

Antenna System Grounding
by
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Intro:

No place on earth, that I know of, is completely free of the threat of lightning; but Texas seems to be especially blessed with plenty of it. It's fun to look at, has great sound effects, and makes for some pretty striking, if you'll pardon the expression, pictures. However, we don't want it inside our shack, running through our radios or, even worse, our bodies. So, let's talk for a few minutes about how we can keep it outside, where it belongs.

What causes lightning?

- WX conditions in spring and summer, tropical climates...and Texas
- Warm air meets cold air, in the upsurging convection air currents are created
- Friction between air masses creates static electricity in the cloud formations
- Charges stratify with negative at bottom and positive at top of the clouds
- Low negative layer positively charges ground – like opposing plates of a capacitor
- When charge exceeds dielectric resistance – the arc to neutralize it is LIGHTNING!
- Cloud to ground or cloud to cloud – both are dangerous and damaging
- C to C induces a current into the ground below the discharge which couples inductively into antenna feedlines, power lines, phone wires, etc.
- Bill took a hit a few years back – in over phone lines??? Over to Bill...

Grounding system design goals:

- Lightning wants to go to ground – so we help it with a well designed and installed grounding system
- Here are the basic design goals of our system
 - No shock or over-voltage hazards
 - No fires due to overheating from current or arcing from voltage
 - Reliable equipment operation
- Commercial broadcast and telecomm sites take hits all the time – no loss of on-air time
- Accomplished by creating low impedance path to ground

- First we'll discuss what to do outside the shack
- Then move inside
- Then tie it together
- Why low impedance path to ground rather than low resistance??

Impedance defined:

- Resistance is opposition to current flow in a DC circuit
- AC current flow affected by reactive components that react to change over time
- Opposition called “reactance” – denoted by “X”
 - Inductive reactance = X_L
 - Capacitive reactance = X_C
- Impedance measures the combined effect of resistance and reactance
- All three measured in ohms

Why a low impedance path?

- Lightning is a series of diminishing electrical pulses
- Lightning’s fast rise and fall time makes it act like RF
- Typical rise time of $2\mu\text{s}$
- 10 to $40\mu\text{s}$ decay
- $2\mu\text{s} = 500\text{ kHz}$ – the old maritime frequency of 600 meters
- Average of 3 pulses per event with avg current of 18 kA for first pulse
- 10% = 60 kA, 1% = 120 kA
- Largest ever recorded > 400 kA
- Must get it to ground without it coming through the gear

How to ground a tower or push-up pole:

- Ground each leg to a ground rod with solid #2 copper minimum
- Connect the ground rods with a ground ring of at least solid #2 copper
- Ufer ground also an option – must be tied to ground rod system
- MUST Take a radial field out from the ring if the tower is a radiator – it’s good even if the tower is not a radiating element
- Connect metallic guy lines together and ground them at anchor points
- Jumper crank-up tower or push-up pole joints with braided strap (shield it from WX)
- Use anti-oxidant on bolted tower joints & ground block connections

Getting the feedlines into the shack:

If antenna(s) tower-mounted:

- Bond coax shield to tower at top and bottom and every $50' \pm$
- Take coax all the way to the bottom of the tower before going to shack
- Buried coax is good. Surges will inductively dissipate into ground
- Ground coax shield at ground level before entering shack
- Use entry bulkhead grounding plate and SPD
- Don’t forget control and power lines for rotators and remote tuners

For wire antennas and other non-tower mounted antennae:

- Route coax to ground level and connect shield to ground rod before entering shack
- Use entry bulkhead grounding plate and SPD

Entry bulkhead grounding plate – SINGLE POINT GROUND:

- Usually mounted on inside wall in amateur practice
- Copper or aluminum plate – steel OK, but not as good a conductor
- All incoming cables have shield grounded to plate
- All equipment grounds to plate
- Plate connected to ground rod immediately outside by minimum #2 AWG Cu wire
- NO daisy-chains
- Also called STAR ground – STAR of STARS is OK

