Modernizing the V Antenna

Want multiband performance with some gain? Try this update of a classic wire antenna.

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I have found that one of the old-time wire antennas—the horizontal V antenna—has much to offer. It has gain in two major directions, needs no ground radials and exhibits a low angle of radiation for good DX. A practical advantage is that the apex (center point) of a V antenna can be a roof peak or tree adjacent to the house, making for a short feed line. The end points can be positioned more or less wherever suitable supports (trees) are located.

Traditional designs require open-wire feed line and a tuner.[1] My V antenna uses coax feed and covers 80, 40, 20, 15 and 10 meters with low SWR and significant gain in various lobes. Operation on 17 meters is also possible with excellent gain, but SWR may be about 3:1.

The keys to the multiband resonance are three homemade coaxial traps[2] in each leg, one each tuned to 15, 20 and 40 meters, and an impedance transformer at the feed point. Each leg is identical and represents 5.25 wavelengths (λ) on 10 meters, 3.75 λ on 15, 2.25 λ on 20, 1.25 λ on 40, and 0.75 λ on 80. Please note that these legs are horizontal (parallel to the ground), unlike the more common inverted V antenna. My installation uses four legs, with pairs of legs selected by remote relays to "rotate" the antenna for optimum directivity.[3] A two-leg antenna also works well in most directions.

Construction

Dimensions are shown in Figure 1, cut to favor the phone bands. Each inside (20 meter) segment is made of two #14 hard-drawn stranded copper wires separated by one-foot spacers. This makes the segments appear to be "fat" and noticeably broadens the antenna. It also lowers the resonant frequency, allowing these sections to be slightly shorter than a single wire. The 40, 15 and 80/10 meter sections use single lengths of #12 stranded copper.

Coax for the traps is marine-grade RG-8X with a solid dielectric to handle maximum legal power.[4] Do not use regular RG-8X with foam insulation because the voltage rating is inadequate for power

[1]Notes appear on page 00.

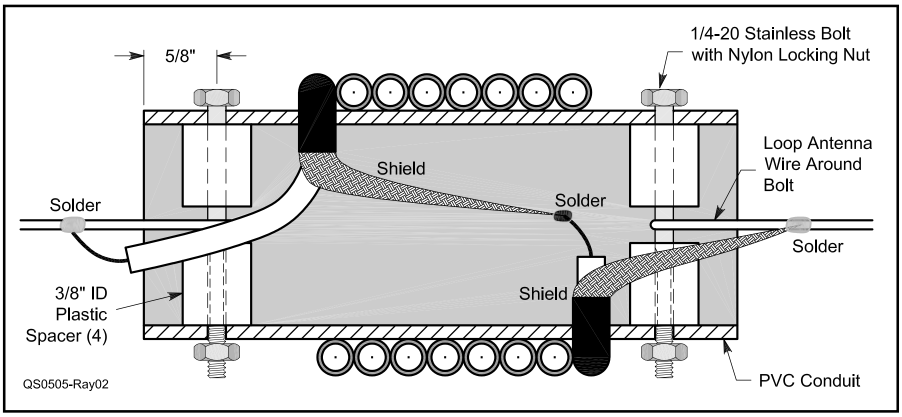
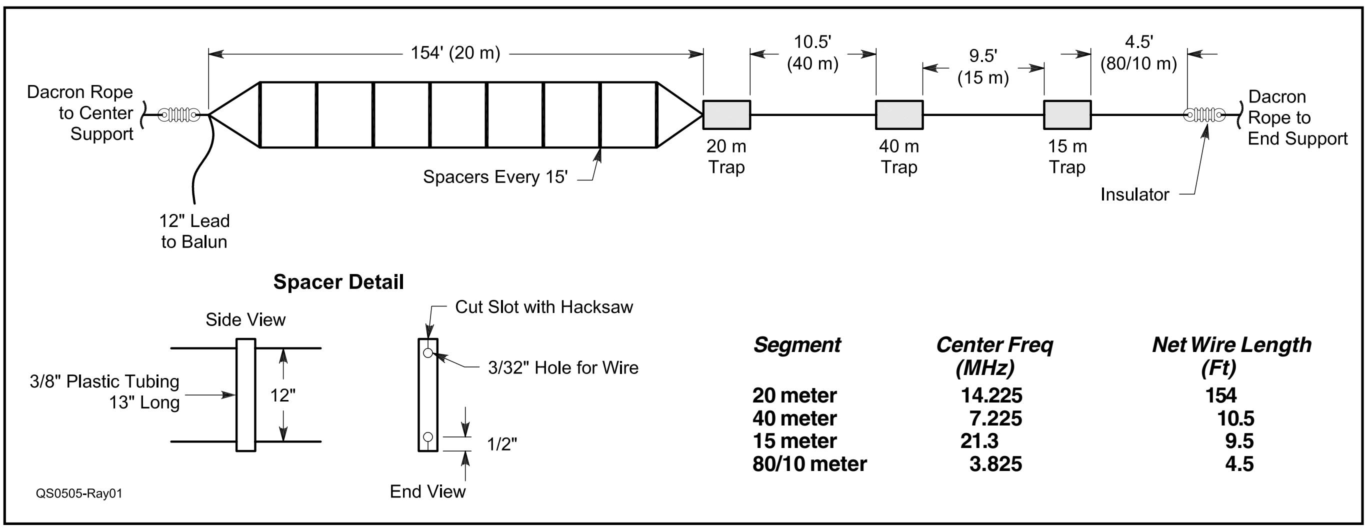


