Achieving pattern symmetry within stacked Yagi arrays with off-set feed points

- including a 4 element LFA-Q for 70cm for self-construction

by Justin Johnson, G0KSC

While experimenting with my quad-style antennas that consist of twin booms vertical LFA yagi shaped elements (which I called the LFA-Q) I noted a number of benefits over traditional Yagis of certain boom lengths. First, from a mechanical perspective there was the very rigid structure the twin boom provided to the LFA-Q. Mounted centrally at the top and bottom of each loop, the twin booms provided a very high wind handling ability and meant rear mounting was possible in longer than usual configurations. From an electromagnetic perspective, traditional benefits normally associated with quads also applied and these include much higher gain levels (than a split dipole Yagi, per metre of boom in antennas shorter than around 1.5w/l) broader bandwidth possibilities and additionally (and most important to me!) a direct 50 Ω feed point was easily achieved. However, the issue for me was the lack of pattern symmetry within the elevation plane due to the off-set of the feed point of this antenna.

While each antenna element is in-line with the next, the feed point is not central (nor can it be) to the antenna and it is this imbalance that causes the elevation plane distortion. See fig. 1 below. The same kind of distortion is introduced to traditional Yagis where a folded dipole replaces a split dipole and care should be taken to ensure that sky temperature and G/T measurements have been taken with the folded dipole in place in order that the Yagi user/owner is not misguided by predicted performance. Additionally, it should be noted that the levels of distortion do increase drastically with frequency and the size/shape of the loop too due to the effective increase in off-set (in respect of frequency). So how can this be managed to best effect?

First it should be noted that it is a good idea to simulate any such antenna with both the feed point below the folded dipole and also above the folded dipole. While it is usual that the cleanest side of the elevation pattern will face towards ground when the feed point is above the antenna (and hence, sky temperature and G/T will be best this way) it is not always the case as sometimes the reverse occurs. Next, there is little more that can be done to improve a single antennas elevation pattern symmetry. However, when stacking 2 or more of the same such Yagis, opposing feeding of each driven element (in pairs) will restore pattern symmetry in the elevation plane provided an even number of Yagis are stacked.

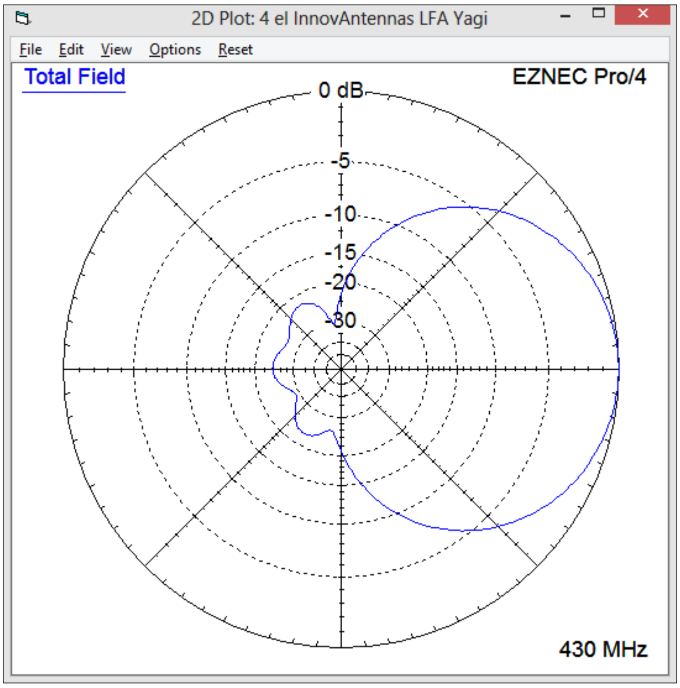
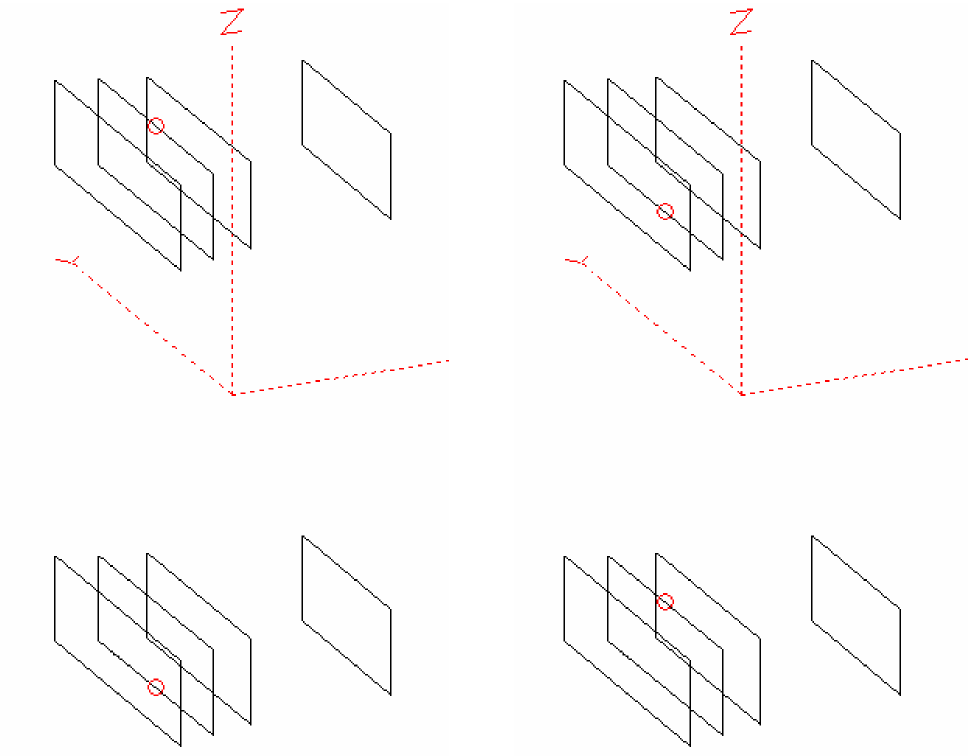


Fig. 1: The LFA-Q is fed at the top of the loop when a single antenna is used in order to achieve the least distortion into the downward direction.

