

Ham Monograph - Tower Grounding

This will be an overview of what I consider to be the minimum requirements for Amateur Radio Station tower grounding. The best document on site grounding is by Motorola¹. Few Hams have the time or the resources to follow commercial standards. Acceptable measures that will mitigate the dangers and the cost of lightning strikes are practical when considering a typical Ham's budget.

The focus is safety and equipment protection. This is not about electrical grounding or grounding for antennas. It is assumed that your 'shack' meets NEC and local codes for electrical grounding. Many antennas need no special grounding requirements - they either have their own ground plane or operate independently of a RF reference to earth ground. Lightning protection is our primary concern.

Lightning has two components; electrical and mechanical². Because of the extreme voltage and current, lightning behaves in unexpected ways. I have been in a dispatch office when a charge came in on coaxial cable and turned into Saint Elmo's Fire. It took about 30 seconds of lightning search and destroy to find everything electrical, annihilate, and dissipate.

1. Once lightning strikes a conductor such as a tower, it does not easily change its physical direction. It takes the path of least electrical and physical resistance to the earth which is a straight line down.
2. Lightning charge (the current) travels on the outside of a conductor.
3. It can't be stopped but it can be mitigated. Hams need to keep as much lightning outside the shack as possible. The best way to do this is to split it up and dissipate most outside. We can use lightning's properties against it.

Towers and poles are straight. Lightning wants to come down straight into the earth so accommodate that desire. The easiest way to do that would be to allow the tower to be in direct contact with the earth, the dirt. The only problem with this is corrosion. Having said this, I have a tower base still in use that was buried in a garden for over 20 years and is still quite serviceable. Hot dip galvanized tower bases will last a very long time in contact with the ground. Here is a Rohn base that is a very good solution for many installations.



FIGURE A

This base would even allow for individual ground rods through each leg.

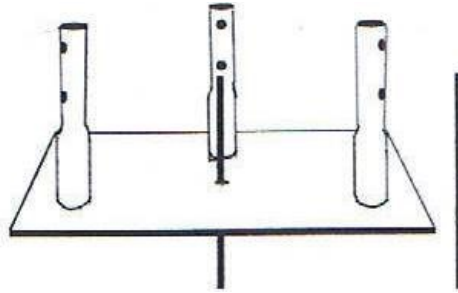
¹ Standards and Guidelines for Communications Sites, Motorola, 2005. This document is heavily copyrighted but readily available on the internet. This document is freely distributed by Motorola to communications engineers.

² Electrons have mass and an individual "electron drift velocity" of about 17 feet per second. Note that there are a lot of them in a lightning strike.

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For one of my short towers supported at the roof eave, the base shown in Figure B works great sitting on the surface of the ground with ground rods preventing lateral movement.

FIGURE B



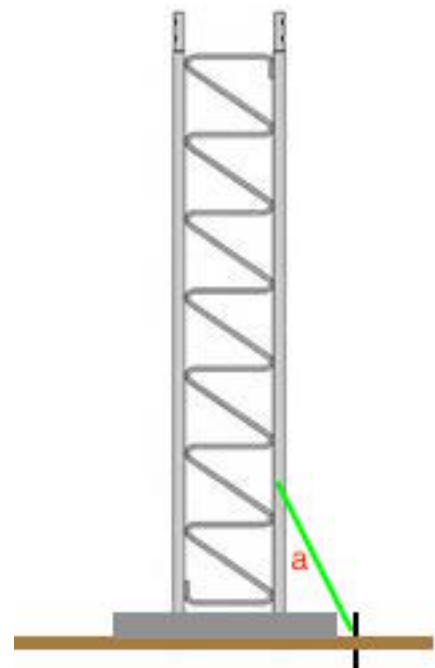
However, this base is designed to sit on concrete which brings up an important point. It is best not to ground through the concrete. This does not mean you can't ground through the concrete. Some explanation is obviously required. "Not grounding through the concrete" really means not letting the bulk of the lighting current travel through the concrete on a conductor in physical contact with the concrete.

