DESIGN AND CONSTRUCTION OF A HEARING AID WITH A CHARGER

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DEDICATION

This report is dedicated to the Most High; God, the I am that I am, who all things good come from and without whom nothing is possible, also to my parents Mr. and Mrs. J. O. Ojo. for giving me the privilege of education.

And most especially to my late sister Miss Oluwatoyin Ojo who slept in the lord April 2005.

DECLARATION

I, OJO OPEOLUWA, declare that this work was done by me and has never been presented elsewhere, for the award of a degree. I hereby give my copyright to the Federal University of Technology, Minna.

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ACKNOWLEDGEMENT

The most gratifying and perhaps the most humble part of writing this project work is to sit down at the very end of the whole tedious process and acknowledge debts incurred to the authors. All students know how dependent they are on the other for support of many others when in school and in preparation of manuscript.

It would take pages to acknowledge everyone who in one way or the other has provided me with assistance, but certain individuals deserve mentioning for their valuable help. To the remaining people my sincere apologies and my grateful thanks.

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To my supervisor, Mr. A.U. Usman; I say thank you for all your support and helpful advice in the course of this work.

And finally my sincere gratitude goes to my dearest friend and fiancée Miss. Jesutofunmi Oguntoye for moral support.

ABSTRACT

The project is on, design and construction of an electronic hearing aid. This is designed to solve the problems encountered within and outside normal audio range as it concerns effectiveness of communication.

The hearing loss threshold frequency varied base on studies, and the use of high gain control integrated circuit to reproduce the threshold and loudness improved the hearing of an impaired listeners. The main objective is to overcome the untold embarrassment that partial hearing or impairment can cause to the listeners.

The condenser microphone (is the input transducer) responsible for the signals pick-up into the preamplification stage which in turn is to the power amplification (where the signals is varied and controlled to the desirable frequency) and finally to the output transducer (i.e. ear phone).

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CHAPTER ONE

1.0 INTRODUCTION

Hearing which is the ability to hear or perceives sound. The human ear outer visible part (pinna) is still part of the sense organ for hearing and very sensitive to pick up myriads of cues about our environment, giving the whole body balance when walking and the ability to sense danger was essential to the survival of our ancestor. So it is no exaggeration to say that we humans owe existence to our highly evolved sense of hearing.

And the ability not to have this sense of hearing functioning properly or impaired is termed as "deafness". Deafness can either be total or partial and can be caused by long exposure to high level noise (above 120dB), drugs, ear infections or deposition of particles in the membrane wall window of the ear and old age. The diseases are mainly the defects of the tympanum, middle ear and inner ear, [7].

And a person suffering from ear defects cannot be involved in effective communication, which is needed in the day-to-day activities for ones proper coordination. In all walks of life, the more effectiveness in communication achieved go along way to move one level of success to another, since there will be an easier coordination of members to the set goals.

However, human senses or organ cannot be replaced the way mechanical parts are interchanged for a faulty part; but can only be improved or managed when impaired by any of the stated causes, which leads to partial loss of hearing.

The device is having a volume controller that will be used to vary frequencies to the desirable threshold level that is best suitable for the impaired listener for correction or possible aid while involved in communication.

CHAPTER TWO

2.0 LITERATURE REVIEW

Various means have been sought for to assist an impaired person or partially deaf people. Over the years, various fashion and styles have been used by man in the prehistoric time for hearing aid.

However, with man desire to make hearing aid more fanciful some were crafted from ornament, silver or expensive jewels, with the primary goal of sound amplification for effective communication. The early hearing aid includes ear trumpets and hearing tubes.

2.1 ANCIENT HEARING AID DEVICE

In time past the importance of hearing was considered and that gave birth to the art and craft of the people in various fashion and style, shapes and sizes of the device.

But in the early part of the last century most hearing aids available then were design in one of the following two ways;

- The first design, involved the speaker holding one end of the apparatus to his/her mouth while the listener held the opposite end in his or her ear.
- The second design, allowed greater distance from the speaker. With the instrument collecting sound energy from the surrounding air via a flat transmitting surface, an example of this latter design is the acoustic fan, which was generally made out of vulcanized rubber.

2.4.2 FREQUENCY

The human ear is sensitive to sound waves in the range of about 20-20000Hertz. This frequency range is called the audible range, and frequencies higher than the audible range is called ultrasonic range and frequencies below the audible range is called infrasonic.

2.4.3 PITCH

The pitch refers to the attribute of sound-wave sensation that enable one classify a note as high (loudness). And it is subjective quantity and cannot be measured with instrument for a pure tone of constant intensity, the pitch becomes higher as the frequency increases but the pitch of a pure tone of constant frequency becomes less as the intensity level increases.

2.4.4 RANGE

By the term range, it simply refers to distance, in relation to sound signal. And it is the distance between transmitted signal and its reception or distance between point of transmission and the user of the device.

