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PC-based diagnostic audiometer using sound card and serial port

Group No. D8

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***Abstract* -** The degree of hearing loss can be determined by PC 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 GUI developed for RS232 serial port communication between PC and hardware. The system has automatic calibration for variation in the amplitude of sound card signal. The audiometer can give standard frequencies 250 Hz, 500 Hz, 1 kHz, 1.5 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, 8 kHz and other audio signals included by the user as the inputs to the two channels separately. It indicates the patient when his response time begins and ends. The patient's feedback will be accepted only in that time interval. The attenuation at which the patient does not hear the audio signal is recorded, it is sent to PC which finally gets plotted on the audiogram.

1. Introduction

The objective of this project is to develop a PC-based diagnostic audiometer using sound card and serial port: sound card for generation of sounds, and a serial port based digital attenuator for level control, feedback switch input, and auto calibration.

2. Main Design

The audiometer has been designed to make it cost effective, occupy less memory and be user friendly. It produces 2-channel output, which can be selected using the graphical user interface. The patient's response can be obtained via RS232. The software eventually plots the audiogram on the PC instantaneously. The Block diagram of the above mentioned audiometer is shown in Fig. 1.

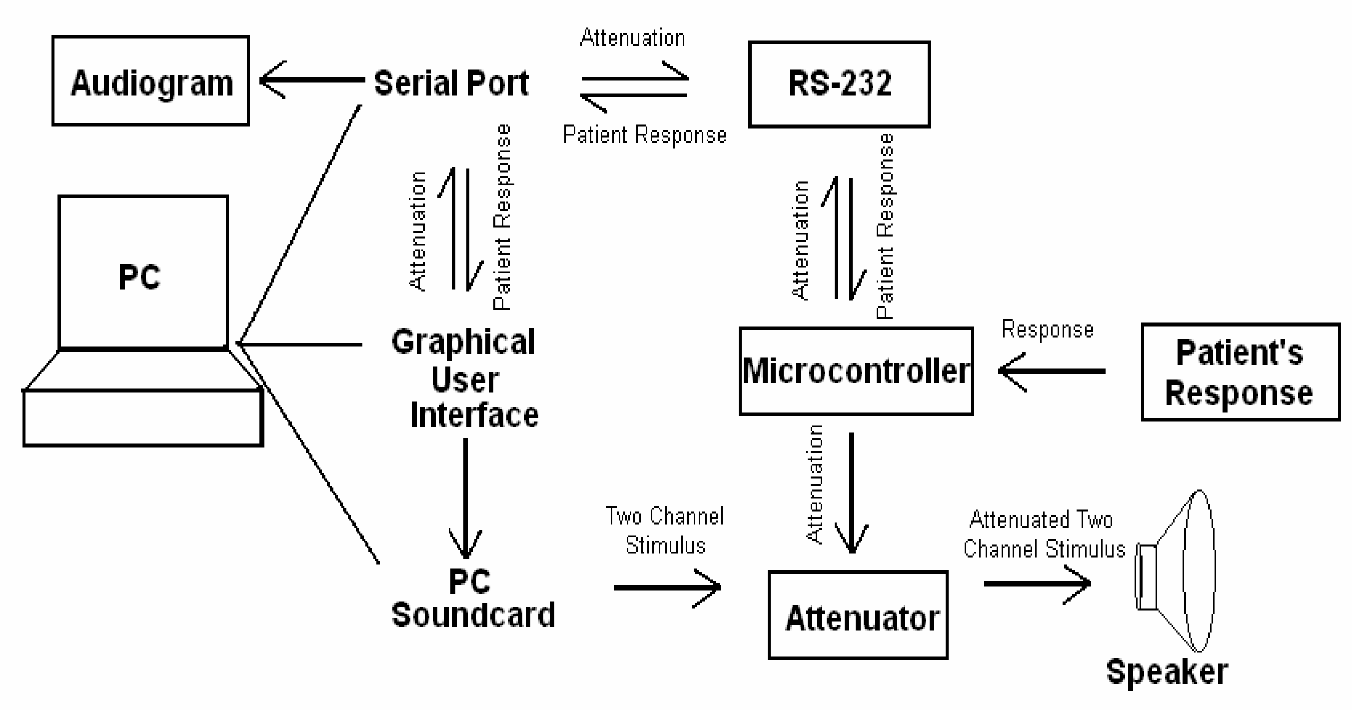

Fig 1. Block diagram of the audiometer

3. Graphical User interface

Though the human audible range is from 20 Hz to 20 kHz but audiometric test are performed for standard eight frequencies i.e. 250 Hz, 500 Hz, 1 kHz, 1.5 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz and 8 kHz for covering audible range.

