Lightning Protection

- **Wisconsin Broadcasters Association**
- **Broadcasters Clinic**

- 14th October 2009
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- Regional Sales Manager, Central U.S.

Making Digital Radio **Work.**

How to avoid the Nightmare

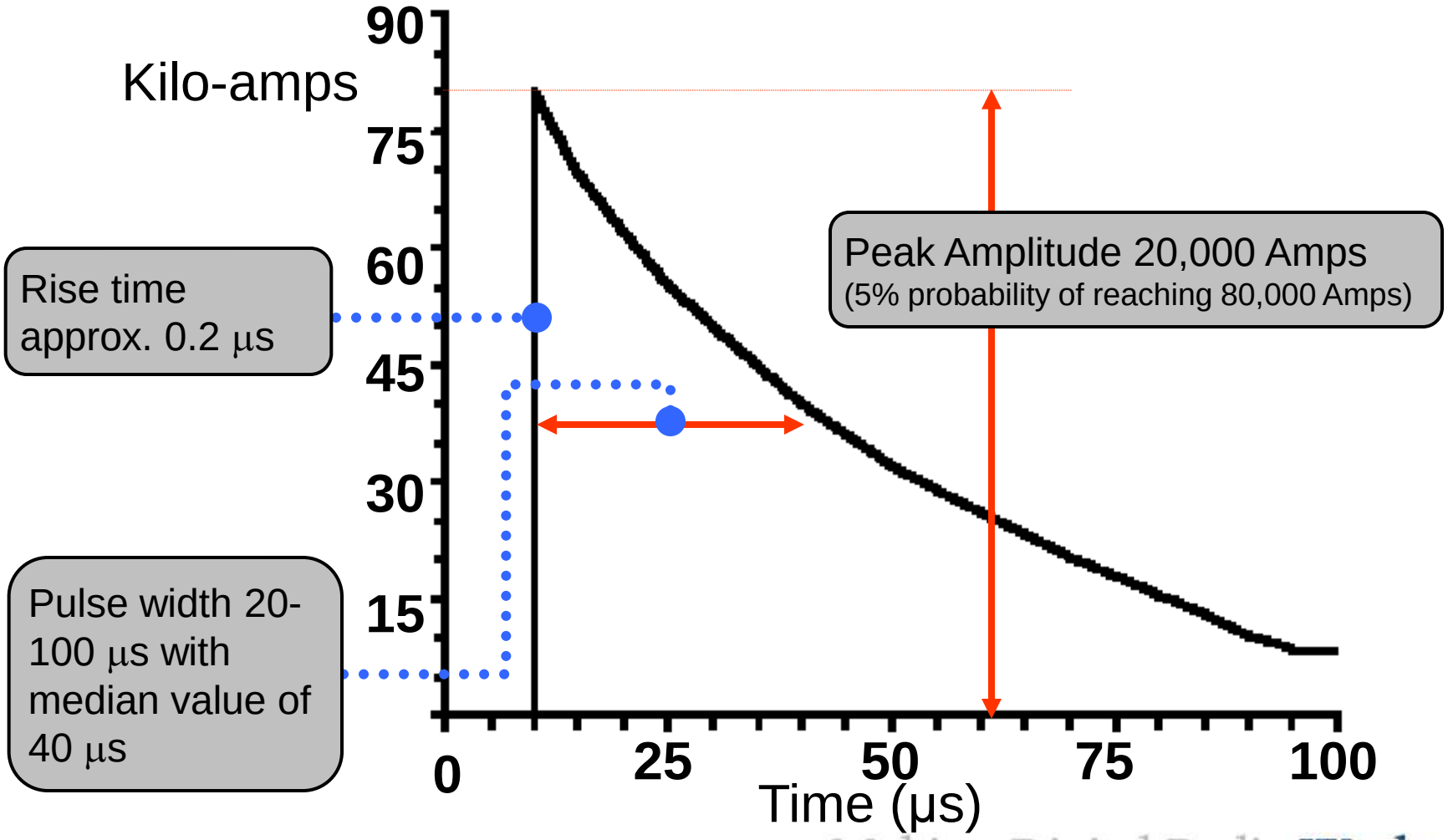
Review Key Areas

- Lightning/Grounding
- Electromagnetic susceptibility

Lightning Protection

- Overall site
- Antenna system
- Transmitter building

Typical Strike Pulse



. . . Facts

- 5% of strikes (1 in 20) are:
  - more than 70,000 amps
  - as high as 200,000 amps

. . . Facts

- Charge transfer:
  - 20 coulombs to 300 coulombs
- MOV's suffer a cumulative decay during repeated energy transfers
- Therefore, they must be fused, as they will eventually fail short-circuit

