VHF/UHF Dual Band J-Pole

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The DBJ-2: A Portable VHF-UHF Roll-Up J-pole Antenna for ARES

WB6IQN reviews the theory of the dual band 2 meter / 70 cm J-pole antenna and then makes detailed measurements of a practical, easy to replicate, "roll-up" portable antenna.

Edison Fong, WB6IQN

It has now been more than three years since my article on the dual band J-pole (DBJ-1) appeared in the February 2003 issue of *QST*.[1] I have had over 500 inquires regarding that antenna. Users have reported good results, and a few individuals even built the antenna and confirmed the reported measurements. Several major cities are using this antenna for their schools, churches and emergency operations center. When asked why they choose the DBJ-1, the most common answer was value. When budgets are tight and you want a good performance-to-price ratio, the DBJ-1 (*Dual Band J-pole–1*) is an excellent choice.

In quantity the materials cost about $5 per antenna and what you get is a VHF/UHF base station antenna with λ/2 vertical performance on both VHF and UHF bands. If a small city builds a dozen of these antennas for schools, public buildings, etc it would cost about $60. Not for one, but the entire dozen!

Since it is constructed using PVC pipe, it is UV protected and it is waterproof. To date I have personally constructed over 400 of these antennas for various groups and individuals and have had excellent results. One has withstood harsh winter conditions in the mountains of McCall, Idaho for four years.

The most common request from users is for a portable "roll-up" version of this antenna for backpacking or emergency use. To address this request, I will describe how the principles of the DBJ-1 can be extended to a portable roll-up antenna. Since it is the second version of this antenna, I call it the DBJ-2.

Principles of the DBJ-1

The earlier DBJ-1 is based on the J-pole,[2] shown in Figure 1. Unlike the popular ground plane antenna, it doesn't need ground radials. The DBJ-1 is easy to construct using inexpensive materials from your local hardware store. For its simplicity and small size, the DBJ-1 offers excellent performance and consistently outperforms a ground plane antenna.

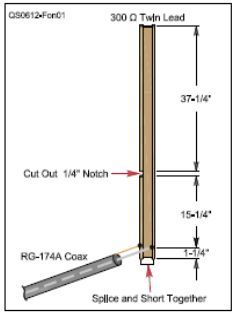


Figure 1 — The original 2 meter ribbon J-pole antenna.

Its radiation pattern is close to that of an ideal vertical dipole because it is end-fed, with virtually no distortion of the radiation pattern due to the feed line. A vertically polarized, center-fed dipole will always have some distortion of its pattern because the feedline comes out at its center, even when a balun is used. A vertically polarized, center-fed antenna is also physically more difficult to construct because of that feed line coming out horizontally from the center.

The basic J-pole antenna is a half-wave vertical configuration. Unlike a vertical dipole, which because of its center feed is usually mounted alongside a tower or some kind of metal supporting structure, the radiation pattern of an end-fed J-pole mounted at the top of a tower is not distorted.

The J-pole works by matching a low impedance (50 Ω) feed line to the high impedance at the end of a λ/2 vertical dipole. This is accomplished with a λ/4 matching stub shorted at one end and open at the other. The impedance repeats every λ/2, or every 360° around the Smith Chart. Between the shorted end and the high impedance end of the λ/4 shorted stub, there is a point that is close to 50 Ω and this is where the 50 Ω coax is connected.

By experimenting, this point is found to be about 1¾ inches from the shorted end on 2 meters. This makes intuitive sense since 50 Ω is closer to a short than to an open circuit. Although the Smith Chart shows that this point is slightly inductive, it is still an excellent match to 50 Ω coax. At resonance the SWR is below 1.2:1. Figure 1 shows the dimensions for a 2-meter J-pole. The 15¼ inch λ/4 section serves as the quarter wave matching transformer.

A commonly asked question is, "Why 15¼ inches?" Isn't a λ/4 at 2 meters about 18½ inches? Yes, but twinlead has a reduced velocity factor (about 0.8) compared to air and must thus be shortened by about 20%.

A conventional J-pole configuration works well because there is decoupling of the feed line from the λ/2 radiator element, since the feed line is in line with the radiating λ/2 element. Thus, pattern distortion is minimized. But this only describes a single band VHF J-pole. How do we make this into a dual band J-pole?

Adding a Second Band to the J pole

To incorporate UHF coverage into a VHF J-pole requires some explanation. (A more detailed explanation is given in my February 2003 *QST* article.) First, a 2 meter antenna does resonate at UHF. The key word here is

[1]Notes appear on page 00.

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.

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.

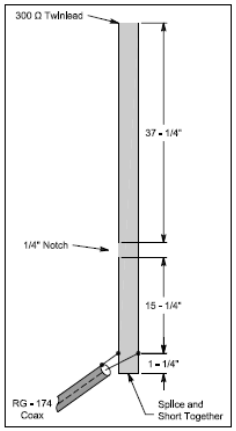


Figure 1—Basic diagram and dimensions for the original 2-meter ribbon J-Pole.

