

Basic Grounding

Safety grounding

Lightning protection

Ground loops



Reasons for this Presentation

- Safety
- Protection of the equipment found in a typical HAM shack.
- During this research I have found that:
 - Grounding/lightning protection is a relatively complex subject.
 - There is a significant level of miss-information and/or **multiplicity of opinion**.
 - The average ham cannot usually implement an ideal ground system.
 - Practical systems will be something of a compromise based on home layout and available resources (cost, time, etc).
 - There are some key things that can be done to help optimize a practical system.

Motivation (continued)

- This presentation strives to:
 - Provide information on lightning and appreciation for the difficulty of lightning protection.
 - Summarize the key features and principles of an effective lightning protection ground system.
 - Help others achieve an effective system for their particular layout and resource.
 - The main reason for this presentation is to increase awareness!
- **Disclaimer** – You are responsible for determining what you install or use for grounding! Not information you get from a well intentioned presentation 😊

Code

- Follow your local / state codes.
- Which code to follow:
 - NEC (National Electrical Code)
 - NFPA (National Fire Protection Association)
 - NEMA (National Electrical Manufacturers Assoc.)
 - NEIS (National Electrical Installation Standards)
 - NESC (National Electric Safety Code)...
- There are many standards organizations across the country but you should always follow the code that your area has adopted.

Section 1

Safety Grounding



Ground
wires

Ground Rod Basics (Service panel)

- **Second ground rod.** A single ground rod that has a resistance to ground of 25 ohms or less must be augmented by a second ground rod. Once the second ground rod is installed, it's not necessary for the two to meet the resistance requirement. As a practical matter, few electricians do the resistance measurement.
- You cannot use a simple ohmmeter to test this because that would require a known perfect ground. Special equipment and procedures are needed.
 - It's common practice to simply drive a second ground rod.
 - **You must locate them at least 8 or more feet apart.** Greater distance is even better.
- Ground resistance will be further diminished if both rods and the bare ground electrode conductor are directly under the drip line of the roof (**bad**).

Ground rod basics (continued)

- During current surge the earth around the ground rod becomes “saturated” lowering it’s resistivity (due to localized underground arcing).
- **Optimal rod placement/spacing is about equal to 2 rod lengths**, thus avoiding overlap of active earth volumes.



Common Ground Rods

Ground rods commonly available include:

- Galvanized steel
- Copper clad steel
- Stainless clad steel
- Copperbonded steel
- Solid stainless steel
- Solid copper



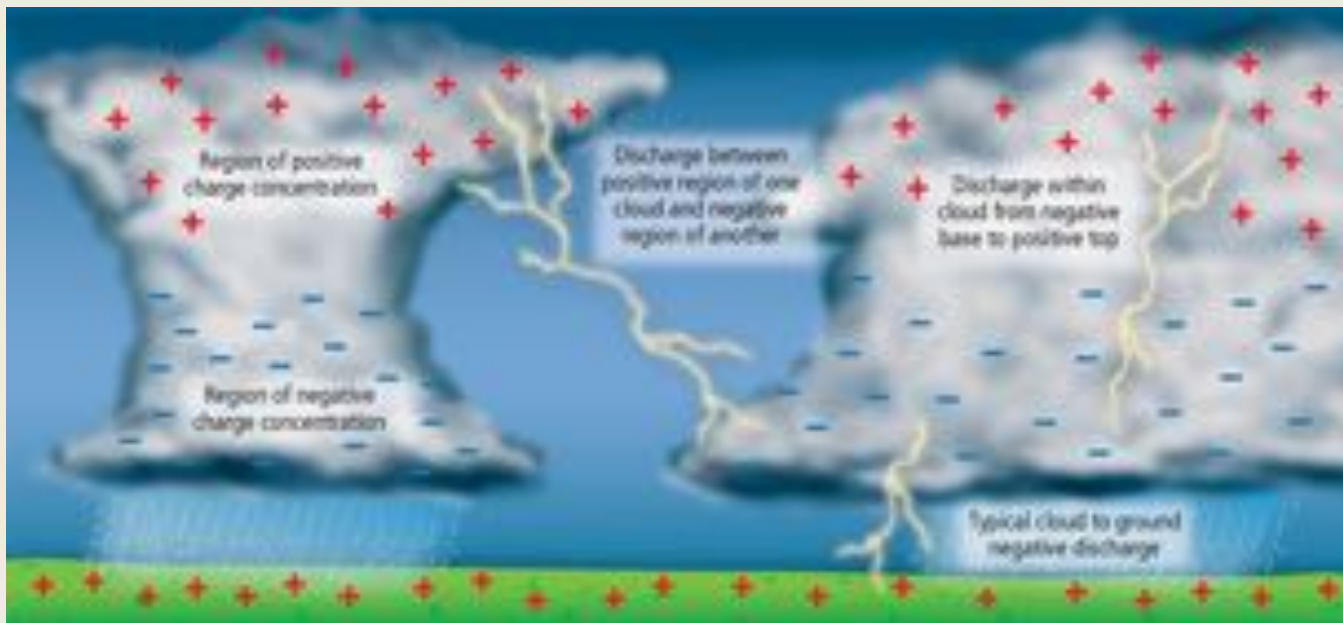
Why do you need ground rods?

Section 2 – Lightning Protection



Source of Lightning

- Originates from charged Cumulonimbus clouds.
- Typically involves electron movement from cloud to earth (although positive lightning can occur occasionally).
- Cloud to cloud lightning is the most frequent.
- Intense electric field creates ionization channels (plasma) in random sequential steps.
- Large current discharges occurs in several repetitive strokes.



