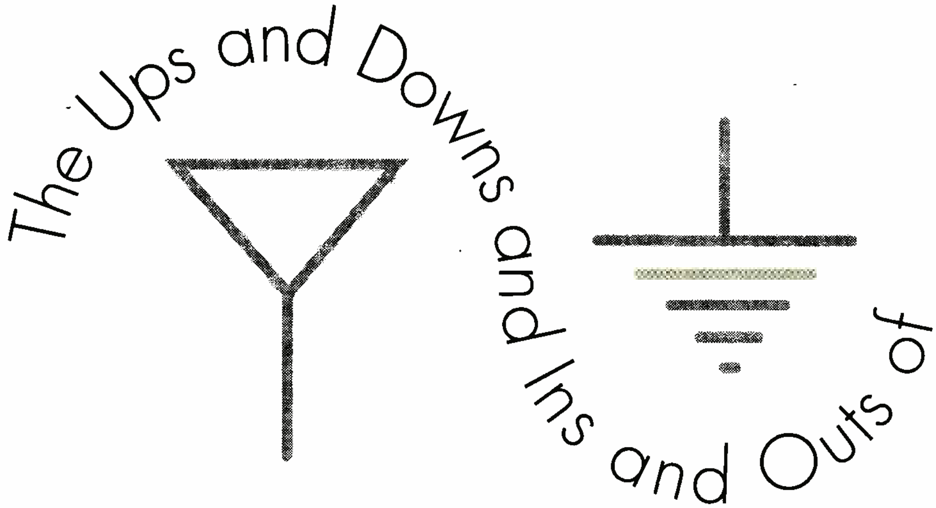


The Ups and Downs and Ins and Outs of ANTENNA GROUNDS

By Joseph J. Carr

A topic of almost perennial discussion amongst shortwave listeners, monitor buffs and amateur radio operators is the antenna ground connection. A lot of silly things are done in the name of antenna grounding; some of them work, some of them don't, and some of them are just plain dangerous.

Several examples pop to mind from my own thirty-plus years of experience. First, I recall a chap—a Novice class ham operator—who lived on the second story of a two-story frame house. He grounded his transmitter and receiver through an 18-foot piece of #22 solid "hook-up" wire. Besides the wire being too small and too long, the "lower end" was ridiculous: it was soldered to a fork stuck into the ground about one-half inch!

Another chap got a top flight electrical ground, but it was none the less ridiculous. In my area, we call this particular ground "Abe's bathtub" because the fellow grounded his ham rig to a massive antique copper bathtub buried six feet underground. Besides wasting a perfectly good (and expensive) antique bathtub, it must've been terribly hard to dig a hole large enough to bury it *(groan)*.

Still another guy grounded the receiver to a pipe in the basement of his house—the natural gas pipe! That kind of ground is not only not very good from a radio point of view, but is dangerous and illegal!

My friend Dave was the chief engineer at a small AM radio station that was erecting a new transmitter site and antenna tower. Noting that there was no sod on the earth, he laid down a grid of copper wire for hundreds of square meters around the tower. Each row and column of the grid consisted of #10 bare copper wire, and the crossover points between rows and columns were soldered with low resistance silver solder. The entire grid was connected to the antenna tower's ground point. Then the sod company was called in to cover the earth. When the power company came out, they found that Dave's ground system had a lower AC resistance than the ground they'd installed!

Only a few of us are rich enough to build "Dave's Ground Grid," and few of us own antique copper bathtubs that we are willing to sacrifice. But it's also true that many readers may not understand what is a good ground. In this article we will look at some aspects of antenna system grounds.

■ Why Ground an Antenna?

There are two basic reasons to build a ground into the antenna system: *lightning and electrical protection* and *to make the radio system work better.* Lightning protection is necessary because antennas sometimes get struck by lightning, and that can set a house on fire or ruin your radio (rather spectacularly, incidentally). Lightning is not "attracted" to the antenna just because it's an antenna, but because it is higher than other objects around (if a nearby tree is higher, then it has a higher probability of a strike).

A ground does not provide absolute protection against lightning, but it can help. For some types of antenna, local electrical and building codes require an appropriate ground for lightning protection. Also, your homeowners' insurance may require such protection in order to keep the policy in effect, especially if local codes require it.

