Mastering the X-pol

by Justin Johnson, G0KSC

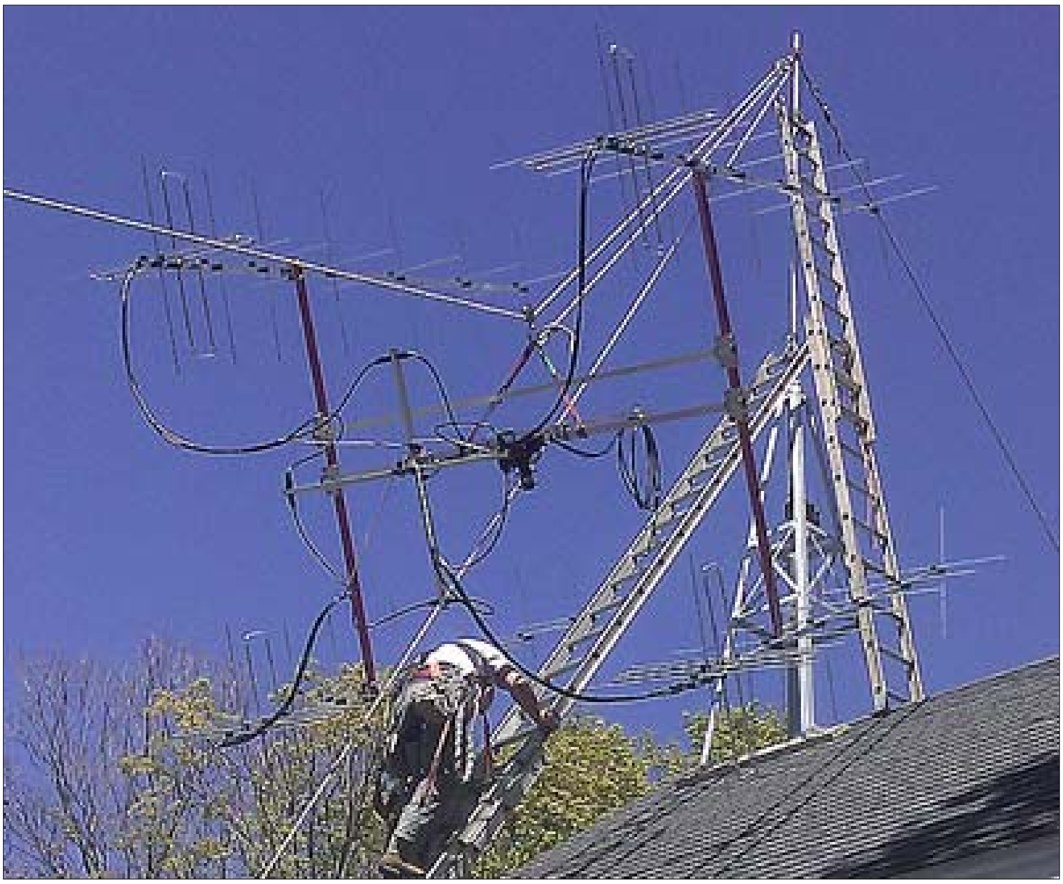

Fig. 1: K2OP installs 4 x 16el X-Pol LFA Yagis

In this article I will a look at some of the pitfalls and common mistakes often seen within an X-pol system that in some cases have become accepted as being ‘OK’.

Many times I have been asked for details of X-pol configured antenna arrays and I try to advise on how best to install the system. More often than not there is a reason why the optimum/least compromise solution cannot be achieved (H-frame already built, etc.) but these very large compromises during construction, individually or collectively are quickly forgotten when sub-standard performance is the result of all that hard work. It is my hope that by demonstrating some of these issues and the impact they have on the overall performance (including sky temperature and G/T), readers might be more mindful of the result of compromises during the design and implementation of any new X-pol system.

Antenna considerations

First, let us look at the antenna configurations and the differences between what might work in a single plane Yagi and how using the same antenna in an X-pol configuration could potentially result in failure.

The rule is to keep everything perfectly in line and to ensure there is nothing that extends into the opposite plane of the antenna, for example, T and BETA matches. Folded dipoles are another big potential issue as is the practice of off-setting all elements above and to the side of the boom, as would be the case when insulated elements are being used. In previous articles I have discussed the distortion caused in the elevation plane by folded dipoles, due in part to the off-set nature of how they are fed and also due to the fact one or both sides of the folded dipole not being aligned with the parasitic elements of the Yagi.

