

A new method for wireless connectivity in hearing aids

By Jason A. Galster

In this era of wireless connectivity, the way we use technology to interact and communicate with each other has changed our perception of the world around us. Happily, hearing aids are no longer an exception, as these devices have become more than just sophisticated signal processors designed to amplify speech. For many patients with hearing loss, a hearing aid is not only a personal communication device, but also a gateway to media connectivity and greater convenience in communication.

Today's digital wireless protocols allow for wireless communication between hearing aids and from hearing aids to numerous forms of media devices. Some of these offerings use frequencies that allow for far-field signal transmission, while others focus on near-field communication. A wide array of frequencies is available for wireless data and audio transmission; the transmission and reception of these signals is performed by small radios embedded in the hearing aids and remote devices.

This article will focus on the wireless communication ability of currently available hearing aids, which, at the time of this publication, function in one of three different frequency bands: 3- to 15-MHz near-field magnetic induction; 2.4-GHz industrial scientific medical band; and 900-MHz industrial scientific medical band.

NEAR-FIELD MAGNETIC INDUCTION

The most common approach to wireless communication in hearing aids is near-field magnetic induction

(NFMI). Wireless communication through NFMI uses technology similar to a traditional telecoil. The range of frequencies used in hearing aids for NFMI data transmission typically falls between 3 and 15 MHz.

The benefits of NFMI technology lie in a few different areas. First, the hardware used in NFMI data transmission is well established, making it accessible for all hearing instrument manufacturers. Second, NFMI operates within a frequency band that easily propagates through and around the human head and body. This ease of propagation allows for ear-to-ear communication between hearing aids, providing the convenience of synchronized adjustments to memory or volume, as well as the benefits of binaural signal processing between hearing aids.

The fundamental drawback to the use of NFMI is limited transmission range. Its use of magnetic signal transmission, similar to a telecoil, results in a wireless signal that degrades quickly. Specifically, the magnetic signal degrades approximately proportionally to the inverse of the transmission distance *cubed*, whereas with far-field or long-distance transmission methods (e.g., 900-MHz and 2.4-GHz), signals degrade at a rate proportional to the inverse of the distance *squared*. This relationship is illustrated in Figure 1. For this reason, most modern hearing aids using NFMI have a transmission range that falls within 1 meter of the hearing aids.

The range of NFMI wireless transmission has been the impetus for the development of intermediate relay accessories that facilitate wireless communication over longer distances. The relay device remains close to the hearing aids, translating the short-range NFMI signal from the hearing aids to a longer-range transmission method, such as Bluetooth.

This type of hybrid wireless transmission must combat delay in the transmission of audio information. These delays result from the audio data compression and transcoding of standardized wireless protocols, such as Bluetooth, to each manufacturer's proprietary NFMI signal. In the case of audio/video media, delayed audio may result in a "lip sync" effect, or a lack of synchrony between the video and the streamed audio. The International Telecommunication Union suggests that audio/video transmission delays should not exceed -40 milliseconds (audio delayed) and +20 milliseconds (audio advanced).¹

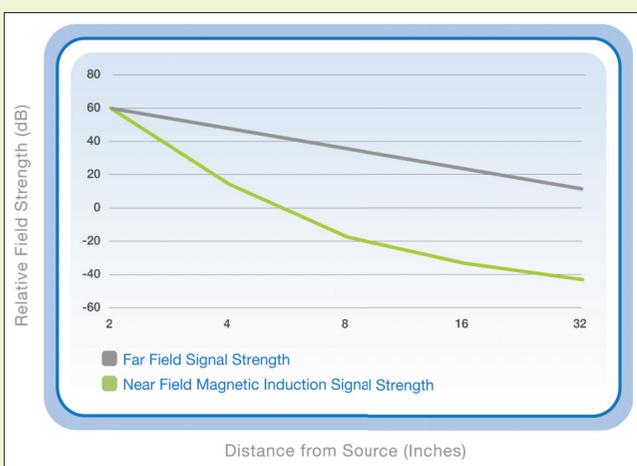


Figure 1. Illustration of relative field strength as a function of distance for near-field magnetic induction and far-field transmission methods.

Listeners' tolerance for delay within an audio stream is even smaller when the amplified audio stream and the airborne, direct audio path are combined, leading to a perceived echo during audio streaming. Small delays in streamed audio may be especially detrimental for patients who enjoy listening to music through open-canal hearing aids. Patients with normal-to-mild, low-frequency thresholds may want to enjoy music through their stereo speakers while simultaneously listening to streamed, amplified audio through their hearing aids. In the case of well vented or open-canal hearing aids, a delay of even 5 milliseconds may degrade sound quality, as the direct, unamplified audio path arrives sooner than the amplified audio.²

2.4-GHz INDUSTRIAL SCIENTIFIC MEDICAL (ISM) BAND

Many wireless technologies operate at or near 2.4 GHz. Some of these technologies include Bluetooth, Wi-Fi, wireless telephones, and wireless video game controllers. In 2001, the Federal Communications Commission (FCC) opened the 2.4-GHz band to public use. This resulted in an influx of products that use this band. A 2010 joint publication from the European Hearing Instrument Manufacturer's Association (EHIMA) and the Hearing Industries Association (HIA) reports the number of FCC product grants (i.e., product approvals) submitted annually since 2001.³ In 2009, the number of product approvals for 2.4-GHz wireless systems was approximately 100 times that for products in all other ISM frequency bands.