Ground rod system:

- Use minimum 6' rods. 8' to 10' preferred. 4' OK if rocky soil prevents longer rods.
- Distance between rods = 2.2 times the length of the rods – “Hemisphere of Influence”
- Closer won't hurt, it's just wasteful
- Connect rods with minimum #6 AWG solid Cu, #2 is better, strap is best
- Go all the way around the house and tie to electrical service ground rod

Roof mounted antennae:

- Bring multiple down-conductors to ground ring surrounding house
- Gentle turns have less inductance than sharp turns – applies to all ground conductors

SPDs – Surge Protection Devices

- Many different types and protection is pretty much proportional to cost
- Gas discharge tube only
 - Alpha-Delta has gas tube in shunt
 - High Sierra and MFJ same
 - All the small ones with SO-239 on each end
- Gas tube alone bad because
 - Intended for use with very limited current capacity conductors (telephone)
 - Compromised each time the gas is ignited (ionized)
 - Can't tell actual condition of protection capability
 - With lightning strike tube conducts for much longer than design spec

- Gas tube plus DC blocking cap – typical of PolyPhaser and others – BETTER
 - Gas tube in shunt, plus blocking cap in series with hot lead
 - No constant drain mechanism provided – coax acts like large capacitor needs drain
 - Lightning event lasts longer than gas tube designed to handle
 - Current in lightning event much greater than tube design parameters
 - No way to determine condition of tube's protective capabilities
 - Failed tubes don't always short, they may fail open which is worthless

- My favorite – by Industrial Communication Engineers (ICE)
 - DC blocking cap in series
 - Gas tube in shunt on antenna side
 - Inductor in shunt on antenna side
 - Drain resistor in shunt on radio side
 - Inductor provides constant drain of static build-up
 - Quieter reception due to static bleed-off
 - In lightning event a back-EMF develops across the inductor
 - Gas tube discharge collapses only the field of the inductor – NO overload damage

DC Grounded Antennas – Coil across terminals forces some voltage down center conductor to radio. We've been trying to get all the voltage to ground through the shield and now the antenna is sending it down the center conductor. Essential to use SPD with DC blocking cap when using DC grounded antennas.

