Building a Five Band G3TXQ Broadband Hexagonal Beam

The hexagonal structure makes for a light and compact Yagi you can build.

Leo Shoemaker, K4KIO

Be ready for the sunspots' return with a home brew five band directional antenna with small footprint but top-notch performance. You can build this beam in six steps with parts from your local hardware store and a few online sites. I bought all my parts for under $350.

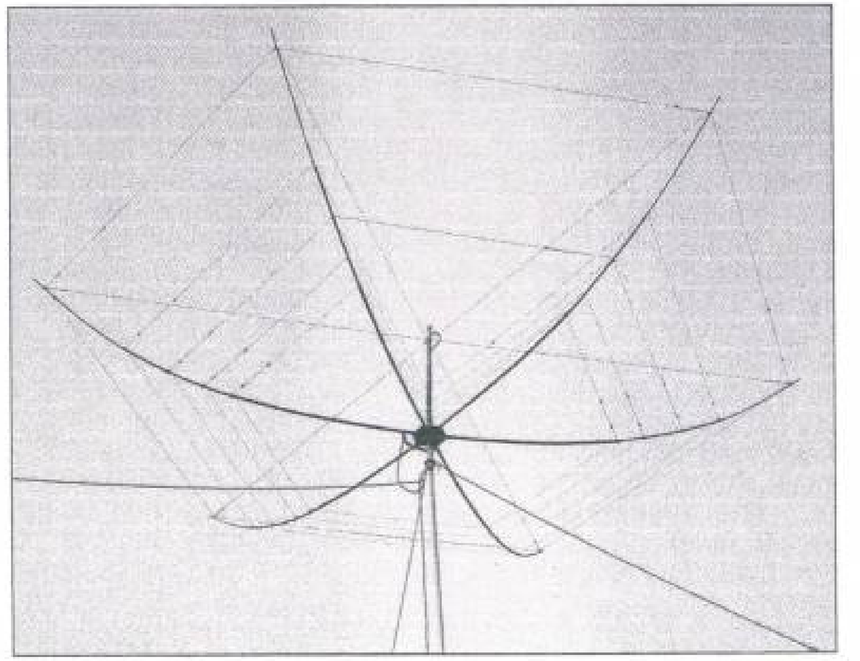

Figure 1 — G3TXQ broadband hexagonal beam built by K4KIO.

Why a Hexagonal Beam?

The G3TXQ broadband hexagonal beam is essentially a two element Yagi compressed to about ½ full size. It looks like nothing so much as an inverted umbrella. Its compact shape and symmetrical construction mean low weight and low wind loading so the beam can fit snugly into a garden home backyard. It can be mounted on a push-up mast and turned with a light duty rotator. It blends in well with trees providing a measure of stealth. The umbrella shape allows nesting of the wires of the five bands and use of a single feed line for them all. No traps or other tuning devices are needed and the antenna presents a 50 Ω SWR of under 2:1 over nearly all of the five bands 10 through 20 meters.

This hexagonal beam offers a number of features as follows:

- Forward gain and front/back nearly comparable to a two element Yagi.
- Five band operation with low SWR without traps or tuning devices.
- Broadband characteristics.
- Low noise performance.
- Low weight and low wind load.
- Construction from general hardware components and ease of adjustment.

The beam consists of two elements for each band. The driven element is in the shape of an M while the reflector element is wrapped around the four spreaders to the rear of the driver wires as shown in Figure 2. The elements are made of wire instead of the tubes used by most Yagi antennas. That means you need the supporting structure made up of six flexible fiberglass tubes attached to a base plate. Viewed from above, it is in the shape of a hexagon, giving the antenna its name. The antenna shape is held together by the base/rod/center post structure, the wires and Kevlar/Dacron cords.

The antenna is just under 22 feet in diameter, is constructed of six fiberglass tubes and 16 gauge stranded copper wire, and weighs about 22 pounds. The center post is a 5 foot piece of fiberglass or PVC. The single 50 Ω coax snakes up the side of the center post where it feeds all the driver wires of the hexagonal beam from the top.

G3TXQ Broadband Hexagonal Beam

This beam resembles in structure the Hex-Beam® described by M. I. Traffie, N1HXA, in *Communications Quarterly*.[1] Many homebrew versions of this antenna, referred to here as the *classic* version, have been built in the past decades. They are built on the same frame as the G3TXQ broadband hexagonal beam described above but are slightly smaller with a diameter of about 19 feet because the reflector wire is bent into a W configuration while the driver wire remains in the shape of an M.