The entire software module is based on Visual Basic coding language and can be divided into three modules

3.1 GUI to play test signals.

The first part of Visual Basic code is essentially the heart of the entire project. It is a graphical user interface (test signal generator). This test signal generator invokes the sound card and presents noise and test tones on two separate channels. The test signal generator has been equipped with two playlists and digital master volume control to compensate for the variations in the outputs of different sound card. The GUI to play test audio signals is shown in Fig. 2. The two playlists hold the mono channel input wav files for each channel. On the press of Play button ►the two channel input files are read and played simultaneously generating a stereo output at the speakers. The user can select any input from the play list of individual channels using the « or » buttons adjacent to the STIMULUS in figure 2. The selected input is displayed in the field between « or » for each channel. The GUI gives the user the flexibility to give attenuations of ±5dB and ±1.25 dB to either channels or individual channels. The amount of attenuation given is calculated in dB and displayed in the field adjacent to dBHL. The GUI also allows the user to select different presentation modes. The 'CONTINUMM' generates the output for two channels continuously, the 'Interval 1s/1s 'generates the stereo audio output for 1s, stops for next second again generates for next second and so on. Similarly, the 'Interval 2s/2s generates the audio signal for 1s and stops for next second. The '1s' and '2s' generates the stereo audio output for 1s or 2s depending upon the selection and stops after that. The patient's response is displayed in the field adjacent to RESPONSE and when the user presses RECORD the data is feed into database called graph.db. When the user presses AUDIOGRAM the program plots the hearing function on the standard audiogram as shown in figure 4.

