First Pan-American/Iberian Meeting on Acoustics, Cancun

Stop that Screech! An Improved Hearing Aid Transducer

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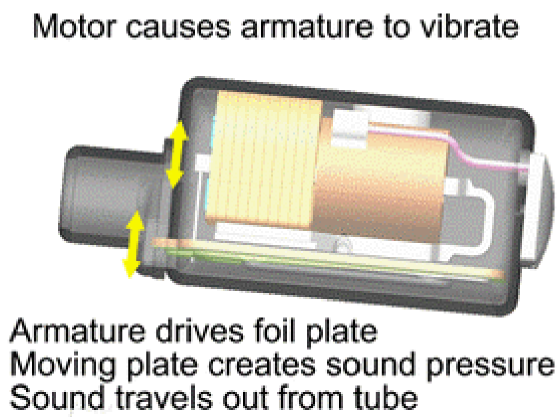
We are all too familiar with the loud SCREECH!!! that can happen in a public address system when the microphone is placed too close to the loudspeaker. Unfortunately, the same thing can happen in a hearing aid. After all, a hearing aid contains a microphone and a loudspeaker connected by a high gain amplifier — and the distance between the microphone and speaker is *very* small. The people and companies who design and fit hearing aids must pay constant attention to minimizing the sound from the speaker that is able to pass from the ear canal back to the microphone.

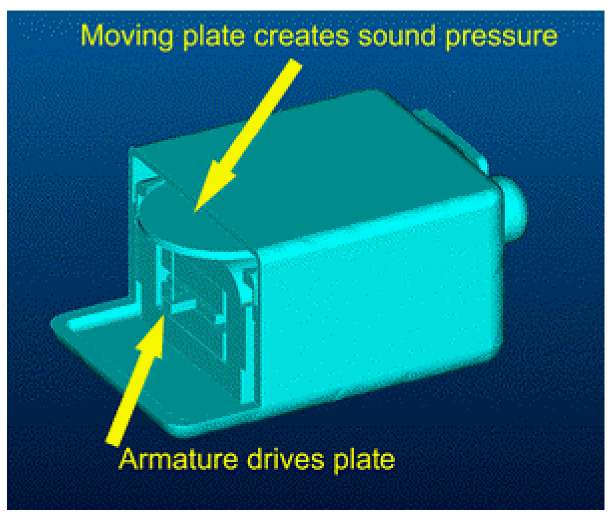
However, there is another way that energy from the speaker can get to the microphone to provide the feedback needed to start a screechy oscillation. All loudspeakers generate at least a small amount of vibration as an unintended consequence of their operation. If this vibration is transferred to the hearing aid shell, it may generate a small amount of sound that is sensed by the microphone. The possibility of feedback from this vibration is much greater in a hearing aid than in a public address system, because the microphone and speaker are connected to each other through the case of the hearing aid. For decades, hearing aid manufacturers have needed to be very careful in the way the microphone and speaker are mounted into the case to minimize the possibility that vibration feedback could cause an oscillation.

The reason that loudspeakers generate vibration is that they contain moving parts. Their intended purpose is to generate sound, which is a pressure wave in the air. To do this, they have a large surface that oscillates quickly and pushes the air in front of it to create the sound pressure. In auto and home stereo systems, this surface is the cone-shaped surface of the loudspeaker. In a hearing aid, the moving surface is a thin foil plate inside a component called the "receiver" that is buried inside the hearing aid shell. The moving foil plate produces a sound pressure inside the receiver, and this sound travels to the ear canal through a small tube.

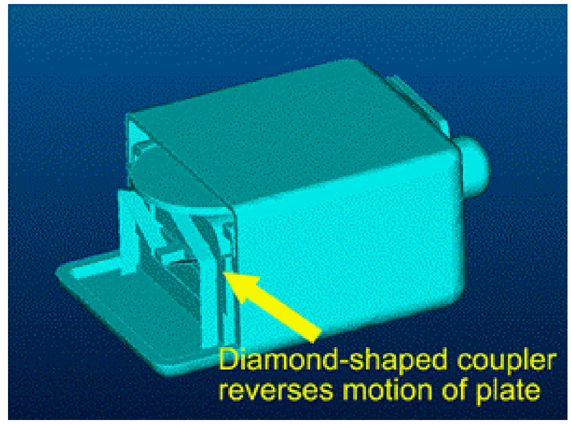


Inside the receiver, the moving plate is pushed by a thin iron armature, that in turn, is pushed by the magnetic field generated by an electrical current from the amplifier. To understand why the receiver generates vibration, the important thing to notice is that the foil plate that generates the sound and the iron armature that drives it are moving together. They move back and forth together, both of them always moving in the same direction at any given time.

Newton's Third Law of Motion says that "for every action, there is an equal and opposite reaction." In this case it means that the force needed to move the foil plate and armature must be balanced by an equal and opposite force from the body of the receiver. This reaction force causes the receiver case to vibrate, as can be seen in the figure at the right. The receiver vibration is all too easily transferred to the hearing aid shell. Once in the shell of the aid, the vibration can easily travel on to the microphone. This paper describes a new receiver design that significantly reduces the amount of vibration from the receiver. The objective of the development is to remove the vibration at its source, so that hearing aid manufacturers can make aids that are more reliably free from the problems of feedback oscillation.

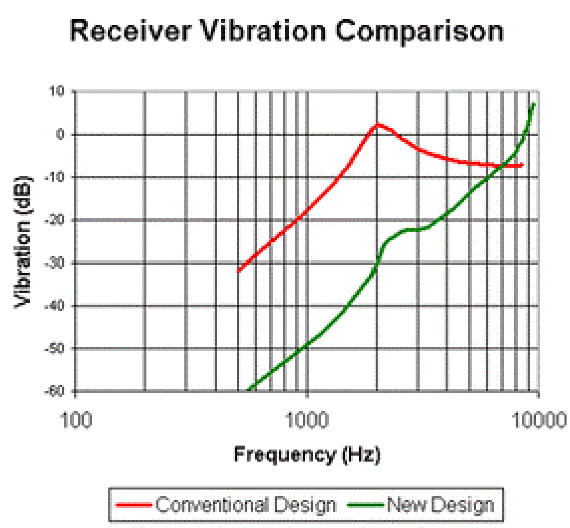


In the old design, the motion of the armature is simply coupled to the foil plate through a thin rod. The armature, the rod and the plate all move together. The new design replaces the rod with a diamond-shaped motion coupler that causes the plate to move in the opposite direction from the armature. With the armature and plate moving in opposite directions, the forces that they exert on the receiver case are in opposite directions, and thus cancel. This allows the possibility of significant reduction in vibration of the case. If the two forces can be made to be equal and opposite, then they will cancel completely, and no vibration force would be transmitted to the case. Notice that the receiver case in the new design to the right does not move as does the conventional design above.



The first thing that must be done to balance the forces is to make the mass of the moving plate equal to that of the armature. This means that a lot of mass must be added to the foil plate, since it is normally much lighter than the iron armature. (The thickness of the armature cannot be decreased, as this would significantly reduce the acoustic output available from the device.) The simple addition of mass to the plate works well at low frequencies, but by itself is not sufficient at higher frequencies. The reason is that, at higher frequencies the plate does not remain completely rigid, but bends a little as it vibrates. At some higher frequency, the plate has a bending resonance in which different parts of the plate move in opposite directions. For all frequencies near to and above the frequency of the first bending mode resonance, where the plate does not move as a rigid mass, it does not properly balance the vibration of the armature. The early prototypes of the design worked quite well for frequencies below 1000 Hz, but had even greater vibration than the conventional receiver for frequencies above 3500 Hz.

A significant effort in the last year has been made to redesign the vibrating plate to increase the frequency of its first bending resonance mode. In current prototypes, this bending resonance occurs at a frequency above 10 kHz. The graph at the right shows that the device provides an improvement over the conventional device for all frequencies below 7 kHz, and provides at least 30 dB (a factor of 30) reduction in vibration at all frequencies below 2 kHz. This receiver thus provides a substantial



reduction in vibration at all frequencies that are normally problematic for hearing aid feedback oscillation. A vibration reduction of this amount has been verified in laboratory prototypes.

We expect that this vibration balanced receiver will have advantages for both hearing aid manufacturers and users of hearing aids. For manufacturers, the advantage should be easier and quicker methods of manufacturing, since less attention need be given to isolating the receiver vibration from the hearing aid shell. For the user of hearing aids, the objective is aids built with the new receiver will have less of a tendency to screech.

Of course it would be wonderful if we could conclude that this new receiver will eliminate all problems related to screeching hearing aids. That is unfortunately not the case. There are other forms of feedback than vibration, and those require different kinds of solution. Much work has been done by others in recent years on the general problem of feedback reduction in hearing aids, and progress is being made on several fronts. The vibration balanced receiver will work well in concert with these other feedback reduction methods. It is realistic to expect that the combination of this new receiver with other feedback reduction methods that have become available will make a substantial improvement in the products available to hearing impaired people.