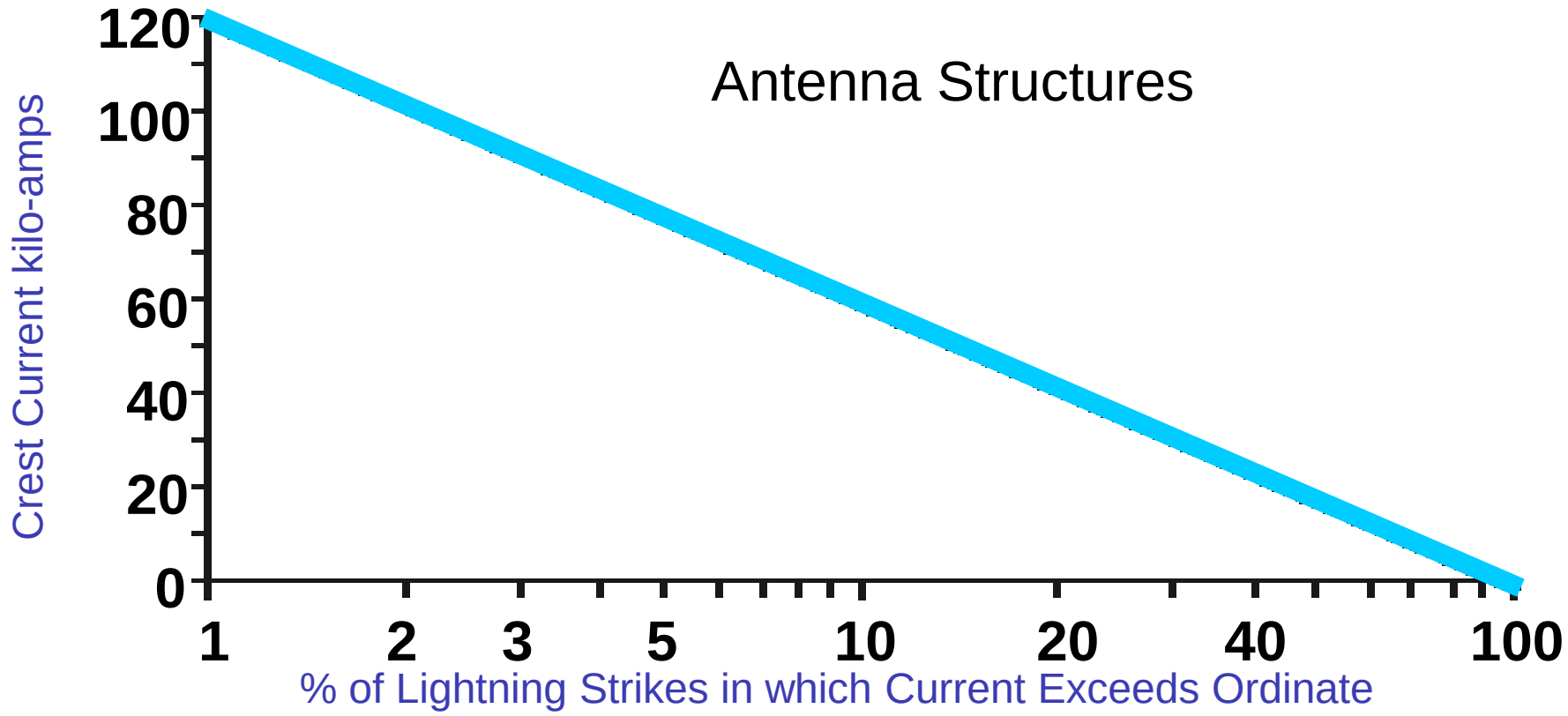
. . . Facts

- Period of half amplitude:
  - about 40 μsec (corresponds to 25 kHz)

. . . Facts

- Rise time 0.2 μsec
- Slower decay

Amplitude vs Probability



Lightning Protection Costs

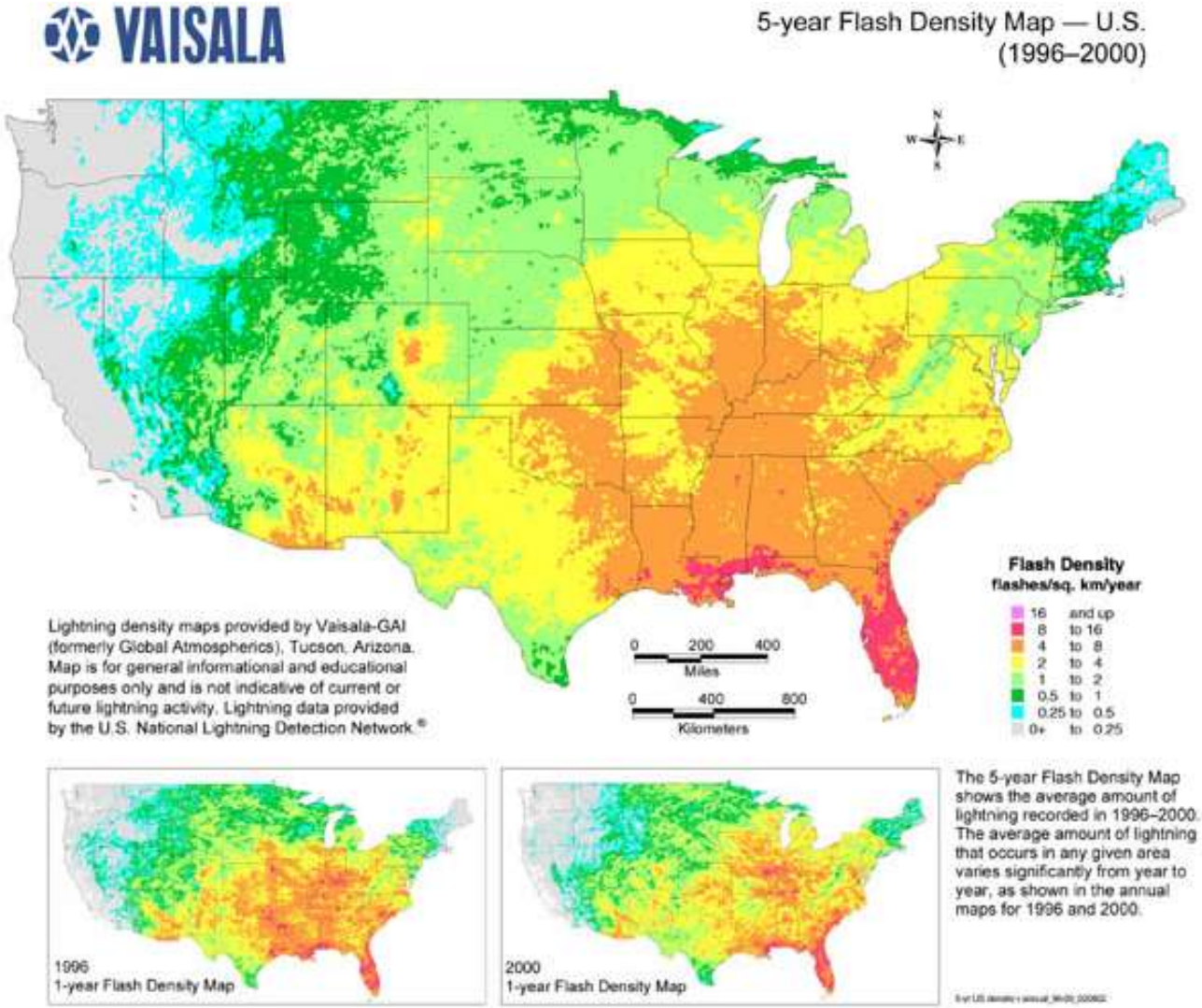
Amount to spend depends on…

- Value of asset you are protecting
- Loss of revenue when off-air and time to return to air
- Probability of getting hit by lightning

