No. 52: Gain vs. Beamwidth

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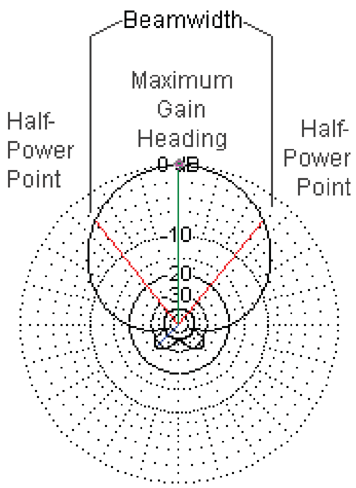
Antenna ads are long on gain numbers, but woefully short on other important data. One of the major absences is a beamwidth specification. Omitting this information has led some wire antenna makers to advertise their wares as having on some bands more gain than a 2-element Yagi. They do not say in what direction the gain occurs relative to the fixed-position wire antenna and they do not say for how much of the horizon the gain number holds true.

If you use a rotatable Yagi or similar array, beamwidth has only secondary importance. For the size beams that are practical on 10 meters, the beamwidth will vary from about 65•À½ for short-boom arrays to about 50•À½ for long-boom Yagis. What these number tell us mostly is that super-precise aiming is not too important, since the gain variation from mis-aiming will not be detectable within about +/-10•À½ of the target bearing. However, if we have a fixed-position antenna that is horizontal, then beamwidth takes on added significance.

Fig. 1



Azimuth Pattern and Beamwidth

Fig. 1 shows a typical azimuth pattern for a 2-element Moxon rectangle only to show what we mean by beamwidth. The vertical centerline on the plot shows the direction of maximum gain. At some angle on either side of this line, the gain level will be 3-dB lower than maximum gain. These two points are called "half-power points." The angle between the half-power points defines the antenna's beamwidth.

If we cannot rotate or switch our antenna to place the main beam where we wish it to be, then beamwidth becomes an important consideration in selecting an antenna for 10 meters. In general, we want to be able to communicate over more of the horizon than we want to leave unattended (because no one lives in those directions). To ensure that we cover the complete horizon, many operators with limited space use vertical antennas and accept the reduced gain as the cost of coverage.

There are too many different antennas to explore beamwidth factors in this short column. So let's take the extreme cases. One of those cases concerns 80- and 40-meter wires, about which manufacturer advertising tends to make misleading statements. The product is usually a 135' (or thereabouts) wire which is resonant on 80 meters and usable on all bands--a very old antenna indeed. The antenna in principle can be fed at the center, at one end, or at a position between, called off-center-feed.

