MICROCONTROLLERS PROJECT REPORT

HEART PULSE RATE COUNTER USING 8051 MICROCONTROLLERS

Report submitted by-

LAVANYA GUNE – 19BEC0367

TALIB ZAFAR – 19BEC0515

TABLE OF CONTENT-

ABSTRACT-

The pulse rate or heart rate is one of the critical parameters of human cardiovascular system. Heart rate is defined as the number of times the heart beats per minute. The knowledge of heart rate helps us to know various states of the body such as concentration, stress, drowsiness and the active state of the autonomic nervous system. This project underlines the design of heart rate monitor system using 8051 microcontroller and Optical sensor. The circuit is designed in order to calculate the heart rate at the fingertip based on the change in blood volume. The finger is placed on the optical sensor and the intensity of reflected light is measured to calculate the heart rate. The result is then displayed Using 3 one digit seven segment displays connected with help of BJT to 8051 microcontroller.A buzzer used to warn in case of abnormality(BPM less 60 or more than 100 for a normal resting person)

INTRODUCTION-

The Heart Rate monitoring device is personal device that allows to measure the heart rate in real time. The heart rate of a healthy adult at rest is around 72 beats per minute(bpm). Athletes have lower rates than less active people while babies have a higher rate at around 120bpm. The readings rise gradually during exercises and returns back to the normal value slowly after exercise. The rate at which the pulse returns to the normal value indicates the fitness level of the person. There is a scientific word known as **Bradycardia** which refers to the condition where lower than the normal heart rate is present. Opposite to that is **tachycardia** referring to higher than the normal heart rate. More than 2 million people are at risk of heart attack. In recent times most of the patients who recovered from covid have experienced heart troubles due to the heavy medication and ventilation methods used. It would be helpful if these people can check their heart rate easily at low cost and stayed updated with their health condition.

Especially for cardiac patients, long-term monitoring plays a pivotal role. It provides critical information for preventive diagnosis for which signal patterns and long-term trends are of special importance. It is difficult to identify patterns using traditional examinations for those cardiac problems that occur customarily during normal daily activities but disappear the moment the patient is hospitalized. This results in diagnostic difficulties and consequently possible therapeutic errors. Real time monitoring is a boon to such patients. For this project AT89S51 microcontroller is used. The device identifies the heart rate from the fingertip using IR reflection method and displays it on a three-digit seven segment display in beats per minute.

METHODOLOGY-

The methodology adapted for this project is referred to as photoplethysmography in medical terms.

Photoplethysmography is the process of optically evaluating the volumetric measurement of an organ. Cardiovascular monitoring, pulse oximetry, heart rate monitoring, respiration detection are some common applications of photoplethysmography. Photoplethysmography plays an important role in heart rate monitoring from the fingertip.

The volume of blood inside the fingertip increases when the heart expands (diastole) and the volume of blood inside the fingertip decreases when the heart contracts (systole). The resultant pulse of blood volume inside the fingertip is directly proportional to the heart rate. Aim is to count the number of pulses in one minute, that’s the heart rate in beats per minute (bpm).

CNY70 optical sensor is preferred as it has super-bright intensity because of which maximum light will pass and spreads if a finger placed on the it and be detected by the detector. For this an IR transmitter/receiver pair placed in contact with the fingertip. When the heart beats, the volume of blood cells under the sensor increases and it becomes opaquer. This reflects more IR waves to sensor. When there is no heart beat the intensity of the reflected beam decreases. The pulsating reflection is converted to a suitable current or voltage pulse by the sensor.

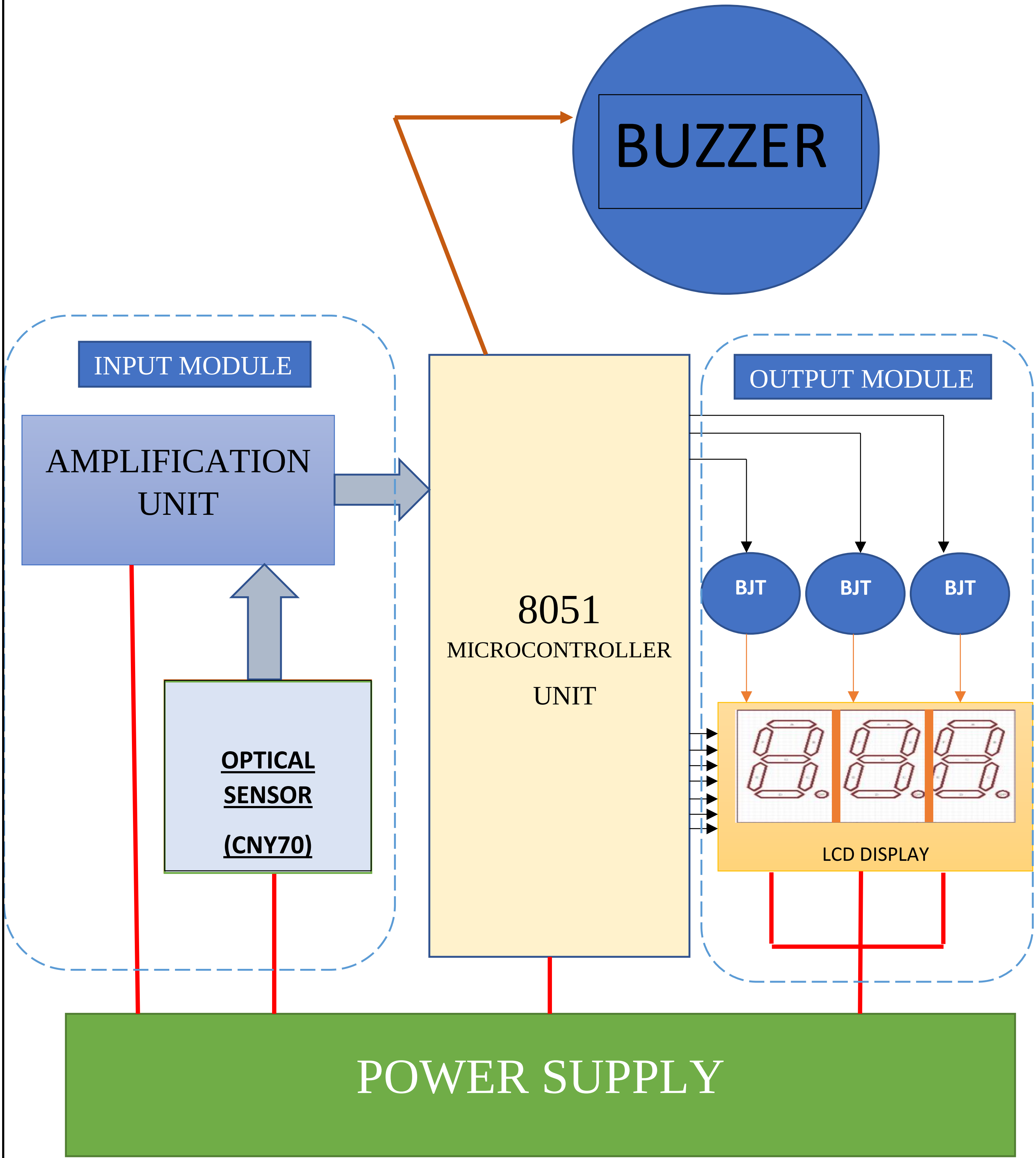
In case the BPM falls below the 60 or goes over 100 the buzzer is turned ON and it keeps ringing for the time BPM is displayed.

