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Screening Audiometer

Group No. D05

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Abstract **-** Screening audiometer is an electrical instrument for early detection of hearing losses of an individual. It gives sinusoidal acoustic output with easily selectable frequency and level (calibrated in dB HL). The instrument developed in this project provides test tones of 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, with intensity variable between 0 to 60 dB HL in 1.25 dB steps. The instrument permits its operation using 4 switches (frequency selection, increasing intensity, decreasing intensity, presence/absence of output). Frequency is varied in a circular manner by first switch. Second and third switches are used for increasing and decreasing intensity levels respectively. Fourth switch decides whether speaker output is present or not.

1. Introduction

The instrument developed in this project is a portable screening audiometer which could produce sinusoidal acoustic signals for the test frequencies of 250 Hz, 500 Hz, 1 kHz, 2 kHz and 4 kHz. Instrument displays frequency and level (in dB HL) on liquid crystal display (LCD). The design involves an Microcontroller (89C51), which gives controls to, tone generator (ICL8038) for frequency selection, attenuator (TDA8551) to set its level, display the values of frequency and level on a liquid crystal display (LCD). LEDs can be used instead of LCD for displaying selection of frequencies and attenuation level to reduce the cost of design but then current requirement for LEDs will be more. As conversion efficiency of speaker depends on frequency of operation, the microcontroller also stores a look-up table for frequency vs. level, and decides number of UP/DOWN pulses to be given to attenuator on the basis of table entries.

2. Design Details

2.1 User Interface

Though the human audible range is from 20 Hz to 20 kHz but most of the audible spectrum lies between 300 Hz to 4 kHz. 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz are common for audiometers available in market. Our product also produces tones of these 5 frequencies. Frequency can be changed by a switch provided. Out of 0, 20, 40, 60 dB HL, output levels can be selected by varying the signal attenuation using two switches for increasing and

decreasing levels respectively. Whenever the frequency or attenuation is changed by the user, the new output will be presented when the fourth switch is pressed.

Main part of digital circuit in figure 5 is microcontroller 89C51 which uses a 12 MHz crystal as clock and 5 V supply. Switches have been connected to port 1 of microcontroller so as to give input to the audiometer. One switch is for frequency selection, two are for increasing and decreasing attenuation, and fourth button decides whether speaker output is present or not. Port 0 gives input to both ICL8038 (function generator) and TDA8551 (volume controller). Port 2 and Port 3 pins are used for input to LCD.

2.2 Tone Generator

ICL8038, waveform generator, produces high accuracy sine, square, triangular, saw-tooth and pulse waveforms. Frequency can be selected externally from 0.001Hz to more than 300 kHz by providing a variable input DC voltage at pin 8 (measured from pin 6). The duty cycle of waveform can be adjusted with the external resistors. The output obtained from ICL8038 shows low distortion of 1% for sinusoidal output. The supply voltage range varies from ±5V to ±15V. One of the advantages of this chip is that it shows very small drift in frequency over a large range of temperature variation (120 ppm per degree centigrade with a temperature range of 0 degrees to 70 degrees celsius).

In this design, ICL8038 has been selected for sine wave generation of variable frequency as output frequency can be changed by varying voltage. The design works for frequencies between 250 Hz to 4 kHz. The frequency selection has been made discrete by providing different voltages input to IC to generate 250 Hz, 500 Hz, 1 kHz, 2 kHz and 4 kHz. A resistor network has been made for providing variable input voltage.

The oscillator is the standard ICL8038 based oscillator circuit as shown in figure 3. Range of output frequency is decided by R2. Duty cycle is decided by the two resistors R1 and R2 on pin no. 4 and pin no.5 respectively as shown in the circuit and the resistor R3 on pin no. 12 is used for distortion control of the output waveform. The input to the chip has been given at the pin no. 8 and difference of voltages between pin no. 8 and power supply at pin no. 6 selects frequency. As the difference of voltages between these two pins increases, frequency also starts increasing. The circuit has been designed to work for 250 Hz to 4 kHz and the frequencies can be digitally selected by choosing the respective voltages, which is governed by the resistance network connected to the microcontroller. The main problem with this IC is, it consumes a supply current of 15 mA which is on the higher side for battery operated devices.

