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Page No: 303 - 308
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# A Survey of Recent Advances in Hearing Aid Technologies and Trends

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## Abstract

*Hearing aids are small electronic devices worn in or behind the ear to amplify sound for individuals with hearing loss. They work by capturing sound through a microphone, processing it electronically, and then delivering it through a speaker into the ear canal. Modern hearing aids come with various features like noise reduction, directional microphones, and wireless connectivity, making them more effective and convenient for users. This survey paper provides an overview of recent advances in hearing aid technologies, exploring the evolving landscape of assistive devices designed to improve the auditory experience for individuals with hearing impairments. The paper reviews key aspects of hearing aids, including signal processing techniques, device designs, connectivity options, and user-centric features. The survey encompasses highlighting innovative solutions aimed at addressing the diverse needs of hearing-impaired individuals.*

**Keywords:** *Hearing Aid, Types of Hearing Aid, Technology Behind, Advancements of Hearing Aid.*

## 1. Introduction

Hearing aids are electronic devices designed to improve the auditory experience of individuals with hearing loss by amplifying sound. They play a crucial role in helping people with various degrees of hearing impairment to communicate more effectively, participate in social activities, and enhance overall quality of life. As technology has advanced, hearing aids have evolved from simple amplification devices to sophisticated instruments that incorporate digital signal processing, wireless connectivity, and various features to address different aspects of hearing loss. A person with the audiometric value of up to 25dB will not have a hearing problem [1].

### 1.1 Causes for Hearing Loss

- The common causes for hearing loss [12]
- Damage of Inner ear.
- Earwax accumulation
- Ear infection
- Injury affecting the delicate membrane in the ear i.e. eardrum

## 2. The Technology Behind Hearing Aid

Traditional hearing aids, known as analog devices, are becoming less prevalent. They enhance continuous sound waves uniformly to amplify all sounds. Some analog models incorporate a microchip, allowing for the storage of various program settings such as listening different environments, whether quiet or noisy. Users can adjust settings by simply pressing a button on the device to adapt to changing surroundings. [13] the limitation of analog hearing aid is they amplify sounds without distinguishing the sound & noise, making everything louder.

**Digital hearing aids** are increasingly common, offering enhanced capabilities compared to analog programmable aids. They convert sound waves into precise digital signals, replicating sounds. Equipped with microchips, these devices analyze both speech and surrounding noises, enabling the storage of multiple program settings for diverse listening environments. They also offer increased flexibility in programming, allowing adjustments to match the

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 02 February 2024
Page No: 303 - 308
https://irjaeh.com

requirements of specific hearing loss patterns.

**The main parts of a modern hearing aid are [7].** Figure 1 shows the block diagram of working of hearing aid, which consists of major parts microphone, amplifier & receiver.

a. **Microphone-** The microphone captures surrounding sounds and converts them into electrical signals.
b. **Amplifier-** The amplifier processes and increases the intensity of the electrical signals received from the microphone based on the user's specific hearing needs.

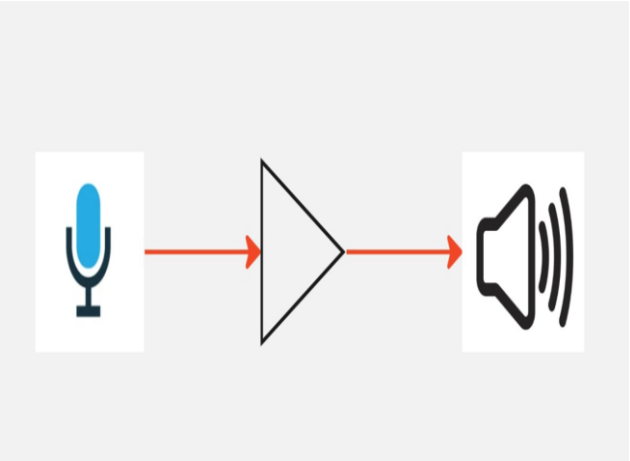

**Figure 1 Block Diagram of Working of Hearing Aid**

c. **Receiver (Speaker)** The receiver converts the amplified signals back into audible sounds and delivers them into the ear.
d. **Power Source -** Hearing aids are powered by batteries, either disposable or rechargeable, providing the necessary energy for the device to function.
e. **Digital Signal Processor -** The digital signal processor is a key component that uses advanced algorithms to analyze and adjust the incoming sound signals. It allows for customization based on the user's unique hearing profile.
f. **User Interface-** Hearing aids feature controls or interfaces that allow users to adjust settings, switch between programs, and customize the device to suit different environments.

Hearing aids are sophisticated devices designed to amplify sound and improve the auditory experience for individuals with hearing impairments. Key aspects of hearing aids encompass various features and functionalities that contribute to their effectiveness and usability. Following are some essential aspects of hearing aids.