COMPONENTS REQUIRED-

1. **8051 MICROCONTROLLERS** (AT89S52)- AT89S52 is a typical 8051 microcontroller produced by Atmel Corporation. This Microcontroller is the brain of this project as it controls all the operations of the circuit such as reading pulses data from the heartbeat sensor.
2. **CNY70(optical sensor)-** CNY70 is used as a photoplethysmography sensor. It is a pair of photo transistor and IR diode. It has a sensing distance of 0.197" (5mm), with maximum collector current of 50mA and operating temperature of -40°C ~ 85°C. the wavelength used is 940nm.
3. **Power supply-** The circuit works on a minimal supply of 5 volts. This will make it portable.
4. **LCD:** This project uses 3 ONE DIGIT SEVEN SEGMENT lcd units to display the pulse rate in bpm (beats per minute). The selection of display depends on considering these parameters: cost of displays(red lcd being cheapest), power consumption, and ambient lighting conditions.
5. **Resistors:** Resistance is the ratio of the voltage applied across its terminals and the current passing through it. The resistor value depends on a fixed voltage that limits the current passing through it.it acts as a blockage in the path of current
6. **Capacitors:** The main purpose of a capacitor is to store charge. The product of the capacitance value and the voltage applied across a capacitor is equal to the charge stored in the capacitor.
7. **Crystal Oscillator:** oscillator circuit may be a defined as an electronic circuit that produces use of the mechanical resonance of a moving circuit used for generating electrical signals by variable frequency. AT89S52 microcontroller uses the crystals for synchronizing its operation. This synchronization is referred to as machine cycle.

8. Two **active low pass filter**s using op amp LM324. LM324 is a quad op amp that is operated from a single rail supply. Two Resistor and a capacitor sets the gain and cut off frequency of the first filter. By varying the component values, gain is set to 11 and cut off frequency will be 2.5Hz. It is a Dual-in-Line Packaged Quad processor which consists of four independent, high gain, internally frequency compensated operational amplifiers which are specifically designed to operate on single power supply over a wide voltage range