2.3 Attenuation Level Control

TDA8551 (figure 4) is a 1 channel audio power amplifier, capable of delivering 1W output power to an 8Ω load using a 5V supply voltage. Using the MODE pin, device can be switched to standby condition, mute condition or normal operating condition. It is in standby mode if the voltage at “mode” pin is between 4.5V and 5V. At a voltage level less than 0.5 V, the amplifier is fully operational. In the range between 1V and 3.6V, the amplifier is in mute condition. In mute condition, output signal gets suppressed with attenuation level remaining same. The volume level is changed by UP/DOWN pulses. Every up pulse is from 2.5 V to 5V and down pulse is from 2.5V to 0 V. In maximum volume control setting, attenuation is 0 dB and in the minimum volume control setting, it is 60 dB, although we can go for attenuation levels as low as 80 dB. The attenuation can be set in 64 steps by the UP/DOWN pin, each step of 1.25 dB. Maximum time for level change is approximately 12 seconds. If the UP/DOWN

pin is floating, it means volume will remain unchanged, the negative pulses starts setting volume towards minimum, while positive pulses lead to increase in volume. When the supply voltage is initially connected, the initial state of the volume is an attenuation of 40 dB, with a total gain of -20 dB. Initially at the start of operation, 16 DOWN pulses have been given to maximize attenuation to 60 dB.

Selection of attenuation levels are based on the chip TDA8551, which has a digital volume control, contains an inbuilt power amplifier and gives 1W output power to 8 ohm speaker. The chip is being used in operating mode and input sinusoidal signal comes from function generator. This chip is capable of varying gain from 20 dB to -60 dB in 64 steps of 1.25 dB each. This IC reduces the cost of design as separate amplifier is not needed.

2.4 Power Supply

The instrument designed in this project involves a 9V battery and 5V voltage regulator (LM7805) for the purpose for power supply. Function generator and operational amplifier need -5V for their operation, and this is done by switched capacitor voltage converter, ICL7660 (figure 2). Current requirements vary from 56 mA (at minimum level of 250 Hz) to 460 mA (at maximum level of 4 kHz).

LM7805 is a 3-terminal positive voltage regulator with internal thermal overload protection, and can deliver in excess of 500 mA output current. ICL 7660 is CMOS switched capacitor voltage converter that performs supply voltage conversions from positive to negative for input range of 1.5 V to 10 V resulting in complementary output voltages of -1.5 V to -10 V. They deliver 10 mA range with a 0.5 V output drop. Applications include generating -5 V supply from +5V logic supply to power analog circuitry.

2.5 Component List

IC Requirements:
1. AT89C51 microcontroller
2. TDA8551 having digital volume control
3. ICL8038 Waveform generator
4. ICL7660 Switched Capacitor voltage converter
5. LM741 Operational Amplifier
6. Liquid Crystal Display (JHD 162A)

3. Observations

TABLE 1: Voltage input to ICL8038 for frequency generation and experimental frequency

Sr. No.	Set Frequency	Control Voltage (in Volts)	Experimental Frequency
1	250 Hz	4.905	220 Hz
2	500 Hz	4.769	525 Hz
3	1 kHz	4.587	1 kHz
4	2 kHz	4.242	2 kHz
5	4 kHz	3.460	3.850 kHz

4. Conclusion

Screening audiometer designed is a portable device, and can be used for early detection of hearing losses. The device is a digitally operated product which makes it easier to handle. There are 5 frequencies and 4 levels available in the product, which are selectable by switches provided. One switch controls frequency, second and third switches increase and decrease attenuation respectively, while fourth switch controls the presence or absence of output on speaker. Portability makes it available for performing the test almost everywhere.

5. Future Scope

There can be variations in designing audiometers from this design. Some of them are listed below:

1. Digital synthesizer IC's are an alternative option for tone generation of variable frequency. They work on a single supply of 5V. ICL7660 converts 5V to -5V but the output contains ripples which results in ripples in sine waves. There wouldn't be any need of negative supply, if digital synthesizers are used.
2. Improvement can be made for power supply voltage level stabilisation. Variations in power supply marks in increased changes in frequency of signals generated by ICL8038 as it is highly sensitive to voltage fluctuations.