2.4.5 LOUDNESS

The term loudness refers to a sensation in the consciousness of human observer. Loudness increases with intensity but there is no simple linear equation for their relationship. Pure tones of the same intensity but different frequency do not necessarily produce sensation of equal loudness and the better the signal produced, while 120dB is the highest tolerable intensity to the human ear.

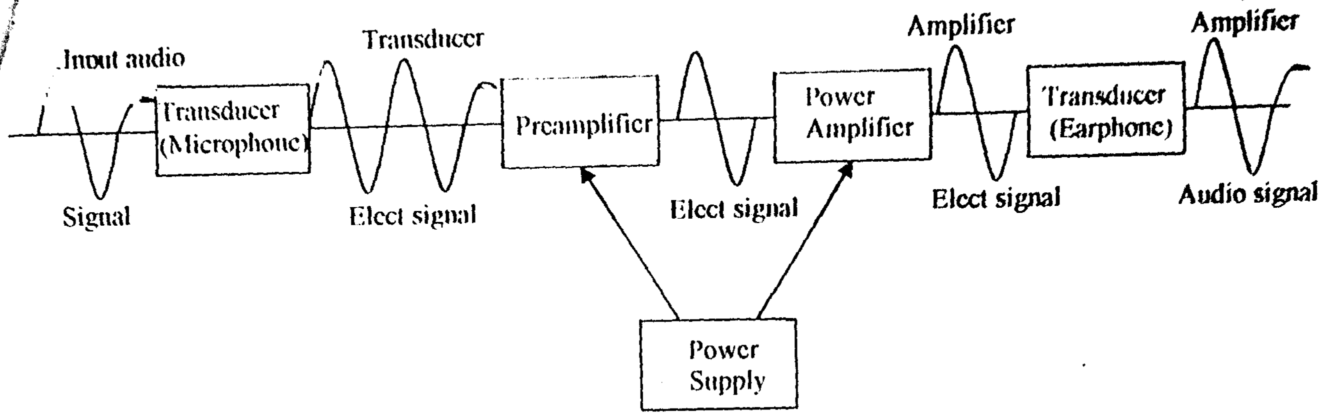


Fig. 3.0 A Block Diagram of the hearing aid

3.1 DESCRIPTION OF COMPONENTS

3.1.1 RESISTORS

They provide us with a means of controlling the current and or voltage present in a circuit. Typical applications involve the provision of bias potential and currents for transistor amplifiers, converting the collector or emitter output current of a transistor into a corresponding output voltage drop, and providing a predetermined value of attenuation [8].

The electrical characteristics of a resistor are largely determined by the material of which it is composed and its construction.

Factors which must be considered when selecting a resistor for a particular application normally include;

-The required value of resistance expressed in ohms.

-The desired accuracy of tolerance.

-The power rating (which must be equal to or greater than the maximum expected power dissipation).

-The temperature coefficient of the resistance

-The stability of the resistor

-Noise performance.

3.1.2 VARIABLE RESISTOR

Are available in variety of forms, most popular of which are the carbon track, cermets, wire wound, multi turn wire wound, potentiometer etc.

Things to consider when selecting variable resistors are resistance range, typical tolerance, power rating, stability, noise performance and applications.

In other to have or give better control over output levels in audio applications use logarithms law potentiometer for the volume control, its range is from 100 to100kΩ.

Applications; for power supplies, test and measuring equipment.[8]

3.1.3 ELECTROLYTIC CAPACITOR

The type most commonly used consists of Aluminum foil, one with an oxide film and one without, the foil being interleaved with a material such as paper saturated with suitable electrolyte, e.g. Ammonium Borate. The Aluminum oxide film is formed on the one foil by passing it through an electrolytic bath of which the foil forms the positive electrode. With the finished unit assembled in a container - usually of Aluminum – and hermetically sealed.

Their functions are blocking and decoupling capacitors.[2]

3.1.4 LM 386

For this project the LM 386 audio power amplifier manufactured by the National series conductor is most suitable because, it has a low signal voltage, among other characteristics as in [6].

3.1.4 TRANSDUCERS

This device responds to an input signal in one form and produces an output signal in another form but with the same magnitude as the input. And for this project the input transducers is a condenser microphone.

It converts sound signals to electrical signal within the audible hearing frequency range of (20 – 20000Hz) and mainly it is energized by the feedback negative voltage from the power amplification stage.

While for the output transducer is the earphone which changes that electrical signal sound receive from the preampliftying stage back to sound signal.

3.1.5 TRANSISTOR BC 337

Transistor is short for transfer resistor, a term which provides something of a clue as how the device operates. The current flowing in one circuit (output) is determined by the current flowing in another (input).

Choice for choosing BC337 is that as transistor which operates at medium power and voltage level and which are often used to precede a final stage which operates at an appreciable power level or as a driver, with the universal applications and its ratings as in the data [6]

3.1.6 TRANSFORMER

Typical application include; stepping down mains voltages in power supplies, coupling signal in AF amplifiers to achieve impedance matching and isolation of dc

They are available in various formats with the round type being most popular. The round LEDs are commonly available in the 3mm and 5mm (0.2inch) diameter plastic package, with the viewing angle in the region of 20 to 40 degrees.

