Gain Antennas --The 80% Solution

by

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PART 1 appears in the BVARC Newsletter January 2008

.....continuing on.....

PART 2

Figure 3 shows the directivity of this antenna as modeled by EZNEC+. The gain in free space is about 6.5dbi and the F/B is 14.5db. This is pretty respectable performance for such a compact beam.

Table 1 includes the gain, F/B, source (feed point) impedance, and SWR for this beam across the 20M band. Notice that the highest gain occurs at the bottom of the band while the best F/B occurs at the top. This is a general characteristic of many directive arrays. Tweaking the dimensions of the beam can improve the F/B but only at the cost of reduced forward gain (and vice versa). Also shown in Table 1, are results for the other HF bands above 20M. In this situation, the beam would need to be fed using ladderline and a tuner would be required. Interestingly, the Moxon beam shows gain over a dipole (=2dbi) and a small F/B even on these higher frequencies. In the SWR column, the values for 17-10M are assuming a 300 ladderline feed. Some minor adjustments in the feedline length might be required to get a match with your tuner on all bands and don't forget that current balun at the end of the feedline.

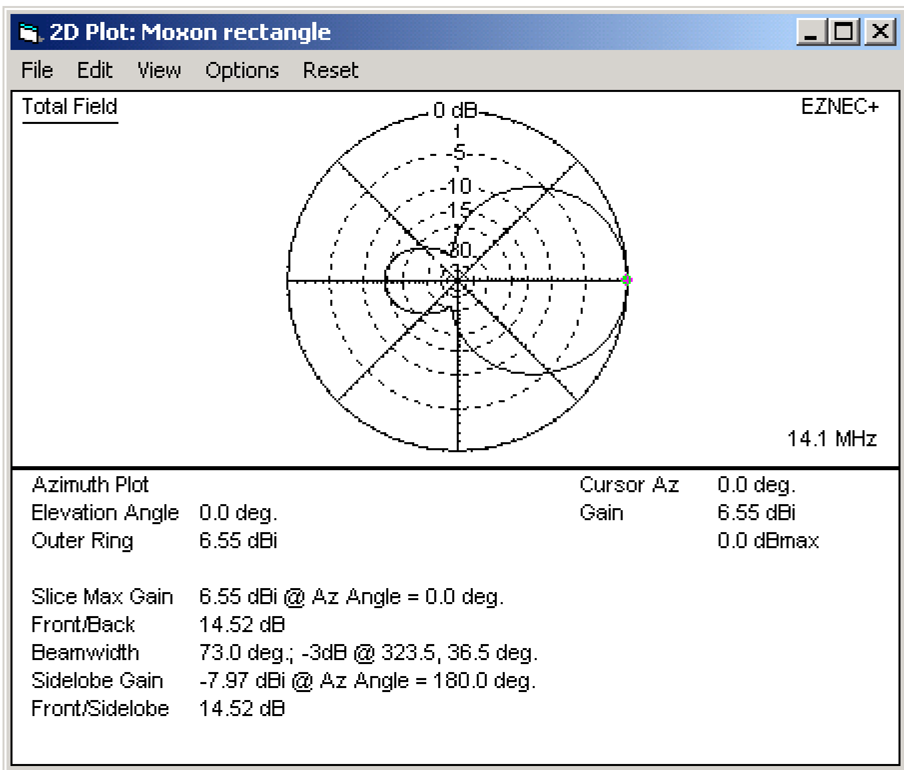

Figure 3. Radiation pattern from EZNEC+ for the Moxon rectangle of Figure 2 at 14.1MHz.

Table 1. Performance Characteristics of a 20M Moxon rectangle.

Freq. (MHz)	Gain (dbi)	F/B (db)	Source Imp. (r+jx)	SWR (50ohm)
14.0	6.7	11.5	22-12.1	2.4
14.1	6.5	14.5	27-1.8	1.8
14.2	6.3	16.3	32-7.4	1.6
14.3	6.1	16.0	37+15.8	1.6
18.1	4.0	4.0	149+288	4.1 (300)
21.1	4.0	3.5	315+558	5.1 (300)
24.9	4.2	3.2	984+925	6.3 (300)
28.5	4.5	2.9	2144-248	7.2 (300)

The W8JK array

The W8JK array (designed by John Krause, sk) is also close spaced (<.1λ) and the element span for a 20M version is also ~28’ but it differs from the Moxon by driving both elements out-of-phase with a phasing line. It does not have the element tips folded back.

