No. 44: A Large 10-Meter Very-Wide-Band Yagi

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In the last episode, we examined a 4-element very-wide-band Yagi on an 8'+ boom. The antenna covered all of 10 meters from 28.0 to 29.7 MHz with reasonable gain (7.0 dBi free-space or about 12.5 dBi over ground), good front-to-back ratio (20 dB), and a direct-feed 50-Ohm SWR of less than 1.25:1 across the band. We also discovered that we could build such a beam using high-grade materials, if we were willing to use mail order and similar sources of supply.

This month, we shall explore a Yagi with similar coverage. The design is based on an original by Dean Straw, N6BV, of ARRL. The difference between Dean's Yagi and my smaller design last time is that his beam uses a 26' boom and has 6 elements. For the increase in boom length, we obtain an additional 3 dB of gain (10 dBi in free space or 15.5 dBi over ground), with all other operating specifications being the same as the smaller unit. The front-to-back ratio is about 20 dB across the band, and the 50-Ohm SWR does not rise above 1.25:1. If you like long-boom Yagis, you may take a shine to this one.

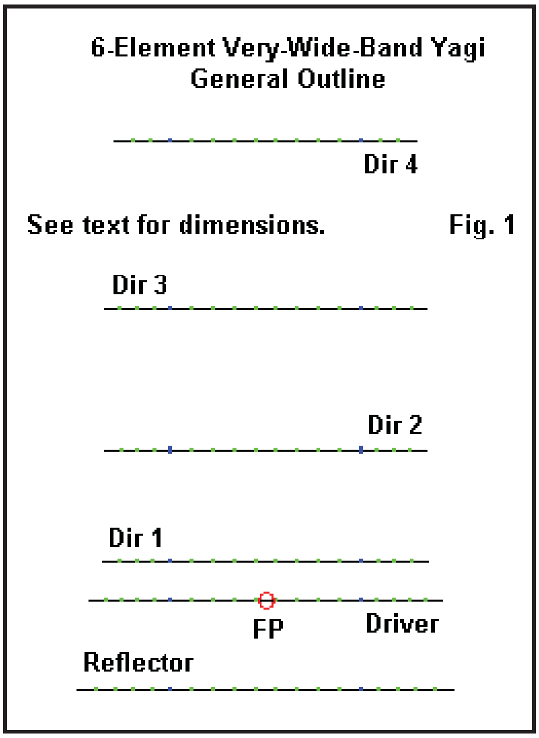
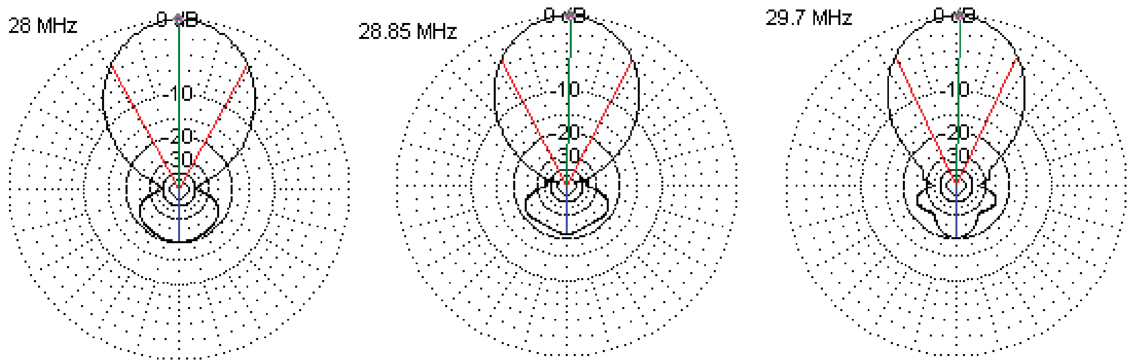


Fig. 1 shows the general proportions of the antenna. Once more, we see that the first director is

quite close to the driver, although not as close as in the short boom Yagi that we presented last time. However, this time, let's look at the performance characteristics before we examine the construction.

