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Design and Implementation of External Hearing Aids Device

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Abstract

Hearing loss is a common health issue that affects nearly 10% of the world population as indicated by many international studies. The hearing impaired typically experience more frustration, anxiety, irritability, depression, and disorientation than those with normal hearing levels. The standard rehabilitation tool for hearing impairment is an electronic hearing aid whose main components are transducers (microphone and receiver) and a digital signal processor. These electronic components are manufactured by supply chain rather than by hearing aid manufacturers. Manufacturers can use custom-designed components or generic off-the-shelf components. These electronic components are available as application-specific or off-the-shelf products, with the former designed for a specific manufacturer and the latter for a generic approach. The choice of custom or generic components will affect the product specifications, pricing, manufacturing, life cycle, and marketing strategies of the product. The World Health Organization is interested in making available to developing countries hearing aids that are inexpensive to purchase and maintain. The hearing aid presented in this article was developed with these specifications in mind together with additional contemporary features such as four channels with wide dynamic range compression, an adjustable compression rate for each channel, four comfort programs, an adaptive feedback manager, and full volume control. This digital hearing aid is fitted using a personal computer with minimal hardware requirements in intuitive three-step fitting software. A trimmer-adjusted version can be developed where human and material resources are scarce.

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Chapter One

Introduction

1.1 Introduction

Hearing aids have been around since the 17th century with the first use of an ear trumpet for those who were partially deaf. Hearing loss is a common health problem affecting nearly 10% of the world's population as indicated by many international studies. Hearing impaired people usually suffer from more frustration, anxiety and depression than those with normal hearing levels. In my humble project, I will try to develop a device to help people with hearing difficulties to have good communication with the surrounding environment, this device is known as ((ear hearing aid)), before we get into the device I will introduce you to the meaning of sound and the anatomy of the ear and how it works. Sound it he they are longitudinal waves generated by mechanical vibration. The human ear can detect sound at frequencies (20HZ-20KHZ) below this. The frequency is called infrasound and is below the level of human hearing, while those higher than the level of human hearing are called ultrasound.

1.2. Project Organization

Chapter One briefly introduces the research topic and provides an overview of the purpose and objectives of the study. This section introduces the topic of the research and provides a brief overview of the background and context of the study. It may also include a statement of the research problem or question the study seeks to address. This section outlines the specific goals and objectives of the research, and it should clearly state what the study aims to achieve and the research questions that will be addressed.

Chapter Two typically provides a literature review or a review of related studies on the topic. It aims to provide a comprehensive and critical overview of the existing knowledge, theories, and research findings related to the research question or problem. This section describes the theories, models, or conceptual frameworks that are relevant to the research. It should explain how these concepts are related to the research question or problem, and the section provides a general overview of the relevant literature related to the research topic.

Chapter Three provides an overview of the chapter and outlines the purpose and objectives of the practical system design and implementation. This section describes the design of the system or the methodology used to develop the system. It should include a detailed explanation of the system architecture, components, and interfaces and describes the process of implementing the system or the methodology. It should include a description of the development environment, programming languages and tools, and testing methodologies used in the implementation process.

Chapter Four provides an overview of the chapter and outlines the purpose and objectives of presenting the practical results of the research, and provides a detailed description of the experiment or study that was conducted to obtain the practical results. It should include a description of the participants or sample, the study design, and the data collection methods. This section interprets the results and discusses their implications. It should provide an analysis of the findings and their significance about the research question or problem. It may also compare the results to the existing literature and discuss any discrepancies or s **Chapter Five** focuses on the conclusions and further works of the research project. This section provides an overview of the chapter and outlines the purpose and objectives of the concluding chapter and provides a conclusion of the research project, and discusses its implications. It should provide a clear answer to the research question or problem and explain how the proposed research contributes to the existing literature on deep-learning techniques for facial emotion recognition.

1.3. The aim of project

The aim of this project is to design and implement an external hearing aid device to address the challenges faced by individuals with hearing impairments. The device should provide an effective and user-friendly solution for enhancing hearing capabilities, enabling users to engage more fully in daily activities and improve their overall quality of life.

1.4. Project Goals

The primary goals of this project are as follows:

a. Design and Development: Design and develop an external hearing aid device that incorporates innovative features and addresses the challenges faced by individuals with hearing impairments.

b. Performance and Accuracy: Ensure the device delivers accurate sound amplification, effective noise reduction, and improved speech intelligibility, while maintaining natural sound quality.

c. User-Friendliness: Create a user-friendly interface with intuitive controls and customizable settings to accommodate individual preferences and hearing needs.

d. Comfort and Aesthetics: Design the device with ergonomics in mind, ensuring it is comfortable to wear and aesthetically appealing to encourage user acceptance and daily usage.

e. Connectivity and Compatibility: Implement wireless connectivity features, enabling the device to seamlessly connect with other audio devices and provide personalized audio experiences.

f. Testing and Evaluation: Conduct rigorous testing and evaluation to assess the device's performance, user satisfaction, and adherence to industry standards and regulations.

Chapter Two

THEORETICAL BACKGROUND

2.1. Introduction

The five human senses had been playing an essential part of providing his needs and requirements, though hearing is consider the most important among these five senses.

