By L. B. Cebik, W4RNL

2×3=6

A simple equation? Indeed! Here are two three-element Yagi designs for 6-meter fun!

Yagi antennas provide good forward gain in a favored direction and excellent front-to-back ratio (F/B) for unwanted-signal rejection. A three-element Yagi for 6 meters is a simple construction project and can make use of readily available materials. However, newer antenna builders are often faced with the question, "Which design should I use?"

To help you make the decision, let's look at two quite different designs. Each antenna is a bit over six feet long. One presses for maximum gain and a good F/B, but sacrifices bandwidth. The other achieves total coverage of 6 meters, but surrenders some gain in the process. By comparing the antennas' capabilities with your operating requirements, you can select the one that best suits your needs.

Despite the similar boom lengths, the two designs have quite different profiles, as shown in Figure 1. The wideband model places more distance between the reflector and the driven element and decreases the driven-element-to-director spacing. In contrast, the high-gain model sets the director far ahead of the driven element and decreases the spacing between the driven element and the reflector. The reflector-to-driven-element spacing not only has an impact on gain, but affects the array feedpoint impedance as well. In general, reducing the reflector-to-driven-element spacing lowers the feedpoint impedance.

Gain

Let's first look at the high-gain model to see what we can achieve and what it will cost. A three-element Yagi is capable of exhibiting a free-space gain of 8 dBi with a F/B greater than 20 dB. However, these figures can be sustained for a bandwidth of only little over ±1.5% of the design frequency. Across this span, the antenna's gain tends to increase, while the F/B peaks at over 25 dB near the design frequency.

Our sample high-gain Yagi is adapted from an optimized 20-meter design by Brian Beezley, K6STI. His original design covers all of 20 meters, but that band is narrow compared to 6 meters. When we scale the antenna for 51 MHz, its bandwidth is only about 1.5 MHz while retaining the desired operating characteristics. Table 1 shows the antenna dimensions for a design using 1/2-inch-diameter tubing. Single-diameter elements are quite practical in VHF Yagis, but before we're finished, we'll see what to do should we decide—or need—to use *two* tubing sizes for each element.

Table 2 shows the antenna's anticipated performance characteristics, as modeled using *NEC 4*. The driven-element length is set near resonance on 51 MHz, and the feedpoint impedance is about 25 Ω. That value isn't a direct match for the 50-Ω coaxial cable normally used in amateur installations. If we shorten the driven element, we can install a beta match. If we lengthen the driven element, we might use a gamma match or a **T** match. If we leave the driven element length as is, we could employ a 1/4-λ, 37-Ω matching section made by con-

Table 1
Element Lengths and Spacing for the High-Gain 6-Meter Design with 1/2-inch-Diameter Elements

Element	*Length (inches)*	*Spacing from Reflector (inches)*
Reflector	114.26	——
Driven Element	108.96	37.8
Director	102.43	77.94

Table 2
Modeled Performance of the High-Gain 6-Meter Design from 50 to 52 MHz

Frequency (MHz)	*Gain (dBi)*	*F/B (dB)*	*Feedpoint Impedance (R ± jX Ω)*	*25-Ω SWR*
50	7.92	16.55	26.9 – *j* 20.2	2.14
50.5	8.07	22.59	26.4 – *j* 11.6	1.57
51	8.24	25.86	24.9 – *j* 2.4	1.10
51.5	8.43	19.33	22.8 + *j* 7.8	1.40
52	8.64	14.66	20.3 + *j* 19.2	2.34

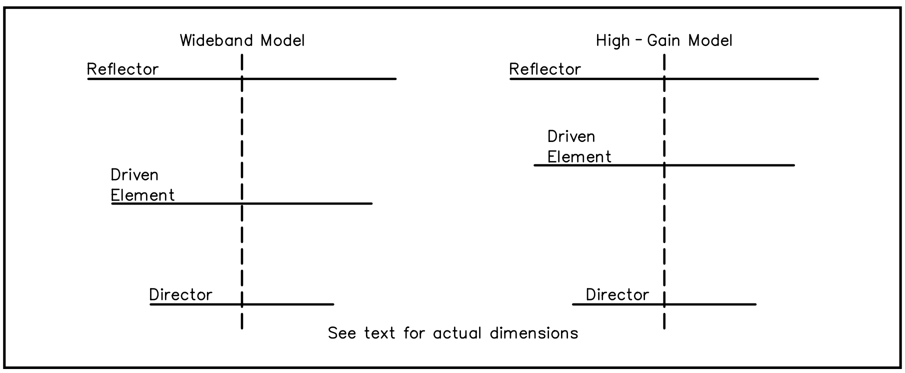

Figure 1—General outline of the wideband and high-gain three-element 6-meter Yagis.