BLOCK DIAGRAM-

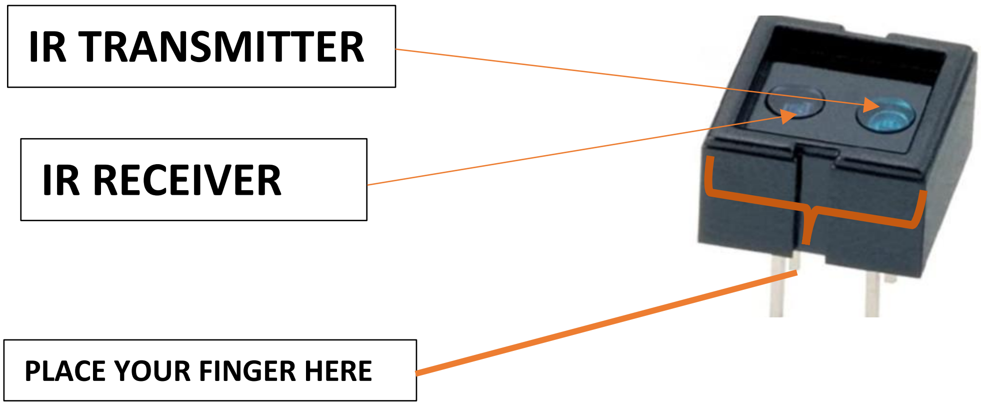


This block diagram can be divided into three parts-

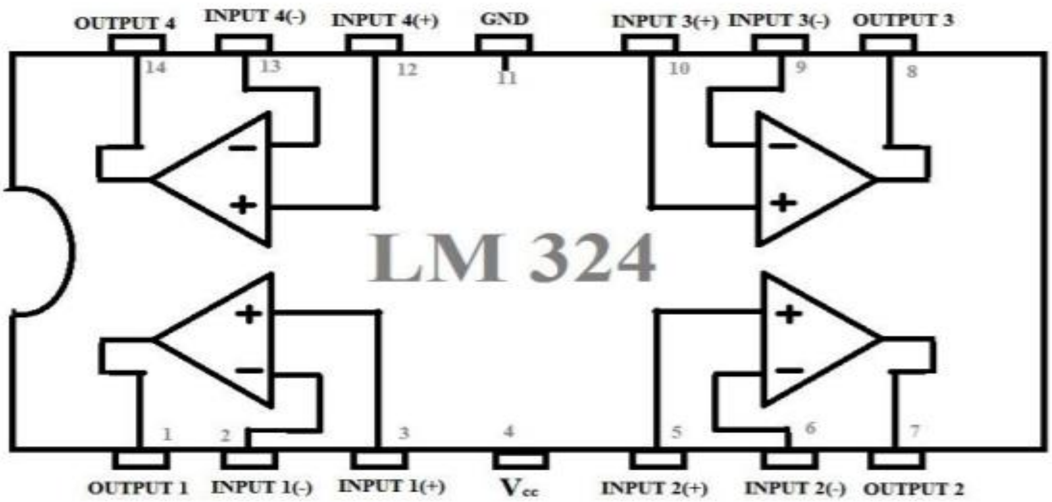
1. Input module
2. Microcontroller
3. Output module

<u>INPUT MODULE- </u>To take the reading using a sensor and amplify it

A. OPTICAL SENSOR(CNY70) - TO TAKE READING FROM FINGER

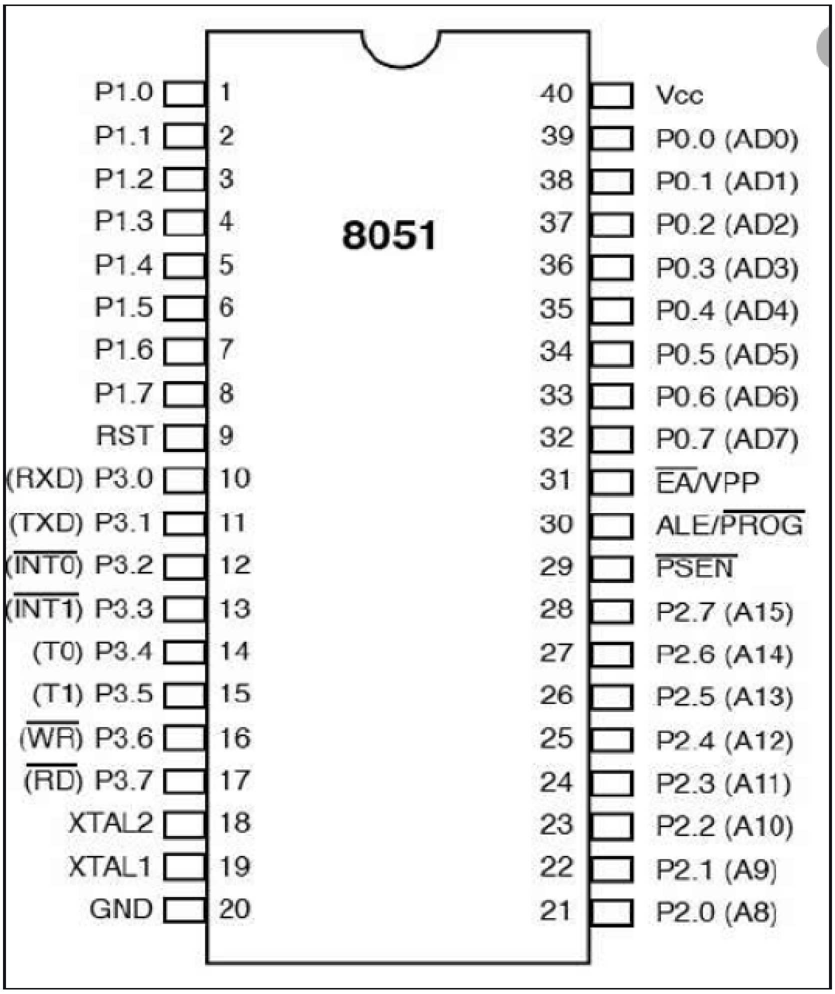


B. LM324- HELPS IN AMPLIFICATION OF SIGNAL



MICROCONTROLLER UNIT-

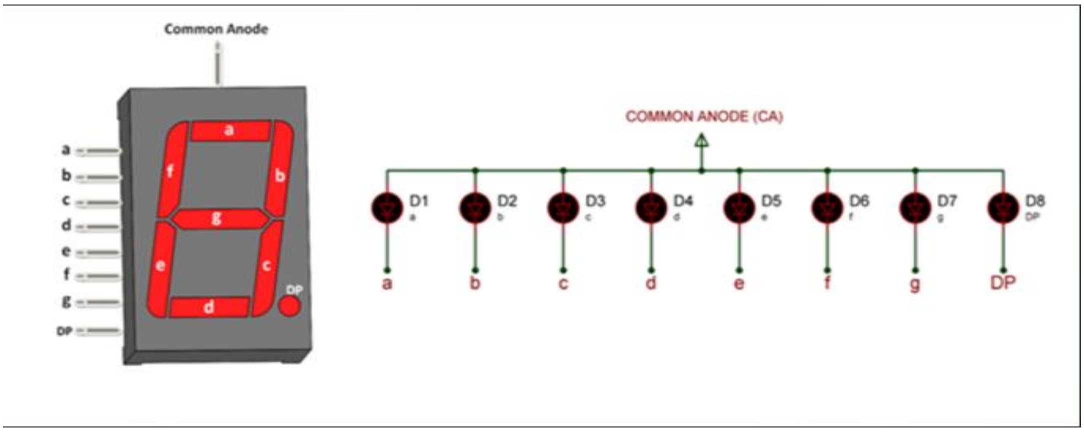
Consisting of an 8051 microcontroller. It has an 8-bit accumulator and 8-bit ALU thus making it an 8-bit processor. This unit also uses a crystal to generate clock frequency. This crystal has been specifically selected to have 11.0593MHz of frequency and the timer and delay programs have been generated taking this into consideration.



