Tech Note - Theory - 17 Theory Different Strokes for Different Folks

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There are two types of grounds involved in a ham station installation when HF operation is considered: 1.) Safety ground, 2.) Radio frequency ground to provide the antenna image.

These are two completely separate grounds, and a segment of our ham population as well as the beginners seem to have difficulty accepting this premise until after the smoke has cleared.

The third wire in your wall socket (U ground) is part of your safety ground and the key word is "part". It is not complete by itself. This third wire is a protection provided to blow a fuse or snap open a circuit breaker should a short develop from the hot side of the AC line to the frame of an appliance.

That is all it was intended for, as far as an RF ground is concerned, at radio frequencies, it is too long and exhibits too much inductance for transients, together with, it is likely to act as an antenna and distribute the RF from your rig all over the house and perhaps into your neighbors house with all the problems that would produce.

Also, you certainly would not want lightning coming in on your antenna and being distributed all over your home and destroying all of your appliances as well as your ham station. From a personal safety standpoint as well as equipment damage the two ground systems should **and** must be treated separately!

1. Safety ground: The ham station must have one or more 10 foot ground rods with as short and as straight a heavy conductor (# 10 or larger) with all of the station equipment connected to a convenient ground bus, (at the rear of the operating position).

   This should include everything on the operating desk. The transceiver, antenna tuner, electronic keyer, modem, two meter rig, power supplies, computer, TNC, tape recorder, anything that is permanently positioned at the operator desk. Do not depend on the hydro ground at your utility panel. They have that ground in place for their equipment protection and for your safety. In case of a problem with the transformer in the vault or up on the pole out on the street.

   Also that water pipe ground may be located too far away from the operating position and posses too much inductance to be effective to afford any protection from induced charges on your antenna.

   The storm may be 10 to 20 miles removed from your location but the lightning discharges taking place can still induce thousands of volts into hydro lines, along which they travel, and induce charges into antennas as the charge passes by it. Any ground lead more than 8 feet long begins to take on quite a bit of inductance and starts to behave like an antenna unless special precautions are taken. More on that later. (*)

   To fully appreciate why all this is necessary, an explanation of how an electrical (lightning) discharge takes place is required.

   During an electrical storm a great deal of turbulence is taking place in a storm cloud, as a result of this turbulence, the molecules and atoms of the material that make up a storm cloud are stripped of free electrons and become ionized. From our basic theory we know that the loss of electrons from molecules or atoms results in a positive charge. In a storm cloud we have Zillions and Zillions of these positive charges created which results in a cloud with a tremendous positive charge scooting across the sky. As this storm cloud moves across the surface of the earth, a negative charge in the earth, follows and tracks the storm cloud directly beneath it. As the charge on the storm cloud grows larger and larger in 1 micro second intervals, a leader from the cloud will reach down for 150 feet or so and begin sucking up electrons to the cloud from the atmosphere beneath it and in the process create a positive ion path. Forty microseconds later this process is repeated again and the positive ion track is extended in a random direction for another 150 feet. This is a continuous process.

   While this is going on from the storm cloud, down below, from the negatively charge earth's surface, electrons are being thrust upwards in a random direction in 1 micro second intervals for 150 feet and producing a negative ion path. Forty micro seconds later this action is repeated and it also is a continuous process.

   Eventually these two happy trails will meet and the result is the tremendous flash we see as lightning. This process has only been revealed with the development of super high speed photography, in the past few years. We now have thousands of amperes of current flowing up to the cloud from the earth's surface to equalize the charge in the cloud. If your home, hydro pole, tree, tower, fence or what have you, happen to be in this path, its crispy critter time!

   It is actually these huge ground surge currents that do the damage as it is drawn through every conceivable conductor in the ground, water lines, gas lines, phone lines, sewer lines, anything imaginable that will conduct electricity. If your tower and equipment happens to be part of this series circuit, POOF, its gone. The secret is, the ham station should or must be balanced to ground, so it does not become part of that series circuit.

   Since it takes about 30 to 50 thousand volts to jump one inch of space, can you imagine the level of voltage involved in the discharge, two to five miles long?

   Lets see, that's 30,000 X 12 (foot) X 5280 (mile) X 2 or 3 miles. It ends up about 10 to the tenth power or more volts. The current involved can be anywhere from 2,000 to 200,000 amperes, depending on which tributary of the stroke your location happens to be on!

   If you look at a photo of a lightning flash in the sky, you will see the various ribbons of lightning originating in different locations across the surface all converging to a central stream. It resembles a river with the tributaries flowing into it and clearly indicating the direction of flow.