3.1.9 VOLTAGE REGULATOR

ICs regulators are commonly employed in conjunction with stabilized dc power supplies. Regulators are invariably of the three terminal variety may be either fixed or variable voltage type.

Most regulator incorporate internal current limiting and thermal shut down.

The choice for chosen 7809 for the work is it dc input voltage compatibility which is in the range of 9v, as in the manufacturer specification.

3.2 CALCULATIONS

$I_cR_C + V_{CE} = Vcc$ (i)

$I_C/I_B = hf_e$

And for a class A

$V_{CE} = ½ Vcc$, to allow for Quiescent bias of best operating point

$R_C = 1.0k\Omega$

$V_{CE} = ½ * 9 = 4.5V$

$V_{bE} = 0.7V$

$hf_e = 258$

From eq (i) $I_cR_C + V_{CE} = Vcc$

$$\frac{4.5}{1 \times 10^3} = 4.5mA$$

From (iii) $\frac{I_C}{I_b} = hf_e$

$I_B = I_C/hfe = \frac{4.5 \times 10^{-3}}{258} = 17.4\mu A$

From (iii) $I_bR_b + V_{bE} = V_{CE}$

$17.4 * 10^{-6}R_b + 0.7 = 4.5$

$R_b = \frac{4.5 - 0.7}{17.4 \times 10^{-6}} = \frac{3.8}{17.4 \times 10^{-6}}$

$R_b = 218k\Omega$

3.2.1 COUPLING CAPACITOR CALCULATION

The reactance of C1 and C2 are set at frequency that is specified in the National Semiconductor data sheet. The maximum audio range is 20 kHz.

setting the reactance at 20 kHz to be 5Ω.

$$C = \frac{1}{2\pi F X_C}$$

Where, Xc = capacitor reactance

f = frequency

C = capacitor

$$C = \frac{1}{2 \times \pi \times 20 \times 10^3 \times 5.0}$$

$C = 1.59\mu F$

$C = 2.2\mu F$ (will be the preferred value available)

A 9 volts battery is used to power the device by linking the earthen terminals and the positive terminals to the device. The whole construction is soldered on the Vero board.

3.3 The design of the project

The design of the project involves four stages, which are thus:

Stage one: Input transducer

Stage two: Preamplifier

Stage three: Power amplifier

Stage four: Output amplifier

3.3.1 Input transducer

The input transducer is the first stage in the project, it involves a metallic condenser microphone with ability to attract signals up to the range of 0 to 20 meters

3.3.2 Preamplifier

The BC 337 transistor is used in this design for preamplifying the input signals before feeding it to the main audio amplifier. The connection between preamplifier and power amplifier is in cascade form.

The diagram below gives the preamplifying structure and steps to ensure full amplification.

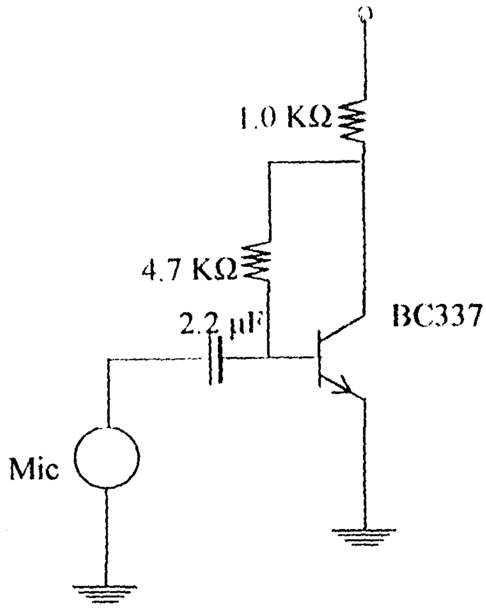


FIG. 3.1: PREAMPLIFYING STAGE

3.4 TYPES OF BIASING METHOD

There are six different methods for transistor biasing, which are thus:

- Fixed current bias method (Base bias) fig.3.5
- Voltage feedback biasing method (Base bias with collector feedback) fig.3.6
- Self bias method (Emitter bias with two supply) fig. 3.7
- Base bias with collector and emitter feedback fig. 3.8
- Base bias with emitter feedback fig.3.9
- Voltage divider bias fig.

3.5 FEEDBACK BIASING METHOD

This biasing method is used for this work. This circuit is similar to the base bias circuit except that the base resistor is returned to the collector rather than the Vcc supply

Derives it name from the fact since voltage for R_B is derived from collector, there exist a negative feedback effect which tends to stabilize Ic against changes in β.

