VHF/UHF Dual Band J-Pole

By: Ed Fong WB6IQN

email: edison_fong@hotmail.com

ARRL VHF/UHF Antenna Classics

ARRL Vol. 8 Antenna Compendium

ARRL Vol. 3 Antenna Compendium

QST March 2007

QST February 2003

QST March 2017

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.

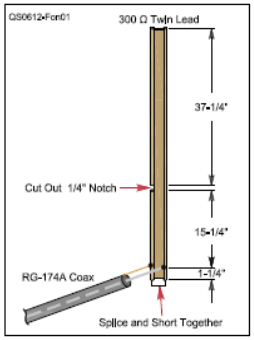


Figure 1 — The original 2 meter ribbon J-pole antenna.

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 feed line 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 15¾ inch λ/4 section serves as the quarter wave matching transformer.

A commonly asked question is, "Why 15¾ 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.

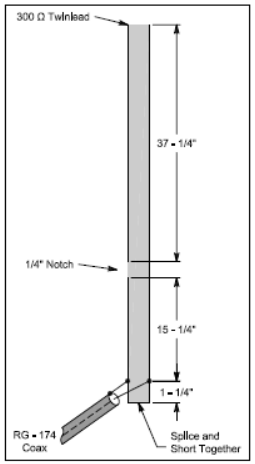


Figure 1—Basic diagram and dimensions for the original 2-meter ribbon J-Pole.

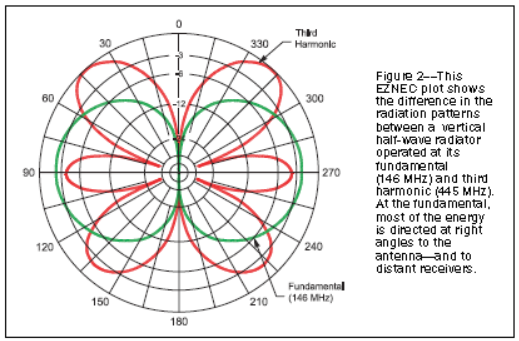


Figure 2—This EZNEC plot shows the difference in the radiation patterns between a vertical half-wave radiator operated at its fundamental (146 MHz) and third harmonic (445 MHz). At the fundamental, most of the energy is directed at right angles to the antenna—and to distant receivers.

A Tri-Band Antenna without Radials for 2 Meters, 1.25 Meters, and 70 Centimeters

An innovative revision of a design the author originally published in QST in 2003.

Edison Fong, WB6IQN, and Tessa Fong, KJ6QXM

Twenty years ago, a single-band handheld transceiver would have been adequate for most emergency activities, because they were conducted on VHF. Today, both VHF and UHF are used for emergency communications by organizations such as ARES and RACES. In some areas, even the UHF amateur band is full. This was the primary motivation for introducing the DBJ-1 dual-band J-pole and the DBJ-2 roll-up portable version.[1, 2] Edison, WB6IQN, and his students have built thousands of these over the last 10 years for various ARES/RACES clubs and government agencies.

[Edison Fong, WB6IQN, photo]

An often-repeated request was whether the 1.25-meter band could be added to the DBJ-1. In the San Francisco Bay Area, 1.25 meters has some FM voice channels, but its most important use is for packet radio.

Since the development of Outpost Packet Message Manager by Jim Oberhofer, KN6PE, 1.25-meter packet is not only popular in the Bay Area, but has spread nationwide.[3] Thus, one antenna that covers 2 meters, 1.25 meters, and 70 centimeters would be very desirable. This would simplify the need for multiple antennas during an emergency deployment. The 1.25-meter band is not harmonically related to any other ham band, and thus, its antenna dimensions for that band are not related to those in the 2-meter or 70-centimeter band. This makes impedance matching difficult, and the construction of such an antenna is not obvious.

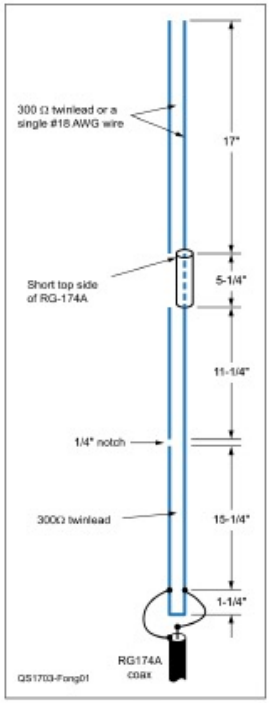


Figure 1 — The original DBJ-1 dual-band J-pole shows the approximate dimensions used when the antenna is inserted into a ¾-inch OD Class 200 PVC pipe.

(12) **United States Patent**
Fong

(10) **Patent No.: US 9,608,336 B1**
(45) **Date of Patent: Mar. 28, 2017**

(54) **RADIAL-FREE COLLINEAR OMNI-DIRECTIONAL TRIBAND HALF WAVELENGTH ANTENNA WITH VIRTUAL GROUND, SINGLE COAXIAL CABLE FEEDPOINT, AND WITH MINIMAL INTERACTION OF ADJUSTMENT BETWEEN BANDS**

(71) Applicant: **Edison Fong**, Sunnyvale, CA (US)

(72) Inventor: **Edison Fong**, Sunnyvale, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 47 days.

(21) Appl. No.: **14/834,435**

(22) Filed: **Aug. 25, 2015**

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 21/30 (2006.01)
H01Q 9/18 (2006.01)
H01Q 1/36 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/30*** (2013.01); ***H01Q 1/362*** (2013.01); ***H01Q 9/18*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,124,424 A * 7/1938 McConnell H01P 5/02 333/26
4,259,673 A * 3/1981 Guretzky H01Q 9/065 343/825
4,675,687 A * 6/1987 Elliott H01Q 5/321 343/715
4,764,773 A * 8/1988 Larsen H01Q 1/1285 333/25
6,191,747 B1 * 2/2001 Cosenza H01Q 1/1285 343/713
9,007,270 B2 * 4/2015 Ngo Bui Hung H01Q 5/00 343/787
2005/0253768 A1 * 11/2005 Bui Hung H01Q 5/00 343/790
2010/0283699 A1 * 11/2010 Apostolos H01Q 1/3275 343/792
2012/0182196 A1 * 7/2012 Ngo Bui Hung H01Q 1/52 343/792
2013/0127676 A1 * 5/2013 Goetz H01Q 21/30 343/715
2014/0111397 A1 * 4/2014 Lim H01Q 1/362 343/826

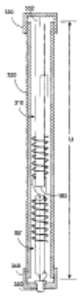
* cited by examiner

Primary Examiner — Trinh Dinh
(74) *Attorney, Agent, or Firm* — Michael A. Kaufman, Esq.

(57) **ABSTRACT**

An omni-directional triband antenna operates without ground radials with gain commensurate with a half wavelength vertical on each band. The triband antenna includes a dual-band twinlead J-pole providing half wavelength radiators for UHF and VHF, and an impedance transformer defining feedpoints to which a length Lc of coaxial cable is attached. The Lc lower end is the triband antenna connector port. Intermediate band radiators are first and second wire elements that collectively are a half-wavelength at the intermediate band. The first element is wound helically about the impedance transformer, with upper end floating and lower end connected to a first feedpoint. The second element is wound helically about the Lc upper portion of coaxial cable, with upper end connected to the remaining feedpoint, and lower end of the element floating. The helical windings radiate vertically and there is no cross-interference between antenna radiation in any of the three bands.