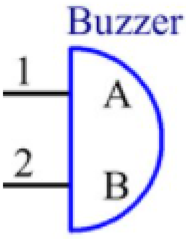
OUTPUT MODULE-

To display the output after calculation on a seven segment 1-digit display. Three LCD are used to provide a 3-digit output, LCD screen is switched using a BJT operating in cut-off and saturation mode. The Red colour one is universally used since it consumes less current than other colours.

A. **LCD DISPLAY-**



B. BUZZER-

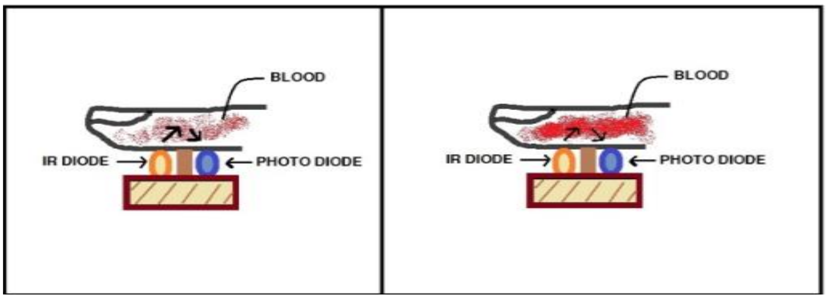


Buzzer is normally used for giving indication and normally this indication is of a warning. Proteus has a built-in component for buzzer and it gives a sound (beep) when it’s turned ON, the buzzer may be a sounding device which will convert audio signals into sound signals. Its usage widely ranges in alarms, microwaves and other electronic products as sound devices. It is of 2 types namely: piezoelectric buzzer and electromagnetic buzzer and they are represented by the letter "H" or "HA" in the circuit. As compared to the magnetic buzzer, the piezo buzzer is a voltage-driven device. The operating voltage is usually higher and will normally be between 12V and 220V, while the current is less than 20mA. The piezo buzzer is modelled as a capacitor.

ALGORITHM-

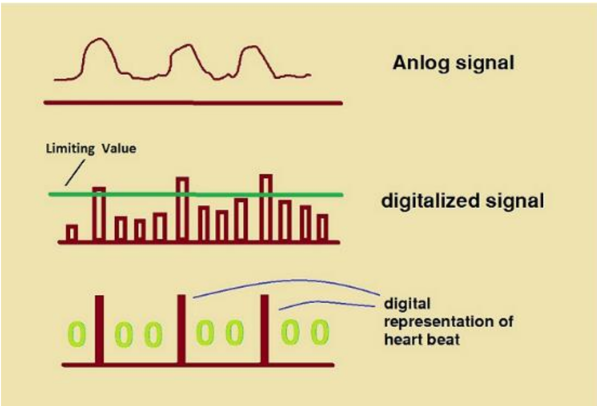
STEP1-

The reflected light is sensed using a photo transistor. Finger is placed between the transmitter and receiver probe of sensor. When more light falls on the photo transistor its conductance increases, so its collector current increases and so its collector voltage decreases. When less light falls on the photo transistor its conductance decreases, its collector current decreases and so its collector voltage decreases. This variation in the collector voltage is proportional to the heart rate.



STEP 2-

Signal received by the photo transistor is feeble and disturbed by high frequency noise. For this signal to be processed in Microcontroller, undesired noise needs to be eliminated. In addition, the signal level has to be raised to an acceptable level so that the spikes coming from the photo transistor every time the heart beats can be distinguished clearly in the Microcontroller.



For noise reduction and amplification purpose, three QUAD OP-AMP are used. Reflection method is used as it serves better performance. The received signal is passed through two consecutive filters to block dc components. Signal components below a defined cut-off frequency are amplified. For this amplification purpose OP-AMP LM324 with class A output stage is used that amplifies the original signal almost ten thousand times. Thus, high frequency components (ripple or noise) automatically get attenuated throughout this amplification process.

For this system we set the value of capacitors and resistors so as to get a gain of each stage is up to 101.The cut off frequency of the low pass filter, determined by 2.34 Hz. Corresponding maximum measurable heart rate is calculated as

