

**Accumulated Acceleration Level**

Definition

\[ A_{\text{AAL}}(r) = 20 \log \left( \frac{P_{\text{rms}}(r)}{P_{\text{rms},\text{ref}}} \right) \]

Absolute value of cone acceleration is accumulated over all points \( r \), so the radiator's surface is weighted by the distance \( r \) and further constants to be comparable with the sound pressure output at observing point \( r \). The far-field radius neglecting any phase information.

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Reference sound pressure \( p_0 \).

**Modal Analysis**

The acceleration \( a(r) \) of each point \( r \) on the radiator's surface can be expressed as a sum of orthogonal modes whereas each mode is represented by a characteristic mode shape \( \phi \), natural frequency \( w \), and modal loss factor \( h \), to the modal frequency response \( H(f) \).

\[ a(r) = \sum H(f) \phi \]

\[ H(f) = \frac{1}{s + \frac{w}{2}} = \frac{1}{s + \frac{2\pi}{T}} \]

**Modal Loss Factor**

- Is defined as a dB bandwidth of the modal resonance divided by natural frequency.
- Depends on frequency and temperature.

**Axial-Symmetrical Decomposition**

Mechanical and acoustical characteristics derived from the results of laser scanning are helpful for selecting the optimal transducer for the particular application and to develop constructive improvements and alternative design choices.

If the radiator has a curved shape the modes propagating in radial direction can be calculated by averaging the vibration versus the circumference. The circumferential component is the difference between total vibration and radial component. Both components can be separately identified and assessed by SPL and AAL quantitatively.

**How to Measure the Influence of the Air Load?**

- Scanned vibration radiator in air and in vacuum
- Compare mechanical vibration (AAL) with and without air load
- Predict sound pressure output (SPL) of both vibration patterns

**Loudspeaker Measurements**

for assessing small signal performance

**Distributed Loudspeaker Parameters**

A laser triangulation scanner provides Vibration and Geometry of the radiator's surface to high accuracy. These mechanical distributed parameters are important data for assessing the mechanical behavior, predicting the sound pressure output and selecting optimal transducer for the particular application.

**Optimal Scanning Grid**

The resolution of the Explore Scan is sufficient to predict the sound pressure output. High frequencies are measured and predicted. The Profile Scan can only detect axial-symmetrical vibrations and the accuracy of the predicted sound pressure may be affected by circumferential modes (i.e., deviations at 3.8 kHz below). The Rectangular Scan is too inefficient for TV and micro-speakers.

**Where to Apply Damping?**

Vibrate the mode shape at these resonances where the modal loss factor is too small. Increase the damping in the material where the amplitude of the mechanical vibration is high. Magnesium used as cone material shifts the first break-up to 8 kHz shown in the example above. Additional damping would be required to use this transducer over the full audio band.

**Diagnostics**

**Asymmetrical Vibration?**

Irregularities in the manufacturing process may cause an uncontrolled vibration at the diaphragm (example: head-phone transducer).

- Is the Rocking Mode Too High?

Rocking mode is usually the first circumferential mode which may cause voice coil rubbing. Check that AAL of the rocking mode is below the total AAL.

**References:**