To understand this action, suppose that β is somehow increase, it will increase Ic as well as IcR_L but decrease Vc, which is applied across R_B. Consequently, I_B will be decreased which will partially compensate for the original increase inβ.

$$- Ic(sat) = \frac{Vcc}{R_L} \quad \text{Since } V_{CE} = 0$$

$$-Vc = Vcc - (I_B + Ic)R_L \cong Vcc - IcR_L$$

$$\text{Also, } Vc = I_B R_B + V_{BE}$$

Equating the two expressions for Vc, we have:

$$I_B R_B + V_{BE} = Vcc - IcR_L$$

Since $I_B = Ic/\beta$, we get

$$\frac{Ic}{\beta} . R_B + V_{BE} \cong Vcc - IcR_L$$

$$\therefore\ Ic = \frac{Vcc - V_{BE}}{R_L + R_B/\beta} \cong \frac{Vcc}{R_L + R_B/\beta}$$

$$Ic \cong I_E$$

The β sensitivity factor is thus:

$$K_\beta = \frac{1}{1 + \beta R_L/R_B} = 1 - \frac{Ic}{Ic(sat)}$$

$$S = \frac{1 + R_B/R_2}{1 + R_B/(1+\beta)R_2} \cong \frac{1 + R_B/R_2}{1 + R_B}$$

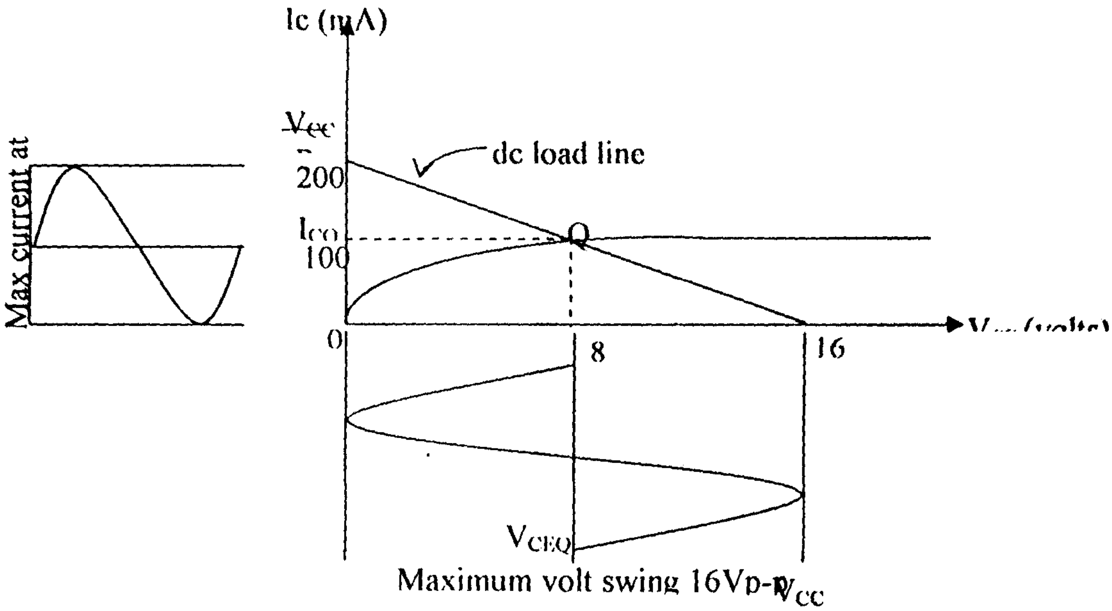


Fig 3.1 Class A Load line[5]

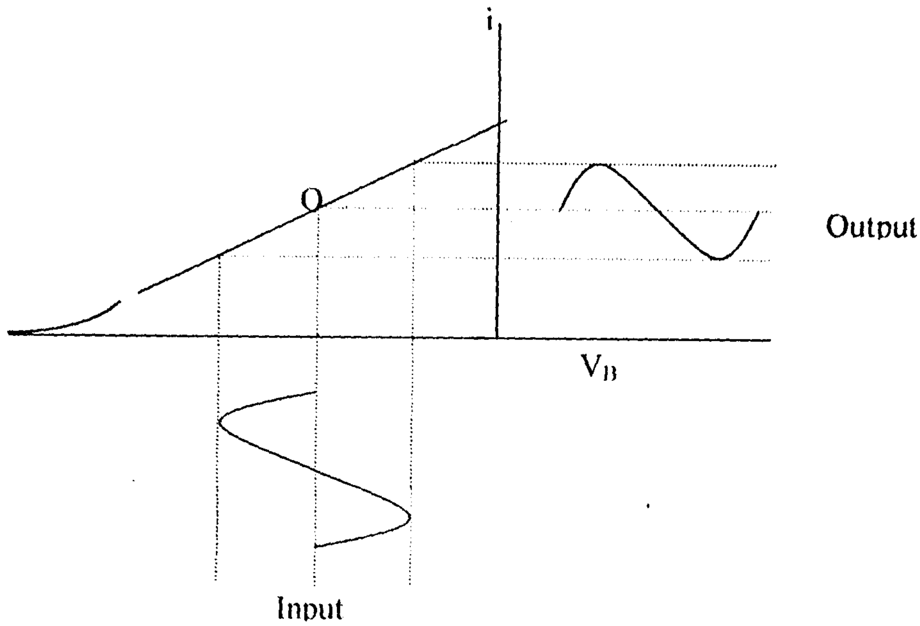


Fig 3.2 Biasing mode for Class A operation [8]

When the potential of A is positive with respect to B, diode D_1 and D_3 conduct and a current flows in the load. When the potential of B is positive with respect to A, diodes D_2 and D_4 conduct and the current in the load is in the same directions before. Thus, a fall wave type of output is obtained. The expression derived for current and load voltage for the full wave circuit will be applicable [2].