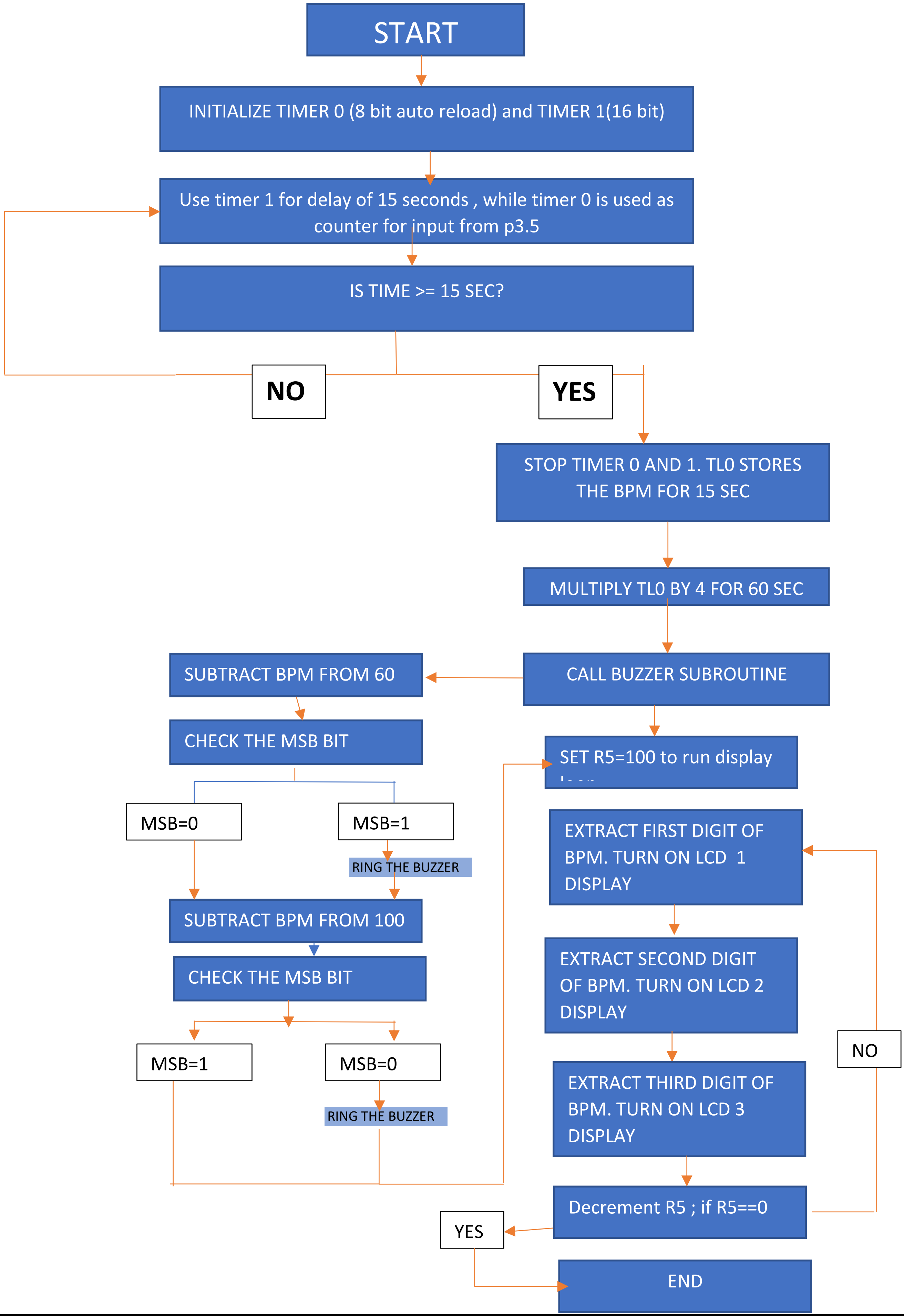
$$2.34\times60\sim=140 \text{ BPM.}$$

The attenuated signal is fed to the Microcontroller where the data processing is done by converting the analog signal to digital bits suitable for the Microcontroller to count the number of heart beats. The output of the filter stage will be a voltage level fluctuating between 0.05 volts and this fluctuation is converted into a 0 to 4V swing using the comparator based on the third op amp. The reference voltage of the comparator is 0.3V.

STEP 3-

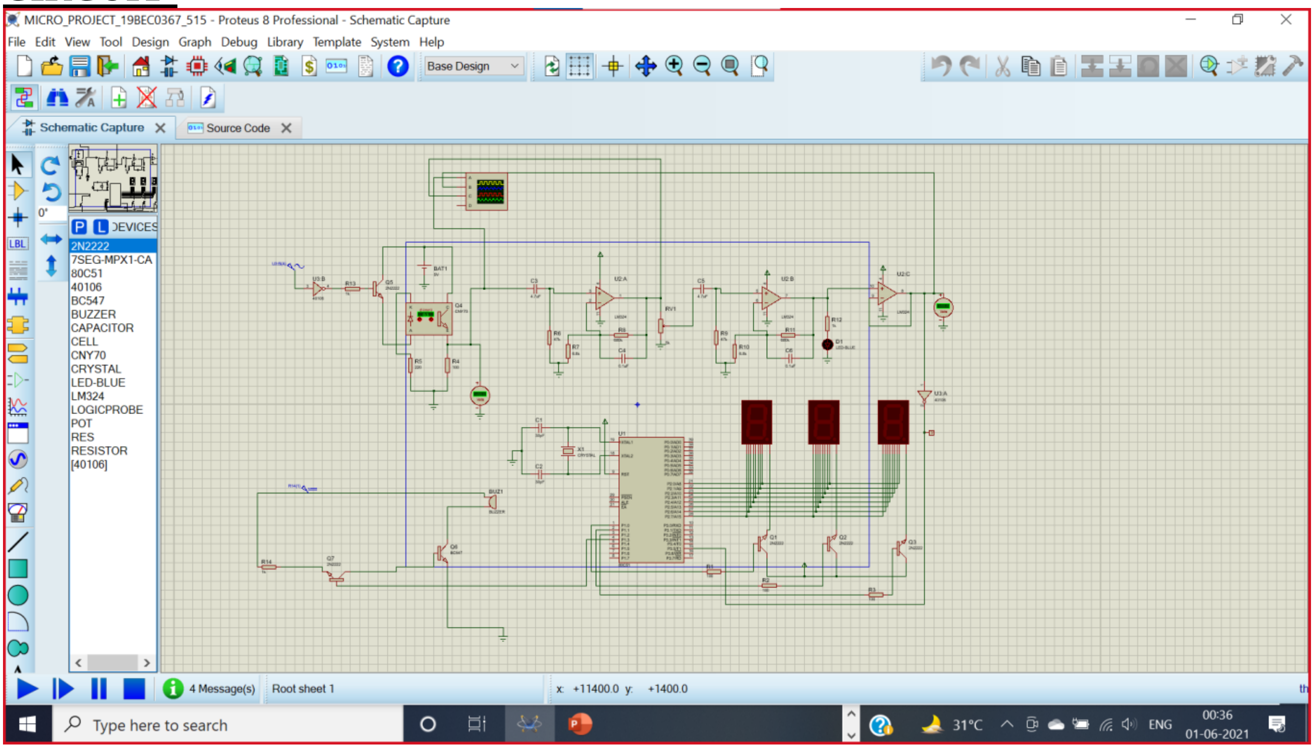
In this step the signal fed to the micro controller is processed. ADC (analog to digital processing) is performed first. 8051 core results in an improved instruction execution speed of between 1.5 and 3 times faster than the original core for the same external clock speed (4 clock cycles per instruction versus 12 clock cycles per instruction) This efficiency translates into an effective throughput improvement of more than 2.5 times, using the same code and same external clock speed. Each ADC operation takes a 1/(33khz) seconds.

