When the wavelength λ of the sound is much larger than the diameter of the cone D – *i.e.* $\lambda >> D$, sound radiation in the forward hemisphere is fairly uniform. Even directly backwards, for such loudspeakers in fully-sealed enclosures, the sound level in the backwards direction is typically only 10-15 *dB* less than in the forward direction for such low frequencies. At higher frequencies, when $\lambda \sim D$ (and for $\lambda < D$), the sound radiation is increasingly concentrated into the forward direction, along the loudspeaker axis.

The angular response of a loudspeaker can be calculated from first-principles of acoustics, for example, simplifying/modeling a loudspeaker as a circular piston of radius *a*, the far-field *RMS* pressure amplitude angular response can be shown to be: $p(\theta) = p_o J_1(ka\sin\theta)/ka\sin\theta$ where p_o is the on-axis *RMS* pressure amplitude, $J_1(x)$ is the ordinary Bessel function of the first kind of order 1, and the wavenumber $k = 2\pi/\lambda$. Real speakers are much more complicated than a simple piston, but can be simulated on a computer, thus angular response predictions for real speakers can be obtained in this manner, via numerical methods/simulations on a computer…

The angular response of a cone-type loudspeaker, measured at various frequencies (*e.g.* 1/3 octave intervals) is commonly given by loudspeaker manufacturers in a series of <u>***polar***</u> <u>***plots***</u>, where the <u>***radial***</u> distance on such plots is given in *dB* units, typically 6 *dB* per radial division, as shown in the figure below for an EV S-152 Two-Way 200W PA loudspeaker cabinet:

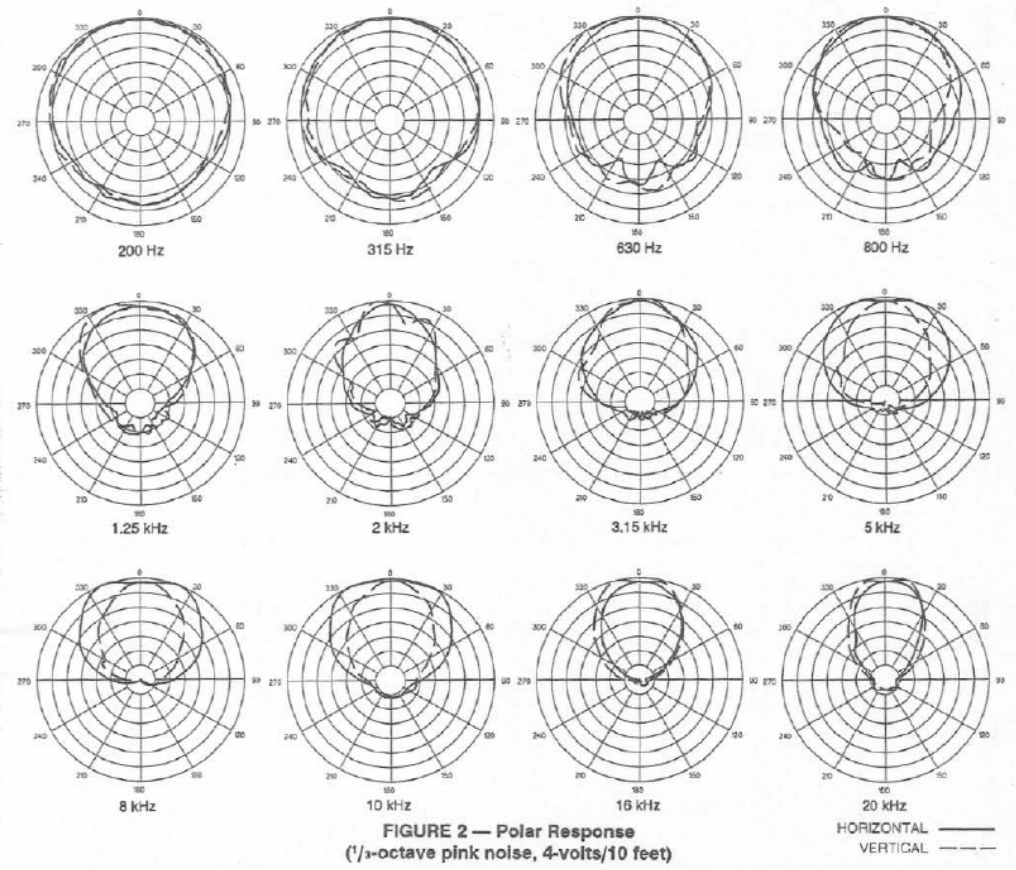

FIGURE 2 — Polar Response
(1/3-octave pink noise, 4-volts/10 feet)