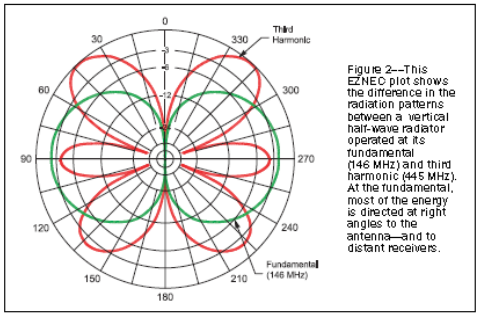


Figure 2—This EZNEC plot shows the difference in the radiation patterns between a vertical half-wave radiator operated at its fundamental (146 MHz) and third harmonic (445 MHz). At the fundamental, most of the energy is directed at right angles to the antenna—and to distant receivers.

Why a J-pole?

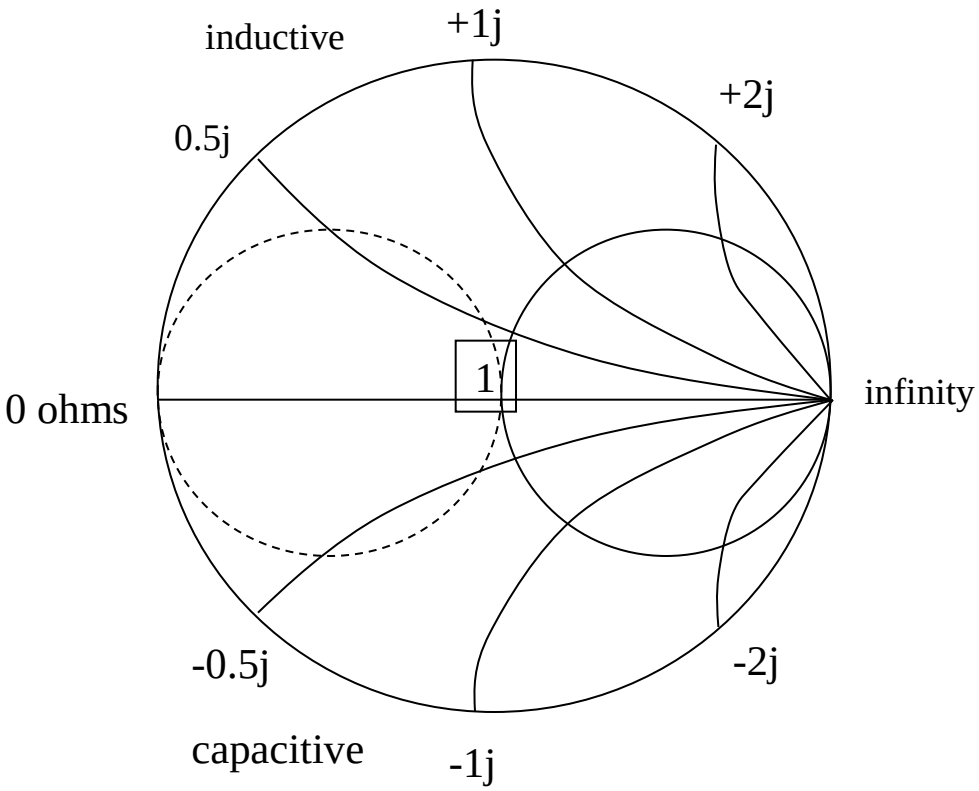
- J-pole configuration - no radials
- Ground plane requires radials – high wind load
- Very close to an ideal dipole pattern

- First introduced to the ribbon J by AE6C in 1990
- Antenna excellent - considering simplicity
- Stick it in a PVC 3/4” - very durable
- Will last for years since PVC is UV protected.
- To date – we have delivered over 10,000
- Price to performance - excellent

- It will also resonate at odd harmonics
- Ah ha!!! It will also work at UHF
- Very poor performance because of phase cancellation
- Typically 6-8 dB of loss at 3rd harmonic
- Goal is to design a dual band J-pole but without the loss
- New design must be simple, reproducible, no radials due to wind load.

- No inductors, no capacitors, because they are not easily reproduced.
- I tried all types of configurations, but this one seems to work the best.
- Basically matching is the same at VHF and UHF.
- A 1/4 wave decoupling stub (RG174) is used at UHF

