Technical Notes Volume 1, Number 7

In-line Stacked Arrays of Flat-front Bi-Radial® Horns

Introduction:

Where excellent vertical pattern control in the 500 Hz range is desired, system designers will usually opt for one of the larger JBL Bi-Radial horns. However, where space is a consideration, stacked Flat-Front Bi-Radials offer nearly equivalent performance, along with increased output.

Horizontal and Vertical Beamwidth Plots:

Figure 3 shows the horizontal and vertical beamwidth plots for a single JBL 2370 horn. The horizontal 90 degree pattern control is maintained over the 1 kHz to 16 kHz range. At the lower part of this range, the pattern is supported by the relatively large horizontal mouth dimension. At the upper part of this range, the wide pattern is maintained by careful development of horn expansion in the throat region. Vertical pattern control is limited at low frequencies by the relatively small mouth dimension in that direction. What we observe is an ever widening coverage angle as we progress downward in frequency.

We can relate the loss in pattern control in the vertical plane directly to the height of the mouth. An examination Of the 2360, 2365, 2370, 2380, and 2385 Bi-Radials shows that they all double their vertical coverage angles at the frequency whose wavelength is approximately 4/3 the mouth height. Those Bi-Radials whose nominal vertical coverage angle is 20 degrees double their vertical coverage angle at the frequency whose wavelength is approximately 2/3 the mouth height. These relationships are shown in Table 1.
Over the years, system designers have stacked horns in an effort to tighten vertical pattern control. Such stacking does not affect the horizontal pattern at all, but it does, in many respects, improve vertical pattern control at lower frequencies. Figure 1 shows the polar response of a stacked pair of 2370s on octave centers from 500 Hz to 16 kHz, and Figure 2 shows the polar plots for a triple stack.

Note that the stacked combinations produce robing in the vertical pattern at high frequencies. If we weight the lobes equally and consider their envelope (shown by dotted lines in the polar plots), we can plot the effective beamwidths of these combinations as shown in Figures 4 and 5.

Observe that in the case of the double stack, the frequency at which the combination has widened to 80 degrees has decreased from approximately 1600 Hz to 800 Hz. The doubling of the effective vertical mouth dimension has halved the vertical pattern control cut-off frequency.

In the case of the triple stack, the vertical pattern control has widened to 80 degrees at a frequency of approximately 630 Hz, or one-third that of the single horn.

Application to Other Flat-Front Bi-Radial Horns:

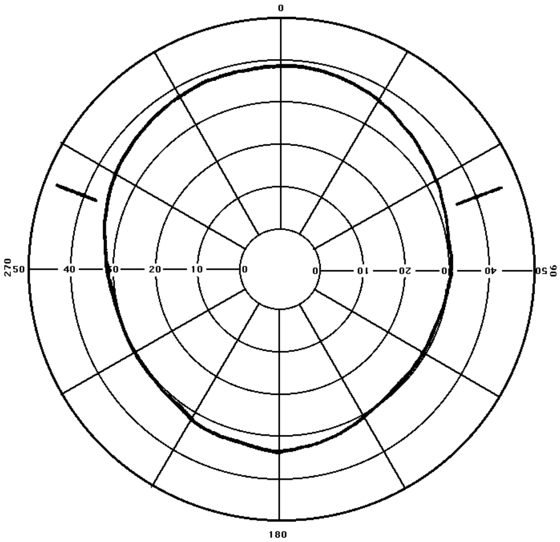
The observations made on the stacking of 2370 horns can be extended to the other members of the family, as shown in Figures 6 through 8. We have only shown the estimated pattern control for double stacks, since these will be most useful to the system designer. The effects of triple stacks may be inferred from the data presented earlier.

Conclusions:

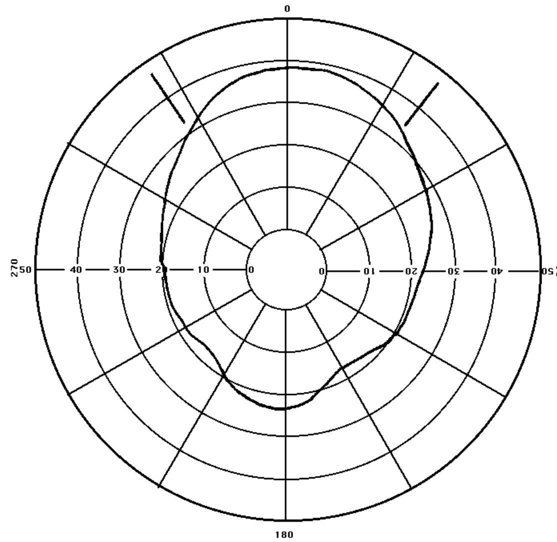
Stacking of JBL Flat-Front Bi-Radial horns offers both improved vertical pattern control and increased power handling with minimal distortion. The added benefit of reduced front-to-back space requirement will dictate this design approach where shallow arrays are required.

