If you have space for a 40-meter inverted Vee antenna … and maybe for a second one about 20 feet away from the first … W3CRI shows you how to turn your wires into a phased array providing switchable directivity broadside to the antenna.

Room for Two 40-Meter Inverted Vees? Make a Bi-directional Antenna!

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Amateurs have been building phased wire arrays for many years.[1] Unlike the closely related parasitic array, all of the elements in the phased array are driven from the transmitter and always contain a means for properly phasing the driven elements.

Many amateurs have space-limited properties that limit antenna extent. A popular antenna configuration for such space often is an inverted Vee. This article shows how to add a second, nearby, inverted Vee antenna with an appropriate phasing network in such a way to produce a >10 dB front-to-back ratio at the maximum take-off angle.

Suppose your house looks something like the one shown in fig. 1. Can you add a second inverted Vee parallel to the first and spaced about 6 meters (19$^1/_2$ feet) away from it? If so, I'll show you how to phase them to put the major signal out broadside to the antenna plane on either side. Note that these calculations are for 40 meters and all dimensions are measured in meters. If you're not metrically adept, there are plenty of converters available online, or just remember that one meter equals approximately 39 inches and do the math yourself.

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Each antenna is fed from a 1:1 current balun attached to two equal-length 50 ohm coax feed lines. These, in turn, terminate in the phase shift network shown as the blue box in fig. 2. I cut the antenna length so that the pair has a minimum SWR at 7.12 MHz of 1.57:1 as presented to the 50-ohm coax feedline from the shack to the phasing network box.

Getting Started

A good place to start your design is to make the center support 10 meters off the ground and the ends anchored at 2 meters above ground. That way you can be pretty sure no one will accidentally get tangled up in the antenna. If the projection of half the antenna on the ground is 6 meters, then the length of the one half antenna (hypotenuse) is 10 meters. This is the famous magic triangle having sides 6 units and 8 units and a hypotenuse of 10 units. It turns out that I had to shorten the antenna length by a little bit in order to move the minimum SWR into a desired location within the 40-meter band.

Now is the time to turn to your favorite antenna modeling software. I use EZNEC, although any other will do (including one or two free ones). As you may be aware, all antenna software programs begin by placing the antenna somewhere in

Fig. 1– Does your house have space for you to put up a 40-m inverted Vee? How about two?

