Simple, Small 2- and 6-Meter Yagis

Gain, pattern, and an easy, wide-band match.

Joe Reisert, W1JR

Sometimes a ham needs a small, efficient handheld 2-meter antenna with moderate performance, especially for emergency communication. They may also need an entry-level 6-meter antenna, especially for chasing DX and utilizing F2 propagation as we approach the peak of Solar Cycle 25.

The basic Yagi is still a good choice for a compact and efficient antenna. Radiation pattern and impedance are determined by the number of elements, the length and diameter of the elements, and the spacing between the elements. Many trade-off studies were conducted 25 years ago on Yagis with 0.1 – 1.0-wavelength booms. The results, which you can read at **www.arrl.org/qst-in-depth**, were published in the winter 1998 issue of *Communications Quarterly*. For a visual representation of these concepts, see the sidebar, "Yagi Gain."

A three-element Yagi on a 0.35-wavelength boom can have a gain of 5 dBd. Inserting an additional director between the driven element and the existing director, and readjusting the element lengths and spacing, can improve the radiation pattern. A front-to-rear ratio greater than 20 dB is possible, and the gain will increase to about 6 dBd with a direct 50 Ω match increased bandwidth. The lead image shows this Yagi as built, and its radiation pattern is shown in Figure 1. It uses a ¾ × ¾-inch square boom that is at least 36 inches long, but similar round tubing can be used. Booms with square tubing tend to have improved symmetry and better, long-lasting contact between the elements and the boom.

In this design, the antenna elements are placed on the top and front ends of the boom to leave room for either handheld or mast-mounting clamps on the

The 2-meter Yagi mounted in the vertical polarization. [Joe Reisert, W1JR, photo]

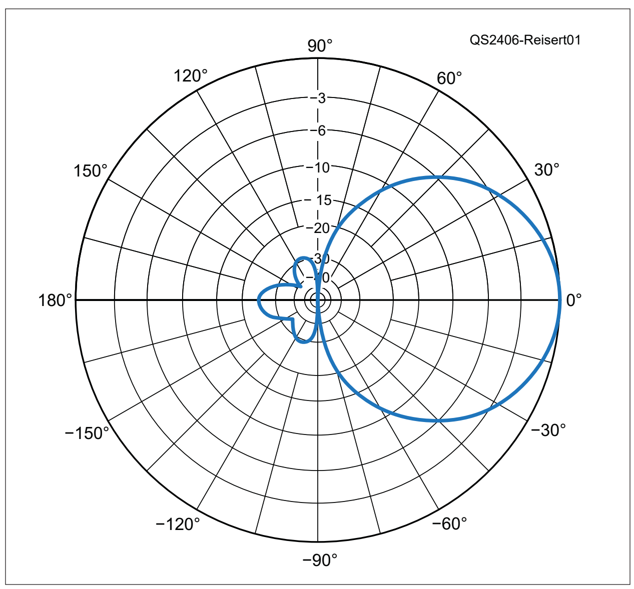


Figure 1 — The *NEC* calculated pattern for the 2-meter Yagi, redrawn for clarity. The front-to-rear ratio is very good.

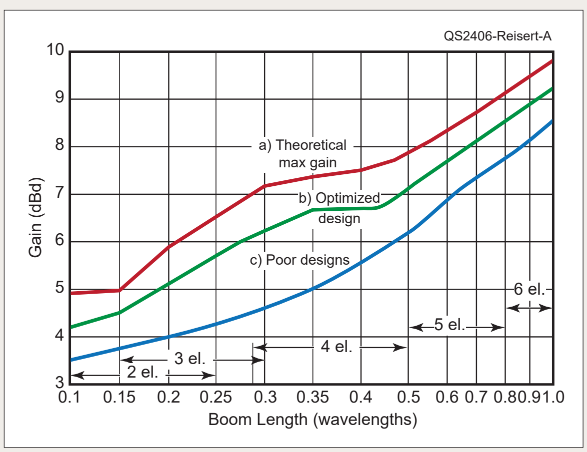
Yagi Gain

Most Yagi antennas work to some extent. High-gain Yagis often have narrow bandwidth and low driven-element impedance (typically 20 – 25 Ω), thus requiring special impedance-matching networks. As mentioned, many trade-off studies were conducted 25 years ago on Yagis with 0.1 – 1.0-wavelength booms. Different optimizing software programs and additional background material have also been published. My article "Yagi/Uda Antenna Design," in the winter 1998 issue of *Communications Quarterly*, is available for reference at **www.arrl.org/qst-in-depth**.

