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Research Article

Arduino Uno Based Audiometer Design

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Abstract: The ability to detect hearing impairment early is an important aspect of preventive efforts in the field of ear and hearing health. An audiometer is a device used to measure a person's hearing threshold by presenting sound stimuli at various frequencies and intensities. This research aims to design and build a simple digital audiometer that can be used as a means of early hearing screening at primary healthcare facilities. The developed audiometer system uses a microcontroller as the control center, equipped with a user interface based on an LCD screen and buttons for adjusting frequency and sound intensity. Sound output is channeled through headphones and calibrated within the frequency range of 125 Hz to 10,000 Hz with intensity levels from 0 dB to 10 - 100 dB. The value obtained from the measurements after making improvements on TP 1 (Input adapter) showed an error of 0.03% TP 2 (Nextion LCD input) at 5.12 V which is still within tolerance. TP 3 (Arduino Input) at 11.64 V which is still within tolerance. TP 4 (Input IC LM2956) at 11.66 V which is still within tolerance. The function of this audiometer tool was tested using a digital multimeter. The highest error value is at a frequency of 500 Hz, which is 0.152%. This is partly due to the tolerance values of the components used. Based on the data collection using a sound level meter, the furthest difference in sound intensity values at the point of 40 dB was found to be 3.46 dB. This is due to the influence of noise in the surrounding measurement area.

Keywords: audiometer; design and development; hearing impairment; microcontroller; screening

1. Background

Ears through a complex hearing process are the gateway for communication and information. A noisy work environment can cause permanent hearing loss. Noise-induced hearing loss can occur suddenly or slowly, over months to years. This is often not realized by the sufferer. Human hearing can be impaired due to several factors, one of which is noise due to work.

The ear has a hearing function that can hear sounds with a frequency of 20 to 20,000 Hz (Syaifudidin, Haji, 2011). Hearing is one of the five human senses used to communicate and interact both between humans and with their environment. Hearing loss is a health problem that has not received serious attention from the community because the symptoms are not visible from the outside. This disorder greatly interferes with productivity and makes sufferers isolated from the environment. Hearing loss that occurs in old age causes communication disorders and has an impact on the quality of life of sufferers.

Several studies in Indonesia show that the elderly generally experience hearing loss. Hearing loss (deafness) is possible for everyone. Deafness is a symptom of ear disease that is very worrying because hearing function is very important for the development of verbal and linguistic language mastery. Verbal and linguistic language are very important in the communication system because they are closely related to social life, mental development, and career. Deafness can occur during pregnancy (prenatal), birth (perinatal), and after birth (postnatal) (Suhardiyana, 2010).

Damayanti (2010) said that the deafness rate has reached 16.8% of the population of Indonesia and 0.4% for deafness with the highest group in school age (7-9 years). In addition, it is estimated that every year there will be around 5200 babies born deaf. This figure places Indonesia among the countries with high deafness rates in Southeast Asia. The level of

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hearing loss (hearing threshold) in individuals can be determined by various types of hearing tests, one of which is a hearing test using an audiometer.

An audiometer is an electronic sound generator used to measure the degree of deafness. This electronic device can generate sounds at various frequencies and is connected to earphones.

2. Theoretical Study

Research related to the Audiometer tool has been conducted previously by several researchers, the first referring to the Final Assignment entitled Design and Construction of an Audiometer Tool Based on the AT89C51 Microcontroller by Santoso (2011), using the AT89C51 Microcontroller makes the audiometer capable of producing frequencies with a range of 125-8000 Hz and producing sound intensity of 10-100 dB.

Research to design an audiometer has also been conducted in a study entitled Designing an Audiometer with Deafness Degree Measurement by Ratrianto (2013), by designing a tool connected to the Eagle CAD software, which then creates a program with the AVR Code Vision software, which becomes a microcontroller-based digital audiometer using a Personal Computer (PC) interface and using the ATMega 8535 microcontroller which can produce a frequency of 250-8000 Hz with an intensity value of 0-80 dB.

There is also a final project research entitled Audiometer Based on Soundcard on Personal Computer by Bahtiar (2006), the tool used is a personal computer that functions to control and process data, which is then connected to a soundcard to process signals that can produce sound frequency and intensity. The generation of audiometer frequencies based on soundcards on personal computers can produce frequencies between 20-20000 Hz with sound intensity of 0-100 dB and has the ability to display and print examination results in the form of sound intensity and frequency graphs that can determine a person's hearing level..

Based on the literature review above, it is necessary to develop a more efficient tool. So the author intends to create an Arduino UNO-based Audiometer tool to improve efficiency, accessibility, and overall quality of health care.

