

Flag Antenna Construction and Test Results

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The Flag Antenna is in the family of terminated loops that can yield a cardioid (heart-shaped, single-direction null) pick-up pattern. Its name comes from its horizontal rectangular shape. Length of the upper and lower horizontal wire members is typically about 2 to 3 times the height of the two vertical sides. Original "relatives" include the Ewe antenna developed by Floyd Koontz, WA2WVL and Gary Breed's K9AY Loop. These rely to some extent on ground conductivity to perform at their best. A "ground independent" terminated loop concept was subsequently developed by Jose Mata Garriga, EA3VY and Earl Cunningham, K6SE. The Flag, Delta, Kaz, and Pennant antennas are in this category.

I set up a Flag Antenna at my home QTH in Billerica, MA (25 km northwest of Boston). Alignment was for a feedpoint on the northeast side and termination on the southwest side. The null to the southwest is advantageous here to reduce interference from broadcasters and 160-m hams (and even storm static) along the "I-95 corridor" of large cities throughout RI, CT, NY, NJ, PA, DE, MD, DC, and VA. By reducing the strong groundwave and short-skip signals from that densely-populated region, European stations (in the opposite direction) can be heard with improved readability.

The K6SE article on Pennants and Flags suggests a horizontal dimension of 8.84 m / 29 ft. and a vertical (side) dimension of 4.27 m / 14 ft. The VE6WZ web site has data suggesting that, as long as the horizontal-to-vertical (H/V) ratio is kept the same, performance in nulling will be comparable with antennas of different sizes. Signal capture, of course, is greater as the area enclosed by the antenna is increased. The K6SE ratio of 29/14 or 2.07 was arrived-at by EZNEC analysis. Ken Alexander had good results with a Pennant measuring 16.45 m horizontally by 5 m vertically for a ratio of 3.29. It would seem that there's a certain amount of "budge room" in the H/V ratio.

The Flag Antenna I installed (see **Figure 1**) used a horizontal dimension of 10.36 m / 34 ft. and a vertical dimension of 4.88 m / 16 ft. Its H/V ratio, 2.125, is quite close to K6SE's 2.07 value. At first I had the bottom wire of the antenna about 2 m off the ground. Since the antenna was fairly close to the house, pick-up of TV and computer hash tended to be a problem. Raising the bottom wire to 7 m / 23 ft. above the ground helped considerably in reducing electrical noise pick-up. This put the top at 11.88 m / 39 ft. with the supporting ropes going over the tops of black locust trees at the (approximately) 17 m height level. The added antenna height also improved nulling and low-angle DX pick-up a bit. The Flag is probably an easier antenna to raise to a good height than are some of the other designs if you have two decent size trees or masts available.

As in my previous tests of Pennant and Kaz antennas at sites in West Yarmouth, Billerica, and East Harwich, MA, I used a remotely-controlled termination resistance scheme. A controller box in the "shack" operating position injects a DC voltage into the coaxial cable. A feedpoint box provides a necessary balanced antenna / high impedance to unbalanced cable / 50 ohm impedance transformation. It also couples the DC control voltage onto the upper and lower halves of the antenna. The termination box contains the Vactrol which changes its resistance as a function of the current passing through the internal LED coupled to its photoresistor.

