Steve Uhrig, SWS Security addresses proper equipment grounding

One amateur asked:

After 8 years in the hobby I've finally decided to address GROUNDING. About all I know is equipment should be grounded and everything in the house (including house electrical) should have a COMMON ground. Well, the shack is at the opposite end of the house electrical ground. To couple the house electrical ground and a shack ground rod would require a trench approx. 80' long ... it's not going to happen soon so I'd like to address just grounding what I can for now.

Steve WA3SWS replies:

There is a world of difference between 60 cycle grounding and protecting equipment from lightning and surges. That makes it fun when you hire electricians to do some of the install. They don't understand and argue with you.

A 60 cycle power ground is an open circuit to lightning. Figure lightning is around a megacycle for purposes of calculating, although it is broadband in reality.

The reason for a single point ground is to prevent voltage drop across ground. A nearby lightning hit induces a LOT of current in any nearby conductor. Multiple paths to ground induces a voltage difference between the different points, and this voltage will force its way to ground through your equipment. Very bad juju.

Figure what a few hundred, or a few thousand, amps will do across a few Ohms' difference in ground.

You need a low impedance ground. That is difficult to achieve. For example, lightning does not turn corners. You cannot bend conductors in less than a certain radius (no tighter than around a coffee can is a good reference).

You are dealing with the skin effect with lightning having the characteristics of RF. So you need a lot of surface area. The current from a lightning hit, or fast-rise-time surge will travel primarily on the surface of a conductor. Large solid conductors are worthless because you don't have much surface area. Large solid conductors are suitable for 60 cycle power (practically DC relatively speaking) but not for lightning or surge protection. Braid is slightly better, but still has far too much inductance to give you the low impedance path you need. Solid copper strap is the best. 1.5 inch is minimum. 3 inch is better. Wider is necessary for longer runs. It comes up to 6 inch in width. 1.5" will do for 95% of installations.

www.polyphaser.com is my source for all this stuff -- protectors, everything for grounding, etc. They publish a booklet on effective grounding which is worth the money. If you're serious and doing work for an organization, classes are available to give you hands on. I highly recommend them if you can justify them.

You need proper protectors specific to each type of equipment. There are 60 cycle protectors for line voltage. There are modules for data, telephone and low voltage. Various inline types for coax. See Polyphaser's website. All coaxial signals are not the same. There are specific protectors for video, and dozens for RF depending on

the max freq and power level they need to pass.

Cheap protectors (99% of them regardless of price) are single stage. Single stage protectors are of minimal use. Polyphaser uses typically 3 stages. Surge protection power strips as are sold to protect your computer area complete waste of money. They're good only as multiple outlet strips. Surge protection is a sales feature. They can't shunt any appreciable amount of power, and the building's power ground has way too high an impedance for quick rise pulses to be any good dissipating them.

The idea is, you need to grab a very quick pulse before it gets to your equipment. Once you grab it, you need to get rid of it in a hurry.

Devices which turn on quickly enough to protect electronics cannot handle much current. The devices which handle adequate current take along time to turn on. Therefore a properly designed protector will have typically three stages, where the initial stage turns on early and starts shunting and providing protection while the longer, higher current stages start to turn on in cascade. The high current stages take longer to turn on. Stages which turn on quickly can't handle much power. So combining them makes an effective combination.

You want quality power and data protectors which fail in the SHORTED position, which is unusual, so when they fail you are forced to replace them. Separately fuse anything on a power buss for obvious reasons. Most protectors fail open and you'll never know they failed. Any protector can operate only a certain number of times. That number may be several thousand, but a single thunderstorm can generate a hundred hits. I have found absent a nearby hit, I need to replace telephone line protectors about every 5 years.

Once you grab this quick surge, you need to do something with it. Feeding it into the 60 cycle power ground is a worthless effort as mentioned above.

You need to get rid of it in a hurry, hence the low impedance ground. The single point ground, usually a large copper plate on which all devices are mounted, gives you a common ground to prevent voltage drops across ground as mentioned. This single point ground is grounded to earth with copper strap. Up to 50 or 75 feet or so is OK for 1.5"strap. Ground the mains power going into the equipment with the appropriate protector. Don't worry about a long trench to ground the entire house electrical system.

Then this strap has to go to ground, using proper 'saddle' clamps and preparation of all copper (strap, clamp and rod) by polishing all to a mirror finish with Scotchbrite and immediately applying copper antioxidant paste to all surfaces. Copper starts to oxidize in seconds.

Saddle clamps are massive two piece pure copper clamps cast to clamp the copper strap onto the copper plated ground rod. The two halves are attached with 1/4-20 hardware and external star lockwashers. I prefer to locktite the hardware too, because copper is relatively soft and will flow under pressure. A properly designed saddle clamp will be molded closely enough to fit the ground rod so as to minimize flowing and is designed to crush itself around the ground rod to

conform and give maximum surface contact. Locktite is cheap, and a lot cheaper than a service call. Hose clamp type attachments are a waste of money and useless for anything other than 60 cycles if even that.

