

Estimation of hearing loss using interactive pure tone audiometric test with embedded system interface

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Abstract - Hearing loss is a commonly occurred problem that develops with aging or caused by repeated exposure to loud sound levels. Hearing loss occurs as a result of sound signal not reaching to the brain. Audiometry is the process of measurement of hearing ability by which an audiologist performs hearing test to a person using a device called audiometer. In this process, hearing level is measured by passing audio signals from lower frequencies to higher frequencies through ear phones. The patient gives response to the heard sound pitches whether it is audible or not. The method we propose implements an automatic audiometric signal generation using an audio signal generator which is controlled by a microcontroller. The patient can give the feedback response using a 'Yes' or 'No' switches through which the system process the collected data and compares with the played frequencies and calculate the hearing ability which can be displayed during the end of the testing process.

Keywords: Audiometry, Hearing test, Audiometer, Audio Oscillator, Conductive Hearing Loss, Hearing loss measurement, Audiology, Hearing Aid.

I.INTRODUCTION

Hearing loss is one of the key issues because it is an abnormality often with non painful symptoms. The hearing loss affects children in developing communication skills, communication difficulties often leading to social separation. It also occurs in elderly persons over the age of 60 year and contributes to difficulties in speech conversation. Hearing testing is an examination of a person's ability to hear sounds which is done by an audiologist [1]. An Audiometer is often used for performing audiometric tests. The test is used to found out and problems in hearing portion of the inner ear. If there is a problem in the middle ear or ear canal, then it is

known as conductive hearing loss, in which the movement of sound is blocked to pass the inner ear [2]. Hearing loss is measured as loudness in decibels versus frequency of the sound waves used for testing. The results of the hearing tests are plotted on an audiogram conventionally. But this method of manual testing and manual plotting introduces human error which reduces the accuracy of test and also this is a time consuming process [3], [4]. So a system that supports different hearing test under one setup with reduced testing time period is a necessary for audiologists.

Hearing loss is mainly classified into four types as:

Mild Hearing Loss: 20-40 dB – One cannot hear soft sounds and struggle to hear or understand speech in noisy environments.

Moderated Hearing Loss: 41-70 dB – One cannot hear moderate sounds and having difficulty in understanding speech when there is background noise.

Severe Hearing Loss: 71-95 dB – One have to ask people to raise their voice to understand the speech and group conversations are extremely difficult.

Profound Hearing Loss: 71-95 dB – One can hear some very loud sounds and communication with others is almost impossible without hearing aids.

a) Process of Audiometry

With ear phones the person under test can hear tones of different frequencies, testing one ear at a time. The intensity of each tones are varied to find the lowest level up to which one can hear sounds which is then used as the threshold for that tone [5].

