T-Coils: Beyond the Telephone

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Introduction

T-coils (also called induction pick-up coils, or magnetic induction systems) have existed within personal hearing aids since the late 1940s (Ross, 2004). T-coils can be thought of as mini-antennas, which receive magnetic information. T-coils are in the majority of new hearing aids and their popularity continues to rise. In 2001, only 37% of all dispensed hearing aids contained T-coils, whereas in 2004, 52% of dispensed units contained T-coils (Kirkwood, 2005). According to the most recent Hearing Journal survey (Kirkwood, 2006), T-coil popularity has again increased and T-coils are now in 54% of all new hearing aids.

Unfortunately, telephone-centric names ("T-coil," "t-coil," "telecoil," etc.) infer the primary application of this technology is indeed, telephone-based. Although certainly telephone-based communication was the primary impetus for Lybarger's development of the T-coil almost 60 years ago, and telephone use is by far the most popular current application, T-coils in 2006 offer far greater application than their telephone-based names imply (see Ross, 2006).

This article will address many issues relating to T-coils, their applications and functionality.

T-Coils

The T-coil receiver within a hearing aid is a tiny piece of metal wrapped tightly with coils of copper. The T-coil detects and converts magnetic energy into electrical energy in much the same way that a microphone converts acoustic energy into electrical energy. Therefore, the T-coil receiver serves essentially the same purpose as the microphone. However, the input to the T-coil is magnetic energy, whereas the input to the microphone is acoustic energy.

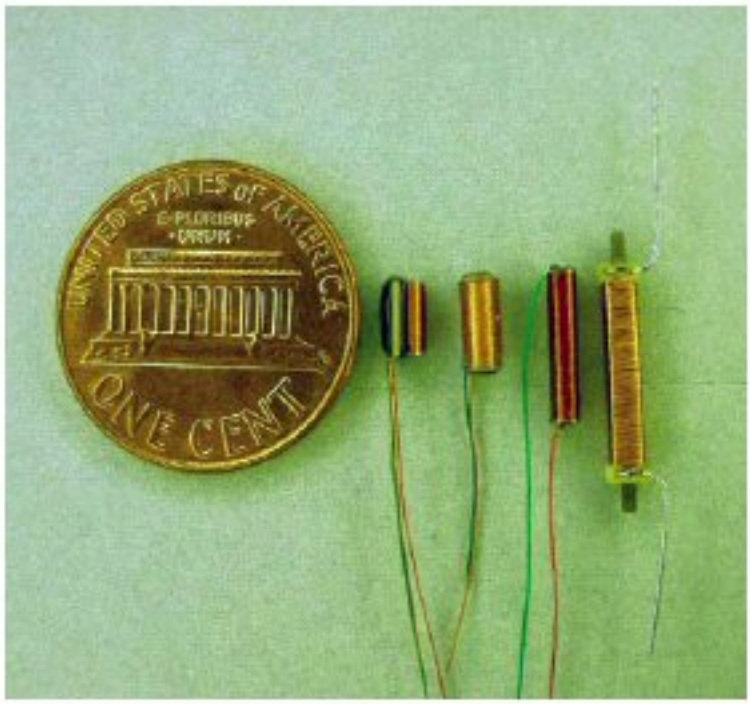

Figure 1. US Penny compared to T-coils (left to right). Generic amplified T-coil (pre-amplifier is the black mass on the left). Oticon T-coil for custom hearing aids. Oticon T-coil for size #13 battery hearing aids, Oticon T-coil for size # 675 battery hearing aids.

Hearing Aid Interference

Although most modern hearing aids are designed to suppress interference, sometimes an audible and annoying “buzz” or “hum” can be heard. Interference can impact microphone and T-coil circuits, depending on the specific programming of the hearing instrument and the strength and proximity of the interference source.

"Shielding" the T-coil to reduce interference is not feasible since effective shielding would render the T-coil useless. Sometimes, very steep low frequency roll-off filters (such as those used in Oticon’s DigiFocus, Atlas, Adapto, Gaia, Tego, Safran, SUMO DM and Syncro) effectively reduce buzzing and humming, but steep roll-offs can negatively impact microphone circuit perception.