20 Claims, 12 Drawing Sheets



(12) **United States Patent**
Fong

(10) **Patent No.: US 8,947,313 B2**
(45) **Date of Patent: Feb. 3, 2015**

(54) **RADIAL-FREE COLLINEAR OMNI-DIRECTIONAL ANTENNA WITH GAIN AND VIRTUAL GROUND**

(76) Inventor: **Edison Fong**, Sunnyvale, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1116 days.

(21) Appl. No.: **12/927,397**

(22) Filed: **Nov. 15, 2010**

(65) **Prior Publication Data**

US 2012/0119968 A1 May 17, 2012

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 9/42 (2006.01)
H01Q 9/30 (2006.01)

(52) **U.S. Cl.**
CPC ... ***H01Q 9/42*** (2013.01); ***H01Q 9/30*** (2013.01)
USPC **343/825**

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/40; H01Q 9/30
USPC 343/790–792
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,124,424 A * 7/1938 McConnell 343/825
4,675,687 A * 6/1987 Elliott 343/715
4,764,773 A * 8/1988 Larsen et al. 343/713
6,191,747 B1 * 2/2001 Cosenza 343/749

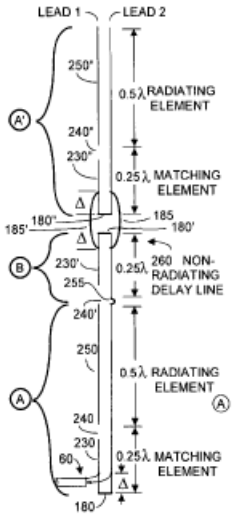
* cited by examiner

Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Michael A. Kaufman, Esq.

(57) **ABSTRACT**

An omni-directional antenna operable absent ground radials and providing at least 3 dB gain at a chosen wavelength relative to a dipole includes first and second like-oriented J-pole antennas and, coupled intermediate said J-pole antennas, a quarter-wavelength non-radiating delay line. Each J-pole antenna includes a half-wave radiating element, and a quarter-wavelength non-radiating section. The quarter-wavelength non-radiating delay line together with the quarter-wavelength non-radiation section of the second J-pole provide a half-wave non-radiating delay line. The result is that RF energy radiated by the first and second half-wave radiating elements are in proper phase, whereby gain is achieved. RF energy is coupled to the first J-pole antenna a distance Δ above the zero impedance end of that antenna.

10 Claims, 6 Drawing Sheets



Why a J-pole?

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

Here is one of the main antenna towers in SF.

Notice there are NO radials on any of the antennas. Most use internal J-pole designs. A lightning arrestor is also not needed since by design, it is a DC short.

Conventional Dipole - works great but cumbersome to mount and there is always feedline distortion and antenna mast distortion. Wind load is also high.

- 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 35,000
- 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

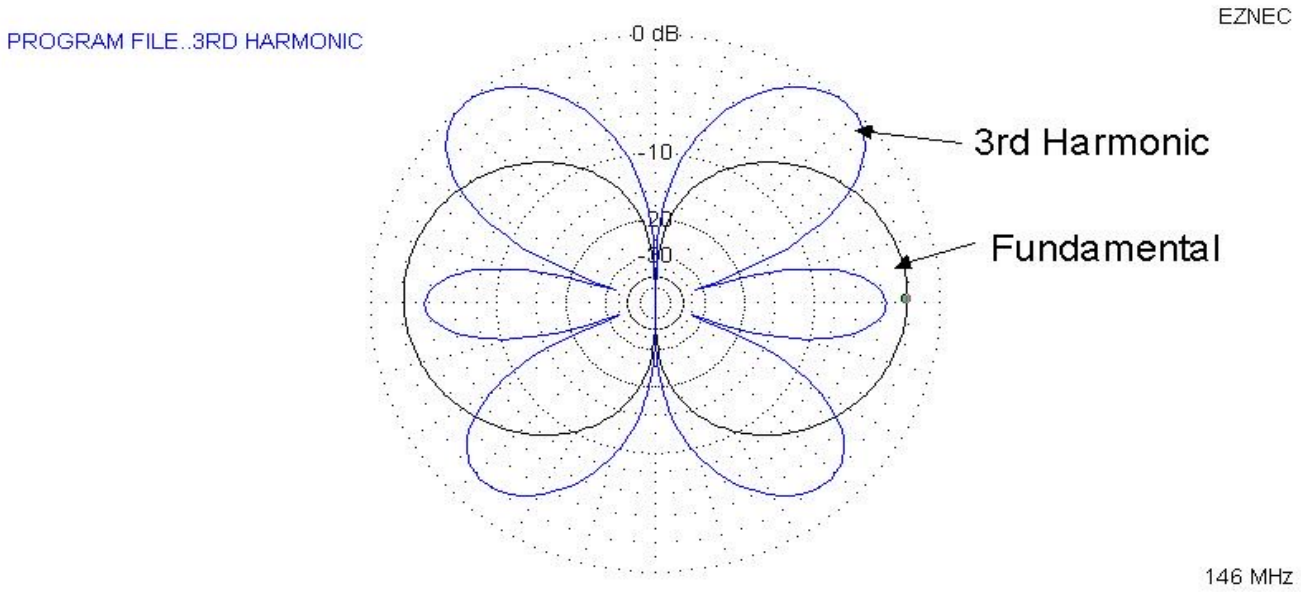
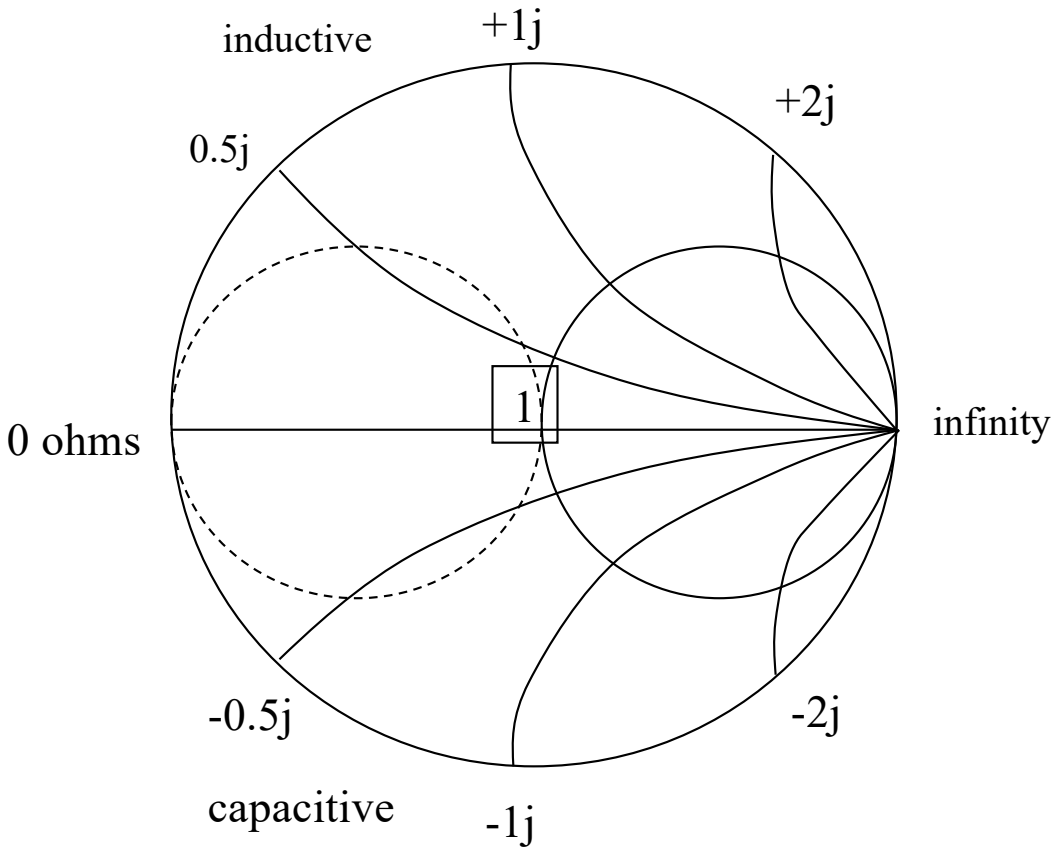


