Gain Antennas --The 80% Solution

by
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PART 1

We are at the bottom of the current solar cycle, which means poor propagation and low activity on the higher HF bands. But, we can look forward to the improving band conditions over the next several years.

Now is the time to start building antennas for the higher HF bands to take advantage of those improving conditions. For many, however, big beams are out of the question because of space restriction, deed limitations, aesthetic consideration, or simply cost. Fortunately, some fairly simple antenna designs offer compact size, decent gain, and low cost. As a matter of fact, small beams will invariably offer the best bang for the buck, illustrating the famous "80% solution" scenario -- achieving 80% of a goal can usually be obtained at low cost, but the acquiring the remaining 20% may be very dear. In this article, I will describe some antenna designs that I have investigated – two of which I actually built and used.

PHILOSOPHY 101

Antenna design is always a struggle to achieve the right combination of generally conflicting, performance parameters. In the good old days, a lot of cut and try was the order of the day. Today, we have some fairly sophisticated modeling software (and the computers to run it). I use EZNEC+. With such programs, many design trade-offs can be investigated before any metal is cut. Still, the antenna configuration and dimensions are the only variables we can adjust to achieve that super antenna!

Comparison of antennas is difficult because some designs are inherently better for a particular application. You would never use (or try to optimize) a beam for local ragchewing on 80M. Still, the best way to compare antennas designed for a particular application is to express their gain in 'free space', in dbi – decibels relative to an isotropic radiator. The isotropic radiator is an antenna that radiates equally well in all directions, but does not exist – it is a mathematical construct. 'Free space' is used because ground reflection enhancement can be substantial and is very dependent on the actual ground conductivity. Free space gain allows us to compare performance parameters between different designs during our design effort. Sometimes investigators will use the dipole in free space as the baseline – a dipole has a broadside gain of 2.15dbi. A design caveat exists in that modeling allows us to design an antenna with a certain performance, but most of us have no way of determining if the antenna that we build achieves the predicted performance. We are left with trying it out and seeing if it works.

My personal objectives in designing the antennas I have used were simplicity, multi-band operation, decent performance, low cost, and unobtrusive appearance. Certainly, all the antennas I will discuss below meet this standard. I will start, however, by discussing a simple vertical loop, which is not a beam in the accepted sense of the word. Furthermore, I started out with the objective of building these antennas for use on 20M and above. All designs can be scaled down if the minimum desired operating frequency is higher than 14MHz.

A VERTICAL LOOP

A simple vertical loop can out-perform a dipole with only a modest increase in structural complexity. One configuration is a triangle – often called a delta. A square or rectangular shape may also be used. Resonant loops (1 λ total circumference) have a feed point impedance above 100 ohms, which means they will require a matching network (ie. 2:1 transformer) for 50-ohm coax, or ladder line and a tuner. Figure 1 shows two configurations: a) is the simplest to construct, while b) has a lower angle of radiation (important for working DX) since the high current portion of the loop is higher up. The radiation pattern is a fat figure 8 – quite similar to that of a dipole.