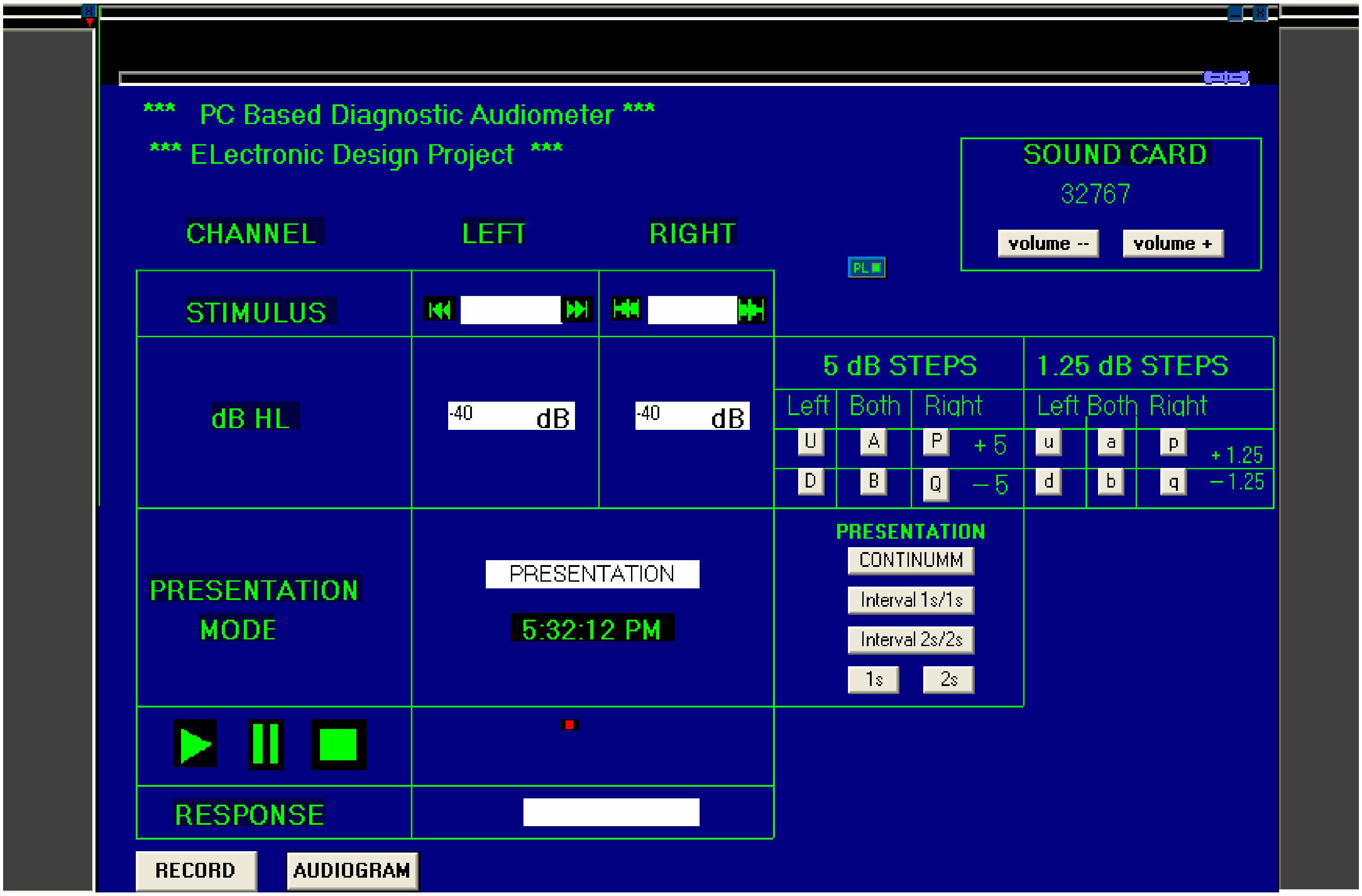

Fig. 2. The GUI to generate test audio signals

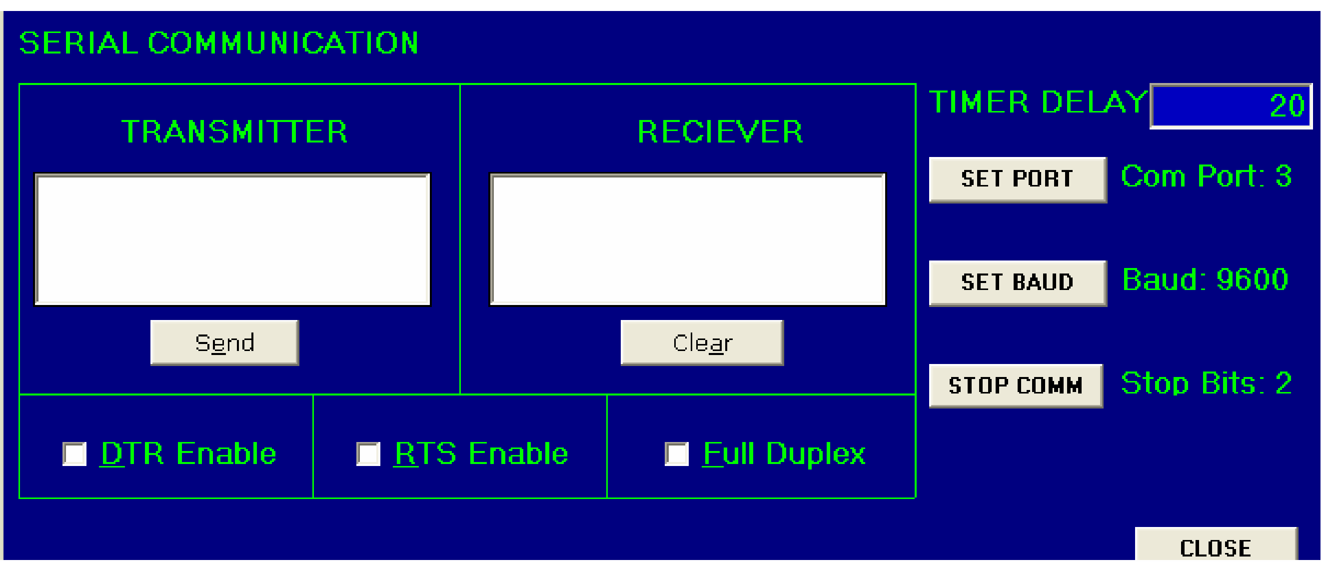

Fig 3. GUI for serial data communication

3.2 GUI for Serial Communication.

This user interface is invoked by the first module. It is designed to communicate directly with micro-controller. The user can select port and baud rate depending upon the convenience of his machine. The GUI sends the amount of attenuation to be given to each channel via the microcontroller and receive the patients/subjects response using the micro-controller. This response is sent to the graph plotting module and can also be stored in a text document. The GUI for serial communication (transceiver) is shown in Fig 3.

3.3 GUI to plot the frequency response(audiogram)

This is the third module in the Visual Basic Code. The sole idea of this module is to provide a graphical picture of the patients/subjects response over the discrete frequency range. The response obtained for each frequency from the micro-controller via serial communication is recorded in real time into a Microsoft Access file called graph db. When the graph plotting module is called from within the first module, the hearing profile of each ear is plotted on the audiogram. The audiogram is shown in Fig 4.

