Grounding Essentials for the Shack

Lightning Protection
AC Power Safety
RF “Grounding” (RF feedback - Tx)
RF Noise (RFI - Rcvr)
What is Lightening?

• 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
What’s the Problem?
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 - Txr
  – RF Noise (RFI) - Rcvr

• Grounding outside “The Ground System”
  – Lightning Protection
Inside the shack
“The Single Point Ground”
Comparison of conductors for ground systems inside and out

<table>
<thead>
<tr>
<th></th>
<th>Copper Braid</th>
<th>Copper Wire</th>
<th>Copper Strap</th>
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<tr>
<td><strong>Suitability for use</strong></td>
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<td>as a DC conductor</td>
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<td>as an RF ground</td>
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<tr>
<td>conductor</td>
<td>GOOD</td>
<td>FAIR</td>
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<td>as a lightning</td>
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<td>ground conductor</td>
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<td>EXCELLENT</td>
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<td><strong>Mechanical flexibility</strong></td>
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<td></td>
<td>EXCELLENT</td>
<td>MODERATE</td>
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<td><strong>Suitable for direct</strong></td>
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<tr>
<td>burial</td>
<td>NO</td>
<td>YES</td>
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<td><strong>Long-term durability</strong></td>
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<tr>
<td>outdoors</td>
<td>FAIR</td>
<td>EXCELLENT</td>
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<td><strong>Large surface area</strong></td>
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<td>to take advantage of</td>
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<tr>
<td>skin effect</td>
<td>GOOD</td>
<td>POOR</td>
<td>EXCELLENT</td>
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</tbody>
</table>
AC Power Ground

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

Impedance of AC “green wire” ground vs. copper strap

*
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
  – at the point of entry of antenna cables
  – bulkhead installation
  – 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 shack Ground
  - SHORT path - very close to the station
  - Use a big Ground Bus or Strap
  - Use Low RF Impedance Leads/Strap
Typical Amateur Station
More complex station layout

All equipment needs to be treated as an island, 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
Typical Coax Lightning Protector

Throughput Energy is less that 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.
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.
Tying the Single Point Ground to Earth

• Short run of Strap or braid.
• Think of Earth Ground as a “System”
  – Ground system design
  – Ground Rods
  – Conductors and Connections
  – Current flow in the ground
Grounding equipment at bottom creates a loop and surge current can traverse the equipment rack, hiccupsing 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.
Voltage divider analysis

OK

ACCEPTABLE
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.

Think of the antenna, when hit, could have 100kV at the top and change in voltage as one moves down the tower acts as a voltage divider with the “building point of entry” a tap on the divider.
The commercial earth ground “System”
Mechanical connections

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

3" Copper Strap Clamped to a 5/8" Copper-Clad Ground Rod using a PolyPhaser Clamp (p/n 58R-112S)

www.GeorgiaCopper.com
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.
Minimum Station Ground System

• Use a Single Point Ground
  – Plate or Bulkhead
  – Lightning Protectors, Surge Protectors

• Entire Shack Grounded to the SPG only.
  – 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
5. Clean all copper joints (polish) before connection
6. Use a conductive joint compound on “mechanical” (non welded) ground connections.

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.
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 (google for pdf)
- IEEE home protection from lightning
- ARRL Web Links
- WR Block & Associates
- Real Time Lightning Map
NZ1Q  Background

Ed Erny

• Licensed in 1961, Extra in 1990

• Worked in high tech for 40 years
  – Digital communications
  – Data Storage
  – Semiconductor manufacturing
  – Automatic test equipment
  – Radio equipment manufacturer

• BS in Electrical Engineering