Efficient All-band HF Flagpole Vertical

Free-standing HF/6m 20 ft. flagpole antenna needs no-radials, is neighbor-friendly, CC&R-proof and works multiple-bands

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What ham hasn't looked at a flagpole and said, "That would make a great antenna; the neighbors wouldn't have a clue." Yet great as this idea may sound, an efficient well-disguised RF flagpole antenna is not as straightforward as many might think.

To be both stealthy yet effective, an RF flag-flier (Figure 1): (1) must be a plain pole without stubs, loading coils, or capacity hats, (2) must not use radials, (3) must work multiple bands and (4) be free standing. Sound difficult? Not so. This home-brew special does it all. See Figure 1.

Figure 1: My stealthy flagpole antenna

Bill of Materials

18 ft.	2 in. OD thin-wall aluminum (not steel) tubing,
4.5 ft.	2 in. ID pultruded fiberglass tubing
2-4 ft.	2½ in. common galvanized water pipe
6 ft.	LMR-400 low-loss coax
	Stainless steel nuts, screws, line pully and flag hardware
	Pole-top decoration (optional)
1	Base antenna tuner (see end of article)

Figure 2 shows how to deploy the pipe and tubing. I obtained the tubing from internet industrial and/or ham radio suppliers. Galvanized water pipe is a hardware store item. For the more-experienced home-brewer, also take a look at using a Harbor Freight 20 ft. flagpole version of this project, on 6nbc.com/articles/harborfreightflagpole.pdf.

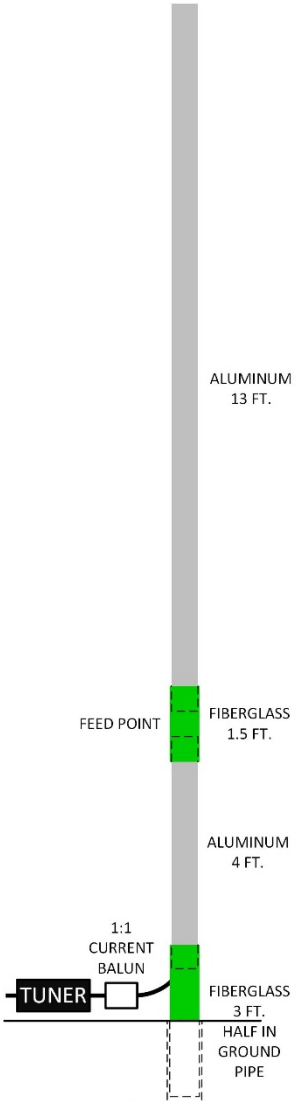

Figure 2: Mechanical Configuration

2-4 ft. of 2½ common galvanized water pipe provides the in-ground free-standing support. 4 ft. buried in soil provides adequate support without concrete. A shorter pipe needs concrete. Fill the bottom half of the support pipe with small gravel to let the pole to only go in 18 in.

At the top, you can add a ball or a brass eagle. Internet flag sellers offer these. On mine I used a solar-powered LED garden-path light with a red filter. You will also need a pully near the top for the flag haul line and a tie-down cleat at roughly five feet. These won't effect the antenna RF-wise.

Design Concepts

It seemed very clear to me when I began considering an HF flagpole antenna, that near the street in front of a small mobile home a flagpole with loading coils, a capacitive top hat or stubs, is not stealthy. The neighbors aren't fooled that easily, even if they aren't hams. The extra hardware is a dead giveaway. A stealthy flagpole antenna must be a plain pole.

My next question was, how does one make a plain flagpole an efficient HF antenna? Many might think a quarter wavelength vertical with radials? Poor choice! How many of us, especially those with small urban lots, have the space for an adequate number of radials, certainly not right near the street.

To me, there is only one choice. An HF flagpole antenna needs to be a half-wavelength (electrical) antenna. This means that there will, be an insulator in the pole at off-center feed point and a second insulator at the base. At ground level, both no-radial half wave verticals and quarter wave verticals with radials have comparable low-angle radiation and gain. EZNEC modeling further showed me that the best feed point position is roughly 20% from the bottom. This percentage is not critical, however.

It is also better for neighbor appeal, to not feed the coax to the OCF feed point part way up the pole from the side. Coaxial feed works just as well and is much stealthier. The coax runs up from the bottom of the pole up through the inside. See again Figure 2. There's a slot in the fiberglass ground insulator for the coax to enter. Figure 3 details the feed point. The dimensions shown at are not critical.

