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PC Sound Card Based Diagnostic Audiometer

Group No: D11

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Abstract

The degree of hearing loss can be determined by PC sound card based diagnostic audiometer. The instrument will provide 2 – channel outputs, with stimulus generation from PC sound card and external programmable attenuators which can be controlled by giving instructions using Software which includes RS 232 serial port communication between PC and hardware. The system has automatic calibration for variation in amplitude of sound card signal. The audiometer can give standard frequencies 125 Hz, 250 Hz, 500 Hz, 1 kHz, 1.5 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, 8 kHz and noise as the inputs to the two channels separately. The patient can response to stimulus by pressing switch. This data is recorded in software and plotted on audiogram.

1 Introduction

A PC sound card based diagnostic audiometer can be used to determine the hearing threshold of a patient and hence his hearing loss. The objective of this project is to construct an audiometer based on PC sound card with proper software and hardware to control audio amplification and attenuation and simultaneously recording user's response and plotting it on audiogram.

2 Design Approach

The audiometer has been built to be cost effective and user friendly. The graphical user interface allows the user to control the sound outputs efficiently. This audiometer supports speaker of 8 ohms along with headphone. The patient's response can be recorded via RS 232 port terminals. The block diagram of above mentioned audiometer is shown in Fig. 1.

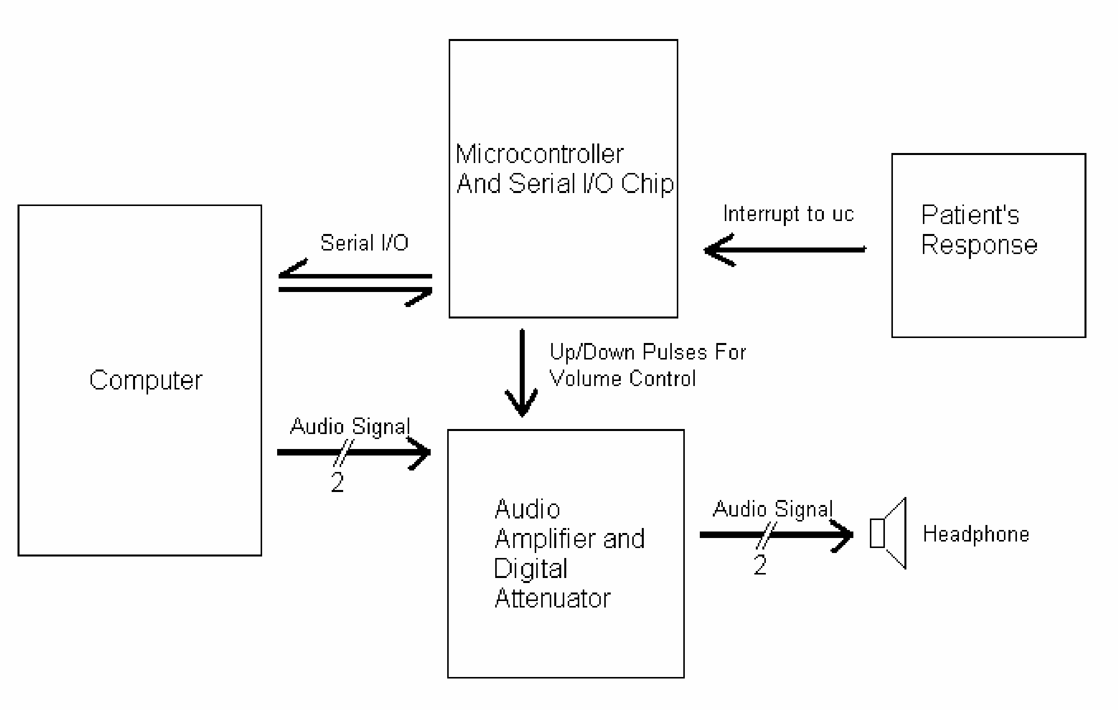

Fig 1. Block Diagram of the Audiometer

3 Graphical User Interface

GUI includes all the software part of audiometer project. It is used to generate tone, control volume levels, record patient's response. This entire software module has been implemented in JAVA programming language. To run this software the PC should have JAVA runtime (JRE) previously installed.

3.1 Generation of tone signals: Human audible range is from 20 Hz to 20 kHz. The test frequencies used to detect hearing loss are 125 Hz, 250 Hz, 500 Hz, 1 kHz, 1.5 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, 8 kHz. These test frequencies are generated using PC sound card. First of all signal of corresponding frequency of length 1 s is synthesized. This signal is repeatedly sent to PC sound card to generate continuous uninterruptible tone signals. To account for sudden change in signal i.e. from mute state to some tone signal these signal are tapered at both ends by increasing and decreasing amplitude continuously over a short time period. The tapering allows a smooth change from mute state to reception of some tone signal.