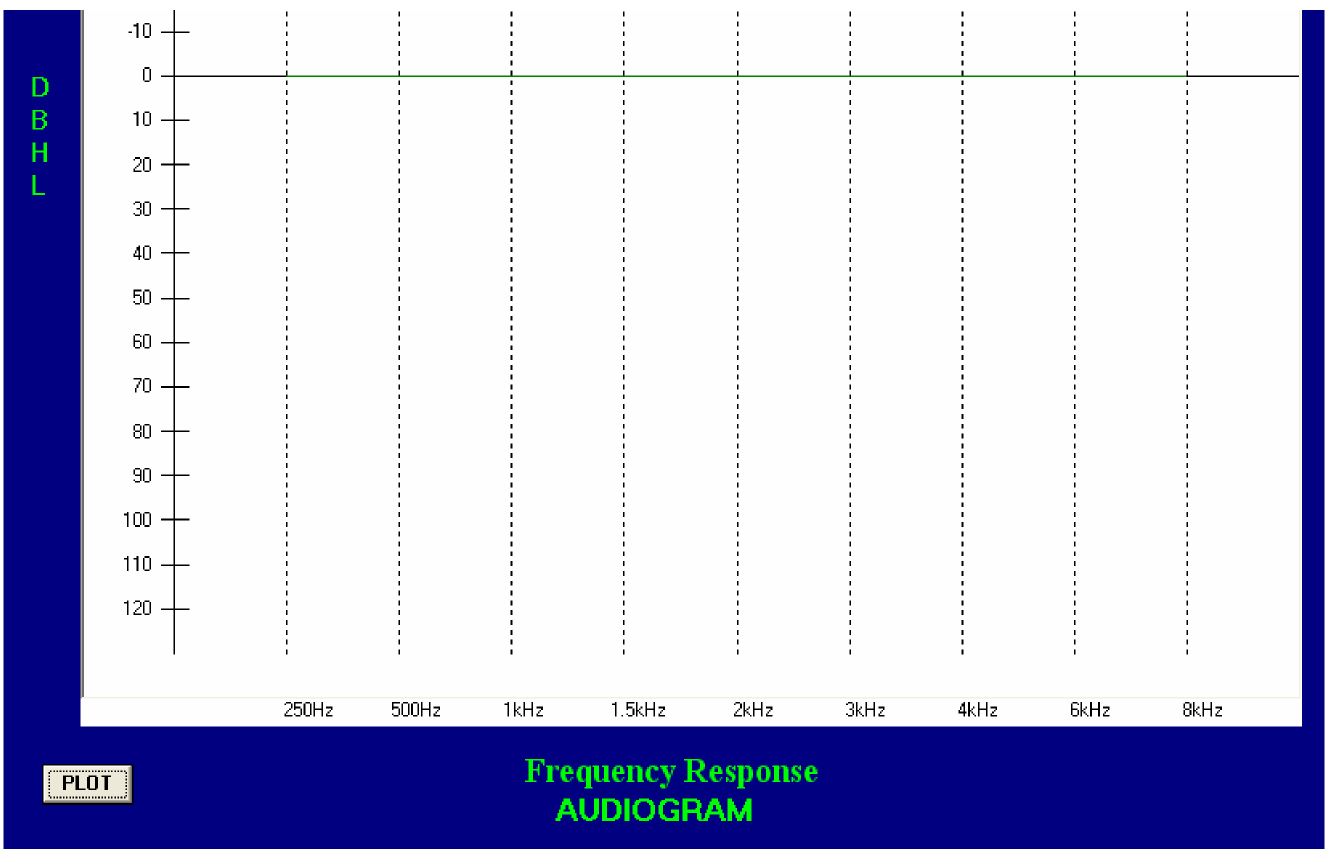

Fig 4. Audiogram used to plot the hearing function

4 Hardware

4.1 Microcontroller section

AT89C52 microcontroller is used by us. It is connected by serial port to PC. Port 0 is used to give up/down pulses to attenuators. Port 1 is used for interrupt handling. Two LED's are connected to 2 port pins of port 0 for testing purpose. For serial port communication IC MAX232 is used. Serial port is required for controlling the hardware through GUI and to send the readings to be plotted to PC. The circuit diagram of microcontroller section is shown in figure 6

When microcontroller is reset, it asks the user for response time to be allowed to the patient to respond and receives the response time entered in GUI of the software through serial port. Then, it starts automatic calibration of the sound card's output audio signal which is explained in detail in the subsection 4.3. This auto calibration circuit gives output logic 1 to microcontroller if calibration is done else it remains to zero. When calibration of both the channels is done, testing is started. Initially, attenuation level is set to 30 dBHL of 250 Hz. If patient does not hear, then he/she is supposed to press a switch 'S1' which will be detected by the microcontroller and corresponding attenuation level in dBHL is transmitted to PC which is received by software and used for plotting audiogram. Similar testing is carried out for next frequency by setting the hardware to 30 dBHL of next standard frequency and so on. After testing for one ear is over, same procedure is carried out for another ear.

4.2 Attenuation control

Circuit in figure 5 is used for giving up/down pulses to TDA8551 by microcontroller. In this circuit, BC557 (PNP transistor) and BC548 (NPN transistor) are connected to V_{cc} and ground as shown in figure 5. When base of BC548 is 0 and BC557 is 1, output is 2.5V because in this case both transistors are cut-off. To give down pulse (i.e. 2.5V to 0V pulse); logic 1 voltage is given to the base of BC548 for short time. This sets BC548 conducting and 0V appears at the output. Similarly, to give up pulse (i.e. 2.5V to 5V pulse); logic 0 voltage is given to the base of BC557 for short time. This sets BC557 conducting and 5V appears at the output.

