Technology shows promise in reducing telecoil interference

By Bowen Marshall

A November 2002 Knowles MarkeTrak VI study investigated what improvements in hearing instruments the most current users would appreciate.[1] The study's author, Sergei Kochkin, PhD, reported that more than eight out of ten consumers would welcome improved performance in understanding speech on the telephone. In fact, only 38% of users said they were satisfied with their telephone hearing experience. These findings suggest that the increased use of telecoils and improvements in telecoil technology would raise the level of user satisfaction with hearing aids.

HOW TELECOILS WORK

The loudspeaker in a telephone earpiece generates an acoustic output that can be detected by a hearing aid microphone. This acoustic signal, however, is subject to background noise and acoustic feedback, which result in degraded intelligibility. Although some manufacturers employ signal processing techniques to reduce feedback, excluding background acoustic noise remains a problem, particularly with behind-the-ear instruments.

Fortunately, the same signal that generates acoustic output also generates an electromagnetic field fluctuating in direct proportion to the acoustic output. An optional hearing aid component known as an audiocoil or telecoil (T-coil) can sense this fluctuating field. This allows a telecoil-enabled hearing aid to reproduce sound directly from a telephone's electromagnetic field without acoustic background noise or acoustic feedback. A hearing aid equipped with a telecoil can significantly improve the wearer's speech comprehension on the phone.

As telecoils have proliferated, the industry has developed a variety of assistive listening systems that use electromagnetic fields to carry signals to hearing aids. These include both interpersonal assistive listening systems and room loop systems that are frequently installed in public spaces such as theaters, auditoriums, and houses of worship.

INTERFERENCE IS A COMMON PROBLEM

Interference caused by stray magnetic fields can create a problem for telecoil use. In fact, this interference has been a primary complaint of users and is probably a significant deterrent to more widespread use of telecoils. The pervasiveness of electronic devices in everyday life is only increasing the prevalence of stray magnetic fields and the problems they cause.

Common sources of telecoil interference include electrical transmission and distribution lines, fluorescent light fixtures, industrial equipment, appliances, computers, and

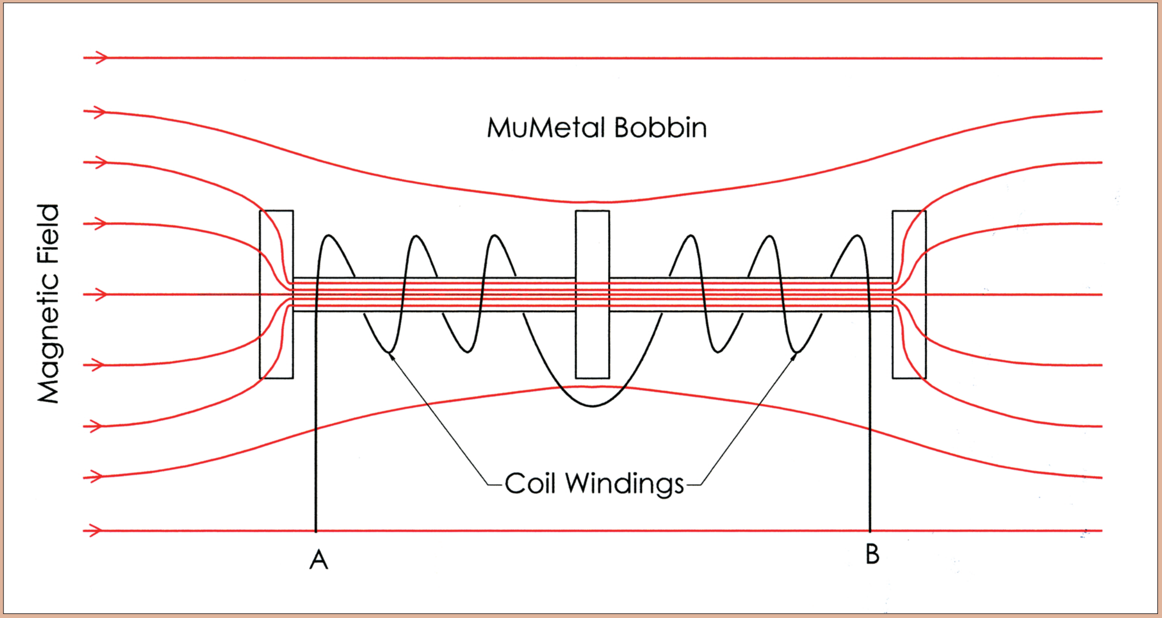

Figure 1. *Far-field canceling coil in a uniform magnetic field.*

other electrical and electronic devices. Stray fields from these sources are generally in the range of 50 to 400 Hz and are perceived as buzzing and/or humming sounds. But, in some instances, interference can extend to 10,000 Hz or beyond and is manifested as hissing or other higher-pitched noises or distortion.

