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Lightning Strikes !

By Steven M. Simons W1SMS

This presentation discusses the natural occurrence of lightning strikes and how we, as radio amateurs, should plan to protect our stations and property.

1) What is lightning ?

Lightning is defined as a potential difference between the clouds and a conductor located on the surface of the earth.

2) How does lightning start ?

Charges in the cloud include both positive & negative and are aligned along the top and bottom surfaces. The rising moisture in the cloud collides with suspended water droplets with electrons being ripped off, causing separation of + & - charged particles. Electrons (-) are repelled by the bottom of cloud. Positively charged buildings, trees and, other objects on the earth's surface attract the lightning bolt and complete the circuit path.

3) The mechanics of a lightning strike

First, static charges in cloud will build up. The air in between the cloud and the earth's surface is normally a good insulator however, the strong electric fields located around the cloud will ionize the air and make it more conductive. The electrified air then turns into a plasma discharge with a low impedance acting as a conductor from the cloud to objects on the earth's surface. Lightning bolts have initial speeds of 60 miles/second lead to speeds accelerating to ultimate speeds of 50,000 miles/second with a current of 30,000 to 120,000 amps! That equates to transferring up to 500 mega joules of energy.

4) How is Lightning Attracted to your Antenna ?

The truth is that no object on earth attracts a lightning bolt. Lightning occurs on a large scale and is not influenced by small objects on earth. The overhead location of the charged cloud (thunderstorm) will determine where lightning will hit the ground.

There are however details that determine if the lightning bolt will hit the antenna/tower. Photographic evidence suggests that the bolt will be attracted if it is within a distance that is equal to or less than the combined antenna/tower's vertical dimension.

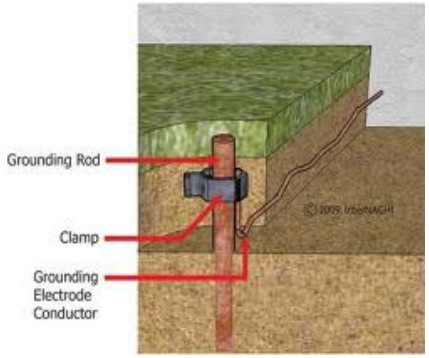
The factors include;

- Object height above earth
- Impedance of the object (as a conductor) to ground
- Object proximity to other low impedance objects

5) What is a (Good) Ground ?

A good ground system is the starting point to protecting a defined area including your shack, antennas / support structure and house.

The "system" needs to be connected to an array of ground rods that are bonded together and intimately connected to the antenna and electronics at the shack end.



A key point here is that the entire radio system (antennas, radios, accessories, feed lines and, AC power source need to remain at the same voltage potential as it rises and falls during a lightning strike. If any part of the system is at a different voltage potential, then damage can and will occur.

5) What is a (Good) Ground ? (continued)

Ground Rods

Ground rod length (and quantity) as well as the soil type they are inserted into affect their overall impedance.

The methods used to connect the ground rods together and to other parts of the radio system also influence the impedance.