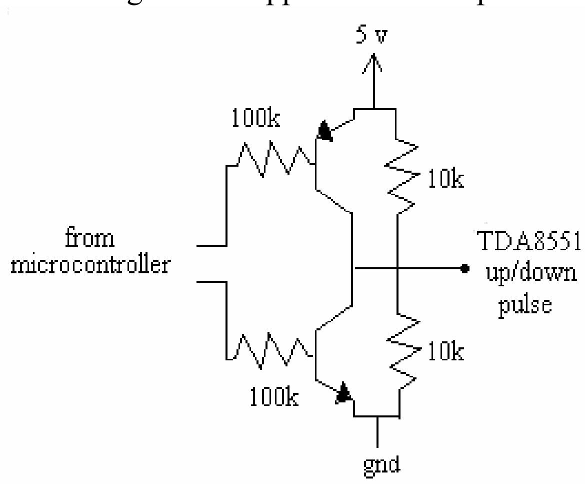

Fig 5 Transistor pair circuit to give up/down pulses to TDA8551

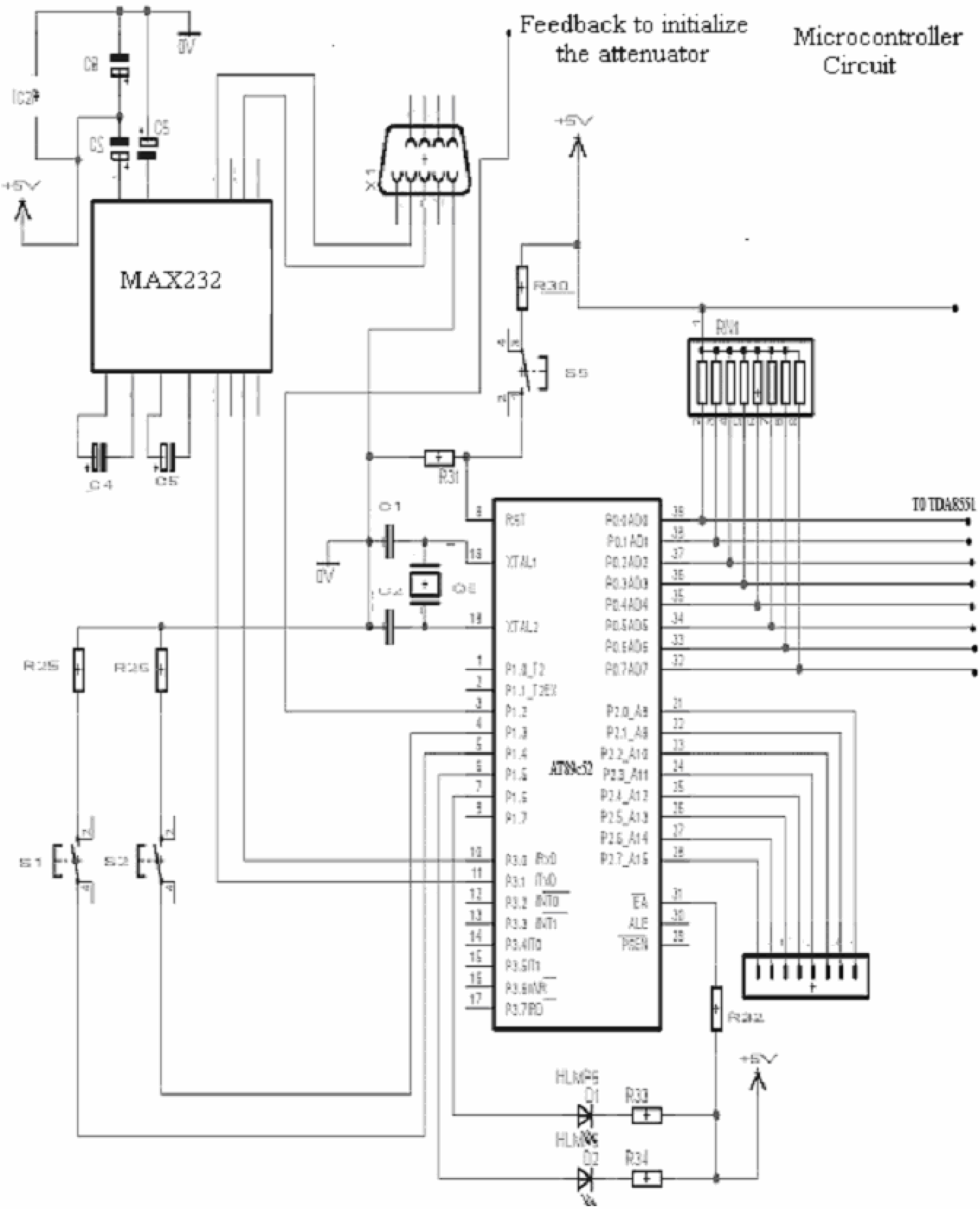

Fig 6 A schematic of microcontroller circuit and serial communication

4.3 Auto calibration feedback circuit

The IC LM324 operational amplifier is used for comparing the output of first TDA8551 in cascaded attenuator with reference voltage obtained by voltage divider circuit as shown in figure 7. This voltage divider gives reference voltage 3.33V to the comparator. The output of first attenuator is audio signal riding on 2.5 V DC. Hence, when amplitude of audio signal output just becomes greater than (3.33-2.5=0.83V) then comparator switches from 0V to 5V and thus gives logic 1 to microcontroller.