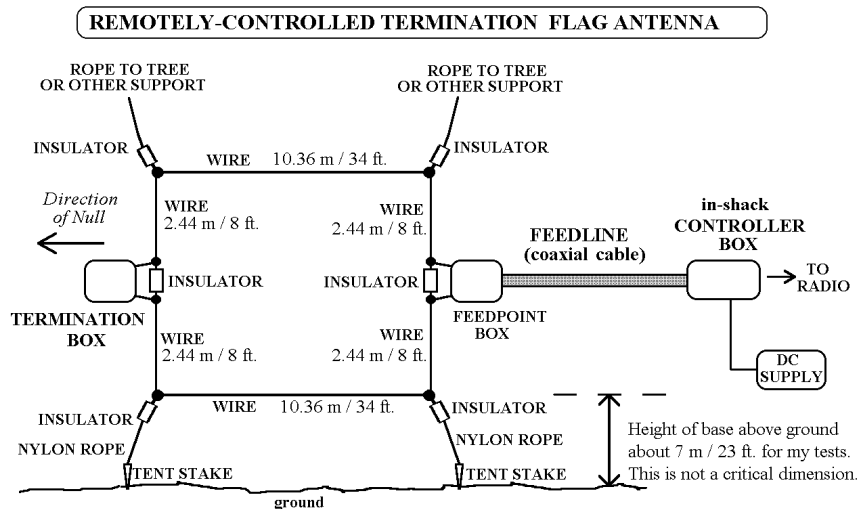


Figure 1: Flag Antenna System Drawing

The three boxes in the Flag Antenna system are somewhat modified (improved) versions of corresponding boxes used in the previous Pennant Antenna tests. Either the old or the new set of boxes would work for any of the balanced terminated loop antenna designs.

The controller box (**Figure 2**) is straightforward in concept. Regulated 10 VDC is divided by a 1K linear potentiometer (preferably a multi-turn wirewound type) and R-L coupled to the coaxial feedline. Antenna RF is capacitively coupled to the receiver (or phasing unit) input. An optional amplifier, such as the W7IUV (2N5109-based) design, may be added as shown.

I tried two different styles of feedpoint box. One uses a Mini-Circuits T16-6T-X65 "off the shelf" 16:1 RF transformer (**Figure 3**) and the other uses a "do-it-yourself" transformer based on an Amidon FT140-43 core (**Figure 4**). The split high-impedance winding of the Amidon core "DIY" transformer decreases any unbalancing effects caused by the choke-coupling of DC to the antenna elements from the coaxial feedline. Also, the large FT140-43 core is likely to create less distortion in the presence of strong signals than the little Mini-Circuits transformer that contains much less ferrite. Tests show the "DIY" transformer to have greater coupling efficiency in many cases, especially below 1 MHz. Most likely because of coaxial cable to antenna interaction differences between the two styles of feedpoint box, slight variations in null depth and optimum termination value were observed on a given station during testing (depending on the feedpoint box used). The nulling and gain advantages of the homebrew transformer design are discussed more in the test results part of this article.

The termination box (**Figure 5**) has a switch in it that can separate (RF-wise) the "test point" input from the upper antenna wire jack. This would be done in the case of a twisted-pair Beverage where you'd connect the test point jack to field site ground. For Flag, Pennant, etc. use, the switch would be set to connect the upper antenna wire to the test point through the 0.1 uF DC-blocking capacitor. With a current of about 30 mA through the Vactrol LED, the pot arm back at the

