# *RF*

By Zack Lau, W1VT

## An Optimized 6-Meter Yagi

This 6-meter Yagi was first designed for QRP portable use—I wanted a simple beam that could be quickly put up and taken down, while being easy to transport in a compact sedan. I decided on a permanently assembled 2×4 foot center section and four thin 3-foot tubes. This easily fits on the back seat of most cars. Assembly is just a matter of sliding in the tubes, adjusting the precise lengths, and tightening down the element clamps. I published a computer model of the design in the 19th Eastern VHF/UHF Society *Proceedings*.

The dimensions shown are different from what I used 10 years ago—I decided to tweak the dimensions for a better front to back ratio in the DX portion of the amateur band. While the gain is 0.5 dB less than the original, the F/B is over 19 dB, much better than the typical 8 to 12 dB one associates with two-element Yagis. The free space gain is still a respectable 6.5 dBi according to Roy Lewallen's *EZNEC* and Brian Beasley's *YA*. Fig 1 shows a *YA* file—the extra non-resonant element is a limitation of the program. It expects at least three elements, so I detuned it and placed it 833 feet away from the other elements, so its effect is negligible. *YA* was once bundled with the *ARRL Antenna Book*. Fig 2 shows the *YW* file—*YW* is Windows program bundled with the current *Antenna Book*. The *YA* antenna element lengths are a little shorter—Brian calibrated his program to match *NEC*. Both programs list half element lengths—assuming symmetry allows programs to work faster and handle more antenna elements. The director element in the model is 0.1-inch shorter than the actual hardware—to account for the shortening effect that occurs when an element is electrically attached to a conductive boom. The driven element, being attached with an insulating plate, does not need this correction factor. Figs 3 through 6 show the dimensions of the various parts.

A Moxon rectangle could be used for even more F/B—at the expense of

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50MHz yagi
50.100 50.150 50.250 50.200 MHz
3 elements, inches
0.500 0.375
0.000 24.000 20.000
10000.000 24.000 35.400
10019.500 23.750 31.500
```

**Fig 1—*YA* file**

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206-02H.YW, 2-ele., 2' boom, 6.56 dBi midband gain
50.0 50.125 50.25 MHz
3 elements, inches
0.500 0.375
0.000 23.750 20.000
10000.000 23.750 35.900
10019.250 23.750 31.900
Match frequency: 50.125 MHz
Driven-element tip: 35.9 inches
Cable Z0: 25.0 ohms
Original file name: C:\ANTBK19\YAGIS\206-02H.YW
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**Fig 2—*YW* file**

a more complicated design that often requires one to bend aluminum tubing. It folds back the elements so the tips are closer to each other to optimize the coupling for best F/B.[1] One source of pre-bent aluminum is old lawn chairs—Dick Stroud converted one into a 6-meter Squalo.[2] Instead, I optimized the element diameter to optimize the coupling. On 6 meters, the electrically optimum thickness also works quite well mechanically.

Frugal amateurs will be delighted to discover that the lengths are also optimized for six-foot tubing stock. Cutting a driven element tip from a six-foot length leaves enough stock for a director tip. Two six-foot lengths of tubing can be used to make the center sections of the beam—you will have a four-foot section left over. It may be used for making another 6-meter beam. If you want to stack Yagis, I suggest reading the online tutorial by Ian White, G3SEK, at **www.ifwtech.co.ukk/g3sek/stacking/stacking2.htm**.

The feed-point impedance is very close to 25 Ω, resistive. This is preferable to lower impedances, which typically result in designs with greater losses. You wouldn't want a design with worse F/B and greater theoretical gain, if the practical implementation resulted in a net gain that was no higher. I chose to split the element and feed it with a λ/4 matching section that doubles as a choke balun. The optimum coax impedance is √(25 Ω × 50 Ω), or 35 Ω. RG-83 coax is ideal—if you can find this specialty 35-Ω coax. It may be possible to obtain it from the Wireman.[3] This cable is occasionally produced by Times Microwave Systems; there isn't much demand for this oddball impedance. A cheaper design is shown in Fig 5—you can parallel two 75-Ω cables to come pretty close to 35 Ω. I've also had success with this method, as shown in Fig 7.