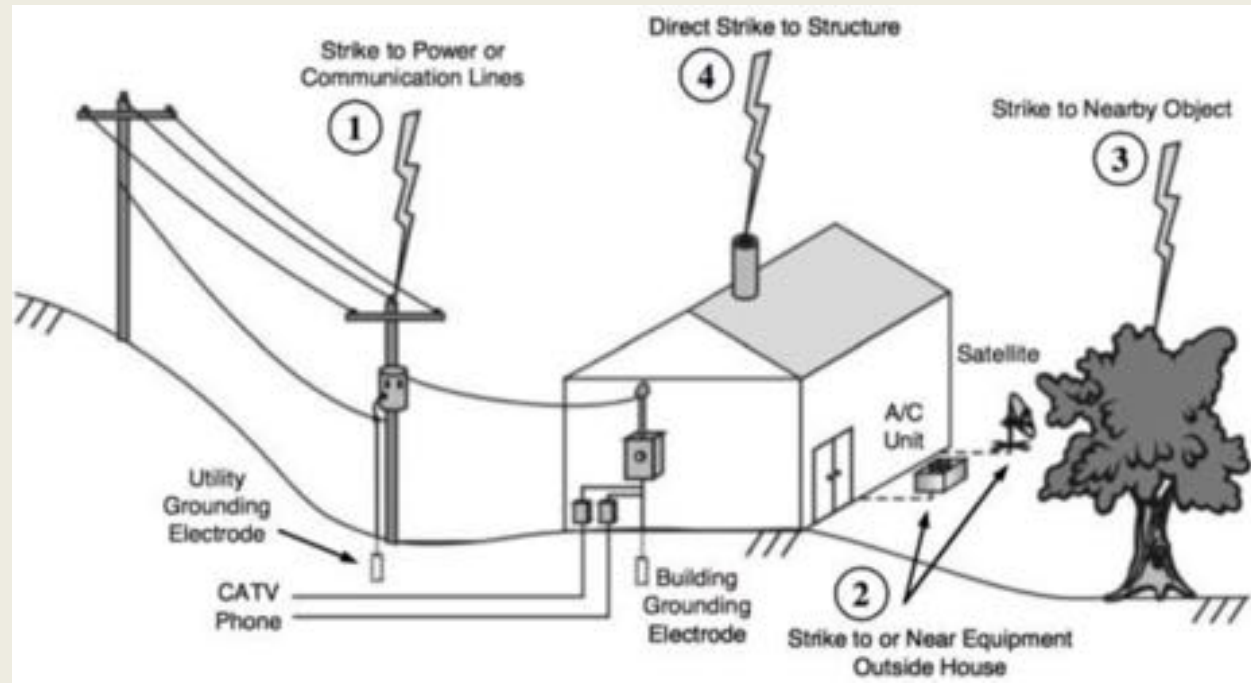
Lightning statistics

A photograph of a barn at night with a bright lightning bolt striking the roof. The barn is dark, and the lightning is a bright white and yellow streak against the dark sky. The barn has a gabled roof and a central door.

- Average US yearly lightning strikes – 22 million.
- Number of yearly US insurance claims filed for lightning damage – 307,000.
- Estimated yearly US lightning damage costs - \$330 million dollars.
- Lightning ionization channel temperature – 15,000 to 30,000 deg. C (about 3 times the surface temperature of the sun).
- Average peak current – 25,000 Amps.
- Average strokes per flash – 4.
- Average channel blast wave energy – Equivalent to 200 pounds of TNT.

Mechanisms of Lightning Invasion Numbered by Commonality

- Direct strikes on dwelling is rare.
- Conduction through utilities system strikes are common.
- Local strikes generate electromagnetic fields that couple to electrical/signal lines.
- The main physical coupling mechanisms are:
 - Conduction
 - Capacitive Coupling
 - Magnetic Coupling



Why should we protect against lightning?