While the classic version is a great antenna, its size compression results in a relatively narrow SWR bandwidth as shown by *EZNEC* modeling outputs with the red trace in Figures 3A and 3B. This means you have to choose which portion of the band, CW or phone, you want to operate in if you want maximal performance. Another unfortunate fact is that the optimal performance "sweet spot" of the classic version is on the downward slope of the SWR curve in the range of 2:1 rather than at the minimal SWR point. This just means you would need to use a tuner to correct the SWR if you are operating away from the optimal design frequency.

The classic version was given a significant performance boost with a design improvement by Steve Hunt, G3TXQ.[2] Steve experimented with and modeled various changes in the reflector seeking to overcome the narrowbanded performance of the classic version. The result was discovery of a change in reflector shape that gives the hexagonal beam a lower Q and big boost in bandwidth while actually improving both gain and SWR performance. The only penalty for this improved performance is a slight increase in size. The classic version of the five band hexagonal beam is 19 feet in diameter; this new broad-

[1]Notes appear on page 33.

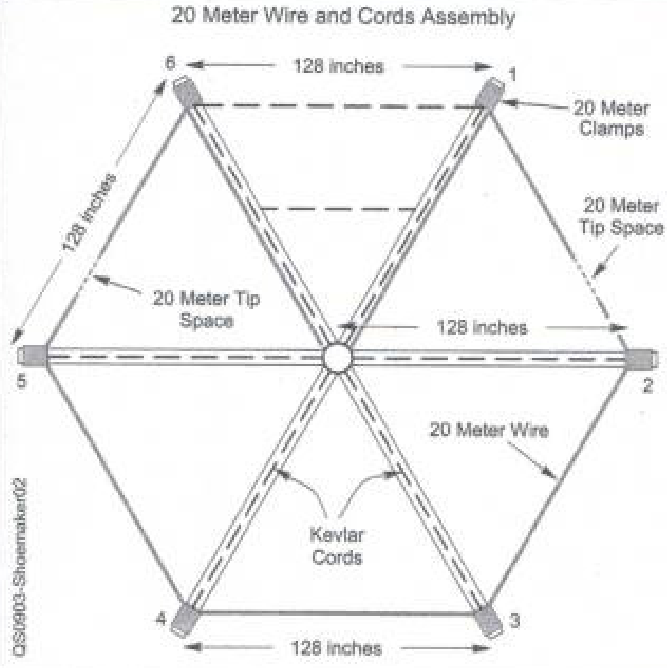

Figure 2 — Top view sketch of single band broadband hexagonal beam, wires and spacers only. The driven element is at the top, the reflector below.

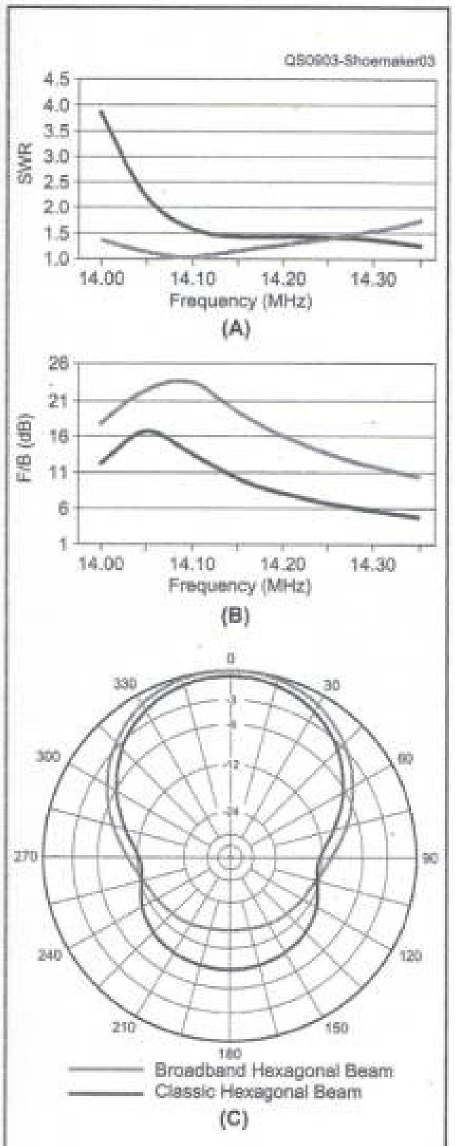

Figure 3 — Comparison of *EZNEC* modeling of broadband hexagonal beam with classic version. At (A) SWR, at (B) front/back performance and at (C) gain in dBi at 30 feet over average ground at optimal elevation angle.

band version is 21.5 feet, or 13%, larger.