You may wish to account for the pigtail leads at either end—the velocity factor is higher when the dielectric is mostly air. The calculation requires some algebra. If *L1* and *L3* are the pigtails and *L2* is the coax cable:

$$L_{total} = \frac{984\ \text{ft MHz}}{4f} = \frac{984}{4 \times 50.1\ \text{MHz}} = 4.91\ \text{ft} \qquad \text{(Eq 1)}$$

$$L_{total} = \frac{L1}{Vf1} + \frac{L2}{Vf2} + \frac{L3}{Vf3}$$

$$4.91\ \text{ft} = \frac{0.75''}{0.95\left(\frac{12''}{\text{ft}}\right)} + \frac{L2}{0.78} + \frac{1''}{0.95\left(\frac{12''}{\text{ft}}\right)}$$

$$= 0.066\ \text{ft} + \frac{L2}{0.78} + 0.088\ \text{ft}$$

$$4.76\ \text{ft} = \frac{L2}{0.78}$$

$$L2 = 3.71\ \text{ft} \qquad \text{(Eq 2)}$$

I used clamps with wing nuts to easily adjust the exact element lengths. Ideally, you would adjust the director lengths for the maximum F/B—while listening to a convenient beacon. There are many beacons between 50.0 and 50.1 MHz. G3USF keeps a list of 6-meter beacons at **www.keele.ac.uk/depts/por/50.htm**.

## Construction

I recommend reading my Jan/Feb 1998 "RF" column that describes a 4-element 6-meter beam. It has many photographs. It describes in detail how to machine your own custom ½-inch tubing clamps that can be finger tightened. Ordinary stainless-steel hose clamps could also be used. I used a 21.75-inch length of 1-inch square tubing for the boom. The tubing wall thickness is 0.080 inches. The director is clamped to the boom with a bent

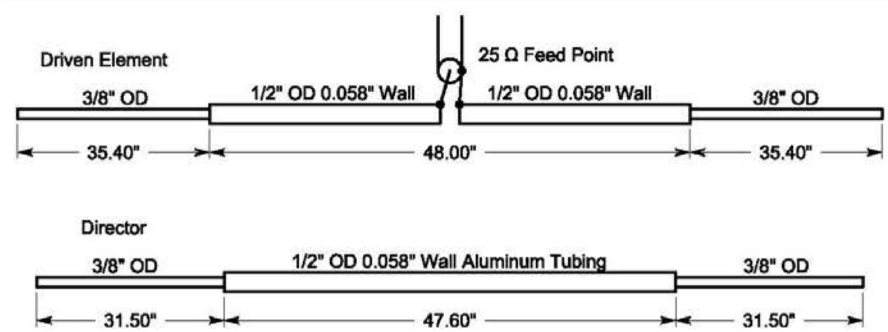


Fig 3—6061-T6 aluminum element dimensions for the 6-meter beam.

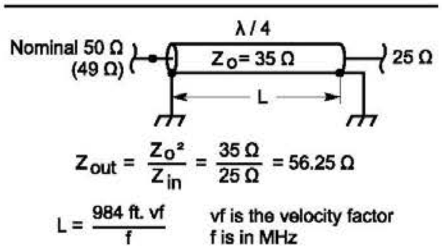


Fig 4—25-Ω to 50-Ω transformer using an electrical λ/4 of 35-Ω cable.

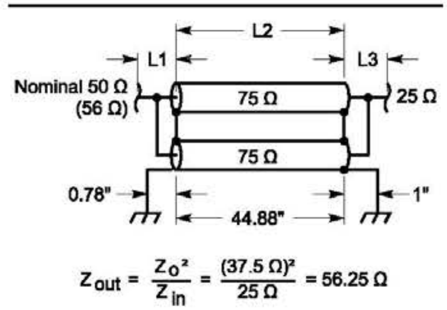


Fig 5—25-Ω to 50-Ω transformer using 75-Ω cable.

[1]Notes appear on page 60.

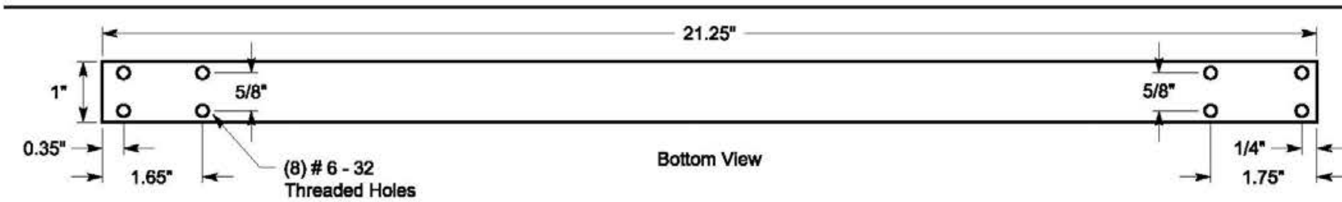


Fig 6—Bottom view of the boom. The top is nearly identical, except that the holes clear #6-32 screws. Use a #36 bit to drill the tapped holes and a #28 bit to drill the holes on top.

aluminum strap. I put a pair of 0.06×0.5×1.0-inch aluminum plates between the screw heads and strap to keep the strap from distorting. The plates fit snugly against the **U** of the strap, as shown in Fig 8.