Considering the widespread use of the 2.4-GHz band for audio transmission, it seems intuitive to use this frequency band for wireless data transmission in hearing aids. The high-frequency nature of the 2.4-GHz band allows signals to propagate easily through air, experiencing much less degradation of signal strength than with NFMI. For this reason, wireless hearing aid communication in this band allows for long-distance audio streaming, as well as wireless programming.

However, the high-frequency nature of the 2.4-GHz signal also results in a short wavelength that does not propagate well through and around the human head and body. Therefore, while the 2.4-GHz band has the benefit of increased transmission distance compared to NFMI, it may not allow a pair of bilateral hearing aids to communicate for the purposes of ear-to-ear processing without high-power consumption or the use of an intermediate relay device.

900-MHz INDUSTRIAL SCIENTIFIC MEDICAL BAND

The 900-MHz ISM band is a third frequency band used with medical devices for wireless data transmission. This band is now being used for communication between hearing aids. The 900-MHz transmission characteristics allow for long-distance wireless programming, audio streaming, and ear-to-ear binaural

processing, without an intermediate relay device.

A 900-MHz signal will propagate through and around the body with less signal degradation than is encountered with a 2.4-GHz signal, making it the only stand-alone option currently available for both far-field wireless transmission and reliable ear-to-ear communication.

These combined benefits relate, in part, to the wavelength of the transmission signal. The calculated wavelength of a signal transmitted at 900 MHz is 0.33 meters; this falls between that of a 2.4-GHz signal and of NFMI, yet is still greater than the width of the human head. This allows for reliable signal propagation through and around the head, which is difficult with the higher 2.4-GHz signal using typical hearing aid power levels, and does so without need for an intermediate relay device positioned within 1 meter of the hearing aids.

Table 1 summarizes the capabilities of currently available wireless technologies.

IRIS—FOR LONG-DISTANCE WIRELESS TRANSMISSION

The 900-MHz implementation of wireless hearing aids features a wireless technology developed by Starkey Laboratories, called Iris. The term calls to mind the eye and connotes the ability to transmit and receive data across a long distance.

Table 1. A comparison of wireless capabilities for transmission within the 3- to 15-MHz, 2.4-GHz, and 90-MHz spectra.

	Far-field Wireless Transmission	No Intermediate Device	Bilateral Signal Processing
NFMI			
2.4 GHz			
900 MHz			

The Iris wireless system is designed to offer long-distance audio streaming, wireless programming, and binaural signal processing, without need for an intermediate relay. For wireless audio streaming, a wireless media device, SURFLink Media, connects to the patient's television or other media source and streams stereo audio directly to the hearing aids—up to 20 feet away. When a hearing aid enters the range of the media device, it can be programmed to detect that streaming device automatically and accept the new audio input.

For instance, if a patient returned home from work, her hearing aids could immediately begin streaming audio from the television when she entered the front door; or the option to manually initiate audio streaming is also available. An unlimited number of hearing aids can access a single SURFLink media device, without the need for pairing. If used in a group living environment, everyone wearing hearing aids with the Iris wireless technology can access the television's audio by simply walking into the same room as the television. Disconnecting from the audio stream is as easy as leaving the room or tapping the memory button on the hearing aid.

Adaptive Frequency Agility

Any robust wireless technology must be designed to avoid interference from nearby electronics. Iris uses a system called Adaptive Frequency Agility for avoiding signal interference, maintaining signal quality, and allowing for wireless communication without need for "pairing" routines.

Adaptive Frequency Agility uses a "look ahead" approach to data transmission. The hearing aid constantly monitors wireless data channels around the 900-MHz frequency band, searching for the optimal frequency channel. If an adjacent frequency channel can offer improved signal quality, the system will transition to the optimum channel. Not only does this maintain a high-quality media stream, but it also allows for

multiple wireless programmers and SURFLink media devices to work in the same office or household.

Enabling the instrument to select among multiple frequency channels around the 900-MHz ISM band dramatically reduces the probability of degraded communication. For example, if the probability for interference on a single channel is 1% and the probability for interference on a second channel is 1%, the probability for interference on both channels simultaneously is 0.01%. Such conditional probabilities across independent channels result in an overall likelihood of interference that is strikingly small.

APPEAL TO PATIENTS AND PROFESSIONALS

In focus groups and personal communication, hearing care providers have requested wireless systems that do not need intermediate relay devices for media streaming and remote programming. They have also asked for systems that do not require pairing for media connectivity.

Meanwhile, professionals say, their patients express delight in the convenience of synchronizing memory and volume adjustments, and they appreciate the hearing benefits that binaural signal processing can provide.

There are many options for wireless connectivity in modern hearing aids. Each of these offers a unique set of benefits that will change quickly as technology advances.

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