Put a Hex on the Magic Band

A Three Element Hex Beam for 50 MHz

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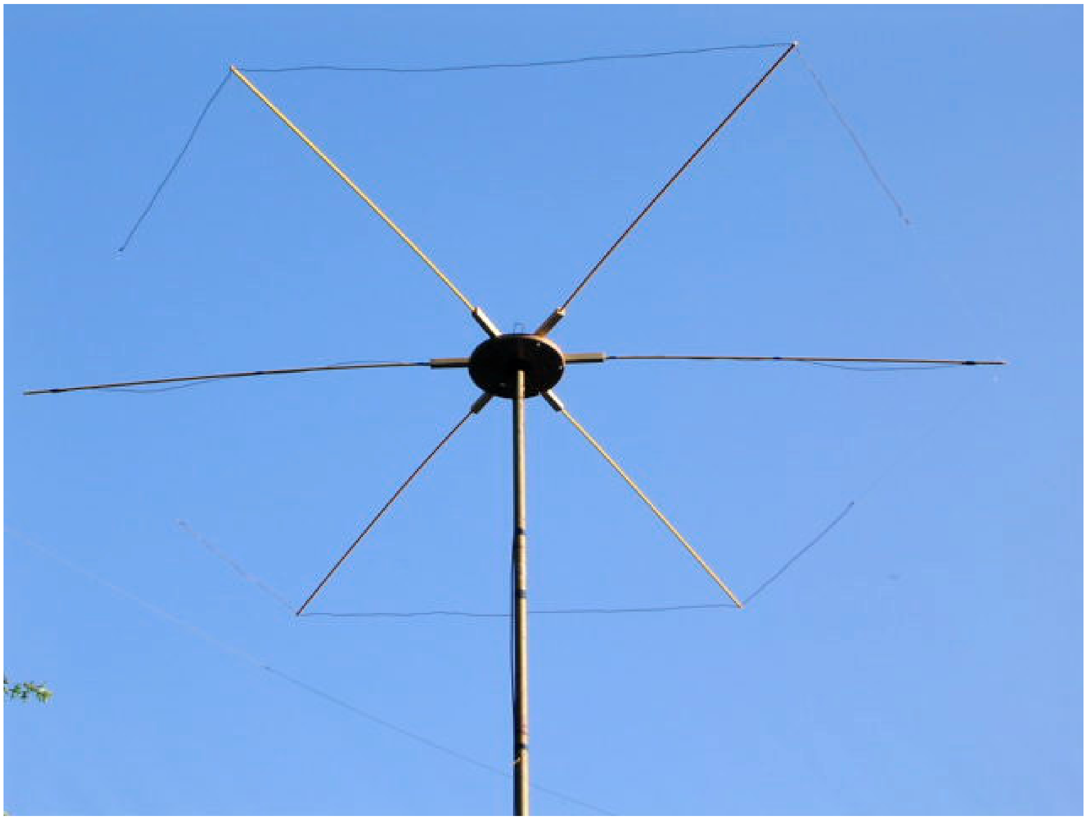


Design of a three element hex beam for 50 MHz (6 meters)   Harry Johnson WB3BEL Copyright 2007.

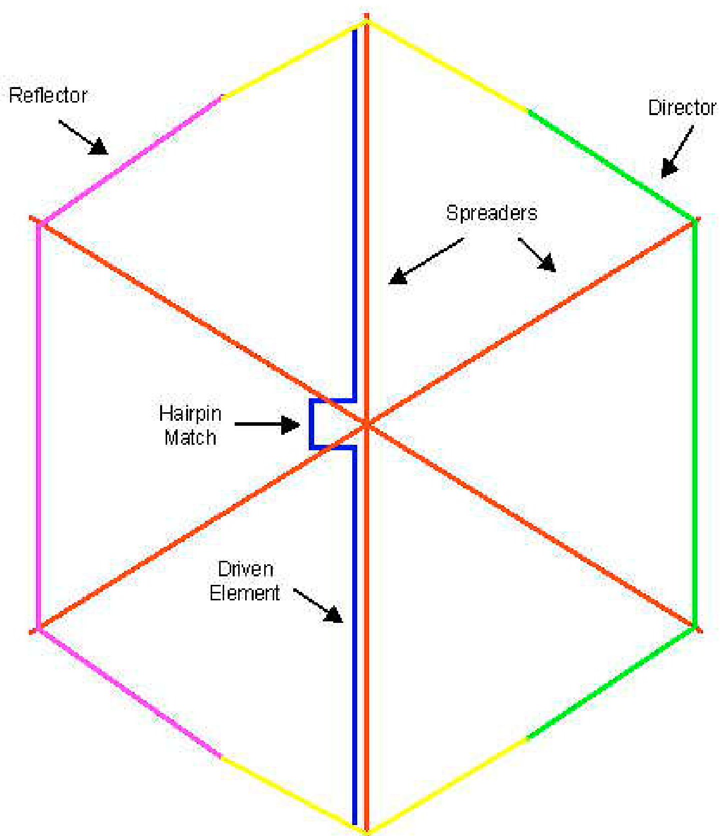
An antenna was desired for portable operation on 50 MHz which was lightweight and had very small wind load so that it could be supported with a small diameter mast with a minimum of guying.