3.2 Controlling Sound levels: Sound levels can be changed using software or hardware. Through software sound levels can be changed while synthesizing signals. But through PC we can attain maximum 80 dB attenuation. But for diagnostic audiometer we require attenuation levels of nearly 160 dB. So appropriate hardware has been implemented. Sound levels can be changed in the steps of 1.25 dB and 2.5 dB. The up and down signals are sent to microcontroller to change the sound levels.

3.3 Serial IO interface

Serial IO interface has been used to communicate with microcontroller. Software is written such that it can detect hardware on any one of the four COM ports available and then continues communication on detected port. Sound up and down signal commands and also mute and operating commands are sent through COM ports. The baudrate is fixed at 9600.

3.4. User Interface

User interface is designed to control the audiometer efficiently. It consists of three windows.

a. Main Window: It consists of all controls necessary to operate an audiometer. The stimulus available at both left and right ears are 10 standard frequencies, mute and noise which can be independently selected for each ear. In manual mode user has to press volume up or down button to control dB sound output after selecting appropriate step i.e. one of 1.25 dB and 2.5 dB. After patient presses the response button then the stimulus which was presented to the ear stops. In automatic mode the stimulus is presented in pre-decided mode for a particular setting of stimulus on left and right ear. The presented stimulus can also be played continuously by selecting appropriate option. The interval between 2 volume up/down events in this case is 2 s. User interface to play test audio signal is shown in Fig. 2:

Fig 2. Audiometer Main window

b. Sound Calibration: Sound calibration can be done using window shown in Fig. 3. Calibration can be done with respect to young person having normal hearing power or using artificial ear. At each test frequencies the gain step of digital attenuator ICs can be decreased or increased till the threshold hearing at that frequency is detected. This process can be repeated for each frequency and saved by using save option so that each time program is started these values of calibration can be loaded from that saved file.

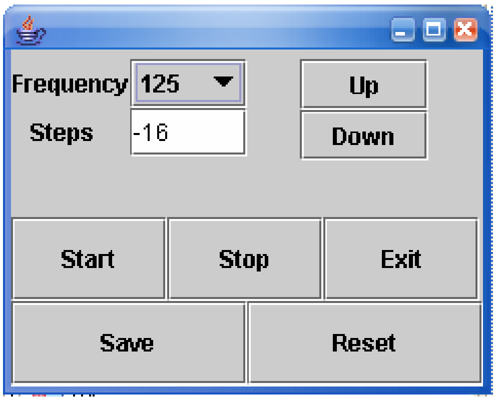

Fig 3. Sound Calibration

c. Audiogram: The response obtained for each frequency from microcontroller via RS232 is plotted on graph as shown in Fig. 4. This process can be invoked by pressing plot button present in main window shown in Fig. 2.