Figure B shows two (four) ground rods. The one outside the base is typical for each leg. If this base is sitting on concrete then the center ground rod (if used) must be insulated from the concrete. This could be done with a PVC pipe through the concrete slab into the earth below the concrete. The grounding rod for each tower leg should be placed outside of the concrete slab.

Primary grounding at right angles must be avoided. Refer to Figure B again assuming a concrete base. It is important not to run your ground conductor for each leg horizontally from the base over to the grounding rods. The main charge will not make that turn and the base and the concrete will probably sustain damage from a primary strike.

Most hams have guyed towers or shorter towers with some support such as an eave mount. This type of tower installation does not require a lot of concrete at the base. Your design should allow for ground rods outside of the concrete and yet as close to the leg as practical. This allows for smaller acute angles. See Figure C - acute angle 'a' should be minimized and the length of the **ground conductor** should be as short as possible.

FIGURE C



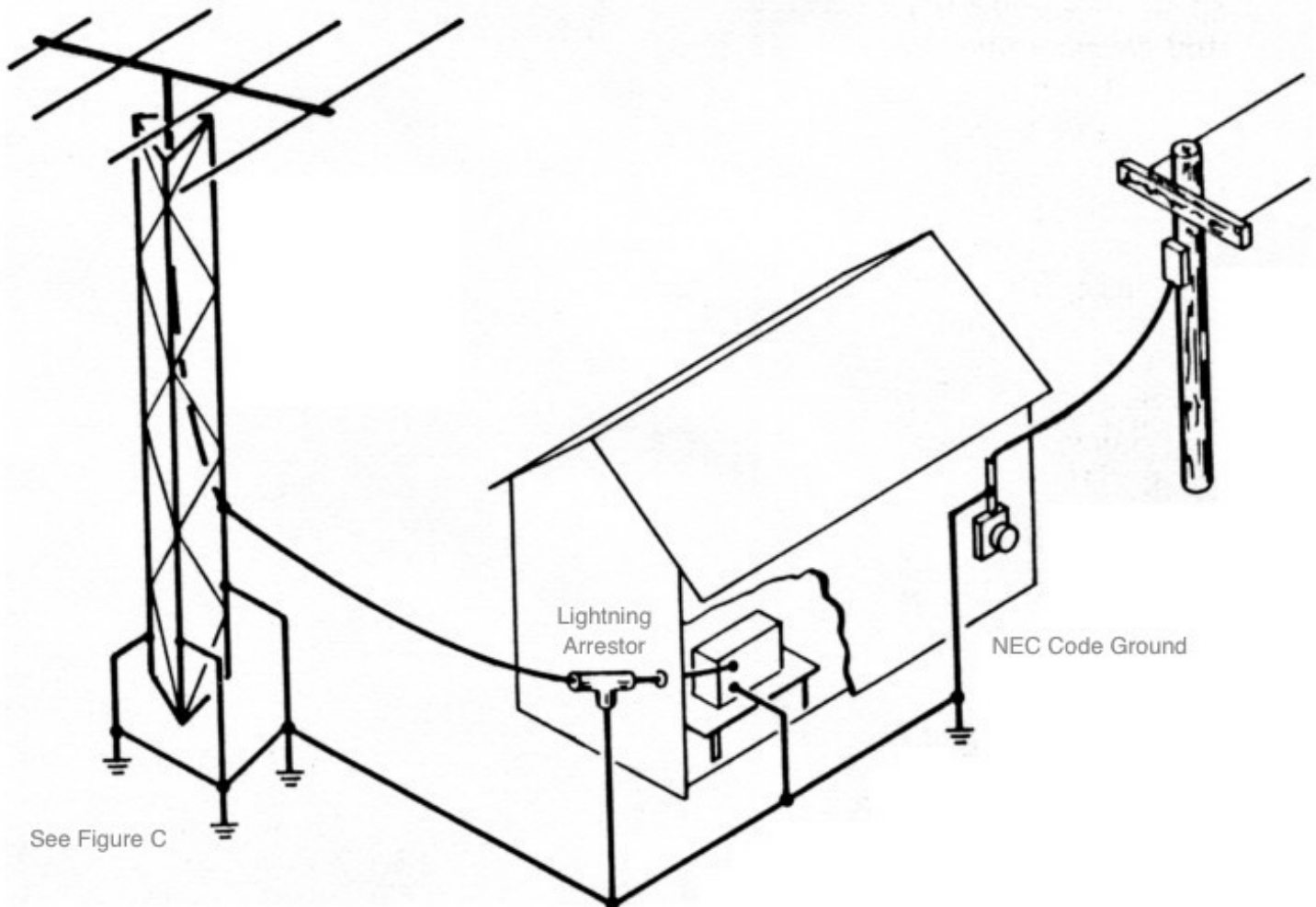
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It is important to understand that for larger installations, lots of concrete may be required and loading must be considered for free standing towers. It is not possible to address every situation here. A tower mounted directly to soil is going to be safest with regard to dissipating a lightning strike. If it has to be on concrete, use only that amount required for your specific type of installation and ground it either through PVC wells in the concrete or outside the concrete per Figure C.