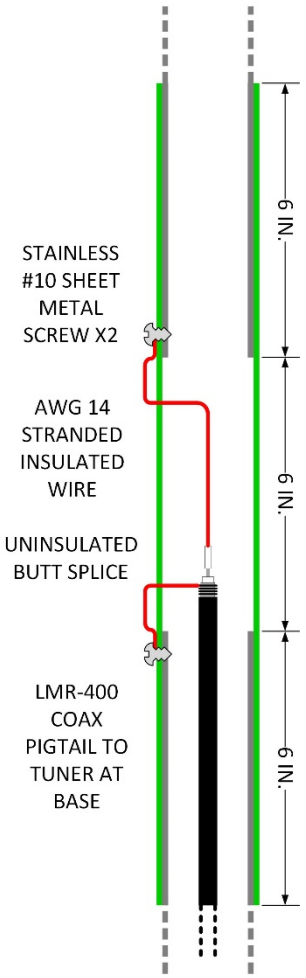

Figure 3: Suggested Feedpoint

Multi-band Operation

Next, how does one make plain-pole 20 ft. flagpole work multiple bands? The only truly suitable way is to locate an antenna tuner right at the base of the pole. *** * *** Carefully read the second part of this article on correctly feeding this antenna *** * *** A tuner at the bae is the only practical way to eliminate loading coils, stubs and capacity hats on a short plain pole. This pole reliably tunes 40-6m. Some tuners may reach 80m.

Many external tuners are useable with this design. It could be a commercially-built remote auto tuner, a manual tuner enclosed in a weather-tight box, or a purpose-built match box. I use an MFJ-993BRT 300W remote auto tuner. There are several other suitable units on the market, such as the LDG RT-100 and the RT-600 remote auto tuners.

NOTE: The tuner must have a true balanced output. Commercially-built tuners often use voltage (Ruthroff) baluns to attempt a balanced output. Bypass this type if present and install an external 1:1 current (Guanella) choke balun. I use a home-brew ferrite-bead sleeve balun on a very short pigtail of low-loss coax (LMR-400), Figure 4. A handful of common computer snap-on split beads is also suitable. My balun came from Palomar-Engineers.com.

Figure 4: 1:1 ferrite sleeve current choke balun

Tilting up the Flagpole

A hinge at the base is not required; I can easily lift the pole to set it in its ground mount tube. Although for convenience during tilt-up, I added a 2½ ft. length of heavy-weight 1 3/8 in. bendable Neoprene tubing in the top end of the ground mount tube, with roughly a foot sticking out. Many hardware stores carry it. I keep a coating of silicon grease on the neoprene tubing. Auto parts stores sell it as dielectric grease.

Admittedly this is a somewhat unconventional approach to vertical antenna design, but it keeps my neighbors happy. Best of all, it is very convenient to use. I just push the tune button on the auto-tuner and I am hauling in the DX. Best of all, the neighbors don't know.

PART TWO: The following is a general discussion of the correct use of non-resonant antennas, such as this flagpole antenna. Non-resonant antennas not unfamiliar to many hams. A clear grasp of the concepts here is essential to avoid costly mistakes. *Read this material carefully*.

Non-Resonant Antennas

Avoid costly mistakes with the 20 ft. no-radial all-band HF flagpole antenna

Hams in general are mostly familiar with resonant antennas. That's the kind that shows a low SWR at the frequency of operation and is normally used without a tuner. Some think, "Don't all antennas have to be resonant? Otherwise they won't 'get out, and their high SWR

might damage my finals?” What’s your opinion? Are these universal truths?

It may be a surprise, but there a whole class of home brew and commercially-made ham antennas that very effectively radiate RF power but aren’t naturally resonant. Sound like an oxymoron? It isn’t. You may be using one right now and not realizing it.

If you have an OCF dipole, a G5RV, a windom, or a short flagpole antenna, you very well may be operating it in non-resonant mode. Understanding the difference between the two modes is essential in avoiding costly mistakes with naturally non-resonant antennas.

Two Main Difference?

ONE: Resonant antennas by their physical design are naturally tuned to the intended operating frequency. Without any matching, they show a resonant “dip” and a low SWR at that frequency. Non-resonant antennas don’t.

TWO: Resonant antennas can generally be fed directly with coax. Because of their physical configuration, or because of added loading coils or capacity hats, they show a feed-point input impedance of 50 Ohms and can generally be fed directly with coax. Non-resonant antennas generally mustn’t be fed directly with coax. A tuner is required.

Technically, resonant and non-resonant aren’t entirely exclusive categories. The operating class depends on frequency. If, for example, you use an antenna tuner on some frequencies with a resonant antenna to achieve a low SWR, you are operating it in the non-resonant mode. This is true even if the antenna is normally considered to be a resonant antenna. If on other bands you can bypass the tuner, you are operating the antenna in resonant mode.

A good example of how an antenna of either type can be operated in either mode, is a simple 40m wire dipole. Many consider a correctly-cut dipole a resonant antenna. But notice Figure 1, it's the SWR curve from 3-30 MHz.