Performance

The very-wide-band 6-element Yagis has very clean patterns that vary only slightly as we move across the band. It is quite natural for the rear lobes to change shape across a wide operating passband, while the forward lobe tends to hold its shape from one band edge to the other,



Representative Azimuth Patterns
6-Element Very-Wide-Band Yagi

Fig. 2

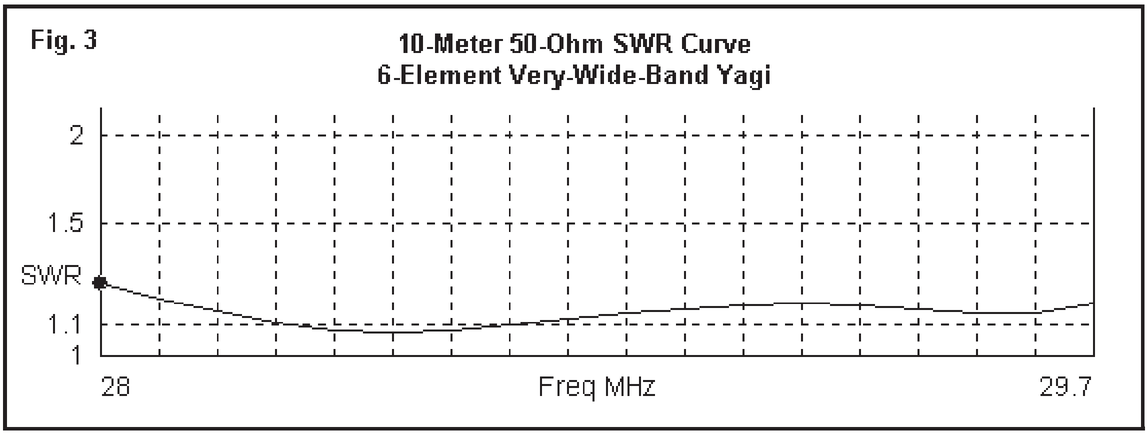
Fig. 2 shows representative azimuth patterns for the antenna at the band edges and at mid-band. The overall area within the rear lobe does not change much across the band, although the perimeter does change shape. The forward lobe is relative constant, with the emergence of very slight bulges at the upper end of the band. If we could have extended the operating range any further, we would find that these bulges would develop into small secondary forward lobes. If we had added more elements for higher gain, the secondary forward lobes would have become a permanent feature of all the patterns, as they are in most VHF Yagi design of 8 or more elements.

Modeled Performance of the 6-Element Wide-Band 10-Meter Yagi

Freq. MHz	Gain dBi	F-B Ratio dB	Impedance R +/- jX Ohms	50-Ohm SWR
28.0	9.63	20.2	44.5 - j10.1	1.25
28.25	9.72	21.8	50.1 - j 5,8	1.12
28.5	9.83	22.9	52.9 - j 2.0	1.07
28.75	9.98	21.8	55.2 + j 1.3	1.11
29.0	10.09	20.9	56.7 + j 3.8	1.16
29.25	10.22	20.1	56.7 + j 5.0	1.17
29.5	10.32	19.8	53.7 + j 5.8	1.14
29.7	10.37	20.2	48.3 + j 7.7	1.18

The table of performance values from the design model shows how smooth the performance is across the band. The gain varies by only 0.75 dB in that entire span, an amount that would be completely undetectable operationally. The front-to-back ratio varies by only 3 dB, again, an amount that we would be hard pressed to detect, even in cross-town checks with a friend.

The antenna uses a direct feed and is a good match for 50-Ohm coaxial cable. As usual, I recommend the use of a means of attenuating common-mode currents on the cable, that is, a ferrite bead choke balun of the W2DU type that is readily available from numerous sources. Unlike 1:1 current balun transformers that are bulky, the ferrite bead balun is relatively thin and liner. Hence, you can tape it to the boom and it projects hardly more than the coaxial cable itself. **Fig. 3** shows the 50-Ohm SWR curves across the band. Notice that the values tend to undulate in minor ways, a feature of the driver-first-director combination.



Construction

Except for requiring a very long boom, the 6-element very-wide-band Yagi uses the same construction as the 4-element version that we have already examined in detail. The elements consist of inner section of 5/8" diameter aluminum, with 1/2" tubing used for the tips. Use 6063-T832 tubing, which is available from suppliers. The design calls for elements that are well insulated from the boom, so the sketches in the last column are completely adaptable to this antenna, right down to the way of mounting a coaxial cable connector to the overall driver assembly.