A note on soil mounting. The bases in Figures A and B will last a very long time in contact with the earth and they provide the best grounding, (because they are in direct contact). I am 70 at the time of this writing. Corrosion is someone else's problem. Safer now is best for me.

Now let us look at the 'whole ham' solution.

FIGURE D

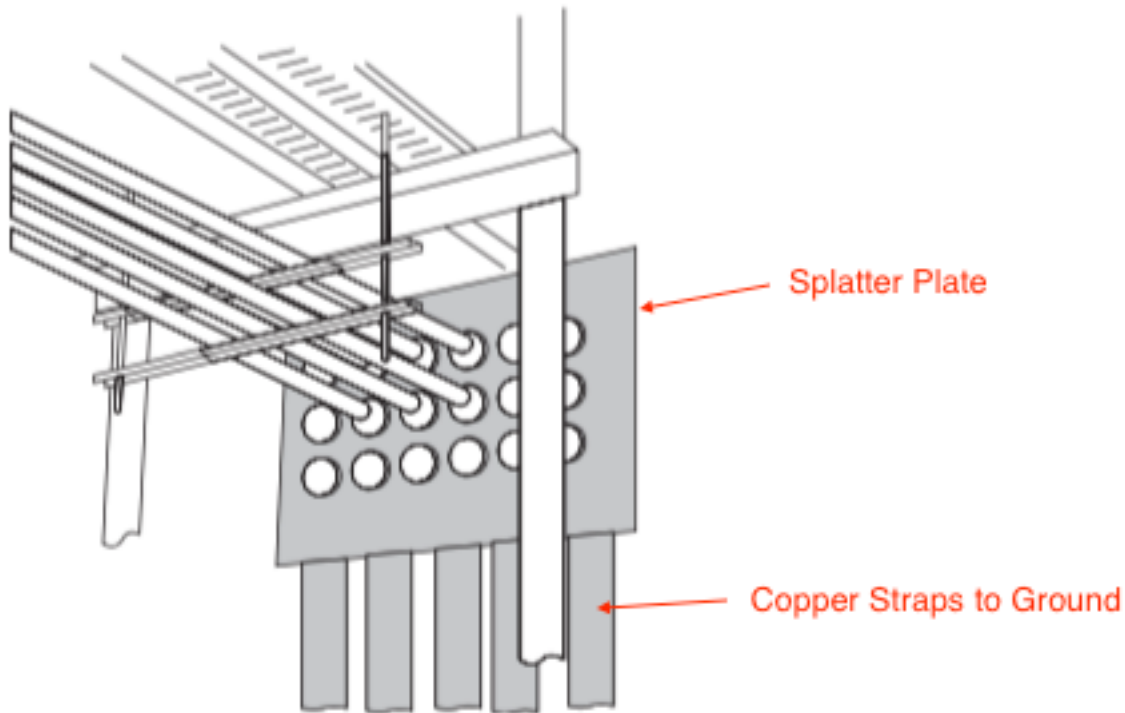


I like the Figure D graphic from the web but there are several points that need discussion. First the coaxial lightning arrester of the type shown should be close to the tower and not the house. Second, it is not always practical to connect the tower grounding to the NEC ground. It is best but again, not always practical or possible.