As illustrated with *EZNEC* modeling, the blue trace in Figures 3A and 3B show this new broadband design has higher front to back performance and better SWR response over a significantly wider frequency range than the older version of the hexagonal beam. The front to back performance (F/B) for the G3TXQ broadband hexagonal beam is in excess of 10 dB over the entire 20 meter band, whereas for the classic version F/B exceeds 10 dB only in a range of 150 kHz. In addition to the improvements in SWR and F/B, the broadband model has a little more forward gain as shown in the *EZNEC* azimuth radiation pattern in Figure 3C. Finally, the *sweet spot* for design is not only broader but is centered on the lowest SWR point making it easier to operate without a tuner. Performance characteristics and comparisons for the other four bands are similar to those for 20 meters.

Building a Broadband Hexagonal Beam

The broad band hexagonal beam has now been built by a sizable number of hams who enthusiastically report on its on-air performance even in the pits of the present sunspot cycle. You can join this group by following these six steps for constructing a G3TXQ broad band hexagonal beam using mainly hardware store components with some parts from online suppliers.

Step One — The Base plate

The base plate is made of a 12 inch square type 6061 T6 aluminum plate that is 3/16 inch thick. This particular type of aluminum is harder than pure aluminum and less likely to bend while being resistant to weather. Sketch the hexagon using the approach shown in the drawing on the *QST* Binaries Web site.[3] You can cut the plate with a hacksaw and drill the center hole using a 1¼ inch metal hole saw. U bolts are used to secure the spreaders to the base plate. A square base floor flange normally used for handrails is ideal for mounting the center post to the base plate. The black arrow shown in Figure 4 helps keep you oriented as you install the wires later in step six. Stainless steel hardware should be used to minimize corrosion and lock washers will help keep the fixtures from loosening with movement of the hexagonal beam by wind and rotation.

Step Two — The Spreaders

Fiberglass tubes are recommended for the spreaders. Three thicknesses are needed: 1, ¾ and ½ inch outside diameter. Max Gain Systems offers fiberglass tubes that are ideal for this.[4] The smaller sizes slip perfectly into the next larger sizes. In fact, due to popular demand, Max Gain recently began packaging the specific sizes for this broadband hexagonal beam as a special kit. Fiberglass has the strength plus the spring needed to hold the hexagonal beam in shape. I know of many who have tried to use PVC for spreaders but none reported good results. PVC is just too heavy and limber for use in this application, although it will work fine for the center post.

The spreader sections can be glued together with adhesive, bolted together or attached together with hose clamps for easy disassembly for DXpedition or ARRL Field Day use. In order to get the proper curvature

Table 1

Table of Wire Lengths and Tip Spacer Lengths

Measurements in inches

Band (Meters)	*Design Frequency (MHz)*	*½ Driver Wire Length*	*Full Reflector Wire Length*	*Tip Space*	*Height of Wires Above Baseplate*
20	14.150	218.0	412.0	24.0	42
17	18.100	169.5	321.0	18.5	20
15	21.250	144.5	274.4	16.0	14
12	24.950	121.7	232.0	13.5	10
10	28.400	106.8	204.4	12.0	6

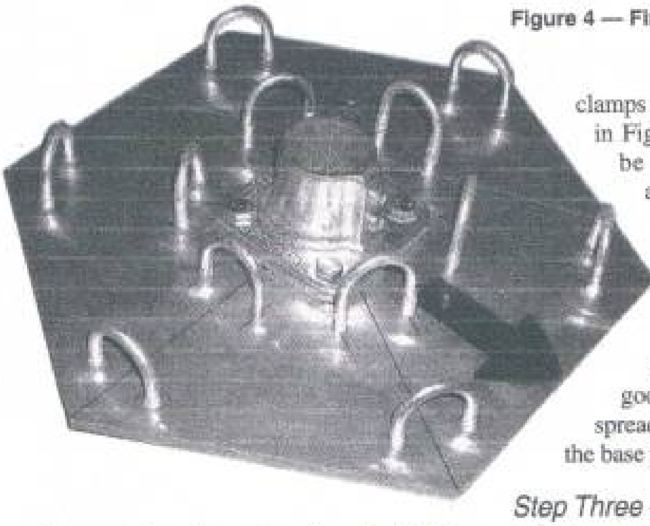

Figure 4 — Finished base plate.

