

## DESIGN AND CONSTRUCTION OF A HEARING AID DEVICE

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### ABSTRACT

Hearing is one of the five senses, therefore, it is very important that the human ear be able to detect sound in the audible frequency range. However, in some cases, certain individuals have difficulty hearing in either or both ears. It is therefore necessary that a device that can help in correcting this be developed.

In this work, a hearing aid has been constructed using readily available circuit components (transistors, capacitors, ICs). This makes the device easily accessible and affordable for anyone who needs it. The hearing aid constructed was tested under different levels of ambient noise and was found to amplify the desired sound while filtering away the noise. Hence, it can be said to function considerably well.

**Keywords:** Hearing aid, transistors, ambient noise, amplify.

### INTRODUCTION

Hearing is defined as the ability to perceive pressure waves generated by vibrating air molecules which had been set in motion by sound from a given source. It is one of the five senses in humans with the ear serving as a receiver of incoming sound. Although the ear receives sound, it is the brain and central nervous system that interpret the sound. The human auditory system can generally hear sounds within the frequency range of 20 Hz and 20 KHz but the frequency range between 100Hz and 6 kHz contains most of the information of human voice (Schum, 2004).

Hearing loss is therefore the inability of the ear to effectively act as a receiver which then reduces the intensity of sound getting to the brain. This can happen in only one ear or in both ears as the case may be (Kinsler et. al., 1982; Holstrum et.al., 2008). Patients suffering from this condition will receive sound with volume that is too low for comprehension. In order to help such people, there is the need to design a device which can capture the desired sound and amplify it as appropriate so it can be audible enough to make sense. In a general sense, a hearing aid device basically consists of a microphone used to pick sound, an amplifier circuit and the earpiece which acts as the output.

### THEORY

Hearing loss is usually experienced by people who have relative insensitivity to sound in the speech frequency range. It can happen when any part of the auditory system is not working in the usual way (Oyler et al., 1988). Therefore, a battery-powered device can be constructed to improve the quality of sound for affected people. The core of the device is an integrated circuit (IC) which amplifies all the signals picked by the condenser microphone, converts them back into sound and sends to the ear. The amplification function of the hearing aid is made possible with several components; a microphone (input transducer) which picks up sound and converts it into electrical signals, an amplifier which increases the volume of the sound, a receiver (output transducer) which changes the electrical signal back into sound and sends it to the ear (Mills, 2011; Holstrum, et al., 2008).

A block diagram of a hearing aid device is shown in figure 1 below:

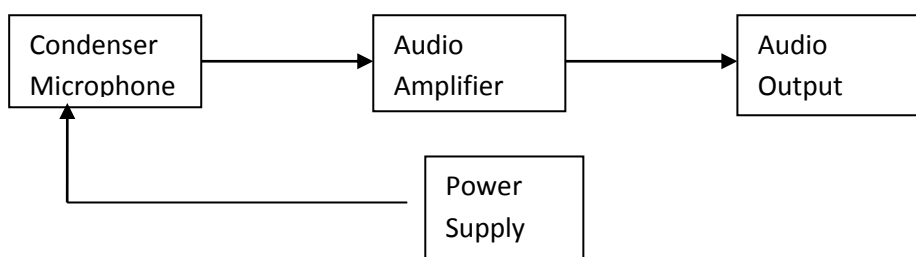


Fig.1. Hearing aid block diagram

**Condenser Microphone:**

Hearing aid microphones must be miniature with a high signal-to noise ratio. It must also be relatively insensitive to vibration from the nearby speaker, and operate at low voltages. The basic technology in microphone condenser is size reduction which maintains high signal-to-noise ratio (Mills, 2011 ; Akande et., al, 2007). At the start of hearing aid signal chain, microphones sense voice and other ambient sound, so improved audio capture can lead to higher performance and lower consumption throughout the signal chain. The acoustical signal is converted into electrical signal by microphone and processed by the hearing aid’s audio signal chain. The diaphragm in a condenser microphone moves in response to an acoustic signal (Kinsler,1982). This motion causes a change in capacitance which is then used to produce an electrical signal.