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There is one important thing missing from Figure D. I call it a 'splatter plate'. A splatter plate in the commercial world (Figure E) is a massive copper plate built into the wall of the communications shelter or mounted just outside the wall. It is grounded to the site ground with large copper straps. All coaxial cable entry to the shelter go through this plate via lightning arrestors. Remember that the charge from the lighting is coming down the outside of the conductor. When it hits this plate, it splatters into the copper and is carried down to the earth.

FIGURE E



You can install a splatter plate near the tower base or near the shack. In a perfect world, use coaxial lightning arrestors where the coax leaves the tower and again at the splatter plate where it enters the shack. Most of us don't have the time or money required to do this.

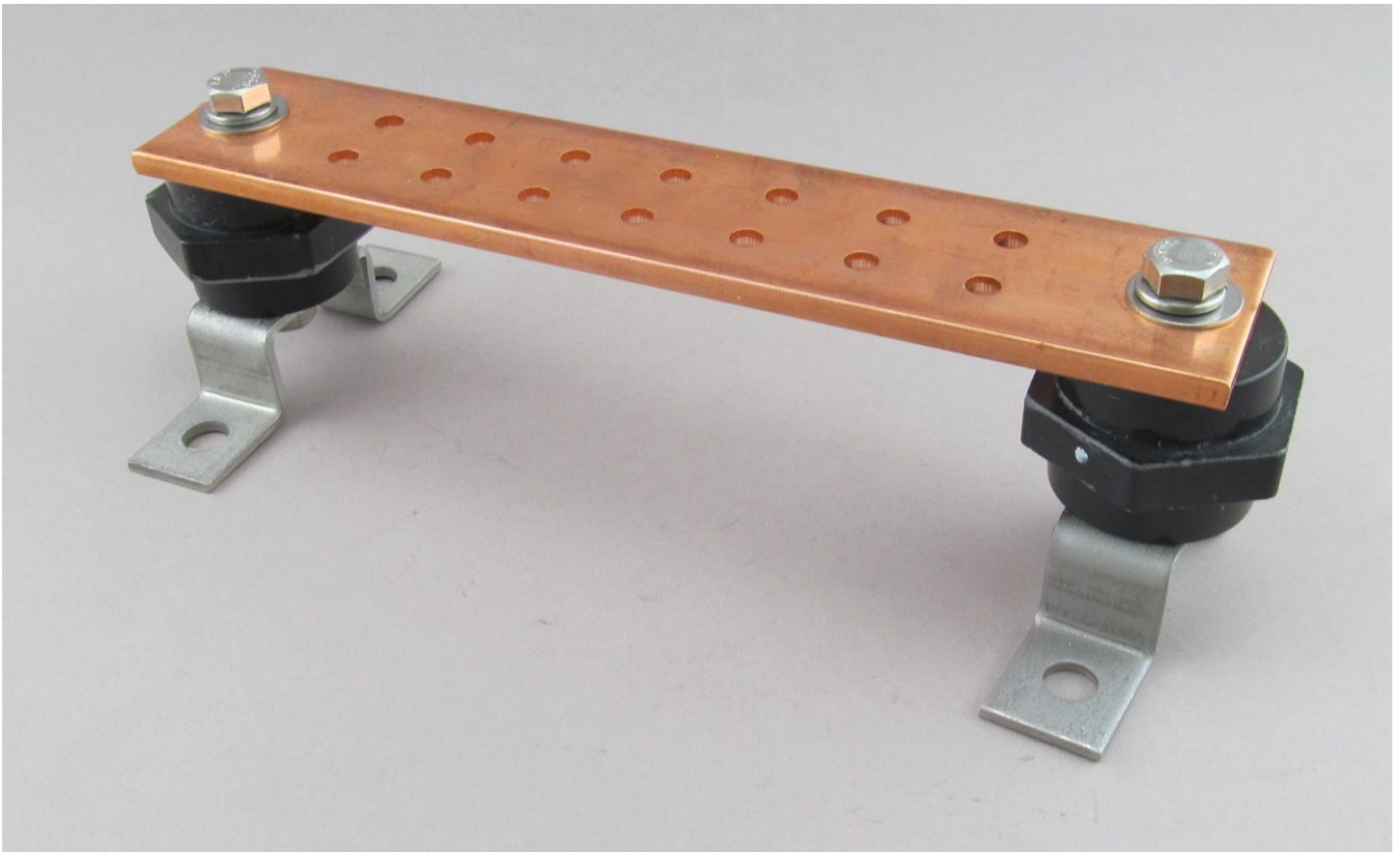
In lieu of the very expensive installation shown above, get creative. An aluminum panel from a 19-inch rack will work. I use this method on one of my towers. I drilled holes for U-bolts in the 19-inch panel. It is bolted to tower legs. I then put feed-through type lightning arrestors into the plate. Coax coming down the tower connects to one side of the plate and coax going to my shack connects to the other side of the plate. Just because the plate is bolted to the tower legs does not mean it is grounded. Connect the plate directly to ground rod(s).