Fig 2a/b shows two configuration possibilities for such an arrangement using the large-loop LFA-Q style antenna at 432MHz. The first shows the highest performance arrangement which consists of the top antenna (vertical stack) being fed at the top of the driven loop and the bottom antenna being fed at the bottom of its driver loop. The second is the most practical and best method in my opinion. In this example, the top antenna is fed at the bottom of its driven loop and the bottom antenna fed at the top of its driven loop. I say more practical for a couple of reasons. The first being the 'higher performance' version which results in gain being higher by not much more than a tenth of a dB while the second results in much shorter feed lines without the requirement for any one (or part thereof) feed line having to be routed between/through or past elements which in turn will result in much less real world distortion by means of other mechanical factors. Furthermore, any power divider could be placed directly between the two antennas and thus minimising feed line/phasing losses too.



This example as mentioned earlier is for 432MHz so for me, placement of 75 Ω cables in order to provide phasing would not be 'best practice' and therefore a splitter should be used. In such an arrangement where rear mounted antennas are used, the size and shape of any splitter might be extremely convenient too. Fig. 3 below shows what I would consider an ideal feed line/splitter arrangement between two LFA-Q antennas.

Fig. 2a (left) and Fig. 2b (right): The circles within the loops denote the feed points of each antenna.

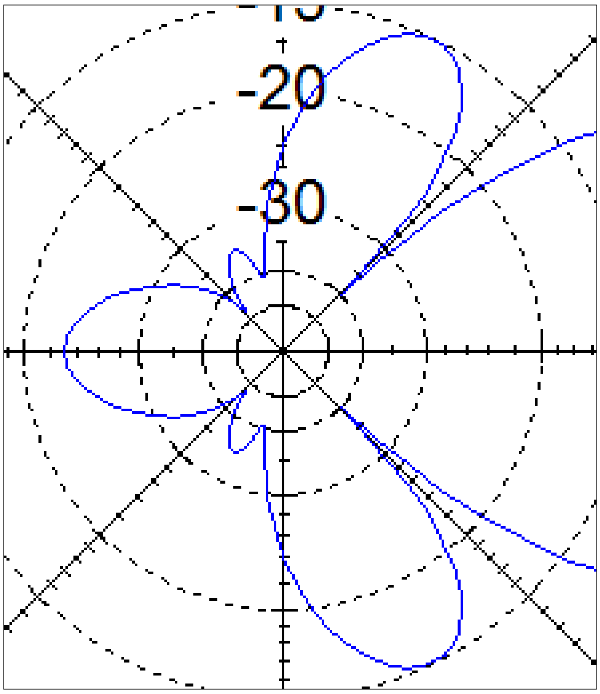


Fig. 2c: The now balanced and symmetrical pattern of stacked LFA-Q Yagis result from switching the feed point position of each antenna to be a mirror-image of one another.

Balun placement?

This has been an area of much debate and there are publications on the subject of loop fed antennas and the suggestion baluns are not required as loops are 'self-balancing'. I have always contested this on the basis of personal experience/testing resulting in the contrary. Simple tests can be applied to establish if RF is flowing on the outer sleeve of the feed line. One such test uses interference clip-on ferrite filters. Check the SWR of your test antenna. Clip on one or more of these ferrite cores (onto the coax near the feed point) and check SWR once more. If the SWR has changed from what it was prior to clipping on the ferrite, you have RF on the feed line (this method can also be used to test the effectiveness of a balun too).

LFA or folded dipole, I have found common mode currents to be present on the feed line of test antennas. However, more recently I discovered that if the side of the loop opposite the feed point was grounded, common mode currents were NOT present on the feed line. It was at this point that I realised test subjects previously had all had fully insulated loops or the ¼ wave stub 'Antenna Balun' on one side of the feed point or the other which while providing a DC ground to the loop, had also effectively unbalanced the loop at the same time. Therefore, it would seem that the fact a loop is self-balancing was part right and only became so when the loop opposite the feed point was grounded.
The twin-boom LFA-Q provides a convenient additional boom central to and opposite the feed point and for this reason, the LFA-Q element opposite the feed point travels through the boom and is grounded there. In fact, I found it appropriate to thru-boom and electrically connect all elements on the LFA-Q which is something I again have been opposed to. This was because I had noted the variance in correction required on elements connected in the way and more notably, the huge difference in correction % of the first and last element on any given antenna due to the boom appearing only on one side of these particular elements. This finding was first made by SM5BSZ and I confirmed his finding (manually) with

both 144MHz and 432MHz antennas. Establishing such corrections in order to replicate model can be quite time consuming and result in ‘best guess’ results and although very close, the result is further from model than the same antenna model built with fully insulated elements. However, as we know, the wide band a given antenna is, the less susceptible it is to variations or inaccuracies. The LFA-Q can easily provide constant performance over 4MHz on the 2m band and 10MHz at 70cms and therefore, in addition to the practicalities of mechanical construction of this kind of antenna, near model performance can be achieved with relative ease. Especially as I have produced these antennas with trombone-style element end sections in order that should the antenna be a little high or low in frequency, adjusting all elements by the same amount will achieve the required results. Add into the mix that no balun is required with this antenna (which can be awkward to achieve at 70cms) and you have a winning antenna!