Figure 2 Horizontal pattern of fundamental and 3rd harmonic. At the third harmonic most of the energy is launched at 45o.

Smith Chart



Represents 1/2 wavelength once around

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

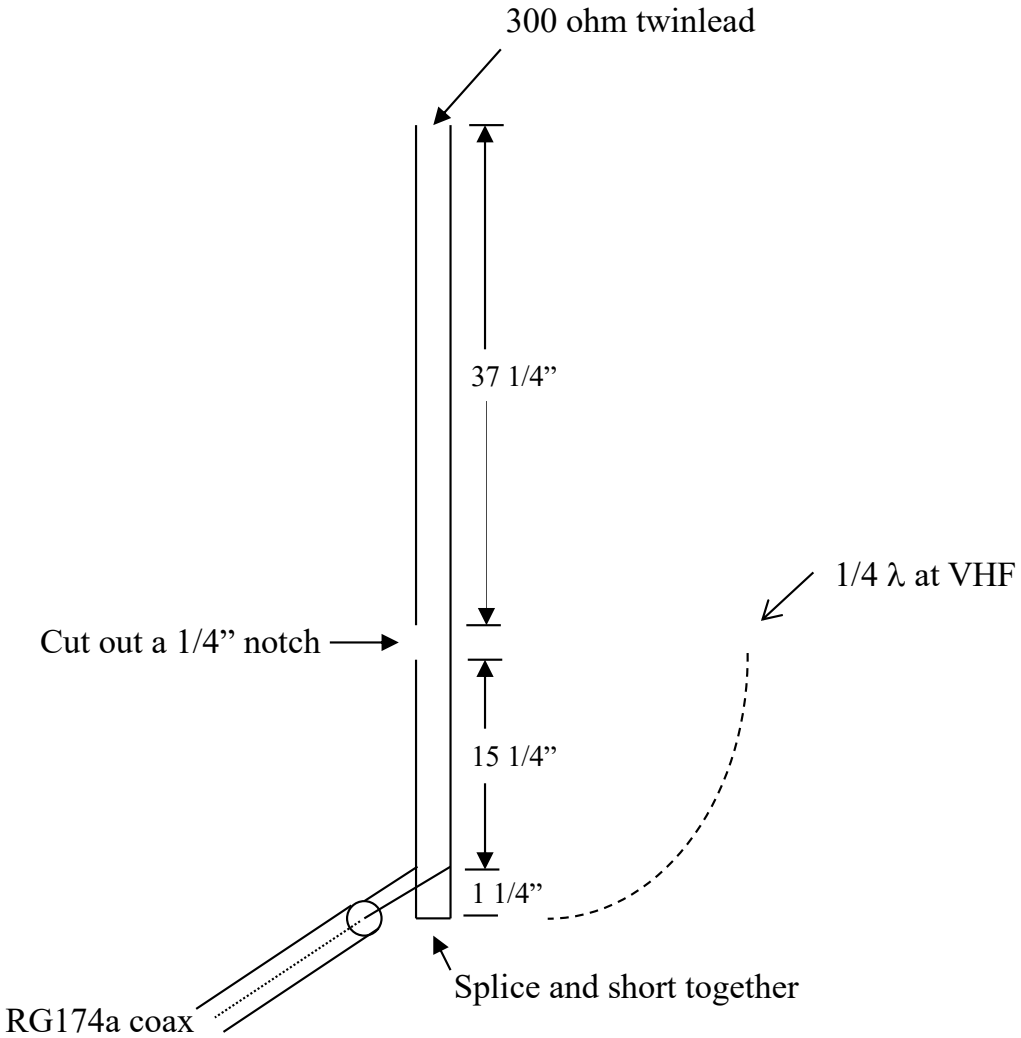
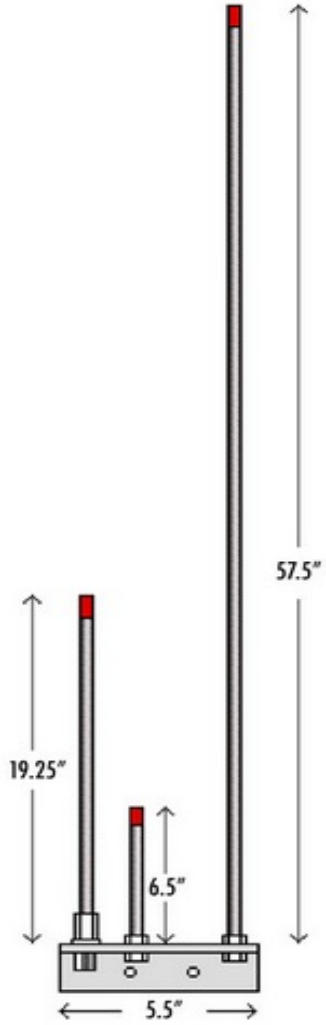
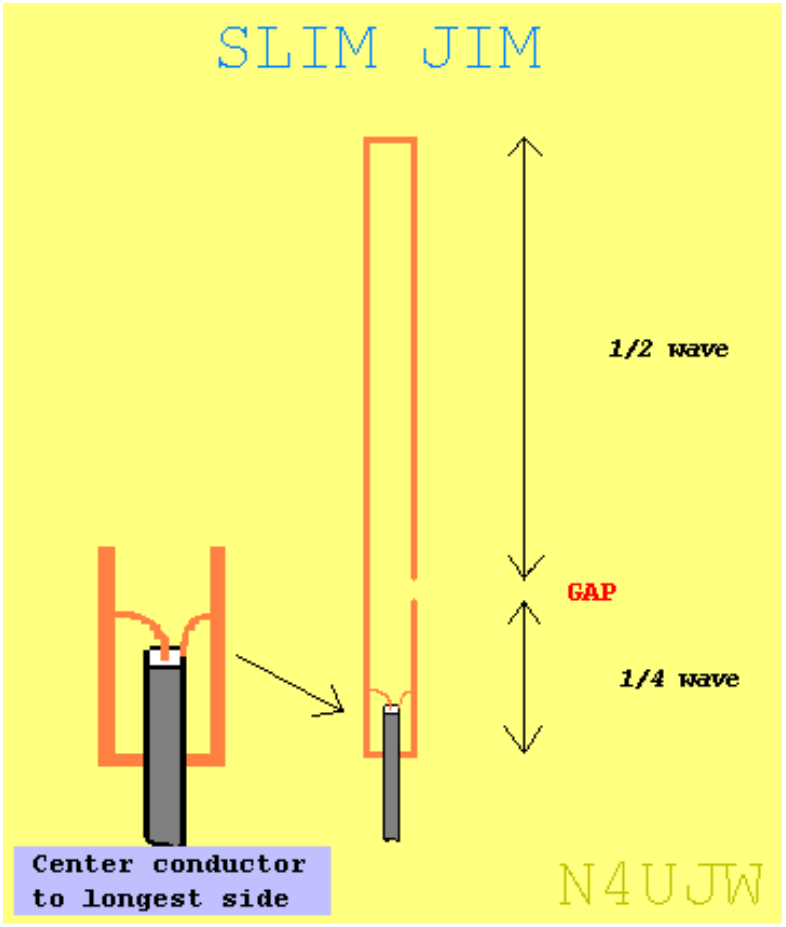