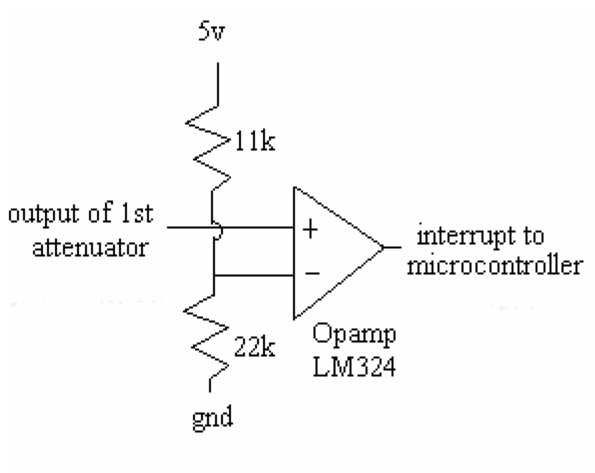

Fig 7 comparator for autocaliberation

4.4 Cascaded TDA8551 attenuator pairs

4.4.1 Details of TDA8551

TDA8551 is 1 channel audio power amplifier capable of delivering 1W output power to 8Ω load and operates on 5V voltage supply. It contains a digital volume control and standby/mute logic. The attenuation level can be changed by giving up or down pulses to pin number 1. Input is given at pin 4. Output is taken from pin 5 and 8. Pin diagram of TDA8551 is shown in figure 8.

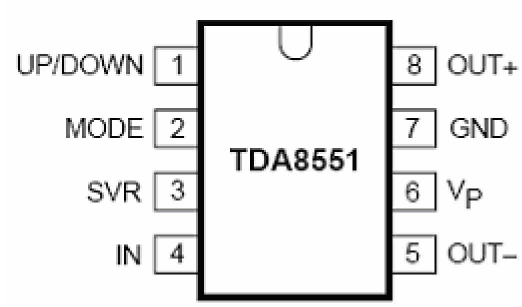

Fig 8. The pin diagram of TDA8551

4.4.2 Cascading TDA8551

Pin number 5 of TDA8551 is connected to the input of next attenuator. This signal is nothing but the attenuated audio input signal riding on 2.5V DC. Hence, coupling capacitor is used to bypass DC & pass only AC component of the signal fed to the input. Pin number 8 is used for auto calibration as described earlier and thus is given to comparator. Circuit diagram of cascaded circuit is given in figure 9.