Nothing has changed since this original study was conducted. Performance detailed in the study has been verified with programs such as *EZNEC*. The final results are shown in this sidebar's graph; I call it the "Yagi Truth Graph," and it should dispel any false claims about the gain of Yagis.

One group of short, optimum-length-boom Yagis has a so-called "sweet spot" between about 0.25 and 0.35 wavelength. These designs tend to have higher gain, wider bandwidth, and a typical impedance of 50 Ω. A typical two-element Yagi has a gain of up to about 3.75 dBd, but the front-to-rear ratio is typically low at 8 – 11 dB. A three-element Yagi on a 0.35-wavelength boom can have a gain of 5 dBd.

By inserting an additional director on this Yagi between the driven element and the existing director, and by readjusting the element lengths and spacing, the radiation pattern can be improved. A front-to-rear ratio (90 – 270 degrees) greater than 20 dB is possible and generally considered to be adequate. Also, the gain increased to about 6 dBd, and the 50 Ω impedance match bandwidth increased. A typical radiation pattern for this Yagi is shown in Figure 1 of this article.



A graph of the actual gain attainable and the recommended number of elements versus the boom length for a Yagi. The upper curve is the maximum gain attainable if other parameters are sacrificed. The middle curve shows an optimized Yagi. The lower curve represents a poor performance design.

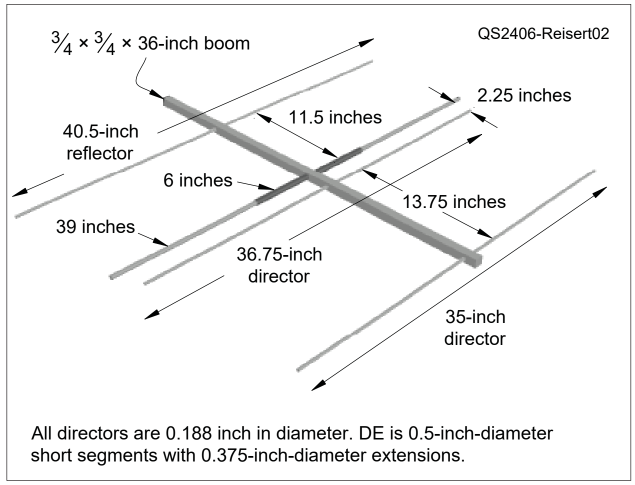


Figure 2 — Dimensions of the 2-meter Yagi.

rear of the boom. The dimensions are shown in Figure 2. It can be used with either vertical or horizontal polarization. The reflector and directors use 0.188-inch-diameter aluminum rods that are connected to the boom with small aluminum clamps. The 39-inch driven element consists of 12-inch-long, ½-inch-diameter aluminum tubing with ⅜-inch sliding extensions, and it is split in half at the center to ease feed-line attachment and length adjustment (see Figure 3). The driven element tubes are held in place between resin support blocks, which insulate them from the 2 × 4-inch plate. A 4-inch, low-loss Delrin® or equivalent insulating rod with a ⅜-inch diameter helps support the feed point and keep the split-driven element straight.

The feed line is directly connected to the center of the split driven element. It should be at least 2 feet long and used with a small-diameter coax (such as RG-58), and it should face the rear of the boom. Three or more ferrite beads placed on this feed line choke common-mode currents. Beads with ¼-inch hole diameters and permeabilities of 800, such as Fair-Rite 2643540002 beads, are widely available on the internet. These are about 1⅛ inches long with just more than a ½-inch outside diameter.

This four-element Yagi design does not require any impedance-matching networks to obtain a 50 Ω impedance match across the 2-meter band. Adjusting the length of the driven element optimizes the voltage standing wave ratio (VSWR) at your operating frequency. A typical VSWR plot is shown in Figure 4.