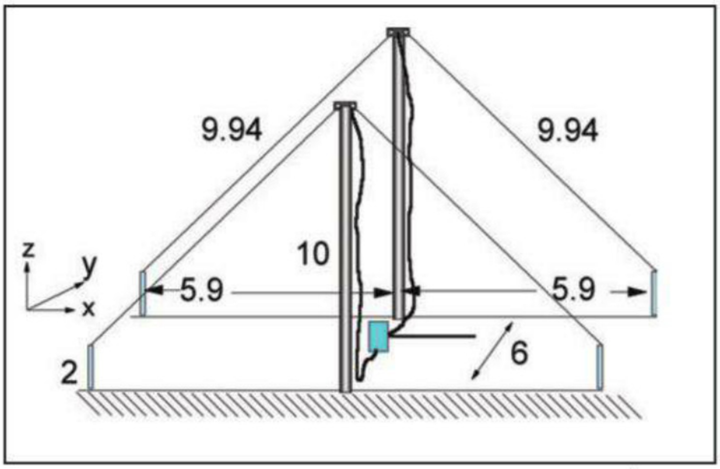

Fig. 2– Two inverted Vees in a phased array. ↑

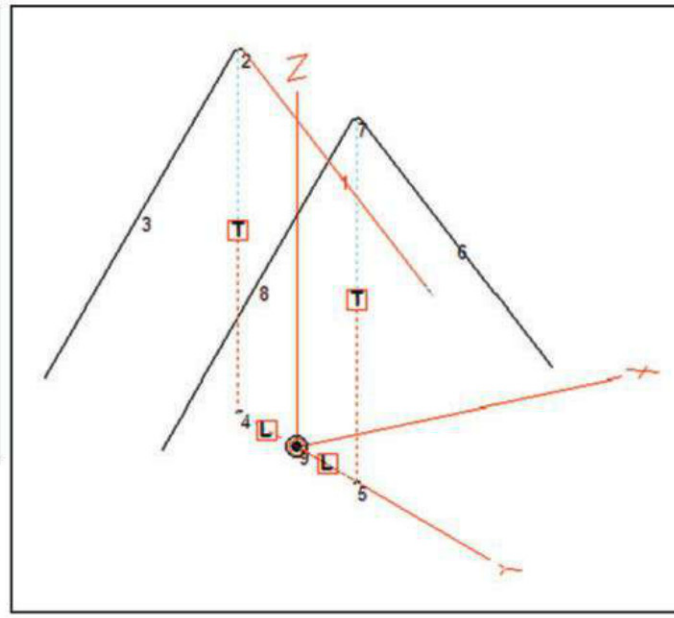

Fig. 3– EZNEC's drawing of the antenna described in the wire table (see Table I). →

space with the configuration you want. The entry data is a spreadsheet wire table that lists the coordinates of the beginning and end of each wire or antenna element. One can use either English or metric units. In Table I, the units for the wire developed for the antenna dimensions shown in fig. 2 are in meters.

Fig. 3 is an illustration of the antenna specified in the wire table as drawn by the antenna software package. Each of the wires is numbered and their beginnings and ends are Cartesian coordinates relative to the x,y,z axes as shown.

Note that wires 2 and 7 are very short and are artifacts needed to attach a transmission line, denoted by T in the drawing. "L" stands for the load(s) described further on in the text.

You'll notice several things in this wire table. First, the antenna itself extends from 5.9 meters to 0.1 meter; the latter segment crosses the top of the mast like the crossbar on a "T." In reality, these little segments don't exist, but are required for anchoring the transmission lines. Second, note the little stubs (wires 4, 5, and 9) that are just above ground. These also are anchor points for the transmission lines feeding the two antennas. The transmission lines themselves are specified as 50-ohm coax with a velocity factor of 0.82. However, this detail is really not necessary, provided both transmission lines are of the same length. The phase shift network is anchored between wire 9 and wires 4 and 5. The program does not recognize its physical size and so treats the network as if it were also a transmission line.

	END 1			END 2		
No.	X	Y	Z	X	Y	Z
1	5.9	–3	2	0.1	–3	10
2	0.1	–3	10	–0.1	–3	10
3	–0.1	–3	10	–5.9	–3	2
4	0.1	–3	0.001	–0.1	–3	0.001
5	0.1	3	0.001	–0.1	3	0.001
6	5.9	3	2	0.1	3	10
7	0.1	3	10	–0.1	3	10
8	–0.1	3	10	–5.9	3	2
9	0.1	0	0.001	–0.1	0	0.001

Table I– Antenna model wire table input. (Units are meters.)