Damage Caused by Lightning



More Lightning Damage



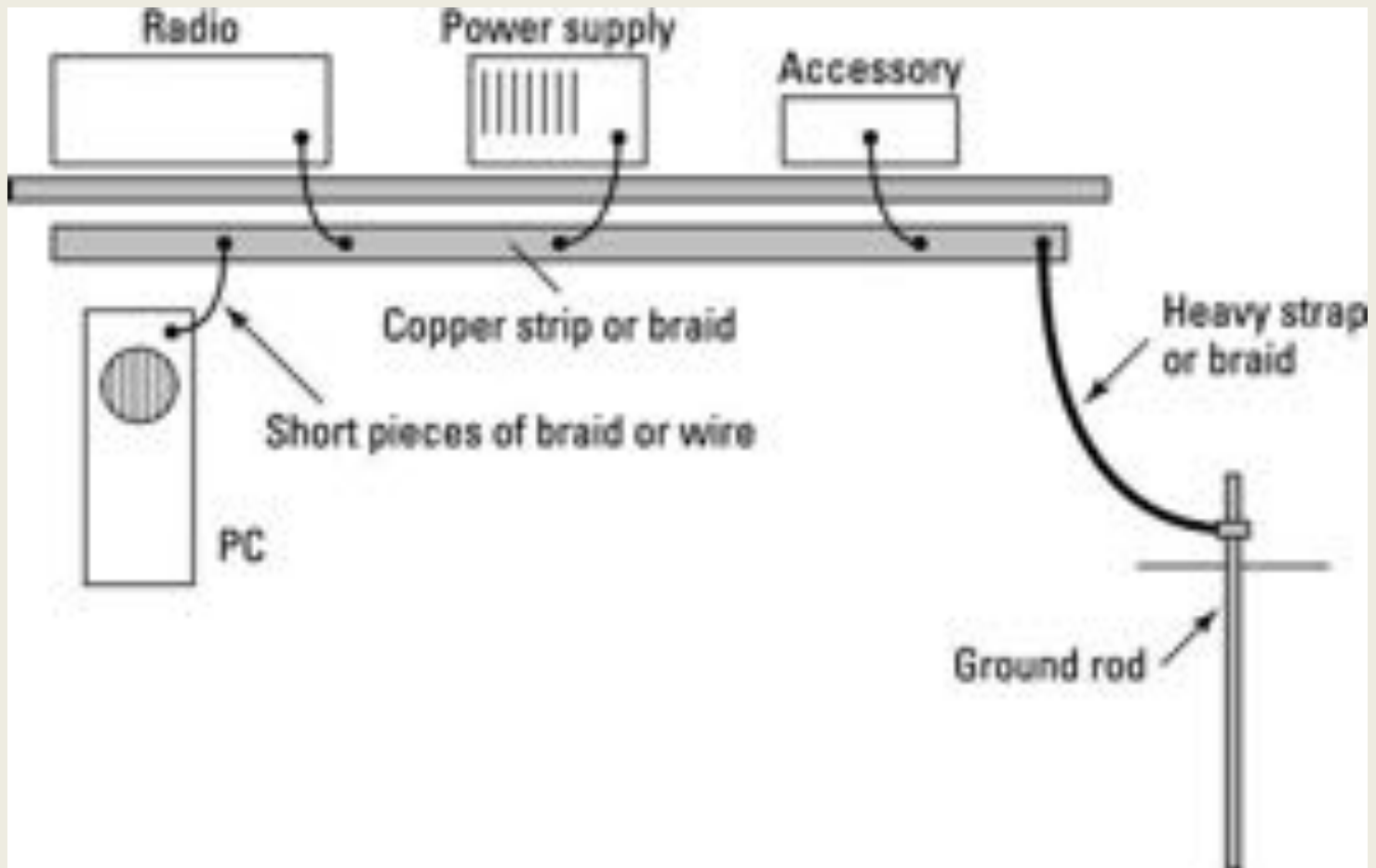
More Lightning Damage



Even breakers are not safe from lightning

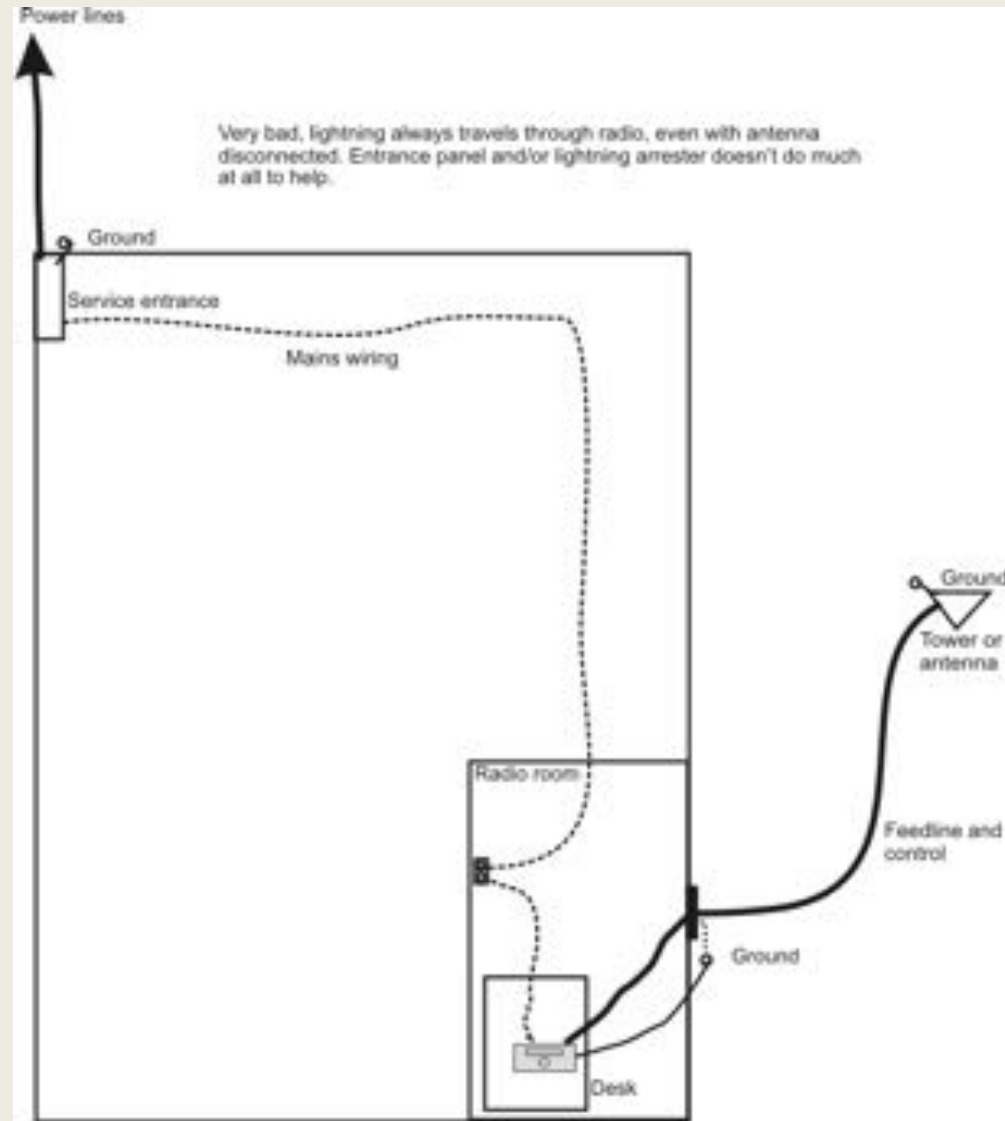


Basic HAM Shack



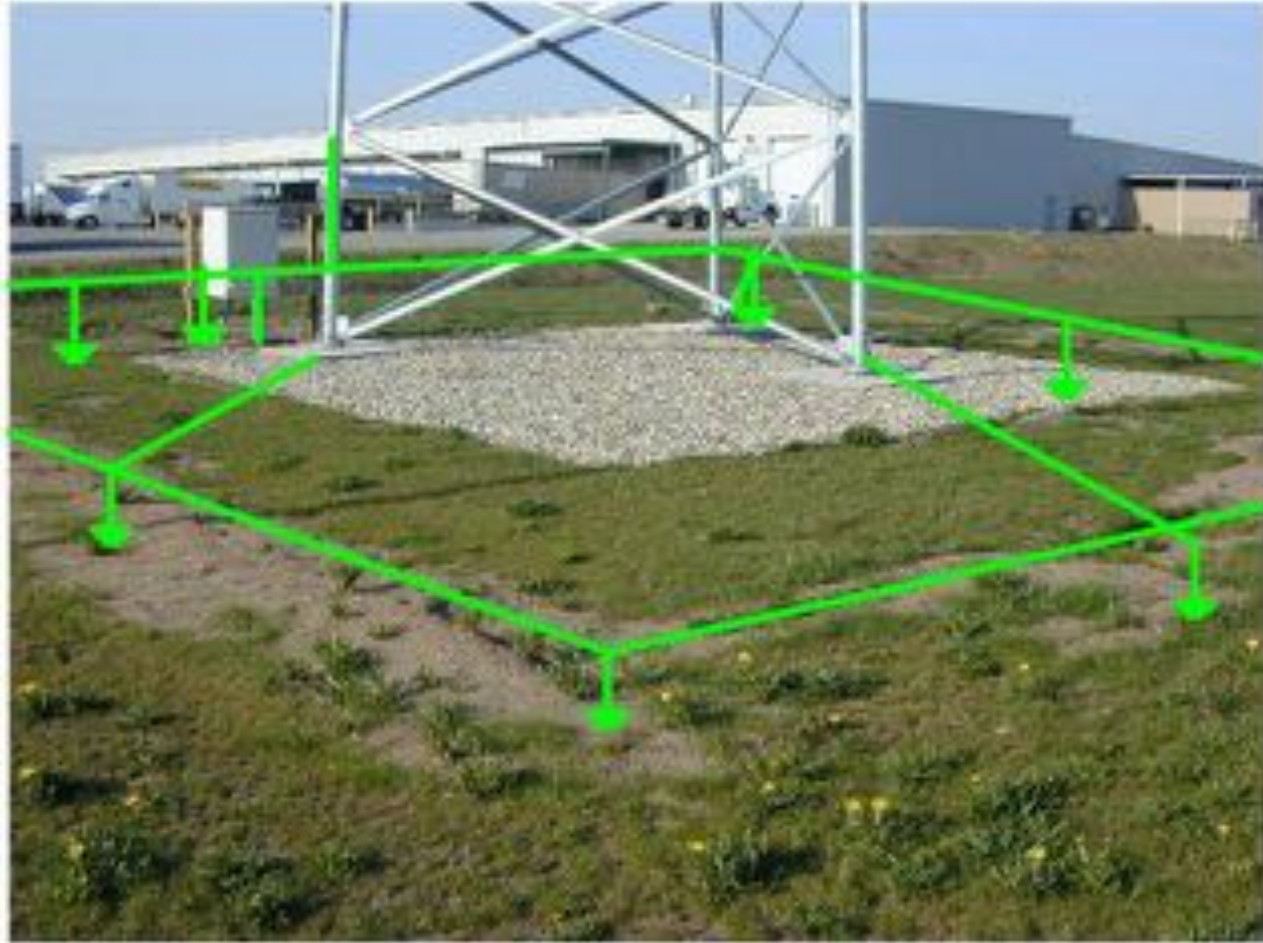
Simplistic Grounding Facts

- Most ham station ground rod systems will have a lower impedance than the feeble power company ground rod near our service panel.
- Lightning transient on power line will seek out the best ground path
