AVOIDING EMP DAMAGE

Electromagnetic Pulse (EMP)is only a real threat from a nuclear explosion in space. It is standard military strategy to use such explosions prior to any nuclear attack, so we need to expect them. The severity of the potential damage is not fully documented at this time, but some damage definitely will occur. Most of all I expect all normal utility power to be damaged severely – blowing out all major transformers and relays. Here are some things that you should know to ensure that critical electronic equipment is not damaged.

1. A regular lightning arrestor reacts too slowly to protect against EMP. You need one that reacts within 2 nanoseconds. Look on the specifications labels on any power strip you buy. Some will match this standard. The Recommended Equipment and Sources section will list several manufacturers that have equipment you can install on your incoming power lines to add protection to your whole house. It's not cheap – several hundred dollars. These units will divert any power surge of high voltage that comes down your lines and shunt them to a large grounding rod. This shunt is a special switch which goes into operation when the voltage spike hits. It does not ground normal voltage (or you would never have any power).

2. All grounded appliances in your home that are UNPLUGGED may be partially protected since the metal chassis will absorb some of the EMP and feed it to ground (if grounded separately and not through the plug). But the plug cord lying out in the open still puts your equipment in jeopardy. The plug cord will act like an antenna, picking up all EMP.

3. Portable electrical equipment run by battery should be stored in a metal box, like a military ammo can with a tight seal. This is the cheapest way to make sure your radios will work when you need them. The EMP cannot penetrate a closed metal box.

4. Use steel shielding around sensitive operating equipment with coils, making sure it is well grounded. In dry climates, grounding rods should have water (mixed with some Epsom salts) poured down and around where they are driven into the earth every six months or a year to make sure they make good conductivity with the earth.

5. Disconnect large radio antennas at the unit unless actually in use. During a nuclear war, connect them only briefly to listen for news. Shelters in a steel-reinforced basement room will have some attenuating effects on electromagnetic waves, but not

enough to rely on. A quick and dirty test of a shelter's attenuating capability to is to turn on an FM receiver and see how well it picks up local FM stations within the shelter. Any significant reception ability of FM signals means you are not protected. Put the portable radio (while turned on with the volume up high) in a metal box and listen to the difference. It should stop broadcasting.

GROUNDING

I will cover house wiring grounding in the the Master Electrical System chapter, but will also cover grounding of equipment in this chapter so that it will give you the complete details on shelter equipment problems. Proper grounding is the most critical aspect of both lightning and EMP protection. Grounding provides a path for electrical currents to travel toward the earth, which is the ultimate destination of all electrical charges. Lightning has both high voltage and high current. EMP has low current but extremely high voltage, and more importantly, an extremely high and sharp voltage spike. This instantaneous rise time in the voltage spike for EMP is the key to why EMP is so dangerous to electronic components. The EMP voltage spike coming down the line can travel through most lightning protectors before they have a chance to react.

PolyPhaser's book, *The "Grounds" for Lightning and EMP Protection*, is probably the best on the market on grounding solutions. It is easy to understand and fairly nontechnical.

Voltage and current spikes are surges of electricity that exceed the capacity of the electrical components in your equipment. The most important thing to do is to keep these surges from entering your home. This is difficult to do when you have things like antennas whose very job is to attract the tiniest of electrical signals. If we are going to try to protect sensitive antennas during operations, that requires a highly sophisticated device that can distinguish between small signals and these big surges and then shut down the path before the surge can enter. This is very difficult.

You can see why it is much easier to protect equipment by disconnecting it from the feedlines and power sources. But it does help to provide a proper equipment ground and add protective devices to your installation. When lightning strikes, it will always try to find the shortest electrical path to ground. Unless you disconnect your station equipment, your antennas will be providing that best path to ground. To prevent lightning from using your feedlines it is best to disconnect them where the feedline from the antenna connects to your through-the-wall connectors. These connectors from outside are attached to surge protectors bolted to a big copper plate which has its own ground rod and is interconnected to other ground rods. So if you disconnect from this connector on the copper plate, the surge will go to ground and not to your equipment. If you disconnect your coax and leave it lying on the floor, close to where it is connected to your radios, lightning can jump a gap of several feet to the equipment. The lightning has already traveled a long way through the air and a few more feet of atmosphere won't stop what we call "side flash."

Proper grounding is critical to lightning and EMP protection. Lightning and EMP contain pulses in a wide range of frequencies, so you must provide a low impedance pathway that is capable of handling many different frequencies as well as high current.

One ground rod is usually not enough. If you only use one, you will have to run a lot of long, thick cables to connect all equipment to this single source. These long cables provide numerous opportunities to side flash to other equipment nearby.