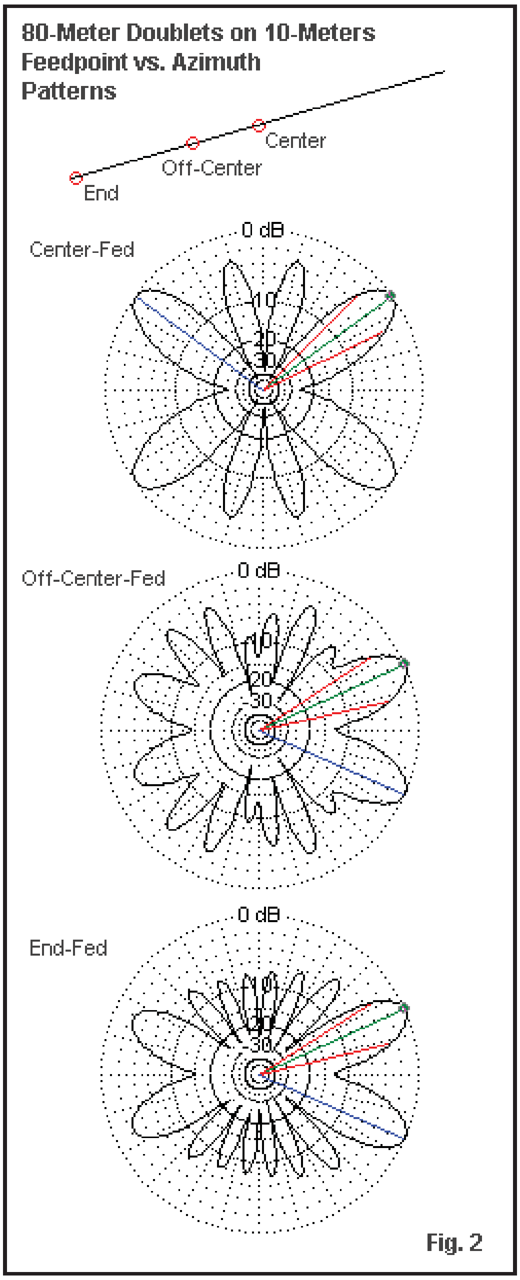


Fig. 2

Fig. 2 shows what happens when we take any of these three feed systems and run the antenna on 10 meters. The maximum 10-meter gain runs between 10.5 and 12.3 dBi, depending on the feed system. However, as the half-power lines on the strongest lobes show, the gain applies only to selected lobes at a wide angle from broadside to the wire--which runs left to right across each pattern. The beamwidth for any of the feed systems is only about 20•À½ wide. In many parts of the US, a 20•À½ beamwidth will not cover all of Europe, assuming that you set up the antenna in exactly the right way. If we factor in wire sway during brisk breezes, we may find that signals vary widely in strength without any changes in the propagation.

There are a number of fixed wire antenna designs that offer considerably more gain and a predictable direction for it. Many operators with budget constraints feel drawn to such antennas because they are cheap, fixed, and relatively easy to build. For example, we need not use aluminum tubing for Yagi elements. With proper design, we can have a high-gain 10-meter Yagi made from wire. Suppose we could have nearly 15-dBi forward gain with a high front-to-back ratio with an antenna that uses very little more wire than the 80-meter doublet.

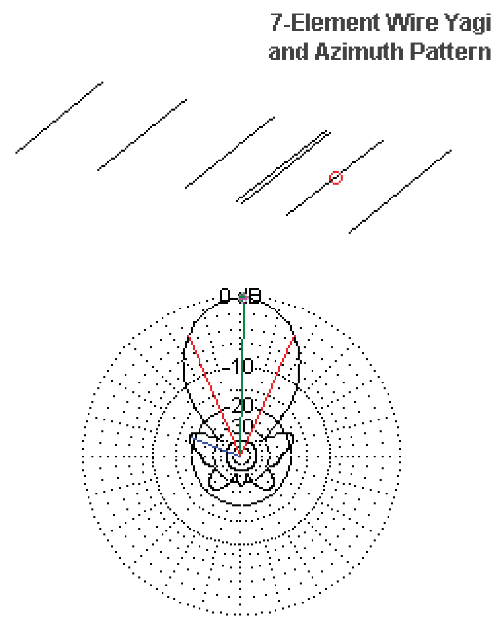


Fig. 3

Fig. 3 shows the outlines of a 7-element wire Yagi with the desired gain. Note that the side and rear lobes have very low strength, giving us excellent forward performance. However, the beamwidth is only 47•À½. This antenna is for special purposes, for example, if we desire to communicate regularly in only one direction. There are numerous operators who maintain regular schedules with family members or colleagues. Others specialize in contacts with only one part of the world. For such folks, this type of antenna may be ideal. However, for the general operator, the antenna gives up over 85% of the horizon.

I recently saw on the Internet some hype for a 10-meter Sterba curtain. The antenna was promoted as having very high gain and also as having multi-band capability. Unfortunately, on all bands other than the one for which the antenna is designed, the patterns, elevation angles, and gain are mediocre. The Sterba curtain arose in the early days of short-wave broadcasting as a bi-directional array with high gain on a selected frequency. In commercial and government circles, the array has fallen out of use in favor of arrays that show a single directional pattern and some frequency nimbleness (such as the LPDA). An alternative is the electrically steerable array.

However, suppose we build the complex array composed of phased sections and end half-sections for only 10 meters. The question is what we may have if we successfully construct a Sterba curtain. The answer is two main lobes broadside to the wires. Each lobe shows a maximum gain of over 15 dBi. However, the beamwidth shrinks to 26•À½. The general arrangement of the antenna appears in **Fig. 4**. Invisible in the outline sketch is the fact that each vertical length of wire (except the end wires) is actually a phasing line consisting of two wires with a constant but relatively close spacing, that is, a transmission line. The pattern shows the main lobes and the narrow beamwidth. If you happen to live directly between two stations with which you wish to communicate regularly, a Sterba curtain might be useful. However, the cost is 85% of the horizon.

