By Edison Fong, WB6IQN

The DBJ-1: A VHF-UHF Dual-Band J-Pole

Searching for an inexpensive, high-performance dual-band base antenna for VHF and UHF? Build a simple antenna that uses a single feed line for less than $10.

Two-meter antennas are small compared to those for the lower frequency bands, and the availability of repeaters on this band greatly extends the range of lightweight low power handhelds and mobile stations. One of the most popular VHF and UHF base station antennas is the J-Pole.

The J-Pole has no ground radials and it is easy to construct using inexpensive materials. For its simplicity and small size, it offers excellent performance. Its radiation pattern is close to that of an "ideal" dipole because it is end fed; this results in virtually no disruption to the radiation pattern by the feed line.

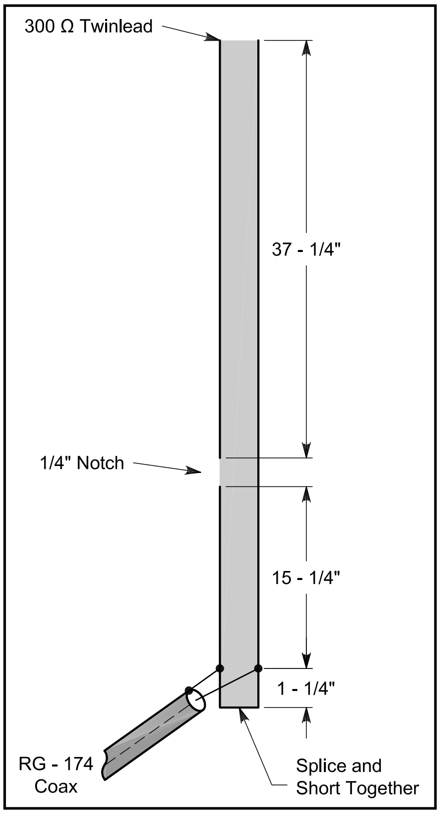

Figure 1—Basic diagram and dimensions for the original 2-meter ribbon J-Pole.

The Conventional J-Pole

I was introduced to the twinlead version of the J-Pole in 1990 by my long-time friend, Dennis Monticelli, AE6C, and I was intrigued by its simplicity and high performance. One can scale this design to one-third size and also use it on UHF. With UHF repeaters becoming more popular in metropolitan areas, I accepted the challenge to incorporate both bands into one antenna with no degradation in performance. A common feed line would also eliminate the need for a duplexer. This article describes how to convert the traditional single band ribbon J-Pole design to dual-band operation. The antenna is enclosed in UV-resistant PVC pipe and can thus withstand the elements with only the antenna connector exposed. I have had this antenna on my roof since 1992 and it has been problem-free in the San Francisco fog.

The basic configuration of the ribbon J-Pole is shown in Figure 1. The dimensions are shown for 2 meters. This design was also discussed by KD6GLF in *QST*.[1] That antenna presented dual-band resonance, operating well at 2 meters but with a 6-7 dB deficit in the horizontal plane at UHF when compared to a dipole. This is attributable to the antenna operating at its third harmonic, with multiple out-of-phase currents.

I have tested single-band J-Pole configurations constructed from copper pipe, 450 Ω ladder line, and aluminum rod. While all the designs performed well, each had shortcomings. The copper pipe J-Pole matching section would be exposed to the

[1] J. Reynante, KD6GLF, "An Easy Dual-Band VHF/UHF Antenna," *QST*, Sep 1994, pp 61-62.

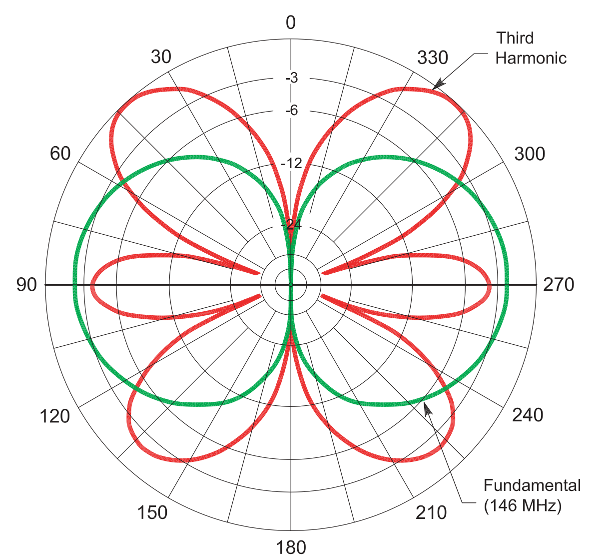

Figure 2—This EZNEC plot shows the difference in the radiation patterns between a vertical half-wave radiator operated at its fundamental (146 MHz) and third harmonic (445 MHz). At the fundamental, most of the energy is directed at right angles to the antenna—and to distant receivers.