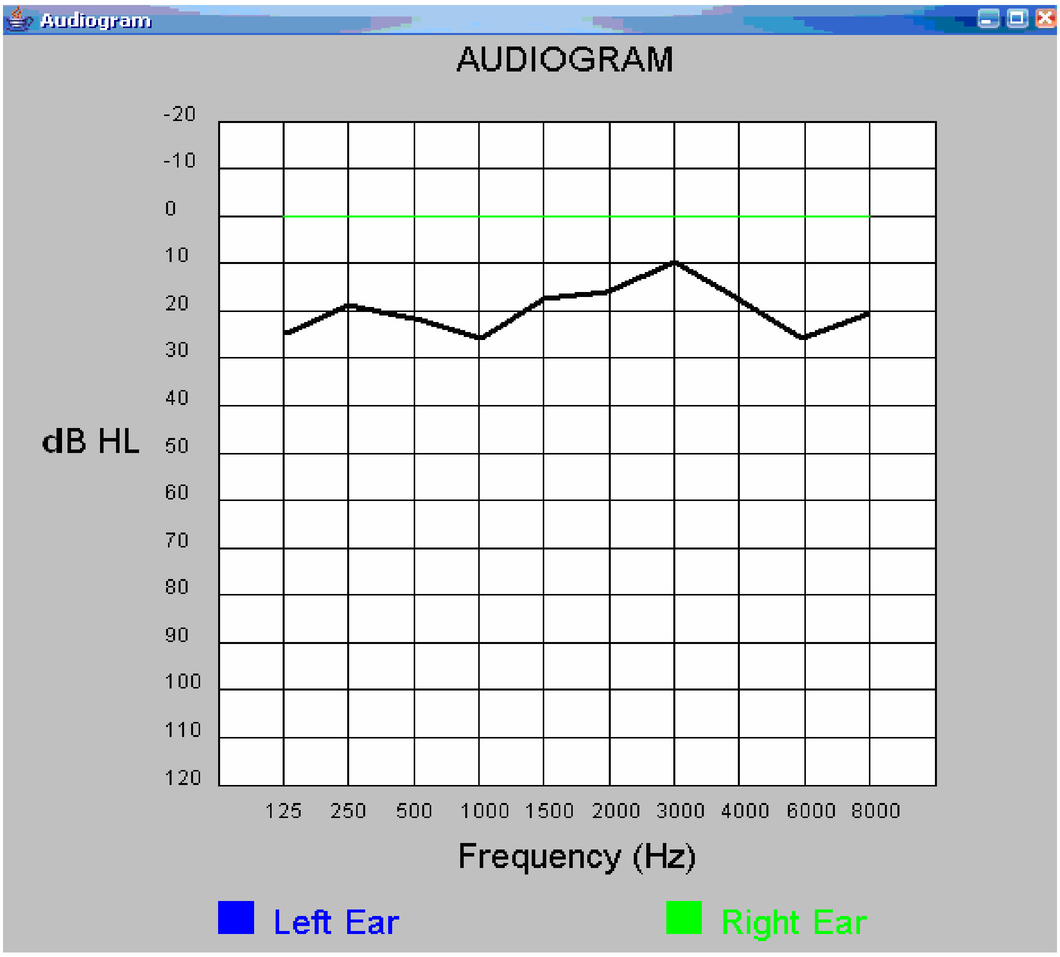

Fig 4. Audiogram

4 Hardware

4.1 Microcontroller: Microcontroller used by us is AT 89C52 as total 3 ports are required. Port 0 is used to give up/down signal to TDA 8551 ICs. Port 2 is used to control modes of TDA 8551 ICs i.e. mute mode and operating mode. Port 3 is used for RS232 interface, patient's response switch and for automatic calibration of sound card's audio output signal. Fig. 5 provides brief idea of connections to microcontroller.

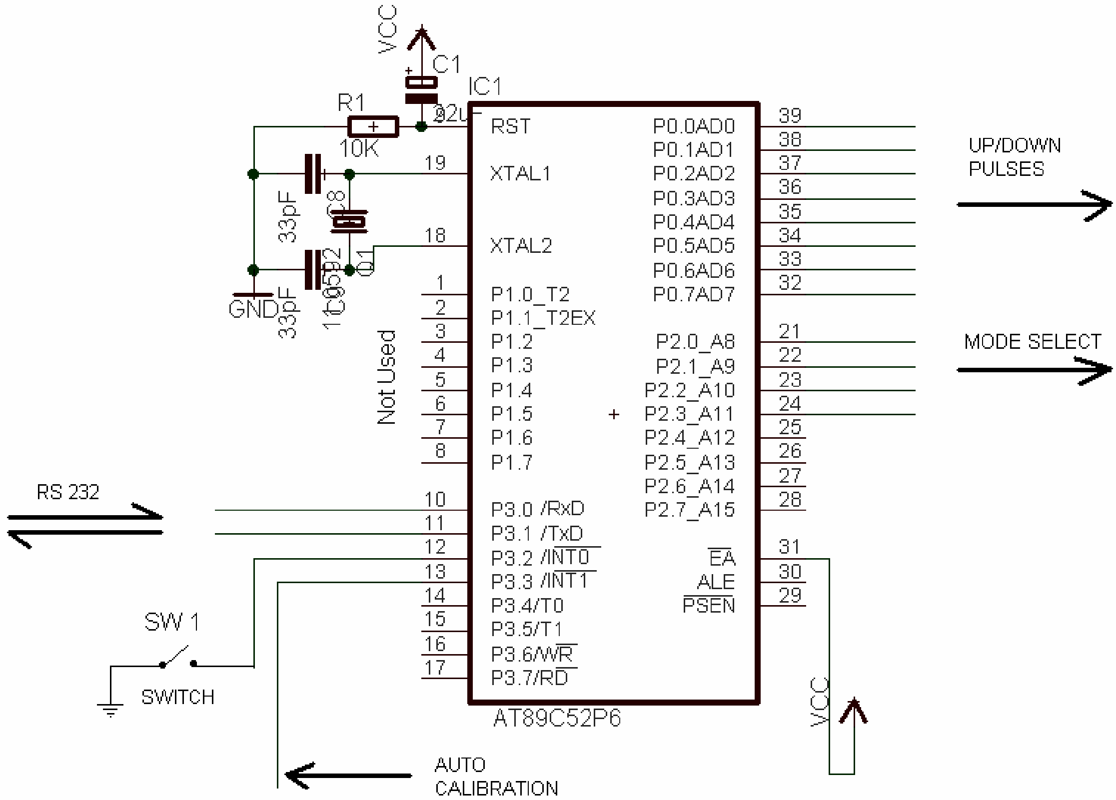

Fig 5. AT89C52

4.2 RS232 Interface: MAX 232 IC has been used for implementing serial interfacing with PC. Serial port is required to control the hardware by using GUI and also to note down patient's response. The connections to MAX 232 IC is shown in Fig. 6.