$V_{rms} = V_{Max}/\sqrt{2}$

$V_{max} = V_{rms} * \sqrt{2}$

$= 18 * \sqrt{2}$

$V_{max} = 25.4$ volts

V_{MAX} is the maximum expected voltage at the output. The 220 / 18 v transformer step down the main voltage to 18 v a.c The 18 v a.c is then rectified by the bridge rectifier network to 18 v alternating d.c. The 18 v alternating d.c is then further smoothened by the 1000μF capacitor. The 18 v d.c which is further regulated to 9v by the 7809 voltage regulator.

The variation in load voltage down during the period when the diode is non-conducting, a longtime constant CR, the operation is identical to that of the half-wave circuit during the charging period, but the capacitor discharges into the load for a shorter period, giving less amplitude of ripple for a given constant during the non-conducting period.

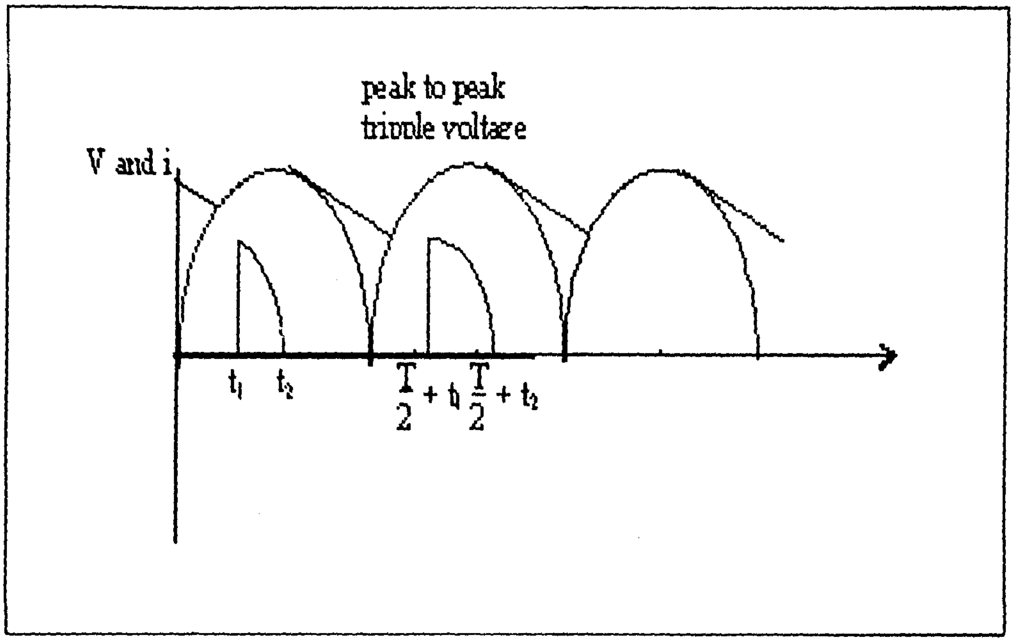


Fig 3.4 Wave forms for full-wave rectifier with Capacitor Input filter[2]

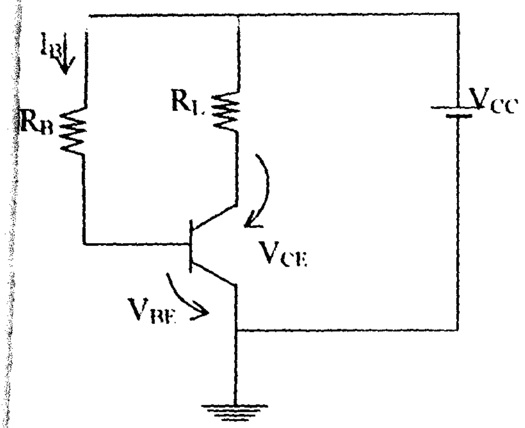


Fig 3.5 (fixed biasing Method)

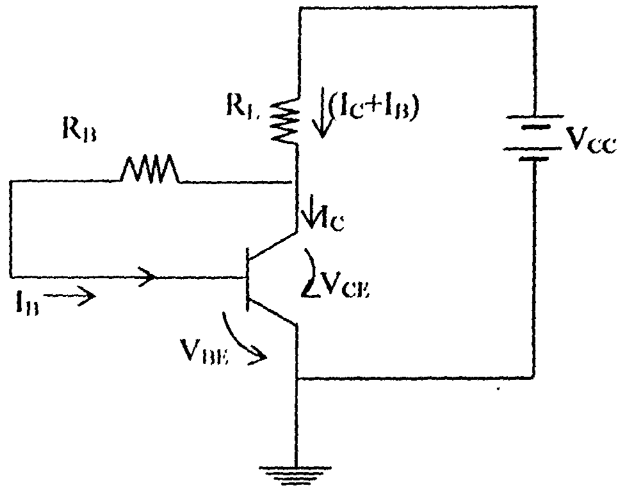


Fig 3.6 (Voltage-feedback biasing Method)

