

Some thoughts on Lightning Protection

By Jon Shea

Protection For Computers, Modems and Telephone Equipment

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Sensitive electronic equipment such as computers, modems and electronic telephone equipment (now including most phone sets) are in need of protection against lightning and power surges.

We basically suggest three lines of defense to avoid damage to this kind of equipment:

- 1) Telephone line arrestors for use outdoors, grounded at the point of entrance to buildings;
- 2) Power line grounding (or negative side of solar system), with surge protectors, all tied together and to equipment grounds where possible;
- 3) Telephone line fuses and protectors (Polyswitch 150 mA, 600 V and Sidactor P2703AB) at the modem or fax, with center of Sidactor ground tied to equipment.

A fourth level tried in one location only is an in-line RS-232 modem cable protector using ten P0300EA70 Sidactors (27 V), one on each line to ground.

ROUTING AND SWITCHING PHONE LINES

Telephone lines entering the premises should be routed so you can install protection right at the entrance before the lines go into the building. For lines serving a modem (for data transfer such as Internet or email connections), the phone line should generally go as directly as possible and not be connected to extensions or other telephone sets and equipment while being used for data transfer. A switch might be installed so other extensions or equipment can be disconnected during a data transfer "connection". This is good for protection but also because the less "stuff" hanging on the line the better accuracy it can deliver to the modem during data transfer. It doesn't seem critical to have "nothing else" attached, but every advantage has to help.

PROTECTIVE DEVICES

The protective device used at the entrance of phone lines to the premises are either "gas" or "solid-state" arrestors. We recommend a standard protector used by telephone companies in the USA such as provided by Reliable Electric (RELTEC, Franklin Park IL), Description R356T, Part No. FF001082.

They are marked only "R356T". In use, each wire of the telephone pair goes by one of the two screw terminals on the protector and its center lug is grounded. The actual device may be an MOV (Metal Oxide Varistor, otherwise called ZNR, Zinc-oxide Non-linear Resistor), having a negative resistance curve during voltage surges. They seem robust, as far as I know we haven't lost one of several dozens in use over many years.

Some phone companies install these or similar protectors, or at least the housing for such a device, but may not install the device itself (nothing inside!). Or they may not provide a ground wire and ground rod to take the surge to earth! If the device is present and grounded to earth, you may feel fairly secure with your protection at the entrance. "Gas" protectors (which are usually in a glass or ceramic tube or button) are not as fast as MOVs/ZNRs. However they are a great improvement on nothing.

With electronic telephone sets now the norm it is necessary that some protection be provided to protect such vulnerable equipment.

Does it work? Well, we lost an electronic phone set about four years ago (no protection had been installed) but since installing R356T type protectors at our line entrances and adding several phone sets and a fax machine to our vulnerable equipment we have (so far) not lost any equipment to lightning. Another operation that did not have such protection either lost their fax machine at least three times to lightning; but after having them install an R356T-type protector four years ago they haven't had any damage at all. A modem on another (unprotected) line in the same building got it, though. Even with protection installed, if a storm comes up while we're around we unplug things to be on the safe side, and we routinely unplug our phone at night in lightning season.

If you have long phone lines between buildings you may want to add an R356T to each end of lines where they enter buildings. With long lines exposed, magnetic induction can pick up a heavy "kick" from a nearby lightning bolt. The ground lugs for these protectors and any additional equipment and other line protectors should be tied to the same ground system consisting of two or three good copper-clad ground rods spaced about three meters apart. It seems the more equipment you can ground together with the fattest ground wires or copper strap, the better. More on the ground rod system below.

ADDITIONAL PHONE LINE PROTECTION AT THE MODEM, FAX OR PHONE SET

We are now using two new devices which may require an electronic technician to install. These are Sidactors (small devices in a TO-220 package) and Polyswitches (resettable fuses). These are even faster-reacting than the MOV/ZNR protector (on the order of <1 nanosecond instead of 1 to 50 nsec) and are becoming widely used for protection of data/phone lines right at vulnerable equipment such as telephone switches (exchanges), modems and fax machines. Sidactors may not stand the gaff that the R356Ts can take at the ends of long lines, but they have got to be the best right close

by modems, faxes and phones. The grounding terminal of the Sidactor must be connected to the grounded equipment and, if provided the power surge protector ground.

The Polyswitches are connected in series with the phone line to "open up" if a high current tries to get through. The wiring drawing is available where you received these instructions and the devices are available from DigiKey or other electronics suppliers.

GROUNDING PRINCIPLES -- WHAT IS THE POINT?

A grounding system that ties all the power and telephone line protectors and equipment together at the equipment itself in effect "bundles" all the lines running to your equipment, computer or modem tightly together. Like a low door makes tall people stoop to enter, protection prevents surges on any line from straying more than a hundred or so volts away from normal. Most equipment connections are expected to stand that, but not surges of five-hundred volts or much-higher spikes that can come shooting down lines when lightning strikes even a mile or more away.

Grounding stuff together is little different from bolting all your car pieces to one chassis so that when you hit a bump not much falls off. The "G's" that shake the paste out of the plates of a car battery are greatly reduced by tightly clamping the battery to the mass of the car; a loose battery rattling around jars it worse and it won't last long. Grounding is like tying to a mass (which is exactly how the French describe it, *relier a la masse*).