STEP 4-

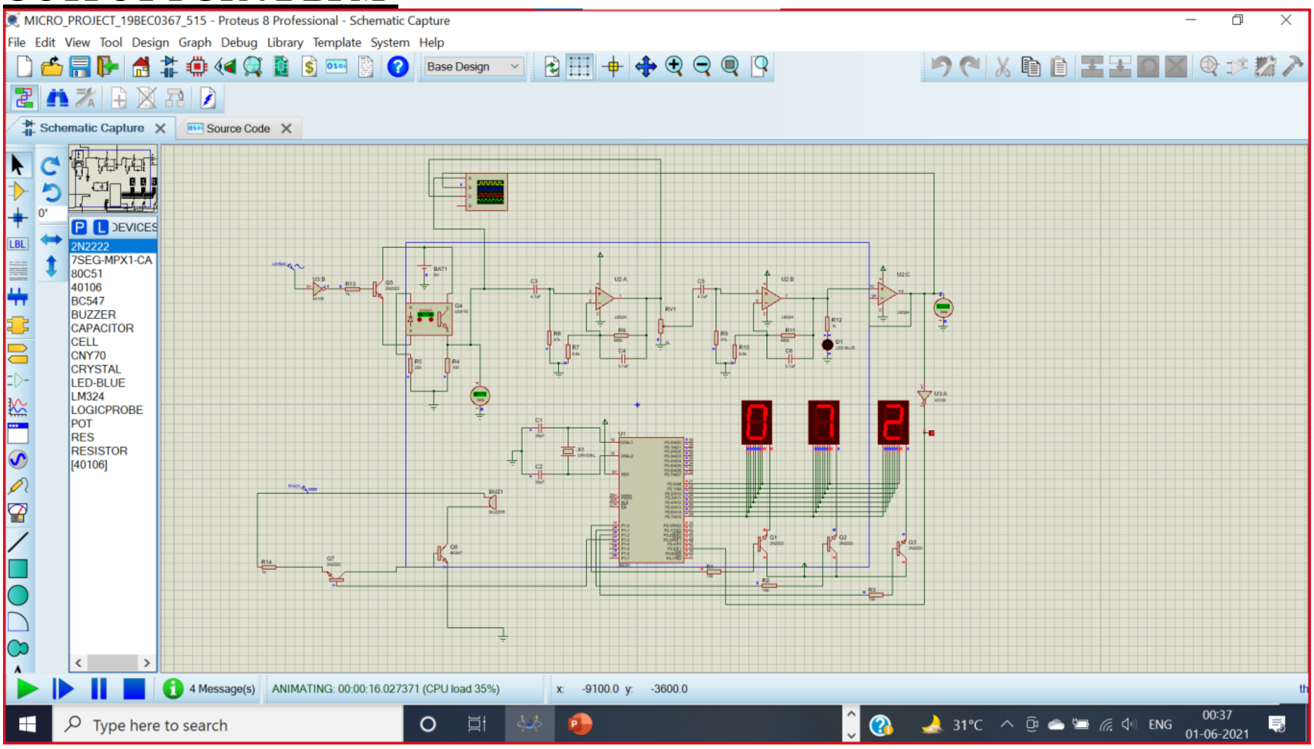

START
INITIALIZE TIMER 0 (8 bit auto reload) and TIMER 1(16 bit)
Use timer 1 for delay of 15 seconds , while timer 0 is used as counter for input from p3.5
IS TIME >= 15 SEC?
NO
YES
STOP TIMER 0 AND 1. TL0 STORES THE BPM FOR 15 SEC
MULTIPLY TL0 BY 4 FOR 60 SEC
CALL BUZZER SUBROUTINE
SUBTRACT BPM FROM 60
CHECK THE MSB BIT
MSB=0
MSB=1
RING THE BUZZER
SUBTRACT BPM FROM 100
CHECK THE MSB BIT
MSB=1
MSB=0
RING THE BUZZER
SET R5=100 to run display
EXTRACT FIRST DIGIT OF BPM. TURN ON LCD 1 DISPLAY
EXTRACT SECOND DIGIT OF BPM. TURN ON LCD 2 DISPLAY
EXTRACT THIRD DIGIT OF BPM. TURN ON LCD 3 DISPLAY
NO
Decrement R5 ; if R5==0
YES
END

SCREENSHOTS-(screen shots for output are corresponding to the values shown during review)

