

Joe Carr's Radio Tech-Notes

What is a "Good Ground?"

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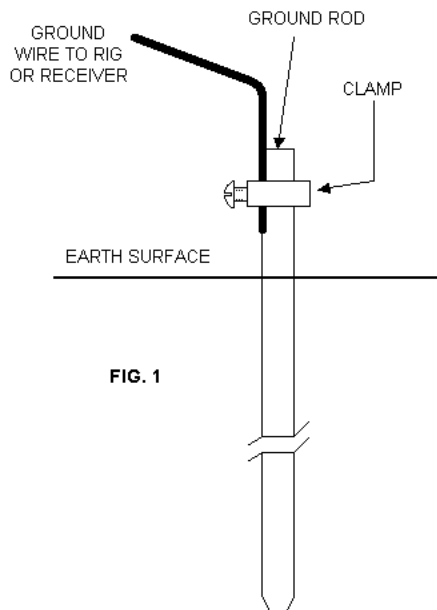
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One of the universal bits of advice given to amateur radio operators and shortwave listeners is to provide a "good ground" for their transmitters, receivers and antennas. A number of antenna designs, especially those that are unbalanced with respect to ground (e.g. Marconi style antennas), require a connection to ground in order to function correctly. Even balanced or "Hertzian" antennas work better if the receiver or transmitter is grounded. The problem is that many books and equipment user manuals ask you to provide a "good ground" but don't say what constitutes a "good ground." Let's take a look at the issue.

A Good Ground Connection

A good ground is one that has a low resistance to the Earth at radio frequencies. A ground that is good enough for DC or low frequency power lines (60 Hz) is not necessarily a good ground at radio frequencies.

Figure 1 shows the most basic form of radio antenna ground. A conductive ground rod is driven into the Earth for a certain distance. Some people use short rods, such as the 3-foot ground rods used for television antennas, but that is not the best solution. A proper radio ground for high frequency (HF) band operations should be 8-feet long. Anything less than that usually results in poorer performance, and may not provide proper lightning protection. Indeed, the shorter size ground rods might not even be legal (your local electrical inspector may have an opinion or two on this matter!).



Some ground rods are made of copper, but many of them are made of copper clad steel. Such rods are made of a steel core with a thin layer of copper on the outer surface. The

low resistance copper is sufficient because RF currents flow on the outside of a conductor (a phenomenon called “skin effect”).

The ground rod is driven into the Earth within a few inches of its top, and then a wire clamp is fastened. This clamp is used to hold the ground wire fast to the ground rod. Soldering is usually out of the question because the Earth and the rod make a dandy heat sink, making unlikely that you can reach solder melt temperatures with anything less than propane torch (it can be done, however).

Hint: From harsh experience let me give you one pointer: *slip the wire clamp over the ground rod before you start pounding the rod into the Earth. Repeated blows with a hand sledge hammer are required to drive the rod down into the soil, and those blows will splay the top end of the rod.* When this happens the clamp will not have sufficient inside diameter to slip over the top of the rod. If you wish to keep the wire clamp from banging around as you hammer, then temporarily fasten it to the rod with its own screw, or with some masking tape.

A few ground rods are made of copper tubing. These grounds are made of 1-inch or larger copper pipe, and should be of thick wall stock rather than ordinary plumbing water pipes. While there is an argument that copper tubing makes a better ground than rods, they are also the very devil to install (later we will deal with an exception).

The ground system shown in Fig. 1 will suffice for most amateur and SWL applications. Some people go to extremes, however. When I was a Novice ham operator in the late 1950s there was a senior ham (“two-letter call”) named Abe in our neighborhood. He made his living building houses, so had built his own. When he had the backhoe dig the basement and foundation footers, he also had it hog out a subterranean alcove for his special breed of “ground rod.” Abe placed an antique copper or brass bathtub in the hole, and then covered it with earth when he back filled against the foundation. Of course, the future monetary value of that buried antique bathtub was not a consideration to a died-in-the-wool ham operator!

Another chap went to his newly built house before the sod was laid down. He installed a grid of bare copper wires spaced about one yard (36-inches) apart. At each crossover juncture the wires were silver-soldered together. At the entrance of the house where the ham rig’s wires would emerge he installed a series of six eight-foot ground rods arranged in a triangle like the Greek letter delta (Δ) when viewed from above. Both of those approaches may be a bit of overkill.