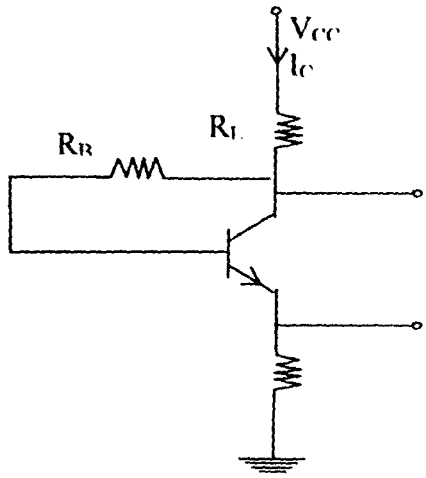


Fig 3.7 (Self biasing with two supply)

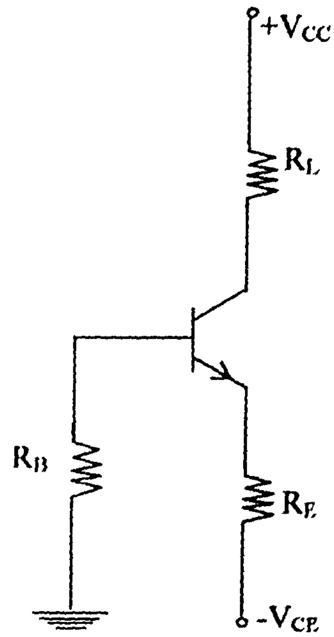


Fig 3.8 (Voltage divider biasing Method)

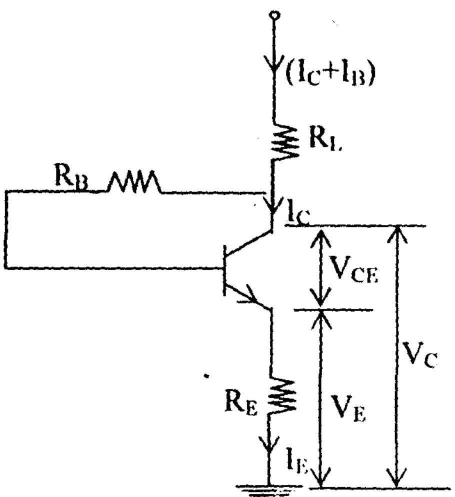


Fig 3.9 (Base Bias with Collector and Emitter feedbacks)

CHAPTER FOUR

4.0 TESTING AND DESIGN

4.1 TESTING

In carrying out the test for the basic components of this project the main instrument used are digital multimeter. and oscilloscope.The testing was carried out on resistors of the charger to determine the limiting resistor of the LED as thus;

$R= (V_S - V_{led})/I_{led}$

$= (9-1.6)/0.01$

$=7.4/ 0.01$

$= 740\Omega$

For the current rating of a 9 v lead acid battery, we assume it not to exceed 500mA

Maximum charging current, $I_m= (500mA)/4$

$=125mA$

$=0.125A$

when the battery drop to say 8 v

$R = (9-8)/0.125$

$= 8\Omega$

Thus the battery is charge via the 8Ω resistor.

The voltage gain of the BC337 = output voltage/input voltage

$=20 \text{ Log}_{10} 250$

$=20 * 2.39794$

$=47.8 \text{ dB}$

4.2 DISCUSSION OF RESULT

The hearing device range is from near distance to 30 meters away. This agrees with the aim of the project since it is still within the communication range. The high power gain was due to the connection of both resistor and capacitor to close the pin 1 and 8 of the operational amplifier, Lm386 as it given in the data sheet.

4.3 MAINTENANCE

If the device is not in use, it is advisable to switch off, as this will enhance a longer life span for the battery and also give out clear reception at both the input and output through the charger port.

Do not tap or knock the device with objects to improve reception as this may cause damage to the components. Replace the battery if there is a notice of weakness over a long period of usage.

4.4 TROUBLESHOOTING

Should the light emitter diodes, LEDs failed to light or come up, check the battery terminals to see if there still exists contact between the anode and the cathode cap, or check to see for corroded contact.

Should there be no signal while LEDs indicates power on, check the output voltage of the preamplifier or the power amplifier. Touch the leg connections of the volume controller

CHAPTER FIVE

5.0 CONCLUSION ANDRECOMMENDATION

5.1 SUMMARY

The device "an electronic hearing aid" work based on the sound signals pickup by the input transducer. With the device been segmented into units, it makes it of more help when troubleshooting in case of any fault or correction.