Table 3
Element Lengths and Spacing for the Wideband 6-Meter Design with 1/2-inch-Diameter Elements

Element	*Length (inches)*	*Spacing from Reflector (inches)*
Reflector	116.80	——
Driven Element	108.10	40.7
Director	96.10	73.5

Table 4
Modeled Performance Figures for the Wideband (50 to 54 MHz) 6-Meter Design

Frequency (MHz)	*Gain (dBi)*	*F/B (dB)*	*Feedpoint Impedance (R±jX Ω)*	*50-Ω SWR*
50	7.00	14.90	48.4 – *j* 21.2	1.54
51	6.92	18.08	51.9 – *j* 9.9	1.22
52	6.96	20.31	51.9 + *j* 1.7	1.05
53	7.13	21.02	48.8 + *j* 15.0	1.35
54	7.44	18.40	43.0 + *j* 31.1	1.96

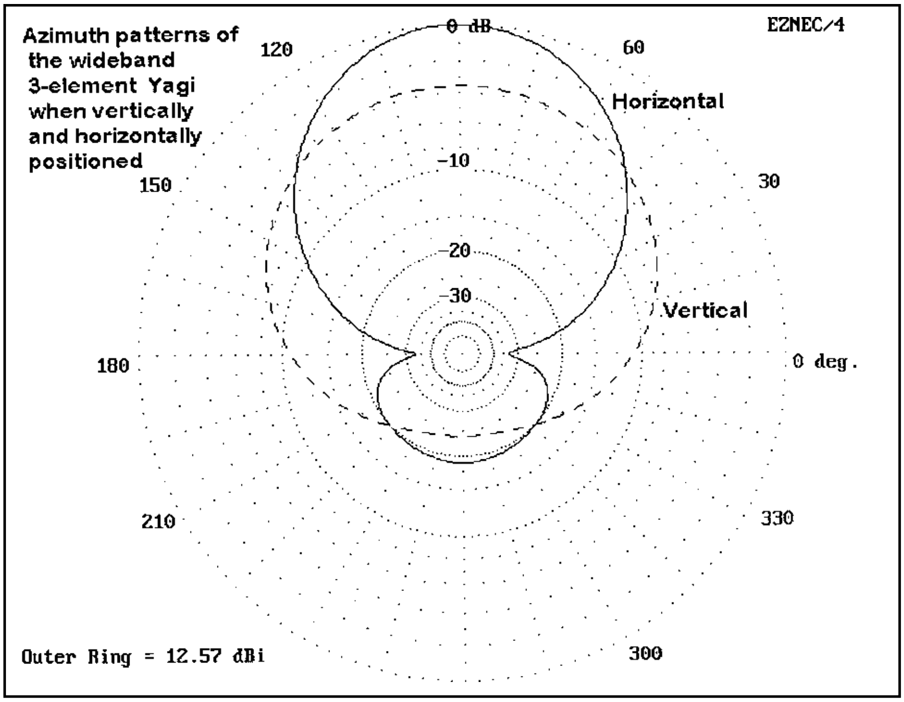

Figure 2—Modeled azimuth patterns for the wideband three-element 6-meter Yagi in horizontal and vertical positions at 30 feet above average earth.

necting two lengths of RG-59 (or RG-11 for high-power operation) in parallel. All of these matching systems are described in *The ARRL Antenna Book*.[1]

The table of projected gain and F/B values shows the rise in gain across the passband, as well as the peak F/B near the design frequency. Notice that the F/B drops rapidly as we approach frequencies only 1 MHz from the design center. For point-to-point communications at the low end of 6 meters, however, the narrow passband—combined with the higher gain—may be just what we need.

[1]Notes appear on page 36.

The target center frequency can be adjusted up or down within 6 meters by adjusting all three element lengths by the percentage of frequency change. To change the design frequency to 50.5 MHz to cover the 50 to 51-MHz range, increase all lengths by about 1%. If we stay at the low end of the band, we need not change the element spacing or diameter.

Builders who are more interested in raw gain than F/B can scale the performance at 52 MHz (or a bit above) down to the desired frequency. Simply scale the antenna dimensions, as given for the 51-MHz design frequency, to about 50 MHz or just a bit lower. You can adjust the driven-element length to resonance or use your favorite matching system. Changing the driven-element length to vary the feedpoint impedance by as much as 25-30 Ω has very little effect on the other performance figures.

