Antenna Feed Point Box Fabrication

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December 2025

Some antennas need a special network at the feed point. For instance an inverted-L will have a low impedance where a 1:2 step-up impedance transformer is useful to improve the match. Or a multi-band vertical such as the popular 43- or 25-footers needs a 4:1 step-down transformer. Maybe a relay or two is required to shift the resonant frequency. Also, every antenna should have a proper common-mode choke for the feedline; sometimes that is all you need as in the case of a simple dipole or Yagi. All of this can be nicely packaged, making it mechanically robust, easy to mount and connect, and weatherproof. Here are some construction techniques that I've been using. At the end of this article are some actual examples.

Enclosure Types: Plastic is preferred because most chokes and inductors will tend to couple to metal, degrading performance. Plastic is easier to fabricate and there's no rust. Look for the NEMA 4X or 6P (IP66 or 68) specification which is waterproof. Cantex or Carlon PVC junction boxes are available from any hardware store. Common sizes are 2x2x4, 4x4x4, 6x6x4, and 8x8x4. Even larger ones are useful as big junction boxes at the base of a tower. Covers screw on and are gasketed. These have thick walls which will be mentioned later. Hammond and Bud also make a wide variety of enclosures. Some are available with a hinged cover which is very useful for networks that may require adjustment (Fig. 1).

Figure 1. Left to right: Cantex/Carlon PVC junction box; Bud HPB series; Hammond 1555 series (great for weatherproof QRP).

Coax Jacks: The square SO239 (Amphenol 83-1R) is usually my first choice (Fig. 2). If the panel is less than 1/8 in. thick, you can rear-mount it via a 3/4 in. hole. Otherwise it must be front-mounted via a 5/8 in. hole. Hold the connector in place while you drill 1/8 in. holes for #4-40 screws. To make the ground connections, I like to make a square copper tab as shown in the photo, but you can just use solder lugs. Connecting to more than one screw adds insurance against one coming loose. Always use stainless screws and nuts.

An alternative is a double-female feed-through with a PL259 connector going to the device inside. This avoids pigtail connections and will perform better for VHF. Be sure you tighten the heck out of the nuts. A threaded SO239 is also tempting because it only requires one hole for mounting. The drawback is that it tends to spin when someone tightens the PL259. Also it may not work with thick-walled PVC boxes unless you spot-face the hole.

Other connector types may have similar options, as with N connectors. If you're building a little QRP box, you might use a BNC.

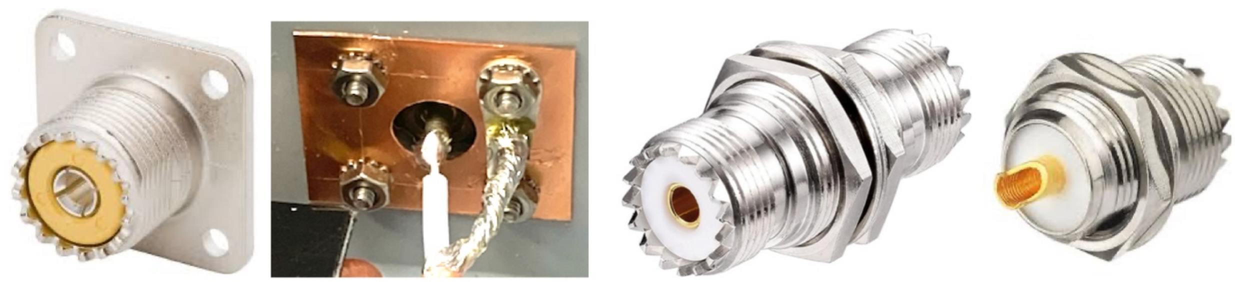


Figure 2. Left to right: Amphenol 83-1R; my copper grounding tab; a double-female feed-through connector; and a threaded SO239.