Figure 1. Audiometer(Medicalology, 2012)

Supporting Technology Components

a. Nextion LCD
b. Headphone
c.Amplifier
d. Oscillator
e. Arduino UNO microcontroller
f. Digital potentiometer
g. VR Resistor
i. Power Supply.

3. Research Method

The type of research used by the author is applied research. Applied research according to Hunt is an investigation conducted by using scientific knowledge, the aim is to solve a problem. This method is carried out by applying, testing and evaluating the ability of a theory to solve a problem so that the problem can be resolved quickly and precisely. Based on the knowledge that has been obtained by the author through literature studies and practices that have been obtained, the author then conducted research, namely the Design and Construction of an Arduino Uno-Based Audiometer Tool.

When the device starts testing, the patient will hear sound from the headphones with an initial frequency of 10 Hz and 10 dB. If the patient hears a sound of 10 dB, then the patient will press the button and change the frequency to 20 Hz with the same process. When the patient does not press the button at a frequency of 20 Hz and 10 dB, then add the sound intensity in multiples of 10 dB. The addition of 10 dB will end up to a value of 100 dB. If the patient does not raise his hand at a value of 100 dB, then the frequency will be changed in stages up to 10,000 Hz.

3.1 System Design

The block diagram serves to make it easier for someone to understand how the device itself works. Figure 2 shows a block diagram of the module that the author made. Power supply to provide voltage to the entire circuit. Sound intensity regulator to adjust the sound frequency and intensity regulator to adjust the sound intensity/deciBell to the patient. The patient is fitted with headphones, then adjust the frequency and intensity of the sound, press the start button, to emit sound to the patient, if the patient hears a sound then the patient is advised to press the button. The intensity and frequency are displayed on the LCD. Amplifier as a frequency and voltage amplifier from the microcontroller to supply to the headphones. The following is Figure 2 Block Diagram.

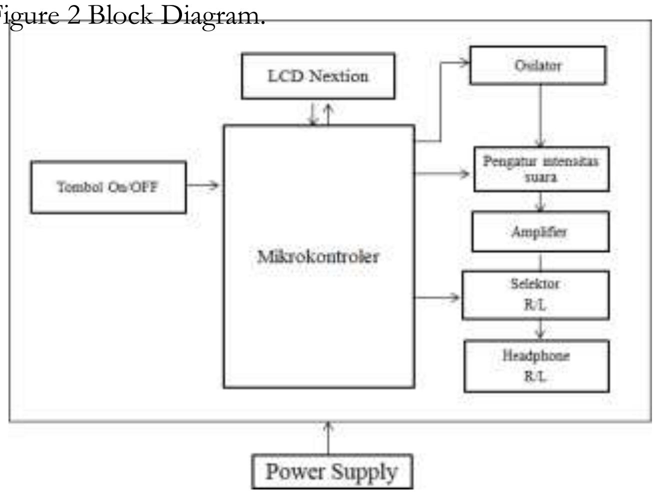

Figure 2. Block diagram

3.2 Program Algorithm (Flowchart)

A flow diagram or flowchart is a diagram or process that displays steps symbolized in the form of boxes, along with their sequence by connecting each step using arrows.

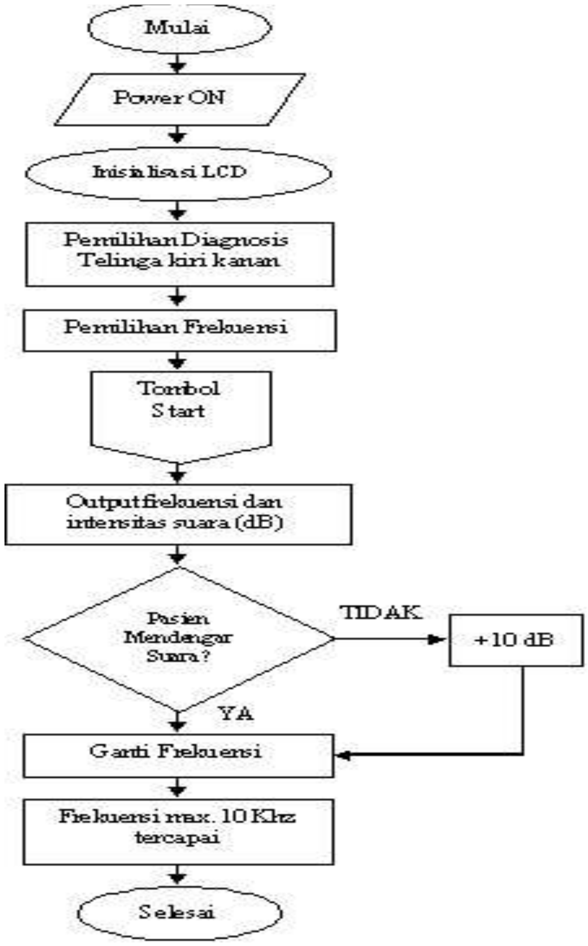

Figure 3. Flowchart of programming flow

3.3 Electronic Circuit Assembly

The series consists of:

- Power Supply Circuit:
  Provides 12V and 5V voltage for microcontroller and sensors.
- Oscillator:
  Generating frequencies in sinusoidal, square and sawtooth forms.
- Nextion LCD
  Displays the Frequency indicator.
- Digital Potentiometer:
  Can adjust the resistance very precisely and stably.

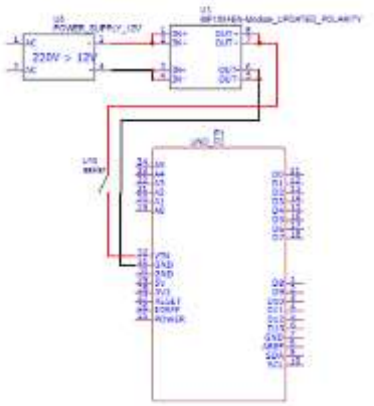

Figure 4. Power supply circuit

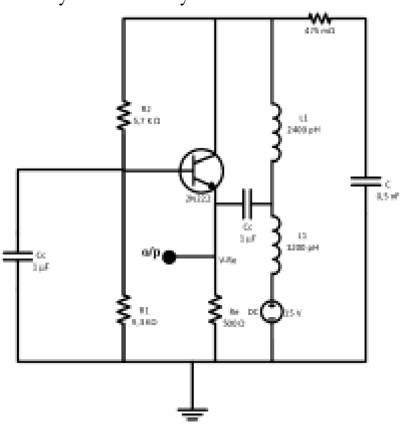

Figure 5. Oscillator

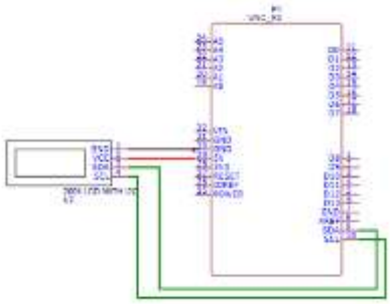

Figure 6. LCD

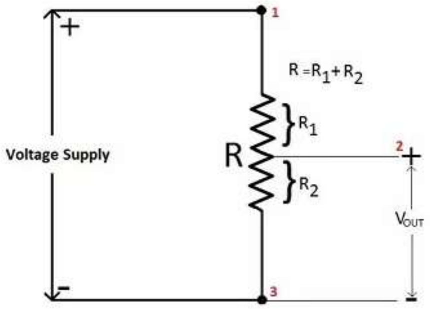

Figure 7. Potentiometer

3.4 Overall Circuit and Tool Design

All components are arranged in a closed system using a heat-resistant metal frame. The position of the control buttons, LCD, and heater are arranged ergonomically.