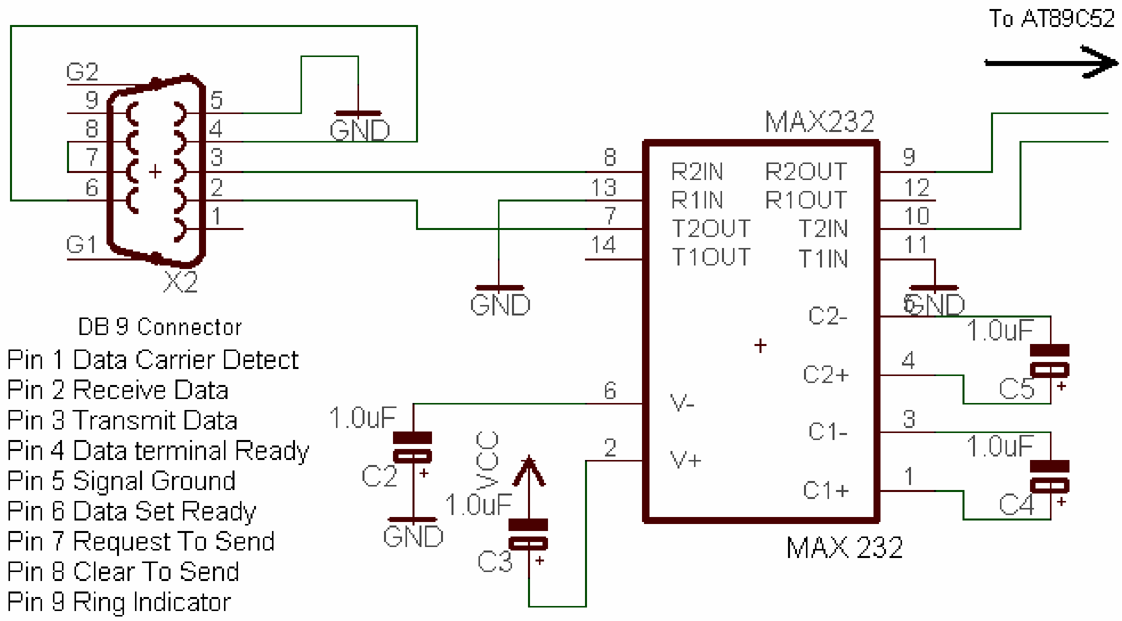

Fig 6. Serial Interfacing

4.3 Switch (SW1): Switch is used to get patient's response by using interrupt 0 available on P3.2. Level triggered interrupt is used. When switch is pressed P3.2 is grounded and thus interrupts the microcontroller which tells PC software to note down reading.

4.4 Details of TDA 8551: TDA 8551 is 1 channel audio power amplifier capable of delivering 1w output power to 8 ohm load and operates on 5V supply. It contains a digital volume control and standby/mute logic. The attenuation level can be changed by giving up/down pulses to pin number 1. Input is given at pin number 4. Output is taken from pin 5 and 8. Pin diagram of TDA 8551 is shown in Fig. 7.

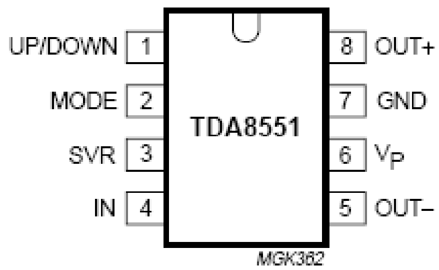

Fig 7. Pin diagram of TDA 8551

4.5 TDA IC connections: Connections of individual TDA 8551 can be seen in Fig. 8. The Up/down pulse pin is connected as shown in Fig. 9. The mode pin is connected to Port 2 of microcontroller along with appropriate voltage divider circuit.

4.6 Cascading Of TDA IC: Cascading of TDA 8551 has been used for two reasons. Firstly the initial 8551 IC is used in auto calibration leaving the cascaded IC untouched. Secondly the total attenuation required in audiometer is 120 dB which is easily attained by using cascaded procedure. Fig. 8 shows the cascaded ICs.

