Lightning Protection for Your Repeater System

You've invested considerable time and money in your repeater system, and we all want it to continue working forever. It probably will, *if* you keep "Old Man Lightning" away.

We'll look at what lightning is, how it can enter a repeater system and how to keep it out, some approaches to minimizing damage, and insurance policies which can cover the cost of damage that can't be avoided.

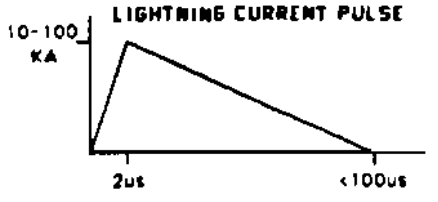
The extent of protection you provide should be based on the amount of investment in your equipment, the frequency of thunderstorm activity in your area, and the level of reliability you want to achieve from your system. But in any case, protection for your equipment will pay in the long run!

Lightning – Free Electricity

Lightning is a cloud-to-cloud, cloud-to-ground, or even ground-to-cloud electrical discharge. Frontal type thunderstorms result in larger strokes, and more strokes to ground, than convection thunderstorms. The southeastern U.S. and portions of the midwest have the greatest incidence of destructive storms. But virtually every area of the country is susceptible to thunderstorms, and being at a high elevation (i.e., at a repeater site) obviously increases the odds of damage.

The actual stroke, or discharge to ground, is equivalent to a current source of magnitude up to a hundred thousand amperes. The current pulse has a typical rise time of 2 microseconds and a decay time of around 40 us. The fast rate of rise of the pulse contributes to its destructive power, since even just a small portion of the stroke traveling through a small inductance can generate large voltage potentials. But its speed also helps make it easier to tame.

Direct hits are rare – the greatest likelihood for damage are near misses and surges induced in power and telephone lines.



Keep Out

The first goal is to *keep destructive lightning current out* of your equipment. The second goal is to make it *easy to exit* if it does enter.

The likely entry points into your system include (most obviously) the antenna, the phone line, and the ac power line. Attention should be paid to each of these potential entry points, but the key to any form of protection is grounding.

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Lightning Protection

Ground It Out

A good ground must be low resistance, and because of the lightning stroke's fast rise time, must be *low inductance*. The good ground is the essential first step, since it provides a non-destructive discharge path for lightning currents that we intend to keep out of our equipment.

The extent of the grounding system needed depends on the resistivity of the soil, and generally more than one ground rod is required to achieve a "good" ground. Several shorter rods, interconnected with bare buried wire, will have a lower impedance than one longer rod. Radials can reduce the impedance further in rocky or sandy earth.

Your earth ground, equipment ground, telephone company, and power company grounds *must* be interconnected properly to prevent large differential voltages from appearing between them due to ground surge currents. Each ground may be connected by a separate line to every other ground, or a "ring" closed loop may surround the installation. The interconnections should be large (#8) solid wire – not braid or stranded wire. The strands eventually oxidize and corrode, and with their many twists become highly inductive. Metals should be similar – copper should never touch steel.

With a good ground system, we can proceed to keeping the lightning current out of the equipment.

The Antenna – The Unwanted Lightning Rod

Since the antenna is the highest point at the installation, it's the most likely entry path. Grounded towers, DC grounded antennas bonded to the tower, and lightning rods are important. The transmission line should run along the tower to the base, then loop before entering the building.

A coaxial impulse suppressor should be mounted at the grounded tower leg or grounded bulkhead panel – not at the equipment. The feedline should wind its way with as many bends as possible to the transmitter.

The Phone Line

The telephone lines are subject to direct hits, as well as induced transients from nearby lightning activity. Although the telephone company usually installs some form of lightning protection, it should not be relied upon.

The best form of protection is a three terminal gas tube which limits differential voltages (between the two conductors) as well as voltage to ground. When the gas ionizes, it provides a simultaneous path to ground for both conductors. Other types of protectors, such as a pair of MOVs to ground, aren't as effective. Since each MOV has a slightly different turnon time, a common mode transient will appear as a full differential signal for a period of time, which can cause *more* damage than if no MOVs were installed.

The telephone cord from the protector to the equipment can be coiled or tied in knots to increase its inductance and help impede the transient.

Power Supply

Another entry point for damaging transients is through the power line. ACC's controllers operate from an external twelve volt supply. Because the available supply is regulated, you may feel that it's regulated from transients on the ac line. *It is not!* A typical supply *will* pass high frequency components of an impulse from the ac line.

A site may be otherwise well engineered, but if your site neighbors protect their equipment from line surges and you don't, you may be the only one to suffer damage.

The MOS large scale integrated circuits used in modern computer based equipment, such as our controllers, are more susceptible to damage from transients than rugged rf transistors in your transmitter and receiver. The best protection is a transient protector which mounts at the fuse box. A variety of surge protectors which plug into the wall are available which are intended for use with small computers and will provide some level of protection. A transient suppressor may be added at the DC output of the power supply to help limit relatively low energy pulses.