Antenna Terminals: For most antennas, you have two wires to connect. I generally use #10-32 stainless machine screws for terminals. Brass is good too. On plastic boxes, it's important to use flat washers inside and out to spread the force. Otherwise the plastic tends to deform and creep away, leaving the fastener a bit loose. For the interior connection, use a large solder lug or crimp lug. On the outside, I sometimes supply a wingnut but regular nuts are fine. Leave a little bit of slack on the internal connection in case the terminal ever spins due to over-torquing the screw. You don't want the wire to shear off.

Antenna Wire Tie Point: To take the strain off of the wire connection, I use stainless eyebolts, usually 1/4 in. That way, the installer can loop the wire through and twist it or use a split-bolt connector to really lock it in place. Since the box is made of plastic, both the tie point and antenna terminals are automatically insulated well enough.

Mounting Toroids: Most often we wind our chokes and transformers on toroids (typically ferrite). Secure mounting is recommended because you never know what somebody is going to do to your nice assembly! I've tried bedding the coil in silicone glue but results are mixed, with adhesion failure to the plastic. Above all, don't leave it just hanging by the wires. A positive method is a long machine screw through the enclosure and through the center of the toroid, with a plastic or phenolic bar across the windings (Fig. 3). Almost any plastic will do, and 1/8 in. or thicker is fine. Acetal (Delrin) is my favorite. Use a nylock nut and don't get carried away tightening it.

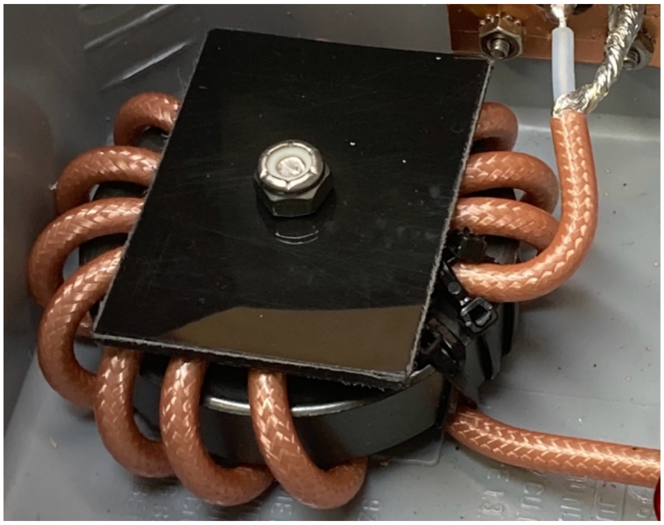


Figure 3. A toroidal choke clamped in place with a piece of 1/8 in. acetal and a machine bolt.

Mounting Solenoidal Coils: Commercial coils like the old B&W Airdux are getting really hard to find and are expensive so I just make my own. They don't usually need a core or support unless they are really huge with a zillion turns. I wind mine from heavy wire such as #10 solid copper or copper refrigerator tubing, then it's easy to solder and holds its shape well. At each end, I form a loop. That loop can accept a bolt that goes into a standoff. The standoff could be metal in some cases but I usually make them from acetal or nylon. Good old porcelain is great if you can find it.

Static Bleeders: Fully-floating antennas might need a path for static electricity to drain to ground, and/or across the coax. For instance a simple vertical with elevated radials has no ground connection anywhere, and triboelectric charging from wind can really zap you when the coax is disconnected. (Your matching circuit may already contain some other components that takes care of all of this.) Inductors or resistors may be used but I prefer resistors because there is no chance of resonance, which is especially problematic with multi-band antennas. To accommodate 1500 W with extra SWR and transient tolerance, a good choice is a 1 Mohm, 1W, carbon resistor. This can be a series-parallel combination. Note that you may need some connection to Earth ground.

Internal Wiring: Coax can be stripped back and the braid fanned out for pigtail connections. Teflon coax, such as RG400, is a joy to use since it won't melt when you solder it. Any heavy-gauge copper wire (#16 or larger) should be fine for most connections since they are pretty short. Thin copper strip or braid is probably overkill but if you have it, use it. Of course a QRP application can get away with very small conductors.

