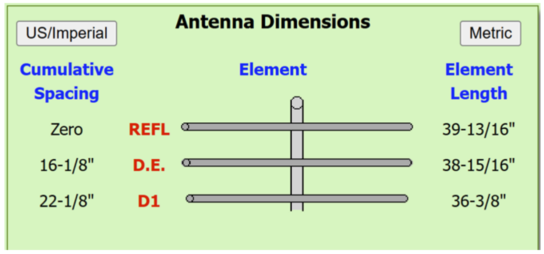
A 2-Meter Yagi Antenna That Definitely 'Measures' Up

146.5 MHz 3-Element Tape Measure Yagi

Updated 3-2026

AD6AE

A compact, lightweight, portable Yagi antenna with folding elements and a 2-piece boom



Materials List: 1/2-inch Sch. 40 PVC. (If using ¾" adjust spacing accordingly.)

- 10' stick for two boom sections (38") plus six 5" element support arms (30") for 68" total
- 3 - 'Crosses' for R, D/E, & Horizontal or Vertical Mast Mounting + rear handle for Fox Hunts
- 1- 'Tee' for D; PVC cement (optional)
- Pack of 10 (#4 x 3/8") sheet metal screws
- Either: 1/16" or 5/64" dia. drill bit (pilot holes). Either 1/8" or 7/64"dia. drill bit (element holes)
- Sandpaper, rosin core solder, solder paste, and soldering iron or gun
- 1 (10' x 1") tape measure ≈7' required
- 1 (8") piece #12 solid wire for a 4" long hairpin (after final tuning, this one was 3-1/4")
- 2 (#43 or #61 mix) clip-on ferrite choke beads or a ferrite toroid or CM currents will be problematic.
- BNC-F to 2-screw adapter or RG-316 pigtail with female connector; length as needed for pigtail
- Velcro tape to secure folded elements; hand tools: old scissors to cut elements, screwdriver, drill

Construction Note: This prototype is not glued together. Another element mounting idea can be found on the link below: "$10 Antenna Reaches Out Far."

Assembly: Boom, Reflector & Director - Refer to Photos for Details.

1. Cut the boom pieces for center-to-center or edge-to-edge element spacings as shown in the diagram. To allow for length added by connectors, measure the **<u>outside diameter</u>** across the connector opening (for ½" PVC, it's ≈1-1/16"). Subtract that length from each boom piece. When fully seated, it should be the correct length for the center-to-center element distance between couplings

Driven Element:

2. Cut the D.E. in half, trim ends at a 45° angle and smooth. **For each half:** Sand to remove a 3/8" wide patch of paint from one end on the **convex** (plain) side; clean, apply soldering paste and tin well.

3. Center punch then drill an 1/8" dia. hole located 3/4" from the tinned ends. (see photo)

4. Using the holes as marking guides, center the 45° cuts into the 'vee' molding lines of the 4-way cross; allowing a 1-inch gap between the two dipole halves; mark then drill a 1/16-inch pilot hole in the 'cross' connector arms for attaching each half of the driven element (see hairpin photo); center punch & drill an 1/8" hole in D/E support arms as done in step 5. and fasten to support arm ends.(photo).

5. Strip 1" of insulation off each end of an 8-inch long piece of #12 solid wire; clean, apply paste & tin.

6. Form hairpin as shown; adjust radius so pins are spaced ≈1" apart, ends even; solder to D/E.

7. Prepare coax with a female connector on one end, thread on ferrite beads; bare, tin ends then solder. Or, use a BNC to 2-screw connector shown in the hairpin photo, tin and solder pigtails to D/E.

8. When tuning is completed and readings are satisfactory, remove card stock and secure screws.

Tuning

1. Install a common mode choke; a must or tuning will be unstable with changes of coax lengths.
2. Calibrate the VNA to an extended reference plane for a 20-25 foot length of coax used for tuning. If using an antenna analyzer, record R and X Values and sign of X if shown.
3. Mount only the DE to the boom, attach the calibrated coax with CM choke, elevate about 10-feet high pointing straight up; step away and position yourself off the tip of the DE. **Record VSWR at 3-points: 144, 146.5, & 148 MHz.**
4. Trim DE for lowest VSWR at 146.5. Then trim corners at 45°; sand smooth. Attach the hairpin.
5. Mount remaining elements; point straight up; elevate 10 ft.; record VSWR, R&X at 146.5 MHz.
6. Match; adjust length of hairpin for a VSWR of ≤1.2 at 146.5MHz; When done, check all 3-points.
7. NOTE: For this one, *6-1/2 inches of wire (after trimming) added sufficient inductance for a 1.2 VSWR.*
8. Tuning Tip: If VSWR is too high at 148 MHz, make the hairpin a little longer; if it's too high at 144MHz, make it a little shorter. After each adjustment, recheck VSWR at 3-points. Aim for ≤1.2 at center & ≤2.5 at band edges. This prototype antenna tuned easily.