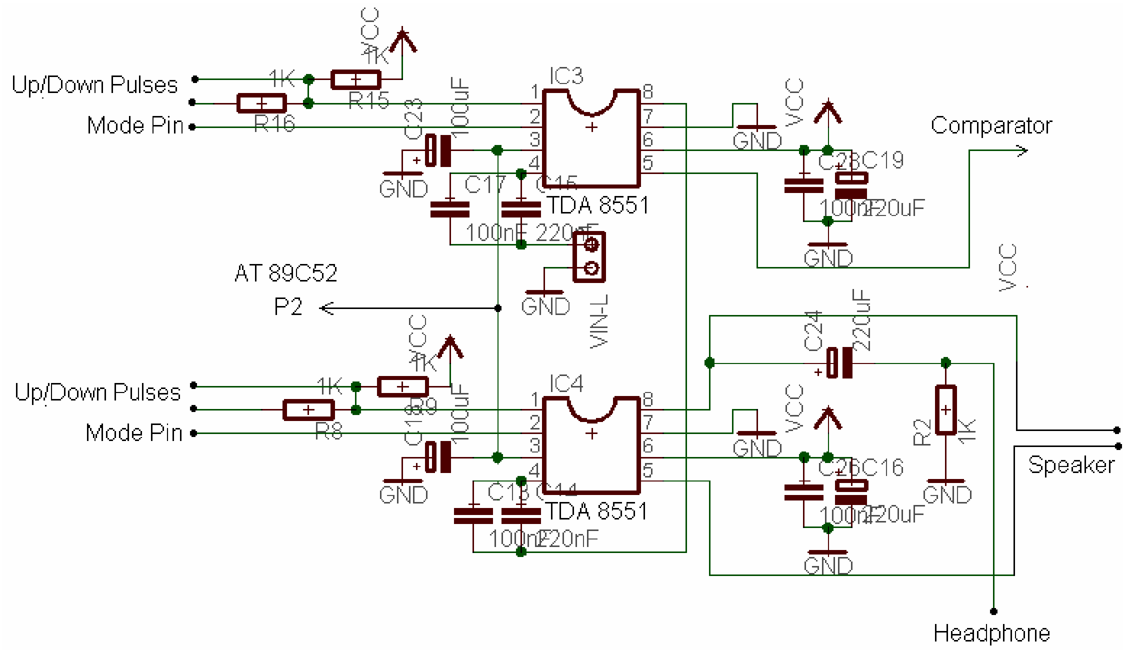

Fig 8. Cascading Of TDA 8551 ICs

4.7 Attenuation Control: Attenuation control can be done by sending up/down pulses to TDA 8551 for adjusting volume up/down. As Port 0 of microcontroller does not have internal pull-ups so external pull up is required to make the output high at this port. This property is used to provide up down pulses to TDA 8551. To generate one up/down signal pin we need 2 port pins connected as shown in Fig. 8. Following table shows signal levels generated by using Port pin 0 and 1 of Port 0.

Table 1. Attenuation Control

P0.0	P0.1	Voltage (V)
0	0	0.0
0	1	0.0
1	0	2.5
1	1	5.0

Fig. 8 shows one signal pin created by using P0.0 and P0.1.

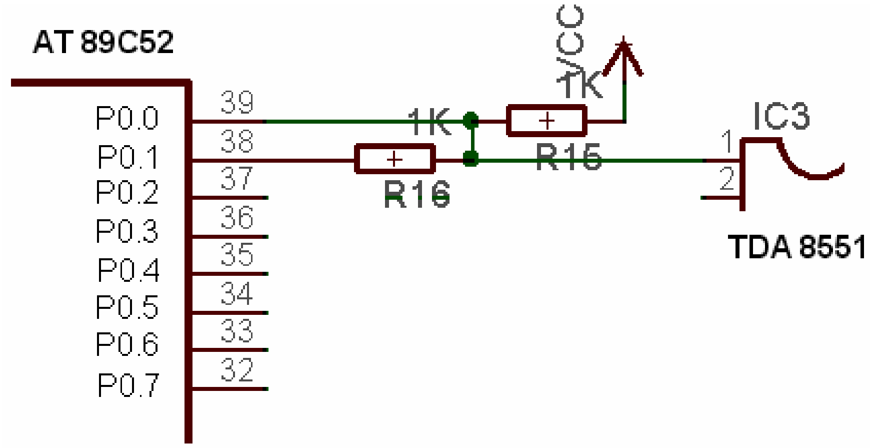

Fig 9. Up/Down Pulse generation

4.8 Mode Control: Different modes of TDA 8551 ICs are attained using Port 2 of AT89C52. A high on Port 2 pin after passing through voltage divider gives 2.5 V, which when given to Pin 2 of TDA IC sends it to mute mode. Operating mode can be obtained by a low on Port 2 pin.

4.9 Auto Calibration Feedback Circuit: Comparator is used for comparing output of TDA8551 in cascaded attenuator to a reference signal which is 3.3V dc here. The audio output of TDA 8551 rides on 2.5V dc. Initially the gain of TDA IC is brought to its lowest level then it is increased step by step. Output of comparator goes to interrupt 1 of microcontroller. Comparator output remains low till audio output is less than 0.83V peak. The square wave is generated at the output of comparator when audio signal peak voltage surpasses 0.83V. As interrupt is edge triggered so the first high to low transition interrupts the microcontroller to stop increasing gain of TDA ICs. This interrupt then sends the gain step to software via RS 232 port to calibrate the hearing threshold frequencies respectively. Fig. 10 shows the calibration circuit.

