4 ELEMENTS OVER 4 ELEMENTS FOR SIX

by Chris Fagas, WB2VVV

I have used a number of six meter antennas over the years, but my current one has a really nice set of trade-offs. It has free space gain similar to the 7 element 24 foot long boom model Ron, WZ1V presented in the last newsletter. Both antennas have free space gain of approximately 10 dBd (referenced to a dipole). However, the antenna I am currently using has a much wider and forgiving 51 degree (+/- 3 dB points) azimuth beam width, since these two shorter stacked yagis have only 12 foot long booms. This is because stacking horizontally polarized yagis, one atop the other, compresses the H-Plane radiation pattern into a narrower elevation pattern on the horizon without materially affecting E-Plane or azimuth beam width, when compared with the radiation pattern of a single similar yagi. On the other hand, doubling the boom length of a yagi compresses both its H-Plane and E-Plane radiation patterns. Mine are stacked only 11 feet apart, which is slightly over one half wavelength, and make a very compact antenna. The stacking distance was in fact not optimized for optimum gain, but for maximum null above and below the stack. This has the double benefit of being very quiet on receive since high angle noise pickup is minimized[1], as well as reducing the amount of transmitted energy below the stack which could potentially cause TVI/RFI. It should be noted that while optimum free space gain is somewhat compromised in this relatively close stacking distance, with stacking gain of only 2.46 dB (compared to a theoretical maxima of 3.0 dB[2]), the improvement in the typical Signal to Noise Ratio is very significant. This stacking distance was derived by modeling a number of possible positions of these antennas above the ground, and was modeled with the effect of the ground. The position of the upper yagi was of course a limiting factor, from a practical standpoint.

These two yagis are physically installed at 64 feet and 53 feet above the ground, and when computer modeled over ground place the maxima of their radiation pattern at 5 degrees above the horizon. The sky directly above the stack, extending down to an elevation angle of 50 degrees above the horizon in all directions, is attenuated by more than 35 dB when referenced to this maxima. This represents an eighty degree wide null cone which exists above and below[3] this stack. Modeled gain over ground is 17.88 dBi (referenced to a theoretical isotropic radiator), with Front to Back of 17.36 dB.

In operation, this antenna is very quiet and has good forward gain. It has a forgiving azimuth beam width allowing more stations to be worked without as much fiddling with the rotator. The wider azimuth beam width is also useful because the optimum beam heading for a band opening is often uncertain. This factor makes this a very good antenna to call CQ with. Its relatively modest Front to Back Ratio allows more stations to be worked off the back of the antenna in contests, and is by design[4].

Now for the best part, you don't need to locate or cut one piece of aluminum to make this antenna. These two yagis are simply slightly modified versions of the very sturdy and inexpensive Hygain HG-64DX. This model has beautiful boom to element clamps and uses all stainless steel hardware. It is a very well designed yagi from a mechanical standpoint, and again it is surprisingly inexpensive[5]. Electrically, it"s no slouch either, although I did take the liberty of changing a couple of dimensions to optimize performance a bit.

Simply build each of the two yagis as Hygain suggests in their instructions. There is plenty of extra boom length in the stock dimension schedule to add 1.75 inches to the spacing between the second and third directors, by repositioning the third (last) director 1.75 inches further out on the boom. The remaining boom overhang should be shared on both ends of the boom, so that the reflector does not enjoy any more overhang than the last director. Finally the reflector can be shortened by 4.0 inches overall, 2.0 inches on each half, to reduce the slightly excessive Front to Back Ratio while simultaneously increasing forward gain.

The recommended power divider, is a simple coaxial harness. A coaxial Tee fitting is used to join two 3/4 wavelength long sections of 75 ohm coaxial cable to the 50 ohm feedline which runs to your shack. Using odd multiples of quarter wavelengths of 75 ohm coaxial cable will transform the impedance of each of the two 50 ohm antennas to 100 ohms, at the other end of each of their respective transmission line transformers, and these two 100 ohm loads in parallel at the Tee fitting equal 50 ohms to match the feedline[6]. You will note that each yagi comes with its own 4:1 coaxial matching balun, and these are to be used in the normal fashion, and in addition to the "power divider" described in this paragraph.