Smith Chart



Represents 1/2 wavelength once around

0 ohms on left side
infinity at right side
normalized to 1 at center

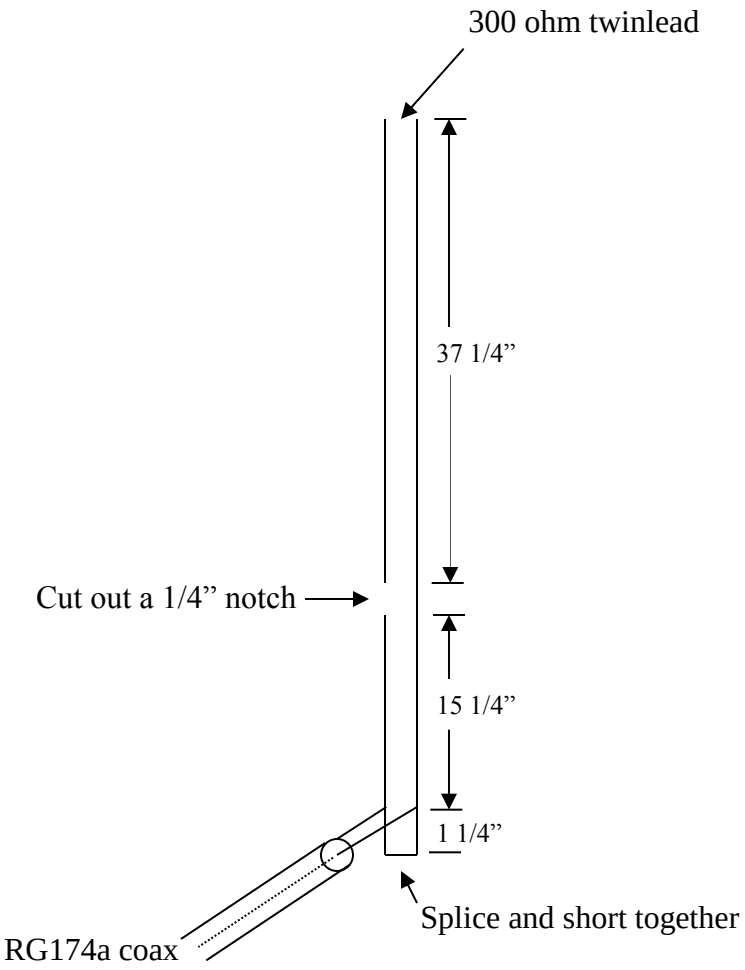


Figure 1 The original 2 meter ribbon J-Pole.

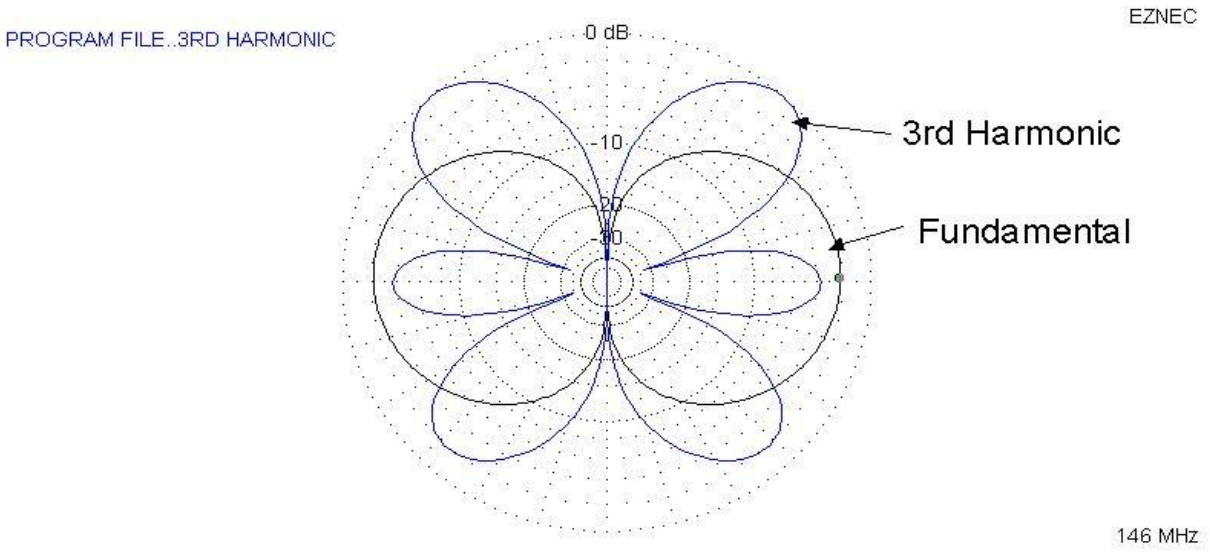


Figure 2 Horizontal pattern of fundamental and 3rd harmonic. At the third harmonic most of the energy is launched at 45o.