Electrical protection is necessary because radio receivers sometimes short out internally, and that can put 110 volt AC on the chassis. If that happens, then the radio chassis becomes electrically "hot," and very dangerous (perhaps fatally so).

A "good ground" also makes radios work better under the right circumstances, especially with long wire or random length wire antennas (in fact, all so-called "Marconi" style antennas). Antenna

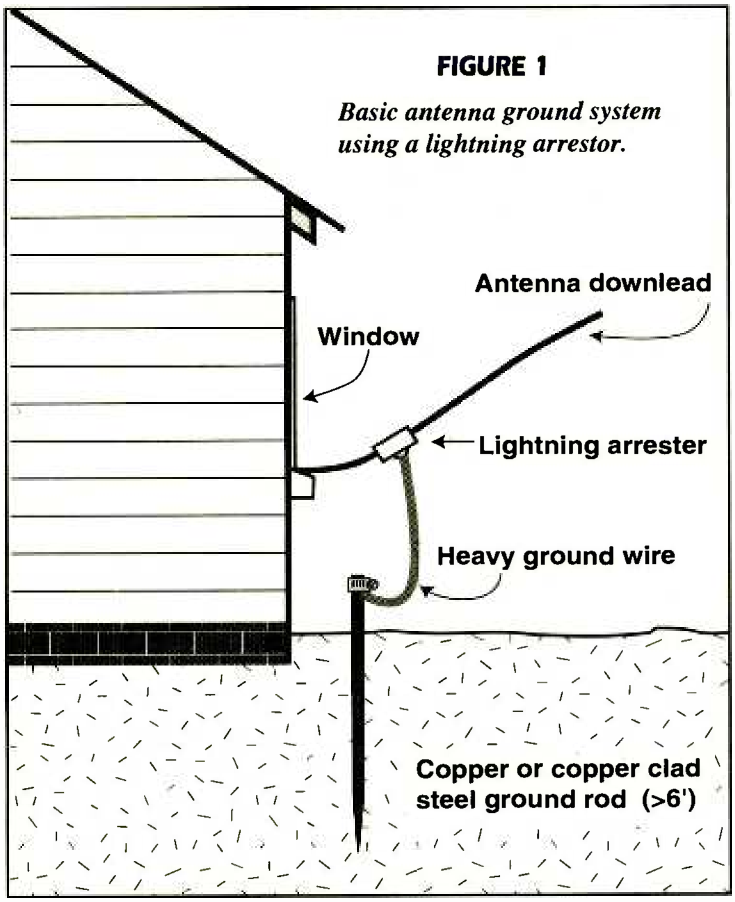


FIGURE 1

Basic antenna ground system using a lightning arrestor.

and radio performance is improved if the antenna system is provided with a good RF ground.

Lightning grounds, electrical safety grounds, and RF grounds are not necessarily the same thing. For example, a lightning ground that works through a lightning arrestor may be a reasonably good protector for lightning, but is totally ineffective for RF or electrical protection purposes. The idea is to design a ground system that will work for all three functions.

Ground Wires

The ground wire, whether from the receiver or a lightning arrestor, should be made of either aluminum or copper, and be as large as possible. Aluminum clothesline is sometimes used, as is aluminum TV antenna ground wire. Another popular form of ground wire is to use multiple sections of #12 or #14 house wiring connected in parallel at both ends. A lot of people use heavy copper flat braided wire, while others buy a roll of automotive battery ground wire. Still others recycle the outer braided shield of the larger size coaxial cable for the ground wire (RG-8/U or RG-11/U). The outer insulation, inner insulation, and center conductor are stripped away from the shield. Whatever type of wire is used it should (a) be legal under local electrical codes, and (b) be a large, heavy duty size.

Basic Antenna Ground System

Figure 1 shows the basic (and most common) antenna ground system for lightning protection. A **lightning arrestor** is connected into the antenna download (or transmission line) some place outside of the building. A heavy ground wire is connected from the "ground" (GND or G) terminal on the lightning arrestor to a ground rod driven into the ground.