- **Digital Signal Processing (DSP) Technology-** Modern hearing aids use advanced DSP algorithms to process incoming sounds, providing improved customization for users.
- **Amplification and Frequency Response-** Hearing aids amplify sound to compensate for hearing loss at different frequencies. The devices are calibrated to address specific hearing profiles, with adjustable settings to accommodate variations in individual hearing loss.
- **Styles and Designs-** Hearing aids come in various styles, including behind-the-ear (BTE), in-the-ear (ITE), in-the-canal (ITC), and completely-in-the-canal (CIC). The choice of style depends on factors such as the degree of hearing loss and comfort.
- **Wireless Connectivity-** Many modern hearing aids feature wireless connectivity, allowing users to connect to smartphones, TVs, and other audio devices. Wireless capabilities enhance accessibility and enable users to stream phone calls, music, and other audio directly to their hearing aids.
- **Directional Microphones-** Directional microphones focus on sounds coming from a specific direction, helping users to hear conversations more clearly in noisy environments. Automatic or manually adjustable settings may be included for optimal performance.
- **Feedback Suppression-** Feedback (whistling or squealing sounds) can occur in hearing aids. Feedback suppression algorithms are used to minimize or eliminate these unwanted noises.
- **Automatic and Adaptive Settings-** Hearing

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 02 February 2024
Page No: 303 - 308
https://irjaeh.com

aids often include automatic settings that adjust to different environments (e.g., quiet, noisy, or windy conditions) for optimal performance. Adaptive technologies help the hearing aids continuously adapt to changing sound environments.

- **Rechargeable Batteries-** Some hearing aids come with rechargeable batteries, eliminating the need for frequent battery replacements and reducing environmental impact.
- **Tinnitus Management-** Tinnitus, or ringing in the ears, is a common issue for individuals with hearing loss. Some hearing aids offer tinnitus management features to provide relief.
- **User Interface and Controls-** User-friendly interfaces, including buttons, touch controls, or smartphone apps, enable users to adjust settings and switch between different programs.
- **Telecoil Technology-** Telecoils (T-coils) allow users to connect to compatible hearing loop systems in public places, such as theatres or churches, for improved hearing in specific environments.

Understanding and considering these key aspects when selecting and using hearing aids can help individuals with hearing loss achieve a better auditory experience tailored to their specific needs and preferences.

## 3. The Various Types of Hearing Aids Are [7][8]

### 3.1 Behind-The-Ear (BTE)

BTE hearing aids are worn behind the ear and are connected to the ear canal via a custom ear mold or a thin tube. A Behind-the-Ear hearing aid is a type of hearing device that is designed to rest behind the ear as shown in Figure 2. The main body of the hearing aidcontains the electronics, microphone and amplifier. This part is typically housed in a small, curved case that fits behind the ear. Thin tubing or wiring connects the housing to the earpiece. In some models, this tubing is clear and barely noticeable. The tubing leads to an ear hook or custom ear mold that fits inside the ear canal. The ear mold is often made from a soft material to provide comfort and to help with sound transmission.BTE hearing aids use batteries for power. Many BTE hearing aids have controls on the housing for adjusting volume, changing settings, or turning the device on and off.

### 3.2 In-The-Ear (ITE)

In-the-Ear" (ITE) refers to a style of hearing aid design that is custom-fitted to sit in the outer ear bowl. The ITE is shown in Figure 3, these hearing aids are individually crafted to match the contours of the wearer's ear, providing a comfortable and discreet solution for individuals with hearing impairments.

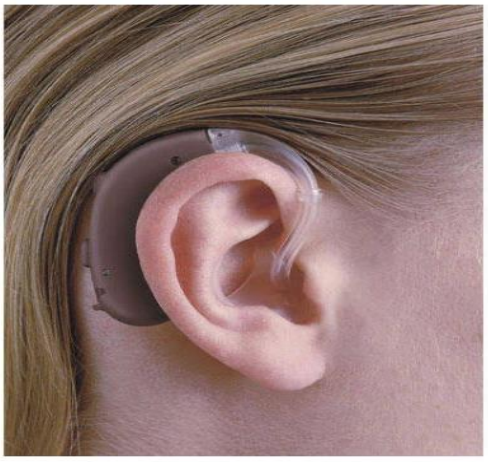

**Figure 2 Behind The Ear – Picture Courtesy – India Mart**

**Figure 3 In The Ear – Picture Courtesy – Andro Hearing Centre**

### 3.3 In-The-Canal (ITC) And Completely-In-The-Canal (CIC)

The In-the-Canal (ITC) hearing aid is a type of

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Vol. 02 Issue: 02 February 2024
Page No: 303 - 308
https://irjaeh.com

hearing aid that is custom-made to fit partially into the ear canal. It is designed to be more discreet than larger hearing aid styles while providing sufficient amplification for individuals with mild to moderate hearing loss. Figure 4 shows the ITC type hearing aid.

### 3.4 Receiver-In-Canal (RIC) Or Receiver-In-The-Ear (RITE)

The Receiver-in-Canal (RIC) hearing aid is a widely embraced hearing aid style that integrates features from both Behind-the-Ear (BTE) and In-the-Ear (ITE) designs. RIC hearing aids feature a compact receiver positioned within the ear canal, linked to the primary body of the device situated behind the ear. The RIC hearing aid is shown in Figure 5.