Figure 2—All traps use marine-grade RG-8X coax with solid (not foam) insulation, close-wound on gray PVC conduit (see text). PVC sizes are nominal inside diameters.
40 meter trap: $9\frac{1}{4}$ turns on 4.5 inch length of 1.5 inch PVC conduit.
20 meter trap: 6 turns on 4 inch length of 1.25 inch PVC conduit.
15 meter trap: $4\frac{1}{8}$ turns on 3.25 inch length of 1.25 inch PVC conduit.



Segment	*Center Freq (MHz)*	*Net Wire Length (Ft)*
20 meter	14.225	154
40 meter	7.225	10.5
15 meter	21.3	9.5
80/10 meter	3.825	4.5

Figure 1—Each leg of the horizontal V antenna is about 180 feet long. The longest (20 meter) section is made of two conductors separated by spacers (see text). Only one leg is shown, but all legs are identical.

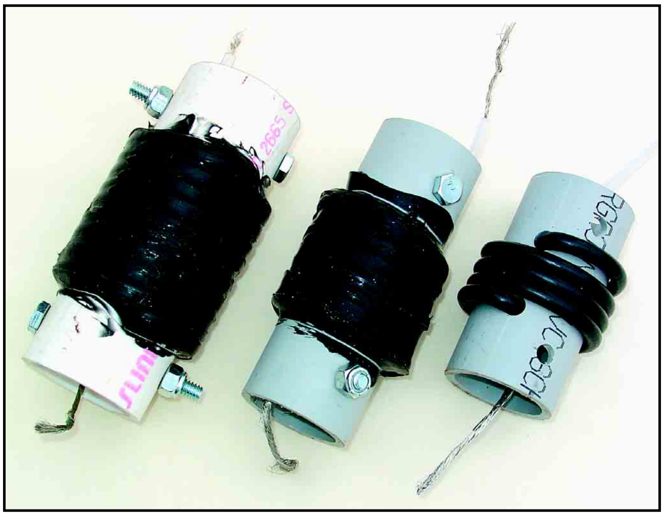


Figure 3—Here are the finished 40, 20 and 15 meter traps. The 15 meter trap is shown before installing the bolts and covering the coax winding with RTV silicone sealant.

