

Grounding and Lightning

[Single point ground comments](#)

K1TTT on grounding and lightning protection

"David J. Windisch" wrote:

> <SNIP> ha ha

>

> The irony is, when an electrical storm approaches, one must disconnect
> appliances from the ground system to keep them from being damaged by a
> lightning strike striking the soil!

>

> >SNIP

>

> I don't understand what's amusing, the irony, or why one must disconnect.
> Would you be kind enough to give your supporting evidence a/o reasoning?

why disconnect? because its easier and much cheaper than installing a proper ground and arrester system that will protect modern equipment.

a lightning stroke hitting the ground or even part of your grounding system where most people would think they would be safe can still cause considerable damage if your ground system is not complete. note when talking of the short pulses associated with lightning there is no such thing as 'ground'. the rate of rise on the front end of a lightning stroke can raise voltages by several 100's of kv/micro-second, this of course propagates at or near the speed of light through the various conductors it encounters.

lets simplify and make all the easy assumptions to see what happens. lets take an average 25ka stroke with a rise time of about 2 microseconds. in a simple ground system lets say this hits near the center of your ground system that has an over all (dc) impedance of 10 ohms (a very good case). at peak this will cause a voltage of 250kv at the peak in 2 us. assuming a linear front on the wave and assuming propagation velocity of c (for a simple thumbrule assume 300m/us), at a distance of 30m the voltage lags by .1us or about 12.5kv. actual wavefronts may be faster, propagation long real conductors is slower, and lightning wavefronts are definately not linear so this voltage difference across the ground could be much higher.

now lets look at what happens when this gets to your shack. the ground voltage starts rising at 125kv/us at your entrance panel. now remember this voltage is on the ground, not the center conductors of the coax or the control wires for rotors or switches, those are still insulated from the ground. at the entrance panel you have some kind of arrester, lets say you use old simple gaps. simple gaps take time to respond, lets pick a fast response of .01us... this allows the voltage difference between the ground and conductor to get to 1250v before clamping it. not bad, but still probably lots more voltage than the front end of most radios would like to see. now assuming that every wire coming into the shack has this type of arrester at the same location, that would be the highest voltage difference you would see.

but now lets look at a more typical situation. the antennas and control lines come through an arrester system at the shack entrance, but the power lines come from the other side of the house. lets even assume they have one of those mov

things at the panel and the panel ground is tied into the shack ground. sound good??? well, lets say the entrance panel is 10m farther from the lightning stroke than the shack is. at 30m we had 12.5kv, so at 10m we would have about 4kv potential difference. but since the power line arrester has a response time it gets worse, but lets ignore that and assume it is a perfect arrester and keeps the voltage on the power lines exactly the same as the ground voltage. remember that the power panel is 10m from the shack, that adds another .03us for that voltage to get back from the panel to the shack to protect the power circuits, which allows for another 4kv difference, so in the shack the power conductors are about 8kv below the entrance panel ground voltage just due to travel time from one end of the house to the other and back. now you have fun and figure out which path will flashover first to equalize that voltage. if you are lucky it just takes out fuse holders, those wimpy mov's on power supplies, pilot lights, or a power supply or two. but where it goes from there is anyone's guess. now also think about the phone line, it has the same problem, except its only path to ground is probably through your computer modem, mother board, and power supply. and the cable tv line equalizes through your tv that you use to monitor the wx channel to know when to disconnect stuff.

how do you avoid this? ALL conductors in the shack must have the same protection at the same physical point. for most of us this is hard because of the preexisting house wiring. so the other option is to disconnect stuff from the power lines AND coax/control lines.

one thing that is new this year is that you can subscribe to a service to warn you when lightning is in your area. <http://www.lightningstorm.com/> has various services where they will page you if lightning is within 30, 15, or 8 miles of a specified location. you can sign up for the service for periods ranging from 3 hours to a year, including a weekend warrior option in case you want warning during a contest weekend or camping trip. and the price is very reasonable. they also have a free country wide map that shows ground stroke lightning activity updated every 15 minutes. they also have services so you can find out just how much current was in that stroke that blew up your station, their detectors can resolve peak currents, polarity, and location in many cases down to 10's of meters, and time to within microseconds.

why do i know this... its my job(not for lightningstorm.com or global atmospherics that runs the detection network). though most of what i do is for hv power transmission the same principles apply on the smaller scale. what do i do??? i disconnect stuff and keep my fingers crossed.

--

David Robbins K1TTT (ex KY1H)

More thoughts:

actually, disconnecting the ground is not what is required. i leave the grounds connected but remove everything else that could be at a different potential. the first key is to not put your equipment in the middle of a current path. what you have to consider is that current can come in on the ground, but if it doesn't have anywhere else to go like back out to the power cable, or back out to the antenna, or through some other station accessory that is grounded somewhere else, there shouldn't be a problem. the real problem is that the voltages can be so high that even the distance between the grounded radio and a nearby power outlet could flashover and destroy both. in my example with a very

good ground the voltage at the ground got up to 250kv at the peak, we generally assume that dry air has a 50% chance of flashing over at a potential difference of about 500kv/m. so anything within about .5m not connected to the ground could be a target. raise the ground resistance to 50 ohms (a single 8' rod in decent soil) and you are up to 1250kv for a 25ka stroke and anything in your shack could be a target. get hit by a 200ka positive stroke and all bets are off.

in that case, the second key is to have good insurance.