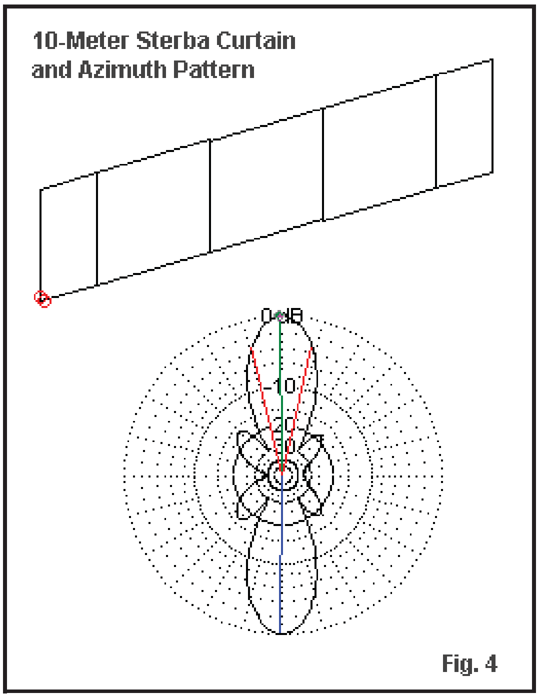


Fig. 4

Perhaps the king of all directional wire arrays by reputation is the rhombic. **Fig. 5** shows the outline and the pattern. Each leg of the rhomboid is multiple wavelengths long, and the designer carefully calculates an angle between legs to yield maximum gain. Called a "traveling wave" antenna, the point furthest from the feedpoint has a terminating resistor, ordinarily about 600-800 O and capable of dissipating at least half the power supplied to the antenna.

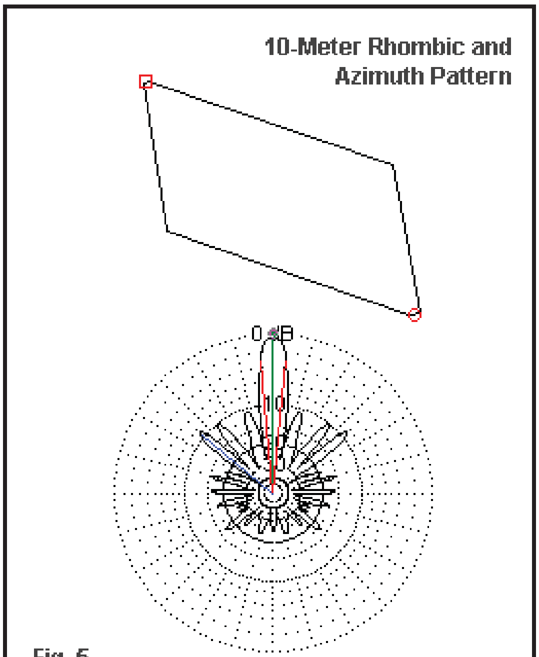


Fig. 5

The rhombic's pattern shows very high gain, almost 18.5 dBi in this design case. For the SW broadcaster or special communicator of the 1930s, the antenna allowed a very narrow beamwidth for point-to-point fixes. In fact, the beamwidth is under 11•À½. If I had the space and desired to communicate with a single city (or perhaps the city and its suburbs), the rhombic might be the antenna of choice. However, for the general operator who wishes access to the entire world, the rhombic is one of the poorest choices possible. The only way to use a rhombic for horizon-wide communications is to mount it in an ocean on a rotatable island.

These notes are designed to alert you to the temptations of gain at the expense of other important specifications that affect our operations. If you cannot install a rotatable antenna due to rotator/tower costs or deed restrictions, then perhaps a vertical or vertical array may be in order. Alternatively, you might be able to manage a TV mast to 20' or more above ground and mount a self-supporting dipole at the top. Then, you may hand rotate the dipole to be broadside to the desired communications path. With its 80•À½ beamwidth for each of the two lobes, you would not have to move the antenna direction very often during the day, and you might lower it out of sight when not in use. (Hang some flags, pennants, or mock laundry from the element to disguise the antenna's true function.) The idea is to swap gain for a wide beamwidth to gain access to more of the horizon and hence more communications targets. Beamwidth does make a difference.