The driven element is attached to the boom with four aluminum straps screwed onto a ¼-inch thick Lexan plate. I used #6-32×1¼-inch long stainless-steel screws to hold down the plate and straps. These screws are just the right size if you tap the bottom of the aluminum boom. You need longer screws if you intend to use nuts and lock washers. I've not had any trouble with the aluminum threads stripping, but this could be a problem with thin-wall tubing. This insulated element-mounting technique could also be used with the director, but the length of the director should be shortened by 0.10 inches.

Don't forget to drill mounting holes on the side of the boom for the mast clamp: Two holes for a **U** bolt and saddle work fine for this little antenna. Drill them near the center of the boom—the exact size and spacing depend on your choice of **U**-bolt. I've had

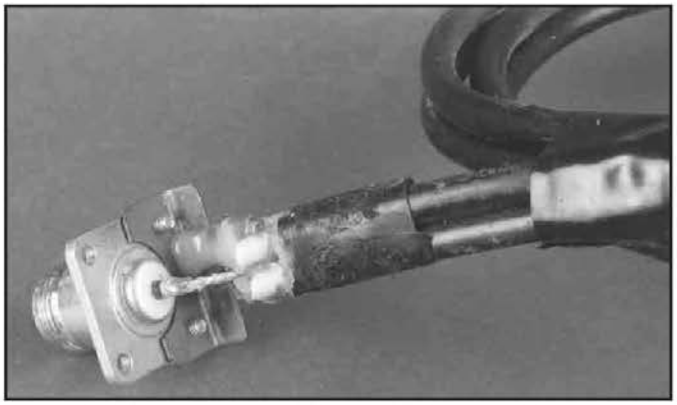

Fig 7—An N connector attached to a pair of 75-Ω cables in parallel.

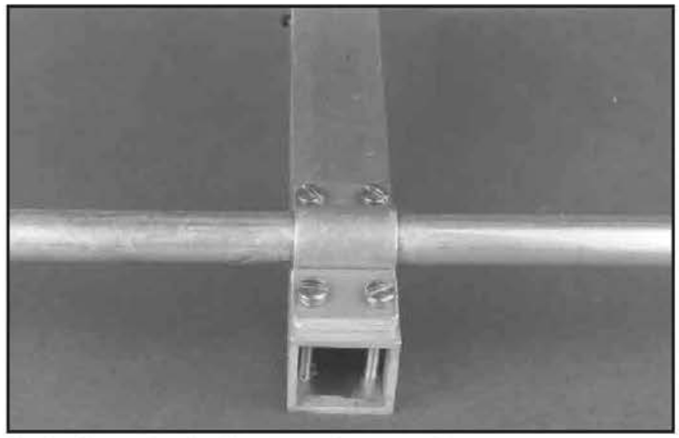

Fig 8—Strapping the director to the square boom.

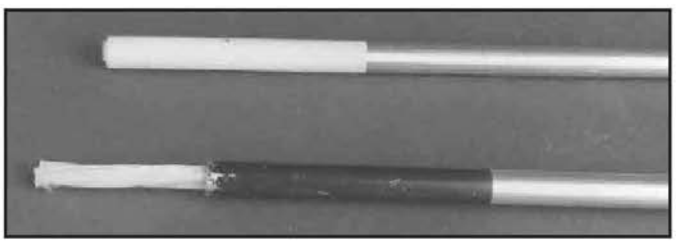

Fig 9—The element tips are painted for color-coding. The rope used to damp vibrations is partially pulled out of the lower element.

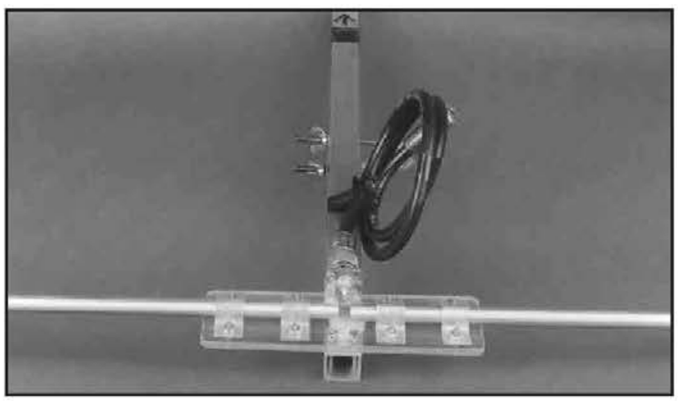

Fig 10(right) —2-turn balun made out of coiled RG-83.

