DESIGN AND CONSTRUCTION OF HEARING AID

BY

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DECLARATION

I Alashi Olayinka, declare that this project work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology Minna.

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DEDICATION

This project work is dedicated to God almighty, and the entire ELDER J.S ALASHI FAMILY

ACKNOWLEDGEMENT

With a deep sense of gratitude I acknowledge all those who in diverse ways have contributed to making my dreams come true.

I am connected to a family genetically woven with strings of excellence to which also I am indebted for gratitude. To great parents indeed, Mr and Mrs J.S Alashi and all their lovely children

I would also like to appreciate my supervisor Engr. Rumala for his fatherly support, patience understanding and good words of advice.

Also my thanks go to the Head of the Department of Electrical and Computer Engineering, and all the lecturers who have sacrificed a lot to impart knowledge on me, may the almighty God reward you all with abundant blessing.

Most importantly, I would like to appreciate God almighty for keeping me alive to be able to carry out this project and for his grace and mercies through my five academics sessions in F.U.T Minna.

ABSTRACT

In the world we live in today, there is a great increase in the number of hearing impaired persons due to noise pollution in urban areas, over exposure to industrial noise, infections, deformities at child birth and aging. As the need to correct this problem increase, it has lead to the development of electronic hearing aids which are device that amplifies sound signals, and boost sound level to compensate for defects in the ear drum structure of the hearing impaired. The unit consists of a pre-amplifier stage that amplifies the picked up voice signal from the input transducer (microphone), converts the sound into electrical signals, amplifies the signals and the amplified signal is converted back to sound at the output (earphone) stage. Computer simulation was used to ensure that the design operates with the specified specifications.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

Communication is the transfer of information, ideas or feelings from one person to another, communication refers to sending, processing and reception of information. The main means of receiving information in humans are the brain and senses. Humans use mainly the sense of seeing and hearing in communication. [22]

The human ear is a sense organ used for hearing and for balance. The ear receives signals which the brain translates into sound and information.

Hearing impairment which occurs when there is a problem with or damage to one or more parts of the ear, however makes communication with other individual difficult. For people who loss their hearing after learning to speak and hear, it can be difficult to adjust because hearing has been an essential aspect of their communication and relationship. According to the National Institutes of Deafness and other Communication disorders, about 28million Americans are deaf or hearing impaired. That's about one out of every ten people have hearing problems [15]. The good news is that new technologies are making it possible for more hearing impaired persons to communicate to a great extent and participate actively with their hearing peers.

The major break through in solving this problem is the electronic hearing aid.

1.2 ABOUT THE PROJECT

The hearing aid is a device that increases the loudness of sound in a user's ear. It is used in some form of deafness to amplify sound before it reaches the auditory organs.

They are usually battery powered and the principal components are a microphone, an amplifier and an ear phone.

Hearing aids are small electronics device that amplifies sound and is worn in or behind the ear to compensate for impaired hearing.

In recent times, a number of advancements have been made to hearing aids, improving the comfort, sensitivity and aesthetic quality of the device.

The work is basically done by carrying out the design, buying the components and soldering and wiring them in a circuit board based on the design that was done, the construction, testing was carried out with corrections made to errors. After the design and construction of the prototype was packaged into a case. All the components used in the construction were bought from the electronic part shops in Minna and Lagos.

During the cause of the design, constructions were made with my supervisor, laboratory technicians and some of my classmates.

1.3 OBJECTIVE OF THE PROJECT

The objective of this project is to design and construct an electronic hearing aid that would be a solution to hearing problems for people with impaired hearing (partial deafness).

This project was done with as minimum circuitry as possible, as reliability of a circuit design decreases with the components used in the circuit. The hearing aid will serves as a great source of relive to the hearing impaired individuals.

1.4 SCOPE OF THE WORK

The degree of hearing impairment can vary widely from person to person. Some people have partial hearing loss meaning that the ear can pick up some sound; others have complete hearing loss, meaning that the ears cannot hear at all (people with complete hearing loss are considered deaf).

Hearing aids however can only be applicable for people with sensorineural hearing loss which result from damaged caused by the outer ear cells not functioning correctly.

This means that the application of this device is limited to particular kinds of partial deafness.

1.5 EXPECTED CONSTRAINTS

Designs of hearing aids have stringent technological requirements. Hearing aids must be small enough to fit inside or behind the ear and be concealed easily, they must also run with extremely low power, and introduce no noise or distortion.

Noise is a major problem in design of hearing aids and the size since it is necessary that it is concealed during usage.

Other problem that a user might experience while adjusting to hearing aids include;

- The hearing aids may be uncomfortable
- The user voice may sound too loud.
- The hearing aid may whistle
- The background noise may be heard by the user.

tinny bones called ossicles/hammer. The ear drum is a thin sensitive membrane stretched tightly over the entrance to the middle ear.

2.2.2 THE MIDDLE EAR

The waves causes the eardrum to vibrate and it passes these vibrations to the ossicles, one of the three tiny bones in the ear. The hammer vibrating causes the anvil, the small bone touching the hammer to vibrate. The anvil passes the vibrations to the stirrup, another small bone which touches the anvil. From the stirrup, the vibrations pass into the inner ear.

2.2.3 THE INNER EAR

The inner ear is made up of a snail shaped chamber called the cochlea, which is filled with the fluid and lined with thousands of tiny hair cells (outer and inner rows). When the vibrations moves through these fluids, the tiny hair translate them into electrical nerve impulse and send them to the auditory nerve, which connects the inner ear to the brain. When these nerve impulses reach the brain they are interpreted as sound. The cochlea is like a piano so that specific areas along the length of the cochlea pick up gradually higher pitches. [4,5]

This process of hearing may seem like a long process but it happens almost instantly. In reality every time a sound is heard the various structures of the ear have to work together to make sure the information gets to the human ear. [17]

2.3 HEARING IMPAIRMENT AND THEIR CAUSES

Hearing impairments occur when there is a problem with or damage to one or more parts of the ear. Some people are born with hearing impairments, others loose their hearing for many reasons. [15,18]

Deafness can be caused by long exposure to higher level noise, drugs, ear infections or deposition of bonnet in the wall window. Deafness is partial or total inability to hear.

