5/8-wavelength vertical antenna for mobile work

Problems with loading coils are eliminated with this design — the coax feedline also acts as a matching stub

Most published 5/8-wavelength vertical antennas have used a base loading coil.[1,2,3] I built several of these but difficulty in obtaining components, weatherproofing, and adjusting the antenna for low vswr led me to seek a better design. This design[4] is mechanically simple, uses readily available components, and best of all is easy to adjust for a low vswr over the entire 2-meter band.

The antenna consists of a 5/8-wavelength radiator fed with a length of coax that also is the matching stub. A diagram appears in **fig. 1**. The mechanical components are simple. A short length of RG-58/U coax cable with the outer insulation removed and one end shorted, is slipped inside a piece of 1/4-inch (6mm) diameter tubing. The stub is connected electrically in series between the radiator and coax center conductor. The tubing is mounted in an insulator that attaches to a PL-259 coax plug. The feasibility of this design can be demonstrated by making an "emergency" antenna from a 48-inch (122cm) length of RG-58/U or RG-8/U cable, as shown in **fig. 2**.

electrical performance

A 5/8-wavelength radiator above a ground plane exhibits an impedance of approximately 50-j185 ohms[5] (see **fig. 3** or **table 1**). Thus its resistive component closely matches 50-ohm coax, but it's highly capacitive. To resonate this 5/8-wavelength radiator and provide a purely resistive load, an inductive reactance of approximately 185 ohms is needed, and a loading coil is usually used. A length of coax cable shorted at one end and less than 1/4-wavelength long also appears as an inductive reactance. If a 0.21-wavelength shorted coaxial stub is connected in series with the 5/8-wavelength radiator, capacitive reactance will be cancelled and a 50-ohm resistive load will be presented to the transmission line.

This coaxial matching scheme can be used with many vertical antennas. In the form presented, it can only compensate for an inductive or capacitive reactance.

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table 1. Impedance of radiators mounted above a ground plane with 50-ohm coax feed (calculated from reference 5).

radiator length (λ)	impedance (ohms) 1/4 in. (6mm) diameter	1/4 in. (13mm) diameter
9/16	111-j310	86-j240
19/32	71-j244	58-j195
5/8	50-j185	44-j147
21/32	39-j133	37-j105

Fortunately, radiator lengths between 9/16 to 5/8 wavelength have 40 to 65-ohm resistive components, depending on diameter, and can be easily matched by this technique. I've used this method of "hiding" the matching stub on collinear arrays using four 5/8-wavelength radiators[6] and also with collinear 1/2-wavelength radiators, rather than using conventional 1/4-wavelength open-wire stubs. The advantages of the coaxial design include no radiation from the phasing stubs and ease of constructing weatherproof arrays from available materials.

construction

Detailed dimensions of the components for a 5/8-wavelength whip are shown in **fig. 4**. The components are assembled as follows. Slip the 36-inch (91cm) long, 1/8-inch (3mm) diameter rod 1-1/2 inches (38mm) into the tubing and solder. You'll probably have to insert a soft copper or brass shim or crimp the tubing to make a tight fit. After joining, the radiator should be 47-1/2 inches (121cm) long overall, and the tubing should be unobstructed for at least 11-1/2 inches (29cm). Next, slip the modified PL-259 connector into the insulator. Epoxy-bond the sleeve, center portion and insulator into a single unit. Be sure to seal between the sleeve and insulator so water can't enter that joint.

The antenna can be made of stainless steel. Stainless-steel welding rods as well as stainless-steel tubing are easily obtainable at low cost. A special soldering flux* is necessary for soldering stainless steel. Use care to clean joints and the inside of tubing to prevent corrosion and to ensure a good solder job. An advantage of stainless steel is that its ductility is good. After several mishaps (garage door, bridges, vandals, trees) it was easy to straighten out an S-shaped whip with no degradation in performance.

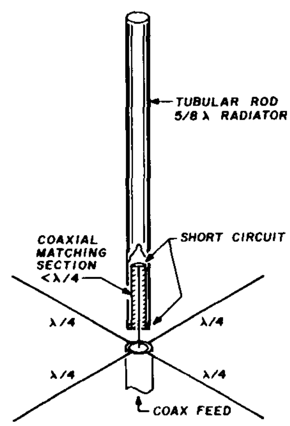

fig. 1. The 5/8-wavelength 2-meter antenna showing series-connected coax matching system. Increasing number of radials will decrease system ohmic resistance and increase radiation resistance.

At this point, you'll have three components: plug and insulator assembly, radiator, and the coaxial matching section. The coax should be carefully soldered at the short circuit so the coax will slide easily into the tubing. Tin the center conductor, cut the end of the braid, and slide the coax into the tubing until the end of the braid is flush with the tubing end. If you wish, the edge of the braid may be carefully soldered to the end of the tubing to ensure better mechanical and electrical stability, although it may also be simply tinned and wedged for a snug mechanical fit. Solder must be kept off the outside of the tubing so that the tubing will slide into the insulator. The coax may be loose inside the tubing with no adverse effects so long as it makes electrical contact near the unshorted end of the braid and can't slip in or out to change its effective length.

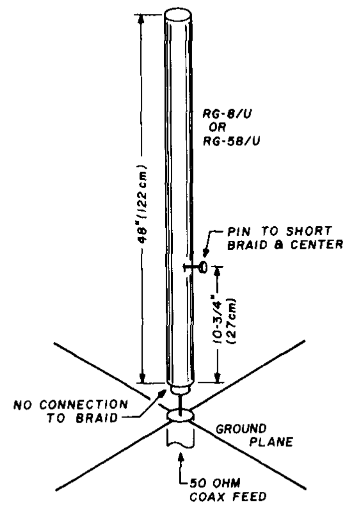

fig. 2. Example of an "emergency" 5/8-wavelength radiator made from coax cable. Outer braid is the radiating element.

When the coax has been inserted into the tubing, measure the distance from the tip of the PL-259 to the top of the insulator. Measure this same distance from the tip of the coax center conductor along the tubing, and scribe the tubing. The radiator tubing should now be inserted into the insulator to the scribe mark and the coax center connector soldered temporarily to check the vswr before applying the epoxy for the final assembly. The assembly shows less than 1.1:1 vswr over the entire 2-meter band. If not, check the dimensions of the coax and radiator carefully, and be sure braid and tubing are flush in the insulator. A 1/4-inch (6mm) error in the coax length will make a difference in vswr. If you wish to make the overall whip length somewhat shorter, say 42 or 43 inches (107 or 109cm), it will be necessary to

*"Stay Clean" brand flux and "Stay Brite" solder are good for this purpose.

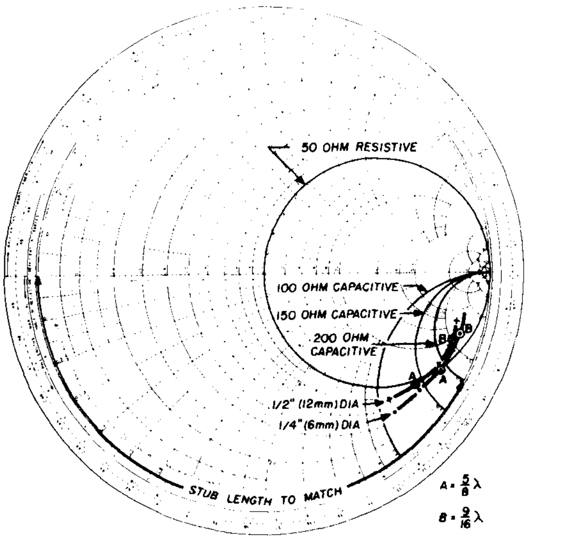

fig. 3. Smith chart showing impedance of 5/8-wavelength radiator mounted above a ground plane and fed with 50-ohm coax cable.

lengthen the coax matching section about 1 *inch* (25mm).

If the vswr is not very low, check at two frequencies, about 2 MHz apart if possible, and determine which vswr is lower. If the lower frequency shows a lower vswr, shorten the coax or shorten the radiator. If the higher frequency shows the lower vswr, the reverse applies.

vswr measurement notes

Most reflectometers and swr bridges don't appear as a purely resistive 50-ohm length of coax. When inserted into a flat (matched) line they may show an swr *not* representative of the true line swr, depending on the line length between bridge and load. When the "impedance" of the vswr meter is placed a multiple of one-half wavelength from the load to be measured, both appear effectively in parallel, sometimes causing questionable results. This is particularly true when very low (less than 2:1) vswr is being measured.

After much frustrating experimentation, I found that the *best* distance to place a vswr meter from the measured load is an odd multiple of one-quarter wavelength at the measuring frequency. Vswr measurements may be checked by adding short 1/8 to 1/4 wavelength lengths of coax to the line between reflectometer and load. For impedance measurements as well as vswr, I use a carefully constructed slotted line.[8] However, such a device is rather impractical to use on a roof or tower.

For best performance the whip should be mounted on a good ground plane. A mounting for a trunk-lid lip, which requires only two holes (invisible and easily patched), is shown in **fig. 5**. This antenna design can also be used on mounts that use the equivalent of an SO-239 fitting.

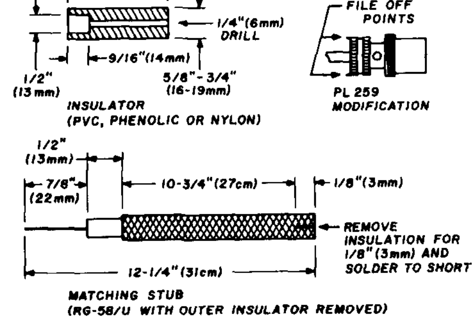

fig. 4. Dimensions of components used in the 5/8-wavelength vertical antenna. Brass or stainless steel may be used for the radiator; the latter is recommended (see text).

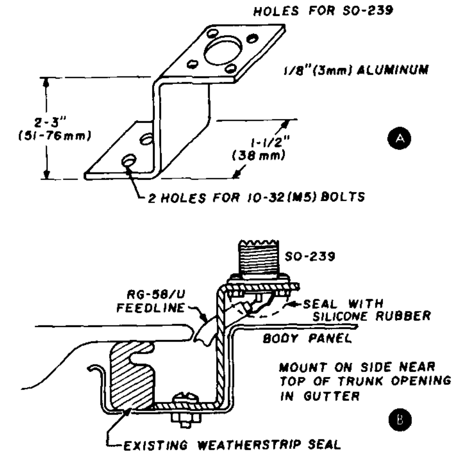

fig. 5. Mounting bracket (A) and suggested mounting details for an automobile trunk lid (B).

references

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8. Ed Tilton, W1HDQ, "Slotted Line for UHF SWR Checks," *QST*, January, 1969, page 36.

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