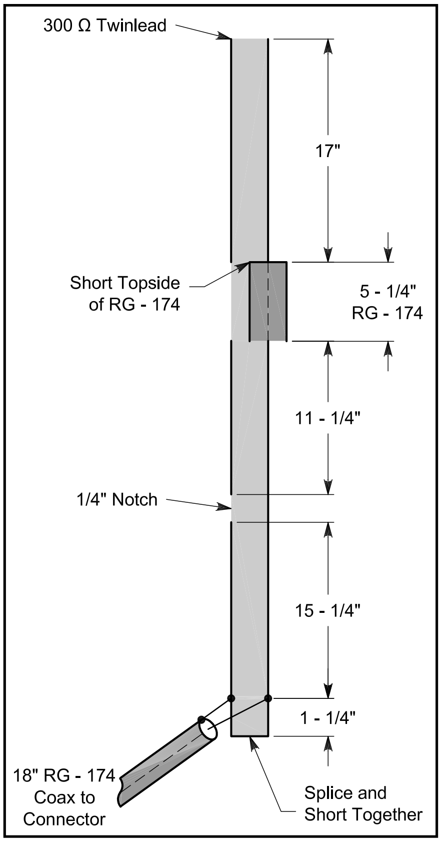

Figure 3—The 2 meter J-Pole modified for both VHF and UHF operation. These measurements are approximate (see text).

air, raising a durability question. The aluminum design would be faced with a similar issue in the salt air of the San Francisco Bay area. I favor the use of 300 Ω twin lead because it is easily obtainable and inexpensive. An advantage of the copper pipe design was an 8 MHz bandwidth—about twice that exhibited by the twin lead version. That was expected, since the copper pipe had a much larger diameter than the twin lead elements used in that version. My final decision was to be based on aesthetics, cost and durability...but the antenna had to be a true dual-band design.

How the J-Pole Works

The basic J-Pole antenna is a half-wave vertical radiator, much like a dipole. What separates this design from a vertical dipole is the method of feeding the half-wave element. In a conventional dipole or groundplane, the radiation pattern can be disrupted by the feed line and there is usually a tower or some other support that acts as a reflector as it is frequently parallel to the antenna. The J-Pole pattern resembles that of an ideal vertical dipole because of its minimal interaction with the feed line. The performance of this J-Pole is, theoretically at least, equal to a ¼ wave radiator over an ideal ground.

The J-Pole also matches the high impedance at the end of a ½ wave radiator to a low feed point impedance suitable for coax feed. This is done with a ¼ wave matching stub, shorted at one end and connected to the ½ wave radiator's high impedance at its other end. Between the shorted and high impedance ends there is a point that is close to 50 Ω. This is where the feed line is attached.

Creating the Dual-Band DBJ-1

So how can one add UHF to the conventional 2-meter J-Pole? First of all, a half-wave 2 meter antenna does resonate at UHF. Resonating is one thing, but working well is another. The DBJ-1 not only resonates, but also performs as a ½ wave radiator on both bands. An interesting fact to note is that ½ wave center-fed dipole-type antennas will resonate at odd harmonics (3rd, 5th, 7th, etc). This is why a 40 meter center-fed ½ wave dipole can be used on 15 meters. Similarly, a 150 MHz antenna can be used at 450 MHz. However, the performance of the antenna at the third harmonic is poor when it is used in a vertical configuration. At UHF (450 MHz) the ½ wave radiator becomes $^3/_2$ wavelengths long. Unfortunately, at UHF, the middle ½ wavelength is out of phase with the top and bottom segments and the resulting partial cancellation results in approximately 2 dB less gain in the horizontal plane compared to a J-Pole operating at its fundamental frequency. Maximum radiation is also directed away from the horizon. Thus, although the J-Pole can be made to work at its third harmonic, its performance is poor, often 6-8 dB below that of a groundplane. Figure 2 shows a polar plot of a vertical ½ wave radiator operating at its fundamental (146 MHz) and third harmonic (445 MHz) frequencies. Note the difference in energies of the two frequencies.