It may be present at birth (congenital) or may be acquired at any age there after. A person who cannot detect sound at amplitude of 20dB in a frequency range of 800 to 1800 vibrations per second is said to be hard of hearing. [15]

The human ear perceives sounds in the range of 20 to 20,000 vibrations per second (Hz). There are two principal kinds of deafness, they are; Conductive and Sensorineural deafness. [6]

2.3.1 CONDUCTIVE DEAFNESS

Conductive problems are those that disrupt the conduction of sound through the outer and inner ear, the passage of sound vibrations through the ear is interrupted. The obstacle may be earwax, a ruptured eardrum, or staples fixation, which prevents the stapes bone from transmitting sound vibrations to the inner ear.

Disturbances of the conductive mechanism are often temporary or curable. The condition usually responds to antibiotic therapy, but serious cases may require drainage of collected fluids through an incision in the eardrum (tympanum) or insertion of a tiny drainage tube.

2.3.2 SENSORINEURAL HEARING LOSS

This hearing loss results from damage to the inner ear (cochlea) or the auditory nerve. The most common type is caused by the outer hair cells not functioning correctly. The person has trouble hearing clearly, understanding speech and interpreting various sounds.

This type of hearing losses permanent and may be treated with hearing aids, or in severe cases, a cochlea implant (tiny devices implanted into the inner ear that translates sound waves into pulses). The causes of sensorineural impairment can be generalized as;

Genetic disorders, injuries to the ear or head, complications during pregnancy or birth , infections or illness, medications and loud noise. [6,7]

The degree of hearing impairment can vary widely from person to person. Some people have partial hearing loss, meaning that the ear can pick up some sounds, others have complete hearing loss, meaning that the ear can not hear at all, this people are considered deaf and can be helped by other methods. [18]

2.4 TREATMENT OF HEARING IMPAIRMENT

A person with difficult in hearing is screened by a doctor who if necessary will refer the person to an audiologist, who is a health professional who specializes in diagnosing and treating hearing problems. The audiologist carries out examinations to determine where the problem is and treatment is carried out in cases that could be treated.

Persons whose deafness cannot be relieved by medical or surgical means may be greatly helped by various types of electronic hearing aids. Hearing aids come in various forms that fit inside or behind the ear and makes sound louder. They are adjusted by the audiologist so that the sound coming in is amplified enough to allow the person with hearing impairment to hear it clearly. A limitation to hearing aid application is that sometimes the hearing loss is so severe that the most powerful hearing aids cannot amplify the sound enough. In this case a cochlea implant may be recommended. [14]

The people who loss their hearing after learning to speak and hear, can be difficult to adjust because hearing has been an essential aspect of their communication and relationship. The good news is that new technology is making it possible for more-hearing impaired people to hear to a great extent.

According to the National Institute on Deafness and other Communication Disorder [17] about 1 out of every 10 people are deaf or hearing impaired and millions of people are exposed to hazardous noise levels on a regular basis. Hearing loss is also the most common birth anomaly.

2.5 THEORETICAL BACKGROUND

The hearing aid is a device used to help the hard-of-hearing hear sounds better. In the past, a funnel-like amplification cone called an "ear trumpet" or 'ear horn" was used, also sometimes used was a desk with built-in amplifier into which a microphone and ear phones could be plugged; these worked better than passive ear trumpets but were not portable. [17]

In recent times however, the most common style of hearing aid is a small electronic device that fits into the wearer's ear. The first variety of this device had a rectangular battery pack connected by a thin wire, intended to be held in a pocket. Such "body aids" though much more portable than the desk types still suffers significant disadvantages because the microphone is not near the user's head, such disadvantages such as clothing noise and being located below the mouth of a person with whom the user was conversing.

During the mid-to late 20th centuries hearing aids that were carried in pockets were replaced by a more inconspicuous sort of model in which small zinc-air batteries were placed in the inserted unit itself [17]

There are many types of hearing aids which vary in sizes, power and circuitry. Among the different sizes and models available are; Body worn aids, behind the air aids (BTE), in the ear aids (ITE), in the canal aids and several other types of aids which are available in the market.

2.5.1 AMPLIFICATION OF SOUND

The Analog/ Adjustable hearing aid which is generally the least expensive is built to meet specifications provided by hearing professionals (Audio metrist, hearing instrument specialist, Hearing aid dispenser or Audiologist).

The specialist determines the volume and other specifications you need in your hearing aid, and it is built to meet specifications.

Amplification of sound is achieved with the use of amplifiers. The system contains a microphone, an amplifier, a battery (power source) and a receiver/speaker.

Most amplifiers incorporate some kind of compression function, essentially a non linear input/output relationship that is used to compensate for loudness requirements. Also the gain is different frequency bands can be adjusted and the number of frequency bands varies but is usually two or three bands [17]

The block diagram in fig 2.2 gives a simple representation of the principles used for the sound amplification.

