

Lightning Protection—Part 1

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Q: I haven't had any lightning problems yet. Why do I need protection?

A: When most hams think of lightning protection, they immediately think about ways to protect their station equipment. Although that is certainly important, you should have far more concern for the health and welfare of yourself and your family. Each year, lightning is responsible for the deaths of over 400 people in the US. Several hundred more suffer from injuries caused by lightning, such as burns, shock and other damage to the body's more vulnerable parts.

Q: How much of a threat do I face?

A: The number of local thunderstorm days per year in this country ranges from 1 to 100, depending on where you live. If you live in a location with a single thunderstorm day, that means that you have at least one opportunity for disaster to strike. The total number of strikes per year is more than 40 million. However impressive these statistics may seem, keep in mind that they do not include all lightning strikes. Lightning can occur even without a thunderstorm—whenever and wherever there is a sufficient charge build-up.

Many things are involved in determining the likelihood of a strike at your QTH. A brief list includes the type of structure, the materials it's made of, the location relative to other structures and so on. One way to gauge your level of risk is to go through the Risk Assessment guide found in the back of the National Fire Protection Association's Lightning Protection Code (see address below). This appendix contains an equation that you can use to determine your overall risk of being struck.

Other reasons for lightning protection include fire prevention and protection of sensitive electronic equipment. Property damage statistics indicate that lightning causes over 40 million dollars damage annually to buildings and equipment in the US.

In addition, your equipment can also be damaged by other electrical disturbances such as power line switching transients and voltage surges, as well as static build-up on outside wires and antennas.

Q: But I already have lightning protection. My station is grounded and I added a lightning arrestor to the coax.

A: Your situation is typical of many hams: a single copper rod driven into the earth as a station equipment ground and an in-line

coax lightning arrestor, often mounted in the shack at the operating position. For lightning protection this sort of installation is *not* adequate. It may even be an invitation to disaster.

Q: So what can I do?

A: Education is the key. Lightning protection is no different from any other complex technical problem; the more you know, the better you will be at making decisions about the protection you need. In this case, however, the local library may not have the information you are looking for. While most libraries have information on lightning as a natural phenomenon, only a few will have anything on lightning protection.

A good source for this information is PolyPhaser Corporation. Although this company is in the business of manufacturing lightning-protection devices, the information they offer on installations goes far beyond product promotion. PolyPhaser's book, "The Grounds for Lightning and EMP Protection," is second to none for comprehensive, easy-to-understand information on grounding systems for lightning. PolyPhaser also has a quarterly newsletter, *Striking News*, that has articles on lightning protection devices and techniques. The February and May 1994 issues of *Striking News* contain articles on Amateur Radio station protection. Complimentary copies of these issues are available from PolyPhaser.

Another good reference is the NFPA Lightning Protection Code (NFPA 780) that I mentioned earlier. In addition to the Risk Assessment Guide, this full-size booklet (44 pages) contains information on terminology, materials and techniques used for lightning protection systems. Bear in mind, however, that this guide is intended for use by professionals; local building codes may require that some parts of the installation be performed by professionals. As the code says, installations must be approved by the local authority having jurisdiction.

Q: Sounds like good information. Do you have any other sources?

A: I sure do! See the list of lightning protection information sources below.

Q: Once I've read all about lightning, what steps should I take first to add protection to my shack?

A: The most important thing to do is to keep lightning outside of your home. This includes disconnecting your equipment from the feedlines and power sources, providing a proper station ground and adding

protective devices to your installation.

As the *ARRL Antenna Book* states, "The best protection from lightning is to disconnect all antennas from equipment and disconnect all equipment from power lines." When lightning strikes, it will always try to find the shortest electrical path to ground. Unless you disconnect your station equipment, you're giving the strike a good return path—through your equipment!

