DESIGN AND CONSTRUCTION OF A LOW-COST HEARING AID

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Abstract

A low-cost hearing aid device was designed and constructed to produce an amplified sound for people with hearing loss. A 9V dc was used as the power supply. The condenser microphone was used as input transducer to pick up sound from the environment for conversion to electrical signal, NPN transistor (BC548C) along with three capacitors and five resistors were used as pre-amplifier.to amplify. The integrated circuit (IC) TDA2822M, available in 8-pin mini chip package and specially designed for portable power amplification was used for the amplification function. A 32 ohms ear phone was used as the output transducer to convert the amplified electrical signals back to sound. The computed current gain was 100. Rc was obtained as 3.3Ω, $I_B = 0.025A$, $I_E = 2.5A$, $R_E = 1.5\Omega$, the impendence $Z_0 = 1.9\Omega$.

Index Terms: Design, construction, hearing aid, hearing loss, integrated circuit, low-cost, npn transistor.

Introduction

Hearing is one of the five senses along with vision, taste, smell and touch. The ear serves as a receiver of incoming sounds. Although the ear receives sound and is the sense organ of hearing, 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 (Kinsler *et al*., 1982). Although the sensation of hearing requires an intact and functioning auditory portion of the central nervous system as well as working ear, human deafness (extreme insensitivity to sound) and hearing loss most commonly occur because of damages of the ear, rather than the central auditory system. Hearing loss is usually reserved for people who have relative insensitivity to sound in the speech frequency range. A hearing loss can happen when any part of the auditory system is not working in the usual way (Oyler, *et al*., 1988). The constructed device can improve the quality of sound for people with hearing loss. The heart of the circuit is an integrated circuit which amplifies all the signals picked by the condenser microphone and converts them back into sound and sent to the ear. It is a battery-powered electronic device that can amplify sound for people with hearing loss. 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

ISSN 2229-5518

which increases the volume or 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).

Materials and Methods

The computation involved in arriving at the component values used in the implementation of the device is based on the equations governing the behavior of electronic circuit devices. The hearing device is made up of the power supply (DC9V), input transducer (microphone), pre-amplifier, amplifier and the output transducer (earphone). The system is presented in figure 1.

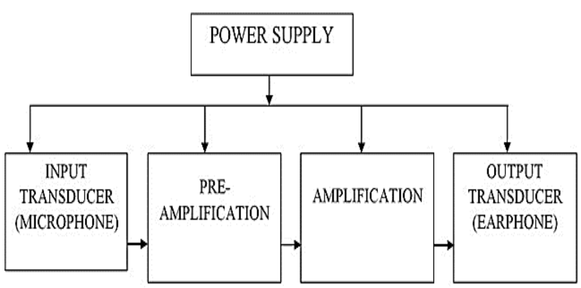

Fig 1: Block diagram of a hearing aid device system

Electronic circuits generally require direct current (dc) to power components. The battery supplies the power to turn the electronic components on and off. The 9 volt battery was used for the power supply. The condenser microphone was used in this work. The primary function of a pre-amplifier (fig. 2) is to pick up signals from its primary source (microphone) and then operate on it in preparation for passage into the amplifier section for further amplification (Akande et al., 2007). Typically, a pre-amplifier amplifies the signal, controls its volume, and perhaps changes its input impedance (Horowitz and Hill, 2010; Lowenberg, 1976). The pre-amplification unit used in this work was designed using an NPN transistor BC547 along with some capacitors and resistors. In this circuit, transistor Q_1 and its associated components form the audio signal pre-amplifier for the signals picked up by the condenser microphone and the audio signal is converted into corresponding electrical signals. Resistor R1 biases the internal circuit of the low-voltage condenser microphone for proper working. The audio output from the pre-amplifier stage is fed to the input of the amplifier circuit via capacitor C_3 and volume control VR_1.