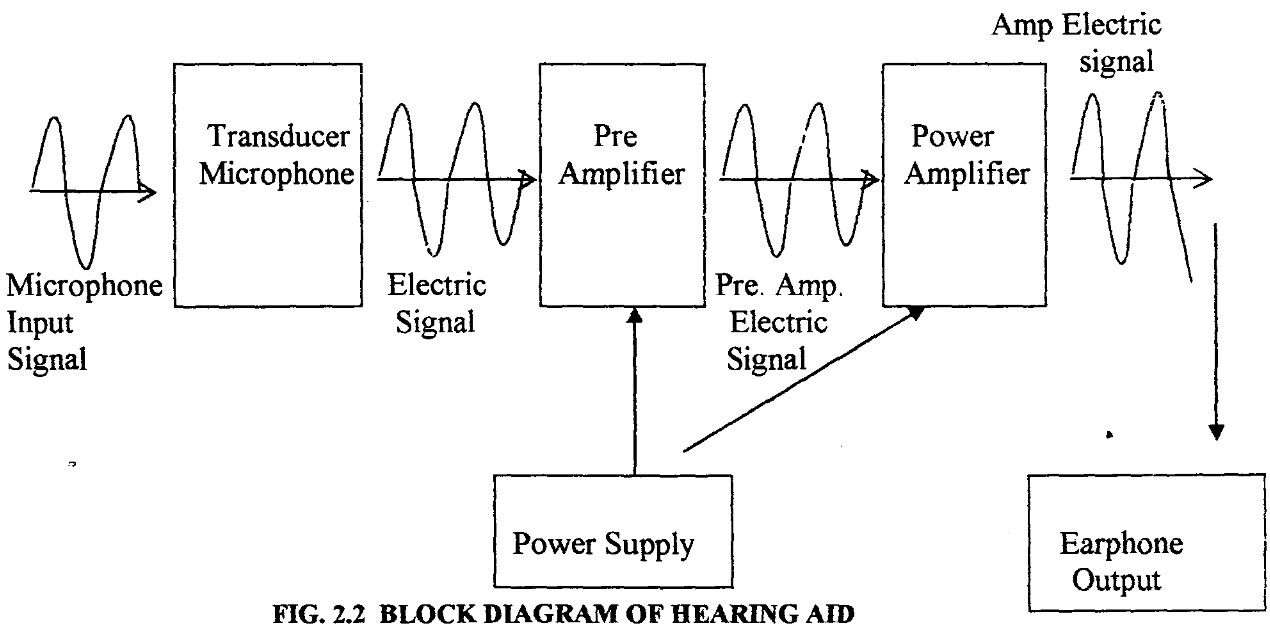


FIG. 2.2 BLOCK DIAGRAM OF HEARING AID

When audio signal is incident or picked up by the microphone, the sound causes acoustic pressure on the microphone. The microphone converts this pressure to equivalent voltage. The microphone output voltage is fed into a broad band amplifier, which pre-amplifies the voltage signals. The output of the pre-amp is then passed into an amplifier stage before it is passed into a transducer (earphone).

The amplification of the input sound is achieved with this process and the volume of the device is adjusted as required.

2.6 HISTORY OF HEARING AID

Since hearing loss is one of the oldest known disabilities, attempts to amplify sound go back several centuries. This collection includes examples on non-electric hearing aids such as speaking tubes, ear trumpets e.t.c. and the development of electrical hearing aids.

Hearing aid manufacturers have tried to improve the quality of sound, to develop a smaller device and in some instances to conceal the device. Non-electric hearing aids such as speaking tubes, and ear trumpets were used in the 1800's and were made of various materials including silver and tortoise shells. Some of the ear trumpets were collapsible for portability some of them were concealed in objects such as canes.

In the 1920's some aids such as the Audi-ear and super ear aids were developed, they had head bands and were designed to fit over and under the external ear. It was thought that these aids would do the same job as placing a brand behind the ear and cupping it to receive sound.

The transition to battery powered hearing aids occurred in the early 1900's. Initially the battery packs were large and were carried in separate boxes or strapped to one's leg. The early aids were carbon type, followed by vacuum tube aids introduced in 1939. In 1944, the first vacuum tube hearing aid was developed which contained the battery inside the aid. [14]

At last true portability has dawned on hearing aids, the invention of the transistor in 1948 drastically shrunk the sizes and price as the transistors advantages of cheapness, small size, low power drain and highly effective operation were to become clear to a marveling world. [17]

The first transistor hearing aid was introduced in 1980's with the development of transistors; the aids were able to become smaller and more powerful.

The use of microchips for programming having aids was introduced in 1985 to better meet individual needs [17]. We look forward to the developments in the 21st century.

CHAPTER THREE

DESIGN AND CONSTRUCTION

3.1 INTRODUCTION

The approach used in this design is the modular approach where the overall design was first broken into functional blocks, where each block represent a section of the circuit that carries out a specific function. The functional block diagram shown in fig 2.2 shows the interconnection between the blocks.

The design and construction of the hearing aid is basically split into major parts.

1. The microphone and pre-amplifier stage.
2. The head phone and power amplifier stage.

However, the specification for the hearing aid designed in this project is explained below. This normally given by he audiologist or audiometrist who determines the extent of the person hearing loss.

3.2 FREQUENCY RANGE

Frequency is the number of waves emitted or received in one second. The unit for sound frequency is the hertz (Hz), named after the German physicist, Henrich Hertz (1857-1894) who was associated with early work in radio waves. The normal human ear can detect sound waves frequency in the range from approximately 16Hz to 16KHz [13]. The design of the hearing aid was done to operate within these ranges of frequency.

3.3 LOUDNESS

Loudness is a subjective effect, in other words, the loudness of sound depends on the individual experiencing it. It cannot therefore be measured. It is possible however, to make measurements which agree reasonably closely to most people's assessment of loudness [13].

The unit used for measurement is decibel (dB). This is done using a device called sound level meter. These have a microphone, amplifier, meter and the appropriate circuitry to match the ear's characteristics. Such units are quoted with the unit dBA, meaning dBs with the "A" circuit incorporated.

Current noise regulations in the UK require ear defenders to be made available in an industrial work place where the noise levels reach 85dB. Above 90dBA their use is mandatory [13]. With this it is noted that for an impaired human ear sound levels up to 80dB would be loud enough to be heard by the hearing impaired

3.4 THE ELECTRETE MICROPHONE

The microphone used in the design and construction is the electrete microphone. The electrete microphone is a microphone that draws so very little current that some models have no ON/OFF switch for their internal batteries [1].

