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OVERHEAD CANOPY DESIGN

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In dB Volume 1, Issue 4, we examined the far field response of an array of plane panels 1 m in width and spaced by 1.25 m. It is important to reiterate the result that periodic arrays, that is arrays formed by the repetition of a single shape, cause an uneven coverage, resulting from lobing in the diffraction directions. These directions are determined solely by the width of the repeating panel. One of commonest occurrences of simple reflector arrays is above stages and audiences in auditoria. In this case, it is not just the response on a far field arc that should be considered, but also the response at application realistic source and receiver positions. In many cases, this will be along a straight line 5-12m below the reflector array. This produces a scattered response that is quite different in characteristic to the far field arc.

Figure 1 shows the scattering from the same array as shown in dB Volume 1, Issue 4 Figure 1, with a far field source, and a line of receivers 8m below the array running parallel to the array. (A far field source is used to simplify matters, but in reality both sources and receivers would probably be 5-12m below the array). Figure 1 also indicates the panel locations.

At the high frequencies, the specular reflection from each panel is apparent. The scattered pressure is uneven with minima where the geometric reflection point for a receiver is between panels, and maxima where the geometric reflection point lies on the panels. For most designs of overhead canopies, this uneven response is undesirable. Due to these absences between reflectors at high frequency, and the strong specular reflections between, it would be normal to use shaped elements, such as arcs, instead of plane panels to scatter energy more evenly to all receivers. However, shape alone will not guarantee uniform coverage. As we will see it is a combination of shape and arraying. While this is difficult to predict, optimization theory can provide a reliable solution in the design phase and remove guesswork, as we will see later in this presentation.

For the middle two frequencies (340 and 3400Hz), the response is a complex mix of minima and maxima. These are near field effects (the 10 kHz case was also in the near field, but the high directivity of the individual panel response weakened the near field effects). The rapidly changing path length differences from the array to the receiver, as the receiver location is moved along the x axis, causes a multitude of minima and maxima. The lowest frequency is in the far field, so something like the dipole response seen previously for the far field arc is obtained.

Rindel used Fresnel theory to investigate arrays of ceiling reflectors. He used square reflectors and investigated the effect of reflector density on the frequency response. He found that if the geometric reflection point lay on a panel, a high pass characteristic with some similarity to the single panel response was obtained. Due to the fact that the reflections come from multiple panels, the actual frequency response had many more local minima and maxima than was the case for the single panel alone.

If the geometric reflection point was between panels, however, the scattering had a low pass filter response. In the later case, the energy is greatest when the scattering is greatest, and this occurs at the low frequencies. At high frequencies, the energy is concentrated in specular directions, and so the scattered energy for these receivers is small. Rindel showed that using smaller panels was advantageous, as it reduced the roll-off at high frequencies for receivers away from the geometric reflection point.

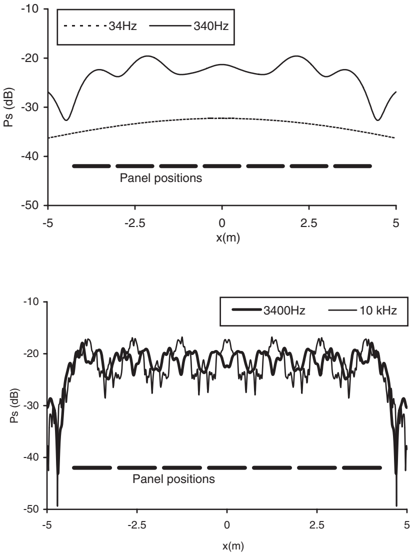

Figure 1. Near field scattering from an array of plane panels along a straight line for various frequencies. (Top) 34 Hz and 340 Hz response. (Bottom) Response at 3.4 kHz and 10 kHzThe panel positions in the x-direction are shown at the bottom of the illustration.

Either the size of the reflectors or the panel density determines the low frequency performance of an array. It is possible to imagine cases where it is a combination of these effects which is important. The mid and high frequency performance is dominated by strong local variations, due to the size of the reflectors and the repeat distance between them. The solution to this and periodic lobing is to use optimized, modulated non-plane surfaces, as shall be discussed later.