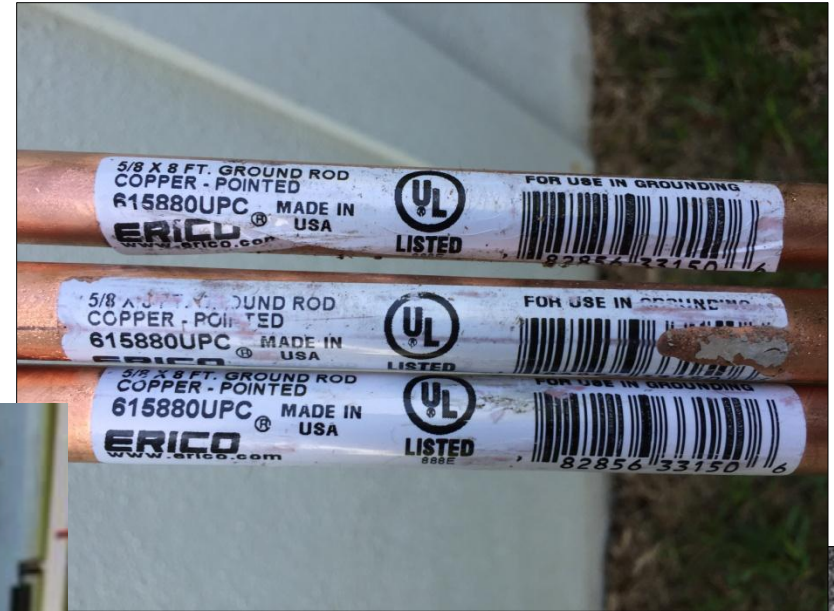
The window was replaced with 3/8 inch acrylic (plexi glass)

Grounding design at NZ1Q



Bulkhead panel
to Ground
System





SS-30 is available at DXEngineering. It contains 70% copper and is a must for all bonded connections to provide low resistance connections and prevent corrosion.



Summary:

Minimum Station Ground System

- Use a Single Point Ground
 - Plate or Bulkhead
 - Lightning Protectors, Surge Protectors
- Entire shack “electrical island” grounded to the SPG.
 - Antenna cables, AC Power, Control lines, Communication
 - Tie outside ground rods into AC Service ground, 6 AWG
 - NEC: Chapter IV, Sec 800.100, Para (D)
- Use strap (or braid) between SPG and Ground Rod System
- Minimum of 3 ground rods with heavy uninsulated wire/cable or strap between them.

Key Points:

Develop a grounding protection plan for inside and out.

Inside:

- 1. Connect all leads to/from equipment to the Single Point Ground (including AC power)**
- 2. Use a SPG Plate or Bulkhead for all connections**
- 3. Use suppressors in each antenna and rotor lead**
- 4. Connect the SPG to earth with copper strap**

Outside:

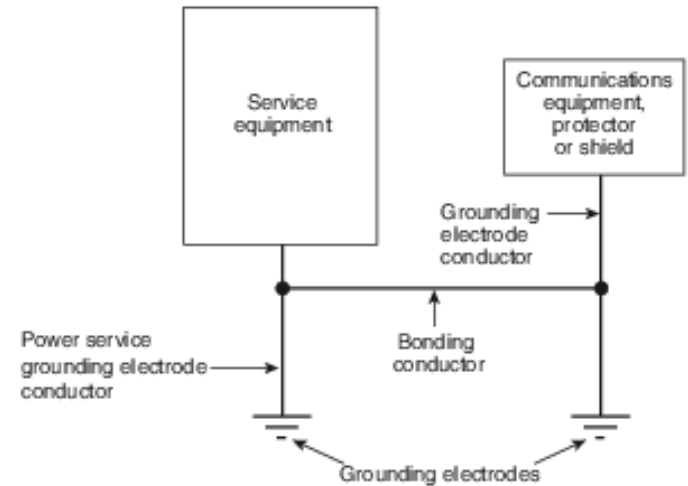
- 1. Bring the SPG to earth with strap and solid connection to the ground rod system.**
- 2. All antenna/rotor cables should be bonded to the lowest point on the tower and bonded to earth ground with straps from the SPG.**
- 3. Copper strap is preferred between SPG and all ground rods.**
- 4. A minimum of 3 ground rods in a triangle are required – one will not do it.**
- 5. Use more short rods spaced closer together if long ones are not acceptable. Place rods at a distance from one another by twice the rod's length.**
- 6. Tying the ground system to the utility ground rod is critical. Use a perimeter ground even if not a complete loop.**
- 7. Clean all copper joints (polish) before connection**
- 8. Use a conductive joint compound on “mechanical” (non welded) ground connections.**

Most Important

- Leave the shack when lightning is near.
- After all this, if you still can't sleep at night, disconnect your rigs and take them out of the shack.

References

- [Grounding and Bonding](#)
- [Poly Phaser](#)
- [National Lightning Safety Institute](#)
- National Electric Code, NFPA
- [Bonding, Grounding, Surge protection](#)
- [Bonding of Ground Systems](#)
- [Lightning Protection QST article \(Polyphaser\)](#)
- [Harger \(parts supplier\)](#)
- [NASA](#)
- [Georgia Copper \(supplier\)](#)
- [DX Engineering - PolyPhaser \(supplier\)](#)
- FAA Grounding Standards STD-019e2
- [IEEE home protection from lightning](#)
- [ARRL Web Links](#)
- [WR Block & Associates](#)
- [Real Time Lightning Map](#)



Informational Note Figure 800(b) Example of the Use of the Term *Grounding Electrode Conductor* Used in a Communications Installation.



2014 Edition

NATIONAL ELECTRICAL CODE

NZ1Q Background

Ed Erny

- Licensed in 1961, Extra in 1990
 - WA2TKE, WA6YMC, N1GSW, NZ1Q
- Worked in high tech for 40 years
 - Digital communications
 - Data Storage
 - Semiconductor manufacturing
 - Automatic test equipment
 - Radio equipment manufacturer
- BS in Electrical Engineering
- <http://www.QRZ.com/db/NZ1Q>

