HexBeam Antenna

There are numerous articles[1, 2, 3] on the design and construction of this popular 5-band broadband antenna and I decided to build one that utilizes all of the best features.

Hub

Most designs use U-bolts to secure the spreaders to an aluminum plate. I used this method on my Dual Band 12m-17m Moxon and discovered that it is very easy to split the fiberglass spreaders, so I decided to try element tubing clamps. These clamps are also called vibration-damping clamps (McMaster-Carr[4]) or resin support blocks (DX Engineering[5]). The 1-inch size is perfect for mounting the 1-inch OD fiberglass spreaders to the hub and provides enough clamping force without damaging the fiberglass.

Spreaders

The spreaders are made from 1, ¾ and ½ inch OD x ⅛ inch wall fiberglass tubing and are available from Max-Gains Systems[6] individually or in a hexbeam kit.

For fastening the elements to the spreaders I used nylon setscrew collars and nylon eyebolts. Although more expensive than the hose-clamp and wire-tie method, it provides easily adjustable clamping locations for wire tension and height and gives a neater overall appearance. Nylon cap screws (5/16NC x 2-inch) screwed into the ends of the ½ inch spreaders serve as S-hook anchors. (Note: be careful not to split the tubing when tapping for the 5/16 inch screws).

Center Post Transmission Line

The center post design with short sections of 50Ω coax transmission lines and terminal strips mounted on the outside of the post exposes the open coax to the weather. Attempts to seal the coax for any length of time have never been successful for me. The center post on HB9MCZ's hexbeam[2] intrigued me and he graciously emailed more information on how it was built. He stated that the dimensions for the central coax feed are not critical as long as the ratio of the inner dimension of the external tube to the dimension of the center conductor is about 2.5.

In an attempt to learn more about this type of feed system I discovered an interesting article entitled "Air-filled square coaxial transmission line and its use in microwave filters"[7]. The design of square cross section metallic cables is discussed with formulas for differing ranges of dimensions. According to equation (2) in the article, when the inside diameter of the outer conductor *b*, divided by the outside diameter of the inner conductor *w* is 2.5, the impedance of the line is very near 50Ω.

Equation 2, for $2.5 \leq b/w \leq 4$:
Zo = 136.7 * LOG (0.9259 * (b/w)
Zo = 136.7 * LOG (0.9259 * 2.5) = 49.83Ω

The ratio was achieved by using 1-½ inch square aluminum tubing with 1/8-inch wall (1-¼ inch ID) as the shield and ½ inch square aluminum bar as the center conductor (1.25/0.5=2.5). The 1-½ inch aluminum is isolated from the hub using ¼" thick fiberglass stock. Center conductor connections are brought to the outside via nylon standoffs and shoulder washers using 6-32 hardware, while the shield connections are screwed directly to the 1-½ inch aluminum. An attempt was made to minimize impedance changes by keeping the structural dimensions uniform. For example, the screws securing the elements to the 1-½ inch aluminum were kept short and installed with several washers to prevent the screw tips from extending past the inside wall of the 1-½ inch aluminum.

An SO-239 connector is mounted one inch above the 20m feed and connects to the center bar using a 2-56NC brass screw. A cap made from fiberglass stock is screwed to the top to complete the design.