With a single antenna, this offset can be used to our advantage, as the distortion in the elevation plane (assuming the antenna is horizontally polarised) will be worse (than a split dipole Yagi) on one side of the elevation plane and better on the other side. The offset and feed point in the folded dipole can therefore be arranged to ensure the side of least distortion is down-facing resulting in better G/T figures than if the folded dipole feed and off-set were transposed. However, when we are applying two antennas together on the same boom, things are very different and greater consideration has to be given as to what parts of the antenna extend into the plane of the other plane/antenna. Optimisation of the boom spacing between the two planes has to be carefully conducted to ensure the point of least distortion can be reached, as any distortion at this stage will be greatly increased when 4 antennas are arranged in a box, or will it?

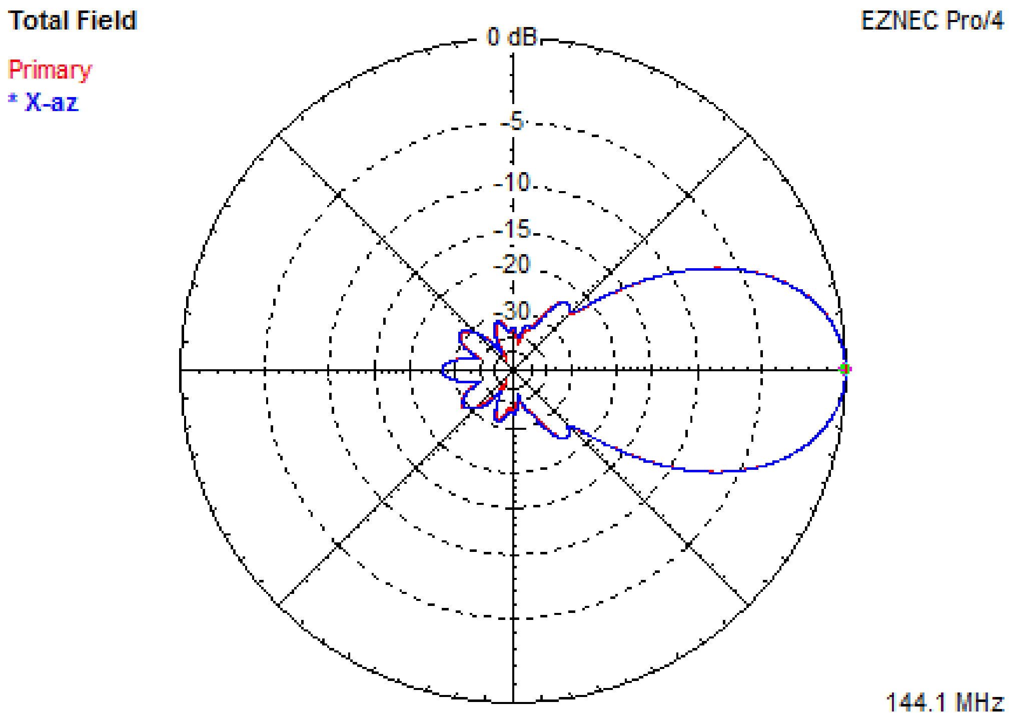

Fig. 2

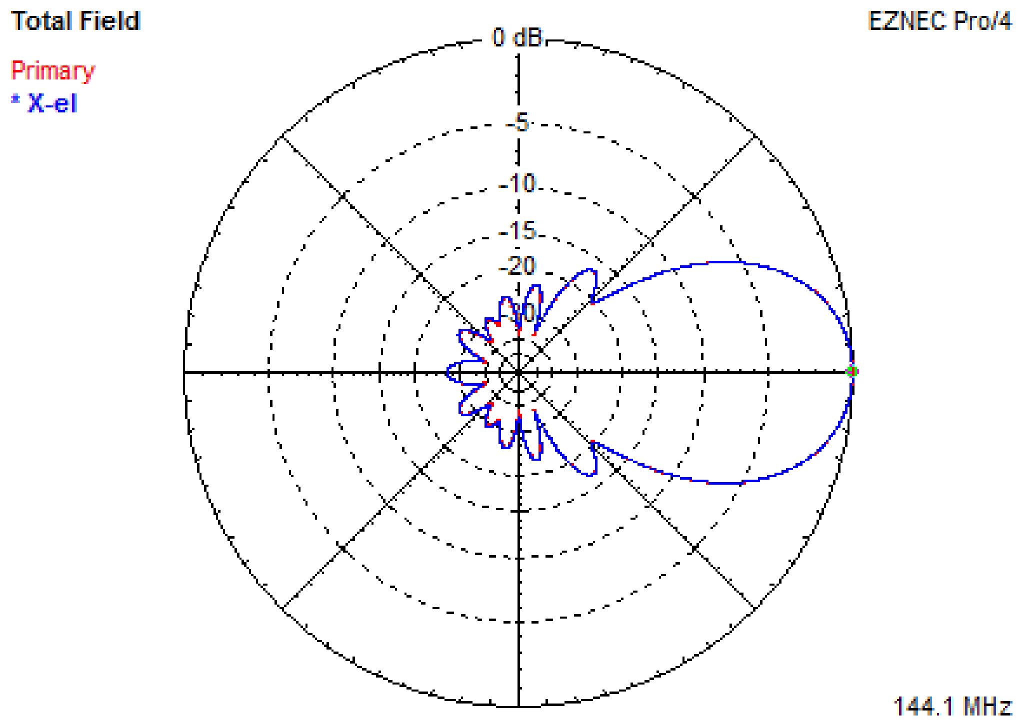

Fig. 3

Fortunately, through model optimisation, I have arrived at a configuration which provides very little distortion from the original, single antenna pattern and the results achieved were very different to what you might think. When configuring the spacing between the two planes, one may expect that the further apart the two arrays are in the X axis, the better and more symmetrical the pattern may become. This was not what I found when experimenting. In fact, the closer I approached ¼ λ spacing, the more pronounced the distortion became. There are other considerations when spacing the LFA Yagi as well. If the two antennas are spaced closely (50 mm apart in the X axis) then the loop sections can be interlaced. If a wider spacing is desired, element overlap becomes a potential issue for other parts of the antenna and needs consideration. Figs. 2 and 3 show the over-laid plots produced by an individual LFA Yagi and the space-optimised X-pol LFA with offset. It is clear that these plots are virtually identical as is the performance, the single 9el LFA having 14.04 dBi gain and 26.39 dB Front to Back Ratio (F/B) and the X-pol offset version 14.03 dBi and 26.45 dB F/B.