If the feedline is connected to the phasing line at the midpoint between the elements (centerline - CL in Figure3), the radiation pattern is bidirectional – a figure 8. Offsetting the attachment point of the feedline ~6” from CL causes the radiation pattern to become unidirectional similar to that for the Moxon. This appears to be a little known fact as I stumbled across it while modeling the antenna and subsequently only saw it mentioned in Les Moxon’s book. Another important property of phased arrays is that they have low radiation resistance and significant reactance at their operating frequency. This property requires they be fed with ladderline. As a matter of fact, the beam shown in Figure 3 has a purely resistive radiation impedance only at ~25MHz and it is ~2500 ohm!

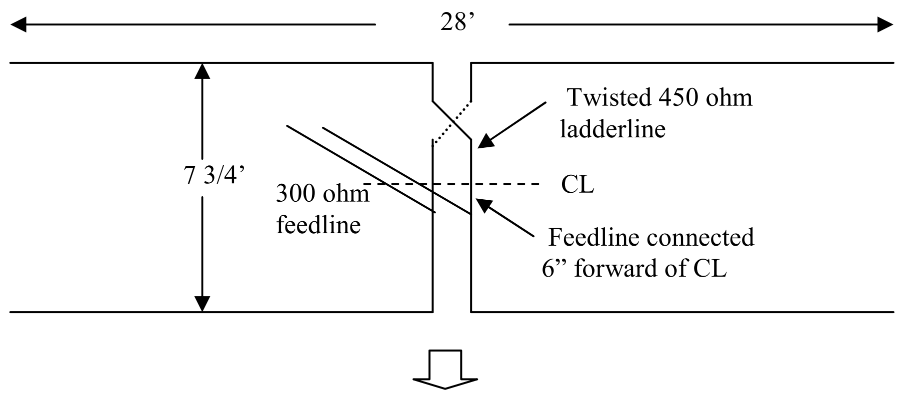

Figure 3. 20M W8JK array

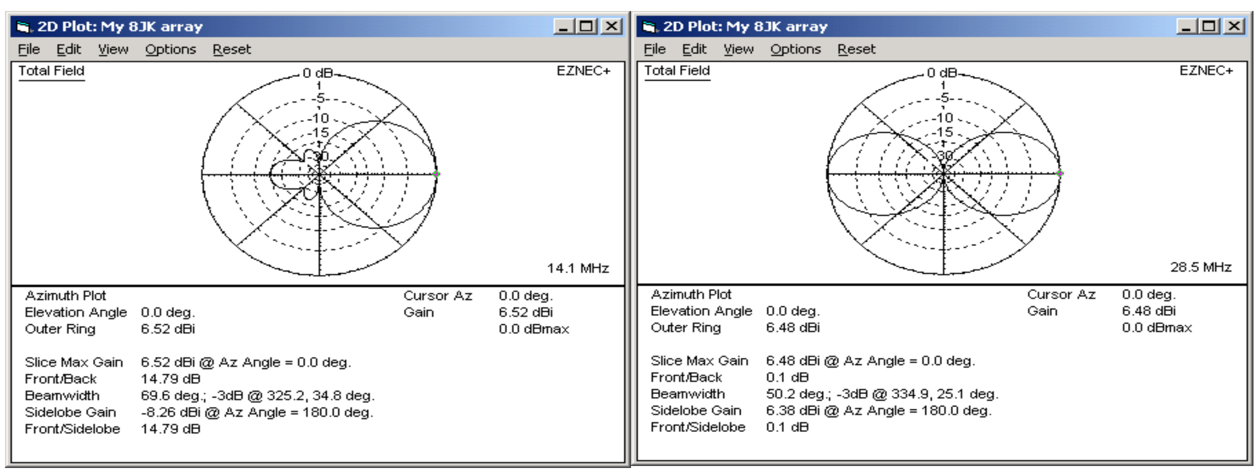

Figure 4. Free space radiation patterns for the W8JK array at 20M on left and at 10M on right.