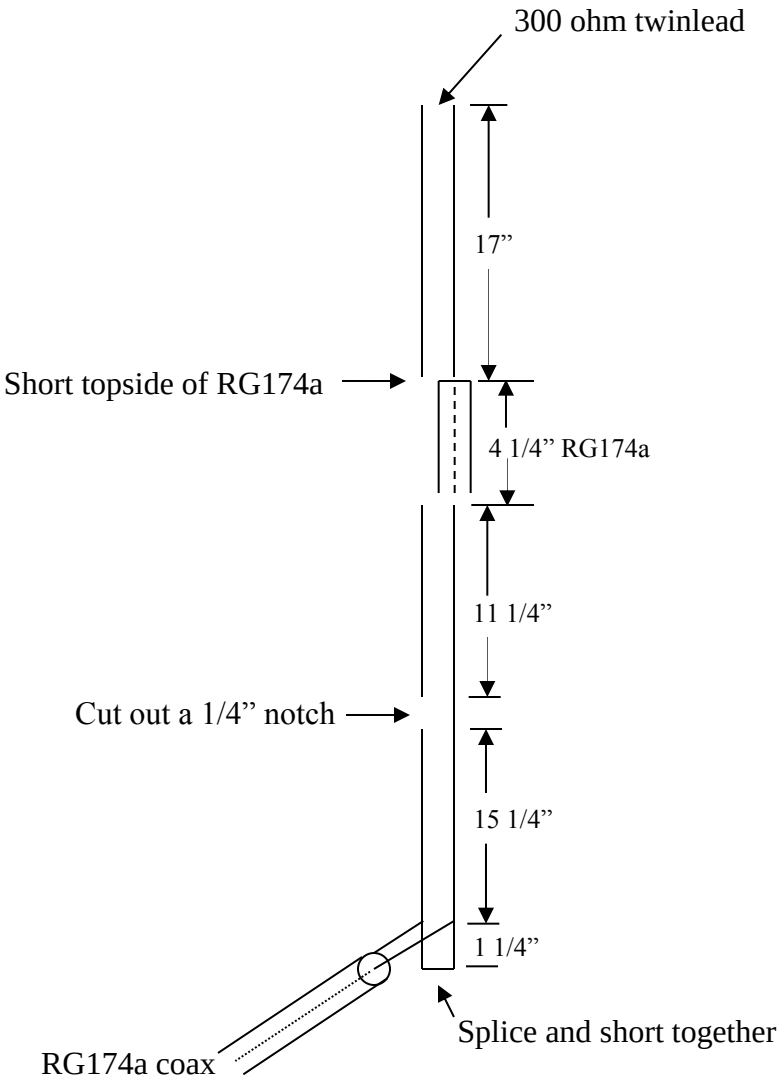


Figure 3 The 2 meter J-pole modified for both VHF and UHF operation.

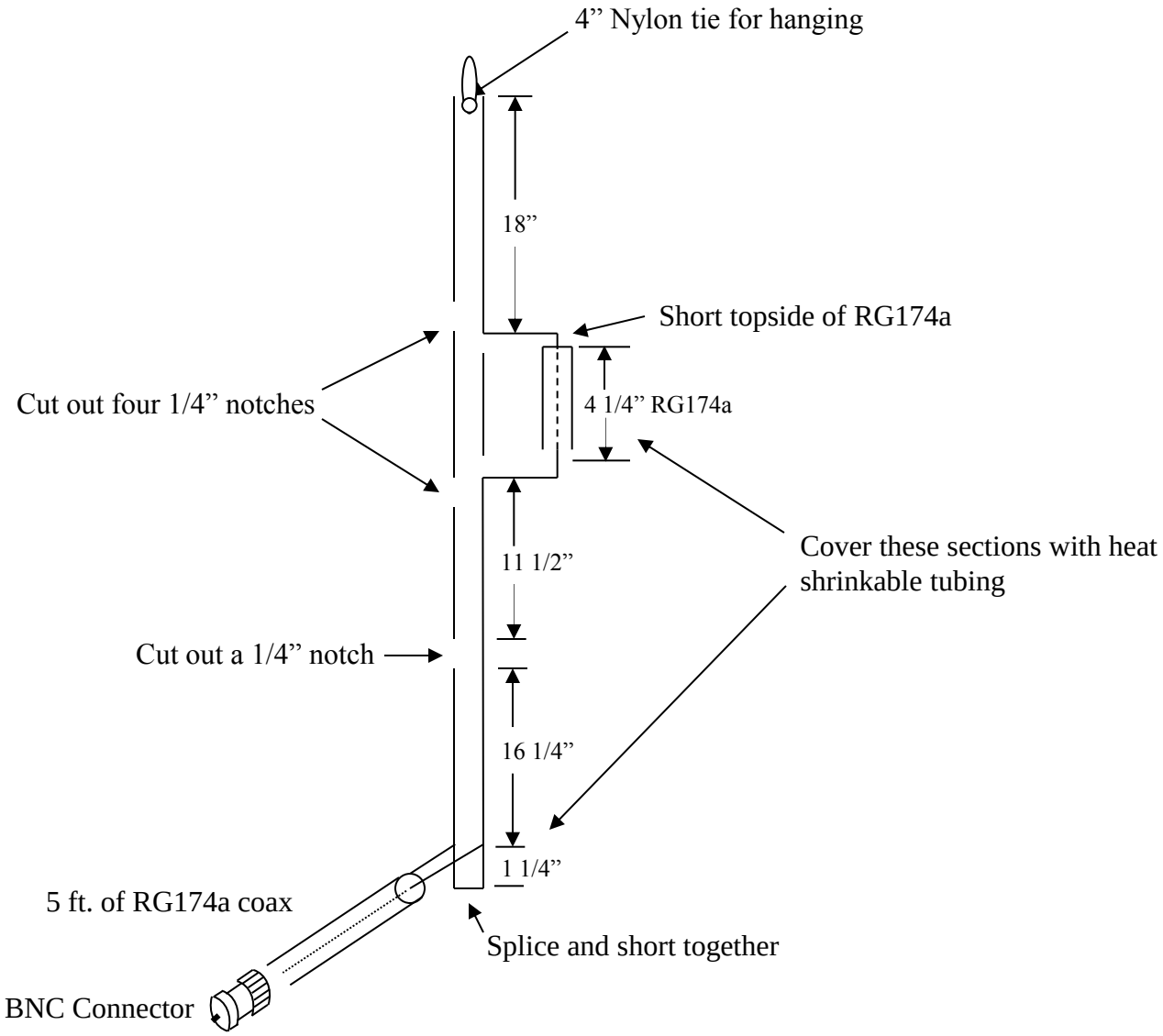


Figure 4 The dual band J-pole modified for portable operation. Note that dimensions are slightly longer due to the velocity factor of air.