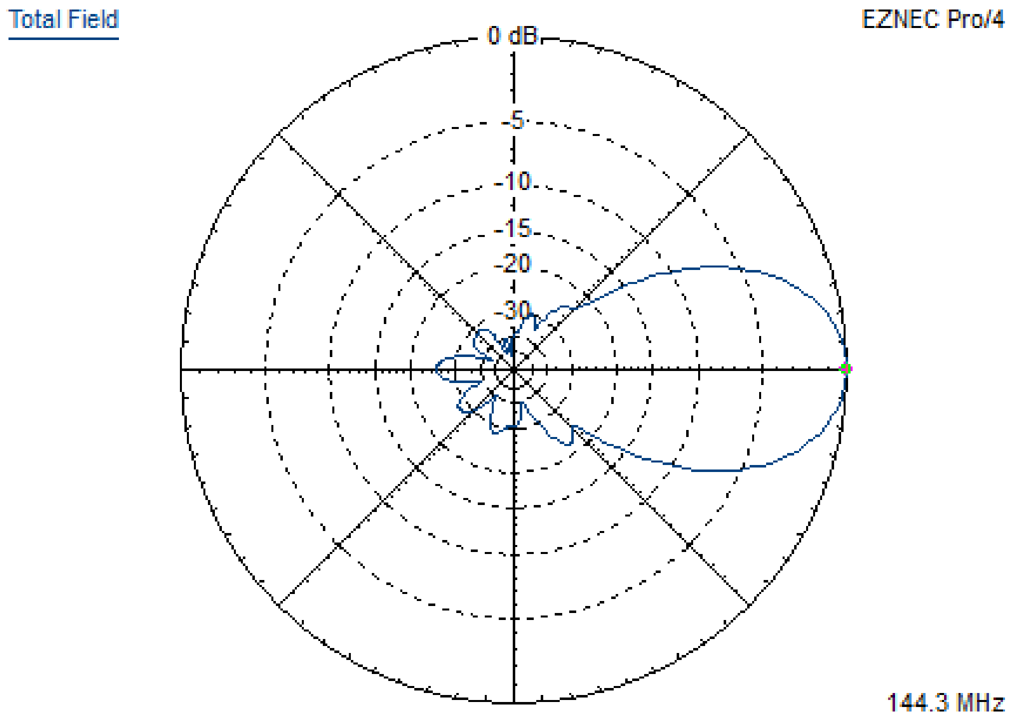

Fig. 4

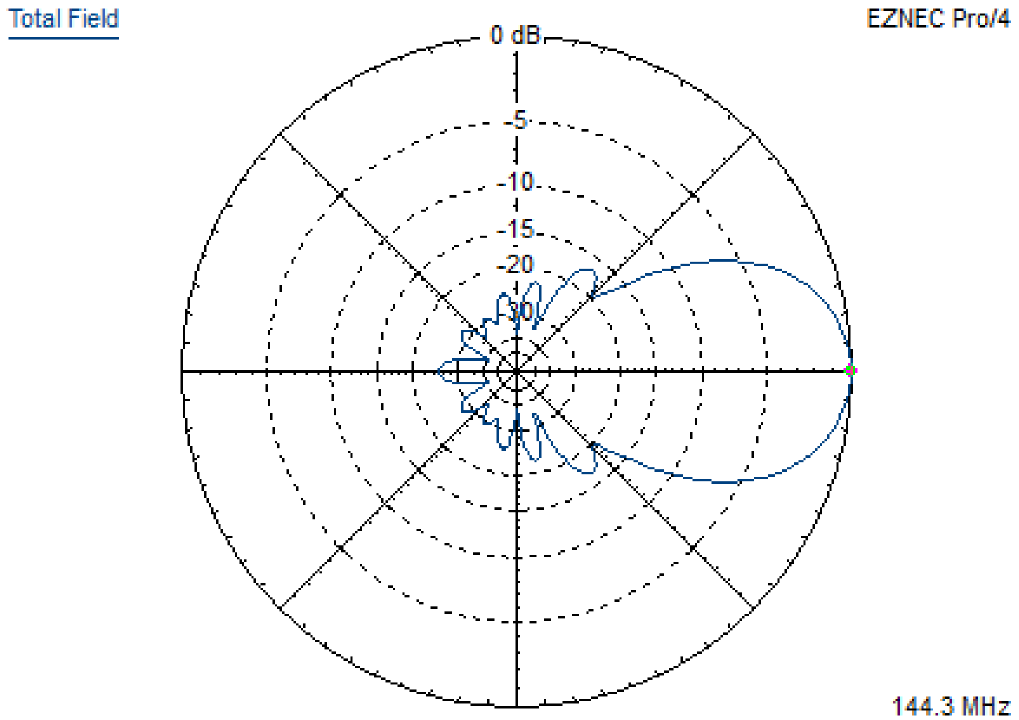

Fig. 5

Figs. 4 and 5 show plots for the same X-pol antenna which has had the X axis spacing increased by 75 cm. Even though the feed points and high current points are much further away from one another, the difference between the closer spaced and wider spaced configurations is quite marked.

The worst distortion is in the azimuth plane with virtually no distortion in the elevation plane, but keep in mind this distortion transfers from one plane to the next when switching from H to V polarisation and the Sky temperature and G/T results are below optimum. This is compounded when multiple antennas are stacked and even the relatively small distortion seen in the closer spaced version above (Fig. 1 and 2) can become more of an issue. Fig. 6 shows 8 x 18el X-pol antennas with the offset on each 1.25'' boom allowing for insulator off-set. While in the forward direction the pattern looks symmetrical, the imbalance caused by the each antenna being arranged symmetrically can be seen in the rearward direction.