- Panel/strap/rod system with no bonding allows the path to go through our ham equipment – this is very dangerous



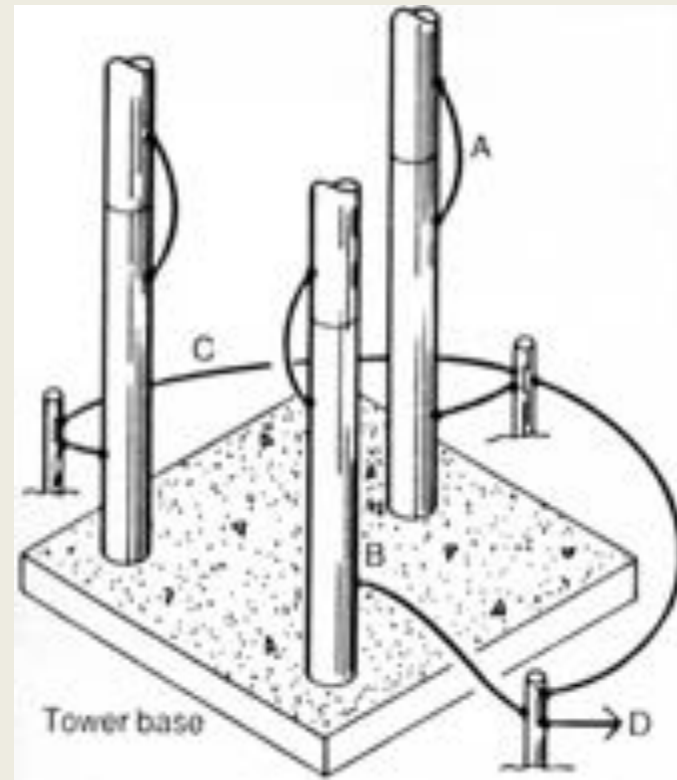
Tower grounding

- The green area is where most lightning current passes.
- The bonding should be wide flashing using either high temperature silver solder or cad welding to the ground rods.
- Grounding does not prevent lightning strikes. It reduces the chance of the cable shields and control wires from being the sole path from a lightning strike.