In analog hearing instruments, high-pass filters have traditionally been used to attenuate the low-frequency noise components. However, the long time constants required make this approach inflexible and cumbersome, especially for higher order filters. Advanced digital signal processors (DSPs) use various noise-reduction algorithms to attenuate certain interfering signals. Yet, effectively recognizing and minimizing the noise from myriad sources of electromagnetic interference that varies in time and space without degrading crucial speech information remains an important, but difficult task.

At this time, it is unclear which DSP strategies will best improve speech comprehension or listening satisfaction, but it seems reasonable to assume that users will benefit from any method that attenuates noise without affecting speech.[2-5] Furthermore, if a hearing aid wearer chooses to use a t-coil for a phone conversation within the field of a room-loop system, DSP cannot distinguish one source of speech from the other. It is clear, then, that a different approach to the problem of noise from electromagnetic sources may be beneficial in many situations.

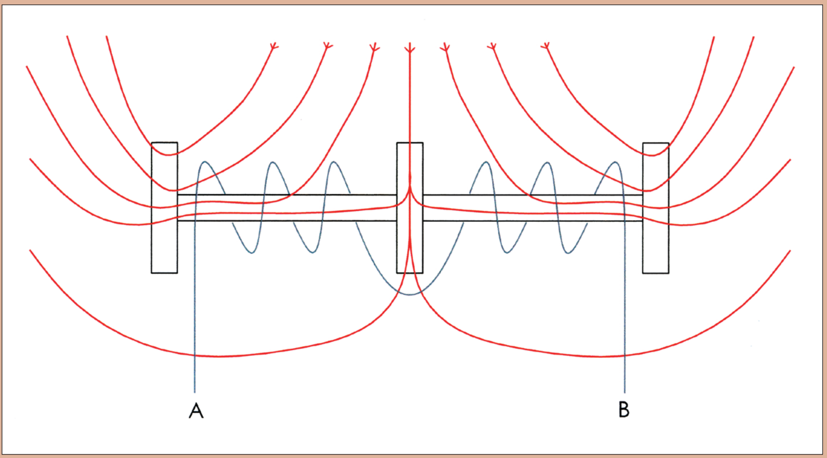

Figure 2a. *Far-field canceling coil in a non-uniform radial magnetic field.*

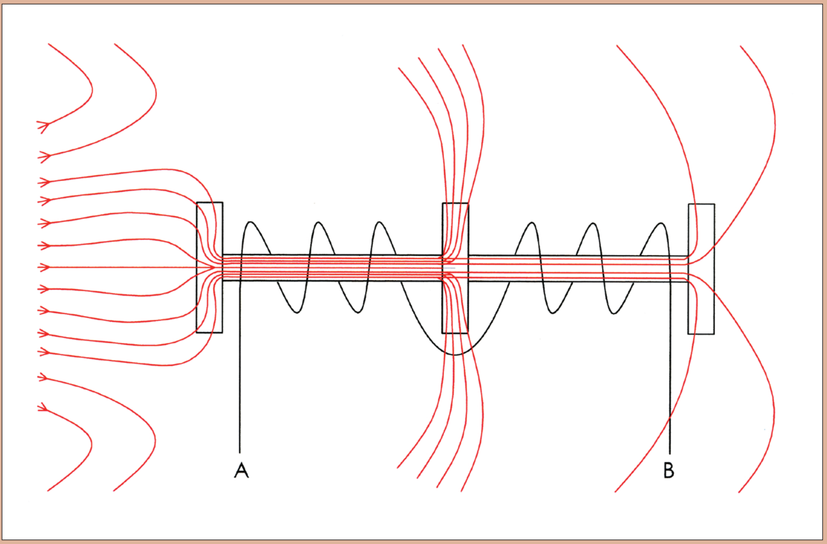

Figure 2b. *Far-field canceling coil in a non-uniform axial magnetic field.*

FAR-FIELD CANCELING T-COILS

Because the sources of interfering magnetic fields are generally located several feet or more from the hearing aid's telecoil, the field strength of these "far-field" sources is relatively uniform within the shell of the aid. Researchers at Global Coils SAGL, a joint venture between Tibbetts Industries, Inc., of Camden, ME, and R. Audemars SA of Cadempino, Switzerland, have developed an approach to the mitigation of this predominant mode of interference with "far-field canceling" (FFC) telecoil technology.