The "innards" of a lightning arrestor are shown in Fig. 2A. The antenna lead is represented by a center conductor ("A"), that is separated from a pointed ground lug by a small air gap. The air gap is an insulator at low voltages, but when a high voltage lightning strike comes along, the air in the gap ionizes and creates a low resistance path to ground (Fig. 2B).

Ground rods are available in 4-foot, 6-foot, and 8-foot lengths. Although some are copper, most are copperclad steel. For lightning protection purposes, the 4-foot and 6-foot lengths are not the best choice. In fact, most local electrical codes require 8-foot lengths. For RF purposes, however, two or three 4-foot rods separated by a few inches, and shorted together above the surface with heavy wire will suffice. However, keep in mind that such an arrangement may not be legal for lightning protection ... If you want multiple ground rods, then drive several 8-footers into the ground.

A somewhat better system is shown in Fig. 3. On the rear panel of most modern shortwave receivers are two connectors: a coaxial connector for the antenna (ANT), and a ground connection (GND). The latter is usually a machine screw and nut that is attached to the metal chassis of the receiver.

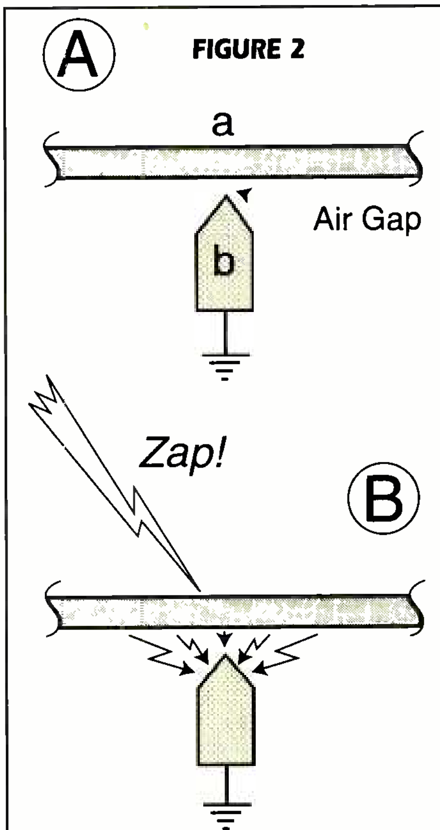
On some receivers, especially older designs, there will be a small phenolic or ceramic strip (see inset to Fig. 3) with either two or three screw terminal connections. If there are two screws, then one is for the single-wire antenna lead, and the other is for the ground connection. On three-wire types, there are two for antennas (A1 and A2) and one for ground (G). If an unbalanced antenna is used with the three wire type, a shorting wire is connected between A2 and G.

The ground system in Fig. 3 uses two ground wires. One goes from the ground connection on the back of the receiver to the ground rod, while the other goes from the ground connection on the lightning arrestor to the ground rod.

Switched Ground System

At one time, all ground systems for wire antennas used a large knife switch to connect the antenna to either the receiver or the ground wire, as needed. The idea is to switch the antenna to the ground side whenever a lightning storm approaches, or whenever the radio is not attended for a period of time. Figure 4

FIGURE 2



A) Structure of an antenna lightning arrestor, B) antenna arrestor in action.

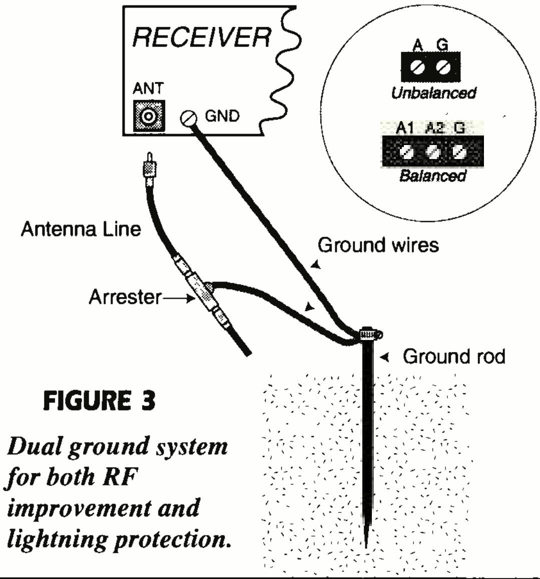


FIGURE 3

Dual ground system for both RF improvement and lightning protection.

shows such a set-up. The nice thing is that these old-fashioned switches are still available in some electrical or radio supply stores.