The electrete microphone uses a permanently polarized material which can be regarded as the electrostatic equivalent of a permanent magnet. The electrete-foil material is given its permanent charge (positive or negative) while in a strong electric field and heated either by corona discharge or electron bombardment.

The advantage of using an electrete microphone is eliminating the need for a high voltage supply that is needed in other microphones and they are very small and rugged. [1]

3.5 THE 741 OPERATIONAL AMPLIFIER BASED MICROPHONE PREAMPLIFIER

The microphone pre-amplifier which is the input stage of the device is built around the 741 operational amplifier as shown below [8].

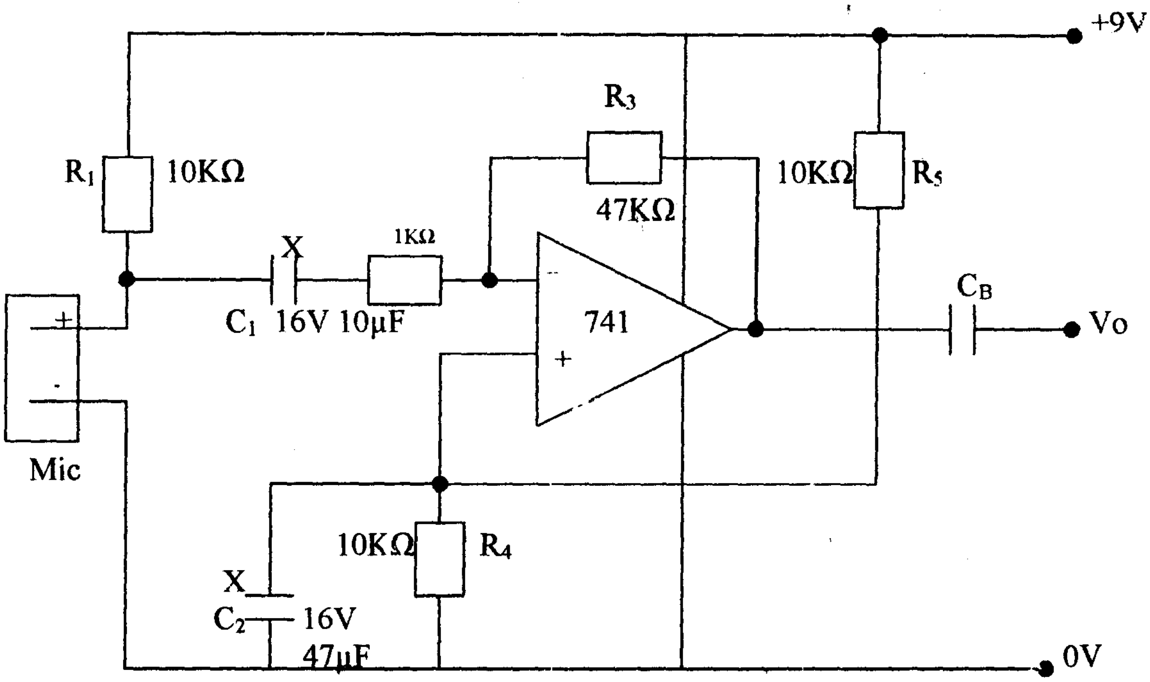


Fig 3.1 Microphone Preamplifier

The 741 operational amplifier is used in this case because frequency above 10KHz is not of much consideration here, since the human ear is most sensitive to sound at 3KHz [11].

The operational amplifier is wired in the inverting mode with negative feed back to provide amplification [2]. The electrete microphone supplies an electrical quantity representing the human spoken words.

Being an electrete microphone, it must be appropriately biased before it can work in the circuit. This biasing is affected using resistor R_1, which is a 10KΩ resistor, and a source voltage +9V yields a maximum bias current of $9/10,000 = 9 \times 10^{-4}$ A (assuming R mic =0Ω).

The resistance of the microphone was measured to be 1.6KΩ and this impedance was matched with the input impedance of the operational amplifier.

The output voltage of the microphone is fed into the inverting input of the 741 op-amp as shown in fig 3.2

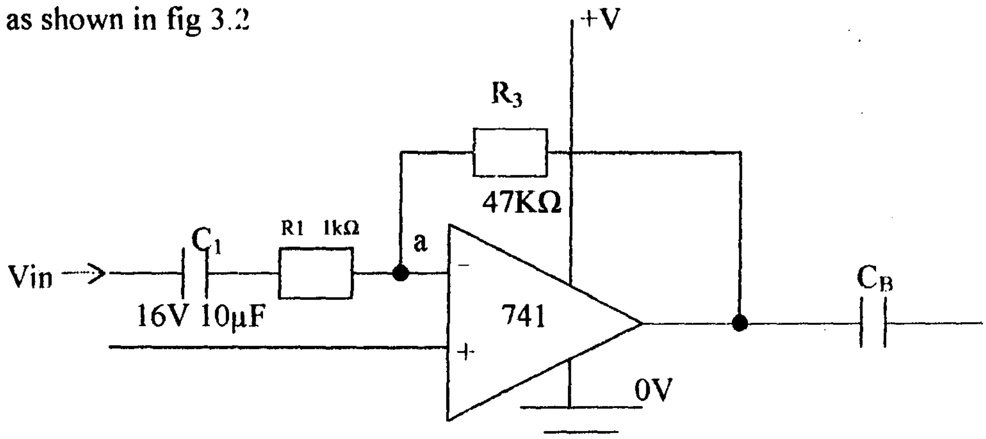


Fig 3.2 741 inverting Op-Amp

The inverting amplifier configuration responds to both A.C and D.C signals. However if you want to get the A.C. frequency of an op-amp or if the A.C input signal is superimposed with D.C level it becomes essential to block the dc component [19]

The circuit shown in fig 3.2 the capacitor blocks DC component of the input and together with the resistor R_1 sets the lower 3dB frequency of the preamplifier stage.

