

# Packable Folding Ground

## Plane Antenna

by Nathan Eng, W6EN



### Introduction

This design builds on the [classic ground plane](#) built around a SO239 socket and welding rod. I was motivated to try some changes when I needed a quick 220 antenna that was less fragile and awkward to store or transport.

This version uses cold forming (crimping, riveting) and off-the-shelf parts to simplify assembly, add hinges and strengthen joints. This avoids solder or bolts that creep and loosen over time. Suggested bands for this size: 2m, 1.25m or 70cm.

### Materials and Preparation



### Tools

- Rivet tool with assorted tips

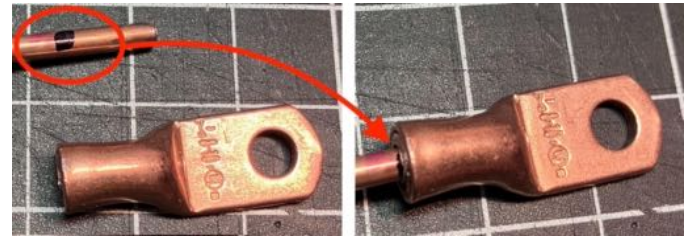
- Hammer
- Needle nose pliers
- Saw or diagonal cutters for antenna elements
- Heavy-duty soldering iron (200+W)
- Electric Drill and bits: step (incl 3/16), Spiral twist: 1/8", 3/16"
- Vice or holding jig for safe work holding during heavy cutting or drilling
- Glue gun, epoxy or 3D filament pen for reinforcing base
- Permanent marker
- Utility knife
- Measuring tape
- Calculator
- Antenna analyzer or NanoVNA with calibration plugs and coax to UHF-M
- Opt: Hydraulic crimper to attach lugs+elements

### Consumable Parts

- Flux core solder and flux
- Cyanoacrylate glue, Hot glue or PLA filament
- 4x ea rivets: 3/16x1/2" Al + 3/16x1/2" stainless
- 8x 8ga heavy copper terminal lugs
- 5x 1/8" solid copper or copper-clad welding wire (better), >1/4 wavelength on intended band
- 1 x SO239 case connector (with 1/8" rear pin hole, see Step 3B)
- 4x ea 5mm wave spring washers and flat #10 washers (fits snug over rivet)
- 2' or more 200psi 3/4" PVC pipe for mast/storage
- (Opt w/o crimper) Inserts for between elements and inside of lugs (ex. 10ga crimp ring terminals, see Step 2)

### Step 1: Preparing Connector

- A. Enlarge socket mounting holes to 3/16 (**sharp** step drill recommended to avoid breaking the hole). Don't hold by hand - use a jig or vice.
- B. While making sure lug flats are oriented clockwise (images in Step 4) and holes are tangent to the central connector, attach each of the 4 large copper lugs with a stainless 3/16 rivet. Depending on the rivet tool's shape, you may need some nuts/washers as spacers to protect the SO-239 threads.



- b. *If using hydraulic crimper:* using correct die (~7AWG for 1/8" radial in these lugs), crimp radial directly into lug with hydraulic crimper. It helps to first position the lug under light pressure and then close over radial.



## Step 2: Prepare Ground Radials X 4

### A. Prepare Radials

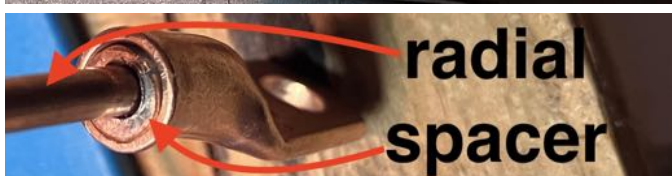
- a. File small taper on end to be inserted



- b. *If using plain copper wire,* you may need to straighten it by rolling it between boards or twisting from one end with a drill

### B. Mechanically secure radials to lugs by either:

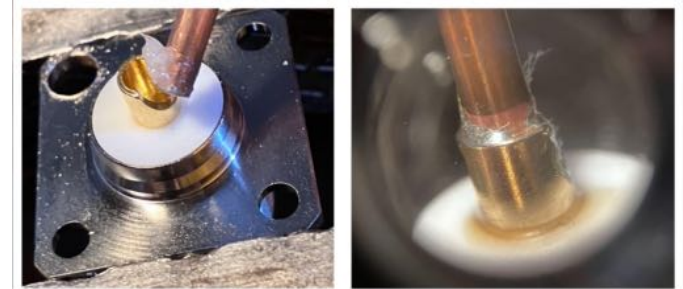
- a. *If making spacer from ring terminals;* strip and clip apart ring terminal, round remaining edges, hammer into lug and drilling out with 1/8" bit for inserting radial. Fill inside of assembly with solder.