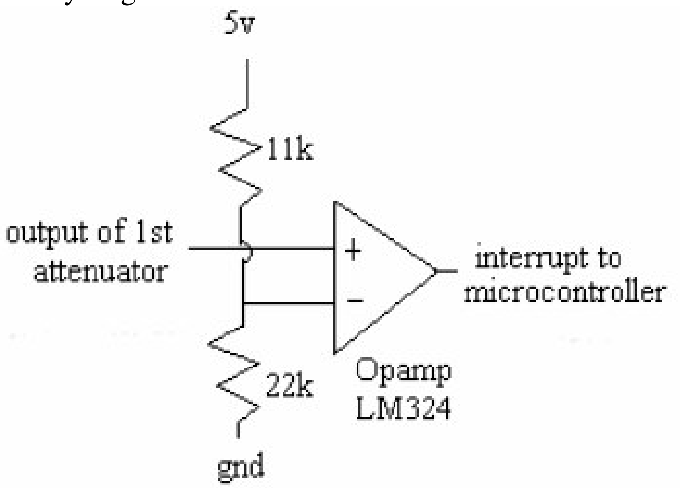

Fig 10. Auto Calibration

5 Algorithmic flow diagram

5.1 Graphical User Interface:

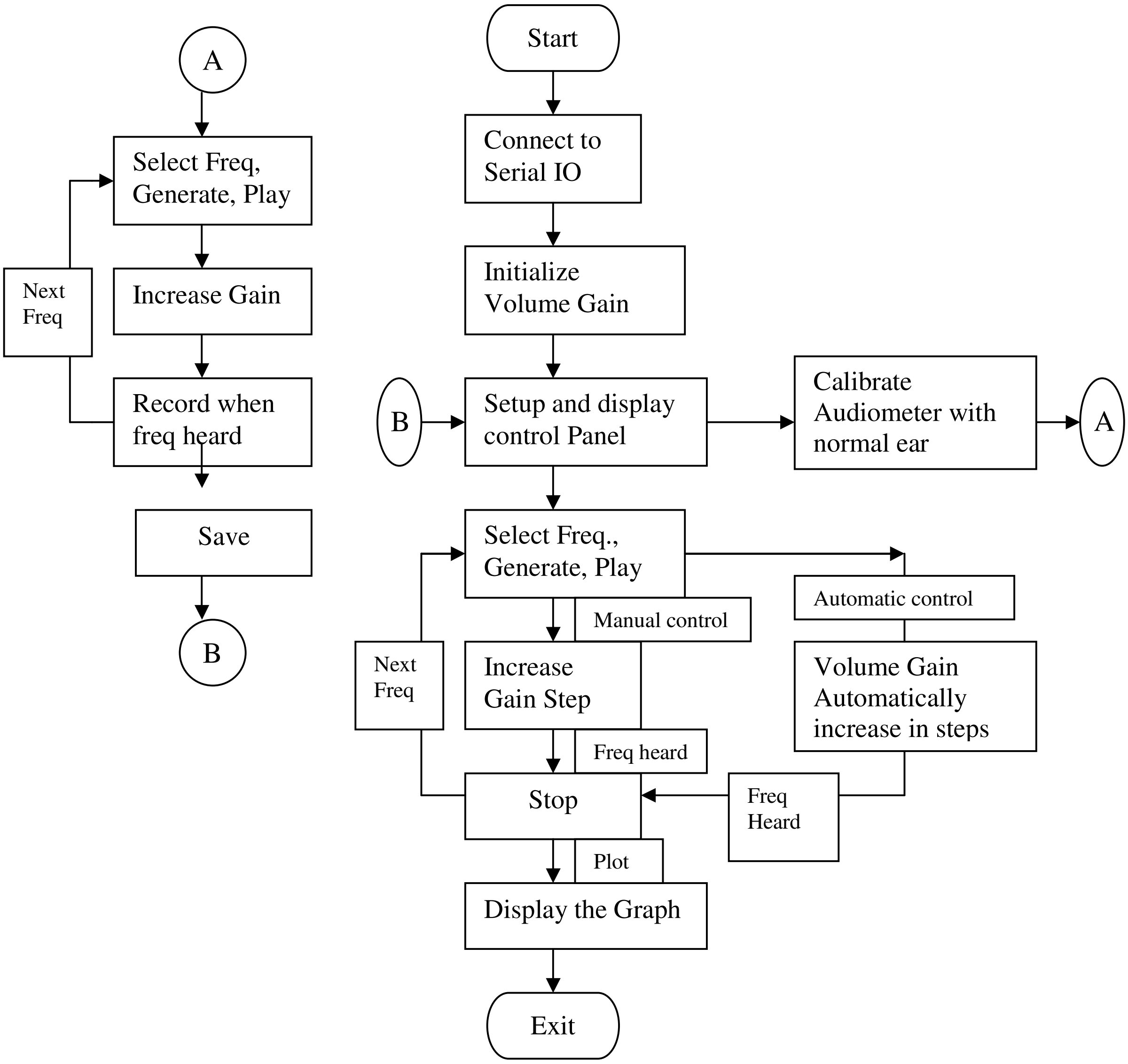

Fig 11. GUI Flowchart

5.2 Embedded operating system:

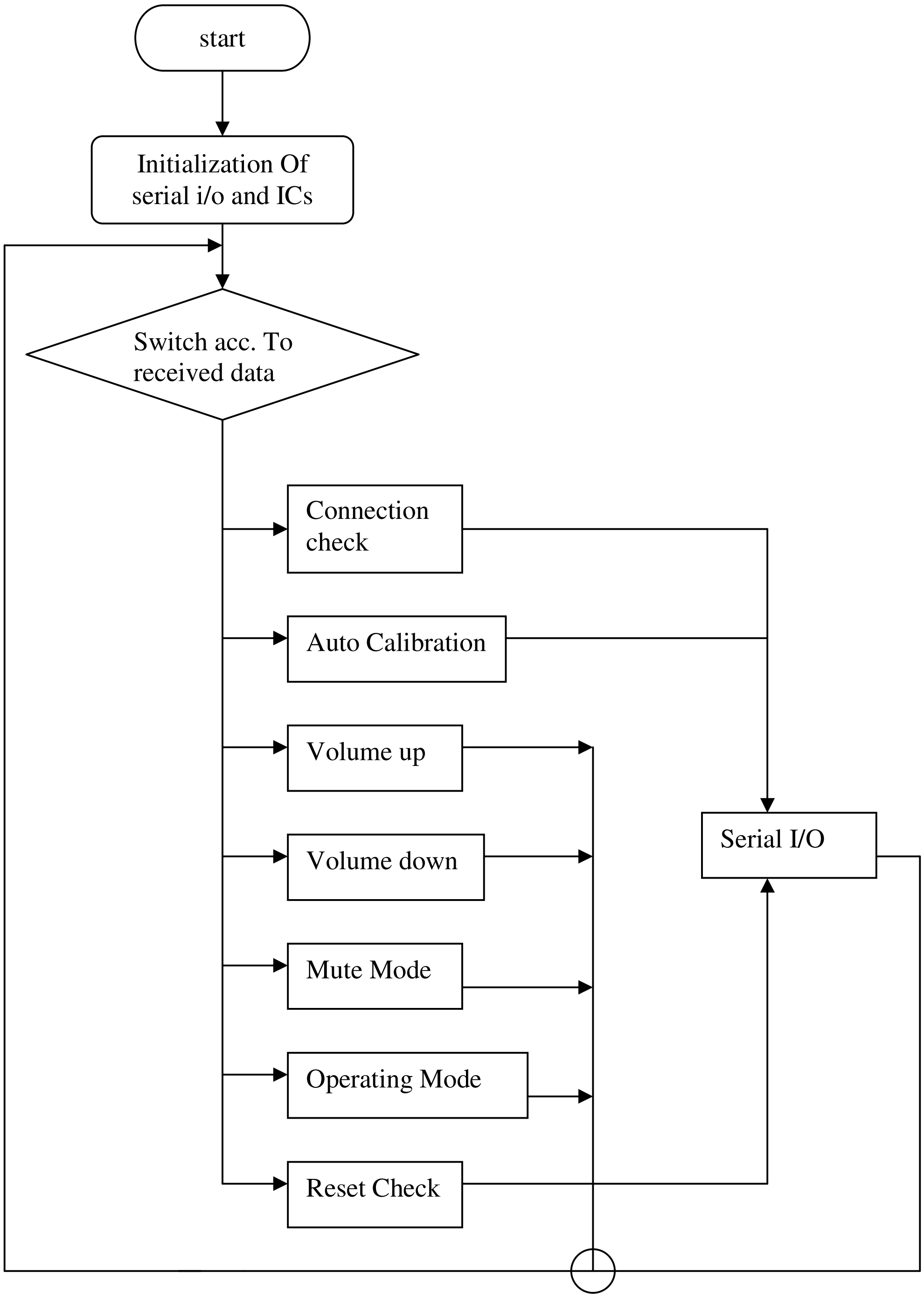

Fig 12. Embedded operating system Flowchart

6 Test Procedure

The procedure to test the audiometer is the standard one as used by a practitioner. When running this software for first time, sound calibration must be done so that actual dB HL values are plotted on audiogram. The sound calibration can be done with respect to young person with good hearing power or using artificial ear. After calibration the actual testing of patient's ear can be performed. The audiometer is independent of sound card used, this can be checked by running this software at different PC volume settings.

7 Test Results

Results obtained by above process can be checked by comparing audiogram obtained from different diagnostic audiometers.

8 Conclusion

PC sound card based diagnostic audiometer can be used for detecting the hearing loss in a person of any age. Test results can be acquired in a short time. This test can be performed almost anywhere with the availability of a PC. The audiometer designed is a portable device, used for measuring hearing functions. It is designed to occupy less memory space. Early detection and intervention can dramatically improve the lives of many people.