Notice that the dimensions on the DBJ-2 (roll up) are longer than the DBJ-1 (base station). This is because we have compensated for the velocity factor of the pvc pipe.

The pvc pipe used is very important. We found that Lowe's item #23990 was the best performance for RF.

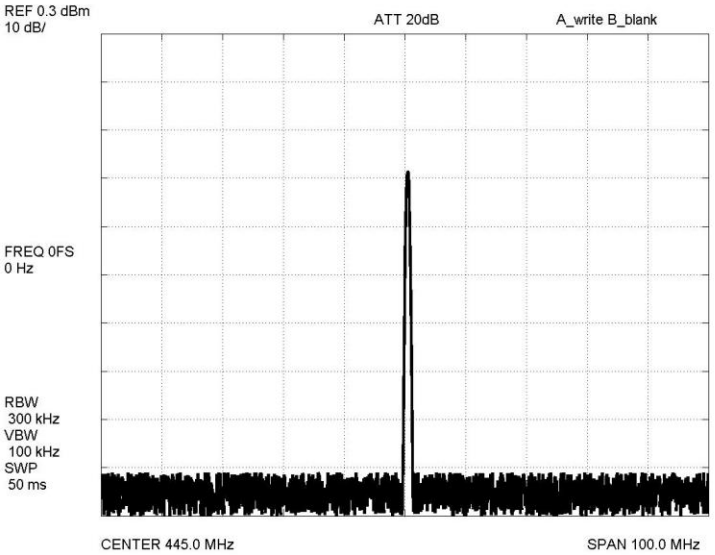


Figure 5a 2 meter J-pole at UHF.

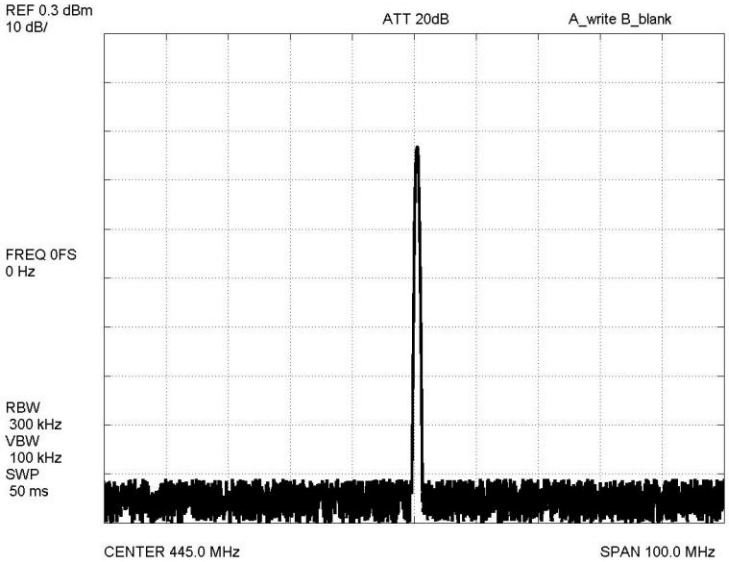


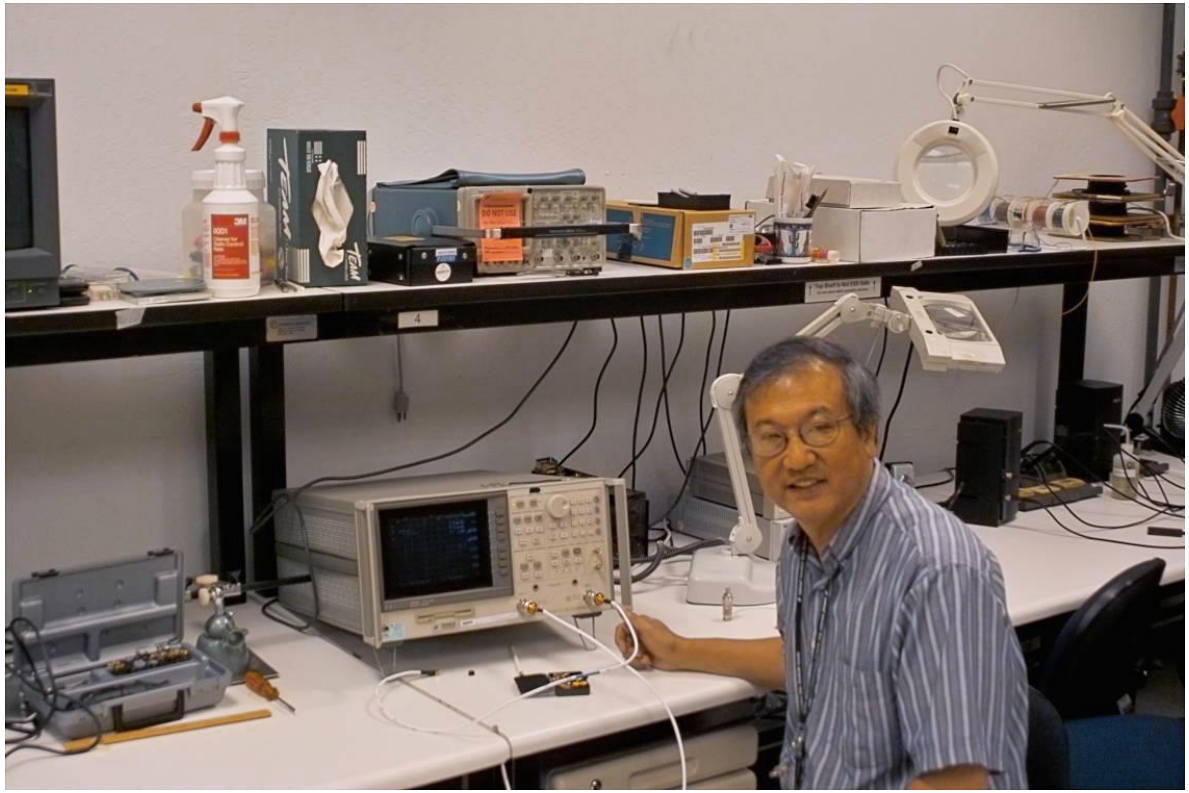
Figure 5b DBJ-1 at at UHF.

