Amateur Radio Station Grounding

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This article comes from Don Young, N7DY, which was in The Wenatchee Radio Club News letter.

A good ground system is an essential part of a good ham station for various reasons. First and foremost, grounding is for the safety of your family, home, and ham equipment. Lightning not only destroys ham radios, but often starts house fires, thereby jeopardizing the safety of your family. An elevated antenna or a tower protruding into the atmosphere naturally increases the odds of a lightning strike. Statistically, most lightning damage comes from the AC power or telephone lines running into your home.

Simple ham station grounding is often done with a water pipe. Indeed a metallic cold water pipe can serve as a basic ground for ham gear. Since outside water pipes normally are buried well below the soil's surface, it does serve some purpose. Remember, though, that a cold water pipe ground should be considered merely one level above a no-ground system at all. You can do much better. A fact significant to hams is that a good ground will not only increase the receiver's sensitivity, but also its transmitting propagation. I have often observed a decrease in surrounding ambient noise from S9 to S5 on 40 meters by simply changing the station's ground by changing a cold water pipe ground using 12 gauge wires to a proper RF grounding system. Your regular ham contacts will usually notice the improvement to your signal. As you probably know, HF antennas work best when they work against a good counterpoise ground reference. Good RF grounding technique is misunderstood and difficult to explain in simple terms. It is a basic phenomenon of impedance. RF grounding requirements are very real, somewhat difficult to measure, and unseen in operation. A common term that is used in RF grounding is "skin effect." In a ground system the majority of electrons run along the surface (or skin) of the conductor. A good RF ground has the least amount of resistance to electrons being conducted to ground. This is obtained by having the largest amount of conducting surface area that is practical. The goal of a good RF ground system is to obtain as little resistance as possible from the antenna/tower to ground and then from the radio to ground. Thus, the more conductor surface area the more ground path conductivity. Effective grounding is measurable. A good grounding system will measure less than 12 ohms from the radio to ground. A typical cold water pipe ground will measure fewer than 35 ohms, assuming the water pipes are not made of PVC.

Measurement is both rare and difficult since most hams do not have a 'Megger' type instrument required to make the measurement accurately. For this reason for some, a well planned and properly installed ground system is the best alternative. Even without an actual measurement you'll know it's as good as you can provide within your means. This paper will assist you by giving examples of relatively good RF ground systems that are often within the means of the average ham. OK then, here we go. Several things need to be contemplated before deciding on your plans for an RF grounding system.

* You should consider your budget and the amount of effort that you are willing to invest to obtain a good RF grounding system. It is not to your advantage to be cheap or lazy – if so, you might just as well use the cold water pipe. Then be prepared to buy new equipment when you get your first lightning strike.

* Dissimilar metals (as it pertains to electrolyzing/galvanic action) can pose a significant problem to the systems' longevity and minimizing maintenance issues to your ground system. One rule is

NEVER connect copper to galvanized or aluminum towers - use a stainless steel interface between the two metals with a stainless steel clamp, bolt, washer, and nut!

* Copper oxide (the greenish copper corrosion) is NOT conductive! Eventually compression clamps WILL allow corrosion to migrate into joints, causing a reduction in conductivity and increase the connections' overall resistance. Weld or solder ALL joints, when possible. This will ensure long life and maintain stable good conductivity between connections. If a stainless steel clamp is used, a conductive grease is required to minimize connection moisture degradation.

* Eliminate ground loops and multi-point ground connections when possible. A ham shack ground loop gives lightning another path to your equipment. Always use a single-point ground between the interior and exterior of your ham shack.

* Run your coax/hard-lines to the base of your tower or antenna mast and directly connect to the coax/hard-line shield clamps to the tower/mast base. This will allow the lightning to get as close to the actual ground connection before attempting to enter the house. When creating a drip bend in coax/hard-line, use a minimum radius of nine inches for the curves.

* Grounding-rod depths are critical. You can find the recommended grounding depth by checking your local plumbing or building codes. In central Wisconsin the minimum depth is six feet, in central Texas it is eight feet, and in part of Arizona it is ten feet-so check that out. The ideal grounding situation is in having your ground system make physical contact with the water table, but this is not very likely.

Grounding Rods vs. Pipes

Due to economics and the effort required to drive rods, I've taken another approach in lieu of rods. (Besides four foot rods are worthless as they do not make enough soil contact for an adequate safety ground, much less an RF ground.) I use ten foot pieces of 0.5" copper pipe fitted with a brass hose fitting. I purchase a brass hose fitting from a local hardware store and solder this fitting to the end of the copper pipe. This allows me to attach a garden water hose and easily hydra-drill the copper pipe into the soil. No mallet or "T" post sledge for me. (Most of the time) I dug a one foot square deep hole in the ground where the ground pipe is to be drilled. I drilled the pipe into the ground until the pipe top was 6" below the surface of the ground. This allowed working room to solder the copper tubing and then cover the hole, making it invisible to all and your lawn mower.