9 Assembly

9.1 PCB board shown in Fig. 13.

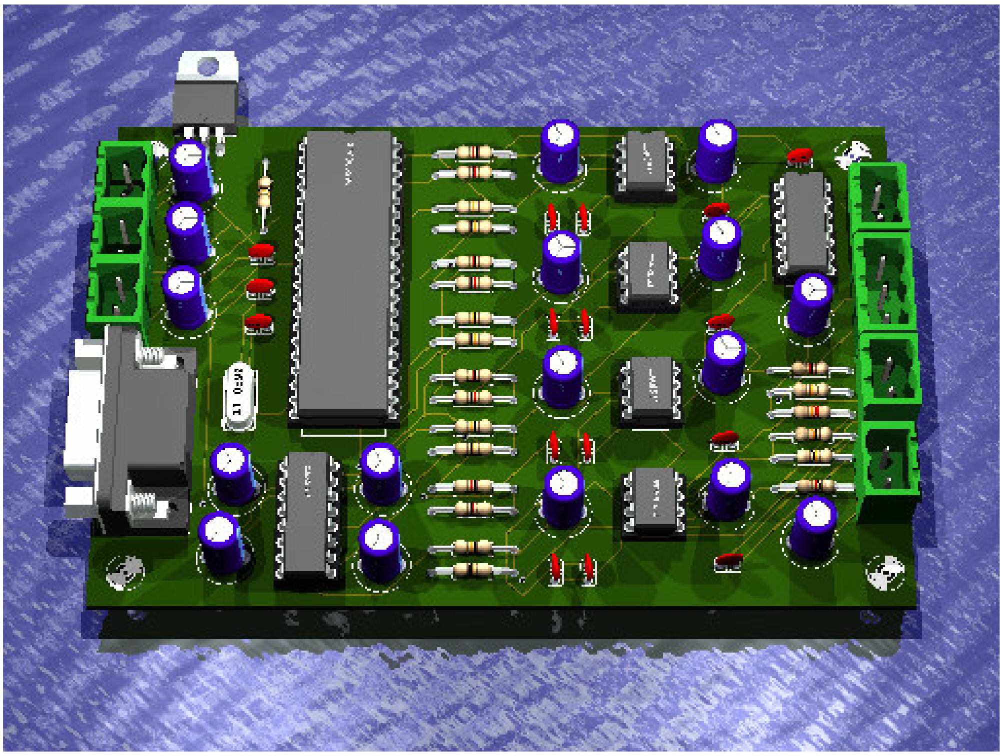

Fig 13. PCB Board

9.2 Top view of final product shown in Fig. 14

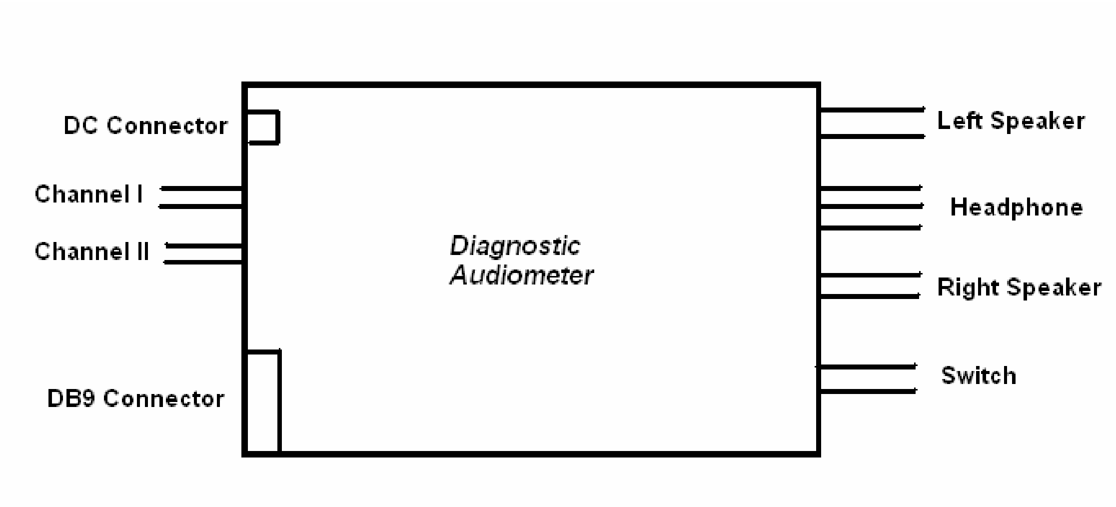

Fig 14. Top View

10 List of components

10.1 Attenuator circuit:

Disc Capacitor	100 nF/50 V	8
Disc Capacitor	330 nF/50 V	4
Electrolytic Capacitor	100 uF/25V	4
Electrolytic Capacitor	220 uF/25 V	6
Resistance	1 K/ 250 V	10
Resistance	10 K/ 250 V	8

10.2 Serial Communication Circuit:

IC Max 232		1
Electrolytic capacitor	1 uF/25 V	5
F09H Serial Port Socket		1

10.3 Microcontroller circuit:

Microcontroller	AT89C52	1
Crystal Oscillator	11.0592 MHz	1
Disc capacitor	33 pF/50 V	2
Electrolytic Capacitor	22 uF/25 V	1
Resistance	10K/250 V	1

10.4 Comparator circuit:

IC LM324		1
Resistor	22K/250 V	1
Resistor	11K/250 V	1

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