VHF ¼ wave mobile	VHF rubber duck	Standard VHF J-Pole	Dual Band J-Pole
-24.7db	-30.5 dB	-23.34 dB	-23.47 dB

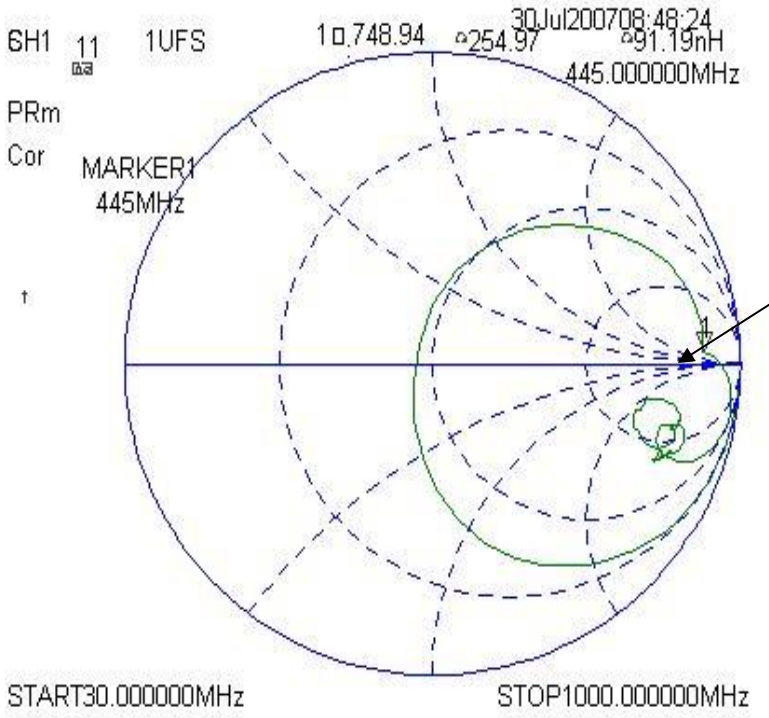
Table I Measured relative performance of the dual band antenna at 146MHz.

UHF ¼ wave mobile	UHF rubber duck	Standard VHF J-Pole	Dual Band J-Pole
-38.8 dB	-41.3 dB	-45 dB	-38.9 dB

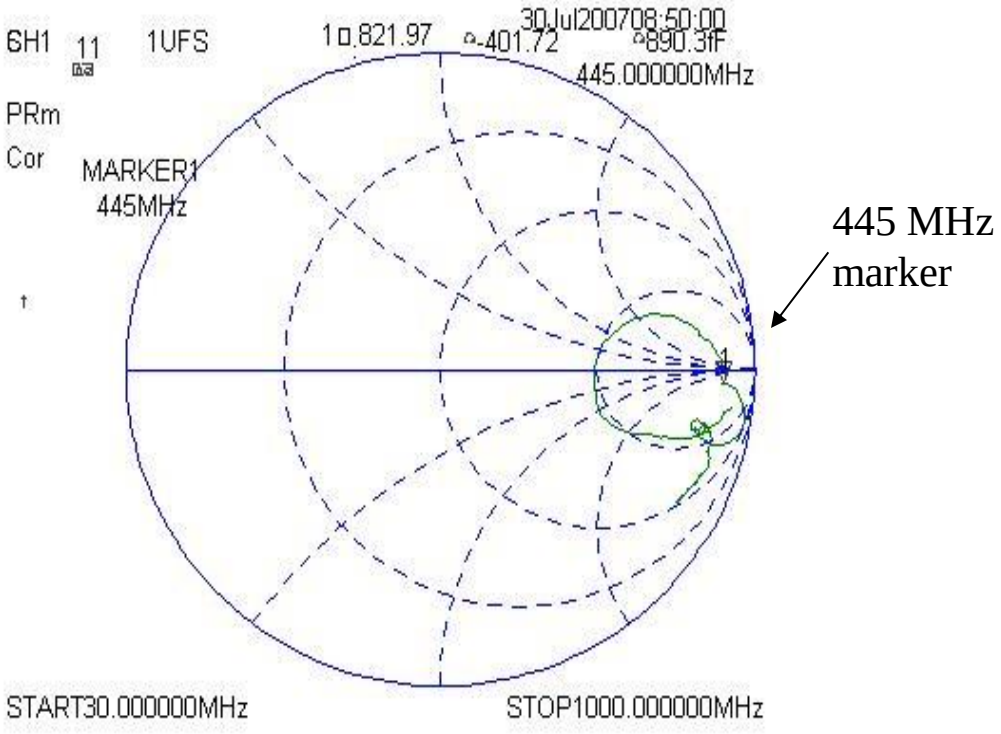
Table II Measured relative performance of the dual band antenna at 445 MHz.