Bandwidth

Suppose we want to cover the entire 6-meter band with a well-matched Yagi having relatively constant performance all the way. Although this 4-MHz span represents a ±4% bandwidth relative to a design frequency, we can redesign the Yagi to achieve this goal. However, we'll pay for the bandwidth with reduced gain and a lower peak F/B. The gain drops about 1 dB and the F/B is perhaps 5 dB off the peak.

From the same 1/2-inch-diameter aluminum tubing, we can build a three-element Yagi with a free-space gain of about 7 dBi and a F/B of up to 21 dB. This antenna exhibits a feedpoint impedance that permits direct connection to a 50-Ω coaxial cable (with a suitable choke to attenuate common-mode currents). The design dimensions shown in Table 3 are adapted from a design for another band originally developed by Bill Orr, W6SAI.[2]

The modeled performance parameters appear in Table 4. Notice that the gain curve is not a single rising line, but has a slight dip toward the low end of the band. The F/B peak has been set at the midband frequency because it tends to taper off fairly equally above and below the design frequency. Most notable are the feedpoint impedance and SWR values. If we insulate the driven element from the boom, we can avoid the use of a matching network altogether.

The wideband model is suited to operators who want to cover the entire 6-meter band. However, effective use may require a mechanical scheme that lets you flip the beam from horizontal to vertical. In the vertical position, as shown in Figure 2, at a height of 30 feet above average ground, the pattern is wider and less strong than when the antenna is used horizontally. Still, these beams are both simple and inexpensive. Hence, you might want to build a high-gain model for the low end of 6 meters and a wideband model to cover the upper 3 MHz of the band.

Figure 3 overlays free-space azimuth patterns of both beams at their design frequencies. The patterns will give you a good idea of their relative performance potentials.

Stepped-Diameter Tubing

The beam dimensions for both models used uniform 1/2-inch-diameter elements. A common building practice is to use at least two tubing sizes in 6-meter beams. Most often, we start with 1/2-inch tubing at the center and use 3/8-inch tubing for the ele-

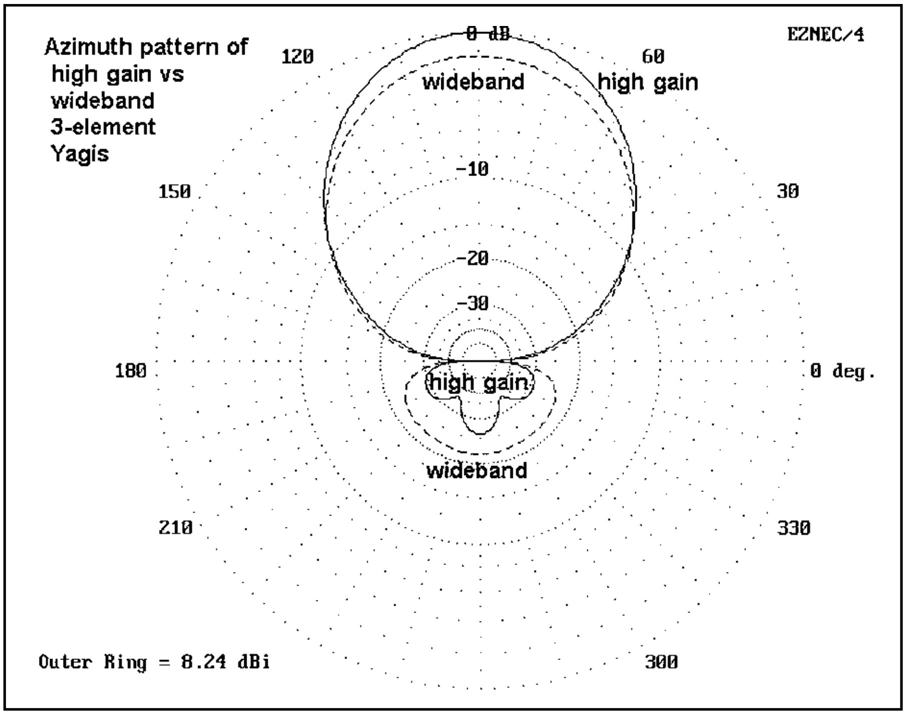

Figure 3—Overlaid models of free-space azimuth patterns for the high-gain and wideband 6-meter designs at their design frequencies.