The node "a" is at virtual ground, the output voltage 'V_o' is given by

$$V_o = -I_{in.} R_f = \frac{-V_i}{R_1 + 1/SC_1} \times R_f \quad \text{.......3.1 [3, 19]}$$

$$\text{Therefore } Av_1 = \frac{V_o}{V_1} = -\frac{R_f}{R_1} \times \frac{S}{S + 1/R_1C_1} \quad \text{.......3.2}$$

The lower 3dB frequency F_L is given by

$$F_L = \frac{1}{2\pi R_1 C_1} \quad \text{.......3.3 [12, 19]}$$

In the mid-band range of frequencies, capacitor C_1 behaves as a short circuit and therefore eqn. 3.1 becomes $Av_1 \approx \frac{-R_f}{R_1}$

This is the maximum gain that could be obtained in the amplifier stage because of the internal circuitry included in an op amp, the gain drops off as frequency increases [12]

The maximum gain $A_{V1} = \frac{-R_f}{R_1}$

$$= \frac{-47K\Omega}{1K\Omega}$$

$$= 47$$

Converting this to decibel (dB)

$$Av_1 = 20 \, Log_{10} \, (Vo/V1)$$

$$= 20 \, Log_{10} \, (47)$$

$$= 33.4419 \text{ dB}$$

The negative sign in the gain indicate out of phase relationship between the input and output voltages [16].

The inverting configuration is chosen because of its higher rejection of external interference. Operating a 741 op-amp which operates on dual mode power supply on a single supply demand that the device be biased appropriately for single supply operations. [12]

3.6 SINGLE SUPPLY BIASING OF OPERATIONAL AMPLIFIER

For a general purpose amplifier like the 741 op-amp, the inputs and output can typically swing to about 1.5V of either supply with V^- (negative pin) connected to ground. You can't have either of the inputs or outputs at ground. Instead, by generating a reference voltage (e.g $0.5V^+$) you can bias the op-amp for successful operation.

This circuit is an active amplifier with a maximum gain of 47, Vref = $0.5V^+$ gives an output swing of about 23V pp before onset of clipping capacitor coupling is used at the input and output to block the DC level which equals Vref [2,10]

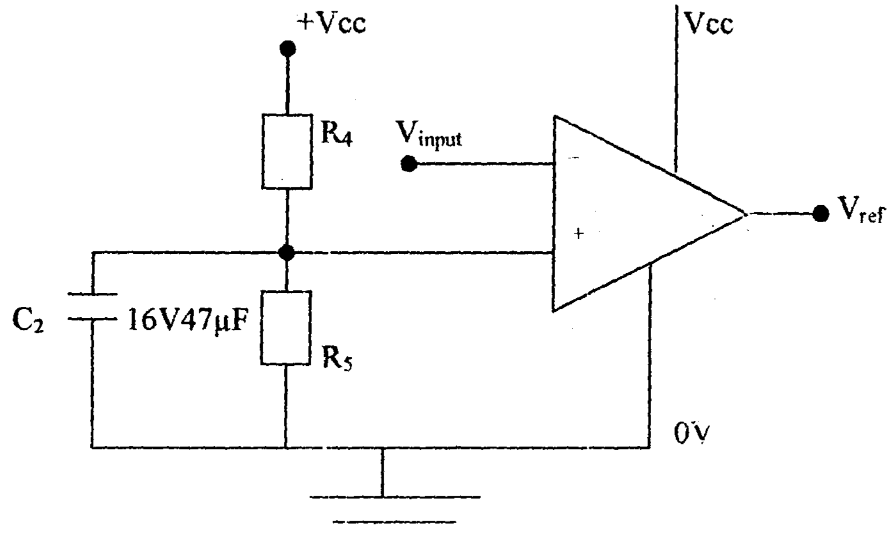


FIG 3.3 SINGLE-SUPPLY BIASING OF AN OP-AMP

The 10KΩ resistance were chosen to source a current 9/20,000 = 450μA to the non-inverting input of the operational amplifier. The 741 op-amp has internal circuitry that automatically limits the current drawn from the output terminal in order to protect the device from damage due to output short circuits or overloads. [21]

Capacitor C_1 a 16V10μF capacitor is used as a DC blocking capacitor at the input of the 741 op-amp and for setting the lower frequencies threshold of the device

$$F_L = \frac{1}{2\pi RC}$$

$$= \frac{1}{2\pi \times 1 \times 103 \times 10 \times 10^{-3}}$$

$F_{low} = 15.92Hz \approx 16KHz$ [12,19]

This is the lower frequency threshold of the device which conforms to the lower range of sound which the human ear could be sensitive to.

Capacitor C_2 a 16V42μF capacitor stabilizes V^+ against large fluctuations in $+V_{cc}$

3.7 VOLUME CONTROL CIRCUIT

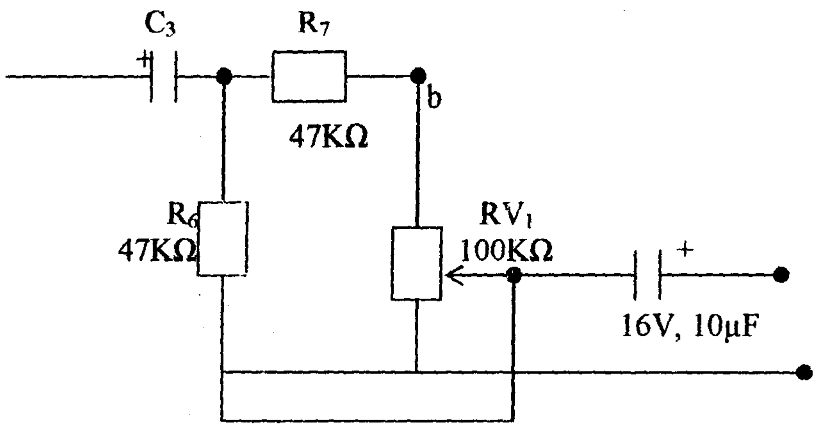


Fig 3.4 Volume Control

The volume control circuit is wired together with a loudness circuit that accentuates the low and high end of the audio spectrum when listening at low volume levels.