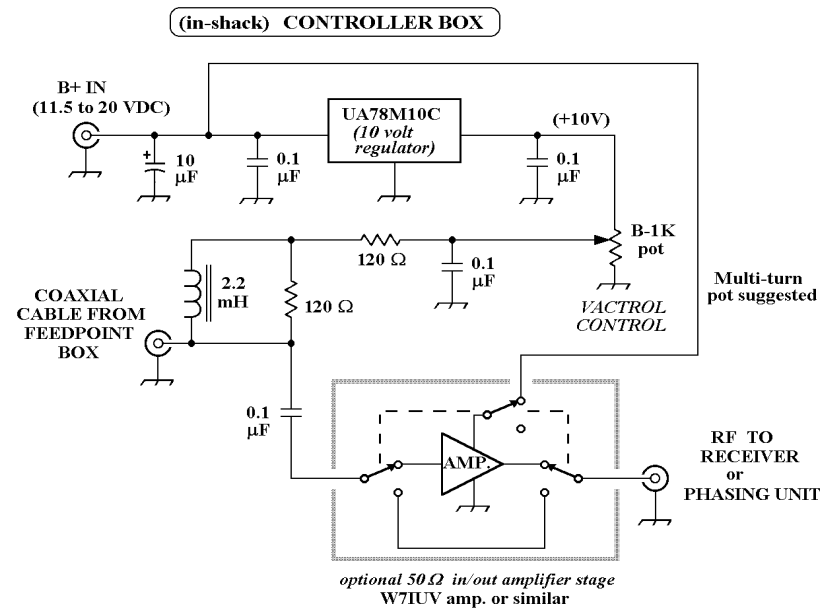


Figure 2: Controller Box Schematic

controller would be close to +10V and the DC voltage between the upper and lower sections of the antenna would be about 6 V (because of the series resistors and chokes in the control and termination boxes). The voltage at the Vactrol LED is clamped to a maximum of about 2.1 V by the three series 1N4003 diodes. This protects it from being damaged by inadvertent application of too high a voltage. Resistance of the Vactrol photoresistor is about 55 ohms at full current and greater than 20K ohms at zero current and voltage. The 100 ohm resistor in series with the Vactrol photoresistor makes adjustment in the often-used 700 to 1500 ohm range less "touchy". Because of that resistor, typical minimum resistance measured between the test point and the lower antenna input jack is about 155 ohms. I developed a table of control voltage versus measured resistance (not included here). With this I can determine the approximate termination resistance yielding a null by measuring the controller box's DC voltage at the operating position and then referring to the V-versus-R spreadsheet.

Testing

Rather than presenting a lot of charts and graphs, results will be summarized in text form.

Several medium-wave AM broadcast stations on various bearings were used to evaluate the antenna's directivity during stable midday conditions. For stations in the 180 degree (= due south) to 270 degree (= due west) quadrant designed to be the "kill zone", a peak signal usually occurred at one extreme of the control pot setting or the other: in other words with a termination approximating either a short or an open. Nulling occurred with termination resistances in the 700 to 1500 ohm range with 900 ohms a good "ballpark" value if one had to resort to a fixed resistor instead of Vactrol control. This is pretty much in agreement with K6SE's article. I feel that the Vactrol method is essential for best performance because, for minor differences in bearing and frequency, different termination values are needed to squeeze out those "last few dB" of null.

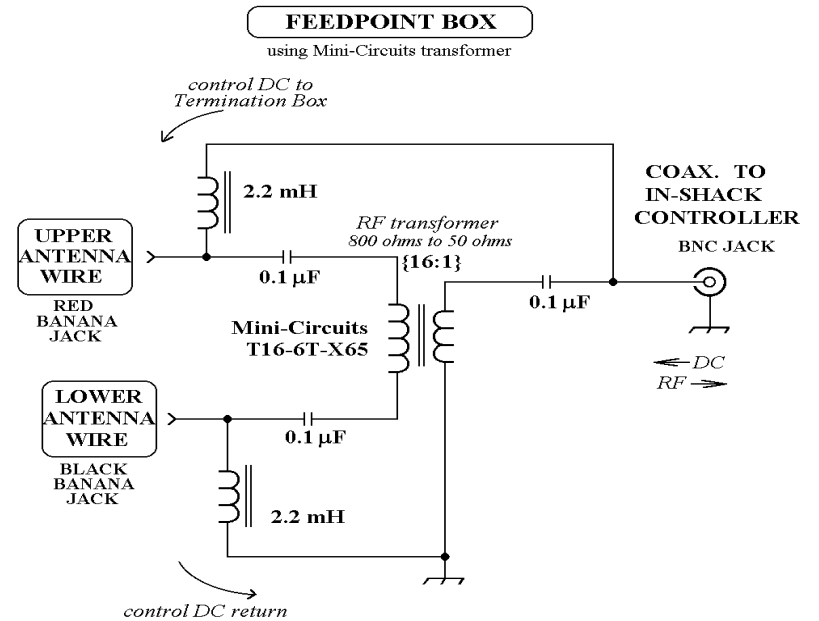


Figure 3: Feedpoint Box with Mini-Circuits Transformer
Using a ballpark value may get you a consistent 15 dB of null in the quadrant of interest, but will only give a deeper null on a handful of ideally-suited signals.