2.2. The anatomy of ear

The ear is divided into three anatomical regions: the external ear, the middle ear and the inner ear. The external ear the visible portion of the ear collects and directs sound waves toward the middle, a chamber located in a thickened portion of the temporal bone. Structures of the middle ear collect and amplify sound waves and transmit them to an appropriate portion of the inner ear. The inner ear contains the sensory organs for hearing and equilibrium.[1]

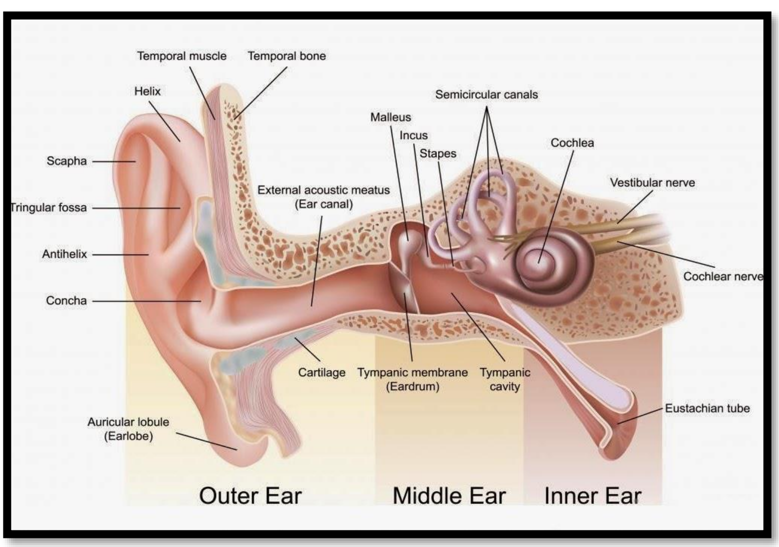

Fig 2.1. The anatomy of Ear

2.3. The external ear

The external ear includes the fleshy auricle or pinna which surrounds the entrance to the external acoustic canal, or ear canal. the auricle which is supported by elastic cartilage protects the opening of the canal. It also provides directional sensivity to the ear: sounds coming from behind the head are partially blocked by the auricle; sounds coming from the side are collected and channeled into the external auditory canal, The tympanic membrane is thin sheet that separates the external ear from the middle ear [2].

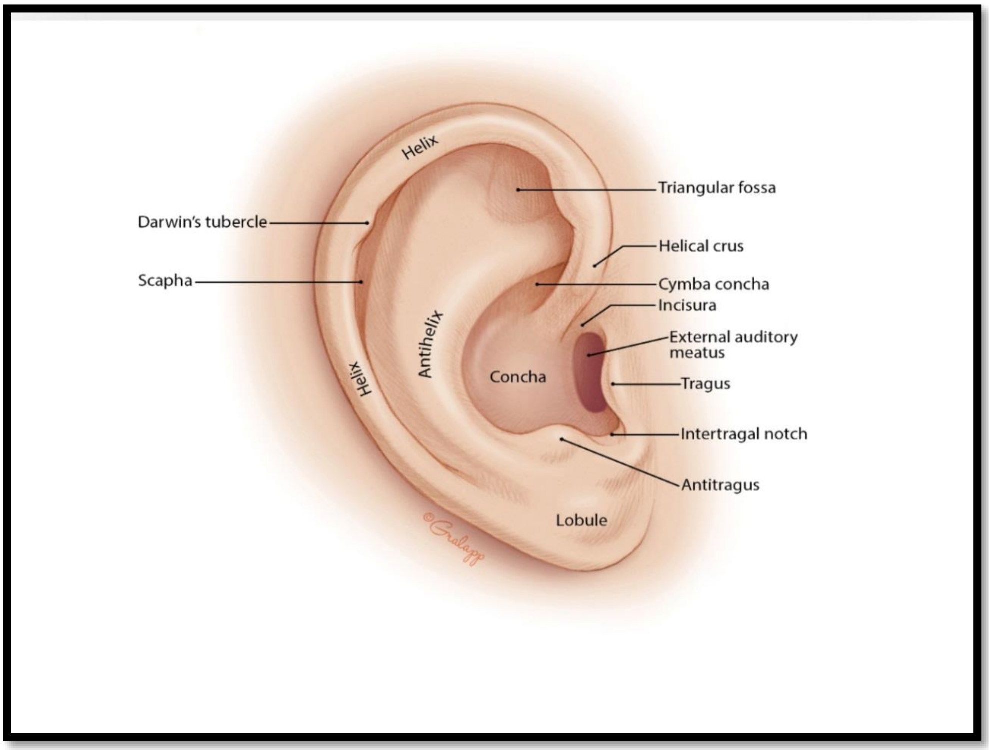

Fig 2.2 The External Ear

2.4. The middle ear

The middle ear, or tympanic cavity, is in air-filled chamber separated from the external acoustic canal by the tympanum, The auditory tube enables the equalization of pressure on either side f the eardrum unfortunately, it can be as allow microorganisms to travel from the nasopharynx into the tympanic cavity leading to an unpleasant middle ear infection known as otitis media [9].