Hearing aid circuits (microphone and T-coil) are susceptible to interference from multiple energy sources. For example: Digital cell phones, cell phone transmitting towers, some cordless telephones, close proximity AM-FM radio stations, supersonic burglar alarms and motion detectors, electrical shavers, fluorescent lights, computer monitors and other electronic equipment, large TVs, transformers, light dimmer switches, fax machines, garage door openers, and others.

Loop Systems

Loop systems offer a simple, reliable and pragmatic approach to amplification. A loop system consists of an input sound (originating in a microphone or plug-in to an alternate sound source, such as a television, an MP3 player, radio, etc), an amplifier, and a cable.

Looping an area is a relatively straightforward process. The cable is "looped" around a desired area, such as the den, living room, classroom or other area. Loops are often placed under the carpet's edge or along chair-rails. However, placing the loop at the same height as the T-coil (as worn in-situ) is advantageous and provides the strongest signal. The loop transmits an electromagnetic signal which is received by the T-coil when the hearing aid(s) is placed in the T or MT position.

Installation of loop systems can be accomplished by almost any able-bodied, energetic professional, end-user, or handyman. The most common application for home-based loop systems is to allow the hearing aid wearer to better appreciate the sounds from a television, further enhancing the value of their hearing aids. Ross (2004) noted that T-coils have achieved great popularity outside the USA. Throughout Europe, Scandinavia and the United Kingdom, churches, cathedrals, other houses of worship, post-offices, auditoriums, movie theaters, train station counters, information and senior citizen centers are looped, to be compatible with T-coils.

Looped signals can also be received by particular bone anchored hearing aids and cochlear implants, too (NDSC, 2006).

Professor David Myers and his colleagues created and maintain an excellent website (www.hearingloop.org) relating to the specific benefits of purchasing, installing and designing loop systems. Audiologists Bill and Christine Diles (Santa Rosa, California) offer a multitude of products, installation tips and resources on their website (www.wirelesshearingsolutions.com) to help hearing professionals better utilize loop technology. The reader is encouraged to visit both websites for specific and timely information relating to design, acquisition and installation of loop systems.

Which Patients Benefit from T-Coils?

The decision to acquire a T-coil is often founded in the professional's knowledge of the patient's hearing loss, and the patient's personal and professional communication needs and desires, and the hearing aid style selected.

Many patients with mild and moderate hearing loss effectively communicate via telephone with and without hearing aids. Sometimes, all that is required is an increase in the loudness of the telephone, repositioning the telephone, or using an amplified telephone in a quieter environment.

However, for many patients with moderate, severe and profound hearing loss, T-coils are beneficial and they may represent the only consistent and reliable option for successful telephone use.

When professionals and patients consider the opportunity for increased successful use with multiple telephones and applications beyond telephones (such as looped systems for television, movie theaters, lectures etc), the advantages of T-coil technology becomes more apparent.

Vertical vs. Horizontal Orientation of the T-coil

The position of the T-coil within the hearing aid is generally referred to as either horizontal or vertical. These positions refer to the physical orientation of the T-coil within the hearing aid, when worn in-situ. In general, looped signals are transmitted horizontally. To maximally receive a looped signal, it is best for the T-coil to be placed vertically. Unfortunately, the best orientation for telephone purposes is generally horizontal. However, telephones can be easily repositioned to take advantage of the "sweet spot" (position of maximal reception) as needed. Therefore, we generally recommend T-coils be placed vertically.

Multi-axis T-coils have been proposed (see Yanz and Pehringer, below) to acquire a strong, consistent magnetic signal with less dependence on spatial orientation. However, multi-axis T-coils sometimes magnetically couple with the receiver inside the hearing aid, potentially causing annoying errant sounds to occur.

Programmable and Pre-Amplified T-coils

Significant differences between the hearing aid's acoustic amplification circuit and the electromagnetic circuit are common (Noe, Davidson, & Mishler, 1997).

T-coils should be programmable and should have dedicated pre-amplifiers to maximize T-coil applicability, while accommodating the specific type and degree of hearing loss of the user (Takahashi, 2005). Programmability allows the audiologist to adjust the T-coil gain for the user's telephones and other sound-source inputs. T-coils with pre-amps have the potential to provide greater amplification than those without.