Central Florida has 37 hits/sq km/year

Other areas may have < 1 hit per/year

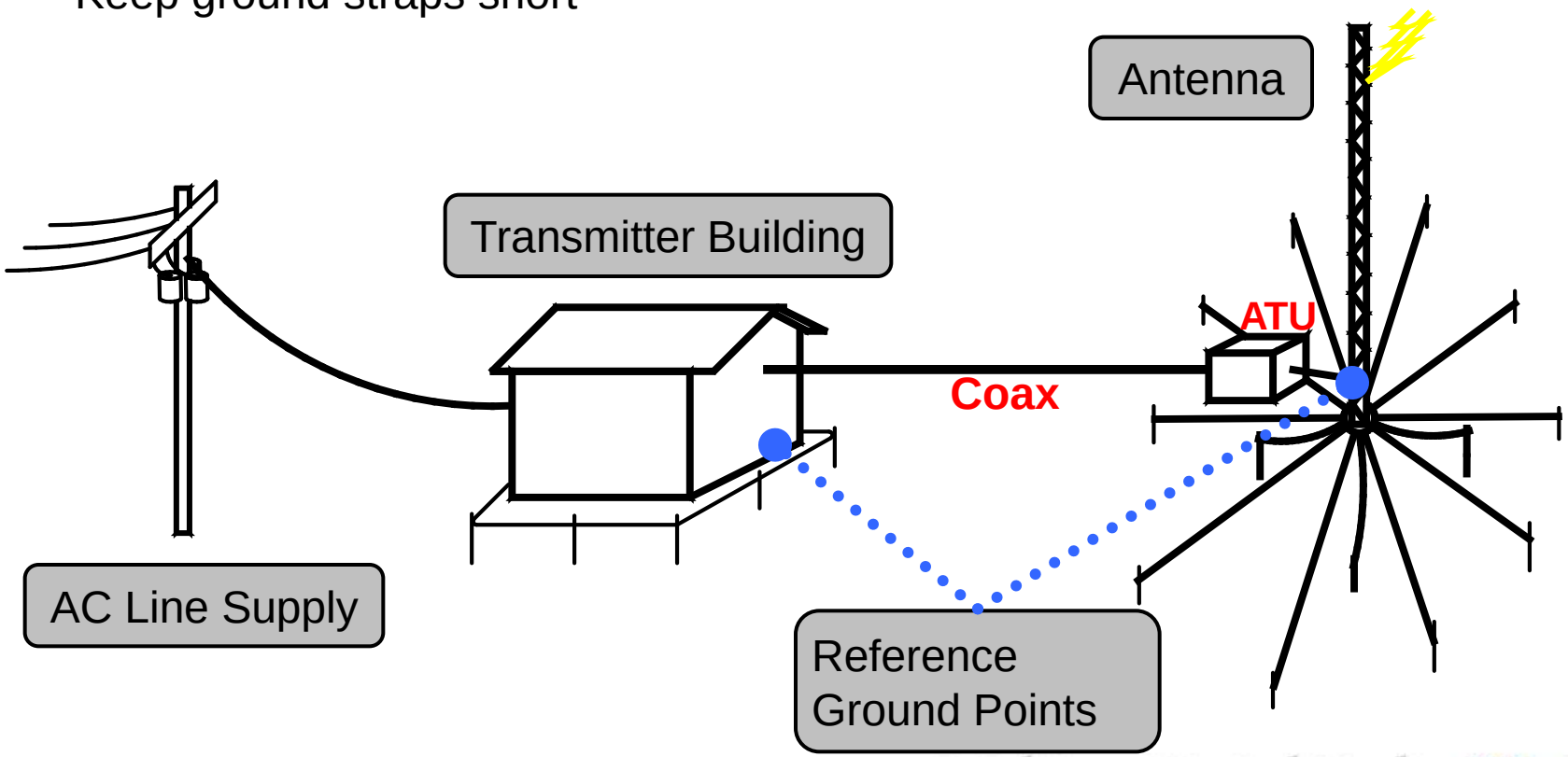
Lightning Density



http://www.lightningsafety.noaa.gov/images/map.jpg

Typical Site

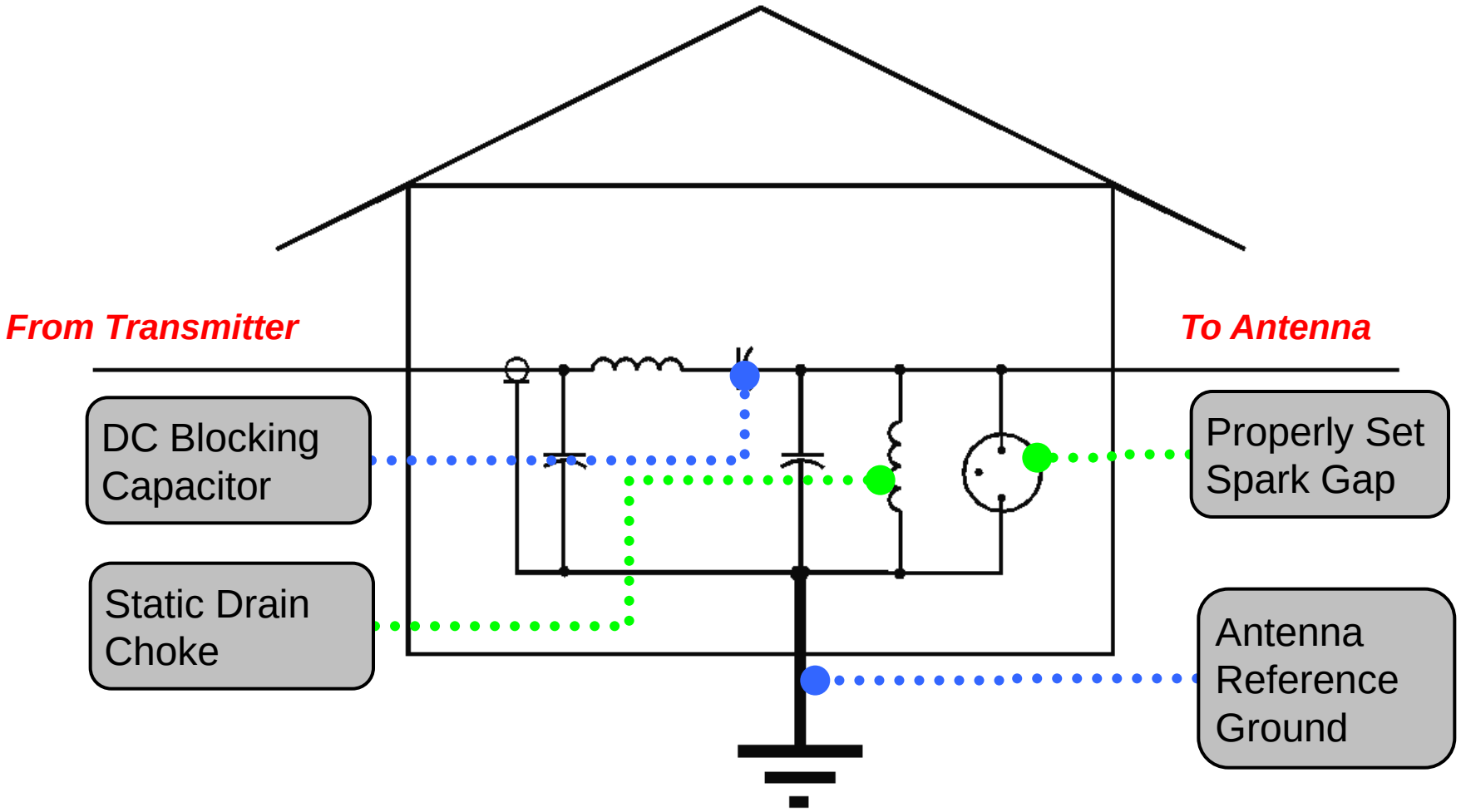
- Try to have AC, coax, and reference ground enter the building in close proximity
- Keep ground straps short



Key to Protection

- Conduct strike pulse current to ground through a low impedance path
- Prevent this destructive current from flowing through your electronic equipment