Heat Dissipation: I once did a series of experiments on ferrite core heating in small enclosures [Ref 1]. The upshot is that a ferrite toroid experiencing 30W of dissipation will overheat and damage the ferrite in about 15 minutes. This amount of heating can occur, for instance, with a choke running 1500W at 30 MHz into an unbalanced load such as an off-center fed dipole. And transformers for end-fed antennas are seriously at risk of thermal damage. If you have any doubts about dissipation, you can ventilate your enclosure. I drill large holes, or a series of small ones, and on the inside cover them with aluminum window screen held in place with silicone glue. As long as the opening faces downward it will be ok.

Weather Proofing: A quality enclosure will include a gasket and should be fine. When you install components through penetrations, seal them with a bit of silicone glue. A perfect hermetic seal can never be obtained, and there will be condensation inside. Drilling 1/16 in. weep holes in the bottom of the enclosure is recommended. Bugs won't get in but the enclosure can breathe and any condensate will drip out. A clever commercial vent device is the Hammond SDV180-1 for about $8.

If you have a control cable, feed it in through a compression type cord grip bushing, also known as a *non-metallic strain relief cord connector* at Home Depot.

Mounting: Smaller enclosures can be suspended via an eyebolt and rope for things like dipoles with no center support pole. Many enclosures have mounting ears for direct bolting to flat surfaces. There are several ways to mount on tubing and pipe. Bolt on a straight bar a bit longer than the enclosure and use hose clamps (Fig. 4). Or drill a small hole in the center of a hose clamp and bolt it directly to the back of the enclosure. A fancy installation might use a saddle clamp or channel strut fittings (Superstrut, Unistrut, etc).

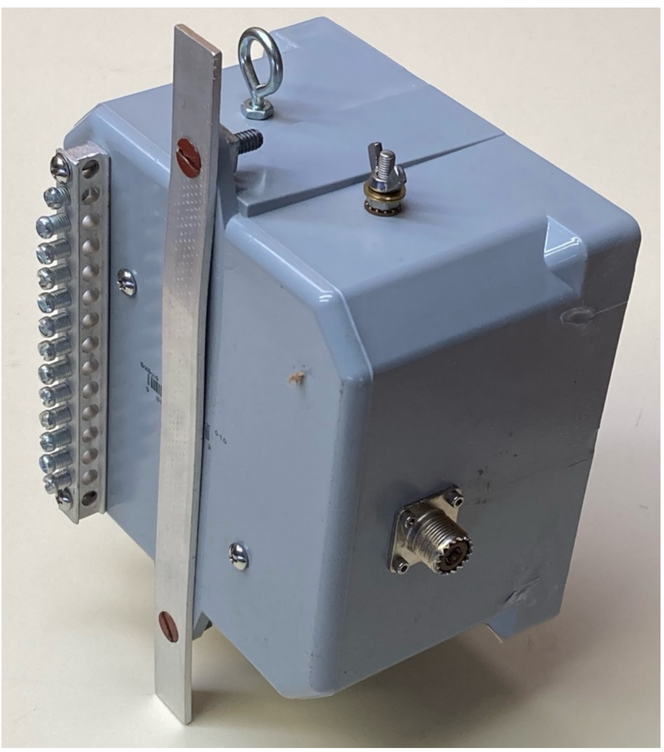


Figure 4. A strip of aluminum allows this enclosure to be clamped to a pipe driven into the ground. Note the ground bus bar for radial connections. That's a standard electrical panel accessory.

Special Tools: *Step bits* are your friend especially for large holes. Easily and safely used with a hand drill, you can blast through thin plastic or metal with ease and obtain a very clean, round hole up to at least 1-3/8 in. Get them at any hardware store.

Choke Design: Every antenna needs a common-mode choke. The place to go for design details is the famous K9YC Choke Cookbook [Ref 2]. He also has a cookbook for VHF/UHF [Ref 3]. For the HF bands, that means a Fair-Rite mix 31 ferrite toroid wound with either RG400 Teflon coax or twisted-pair wires. He lists optimum turns counts for each band (or set of bands), and has links to spreadsheets with more details on each design. I prefer RG400 because it's always 50 ohms. Chinese sources on eBay are fine; every batch I've tested met all specifications.