For hearing aids without T-coils, sometimes a dedicated memory/program can be programmed to maximize acoustic telephone reception. For example, high frequencies might be rolled-off to allow more loudness with less acoustic feedback when acoustically coupling a telephone and a hearing aid.

Dedicated "T" and "MT" Switches

Dedicated “T” switches allow the user to choose to receive input only from the T-coil, isolated from all other sound inputs. Use of the T switch can be advantageous while using a telephone in a noisy restaurant, at a cocktail part, or in other adverse noisy situations.

However, another important hearing aid feature is an “MT” switch. The MT switch allows the user to attend to the T-coil input signal as well as the environmental microphone input, simultaneously. MT is advantageous while the user is listening to television via a loop system with another individual in the room, or if the telephone or doorbell rings, etc. However, because phone systems vary in magnetic strength, it is advantageous to program the MT switch to assure both inputs (microphone and T-coil) are “mixed” in a useful fashion, rather than one source dominating the circuit.

Automatic T-coils

Automatic T-coils (auto T-coils) use the exact same T-coil as standard units. The difference is auto-T-coil units have a magnetic reed switch (MRS). The MRS (see Figure Two) can only be activated by a real, static, or permanent magnet, such as those found within the handset of most standard telephones. The auto-T-coil cannot be activated by a magnetic induction field, such as a loop system. Some telephones have small magnets which are not significant enough to trigger the MRS, and therefore, sometimes it is necessary to have an additional permanent magnet (or two) attached to the telephone. Oticon supplies these useful “stick-on” magnets.

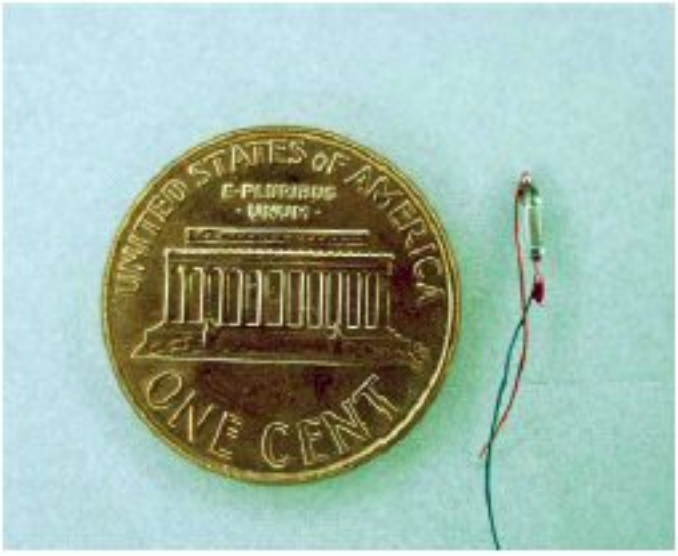

Figure 2. US Penny compared to Magnetic Reed Switch

Evaluating T-coils

Yanz and Pehringer (2003) surveyed 88 respondents at the 2002 American Academy of Audiology (AAA) annual convention with regard to T-coil performance assessment. The vast majority of respondents indicated that in contrast to the hearing aid microphone circuit performance analysis, T-coil performance was evaluated using subjective and barely-quantifiable measures -- if at all. There are many reasons for informal and often negligible T-coil analysis, not the least of which is the highly variable sound sources T-coils depend on.

For example, most telephones have variable and unknown electromagnetic outputs and spectral signatures. Yanz and Pehringer (2003) recommended 7 steps to standardize and assess T-coil systems. Their 7 steps included: T-coils should be amplified and programmable, T-coils systems should have their own memory within multi-memory hearing aid circuits, T-coils should easily and automatically switch from microphone-to-T-coil inputs, binaural T-coils should be standard, multi-axis T-coils should be used to accommodate signal orientation, a standardized inductive signal source should be developed and used, and, a simple field strength meter should be available to evaluate the patient's home, recreational and office phones to explore signal transmission strength and to provide appropriate counseling.

T-Coil Standards

Within the USA, we have not yet sanctioned requirements for T-coil sensitivity. Currently, although induction coils are tested according to ANSI S3.22, within a specified electromagnetic field, there are no specific ANSI-sanctioned sensitivity requirements.

