PW Publishing Ltd., Arrowsmith Court, Station Approach, Broadstone, Dorset BH18 8PW
E-Mail: antennas@pwpublishing.ltd.uk

Hexbeam – A Multi-Band Antennna

Steve Hunt G3TXQ describes the development and construction of a new version of the Hexbeam. It trades a modest increase in turning radius for a very significant improvement in performance bandwidth.

The classic Hexbeam is an attractive antenna for anyone with limited space. It offers reasonable five band (14-28MHz) performance in a lightweight package, and has a small turning radius. What's more, if you prefer to make your own rather than buy the commercial version, it can be built at low cost without needing specialist tools.

The defining feature of the Hexbeam is its shape: the driver and reflector elements of this 2-element parasitic beam are bent into a 'W' shape to conserve space, **Fig. 1**. Unfortunately this has the effect of raising the element *Q* (from 10 for a linear element, to 30 for the 'W' shaped element) and so reducing the performance bandwidth.

The increase in *Q* also produces a feed-point impedance that is only a moderate match (2.1:1) to 50Ω at the frequencies where the front-to-back ratio (F/B) and forward gain peak. If we define the performance bandwidth of the antenna as the range over which it exhibits a F/B > 10dB, an s.w.r. < 2:1, and forward gain > 2dBd, the classic Hexbeam manages just 120kHz of the 14MHz (20m) band.

Modelling the antenna shows that the performance bandwidth is almost entirely dependent on the *Q* of the reflector - the *Q* of the driver has little impact. I spent many hours modelling, and testing on a 10m prototype, various reflector constructions designed to have low *Q*.

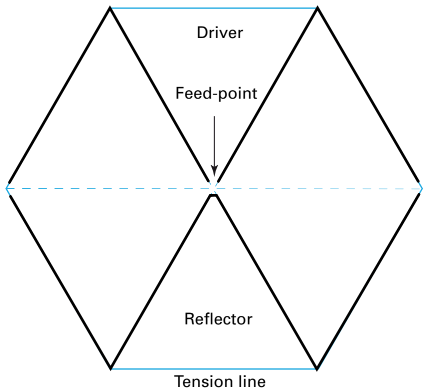

Fig. 1: The 'classic' Hexbeam based on a hexagonal shape is formed from two 'W's.

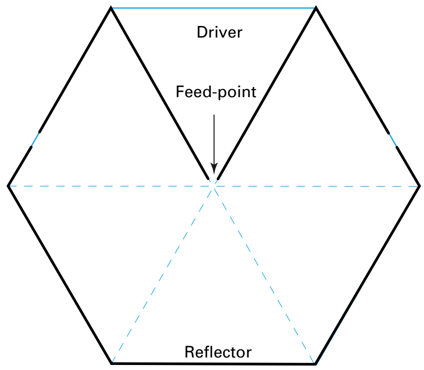

Fig. 2: Changing the shape of the reflector has advantages of performance, with minor increases in the turning circle.

Fatter Wires

The variations I tried included 'fatter' wires constructed from coaxial cable, commercial ladder-line and 'caged wires', and also modifications to the shape. As is often the case, the simplest idea turned out to be the most effective. 'Straightening' the reflector as much as possible, within the bounds of the hexagonal shape, **Fig. 2** had a dramatic effect on its Q, reducing it from 30 to about 14.

The lowered *Q*, translates to a performance bandwidth which now covers the whole of each of the bands 14 to 24MHz, and a 1MHz slice of the 28MHz (10m) band. The penalty is a modest increase in turning radius from 2.9m to 3.3m for a 14MHz version.

It turns out there's no point making the same change to the driver. Keeping the 'W' shape avoids a further increase in turning radius, retains the convenience of a feed-point that can be supported by a

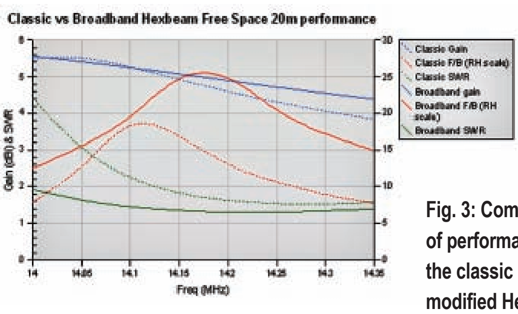

Fig. 3: Comparison of performances of the classic and the modified Hexbeam.