The inner 5/8"-diameter tubing sections extend 54" each side of centerline. Some builders may be concerned about the wind loading capability of such long inner sections. If you wish to strengthen them a good bit, the simply extend the inner tubes about a foot or so beyond the limits of the 9-12-inch long mounting plates. For the parasitic elements, these inner tubes will be 1/2" diameter aluminum. For the driver, the inner piece will be a non-conductive tube or a fiberglass rod, either with a 1/2" diameter.

The following table provides element length and spacing dimensions. Be sure to add 2 to 3 inches to the lengths of the tips for the required overlap. An overlap under 2" is likely to be insecure, while one longer than about 3" simply adds unnecessary weight to the beam.

Element Lengths and Spacing: 6-Element Wide-Band 10-Meter Yagi

Element	Tip-to-Tip Length Inches	Outer Tip Length Inches	Space from Reflector Inches	Space from Preceding Element Inches
Reflector	214.6	53.5	----	----
Driver	201.6	46.6	50.9	50.9
Director 1	186.6	39.3	72.8	21.9
Director 2	184.0	38.0	136.2	63.4
Director 3	184.8	38.4	216.8	80.6
Director 4	174.0	33.0	312.0	95.2

Fig. 4 shows three generally accepted ways of joining two sections of elements. The easiest way is to use sheet metal screws. Most builders use two per junction, although they are divided on where to place them. Some builders place them in a line, while others place one on each side of the tube so that the points face each other. The second method uses a hole all the way through both tubes. Some builders are now using aircraft (not hobbyist) rivets, while others use a nut-bolt assembly with lock washers on each side. The third method cuts slots in the larger tube and uses stainless steel hose clamps to lock the sections together. With all hardware, be certain that all parts of it are stainless steel. Some auto hose clamps use stainless straps but plated (rustable) screws.

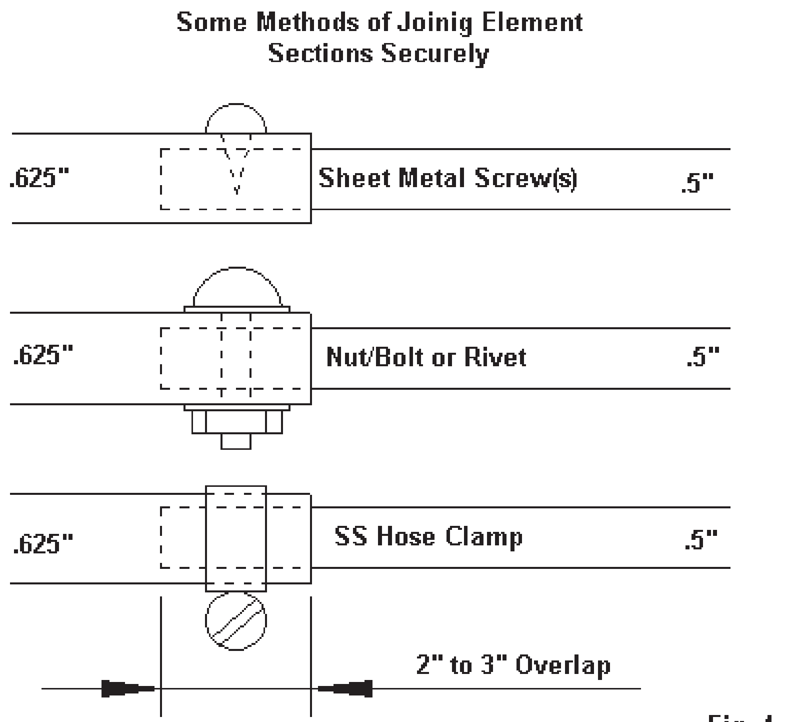


Fig. 4

Like the smaller antenna, the design uses very specific element section diameters. Even changing the relative lengths of the inner and outer element sections can change performance noticeably. Trying to change the overall element diameters to use larger or smaller tubing will throw off the design even more. A Yagi depends for its performance on the mutual coupling between adjacent elements, and changes in element diameter alter that coupling. Unfortunately, too few books and articles point out this limitation of Yagi design, and too many beginning beam builders try to substitute handy materials--usually with very frustrating results. If you do not have the means of performing the re-design work, try to replicate any design that you like as exactly as possible.

The 26' long 6-element very-wide-band Yagi is a sample of what can be done with Yagis. You may wish to compare its dimensions with designs that aim only to cover the first MHz of the band. The differences in element lengths, spacing, and overall boom length may be instructive.