of the spreaders the construction should follow the guidance in Figure 5A. If you depart from this approach, your curvature might be different and it might, in turn, require different vertical center post positions for the wire terminals. You will need 139 inches in length for each spreader. Slip five stainless hose clamps on the spreaders as shown in Figure 5B. These clamps will be used to anchor the wire assemblies to the spreaders and the exact locations will be adjusted later in Step Six. Painting the spreaders with a primer and your choice of colors for UV protection is a good idea. Figure 5B shows the spreaders ready for installation on the base plate.

Step Three — Center Post

The center post provides the anchor for the driver wires and the support cords, as well as a feeding arrangement for the driver wires. It is 1¼ inch outside diameter fiberglass tube or 1 inch inside diameter PVC 5 feet long with European style double terminals for connections of the driver wires and coax feed line. These terminals are sold in 12 piece assemblies at RadioShack and can be easily cut into doublets. Holes for #6-32 by 2 inch brass round head bolts should be drilled at the vertical locations as shown in Figure 6A for mounting the terminals.

The transmission line itself is 50 Ω coax and should be connected at the top of the post to the terminals for 20 meters. Modeling as well as actual testing has shown that top feeding is slightly preferable to connecting the feed line at the bottom. Each set of driver wires is connected via small pieces of coax as shown in Figure 6B. Use RG-58 coax if you plan to keep power levels under 500 W; otherwise RG-213 is recommended. After completing the installation of the feed line components, it would be a good idea to do an ohmmeter check to make sure there are no short circuits of coax braid to the inside wire. Later, after the wires have been connected, smearing liquid tape over the exposed coax braid will keep moisture from wicking in and prevent rusting of the terminals.

Drill a hole for a stainless steel bolt through a PVC cap as shown in Figure 6B for the center post. Install a bolt to be used as an anchor point for the radial support cords in step four. The center post is slid through the floor flange on the base plate and the flange set screws are used to hold it in position. It should be positioned about 4 feet above the base and 1 foot below for insertion into the mast.

Step Four — Making the Wire/Tip Spacer Assemblies and Support Cords

The driven elements consist of two pieces of wire for each band. The reflectors are a single piece of wire for each band. Each driven element piece will be shaped by the hex beam structure into an inverted V and when arranged next to the other piece, will form an M. Each reflector piece will be wrapped around the four spreaders and attached to non-conducting cords called tip spacers, which in turn are attached to the driver wires.

Lengths of the driver and reflector wires for 16 gauge stranded wire and tip spacers are shown in Table 1. Be precise in cutting the wires as an inch can make a difference in the resonant frequency. A ring terminal should be soldered on one end of each driver wire and both ends of the reflector wire to tie the tip spacers between the driver wires and the reflector. About ½ inch of the other end of the driver wires should be bent into an L shape for insertion into the terminals on the center post. Add this L length to the specifications in Table 1.

The tip spacers are made up of very strong Kevlar/Dacron cord. It does not stretch and resists UV radiation. Add a few inches for knotting the tip spacers to the specifications in Table 1.