A volume control is in fact a variable resistor connected as a potentiometer. The output voltage of such a circuit is now majorly a function of the relative resistances on either sides of the divider

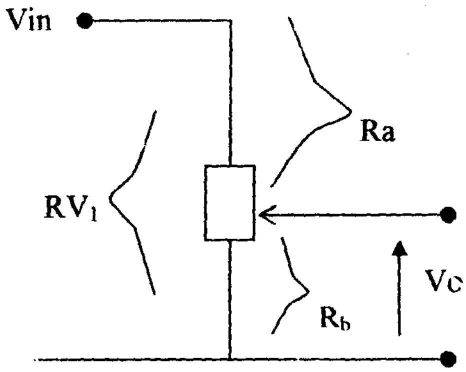


Fig 3.5 Potentiometer

The potential divider can be seen to consist of two resistances Ra and R_b. Assuming that the voltage seen at point 'b' is Vin.

$$Vo = io\,R_b \qquad \ldots\ldots 3.4$$

$$io = \frac{Vin}{Ra + R_b} \qquad \ldots\ldots 3.5$$

$$Vo = \frac{Vin}{Ra + R_b} \cdot R_b \qquad \ldots\ldots 3.6$$

$$\frac{Vo}{Vin} = \frac{Rb}{Ra + R_b} \qquad \ldots\ldots 3.7$$

The output voltage V_0 is a direct function of resistance R_b. Assuming the resistance is evenly distributed along the track.

DC blocking capacitor C_3 is incorporated at the output of the microphone pre-amplifier to prevent the DC heating of the variable resistor which would cause a hissing noise on the audio output.

3.8 LOUDNESS CIRCUIT

The loudness function is achieved by R_b, a 47KΩ resistance. This serves as an optional path for the amplified microphone signal when the volume is set at a very low level. This compensates for the extreme attenuation of the low and high end of the audible spectrum at low volume settings.

A typical loudness compensated volume characteristics is shown below.[9]

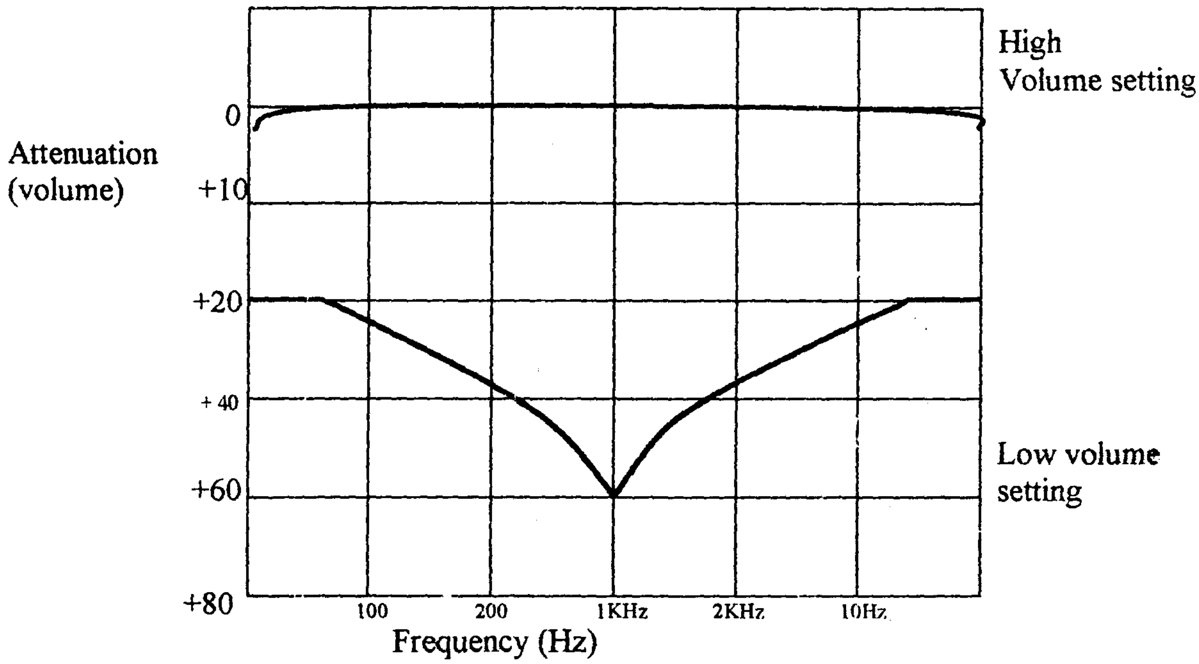


Fig 3.6 Loudness function

3.8 THE EAR PHONE-AMPLIFIER STAGE

The power amplifier section for the device is designed using a TEA2025 audio power amplifier. The TEA device is packaged in a 16-pin plastic dual in line package. The IC runs on a maximum supply of +15V with a peak output current of 1.5A.

The pin configuration for the device is shown in the fig 3.7 [20]

The TEA2025 is wire with both channels used as shown fig 3.8

From the application information obtained from the data sheet, input capacitor is PNP type allowing source to be referenced to ground. In this way no input coupling capacitor is required. However, a series capacitor (0.27μF) to the input side can be used in case of noise due to variable resistor contact.