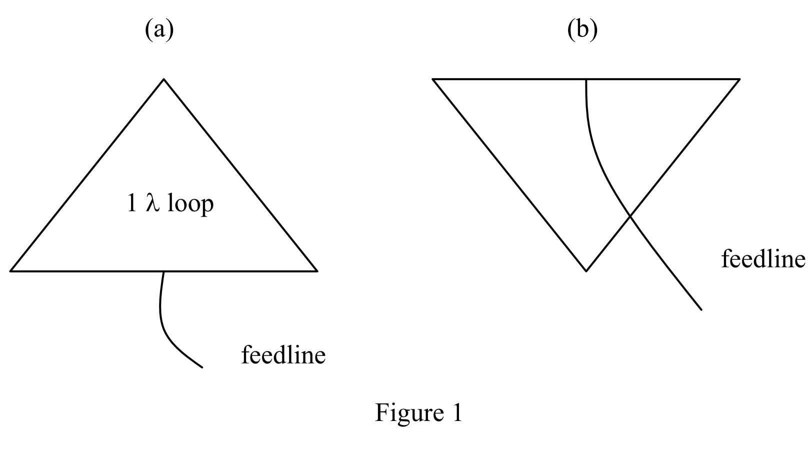

Figure 1

Since loops are usually one wavelength long, they will have a slight gain advantage over a simple dipole of 1db. Moreover, they will have a horizontal span less than a dipole. If fed with ladderline, they can operate across multiple bands, i.e. a 20M loop will work fine on 20M, 17M, and 15M. On 15M it is 1.33 wavelengths long and has a gain over a dipole of ~2db. A 20M loop has a rather strange radiation pattern on 12M and 10M, so use on these bands is not recommended. A decent compromise that works well from 20M thru 10M is to use a 17M loop, i.e. a full wavelength on 17M (~54 feet total loop circumference). The loop is a bit short on 20M, but still has gain over a dipole (~.75bd), and it functions well on 10M with a gain of 2 db over a .5λ dipole.

I constructed a 17M loop (along the lines of Figure 1a) using various sizes of PVC pipe configured in the form of a cross. The horizontal portion of the loop was 24' above ground and the peak was at approximately 38'. The mid-point of the lower vertical PVC pipe was secured to the edge of the roof using a slip ring – this way I could rotate (by hand) the antenna to be broadside to any desired direction. I used this antenna for many years in the mid '90's with considerable success.

SUPER GAIN BEAMS

This term has been coined (I guess) to describe beams with greater gain than would be achieved with a classic yagi configuration on an identical length boom. Common examples are the Moxon Rectangle, the W8JK phased array, and log periodics. All have short inter-element spacing (~.1λ) and tight current coupling and phase control between the elements. The 'super' part is a bit of an exaggeration since, in the end, these antenna designs will only have about the same gain as an "optimized" yagi with the same number of elements, but they will do it with a much more compact configuration. I will here discuss only the Moxon Rectangle, which I have not actually used, and the W8JK, which I have used.

MOXON RECTANGLE

This beam antenna was developed by Les Moxon, G6XN, sk (see his book: "HF Antennas for All Locations" available from ARRL) and is a parasitic array with a driven element and a reflector spaced .1λ a part. What makes the Moxon Rectangle really different from a standard short-spaced yagi is that the ends of both elements are folded back towards each other so that the ends are separated by only small gap. See Figure 2. This provides the tight coupling necessary to achieve the high gain of this compact arrangement. On 20M we now have a 2 element beam with only a ~28' span and an 8' boom yet the gain exceeds 6dbi in free space – this is about 4 db better than a dipole and equivalent to a wide spaced (>.2λ) 2 element yagi with an element span of 34'. The beam also has a modest F/B ratio of 10-15db. Modeling shows that rectangles for other higher frequency bands can be nested within the lowest frequency one and fed with a common coaxial feed line. Some tweaking of the dimensions may be required to compensate for the interactions of nested rectangles, however.

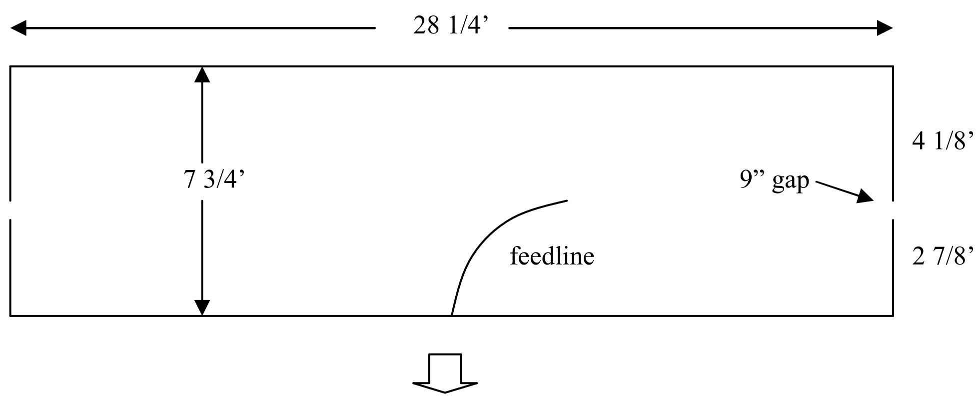

Figure 2. 20M Moxon rectangle

PART 2 of "Gain Antennas – The 80% Solution" will appear in the February issue