COMPARISON OF LARGE AREA ASSISTIVE LISTENING SYSTEMS

Why Use an Assistive Listening System?

Distance from the sound source, background noise, and reverberation combine to degrade signal intelligibility, making it difficult for people to hear and understand speech in large rooms. For people with hearing loss, the challenge becomes even greater. Even the best public address systems, combined with the best hearing aid and/or cochlear implant, cannot solve the intelligibility problems faced by people with hearing loss. This situation prevents people with hearing loss from participating on equal terms with hearing people in large assembly areas. To provide people with equal access in these and other venues, requirements for making assistive listening systems available in places of public accommodation were included in the Americans with Disabilities Act (ADA) signed into law in July 1990.

What is the Concept Behind an Assistive Listening System?

I like to think of assistive listening systems as "Binoculars for the Ears." Just as binoculars take a faraway, hard-to-see image and bring it close to your eyes so it's easier to see; placing a microphone close to the talker's mouth catches the desired speech and sends it directly to the listener's ears before it travels across the room, loses energy, and becomes degraded by noise and reverberation. Assistive listening systems work via a concept we can call "the three Cs" – catch, carry, and couple. The desired sound – for example, a person giving a presentation in the front of a room – is first **captured** at its source, using a microphone placed near the talker's mouth. The microphone changes the acoustic signal of the talker's voice into an electrical signal and is sent to a wireless transmitter. The transmitter broadcasts or **carries** the desired signal across the room wirelessly, using radio waves. A receiver worn by the listener is **coupled** to the listener using earphones or special connections to the listener's hearing aid or cochlear implant. By employing this wireless technology, the desired sound is sent directly to the listener, bypassing the deleterious effects of distance, background noise, and reverberation.

Wireless Technologies, How They Work, Advantages and Disadvantages

Today there are three basic wireless technologies available that are used in public areas such as movie theaters, live theater, concerts, lecture halls, community centers, government agencies, etc. Each of these systems uses a different method of sound transmission: 1) *Induction Loop Systems* (also known as hearing loops*,* 2) *Frequency Modulation (FM)* broadcast technology, and 3) *Infrared (IR)* light technology. Each method has its own advantages and disadvantages and all three technologies can be employed, not only in public venues, but also for personal use at home, at school, in the workplace, or when traveling.

Induction Loop (Hearing Loop) Technology

When AC current is sent through a piece of cable wire, it generates a magnetic field around the wire. If you then bring a second wire within this magnetic field, a corresponding alternating current is created, or *induced*, within the second wire. This is the origin of the term *induction loop system* and it is the same principle behind electronic motors, generators and transformers.

A hearing loop consists of a microphone used by a talker or a cable used to pick up a signal from a TV or other sound source. The input signal enters the loop amplifier, which increases the voltage of the signal. The loop amplifier then sends the electrical signal through the cable wire that surrounds the seating area (usually on the floor) and that is connected to the output and input jacks of the loop amplifier. The loop wire transforms the electrical signal into electromagnetic energy that is transmitted by the loop to the room. Special sensors or receivers called *telecoils* are used to pick up the loop signal and deliver it to the listener. Telecoils can be installed inside hearing aids and cochlear implants or inside a battery-powered, body-worn amplifier that is equipped with earphones. The loop signal can be received in various ways described below:

- **Hearing Aid Telecoil:** The telecoil inside a hearing aid picks up the loop signal and then changes it into an electrical signal that is then processed inside of the hearing aid and eventually delivered to the listener's ear as sound.

- **Cochlear Implant Telecoil:** The telecoil inside an implant picks up the loop signal and then changes it into an electrical signal that is processed inside the implant and then sent directly to the listener's cochlea.

- **Telecoil Receiver with Earphones:** For listeners who do not use hearing aids or do not have hearing aids equipped with telecoils, a battery-powered body-worn, telecoil-equipped loop receiver is worn with earphones. The telecoil inside the receiver picks up the loop signal, changes it into electrical energy and sends it to the earphones which changes it to sound for the listener.