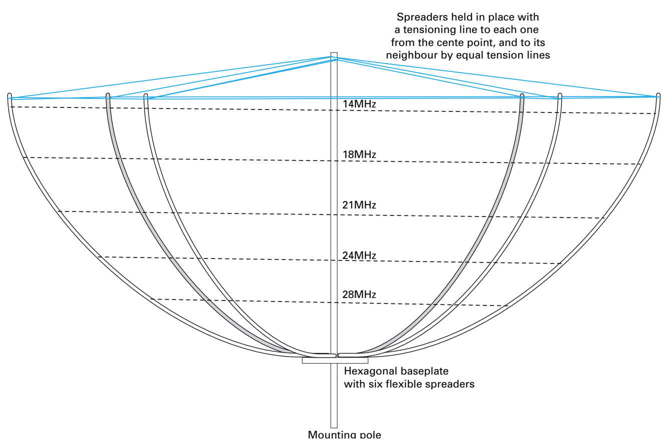

Fig. 4: A cross-section view of the tensioned spreaders, and the relative placings for each band. (Not to scale).

Fig. 5: A closer look at the centre bracket on Steve G3TXQ's prototype.

Fig. 6: Steve made up tie-point rings to be put into the ends of each spreader, making tying off easier.

Fig. 7: Two 'tie-wraps make a good 'P"-clip, A few layers of insulated tape wrapped around the spreader. keep it from moving.

Table 1

	14MHz	18MHz	21MHz	24MHz	28-29MHz
Driver (half-length)	5.88m	4.52m	3.9m	3.28m	2.71m
Reflector (half-length)	5.55m	4.33m	3.7m	3.13m	2.76m
End spacing	610mm	470mm	406mm	343mm	305mm
Hexagon side dimensions	3.46m	2.67m	2.3m	1.94m	1.71m
Vertical distance from 10m wires	965mm	381mm	229mm	127mm	–

centre post, and provides a better match to 50Ω. In fact, the driver length can now be adjusted to set minimum s.w.r. to coincide with peak F/B performance.

The modelled free-space 14MHz performance of the new design compared to a classic Hexbeam is presented in **Fig. 3**, and clearly shows its advantages:

Incidentally, we should notice that the s.w.r. of the classic Hexbeam is much better at frequencies where its F/B performance is mediocre. This helps explain why constructors who are tempted to tune their classic Hexbeams for minimum s.w.r. are invariably disappointed by its performance!

As with the classic Hexbeam, better peak F/B figures can be achieved on the broadband version by increasing the end spacing between the tips of the Driver and Reflector elements. However this always causes some deterioration in the s.w.r., and often the high F/B figures are illusory - they result from deep but narrow 'notches' at the rear of the azimuth pattern. A closer look at the pattern often shows a front-to back performance that is little improved, and not worth the trade-off with s.w.r.

Self Resonant

The performance presented above is typical of an antenna whose reflector and driver are self resonant 0.7% below, and 0.7% above, the frequency of peak F/B respectively. Corresponding physical dimensions for a mono-band antenna constructed from 1.6mm (16s.w.g.) wire are shown in **Table 1**, or calculated as below:

Corresponding physical dimensions for a mono-band antenna constructed from 1.65mm (16s.w.g.) wire are:

Driver (half-length) = 78.36/f (m)

Reflector (half-length) = 74.04/f (m)

End spacing = 8.64/f (m)

Where f is the frequency in MHz of peak F/B ratio. When choosing this frequency, notice that the F/B performance falls more rapidly at frequencies below the peak than above it, so pick a frequency about one third the way into your band of interest.

Don't be alarmed on spotting that drivers are longer than reflectors - this is a consequence of their differing shapes! What matters is not their length, but where they resonate.