GROUND RODS AND CABLES

To make an actual connection to the earth, ground rods at least one meter long (preferably two meters or more) must be driven into the earth outside the building, preferably just beneath the point where your telephone lines enter the building and protectors are installed. Also ground rods are located near your power distribution or fuse-boxes. The protectors and power distribution boxes are connected to the ground rods by heavy copper cables or straps which are clamped to the ground rods. If a ground rod is loose in the ground, it is not of any value and must be driven in another place or driven deeper.

If the earth is poor or rocky, several ground rods may be needed, all connected together. They should be spaced a minimum of three meters apart. The farther apart, the better. Suitable ground rods and copper cables are usually available at good hardware stores anywhere. Rods should be at least one meter, preferably two meters long, and copper-clad (not just copper plated) steel. Galvanized water pipe is not nearly as good but is still far and away better than nothing if the wires are solidly connected.

The cables must be at least 7 mm diameter or more and must be securely clamped to the rods.

SALTING THE GROUND RODS

An additional practice seen more frequently in the last ten years is the use of hollow ground rods with holes in them. Salt solutions (saline or copper sulfate) are poured inside to infuse the earth around the ground rod. This creates a large, conductive cylinder around the ground rod, increasing its effectiveness many times. An approach which is more practical than finding hollow, perforated ground rods and just as effective is to use ordinary ground rods and accompany each one with a perforated 20 mm (1/2" nominal) plastic pipe located about 15 cm away and parallel to it. With sufficient saltwater infused, this will create the column of wet earth all around the ground rod.

Twice or thrice a year, depending on the amount of rainfall, these perforated applicators are "dosed" with salt solution which multiplies the ground conductance mightily. As lightning storms frequently arrive before heavy rains, when the ground is also the driest, early and again late dry season is a good time to pour six or more liters (a couple of gallons) down beside each ground rod. We use a large funnel fitted to a one-meter pipe extension so we can really force the stuff down into the length of perforated pipe.

POWER SYSTEM PROTECTION

Power surges, noticed as brightening or dimming of the lights, can do great damage. This can be caused by poor generating equipment, poor distribution wiring, poor house wiring or heavy industrial equipment in use nearby. Of course you may not notice equally damaging "spikes" on your lines, caused by heavy industrial equipment and power-line switching. However, lightning generally remains the worst threat around to electronic equipment.

Proper grounding with good ground rods, thick cable and tough connections make huge improvements in the life of equipment in offices and homes. It can reduce damage to appliances, radios and similar sensitive gear otherwise lost to surges or lightning.

For effective protection of incoming power lines, heavy MOV protectors are needed. These can be obtained from large electronics or electrical supply houses for either 220/380 volt lines or 120/240 volt lines. These are big enough to pop a fuse or breaker if a spike over the prescribed voltage (typically 270 or 150 VAC) comes hurtling along. The MOVs are pretty expensive, can cost \$25-\$50 apiece, and last a long time, though they might sacrifice themselves if the blip was a bit large. The expense of these MOVs may be justified if they are protecting thousands of dollars of equipment concentrated in one or two rooms such as a computer network or lab, or radio production studio.

The main thing everyone can assure is that you use surge protectors and that your ground wires (the third wire in your wall receptacles) are really there. These ground wires must also be well-grounded to earth, perhaps in more than one place around the building or even a place or two under major receptacles or feeds around the computer room in addition to the distribution box in the building. The very shortest path to earth is what will afford the best protection. A small ground wire running up into the attic and all over creation with multiple sharp corners is about like a piece of rope! Use heavy wire, go

direct to ground, avoid sharp corners. (These three practices are to reduce "inductance" that prevents the sharp lightning stroke from getting to ground.)

Further information on the Reltec device: RELTEC R356T (solid-state) phone line protector electrical specs.

DC Breakdown voltage (1mA) minimum 200V

AC Breakdown voltage (60Hz) maximum 265v

Impulse breakdown voltage:

< 350v @ 100v/us

< 350v @ 1Kv/us

DC Holdover:

< 30ms maximum with 25A (10x1000us) surge

@ 260mA and +/- 52vdc

@ 200mA and +/- 135vdc

@ 140mA and +/- 150vdc

Service life:

10A for 1s; 10 surges, 60Hz, 480v

+/- 10A (10x1000us), unlimited > 3000 surges

+/- 100A (10x1000us), unlimited >3000 surges

+/- 10,000A (8 x 20us), fail-safe

Power Cross Operation:

Fail-safe 5A for 15 minutes

Fail-safe 10A for 15 minutes

Fail-safe 30A for 15 minutes

Fail-safe 60A for 3 seconds

Fail-safe 120A for 0.6 seconds

Fail-safe 350A for 0.04 seconds

Comment by Alan Shea

Sparky had the idea that he should use Sidactors on power lines for surge protectors. At first I was thinking that too. But then looking through the data book, I realized that they are not appropriate. As a semi-conductor device, they are pretty limited in how much power they can dissipate. They top out at 175A, so they should be used only in power-limited circuits like telephone and communications cables. A phone call to an application engineer at Teccor confirmed this. Sidactors will blow up before they can dissipate the energy of a surge. A ZNR from Digi-Key costing about \$0.40 will conduct 6500A at a clamping voltage of 180v on a 120v line, compared to a \$1.50 Sidactor [which can only handle 175A].

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