Ground conductors are like bullets; more conductors are better than less conductors and big conductors are better than small conductors.

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Here is a cool solution for a minimal splatter plate.

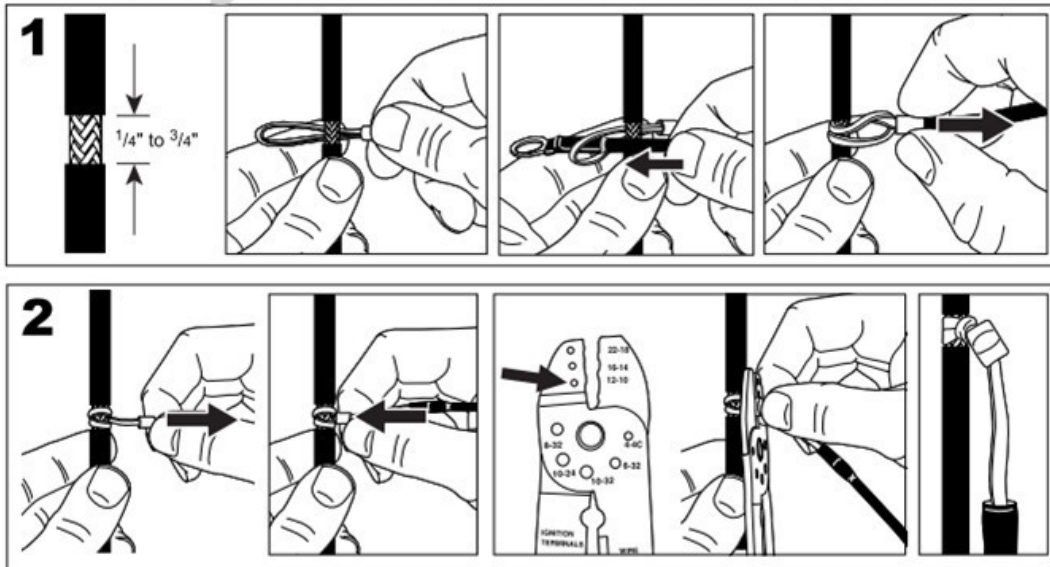
FIGURE F



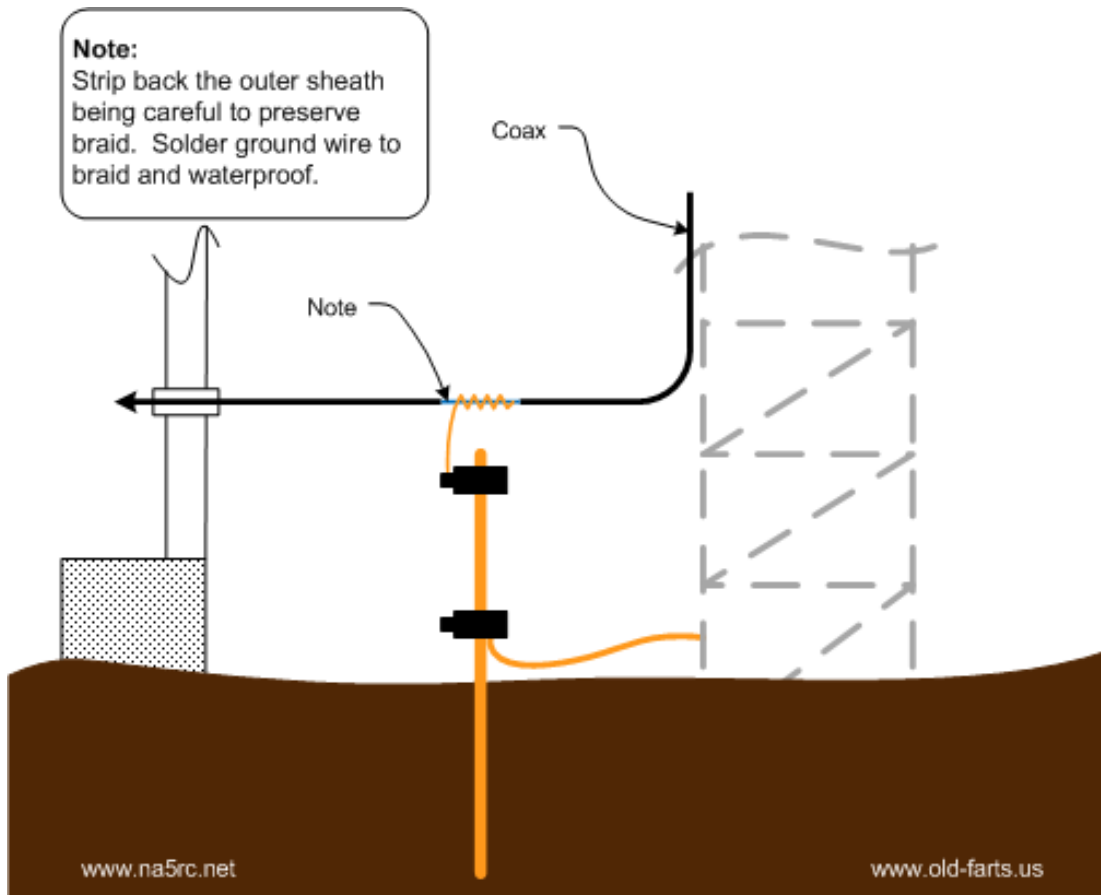
These are used for electrical grounds and are readily available. There is a size that almost exactly fits the spacing of Rohn 25G tower legs. Drill out some of the holes for coaxial barrel connectors or feed-thru lightning arrestors.

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Another method of mitigating lightning is to ground the coax shield as it leaves the tower. Commercial installations have kits for coax or heliax cables. Here are the instructions for a simple kit.



And here is a graphic I did to illustrate.



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In summary, do whatever you can to keep that nasty stuff out of your shack and your body. Remember that lightning can reach out over 20 miles from a thunder storm. Don't try to disconnect coaxial cable when a storm is too close. Disconnecting is good but it can also get you fried. Another thing to consider is ARRL insurance - it costs about \$1.40 per hundred per year.

Post Script:

I am running an experiment. On my repeater tower with concrete base, I put a PVC grounding well in the middle of the slab. I run three heavy braided conductors up from the ground rod inside the tower to each leg. The acute angle in Figure C is quite small using this method. The tower has not been hit yet or if it has, there has been no damage. This is not for want of lightning because there has been plenty.