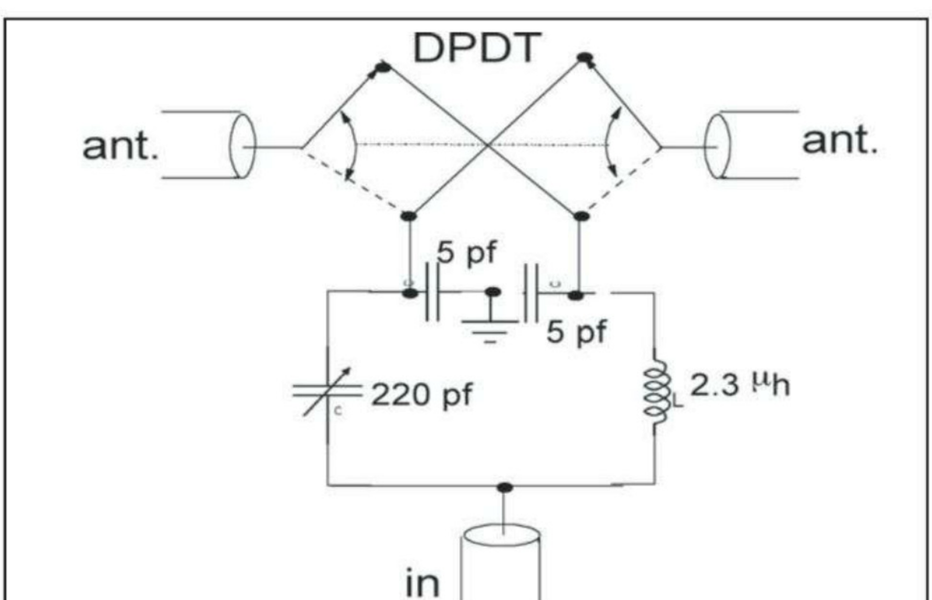

Fig. 4– Phase-shift network for the phased array.

Designing the Phasing Network

A bidirectional radiation pattern occurs when one antenna is driven in a phase relation to the other such that the radiation field largely cancels in one direction and is additive in the opposite direction. The exact phase relationship is established by the antenna spacing and the interaction between the two antennas. In general, something close to a 180-degree phase shift between the antennas is needed.

This phase shift easily could be accomplished by placing a length of coax cable in one arm feeding the antenna pair, or by its equivalent lumped circuit. I've chosen the latter arrangement, as illustrated in fig. 4.

As we will show, this network, composed of two L sections, makes a good match to 50-ohm cable with less than a 3:1 SWR from 7.0 to 7.22 MHz (see fig. 5). The DPDT switch causes a 180-degree shift in the main radiation lobe. I used #14 copper wire throughout the antenna, including the coil of approximately 2.3 microHenries. The coil consists of 12.3 turns, 3 inches long, wound on a 1.5-inch diameter mandrel. You'll have to pinch or stretch the coil for fine tuning. The results of the calculation for this inverted Vee two-element phased array are shown in fig. 6 (elevation plot) and 7 (azimuth plot).

Looking at the Predicted Results

The plots show substantial suppression of the back lobe—as much as 17 dB, with a forward gain of more than 5 dB. Further, the antenna modeling software shows that the efficiency of the antenna is about 40%, meaning that 40% of the input power is radiated and 60% dissipated as heat, mostly in the ground. This heat loss is an expected penalty to be paid by the antenna's proximity to the ground.

Fig. 8 shows how the array's front-to-back ratio varies with operating frequency within the 3:1 SWR range. Although the front-to-back ratio peaks at the SWR minimum, it is maintained fairly evenly over the entire tuning range.