The easiest way to remember to do this is to disconnect your station whenever you're not using it. To prevent lightning from using your feedlines as a sneak path into your shack, disconnect them outside. If you disconnect your coax and leave it lying on the floor, lightning can jump a gap of several feet to your grounded equipment. Remember that it has already traveled quite a distance through the air. A few more feet of atmosphere won't stop it (this phenomenon is known as a "side flash").

Install an entrance panel for your feedlines and control cables. Place the panel ground connection on the outside of your home. Don't attach it to an inside source such as the power company ground or a cold water pipe. This panel will provide a convenient disconnect point for your equipment, as well as a place to mount feedline and control cable transient protectors.

Q: I can do that. But what about my station ground system?

A: Proper grounding is critical to lightning protection. Lightning contains energy in a wide range of frequencies (which is why you can hear "static crashes" on an AM radio when a storm approaches). You must provide a low-impedance path to ground for the energy.

A single ground rod will not suffice as a lightning ground. The basic idea is to give the strike energy a place to dissipate. Given the number of station-configuration possibilities, there are too many different ground system requirements for me to detail here. The issues of *Striking News* that I mentioned earlier contain information on grounding ham installations.

Q: You also mentioned protective devices. Can you tell me more about those?

A: Products for lightning protection include feedline transient protectors, power line transient and surge protectors and transient protectors for rotor control boxes and telephone lines. Each of these devices is designed for a specific job and you should always select the correct product for each line you're trying to protect. I'll provide more details about these devices next time.

For now, you should be aware that the quality and type of products is critical for proper protection.

In the second installment of this two-part Lab Notes series, I'll discuss the techniques and products you can use to protect your home. In addition, I'll provide a list of manufacturers of lightning-protection products.

Thanks to ARRL Technical Adviser John Bittinger, KI7GW, for his assistance during the preparation of this column.

Lightning Protection Information

The *ARRL Antenna Book*

The *ARRL Handbook* (Electrical Safety chapter)

Striking News, February and May, 1994; "Ham Radio Station Protection"; PolyPhaser Corporation, PO Box 9000, Minden, NV 89423-9000


The "Grounds" for Lightning and EMP Protection; PolyPhaser Corporation

Lightning Protection Code (NFPA 780-1992); National Fire Protection Association, PO Box 9101, Quincy, MA 02269-9101

LPI Installation Code (LPI 175); Lightning Protection Institute, 3365 N. Arlington Hts Rd, Suite J, Arlington Heights, IL 60004.

Installation Requirements for Lightning Protection Systems (UL 96A); Underwriters Laboratories, 333-T Pfingsten Rd, Northbrook, IL 60062

National Electrical Code (NFPA 70-1993); National Fire Protection Association

Lightning and Lightning Protection; D. W. Consultants, Inc, State Route 625, PO Box D, Gainesville, VA 22065 

Lightning Protection—Part 2

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Q: I want to protect my station against lightning. What's the best way?

A: There is no single "best way." In this column, continuing where we left off in October, I'll describe products and methods for lightning control and tell you how they're applied in general terms. However, every amateur station is unique and there are no solutions that apply to *all* installations. You really need to consult the experts for specific applications.

Q: But how do I find an expert?

A: Start with your local government. Find out what building codes apply in your area and have someone explain the regulations about antenna installation and safety. I'll also list several companies that sell lightning-protection products. Some of these companies offer considerable help in determining how their products should be applied to a specific installation. The yellow pages of most telephone directories will provide a list of professional engineers, lightning protection suppliers and contractors who can give you advice and assistance. Contact your ARRL Section Manager or Technical Coordinator. They may be able to direct you to an ARRL Technical Advisor or other knowledgeable ham in your area.

Q: I'll do that, but I want to know more so I can talk to them intelligently. Where do I begin?

A: Before I get into the "how-to" part, we need to look at some of the more common materials used for lightning protection.

Grounding materials are available from a variety of sources. In addition to your local hamfest, check building-supply and electrical-supply stores. Ground rods should be either solid copper, copper-clad steel, hot-dipped galvanized steel or stainless steel. They shouldn't be smaller than 8 feet in length and 1/2 inch in diameter.