- **Telecoil-equipped Hearing Aid Streamer:** Some hearing aid users might use new so-called *wireless* hearing aids along with a battery-powered wireless accessory called a *streamer*. Worn around the neck, held in the hand or placed in a pocket, the streamer is a *gateway* or *intermediary device* used to pick up Bluetooth signals from a TV, tablet, laptop or cell phone. It then rebroadcasts the signal of interest as a proprietary (each hearing aid manufacturer uses their own patented radio transmission and reception) radio wave to the hearing aid. These systems provide listeners with convenient "connectivity" to many sound sources at home, at the workplace, and in other settings. However, currently there are no large area systems that broadcast on Bluetooth to these gateway devices. So, the only way a listener can access

a large area system is to have a telecoil installed inside the hearing aid. The reason we are mentioning streamers here is because some hearing aid users might have wireless hearing aids that are very small and do not contain telecoils. Some streamers can be equipped with a telecoil. So, in this situation, the wireless hearing aid user would walk into a looped venue and activate the telecoil in the streamer. The streamer's telecoil would pick up the loop signal and then rebroadcast the signal in the form of a proprietary radio wave to the wireless hearing aid.

The takeaway message is that is it always best if the telecoil is located inside the hearing aid (or cochlear implant) as this allows the listener to simply walk into a looped room and activate the telecoil circuit (and not have to worry about bringing and using additional equipment).

Advantages

- Listeners with telecoil-equipped hearing aids or implants do not need to borrow a receiver because the telecoil IS the receiver.
- Discrete and dignified for listeners with telecoils inside their hearing aids or cochlear implants.
- Universal and directly compatible with any telecoil-equipped hearing device, independent of the manufacturer.
- No receiver management needed if all listeners have telecoils.
- A receiver must be borrowed only when the listener does not have a telecoil in his or her personal hearing device or does not use one.

Disadvantages

- Perimeter loops (single wire around the room) cannot be used at the same time in adjacent rooms due to the spillover effect. However, phased array technology (a "mat" or "grid" of multiple wires) provides significantly less spillover, thus allowing loops to be installed and used simultaneously in adjacent rooms.
- Loops might be difficult or impractical to install at some facilities and consultation with architects might be needed to ensure the hearing loop meets IEC standards.
- Signal is universal and not encrypted so use of a loop is contraindicated where privacy is a concern.
- While it's possible that fewer receivers will be needed, some patrons might not use hearing aids but still experience difficulty hearing in large venues. Hence, facility owners will still be required to maintain, clean, dispense and collect receivers and keep receiver batteries charged.
- Telecoil receivers (inside hearing aids/cochlear implants or used with earphones) are susceptible to electromagnetic interference from electrical equipment. Therefore, care needs to be taken to reduce/eliminate this interference before installing the loop system.
- Single channel only: Cannot support hearing assistance and audio description for the blind; cannot support multiple languages.

- Loop receivers (borrowed or inside hearing aids/cochlear implants) are directional (orientation-sensitive) unless a phased array loop is used.

FM Broadcast Systems

In principle, FM systems designed for hearing assistance application work just like commercial FM broadcast systems operating in the 88 to 108 MHz range. However, in the United States, the FM systems operate at FCC-designated frequency band in the range from 72 to 76 MHz and from 216 to 217 MHz. The 72 to 76 MHz band is an older form of transmission, subject to interference but might still be found in some public venues. The 216 to 217 MHz band is newer and intended for auditory assistance applications only. Since each FM installation might use its own broadcast frequency or (channel), several FM systems can operate simultaneously at one location without interfering with one another. The FM transmitter can be worn by a talker along with a lapel microphone. It also can be connected to a public address system's mixer so that inputs of various types will be sent through the system (voice, music, pre-recorded information). The FM signal broadcast into the room is then received by the FM receiver worn by the listener and tuned to the same channel as the FM transmitter.

