LIGHTNING AVOIDANCE AND STATIC ELECTRICITY DAMAGE PROTECTION FOR YOUR VHF AND UHF EQUIPMENT

By Ed Butorajac, AAR4AJ / KM4QQ

During the antenna seminar that was by conducted by Army MARS, for a five month period beginning in October 2001, many antennas, grounding systems, lightning avoidance techniques, and other related subjects were presented. One subject was not discussed: lightning avoidance for VHF and UHF equipment. This is important because most, if not all of us use these frequency ranges for both MARS and amateur communications purposes. In MARS, we have both voice repeaters and digital stations that make up the backbone of the digital and VHF voice message systems in many states. The repeater sites and the individual stations need protected from lightning damage if these systems are to remain operational and give the measure of service expected of them. While this paper is not a direct part of the MARS wideband HF antenna discussion, when the vast quantity of discussion about lightning avoidance that was discussed is considered, this information has a place here. If our VHF/UHF equipment's antenna system allows the static charges into the station, it is hard to say what kind of damage to the overall station may result.

There are many lightning arrestor devices on the market at various prices. Most if not all of them have one drawback: Namely, lightning strikes and near strikes can cause the cartridges in some of these devices to short permanently. When this happens, the station is down until the protection cartridge is replaced. Some will permanently short after a certain amount of energy is passed to ground. Others, will only short with a strike of a certain severity. A second danger from an arrestor that can short is damage to station equipment. If a transmitter connected to an antenna which has been shorted transmits into the short, the final amplifier, and possibly other circuitry can be damaged. Another consideration is the cost of the protection device. Other devices may not be prone to shorting because a gas discharge tube is used which will not fire below a certain voltage that may be in excess of that needed to actually cause equipment damage. Very few manufacturers actually discuss the method by which their products work and therefore one can not make an informed decision about which suppressor may work best for the most reasonable cost.

So far, I have discussed several factors to consider when selecting a lightning/surge suppressor for your VHF/UHF antenna system: reliability and effectiveness under extended use, as-well-as cost.

Also important to know is what you are trying to protect your station equipment from. Most of the energy contained in a lightning discharge is located in the lower frequency spectrum. The HF, MF and LF bands contain the vast majority of the energy that will be encountered in lightning strikes. While extraordinary methods may be required at those frequencies, the VHF/UHF bands seem to be a bit easier to deal with. Even though the majority of the static energy is at a low frequency, if it is present across the input of your VHF/UHF equipment it will cause damage. There is a simple solution for this problem.

There are those that will say the device I am about to present does not work as well as the suppressors their company has for sale. I can only say this: I have been associated with several installations that use the device described here, and there has not been one piece of radio equipment damaged by lightning of which I am aware (and this author is the individual doing all the repair on this equipment) since 1987 when the oldest of these systems was installed. Now, for over 275 transmitter/receiver combinations (or transceivers in some cases), not one piece of RF equipment has had a lightning or static charge-related failure recorded. Yes, there have been lightning strikes and antennas have been blown completely off their mounts. Coaxial cable was fried to a cinder. This little device saved the equipment, though. A fifteen Dollar ground plane antenna and twenty Dollars worth of coax is a lot cheaper to replace than replacing the radio equipment, and is even cheaper than the cost of many commercial lightning arrestors, which won't protect the antenna system anyway.

The device I am about to present here is the quarter-wave shorted stub. I will discuss how it is connected in the antenna system, how it is made, the calculations on the length of the stub, how to measure the stub's length and how to ground it, among other topics. Just a short note: This device should not cost more than ten Dollars to make, if all parts are bought new. It never breaks down and requires replacement. It can be mounted inside the station or outside the station building. It is a very flexible device as far as where it is installed.

First, let me state that we are going to be dealing with a device that is going to totally ground your antenna system to which it is connected. Many ground plane antennas have a vertical radiating element that is isolated from ground. This is an invitation for static or lightning damage to the equipment connected to the antenna system.

The characteristics of the quarter-wave shorted stub are very interesting, in that they have the characteristic of providing an infinitely high impedance to any RF signal at the frequency of resonance to which the stub is cut. This means that the stub will not allow your RF signal to be shorted out! In fact, your radio will never know this device is connected. It will not affect your signal's strength at distant stations at all. Nor will it cause any degradation of your receive signal. For stations using only FM transmission and reception, little if any differences will be noted, unless you have been plagued by high static that bothers even FM during storm activity. The stub should eliminate most if not all of this problem. In the case of individuals that use SSB, CW or AM on the UHF and VHF bands, this device will provide from six to nine, or even more dB of quieting from atmospheric static.

One other advantage the quarter-wave shorted stub can provide is the reduction of interference from strong transmitters out of the frequency range of the stub. (At 2 Meters, the normal stub has a bandwidth of approximately 10 MHz. For example, if your station is close to a strong FM broadcast station, and there is RF overload from the signal it presents to your station antenna, the stub will act as a tuned filter and eliminate a great portion of the interfering RF signal. In many cases it eliminates enough of the interfering signal to totally stop its effects on the station receiver.

