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OVERHEAD CANOPY DESIGN

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Up to this point, we have been considering the response of single flat panel scattering surfaces. However, in the design of an overhead canopy, multiple panels of a given size and separation are utilized to form an array. Traditionally this grouping comprises a periodic array in which a single panel is repeated in one or two directions.

When multiple plane panels in an array are used, then the response is a combination of both the response of a single panel and the periodic arrangement of the array.

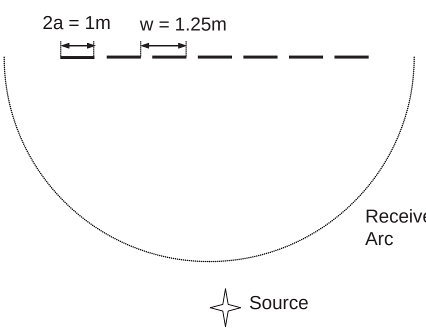

Figure 1. Sketch of array of plane panels tested (source and receiver positions not to scale).

Figure 1 shows a sketch of an array which will be used to demonstrate the response. For simplicity, scattering in one plane, predicted using a 2D model, will be used. The findings can be generalized to a 3D array, as the general principles are the same.

Using the simple Fourier Theory, it is possible to represent the array response, p_a, as a multiplication of the single panel response and a set of delta functions:

$$p_a(\beta) = p_1(\beta)\sum_{n=-\infty}^{n=\infty} \delta\left(\beta - \frac{m\lambda}{W}\right) \quad (1)$$

$$\beta = \sin(\psi) + \sin(\theta) \quad (2)$$

Where:
β is the transform variable
ψ and θ are the incidence and reflection angles respectively;
p_a is the pressure from the array;
p_1 is the pressure from a single panel;
m is an integer;
λ the wavelength;
2a the single panel width;
W the repeat distance,
and δ the delta function.

This formulation is for the far field. It is an approximate representation, and so the graphs which are being shown are actually generated by an accurate BEM model. Equation 1 is being used purely to aid understanding of the physical processes.

Figure 2 shows the scattering for three contrasting frequencies. The last term in Equation 1 means that it would be expected that whenever:

$$\beta = \sin(\psi) + \sin(\alpha) = \frac{m\lambda}{W} \quad (3)$$

there should be a reflection similar to the single panel alone. For the middle frequency in Figure 2, Equation 3 predicts lobes at 0, +/- 53^0 and this is borne out by the prediction or grating lobes results. Consequently, at mid frequencies, periodicity effects will often dominate, and Equation 3 will predict their location.

At low frequencies, the scattering from a single panel is rather small (20dB less in

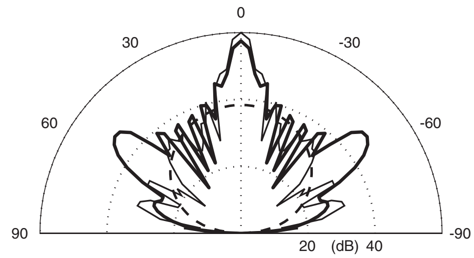

Figure 2. Scattering from an array of plane panels for three different frequencies.

- - - - - - ***34 Hz; l=20a***

▬▬▬ ***340 Hz; l=2a***

——— ***10 kHz; l=0.07a***

the specular reflection direction) and follows a dipole response as the wavelength is large compared to panel size. In this case, the single panel response $p_1(\beta)$ is dominating the scattered level. The array produces a polar response which is very similar to a single panel, albeit with an increased power to the greater surface area of the array of panels compared to a single panel. There are no periodicity lobes, because the wavelength is so large, that only the zeroth order mode (m=0) can exist in the far field.

At the highest frequencies, the scattering is dominated by a strong specular reflection. Equation 3 predicts a large number of side lobes (~70), but these are not seen. The reason for this is that the response of the single panel, p_1 is highly directional as was shown in Figure 2, dB Volume 1, Issue 3. Consequently, most of the side lobes are of very low level. In fact, the scattering from the array of panels is not too dissimilar to that of a single panel, except for a change in radiated power due to greater surface area in the array.

In dB Volume 1, Issue 5 we describe the near field response of a panel array used in canopy design.