Unlike the loop system, the FM system requires that the listener **always** borrows an FM receiver, whether he or she has a hearing aid or cochlear implant. There are several listening options available:

- **FM Receiver with Neckloop + Telecoil-equipped Hearing Aid**: Listeners wearing hearing aids equipped with telecoils borrow an FM receiver along with a tiny loop of wire worn around the neck called a *neckloop.* The FM receiver changes the FM signal to an electrical signal that is sent to the neckloop. The neckloop changes the electrical signal into an electromagnetic signal that is picked up by the hearing aid's telecoil. This signal is changed back to an electrical signal that is processed in the hearing aid and then changed to (audio) sound in the listener's ear.
- **FM Receiver with Neckloop + Telecoil-equipped Implant**: Listeners wearing implants equipped with telecoils borrow an FM receiver along with a tiny loop of wire worn around the neck called a neckloop. The FM receiver changes the FM signal to an electrical signal that is then processed by the implant and sent to the listener's cochlea.
- **FM Receiver with Earphones:** For listeners who do not have telecoils or hearing aids, they can borrow an FM receiver equipped with earphones. The FM receiver changes the FM radio wave to an electrical signal that is sent to the earphones which then changes the electrical signal to sound.
- **Telecoil-equipped Hearing Aid Streamer + FM Receiver with Neckloop:** Some hearing aid users might use new so-called wireless hearing aids along with a battery-powered wireless accessory called a streamer. Worn around the neck, held in the hand or placed in a pocket, the streamer is a **gateway** or **intermediary device** used to pick up Bluetooth signals from a TV, tablet, laptop or cell phone. It then rebroadcasts the signal of interest as a

proprietary (each hearing aid manufacturer uses their own patented radio transmission and reception) radio wave to the hearing aid. These systems provide listeners with convenient “connectivity” to many sound sources at home, at the workplace, and in other settings. However, currently there are no large area systems that broadcast on Bluetooth to these gateway devices. So, the only way a listener can access a large area system is to have a telecoil installed inside the hearing aid. The reason we are mentioning streamers here is because some hearing aid users might have wireless hearing aids that are very small and do not contain telecoils. But, some streamers can be equipped with a telecoil. So, in this situation, the wireless hearing aid user would need to borrow an FM receiver and neckloop, activate the telecoil in the streamer and place it inside the neckloop until good reception is achieved. The streamer’s telecoil would pick up the FM signal and then rebroadcast the signal in the form of a proprietary radio wave to the wireless hearing aid.

The takeaway message here is that FM systems require that all listeners must borrow an FM receiver. While some listeners might be able to use an FM receiver with a set of earphones, people who must use hearing aids all the time as well as cochlear implant users will find it much easier to couple to an FM receiver by having a telecoil inside the personal hearing instrument or implant.

Advantages

- Highly portable – can be used by tour groups.
- Easy to install/lowest installation cost.
- Can easily cover very large seating areas.
- Several channels available for multiple systems installed in adjacent rooms as well as for language translation and audio description for the blind.
- Can be used indoors or outdoors.

Disadvantages

- Receivers required for everyone; listeners must borrow a receiver.
- Both headphones and neckloops must be available at public facilities as coupling options.
- Signal travels through solid surfaces so use is contraindicated where privacy is a concern. Note: Encrypted digitally-modulated (DM) systems are available for use where privacy is a concern. In addition, some of the digitally-modulated systems provide two-way communication for question/answer sessions and interpreting needs.
- Facility owners are required to maintain, clean, dispense and collect receivers and keep receiver batteries charged.
- Radio interference from other services is possible.
- For listeners who desire to use an FM receiver equipped with a neckloop along with his or her hearing aid/cochlear implant telecoil), it is possible that the

telecoil may pick up electromagnetic interference if it is present in the room. Just as with loop systems, care should be taken to reduce/eliminate spurious electromagnetic interference in the room prior to the installation of an FM system.