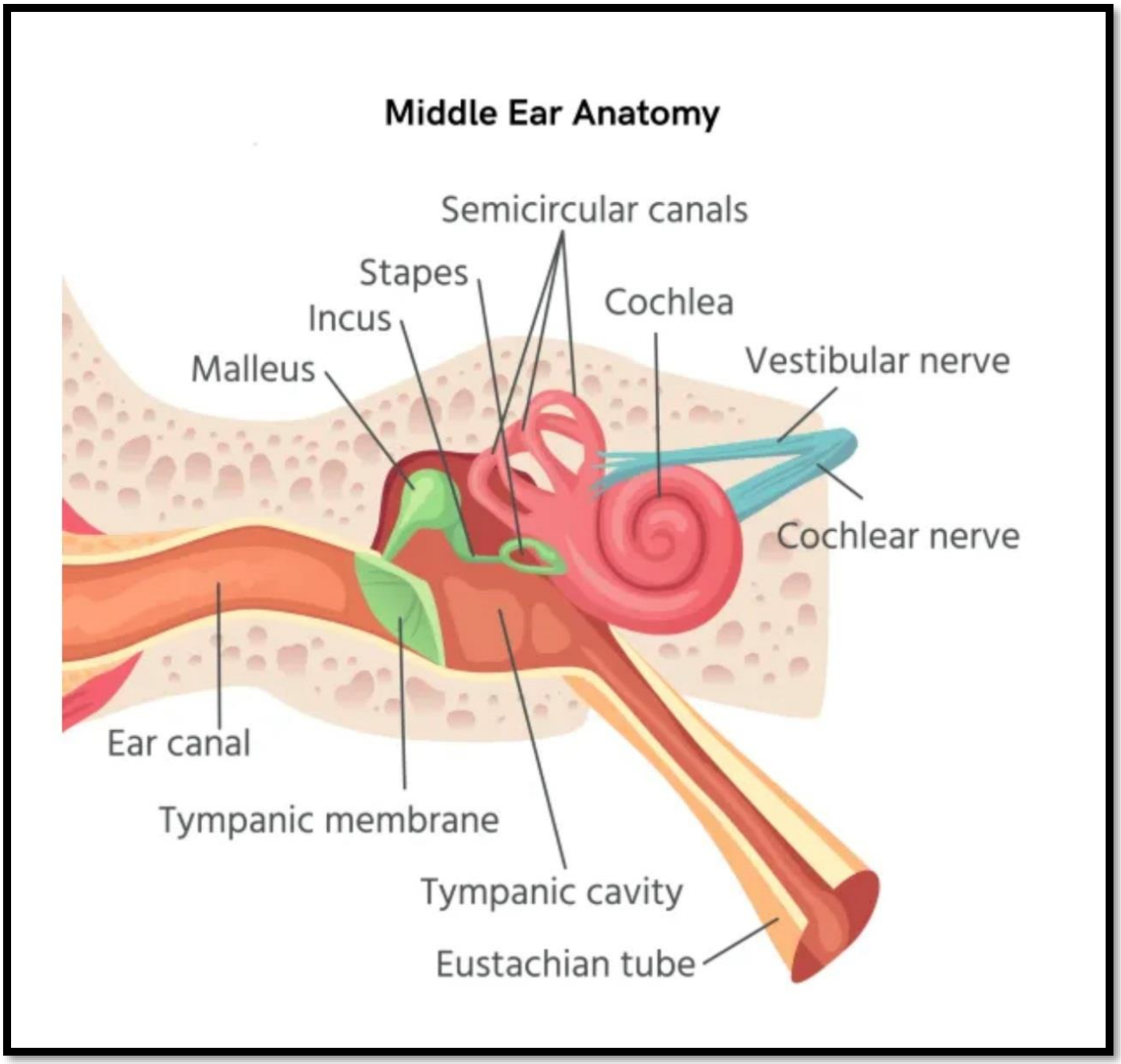

Fig 2.3. The middle ear

2.5. The Auditory ossicl

The middle ear contains three tiny ear bones, collectively called auditory ossicle, the ear bones connect the tympanum with the receptor complex of the inner ear, The malleus (hammer) attaches at three points to the interior surface of the tympanum. The middle bone-the incus (incus, avil) - attaches the malleus to the inner bone, the stapes. The base of the the stapes almost completely fills the oval window, a small opening in the bone that encloses the inner ear. P bola The tympanum is larger and heavier than the delicate membrane spanning the oval window, so the amounts of movement increase markedly from tympanum to oval window [4].