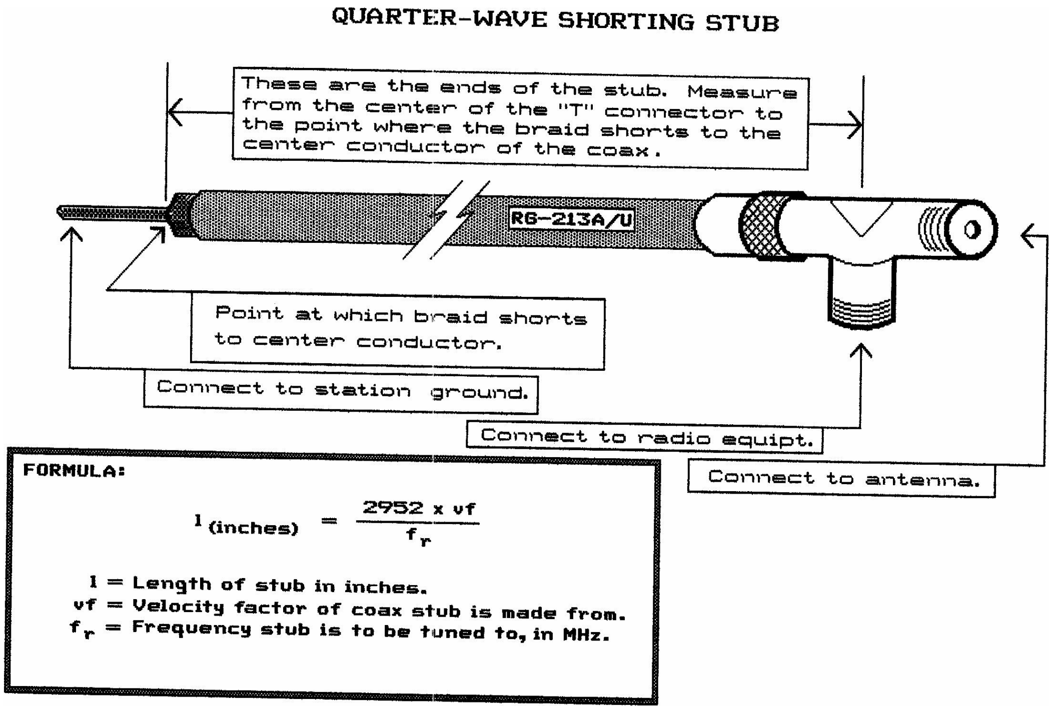

Figure 1.

Refer to the drawing in figure 1. This drawing shows several things.

1. The length of the stub is measured from the center of the "T" connector to the point at which the coax braid is shorted to the center conductor of the stub's coax. This is important! If measurement is done in any other manner, it will be found the stub will not have the desired resonant frequency.

2. Each port of the "T" connector has a specific connection specified.

a. The stub is connected to one of the two straight-through ports.

b. The antenna cable is to connect to the other straight-through port.

c. The 90-degree port is connected to the radio equipment.

3. The "T" connector pictured here is a three-female type connector. This is only because this is what I normally use. Other types can be used, such as one with a male connector on the 90-degree port. This is handy if you intend to connect the "T" connector directly to the radio equipment. This can be done, and is done in quite a few installations I work with, including my own home station.

The diagram shows the best protection method for connecting the three devices. The antenna and stub are connected to the two straight through ports because static and lightning charges do not like to go around bends, especially sharp ones like presented by the 90-degree port to either of the straight-through ports. That alone is going to reduce the strength of any damaging charges going to the radio equipment.

The Formula is shown in the inset box at the bottom of the diagram. The figure "2952" is a value that represents the constant for inch measurements. Measurements in inches are much easier to deal with when measuring and cutting VHF and UHF antennas, etc.

The term "vf" is the velocity factor of the cable used to make the stub. I recommend using a cable with the velocity factor of 0.66, and a 50-Ohm impedance. Some of these types are RG-213, RG-214, RG-58, RG-223, etc. If you are using a 75-Ohm feedline, then RG-11 or RG-59 would be good choices for matching the 75-Ohm feedline system. The use of a cable with foam insulation is likely to cause problems. This is true in any antenna system. There is a good bit of heat required in soldering this device, and this can cause migration of the center conductor of a cable with foam-type insulation. Secondly, foam-type cable has a much lower dielectric strength. If the insulation breaks down, that will allow arcing and cause the stub to change frequency. Use RG-213A/U or RG-58()/U. RG-8X is specifically **not** recommended for use.

CONSTRUCTION:

STEP 1. Select the type of cable, connectors and "T" connector to be used. Make sure these are all compatible with the rest of the antenna system. (Must match the feedline's impedance.)

