Optimised reflector arrays for enhanced performance in Yagi antennas

by Justin Johnson, G0KSC

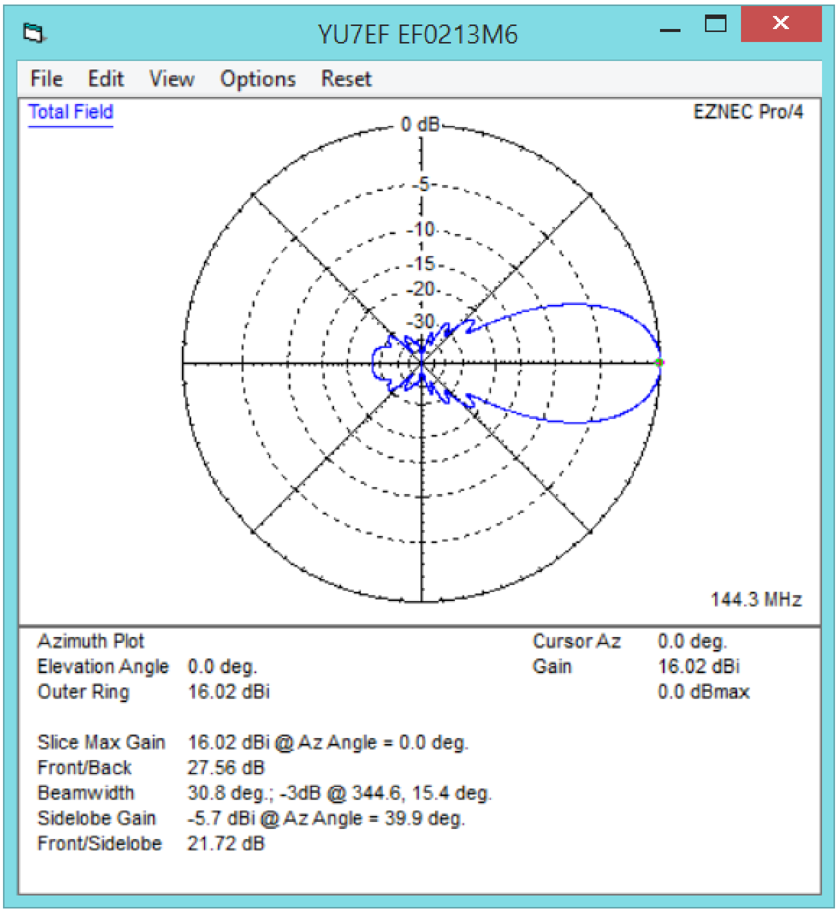
Introduction

Within the pages of DUBUS 4/13 Brian Cake, KF2YN demonstrated the effect of his choke ring within his POLLY variable polarisation beam antenna. Within this article we will look at how straight wire reflectors can be used in order to create the same performance enhancements as the choke ring without the mechanical complications of such a ring arrangement being incorporated into a conventional Yagi antenna. Simple and complex versions will be discussed and effects demonstrated in software model.

Two additional reflectors or more

Pop, YU7EF and I were discussing one evening the effects of the choke ring on the YU7EF EF7015M-5 Brian KF2YN demonstrated and the resulting improvements. I recalled when developing the LFA Plus 2 (which applies 2 additional reflectors above and below the first) had shown a similar result although not as pronounced as those seen by Brain within his POLLY beam.
Pop had been experimenting with the choke ring on one of his newer 2m models, the EF0213M6 and forwarded me the associated EZNEC files for this antenna, I applied a pair of additional reflectors to the Yagi but rather than set these behind the existing reflector, moved them forward to a similar position to that of Brian's choke ring, the results of which are detailed below.

Fig. 1 shows the EF0213M6 Yagi with a single reflector as originally designed while Fig. 2 shows the addition of the KF2YN choke ring along with the associated pattern improvements. Fig. 3 shows the results when the choke ring is removed and 2 additional straight-wire reflectors placed above and below the original Yagi reflector.



Exhaustive experimentation was not made on the size of the choke ring, nor were the positions of the ring and reflectors optimised along the boom (or reflector size). However, both scenarios seem to peak in deliverable improvements when positioned around 25mm forward of the original reflector where very good results are seen. The twin straight-wire reflector exhibit an improvement in side lobe reduction and F/B over both the original and the choke ring version (F/B improvement 8.04dB and 2.71dB over the original EF0213M6 and choke ring version, respectively) while gain is improved over the original but down on the choke ring version by 0.01dB.