Some builders fine tune by excessively distorting the hairpin. Don't bother. The VSWR will change when using it in close proximity to anything (yourself), so disregard. Unfortunately, many hams ignore the importance of using a CM choke or 1:1 coax balun on a dipole for proper tuning and improved operation.

Summary: This design was taken from the K7MEM designer choosing the DL6WU spacing option. His designs claim improved detuning immunity over other designs that are caused by variances in construction and environmental factors. After testing this prototype, I agree.

My initial reaction was that elements made with unplated, painted, spring-steel ribbon indicated that design calculations may be more of suggestion than of fact. Without copper plating, steel is a very poor material for VHF due to lower efficiency from increased skin effect depth and higher heat losses.

BUT the range test results still '*Measured Up*' to be very close to designs using aluminum elements.

Theory: As explained in the video links below,[4,5] as each element is added, capacitive coupling between the D/E and the parasitics increases as each one draws excitation power from the D/E as the wave travels thru each element. As such, they become impedances in parallel with that of the driven element which, like resistors in parallel, lowers the antenna's *input impedance and resonance*. The feedpoint impedance decreased from 50Ω resistive to approximately 35Ω capacitive so the antenna resonance and VSWR shifted accordingly.

However, *the resonant length of the D/E has not been altered so do not attempt tuning by adjusting its length* or those of the elements. Initially, the DE was isolated then tuned by trimming to length until R≈50Ω, X≈0. Therefore, the VSWR issue does not involve element resonances. Rather, it is that of matching the lower *input impedance of the antenna*, (which is capacitive X_C), to that of the 50-ohm line (resistive) and is achieved by adding an inductive reactance (X_L) of equal value *(the hairpin)* to compensate for (X_C) so that $R+X_L-X_C=R$ or more properly stated, R50+j0Ω.

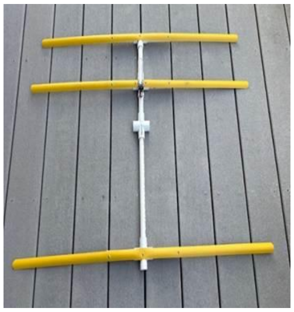
NOTE: K7MEM's gain figures are expressed in dBd. For dBi as used here, simply add 2.15 to his.

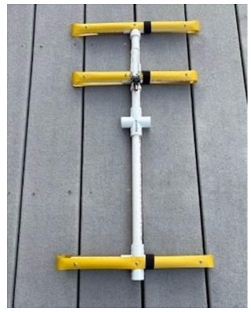
PHOTOS

Antenna elements fold and boom breaks down into a 14x14-inch package.

For reference, the deck boards with spaces are 6" wide.

Velcro strips were attached to one support arms underside to secure elements when folded.





H or V Mast Mount **Hairpin Match** **Elements Folded** **Broken Down** **Nested**

Velcro strips were later attached using screws and washers on one of the support undersides.

TRACE LEGEND. Yellow: Reactance (X) **Green:** Smith Chart **Magenta:** Resistance (R) **Blue:** VSWR

Test Setup w/CM Chokes using a calibrated 15' piece of RG-316

146.5MHz – SWR 1.22 (Blue)
Smith Chart shows 60Ω, -j3.7Ω (capacitive)

SPECS

NOTE: The K7MEM calculator gives the calculated gain in dBd for a 3-foot boom and one director to be ≈ 4.8 dBd.
Converting: dBi = dBd + 2.15 or ≈7 dBi.
This prototype range tested at 8.3 dBi. So the phrase; "It works real good" is quantified.

SWR: 144MHz: 2.34 ‖ 146.5MHz: 1.22 ‖ 148MHz: 2.25

Measurement Method: Friis 3-antenna; spaced 20 meters, elevated 10'; nanoVNA s11(Tx); s21 (Rx)

Gain: 8.35 dBi ‖ **Beamwidth:** 58° ‖ **F/B Ratio:** 13 dB ‖ **F/S Ratio:** 35 dB

Nested Size: 14x14" ‖ **Weight:** 1 lb.3 ozs ‖ **Assembled Length:** 25-1/2" ‖ **Width:** 39-3/16"

Resources:

1. Ideas from: Tape Measure Yagi – KC3SMW https://www.youtube.com/watch?v=ktoiyKoo36A&t=991s, $10 Antenna Reaches Out Far! , et.al.
2. Yagi Antenna Designer: VHF/UHF Yagi Antenna Quick Designer - K7MEM
3. Includes other antenna design calculators: DL6WU Yagi-Uda antenna online calculator - 3G-aerial
4. Parasitic Antenna element interactions 1: https://www.youtube.com/watch?v=2DcvmGPLdT0
5. Parasitic Antenna element interactions 2: https://www.youtube.com/watch?v=J8S3iZ9-848.
6. Element spacing reference points were not specified so they were assigned as center-to-center.
7. **1:1 current balun:** 8 bifilar turns of RG-316 on an FT140-61 core (about 18-inches required..

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