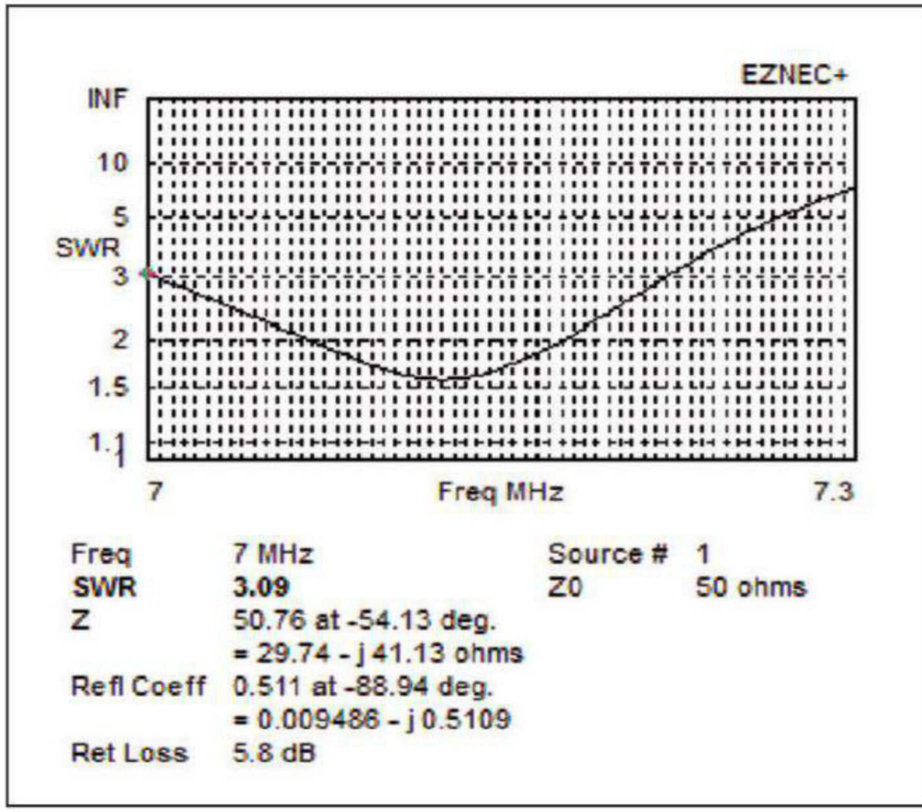

Fig. 5– The SWR is less than 3:1 between 7.0 and 7.2 MHz.

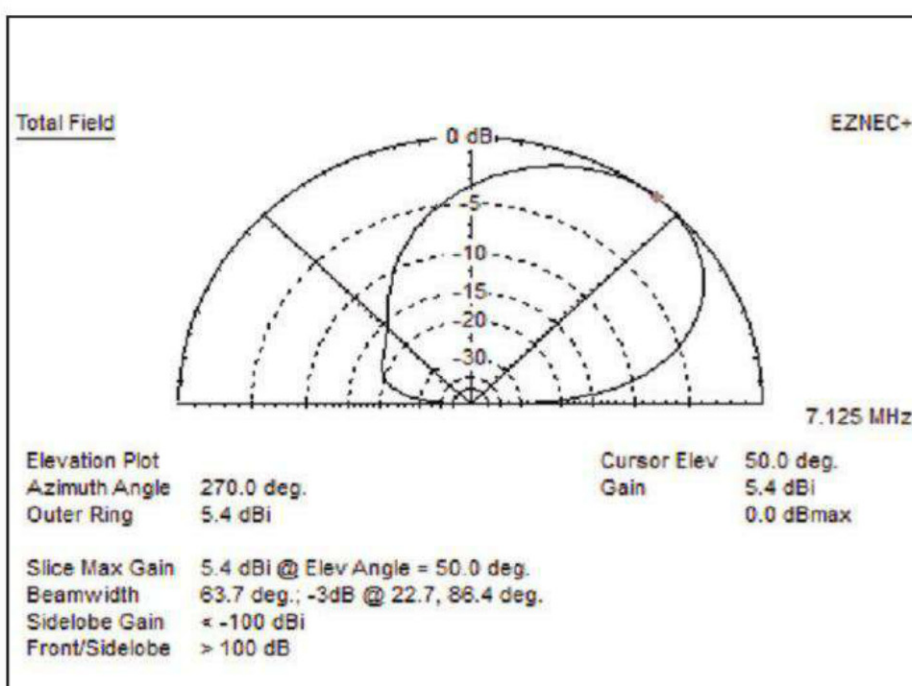

Fig. 6– Elevation plot of the array.

To conclude, the analysis for a two-element steerable array based upon an additional inverted Vee wire shows very respectable performance for directivity and average performance for efficiency. The latter would be improved by raisingthe array, but efficiency is not the primary concern of a space-limited modern amateur.