Fig. 1

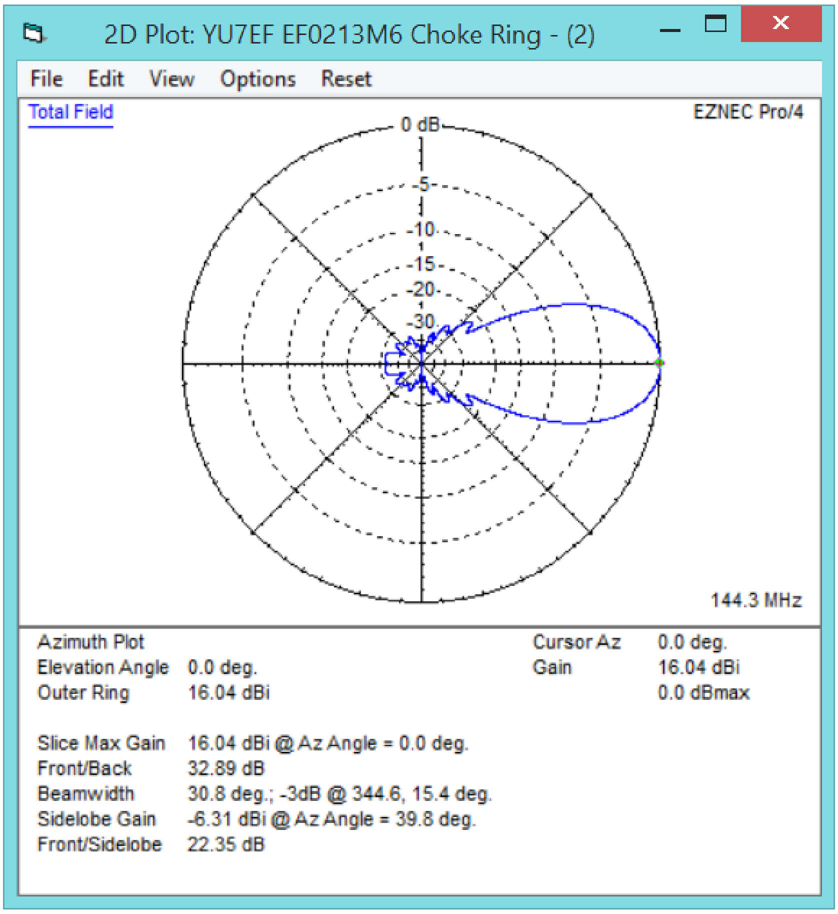


Fig. 2

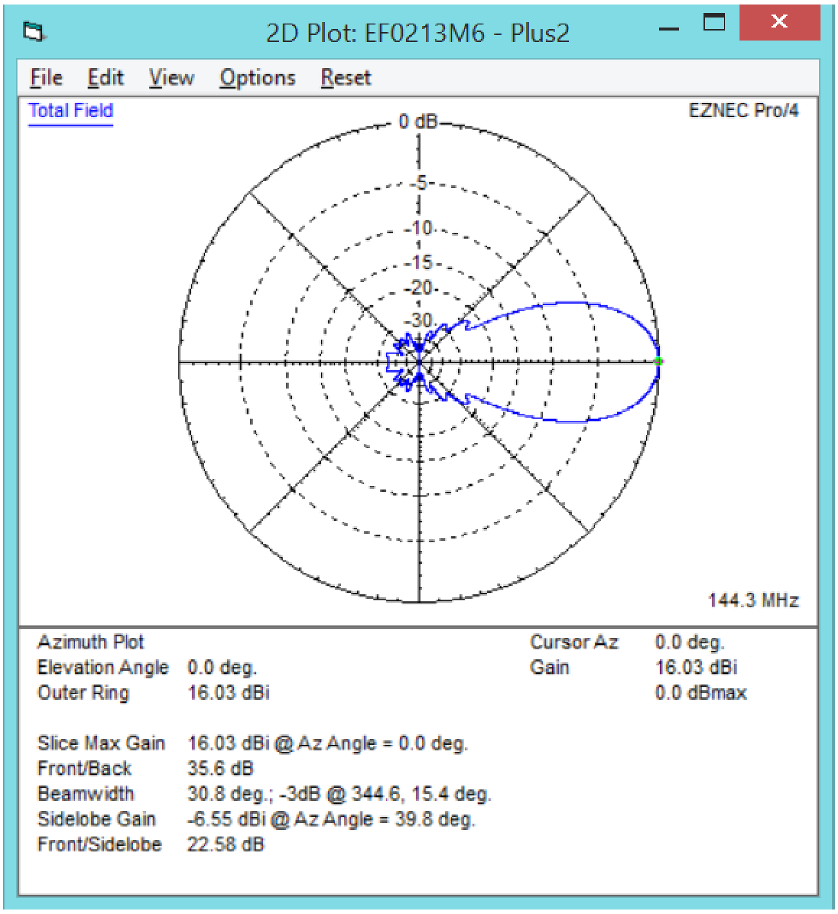


Fig. 3

Fig. 4 and Fig. 5 show the YU7EF EF0213M6 layout with choke ring and Plus 2 elements installed, respectively.

With my original Plus2 LFA, the additional reflectors were behind the original reflector rather than in front and thus increased boom length for any given antenna and therefore, the forward positioning of any choke ring or reflectors as per the KF2YN design certainly is a find worth noting and led me to experiment a little