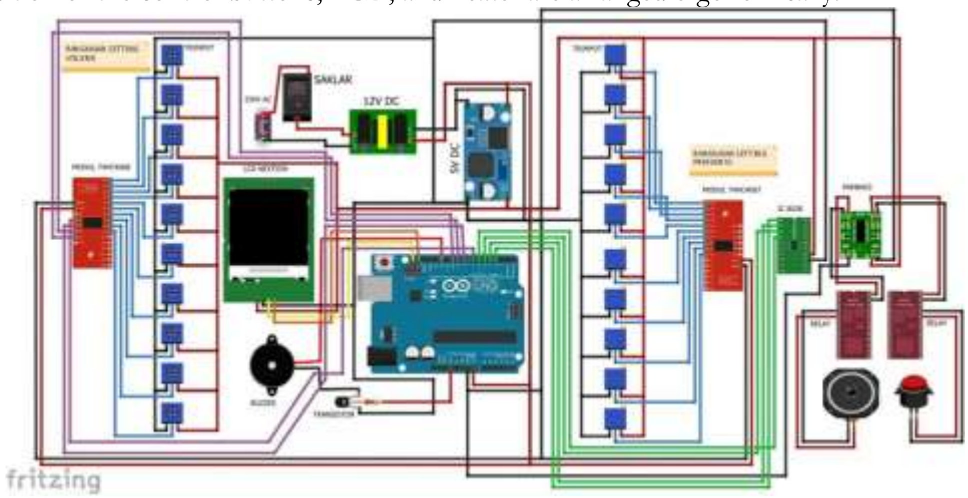

Figure 8. Overall circuit

3.5 Wearing Diagram Procedure

Part of the module workflow diagram can be seen in Figure 8 below. How the flow diagram works, to start turning on the device by pressing the power ON button, then the operator selects the right or left ear diagnosis and presses the start button to start the test. When the device starts testing, the patient will hear sound from the headphones with an initial frequency of 10 Hz and 10 dB. If the patient hears a sound of 10 dB, then the patient will press the button and change the frequency to 20 Hz with the same process. When the patient does not press the button at a frequency of 20 Hz and 10 dB, then add the sound intensity in multiples of 10 dB. The addition of 10 dB will end up to a value of 100 dB. If the patient does not raise his hand at a value of 100 dB, then the frequency will be changed in stages up to 10,000 Hz. The following is Figure 8.

4. Results and Discussion

It can be seen the frequency measurement data based on the comparison between digital multimeters. Many factors affect the results of the measurement data, such as unstable voltage that causes the measurement value to fluctuate and the tolerance of the components used As in Table 1.

Table 1. Frequency testing conclusion

Experimental Results		Difference	*Error (%)*
Setting Frequency On Display	Output Frequency		
125Hz	124.8 Hz	0.2 Hz	0.16%
250Hz	251.9 Hz	1.9 Hz	0.76%

500 Hz	507.6 Hz	7.6 Hz	0.152%
1000 Hz	1007.3 Hz	7.16 Hz	0.73%
2000 Hz	2005.6 Hz	5.63 Hz	0.28%
3000 Hz	3008.26 Hz	8.26 Hz	0.27%
4000 Hz	4005.26 Hz	5.26 Hz	0.13%
8000 Hz	8004.5 Hz	4.5 Hz	0.56%
9000 Hz	9005.56 Hz	5.56 Hz	0.61%
10000 Hz	10007.13 Hz	7.13 Hz	0.17%

$$\% \, Kesalahan = \left| \frac{Setting\ Frekuensi - Output\ Frekuensi}{Setting\ Frekuensi} \right| x100\%$$

$$= \left| \frac{125-124{,}8}{125} \right| x100\%$$

= 0.16%

Measurements were carried out in a soundproof room, with the aim of reducing the influence of noise caused by the surrounding environment.

Measurement is done by attaching the earphone surface to the microphone owned by the sound level meter. The sound from the earphone is received by the microphone to be converted into an electrical signal. The electrical signal is an analog quantity that is converted into digital to be displayed on the sound level meter screen.

The results of sound intensity testing using a sound level meter. Data collection is carried out to test the setting value with the actual value/output of the sound level meter according to the audiometer working method. The test results and analysis can be seen in the following table

Table 2. Results of dB sound meter testing

Frequency	*Hearing* Level	Results Pemeasuring (dB)			Flat -flat	Error (%)
		1	2	3		
125Hz	40 dB	41.6	43.9	42.3	42.6	0.065%
250Hz	20 dB	24.6	22.0	23.2	23.3	0.165%
500 Hz	50 dB	50.9	52.4	51.8	51.7	0.034%
1000 Hz	60 dB	60.4	57.8	58.2	58.8	0.02%
2000 Hz	60 dB	62.3	64.0	63.7	63.2	0.053%
3000 Hz	60 dB	62.8	61.3	58.9	60.7	0.011%
4000 Hz	60 dB	61.9	62.7	59.6	61.4	0.023%
8000 Hz	70 dB	70.4	71.2	72.8	71.4	0.02%
9000 Hz	70 dB	72.7	72.5	73.4	72.8	0.04%
10000 Hz	80 dB	80.3	82.6	81.8	81.5	0.018%

$$\% \, Kesalahan = \left| \frac{Hearing\ Level - Rata - rata}{Hearing\ Level} \right| x100\%$$

$$= \left|\frac{40-42,6}{40}\right| x100\%$$

= 0.065%

From table 2 above, at hearing level 40 dB, the measurement result is 42.6 dB. At hearing level 20 dB, the measurement result is 23.3 dB. At hearing level 50 dB, the measurement result is 51.7 dB. At hearing level 60 dB, the measurement result is 58.2 dB, 63.2 dB, 60.7 dB, 61.4 dB. At hearing level 70 dB, the measurement result is 71.4 dB, 72.8 dB. At hearing level 80 dB, the measurement result is 81.5 dB.