In the position shown ("A"), the knife switch connects the antenna downlead to the receiver lead; normal signal reception occurs. But if the switch is flipped to "B," then the antenna downlead is connected to the ground rod through a heavy ground wire.

A lightning arrestor is used in the line. Just because the switch can connect the antenna wire to the ground side does not mean that no arrestor is needed. Besides the fact that the switch can fail, there is always the possibility that a surprise storm or a lapse of memory will occur, and the switch will be in the wrong position.

■ Grounds for Vertical Antennas and Towers

The ground systems shown so far are used for horizontal wire antennas, and others. The transmission line or downlead lightning arrestor can be used for any type of antenna, and indeed should always be used. Vertical antennas can be additionally protected, however.

Figure 5 shows a method for providing a subsidiary lightning arrestor for vertical antennas. A stiff heavy duty wire, or strip of sheet copper, is placed in close proximity (1/4 to 1/2 inch) to the base of the antenna, forming a spark gap for a lightning arrestor. This "arrestor" is connected to the ground rod via heavy wire. This system can be used on either ground-mounted or mast-mounted vertical antennas. In fact, many commercial vertical antennas have some similar system in place.

Another method is shown in Fig. 6. This method provides both an RF ground and a lightning protection ground. On vertical antennas, the outer shield of the coaxial cable transmission line forms the ground connection to the receiver. This shield should be grounded via heavy wire to an 8-foot copperclad ground rod that is legal under local codes.

A secondary ground in Fig. 6 is the quarter wavelength (λ/4) radial; this is an RF ground. Radials are #14 or #12 (or larger) wire, cut to a quarter wavelength at a frequency in the center of the band of interest. Of course, for a wide frequency band, such as the high frequency shortwave bands, proper operation requires a multiple radial system for different frequencies a couple of megahertz (MHz) apart. A general rule is to use at least two radials on each frequency, but the real situation is: *the more the merrier*. AM broadcast stations install upwards of 120 radials for a single frequency, but the engineering literature shows decreasing effectiveness above 15 or 16 per frequency. For most SWL purposes, two radials will work well.

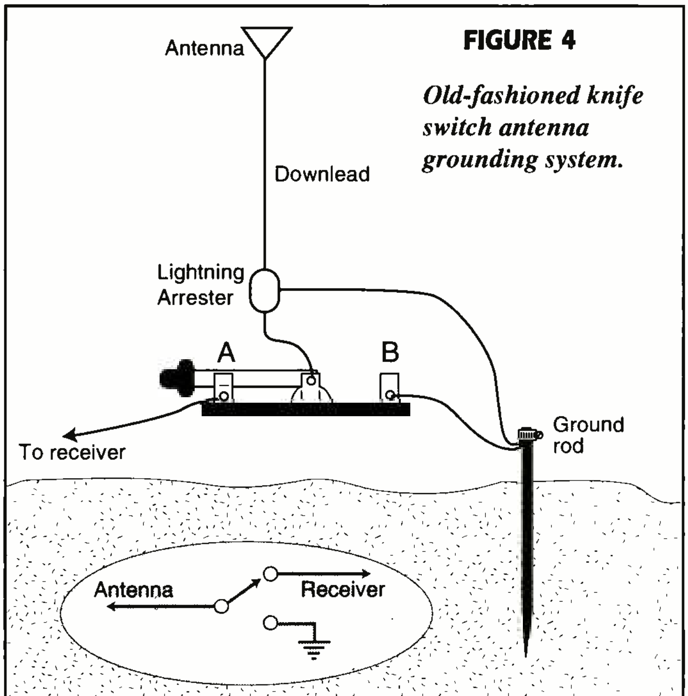


FIGURE 4

Old-fashioned knife switch antenna grounding system.

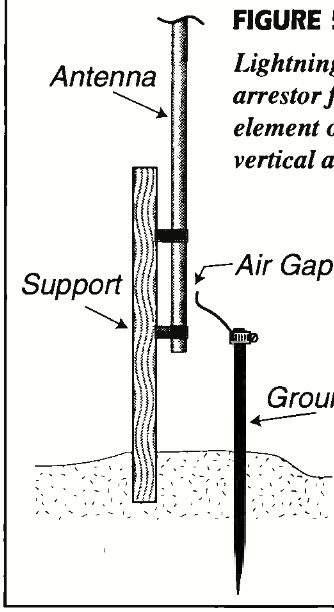


FIGURE 5

Lightning arrestor for the element of a vertical antenna.