The standard hexbeam configuration uses six insulating supports at 60 degree angles in a horizontal plane. On this framework are placed two wire elements one acting as the driven element and the other generally used as a parasitic reflector although parasitic director mode is possible.   These elements are formed in a "W" shape.   After looking at this design which meets the small and lightweight criteria, I became interested in finding a solution with a bit more gain at the expense of a bit more size and weight. The hex beam has 5.5 to 6 dBi free space gain.

Next I performed some antenna modeling for the three element bird yagi or spiderbeam style antenna, which has approx 7 dBi free space gain. But I was still not satisfied and I returned to a design investigation using the hex style spreaders in order to obtain wider spacing between the parasitic elements and the driven element to increase the gain. The trade off being adding two extra spreader supports for the wire elements. While the additional length of the spreaders and area of the antenna may be a concern at 14 MHz, it is not an issue at VHF

The three element hex beam uses a straight configuration driven element and the parasitic elements are supported in "U" configuration. Refer to Figure 1. I have not seen this geometry documented in any antenna design previously.

Figure 1



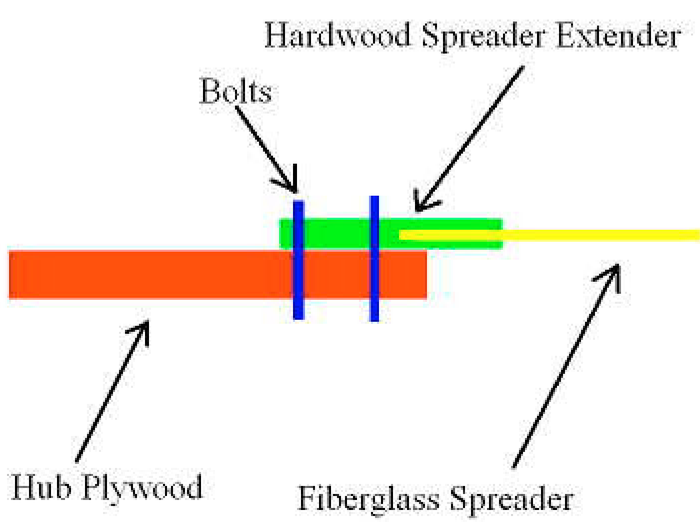
In Figure 1, the red lines represent fiberglass rod spreaders which support the wire elements. The blue lines represent the driven element wires which run parallel to the blue spreaders. The green lines represent the Director element. The magenta lines represent the Reflector element. The yellow lines represent monofilament fishing lines, which support the ends of the parasitic elements and are attached to the driven element spreaders.

All elements used 14 gauge stranded bare copper wire. This wire has 0.064 inch diameter although other sizes and types of wire could be substituted if the conductor lengths were scaled. Do not use plastic jacketed wire without compensating for the lengths.