Figure 1 The original 2 meter ribbon J-Pole.

Copper J limited to VHF due to minimum spacing of the parallel pipes. Does not work well for 70cm.



Arrow – VHF/UHF J-pole – does not have decoupling at UHF.



According to Dr. Larry Cebik and myself, there is NO validlity to the Slim Jim. Every simulation we have done and physical models both Dr. Cebik and myself have built give the same results as a J-pole.

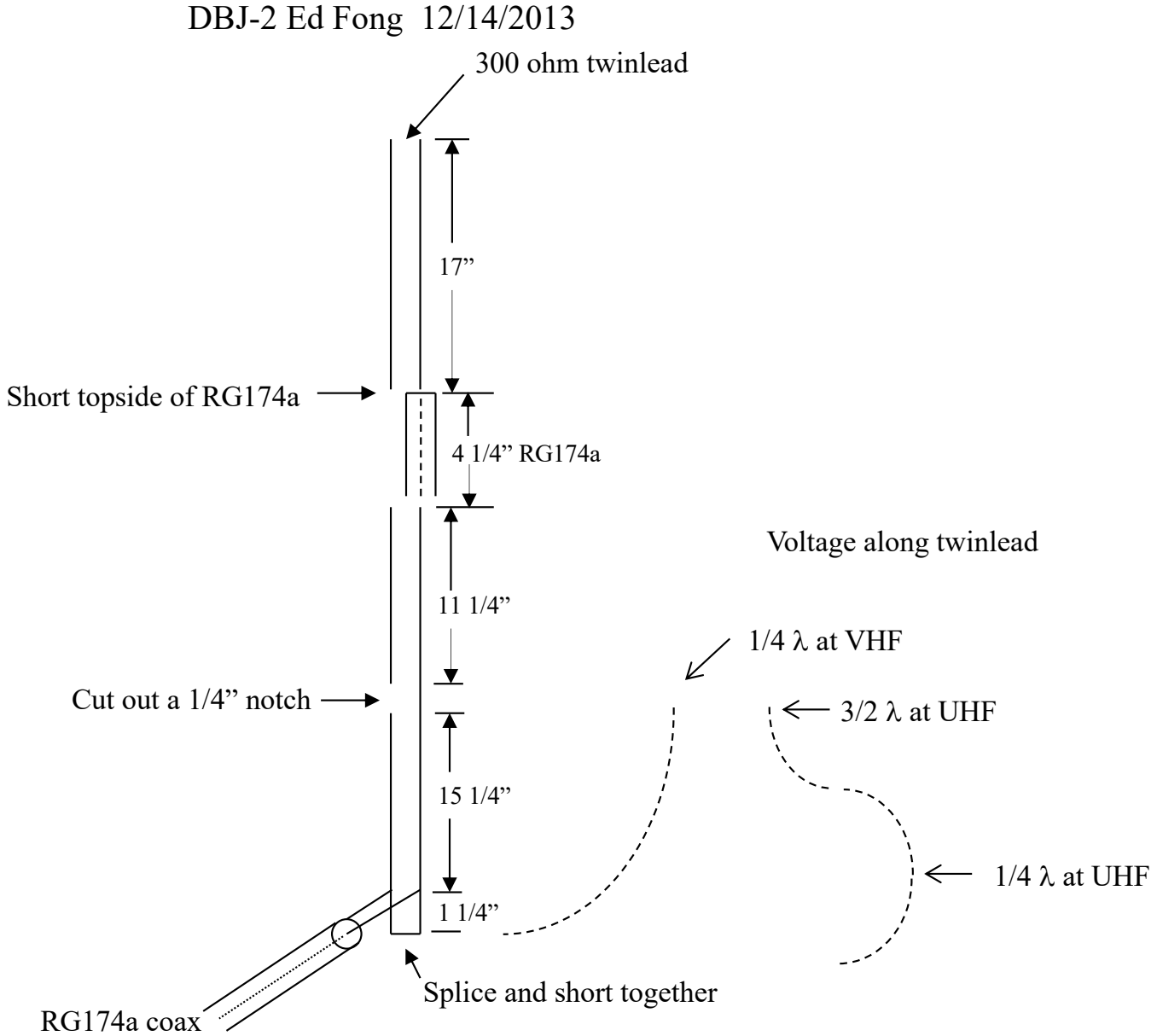


Figure 3 The 2 meter J-pole modified for both VHF and UHF operation.