The 'traditional' and elegant way to construct a multi-band Hexbeam is to build a lightweight support structure comprising six radial fibreglass spreaders. The spreaders are 'bowed' to create a 3-dimensional structure within which the various band elements can be stacked vertically **Fig. 4**.

With care, the various bands can be fed with a common feedline with little detriment to performance. The trick is to feed it at the top of the array – the lowest frequency band – and to interconnect the feed-points with 50Ω coaxial cable rather than a higher-impedance line.

Minor Adjustments

Compared to mono-band dimensions, minor adjustments have to be made to the drivers to optimise the impedance match, and to the reflectors to compensate for the de-tuning effect of adjacent wires. There is a particular problem with interaction between the 28 and 24MHz elements because the shallow angle at the bottom of the typical support structure often results in little vertical separation between these wires. A combination of EZNEC modelling, and optimisation on a prototype antenna, produced the set of dimensions, shown in Table 1 for a 14–28MHz array:

There are probably as many ways of building a Hexbeam as there are constructors out there in *PW* land! I started with a 6mm thick hexagonal aluminium baseplate that I attached with U-bolts to a suitable fibreglass centre-post using two brackets formed from aluminium channel **Fig. 5**. The centre post need to extend about 1.3m above the baseplate, and far enough below it to suit your rotator fixing arrangements.

I chose to attach the spreaders by bolting some aluminium tubing to the baseplate and slotting the spreaders into them. Use U-bolts if you prefer, but be sure not to over-tighten them and crush the spreaders.

I've found that spreaders made of cheap telescopic fishing poles stand up to UK weather conditions pretty well. However, if you live somewhere less benign you may want to invest in something more substantial. The spreaders will need to extend about 3.9m from the centre post to produce the required 3.5m horizontal radius at the top of the array after 'bowing' – but **please check this with the materials you've chosen** - yours may 'bow' a different amount than mine!

If you go the fishing pole route, buy

long enough ones that you can throw away the top 'whippy' section. It's nearly always too thin and flexible to be useful.

The spreaders are held under tension in the required shape by a combination of the 14MHz wires and extra support cords at the top of the array **Fig. 6**. To get fixings for them I pushed plastic wall plugs into the ends of spreaders and then inserted stainless self-tapping screws. Wires for the other bands sit lower down and can be strung more loosely.

Right Shape

It's much easier to mount the 14MHz wires if you first get the structure into the right shape. This can be achieved by tying the spreader tips to the centre post with six 3.5m radial cords, and then tying their tips together laterally with six more 3.5m circumferential cords. Then – because all the cords are the same length – you must end up with a regular hexagon.

Once the 14MHz wires are in place and under tension you will find that two of the radial cords and five of the circumferential cords are redundant and can be removed. Depending on the stiffness of your spreaders and how tightly you've strung wires for the other bands, you may find you need one more lateral cord between the mid-points of the 21MHz (15m) drivers to retain the shape.

To get fixings for the other bands I made small loops out of plastic tie-wraps and fixed them to the spreaders with a second tie wrap **Fig. 7**. A few turns of insulating tape prevents any tendency for them to slide along the spreader.

At the feed-point, the driver wires are fixed to terminal posts comprising brass screws bolted through the centre post. I soldered brass 'dome nuts' onto the driver wires which then screw onto the terminals, but using 'spade terminals' would have been easier! An extra nut and pair of washers on each terminal post allows for the inter-band coaxial cable connections.

If you use particularly long terminals, remember to take account of them as part of the wire dimensions. The feed-points for each band are interconnected with 50Ω coaxial cable running down the outside of the centre post, and the antenna is fed at the 14MHz position with 50Ω line. Be sure to keep the braid of the interconnecting cables always connected to the same side of the array.

The end-spacing between the tips of the drivers and reflectors is formed with a length of Dacron cord. I used brass terminal blocks to clamp the wires to the cord and allow easy adjustment of the spacing. These terminal blocks add a significant amount of 'capacity loading' which has been taken into account in the 5-band dimensions given in Table 1.

