# Using EZNEC to solve a practical antenna problem

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**The Problem:**

In 2007 I decided to install a second tower at the home QTH and wanted to design an antenna system for 144, 222, and 432 MHz terrestrial weak signal work. While I had plenty of experience with HF antennas, I really wasn't sure how big a VHF array I could put up on a single 15-foot mast. And while I was willing to entertain the idea of stacking yagi antennas vertically, I really didn't want any large H-frames fo rvarious reasons. So in the end the question was could I vertically stack a pair of yagis for 144, 222, and 432 MHz on a single mast? And if I could what interaction would occur?

Being a long time member of the Mount Greylock Expeditionary Force (MGEF), I turned to Dick, WA2AAU and others for advice. Dick's response to my stacking question was that he wasn't sure and therefore suggested modeling what I wanted to try. I also turned to K1FO and K1WHS for advice and basically got the same response. While I had purchased EZNEC 5.0, I really had not done much with it other then to model simple wire antennas.

**Modeling single yagis:**

After researching various commercial yagis, I decided on the DSFO144-12 (12el on 144) the DSFO222-16 (16 el on 222), and the DSFO432-25 (25el on 432) yagis. All three antennas were designed by K1FO, have a good reputation, and have been around for years. So with the three users manuals, I created my first set of models and compared the results to the published performance (refer to Table 1, 2 and 3).

| | Model | MFG Specs | Difference |
|---|---|---|---|
| Gain (dB) | 12.16 | 12.60 | -0.44 |
| F/B (dB) | 19.86 | 23.00 | -3.14 |
| 3 dB E-plane BW (Deg) | 34.20 | 34.00 | 0.20 |
| 3 dB H-plane BW (Deg) | 37.40 | 37.00 | 0.40 |

**Table 1 - DSFO144-12 Performance comparison**

| | Model | MFG Specs | Difference |
|---|---|---|---|
| Gain (dB) | 13.63 | 14.00 | -0.37 |
| F/B (dB) | 20.40 | 22.00 | -1.60 |
| 3 dB E-plane BW (Deg) | 29.00 | 31.00 | -2.00 |
| 3 dB H-plane BW (Deg) | 30.60 | 33.00 | -2.40 |

**Table 2 - DSFO222-16 Performance comparison**

| | Model | MFG Specs | Difference |
|---|---|---|---|
| Gain (dB) | 15.61 | 16.50 | -0.89 |
| F/B (dB) | 20.72 | 24.00 | -3.28 |
| 3 dB E-plane BW (Deg) | 21.40 | 22.00 | -0.60 |
| 3 dB H-plane BW (Deg) | 22.20 | 23.00 | -0.80 |

**Table 3 - DSFO432-25 Performance comparison**

As you can see the results obtained from my model don't correlate as well as I had hoped with the manufacturers published specifications. But since my goal was to determine the relative change in performance between a pair of stacked yagis when another antenna was placed within the aperture of the first two, I decided this might just work.

**Modeling vertically stacked pairs of yagis:**

I modeled a vertical stack of two DSFO144-12 yagis using the manufacturers recommened stacking distance which produced the expected results (reduced E-plane beam width by 50% and increased gain by 3 dB). I also modeled two DSFO222-16 yagis and then two DSFO432-25 yagis with the same results.

**Modeling 2xDSFO432-25 inside 2xDSFO144-12 yagis:**

I then modeled a vertical stack of two DSFO432-25 yagis inside a stack of two DSFO144-12 yagis. This model produced no performance degradation on the DSFO144-12 stack as compared to the DSFO144-12 stack by itself. There was however a slight reduction in gain (0.16 dB) on the DSFO432-25 stack as compared to the DSFO432-25 stack by itself (refer to Table-4).

| | 432 w\ 144 | 432 (REF) | Difference |
|---|---|---|---|
| Gain (dB) | 18.35 | 18.51 | -0.16 |
| F/B (dB) | 21.27 | 20.76 | 0.51 |
| 3 dB E-plane BW (Deg) | 21.60 | 21.40 | 0.20 |
| 3 dB H-plane BW (Deg) | 20.80 | 20.60 | 0.20 |

**Table 4 - 2xDSFO432-25 Performance affected by 2xDSFO144-12**

**Modeling 2xDSFO222-16 inside 2xDSFO144-12 yagis:**

I modeled a vertical stack of two DSFO222-16 yagis inside a stack of two DSFO144-12 yagis. This model produced performance degradation on both the DSFO144-12 stack as well as the DSFO222-16 stack when compared to the two stacks by themselves (refer to Tables 5 & 6).

| | 222 w\ 144 | 222 (REF) | Difference |
|---|---|---|---|
| Gain (dB) | 16.08 | 16.54 | -0.46 |
| F/B (dB) | 18.34 | 21.43 | -3.09 |
| 3 dB E-plane BW (Deg) | 30.40 | 29.20 | 1.20 |
| 3 dB H-plane BW (Deg) | 15.80 | 14.40 | 1.40 |

**Table 5 - 2xDSFO222-16 Performance affected by 2xDSFO144-12**

| | 144 W\ 222 | 144 (REF) | Difference |
|---|---|---|---|
| Gain (dB) | 11.25 | 15.20 | -3.95 |
| F/B (dB) | 12.43 | 20.43 | -8.00 |
| 3 dB E-plane BW (Deg) | 33.80 | 35.20 | -1.40 |
| 3 dB H-plane BW (Deg) | 20.80 | 10.60 | 10.20 |