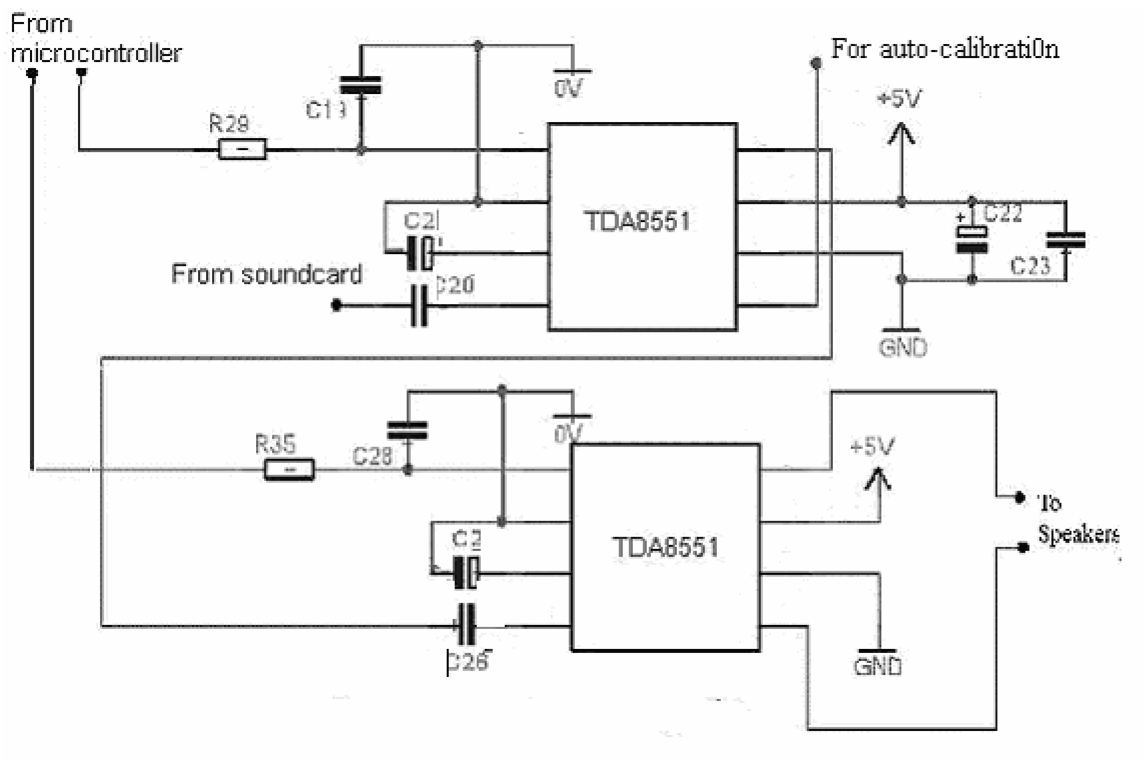

Fig 9. Schematic of two TDA8551 cascaded

5 Assembly

5.1) The top view of final product is as shown in figure 10.

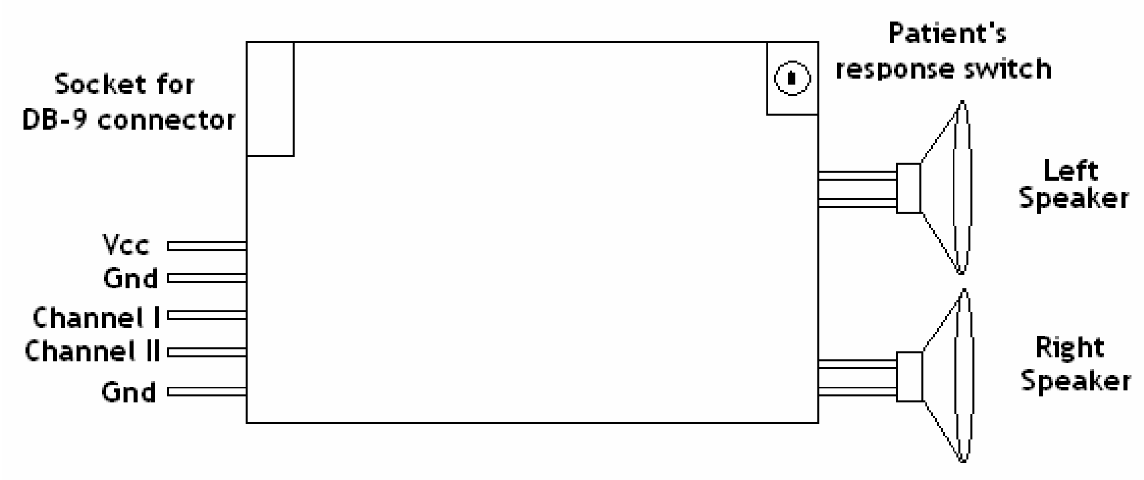

Fig 10 The top view of final boxed unit product

Component list

Attenuator circuit

1	capacitor	100nf	8
2	electrolytic capacitor	220uf / 25 V	4
3	electrolytic capacitor	100uf / 25V	4
4	capacitor	330nf	4
5	resistance	2.2k	4
6	TDA8551		4

Transistor switch circuit

1	npn	BC548 4	4
2	pnp	BC557 4	4
3	resistors	10k	3

Serial Communication circuit

1	electrolytic capacitance	10uf / 25V	5
2	IC max232		1
3	F09H serial port socket		1

Microcontroller circuit

1	microcontroller	AT89C52	1
2	crystal oscillator	10.059Mhz	1
3	capacitor	33pf	2
4	SIP resistor (9pin)	10k	1
5	resistance	1k	6
7	resistance	10k	1
8	8 pin IC socket		1
9	red LED		1
10	green LED		1

Comparator circuit

1	LM324		1
2	resistor	22k	3
3	resistor	220	3

7. Conclusion

PC 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

References

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