Protection At The Antenna



Routine Inspections

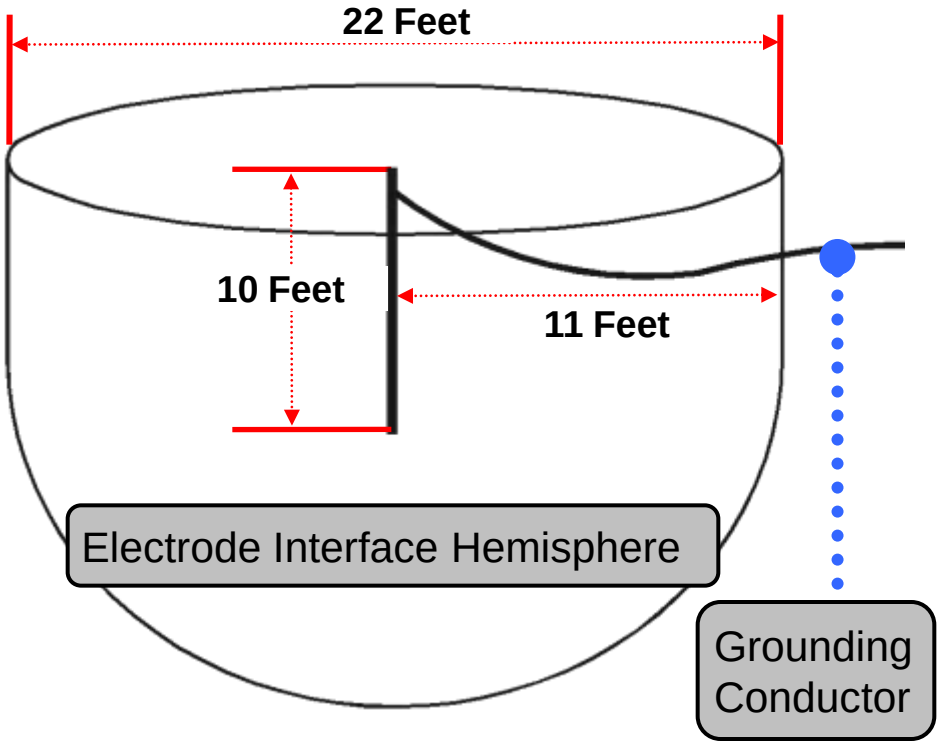
A regular visual inspection of the ATU and lightning protection components helps to prevent damage caused by failures like this.

Sealed ATU's

Keep rodents and animals out, as well as providing protection from the elements.

Inspect seals and lock assemblies annually.

- Penetrate below the frost line
- Moist soil or the water table
- Diameter 3/8” or larger
- Connected with Cad welded or silver soldered copper straps
- Copper or copper clad steel