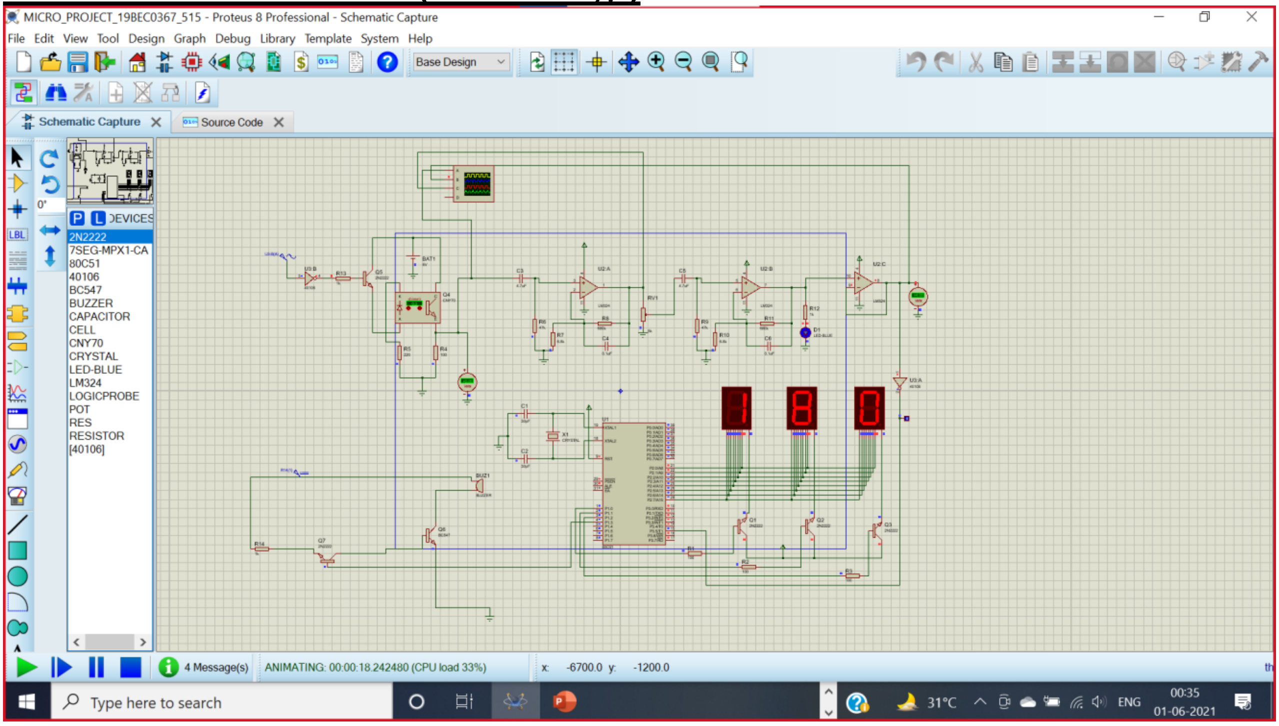
CIRCUIT-



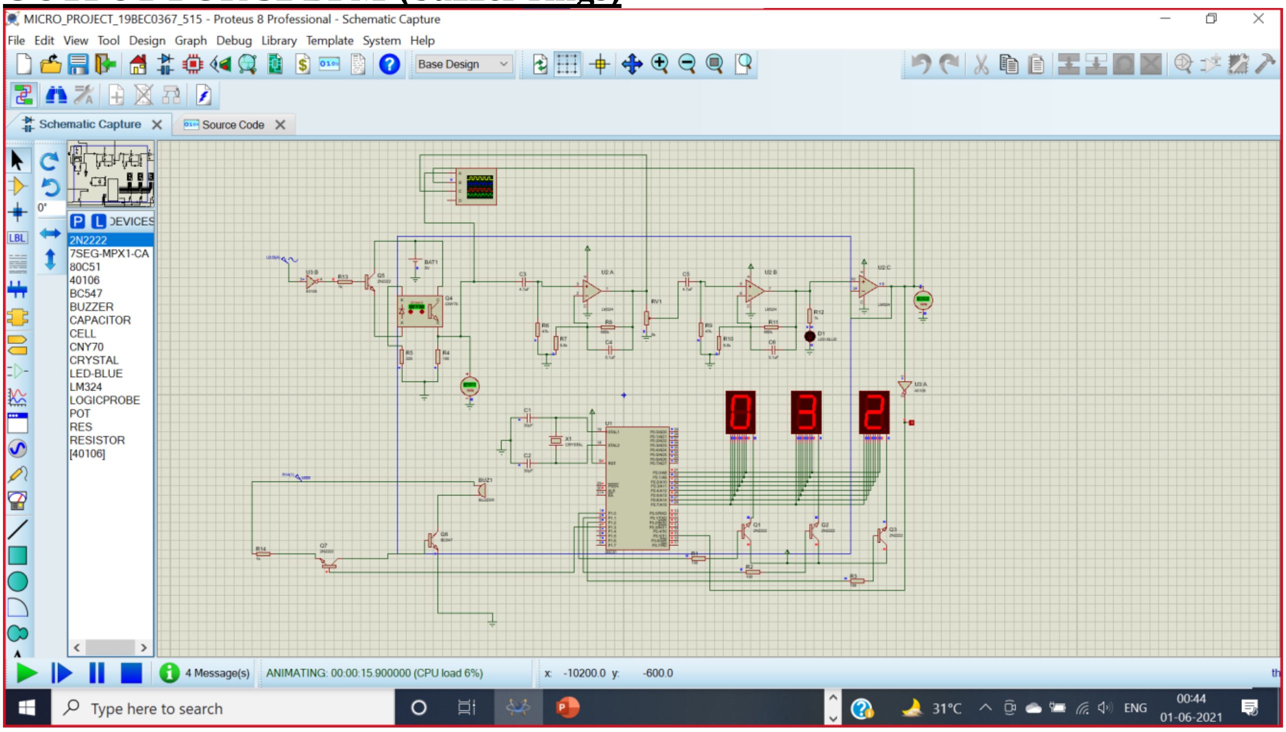
OUTPUT FOR 72 BPM-