The six spreaders were made from 48 inch long driveway markers. These are solid fiberglass rod about 0.25 inch diameter which were locally obtained from the hardware store (Home Depot). These are very economical at about $2 each and kept catching my eye for antenna applications when I was looking for other hardware during the course of a long winter. It was determined that the driven element would need to be about 53 inches in length. So a wooden extender of which was 7 inches long and 0.75 inch in width and height provides this length. The extenders were drilled and the fiberglass rods were glued into the ends. The driveway markers had light reflective tape at the ends which were made of metallized film. These were scraped off with a razor knife. These may not be an issue for all of the spreaders, but the impact of the conducting material on the nearby driver wire considered a risk and they were all removed. If you use these materials, and you wish to do portable operation at night using a mast without a rotator you may consider leaving the tape on two of the spreaders supporting the director wire so that the antenna direction can be discerned by shining a flashlight on the antenna. Shorter spreaders may be used by loading the driven element and rescaling the wire dimensions. The gain may be a few tenths of a dB less if the overall spreader length is only 48 inches.

Refer to Figure 2 which shows a side view of the hub and spreader attachment.

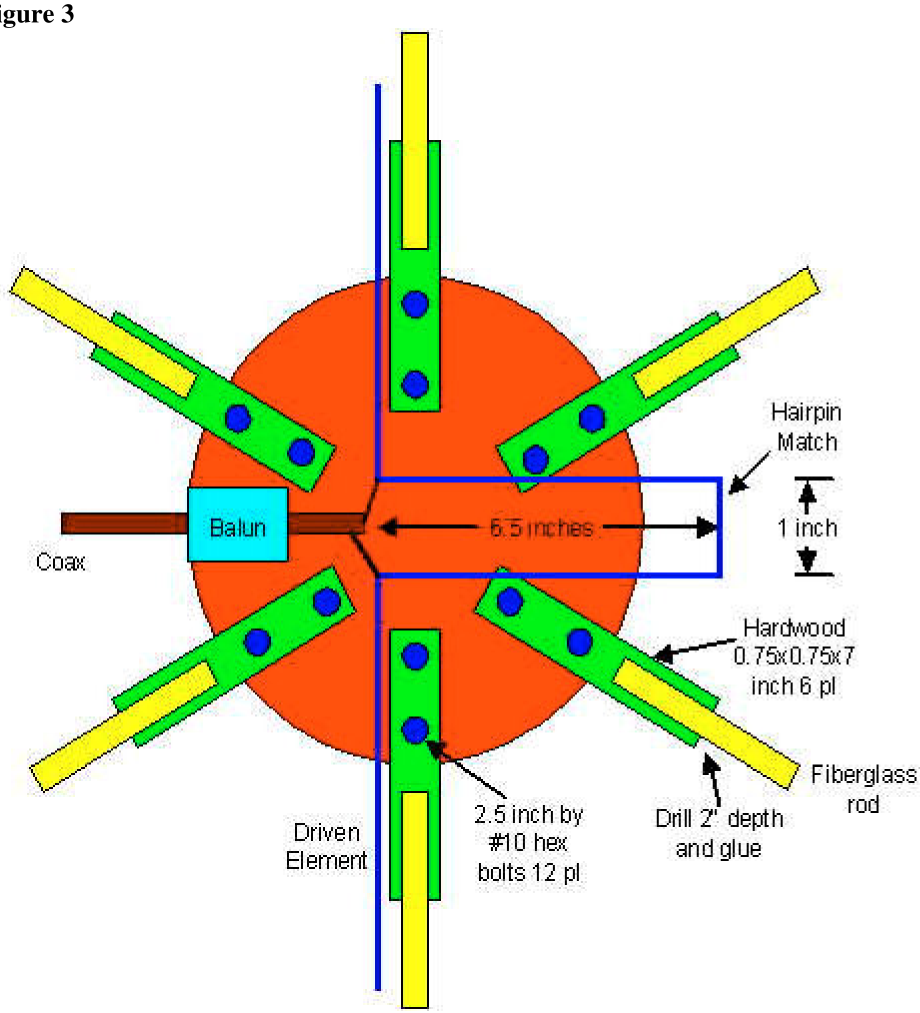
Figure 2



These spreaders were mounted on plate formed from round 11 inch diameter ¾ inch plywood to form 60 degree angles. This thick plywood is overkill for the application, but it was on hand and was used for the prototype. The spreaders are attached to the plywood hub by means of two 2.5 inch #10 bolts per spreader using flat washers and nuts. This allows for removal of the spreader arms from the hub for transportation or storage.