Antenna Spark Gap

Rain shields should be fitted to outdoor gaps

Lead screws allow for easy accurate adjustment

Carbon balls require little or no maintenance

Spark Gap At ATU Input

Ball gaps

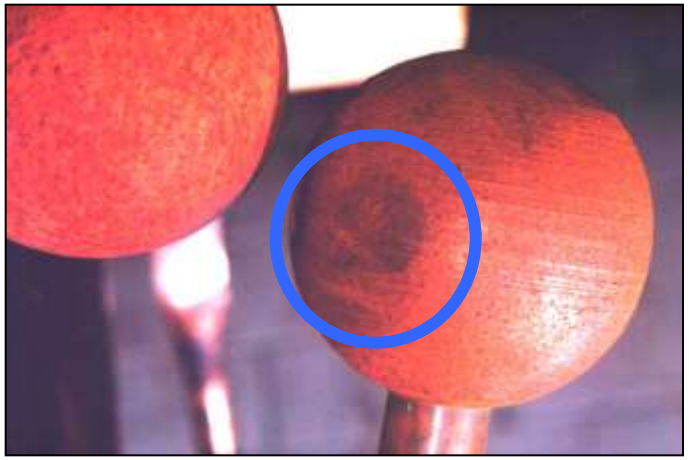
- 1/2” and larger, can be calculated

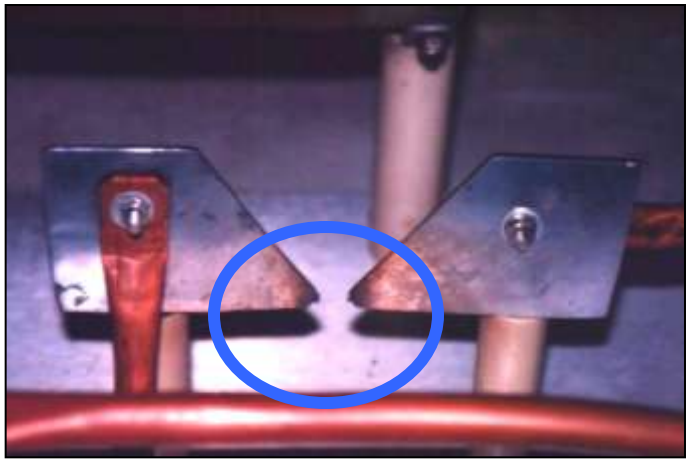
Steel balls

- require frequent maintenance

Horn gaps

- difficult to calculate
- some require major rework after a strike





Indoor Ball Gaps

…prevent most false trips from rodents and insects

If It's Not Live, Ground It

- Electrolysis caused by static and lightning strike dissipation can cause the guy anchor to fail.
- Ground all guy wires to prevent major antenna system failures.
- Save the anchors

If It's Arced, Replace It

Once a guy wire insulator has arced, it's no longer an insulator – it's a conductor waiting to happen!

Arcing insulators rapidly change the load the transmitter sees, and stress the system.

Key Items

- **Antenna Ball Gap**
  - low inductance straps to antenna ground rods

- **Antenna Ground Rods**
  - minimum of 4, 10-15 ft. long

- **Static Drain Path**
  - antenna to ground

- **DC Blocking Capacitor**
  - high pass section - designed into matching unit

High RF Voltage Concerns

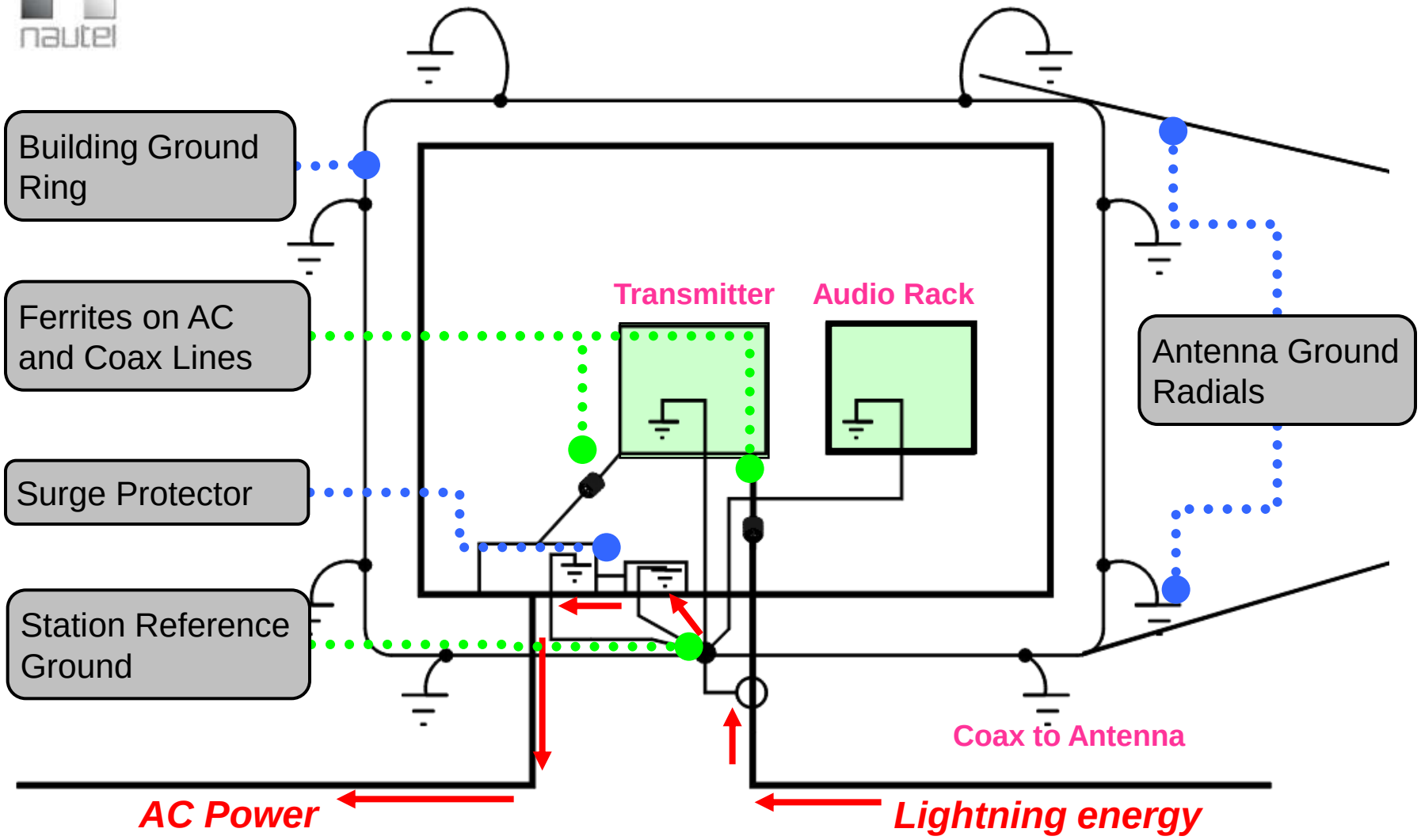
- Calculate peak voltage produced by the transmitter at the antenna base during worst case conditions
- 100 % modulation
- Maximum output power
- VSWR 1.5:1
- Antenna Impedance (Ω + j) must be included