A single ground rod is not adequate. A ground rod will 'saturate' the ground for a radius of twice its depth. Saturated ground will not sink much current, so additional ground rods provide a much larger earth area to absorb the huge amount of power you're trying to dump. If you can't dump it well enough, it will find its way to ground through other parallel paths, like your equipment.

The industry standard is three eight foot ground rods spaced twice their length apart, connected in a Delta, Tee or daisy chain fashion with the copper strap and saddle clamps. Use 7/8" copper plated steel ground rods. Get properly sized saddle clamps.

If you happen to be on a mountain with a repeater site on rock, you don't even need ground rods. Simply lay a few hundred feet of 3 inch strap on the ground and it will couple adequately.

Remember with the strap, no 90 degree turns unless very gently radiused. Very quick pulses will hit that 90 and keep going straight. I've seen it in videos of testing. Impressive.

All this is not as difficult as it seems, HOWEVER, you cannot take ANY shortcuts. Do it properly according to Polyphaser's instructions and it will work. Take one shortcut, like something you don't understand or seems too difficult, and you may be wasting your time.

I have no relationship with Polyphaser other than as a long time customer.

My company manufactures and installs man-rated commo and surveillance systems all over the world. I can't afford to send someone to Delhi to replace a piece of equipment damaged by lightning. We were forced to learn long ago how to do grounds properly, and if you do them properly, you won't have problems. My own home office has had lightning hit in the woods within a few hundred yards of the building. We had zero damage. Others in the area to half a mile away lost telephones, computers, video and other stuff. In demos, I've seen wires exploded going into a properly protected system, and consumer grade electronics on the protected side unaffected. I've got a lot of antennas and commo here, never disconnect anything, and have never lost anything since putting in a proper grounding network some years ago.

If you want to discuss this in more detail, email me and we can get together on the phone. I don't have time to key in everything you need to know, but we could discuss it on the phone. Could also send you some photos of large ground networks from some of our jobs. In some cases, the grounding costs more than the equipment.

It's worth the effort to do it properly.

Steve WA3SWS

And another amateur asks further:

My Oregon QTH supposedly 'meets code', according to a home inspection made a year ago, and it has three separate grounds: AC Mains, Telephone and Cable TV. Each one goes to a separate and independent ground stake some distance from the others at various points around the house where the wires enter. I'm inclined to bond the three of them together to prevent one of those grounds from 'floating' to a voltage different from the others, and then them to the antenna ground as well.

Steve WA3SWS replies:

You've got the right idea.

If you tie the grounds together properly, it will be a good thing. If not done properly, it will be dangerous, possibly more so than if left alone.

Remember a ground for lightning is very different from a DC ground or a ground for 60 cycles. Few electricians appreciate the difference. Your application could be perfectly adequate for 60 cycles and useless to protect electronics during storms or from power surges.

Lightning typically has a frequency about 1 megacycle, and this is what is used in calculations. Think RF, not mains frequencies.

It is very difficult to make a low impedance connection at those frequencies capable of handling high current. But you must. Remember what potential will develop across a 1 ohm ground system at 1000 amps. You can have 50 or 100 ohms between different ground rods as mentioned above. You cannot measure impedance accurately with a DC ohmmeter although one will give you a rough relative idea.

A single point ground is ideal, and difficult and expensive to achieve. We install electronic intelligence systems for foreign governments in the desert on water towers and the like, with a high likelihood of taking hits. Intercept systems want the highest sites around, and are the most attractive to lightning.

A minimum low impedance ground to prevent damage to commo gear consists of three 8 foot ground rods spaced 16 feet apart, bonded together with 1.5" copper strap and massive copper saddle clamps. The ground rods must be Scotchbrited clean to a mirror finish, then immediately protected with conductive antioxidant which is like a very thick gold colored grease containing suspended copper particles. Clean copper starts to oxidize immediately, so you don't stop for lunch between cleaning them and painting them. Polyphaser, my favorite manufacturer of protection components, sells a CCK Copper Cleaning Kit which contains Scotchbrite, antioxidant, and hand cleaner for getting the antioxidant pasts off your mitts. Better to wear gloves.

That copper strap goes to a heavy copper plate mounted on insulators off the wall of the comm. shack. The copper plate is sized so as to straddle studs for ease in mounting, and is backed by a thick piece of wood to let you use long sheet metal screws for mounting components. I use #10 panhead sheet metal screws. All coax protectors are bolted to that plate using the same cleaning and antioxidant. Power protection and telco line protection the same way. All hardware uses external star lockwashers to cut into the material being fastened.

In dry soil or where conductivity is low, the soil may need to be saturated with copper sulfate to increase conductivity. Hollow spikes with a plastic bottle of copper sulfate on top are driven into several areas around the grounding system, where rain will dissolve and leach the substance into the soil. This is not necessary very often, but in dry soil you must do it or the rest of the effort is wasted. This is really beyond the abilities of anyone not specifically experienced in grounding systems for communications. That virtually always excludes electricians.