   You have probably observed flashes of lightning within clouds or cloud to cloud. This happens because one cloud or one part of a cloud may be more positive than the other. When the charge reaches a sufficient potential equalization takes place.

   The thunder that you hear is the air expanding super fast as it is heated and turned to plasma with the passage of the electron stream. Sheet lightning beneath a storm cloud is again equalization of charges in a layer of super charge atmosphere.

   All of this takes place much too fast for the eye to follow and appears as a single event but may actually be 5 to 10 rapid succession flashes blended into one. The stroke may last from 1 to 10 micro seconds.

   It has been estimated that there are at least 2000 electrical storms going on around the world every minute of the day and up to 6000 strokes every minute of the day. Is it any wonder that the HF bands are so noisy with static.

   Now that you understand the ferocity involved in a lightning storm, what can we as hams do to protect our property and our equipment?

   The concept of lightning protection can be summed up in a few words. You have control over the lightning strikes energy, not Mother Nature, this is one case where you can mess with her and get away with it. What this means is that you are going to provide a path to earth and not allow the lightning to choose a random path. It is not possible to stop a lightning strike, nor is it possible to prevent a lightning strike from happening! Therefore you must be prepared to divert the strike energy to earth via a deliberate and controlled path so that no damage will be incurred.

   Building or structural protection is more forgiving than protection of electronics. A building can handle 100,000 volts while electronics will be damaged with just a few volts.

   Tapping that four foot ground rod into the earth at the base of the tower will provide no protection and may even create side flashes to other structures and do even more damage than would normally be expected. Each leg of the tower must have a separate 10 foot rod driven with no less than a #10 conductor as short as possible connecting the two. Any antenna mounted on the tower should be of the DC ground potential type. Since the tower is the highest conducting structure on your property, it will receive the bulk of the strike and provide a cone of protection

beneath and around the tower. Incidentally, a tower with a large HF beam antenna on it is less likely to take a strike than one with only a vertical HF or vhf/uhf antenna on it. This is because that ground charge that is tracking the cloud charge, reaches your antenna and attempts to produce those upward negative leaders, are quickly dissipated in the atmosphere due to the large surface area of the beam. A self supporting tower is more susceptible than a guyed tower for the same reason. By the way, where ever the guy anchors are located those ends must also be grounded with a 10 foot ground rod to keep the tower electrically balanced to ground. Remember the tower possesses inductance, resistance and capacitance and it has a self resonant point. The inductive part is going to produce XL (resistance) and a potential will develop across this resistance (XL) which could be thousands of volts even though the DC resistance of the tower from top to bottom is less than an ohm.

The magnetic field around a tower leg with 5 to 10 thousand amperes flowing through it is fantastic and has been known to crush coaxial cable, distort the configuration of the tower, thereby destroying its integrity. For this reason alone, each leg must be grounded separately to equalize and distribute current flow evenly. Any cables coming down the tower must be grounded to the tower at the top and at the point where the cable leaves the tower to enter the radio shack. Some form of protection must also be provided for the rotor cable which most hams neglect and as a consequence some of the strike is conducted into the shack and equipment damage results with side flashes taking place in the shack. There should also be a common ground right at the entrance to the ham shack if the base of the tower is more than 6 or 7 feet from the shack.

This will be required anyway as the station ground bus is going to be returned to this ground rod. The idea is to keep as much if not all of the strike outside to allow it to dissipate harmlessly.

Drilling a hole in the concrete floor of your basement to drive a ground rod close to the operating position could prove to be counterproductive, particularly if one of the outside grounds has been accidentally removed by a lawn mower or garden tractor. I have actually seen this happen with disasterous results

2. If you can spare the time and expense after this effort it will also pay to lay out a number of ground radials and bring them back to a common ground point to become part of your overall ground system. This will help to disipate a charge more readily in case your rod grounds are too high a resistance and in some types of soil this is a major consideration.

The safety ground in the house should also be tied into this overall ground system by a short a path as is possible. This will bring the house into balance to ground as well. Any protective devices installed in the home will now operate efficiently.

The very first step in providing protection to all electrical and electronic devices in your home is to install a proper MOV surge protector right at your electrical service entrance. Since this will require the removal of the front panel on the circuit breaker panel I would recommend that you enlist the aid of a qualified person to do this type of work. 90 % of the damage caused by transients and surges originate at this point. The MOV devices will clip off the the high potential peak of the spike.