6. References

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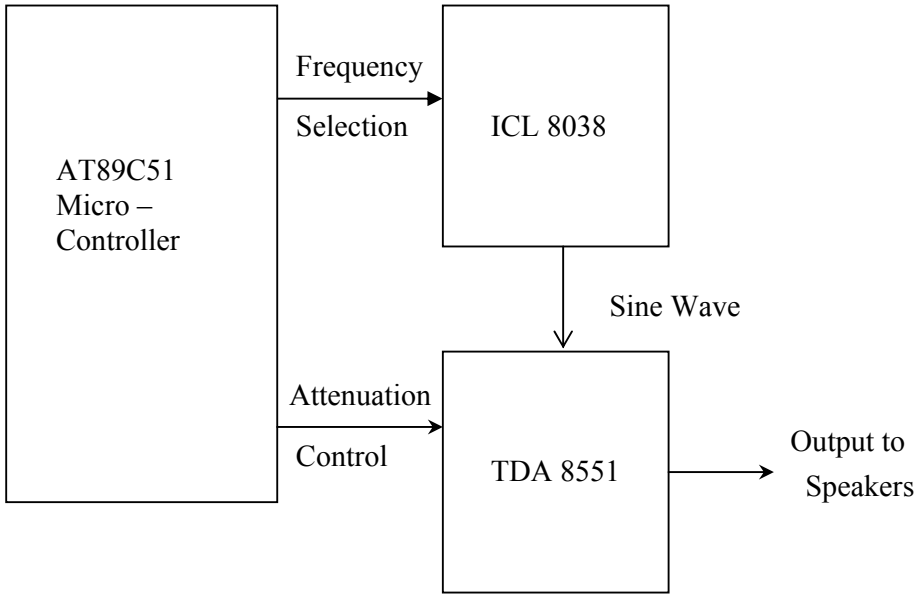