In particular, a stack of 2380s performs in many ways as a single 2360 with dual drivers might. There is, of course, no dual throat adaptor for the 2360, and we do not believe that such a design would be feasible, because of high- frequency interference effects in the throat and the increase in distortion that dual throat adaptors exhibit. Therefore, we suggest that the double-stacked 2380s be considered as its equivalent.

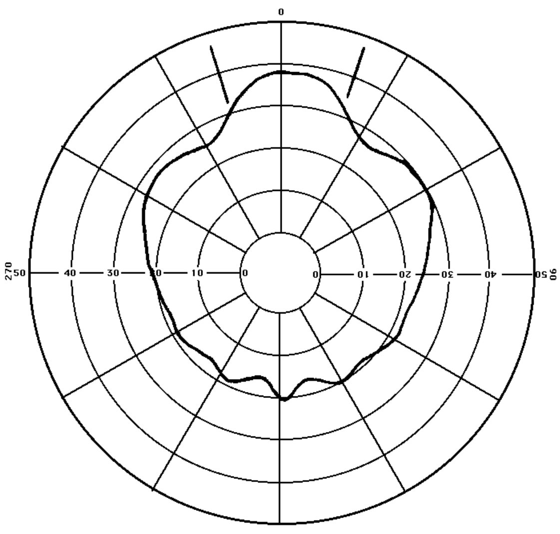
***Figure 1.* Vertical Polar Plots for Double-stacked 2370s**