Because energy travels slower through coaxial cable than it does through free space[7], an electrical quarter wavelength of coaxial cable will be shorter than a free space wave length. This difference is indicated by the Velocity Factor of the particular coaxial cable. The Velocity Factor is merely a decimal factor which shows the velocity of propagation through a medium with respect to the velocity of propagation through free space. The Velocity Factor of energy traveling in free space is 1.000, while the Velocity Factor of energy traveling in solid polyethylene dielectric coaxial cable is approximately 0.667. This means that in the amount of time that energy will travel a given distance in free space, it will only travel 0.667, or 66.7 percent, as far as it will travel in solid polyethylene dielectric coaxial cable. I recommend that you use solid polyethylene dielectric coaxial cable for the "power divider" since its velocity of propagation is very predictable and consistent from run to run, and it is relatively stable in an outdoor environment. It will also make the shortest physical length 3/4 wave transmission line transformer, since it is about the lossiest dielectric coaxial cable. Please do not worry about the loss, since it is insignificant on such a short length at such a low frequency. You should note though that

Velocity Factor is a reliable gauge of the relative lossyness of a dielectric material, and can be used to grade coaxial cables of the same diameter with respect to loss characteristics. Standard designations for 75 ohm solid polyethylene dielectric coaxial cables in increasing order of desirability are: RG-59, RG-11, and RG-216. RG-59 has a very small diameter of 0.250 inches, while the other two are larger in diameter at 0.415 and 0.432 inches, respectively. I happened to use RG-216 since it was available and it happens to be double shielded, which makes it stronger physically but offers little electrical advantage in this application. Of course the larger diameter coaxial cables will handle more power and are lower loss. From a power handling standpoint the 4:1 coaxial matching baluns which comes with the yagis is the limiting factor, but remember that each need only handle half of the power that makes it to the power divider. They are made of RG-58 coax but could be easily replaced with heavier coax such as RG-213. At 50 MHz RG-58 is rated to handle 300 watts of continuous power, which is roughly the same as 500 watts PEP SSB, with a typical duty cycle. This means that if you plan to exceed twice these amounts at the power divider, then you should upgrade the RG-58 to something heavier. I also used several large ferrite beads at the yagi ends of the transmission line transformers to reduce the likelihood of feeder radiation distorting the overall radiation pattern. The feedpoint of the HG-64DX yagis are made by stripping back the coaxial cable transformer feeders to make a short neat pig-tail "Y" with ring eyes soldered to each side, and installed across the driven element and the 4:1 transformer in the normal fashion.

Using solid polyethylene dielectric coaxial cable each half of the "power divider" will be 9.815 feet, or 9 feet 9 and 3/4 inches long, measured from the center of the coaxial Tee fitting to the point where the transmission line transformer splits into a "Y" (and is no longer coaxial). The mathematical formula for this is as follows:

(Free Space Wavelength of 984 / 50.150 MHz) X (3/4 Wavelength) X (0.667 VF) = feet

The methodology behind this simple 75 ohm coaxial cable "power divider" can be used on other bands, and even for many other applications as well.

If you have the vertical space on your mast, you should always give serious thought to stacking yagis. Stacked yagis offer a very endearing set of trade-offs, which will not likely disappoint you.

References/Notes: 1. The VHF/UHF DX Book, Ian White, DIR Publishing Ltd. 2,3,6,7. Antennas, John D. Kraus, Second Edition, McGraw-Hill Book Company 4. The bulk of stations which I work are either to the Northeast or the Southwest, precisely 180 degrees apart which makes for a lot of rotating back and forth. 5. Approximately $105 each, discounted.