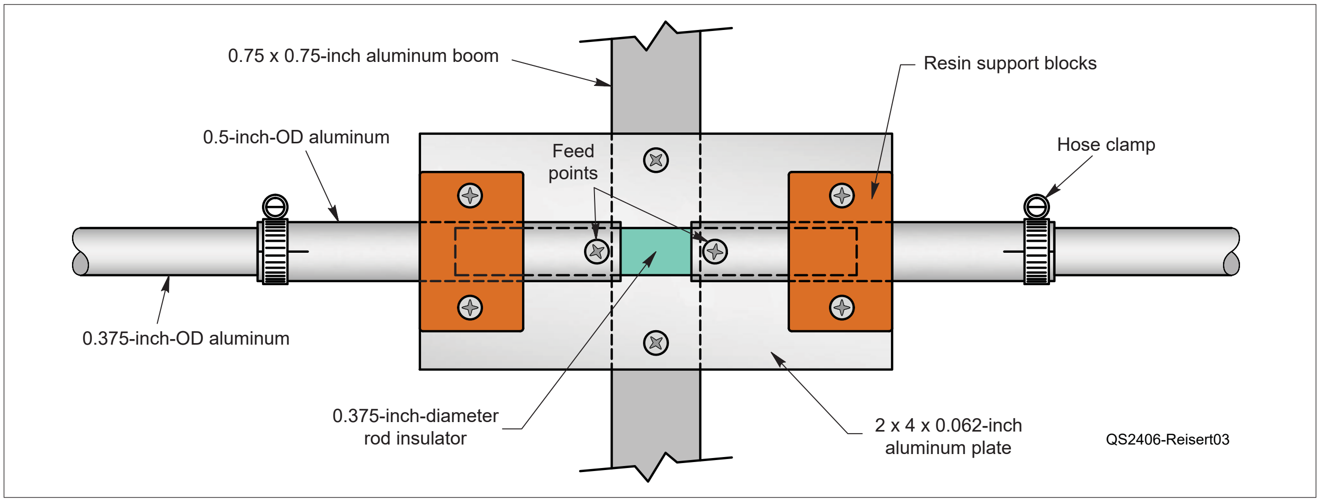


Figure 3 — Driven element construction details.

A 6-Meter Version

I also designed a four-element, 0.29-wavelength 6-meter Yagi. The boom length was shortened slightly in order to accommodate a commonly available, 6-foot-long aluminum boom with only a few tenths of a dB of less gain. The center elements all use 48-inch-long × ⅝-inch-diameter 0.057-inch wall aluminum tubing. The end tubes use ½-inch-diameter aluminum tubing. Overall recommended element lengths and spacing are shown in Figure 5.

Construction details for the driven element are similar to those for the 2-meter version, except the diameter of the insulating rod should be half an inch. Insulated resin-type clamps similar to those used on the 2-meter Yagi's driven element hold the inner tubing of the driven element. The element mounting plate is larger than that of the 2-meter Yagi to accommodate boom attachment clamps.

It is recommended that the reflector and director elements use the same resin clamp configuration

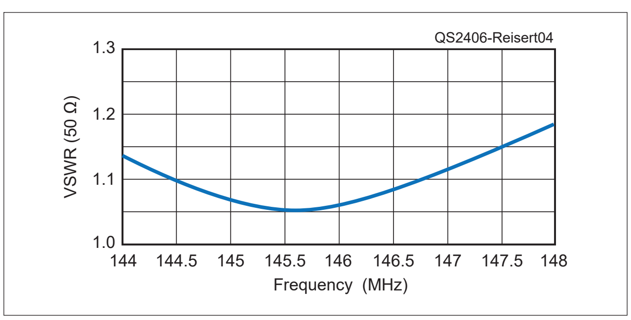


Figure 4 — Voltage standing wave ratio (VSWR) versus frequency, as calculated by *NEC* and redrawn for clarity.