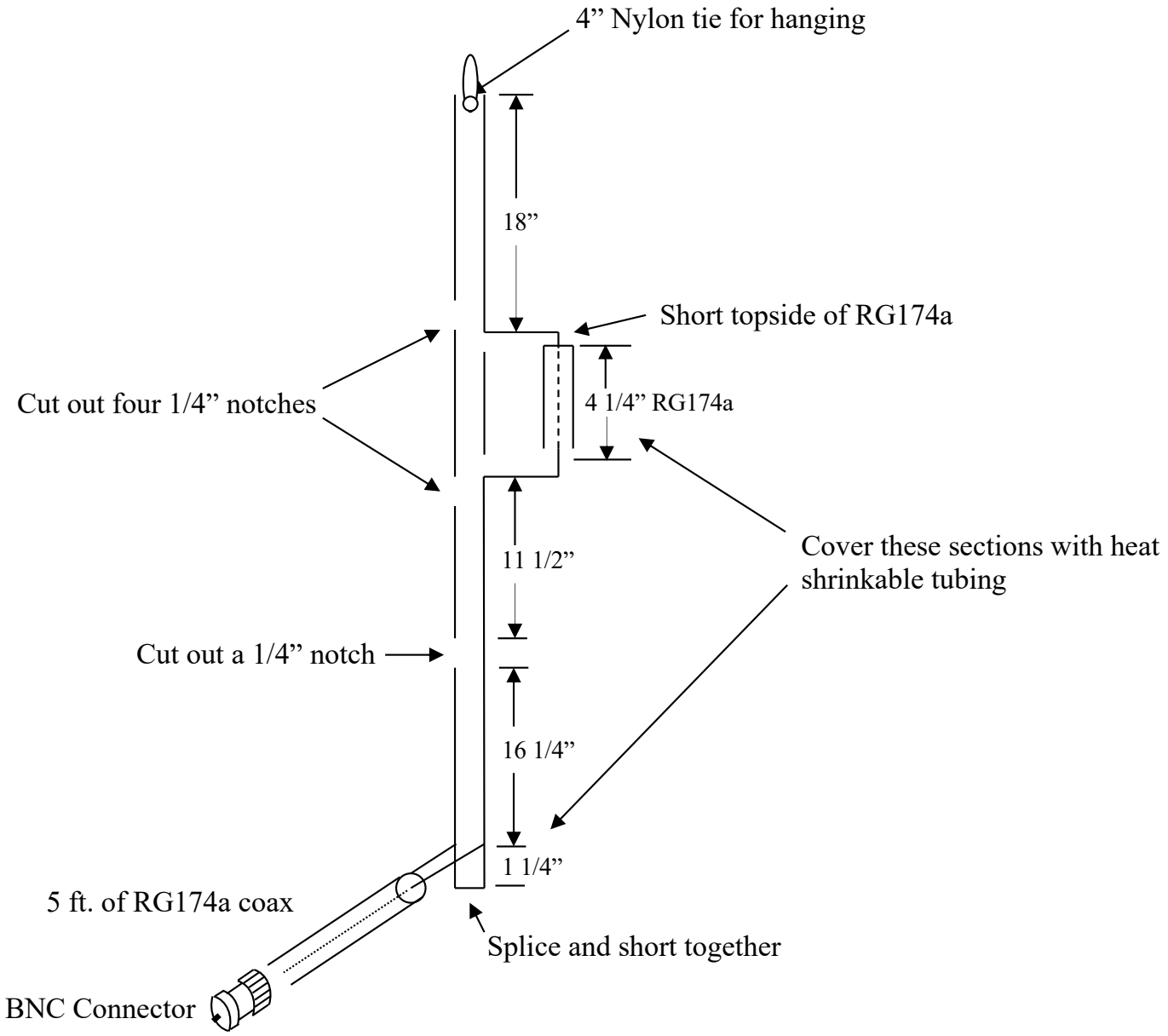


Figure 4 The dual band J-pole modified for portable operation. Note that dimensions are slightly longer due to the velocity factor of air.

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.

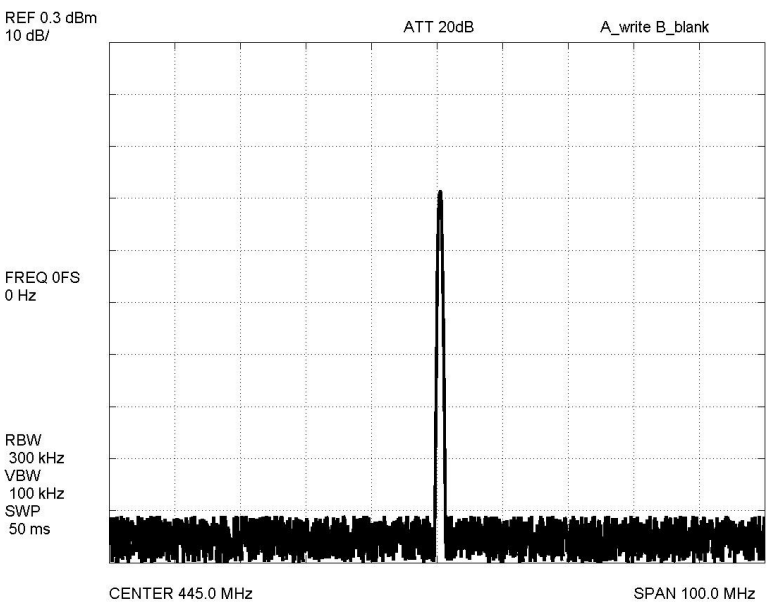


Figure 5a 2 meter J-pole at UHF.

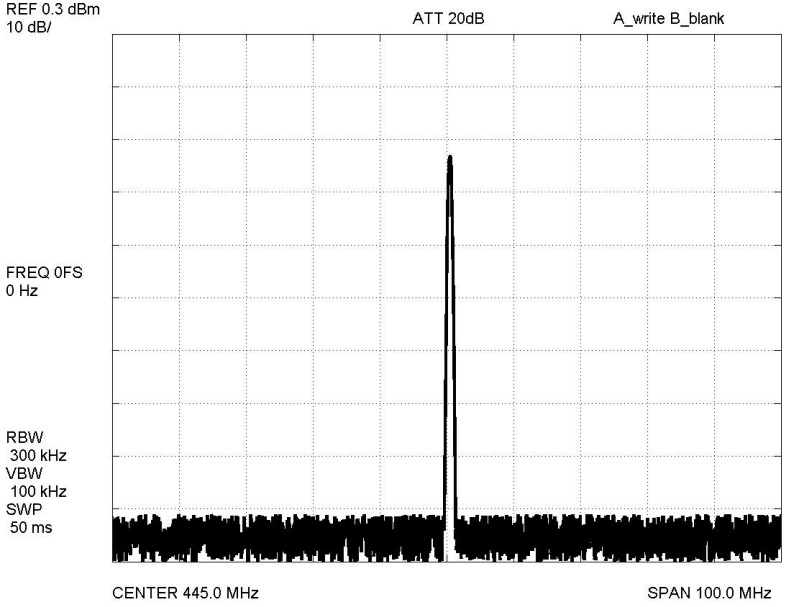


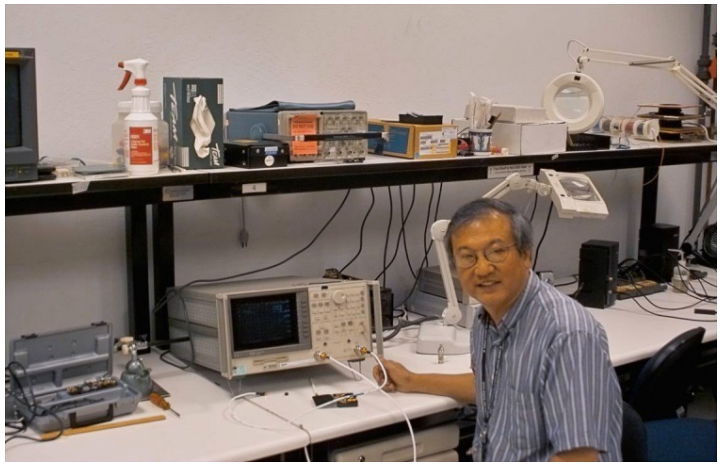
Figure 5b DBJ-1 at UHF.

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

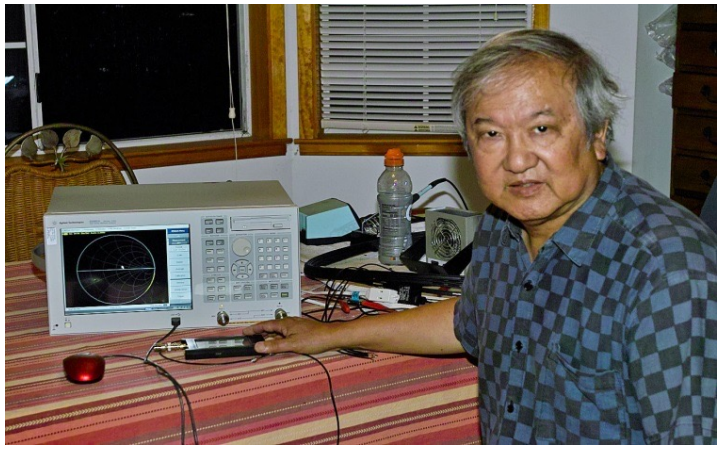
Table I Measured relative performance of the dual band antenna at 146MHz.