Figure 1: Block Diagram of Screening Audiometer

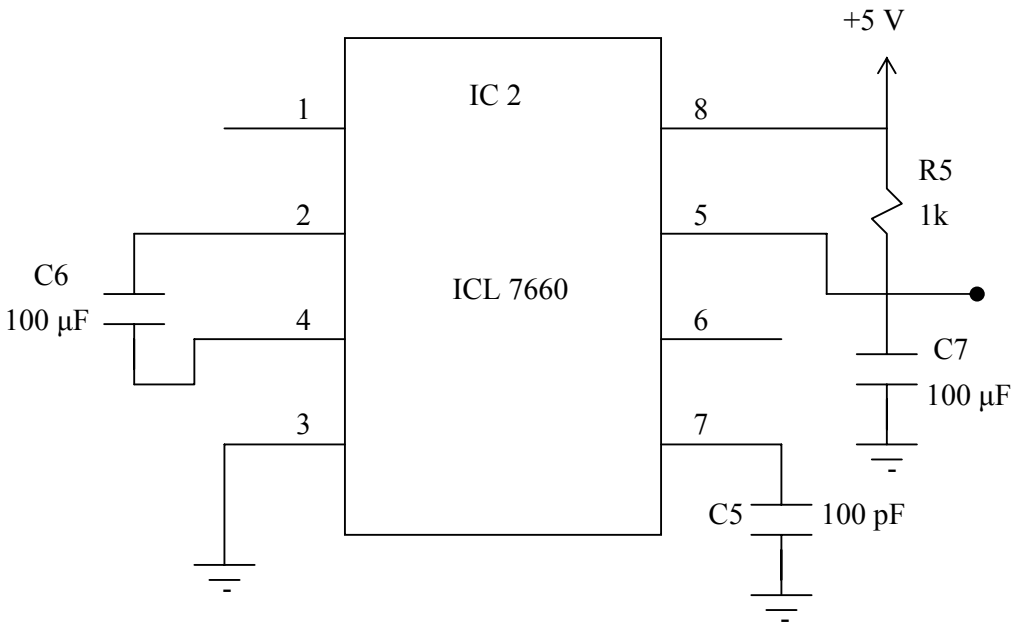

Figure 2: Switched capacitor voltage converter

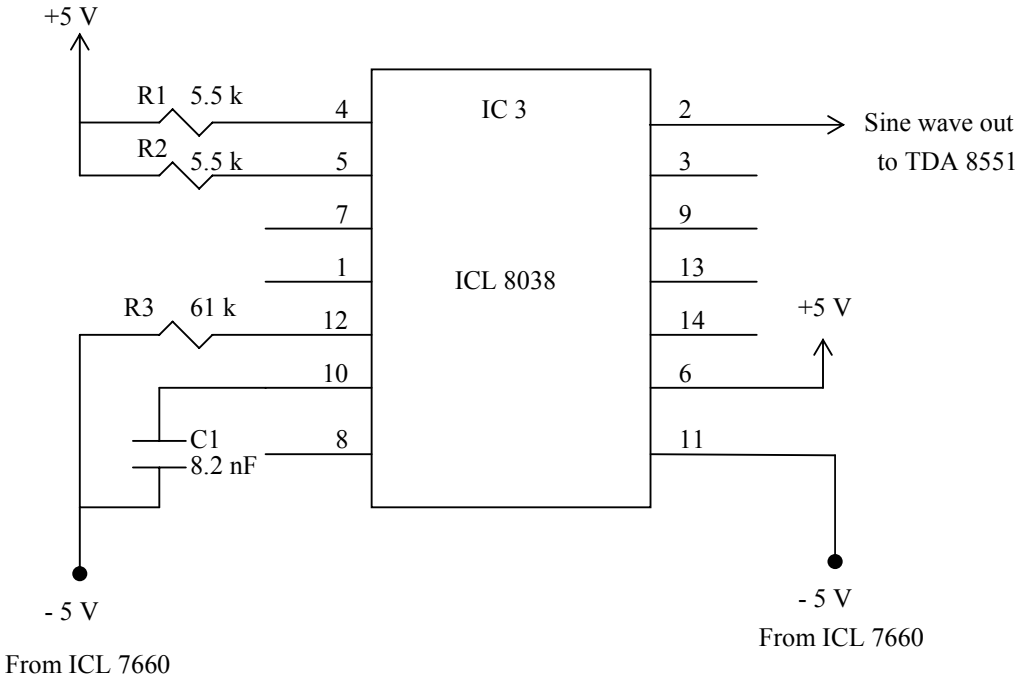