5.2 LIMITATIONS

The construction of the hearing aid put into account needs for its simplicity and portability. But in engineering designs, it is widely believed that there is no such a design, which can be, adjudge completely perfect. This work is no exception to this fact. However there are possible remedies to the defects in any design.

Shortcomings that are likely encountered in this design are in the area of components availability, reduction in the size of the actual design into a smaller size and cost of implementation.

More so, there are yet some unpronounced but one significant limitation is the range the carrier of the device will be standing to the speaker. This limitation can not withstanding be accommodated within audio range.

5.3 REMEDIES

While coupling the components of the device (i.e. the electrolytic capacitor, resistor, and the LM 386 IC), the problem of getting the suitable gain, to enable it function as required in the design. Nevertheless, this problem was tided over by constant and persistent rotating of the capacitors in line with the legs of the IC as shown in the circuit diagram (appendix).

On the charger port, a Wheatstone bridge form was chosen for the full wave rectification which uses $C_8 = 2200\mu F$ to smoothen the current entering, alongside with voltage regulator the circuit from the transformer, at the step down side.

More so, in turn on and turn off of the power variable resistor of 10.kΩ rating serves the purpose of the power switch when the arm varied.

5.4 CONCLUSION

The project so far has been a worthwhile experience, it has given me a better understanding of the human organ of hearing generally known as ear, on how it (can) receives incoming pickup vibrations through the auditory canal down to eardrum, ossicle and then interpreted by the brain.

This amplifier is a small signal amplifier i.e. it can only amplify small signal. And since there is a low power transfer, this type of amplifier is the same as voltage amplifier. A small signal amplifier, in addition suffers from background noise due to electrical and transistor noises, in order, to reduce the noise and improve its gain at – 3dB for high frequency signal, a low noise and high cut off frequency f_T transistor is used.

5.5 RECOMMENDATION

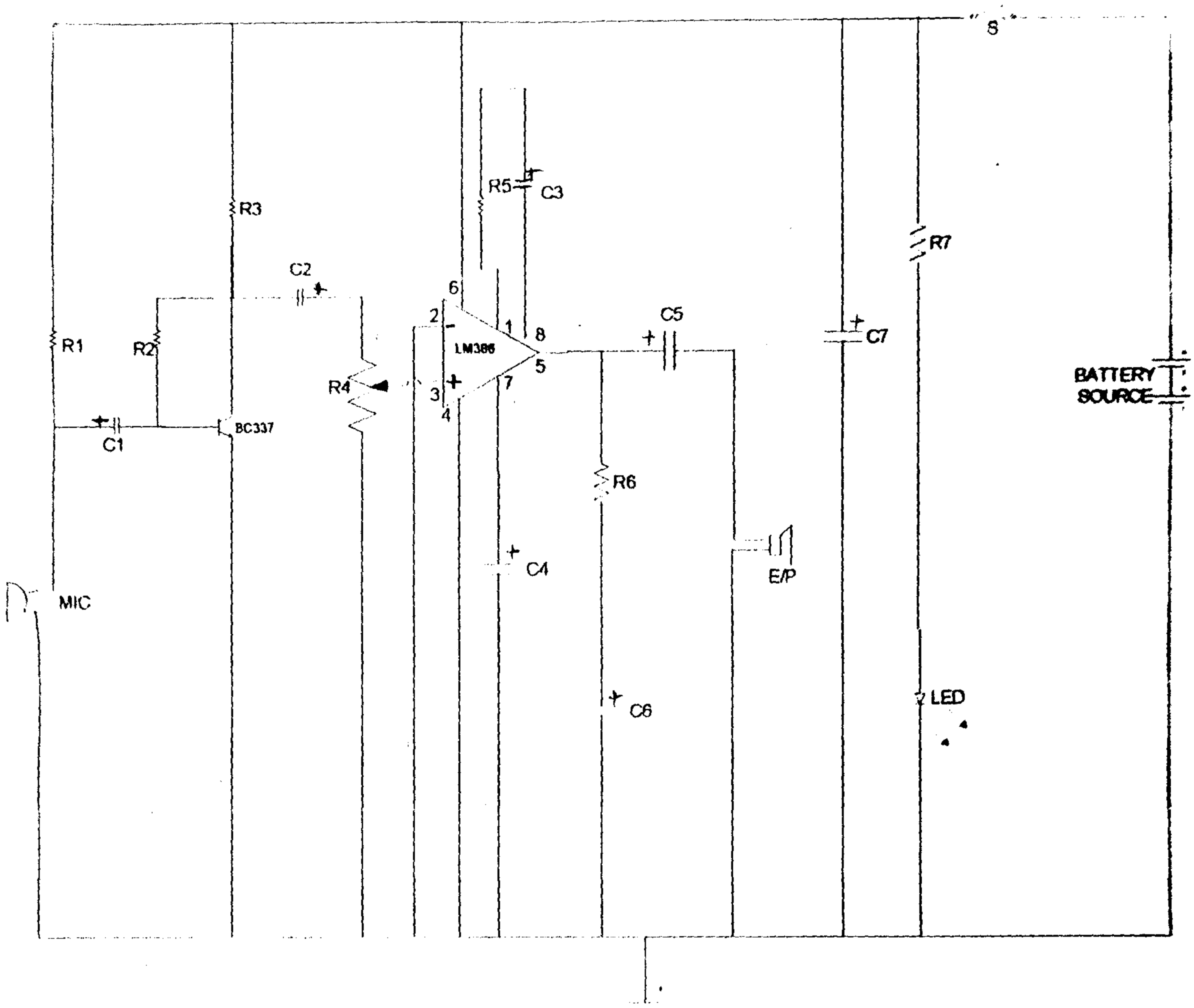
Hearing loss typically occurs non-uniformly over the frequency range. Each client is tested with a series of tone in which, the volume best suit to his/her hearing frequency is adjusted to. This made it to be of use in the medical field, to be recommended by the doctor to intended user.