**Audio-Amplifier:**

An audio power amplifier is an electronic amplifier that strengthens low power, inaudible electronic audio signals to make them audible to listeners. Key design parameters for audio power amplifier are frequency response, gain, noise and distortions (Millman and Halkias, 2003). The increase in gain often leads to undesirable increase in noise and distortion. Amplifier is a circuit that can perform such mathematical operations as addition, subtraction, integration and differentiation. An operational amplifier, abbreviated as op-amp, is basically a multi-stage, very high gain (typically 2,00,000), direct-coupled, negative feedback amplifier that uses voltage-shunt feedback to provide a stabilized voltage gain (Millman and Halkias, 2003 , Theraja, 2008). An op-amp has high input impedance (exceeding 100kΩ) and low output impedance (< 100Ω) and has capability of amplifying signals having frequency ranging from 0Hz to 1 MHz i.e op-amp can be used to amplify DC as well as AC input signals (Horowitz and Hill, 2010).

**Audio Output:**

The audio output are used here as hearing impaired earphones which are a personal sound amplifying device worn by individuals for enhancing their hearing through increasing the volume of sounds and spoken words. Conventional voices are boosted by hearing impaired earphones

**Power Supply:**

Hearing aids require a steady power supply in order to work properly, because even subtle changes in power output can affect performance, clarity, and volume control. Different hearing aids require different types of batteries.

**MATERIALS AND METHOD**

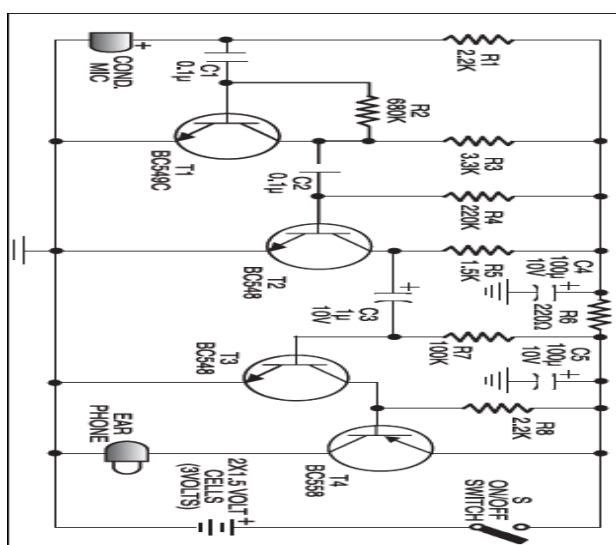


Fig. 2. Circuit diagram of the device

In figure 2 above, the condenser microphone, amplifier, output (ear phone) and power supply are shown as previously discussed.

The amplifier circuit consists of 4 transistors as shown in figure 2. A transistor is a semiconductor circuit component used to amplify electronic signals. It also acts as a switch in a circuit (Theraja, 2008). In this circuit, the transistor are designated as T1 = BC 549C, T2 = BC 548, T3 = BC 548 and T4 = BC 558.

**Capacitor:** A capacitor is a passive two terminal electrical component used to store electrical energy temporary as electric charges (Theraja, 2008). In audio circuits, capacitors also act as filters so as to produce a clean output. The capacitors used in this work are designed as C1 and C2 = 50 $\mu$ f, C3 = 1 $\mu$ f, C4 and C5 = 100 $\mu$ f.

**Resistor:** Resistor is a passive two terminal electrical component that implements electrical resistance as a circuit element. The resistors used are designated as R1= 2.2k, R2 = 680k, R3 = 3.3k, R4 = 220k, R5 = 1.5k, R6 = 220 $\Omega$ , R7= 100k and R8 = 2.2k.

**Integrated Circuit (IC):** It is a small piece of semiconductor material performing the same function as a larger circuit made from discrete components (Millman and Halkias, 2003; Sudhakara,2008,). The integrated circuit (IC) used in this work are IC1- CO 4017 and IC2 - NE 555.