The wire clamp is a special fitting intended to fasten the ground wire from the receiver, transmitter or antenna to the ground rod. The clamp is a collar that goes around the ground rod, and has a set screw on one side. When the set screw is tightened it forces the wire tightly against the pipe.

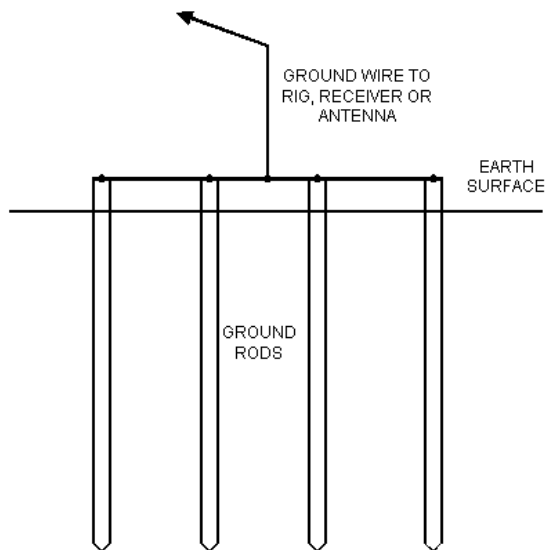


FIG. 2

A lower RF resistance can be obtained by using multiple ground rods (Fig. 2). This system is recommended by some lightning protection experts. Each ground rod is the normal 8-feet long. They are joined together at the top by a heavy copper wire that shorts all four rods together. The best operation is afforded when there is a spacing of 1 to 3 yards between rods. This spacing argues for the triangular or circular pattern, rather than the in-line. You will find such systems discussed in books on lightning protection.

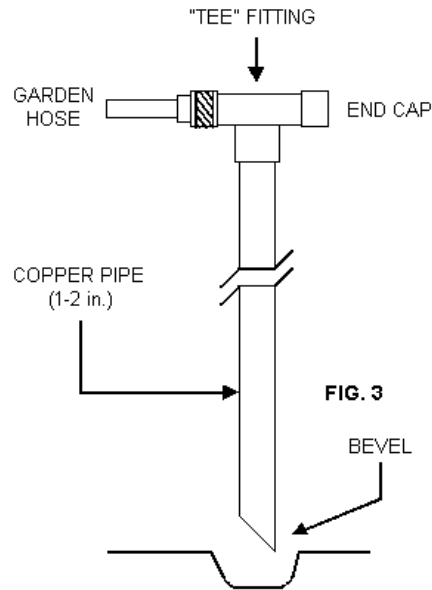
The Hard Cases

I live in northern Virginia, where my cattle thief ancestors settled after being run out of Scotland before the American Revolution. A large amount of land in this area consists of an overburden of good, rich soil...about 12 to 36 inches deep. Underneath that wonderful soil is a couple meters of white marine clay that is as hard as nails. When I moved my family into our first house, I attempted to install an eight-foot copper clad steel ground rod beneath the window where my ham shack would be located. After three hours of unaccustomed hard labor my son ran into the house yelling "...Mommy! Daddy's using those words again!" That marine clay would not budge!

Some years later, when I built an addition on the house, a contractor lost his shirt on digging the footers for the concrete slab the addition rested on. He bid the job assuming that two laborers with shovels could dig out the required 28-inch deep by 12-inch wide trench in about three hours. It took two days...pick and spade work against that marine clay for the last few inches.

Later, before I tried to install another ground rod, I got some advice from a reader of one of my magazine columns. He recommended using a homebrew water drill (Fig. 3). The "drill" is a 1.5-inch diameter copper pipe (plumbing pipe will do), bevelled at one end by a hacksaw. At the other end a "tee" junction is sweat soldered. One side of the tee is fitted with an end cap (also sweat soldered). The other end is fitted with a standard nipple for a garden hose. By placing the beveled end into the soil, and then turning on the water at its

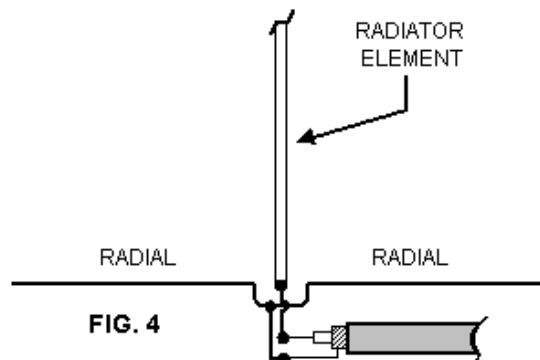
highest pressure, the pipe was able to slip into the ground at a rate of about half inch per second. Slow, but one heckuva lot faster than the “bang-bang” method.