Copper strapping (or *flashing*) 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. On the other hand, it's more expensive and harder to find.

Bare copper should be used for buried ground wires. There are some exceptions for corrosive soil; an expert's advice may be required. Exposed runs above ground

that are subject to physical damage may require additional protection (a conduit) to meet code requirements. The size you should use depends on the application, but never use anything smaller than #6 AWG for bonding conductors. Your local lightning-protection experts or building inspectors can tell you what sizes you should use for each application.

Q: Okay, I know what to look for. Now what do I do with all this stuff?

A: Start with your tower and antennas. Because a tower is usually the highest metal object on the property, it becomes the most likely target for a strike. Proper tower grounding is essential to lightning protection. The goal is to establish multiple paths to 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 bonding conductor between the tower "ring" ground and the bulkhead panel at the entrance to your home. All connections should be made using connectors and fittings approved for grounding applications. **Do not use solder for these connections.** Solder connections will be destroyed by the heat of a lightning strike.

Unless the tower is being used as a shunt-fed antenna, grounded metal guys should always be used. If the tower is a crank-up or telescoping type, be sure to add a strap jumper at the junction of each section to keep the resistance low. Because galvanized steel (which has a zinc coating) reacts with copper when combined with moisture, stainless steel hardware should be used between the galvanized metal and the copper grounding materials.

All grounding media at the home must be bonded together. This includes lightning-protection conductors, your electrical service, telephone, antenna system grounds and underground metal piping. Any 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.

Q: If the strike energy takes several paths to ground, doesn't it follow the feed line as well?

A: Yes, it sure does! To prevent the strike

energy from entering the shack via your feed line, you must ground the feed line *outside* your home. The portion of the coax that runs down the tower should also be grounded to the tower to keep the tower and line at the same potential. This helps prevent the *side-flash* phenomenon mentioned in Part 1 of this series. Ground the coax at the top of the tower and at the lowest point on the tower (just before it's routed to the shack). Several companies offer grounding blocks that make this job easy. PolyPhaser offers a coax-grounding kit that uses straps instead of blocks. The straps can easily accommodate many different coax sizes.

The feed line should also be grounded just before it enters the shack. You can do this with an in-line arresistor mounted on an entrance panel. We'll discuss this in a moment.

Q: Is there anything else I should know about feed lines?

A: Most lightning-protection schemes have one goal in mind: Controlling the flow of the energy in a strike. The energy is most dangerous when it goes in unintended or unexpected directions. To avoid a surprise, you must eliminate any possible paths for surges to enter the building. This involves routing the feed lines, rotator control cables, and so on at least 6 feet away from other nearby grounded metal objects.

Q: What about the lightning arrestors that I see advertised?

A: They are another important part of your protection plan. Feed-line 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* suppressor is available from ICE (see their address at the end of this column).

Arrestors for coaxial cable also come in several types, each of which functions somewhat differently. DC blocking-type arrestors have a fixed frequency range and must be selected for a specific application. 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.

Arrestors that have dc continuity (the gas tube and spark gap types) are broadband and can be used over a wider frequency range than the dc-blocking types. Also, in installations where the coax is also 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 the *outside* of the building—using a secure grounding connection. The easiest way to do this is to install a large metal (preferably copper) enclosure as a bulkhead and grounding block. This bulkhead serves as your last line of defense by keeping the lightning energy from entering your home, so it's critical that it be installed properly. You can homebrew a bulkhead panel from 1/8-inch copper sheet, bent into a box shape. Position the bulkhead on the building exterior, 4 to 6 inches (minimum) away from nearby combustible materials. Install a separate ground rod for this panel and connect it to the bulkhead with a short, direct connection. Also, bond this ground rod to the rest of the ground system. Mount all protective devices, switches and relay disconnects on the outside wall of the bulkhead.

Q: What about my rotator control lines?