The two half driver wires, the reflector wire

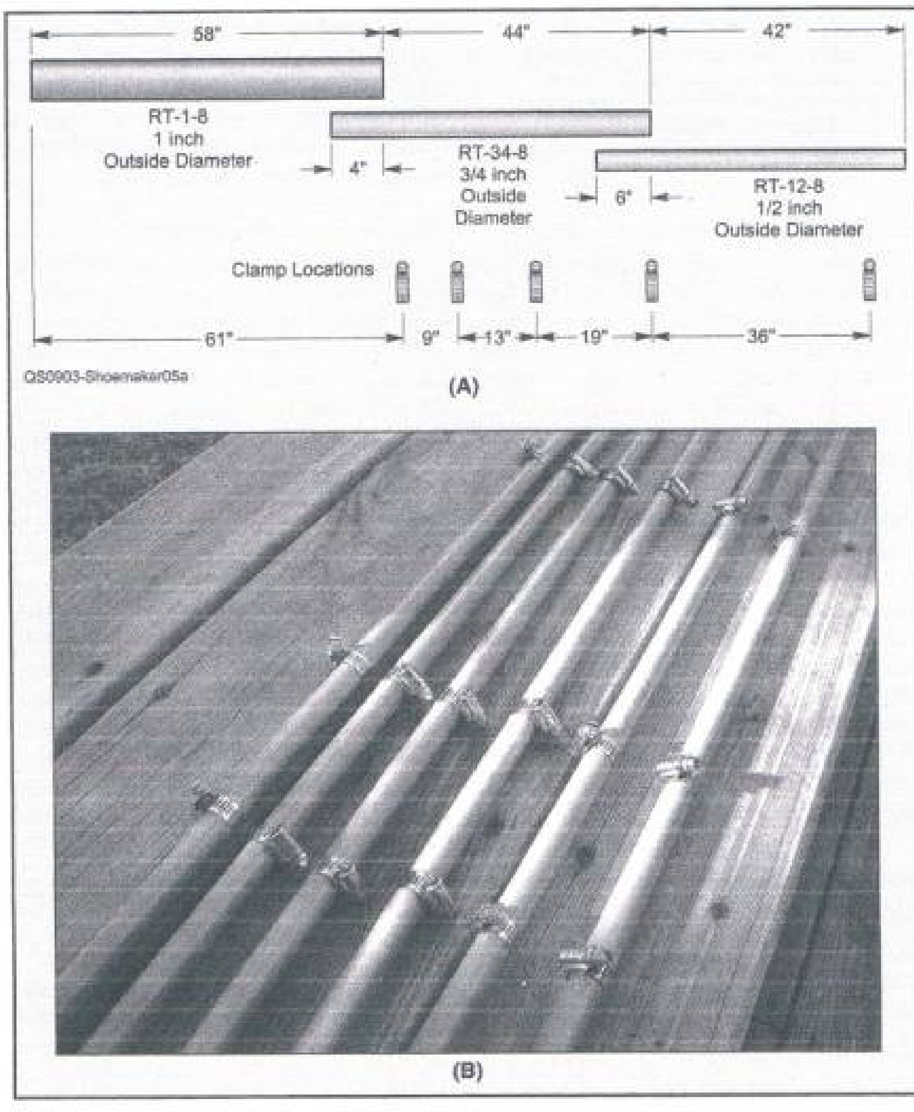

Figure 5 — Spreader details. At (A) spreader components and clamp locations, at (B) spreaders with clamps in place for assembly.

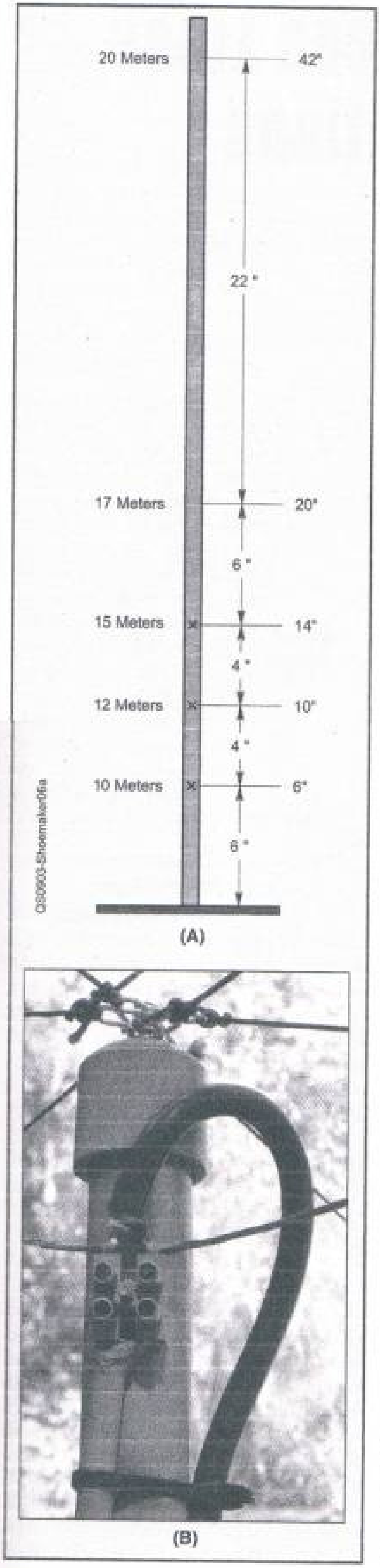

Figure 6 — Center post details. At (A) vertical locations of terminals on center post. At (B) center post with terminals and wires installed. Note the coax feed line up the side of the post.

and the two tip spacers should be measured and assembled as single end to end sets before installation on the spreaders using the approach below for each band. It is easy to get the five bands wire/tip spacer assemblies mixed up so careful labeling of them is a good idea.