STEP 2. Install the coax connector on one end of the coax you will use for the stub. Make sure you solder all connections if necessary for the type of connector you are using. **Recommend you do not use any crimp-type connectors on this project because they tend to corrode over time and provide less than maximum protection.** (Some types of BNC, N and other types of connectors are designed to be solderless except for the connection on the center pin. These are acceptable for indoor use or when very well sealed against the elements outdoors.) **Always use coax seal on all exterior connections on any antenna installation project. Moisture must be kept out to maintain optimum performance of your antenna system.**

STEP 3. Perform the calculations to determine the length of the stub. Use the formula found in the inset box on figure 1. Do not forget the velocity factor of the cable (vf) must be multiplied by the constant.

STEP 4. Install the coaxial stub's connector on one of the "T" connector's straight through ports.

STEP 5. Measure from the center of the "T" connector, down the stub's length and mark the point at which the short needs to be made. Refer to the drawing for correct measuring points. Now, mark another point about two inches further down the coax. After marking this point, cut off any excess cable beyond this point. (The portion beyond where the center conductor is to be shorted to the braid will be used to connect the stub to the station grounding system. Some extra length can be left here if necessary to make connection to ground easier in your system.)

STEP 6. Remove the outer jacket of the coax from about 1/4th inch above the mark you made for the point at which the cable must have the short made. (Note: retain this piece of insulation for reference until the project is finished.)

STEP 7. Fold the shield of the coax back over the outer insulation of the cable, thereby exposing the center insulation. Using the outer insulation you saved, mark the point on the center insulator you need to make the short. Remove the center insulation from the center conductor about 1/32 inch above this point. (This is not a critical measurement, but don't get too sloppy. This will be discussed later.)

STEP 8. Bring the shield you folded back over the outside jacket back over the now exposed center conductor. Stretch it out. Press it over the exposed portion of the center insulation and insure it makes good contact with the center conductor as close to the end of the center insulation as possible.

STEP 9. Solder the braid to the center conductor. All exposed braid should be solder-filled. This will insure a good conduction path for the ground side of the antenna system, and provide a low impedance path for any static charge or lightning energy on the center conductor to be properly conducted to the station ground, and away from the station equipment.

STEP 10. Install the shorting stub and enjoy peace of mind. Other doubters that have used this device as a last resort have come to find that it is the most simple way to insure true freedom from expensive equipment damage and periodic lightning suppression equipment replacement.

LIMITATIONS AND EXPANDED COVERAGE:

While this is a very simple and effective device, there are certain things that should not be attempted with this device. Keep in mind, this is basically a VHF and UHF device. When we get down into the HF frequency range, these stubs would be so long that their very size would cause problems and reduce efficiencies because of transit times involved. In other words, there is a frequency at which the quarter- wave shorting stub starts to loose its magic. Also, keep in mind the lower you go in frequency, the more energy is present in a lightning strike. As I pointed out, the stub is a tuned circuit that has a very high impedance to signals at the frequency at which it is tuned. This is true for signals you might not want to receive as well as damaging energy in the form of static and lightning energy.

If there is any way possible, all HF antenna assemblies should be totally grounded. There should be no part of an antenna that is above ground potential. Grounded arrays will protect the HF portion of the station from static damage. This is the major cause of equipment failure, not lightning strikes! This is another subject, and much of this has been covered by other topics during the antenna seminar.

If you feel any doubt about the efficiency of this method of surge suppression for you VHF/UHF antenna system, you may want to add one of the expensive devices advertised in the amateur magazines. One thing, place this device *after* the stub. If that will bring additional peace of mind, fine! One thing: You will never have to worry about it shorting and putting you off the air!

Remember, this device is an electrical quarter wavelength long. It will also work at 3/4ths wavelength as well. Since the stub exhibits a bandwidth of about 10 MHz (plus or minus 5 MHz from the design frequency,) with a little adjustment within the 2 meter band, it should work just fine in either the upper or lower portion of the 440 MHz band as well, for those with dual-band equipment and a dual-band antenna. (Tests should be run before deciding go use this device as a dual-band protection device.) A bit of experimentation will prove helpful here. As with a 40 meter antenna working on 15 meters, here we are talking about a tripling of the operating frequency. From this author's experience, a 2 meter stub tuned for 147 MHz works well on all of 2 meters including the MARS and CAP frequencies adjacent to the band. It also works well in the 430 to 450 MHz region as well.

A reminder: Each major change of season (before the start of summer and winter) is a very good time to check over your antenna and grounding systems. Your lightning protection is only as good as the integrity of your grounding system! Make sure it is sound. A few hours spent going over this important part of your station is time well spent, and may save you a lot of money for equipment repairs and replacement.

Remember, **all** your station must be protected, not just the HF antennas and equipment, or not just the VHF/UHF antennas and equipment. The better your protection scheme, the better your station will be equipped to insure survivability from static discharge damage. With a properly protected station, you will more likely be an assist able to provide emergency communications, if the need ever does arise.

The author may be contacted at km4qq@arrl.net or by snail mail at 3604 San Sebastian Dr., Hephzibah, GA 30815-6528. Any questions or comments are welcome.

NOTES: