All-band HF Flagpole Vertical

No-radial, 21 ft. free-standing flagpole antenna is inexpensive, works all HF bands, and is neighbor/CC&R proof.

By John Portune W6NBC

Figure 1: 20 ft. modified Harbor Freight flagpole

What ham hasn't looked at a flagpole and thought, "That would make a great HF antenna. My neighbors wouldn't have a clue." Great as this idea may sound, home brewing a well-disguised yet efficient HF flagpole antenna isn't as easy as many might think.

These are the challenges. To be both stealthy and a good performer, a flag-flying HF antenna should (1) have no radials (2) be just a plain pole that is externally tuned and matched (3) work multi-bands and (4) be fed coaxially (5) be free standing. Sound difficult? Not so. This attractive patriotic home-brew special (Figure 1), accomplishes all these at modest cost.

What's more, you don't have to search the internet or local metal dealers for aluminum tubing. The antenna is almost ready made for you in an attractive 20 ft. Harbor Freight telescopic flagpole ($59, June, 2017). It has five 4 ft. locking sections. You'll only need to add an insulated ground-mount and a feed point. These are quickly constructed with ordinary workshop tools from hardware-store materials. If you prefer, there's a heavy-duty commercial version available from Force-12 Antennas. (end of article)

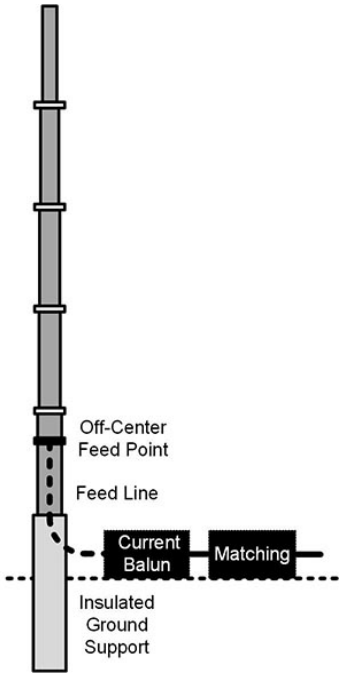

Figure 3: Physical Configuration

(1) no radials?

Few hams have the space for radials, especially on an urban lot. A small-footprint is basic to flagpole antennas. And only one design satisfies this, a no-radial vertical half-wavelength (λ/2) dipole. A traditional quarter-wavelength (λ/4) vertical is a monopole. It needs radials. The need for radials to me has always precluded λ/4 verticals from the realm of flagpole antennas.

Half-wavelength vertical dipoles, however, present two challenges of their own. First, the feed-point isn't conveniently at the bottom as for a λ/4 vertical. It's higher, though not necessarily exactly in the middle. For this pole, it's roughly 20% from the bottom. See Figure 2. In more familiar terms, this antenna is off-center-fed (OCF). Secondly, the bottom of a half-wavelength dipole must be insulated from ground. The bottom of a λ/4 vertical is usually grounded. We'll deal with these below.

(2) Plain Pole, (3) Multi-Band

It has also long been obvious to me that traps, stubs, loading coils, and capacitive hats are a dead giveaway to CC&R-toting neighbors. The locals won't be fooled into thinking that such RF hardware belongs on a flagpole. To be truly disguised, a flagpole antenna must look like a flagpole – just a plain pole. Tuning and matching needs to be done elsewhere, not on the pole.

Okay, then how then do we match a plain pole to Ohm rig and feed line on multi-bands? Notice Figure 3. It shows the feed impedances of the plain pole, measured with my vector network analyzer. Notice, that there isn't a 50 Ohms match (1:1 SWR) on any ham band. Clearly just a plain pole needs

MHz	|Z| Ω	SWR
3.8	588	269:1
7.2	142	48:1
10.0	147	52:1
14.2	36	1:1.5
18.0	112	3:1
21.2	172	6:1

Figure 3: Flagpole impedances and SWR's

matching, but again without coils, hats or stubs. Otherwise the neighbors will know.

The only practical way is with a weather-proof match box at the base. Unlike pole-mounted coils, hats or stubs, a “black box” in the bushes doesn’t shout “antenna.” The neighbors will only see a controller for perhaps your lawn sprinklers, or something else non-radio. We will look at the design of the matchbox below.

CAUTION: Do not consider feeding the pole directly with coax, without a matchbox. If you do, high SWR on the coax (Figure 3) will ”eat you alive” in loss. It may even damage your rig.

(4) Coaxial Feed

Also for stealth, a half-wavelength flagpole antenna is best configured as a coaxial dipole. That is, the feed line enters at the very bottom of the pole and runs up to the feed point through the center of the antenna tubing itself. A traditional sideways feed is not stealthy. See Figure 2. I tested both sideways and coaxial feed and there is no difference.

(5) Free Standing

Lastly, who puts guy cables on a flagpole? This pole is made free-standing by five feet of 2½ in. rigid PVC electrical conduit, buried 3 ft. in the ground. Do not use metal. Remember, the bottom must be insulated. There is a stainless hose clamp on the pole, 12 in. from the end, to stops the pole 6 in. above ground to form the ground insulator.

In soil alone, 3 ft. of buried conduit is satisfactory. In concrete, 18 in. is plenty. My soil-mounted pole has flown a 3x5 ft. flag for many months in stiff breezes. I used a water drill, made from 6 ft. of 2 in. ABS pipe and a garden hose fitting, to make the hole in the ground.

Does it “Get Out?”

Let’s be honest. It would be apples and oranges to compare this flagpole to a large multi-element beam on a tower or an elevated full-size horizontal wire dipole. It’s a small ground-mounted antenna to

keep the neighbors happy, not the big gun at a mega-station. Meaningful comparison needs to be with is other similar small verticals mounted at the same height. A tower-mounted Yagi will always be king of the hill, but lots of great and economical hamming is done with a modest antenna like this. Figure 4 make the comparison to three other small ground-mounted verticals.

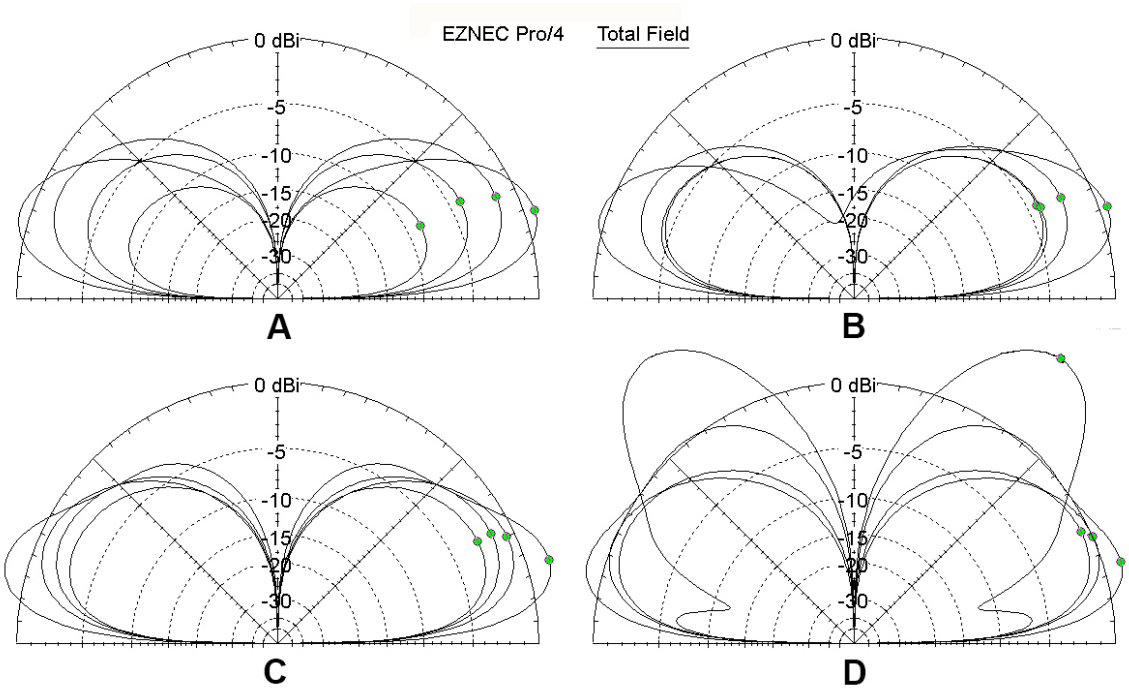

Figure 4: (A) Flagpole, (B) Cushcraft R9, (C) 20 ft. pole with four 20 ft. radials, (D) 43 ft. vertical with four 43 ft. radials, Green dots (working inward) indicate maximum gains as the best wave angles on 10m, 20m, 40m and 80m. All are mounted 1 ft. above ground

(1) All four have a low-angle radiation angle, even the flagpole. A low take-off is the chief asset of a low vertical – good for low-band DX.

(2) The gains are quite comparable.

(3) The 43 ft. vertical (D) has more gain than the flagpole on the lower bands, but it's over twice as tall – unsuitable for a flagpole on a domestic lot.

(4) The Cushcraft R9 (B) also has better gain on the lower bands, again due to its height plus the addition of highly-visible top and bottom capacitive hats – not stealthy.

(5) Both (C) and (D) have large radials – too large a footprint.

The radiation efficiency of the flagpole (conductor resistance vs. radiation resistance) is excellent. It's in the high 90 percentiles on all bands. This is due to the highly-conductive large-diameter aluminum tubing of the pole. Another asset is our flag waver's economy. This modestly-priced antenna will deliver more "QSO's for the buck" than a big beam on a tall tower.

Let's Build One

Begin by cutting the Harbor Freight flagpole 9 in. below the bottom locking ring. This is for off-center feed point assembly. Make the cut carefully so as not to distort the tube; the assembly is a close fit. I used a common hacksaw and the supplied ground-mount tube as a guide to make a clean square cut. File the edges smooth and clean the inside of the tube ends.

You also need to connect all the pole sections together electrically. They do not adequately connect as is. Use #12 x ¾ in stainless sheet metal screws just below the locking rings. The pole, therefore, will no longer telescope. You will have to attach the flag and erect it fully extended. I can, however, easily raise mine at full length with a flag attached. I also do not recommend adding a rope and pully. The plastic flag attachments allow the flag to rotate around the pole to prevent the flag from wrapping around the pole with changes in wind direction.

Constructing the Feed Point Assembly

Cut a 12 in. length of 2 in. PVC pipe. See Figures 5 and 6. Make two cross cuts, part way (¾) through the PVC, 4½ in. from each end. Then cut 1 in. wide longitudinal slots from ends, up to the center of the cross cuts. Three inches in the middle remains as is.

The feed line connects to the cut pole ends via two 4 x 6½ in. rectangles of thin (9 mil) flexible aluminum flashing rolled into sleeves around the feed-point assembly. Flashing aluminum is available at most hardware stores. Pre-form the sleeves, by gently bending the flashing around a piece of ¾ in. PVC pipe. Also bend a ¾ in. right angle tab across a 4 in. end of each sleeve. Be careful not to

break the aluminum with too sharp a bend. Drill a 6-32 screw clearance hole in the same end of both tabs for the connection to the feed line.

During final assembly, you will temporarily compress the sleeves and concentric assembly ends with stainless hose clamps until the ends slip into the pole ends. When the clamps are removed, the slotted PVC ends will expand to tightly press the aluminum flashing against the inside of the pole tubing for a good RF connection. NOTE: There is a plastic coating on the aluminum flashing that you must first remove by sanding or scraping.

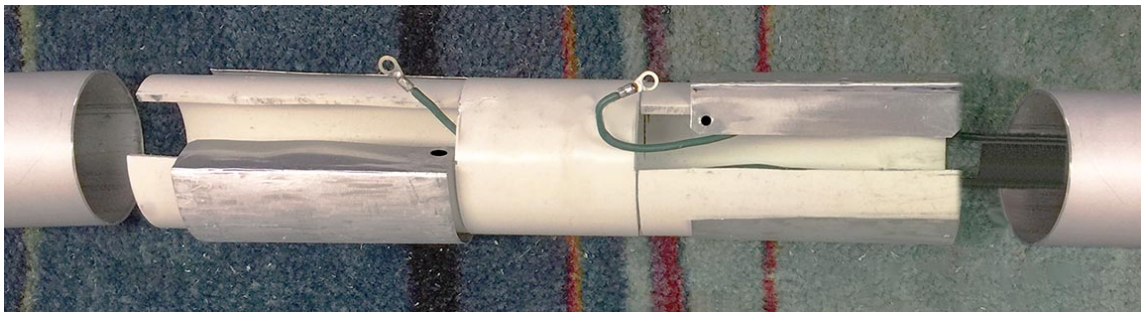

Figure 5: The feed-point assembly laid out for final assembly

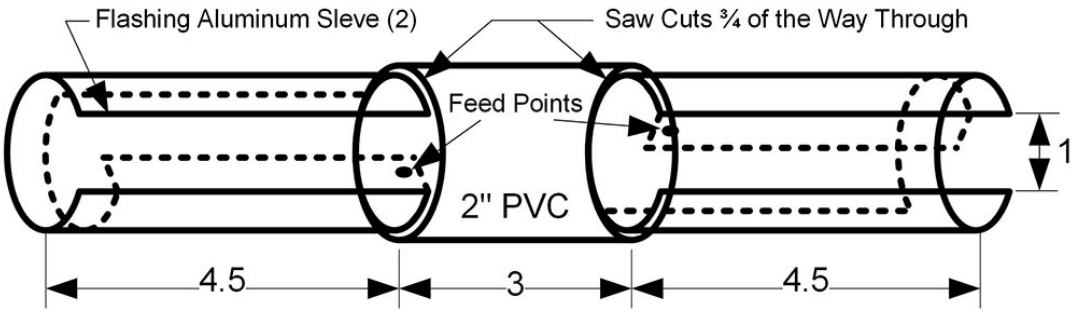

Figure 6: Transparent view of the compressed feed-point assembly

The feed line is 5 ft. of 450 Ohm balanced window line that runs down from the feed point inside of the pole to the bottom and out to the match box. It is encased in polyethylene foam tubing for centering and support. The foam tubing is readily available at hardware stores. It is normally used to insulate ¾ in water pipes. Cut a thin slot in the new ground-mount tube just below the bottom of the flagpole for the feed line to exit.

If you prefer, you my use low-loss coax from feed point to match box, such as LMR-400, instead of open line. There will, however, be roughly half a dB more loss. Solder or crimp two pigtails of 14 AWG stranded insulated wire, onto the feed line, one 8½ in. long, the other 5 in. Add ring terminals to the ends for #6 lugs.

Final Feed-Point Assembly

Lay out the pieces as shown in Figure 5. First, connect the wire pigtails to the aluminum sleeves with 6-32 brass or stainless hardware. 1/8 in. pop rivets with washers are even better.

Then compress one assembly end and its flashing sleeve with two stainless hose clamps until the compressed end fits easily into a pole end. By moving the clamps in small increments, and tapping the pole ends with a hammer and a wooden block, the assembly can easily be snugged up. Repeat for the other side.

Lastly, push the polyethylene foam tubing in over the window line from the bottom and cut off the excess. Secure the foam with a small amount of clear silicone RTV adhesive. Then use the supplied ground mount fiberglass tube to cover and stabilize the feed point. I added four 1 x 3 x 1/16 in, aluminum shims to take up the small gap. Place a stainless hose clamp around the flagpole just below the fiberglass tube. You are now ready to attach the flag, telescope the pole and insert it in the ground mount. Remember to push the feed line through the slot in the bottom of the mounting tube.

The Match Box

As mentioned above, this antenna requires a match box at the base of the pole. The easiest way, though not most economical, is to use one of the several excellent outdoor remote auto-tuners on the market today. Another is a home-brew, purpose-built matchbox. But AGAIN, do not try to omit the match box and feed the pole directly with coax. If you try to use a tuner back in the shack, the naturally high SWR’s of the pole (Figure 3) will cause very high losses in the coax on several bans. You may even may even damage a tuner built into a transceiver.

You will also need a balun between the pole and the matching network. The pole must be fully isolated from ground. The balun also needs to be a Guanella current balun. Do not use a voltage (Ruthroff) balun, the kind commonly found in antenna tuners for balanced output. Voltage baluns are not suitable at high SWR's. I built a weather-proof 1:1 Guanella current balun from an FT-240-61 toroid kit from Amadon (roughly $20): Part No. AB-240-125. Commercial 1:1 current baluns are also satisfactory. The balun will require terminals suitable for the open-wire line and the matching network. I used banana plugs for the window line and a very short length of low-loss coax with PL-259 connectors for my tuner.

Admittedly this little vertical is somewhat unconventional, but to me it is well within the limits of good ham practice and it is working very satisfactorily for me. It is also very convenient; push the button on the auto-tuner and voila, contacts and no unhappy neighbors.

Many thanks to Jim Bailey W6OEK, and Dayle Good KK6HNS for their invaluable assistance on this article and project.

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