Nominal Gap Settings

Kilowatts	Kilovolts	Gap (inch)
1	1.867	0.016
5	4.175	0.048
10	5.904	0.077
15	7.231	0.101
30	10.226	0.161
55	13.846	0.249

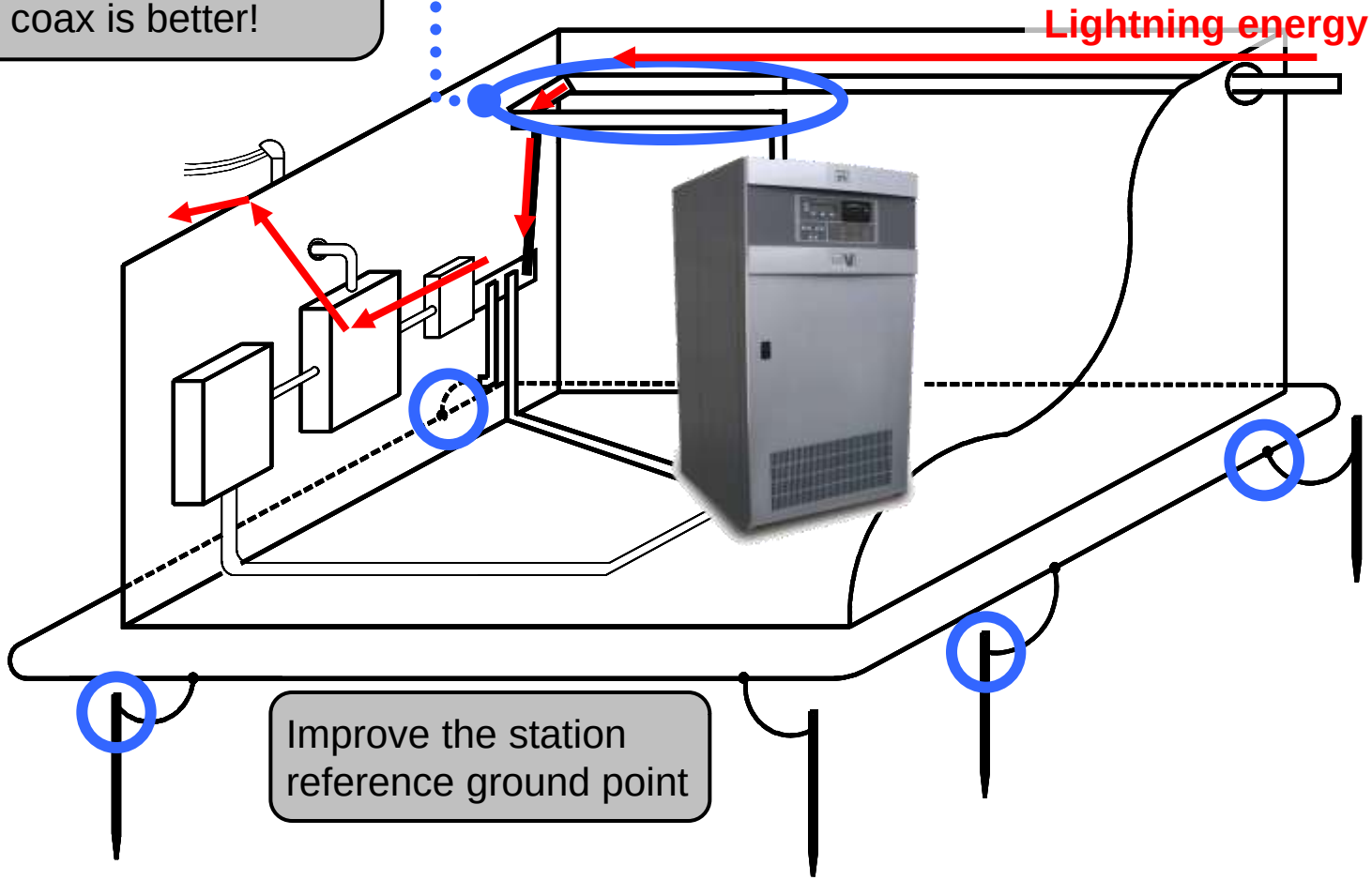
(sea level, 1 inch balls, 133 + j 15 antenna)

Ideal Transmitter Building



Improving Layout

Reroute the coax to allow a short ground strap, a longer coax is better!