What is left is small in duration and of little energy content and will be disapated in the house wiring before it reaches any delicate electronics. This method of protection prevents transients from entering the home via the AC lines and prevents any internally generated transients from leaving the home.

Any internally generated transients produced by motors in refrigerators, fans, airconditioners, microwave ovens pumps, relays etc., anything that draws an appreciable amount of current and this current is abruptly interupted will create a large magnetic field around the AC line and the collapse of this magnetic field will induce a voltage transient in the ac wiring, since this energy has to go some where, why not into an MOV rather than into that megabuck sterio or amateur transceiver.

Your ham station should receive its AC feed via a "brute force ac line filter". This should be augmented with a set of low duty MOV's right in the filter. This filter should also be incorporated to the station ground bus.

The MOV's (metal oxide varistor) or equivalents I use for protection from internally generated transients is sold by your local RS store and has a catalogue number 276-568 also the GE number is V1301A20A. The one for the service panel is quite large and mounts through a knockout hole in the side of the panel. Again as previously mentioned a qualified person should be doing this part of the work.

Protecting incoming lines requires that both common mode and differential mode be protected. That is why three MOV's would be used in each case. By way of explanation, common mode is wire to ground and differential mode is wire to wire.

The phone line in today's home is in all likelihood connected to a computer through a modem and to a ham transceiver through a phone patch so the phone line should be regarded as a threat as well as the AC line. A couple of gas diodes in series across the phone line is a good start. Three of the above mentioned MOV's would complete the protection of the phone line. This should be done right at the point where the bell line enters the house and as close to the house safety ground as possible.

Usually forgotten until after the TV set and VCR are toast is the local cable company's cable for your pay TV. The very least the "the cable guy" should do is include a "cable ground block" installed as close as possible to the house safety ground. From this point the cable can branch out to feed the TV sets in the Home. If you really insist loud enough and long enough you may even get him to install a coaxial cable surge protector right at the cable ground block. If he says no, or excuses it by saying he does not have one with him in the truck make sure you get his name and his supervisors name. This usually gets their attention. If worse comes to the worse indicate that you would be prepared to pay for one if they will sell it to you at cost. Either case will require a bit of pressure, unless of course you are well known to them in which case they may do it out of kindness. They do use the devices in their trunk and drop lines. After all they share the same poles as the Hydro Utility and bell CANADA. So the possibility that they are not bothered by transients on their cables is very remote

The coaxial cables entering your home should be protected by coaxial surge protectors. Again, RS cat. #20-021 is typical. They no longer stock them but will order for you on request. It's not cheap out of wallet but still cheap insurance. It's in the 30 to 40 dollar range. If you think this is expensive wait till you see one of the questionnaires some insurance companies are requesting you fill out when you apply for damages after a lightning strike.

They want to know what protective devices you had installed and can you prove it. Its starting to get expensive for them with all the computers and accessories found in today's homes

Also available for coaxial line is what is commonly known as a blitz bug. It is merely a fancy form of spark gap and provides protection maybe once as the points of the gap may melt and form a partial short or the gap may be so wide that little or no protection is provided. They were widely used by the chicken band operators and it was usually the cheap model to boot, as a result there were a large number toasty CB stations.

The Cushcraft LAC 4 is the only one I am aware of that has been submitted for field testing and approved. That is the minimum protector I would attach to my HF antenna for coaxial surge protection. The RS unit is tested and rated as to insertion loss and VSWR up to 1.5 GHz. It is worth the price. This units protection is provided by the use of a replaceable gas discharge tube. It's good for many cycles of protection so should last for many years.

Getting back to the phone lines for a moment, the gas diodes that I use are the little NE2 neon lamps. I find and buy them at flea markets by the handful for pennies apiece. Since they are rated at only 60 volts and the telephone line ringing voltage is 12 hertz 90 volt pulse, two in series will provide a bit of overvoltage protection. One of these is an excellent method of protecting the front end of a receiver from spikes coming in on the antenna. (RS # 272-1102).

The previously mentioned MOV, light duty, is ideal protection for another reason. Inherent in their design each MOV is possessed of from 800 to 1000 pf. of capacitance, which is an excellent rf bypass capacitor. So any rf picked up on the phone lines out on the street will be

bypassed to ground right at the entrance to the home as well as transient protected. These MOV devices are also bipolar, it doesn't matter whether the transient is positive or negative, the MOV will act on any pulse above it's conduction point!