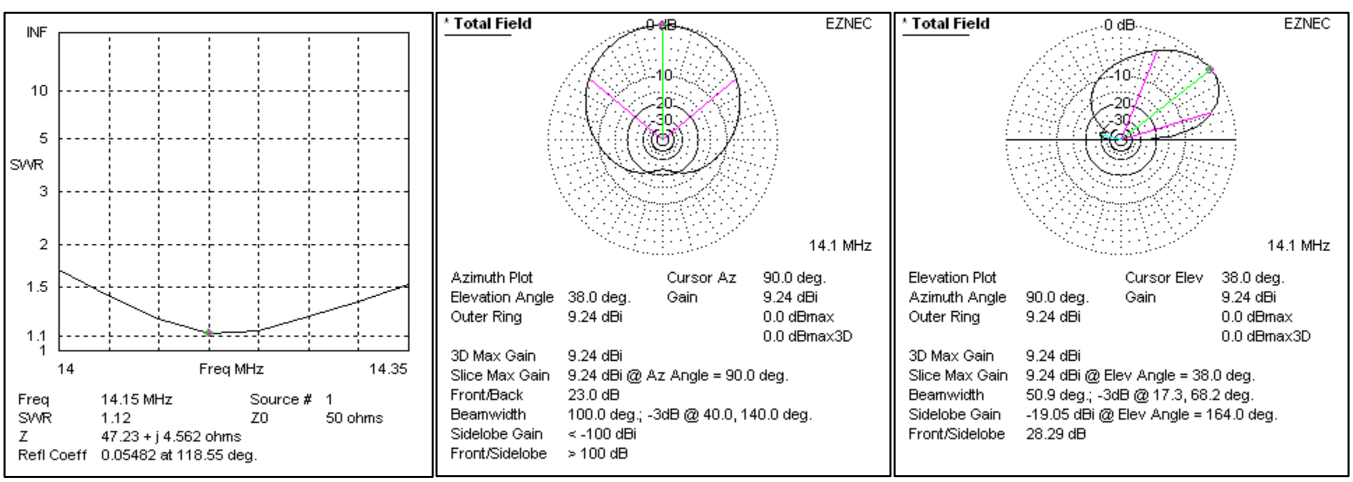
Elements and Modeling

The EZNEC model provided by G3TXQ provided the starting point for this version. I kept the tapered segmentation and rebuilt the layout to reflect the new center post feed system, the larger #14 wire, and to reduce interference between bands. This led to slightly longer wire lengths. The model is based on the hub mounted at a 20 foot height.

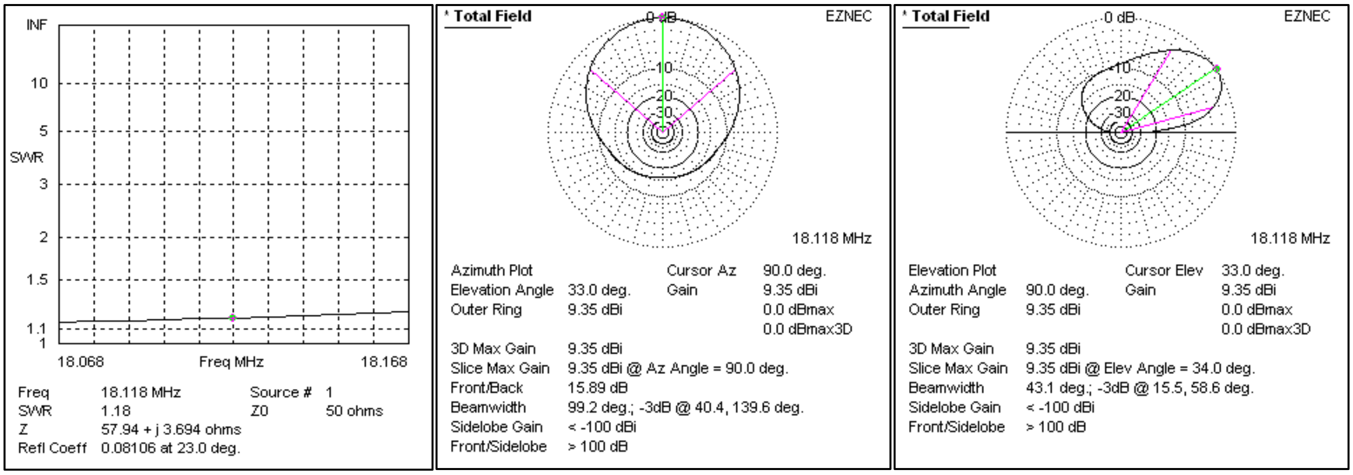
The elements are cut from #14 Silky wire (Wireman #523) according to the cutting schedule. 275 feet of wire will provide enough length for all five bands. The elements are attached to the insulators and feedpoints by crimping and soldering ring terminals to the wire ends and securing them to the insulators. Be sure to include the lengths of the ring terminals when cutting the wire to get the correct lengths. Crimp and solder the ring terminals as soon as the wire is cut as the wire will unravel if not handled gently.

The 1-½ inch aluminum center post and the 12 inch diameter hub were added to the model but did not have any significant effects so they were deleted to reduce the number of segments. Slanted elements were also modeled in which the spreader tie points were two inches higher than the feed points. Similarly, this didn't significantly affect the model as long as the elements were parallel.