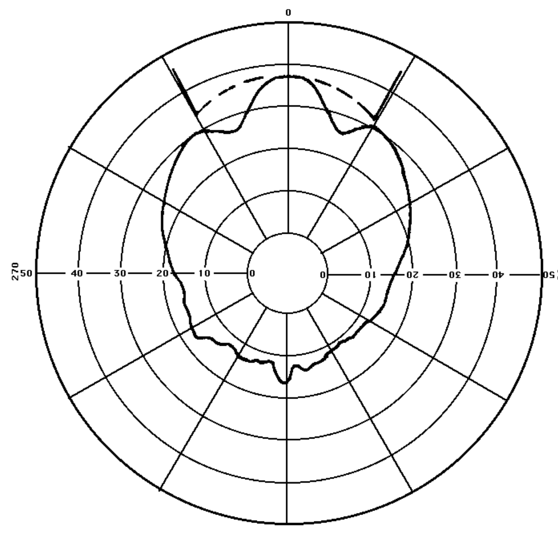
A. 500 Hz



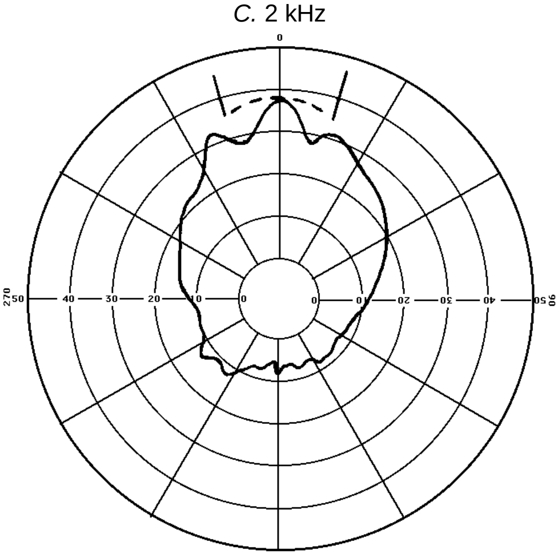
B. 1 kHz



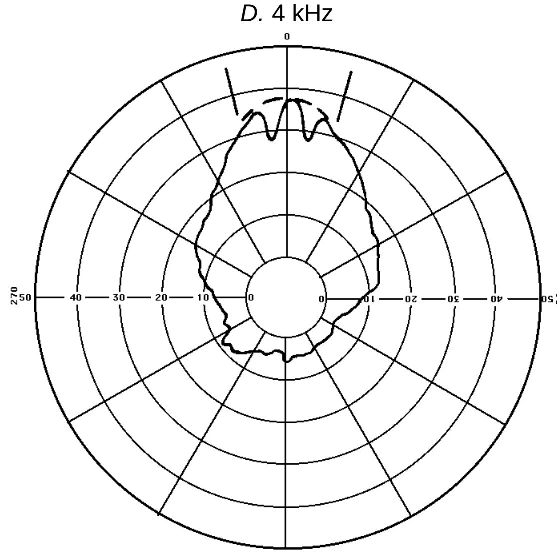
C. 2 kHz



D. 4 kHz

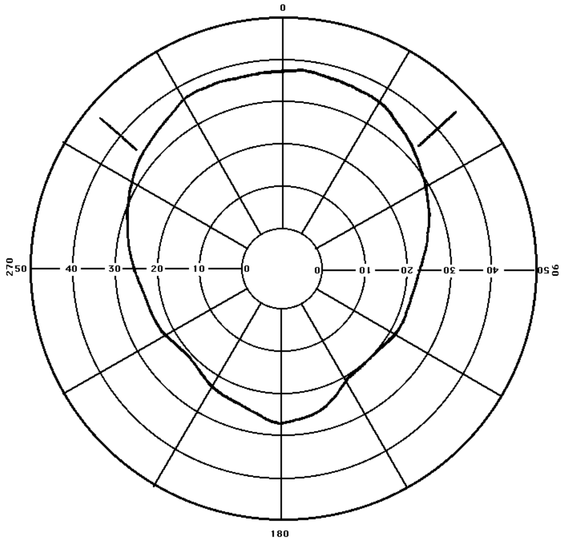


E. 8 kHz

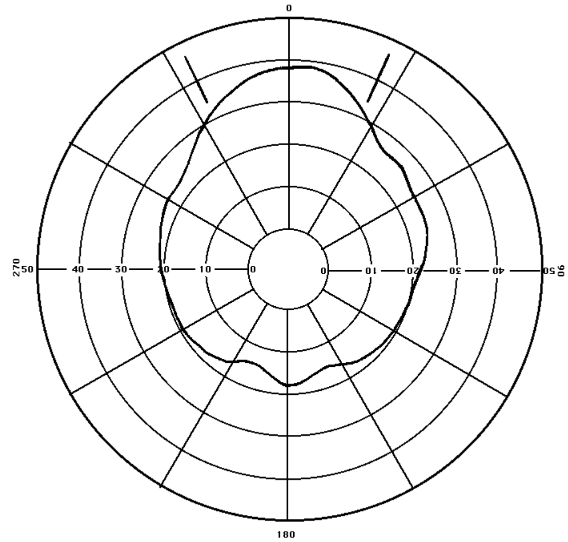


F. 16 kHz

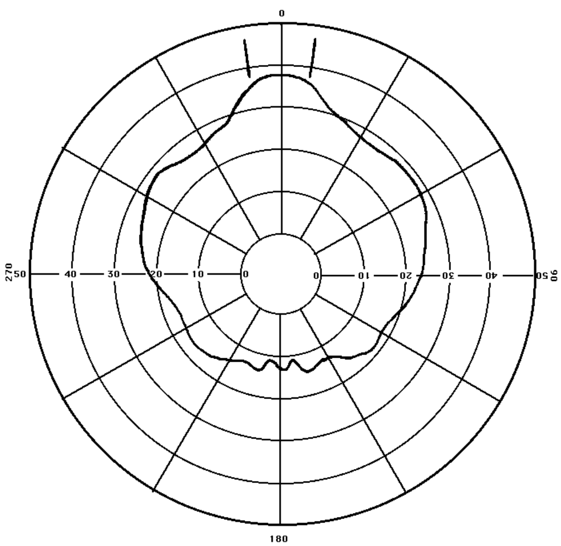
***Figure 2.* Vertical Polar Plots for Triple-stacked 2370s**