Review

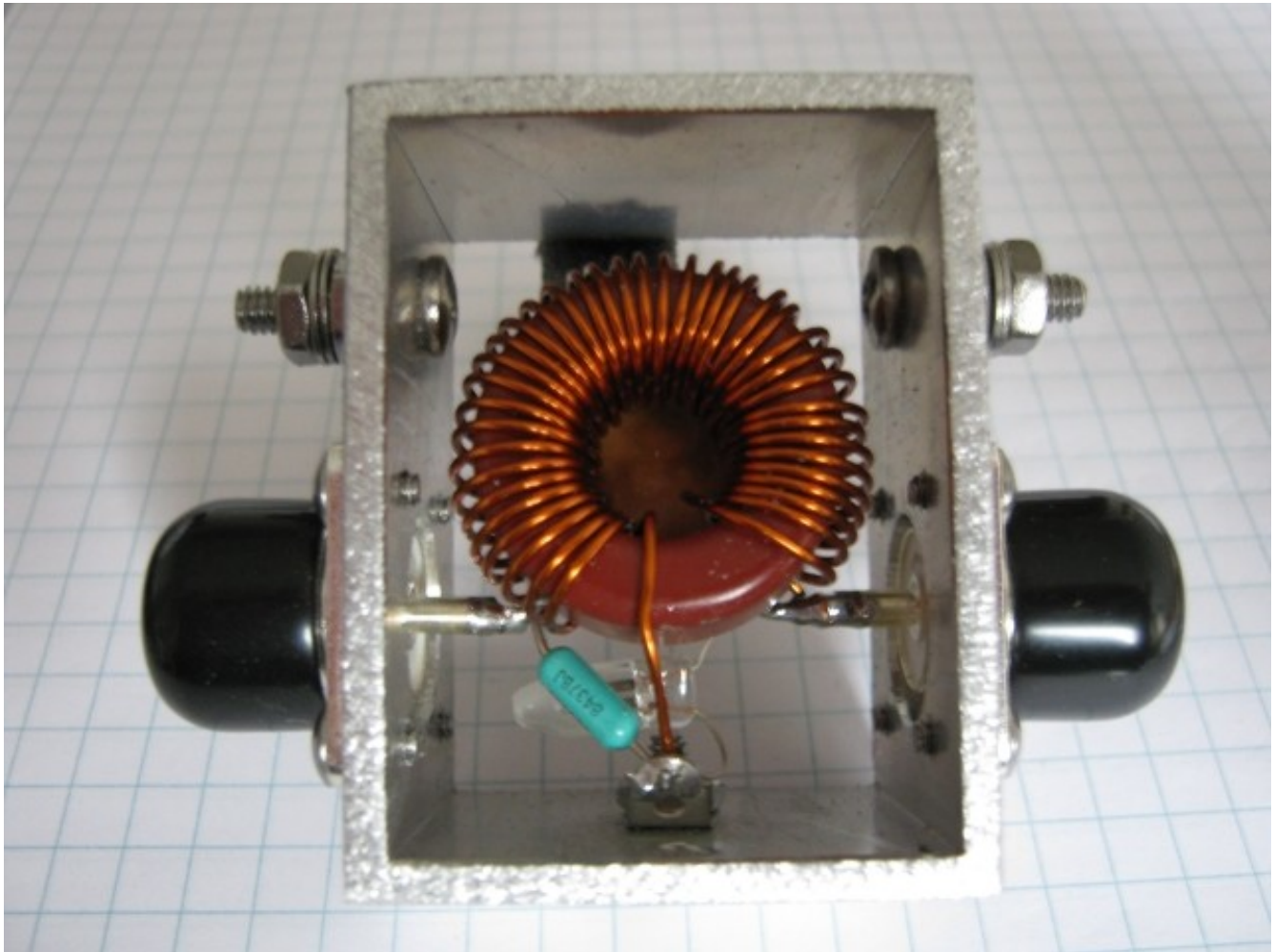
- Good tower ground if tower used
- If tower, ground coax shields at top and bottom – mids if required due to height
- Tower or not, take cables to ground level before entering shack and ground shield
- Use entry grounding plate and SPDs
- Use single point – STAR – ground or STAR of STARS
- NO daisy chains
- Tie grounding system to house electrical ground
- DO NOT use water or gas pipes for grounding purposes
- Protect ground connections from weather by using protective coatings if possible
- Use SPDs for AC service entry and for telephone, telecomm and control lines

ABSOLUTE BEST WAY TO ELIMINATE LIGHTNING DANGER – Disconnect the coax cables outside the shack and throw them on the ground BEFORE the storm gets close