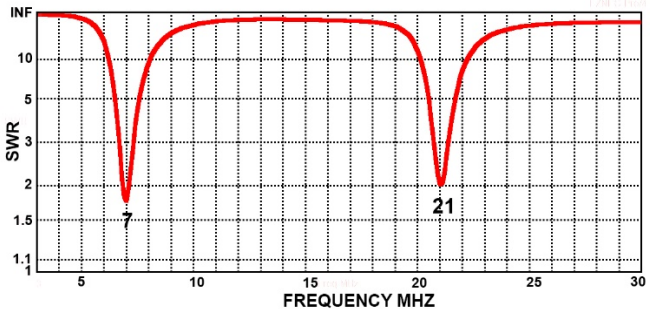

Figure 5: SWR curve, 40 meter dipole

Only for a narrow range of frequencies near 7 MHz or 21 MHz does it operate naturally in resonant mode. However, since most hams use a properly-cut 40m dipole only on those frequencies, it is not unreasonable to generally considered it a resonant antenna. But suppose you want to operate it on 20m. Now you use a tuner to operate it in non-resonant mode. Without the tuner, a 40m dipole on 20m, can't be fed directly with coax.

The reason some antennas are intentionally built to mainly operate in the non-resonant mode can be seen in the popular 43 ft vertical. As a vertical monopole with radials, a 43 ft vertical is not naturally resonant on any HF ham band. Its natural resonant frequency is 5.7 MHz. The 43 ft. non-resonant length has better radiation patterns than its naturally-resonant ham cousins. Non-resonance is often chosen to achieve beneficial characteristics that cannot be implemented in a resonant design or because an antenna may be too small to be resonant.

MHz	R	jX	SWR
3.8	2	-213	513
7.2	2	-101	136
10	4	-61	32
14.2	40	-16	1.5
18	6	-42	14
21.2	2	-20	38
24.9	6	9.3	9
28.5	4	3.1	13

Figure 6: Feed-point impedances of 20 ft, no-radial flagpole antenna

The all-band 20 ft. no-radial flagpole vertical is just such an antenna. See Figure 2. It does not match 50 Ohm transmission line nor does it show an ideal SWR on any ham band, especially 40m and 80m. Below 20m it is too short to be resonant. Above, the length is incorrect for natural resonance.

A tuner, therefore, is required at the base of this and most non-resonant antennas. Optimally it would be a remote outdoor auto-tuner. The tuner transforms the

natural non-resonant impedances of the plain pole to 50. Only with a base tuner can a naturally non-resonant, high-impedance antenna like the flagpole be safely fed with coax.

Some may still consider omitting the base auto-tuner, thinking to use a long run of coax and a tuner in the shack. Further they may consider using the tuner built into their transceiver. BOTH options are poor and may damage the rig.

Why a Base-mounted Tuner is Mandatory

Notice Figure 2. Coax loss increase dramatically with SWR. Note the percentage of the transmitter's power that reaches the end of 100 ft. of RG-8 when the SWR is high. RG-58 or Mini-8 are much worse. Non-resonant antennas can easily cause very high SWR. See again Figure 2.

	Percent Power Out.						
MHz	**1:1**	**3:1**	**10:1**	**30:1**	**100:1**	**300:1**	**1k:1**
3.8	95	92	78	55	27	11	4
7.2	93	89	72	47	21	8	3
10	91	87	69	43	18	7	2
14.2	90	84	65	38	16	6	2
18	89	83	62	35	14	5	2
21.2	88	81	60	34	13	5	2
24.9	87	80	58	32	12	4	1
28.5	86	79	56	30	12	4	1

Fig. 2 RG-8 Coax Loss by SWR and frequency

Also, peak voltages and currents on a transmission line, and reflected back to a tuner, also increase with SWR (by the square root of double the SWR). At an SWR of 1:1, a transmitter putting 100 Watt into 50 Ohm coax, generates 70 Volts and the current 1.4 Amps. On 80m with the flagpole, where the SWR is 513:1, the peak voltage and current is 31 times greater: 2200 Volts and 45 Amps.

Outboard tuners can generally handle such levels, but the light-weight tuners built into most ham rigs may not. They may be

damaged. Rig tuners are generally designed only to correct minor changes in SWR caused by only-slightly-out-of-tune resonant antennas. They will not tune most non-resonant antennas.

Lower Cost Alternatives to an Auto-tuner at the Base

Here are some less-than-optimum but workable substitutes for a base-mounted remote auto-tuner.

(1) Use a short run of 450 Ohm slotted window line directly from the elevated feed point of antenna all the way into the shack. It will require proper support on the run and a 1:1 current balun in the shack.

(2) Use the flagpole on only one band at a time with a discrete L/C matching networks in an outdoor enclosure at the base. A parallel coil, series capacitor L-match will match the flagpole on all bands. Several remote relay switched fixed networks are also feasible.

(3) Use a manual tuner in an outdoor enclosure. Tune it up once on all bands and then mark the scales for subsequent band changes. A second tuner in the shack or built into the rig will then safely touch up small mis-adjustment of the base tuner.

(4) **NOTE:** A 4:1 or 9:1 current balun at the base is NOT an alternate. These will help the SWR on some bands but make it worse on others.