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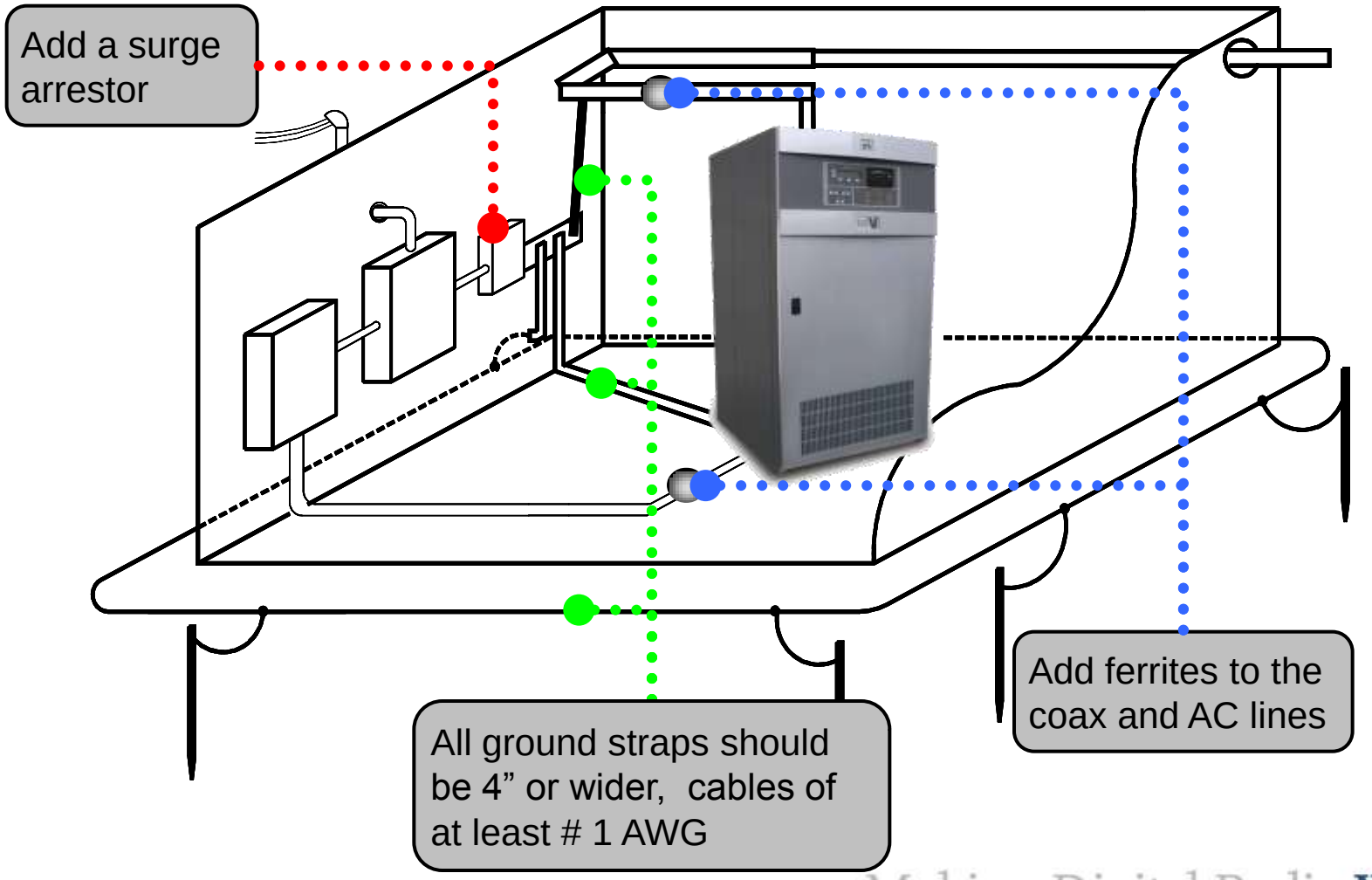


Ferrite Choke Locations

- ON the coax near the transmitter
- ON the coax near the input to the antenna tuning unit (ATU)
- ON audio cables near their termination point
  - only twisted pair, shielded cables should be used
- ON the AC to the transmitter
  - all AC phases and AC ground go through the same ferrite
- ON the remote control cables
  - only twisted pair, shielded cables should be used
- ON AC cables to any external equipment

Electromagnetic Susceptibility

- Electromagnetic feedback
  - into equipment within transmitter building

- Antenna current feedback
  - through coax feeder and/or AC supply

How to…

- Reduce Unwanted Antenna Return Currents

  - Either bury coax feed below counterpoise or install inside a conductive sleeve which is part of ground plane.

  - Connect ground radials to Faraday Shield only - not to equipment.

  - Filters or balun toroids on AC supply input to transmitter.