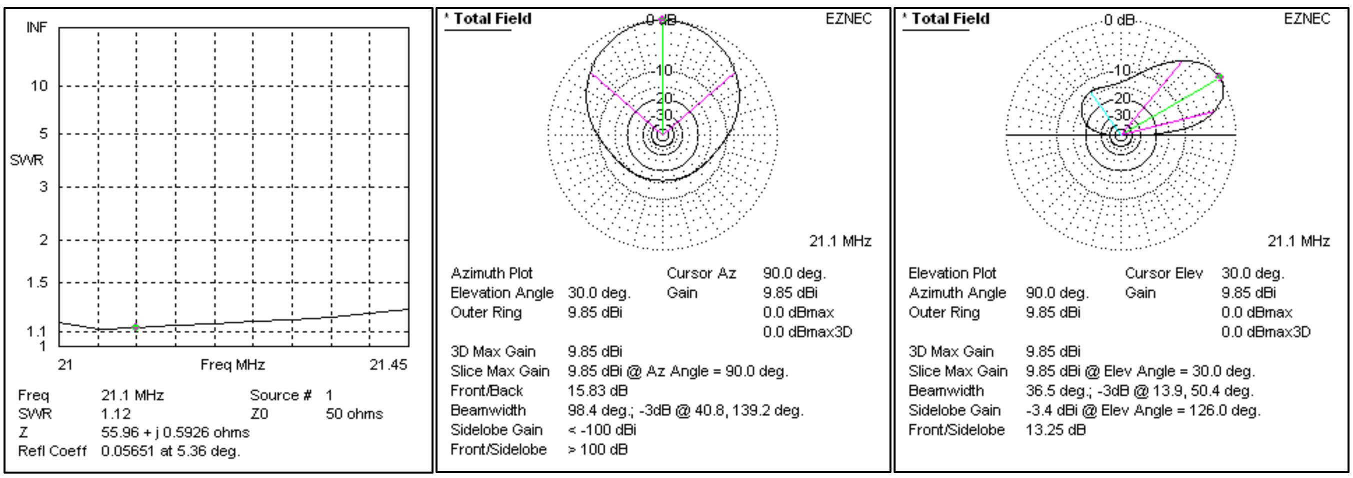
The following EZNEC plots were modeled with the base at 20 feet:



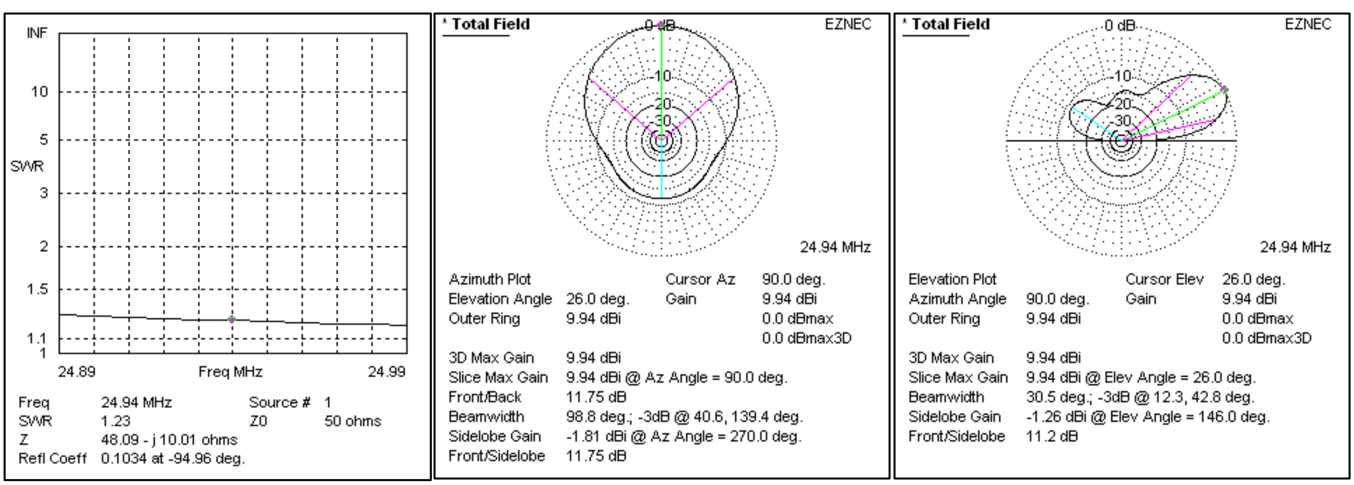
20M


INF
10
5
SWR
3
2
1.5
1.1
1
18.068
Freq MHz
18.168
Freq 18.118 MHz Source # 1
SWR 1.18 Z0 50 ohms
Z 57.94 + j 3.694 ohms
Refl Coeff 0.08106 at 23.0 deg.
Total Field
EZNEC
0 dB
10
20
30
18.118 MHz
Azimuth Plot
Elevation Angle 33.0 deg.
Outer Ring 9.35 dBi
Cursor Az 90.0 deg.
Gain 9.35 dBi
0.0 dBmax
0.0 dBmax3D
3D Max Gain 9.35 dBi
Slice Max Gain 9.35 dBi @ Az Angle = 90.0 deg.
Front/Back 15.89 dB
Beamwidth 99.2 deg.; -3dB @ 40.4, 139.6 deg.
Sidelobe Gain < -100 dBi
Front/Sidelobe > 100 dB
Total Field
EZNEC
0 dB
10
20
30
18.118 MHz
Elevation Plot
Azimuth Angle 90.0 deg.
Outer Ring 9.35 dBi
Cursor Elev 33.0 deg.
Gain 9.35 dBi
0.0 dBmax
0.0 dBmax3D
3D Max Gain 9.35 dBi
Slice Max Gain 9.35 dBi @ Elev Angle = 34.0 deg.
Beamwidth 43.1 deg.; -3dB @ 15.5, 58.6 deg.
Sidelobe Gain < -100 dBi
Front/Sidelobe > 100 dB

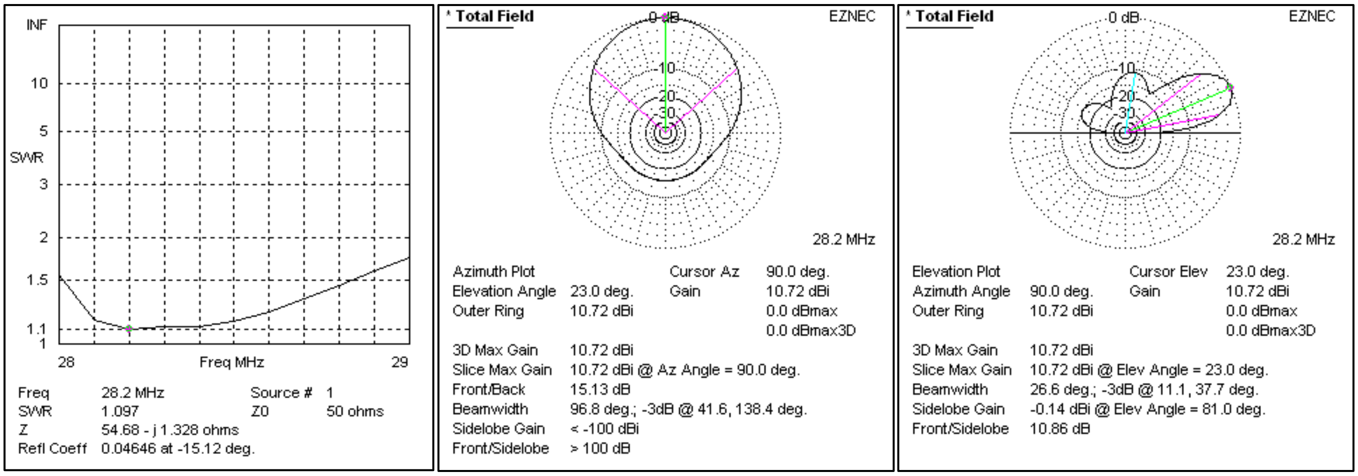
17M


INF
10
5
SWR
3
2
1.5
1.1
1
21
Freq MHz
21.45
Freq 21.1 MHz Source # 1
SWR 1.12 Z0 50 ohms
Z 55.96 + j 0.5926 ohms
Refl Coeff 0.05651 at 5.36 deg.
Total Field
EZNEC
0 dB
10
20
30
21.1 MHz
Azimuth Plot
Elevation Angle 30.0 deg.
Outer Ring 9.85 dBi
Cursor Az 90.0 deg.
Gain 9.85 dBi
0.0 dBmax
0.0 dBmax3D
3D Max Gain 9.85 dBi
Slice Max Gain 9.85 dBi @ Az Angle = 90.0 deg.
Front/Back 15.83 dB
Beamwidth 98.4 deg.; -3dB @ 40.8, 139.2 deg.
Sidelobe Gain < -100 dBi
Front/Sidelobe > 100 dB
Total Field
EZNEC
0 dB
10
20
30
21.1 MHz
Elevation Plot
Azimuth Angle 90.0 deg.
Outer Ring 9.85 dBi
Cursor Elev 30.0 deg.
Gain 9.85 dBi
0.0 dBmax
0.0 dBmax3D
3D Max Gain 9.85 dBi
Slice Max Gain 9.85 dBi @ Elev Angle = 30.0 deg.
Beamwidth 36.5 deg.; -3dB @ 13.9, 50.4 deg.
Sidelobe Gain -3.4 dBi @ Elev Angle = 126.0 deg.
Front/Sidelobe 13.25 dB