## TESTING and RESULT

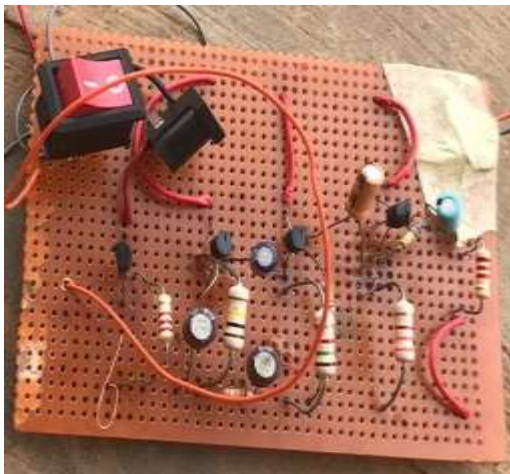


Plate 1. The Veroboard.

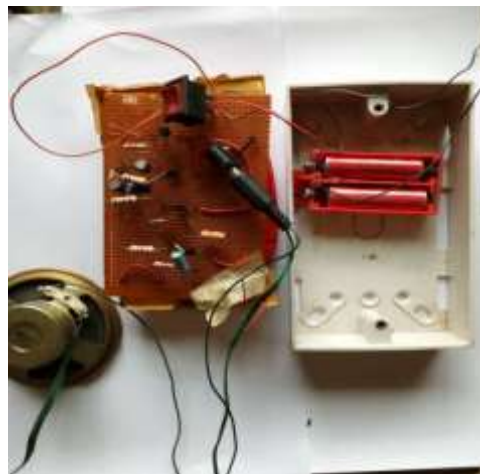


Plate2. The device with packaging.

After construction, the unit was tested in 3 stages.

Firstly, power was supplied to the unit and then the microphone was tapped repeatedly. The sound produced was the amplified before being produced at the earpiece.

Secondly, words were spoken into the microphone at a low volume and a greatly amplified result was obtained at the output. This test was carried out repeatedly under varying ambient noise levels, and the output was considerably pure. This shows that the constructed device can filter noise as well as magnify sound input.

Finally, the device was tested on people with hearing impairment. The result showed that there was significant improvement in their hearing ability in all the cases. It was realized that although hearing aid device may not cure hearing loss, it can make sounds more accessible in the affected ear.

## RECOMMENDATION AND CONCLUSION

This work has shown that a hearing aid device can be constructed locally. It is therefore advised that patients with hearing deficiency seek help in getting a locally made unit instead of suffering in silence.

In conclusion, the aim of this work was to construct a circuit that will filter noise and magnify the desired sound. The circuit was constructed using a vero-board on which all other components were soldered. The circuit was then tested and was found to work efficiently at various ambient noise levels. Future efforts should be geared towards miniaturizing the locally constructed device for easier mobility.

## REFERENCES

- 1) Akande, S.F., Kwaha, B.J., and Alao, S.O.: Fundamentals in Electronics: Jos University Press Ltd, p 191 (2007).
- 2) Holstrum, W. J., Gaffney, M., Gravel, J. and Oyler, R.: Early Intervention for children with unilateral and mild bilateral degrees of hearing loss. Trends in Amplification, 12: p 35- 41 (2008).
- 3) Horowitz, P. and Hill, W. The art of electronics second edn. New York: Cambridge University Press, p 1125 (2010)
- 4) Jacob Millman and Christos Halkias: Integrated Electronics Analog and Digital Circuits and Systems, Tata Mc Graw-Hill Publishing Company New Delhi, pp. 372-374, 593 (2003).
- 5) Kinsler, L.E. Frey, A.R., Coppers, A.B. and Sanders, J.V.: Fundamentals of Acoustics 3rd edn. New York: John Wiley and Sons, p 480 (1982).
- 6) Mills, M. "Hearing Aids and the History of Electronics Miniaturization." IEEE Annals of the History of Computing 33(2): pp 24-44 (2011).
- 7) Oyler, R., Oyler, A., and Matkin, N.: Unilateral hearing loss: Demographics and educational impact. American Speech-Language-Hearing Association (1988).
- 8) Schum, D.J. The New Advanced Technology in Hearing aids "Artificial Intelligence Unit", London. P. pp 50-78 (2004).
- 9) Sudhakara,A.: Linear and Digital Integrated Circuit Design, University Science Press (2008).
- 10) Theraja, B.L.: Fundamentals of Electrical Engineering and Electronics, S.Chand and Co. Ltd,New Delhi, pp 101-102,624-626 (2008).