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OVERHEAD CANOPY DESIGN

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We have discussed the time and frequency response of the total field, direct plus scattered, from a flat panel surface. Now we examine the spatial distribution of the scattered sound, as described by a polar response. As we will see the polar response is a far field indicator and is very dependent on the relationship between the panel size, 2a, and the wavelength, λ.

Measurement of the polar response of a scattering surface, has been described in AES-4id-2001. To be in the far field of a scattering surface, the difference between the longest and shortest paths from source to panel to observer, should be small compared to the wavelength.. Typically the longest path is from the source to the edge of the panel to the observer and the shortest path is the specular one.

Figure 1 shows the scattering from a plane thin rigid surface as a polar response, using the thin panel boundary element method (BEM) prediction. The scattering is shown for several frequencies and is in the far field. For the largest wavelengths (lowest frequencies), the scattered response is exactly the same as that produced by a dipole, following a function typical of a low frequency dipole approximation. At |cos(ψ)| grazing angles there is zero pressure. This only happens for the infinitesimally thin surface, since surfaces with finite thickness produce finite pressure. In fact, the pressure for all angles is relatively low for large wavelengths, as destructive interference is the dominant phenomenon, as is true of dipoles. To put this in a less technical language, when the wavelength is much larger than the panel size, the wave does not "see" the panel and propagates largely undisturbed.

As the frequency increases, and the wavelength becomes comparable and then smaller than the panel size; eventually a specular reflection becomes apparent. Energy is concentrated in the specular reflection direction obeying Snell's law, where the angle of incidence equals the angle of reflection. This is a special case of Fermant's principle, where the specular reflection direction is the shortest possible path length and so is preferred.

Figure 1 presents the far field response. In real spaces, however, listeners and sources can be quite close to surfaces. Figure 2 shows how the scattered pressure distribution varies for a high frequency, as the receiver approaches the panel. At 0.8m from the panel, the receiver arc diameter is actually smaller than the panel width. For all receivers on the 0.8m arc, the scattered pressure is high, because for every receiver there is a geometric reflection point on the panel giving a strong specular reflection. As the receiver arc moves further from the panel, fewer receivers get a strong reflection, eventually the far field response is achieved.

Figure 2 implies that, close to the panel, the flat surface is good at dispersing sound. In particular, good coverage is achieved because all receivers get similar energy in the reflection. Does this imply that a plane surface is a good diffuser as it is dispersing scattered energy evenly to all receivers? The answer is no, because, in reality, the plots in Figure 2 are only telling part of the story. The polar plots of scattered energy do not show how the direct and reflected sounds interfere, or the effect this has on the sound heard by the listener. In fact, a comb filter response would result, and this is likely to colour the sound due to changes in emphasis of different frequency components. At 1.2 m the polar response has a flat top. We call this the specular zone. It is within this angular region that the observer is receiving specular reflections from the panel. At 5 m this specular zone become smaller and at 100 m it is very small.

In dB Volume 1, Issue 4, we discuss the response of panel arrays, which are used in canopy design.

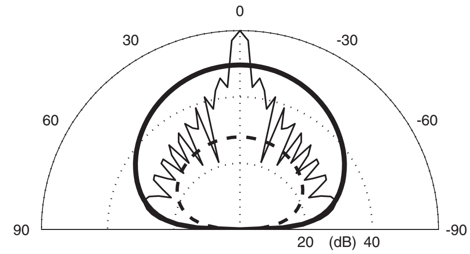

Figure 1. Polar resonse for scattered pressure from a plane panel for three different frequencies. Radial axis, 20 dB/div. Thin panel BEM prediction.

- - - - - λ=20a ▬▬ λ=2a —— λ=0.2a

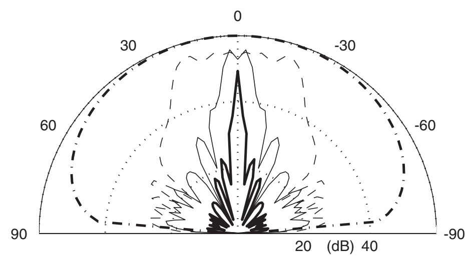

Figure 2. High frequency scattering from a plane surface 1 m wide (= 36 l) for four different receiver radii.

– · – 0.8 m - - - - - 1.2 m

—— 5 m ▬▬ 100 m