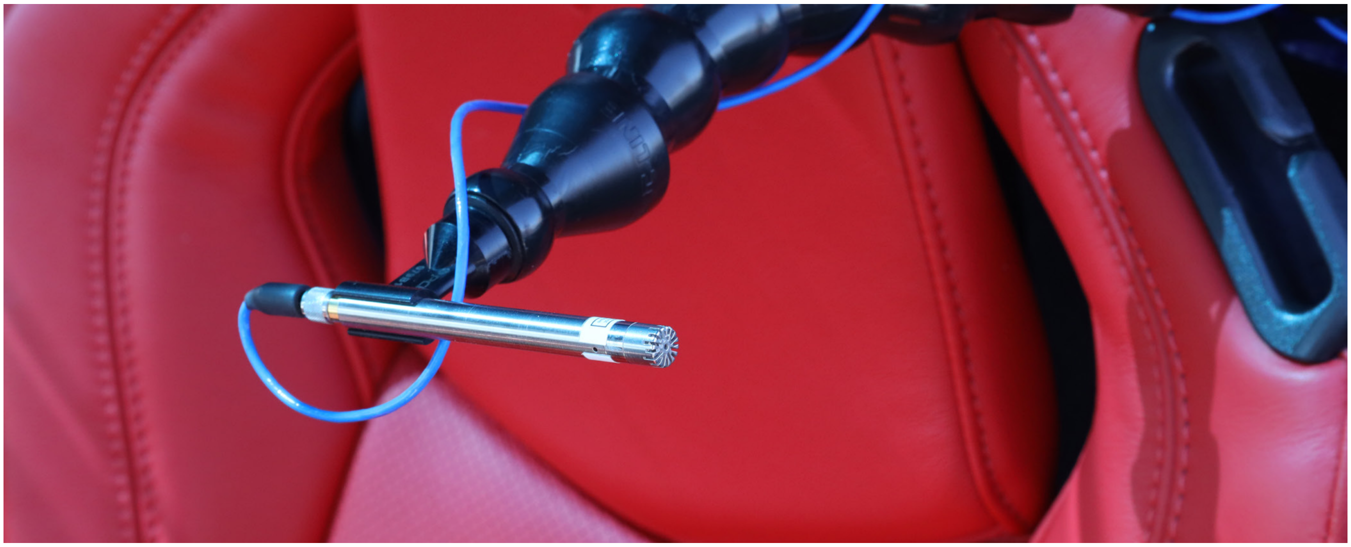

Small Microphone Has Big Impact on NVH Testing

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PCB Piezotronics has introduced an innovative microphone, that with a 22 dB(A) noise floor is the quietest ¼” measurement microphone in the world. Its compact size, high sensitivity, and exceptionally low noise floor make it ideally designed to tackle the testing needs of Electric Vehicle (EV) Noise, Vibration, and Harshness (NVH), or any other application where the use of a larger microphone could lead to significant diffraction errors.

EVs are considerably quieter compared to their traditional internal combustion counterparts. This quietness leads to drivers noticing low-level noises that would have been drowned out by engine sound. The sources of these noises in EVs can range from traditional factors like tires, auxiliary systems, aerodynamics, bearings, and drivetrain, to high-pitched tonal noises coming from electrical components, such as the motors and inverters. Even though these tonal noises have a low sound pressure level (SPL), they are often characterized as "whining" or "annoying" and have a significant impact on overall sound quality.

Traditional ¼” and ½” microphone technology struggles when it comes to accurately measuring low SPL at high frequencies. Detecting low SPL demands a microphone with high sensitivity and an adequately low noise floor. Previously, only a ½” microphone could meet the noise floor and sensitivity requirements. However, a microphone of this size will generate substantial diffraction errors at high frequencies.

Figure 1. *PCB 378A08*

Diffraction, or interference with the sound field, becomes a problem when the microphone diameter is on the same order or larger than the wavelength of sound. Given that wavelength is inversely proportional to frequency, diffraction errors are most pronounced when larger microphones are used at higher frequencies. Various factors contribute to these diffraction errors, including the characteristics of the sound field, the size of the microphone, the microphone's orientation within the sound field, and the frequency of interest.

To mitigate diffraction errors, microphones are designed specifically for certain sound fields. These sound fields and corresponding microphone types are: pressure, random incident (also known as diffuse), and free field. The design goal is, for the particular field type, to achieve constant sensitivity regardless of frequency, which is known as a flat frequency response. In usage, to achieve the flat response the microphone must be correctly aligned with the field. For instance, a free-field microphone is optimized for 0° incidence to the free-field - meaning it points towards the sound source and is located far from any reflecting surfaces. If the microphone is directed at angles differing from 0°, the sensitivity at high frequencies will be diminished.