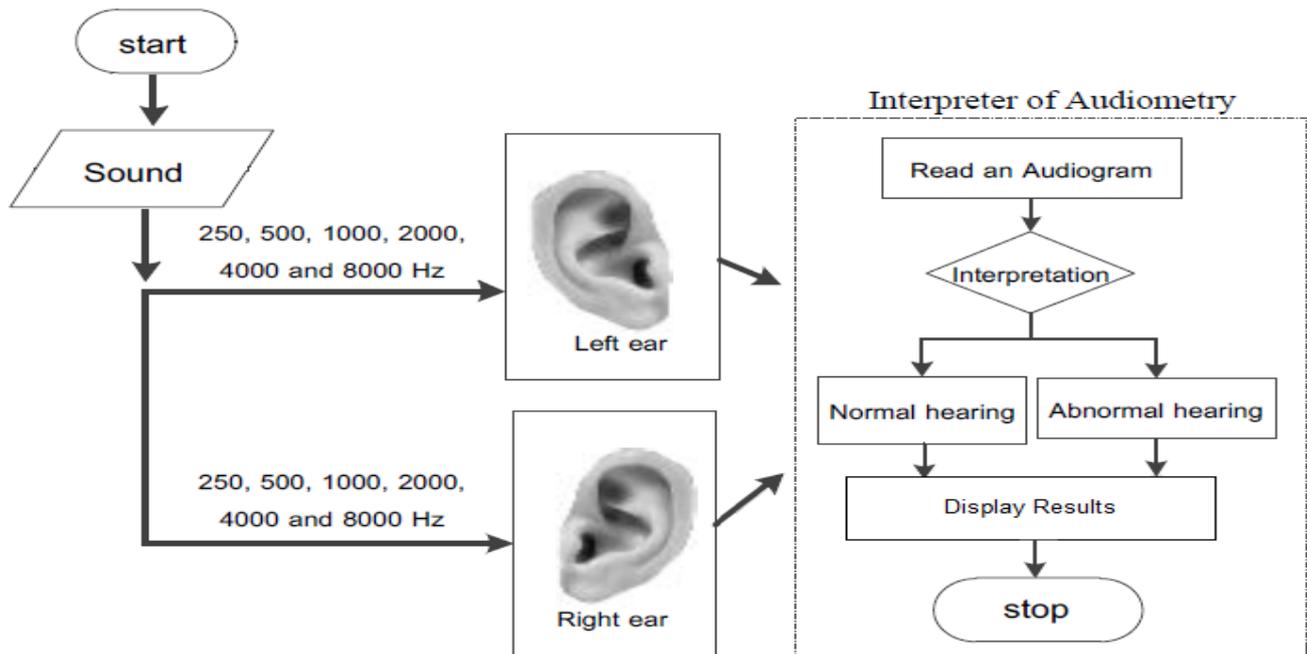


Figure.1 Process of Audiometry

b) Degree of Hearing Loss

The hearing threshold differs with different frequencies and typically there is a greater loss for higher frequency audio tones.

Table.1 Degree of Hearing Loss

Hearing Loss range (dB)	Degree of Hearing Loss
-10 to 15b	Normal
16 to 25	Slight
26 - 40	Mild
41 - 55	Moderate
56 – 70	Moderately - Severe
71 – 90	Severe
≥90	Profound

II. METHODOLOGY USED

Here we propose a unique a testing technology that allows audiologists to perform a wide range of hearing tests for identifying the type of hearing loss in patients. The system we implement here automatically estimates the hearing levels by using user feedback response to each of the audio tones at different decibel levels.

A wide frequency range audio oscillator produces tones ranging from 200Hz to 12 KHz. The frequency of the audio signals is controlled by a microcontroller which randomly chooses different frequencies to be generated. The test begins when the start button is pressed and the instruction is displayed in a LCD. The test subject hears those audio tones played through headphones and after confirming the heard test tone they provide the feedback through corresponding push buttons. Microcontroller stores the frequencies played and the given feedback of the user and cross check the database and estimates the hearing level to different frequencies and the total hearing level percentage [6].

The output of the audiometry result is displayed in an LCD display where the audiologist can know the hearing ability of the tested person. This system reduces manual effort and errors by automatically perform the complete hearing tests and also displaying the results immediately [7], [8]. The overall time taken for performing the test also gets reduced with a highly accurate result calculation.

The test frequencies used ranges in order of 1k, 2k, 3k, 4k, 6k, 8k, 10k, 12k, 200, 400,650 and 850Hz. Each ear is tested separately; when one ear is tested then the other ear is tested according to displayed instructions [9]. The test data and the results of the subjects are stored temporarily to the memory of microcontroller and after the finish of test the display shows the results of audiogram.

III. PROPOSED SYSTEM

a) Atmega8535 microcontroller:

The core function of the system is controlled by Atmega8535 microcontroller which is a low-power 8-bit microcontroller based on RISC architecture. Here port B is configured as digital input which accepts input signals from the button controls. Port A and port C are configured as digital outputs.