When fully assembled, I measured the F/B performance and input impedance of the prototype antenna with the baseplate at a test height of about 6m. Note that, at this height the 14 and 18MHz F/B performance is enhanced over its free space value, and the 24 and 28MHz performance is suppressed. My findings are shown in **Fig.**s **8 – 12**.

My modified Hexabeam isn't a 'magic' antenna and it will not outperform a full-size Yagi design. However, if you are looking for useful directivity for 14-24MHz, plus a good slice of the 28MHz band, in a lightweight, low-cost, package with a turning radius less than 3.6m, this new broadband Hexbeam design should be high on your list of options. Try one yourself and let me know how you get on! ●

References
If you'd like to know more about the Hexbeam - classic and broadband versions - including more constructional ideas, take a look at my web site:
www.karinya.net/g3txq/hexbeam/

Note: Leo Shoemaker K4KIO has an excellent site with step-by-step building instructions:
www.leoshoemaker.com/hexbeambyk4kio/general.html

There is also a very active and helpful Yahoo Hexbeam group:
http://groups.yahoo.com/group/hex-beam/

And finally, the classic Hexbeam is still available commercially from **Mike Traffie**:
www.hexbeam.com/

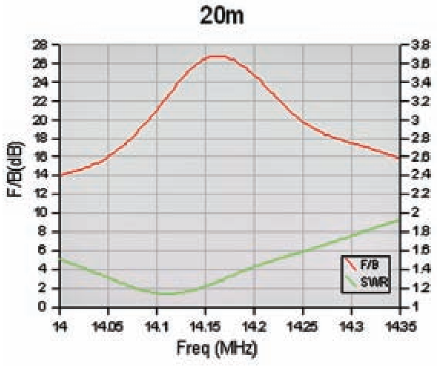

Fig. 8: Performance on 14MHz.

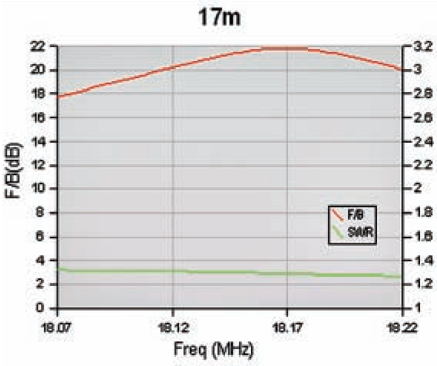

Fig. 9: Performance on 18MHz.

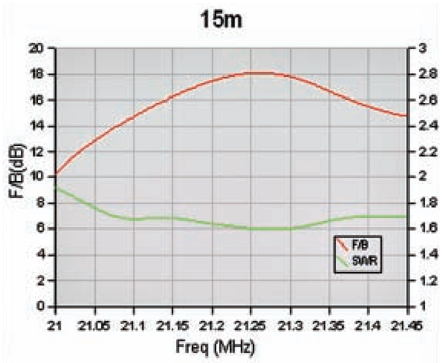

Fig. 10: Performance on 21MHz.

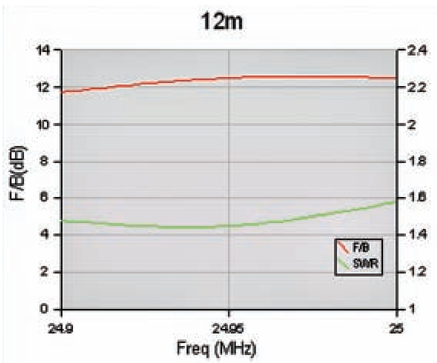

Fig. 11: Performance on 24MHz.

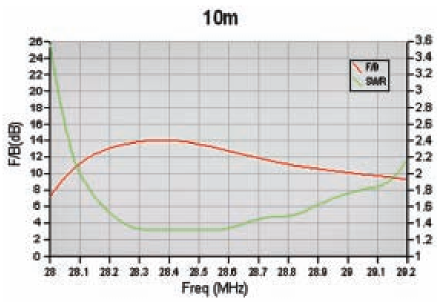

Fig. 12: Performance on 28MHz.

It's not a 'magic' antenna but Steve G3TXQ has made some improvements!