Oticon's T-coils are standardized to have essentially the same electromagnetic sensitivity across our products. In essence, using 10 mA/m input to the hearing aid set in the T position, the dB SPL output is identical (+/- 2 dB) to that achieved using a 50 dB SPL acoustic input, in the M position.

The "Nordic" governments (Denmark, Sweden, Norway and Finland) specify output SPL from hearing aids on government contracts, when subjected to 31.6 mA/m inductive input, must be greater than or equal to the output SPL secondary to a 55 dB SPL acoustic input. Oticon's T-coils are consistently 5 dB greater than that which is required.

T-coil compatible telephones produce a magnetic field of approximately 100 mA/m, which is 20 dB more than the 10 mA/m described above, or equivalent to a 70 dB SPL acoustic input. Such a signal will activate the compression in full dynamic range compression hearing aids. Therefore, to get a stronger T-coil signal, it is desirable to set the T-coil program to linear mode. It should be noted that all phones – corded or cordless – sold in the USA since 1991, are by law, T-coil compatible. Through September 2006 cellular phones were exempt from this law as they (cell phones) were considered radio devices.

T and M Telephone Ratings

As of September, 2006, the Federal Communications Commission (FCC) has mandated that manufacturers of digital cell phones must offer at least two of their telephones models to be hearing aid compatible (HAC). By 2008, 50% of all handsets sold in the USA will be required to meet hearing aid compatibility guidelines (http://www.fcc.gov/cgb/consumerfacts/hac.html).

Two descriptive rating systems (T-ratings and M-ratings) were developed to allow consumers and professionals to predict compatibility of telephones with hearing aids. The rating scales are from 1 (worst) to 4 (best). If there is no rating, the phone is not likely to be hearing aid compatible.

T-ratings describe the level of T-coil (T) compatibility within a telephone.
M-ratings describe the level of hearing aid microphone (M) compatibility within a telephone. A T3 rating indicates the telephone meets the FCC requirements and should work well with most hearing aids equipped with a T-coil. However, a T4 rating indicates the telephone exceeds the FCC Standard. T4 is the highest rating available. Similarly, telephones rated M3 meet the FCC standard, and M4 rating exceeds the standard. Generally, if a telephone has a high M rating, it is likely to have a high T rating. As T and M ratings increase, the likelihood of interference decreases. However, T and M ratings are not exact. Consumers should always be encouraged to try the combined hearing aid/phone system prior to purchase (http://atis.org/hac/docs/2005/HAC%20brochure.pdf).

Oticon T-Coils

T-coils come in many sizes (see Figure One, above). As a general rule, the larger they are, the greater the signal output they produce. Some companies manufacture very small T-coils with pre-amplifiers mounted directly onto the T-coil to save space. However, there can be a trade-off between saving space, and creating a smaller T-coil. Oticon uses “full size” T-coils with the pre-amplifier as part of the circuit chip. Most Oticon hearing aids can be programmed to provide an extra 6 dB through T-coil output. T-coils are standard in all Oticon BTEs and are optional in full shell, half-shell, low-profile and some canal-style hearing aids. Oticon’s newer custom models can be made with automatic T-coils which are activated by an MRS (see above) when subjected to an external permanent magnetic field.

Discussion

T-coil technology continues to improve and new looped applications are emerging across the world. T-coils are founded upon a clearly established history of pragmatic, successful and relatively inexpensive application. Programmable, pre-amplified and automatic T-

coils are available from a variety of manufacturers and offer an excellent value and alternative for many hearing aid users while listening in challenging and/or difficult acoustic situations.

Nonetheless, despite the utility and ease of use of T-coils, many audiologists and patients have not previously considered the multiple uses and sound sources deliverable via T-coil technology when enhanced through modern loop systems. Loop systems are inexpensive, easy to install, and loop systems expand the applicability of T-coils beyond the electromagnetic coupling of telephones and hearing aids.

Therefore, for many patients, T-coils offer an extraordinary value as well an alternative sound delivery system for telephones, television, lecture halls, banks, and an increasing number of public venues.

Please Note: An earlier version of this article was provided by Oticon to audiology graduate students as a special supplement to the Hearing Journal, October, 2006.

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