Infrared Systems (IR)

An infrared system consists of three basic components: a transmitter (base station), an emitter, and a receiver. The audio signal is conveyed onto a sub-carrier (2.3 MHz and 2.8 MHz) in the base station, which in turn is converted into invisible infrared light by the emitter. The base station and emitter can be housed together in a personal system used for TV reception or for a meeting in the workplace. For large area installations, the base station is connected to the mixer of a PA system and one or more emitters are placed around the room. All listeners, whether they used personal hearing instruments or not, must wear an IR receiver. The IR light is picked up by a photosensitive cell residing on the receiver. Listeners access the IR system in various ways:

- **IR Receiver with Neckloop + Telecoil-equipped Hearing Aid**: Listeners wearing hearing aids equipped with telecoils borrow an IR receiver along with a tiny loop of wire worn around the neck called a **neckloop**. The IR receiver changes the IR signal to an electrical signal that is sent to the neckloop. The neckloop changes the electrical signal into an electromagnetic signal that is then picked up by the hearing aid's telecoil and changed into an electrical signal that is processed in the hearing aid or implant and changed to sound in the listener's ear.
- **IR Receiver with Neckloop + Telecoil-equipped Implant**: Listeners wearing implants equipped with telecoils borrow an IR receiver along with a tiny loop of wire worn around the neck called a neckloop. The IR receiver changes the IR signal to an electrical signal that is processed by the implant and sent to the listener's cochlea.
- **IR Receiver with Earphones:** For listeners who do not have telecoils or hearing aids, can borrow an IR receiver equipped with earphones. The IR receiver changes the FM radio wave to an electrical signal that is sent to the earphones which then changes the electrical signal to sound.
- **Telecoil-equipped Hearing Aid Streamer + IR Receiver with Neckloop:** Some hearing aid users might use new so-called wireless hearing aids along with a battery-powered wireless accessory called a streamer. Worn around the neck, held in the hand or placed in a pocket, the streamer is a gateway or intermediary device used to pick up Bluetooth signals from a TV, tablet, laptop or cell phone. It then rebroadcasts the signal of interest as a proprietary (each hearing aid manufacturer uses their own patented radio transmission and reception) radio wave to the hearing aid. These systems provide listeners with convenient "connectivity" to many sound sources at home, at the workplace, and in other settings. However, currently there are no large area systems that broadcast on Bluetooth to these gateway devices. So, the only way a listener can access a large area system is to have a

telecoil installed inside the hearing aid. The reason we are mentioning streamers here is because some hearing aid users might have wireless hearing aids that are very small and do not contain telecoils. But, some streamers can be equipped with a telecoil. So, in this situation, the wireless hearing aid user would need to borrow an IR receiver and neckloop, activate the telecoil in the streamer and place it inside the neckloop until good reception is achieved. The streamer's telecoil would pick up the IR signal and then rebroadcast the signal in the form of a proprietary radio wave to the wireless hearing aid.

As with FM technology, each person must use a receiver, if they have a hearing aid. Receiver types include lightweight under-the-chin style, over-the-head receivers for 360° reception and lavaliere style. Similar to FM systems, the listening options receivers include under-the-chin type steto-clip headsets, Walkman style headsets, earbuds, and neckloops for telecoil users.

Advantages

- Normally not susceptible to radio interference or interference from other electrical equipment. Note: For listeners who desire to use an FM receiver equipped with a neckloop along with his or her hearing aid/implant telecoil), it is possible that the telecoil might pick up electromagnetic interference if it is present in the room. Just as with loop systems, care should be taken to reduce/eliminate spurious electromagnetic interference in the room prior to the installation of an FM system.
- Multiple applications (e.g., multiple languages) can run simultaneously without interfering with one another.
- Signal does not travel through solid surfaces (windows must be covered) so it can be used where confidentiality is a concern.
- Emitter panels can be interconnected to provide coverage for large areas.

Disadvantages

- Receivers required for everyone; listeners must call attention to themselves by asking to borrow a receiver.
- Both headphone output and neckloop listening devices must be available at public facilities.
- Facility owners are required to maintain, clean, dispense, and collect receivers.
- Not practical for outdoor applications (sunlight interference).
- Facility owners are required to maintain, clean, dispense and collect receivers and keep receiver batteries charged.
- IR energy travels in straight lines, requiring "line of sight" between the emitters and the photosensitive cells on the listener's receiver. Therefore, a sufficient number of emitters must be installed to ensure that objects in the

room (columns, chairs, etc.) do not interfere with signal transmission. Listeners also need to be counseled to wear the receiver with the photosensitive cell facing out into the room and to not block the cell with clothing, etc.

- More difficult and expensive to cover very large seating areas (e.g., stadiums).

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