If your ground run is long, like up the side of a building, you may end up with 3 inch or even 6 inch wide copper strap to get the low inductance needed. In one job, we had to go up 15 stories to the roof of a government building in Delhi, and the cost of the grounding system exceeded the cost of the commo gear. The customer does not like to see the cost of this in the design and spec, especially where other companies with little experience overlook it or allow a hundred bucks for a surge protector. If you want it to be reliable you have no choice.

Remember, also, lightning does not turn corners. Any bends in the system must be very gradual. A sharp bend is like an open circuit to lightning. In school you see videos of a lightning bolt traveling down a ground wire wrapped around an eave. When it gets to the corner, the lightning continues to go straight. Radius any conductor no larger than the diameter of a coffee can. Larger is better.

At home, remember a single ground rod and a single wire, even if large gauge, is not effective. If a single ground rod is pounded in near the foundation, even less effective. Go out from the building, drive three 8 foot ground rods 16 feet apart, use the clamps and strap I mentioned above, bury the strap in a simple shovel slit, and run it into the house. Use that as the drain for your single point ground.

I have done precisely this and have had in the past a fairly busy shack with amateur and commercial equipment and many antennas. Everything is protected as described above. We have taken lightning hits directly on the property which destroyed trees, and I have not lost anything in any system ever. I do not disconnect antennas or phone lines from anything and have no concerns. Neighbors are always replacing answering machines, modems and sometimes televisions.

Polyphaser is our source for all material and equipment other than standard 8 foot long, 7/8" diameter copper plated steel ground rods which you can get anywhere. If we do everything properly we never have problems. If we think we have found a shortcut or we try to pinch pennies, we do have problems. Expensive ones.

http://www.polyphaser.com

Polyphaser has a fairly large ($500) minimum order, and sells only at full retail. Tessco www.tessco.com sells their stuff also and at dealer prices, but you will only get the advice directly from the factory. Tessco sells only to dealers or government, not to end users. I probably can supply anything needed for anyone interested.

Remember, also, protectors have a finite life. Better ones are designed to fail closed, forcing you to replace them. Cheap stuff fails open so you never know.

We took a direct lightning hit on the property once which literally vaporized the overhead phone line. There was copper blasted into the wood siding of the building up to the protectors along the former route of the cable. Nothing on the customer side of the protector was damaged. Polyphaser replaced the protector for nothing. Telco ran a new drop from the pole down to the house, this time underground.

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"In God we trust, all others we monitor"
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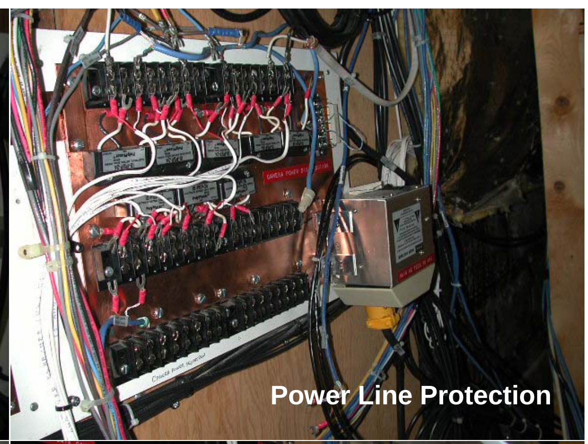
Video Surge Protection



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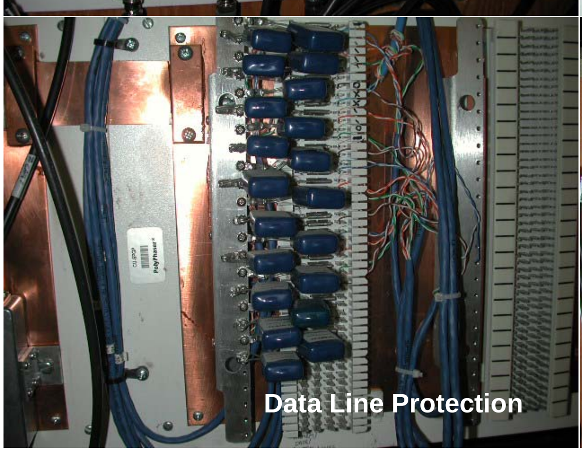

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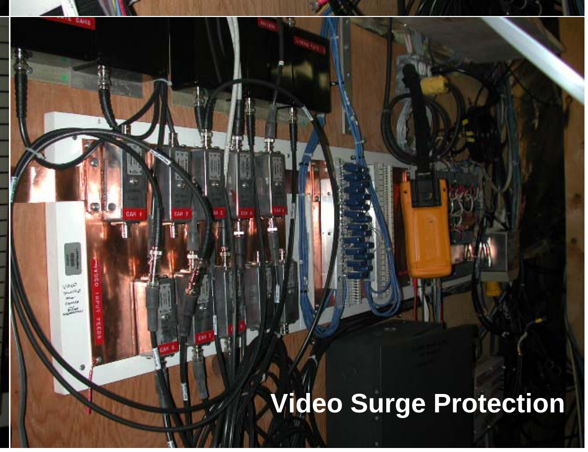

Video Surge Protection