Transformer Design: For antennas with an impedance far from 50 ohms, sometimes an efficient transformer is a good matching solution. My primary reference is a book by Jerry Sevick, W2FMI (SK) [Ref 4]. He covers a vast number of impedance matching transformer designs configured as baluns and ununs, all with actual samples that he built and tested. Efficiency is very important, so be sure to use the recommended core and wire types. For most applications I use a 2.4 in. Fair-Rite mix 52 (mu = 250) toroid. Mix 61 (mu = 125) is recommended for some cases, and VHF. These are both very low-loss materials. Mix 43 (mu = 800) is also sometimes useful. Most transformers are wound with bifilar or trifilar magnet wire; 14 gauge is a good choice (smaller for low power). Larger sizes are finger killers when you wind them.

Labelling: If something has a polarity or special function, please apply a label. I always show my call sign, date, and a short description of the device. *Brother* labels hold up very well in the weather. If it's a very large and complex box, print the schematic at reduced size and tape or glue it inside the lid.

Example 1: Choke for a Fan Dipole

Commercial chokes (they always seem to call them 1:1 baluns) are pretty expensive and often the specification include some pretty wild claims. Follow the K9YC winding guidelines and the other info presented here and you can build a better product at a fraction of the cost. Figure 5 shows one that I made for a fan dipole, based on a Fair-Rite 2631803802 mix 31 core wound with RG400 in a 4x4x2 Cantex box. There are eyebolts for the antenna wires to tie to and another one for hanging. Total cost is around $35.

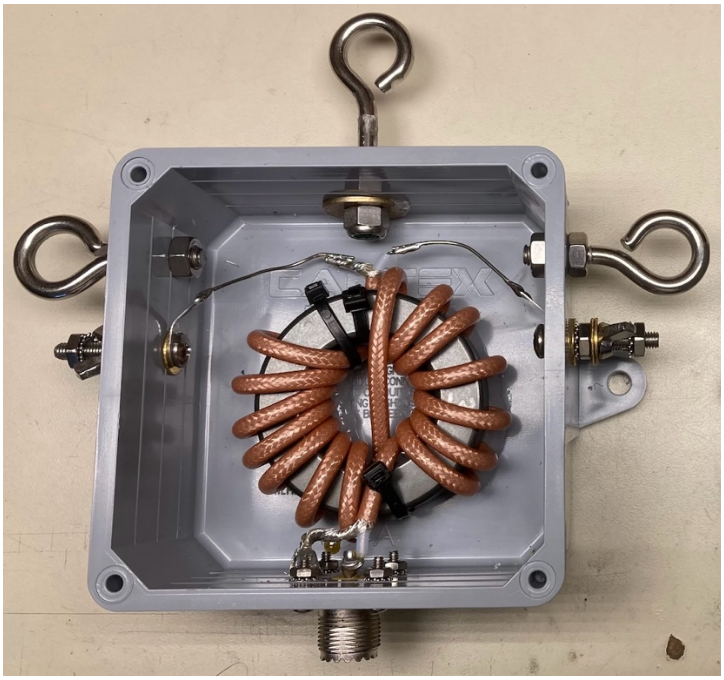
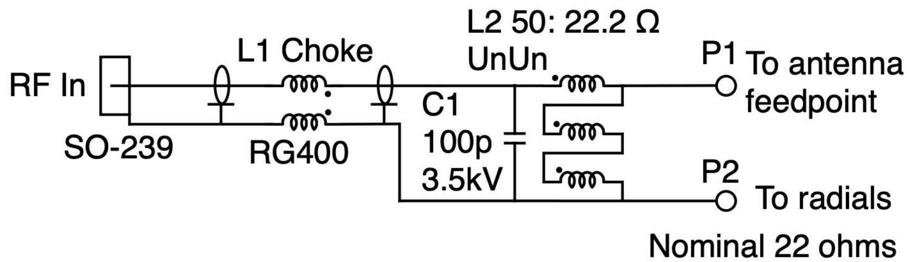


Figure 5. Choke for a fan dipole. Anyone can build one of these!