Here I am in my lab using the HP8753D 6 GHz network analyzer.

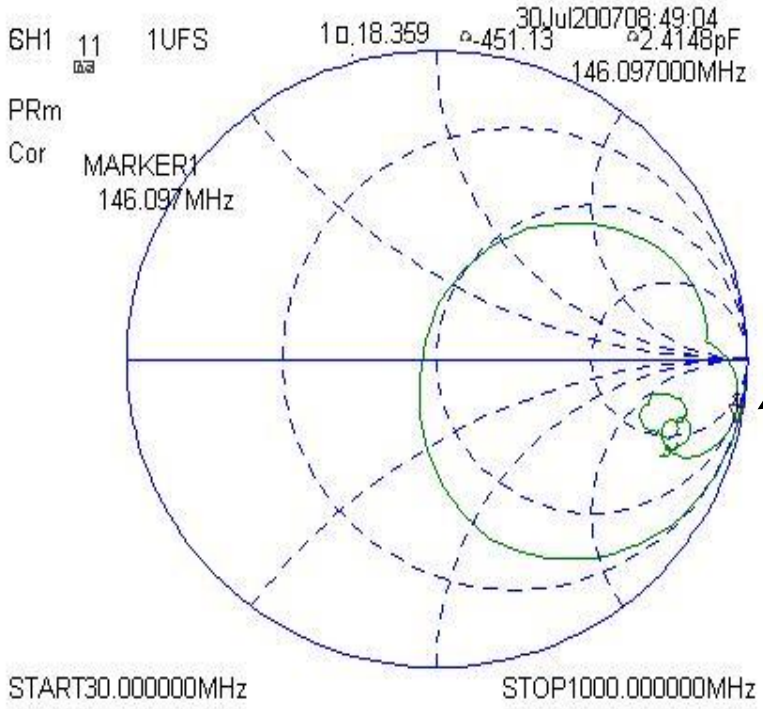


Stub shows a clear resonant at 445MHz.



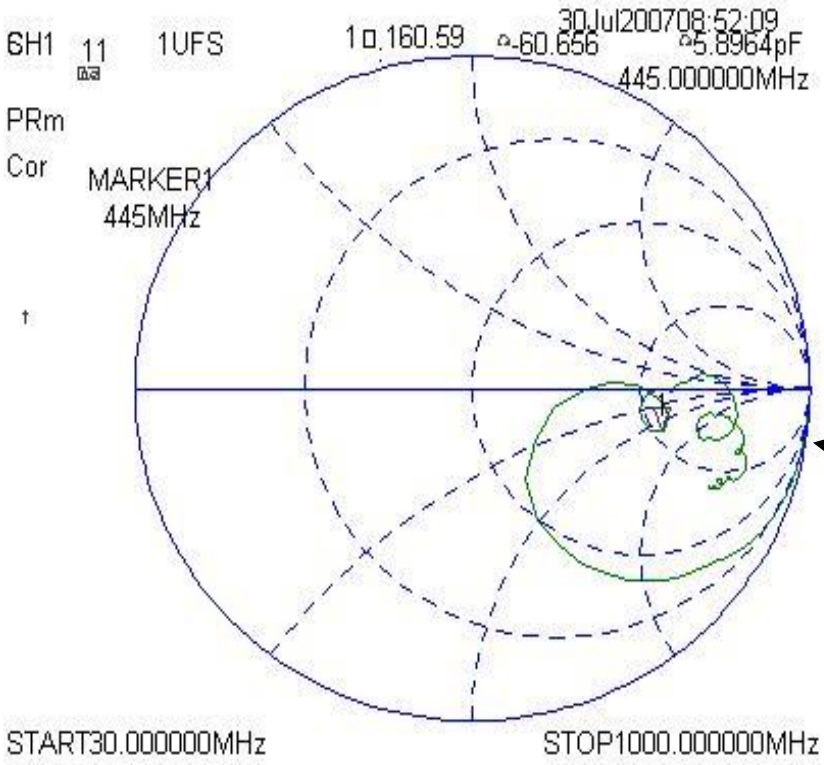
445 MHz marker

Hands touching at shorted end. Graphs changes, but not 445MHz resonant point. This says I can place anything at shorted end without affecting the 445MHz resonant high impedance.