Reduction Of Unwanted Feedback

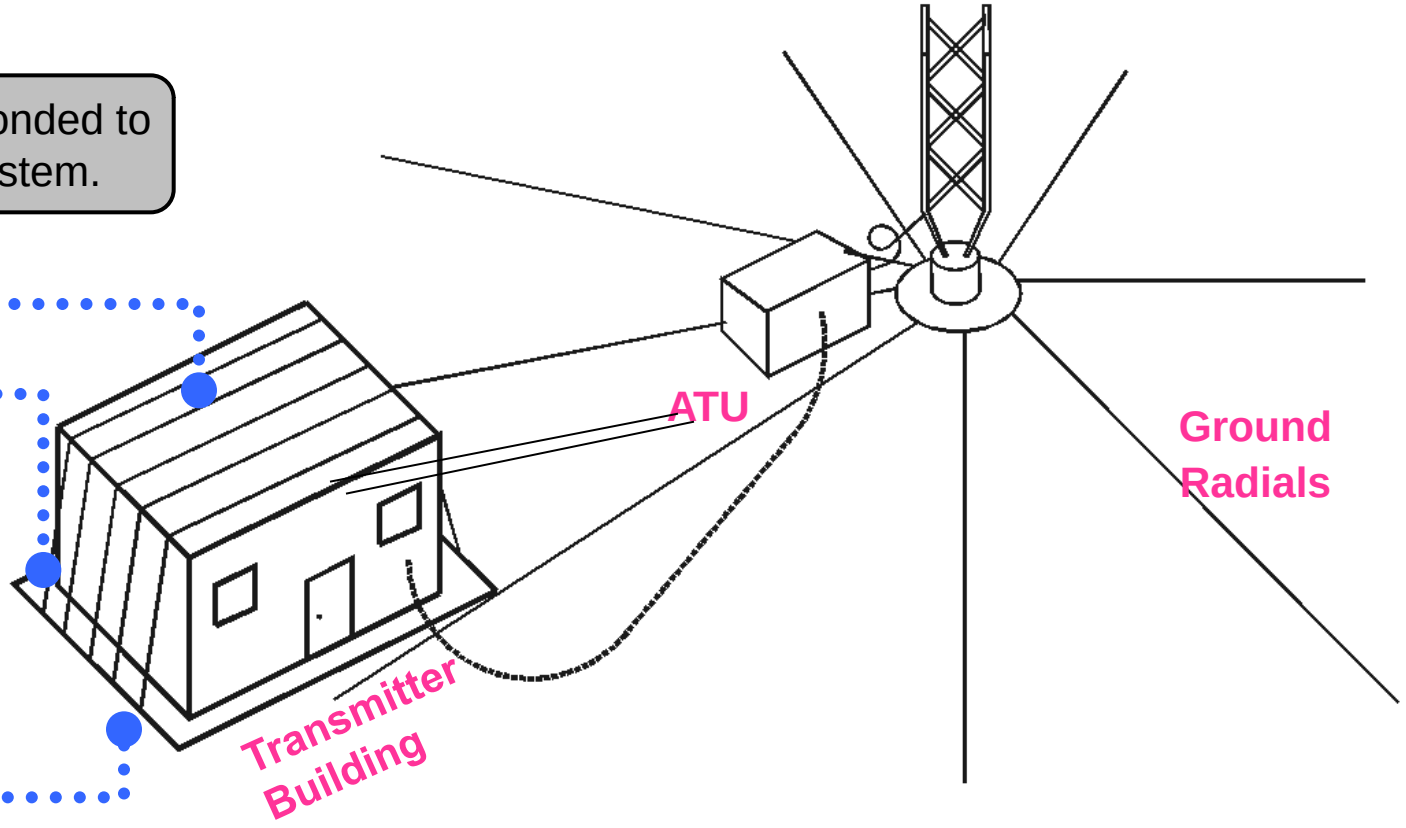
- From Antenna To Equipment

  • Maximum separation between antenna and transmitter

  • Faraday shield or screen enclosing transmitter building

Faraday Cage

Set of conductors bonded to reference ground system.



Safety Ground Ring Around Building

Coax Cable below Ground Radials

Where Are Highest Voltages?

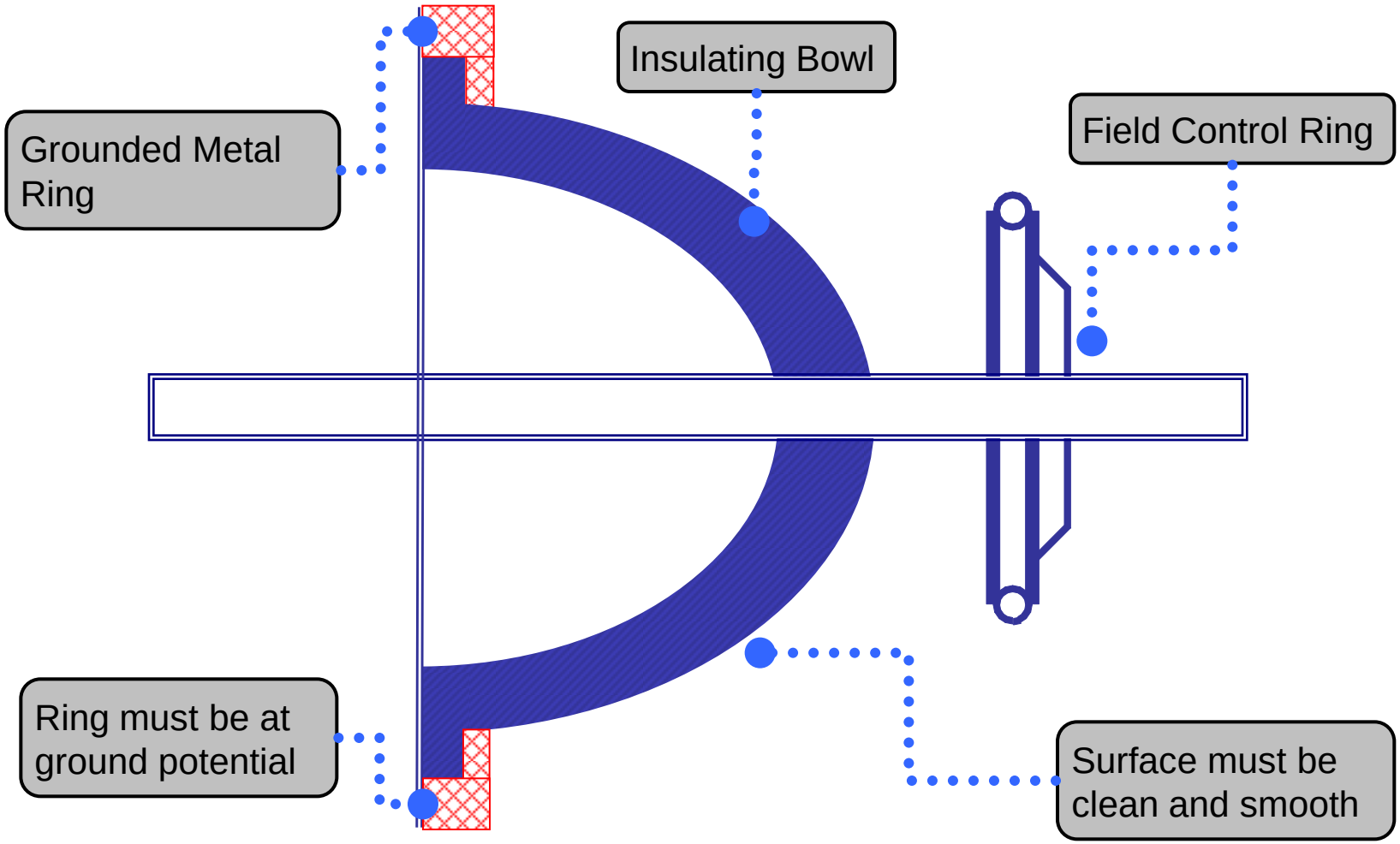
- In the solid state transmitter the highest impedance point, and therefore the highest voltage, is at the transmitter output

- In the transmission system, if the antenna impedance is greater than 50 ohms, the highest voltage will be at its base

Good High Voltage Practice

- Reduce voltage gradients - use smooth rounded surfaces wherever possible.
- Create a definite ground reference so voltage is developed across insulators instead of adjacent components.

Corona Shield



References

Nautel

Recommendations for Transmitter Site Preparation

PolyPhaser Corporation

The Grounds for Lightning and EMP Protection