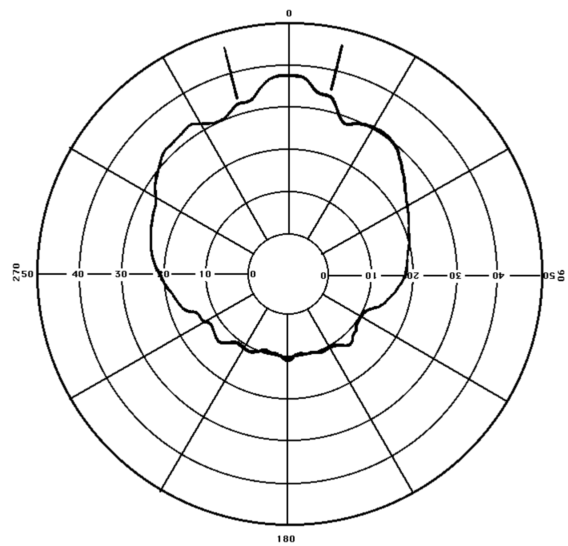
A. 500 Hz



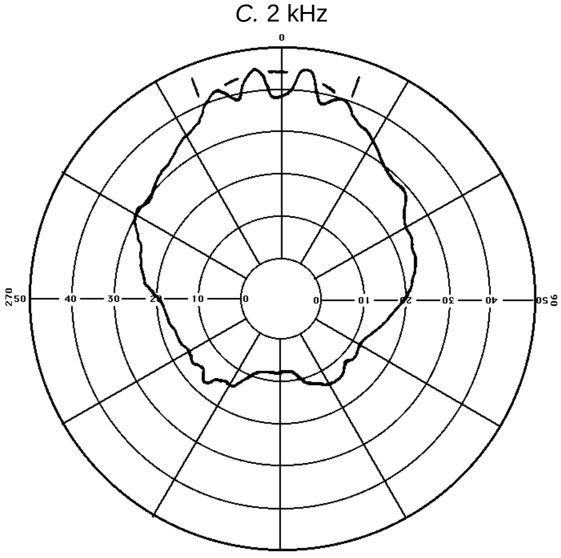
B. 1 kHz



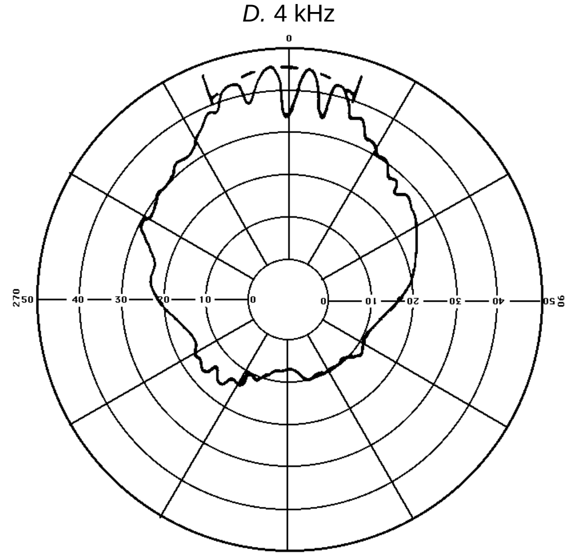
C. 2 kHz



D. 4 kHz



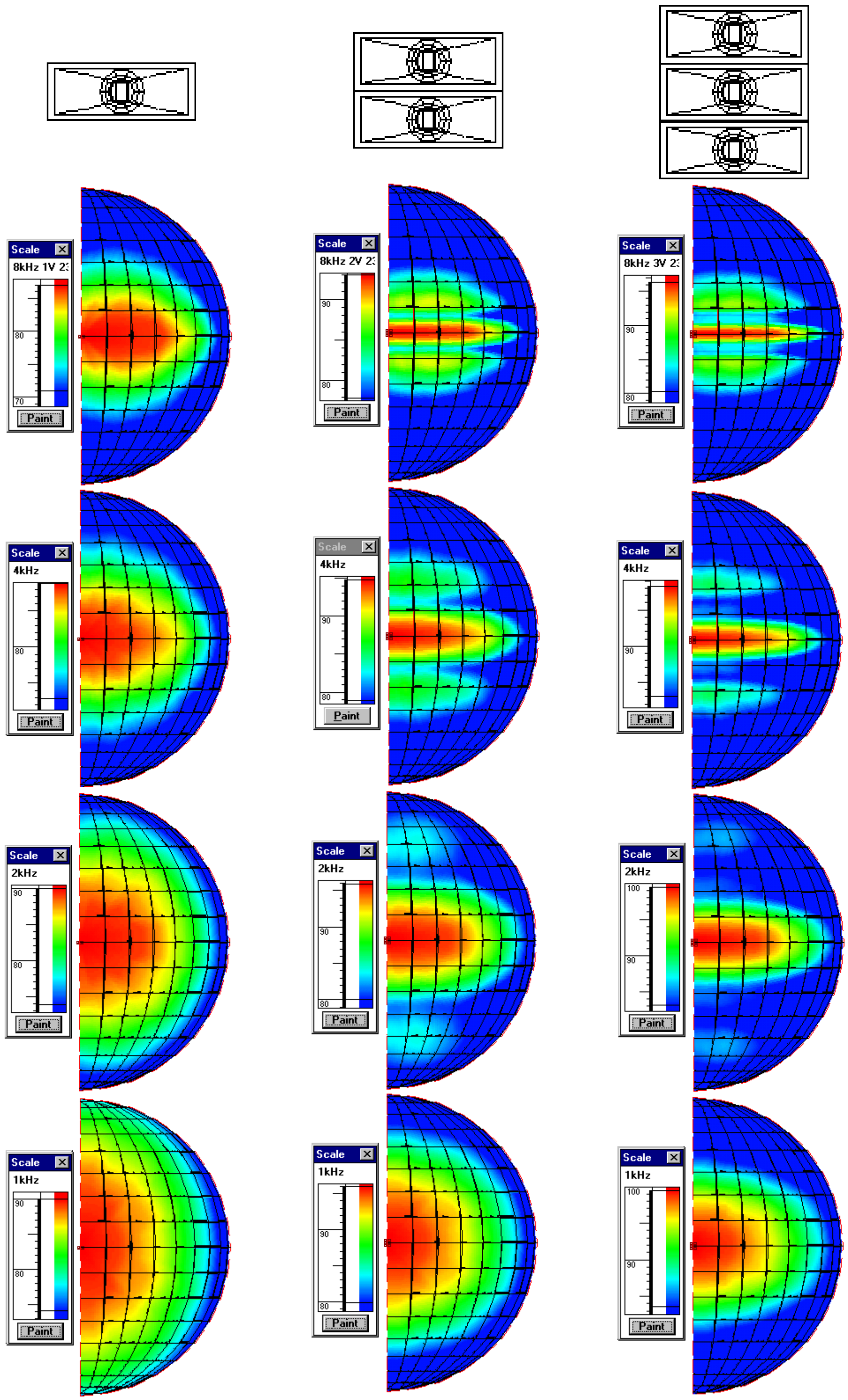
E. 8 kHz



F. 16 kHz

Figure 3. **Vertical Polar Predictions for Stacked 2370s**

The computations are predicted at a 10m distance and the sound level results painted to a quarter sphere surface. Gradations for the sphere are every ten degrees. The calculations are for each