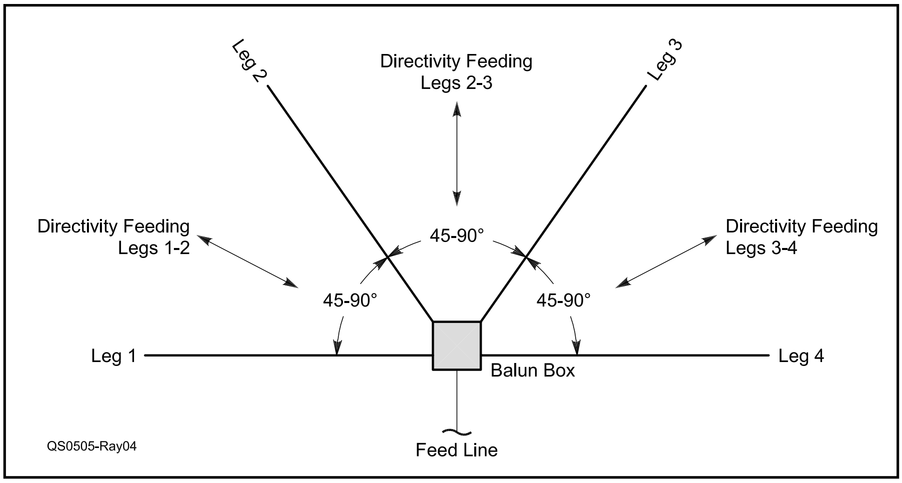


Figure 4—The basic V antenna is bidirectional. A four-leg V antenna can cover six directions by switching among the legs (1-2, 2-3, 3-4). Feeding legs 1-4 creates an extended doublet.

above about 400 W (I speak from experience). Gray PVC conduit is UV resistant and is a better choice for trap forms than white PVC water pipe. See Figures 2 and 3. Tuning of the traps is not critical. If a dip meter is available, adjust resonance of each trap to the desired center frequency by adjusting the spacing of the coax turns.

The end bolts have two small plastic spacers cut from 3/8 inch PEX tubing or similar material.[5] The antenna wire loops will fit in the gap between the spacers, keeping the wire centered on the trap bolts. I also filed the bolt threads a little in the center to smooth the sharp thread edges. When connecting the traps to the antenna wire, orient each trap so that the center-conductor lead is connected toward the antenna apex (feedpoint).

After fabrication and adjustment, the coax windings are covered with a neutral-curing black silicone rubber to hold windings in place. (Use GE RTV5223 or equivalent non-acetic sealant.[6] If it smells vinegary, don't use it.) Also put some sealant where the center conductors separate from the braid to avoid water infiltration into the coax.

Installation circumstances may affect resonance, so cut each antenna wire segment at least 2 feet longer than the shown finished lengths to allow for adjustment. To aid in adjustments during initial setup and tuning, I recommend using split-bolt connectors (Thomas & Betts 9H or equiv) to make easy temporary connections. Later, you can remove these connectors and solder the wires. Finished lengths shown make allowance for a 1 foot connecting lead (#12 stranded wire) from leg ends to balun box. If your installation requires longer leads, shorten the 20 meter legs accordingly.

The spreaders are cut from gray 3/8 inch PEX tubing. If you buy 30 inch lengths you can get two 13 inch spreaders from each. You will need 10 spreaders per leg. Drill a 3/32 inch hole through the tubing at 1/2 inch from each end, then slot the end to the hole using a hacksaw. Install the spreaders at intervals of about 15 feet in the 20 meter segments. Squirt some hot glue into each spreader end to hold them in place on the wires. A 1/8 or 3/16 inch Dacron rope is ideal for supporting the antenna legs. Polyethylene rope is not recommended since it is not UV-resistant. To counteract tree sway and keep antenna tension I used three 48 inch bungee cords in parallel at the end of each leg. Don't worry if your terrain has a slope as this will tend to lower the radiation angle in the downhill direction and make long-haul DX even more favorable in that direction.

Figure 4 shows one possible configuration for a four-leg V antenna. Optimum apex angle between legs for 20 meters is about 67° and is a compromise for the other bands. Almost any angle between 45° and 90° will work (90° works well to optimize 40 and 80, and 45° would be better for 10 and 15 meters). My antenna uses four legs so I can switch among three different V directions (using legs 1-2, 2-3 or 3-4) plus a fourth direction using two opposite legs (legs 1-4) as an extended doublet.

Balun and Relays

Figure 5 shows the circuit of the balun box that I use to match the antenna to a 50 Ω feed line and to switch among the four legs of my antenna. To match the antenna impedance of about 100 to 130 ohms, a 1:2.25 impedance transformer is connected at the antenna feed point. My transformer consists of two toroids: a Guanella 1:1 balun followed by a Ruthroff 1:2.25 unun transformer (see Figure 6). Construction was based on information in Jerry Sevick's excellent book on transmission line transformers.[7] This transformer has virtually no loss and has a flat SWR from below 1.8 MHz to above 40 MHz. For safety reasons, use low-voltage relays. I selected relays with 24 V dc coils since dc relay coils require less current than ac and thus less voltage drop on a long control cable (mine has #22 conductors and works well). Small chokes connected between each antenna terminal and ground help to eliminate static buildup on legs not in use. You will also need a control box. Mine is a simple 24 V dc supply and switch mounted in a small RadioShack box (Figure 5B).