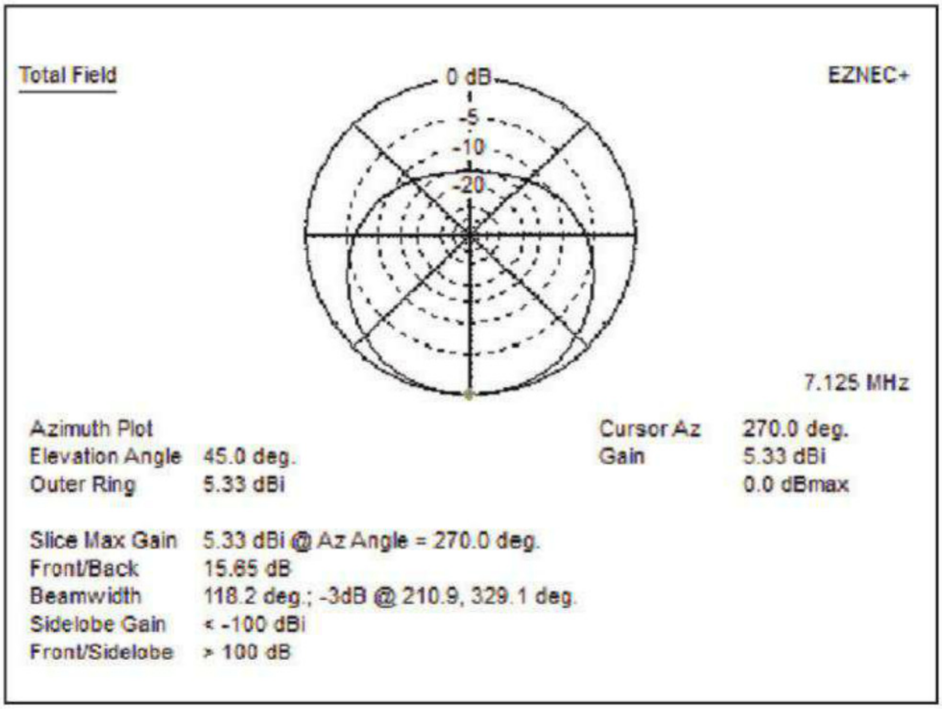

Fig. 7– Azimuth plot of the antenna pattern for a 45-degree take-off angle.

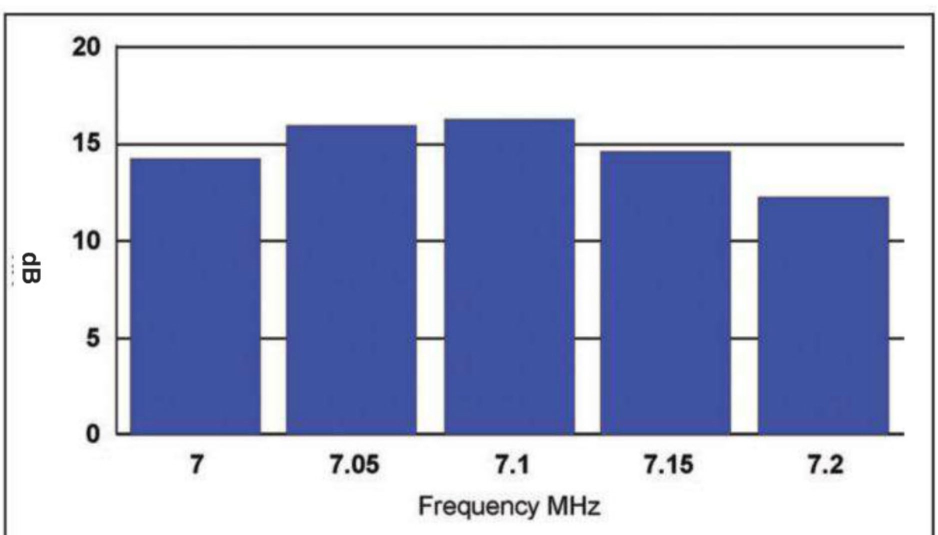

Fig. 8– Bar graph showing the array's front-to-back ratio within the 3:1 SWR range.

Note

1. The literature is extensive. Here are three samples:

J. Blaine, ACØC, "40 m 2-element wire beam parasitic -> phased array conversion." (AC0C.com)

N4JTE, "Vertical Array—Phased verticals on 40 meters!" (www.hamuniverse.com/vertical_array.html)

W6TRW, "An 80 meter Aerostat-borne Phased Array for Field-Day" (www.W6TRW .com)