Figure 3 shows the top view of the hub and spreader attachment

Figure 3



In the interest of lowering the weight of this already lightweight antenna further optimization of the hub and spreaders is anticipated. Hollow fiberglass kite spars are available in a wide variety of lengths and diameters and could be used in conjunction with an ultra-lightweight hub assembly. I think that with some ingenuity the antenna weight could be lowered to about 1 lb. Probably the coax cable would weigh more than the antenna. The prototype antenna was not weighed but I think it exceeds five pounds; most of the weight is in the hub.

The antenna electrical performance was modeled using 4NEC2 by Arie Voors which uses the NEC2 engine. The driven element is intentionally slightly short in electrical length and is tuned to 50 ohms by implementation of a hairpin match which is formed in the driven element wire. The impedance of the antenna without the hairpin is approximately ~ 35 –j30 ohms.

The antenna simulation used 54 inches of wire on each side of the source for the driven element. When the antenna was made, it was estimated that the wire should be shortened by about 1 inch (53 inches) on each side to account for the dielectric factor of the wire running alongside the fiberglass spreader.

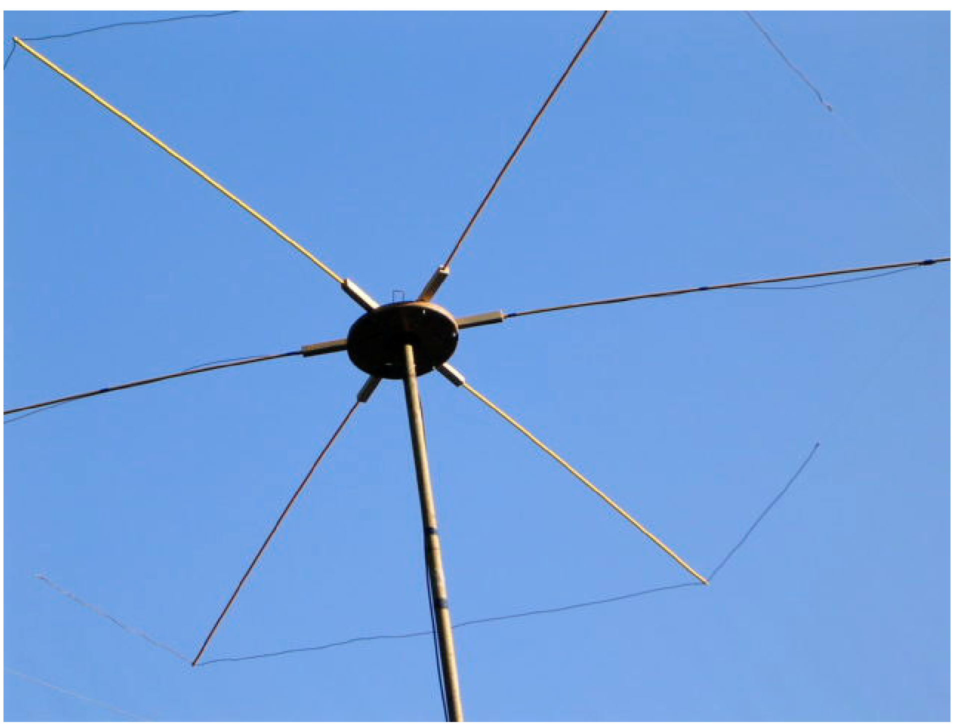
The hairpin is 6.5 inches long and has 1 inch spacing between the wires. So, the driven element wire is formed from a continuous segment of wire which has 54+54+6.5+6.5+1 or 123 inches. I folded the ends of the wire back one inch on each end just in case it needed tuning. Attach the coax center conductor to one corner of the hairpin nearest the driven element and the braid to the other corner. I wrapped three turns of RG58 coax through a ferrite core right at the feed point to act as a balun.

The director is fastened at 54 inches out the spreaders radially from the axis of the spreader hub and is formed from 111.6 inches of wire with about 1.5 inches folded back at the ends to form 2*54.3 inches of wire. The wire is supported at the spreader by drilling a small hole through the fiberglass rod near the end and threading the wire through. A monofilament fishing line supports the free end of the director to the driven element spreader.