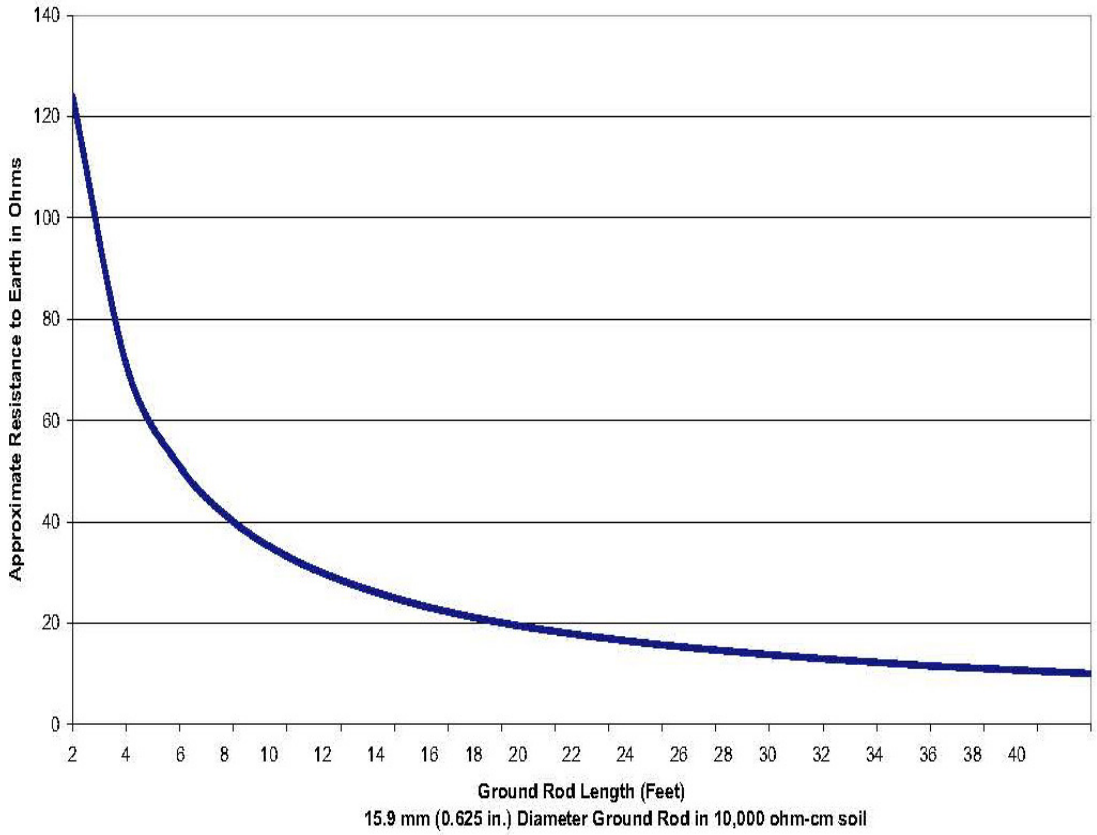


FIGURE 4-12 RESISTANCE TO EARTH DUE TO GROUND ROD LENGTH

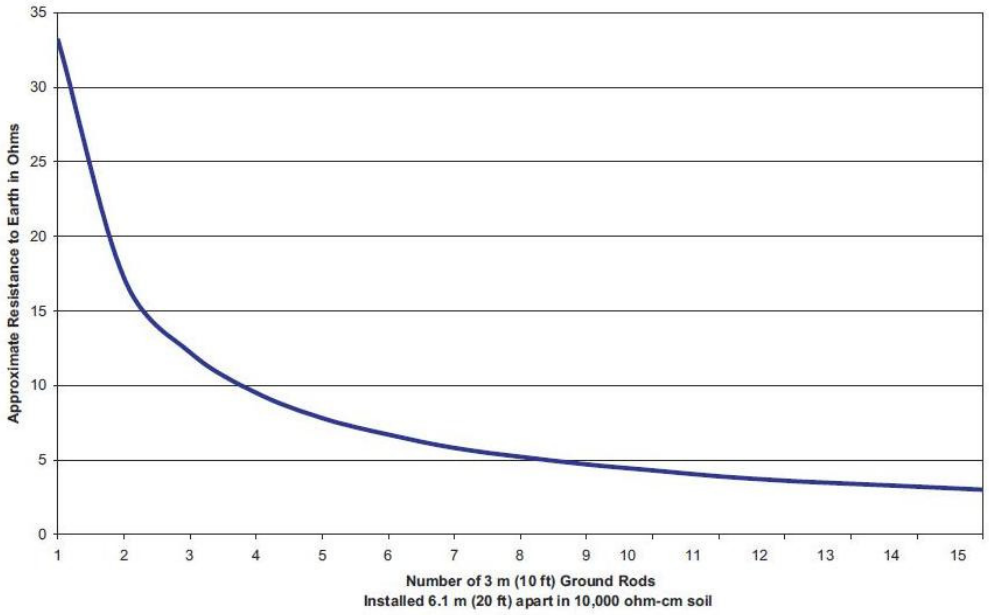
5) What is a (Good) Ground ? (continued)

Ground Rods

A single ground rod is not sufficient and multiple (parallel connected) ground rods are required to provide the lowest ground impedance. Four to six rods (minimum) are a good start with smaller incremental effects as the number of rods increases.