Ground Conductor Copper Buss-Bar vs. Soft Copper Tubing

Again, due to the economics and availability of copper bussbar material, I found the costs to be prohibitive to a normal ham's budget. Instead, I use soft copper tubing that is easily obtained at your local hardware stores. The tradeoff is the amount of surface area the copper tubing will have in comparison to copper buss-bars. I highly recommend that you use 0.5" copper tubing for short runs, i.e. 10', or as your budget will allow - but attempt to keep the conductor surface area high as near to 1.0" copper tubing as you can afford. Remember, the more surface area, the better the ground conductivity. I use soft copper tubing for practical reasons and ease of use. Where a soldered or clamped connection is to be made, I hammer the tubing flat. Then using vice-grips, I wrap the flattened tubing very tight around the copper ground pipe/rod and make a good soldered connection. The copper tubing is buried at least 6" deep. This will keep you from hitting the ground system with the lawn mower or becoming a trip hazard. The buried copper tubing is also part of the energy dissipating ground system. In using buried interconnect bare copper tubing, the whole "ground system" conductivity can be increased by watering the

lawn, as the near surface soil conductivity will increase. Watering should be done whenever you contest or when the soil becomes very dry.

Ground Plate

This item is controversial to some; few hams want to mount or put a fair sized hole in the side of their house. The ground plate is a solid barrier to possible lightning entering your house via your coax/cables. Also this ground plate is the fundamental item that creates your “single point” ground and gives you the proper place to install other protective devices, i.e. rotor cable protector, telephone line protector, etc. I recommend that the ground plate be made from 0.125" stainless steel. The dimensions depend on how many protectors will be mounted. Stainless steel eliminates the dissimilar metals’ concern and allows for direct copper attachment. If you do not want to actually mount the plate into the wall of the house, then mount the plate ON the house perpendicular to the wall very near to the coax ham shack entrance. Run the coaxes on one side of the plate, clear of the house entrance, then from the opposite side of the plate run the cables and internal station ground conductor into the house. Connect the ground plate to a ground pipe that is within three feet of the house. The closer the connection between the nearest ground pipe and the ground plate, the better the conductivity. I would use 1" or three 5/8" copper tubing pieces between these two points and then reduce the copper tubing size to the other ground pipes. The ground plate is also used for mounting bulkhead surge/lightning protectors. The only such protection that I have used is the PolyPhaser brand.

The PolyPhaser blocks and/or redirects the energy surge directly to your ground system. There are other brands of such protective devices that I haven’t used. This type of protective device is your last and perhaps best line of defense. Obviously, use of these devices will require that you install a good enough ground system to fully dissipate the energy. One of the biggest issues facing you is HOW MANY ground pipes/rods should you install?

This is hard to determine, as it is based on soil conduction, how potent is the lightning strike, how much room do you have, and what can you afford. If you look at a commercial system, they have multiple ground radials (seven or more) each 32 feet long and four ground rods on each radial. Some of the ground rods can be sunk as deep as 40 feet. Well, this is not in my budget or in most hams! Obviously, the more ground radials and ground rods the better. I try to run at least three ground rods in a non-tower ham shack. One directly outside the ham shack at the coax cable entrance point (the shack ground), and at least two more ground radials with ground rods at their ends, separated by at least eight feet, from the shack ground. The tower increases the potential of a lightning strike, so in addition to the above scenario, two or more rods should be placed just for the tower. Put one rod near the tower base and the other rod eight feet away. Use 1" or two 5/8" pieces of copper tubing between the first tower rod and the tower. The goal of a grounding rod is to make contact with the water table. Falling short of that, it is to dissipate as much energy as possible by driving the ground rod directly down, attempting to traverse as many soil layers as possible, so energy can be dissipated into these various soil layers. Some soils conduct better than others, dry sand being the worst, followed by hard clay. But a hard clay layer may have some amount of water riding on the clay, seeking penetration points.

Placing the ground rod at a 45° angle can increase the overall length of the radial and allow some energy to be dissipated. Angled ground rods are often used in rocky soil. The interior ground conductor is just as important as the exterior ground system. I have 5/8" copper pipe on the back of my bench. I use ½” tinned copper strap coming from each piece of equipment to the pipe. From the pipe, I use 1” tinned copper strap to go outdoors to my ground rods. All my equipment grounds go to a central point (pipe) and then go outdoors with one strap. No daisy

chaining. Most radio equipment comes with an extruding bolt, washers, and a wing-nut - if not find a good chassis screw to place the braid with washer beneath.

The goal is to have an effective ground connection with short ground straps and to keep a clean unobtrusive appearance to the ham shack.