4.1 Discussion.

To find out how much the sound intensity deviation is by measuring using a sound level meter. In this study, the DEKKO FT 7965 sound level meter was used. The image shows the DEKKO FT 7965 sound level meter measuring instrument.

Figure 9. Sound level meter tool

Measurements are made in a soundproof room, with the aim of minimizing the influence of noise caused by the surrounding environment. Measurements are made by attaching the surface of the earphone to the microphone owned by the sound level meter. The sound from the earphone is received by the microphone to be converted into an electrical signal. The electrical signal is an analog quantity that is converted into digital to be displayed on the sound level meter screen.

The results of sound intensity testing using a sound level meter. Data collection is carried out to test the setting value with the actual value/output of the sound level meter according to the audiometer working method.

5. Conclusions and Suggestions

After completing the creation of the Arduino Uno-based Audiometer Tool, starting from field observations, literature studies, planning, experiments, data collection, and data analysis, the author draws the following conclusions:

Arduino Uno-based Audiometer Tool has been successfully designed with Audiometer frequency ranging from 125 Hz-10000 Hz and sound intensity (dB) between 10-100 dB as a tool to measure a person's hearing level. This tool can display frequency and sound intensity (dB) information on the Nextion LCD as well as a comparison with the DEKKO FT 7965 sound level meter.

Functional tests performed on the Audiometer Tool can determine the error value of frequency testing and sound intensity testing (dB). From the tests carried out, the Tool works well with a frequency of 125 Hz - 1000 Hz and the results obtained are that the average error value of frequency testing and sound intensity testing (dB) is still within the tolerance limit so that it can be said that the tool can work well.

References

[1] S. Bahtiar, “Soundcard Based Audiometer on Personal Computer,” Final Project, Dept. Electro. & Telecommunication, Diponegoro Univ., Semarang, 2006.

[2] M. Damayanti, Therapeutic Communication in Nursing Practice. Bandung: Refika Aditama, 2010.

[3] A. Ratrianto, "Design of audiometer device for deafness level measurement using Atmega 8535 microcontroller," Scientific Journal of Electrical Engineering, pp. 834–841, 2013.
[4] H. J. Santoso, Design and Construction of an Audiometer Tool Based on the AT89C51 Microcontroller, Final Assignment, 2011.
[5] Suhardiyana, Improving Children's Cognitive Ability Through Number and Picture Card Games for Students in the Preparatory Class for the Deaf and Mute of SLBN in the Academic Year of 2009/2010, Thesis, UNS, Surakarta, 2010.
[6] H. Syaifuddin, Anatomy and Physiology: A Competency-Based Curriculum for Nursing and Midwifery, 4th ed. Jakarta: EGC, 2011.
[7] N. H. Wijaya, M. Ibrahim, N. Shahu, and M. U. Sattar, "Arduino-based digital advanced audiometer," Journal of Robotics and Control (JRC), vol. 2, no. 2, pp. 83–87, 2021.
[8] A. Rahmawati, I. D. G. H. Wisana, and E. D. Setioningsih, "Improving the effectiveness of automatic pure tone audiometer with audiogram and patient diagnosis," Indonesian Journal of Electronics, Electromedical Engineering, and Medical Informatics, vol. 2, no. 3, pp. 113–121, 2020.
[9] A. Suwandi and D. Hermawanto, "Developing a computer-based audiometer for hearing loss screening," MAPAN, vol. 27, pp. 205–212, 2013.
[10] S. Naida et al., "Objective audiometry based on the formula of the middle ear parameter," in Proc. IEEE 39th Int. Conf. Electron. Nanotechnol. (ELNANO), pp. 425–428, 2019.
[11] H. W. Noh et al., "Development of a portable A-ABR screener using a microprocessor," in Proc. IEEE EMBS Int. Conf., pp. 915–918, 2009.
[12] M. Gargouri, M. Chaoui, and P. Wira, "Development of hearing self-assessment pure tone audiometer," in IEEE Int. Conf. Design & Test Micro & Nano-Systems (DTS), pp. 1–5, 2020.
[13] C. Liao, P. Li, S. Young, Y. Lai, and Y. Tsao, "iOS-based Ear Scale application for clinical audiology," in Proc. Int. Symp. Chinese Spoken Language Process. (ISCSLP), pp. 497–498, 2018.
[14] J. M. Choi, J. Sohn, Y. Ku, D. Kim, and J. Lee, "Phoneme-based self hearing assessment on a smartphone," IEEE J. Biomed. Health Informatics, vol. 17, no. 3, pp. 526–529, 2013.
[15] A. S. Zaman, "Wireless earbuds for low-cost hearing screening," arXiv preprint, arXiv:2212.05435, Dec. 2022.