Example 2: Feed Point Box for a 160m Inverted-L

Simulation shows that the feed point impedance of my 160m inverted-L with elevated radials will be around 20 ohms, so a 2.25:1 impedance transformer is nearly perfect. A Fair-Rite 5952003801 mix 52 core is wound with 5 turns trifilar 14 AWG magnet wire. A 100 pF high-voltage “doorknob” transmitting capacitor is added at the 50 ohm side of the transformer to cancel leakage inductance, improving the match. Figure 6 shows the schematic and Fig. 7 the final product. Multiple eyebolts are needed for the vertical element and the elevated radials.

You can test a device like this with a VNA or antenna analyzer. Connect an appropriate resistor (22.2 ohms) across the antenna terminals and observe the input SWR.



L1: 16T RG400 on FT240-31. Z=6k. Loss .02 dB, Pd=8W at 1500W.
L2: 5T trifilar #10 magnet wire on FT240-52.
C1: K15Y 100 pF 3.5 kV doorknob (Ukrainian, eBay)
P1, P2: 1/4-20 brass machine screw.
Enclosure: 6x6x4 PVC NEMA-4, Cantex 5133710.
Eyebolts: (3X) 1/4-20 SS with nuts and washers.

Figure 6. Schematic of the 160m feed point box.

Figure 7. Feedpoint box for a 160m inverted-L. A compensation capacitor is barely visible next to the 2.25:1 transformer. The hold-down clamp for the transformer is removed for clarity.

Example 3: Feed Point Box for an 80m Vertical

Here is a complex design for an 80m full-sized vertical with a single elevated 1/4-wavelength radial formed in a square, per N6BT (Figs. 8, 9). Besides the usual choke, this antenna needs a hairpin match (an inductor across the antenna feed). We also want to use this on SSB and CW portions of the band, so an inductor in series with the radial is added via a relay to shift resonance lower in the band. Coils are wound from #10 AWG solid copper wire, about 2 in. diameter and not too closely spaced. One is mounted on acetal standoffs while the other is clamped in place with a Teflon contraption I came up with. A larger 8x8x4 Cantex box was needed.