The reflector is fastened at 54 inches out the spreaders radially from the axis of the spreader hub and is formed from 118.6 inches of wire with about 1.5 inches folded back at the ends to form 2*57.8 inches of wire. The wire is supported by the spreaders in similar fashion to the director. The monofilament lines from the directors to the driven element spreaders are separate lines from the one from the reflectors to the spreaders. This prevents movement of the wires through the spreader holes. The monofilament is tensioned to maintain 60 degree angle of the spreaders with equal lengths of monofilament on each side of the parasitic element to its spreader. The lines are not tensioned to bow the spreaders as is done in the traditional hex beam as there is only a single band used and the support of the bow is not needed for this small antenna. But it is possible to implement a multi-element VHF hex structure of 3,4 or more elements within a multi-band hex by using a separate feed line.

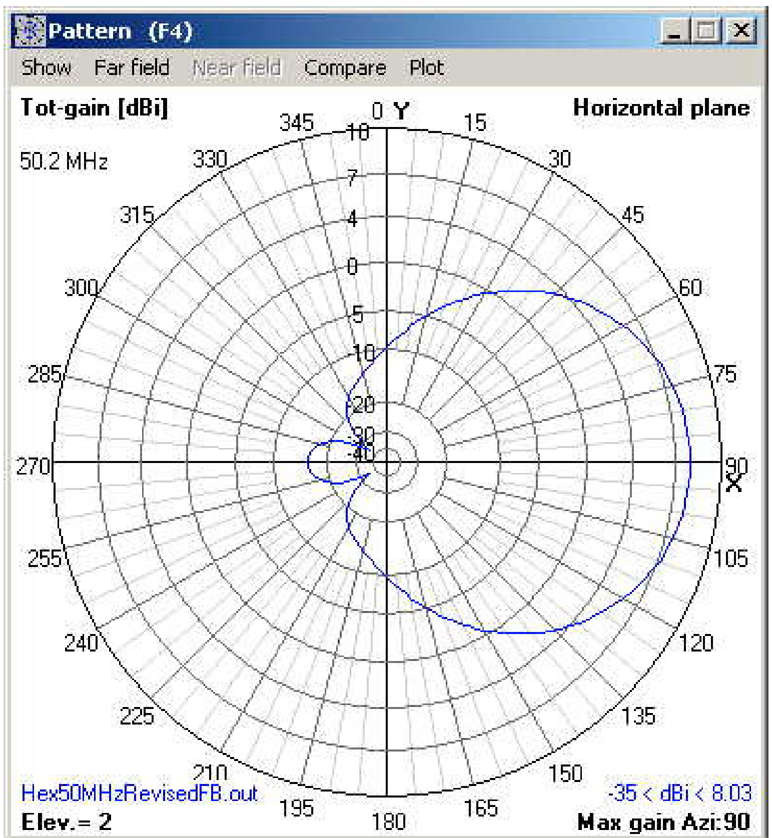
The antenna has about 8 dBi free space gain and the front to back ratio exceeds 20 dB over the lower 500 KHz of six meters.

Figure 4



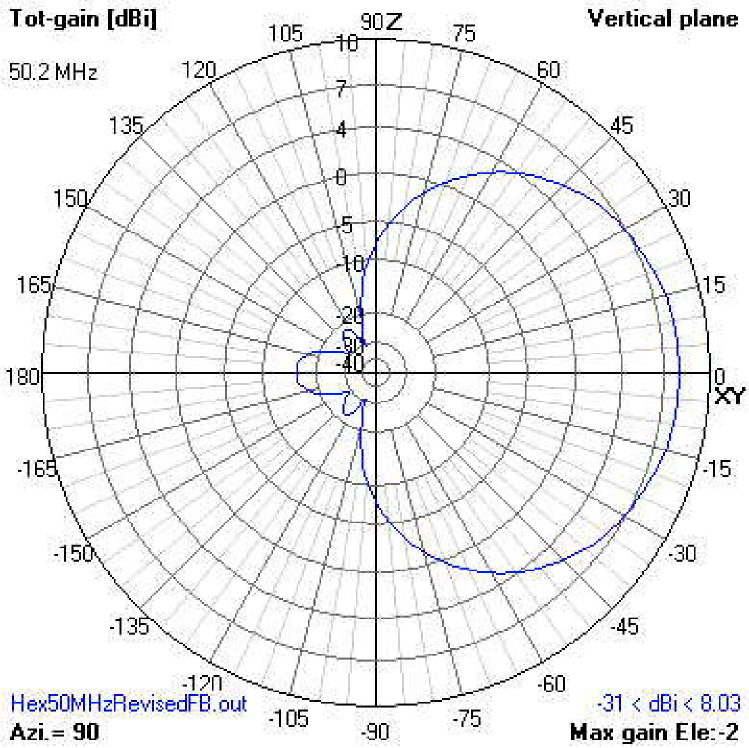
Refer to Figure 5 for the simulated free space horizontal antenna pattern at 50.2 MHz. Note the broad main lobe and excellent front to back and front to rear performance. It is possible to tweak the element lengths to optimize further the front to back ratio, but I think that if this is desired it should be done in the field instead of in front of the computer where astronomical F/B results may not really be met in the real world. You should also keep an eye on tradeoff where you may see 30+ dB of F/B but the F/R is only 15 dB. It all depends on what your objectives are. I like to balance the F/B and F/R while obtaining good forward gain.

