

Lightning Protection for Comrex Equipment

Lightning protection is not an exact science: You can follow all the rules and still lose equipment in a severe storm. This paper attempts to separate the desired protection practices from folklore and marketing hype. Please use it as a starting point to analyze your installation and experience at that location.

Lightning discharges happen over a path with a large potential difference. For those of us not living in the clouds, that usually means from clouds to ground. Tremendous currents flow in a lightning discharge, and we are more likely to be concerned with the voltage it induces in nearby conductors than in avoiding the primary strike. In all cases, your goal is to direct the surge from the lightning hit off to ground away from your equipment, probably in another part of the building. Professional audio gear may have a metal case and a 3-wire power cord for electrical shock safety and electronic noise purposes, but if that big spike is allowed to find a ground path through your gear, then the solid-state circuitry will likely be affected. We encourage you to develop separate audio and surge ground paths, even though they may eventually come together at a ground rod or similar system.

In repairing lightning damage to our equipment, we find three typical paths:

- Through the telephone line.
- Through the audio wiring.
- Through the power line.

Telephone line paths typically mean damage to modems and interface (DAA) modules, with possible jumps into digital control circuitry. Audio wiring surges account for more than 50% of our “zapped equipment” repairs, and frequently take out the active-balanced input and output chips. Some of those surges do more damage through an analog section, and may cross into DSP and control circuitry. Power line surge effects seem to be less common in our equipment, but they seem to target the sometime dense digital control sections of circuit boards. Of these three categories, the audio paths are most under your control, and we will offer some tips about shielding and routing of long wiring runs. Power line surge protection is routinely done these days to protect computer equipment, and may already be in place at your location. Advice on that subject is best obtained from the “pros” in that field. So let’s start with telephone lines:

Telephone Line Surge Protection

“Telephone lines” include POTS dial lines, DSL lines, ISDN lines and dedicated data circuits. Traditionally, these things are provided by your telephone company, and represent wires from your building to the telephone company office in your community. The lines may not go that far these days, perhaps only to a cabinet on a nearby street. The telephone company is primarily concerned about two types of surges:

- Lightning-induced surges from nearby strikes.
- Cross-connection surges caused by power lines coming in contact with telephone lines.

Notice that we did not mention direct lightning hits to telephone lines! First, they aren't as common as nearby hits. Second, there's no reasonable way to prevent catastrophic damage in such events. Most lightning surges on phone lines are the result of strikes to power lines (higher up on poles) or other metallic conductors. Crosses between telephone and power conductors are less common than they used to be back in the days of un-insulated wire, but they do sometimes happen when utility poles come down, or wiring is exposed to fires or floods.

Most telephone circuits involve a pair of wires, with the signals being carried between the wires. No ground connection is used at either end. If one side of the line were to be grounded, you would hear hum and other noises on a voice line, or data would be corrupted by noise on a digital line. Keeping those pairs of wires balanced with respect to ground is very important to the telephone guys. But in the case of a voltage surge well in excess of the normal voltages on the line, some means should be provided to temporarily shunt it off to ground. This is the job of the surge arrestor that the phone company places on each end of their lines. That arrestor may also limit the amount of voltage between wires, which is a consideration in the case of a power line cross.

The telephone company does several things to mitigate the effect of electrical surges:

- They provide surge arrestors from each of their wires to ground at both ends of a circuit.
- The available grounds at their central office, intermediate cabinets and at the entry point to your building are made as low resistance as economically possible.
- Much of their above and underground wiring has an overall metallic shield, which is grounded at intervals.

These things all form what is called *primary surge protection*, and are mostly out of your control as a user. Your only obligation is to make sure that their safety ground is not disturbed by you or any contractors working around the telephone terminations at your building. **If you are having problems with lightning surges on phone lines, start by checking that ground!** If you are in an old building, it may have been made to water piping with threaded connections, or pipes that now connect to plastic pipe underground. You need to check that the ground for the telephone company's protectors is bonded well to the electrical grounds in your building. Those grounds almost always involve ground rods, and may or may not tie back to the plumbing system. If there is significant resistance between the electrical and telephone grounds, then you may have found the culprit.

The primary surge arrestors provided by your telephone company are probably gas-tube devices that flash over and conduct when the voltage across them reaches several hundred volts. They are designed to take repeated hits, and should last for many years. But if you have had a big-time lightning hit near your building, it is possible that they may have been damaged, and should be checked by the telephone company. It may cost you the price of a service call, but it might be money well spent. Older types of telephone surge arrestors involved carbon blocks or other carbon devices. They require frequent attention or replacement in a lightning-prone area, and should be replaced. Most U.S.

telephone companies have completed programs of replacing them, but it's worth asking if you have having troubles.

This being the 21st century, many of you no longer get your phone lines on individual pairs from the traditional phone company. You may instead be working from a high-speed data circuit (T1 or E1), with the individual phone lines being broken out right in your building. You have to keep your hands off of the data circuit! It's the phone company's job to install and maintain surge protection on such things. The best you can do is see that proper grounding is done, and possibly install the secondary protection mentioned below. If your lines from the demultiplexing equipment are short, you may not need to do anything at all.