Table 5
Half-Element Lengths for Uniform Half-Inch and Stepped 1/2-Inch to 3/8-Inch-Diameter Elements

High-Gain Design

Element	*Uniform Diameter Length*	*Stepped-Diameter Length*
Reflector	114.36	116.4
Driven-element	108.96	111.0
Director	102.43	104.0

Wideband Design

Element	*Uniform-Diameter Length*	*Stepped-Diameter Length*
Reflector	116.80	118.6
Driven-element	108.10	110.0
Director	96.10	97.6

Note: All dimensions are in inches.
For the stepped-diameter elements, the inner 36-inch length uses 1/2-inch-diameter tubing, with 3/8-inch-diameter tubing used for the remainder of the element.

ment ends. Let's suppose we make the center portions of each element from 6-foot lengths of 1/2-inch tubing—3 feet of tubing on each side of the boom. What happens to the overall element lengths?

Table 5 compares the element lengths from the boom outward for each beam (commonly called "element half-lengths"). One model uses 1/2-inch-diameter tubing throughout, and the other uses 3/8-inch-diameter tubing for the ends. The stepped-diameter lengths are chosen so that the antenna performance is essentially the same as with uniform-diameter elements. Note that the element lengths become significantly longer when we step the element diameter downward on the way to the element end. The amount of change differs for each element.

You can calculate the end lengths by subtracting 36 inches from the overall element length. However, be sure to add about three inches per end section to allow for telescoping the tubing.

I'll leave the remaining construction details up to you, since there are many acceptable ways to construct either of these Yagis. Again, *The ARRL Antenna Book* and articles in *QST* and recent editions of *The ARRL Antenna Compendium*[3] are full of good ideas. Simply select those that best fit your available materials and individual skills.

Both of these Yagis—adapted from the work of veteran antenna designers—are good designs. Which you choose will depend on what you want to do on 6 meters during the present sunspot cycle and beyond.

Notes

[1]ARRL Publications are available from your local ARRL dealer or directly from ARRL. Mail orders to Publication Sales Dept, ARRL, 225 Main St, Newington, CT 06111-1494; tel (toll free) 888-277-5289, 860-594-0355; fax 860-594-0303; e-mail to pubsales@arrl.org. Check out the full ARRL publications line on the World Wide Web at http://www.arrl.org/ and the Bookcase in each issue of *QST*.

[2]Bill Orr, W6SAI, Ham Radio Techniques, "May Perambulation," *ham radio magazine*, May 1990 pp 56-61.

[3]See Note 1.

*An ARRL Life Member and educational advisor, L. B. Cebik, W4RNL, recently retired from The University of Tennessee, Knoxville, to pursue his interests in antenna research and education, much of which appears at his Web site (***http://www.cebik.com***). A ham for over 45 years, his articles have appeared in several League publications including* QST, QEX, NCJ *and* The ARRL Antenna Compendium. *You can contact L. B. at 1434 High Mesa Dr, Knoxville, TN 37938-4443;* **cebik@utk.edu**.

NEW PRODUCTS

NEW ATV TRANSCEIVER FROM PC ELECTRONICS

◊ PC Electronics has recently released a new version of their popular TC70-10 70-cm amateur television transceiver—the TC70-20. The new model includes a more powerful output module that's capable of providing over 20 W PEP, about twice that of the earlier unit.

The manufacturer estimates that the clear picture line-of-sight simplex range, using 14 dBd or greater directional antennas, will exceed 100 miles. The power output is adjustable down to 2 W.

The TC70-20 contains a GaAsFET downconverter that tunes from 420 to 450 MHz. Received ATV signals are converted to TV channel 2, 3 or 4 for full-color viewing on your connected television. One transmitting crystal is included—your choice of 439.25, 434.0, 427.25 or 426.25 MHz. A second crystal can be ordered for an additional $20 and is selectable from a front panel switch.

Video and line level audio can be input from a camcorder, camera or VCR. A separate low impedance mike input, with a separate volume control, is also provided—very handy for adding voice-over information to prerecorded video.

The TC70-20 ATV Transceiver is packaged in a rugged die cast aluminum box measuring approximately 7 1/2×7 1/2×2 3/4 inches. Simply connect a 70-cm antenna, TV, camera (or other video source) and 13.8 V dc at 5 A and you are on the air.

Price: $529. For additional information contact PC Electronics, 2522 Paxson Ln, Arcadia, CA 91007; tel 626-447-4565; fax 626-447-0489; **tom@hamtv.com**, **http://www.hamtv.com**.

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