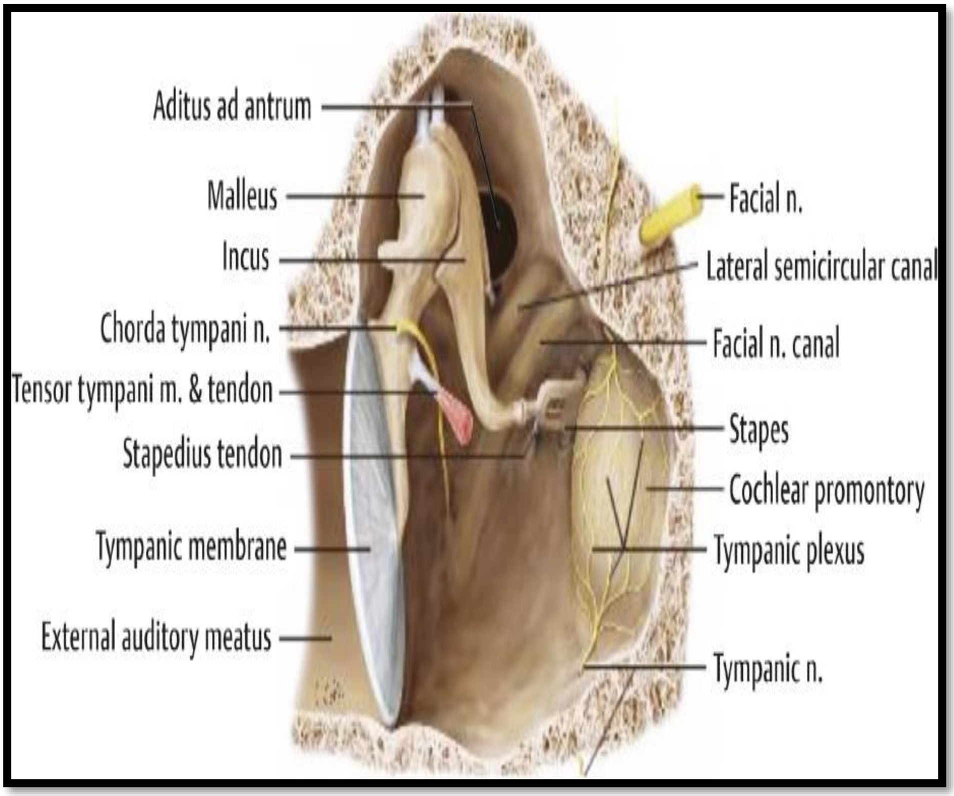

Fig 2.4. THE AUDIOTRY OSSICL

2.6. The inner ear

The senses of equilibrium and hearing are provided by the receptors within the inner ear. These receptors are protected by the bony labyrinth; its outer walls are fused with the surrounding temporal bone. The bony labyrinth surrounded and protected the membranous labyrinth, a collection f tubes and chambers that flow the contours of surrounding bony labyrinth and are filled with a fluid called endolymph. Between the bony and membranous labyrinths flows another fluid, the perilymph [1].

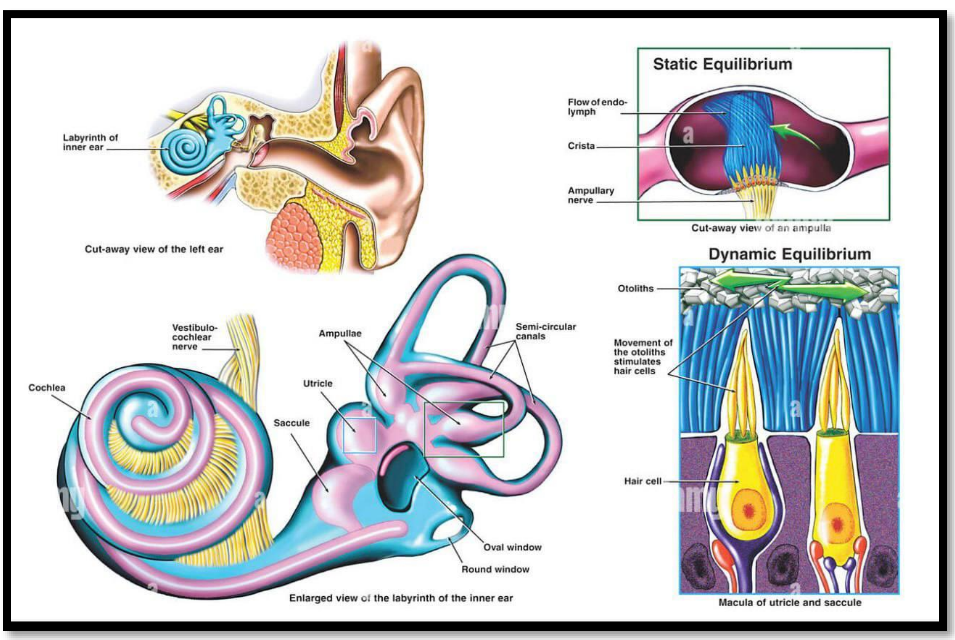

Fig 2.5. The inner ear

2.7. The bony labyrinth parts

- Vestibule: The Vestibule includes apair of membranous sacs, the saccule and the utricle. Receptors in these sacs provided sensation of gravity and linear acceleration.
- Semicircular canals: The semicircular canals enclose slender semicircular ducts. Receptors in the semicircular duct are stimulated by rotation of the head. The combination of vestibule and semicircular canals is called the vestibular complex, because the fluid-filled chambers within the vestibule are continuous with those of the semicircular canals.
- Cochlea the bony spiral-shaped b cochlea contains the cochlear ducts of the membranous labyrinth. Receptor in the cochlear duct is sandwiched between a pair of perilymph-filled chambers and the entire complex is coiled around a central bony hub.