The conventional workhorse for acoustic measurements is a ½" free-field measurement microphone such as PCB's 378B02. With its low power, 2-wire ICP® operation, excellent environmental stability, low noise floor, and high sensitivity of 50 mV/Pa it brings a number of advantages to NVH testing. However, a microphone of this size will suffer from the diffraction and orientation errors previously outlined. These errors can be lessened to an acceptable level using a smaller size ¼" free-field microphone, like PCB's 378C01. However, the higher noise floor (equal to 42 dB(A) SPL typical) and lower sensitivity (equal to 2 mV/Pa) make the conventional ¼" microphone unsuitable for low SPL measurements.

The 378A08 overcomes these challenges by combining low noise with small size, blending the best features of ¼" and ½" microphones while maintaining the ICP® signal conditioning low power, 2-wire connectivity, and environmental stability that PCB Piezotronics microphones are known.

Figure (2) depicts the difference in ¼" and ½" microphones' sensitivity from its calibrated value. This deviation, if left uncorrected is a measurement error. This figure illustrates the advantage of using a ¼" microphone in a sound field or an orientation that is not clearly defined. The figure clearly shows sensitivity attenuation with respect to frequency for both ¼" and ½" microphones. However, the drop in sensitivity for the ½" microphone at higher frequencies is significantly more pronounced than for the ¼" leading to unacceptable measurement error.

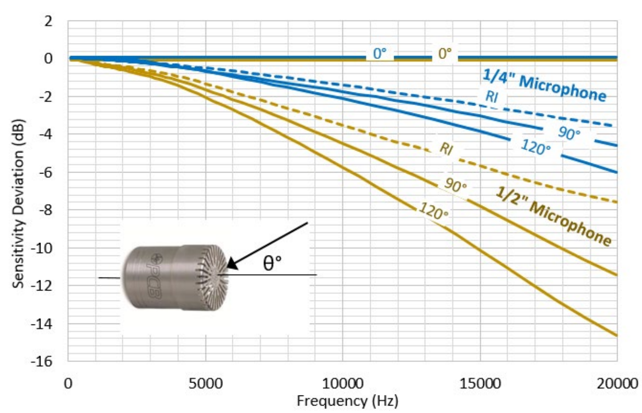

Figure 2. *Sensitivity difference from calibrated value (error), for free-field microphone when used in a free-field with orientations 0°, 90° and 120° to the field. Microphone is calibrated at 0° orientation and 120° is close to worst case angle. The dashed lines indicate the sensitivity difference in a random incidence (RI) field.*

The smaller ¼" microphone has the additional benefit of its noise floor being less affected by orientation and field type. A microphone's free-field noise specification is published for the device set up in a free field at a 0° incidence. In use, if the microphone is a different field type or in a free field with an orientation differing from 0°, the noise floor will inevitably rise due to diffraction. Figure (3) demonstrates that, due to its compact size the ¼" microphone maintains a low noise floor regardless of orientation. Surprisingly, for an orientation of 120° and frequencies greater than 13.5 kHz, the 378A08 microphone has lower noise than the ½" microphone.

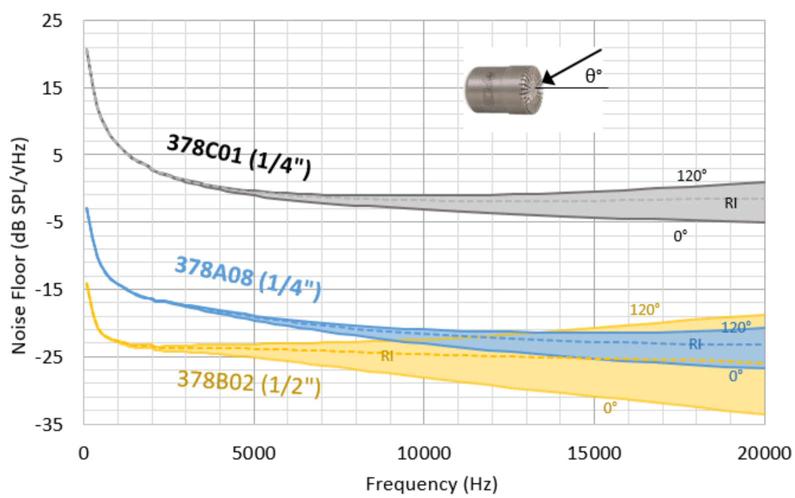

Figure 3. *Typical spectral noise floor for free field microphone in different orientations and fields. Shaded area depicts noise in a free field with orientations ranging from 0° to 120°. Dashed line is noise in random incident (RI) field.*

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