further with more reflectors but this time, using LFA templates on 70cms where additional reflectors of this kind would be a much more viable option than on 2m.

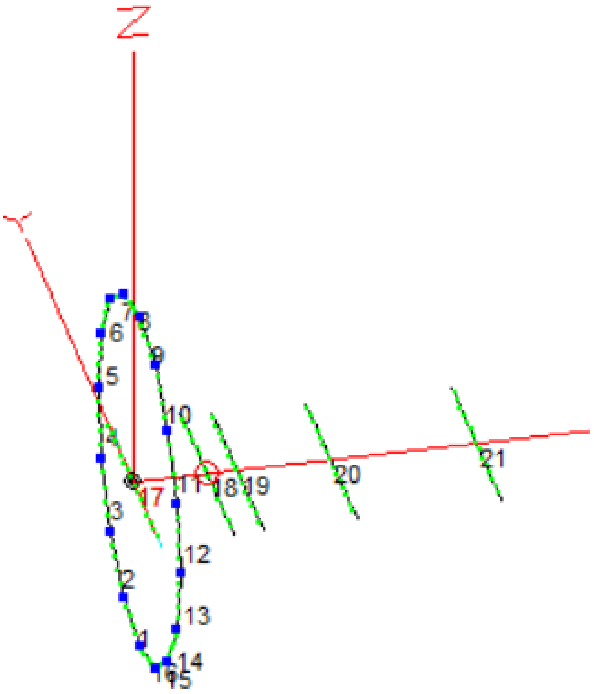


Fig. 4

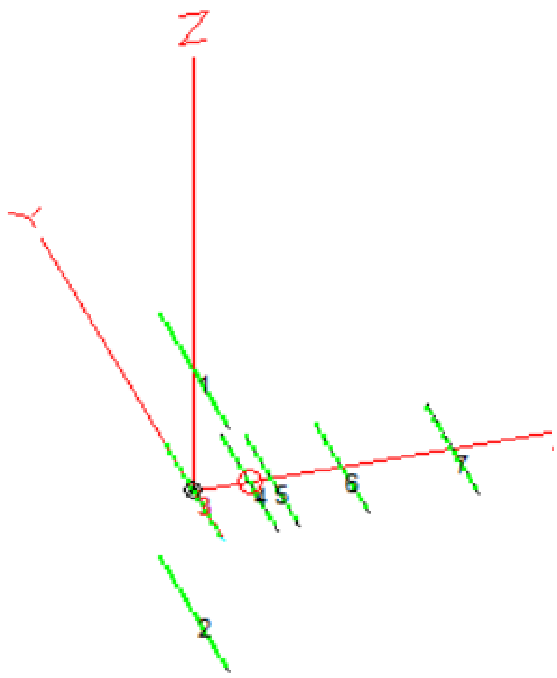


Fig. 5

Optimised reflector arrays within Yagi antennas

It became clear early on in my experimentation that clustering reflectors at a predetermined spacing did not yield best results and that allowing a 'free hand' to computer optimisers resulted in some very unconventional reflector layouts.