The voltage gain is determined by on-chip resistors R_1 and R_2 together with the external RFC_1 series connected between pin 6 (11) and ground.

The frequency response is given approximately by:

$$\frac{Vout}{Vm} = \frac{R_1}{R_f + R_2 + \frac{1}{jwC_1}} \quad \ldots\ldots 3.8$$

with $R_f = 0$, $C_1 = 100\mu F$, the gain results to 46db with pole at f = 32Hz.

The purpose of R_f is to reduce the gain. It is recommended not to reduce it under 36db [20].

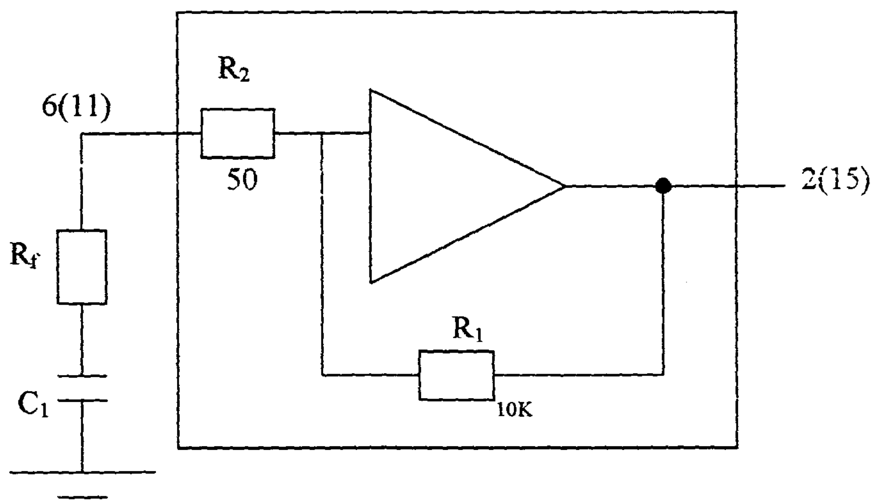


Fig 3.9 TEA2025 Voltage Gain

The electrical characteristic of the TEA2025 is shown fig 3.9

Other components that were used in the design are the switch for ON/OFF position, a earphone input jack and a diode.

The diode used to indicate on/off state of the device had to be protected so it does not get burnt.

$$R_{doide} \text{ (minimum)} = \frac{Vs - V_{doide}}{I_{diode}} = \frac{9V - 2V}{(5mA)(min)} = 350\Omega$$

$$R_{doide} \text{ (maximum)} = \frac{Vs - V_{doide}}{I_{diode}} = \frac{9V - 2V}{20mA(max)} = 1200\Omega$$

Therefore. The value of R_{doide} was chosen to be 500Ω used as limiting resistor for the diode.