What is needed is a method to decouple the extra length of the 2 meter radiator at UHF in order to create independent ½ wavelength radiators at both VHF and UHF. The DBJ-1 accomplishes this by using a coaxial stub, as shown in the antenna drawing of Figure 3.

There is 18 inches of RG-174 transmission line connecting the bottom RF connector to the radiating element. Eighteen inches was chosen so that the bottom portion of the antenna housing can be used to mount the antenna without disturbing its electrical characteristics. [The use of RG-174 coax in this design limits the power the antenna can handle to less than 60 W at low SWR. By substituting RG-213, RG-8 or RG-58 cable, power ratings can be improved considerably. However, the length of the decoupling stub at the UHF antenna may have to be recalculated, because of the change in velocity factor (VF) of the different cable.—*Ed.*]

The 16½ inch matching stub of 300 Ω twin lead works like a ¼ wave stub at VHF and a ¾ wave stub at UHF with virtually no penalty, except for a slight 0.1 db loss from the extra ½ wavelength of feedline. By experimentation, the 50 Ω point was found to be 1¼ inches from the shorted end of the stub. Although the impedance at this point is slightly inductive, it is still an excellent match to 50 Ω, with an SWR of approximately 1.3:1.

Connected to the open end of the matching stub, the radiating element for UHF is 11¼ inches long. The stub and radiator are constructed of a single piece of twin lead, separated from the matching stub by a ¼ inch notch in one conductor, as shown in Figure 3. The extra wire in the twin lead radiator sections radiates along with the driven wire, creating a thick element that is shorter than its free-space equivalent. To terminate the UHF radiating section, a shorted stub, using RG-174 coaxial cable, is used. As with the input matching stub, the open end presents a high impedance and is connected to the upper end of the UHF radiating section. Note that the stub is only an open-circuit at UHF, acting as a small inductance instead, at VHF.

The RG-174 stub connects to the upper section of 300 Ω twin lead and that completes the VHF radiating element. Note that the total length of the UHF and VHF radiating elements plus the coaxial stub do not add up to a full ½ wavelength at VHF because the inductance of the coaxial stub acts to shorten the antenna slightly.

Construction Details

The dimensions given in Figure 3 should be considered a starting point for adjustment, with final tuning requiring an SWR analyzer or bridge. During the antenna's construction phase, I started at the feed point (see Figure 3) and after each section was assembled, the input SWR was checked. After the ¼ wave VHF matching section is connected to the 11¼ inch UHF ½ wave section, check the SWR at UHF. Then add the ¼ wave UHF shorted RG-174 stub. The stub will require trimming for minimum SWR at UHF. Start with the stub 10–15% long and trim the open end for lowest SWR. As a last step, add the 17 inch section of twin lead. Again, this section should be trimmed for the lowest SWR at your frequency of choice in the 2 meter band.

To weatherize the antenna, enclose it in ¾ inch schedule-200 PVC pipe with end caps. These can be obtained from your local hardware or building supply store. When sliding the antenna into the PVC tubing, I found no need to anchor the antenna once it was inside. [If larger coaxial

Table 1
Measured Relative Performance of the Dual-Band Antenna at 146 MHz

	VHF ¼ Wave Mobile Reference	*VHF Flex Antenna (“Rubber Duck”)*	*Standard VHF J-Pole*	*DBJ-1 J-Pole*
Received Signal Strength	–24.7 dBm	–30.5 dBm	–24.3 dBm	–23.5 dBm
Difference from Reference	0 dB	–5.8 dB	+0.4 dB	+1.2 dB

Table 2
Measured Relative Performance of the Dual-Band Antenna at 445 MHz

	VHF ¼ Wave Mobile Reference	*VHF Flex Antenna (“Rubber Duck”)*	*Standard VHF J-Pole*	*DBJ-1 J-Pole*
Received Signal Strength	–38.8 dBm	–45.3 dBm	–45 dBm	–38.8 dBm
Difference from Reference	0 dB	–6.5 dB	–6.2 dB	0 dB