First I picked a longer 70cms Yagi, a 24 element wide band version which provides a flat SWR response between 430MHz and 435MHz. The bandwidth part is significant as the overall 'rear bubble' size tends to increase as bandwidth so should the addition of an optimised reflector array further increase pattern suppression while maintaining a wide flat SWR curve, a double-win would have been achieved.

Upon applying 2 additional elements to the above antenna, similar improvements where seen to those seen on the YU7EF 2m example and can be seen below in Fig. 6 and Fig. 7. The rear bubble is reduced in all areas with an improvement in F/B of 7.7dB (41.1dB, up from 33.4dB) with the same 0.01dB drop in gain experienced on the 2m example shown earlier. While the vertical spacing of the additional straight wire reflectors is similar in percentage terms to the 2m version, the boom positioning is a little different as the new reflectors are in the same plane as the original. Moving the additional reflectors back behind the original (as per the original Plus2 design) continues improvements in side lobe reduction and F/R. However, any further improvements are small and by so doing, boom length is increased.

Using my computer optimisers, I was able to achieve even better results with multiple reflectors although after two (a 4 additional reflector version (built) is shown in picture 1), we quickly arrive at a point of diminishing returns. For example, the implementation of corner reflector arrays within individually optimised lengths improved F/R further (from the 45 degree line on the azimuth plot backwards) in order that F/R exceeds 40dB significantly although it could be said a F/R in excess of 38dB as provided by the Plus2 version is plenty enough for most amateur applications.

Picture 1: A modern computer optimised 4 reflector array

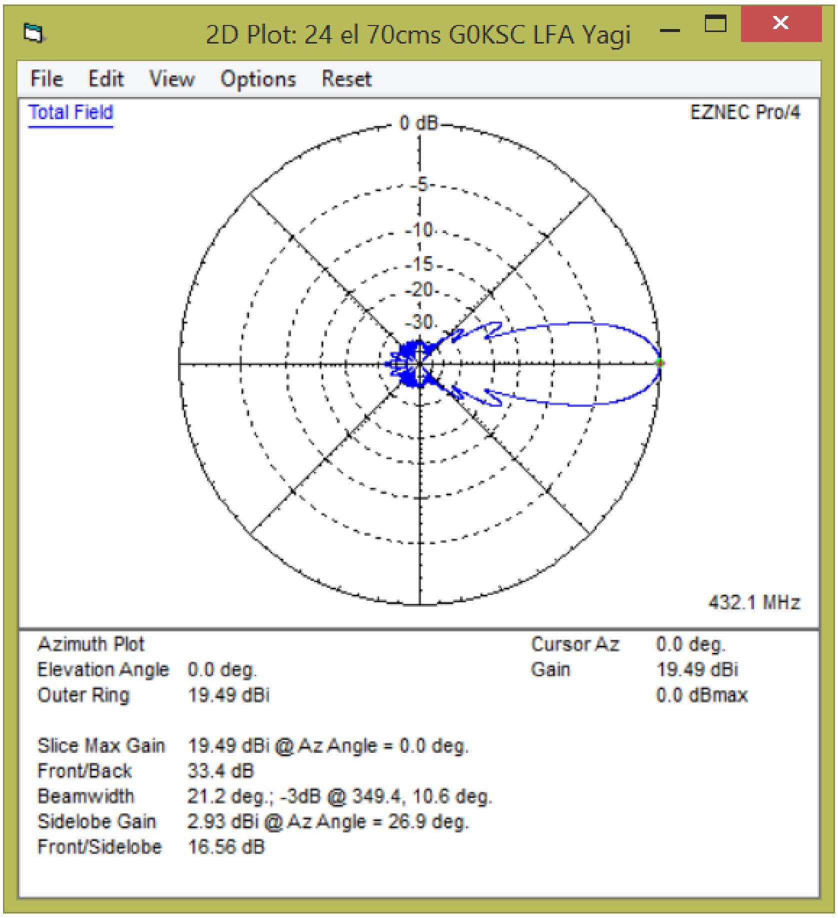


Fig. 6

Before and after – Fig. 6 shows the 24el 70cms LFA with a single reflector while Fig. 7 shows the same antenna with an additional pair.