146 MHz marker

146 MHz marker of the UHF shorted stub.

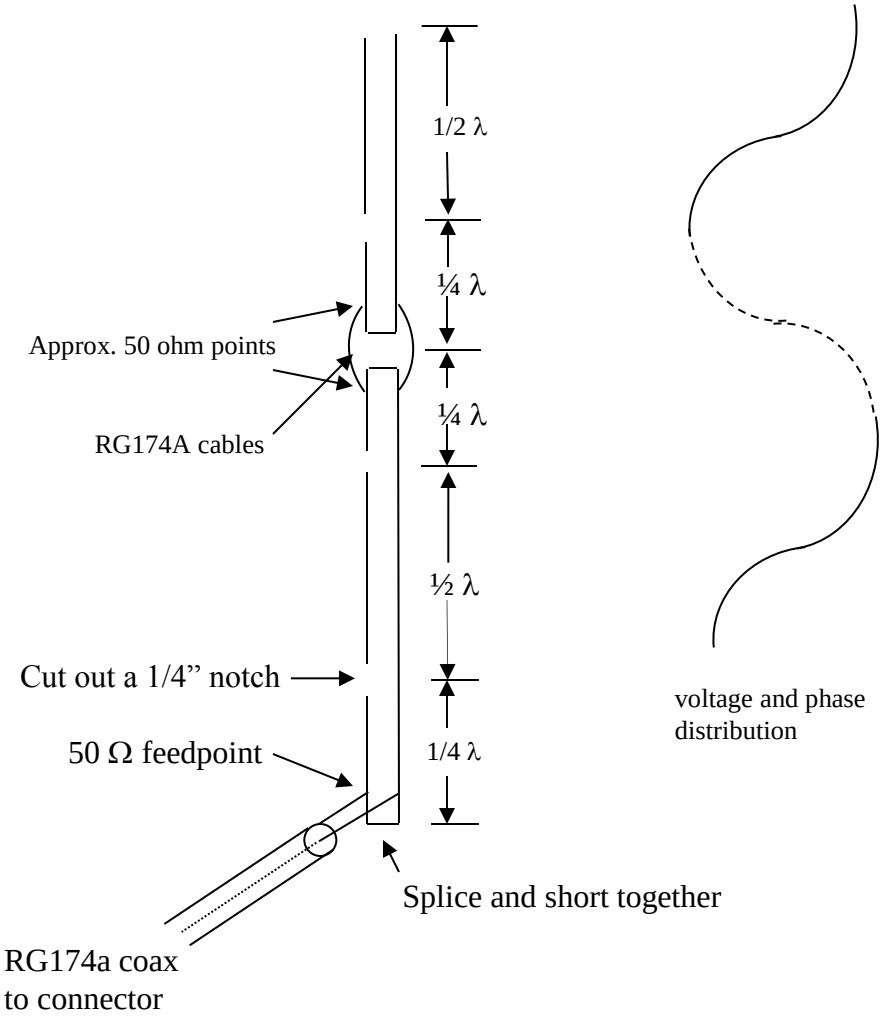


146MHz marker

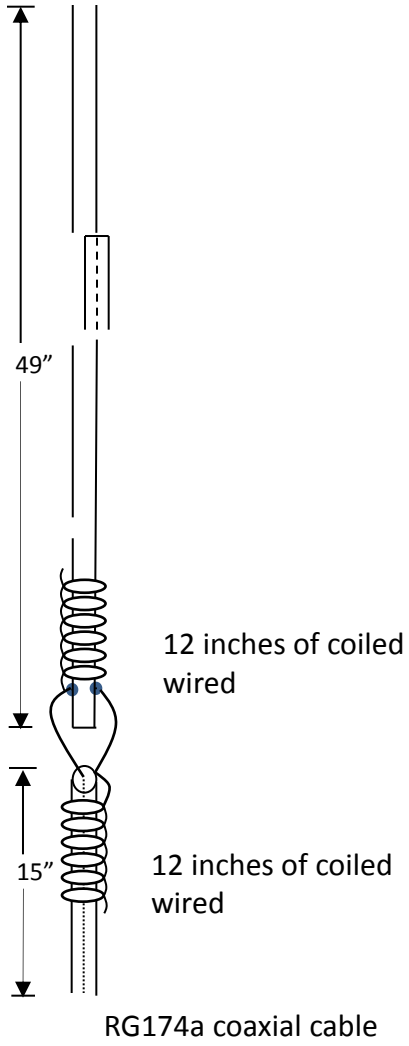
445 MHz marker of open wire.

DBJ-1 mounted on the side of the roof.

DBJ-2 kit – roll up dual band with BNC, SMA, and reverse SMA. Also 6ft extension cable.



The two element UHF phase conlinear with the voltage and phase given on the right. Dimensions are given for insertion into ¾ inch 200 PSI pvc pipe. US patent 8,947,313



2mt / 220 MHz/ 70 cm - Tri band antenna with helical loop which allows for insertion into a ¾ inch pvc pipe. Total length is 5 ½ feet which is a practical length for ¾ inch 200 psi pvc pipe.

DBJ-1 dual band base antenna - available in HAM (144-148 MHz and 440-450 MHz) or Commercial (152-157 MHz and 460-470 MHz) $25

DBJ-2 dual band roll up antenna - available in HAM (144-148 MHz and 440-450 MHz) or Commercial (152-157 MHz and 460-470 MHz) includes 6ft extension, BNC, SMA and SMA female adapter $25

TBJ-1 triband base antenna 2mt/220 MHz/70 cm –- $60 - includes shipping with 6ft of pvc pipe.

50 ft RG8x coax cable with molded PL259 connectors $25

6ft extensions cables (BNC male to BNC female $5

BNC – female to PL259 (adapter for roll up DBJ-2 to mobile or base) $2