15M


INF
10
5
SWR
3
2
1.5
1.1
1
24.89
Freq MHz
24.99
Freq 24.94 MHz Source # 1
SWR 1.23 Z0 50 ohms
Z 48.09 - j 10.01 ohms
Refl Coeff 0.1034 at -94.96 deg.
Total Field
EZNEC
0 dB
10
20
30
24.94 MHz
Azimuth Plot
Elevation Angle 26.0 deg.
Outer Ring 9.94 dBi
Cursor Az 90.0 deg.
Gain 9.94 dBi
0.0 dBmax
0.0 dBmax3D
3D Max Gain 9.94 dBi
Slice Max Gain 9.94 dBi @ Az Angle = 90.0 deg.
Front/Back 11.75 dB
Beamwidth 98.8 deg.; -3dB @ 40.6, 139.4 deg.
Sidelobe Gain -1.81 dBi @ Az Angle = 270.0 deg.
Front/Sidelobe 11.75 dB
Total Field
EZNEC
0 dB
10
20
30
24.94 MHz
Elevation Plot
Azimuth Angle 90.0 deg.
Outer Ring 9.94 dBi
Cursor Elev 26.0 deg.
Gain 9.94 dBi
0.0 dBmax
0.0 dBmax3D
3D Max Gain 9.94 dBi
Slice Max Gain 9.94 dBi @ Elev Angle = 26.0 deg.
Beamwidth 30.5 deg.; -3dB @ 12.3, 42.8 deg.
Sidelobe Gain -1.26 dBi @ Elev Angle = 146.0 deg.
Front/Sidelobe 11.2 dB

12M



10M

Guy Lines

The Dacron cord sold by Max-Gain Systems is durable but somewhat stretchy. When making the guy ropes, the cords should be pulled to a reasonable and consistent amount of tension during the measurement and S-hook tying process. Leave several inches of spare cord on one end to allow the lengths to be adjusted.

Assembly

The fiberglass spreaders were fastened with a #6 thread-cutting screw at each junction. All 30 nylon collars were drilled and tapped for ¼-20NC threads on the side opposite the set screw. The nylon eyebolt lengths were cut as needed to keep the band elements tensioned and equidistant from each other. Element gaps were made from Kevlar thread. With all eyebolts cut to minimum length, 30 inch guy ropes, and the element wires fairly taut, the elements slope upward slightly from the feedpoint. I may decide to make further adjustments to level the elements, but the EZNEC model indicates that this is not a problem.

Initial Results

Due to the increased weight of the center post the finished antenna weighs about 28 pounds. Initial testing with the antenna mounted near the ground looks promising and I expect the resonant frequencies to increase as the antenna is raised to 20 feet. Activity from the ongoing CQ WPX Contest was monitored with the low mounted antenna providing good reception and directivity. I will provide a follow-up when the antenna is elevated.

73,

Allen Baker, KG4JJH
Email: kg4jjh@arrl.net

Notes

1. Leo Shoemaker, K4KIO, *Hexagonal Beam*; http://leoshoemaker.com/hexbeambyk4kio/broadhexgeneral.html
2. J-F. Zürcher; HB9MCZ, *A homemade 5-band Hexbeam antenna for 10, 12, 15, 17 and 20m*, http://itopwww.epfl.ch/LEMA/Membres/hexbeam_HB9MCZ.html
3. S. Hunt, G3TXQ, *Hexbeam*; http://www.karinya.net/g3txq/hexbeam/index.html
4. McMaster-Carr; http://www.mcmaster.com/
5. DX Engineering; http://www.dxengineering.com/
6. Max-Gain Systems, http://www.mgs4u.com/hexbeam-kit.htm
7. L. Garro, M. Lancaster, P. Hall, *Air-filled square coaxial transmission line and its use in microwave filters*, IEEE Proc.-Microw. Antenna Propag., Vol. 152, No. 3, June 2005; http://ieeexplore.ieee.org/iel5/2196/31508/01468725.pdf?arnumber=1468725