Protection Devices

A variety of technologies are available, ranging from semiconductors, to gas discharge tubes, to simple inductance. Zener diodes can offer a low level of protection, limited by their turnon speed and energy absorbing capability. A better device is the TransZorb (General Semiconductor) which is similar to a Zener but optimized for surge protection.

MOVs (metal oxide varistors) are effective for higher voltages, but are slower and allow a high peak voltage to result, relative to their rated clamp voltage. Gas discharge devices are also effective for high voltage applications (such as telephone line protection), and can handle very high transient currents. They're particularly effective for phone line use since they provide both excellent common mode and differential mode protection.

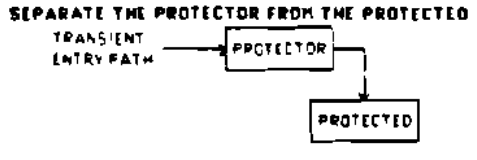
None of these devices *by themselves* offer complete protection for sensitive components at a typical repeater site. A well-engineered protector combines several technologies and must be applied properly in the system.

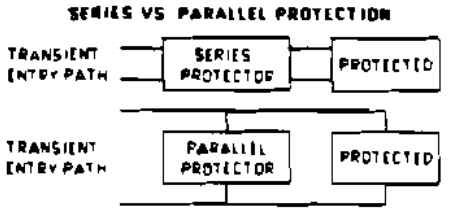
Important Guidelines

The protector should be separated from the protected. Keep the transient energy *away* from the sensitive circuits. Provide the protection well away from the equipment being protected – not inside it.

Separate the exposed wires from the protected wires. Run the input and output lines from the protector with as much separation as possible, and preferably at right angles.

A "series" protector will provide considerably greater protection than a "parallel" protector. A protection device installed across the equipment (like a TransZorb) will obviously only *share* the transient with the equipment. A series protector will prevent the transient from *reaching* the equipment.





Protection Inside ACC Controllers

ACC's RC-850 and RC-85 Repeater Controllers include built-in protection from transients due to lightning. As we've seen, this built-in protection should be considered as a last resort safeguard only and should not be viewed as a substitute for following the principles discussed above.

Each controller has at least one TransZorb protector across the twelve volt power supply input. This device protects against relatively low energy surges reaching the controller from the power supply.

The RC-85 controller and the RC-850 controller with the TP-3 Telephone Interface Board include a three terminal gas-discharge tube installed across the phone line. The RC-85 controller returns the tube's third terminal to the power connector ground. The RC-850 controller TP-3 board takes the third terminal to a separate terminal block connector – it should be wired directly to the main ground system.

Insurance

Assuming reasonable precautions are taken to prevent damage, insurance is a viable option to protect against unavoidable damage. Some homeowner's policies cover the cost of repair or replacement of equipment damaged by lightning – check your policy.

The best value appears to be available to ARRL Members, with the "All-Risk" Ham Radio Equipment Insurance Program. At a cost of only 1% of the equipment value per year (plus a $5 administrative fee), the insurance covers virtually all forms of loss, including lightning damage. For $5000 worth of repeater equipment, that's just $55 per year. If you're not an ARRL member, their insurance program is a good reason to join.

Bottom Line

For a high level of protection we'd suggest the LEA TET-200-100 device on the phone line, the LEA SE-115-10-BF on the ac power line, and a PolyPhaser coaxial impulse suppressor appropriate to your frequency and power level. Devices from the manufacturers listed below, and others, may also provide effective levels of protection.

Sources for Protection Equipment

Lightning Elimination Associates
12516 Lakeland Road
Sante Fe Springs, CA 90670
(213) 944-0916
(power line and phone line protectors)

Joslyn Electric Systems
P.O. Box 817
Goleta, CA 93116
(3 terminal gas tube phone line protectors)

Decibel Products, Inc.
3184 Quebec
Dallas, TX 75247
(214) 631-0310
(coaxial impulse suppressors)

PolyPhaser Corporation
1420 Industrial Way \ P.O. Box 1237
Gardnerville, NV 89410
(coaxial impulse suppressors)

References

This writeup is based on information condensed from the publications listed below. It is intended as an introduction to the subject. We encourage you to write the companies for the literature mentioned below. We also thank Doug Zastrow, WBØUPJ and John Williams, K8JW for their ideas and suggestions.

"About Lightning", Decibel Products, Inc.
"Impulse Protection", PolyPhaser Corporation
"Protection Requirements and Concepts for Data and Control Lines", Lightning Elimination Associates
"Lightning" Newsletter, Quintron Corp., 13 B Commercial Dr., Quincy, IL 62301