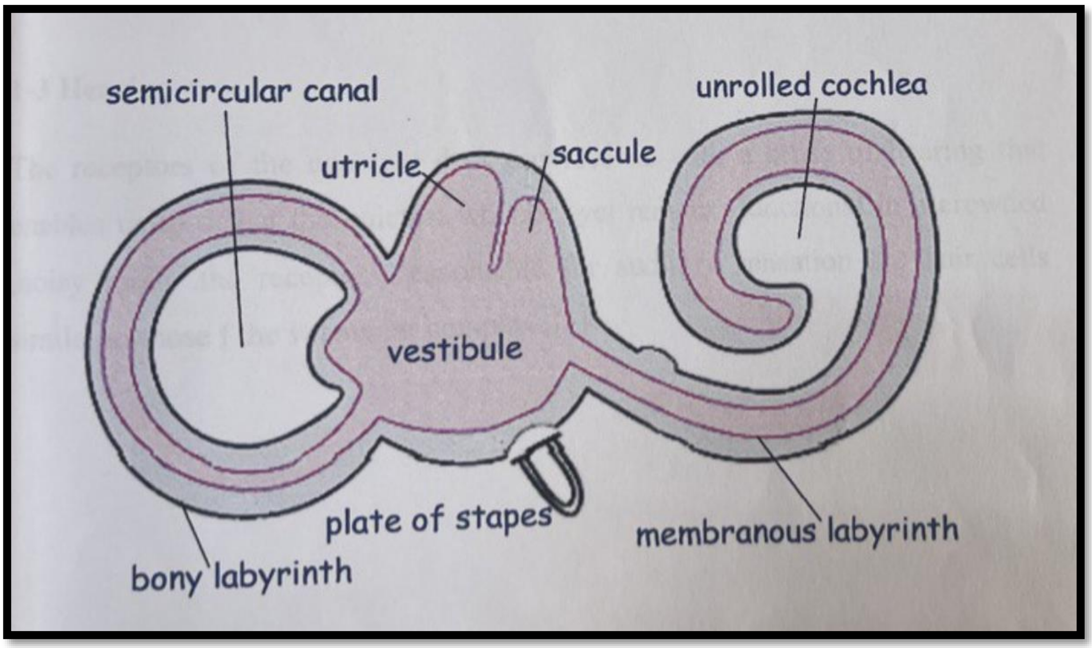

Fig 2.6. The Bony Labyrinth

2.8. RECEPTORS FUNCTION IN THE INNER EAR:

The receptors of the inner ear are called hair cells, regardless of location they are always surrounded by supporting cells and monitored by the dendrites of sensory neurons, each hair cell communicates with a sensory neuron by continually releasing small quantities of neurotransmitter [5].

2.9. The cochlea duct

In sectional view, the cochlea duct or scale media, lies between a pair of chambers containing perilymph: the vestibular duct and the tympanic duct, the vestibular and tympanic ducts are interconnected at the tip of the cochlea spiral. The outer surfaces of these ducts are encased by the bony labyrinth everywhere except at the oval window (the base of the vestibular duct) and the round window (the base of the tympanic duct) [9].

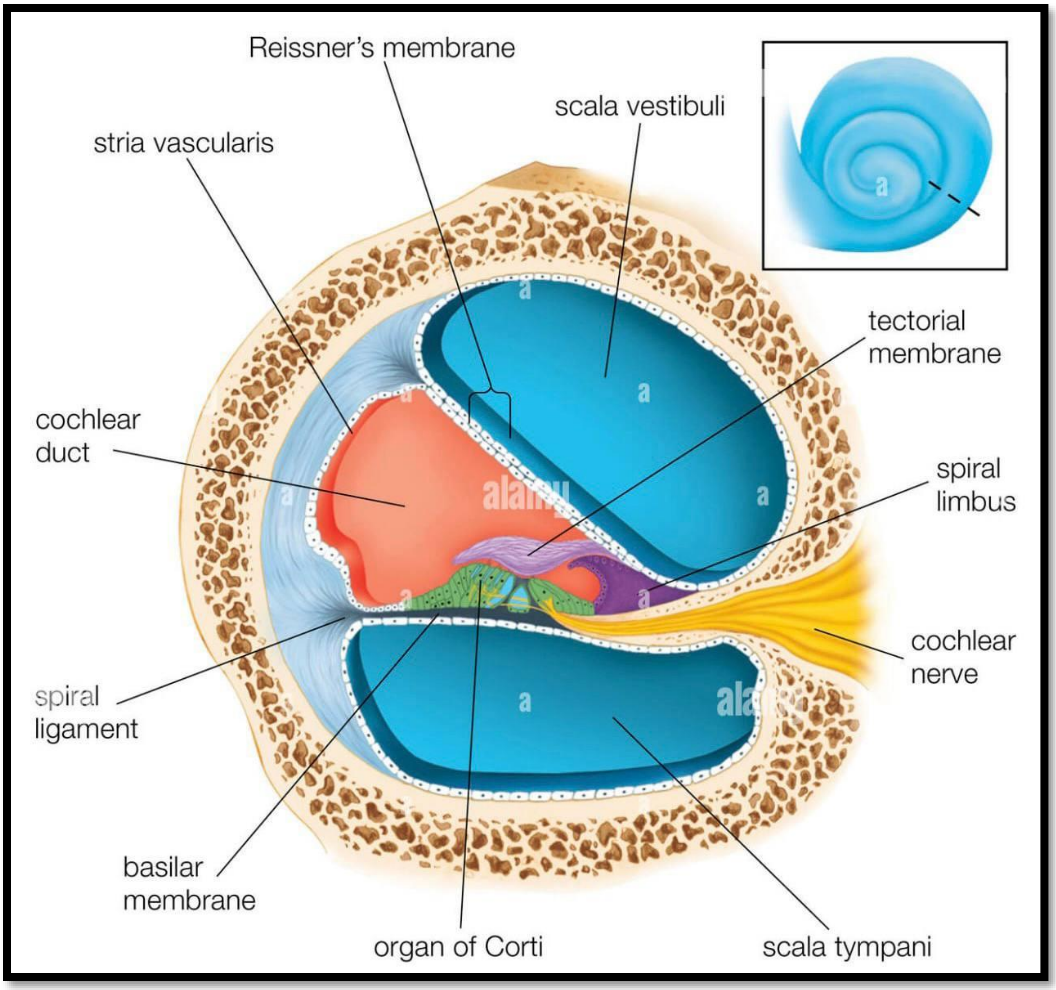

Fig 2.7. The cochlea duct

2.10 Hearing

The receptors of the cochlear duct provides us with a sense of hearing that enables us to detect the quietest whisper, yet remain functional in a crowded noisy room the receptors responsible for auditory sensation are hair cells similar to those the vestibular complex. Stages of Passes Sound in ear as sound passes through each ear, it sets off a chain reaction. The outer ear [11].