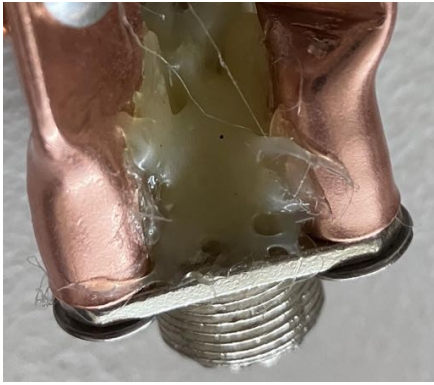
## Step 3: Attach Radiator

**!!! Warning: This connection is fragile until reinforced with thermoplastic or hot glue. Excess bending before reinforcement will break the connector pin and you'll have to start over !!!**

- A. Round and smooth radiator base as in Step 2A  
 B. Coat end of radiator and inside of socket pin with solder flux.



- C. Solder in place, applying just enough heat to flow solder from across the pin. Wiping away excess flux should reveal a concave layer of solder from all edges, especially areas that were not in contact with the iron or solder wire. (image above right shows gap requiring brief re-flow of solder).
- D. Reinforce the radiator mount to prevent bending
- "Prime" surfaces by preheating with solder iron until glue melts on contact.
  - Using hot glue gun or 3D pen, slowly build up coating on each part, then back and forth across gaps. Get a little around the edges of the connector for maximum hold.



## Step 5: Pipe Mast/Case

### Step 4: Attach Ground Radials X 4

- A. Check rivet tool has correct shank size insert.  
Steel and aluminum rivets use different ones.



- B. Assemble "rivet stack" as shown with **aluminum** rivets (steel ones apply too much tension): Rivet flat, radial lug (flat towards rivet), connector lug (flat facing away from rivet, wave washer, flat washer.



- C. Rivet the assembly in place, making sure the flat washer gets caught by the deforming rivet as it starts.



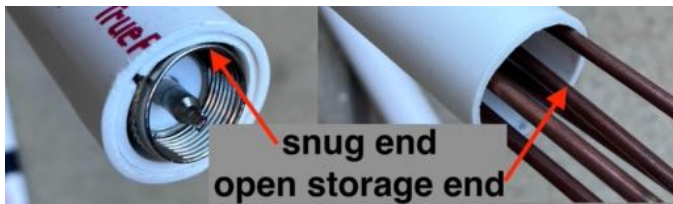
- A. Cut a 2' length of PVC (or slightly longer than  $\frac{1}{4}$  wavelength on selected band)  
B. Cut 2" section of pvc and remove  $\frac{1}{2}$ " slot along the length to squeeze it into one end of the mast/case section.



- C. Depending on the intended co-ax, use a combination of inserts and tape wraps so it sits snugly in the end of the mast/case.



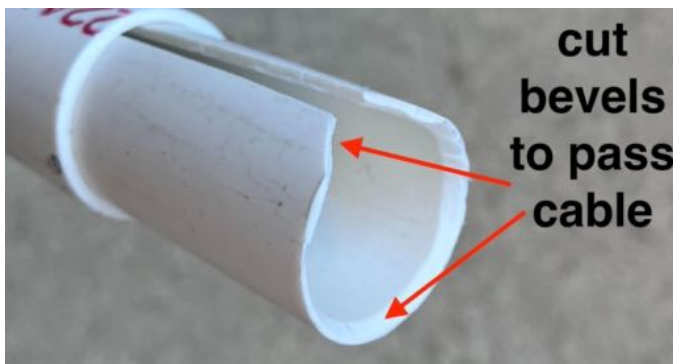
- D. This tube now has an open end for stowing the antenna and a narrow end for holding it when deployed.



- E. If desired, use a longer slotted section of PVC to make more extensions for your mast:
- a. As above, cut other 2'+ and 4" sections of PVC, slot the small piece, prime ends with glue and insert.



- b. Using a utility knife, taper inside edges of insert tube to ease assembly and running coax within tube.



## Step 6: Tuning

- A. Use an antenna analyzer to find the resonance point of the antenna deployed as it would be used on the mast.
- B. Calculate the ratio of radial to cut off, aiming for the bottom of the intended band:

$$\frac{(\text{as-is element length}) \times (\text{measured resonance frequency})}{(\text{desired resonance frequency})} = \text{target element length}$$

- C. Find resulting resonance and adjust remaining length to cut as before, again leaving a few mm just in case.
- D. Once filed, use a file to round off any sharp edges on the elements tips.

## Optional Refinements

- If you want to skip the folding aspect, just prepare the radials as in step 4 and rivet them side-ways directly onto the connector.
- Use a layer of epoxy to reinforce the hot glue around the base for extra ruggedness. This will,

however, be harder to melt away for repair/rebuild if needed.

- Tune the tension on the radial rotation by tapping them tighter between a hammer and striking surface.