3. Now back to the RF ground. Placing those radials in your back yard under the antenna will not only help the ground rods dissipate the transient energy but will enhance the natural ground required by your antenna to achieve its characteristics of Rr. (height above ground) It will stabilize the angle of radiation (height above ground) and improve the efficiency of radiation.

   Fewer ground losses. None of these characteristics can possibly be improved with a single pipe driven into the ground somewhere on the property, nor will that so called ground attached to the third wire in the wall plug help improve radiation.

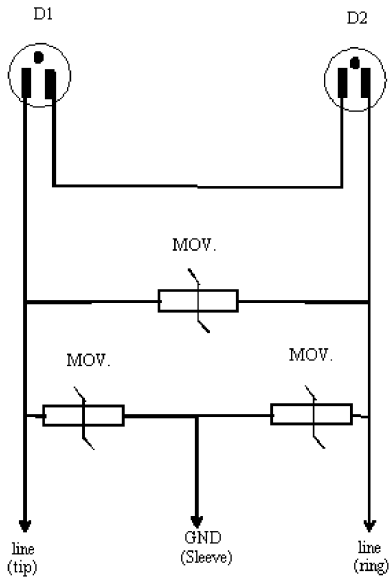
   (*) There you have it, the two grounds separated and each one's purpose clearly defined. If your ham shack is located on the second floor as mine is, all is not lost. If you install a safety ground from the second floor shack, it is usually fairly long and on some bands your equipment will be RF hot to the touch resulting in bruised lips as you bang into the mic or sore fingers as each time you touch the key you receive a nip of rf and sometimes a real bite.

   I resolved this dilemma by constructing and installing a series resonant tuner and placing it in series with the common ground buss at the rear of the operating desk and the safety ground run.

   This is sometimes known as an artificial ground but that is an incorrect name for the device. Properly adjusted, since it is series tuned, you cause Max current right at the rig on the band of operation and move the high voltage point away from the rig, hopefully far enough away that the bites are no longer a problem.

   It's also a good idea to place a heavy duty rf choke in parallel with the tuned circuit to maintain dc continuity. Also be careful where you route your ground lead wire around the room to reach the point of exit as somewhere on its length there is going to be a high voltage point. In my case I used old braid from coax and tucked it behind the base board for a neat appearance. Where this bare braid exited out the window it was in close proximity to the curtains and one evening the incoming breeze brushed the curtains against the wire. Along with the excitement of the DX contact came the smell of smoke! Glancing over to the window thinking we had another grass fire in the neighborhood, I saw smoke curling away from the curtains. Luckily, they were treated with a fire retardant and one quick shot from the CO2 extinguisher had it under control. That is another item no self respecting ham should be without in the ham shack. The dry chemical type is cheaper but did you ever try to clean up the mess they leave, especially inside a computer or transceiver. No thanks, I will take the extra bucks required for a CO2 type of fire extinguisher. Tip, use insulated wire for this ground lead in case the family pet or jr ops come in contact with it.

Telephone Line Transient Protector



MOV.=RS # 276-568, or GE # V13Ø1A 2ØA

D1, D2=Ne2 miniature neon lamps. RS # 272-1102 Mount components on a 3 point terminal strip. © *August 30, 1997*

Tom Vince VE3HM

   Other things you can do to reduce the threat of transients is, curl up all surplus leads and tie them with nylon ties, this not only makes things look neat and tidy but creates inductance in the lead and transients do not like inductance. You might also try slipping a RS 273-105 ferrite over the AC lead of sensitive equipment such as modems and computers. Again you are creating inductance in series with any transient pathway before it reaches the equipment. A couple or three of these ferrites (RS 273-105) placed strategically along the coax feedline will reduce the possibility of transients on the cable shield as well as suppress any unwanted rf on the outside of the shield that produce those funny readings on the VSWR meter.

   The split core ferrite snap on choke is another very convenient way of treating the ham shack as well as the rest of the home for rf and transient protection. It's great for individual phones, answering machines, set back thermostats, TV sets, VCR's and stereo sets and their speaker leads. I have found them very effective even in the most stubborn case by stacking two or three together and increasing the inductance they provide. One of these on the CTV cable at the rear of the set wont hurt either. Another recently discovered item at my local CTC store is catalogue # 52-7196-8.

   This is a combination six outlet, plug in wall socket. It includes transient protection for common and differential modes, EMI/RFI filter, with indicator lights, but the real plus of this device is a coaxial surge suppresser is also mounted in the same housing with the appropriate type F connectors. I hope I have stirred up your interest in getting your station protected. If it saves you from the heartache that results after even a minor strike it will have been worth it.