one octave band, using average complex-summation (ACS), which yield results that are more representative to the critical bandwidth listening of actual program material. The dynamic range, red to blue, for each prediction has been fix at 16 dB



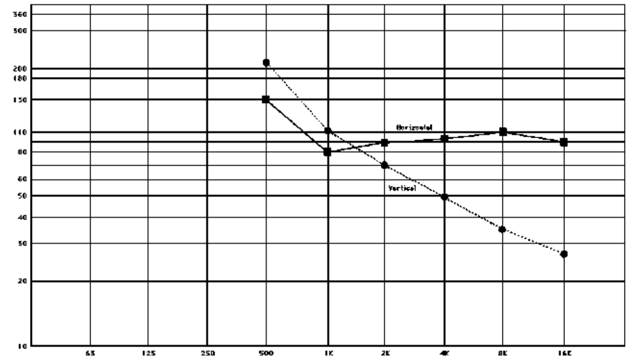


Figure 4. **Horizontal and Vertical Beamwidth (-6 dB) for a Single 2370**

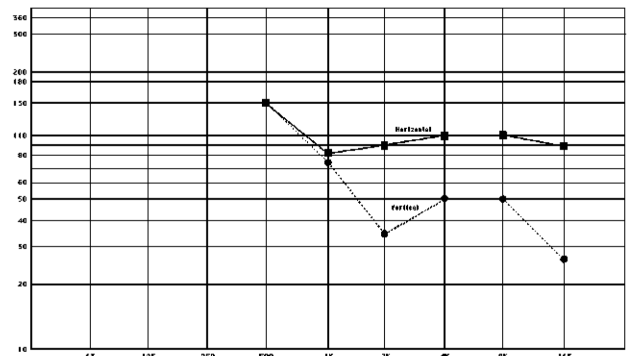


Figure 5. **Horizontal and Vertical Beamwidth (6 dB) for a Double-stacked 2370s**