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

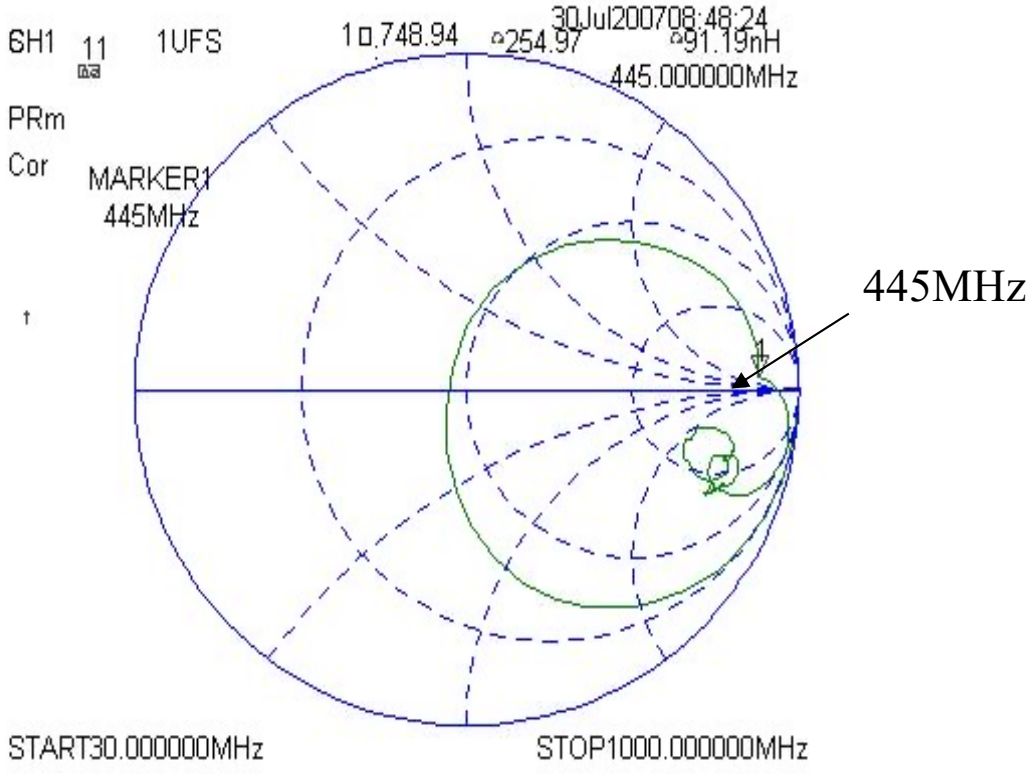
Table II Measured relative performance of the dual band antenna at 445 MHz.



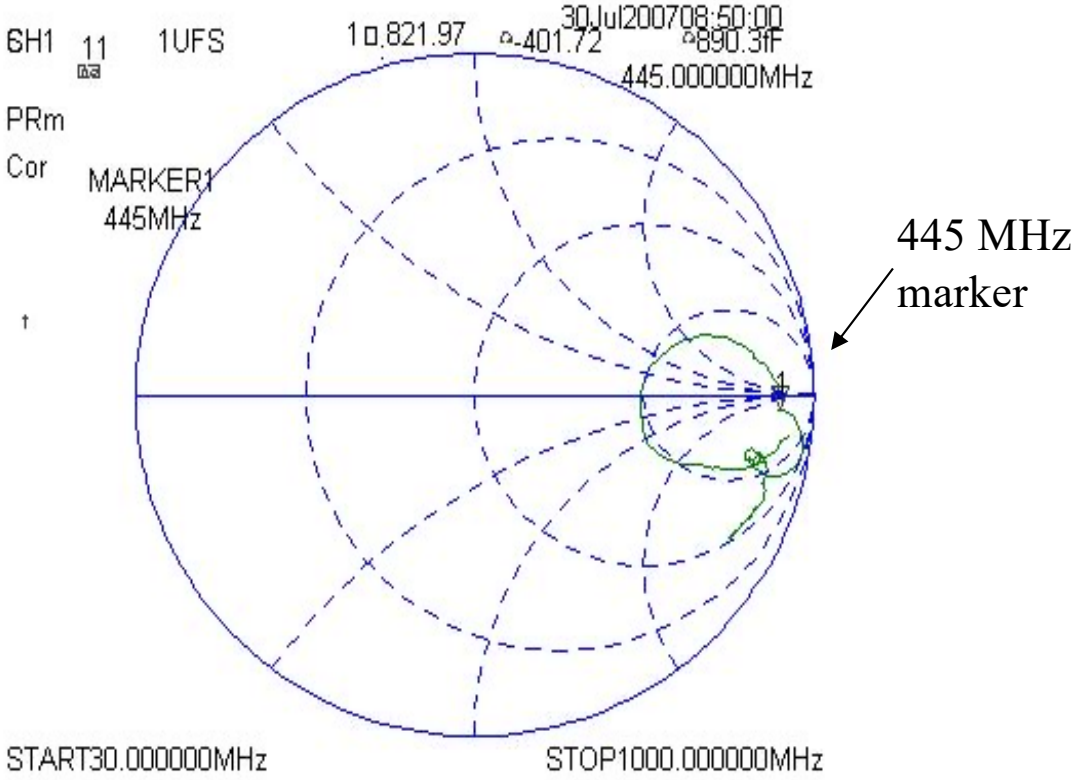
Our old HP 8753D network analyzer - 2008



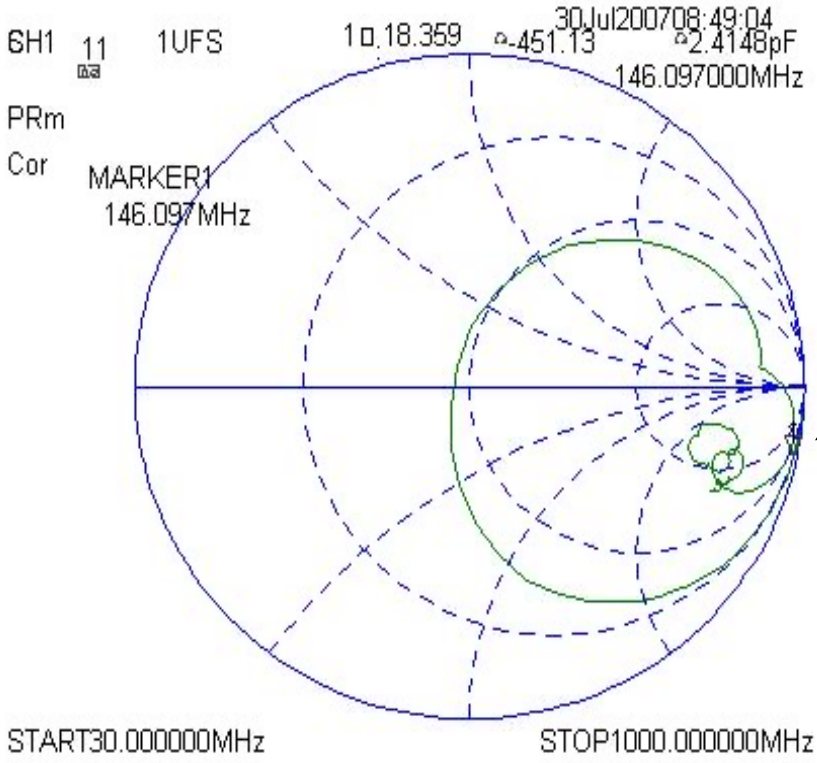
Our new Keysight 5062A network analyzer 2021



Stub shows a clear resonant at 445MHz.