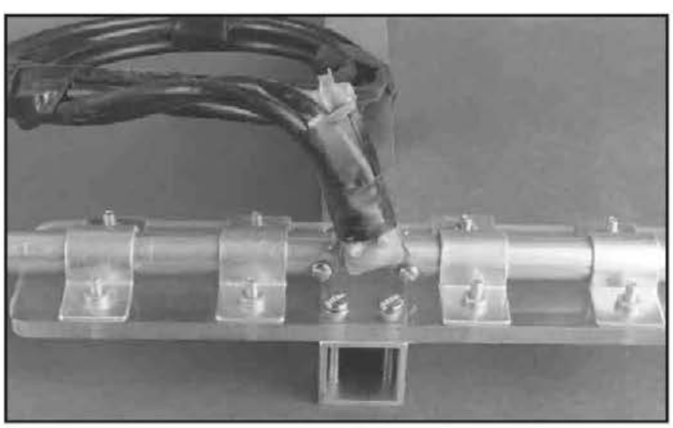

Fig 11—Terminals are swaged to a G-10 insulator and brass strips.

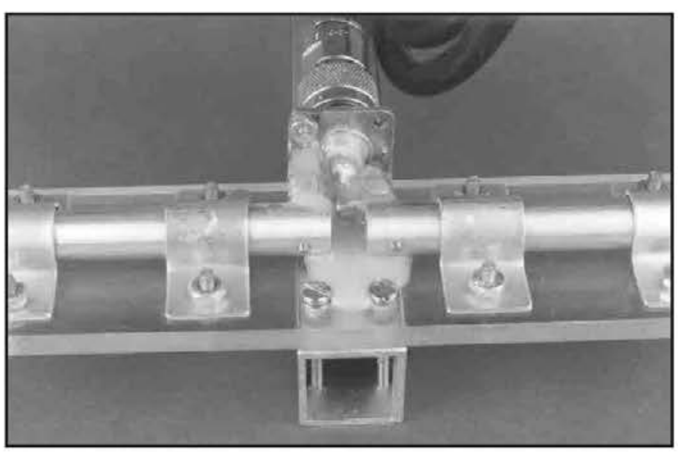

Fig 12—Dow 3140 RTV conformal coating is used to protect the feed-point connection.

good luck with stainless **U**-bolts with $^1/_4$-20 threads. Instead of the usual hex nuts, I use stainless-steel wing nuts.

The ends of the $^1/_2$-inch aluminum tubing are slotted with a hacksaw or band saw; this allows the clamp to easily compress it against the $^3/_8$-inch tubing. The $^1/_2$-inch tubing should have a wall thickness of 0.058 inches. This size telescopes nicely with $^3/_8$-inch tubing. I cut the element tips to 38 and 34 inches—there will be about $2^1/_2$ inches of overlap between the tubes. I painted the element tips for color-coding, as shown in Fig 9. It is a good idea to stuff some rope in the element tips—this damps out vibrations and prevents the antenna from whistling in the wind. I used scrap polypropylene cord from electrical cable.

Standard N connectors are easily installed on RG-83 coax. I mounted an N female on one side and an N-male on the other. The coax is coiled into two turns with an inside diameter of 3.75 inches, as shown in Fig 10. It is taped to the boom with electrical tape. Making a choke balun out of two 75-Ω RG-59 coax cables is a little more difficult. If possible, I'd look for RG-59 coax with stranded copper braid and center conductor. I used Belden 9259. Copper is easy to solder—don't make the mistake of trying to solder aluminum with techniques designed for tinned copper. A stranded center conductor is less likely to break. It helps even more to add strain relief to the soldered connections. At the antenna feed point, I swaged a pair of terminal posts to a $^5/_8 \times 2^1/_8$-inch piece of unetched circuit board, as shown in Fig 11. The terminal posts also riveted two thin brass strips to the board—the strips are screwed to the elements with #4-40 hardware. Strain relief is obtained by taping the coax cables to the board—black electrical tape works fine. I made a similar strain relief at the other end—a brass strip attached to an N connector also clamps around the shield braids for good electrical and mechanical contact. Just like the RG-83 coax, the parallel RG-59 pair is coiled into two turns, for totaling four coils of coax.

For protection against corrosion, I coated the exposed feed point and braided coax shields with Corning 3140 RTV, as shown in Fig 12. Since the material is transparent, it is easy to see that the connections are still good after a decade of intermittent use.

I included an indicator arrow made of black electrical tape, so it is easier to remember which way to point the antenna.

**Notes**

[1]L. B. Cebik has a 10-meter design on his Web site: **www.cebik.com/mox.html**.

[2]R. Stroud, W9SR, "Six Meters from Your Easy Chair," *QST*, Jan 2002, pp 33-34.

[3]The WireMan Inc, 261 Pittman Rd, Landrum, SC 29356; tel 800-727-WIRE, Orders 864-895-4195, fax 864-895-5811; **www.thewireman.com/**.