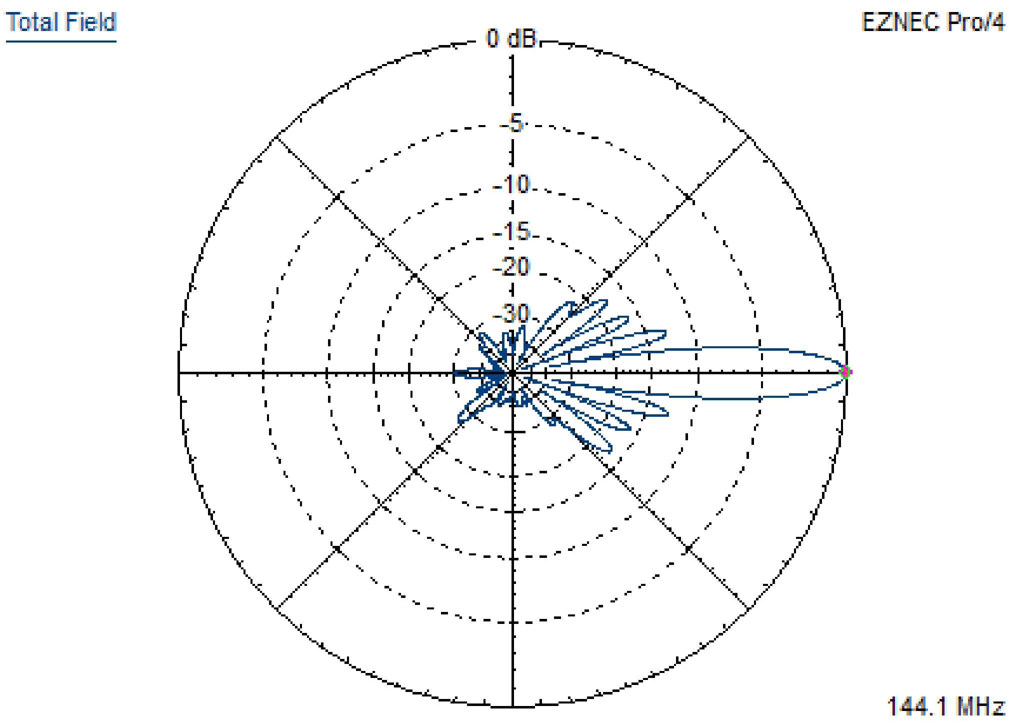

Fig. 6

So what can we do to bring balance and symmetry back to the pattern? Each antenna within a 4-box configuration has to be rotated 45 degrees from the last in order to balance the off-set. If stacking 8 antennas, 4 of the above mentioned boxes of 4 antennas should be used. Fig. 7 below shows how an X-pol would look if we stacked them in the traditional configuration.

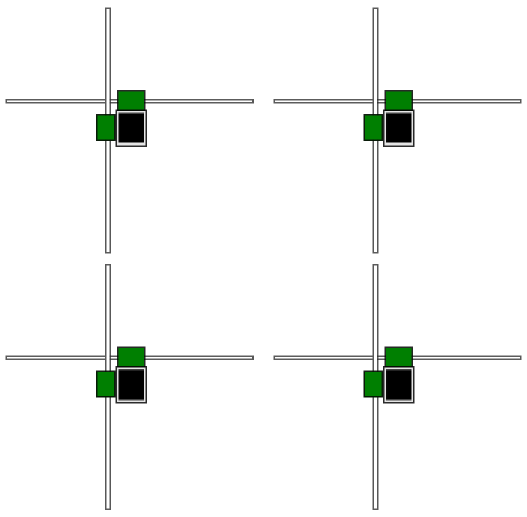

Fig. 7

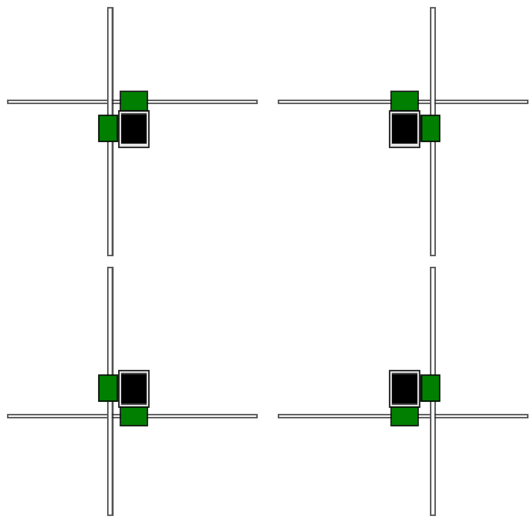

Fig. 8

Fig. 8 alongside it shows how an off-set X-pol Yagi combination array needs to be configured in order to get a symmetrical pattern. Where 8 (or multiples of 4) antennas will be used, two boxes of 4 as per Fig. 8 would need to be placed side by side. The illustrations show the 4 antennas looking from the boom end back along the antenna. The ***green*** blocks represent the insulators spacing the elements from the boom.