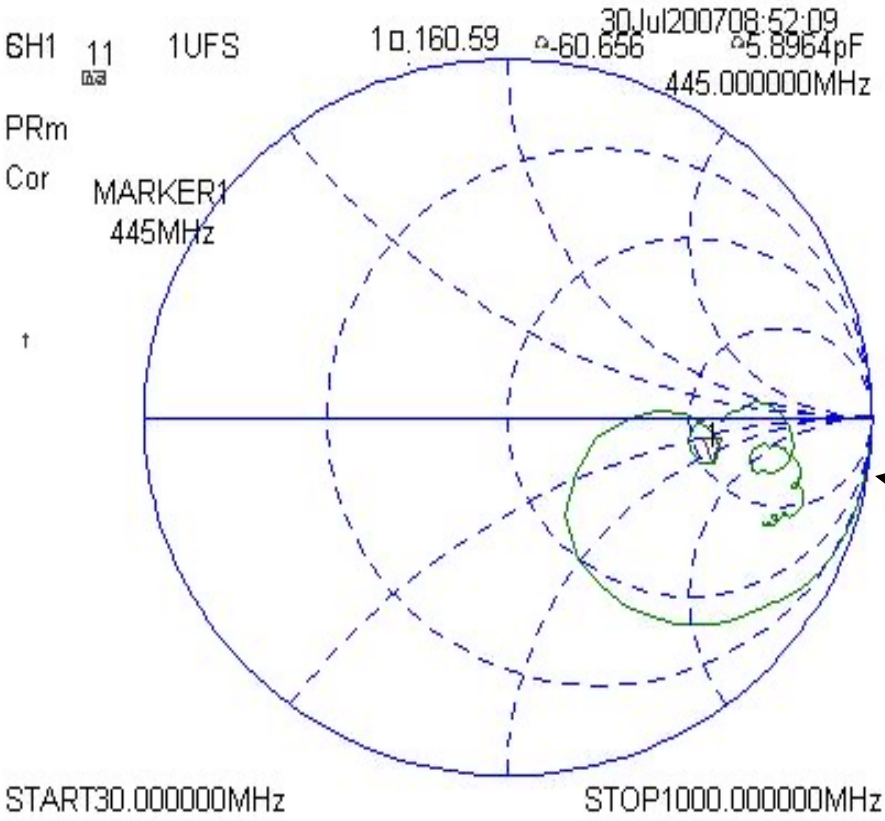


Hands touching at shorted end. Graphs changes, but not 445MHz resonant point. This says I can place anything at shorted end without affecting the 445MHz resonant high impedance.