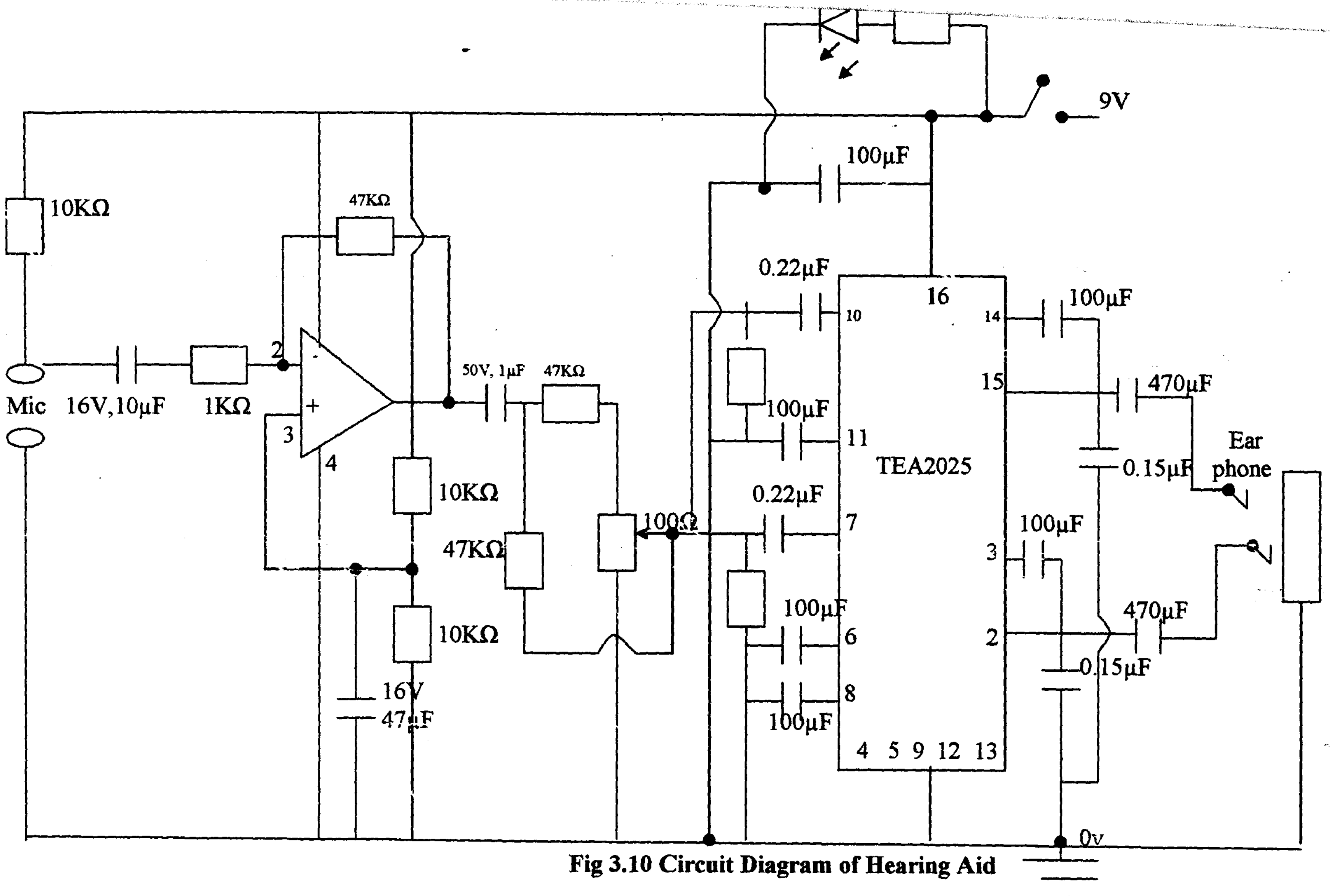


Fig 3.10 Circuit Diagram of Hearing Aid

4.3 TESTING OF CIRCUIT

The testing followed the modular pattern that was followed in the design, with each functional block being tested as described as follows. For any block that was not working, the faults were check and corrected.

4.3.1 TESTING OF THE POWER SUPPLY

The digital Multimeter was the tool that was used for testing the power supply. Power supply OFF test was carried out to check for continuity and power ON test was carried out to check for the input voltage level at the ICs and microphone. The unit was functioning properly when tested.

4.3.2 TESTING OF AMPLIFIER STAGES

The amplifier stages were tested for the output voltage level, using the Multimeter. Thereafter the ear phone was connected at the earphone jack and the microphone was spoken into. There was no sound output. The circuit was trouble checked for both short circuit and open circuit faults. And the TEA2025 chip had to be replaced after which the circuit began to function. Initially there was a very loud noise in the circuit and the microphone had to be adequately biased by a 10KΩ resistor before the circuit stated operating properly.

4.4 TESTING OF THE ENTIRE CIRCUIT

The entire circuit was tested for short circuit and open circuit faults that could result in problems in the nearest future. All faults were corrected. Some components had to be soldered more firmly. The ear phone was put in placed and the power switch put on. The microphone was able to pick sound and speech at different distances and there was adequate amplification and the loudness in the output sound from the earphone.

The overall gain for the system "A_V" is calculated as

$$A_V = A_{V1} \times A_{V2}$$

But because this gain is in decibel (dB) we add them as $A_V = A_{V1}dB + A_{V2}dB$

$$= 79.5dB$$

The result here is close the specification for the design which is 80 decibels. This result conforms with the specifications for the design. The result is obtained by assuming that we neglect the loading effect of the first stage by the second stage. The result will be approximately true as long as the impedance loading into the output impedance of the second stage is much greater than the output impedance of the first stage. Otherwise, the overall gain will be much less. [3]

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

From the theoretical analysis made before commencement of the design, the design was done using a modular or top-down approach. The design was first of all broken into functional blocks and analyzed. Decisions were made based on the analyzes for the choice of component used. Simulation of the circuit was then made on Multism electronic work bench.

From the modular design the maximum gain for the pre-amplifier stage was calculated to be approximately 80dB

With this result and the lower frequency threshold of the device being approximately 16Hz, it could be said that the specification for the design was meet.

The construction involved mainly soldering of the components on a matrix board and wiring appropriately according to the design.

The work was then tested following the modular pattern that was incorporated for the design. It was tested functionally and electrically. The hearing aid was tested and there was good amplification of sound at very low noise level, this makes it a good solution for a mildly hearing impaired person.

5.2 RECOMMENDATION

Like every other work, this project work is not without its limitations and can be improved upon. On this basis recommendations are made for improvement on this work in the future.

To improve the portability of the device, the number of components in the design should be reduced to the minimum that would give the required amplification at the lowest attainable noise levels.

The device should be designed to run with extremely low power and introduce no noise or distortion.

The analogue hearing aids should be replaced by the digital ones due to the fact that analogue processing suffers from a dependency on custom circuit, lack of programmability and a higher cost when compared to digital processing.

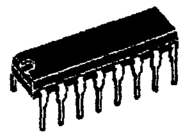
However, it should be stated that prevention is better than care. Many cause of hearing loss or deafness are not preventable, but it is important to realize that hearing loss caused by loud noise can be prevented.

It is therefore recommended that people should avoid prolonged exposure to things like loud noise, sirens, engines and industrial noise.

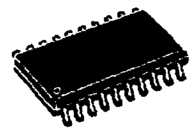
APPENDIX

STEREO AUDIO AMPLIFIER

- DUAL OR BRIDGE CONNECTION MODES
- FEW EXTERNAL COMPONENTS
- SUPPLY VOLTAGE DOWN TO 3V
- HIGH CHANNEL SEPARATION
- VERY LOW SWITCH ON/OFF NOISE
- MAX GAIN OF 45dB WITH ADJUST EXTERNAL RESISTOR
- SOFT CLIPPING
- THERMAL PROTECTION
- $3V < V_{CC} < 15V$
- $P = 2 \bullet 1W$, $V_{CC} = 6V$, $R_L = 4\Omega$
- $P = 2 \bullet 2.3W$, $V_{CC} = 9V$, $R_L = 4\Omega$
- $P = 2 \bullet 0.1W$, $V_{CC} = 3V$, $R_L = 4\Omega$



POWERDIP 12+2+2



SO20 (12+4+4)

ORDERING NUMBERS: TEA2025B (PDIP)
TEA2025D (SO)

DESCRIPTION

The TEA2025B/D is a monolithic integrated circuit in 12+2+2 Powerdip and 12+4+4 SO, intended for use as dual or bridge power audio amplifier portable radio cassette players.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Test Conditions	Unit
V_S	Supply Voltage	15	V
I_O	Ouput Peak Current	1.5	A
T_J	Junction Temperature	150	°C
T_{stg}	Storage Temperature	150	°C

BLOCK DIAGRAM