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Technical Correspondence

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BEGINNER'S BOOMERS REVISITED

By Roy Lewallen, W7EL, ARRL Technical Advisor, 5470 SW 152nd Ave, Beaverton, OR 97007

◊ "Beginner's Boomers: Two Phased Vertical Arrays for 30 Meters"[1] contains a common misconception about feeding phased-array elements. The article says that a cardioid pattern results from feeding two 1/4-wavelength-spaced elements with feed lines that differ in length by an electrical quarter wavelength. Unfortunately, this isn't so. Because of mutual coupling, the element impedances become significantly different. Even if the element feed-point impedances perfectly match the feed lines when the elements are isolated, mutual coupling raises the resistance of one element, lowers that of the other, and both become reactive. Feed lines terminated in the resulting impedances won't shift the current phase by amounts equal to their electrical lengths, and will also alter the current magnitudes. This results in an incorrect current phase and magnitude ratio in the two elements. In general, the described approach produces a very poor reverse null, although the forward gain may be approximately as predicted.

Mutual coupling changes the element impedances in the broadside and endfire cases also, causing the matching problems noted by the authors. In these cases, however, both element impedances change equally, resulting in equal phase shifts and amplitude transformations in the two feed lines, and consequently correct current ratios and patterns.

More information about this topic can be found in Chapter 8 of *The ARRL Antenna Book*, and "The Simplest Phased Array Feed System...That Works" in *The ARRL Antenna Compendium, Vol. 2*.

MORE ON CURRENT DISTRIBUTION AND PATTERN NULLS

By Charles J. Michaels, W7XC, 13431 N 24th Ave, Phoenix, AZ 85029

◊ An inspection of the 2-element phased array patterns for 0° wave angle on pages 8-6 and 8-7, and the associated text of the 16th edition (and 17th edition—*Ed.*) of *The ARRL Antenna Book*, may leave the reader unaware of the incredibly deep nulls of which the 2-element phased arrays discussed are capable. The pattern nulls, excepting only those for 180° phasing at all spacings, and 0° phasing for 1/2-λ spacing, are quite shallow compared with the infinitely deep null depths shown for those same arrays in the 15th edition of *The ARRL Antenna Book*.

The 15th-edition patterns are based on classic algebraic-trigonometric calculations and the assumption of equal currents of exactly sinusoidal distribution in infinitely thin elements. According to the figure caption, the 16th-edition patterns were generated by *ELNEC*.[2] Roy Lewallen's July 1990 *QST* Technical Correspondence article[3] explains the reason for some of these shallow nulls. Does this mean that very deep nulls are *not* possible in these arrays at the other phasings? Experience with continuously variable phased arrays told me otherwise.

I explored this question using *ELNEC*. I chose an element diameter of 1 inch, a 1/4-λ height (per the caption of the pattern figure) and element spacing of 1/4 λ at an arbitrary frequency of 7 MHz. I chose the 1-inch diameter element because it produced a pattern similar to that presented in the 16th edition for 1:1 current ratio, 90° phasing and unspecified element diameter. As shown in Figure 1, *ELNEC* produces a 0° wave-angle pattern with two nulls of approximately –30 dBi at about 14° each side of the array line with a bump of approximately –28 dBi on the array line.

My investigations show that current values and phase along the elements are indeed identical for the 0° phase patterns as Roy indicates in his TC article. And, with very small step size (ie, small azimuth angle increments), the plots and tables *do* show the expected deep nulls. This indicates that perhaps the 0° phase patterns in *The ARRL Antenna Book* were made with azimuth-angle step increments too large to resolve the depth of the very narrow nulls inherent in these multilobed patterns. This leaves us with the question of the other-than-0° and 180° patterns.

By careful adjustment of the feed-point current amplitude and phase, nulls of great depth can be achieved at any chosen azimuth and wave angle. Using the same antennas, a current ratio of 1.0613 and phase of 87.4804° produced a single-null cardioid in the line of the array (within 1° plotting resolution) of at least 99.99 dB (the limit of the *ELNEC* listing value) down from the lobe (see Figure 2). The sensitivity to the current ratio can be seen in that changing the current ratio to 1.0614 reduced the null by more than 20 dB. Changing the phase angle simply moved the nulls off the array line leaving a tail on the array line.

The *ELNEC*-predicted departure from the classical phase angle of 90° and current ratio of 1:1 for maximum null depth in this case are greatest in the 0° wave-angle cardioid condition and decrease as the azimuth and

[1] G. Borich and R. Logan, "Beginner's Boomers: Two Phased Vertical Arrays for 30 Meters," *QST*, Jun 1994, pp 37-40.

[2] *ELNEC* is available from Roy Lewallen, W7EL, PO Box 6658, Beaverton, OR 97007. Price: $49 postpaid in the US and Canada; add $3 for airmail elsewhere; MasterCard and VISA orders accepted.

[3] R. Lewallen, "The Impact of Current Distribution on Array Patterns," Technical Correspondence, *QST*, Jul 1990, pp 39-40.

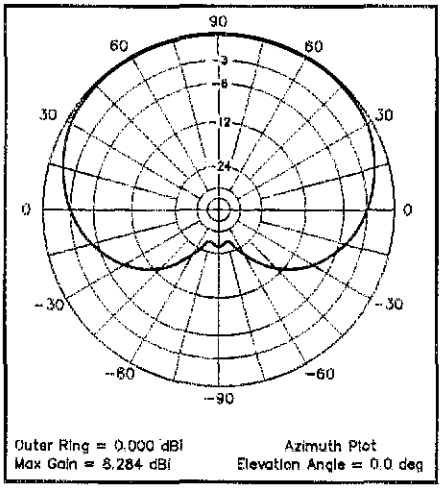


Figure 1—At 7 MHz, with an element diameter of 1 inch and 1/4-λ height, with elements separated by 1/4 λ, *ELNEC* produced a 0° wave-angle pattern with two nulls of approximately –30 dBi at about 14° each side of the array line, with a bump of approximately –28 dBi on the array line.

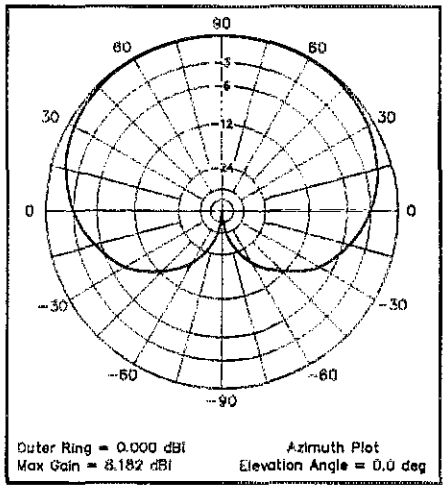


Figure 2—Using the same antennas, a current ratio of 1.0613 and phase of 87.4804° produced a single null cardioid in the line of the array (within 1° plotting resolution) of at least 99.99 dB (the limit of the *ELNEC* listing value) down from the lobe. The sensitivity to the current ratio can be seen in that changing the current ratio to 1.0614 reduced the null by more than 20 dB. Changing the phase angle simply moved the nulls off the array line leaving a tail on the array line.