Duane Fischer wrote:

>
>
> Hi Tom and All,
>
> What will happen to the equipment attached to the station ground if
> lightning strikes the earth? Even though the antennas are disconnected and
> the AC power cords disconnected, the equipment ground straps still
> attached to the ground bus and that is attached to the ground system. The
> lightning can travel through the earth, go into the ground rod and right
> to the equipment. Hence, my comment about disconnecting the station ground
> during electrical activity.
>
> The irony? Just that the station is grounded in the first place to keep
> the equipment safe and then disconnected to keep the station safe.
>
> Duane Fischer W8DBF
>
> -----
> Submissions: antennas@qth.net

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David Robbins K1TTT (ex KY1H)

Date: Tue, 13 Jun 1995 18:27:26 GMT
From: gary@ke4zv.atl.ga.us (Gary Coffman)

References<3r4qj0\$kuj@noc.tor.hookup.net>
<1995Jun8.141125.18173@ke4zv.atl.ga.us>,
Reply-To: gary@ke4zv.atl.ga.us (Gary Coffman)
Subject: Re: NEED HELP! Respond : Grounding 'Experts' !

In article rapp@lmr.mv.com (L. M. Rappaport) writes:

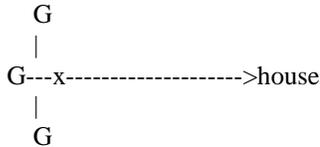
>gary@ke4zv.atl.ga.us (Gary Coffman) wrote:
>... edited
>>Single point grounding is simple in concept, but often subtle in execution.
>
> Excellent article. One question, however: Assuming you bond everything
properly like a reverse daisy chain to a single point ground at the meter
entrance, is it ok to extend that ground by bonding multiple ground rods together?
Something like this
>

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> Ground Rod -----+      +-----Stuff in shack
>                   |      |
> Ground Rod -----+-----+-----Entrance Panel
>                   |      |
> Ground Rod -----+      +-----Tower, etc

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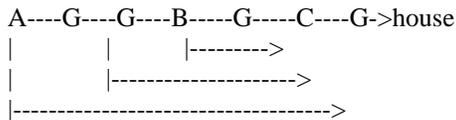
Daisy chaining of any sort is generally to be avoided. However, this is not a daisy chain if I read the diagram correctly. What you have is a star connected group of grounds (I'm assuming you left out a couple of |'s in the drawing) that are connected to a single entrance point. That's a perfectly acceptable way to do it. IE



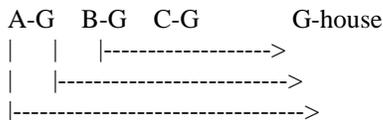
That's fine. Now, if you were to do this;



That would be Ok too, but not as desirable because of the accumulated voltage drops in the daisy chain. What you want to avoid is this;

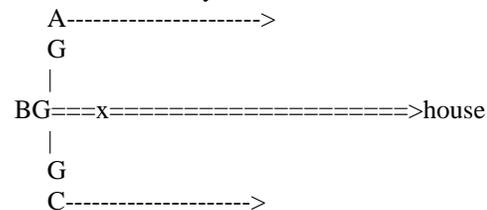


with A, B, and C representing antennas or other external equipment. Now you have a nasty ground loop through the chain of G's and that's going to lead to trouble. If you do this;



This is **real** trouble. Now you're depending on the (poor) conductivity of Earth to tie the grounds together, and they'll be at wildly different potentials during a strike. Those potentials will be reflected on the cables from A, B, and C, and will do big time damage to the station if not shorted by a ground window.

Now the better way is to do this;



B's cable closely parallels the star ground run in the drawing. Since A, B, and C's grounds are tied in star, they will be at nearly the same potential. Best,

however, would be individual ground runs from A, B, and C's grounds back to a single common point at the house. That avoids any ground loops.

Any of the situations that create external ground loops can be shorted by a ground window at the station entrance. That will protect the equipment *inside*, but equipment in the external circuit, preamps, rotators, etc, can still be damaged by the circulating ground currents. So it's best to avoid ground loops in the external circuit and always use a star topology.

Remember, for lightning, just having good DC conductivity isn't enough. In the first place, at 8,000+ amps of surge, even good conductivity is rarely enough to prevent substantial voltage drops. More important, however, is that lightning is RF, and low *impedances*, including reactance, are important to keep the potential differences at bay. It's always the *difference* in potential that matters. It doesn't matter if everything becomes elevated in potential, as long as everything is elevated to the *same* potential. Star topology is important to make this happen.

Gary

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Gary Coffman KE4ZV | You make it, | gatech!wa4mei!ke4zv!gary
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