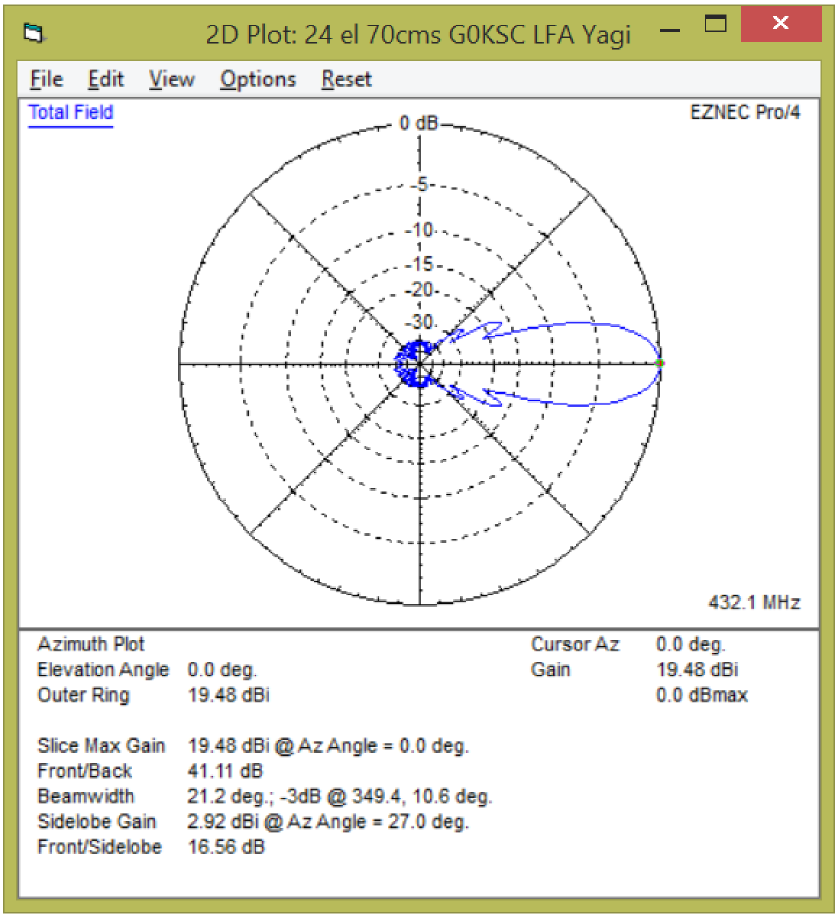


Fig. 7

Fig. 8 shows the layout of an optimised corner reflector in model form and Fig. 9 the resulting pattern improvements.

Tuning impacts upon a legacy design

Very little effect is had upon impedance or VSWR through the implementation of such reflectors, at least on a stable, wideband antenna such as those discussed within this article and with minor driven element and perhaps D1 (impedance controller) adjustments, things look extremely similar to pre-reflector array performance. This does mean that with careful optimisation and placement consideration, an additional pair of reflectors could be added to existing Yagi antennas with little additional tuning being required while all performance related benefits are realised.