1) Collects pressure (sound) waves and funnels them through to the ear canal. These vibrations strike the eardrum. The eardrum vibrates the delicate bones of the middle ear.
2) That conduct the vibrations into fluid in the inner ear.
3) The vibrations stimulate tiny nerve endings (hair cells) that transform vibrations into electro-chemical impulses. The impulses travel to the brain
4) Where they are understood as sounds, such as speech, music, or noise.

2.11. Deafness and hearing loss

Deafness is a disorder affecting the ability to hear, includes a complete inability to hear, the diagnostic category of deafness does not include people with limited hearing, deafness can cause difficulty communicating and people who are deaf may be at risk of physical and social isolation, They are also at greater risk of accidents because they may not hear warning alarms and sirens. From 40 years old, more men than women become hard of hearing, Among people over the age of 80, more women than men are deaf or hard of hearing, not because women are more likely to become deaf but because women live longer [4] .

2.11.1 Signs of Deafness:

You should have your hearing checked if you have experienced more than a couple of these signs of hearing loss.

1. Tired or stressed from trying to hear.
2. Believe that everybody mumbles.
3. Find it easier to understand others when you are looking directly at their faces.
4. Frequently ask others to repeat themselves.
5. Have difficulty understanding speech in noisy places like cars, restaurants and theaters.
6. Fail to understand doctor's instructions about medications.
7. Make inappropriate responses because you didn't understand the questions.

2.11.2 Factors causes hearing loss:

1. It can result from damage or disruption to any part of the hearing system.
2. From wax blocking the ear canal and age-related changes to the sensory cells of the cochlea to brain damage.
3. Excessive exposure to noise is an important cause of a particular pattern of hearing loss, upwards 50% of deaf people. Often people fail to realize the damage they're doing to their ears until it's too late.

2.11.3 The protection from Deafness

1. Vaccination against infections and avoiding excessive noise exposure reduces the risk of deafness.
2. Removing wax and foreign bodies.
3. Treating infections and glue ear helps improve hearing.
4. For some people cochlear implants, enable hearing.

CHAPTER THREE

Experiment

3.1 Hardware Requirements

The main parts that used in this project:

1. Power Supply
2. Connecting wire
3. Crystal microphone
4. Bc337 NPN transistor
5. PAM8403
6. Resistance
7. capacitor 2.2uf , 25v
8. Switch
9. Ferro board

3.1.1 The Power Supply

The 3.7-volt lithium battery is one of the commonly used rechargeable battery types in a wide range of applications. These batteries are known for their high efficiency and excellent energy density, making them ideal for use in portable electronic devices such as smartphones, tablets, and smartwatches The Advantages of the 3.7-volt Lithium Battery [2]:

1. High Efficiency: Lithium batteries exhibit high efficiency in converting chemical energy into electrical energy, resulting in excellent performance and longer device runtime.

2. Excellent Energy Density: Lithium batteries have a high energy density, meaning they provide more energy for their size. This helps in reducing the overall size and weight of devices.

3. Longer Cycle Life: The 3.7-volt lithium battery offers a longer cycle life compared to other battery types. It can endure numerous charge and discharge cycles without significant degradation, providing prolonged usability.

Fig 3.1 3.7-volt lithium battery

3.1.2 Connecting Wire

Is an electrical wire or group of the mina cable with a connector or pin at each end. As shown in the figure below.

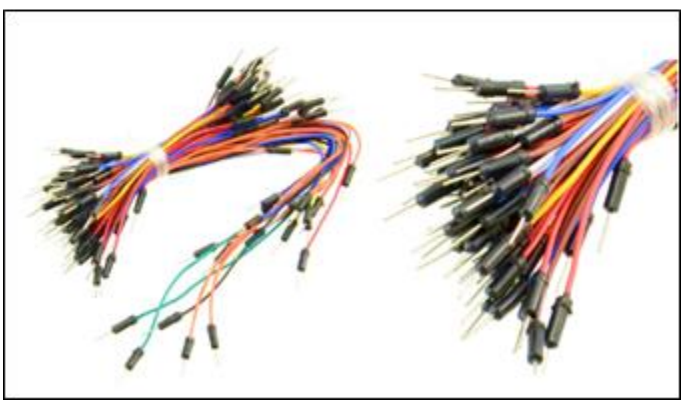

Fig. 3.2 the connecting wire

3.1.3 Crystal microphone

It is very small compared to other types of microphones, and usually consists of a small, conical inner part, with a flexible plate coated with salt at its small, pointed end [3].