**Table 5 - 2xDSFO144-12 Performance affected by 2xDSFO222-16**

**Proposed VHF array:**

With significant interaction between the DSFO144-12 and DSFO222-16 stacks, I decided to remove one DSFO222-16 yagi and move the other to the center of the DSFO144-12 stack. I generated a new model with the DSFO144-12 stack, single DSFO222-16, and added the DSFO432-25 stack. The model shows no interaction on 144 MHz, and only a slight interaction on 222 and 432 MHz when compared to the reference (refer to Table 6).

| | (2) DSFO144-12 | | (2) DSFO432-25 | | DSFO222-16 | |
|---|---|---|---|---|---|---|
| | Measured | Reference | Measured | Reference | Measured | Reference |
| Gain (dB) | 15.20 | 15.20 | 18.32 | 18.51 | 13.78 | 13.63 |
| F/B (dB) | 21.61 | 21.51 | 22.17 | 20.76 | 18.36 | 20.40 |
| 3 dB E-plane BW (Deg) | 14.60 | 14.60 | 10.00 | 10.60 | 29.40 | 29.00 |
| 3 dB H-plane BW (Deg) | 34.80 | 35.00 | 21.20 | 21.40 | 29.60 | 30.60 |

**Table 6 – Proposed VHF array performance**

**Conclusion:**

After the completion of my modeling, I had several people with a much greater knowledge of antenna modeling then I reviewed my work. The conclusion was that the results appear to be correct. The compromise made on 222 MHz is in line with the bands activity level and allows for greater performance on 144 and 432 MHz. While antenna modeling took a lot of time and effort it provided invaluable insight as to what might work and what would not without having to resort to costly trial and error. In the fall of 2007 this array was installed and has performed well ever since.

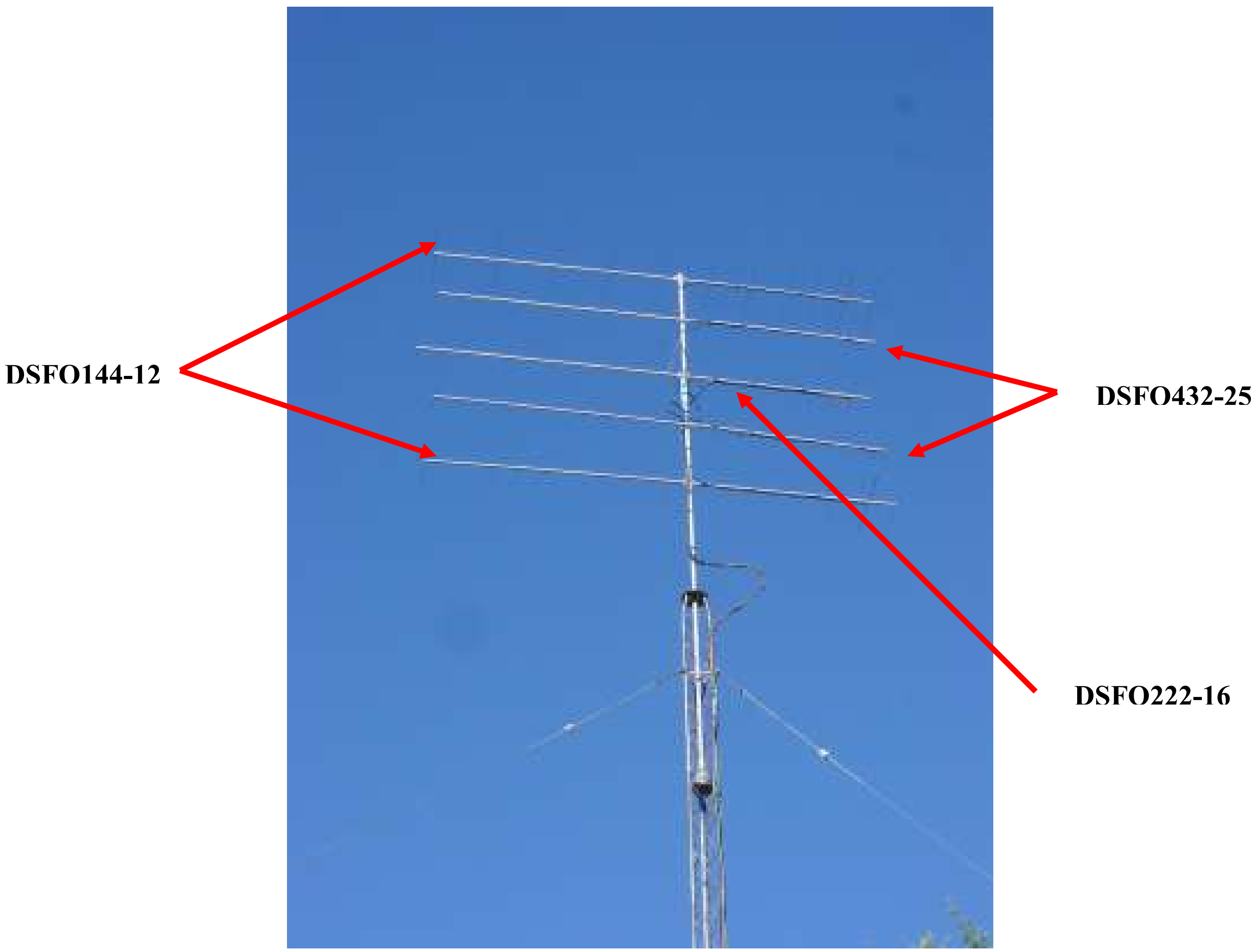


**Figure 1 – Final VHF array**