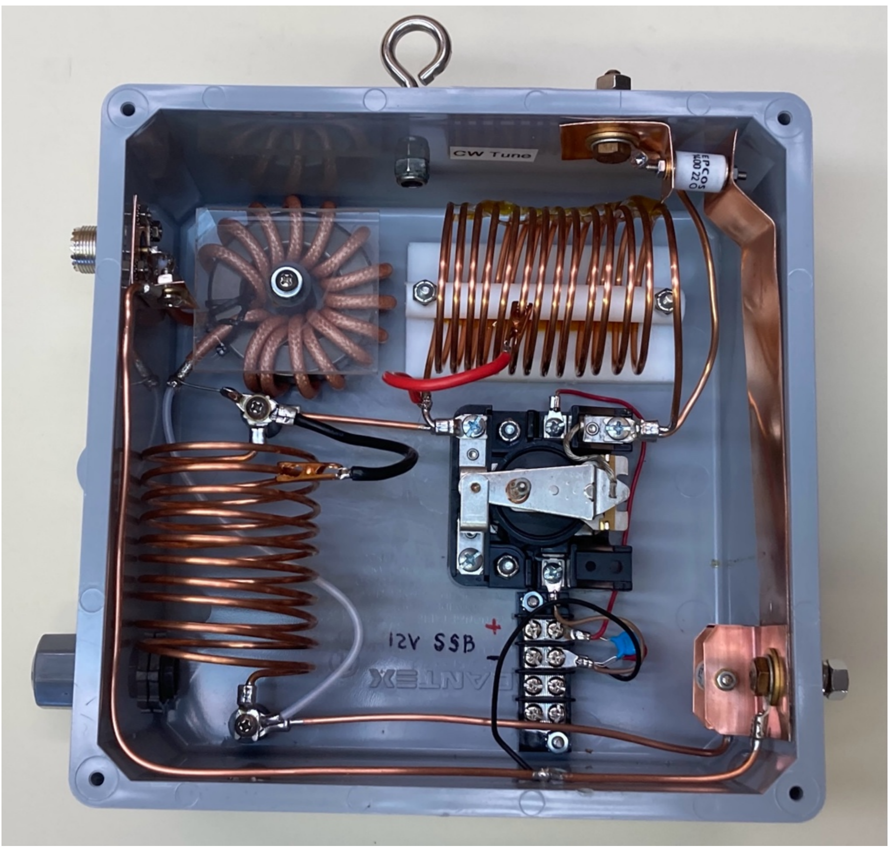
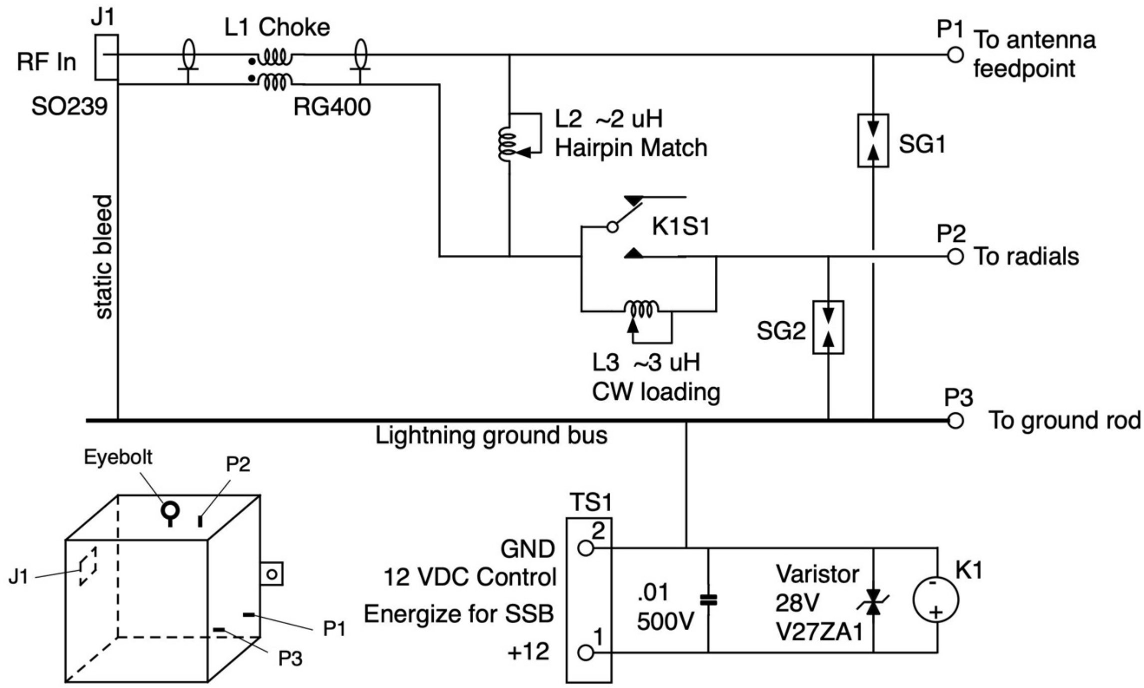


Figure 8. Complex 80m vertical feed point box with hairpin coil, CW-shift coil with a relay, choke, and lightning arrestors. This box is bolted to Unistrut.

Because of lightning risk where this was installed, 1.4 kV gas discharge tubes (Epcos) were included on the vertical element and the radial with heavy copper sheet connected to a grounding bolt. It may be overkill but it’s easy enough to install here.

I do initial adjustments of the coil taps with a small copper alligator clip on the shorting wire. This can be soldered in place when we’re happy with the settings. Only solder one side of the clip so that you can change it if needed. Finding old-school coil clips is nearly impossible...