Figure 4 shows the free space radiation pattern for 20M on the left and for 10M on the right. The unidirectional pattern at 20M is similar to that of the Moxon. At higher frequencies, the W8JK reverts to the classical figure 8 pattern typical of the phased array beams. Table 2 summarizes the performance factors for the W8JK array in a similar manner as was done for the Moxon. The gain on 20M is roughly constant across the band which is a bit different but the F/B decreases with increasing frequency. The gain and F/B are sensitive to the displacement of the feedline attachment point (6”) from the midpoint between the elements. An important difference from the Moxon, is that the gain on the other bands is not substantially different from that for 20M, i.e.. gain is roughly 6dbi on all bands. Actually it is slightly higher on 20M because of the directional properties of the beam and drops slightly at 18.1 as the F/B disappears but grows slowly thereafter as the beam becomes much longer than a simple half wave. By 10M it has gain similar to that on 20M. As can be seen in Table 2 this variability thru the bands is only ~.5db – almost unnoticeable.

Table 2. Performance properties of the W8JK array.

Freq. (MHz)	Gain (dbi)	F/B (db)	Source Imp. (r+jx)	SWR (300ohm)
14.0	6.5	16.0	4.6+6.9	65
14.1	6.5	14.8	4.7+9.9	64
14.2	6.5	13.3	4.7+13.1	64
14.3	6.5	11.9	4.7+16.2	64
18.1	6.1	1.0	149+288	33
21.1	6.1	-	315+558	15
24.9	6.3	-	984+925	9.1
28.5	6.5	-	2144-248	8.9

Another important difference is the low radiation resistance on 20M (~4.6 ohms). This is scary! Care must be exercised in building the beam to minimize resistive losses. The high SWR at the feed point also requires high quality ladderline that possess minimal loss. Fortunately most ladderline meets this need. It is also fortunate that the SWR decreases substantially as the frequency increases. I use 300 ohm ladderline (available from 'The Wireman' and DX Engineering) since it can be spaced away from the tower with standard TV spacers available at Radio Shack. This keeps the feedline about 3-4" from the nearest metal which is 6-8 times the conductor separation in the ladderline. Of course, a tuner is always required when using ladderline and a good current balun between the line and the tuner is a must. The balun minimizes feedline radiation that could seriously effect the directive properties of the beam. And, as always, some experimentation with the feedline length may be required to get transformed impedances at the tuner that it can handle on all bands.

Summary and other ruminations

I hope this discussion is useful for those considering building their own antenna. While I have not actually built a Moxon, I have studied it extensively and it has some attractive properties. It should be a bit easier to feed than the W8JK I've used my version of the W8JK for the last seven years, it has performed well and cost little. It shows relatively constant gain across all bands. Having achieve DXCC Honor Roll status since installing it is a testament to how well it works.

I have used a remotely controlled (not automatic) tuner for several years located about 10 feet up my tower to minimize the length of ladderline for my beam (my shack is ~150 feet from my tower, so something like this is required). This would be an ideal application for an auto tuner but I have never tried one so I can't comment on how well it might work.

With the increasingly availability of auto tuners, one can consider locating the tuner function very close to the antenna – even right at the feed point. Many of the problems that arise because of highly reactive feed point impedance could be eliminated in that manner. Beam design is always a struggle to optimize forward gain, F/B, and source impedance by manipulating the dimensions of the array. They are somewhat conflicting so eliminating the need to worry about one of them (source impedance) would simplify the design effort significantly.

What validates the dictum I asserted at the beginning is that these relatively simple, small, and inexpensive beam antennas have a forward gain of ~6dbi. A 3 element full sized yagi will get you 7+dbi, a 4 element yagi another 1 db. Have you priced these antennas lately? Have you examined their physical size? One S unit is 6db – even a 4 element yagi gets you only an additional small fraction of an S unit! These db's are very dear indeed!

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See the notice elsewhere in this newsletter about "The 5 'Tennas" Mini-Antenna Seminar being presented at the BVARC General meeting – April 10th