Ground rods should be made out of solid copper, copper-clad steel, hot-dipped galvanized steel, or stainless steel. They usually come in lengths of at least 8 feet and are 1/2 inch around.

Copper strapping comes in a number of sizes, but a strap 1-1/2 inches wide and 0.051-inch thick is the minimum recommended for ground connections. A copper strap makes a better lightning and RF ground than a wire because of its lower inductance. The woven or braided kinds are most effective and easy to work with.

Bare copper wire should be used for buried ground wires – it is less subject to corrosion than woven cable. The size you should use depends on the length of the run. I usually use #4 or #6 awg (American Wire Gauge).

Antenna Towers

Your antenna and tower are the prime points of surge entrance, so proper tower grounding is important. The goal is to establish multiple paths to the earth ground at the tower so that the strike energy is divided and dissipated. To establish multiple current paths on a tower, connect each of the tower legs and all of the metal guy wires to separately-driven ground rods. The ground rods must not be closer than 6 feet from each other. Bond the tower ground rods together with a #6 awg or larger copper bonding conductor (forming a "ring" around the tower base). In addition, connect a continuous conductor between the tower "ring" ground and the bulkhead panel (that big copper or aluminum plate) at the entrance to your radio shack in the home. All connections should be made using connectors and fittings approved for grounding applications. Use bolt or crimp connectors but not solder alone. Solder can melt when lightning strikes. I will use it though if I also have a clamping connector. I have found that the wires don't corrode under the clamps if soldered first.

All grounding rods and wires around the home need to be connected electrically. This includes lightning rods, your electrical service ground from the utilities, your telephone, antenna system grounds, and underground metal piping. Ground rods used for lightning protection or entrance-panel grounding must be separate and spaced at least 6 feet from the electrical service or other utility ground so side flashes don't occur. The purpose of connecting all grounds is to make sure the entire system stays at the same voltage "potential." If you had a lot of separately-grounded equipment, one portion would have a different electrical charge than another during a surge and electricity could arc from one ground to another.

On antennas, ground the shield of the cable at the top of the tower as well as at the bottom. Several companies offer grounding blocks that make multiple ground connections easier. See the Recommended Equipment and Sources section.

Feedlines and Bulkheads

The feedline should also be grounded just before it enters the shack on a large grounded copper plate as previously described. Feedline lightning arrestors are available for both coax cable and balanced line. Most of the balanced line arrestors use a simple spark gap arrangement, but a balanced-line impulse suppresser is also available from several companies.

Arrestors for coaxial cable also come in several types. DC blocking-type arrestors have a fixed frequency range and must be selected for a specific application. You will use different types for antennas of different frequencies and different ones for solar panels as well. Their main advantage is that they present a high-impedance path to the frequencies found in lightning (less than 1 MHz) while offering a low impedance to signals created by your radio. This is very important so that the radio signals get through and the surges do not.

Arrestors that have DC continuity (the gas tube and spark gap types) are broadband and can be used over a wider frequency range of antennas than the DC-blocking types. In installations where the coax is used to supply voltages to a remote device (such as a mast-mounted preamp or remote coax switch), the DC continuity-type arrestor must be used.

Whether you use balanced line or coax arrestors, they should be mounted at the entry point to your shack – on what ham radio people call a "bulkhead." Install a 1/8-inch thick copper or aluminum sheet on the wall of your home where your radios are. Install a separate ground rod for this panel and connect it to the bulkhead with a short, copper strap. Also, bond this ground rod to the rest of the ground system. Then mount all protective surge arrestors, antenna switches and relay disconnects on the outside wall of the bulkhead. This makes sure they are all connected to a big ground rod so that surges won't enter the house.

Since disconnecting the equipment is the best protection, it is more convenient to install a feedline disconnect switch rather than unscrewing all your antenna connections every time (which wears them out). If you use a coaxial feedline, you can use a manual, multi-position coax switch, a remote coax switch or an in-line coaxial relay.

Surge Protectors

One area often neglected is power line protection. Inexpensive multi-outlet strips usually offer little or no protection against surges or transients unless the power strips are heavy duty and have quick reaction times. Check the label to make sure they react in *less than* two nanoseconds. Power line protectors use several different protection schemes, each of which solves a different power-line problem. Inrush current limiters keep the input current to the equipment's power supply from exceeding a fixed level. Transient suppressers (usually semiconductor-type devices) absorb voltage spikes that could damage sensitive digital IC's. Surge suppressers limit the input voltage on the line (usually by a clamping effect) to prevent damage. To protect your equipment against transients caused by lightning-induced voltage surges on the AC line, unplug the power strip at the wall socket. Don't depend on the built-in switch or wall-outlet switch. A nearby strike can induce voltage surges that will easily jump the gap and overload the protective circuits.