146 MHz marker

146 MHz marker of the UHF shorted stub.

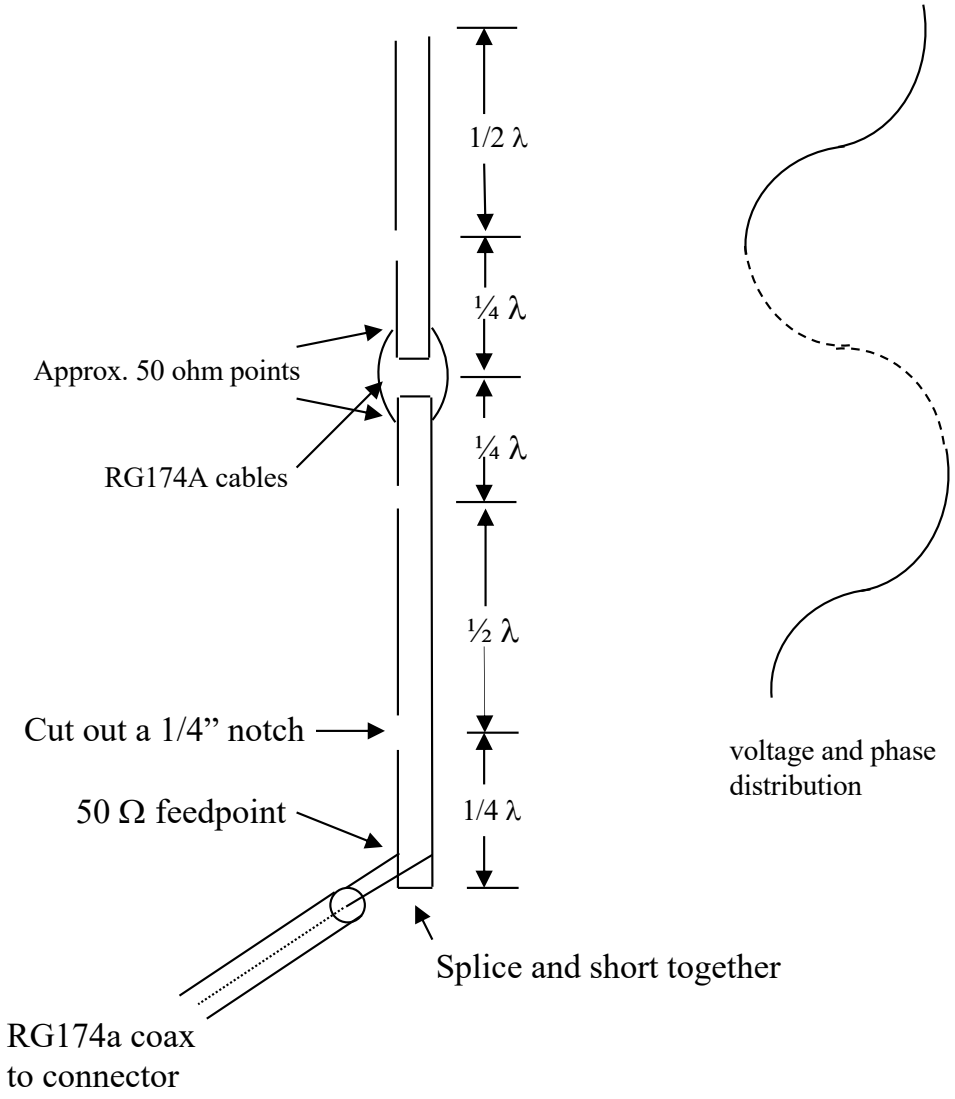


146MHz marker

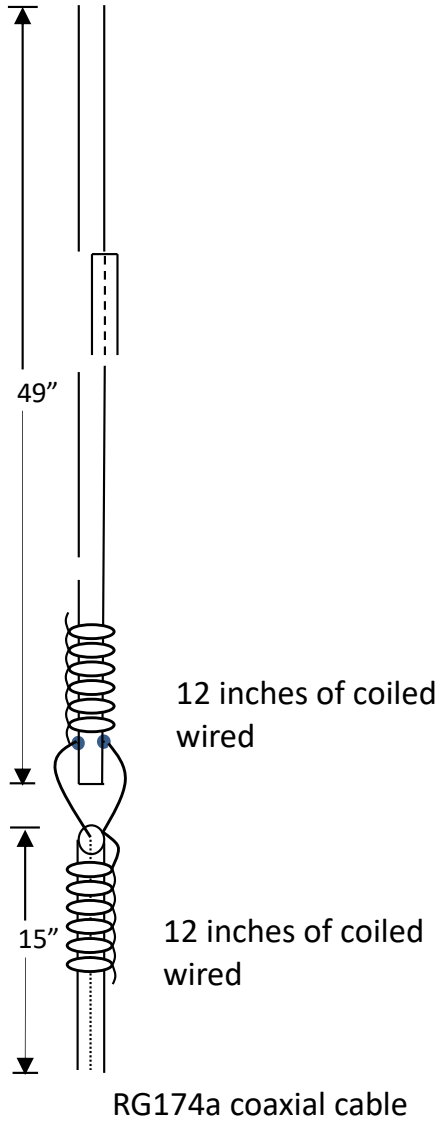
445 MHz marker of open wire.

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



TBJ-1 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. March 2017 QST

US Patent – 9,608,336

TBJ-1 is perfect companion to the new Triband radios which run under $150

BTECH MINI UV-25X4 25 Watt Tri-band Base, Mobile Radio: 136-174mhz (VHF), 220-230mhz (1.25M), 400-520mhz (UHF) Amateur (Ham)
by BTECH

$128.86 prime
Get it by **Tomorrow, Jul 22**
FREE Shipping on eligible orders

4.5 ▾ 37

Product Features
... Mobile Radio Kit Includes: *BTECH UV-25X4*, Speaker Mic, 6 foot DC ...

Amazon's Choice

Radioddity QB25 Quad Band Quad-Standby Mini Mobile Car Truck Radio VHF UHF 25W/10W Car Transceiver with Programming Cable & CD
by Radioddity

$99.99 prime
FREE Delivery by **Sat, Jan 19**
Only 20 left in stock - order soon.

4.0 ▾ 14

Product Features
... ▼ MULTI FUNCTIONS: *Radioddity QB25* is the latest car radio model of ...

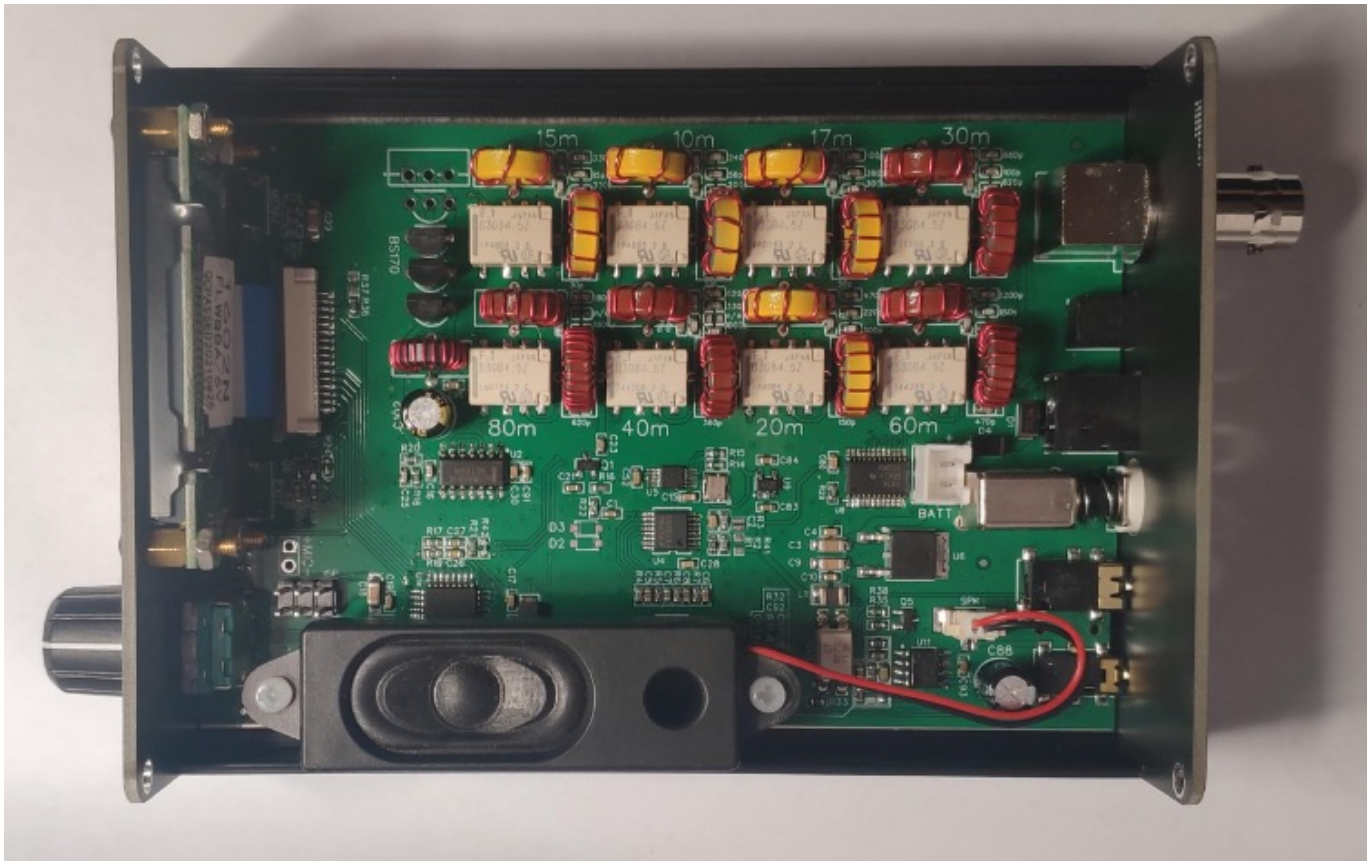
BTECH UV-5X3 5 Watt Tri-Band Radio: 130-179.99mhz (VHF), 220-225.99mhz (1.25M), 400-520.99mhz (UHF) Amateur (Ham)
by BTECH

$59.89 prime
Get it by **Sunday, Jul 23**
FREE Shipping on eligible orders

More Buying Choices
$60.46 (1 used offer)

4.5 ▾ 328

uSDX+ 80-10 all mode transceiver – Class S RF amplifier - $155



Inside view - very nicely layed out. No heat sinks.
Power output transistors are at top left. BS170 fets.

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) $38 (retail $55)

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 $40 (retail $60)

TBJ-1 triband base antenna 2mt/220 MHz/70 cm –- $65 - includes shipping with 6ft of pvc pipe. (retail $90)

GMRS 5dB gain base antenna $43 (retails for $60)

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

BNC – female to PL259 (adapter for roll up DBJ-2 to mobile or base) $2.50