The physical length of radials is found from:

$$L_{feet} = \frac{246}{F_{MHz}}$$

Where: L is the length of the radial in feet, and F is the frequency of resonance in megahertz.

Example

What is the length of a radial cut for a frequency of 9750 kHz (i.e. 9.75 MHz)?

$$L_{feet} = \frac{246}{F_{MHz}}$$

$$L_{feet} = \frac{492}{9.75_{MHz}} = 25.23 \text{ feet}$$

Radials can be installed either above ground, or buried underground a few inches. For the sake of safety, keep the above-ground radials for mast-mounted verticals only ...bury all others (you don't want anyone tripping over the radial that is installed only a few centimeters above the ground, or buried in the grass).

If you are lucky enough to have a tower system for your antenna, then you might want to use a ground system such as Fig. 7. In this case, there are two or more 8-foot ground rods connected to the base of the metal tower through heavy wire. Your local electrical code will most certainly require at least one such ground rod, but given the height of most towers it is probably a safer bet to use multiple ground rods around the base of the tower.

Conclusion

For an antenna to work at its optimum peak performance, and yet still provide at least reasonable protection against lightning strikes and electrical failures in the receiver, a proper ground system is needed. Following these guidelines, you can improve your installation on all of these points. No form of protection is totally foolproof, or gives absolute protection, but it's better than no protection by a long shot.

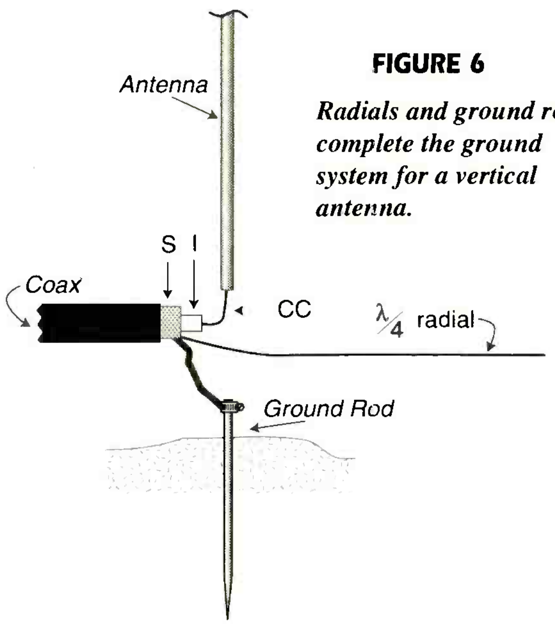


FIGURE 6

Radials and ground rods complete the ground system for a vertical antenna.

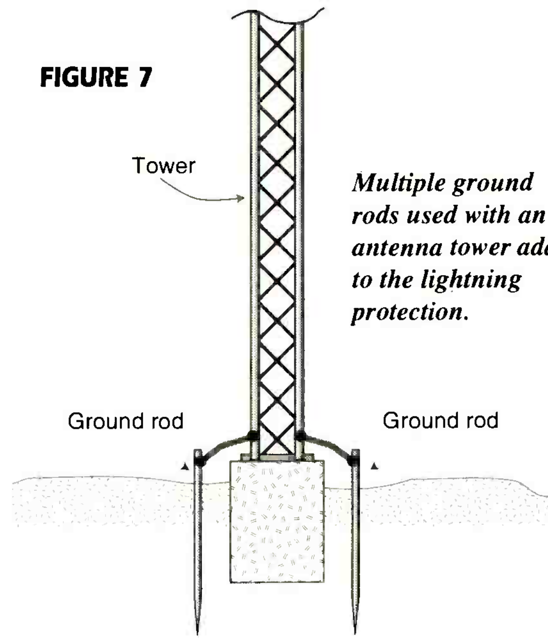


FIGURE 7

Multiple ground rods used with an antenna tower adds to the lightning protection.