Through extensive experimentation and testing at the Global Coils facility in Maine, the concept of using cancellation techniques to attenuate telecoil response to interfering fields has been shown to be effective. Far-field canceling performance is achieved in a uniform magnetic field by configuring two identical coils such that both carry the same magnetic flux, but have opposing output signals.

Winding such identical but opposing coils end to end on a common core ensures that in uniform fields (see Figure 1) the combined output will be near zero. In the presence of a non-uniform magnetic field, such as may exist in close proximity to a telephone receiver (see Figures 2a and 2b), the magnetic flux in each coil winding—differing in magnitude and/or direction—generates signals that combine to provide an effective output for telephone listening. Although the dual-coil assembly is necessarily longer than a standard telecoil, ample sensitivity to telephone signals is possible from FFC coils on the order of 9 mm (.35 inches) in length and 2 mm (.078 inches) in diameter.

Far-field canceling telecoil assemblies have demonstrated dramatic reductions in interfering fields when compared with standard telecoil geometry. Attenuation of audio band interference exceeding 40 dB (100:1) has been achieved. A 40-dB decrease in sound pressure level is roughly equivalent to going from a very loud rock band to soft classical music or from the noise inside a New York subway car to a quiet conversation. (To hear the noise reduction FFC telecoils can achieve in electromagnetically noisy environments, visit www.tibbettsindustries.com/technical/ffc. This link offers a brief soundtrack comparing the performance of an FFC coil and a standard telecoil in the presence of common electromagnetic interference.)

WITH ASSISTIVE DEVICES

In addition to facilitating telephone use for hearing aid wearers, FFC technology can enhance the user's experience with assistive listening systems (ALS) that use electromagnetic fields generated in close proximity to the hearing aid to carry signals. Such devices include Sensorcom's "T-link" (www.sensorcom.com) and a variety of devices marketed by HATIS (www.hatis.com).

A collaborative effort between Global Coils and Gennum Corp. has demonstrated that the ability of FFC telecoils to respond selectively to telephone or near-field ALS signals can be exploited to provide automatic hands-free switching to these inputs without requiring the presence of a DC magnetic field. Room loop functionality can also be added to FFC coils with a minimal increase (~0.25 mm/0.01 inches) in diameter.

Because a loop system transmission is itself a far-field signal, the user must first disable the far-field canceling functionality to access a loop system magnetic field. Replacing the traditional M-T (microphone-telecoil) switch on the hearing aid with an M-L (microphone-loop) switch would accomplish this while still allowing automatic switching to telephone signals from either microphone or loop mode. Alternatively, the hearing aid manufacturer can forego the hands-free capability by utilizing a three-position (M-T-L) switch to select microphone, telephone, or loop mode manually.

A secondary benefit would be the ability to use the FFC telecoil for phone calls within the confines of a room loop without interference from the loop signal. In addition, because FFC coils can be configured to have virtually the same telephone sensitivity in either a vertical or horizontal orientation, it can be oriented vertically to optimize loop sensitivity (with FFC switched off) without sacrificing performance in the telephone mode.

Once optimized for general use, an FFC telecoil could be integrated easily into the hearing aid manufacturing process. Because of its slightly larger size, it is currently best suited for behind-the-ear and larger in-the-ear aids. But most importantly, it would offer an impressive reduction of wide-band magnetic interference signals in telephone use, enhancing the quality of life for a higher percentage of hearing aid users.

Bowen Marshall, MS, is Principal Design Engineer at Tibbetts Industries, Inc., where he heads coil-product design and development activities. Correspondence to the author at bmarshall@tibbettsindustries.com.

REFERENCES

1. Kochkin S: MarkeTrak VI: Consumers rate improvements sought in hearing instruments. *Hear Rev* 2002;9(11):18-22.
2. Schum DJ: Noise reduction via signal processing: Strategies used in other industries. *Hear J* 2003;56(5):27-32.
3. Schum DJ: Noise reduction via signal processing: Goals and current strategies. *Hear J* 2003;56(6):32-41.
4. Tellier N, Arndt H, Luo H: Speech or noise? Using signal detection and noise reduction. *Hear Rev* 2003;10(5):48-51.
5. Bentler RA: Digital noise reduction: (A little) beyond the basics. Presentation at the American Academy of Audiology Convention, April 2003, San Antonio.