K1: SPST, 12V coil. P&B PRD5GO-12V.
L1: 15T RG400 on FT240-31. Loss .03 dB, Pd=13W at 1500W.
L2, L3: #10 BC, 10 turns, 2" dia, 2.5" long. Stretch for match.
P1, P2, P3: 1/4-20 X1.5 brass bolts, nuts, washers.
SG1, SG2: GDT, 1400V, 25 kA. Epcos B88069X4300B152. M3 bolts.
TS1: Barrier strip.
Enclosure: 8x8x4 PVC NEMA-4, Cantex R5133712.

Figure 9. Schematic of the 80m vertical feed point box with parts list.

Example 4: 25-Foot Portable Vertical

This non-resonant antenna uses ground radials and presents an impedance in the region 200 ohms on many bands. An easy way to match this is a 4:1 impedance transformer (unun) with a common-mode choke. For 100W maximum power, small toroids can be used. The transformer has 12 bifilar turns of 23 AWG magnet wire on an FT140-61 core. Loss is only 0.17 dB at 30 MHz. For the choke, RG316 coax is sufficient for this power level and 12 turns are wound on a small Fair-Rite 2631801202 mix 31 core; this is a *very* broadband choke. The enclosure is a Hammond 1555 with a nice gasket seal (Fig. 10). Binding posts were ideal for this simple antenna and in fact it’s being used by a blind ham.

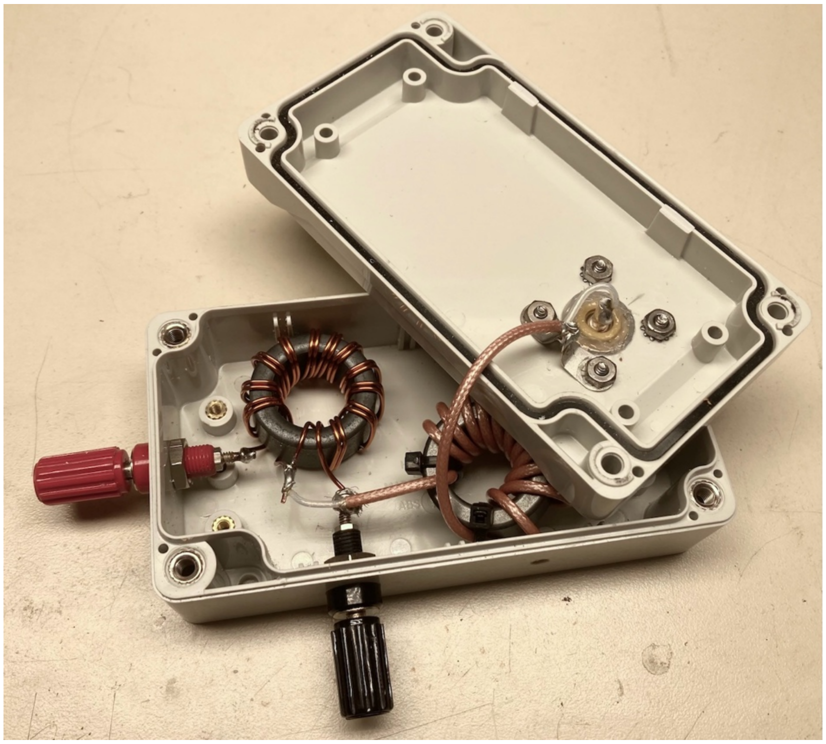


Figure 10. Match box for a portable 25-foot vertical.

References

1. *Four-Square Rebuild at N6RO* by NA6O. Includes feed point box design and thermal studies. https://na6o.com/amateur_radio/ewExternalFiles/Four_square_rebuild_at_N6RO.pdf

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4. Jerry Sevick, W2FMI, *Understanding, Building, and Using Baluns And Ununs*. Now out of print but available as a PDF download. https://na6o.com/amateur_radio/ewExternalFiles/W2FMI_Baluns_and_Ununs.pdf