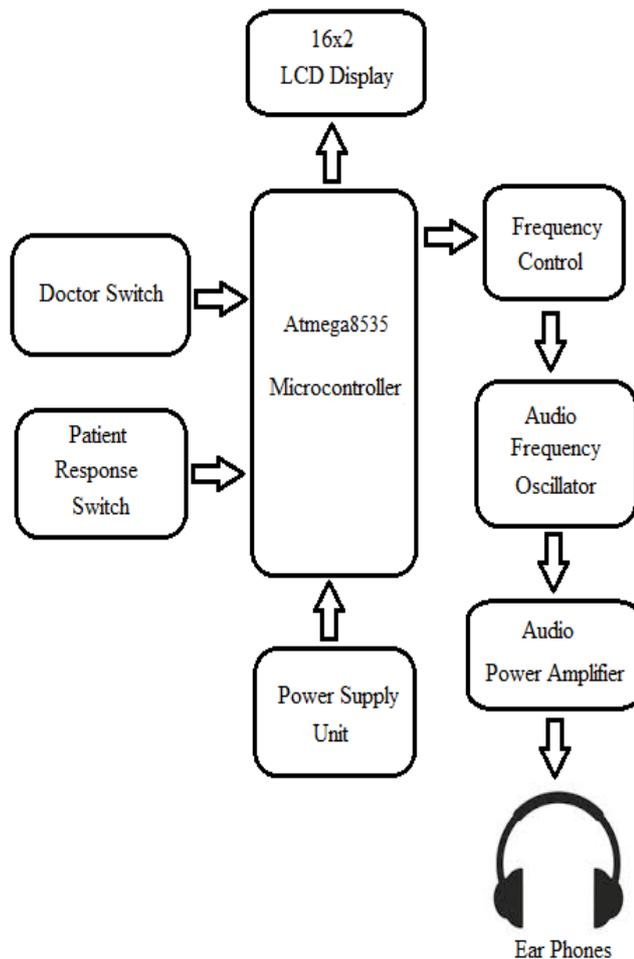


Figure.2: Proposed Block Diagram

b) Doctor Switch:

To start the test, doctor has to press this button. After this the audiometric test executes automatically by playing different tones sequentially.

c) Patient Response Switch:

During test process the subject has to press either 'Yes' switch or 'No' switch after the displayed instruction to record whether he/she heard the tone or not.

d) Audio frequency Oscillator:

In this hardware, ICL8038 chip is used for building audio oscillator circuit. This oscillator is configured to produce pure sine wave AF signals under the range of 200 Hz to 15 kHz.

e) Frequency Control:

Frequency of oscillations in AF oscillator is set by frequency control circuit. This consists of a set of relays and capacitors in which RC values are selected under different combinations to set the frequency of tones to be generated from the oscillator circuit.

f) Audio Power Amplifier:

A 1Watt IC amplifier build using TDA2822 amplifies the audio tones from the oscillator to various dB levels as set by the microcontroller. The gain of audio signal is boosted and given to a pair of ear phones where the patient can hear multiple test tones.

g) 16X2 LCD Display:

The display used here is HD44780 16x2 LCD which is a 2line alphanumeric display. Instructions during the testing and test results are displayed using this display.

h) Power Supply unit:

Here a 12v and 5v regulated power supply is used to power the entire system. 5v is given to all the digital interfaces and 12v is given to frequency control unit and audio circuits.

IV.RESULT AND DISCUSSION

The system prototype is constructed and tested for different frequency and decibel levels under hearing range. A sample test is done in which a total of 16 different tones and 5 decibel levels are played. Results are obtained based on the user response to the sounds and a hearing ability is calculated. The total times taken for completion of tests are in range of 90-120 seconds for both ears.



Prototype of Hardware

The system prototype is designed as shown in fig. The audio power amplifier and AF oscillator circuits are assembled in a general purpose dotted PCB. The microcontroller, push buttons and frequency selection unit are assembled on a printed PCB. All the systems are wired together and output is connected to a 8ohms ear phone ready to be used for testing purpose.

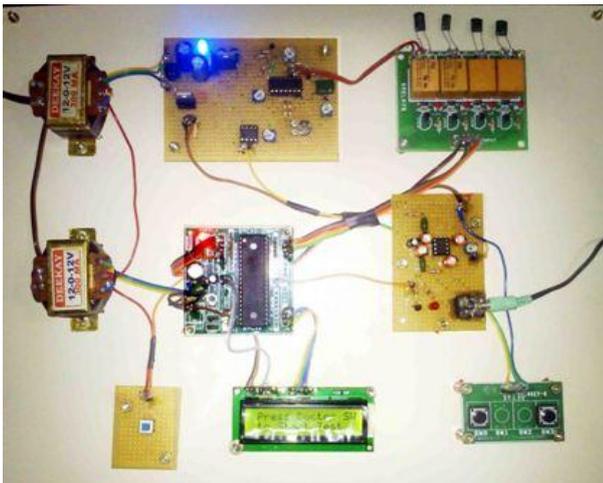


Figure.3: Prototype of Hardware Model

V.CONCLUSION

We developed a multi featured method of hearing assessment by designing an audiometer with auto functionality which can perform hearing tests with one touch control. Our interactive design reduces the effort of audiologists and test subjects in testing process. In addition the mean test time was reduced significantly because of auto configuration of the test tones. We

conclude that the developed system is best suitable for clinical audiometric tests with significant result accuracy, reduced effort and testing time.

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