Figure 5



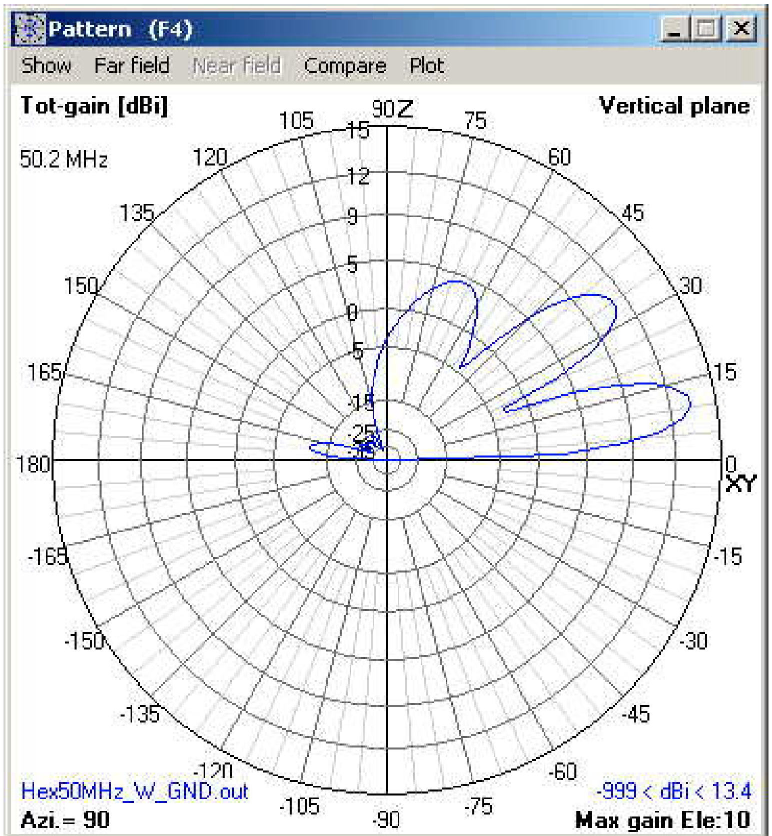
Refer to Figure 6 for the corresponding simulated free space vertical antenna pattern at 50.2 MHz.