A: You'll find multi-wire surge suppressors for these and other wires leading to your antenna system. They are available from a number of manufacturers, including ICE and PolyPhaser. As with the feed-line arrestors, these should be mounted on the grounded entrance panel.

Q: Can I do anything else to keep a strike from reaching my equipment?

A: The only foolproof way to protect your station equipment is to completely disconnect each item from the antenna system and the wall outlets when you're not operating. Even when you're on the air, however, you could encounter the rare "bolt from the blue."

Let's admit it; we sometimes forget to disconnect our station before we go off to our other activities. Don't let the lack of a thunderstorm forecast lull you into a sense of false security. Although lightning usually occurs during summer thunderstorms, it has also been known to strike during winter storms—and even when there are no storms at all. The strike that comes before the first clap of thunder may be the one that hits your station.

Q: Is there an easy way to disconnect my setup?

A: A quick, convenient way to disconnect your feed lines is through a feed-line switch. If you're using a coaxial feed line, you can use a manual, multiposition coax switch, a remote coax switch or an in-line coaxial relay.

Although you could also simply disconnect your coax by hand, it's awkward and the connectors will become worn after repeated connecting and disconnecting. Some coax switches also contain lightning arrestors.

For open wire or ladder line, you could install a knife switch or electrically operated remote 2-pole relay. Whichever method you choose, be sure to mount the switch on the *outside* of your entrance panel.

Q: Is there anything else I should do to protect my equipment?

A: One area often neglected is power line protection. Inexpensive multioutlet strips usually have little or no protection against surges or transients. Sensitive electronic equipment (modern digital radios, TNCs, computers, etc) sometimes need more protection than the factory provides.

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 suppressors* (usually semiconductor-type devices) absorb voltage spikes that could damage sensitive digital ICs. *Surge suppressors* limit the input voltage on the line (usually by a clamping or "crowbar" method) 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 voltages that will easily jump the gap and overload the protective circuits.

Q: Now what about that list of manufacturers?

A: As promised, here they are:

Alpha Delta Communications
PO Box 620
Manchester, KY 40962
tel 606-598-2029

Note: Coax lightning arrestors, coax switches with surge protectors

Ameritron
921 Louisville Road
Starkville, MS 39759
tel 601-323-8211

Note: Remote coax switches, inrush ac current protector

Certified Quality (The Wireman)
261 Pittman Rd
Landrum, SC 29356
tel 800-727-9473 (orders)
803-895-4195 (Tech line)

Note: The Wireman stocks copper wire up to #4 AWG, 2-inch flat copper strap, 8-foot copper-clad ground rod and 1x1/4 inch bus bar.

Cushcraft Corporation
48 Perimeter Rd
Manchester, NH 03108
tel 603-627-7887

Note: Coax lightning arrestors

Industrial Communication Engineers,
Ltd.

PO Box 18495
Indianapolis, IN 46218-0495
tel 317-545-5412
fax 317-545-9645

Note: Coax lightning arrestors

Lightning and Noise Protectors
PO Box 380054
Birmingham, AL 35238-0054
tel 800-776-8357

MFJ Enterprises
Box 494
Mississippi State, MS 39672
Note: Model 1704 coax switch with lightning arrestor

PolyPhaser Corporation
PO Box 9000
Minden, NV 89423-9000
tel 702-782-2511
Note: Many lightning protection products for feed lines, towers, equipment, etc

Radioware Corporation
87 Belmont Street
North Andover, MA 01845
tel 800-950-9273
Note: Amateur products distributor; Radioware stocks grounding blocks, other grounding products and many ICE products

Rohn
PO Box 2000
Peoria, IL 61656
tel: 309-697-5612
Note: Copper strap and other tower grounding products

Zero Surge Inc
944 State Route 12
Frenchtown, NJ 08825
tel 908-996-7700
Note: Power line surge protector

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We welcome your suggestions for topics to be discussed in *Lab Notes*, but we are unable to answer individual questions. Please send your comments or suggestions to: *Lab Notes*, ARRL, 225 Main St, Newington, CT 06111. 