When the microphone is exposed to sound waves, the small conical part moves and presses on that thin layer called the plate, and those vibrations produce electric waves with the help of the salt layers that the plate has been coated with, and those waves are proportional to the strength of the waves and sound vibrations, and on the basis of them the final sound comes out through the speakers [1].

As I explained, it is a very small microphone, but its signal is strong and pure. Its only drawback is the weak output resulting from it, and therefore it needs suitable headphones [9].

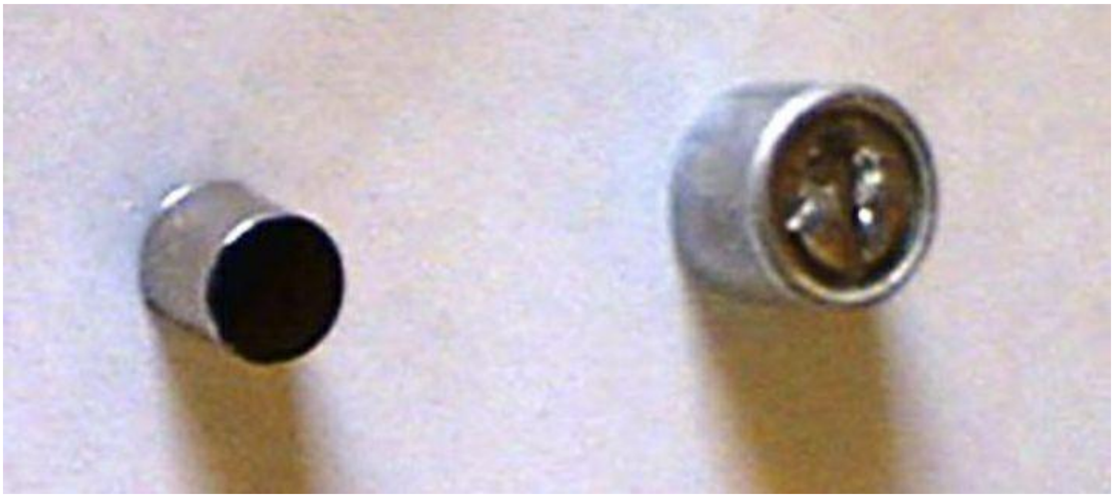

Fig. 3.3 Crystal microphone

3.1.4 BC337 NPN transistor

Is a commonly used bipolar junction transistor (BJT) that belongs to the BC series of transistors. It is widely used in various electronic circuits for amplification, switching, and voltage regulation purposes. Here are some general features and characteristics of the BC337 transistor: NPN Configuration: The BC337 is an NPN transistor, which means it has a layer of p-type semiconductor (base) sandwiched between two layers of n-type semiconductor (emitter and collector).The Amplification: The BC337 transistor is designed for general-purpose amplification applications. It offers moderate gain and can be used in small-signal amplification circuits [4].

Low Power: This transistor is suitable for low-power applications, typically operating at collector currents (Ic) in the range of a few mill amperes to a few hundred mill amperes. Medium Voltage Rating:

The BC337 transistor has a medium voltage rating, with a collector-emitter voltage (Vce) typically ranging from 30V to 50V. This makes it suitable for low to medium voltage applications. Current Gain: The current gain or DC current gain (hFE) of the BC337 transistor typically falls within the range of 100 to 630. The hFE value determines the amplification capability of the transistor. Low Noise: The BC337 transistor exhibits low noise characteristics, making it suitable for use in audio amplifier circuits and other noise-sensitive applications. Switching Speed The switching speed of the BC337 transistor is moderate, allowing it to be used in various switching applications such as signal switching, digital logic circuits, and small motor control [5].

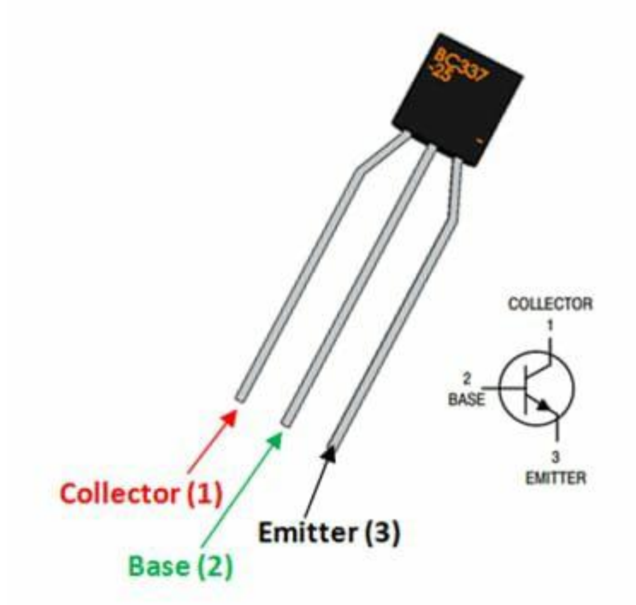

Fig. 3.4. BC337 NPN transistor

3.1.5 PAM8403

The PAM8403 is a class D audio amplifier with built-in 2-channel 3W output capability. It offers high-quality audio reproduction with low power consumption and minimal external components. The amplifier operates on a 5V power supply and is designed to deliver high-quality sound in various applications such as portable speakers, multimedia devices, and other audio systems. Key Features: Small Package Size: The PAM8403 is housed in a compact 16-pin SOP package, making it suitable for space-constrained applications. High Efficiency: The class D architecture of the amplifier ensures high efficiency, minimizing power loss and maximizing battery life. Low Quiescent Current: The amplifier has a low quiescent current, reducing power consumption during standby or idle mode. Wide Voltage Range: The PAM8403 operates within a wide voltage range of 2.5V to 5.5V, providing flexibility in power supply options. Low THD+N: Total Harmonic Distortion plus Noise (THD+N) is kept low, ensuring high-fidelity audio reproduction with minimal distort [1].