Figure 6



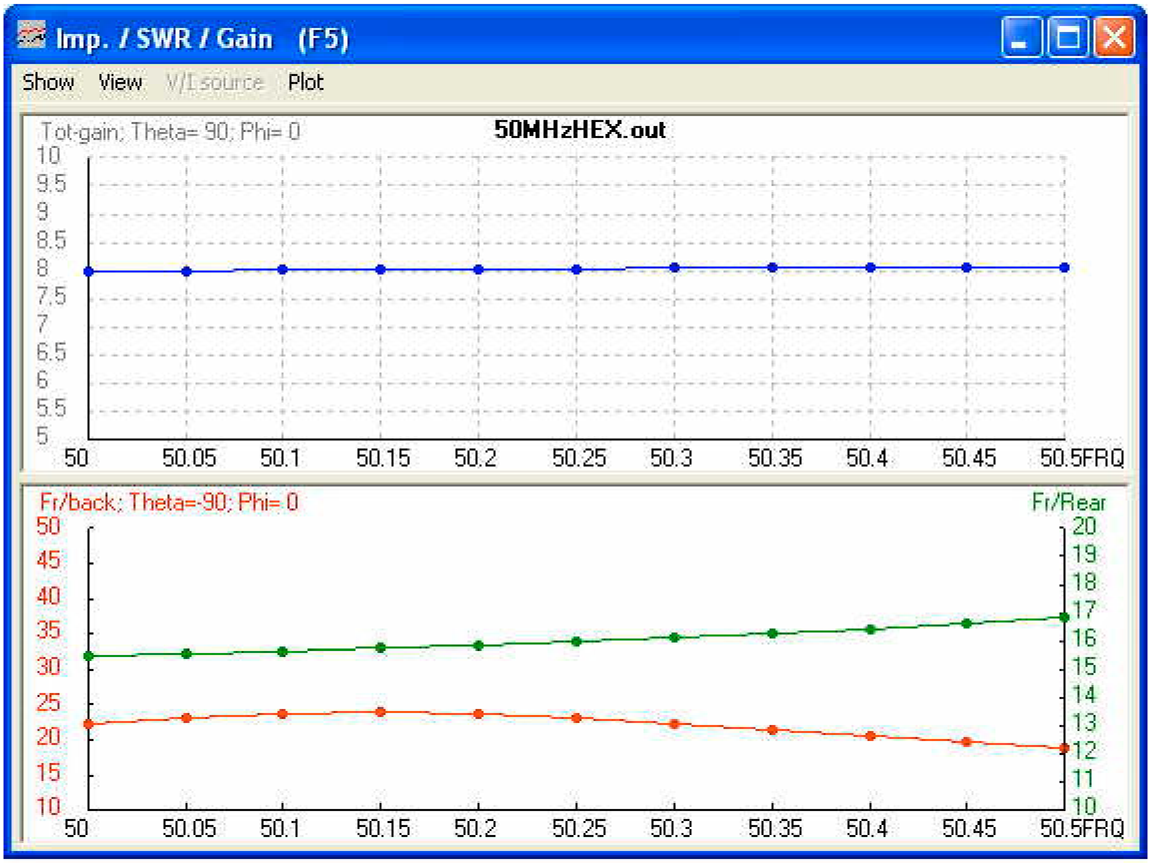
Refer to Figure 7 for the simulated vertical antenna pattern at 50.2 MHz. with antenna at 25 feet elevation over average ground (Dielectric constant = 13 ; conductivity = 0.006). The antenna shows grating lobes as expected from the antenna height. In addition the antenna gain is enhanced in the first lobe by its ground reflection. There is about 5.4 dB gain from this reflection above the free space simulation.

Figure 7



Refer to Figure 8 for the simulated antenna free space gain and front to back ratio. The graph shows that the free space gain exceeds 8 dBi (blue curve) over the lower 500 KHz of six meters and the front to back ratio exceeds 20 dB (red curve with scale on the left axis) with a peak near 50.150 MHz. The front to rear ratio exceeds 15 dB (green curve with scale on the right axis).

Figure 8



The antenna was built in May of 2007, raised to 25 feet on a push up mast and the VSWR was less than 1.2:1 from 50 to 50.5 MHz as measured with an MFJ259B antenna analyzer and required no adjustment to the hairpin match with the antenna as simulated. The total cost of the prototype was around $25 with some junk box pillaging.

The front to back ratio was investigated and seems to exceed 15 dB. Further measurement may be performed to obtain more accurate results. But, as it is now June and the Sporadic E is upon us, I have been making contacts and not doing field measurements. If I could make it lighter and get it up about ten feet higher… But I already expounded on some thoughts for that It might make sense to use aluminum tubing for the driven element instead of the wire and spreader and use fiberglass tubing for the four parasitic element supports. I don't think that it would be lighter, but it might be a little simpler to assemble and disassemble.

There is no reason that this three element hex beam structure can not be used on other bands including HF bands if the additional area is manageable for the specific installation. It has better gain with less slope and superior F/B than the 2 element traditional hex W configuration. However the required area is almost double. 16 foot spreaders would be needed at 14 MHz.

73, and I hope to see you on six meters soon!
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