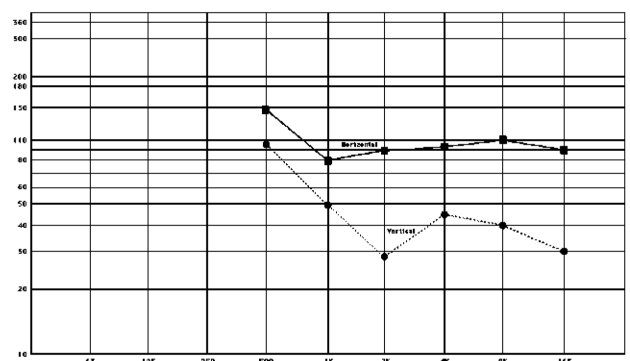


Figure 6. **Horizontal and Vertical Beamwidth (-6 dB) for a Triple-stacked 2370s**

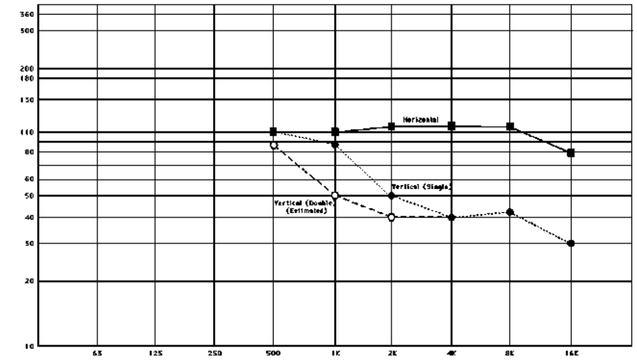


Figure 7. **Horizontal and Vertical Beamwidth (-6 dB) for a Single 2380 and Double-stacked 2380s**

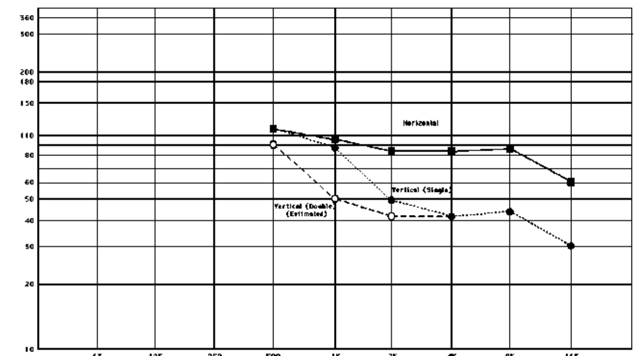


Figure8.. **Horizontal and Vertical Beamwidth (-6 dB) for a Single 2385 and Double-stacked 2385s**

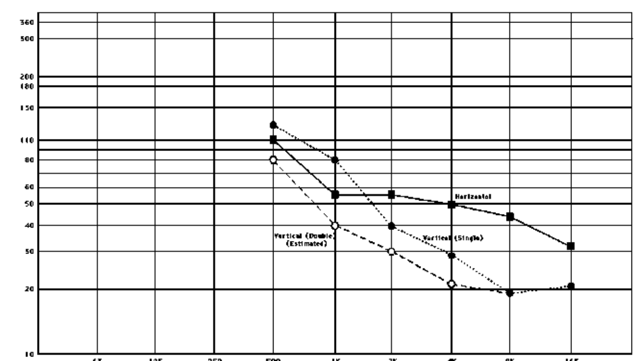


Figure 9. **Horizontal and Vertical Beamwidth (-6 dB) for a Single 2386 and Double-stacked 2386s**

TABLE 1. VERTICAL PATTERN CONTROL AS A FUNCTION OF MOUTH HEIGHT (CALCULATION OF FREQUENCY AT WHICH VERTICAL COVERAGE ANGLE HAS DOUBLED)

Horn	Mouth Height (m)	λ (4/3 Mouth Height):	Frequency(334/λ)	Measured Frequency
2360	0.8 m	1.07 m	321 Hz	315 Hz
2365	0.8 m	1.07 m	321 Hz	315 Hz
2370	0.173 m	0.23 m	1.5 kHz	1.5 kHz
2380	0.235 m	0.313 m	1.1 kHz	1 kHz
2385	0.235 m	0.313 m	1.1 kHz	1 kHz
Horn	**Mouth Height (m)**	**λ (2/3 Mouth Height):**	**Frequency(334/λ)**	**Measured Frequency**
2366	0.8 m	0.533 m	645 Hz	630 kHz
2386	0.235 m	0.1567 m	2.2 kHz	2 kHz

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