The availability of a rechargeable lead acid 9 volts brings about a small set back in the usage of the designed battery charger to go along with the device each time the battery is discharged.

In the aspect of improving this work, I will implored the subsequent designer(s) to drastically reduced the device size and make to be of wireless and trendy in the case of mass producing it.

APPENDIX 1

CIRCUIT DIAGRAM OF HEARING AIDS



VALUES OF COMPONENTS

$R_1 = 10K\Omega$

$R_2 = 4.7K\Omega$

$R_3 = 1.0K\Omega$

$R_4 = 10K\Omega$

$R_5 = 1.2K\Omega$

$R_6 = 1.0K\Omega$

$R_7 = 1.0K\Omega$

$C_1 = 2.2\mu F$

$C_2 = 2.2\mu F$

$C_3 = 10\mu F$

$C_4 = 0.1\mu F$

$C_5 = 250\mu F$

$C_6 = 10\mu F$

$C_7 = 100\mu F$

$C_8 = 220\mu F$

$C_9 = 1000\mu F$

Condenser microphone

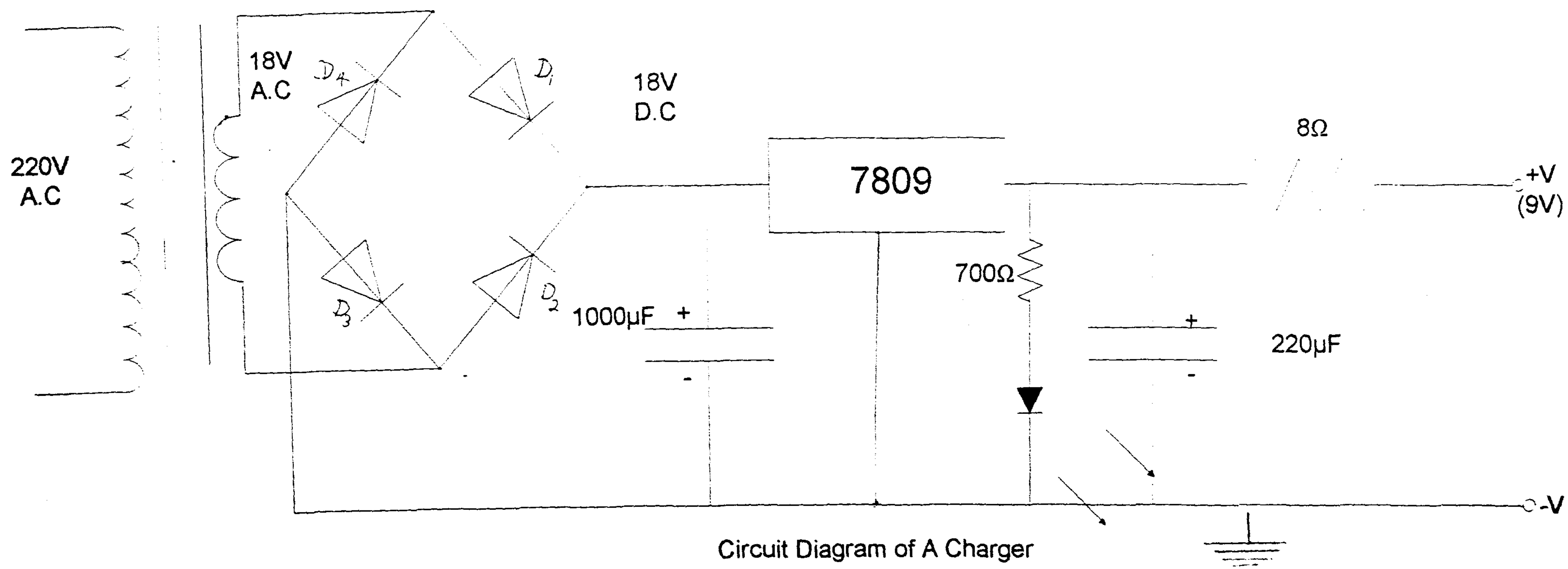
Diode 4 in number

Transistor BC 337

IC LM 386

LEDs 1.6V

Transformer 9-0-9 step down



Circuit Diagram of A Charger

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