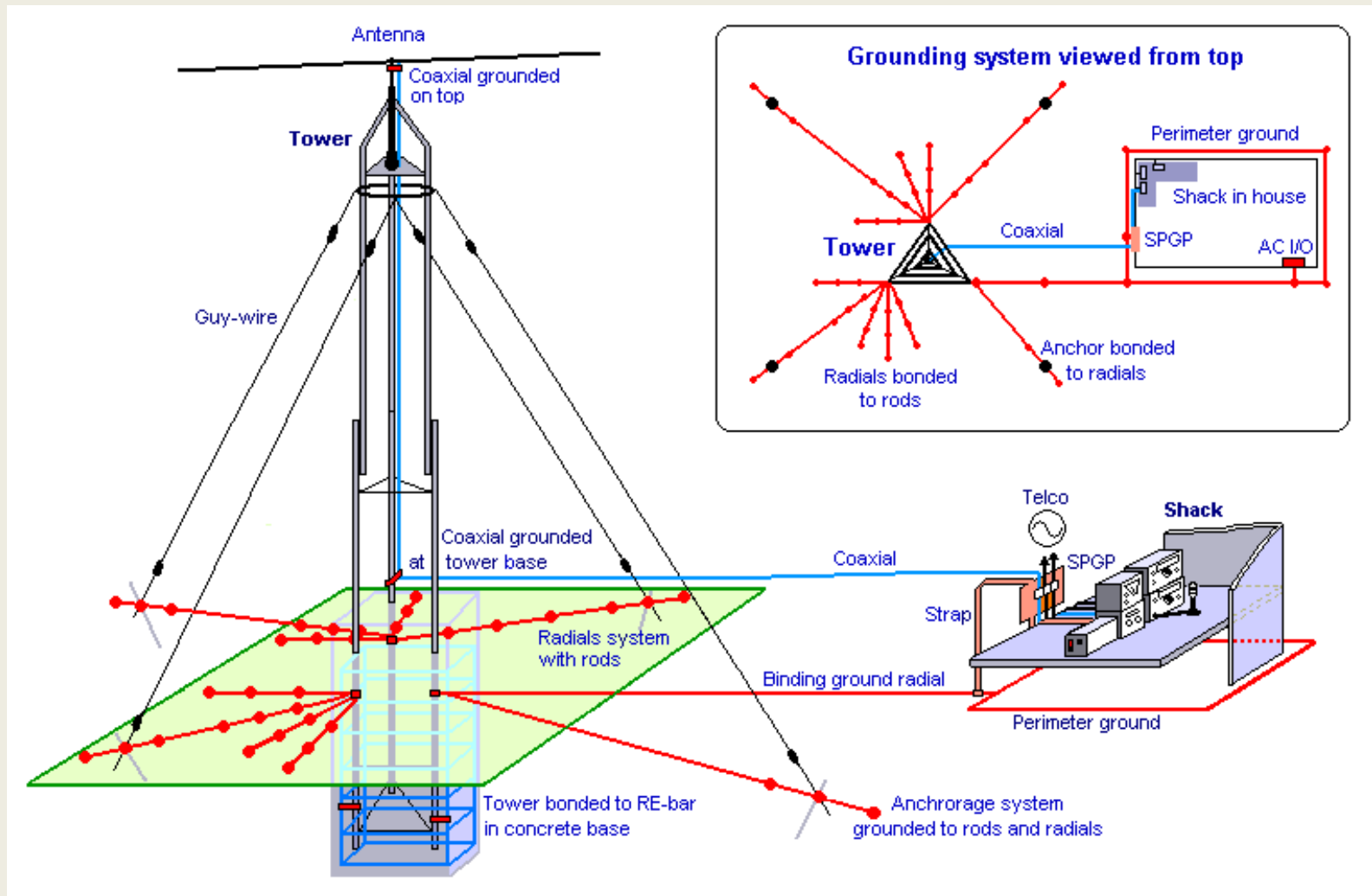


Basic tower ground

- In this diagram there is one ground rod per tower leg.
- Each leg is tied to its own rod.
- All rods are bonded together.



Tower – Shack Ground



This slide shows many points where you should ground a tower, antenna, and your shack. We often forget to bond all connections together. See the red dots where ground rods are spaced every 8 or so feet along the ground wire used. Follow the NEC guidelines.

Ball Gap Lightning Protection

Insulated towers require rugged lightning discharge points



Ground Connections



Grounding - Water Pipes



Good and bad

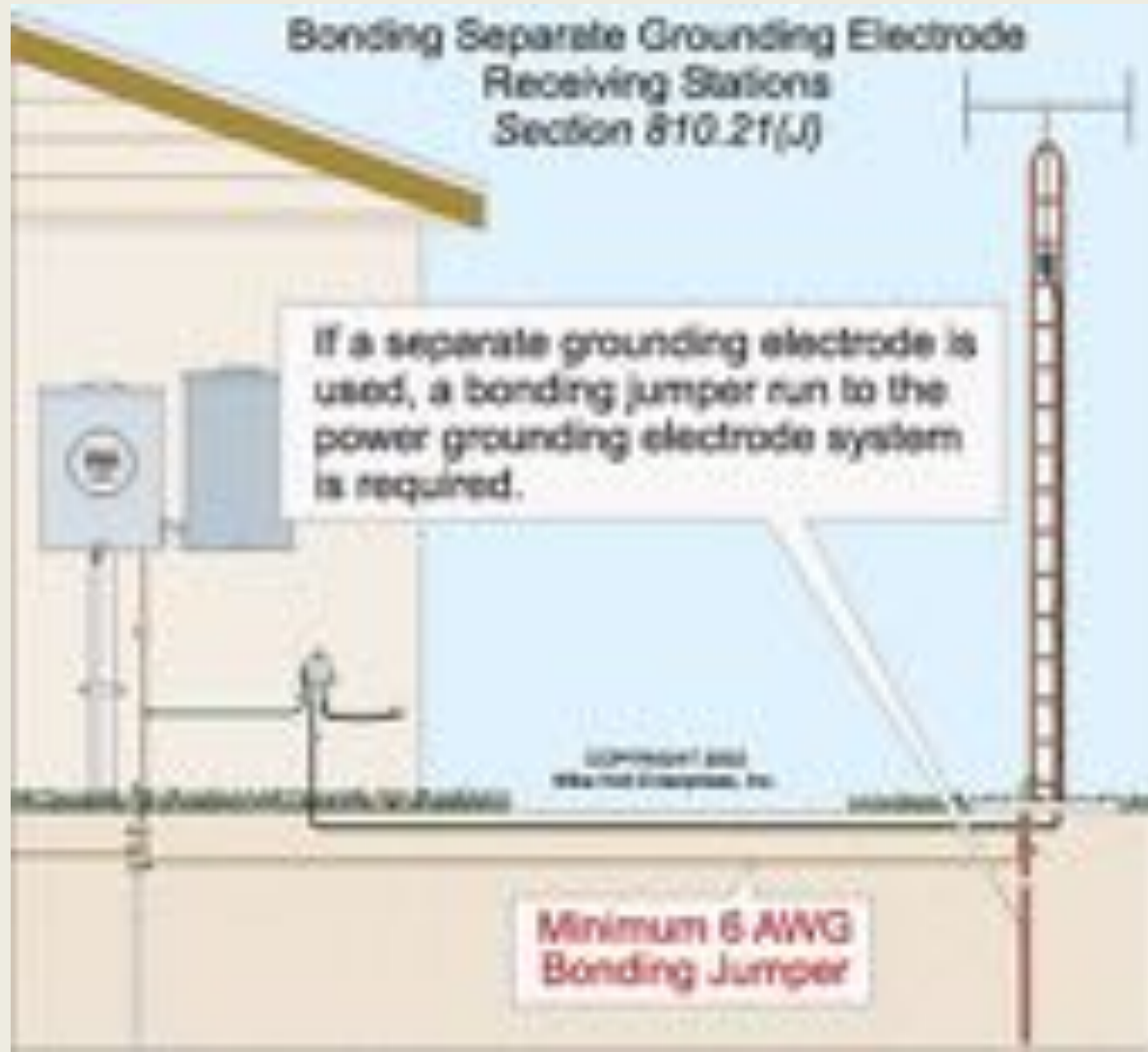


What's wrong with this?



Bonding Ground Rods

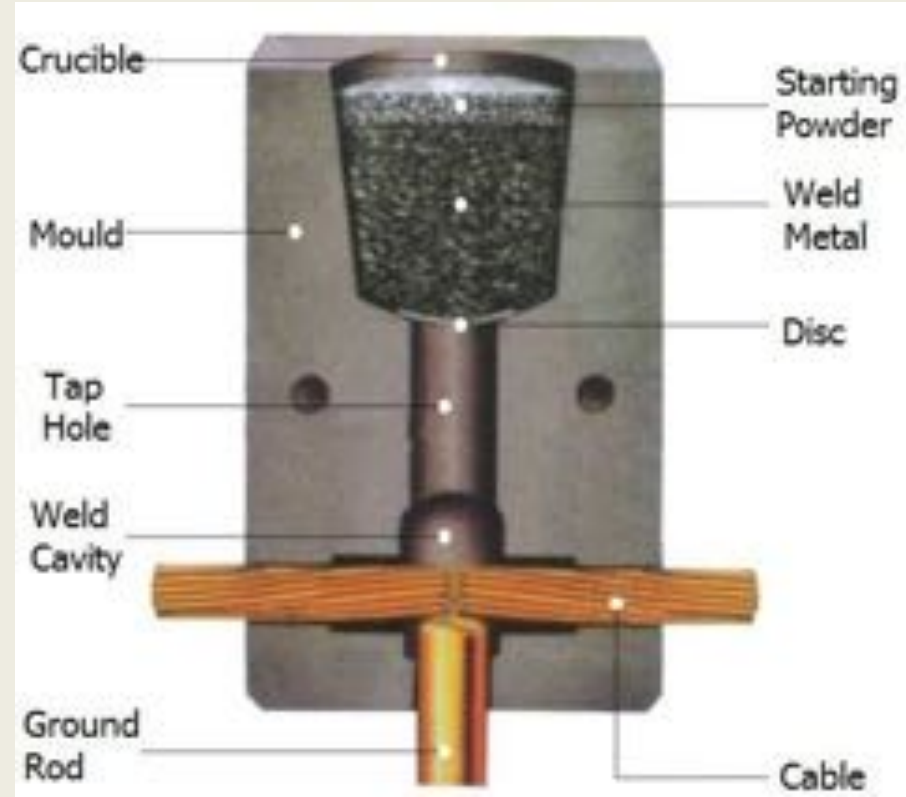
- Bonding (connecting) ground rods.
- When bonding ground rods, follow your local electrical code. NEC 810.21(J)
- The NEC code state that all ground rods need to be bonded to equalize impedance.
- Some people prefer to use 4 AWG as the bonding jumper.



Making connections Exothermic (cad) Welding

Video of Cad Welding - 2:38

<https://youtu.be/T5DoB26TftI>



High Temp Silver Soldering

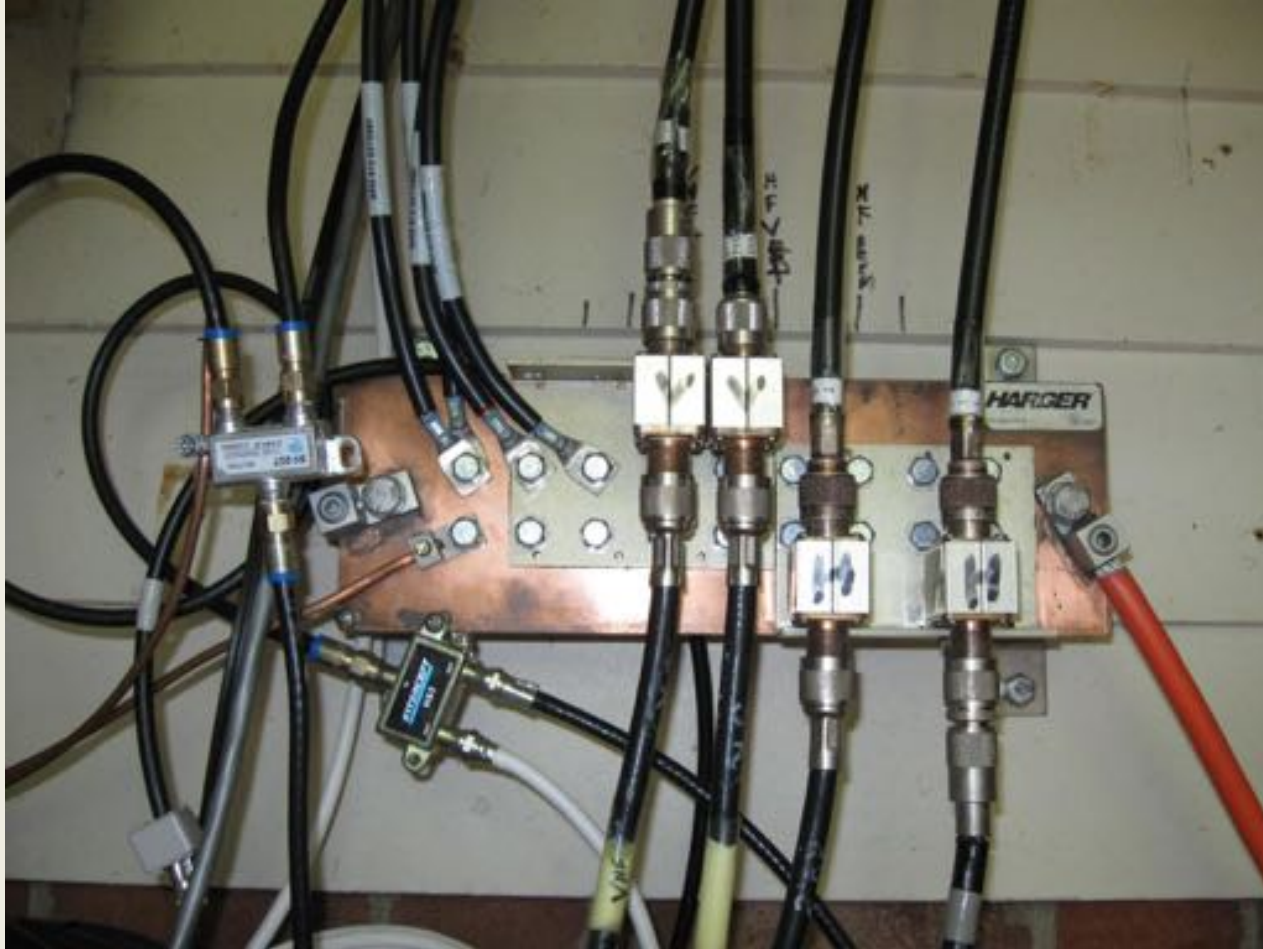


Shack Entrance

- Shack ground rod – steel clad copper.
- Stainless steel fasteners.
- Attached lightning arrestors.
- Braided ground cable feeding to shack.
- Incorrectly used pipe clamp at the bottom with attached solid copper wire.
- The ground rod has a pipe over it to increase the rods size. ☹️