A Carlon brand 4×4×2 thermoplastic junction box (available from most electrical supply houses) makes an ideal waterproof housing for the balun. If you install more than two legs, heavy-duty relays can be placed in a larger 6×6×4 Carlon box to remotely switch among the legs (see Figure 7).

My antenna location is in the Sangre de Cristo mountain range of Colorado and frequent storms make lightning protection

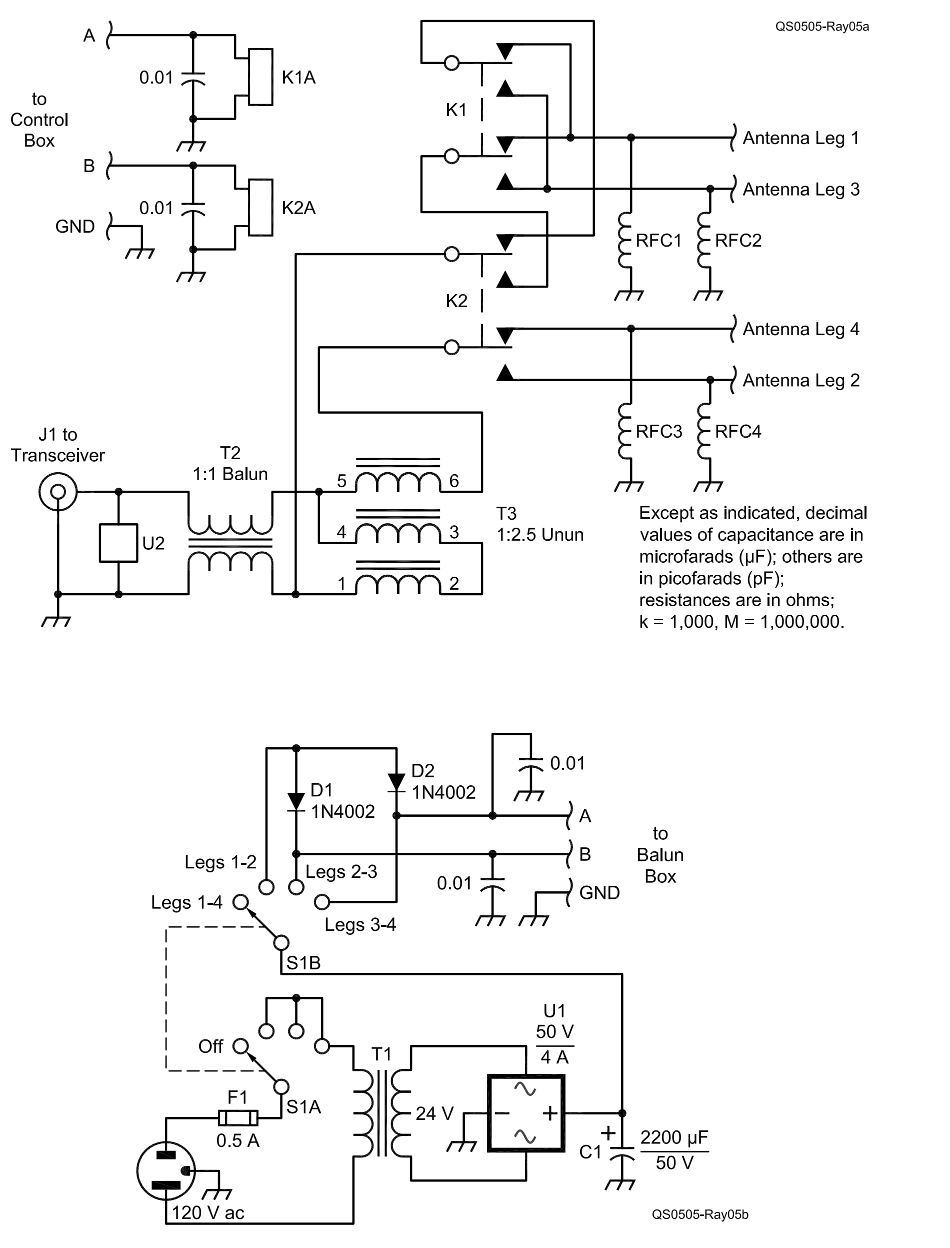


Figure 5—Schematic and parts list for the balun box (impedance matching and switching circuitry) and control circuitry for the four-leg V antenna. Parts are available from RadioShack (RS) (www.radioshack.com), Mouser (www.mouser.com) and W. W. Grainger (www.grainger.com). If you're building a V antenna with only two legs, you won't need relays K1 and K2 and the control circuitry.