On the theory that if one thing is good, then two must be better, let's talk about *secondary surge protection*. You should consider installing your own telephone line surge suppressors, especially if you have already had trouble at your location. Such devices are usually placed closer to your equipment, and are an absolute necessity if you have multiple buildings or very long cable runs. The major function of a secondary arrestor is the same as for a primary: to shunt surges on any conductor off to ground. Again, you must use a good quality ground that is well bonded to your electrical ground. The location of the protectors may be dictated as much by the availability of a good ground path as by the location of the equipment. If your telephone lines come into a cellar, and then route to a distribution room, add secondary protection in the distribution room and provide a good heavy wire or strap ground path back to the power ground. While the cases of rack-mounted equipment are usually grounded through the (steel) rack, don't depend on that path for surge protection. Make sure that any surge protectors have a ground path that doesn't go *through your equipment or its normal audio grounds!*

The secondary arrestor may also provide protection across the line. Since Comrex equipment already has such "differential" protection, that is less critical than providing the surge path to ground.

What to buy for a secondary surge arrestor? First, nothing without a decent ground terminal should even be considered. This rules out a lot of the "bubble pack" stuff on the consumer market. We suggest looking at telephone surge protectors through telephone or electrical distributors. Graybar Electric carries a wide range of such items. You can find protectors with individual RJ-11 jacks, with screw terminals, with punch-down terminals, and so forth. There are also plug-in surge arrestors made to fit in the center of split "66" style blocks. Use what applies to your wiring situation. One tip: We have not found a commercially available telephone surge protector that works directly with the RJ-45 line arrangement on the Comrex STAC system. While there are "Cat 5" arrestors on the market, they are designed for the lower voltages in a computer network, and will affect ringing and other signaling on a telephone line.

Here are some links to sources for secondary telephone line surge protectors:

Graybar Electric: <http://www.graybar.com/>

Porta Systems: <http://www.portasystems.com/>

Mike Sandman's products: <http://www.sandman.com/surge.html>

Citel Protection: <http://www.citelprotection.com/>

ITW Linx: <http://www.itwlinx.com/home/default.asp>

Burke Technology TS-1: http://www.burk.com/products/ds/ts1_ds.pdf

If you have a large facility, particularly one with multiple buildings, you should consider the wiring practices for your telephone lines. Long cable runs should be shielded. Well-grounded conduit can provide good shielding in the case of nearby lightning strikes. PVC conduit is obviously useless for that purpose, and if it must be used underground, some other means must be provided to shield the telephone wiring.

Audio Wiring Surge Protection

Lightning damage due to surges in audio wiring is fairly common in broadcast facilities. If you are having such troubles, look first to your wiring and grounding practices. Don't depend on 12 or 14 gauge power wiring to provide grounds between rooms. Studio and distribution room grounds should be bonded together with copper strap or large diameter wire. Keeping audio equipment with active balanced inputs and outputs properly grounded is very important not only for surge protection, but for audio noise.

You may need to shield all of your audio wiring. Cable shields should be grounded at one end, and you may have to do additional grounding in some environments. The trade-off in grounding both ends of an audio cable shield is that you may create noise from ground loops. The better the bonding between room grounds, however, the lower the noise will be. Consider doing runs between rooms in well-grounded metal conduit. Cable runs between buildings are troublesome. As noted above, you must try to shield the wiring, and keep equipment throughout the facility at the same ground potential.

Good audio transformers are not cheap, but they may be advisable on lines in lightning-prone areas such as transmitter/tower sites. Jensen Transformers (<http://www.jensen-transformers.com>) is an excellent source of new high-quality audio transformers. Don't overlook the old Western Electric "111C" coils or UTC "Linear Standard" transformers which can sometimes be found in closets or at ham radio flea markets.

The lower voltage surge protectors available for data lines could be useful for protecting balanced audio wiring in difficult environments. Consider using such suppressors if wiring is run between buildings, or near ground paths that might take a big "hit" in a thunderstorm.

Buildings and Towers

You may find this amusing, but it's true: Many of our lightning-damage repairs come from churches! It's not so strange, when you think about it. Church steeples are well-known targets for thunderstorms. Most seem to be equipped with some form of lightning protection, usually a heavy copper cable running a long distance to ground. That's fine, but there can be some pretty intense magnetic fields around that cable during a lightning

hit. Operators of broadcast-type equipment in such buildings should consider keeping their audio and telephone wiring shielded. It might also be worth talking with a lightning protection company about providing multiple paths from the steeple to ground.

Broadcast stations frequently have towers close to buildings with Comrex or similar equipment. If the gear inside the building is frequently being damaged, you may need to re-evaluate the ground discharge paths from the tower, or perhaps look into a dissipation arrangement at the top of the tower. We have no particular advice here, other than the observation that you should avoid single-point grounds. That's no trouble for an AM broadcast tower, which has a radial ground system, but is frequently overlooked at FM sites. Consider doing a simple buried-wire radial ground system to spread the discharge over a wider area.