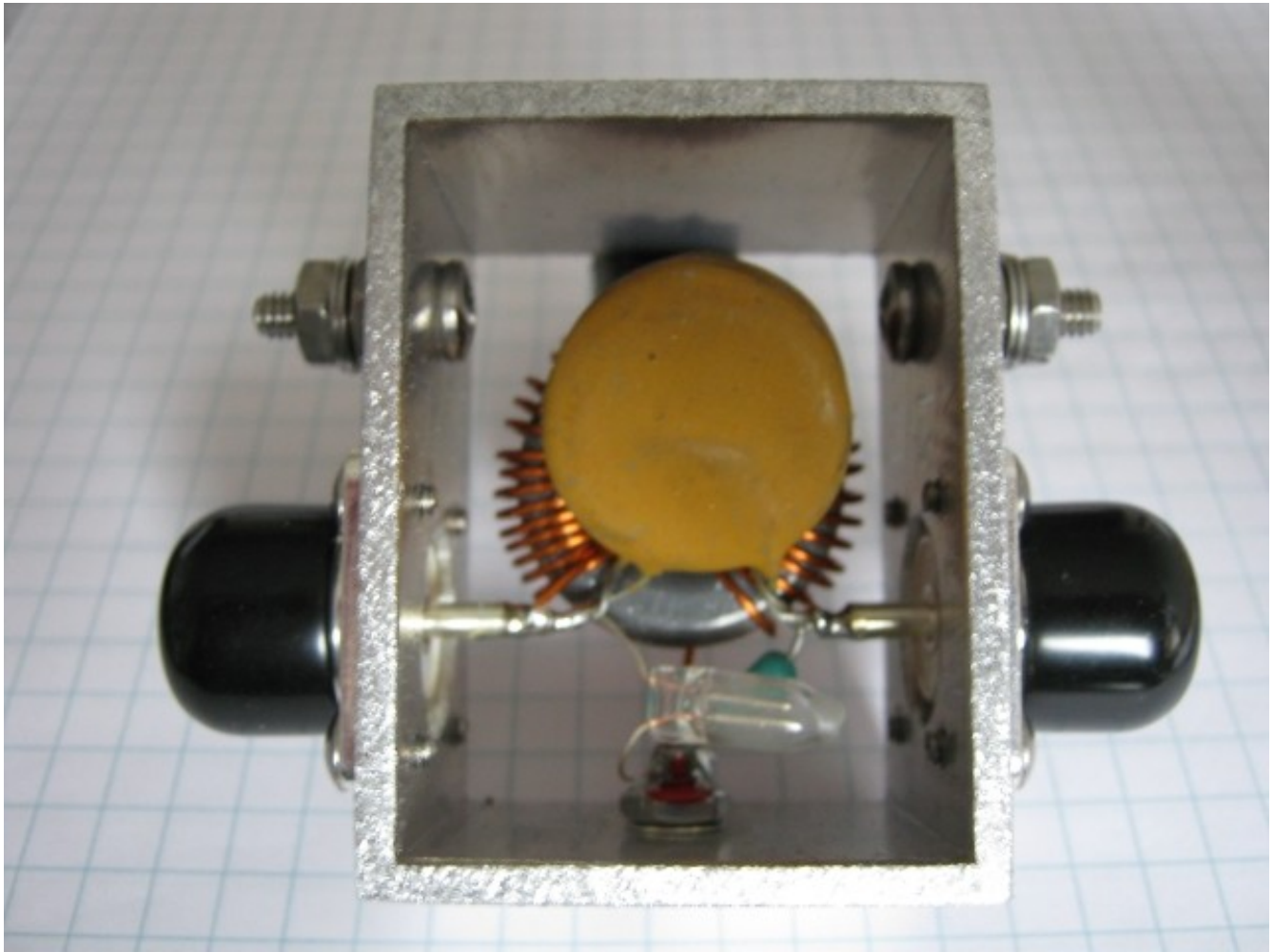
Don't forget the 30-30 rule...Go inside if you hear thunder within 30 seconds of a lightning flash and stay inside for 30 minutes after the last clap of thunder.



External view of ICE Model 303 surge protection device (SPD). Note the power rating! You can go ahead and buy an amp if you have this one. Thanks to KD5ZMZ for letting me photograph – and then disassemble and photograph his new toy. Photo by K5WLF.



Internal view of ICE Model 303 lightning arrester. Antenna terminal is to the right of photo. Note hefty toroidal inductor in shunt from antenna center conductor to ground. The DC blocking cap can be seen through the center of the toroid. Resistor on left drains off the tiny voltages that feed through the capacitor dielectric during an impulse event. Photo by K5WLF.



Internal view of ICE Model 303 lightning arrester. Station side is to the right of the photo. The DC blocking caps (there are two caps in parallel) are visible. The clear glass tube is the gas discharge device that discharges the back-EMF across the inductor during a lightning event. Photo by K5WLF.