Fig. 3.5. PAM8403

3.1.6. Resistance

The resistance 1KΩ and the variable resistance: it is to control the amount of the Bias output of the circuit in order to operate the transistor within the Active Region linear state

The resistor 10KΩ function: Protects the transistor from overheating and maintains the amplification without any manipulation.

The resistor 100KΩ function: Controls the amount of collector current flowing through the transistor.

Fig. 3.6. Resistance

3.1.7. capacitor 2.2uf , 25v

Its function in the circuit is to prevent the passage of direct current and allow the passage of alternating current through it, and it has positive and negative polarity [6].

Also, the function of the 470μF capacitor connected in series with the amplifier is to eliminate the DC current and maintain the volume maintains the volume [13].

3.2. device design

Fig.3.7. design of device

Chapter four

Result and Discussion

4.1. The introduction

The purpose of this study was to design and implement an external hearing aids device that can provide improved sound amplification and enhanced hearing capabilities for individuals with hearing impairments. The device aimed to be user-friendly, comfortable to wear, and capable of adapting to different listening environments. This paper presents the results and discussions of the design and implementation process, including the evaluation of the device's performance and user feedback [12]**.**

4.2 The Methods

The design process involved a multidisciplinary approach, incorporating input from audiologists, engineers, and end-users. The device was designed to be compact, lightweight, and aesthetically pleasing, while ensuring optimal functionality. Advanced digital signal processing techniques were employed to enhance sound quality and reduce background noise. The device consisted of a microphone, a signal processing unit, and a receiver, which delivered the amplified sound to the user's ear. Results: The implemented external hearing aids device showed promising results in improving the hearing capabilities of individuals with hearing impairments. The digital signal processing algorithms effectively amplified the desired sound frequencies while suppressing background noise, leading to a clearer and more intelligible auditory experience. The device demonstrated good performance across various listening environments, including quiet settings and noisy environments, such as crowded areas or busy streets.

4.3 User Feedback

The device was evaluated by a group of individuals with varying degrees of hearing impairments. Overall, the user feedback was positive, with many participants reporting significant improvements in their ability to hear and understand speech. The device's comfort and ease of use were highlighted as key strengths, with users appreciating its lightweight design and adjustable settings. However, some users noted that the device's battery life could be improved, requiring frequent recharging [15].

4.4 The Discussion

The design and implementation of the external hearing aids device addressed several challenges associated with hearing impairments. The use of digital signal processing techniques allowed for personalized amplification and adaptive noise reduction, enhancing the device's performance in different listening environments. The positive user feedback indicates the device's potential as an effective tool for individuals with hearing impairments, improving their quality of life and communication abilities. The battery life concern raised by some users is an area for further improvement in future iterations of the device [16].

CHAPTER FIVE

Conclusions and Recommendations

5.1 Conclusions and Recommendations

Based on the design and implementation of the external hearing aid device, the following conclusions can be drawn:

a. The device successfully addresses the challenges faced by individuals with hearing impairments by providing enhanced sound amplification, noise reduction, and speech intelligibility.

b. The user-friendly controls and intuitive interface contribute to a positive user experience, allowing users to adjust settings and personalize their hearing preferences easily.

c. The ergonomic design and comfortable fit of the device promote long-term usage and user acceptance.

d. The incorporation of connectivity options enables seamless integration with other audio devices, enhancing the versatility and functionality of the device.

e. The device's durability, water resistance, and efficient power management contribute to its reliability and suitability for everyday use.

5.2 Recommendations

Based on the project's outcomes, the following recommendations can be made to further improve the design and implementation of the external hearing aid device:

a. Continuous Research and Development: As technology evolves, it is crucial to stay updated with the latest advancements in hearing aid technology. Continuously conduct research and development to incorporate new features, algorithms, and connectivity options into future iterations of the device.

b. User Testing and Feedback: Engage with a diverse group of users to gather feedback on the device's performance, usability, and comfort. Incorporate user suggestions and address any identified areas for improvement in subsequent iterations of the device.

c. Collaboration with Audiologists and Hearing Professionals: Establish collaborations with audiologists and hearing professionals to ensure that the device meets the specific needs and requirements of individuals with different types and degrees of hearing impairments. Seek their expertise for fine-tuning the device's functionality and customization options.

d. Regulatory Compliance: Ensure that the device adheres to industry standards and regulations, including safety and electromagnetic compatibility requirements. Obtain necessary certifications and approvals to ensure the device's compliance with applicable regulations in different regions.

e. Long-Term Reliability: Conduct thorough testing and quality assurance measures to ensure the long-term reliability and performance of the device. Consider implementing regular software updates and maintenance protocols to address any potential issues and enhance the device's longevity.

f. Cost Considerations: Explore opportunities to optimize the manufacturing process and reduce production costs without compromising the device's quality and performance. This will contribute to making the device more accessible and affordable for a wider range of users.

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