C1—Electrolytic capacitor, 2200 µF, 50 V (RS 272-1049).
D1, D2—1N4002 diode (RS 276-1653).
J1—SO-239A chassis mount coaxial connector (Mouser 523-83-798).
K1, K2—Dayton DPDT power relays with 30 A contacts and 24 V dc coil (Grainger 3X749).
RFC1-RFC4—2.5 mH RF choke (Mouser 434-2250).
S1—Rotary switch, 2 pole 4 position (RS 275-1386).
T1—Power transformer. Primary, 120 V; secondary, 24 V, 2 A (RS 273-1512).
T2—1:1 balun, 9 bifilar turns #14 enameled wire on F-240-61 toroid core. Ferrite cores are available from Palomar Engineers (www.palomar-engineers.com) and others.
T3—1:2.25 unun, 13 trifilar turns #14 enameled wire on F-240-61 toroid core.
U1—Bridge rectifier, 50 PIV, 4 A (RS 276-1146).
U2—Xicon gas tube surge arrestor (Mouser 444-GT-350L). Use two in series for transmitter power above 500 W (see text).
Box is a 6×6×4" thermoplastic junction box (Carlon E987R-CAR).

a must for any antenna, particularly one with so much wire up in the air. Multiple pathways to ground will reduce risk to your equipment. The balun box has a heavy wire running down to ground. The coax connector on the balun box has a gas tube surge arrestor (U2 in Figure 5) connected from center pin to ground (use two in series for power above 500 W). Near the base of my center tree, I cut the coax feed line and installed a coax junction connector. A short, heavy ground wire is connected between this junction and the same ground rod that grounds the balun. The coax is routed through 50 feet of buried flex aluminum conduit, the end of which is grounded where the coax enters the station. A coax lightning protector connected to the same ground completes my antenna protection system.

Tuning

An antenna analyzer or noise bridge is highly recommended to do a good job of adjusting resonances. If possible, connect the unit directly to the coax connector on the balun box. Since the impedance of wire antennas varies with installed height, the best balun match will be achieved if the antenna is at least 30 feet above ground. Adjust the length of the 20 meter section on each leg first, then 40, then 15, and finally the short 80/10 meter end section. As a guide for adjustment, one foot of wire (per leg) affects resonance by about 80 kHz on 20 meters, 40 kHz on 40, and 120 kHz on 15. Since both 80 and 10 meters utilize the entire antenna, adjusting the last seg-

Figure 6—Impedance transformation is accomplished with a 1:1 balun and a 1:2.25 unun, each wound on a separate ferrite core and held together with cable ties. In this photo, the 1:1 balun (with bifilar winding) is toward the front. See text and Figure 5 for details.

Table 1
SWR on Each of the Five Bands

Freq (MHz)	*SWR*	*Freq (MHz)*	*SWR*	*Freq (MHz)*	*SWR*	*Freq (MHz)*	*SWR*	*Freq (MHz)*	*SWR*
3.5	5.0	7.0	5.0	14.0	2.0	21.0	1.8	28.0	3.0
3.6	4.0	7.05	4.0	14.05	1.6	21.05	1.6	28.25	2.6
3.7	3.0	7.1	2.9	14.1	1.4	21.1	1.5	28.5	2.2
3.75	2.3	7.15	2.2	14.15	1.3	21.15	1.4	28.75	1.8
3.8	1.4	7.2	1.5	14.2	1.2	21.2	1.4	29.0	1.4
3.85	1.0	7.25	1.2	14.25	1.2	21.25	1.3	29.25	1.4
3.9	1.3	7.3	1.5	14.3	1.3	21.3	1.3	29.5	1.6
3.95	1.6			14.35	1.5	21.35	1.4	29.7	1.8
4.0	2.0					21.4	1.4		
						21.45	1.5		

ment affects resonance on both of these bands (20 kHz per foot on 80 and 160 kHz on 10 meters).