Twelve support cords are also needed as shown in Figure 2. These cords should be made of Kevlar/Dacron cord 129 inches long, not including the little S hooks on the ends. Six cords are used for radial support from the ends of the spreaders to the top of the center post. The other six cords are used for perimeter support around the ends of the spreaders to keep them in position. Together these cords establish and maintain the upside down umbrella shape that is needed to mount wire/tip spacer assemblies for the five bands.

Step Five — Assembling the Frame

You will need a temporary test stand for mounting the hex beam during assembly of the wires. This can be a 2 inch steel pipe driven in the ground, a table, stand or other arrangement to hold the assembly erect while wires are installed and adjusted.

Attach the spreaders to the base plate using the ½ inch pipe U bolts and ¼ inch split lock washers. Be careful not to crush the spreaders with the U bolts.

First, establish the inverted umbrella shape of the hex beam using 12 support cords. This will make it much easier to install the wires with a minimum of fuss because you won't have the tension of the spreaders making it difficult to pull the clamps and wires into the right position on the spreaders.

Hook one of the support cords to a spreader end and then to the center post cap, pulling the spreader up into the bowed position. Repeat this for the other five spreaders. Now, hook support cords from the ends of each of the spreaders, as shown in detail on the *QST* binaries Web site, to the adjacent spreader until you have 12 cords installed and the shape of the hex beam is established in preparation for installation of the wires.

Step Six — Installing the Wire/Tip Space Assemblies

Attach the wire/tip spacer assembly to the spreader hose clamps closest to the center post using cable ties starting with the 10 meter band. Leave the cable ties open so the wires can move freely. Insert the ends of the driver wires into the bottom center post terminal and tighten the set screws. If the wire is too short to reach the terminal, then loosen one of the hose clamps and let it slide inward creating more slack. After connecting to the terminals, adjust the position of the hose clamps to take most of the slack out of the wire/tip spacer assembly. But do not make it too taut since this could distort the overall shape of the hexagonal beam. Loose wires do not harm performance, within limits of course. Repeat this process for 12 meters and continue on until all five bands' wire/tip spacer assemblies have been installed and adjusted.

Adjust to make the wire sections level, and parallel with one another by only making small changes in clamp positions. Look along the vertical alignment of the bent spreaders to make sure none are twisted out of shape. This is more art than science, but if you are patient, you will obtain a well balanced, symmetrical hexagonal beam.

The beam is now ready for mounting on a mast or tower. You should run SWR tests first to ensure that the wires are tuned properly. At near ground level, the SWR will not be nearly as good as what you should expect when the beam is 20 to 40 feet high, but you should be able to see a dip in SWR to the range of 2 or 3:1 while the beam is on the test stand. Use a portable SWR test set and a short coax connector cable to get a better dip on this first round of tests at ground level.

The beam can now be mounted on a push-up mast or tower. These steps are explained and illustrated in more detail on my Web site at **www.hex-beam.com**.

Conclusion

Many hams have longed for a directional high frequency multiband beam that is affordable and more compact than a full scale Yagi. This G3TXQ broadband hexagonal beam could be the answer for you as it was for me. If you rise to the challenge of building one while awaiting the return of decent propagation you will be ready for the sunspots.

Notes

[1]Registered Trademark of Traffie Technology. M. Traffie, N1HXA, "Miniature Antennas," *Communications Quarterly*, Spring 1996, pp 99-103.

[2]S. Hunt, G3TXQ, "A Broadband Hexagonal Beam," *AntenneX* Online Issue No. 128, Dec 2007.

[3]Detailed parts list and drawings may be found at **www.arrl.org/files/qst-binaries**.

[4]**www.mgs4u.com**.

Leo Shoemaker, K4KIO, was first licensed as a Novice in 1956. He holds an Amateur Extra class license, a degree in electrical engineering from the University of Louisville and he spent his career with BellSouth. He enjoys working DX on both CW and SSB and experimenting with wire beam antennas. Leo is an ARRL member and can be reached at 2610 Acton Rd, Birmingham, AL 35243 or through his Web site at **www.leoshoemaker.com/k4kio.html**.