4.4.1.2.4 EFFECT OF PARALLEL GROUND RODS

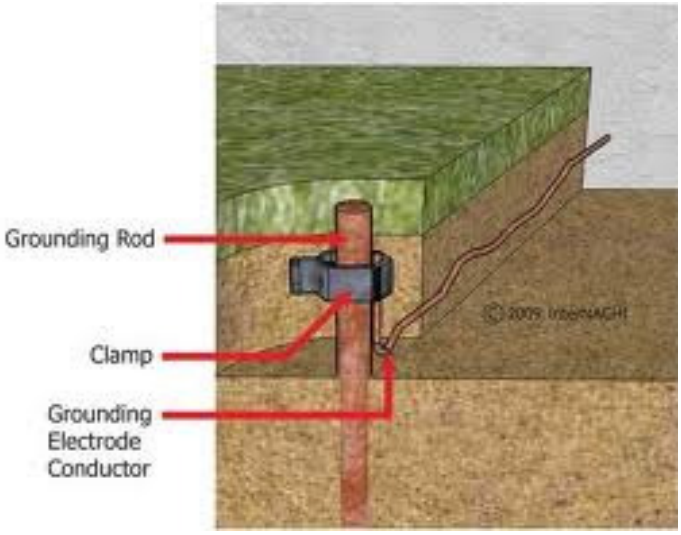
Figure 4-13 below shows the effects of adding additional ground rods (15.9 mm (0.625 in.) diameter by 3 m (10 ft.) long) together in parallel. As seen in the figure, the addition of one ground rod to the first ground rod (for a total of two rods) significantly reduces the resistance to earth of the ground rod system. Each subsequent ground rod added in parallel has less of an effect on the resistance to earth of the ground rod system.



5) What is a (Good) Ground ? (continued)

Effects of Poor Grounding

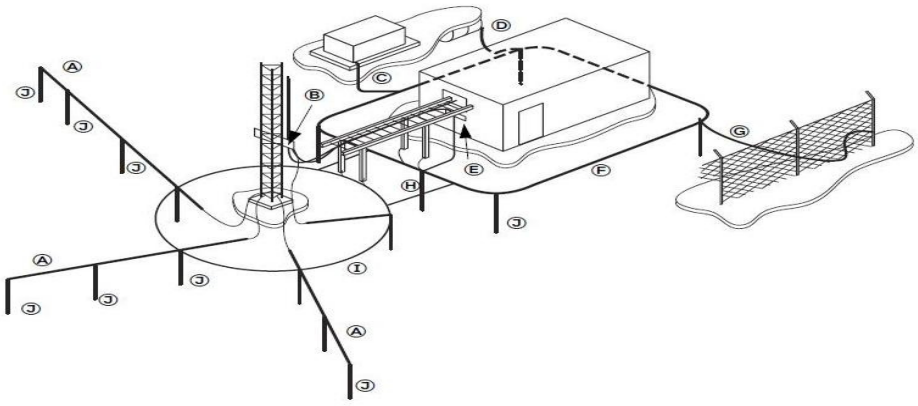
During a lightning strike, the bolt will find the lowest impedance ground point which may be your (water) well pump or through the house's AC electrical system. The extremely high currents flowing through the AC wiring to ground will cause failures of the wires and connected devices.



6) Designing and implementing a lighting protection system

The design of your grounding system is unique to your station and budget. Each system should be designed to, at least, provide the minimum protection based on the QTH location, station hardware complexity and of course, budget.

We can start by referring to the commercial standards and design criteria as these installations are designed for maximum protection. Most commercial and industrial systems are required to operate on a 24hr / 365 days per year basis so disconnection and isolation of equipment is not an option.



A: Grounding Radials
B. Tower Ground Bus Bar and Down Conductor
C. Generator Grounding Conductor
D. Buried Fuel Tank Grounding Conductor
E. External Ground Bus Bar
F. Shelter Ground Ring
G. Fence Grounding Conductor
H. Ground Ring Bonding Conductors (2 minimum)
I. Tower Ground Ring
J. Earthing Electrodes (Ground Rods)

6) Designing and implementing a lighting protection system (continued)

Amateur radio stations are different as the equipment can be disconnected during a storm or is connected and in use during specific times.