After adjusting my first two legs, I found that I could duplicate the dimensions for my third and fourth legs without further adjustment.

Variations

Not everyone has the space to install a multiple-leg V antenna of this size. However, this antenna works fine with only two legs. One or more main lobes and a number of minor lobes make for an effective antenna. A horizontal V configuration is also not necessary. WØVRW installed his two-leg version as an extended doublet with very good performance. Only have one tall support? No problem. Install a two leg version as an inverted V. The Johnson County (Kansas) Radio Amateur Club (WØERH) used the inverted V configuration for Field Day with exceptional results.

If your end supports are less than 180 feet apart from the apex, you can let the 15 and 80/10 meter sections dangle down or at an angle. If so, black #14 house electrical wire works well for these sections. If 80 meters is not of interest, you can eliminate the 15 meter trap and the 80/10 meter segment (this will also make 10 meters nonresonant, however). Or if 15 meters is not needed, eliminate the 15 meter trap and make the 80/10 meter segment 16 feet long.

Table 2
Main Lobe Gain (dBi) for Various Elevation Angles

Antenna 60 feet above medium ground

	Elevation Angle (degrees)								
	5	*10*	*15*	*20*	*25*	*35*	*45*	*55*	*65*
70° V Antenna									
3.9 MHz	–7.1	–1.4	1.7	3.7	5.0	6.7	7.3	6.9	5.6
7.225	1.1	6.6	9.3	10.7	11.3	10.7	8.1	3.7	–0.3
14.25	9.8	14.2	15.2	13.9	10.2	0.9	3.8	5.5	4.6
18.1	11.4	14.8	13.8	10.0	4.0	7.1	7.1	1.7	–7.4
21.25	11.7	15.0	13.4	5.9	5.1	7.1	1.9	–2.2	1.8
29.0	15.0	15.1	6.2	9.9	11.7	–2.6	6.8	–3.3	–0.7
Extended Doublet									
3.9 MHz	–6.7	–1.1	2.1	4.1	5.6	7.4	8.3	8.6	8.8
7.225	–1.4	4.1	6.9	8.4	9.3	9.5	8.4	6.5	4.2
14.25	6.5	10.6	11.2	10.0	7.3	–2.9	4.5	6.0	5.8
18.1	9.6	13.3	13.0	9.9	5.9	7.2	8.5	4.0	–5.0
21.25	12.4	15.1	13.0	9.3	7.9	8.7	3.2	–1.5	4.2
29.0	13.3	13.1	9.4	8.0	8.7	-0.6	6.8	–0.8	1.3

Performance

Table 1 shows the SWR on each of the five bands with the antenna optimized for the phone segments. These SWR values are measured at the balun box. Switching between pairs of legs does not require retuning the transmitter.

I used *EZNEC* 4.0 antenna modeling software[8] to calculate main lobe gain, which can exceed 14 dBi on the upper bands. See Table 2 for gain data for both V and extended doublet configurations using a height of 60 feet in the model. Azimuth and elevation plots for each band for the V antenna with a 70° spread between legs are available on the ARRL Web site, along with azimuth plots for the extended doublet configuration.[9] As expected, the V antenna patterns are bidirectional with some significant minor lobes. The extended doublet configuration azimuth plots look similar to that of traditional harmonic dipoles.

In both configurations the radiation angles are quite low. For chasing 20 meter DX it's hard to beat a 14 dBi gain at a 10° angle. Or how about a 40 meter gain of 9 dBi at 15°? As with most wire antennas, lowering the antenna to 35 feet or so will increase radiation angles by 5° to 10° on all bands and make the patterns somewhat more messy. Main lobe gain will also decrease by 2 to 3 dB.