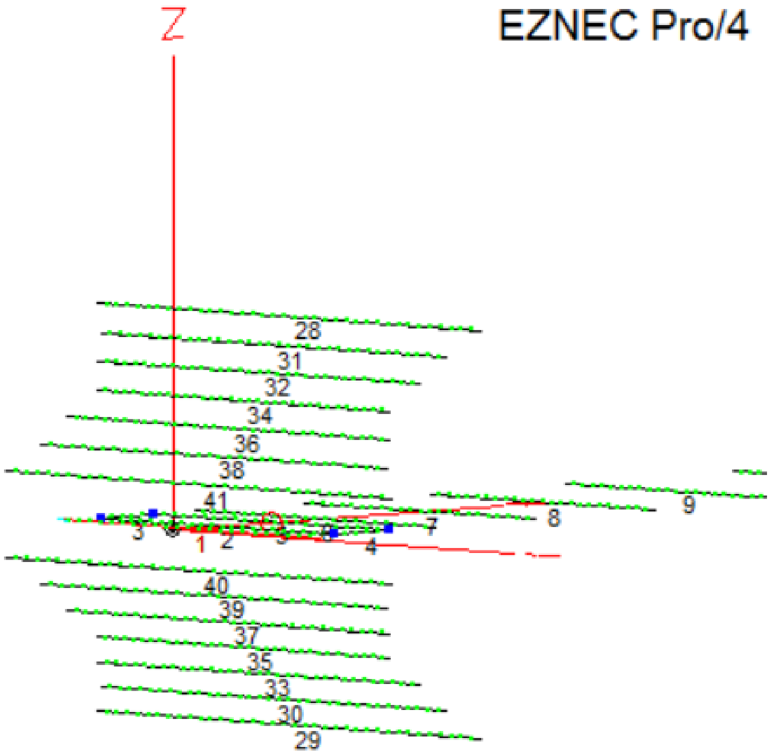


Fig. 8

Conclusion

It has long been observed that additional reflectors will broadband a Yagi but to my knowledge, it has not been widely appreciated that as few as 2 additional reflectors placed unconventionally, could provide such a marked improvement over the traditionally set 1 reflector version. Additionally, having just two additional reflectors could mean that such a reflector implementation installed upon 2m Yagis is a much more realistic proposition than a multi-element, computer optimised corner reflector array, one reason why such arrangements are seldom seen within 2m Yagis today. Experimentation has not been extended into X-pol versions of these antennas to establish if such antennas would prove viable or not. However, a few simple software models show that such an arrangement could prove successful if carefully optimised.

Naturally, a traditional X-pol Yagi is a desirable frontend for modes such as MAP65 requires a constant (horizontal) transmit polarisation to ensure operators are not 'chasing' each other from a polarisation perspective and therefore, further enhancements of this mode could be seen through such a reflector implementation in X-pol configured antenna arrays.

Credits: Bryan Cake, KF2YN (DUBUS) and YU7EF - YU7EF.com

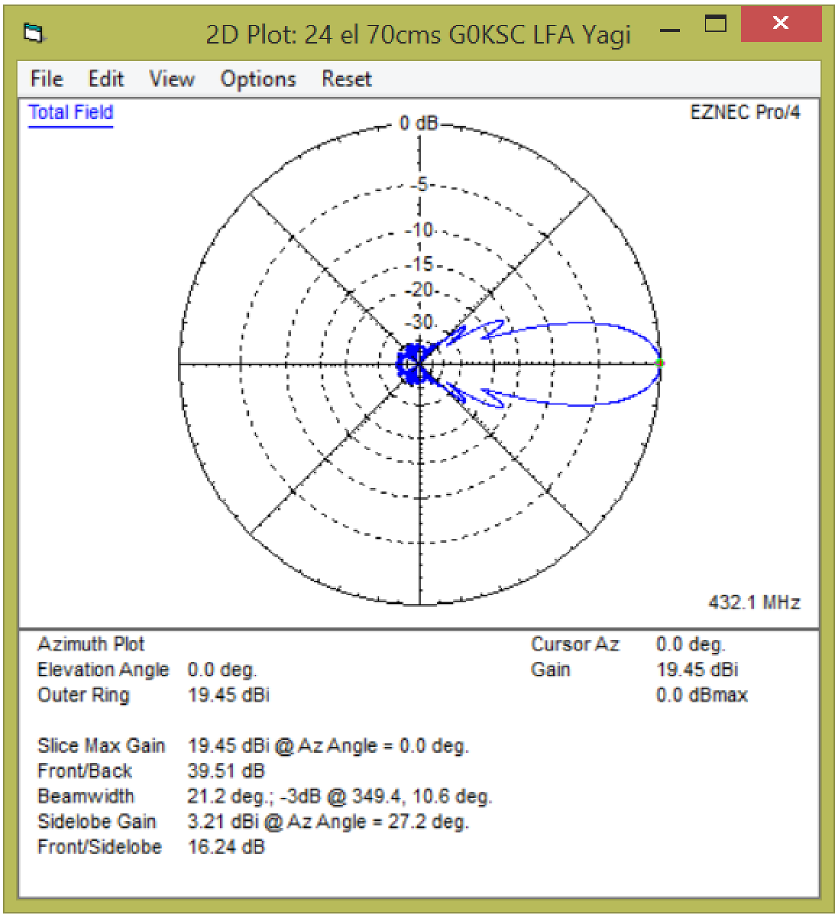


Fig. 9