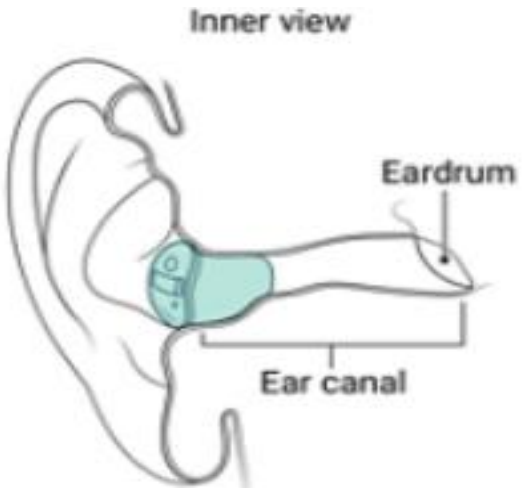


**Figure 4 In The Canal –Picture Courtesy: UVM Health Network**

**Figure 5 Receiver-In- Canal (RIC)-Picture Courtesy – I stock**

**Table 1 Minimum to Maximum Price Range of Hearing Aid**

| Type of hearing aid | Min price | Max price |
|---|---|---|
| Behind the ear | INR 10,000 | INR 1.7 lakh[8] |
| In-the-Ear (ITE)- | INR 18,500 | INR 7,59,995[9] |
| In-the-Canal (ITC) | INR 20, 000 | INR 7,09,990[9] |
| Receiver-in-Canal (RIC) | INR 20,000 | INR 7,59,995[9] |

Table 1 shows the range of prices for various hearing aid models, which can differ based on factors such as the manufacturer, materials used, technology level, and features include. [11]

### 3.5 Connectivity Options of Hearing Aid [6]

Hearing aids typically come with various connectivity options to enhance their functionality and provide users with more versatile and personalized hearing experiences. In simpler terms, hearing aid connectivity refers to how well your hearing aids can link up with other devices or systems such as smartphones or a TV. Here are some common connectivity options found in modern hearing aids.

- **Bluetooth Connectivity:** Many hearing aids feature Bluetooth technology, allowing them to connect wirelessly to smartphones, tablets, and other compatible devices. Bluetooth connectivity enables users to stream audio directly from their devices to their hearing aids, which can include phone calls, music, podcasts, and more.
- **Telecoil (T-Coil) Technology:** Atelecoil is a small coil of wire inside the hearing aid that allows it to pick up signals from compatible sound systems. [10] It is often used in public spaces, such as theaters, churches, and lecture halls, where loop systems are installed. These systems transmit audio signals directly to the hearing aid.
- **Direct Audio Input (DAI):** Some hearing aids come with a direct audio input option,

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 02 February 2024
Page No: 303 - 308
https://irjaeh.com

allowing users to connect their hearing aids directly to audio sources such as TVs or music players using a wired connection.

- **Wireless Accessories:** Manufacturers often offer a range of wireless accessories that can be used in conjunction with hearing aids. These accessories may include remote controls, microphones, and TV streamers.
- **Smartphone Apps:** Many hearing aid manufacturers provide smartphone apps that allow users to control and adjust settings on their hearing aids. Users can customize volume, program settings, and more through the app. Designs of apps, enabling you to read the spoken words of the other person in real-time.
- **Remote Programming:** Some hearing aids offer remote programming capabilities, allowing audiologists to make adjustments to the device settings without the need for an in-person appointment.
- **Compatibility with Assistive Listening Devices (ALDs):** Hearing aids may be compatible with various assistive listening devices, such as FM systems or captioned telephones, to further enhance the user's listening experience.

### 3.6 Recent Advances in Hearing Aid Technologies

In recent years, there have been notable advancements in hearing aid technology, resulting in enhanced hearing experiences and an improved quality of life for individuals facing hearing loss. [2]AI-powered hearing aids uses machine learning algorithms and deep neural networks to analyze and process audio signals in real-time. This enables smart volume control, customization of preferences for different sound [15] environments, and personalized sound adjustments tailored to individual user preferences. Noise reduction technologies play a pivotal role in enhancing the clarity of speech signals, making conversations easier to follow, and ultimately improving the overall sound quality for users. [3] Advancements in sound enhancement technologies, particularly those incorporating deep learning algorithms, have made significant progress in enhancing speech intelligibility. These technologies effectively distinguish speech from environmental noises, resulting in improved speech clarity, particularly in challenging and noisy environments. [4] A tinnitus masker produces white noise to conceal or overshadow the sound of tinnitus. White noise is similar to the sound of air escaping from a compressed container, and this technique is commonly referred to as tinnitus masking. [5]

## Conclusion

This comprehensive overview aims to inform researchers, about the current state of the field and guide future developments in hearing aid technologies. Current hearing aid technology with its innovations better meet needs of individuals who are hard of hearing. Hearing aids continue to advance, incorporating cutting-edge technologies to address the [14] diverse needs of individuals with hearing loss. Regular consultations with audiologists are crucial to ensure proper fitting, adjustment, and ongoing support for optimal hearing aid performance.

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International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 02 February 2024
Page No: 303 - 308
https://irjaeh.com

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