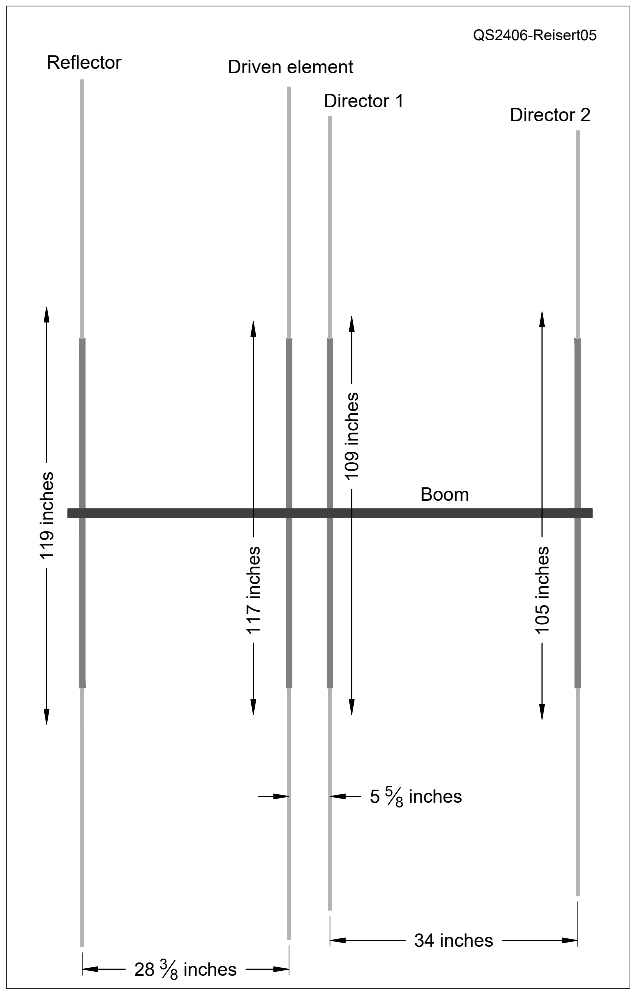


Figure 5 — Dimensions of the four-element, 0.29-wavelength 6-meter Yagi.

used on the driven element. The element-holding plates should then be attached to a 6-foot-long boom with at least a 1.25-inch diameter. This mounting method holds the elements firmly and symmetrically in place without boom-to-element interaction. Because only two element tubing diameters are required, the strength of the element is increased.

The feed line should use at least a foot of RG-58 or equivalent coax. Use five ferrite beads for the choke, similar to the ones used on the 2-meter feed line. If high power (greater than 250 W) is being transmitted, it is highly recommended that you use seven ferrite beads and a polytetrafluoroethylene dielectric coax, such as RG-303 or equivalent. Don't forget to put a suitable sealant on the feed points to prevent moisture ingress.

The 6-meter antenna boom should be mounted on a 6 × 6-inch aluminum plate that is at least 0.188 inch thick and attached to a suitable mast using four boom clamps. Remember that feed-line loss between an antenna and the radio decreases the antenna gain when both receiving and transmitting. Therefore, if the feed line is long — especially on 2 meters — a larger-diameter, low-loss coax is recommended.

An SWR meter can be inserted between the antenna and the feed line to test the impedance match. After that, the length of the driven element can be slightly adjusted for minimum VSWR at the desired center frequency.

Both 2- and 6-meter Yagi designs use short, optimum boom lengths. More photos of each design can be seen at **www.arrl.org/qst-in-depth**. The 2-meter Yagi may be a good candidate for a club project, especially for emergency or portable communications. The 6-meter Yagi can be a starter antenna to help get you active on the 6-meter band. These designs can also be easily scaled for use on the HF bands.

See *QST* in Depth for More!

Visit www.arrl.org/qst-in-depth for the following supplementary materials and updates:

- ✓ The author's article, "Yagi/Uda Antenna Design," from the winter 1998 issue of *Communications Quarterly*
- ✓ More photos of the 2- and 6-meter Yagis described in this article

Access the digital edition of *QST* (**www.arrl.org/qst-in-depth**) to watch W1AW Station Manager Joe Carcia, NJ1Q, build the 2-meter Yagi described in this article.

ARRL Life Member and Amateur Extra-class licensee Joe Reisert, W1JR, was one of the first licensed Novices in 1951. In 1956, he received his AAS degree in Electronic Technology from the State University of New York in Farmingdale. Joe has been employed at Sperry, IBM, Lockheed Missiles and Space Company, Fairchild Microwave, The MITRE Corp., Wang Labs, and Cushcraft. In 1992, he founded Antennaco, Inc., and he designed and manufactured commercial VHF, UHF, and microwave antennas. Joe is interested in DX from HF through the microwaves and was an early EME pioneer in the 1970s. He has earned DXCC 392/340, DX Challenge 3180, 13BWAS, 11BDXCC, and DXCC, with 315 entities confirmed on 160 meters. He was inducted into the CQ DX Hall of Fame in 2014. Joe has served on the ARRL DX Advisory Committee and was Chairman of the VHF/UHF Advisory Committee. He has published more than 150 technical papers and given more than 130 invited talks on various amateur radio subjects. You can reach Joe at **w1jr@arrl.net**.

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