Figure 3: Waveform Generator

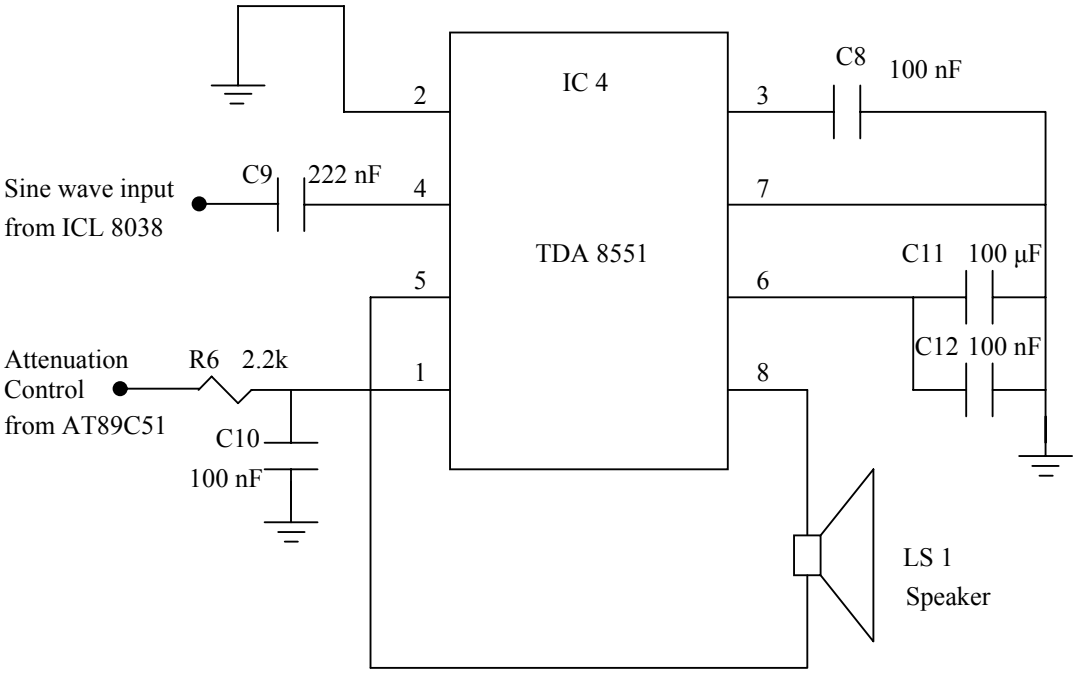

Figure 4: Volume Controller

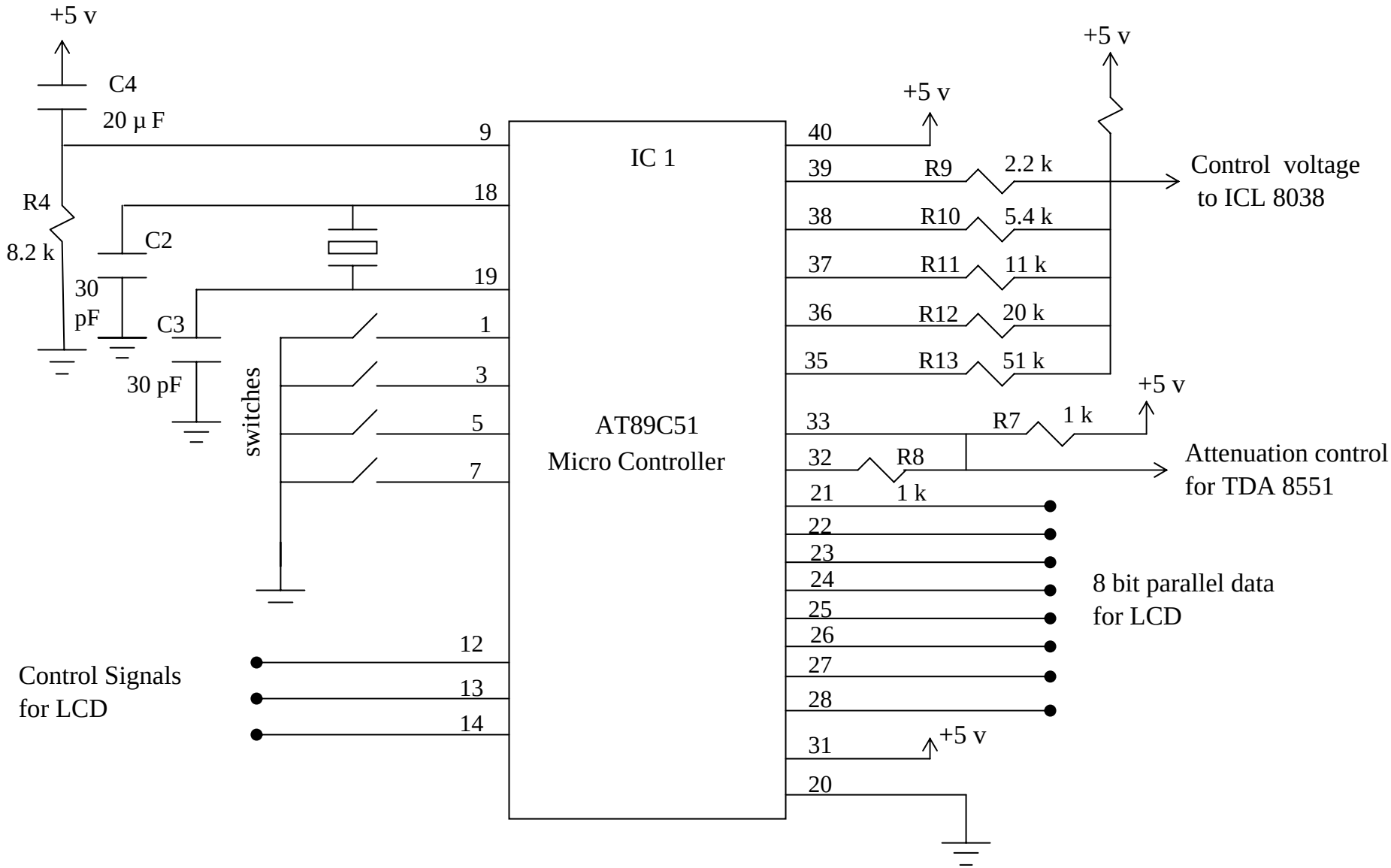

Figure 5: Schematic of Digital Module