



## Dissipation of Lightning Energy on Antennas and Towers

by Mike Higgins - K6AER

This short white paper is not intended to be a complete paper on the proper surge suppression techniques but as an aid to understanding the issues in considering the use and application of surge protection products with antenna and tower systems.

### What is lightning?

The focus of this paper is Cloud to Ground lightning. First, a brief overview of what a lightning strike is in order to understand what the suppression issues are. Air movement and the friction of particles in clouds create static electricity. This friction enables a positive charge to build up until a discharge is inevitable and a potential path is established with another cloud or earth. A strike leader will start to arc skyward from a ground source until a discharge path is created from the charged source (Cloud) and the discharged potential (Earth). The discharge cloud to earth potential is complete when air molecules ionize and an electrical path has been completed. With this, we have lightning. A lightning strike is not a single strike but several strikes along the same ionized path. Each strike is about 8-20 $\mu$ s in length and will repeat in numbers until the cloud potential is decreased and the ionized path is lost. A lightning strike, although short in duration, contains millions of volts, thousands of amps and has a great RF as well as a DC energy component.

### Why surge protectors?

The DC and RF component must be addressed in setting up a lightning firewall suppression system. In commercial systems, the building has a ground halo installed around the perimeter with an internal ground halo and a suppression demarcation point for all outside wiring and coax entries. Homes are built to a different standard and we must adapt where possible. The often misunderstood NEC code for grounding is not applicable when you are protecting your HAM radio equipment from external surge potential. Grounding your equipment to the AC panel ground will not protect your equipment from high current surges coupled on the antenna lines. This will only prevent AC ground loops should you lose your primary AC return ground. Because lightning has a great amount of RF contained in the strike, any long ground leads will not ground off RF energy and at may best delay grounding of DC spikes due to lead inductance. The best way to prevent RF and DC surges from entering the Shack is at the cable entrance or at the base of the tower. Each of these points can be considered a surge firewall demarcation point. This ground point must be as short as possible. Even a nearby strike can inductively and or capacitively couple thousands of volts into your cable and coax system.

### Typical Installation

Let's follow the proper grounding procedures from the antenna down to the radio. The antenna lines should be grounded at the top of the tower when possible. Should your tower be a crank-up, you will only be able to effectively ground at the tower base. A fixed, guyed tower represents the greatest conductor to ground. Running a ground wire up to the tower top, although popular, is a waste of time unless the conductor is larger than the tower or the tower is of the crank up variety. For guyed towers, all guy points need to be grounded as well. Always place ground rods into the soil around the tower and not through the concrete base. Each ground should be at least twice the rod length in distance from the next ground rod. The concrete of an ungrounded tower base will shatter when hit by lightning if the base is not grounded. The tower should have at least three ground rods spaced about eight feet out from the tower with connections to each leg of the tower base.



Tower grounding halo points



Tower base feed line ground connections.



NEMA box with RF and DC Surge protectors

Use copper or brass lugs when connecting to the tower base. Other metals can cause corrosion on galvanized metal and can weaken the tower base. Three would be a minimum number of rods in good conductive soil for a ground halo. In poor

soil such as in the mountains and in the western U.S., you might need more ground rods provide a good coupling to earth or the use of a deep ground rod up to 40 feet. Use solid copper wire of at least 2 gage and connect all ground rods with brass or copper ground clamps. For underground connections you will need to CAD Weld the copper connections. All above ground connections should have a coat of Ox-Gard paste to maintain the connection integrity with lugs and clamps.

The coax cables need to have their outer conductors grounded at the tower base and attached to the tower ground halo system. At this point surge protectors need to be installed in series with the coax lead before routing antenna feeds into the home and to the radio equipment. It is best, whenever possible, to protect the RF surge protectors from weather by enclosing them in a NEMA or weather resistance box. If this is not possible use a moisture protector barrier tape over the connections and surge protectors.

The surge protection box would be the best location for all other surge protectors such as those needed for Rotors, SteppIR Controllers and remote control lines. The surge protectors should be attached to a mounting strip with copper conductive (flat ribbon or cable) to the tower base ground halo system.

Inside the radio room all coaxes should be attached to a grounded antenna routing switch with a common grounding position for all entries. This grounding location must be attached to the operating station grounding buss bar. All coax and radio connections should be grounded at this point. Remember we are also grounding RF energy as well as DC potential and long ground runs are self defeating due to series inductance. A 33-foot ground run will present a high impedance connection at 7 MHz during a lightning strike. Use of a grounded antenna switch, will aid in radio isolation. All radio equipment in the shack should be connected during periods of non use, adding an extra layer of protection when connected to the ground copper buss bar. This bus bar is your equipment demarcation point. Connections should be made the outside halo ground system via a short #2 GA copper ground cable or a flat ground strap.



Use of a grounded antenna switch will aid in radio isolation during periods of non use, adding an extra layer of radio protection.



All radio equipment in the shack should be connected to a common ground copper buss bar. This bus bar is connected to the outside halo ground system via a short #2 GA copper ground cable.

### Other Potential Sources

Many times radio amateurs will assume that a lightning strike came into the radio room via the antenna connections. This may often not be the case. Often electronic damage is via the phone, cable and especially AC lines in search of a good ground. It is also imperative that surge protectors be mounted on all entry conductors. In a typical home, AC mains, will only have one ground rod. Though this may satisfy the NEC and local building codes is not adequate for lightning surge grounding. Several ground rods must be added for AC lightning protection. Your grounding solution and protection will be only as good as the weakest link.

Many AC surge protectors are available to add to the AC panel to stop high voltage surges from racing through the home wiring in search of the perfect ground like your tower via your radio equipment. In all cases, the tower ground, station ground and the AC panel ground must be bonded together with at least a number 6 and preferably a number 2 solid copper wire.

### Which Surge Protector?

The RMS voltage /wattage rating on a RF surge protector are as follows: 100 watts =70 volts, 500 watts=158 volts, 1000 watts=223 volts, 1500 watts =273 volts and 3000 watts=387 volts. If the break down voltage is too low you will experience VSWR spikes on coax peak RF power. NextTek, ICS, PolyPhaser, Hubner+Suhner are some of the manufacturers of RF surge protectors. You have to choose the proper voltage surge protector for your working wattage.

Most rotor and controller line protectors can be a 35 volt MOV with a parallel .01 capacitor 100V from each DC line to a common ground. These can be bought commercially or you can make your own from over the counter components. These components can be bought from Digi-Key, Mouser, Allied and other distributors. Commercial units can be had from PolyPhaser, ICE and others.