Grounding Hardware

Ground rods, clamps and wire can be purchased from many ham radio distributors as well as local electrical suppliers and via website companies.

Grounding Hardware Types

Based on your budget, you can obtain the basic hardware that is considered "bolt together" or purchase sophisticated types such as Cad-Weld.

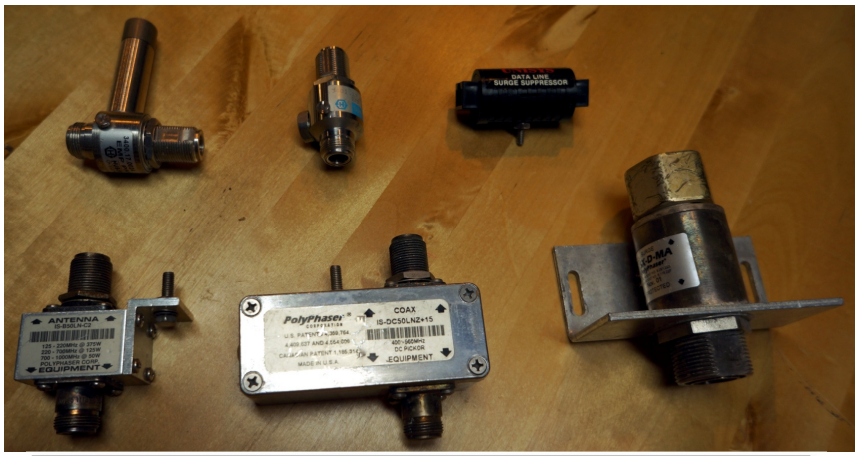
Typical hardware (image to the right) includes a ground rod, clamp and an isolated distribution bus.

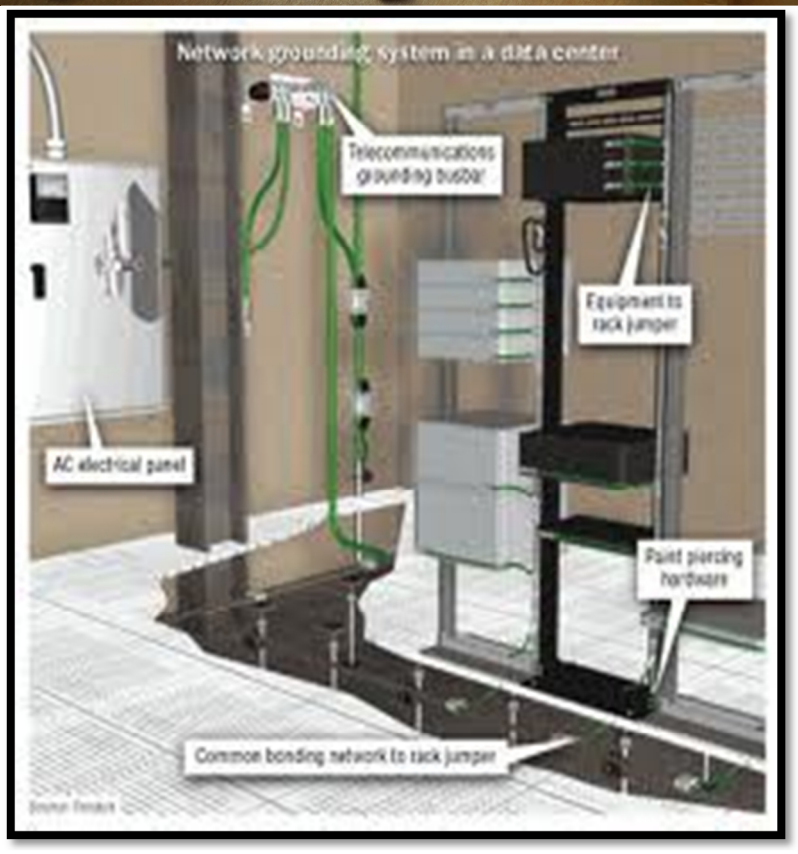
6) Designing and implementing a lighting protection system (continued)

Inside Hardware

The hardware inside the shack will vary per the station complexity.
The items will include:

- Coaxial lighting arrestor(s)
- Telephone/data lightning arrestor(s)
- Isolated Copper ground bus to connect the grounding conductors
- AC power surge arrestors
- Grounded equipment racks/cabinets and supports



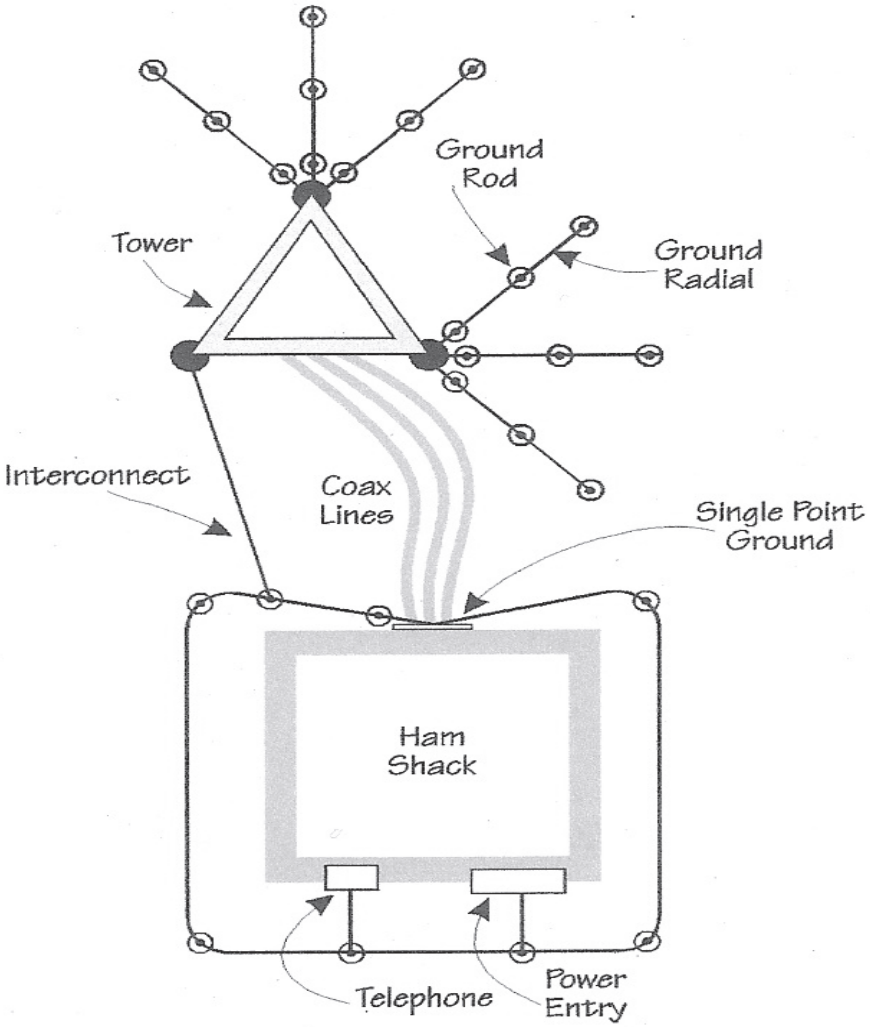


6) Designing and implementing a lighting protection system (continued)

Connecting the Hardware

Typical guidelines for connection include:

- Only one grounding electrode system.
  i.e. all ground rods should be bonded together to form a single electrode system.
- All grounding in or on a structure shall be interconnected to provide a common ground potential. This includes the AC power system ground, tower/antenna ground, lightning protection system ground, telephone system ground, exposed structural building steel, and underground metallic piping systems.
- Coaxial cables should have their shields grounded at the base of the tower and at the entrance to the shack.
- Clamps used to secure ground rods/wires should be weatherproofed and sealed to protect against moisture.
- Use multiple ground rods for lowest impedance.
- Use lightning arrestors at cable entry points to the shack.



7) References

- **McMaster-Carr Supply**
- **Grainger**
- **Rohn Towers www.rohnnet.com**