To see how much deviating from the "sweet spot" value degrades null depth, consider the following case study: WORC-1310, Worcester, MA nulls better than 5 S-units (more than 30 dB) with a termination of 808 ohms. This degrades to 25 dB at 742 and 847 ohms, 20 dB at 694 and 911 ohms, 15 dB at 568 and 1104 ohms, and 10 dB at 305 and 1740 ohms.

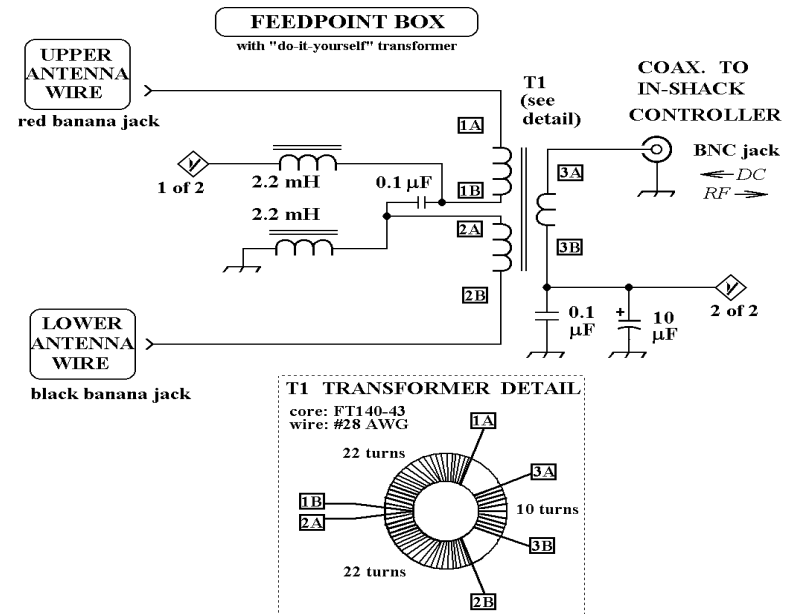
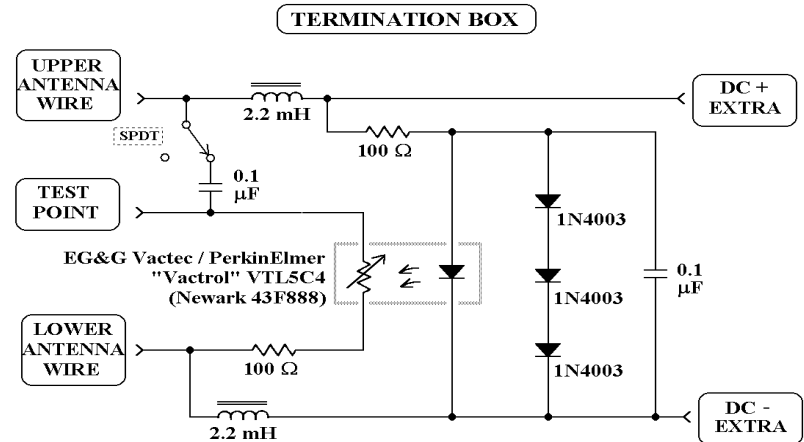


Figure 4: Feedpoint Box with "Do It Yourself" Transformer



Note

1N4003 diodes clamp maximum voltage to ≈ 2 VDC, corresponding to ≈ 30 mA through Vactrol LED. This sets photoresistor to minimum value, about 54Ω .

Figure 5: Termination Box schematic

I get typical good-depth nulls with as little as 700 ohms and as much as 1500 ohms depending on the station. From the previous null-degradation analysis, you can see the importance of hitting the proper termination "spot on", something you can only do with the Vactrol approach.