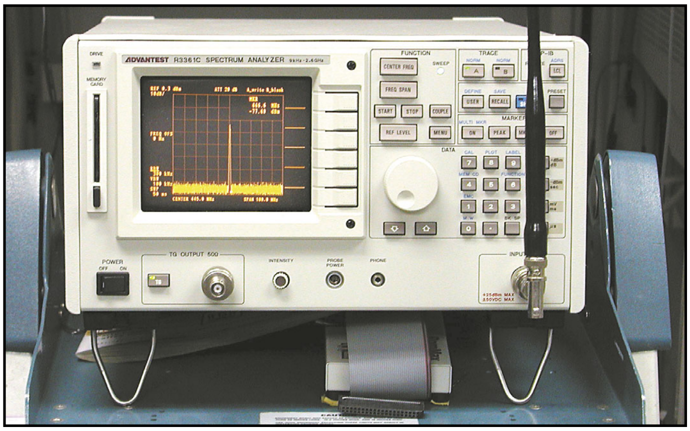

Figure 4—The Advantest R3361 spectrum analyzer used in the test.

cable is used for the stub, it is likely that the top of the antenna will require some glue or foam to hold the antenna in place because of the additional cable weight. —*Ed*.] The 300 Ω twin lead is sufficiently rigid so as not to bend once it is inside the pipe. Install an SO-239 connector in the bottom end cap. Once the antenna is trimmed to the desired operating frequency, glue both end caps and seal around the SO-239 connector. Presto! For a few dollars, you’ll have a dynamite antenna that should last for years.

The antenna should be supported only by the lower 12 inches of the housing to avoid interaction between the matching stub and any nearby metal, such as an antenna or tower. The results from the antenna are excellent considering its simplicity.

Measured Results

Brian Woodson, KE6SVX, helped me make measurements in a large parking lot, approximating a fairly good antenna range, using the Advantest R3361C spectrum analyzer shown in Figure 4.

The transmitter was a Yaesu FT-5200 located about 50 yards from the analyzer. The reference antenna consisted of mobile ¼ wave Motorola ground plane antennas mounted on an NMO connector on the top of my vehicle. The flex antenna (“rubber duck”) was mounted at the end of 3 feet of coax held at the same elevation as the groundplane without radials. The J-Pole measurements were made with no groundplane and the base held at the same height as the mobile ground plane. Table 1 gives performance measurements at 146 MHz, while Table 2 gives those same measurements at 445 MHz.

As can be seen in the UHF results, the DBJ-1 outperforms the standard 2 meter J-Pole by about 6 dB (when used at UHF), a significant difference. The standard 2 meter J-Pole performance is equivalent to a flex antenna at UHF. Also note that there is no significant difference in performance at 2 meters between the DBJ-1 and a standard J-Pole. The flex antenna is about 6 dB below the ¼ wave mobile antenna at both VHF and UHF. This agrees well with the previous literature.

The completed antenna can be seen mounted to the author’s roof in Figure 5.

If you do not have the equipment to construct or tune this antenna at both VHF and UHF, the completed antenna is available from the author, tuned to your desired frequency. The cost is $20. E-mail him for details.

Figure 5—The completed antenna mounted to the roof.

Ed Fong was first licensed in 1968 as WN6IQN. His Extra Class came with WB6IQN. He obtained the BSEE and MSEE degrees from the University of California at Berkeley and his PhD from the University of San Francisco. A Senior Member of the IEEE, he has seven patents and two-dozen published papers in the area of communications and integrated circuit design. Presently, he is employed by the University of California at Berkeley teaching graduate classes in RF design and is a Senior Member of the Technical Staff at Foveon Corporation in Santa Clara, California. You can contact the author at 1163 Quince Ave, Sunnyvale, CA 94087; **edison_fong@hotmail.com**.

FEEDBACK

◊ In "The DBJ-1: A VHF-UHF Dual-Band J-Pole" [Feb 2003, p 40], replace "VHF" with "UHF" in the headings of Table 2, columns 1 and 2. Column 3 remains "VHF," as it refers to the use of a 2 meter VHF J-Pole on its third harmonic. Also, the area immediately to the left of the RG-174 stub should not be shaded. The decoupling stub is in series with two separate pieces of twin-lead.

◊ In "The DBJ-1: A VHF-UHF Dual-Band J-Pole" (Feb 2003, pp 38-40), the length of the RG-174 matching stub should be shortened a bit to get the antenna closer to a 1:1 SWR. Using the formula for line length versus frequency and wavelength,

$L = (VF \times 984 \times N) / f$

where

L = length (in feet),

VF = velocity factor,

N = number of wavelengths and

f = frequency in MHz