ISSN 2229-5518

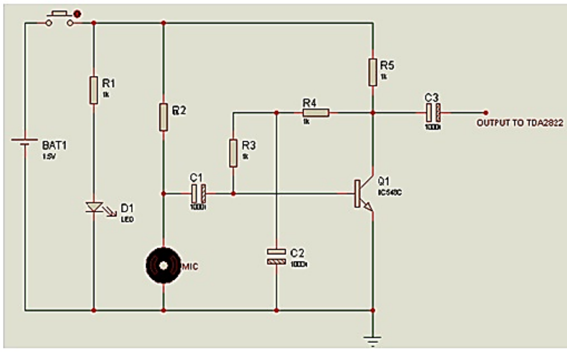

Fig 3: Circuit diagram of pre-amplification stage

Fig 2: Circuit Diagram of the Pre-Amplifier

Data

$V_{cc} = 9V$

$\beta = 100$

$R_f = 4.7\Omega$

$R_c = 3.3\Omega$

$V_{BE} = 0.7\ (tansistor\ fixed\ value)$

$$I_B = \frac{V_{cc} - V_{BE}}{R_f + \beta R_c} = \frac{9 - 0.7}{4.7 + 100(3.3)} = 2.5x10^{-2}A$$

The emitter current, $I_E = \beta I_B = 100x2.5x10^{-2} = 2.5A$

$$V_E = \frac{V_{cc}}{2} - V_{BE} = \frac{9}{2} - 0.7 = 3.8V$$

$$R_E = \frac{V_E}{I_E} = \frac{3.8}{2.5} = 1.5\Omega$$

$$R_c = \frac{V_{cc} - V_{BE}}{I_E} = \frac{9 - 0.7}{2.5} = 3.3\Omega$$

$$hfe = \frac{I_E}{I_B} = \frac{2.5}{2.5x10^{-2}} = 100$$

$$Z_0 = \frac{R_E x R_f}{R_E + R_f} = \frac{3.3x4.7}{3.3+4.7} = 1.94\Omega$$

$$\beta = hfe = A_i = 100$$

Where R_c *is the collector resistor*

R_E *is the emitter resistor*

I_B *is the base current*

R_f *is the feedback resistor*

β *is the current gain*

$A_i = hfe$ *is the current gain*

The amplification function is carried out by the integrated circuit (IC) TDA2822M. This IC, specially designed for portable low power applications, is available in 8-pin mini DIP package. Here, the IC was wired to drive the 32 ohm earphone. In this design, TDA2822M which operates with only a single power supply voltage has two differential inputs and two outputs. The parameters of the TDA2822M are:

VCC MAX=15V

VCC TYP=6V

VCC RNG=1, 8...15V

PO=2X0, 65W

RL=4 Ohm

TDH=10%

1CCO TYP=6mA

ICCO MAX=9mA

I MAX=1A

RIN=100K

GAIN=39 dB

Noise=1,5mk/V

RTHJ-C=70C/V

Case MINIDIP

The output transducer changes the enhanced signals back into sound waves that the brain can properly perceive. Here electrical signals are converted into acoustical output signals or sound waves and are directed into the ear canal. The 32ohm earphone was used as the output transducer. The design and construction of this device involved:

(i) Designing and choice of components bearing in mind the availability and cost of components.

(ii) Arranging the components on the bread board.

(iii) Soldering the components on the Vero board.

(iv) Designing and cutting of the plastic that houses the components. The plastic material that houses the device was chosen according to its mechanical strength, thermal conductivity and ease of installation. A thin plastic sheet was cast into a box case and an outlet from the circuit serves as port for interaction with the user and the device. The case houses the various components such as power switch, LED (light emitting diode) which shows when the power is on or off, the microphone and the ear jack.

Result and Discussion

The results obtained from the various test performed show that the system units and the system as a whole work effectively and efficiently as amplified sound was produced by the output transducer (earphone). However, a noisy output is produced when the hearing aid is close to an electrical wave signal and when close to noisy environment. This is because the diaphragm of the microphone is very sensitive to noise and to electrical waves.

Conclusion and Recommendation

A hearing aid capable of amplifying sound was designed and constructed using a 9V DC power supply, a condenser microphone, a transistor (BC548C), an IC TDA2822M, a 320hm earphone together with some passive components (resistors and capacitors).

The device was realized with economic considerations so that it is cost-effective, could be made readily available and with easy maintenance. It is recommended that this hearing aid could be subjected to some modifications by using filters to enhance efficiency and better quality.

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