Actual on-the-air operation confirms the model data. The antenna "gets out" very well and I've received many extremely favorable DX reports and "strongest on the band" comments. If you have the space for at least two legs, this antenna

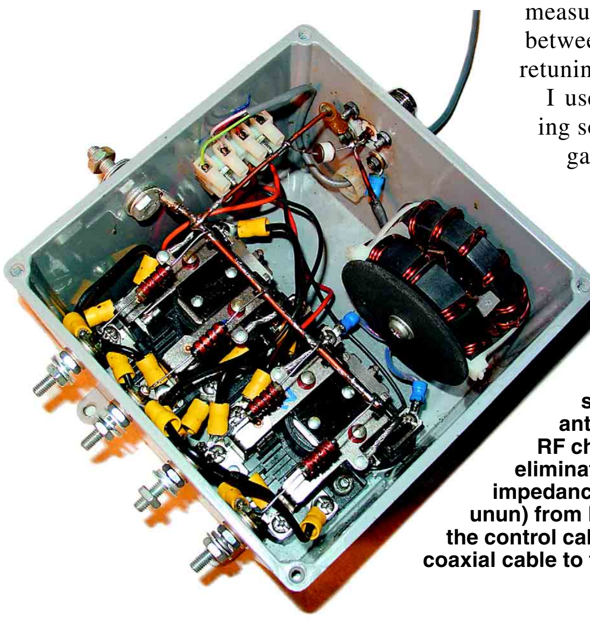


Figure 7—The completed balun box for a four-leg V antenna fits in a waterproof Carlon plastic electrical junction box. Shown in the lower left are two DPDT relays. At the bottom are four screws used as connections to antenna legs, and also four small RF chokes used for dc static elimination. At upper right is the impedance transformer (balun plus unun) from Figure 6. A terminal strip for the control cable and the connector for coaxial cable to the station are near the top.

or one of its variations will likely work for you too.

Notes

[1]Information on classic V antennas from older editions of the *ARRL Antenna Book* is reproduced in *ARRL's Wire Antenna Classics*, pp 5-1-5-3. Available from your local dealer, or from the ARRL Bookstore, ARRL order no. 7075. Telephone toll-free in the US 888-277-5289, or 860-594-0355, fax 860-594-0303; **www.arrl.org/shop/**; **pubsales@arrl.org**.

[2]R. Sommer, "Optimizing Coaxial-Cable Traps," *QST*, Dec 1984, pp 37-42.

[3]L. Colvin, "Multiple V Beams," *QST*, Aug 1956, pp 28-29. This article is reproduced in *ARRL's Wire Antenna Classics*, pp 5-4-5-5 (see Note 1).

[4]I got my RG-8X Marine Coax from The RF Connection (**www.therfc.com** or tel 800-783-2666). Their part number is WIR-117. Solid dielectric RG-8X is available from other suppliers as well—check with your favorite cable supplier.

[5]PEX is a type of polyethlyene (plastic) tubing commonly sold as inexpensive water supply line at many hardware stores and home centers.

[6]I got mine from MSC Industrial Supply, 75 Maxess Rd, Melville, NY 11747, **www.mscdirect.com**. Manufacturer's part no. RTV5223 12C, MSC order no. 06904841.

[7]J. Sevick, *Transmission Line Transformers*, 4th edition (Noble Publishing: 2001), Figures 7-14 and 9-3. Available from your local dealer, or from the ARRL Bookstore, ARRL order no. TLT4. Telephone toll-free in the US 888-277-5289, or 860-594-0355, fax 860-594-0303; **www.arrl.org/shop/**; **pubsales@arrl.org**.

[8]*EZNEC* 4.0 software available from W7EL at **www.eznec.com**.

[9]Visit **www.arrl.org/files/qst-binaries/Raydo.zip** for *EZNEC* azimuth and elevation plots of a V antenna with 70° leg spacing and an extended doublet, both at 60 feet.

Photos by the author.

John Raydo, KØIZ, received his Novice license in 1957 at the age of 13. He worked his way up through the licensing steps as KØLMZ and changed to a vanity call a couple of years ago. From early on he has enjoyed designing and building ham radio equipment and in the mid sixties he authored two construction articles for QST *and the* Mobile Manual. *After an extended period of amateur radio inactivity he recently purchased some classic Collins equipment (KWM-2A, 75S-3B, 30L-1) and set up his four-leg V antenna at his Colorado station. He is a graduate electrical engineer and also has a liberal arts degree in math and science, plus an MBA. He started his career working for TWA in the engineering department and later headed their information services and purchasing departments. He is currently president and CFO for a securities broker/dealer that he helped start several years ago. You can contact the author at* **kcflyers@yahoo.com**.