Not for everyone



Practical systems will be something of a compromise based on home layout and available resources (cost, time, etc)

Section 3

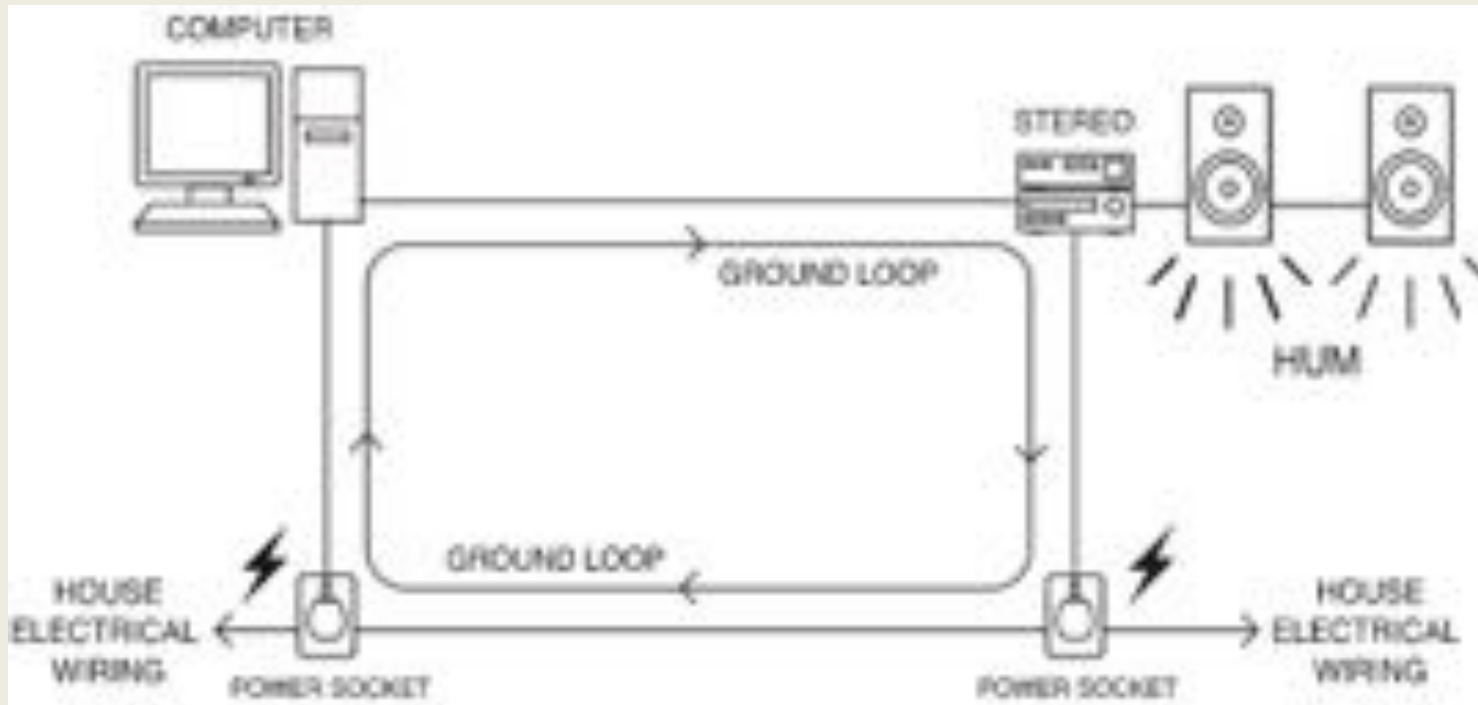
Ground Loops

What are ground loops?

