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INTENSITY MEASUREMENTS

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The measurement of intensity has undergone a very rapid development in the last few years. From a laboratory tool for the researcher, the instrumentation for intensity measurement has developed into practical tools allowing intensity to be measured in daily field situations.

The practician using the two pressure microphone method with proper phase calibrated microphones, will have found a multitude of application. Measurements in the very near field of a vibrating panel give a lot of information which may be very useful once properly understood.

The capability to measure in the very near field of a plate is very demanding on the instrumentation. The field is reactive which means that the pressure component is high and the intensity component low. The velocity vector is out of phase with the pressure component. If for instance the pressure level is equal to the intensity level at 400 Hz, the phase difference seen by the two microphone channels is 5 degrees. 1 dB intensity error corresponds to 1 degree phase error for a Δr of 12 mm between the two microphones. If for instance the pressure level is 6 dB higher than the intensity level, the phase between the two channels is only 1,3 degree, and 0,3 degree phase shift in the instrumentation will cause an intensity reading of 1 dB too low or 2,2 dB too high depending on the sign of the phase error. [1]

With the instrumentation error under control and using the best compromise in spacing Δr between the two microphones, valuable information about the vibrational behaviour of plates may be derived from measurements of the evanescent waves close to plates by mapping the iso contours surrounding the sink and source centers.

As an example, a series of measurements have been carried out on two loudspeakers mounted in a large particle board plate. Mapping was carried out with the instrumentation shown in fig. 1.

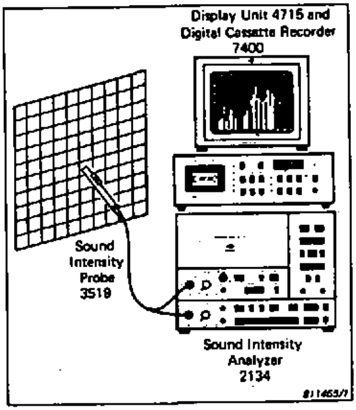
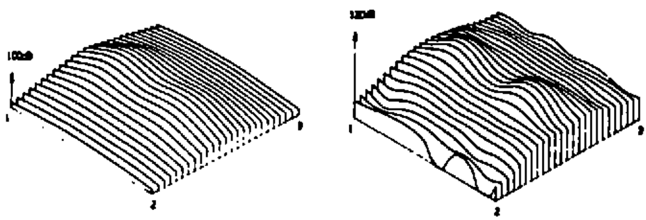


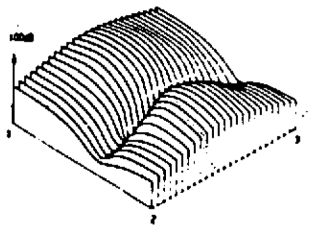
Fig. 1. Intensity measuring set-up

Pressure and intensity were mapped, and at 315 Hz (λ=1,08 m) the 3-dimensional contour maps look as shown in fig. 2 when the loudspeakers were in phase and as in fig. 3 when they were in opposite phase.

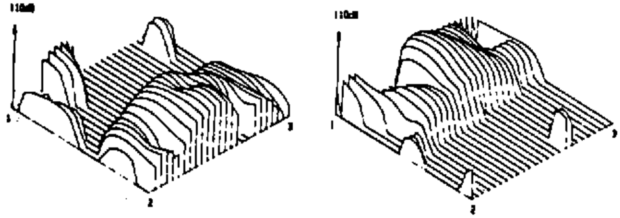


a) Sound pressure b) Positive intensity

Fig. 2. Contour maps of two loudspeakers in phase at 315 Hz



a) Sound pressure



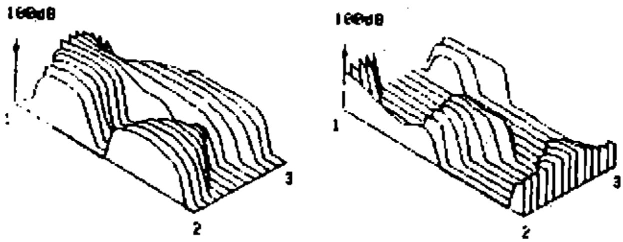
b) Positive intensity   c) Negative intensity

Fig. 3. Contour maps of two loudspeakers in opposite phase at 315 Hz

Similar measurements were performed on a panel standing freely on the floor in the middle of a room (215x280x415 cm). The panel consisted of an iron plate (1,25x600x800 mm) with 25x25 mm square profile steel tubes screwed to the edges and was excited with a vibration exciter.

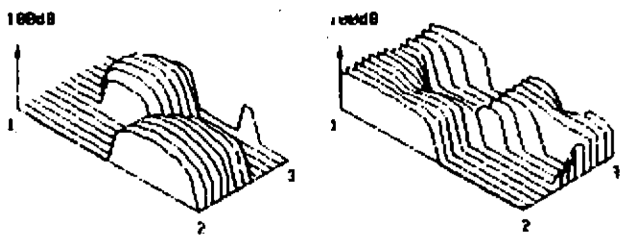
As for the two loudspeakers in opposite phase, the panel is at certain areas absorbing sound energy, fig. 4, and the total radiated sound power is reduced. The areas of energy radiation and absorption are related to the vibration pattern of the plate, but are also influenced by the acoustical environment. This can be seen by comparing the contour mappings of the two sides of the panel, figs. 4 and 5.

It is seen that an area on one side radiating (or absorbing) sound energy, may on the other side of the panel equally well be absorbing or radiating energy. Since the vibration pattern on the two sides of the panel are identical, it is not possible from measurements of vibration phase and amplitude alone to identify radiating and absorbing areas.



a) Positive intensity b) Negative intensity

Fig. 4. Contour maps of panel at 100 Hz, front side



a) Positive intensity b) Negative intensity

Fig. 5. Contour maps of panel at 100 Hz, back side

The negative sound intensity, corresponding to sound absorption, is limited to the frequency range below the coincidence frequency, i.e. the frequency where the wavelength of transversal waves in the plate equals the wavelength of sound in air. [2] Furthermore, the negative intensity can only be measured in the nearfield of the source. The extent of the nearfield is related to frequency, but is smaller than the wavelength of the sound. At 400 Hz the nearfield extends to approximately 25 cm while the wavelength is 85 cm, and at 800 Hz the nearfield is reduced to about 10 cm.

REFERENCES

[1] Michael Brock, "Intensity Measurements using Tape Recorder", Brüel & Kjær Technical Note, and Rasmussen et Brock, "Transducers for intensity measurements", 11^{e} ICA, Paris, 1983.

[2] E. Skudrzyk, "Sound Radiation of an Infinite Plate Excited to a Sinusoidal Vibration Pattern", The Foundations of Acoustics, pp 319-325, Springer-Verlag, 1971.