A Method for Measuring the Vibrational Sensitivity of Hearing Aid Microphones

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Electret-Condenser Microphones

The typical microphone used in a hearing aid is the electret-condenser microphone. An electret-condenser microphone mainly consists of a capacitor made of a thin metalized diaphragm and a rigid metal back plate. A permanent electric charge is applied to the back plate. Therefore the electret-condenser microphone can be operated without external polarization voltage. A variation of the air pressure acting on the diaphragm changes the diaphragm deflection relative to the back plate. The resulting change of the voltage between back plate and diaphragm is converted into an AC signal at the output panel of the microphone [1].

Vibration Sensitivity of Hearing Aid Microphones

A variation of the distance between diaphragm and back plate can not only be caused by sound but also by vibrating the microphone. The back plate has a rigid connection to the microphone housing and follows the movement of the housing directly while the diaphragm has a certain inertia. When the microphone back plate moves due to vibration of the microphone housing the diaphragm does not follow the movement of the back plate immediately. In this way vibration as well as sound causes an electrical signal at the output panel of an electret-condenser microphone. Therefore not only acoustical but also mechanical feedback can occur in a hearing aid.

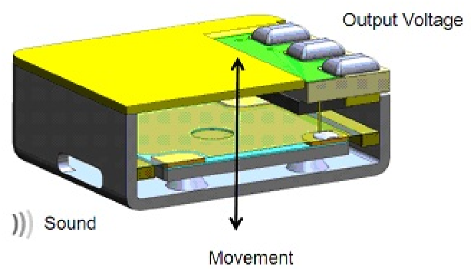

Figure 1: Vibration as well as sound causes an electrical signal at the output panel of an electret-condenser microphone.

Traditional Method for Measuring the Vibration Sensitivity

For the measurement of the vibration sensitivity of a hearing aid microphone the microphone traditionally is vibrated using a shaker. When vibrating the microphone the shaker generates sound. One of the greatest challenges in measuring the vibration sensitivity is to separate the microphone output signal caused by vibration from the output signal caused by the sound of the shaker.

The traditional approach would be either to vibrate the microphone in a soundproof enclosure or to build a soundproof enclosure around the shaker [2].

This publication presents a novel solution that allows for a vibration sensitivity measurement of a hearing aid microphone without using a sound proof enclosure.

Input separation by phase invertion

The approach is to place the microphone on a shaker and vibrate it while measuring the vibration input and the microphone output (U_{Mic1}). This measurement step is similar to the traditional vibration sensitivity measurement discribed above. Only the soundproof enclosure is not necessary. The next step is to rotate the microphone by 180°. Then the microphone is vibrated again using the same vibration input as in the previous measurement. The output of the rotated microphone is measured (U_{Mic2}).

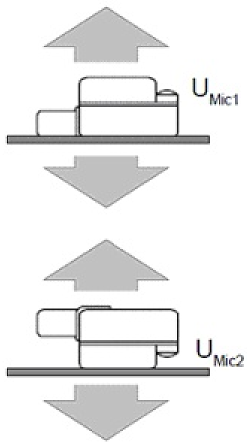

Figure 2: Microphone placed on Shaker surface during up side and down side measurement.

By rotating the microphone by 180° the microphone output component caused by vibration is inverted while the component caused by sound remains unaltered. The influence of the sound generated by the shaker can be cancelled out by subtracting the results of both measurements:

$$U_{Mic1} = U_{Sound} + U_{Vib} \qquad [V] \qquad (1)$$

$$U_{Mic2} = U_{Sound} - U_{Vib} \quad [V] \quad (2)$$

$$U_{Vib} = \frac{U_{Mic1} - U_{Mic2}}{2} \quad [V] \quad (3)$$

The Microphone output voltage caused by vibration U_{Vib} can be related to the vibration input to determine the vibration sensitivity of the microphone under test. If the sensitivity of the measured microphone is known an input sound pressure level that would cause the same output voltage as the applied vibration can be determined (Input referred Vibration Sensitivity).

Figure 3 shows the result of a vibration sensitivity measurement using the phase inversion method described above. In addition the microphone output voltage of up and down side measurement related to the vibration input is shown.

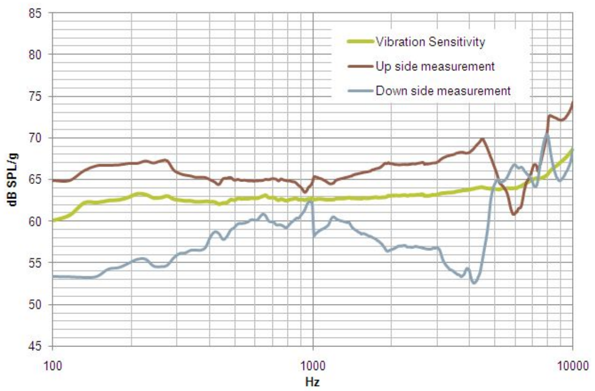

Figure 3: Microphone output signal during up side and down side measurement.

Conclusions

Changing the orientation of a microphone relative to a vibration source by 180° inverts the microphone output signal caused by the vibration. In case of rotational symmetry of the sound inlet geometry a rotation of the microphone does not influence the microphone output voltage caused by sound. Therefore it is possible to separate the microphone output signal caused by vibration from the output signal caused by sound when measuring the vibration sensitivity of a hearing aid microphone.

References

[1] Vonlanthen, A.; Arndt, H.: Hearing instrument technology for the hearing healthcare professional. Cengage Learning, 2006

[2] Killion, M.: Vibration Sensitivity Measurements on Subminiature Condenser Microphones, `http://www.etymotic.com/publications/erl-0057-1975.pdf`, March 2010