Nulls of selected stations in the design sector (south to west) were typically 18.8 dB with the Mini-

Circuits T16-6T-X65 based feedpoint box and 22.6 dB with the "DIY" transformer based version. This says that the stray coupling effects of the coaxial feedline were reduced by the "DIY" design. In a few individual cases, the Mini-Circuits box showed a deeper null (but, more often, not). Previous Kaz and Pennant tests (with the Mini-Circuits based feedpoint box) showed somewhat shallower average design-zone nulls: 14.9 dB Pennant, 16.6 dB Kaz.

Some nulls exceeded 30 dB. For many stations on southwesterly bearings, a 25 dB null was not uncommon. Even at night on high-angle skip pests like WQEW-1560 NYC, nulls of better than 15 dB could be maintained for a long time.

When you attempt to null stations 45 or more degrees off the main null axis, the null resistance setting migrates towards either a short or an open. What happens is that the cardioid gradually degrades to a pattern with two shallower nulls clockwise and anticlockwise of the design null axis. Eventually, with the two nulls close to a right angle to the axis, you develop a figure-of-eight pattern just like a normal loop antenna. This finding was also noted in the Kaz and Pennant studies.

Stations close to the opposite direction of the design null bearing show little signal variation with changes in the termination resistance. WESX-1230 and WNSH-1570 to the east and WNBK-1450 to the northeast are in this category. These stations, and some of the Maine and Canadian Maritimes stations, are among the few domestic stations I like to see enhanced by antennas being tested. That's because the bearings to them continue on towards desired DX targets in Europe, North Africa, and the Middle East.

Sensitivity on peaked signals with the 4.88 m by 10.36 m Flag Antenna with the Mini-Circuits based feedpoint box averaged 16 dB below the reference sloper. The Flag using with the "DIY" transformer feedpoint box was 11 dB below the sloper. Again, this shows an advantage to using the homebrew transformer.

The previous Kaz and Pennant tests showed 23 dB less sensitivity than the sloper: those antennas had an enclosed area of only about half as much as the area of the Flag.

I can use the antenna as a "straight" broadband loop either by setting the Vactrol to minimum resistance or, even better, by removing the three boxes and just using a 4:1 transformer at the feedpoint. In this case, the two leads that normally go to the termination box would be shorted together. This large broadband loop has a good amount of pick-up in its figure-of-eight pattern. It is even less susceptible to local electrical noise than the Flag configuration. Two of these broadband loops at a right angle can be presented to two phasing unit inputs for versatile nulling. Also, one of these vertical-plane broadband loops could be phased against a non-directional antenna such as a broadband-transformer-matched vertical ground plane, vertical dipole, or horizontal loop.

The Flag Antenna, especially if made a reasonably-large size and mounted at a good height, is a very effective antenna. Though claims of it being a "backyard Beverage" may be exaggerated, it can have a commendable front-to-back ratio for situations requiring that kind of directivity. Refinements such as Vactrol termination and in-shack amplification are worthwhile performance-enhancers to consider.

Further Reading

The following articles and other potentially useful ones are available from links at <http://www.qsl.net/wa1ion/index.html>. Some may also be available on paper through the reprints services of the National Radio Club and the International Radio Club of America. These articles have references and links to other published material. The Hard Core DX and ARRL web sites also have useful material that can be located through common Web search engines.

* Remote Termination of Beverage and Ewe Antennas

- * Phasing Improves Kaz Antenna Nulls
- * W7IUW Amplifier Card
- * VTL5C4 / VTL5C3 Vactrol Data Sheet
- * Pennant and Kaz Antenna Tests
- * "Kaz Antenna" Tests by John Bryant
- * Pennant Antenna with Remote Termination Control
- * K9AY antenna links
- * Flag and Pennant antenna links
- * Flag and Pennant Antenna Compendium
- * Is this Ewe for You ?
- * More Ewes for You
- * K9AY Loop