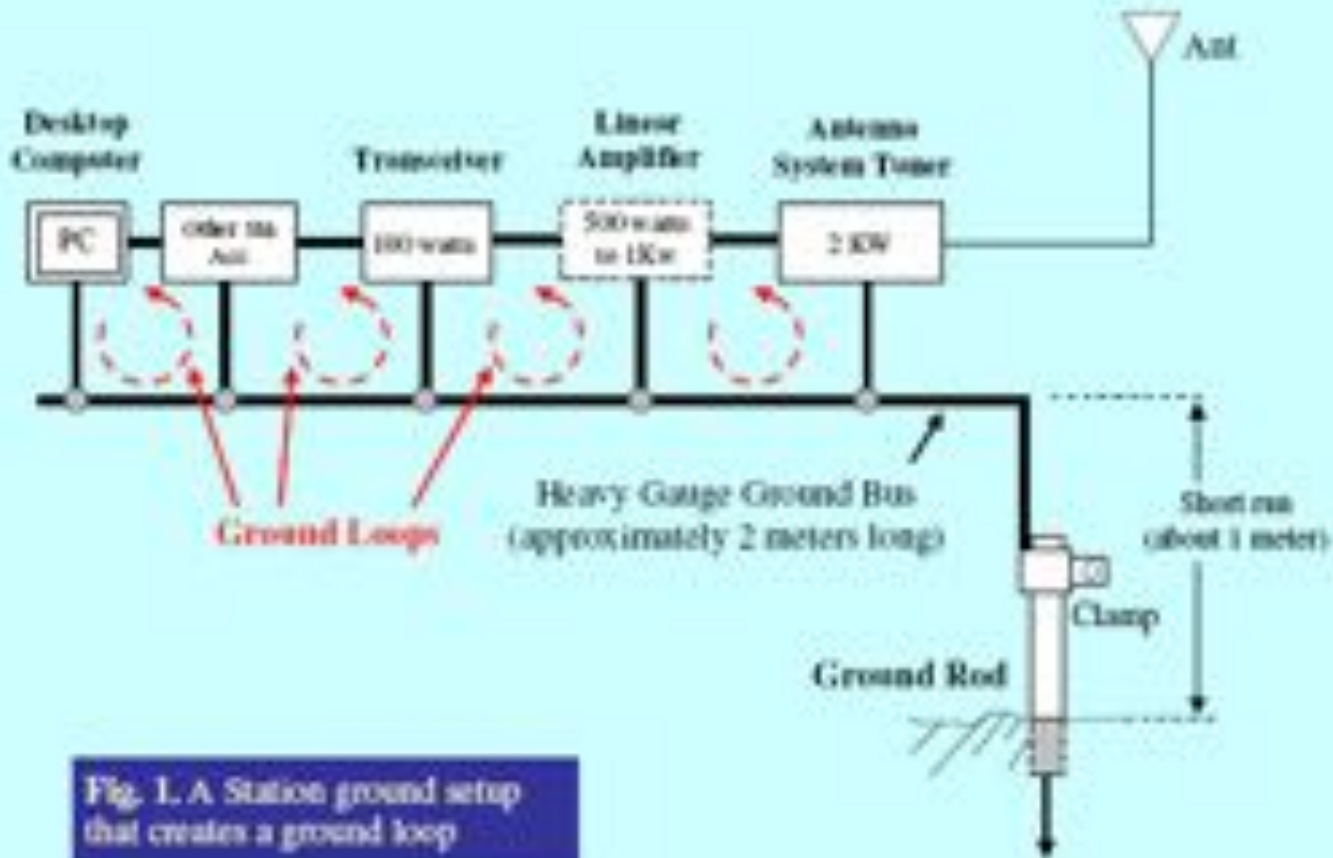
- Unwanted electric current path in a circuit resulting in stray signals or interference occurring, e.g., when two earthed points in the same circuit have different potentials.
- **Video** 3:11
 - Ground loops can = Noise in your radio
 - <https://youtu.be/WIfcNKkkuvE>

Ground Loops

- What is a ground loop (noise)
- Picture of common ground loop



Many loops



Some simple fixes to ground loops

Transformers/Isolator



Prepackaged solutions



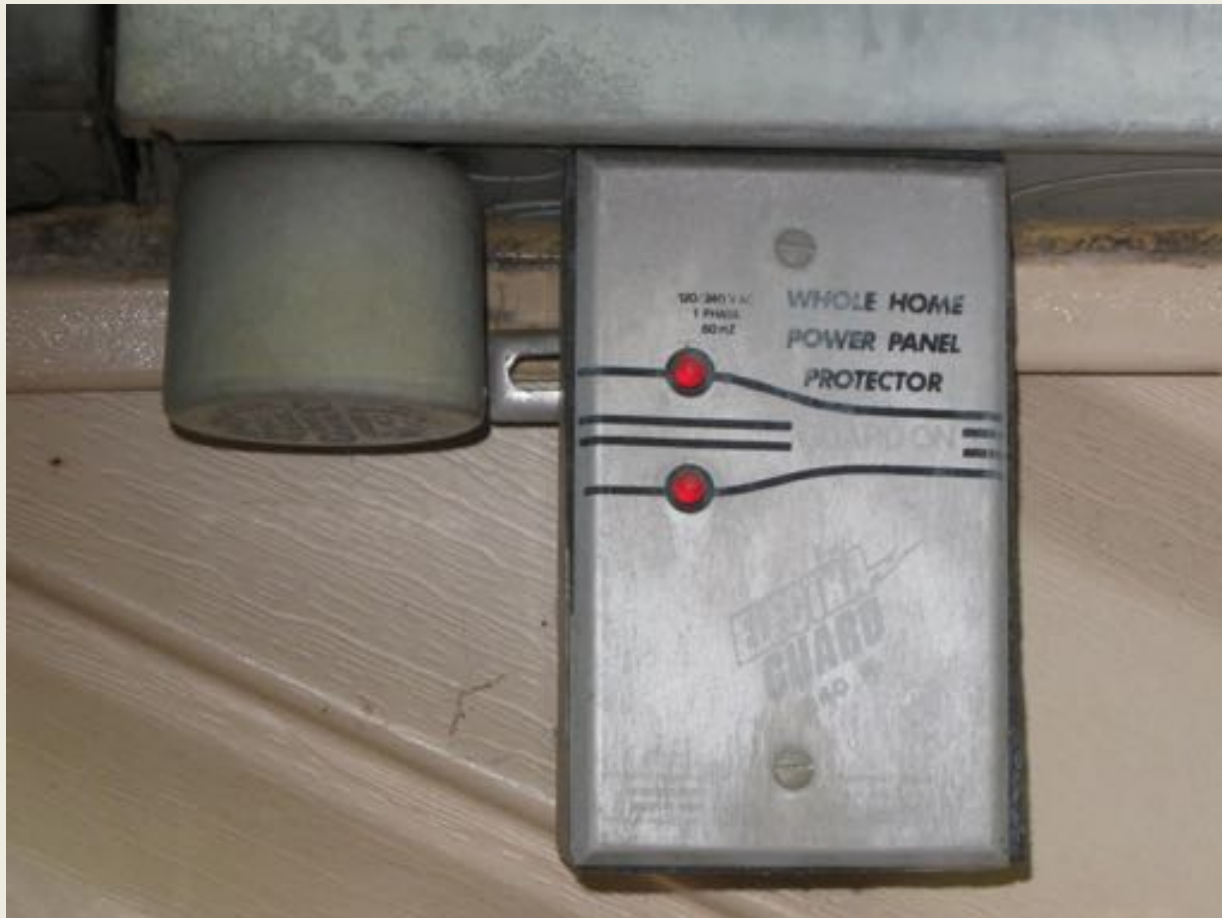
Eliminate redundant grounding



Warning – Do not eliminate your safety ground!!!

What else might be needed

Whole house surge protection



There are many possible problems and solutions

- Grounding issues.
- Antenna and cabling issues.
- Radios, Antenna turners, coax switches, power supplies...
- Now is the time to bring in your friends and Elmer's!

The most important thing to know is
have Fun with your hobby!