Artificial Ground Tuners. Sometimes the reason why a ground is not so good is that the ground wire is too long. Any time the wire is an appreciable fraction of one wavelength, it will be a poor ground at least on some frequencies. One approach is to insert an artificial ground tuner between the ground side of the antenna tuner or transmitter. The artificial ground tuner consists of a series resonant tank circuit and an RF ammeter. The tuner is adjusted to maximize the flow of current in the ground wire.

Counterpoise Grounds

A “counterpoise” ground (Fig. 4) is one that is an artificial ground plane. The vertical antenna is familiar to most ham operators and SWLs. It consists of a vertical radiator (usually, but not always, quarter wavelength long). The center conductor of the coaxial cable feedline is connected to the vertical radiator, while the shield is connected to ground.



In some cases, especially if the vertical is mounted above the surface of the Earth, a “good ground” is virtually impossible. As a result, antenna installers use a system of radials (Fig. 4), each quarter wavelength long, all tied to the ground point of the vertical, as the counterpoise ground.

Use at least two radials per band, although the more the merrier. Medium wave AM broadcast stations in the USA must install 120 radials to comply with engineering standards, but ham/SWL sources usually recommend sixteen or less. The reason is that it is a lot of effort to install more than that, yet there is a “knee” in the performance gain experienced over that number so a “diminishing returns” situation exists. The radials can be either perpendicular to the radiator element or, as shown, they can droop up to 60 degrees from horizontal.

It is also possible to install the radials on the surface, or buried a few centimeters below the surface. The latter is preferred for safety reasons. Pedestrian traffic in the yard can easily trip over the wires laid on the surface. Indeed, it could be you! In that case, while you are waiting for the emergency medical technicians to arrive with their splints, bandages and ambulance, you can hear your kid say: “Mommy, what’s those words Daddy’s yelling?” To which mom replies: “He’s inventing new curve words.”

Figure 5 shows the method for connecting ground level or buried radials. The ground rod is a standard 8-foot or longer ground rod (again, copper clad steel). The radials are fastened under a wire clamp. Either the same one as the ground wire to the antenna and/or rig can be used, or a separate clamp provided.

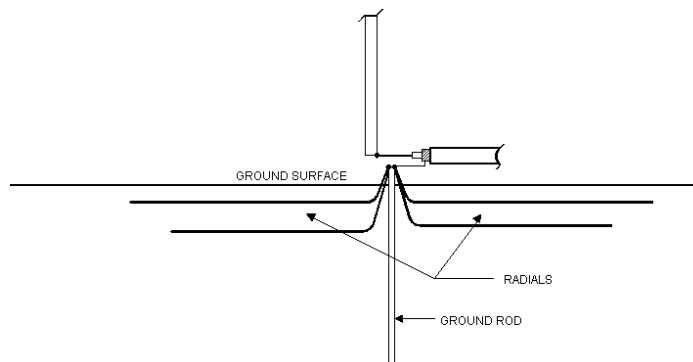


FIG. 5

The same ground system can be used for nearly all Marconi style antennas, not just verticals.

Lightning Arrestors

Lightning is not attracted to radio antennas unless the antenna is one of the highest points around. Unfortunately, that's where antennas work best: *up high*. Because of this problem, it is necessary to provide some protection against lightning strikes.

Get one thing straight right away: a direct hit on your antenna will destroy the antenna and the radio equipment connected to it. It might also set fire to your house. No amount of protection will guarantee that no damage will occur, but you can mitigate the damage by taking certain steps. Also, a lightning bolt need not strike the antenna to damage radio equipment. A lightning bolt that strikes the ground nearby, or strikes between two clouds overhead, will produce a high enough electrical field to put very high voltage spikes into the receiver front-end. Older vacuum tube equipment was relatively immune to such transient voltages, but modern solid-state equipment is sensitive.

All antenna installations should have a lightning arrester either in the feedline or at the base of the antenna in the case of verticals. Your radio dealer can sell you approved types. The lightning arrester should be installed outside of the house, and be well grounded.

Note: *In many cases your homeowners insurance may not pay off in the case of lightning damage if you failed to use an approved lightning arrester properly installed. Some companies also require that the installation be inspected by the local government electrical inspector.*

Conclusion

If you follow the principles discussed in this paper, you should achieve a good ground, with the expected improvement in the performance of receivers, transmitters and antennas.