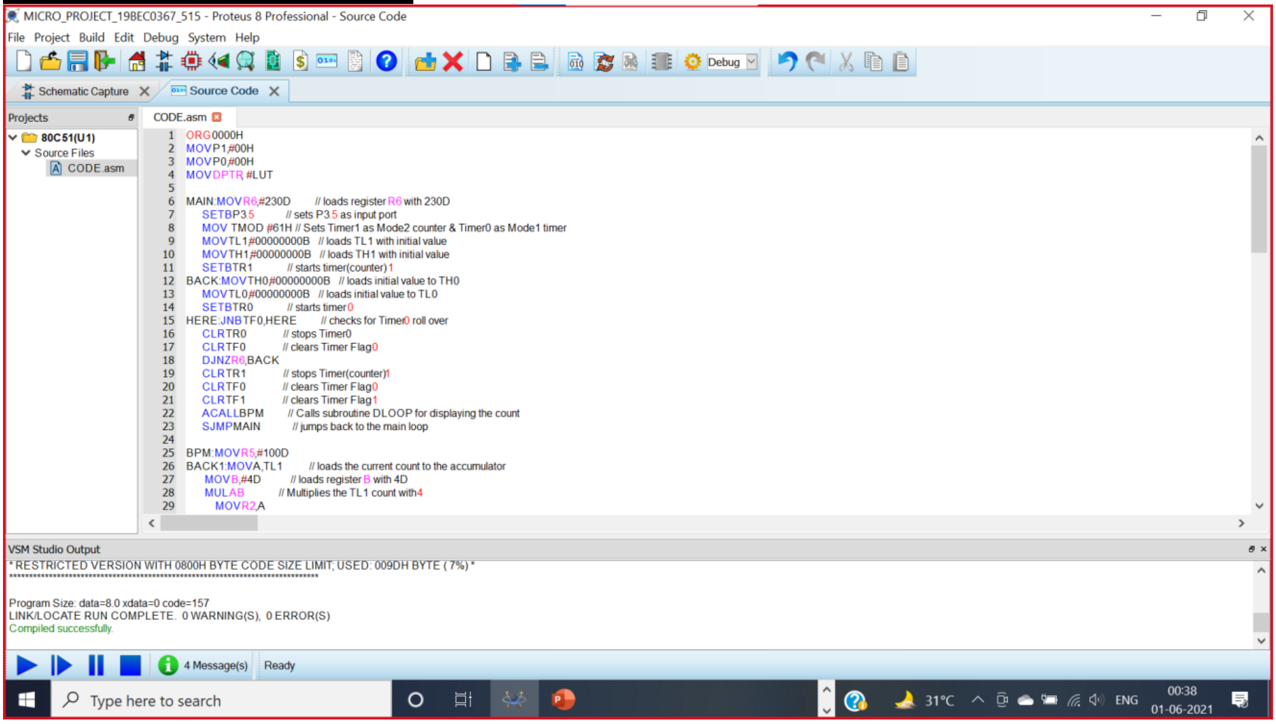
OUTPUT FOR 180 BPM-(buzzer rings)

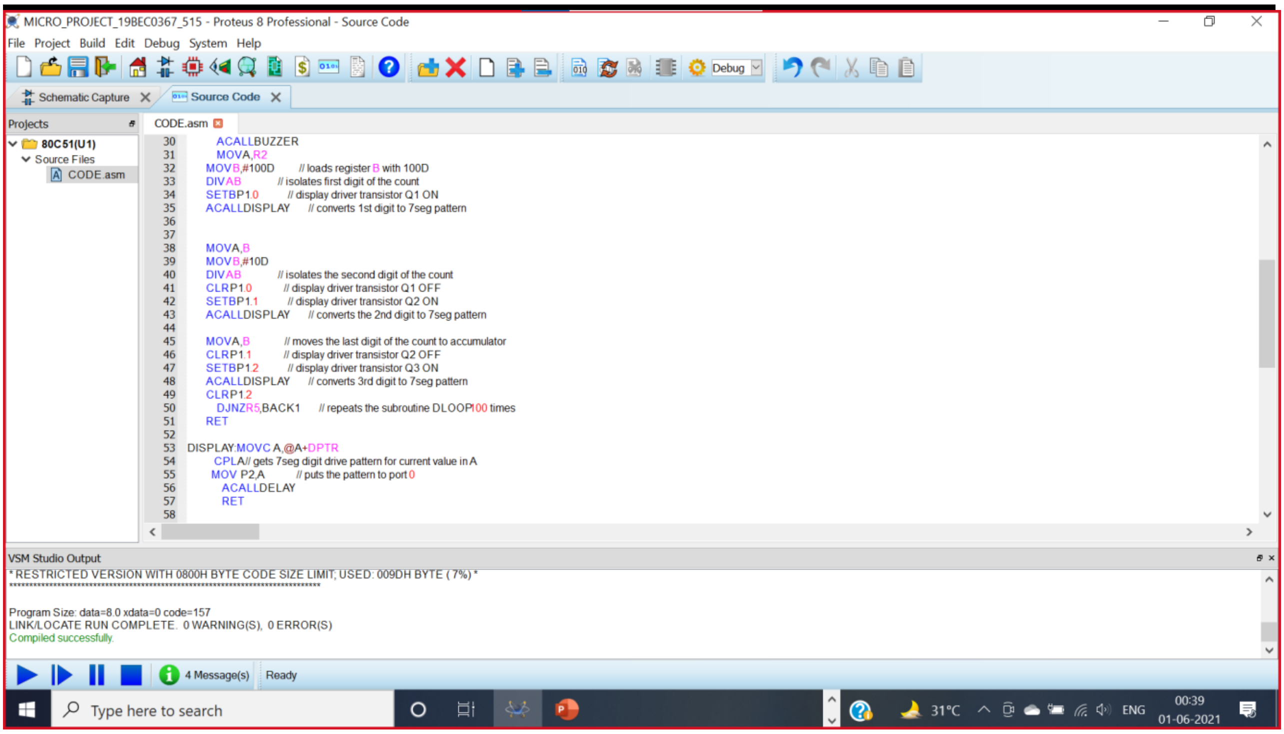


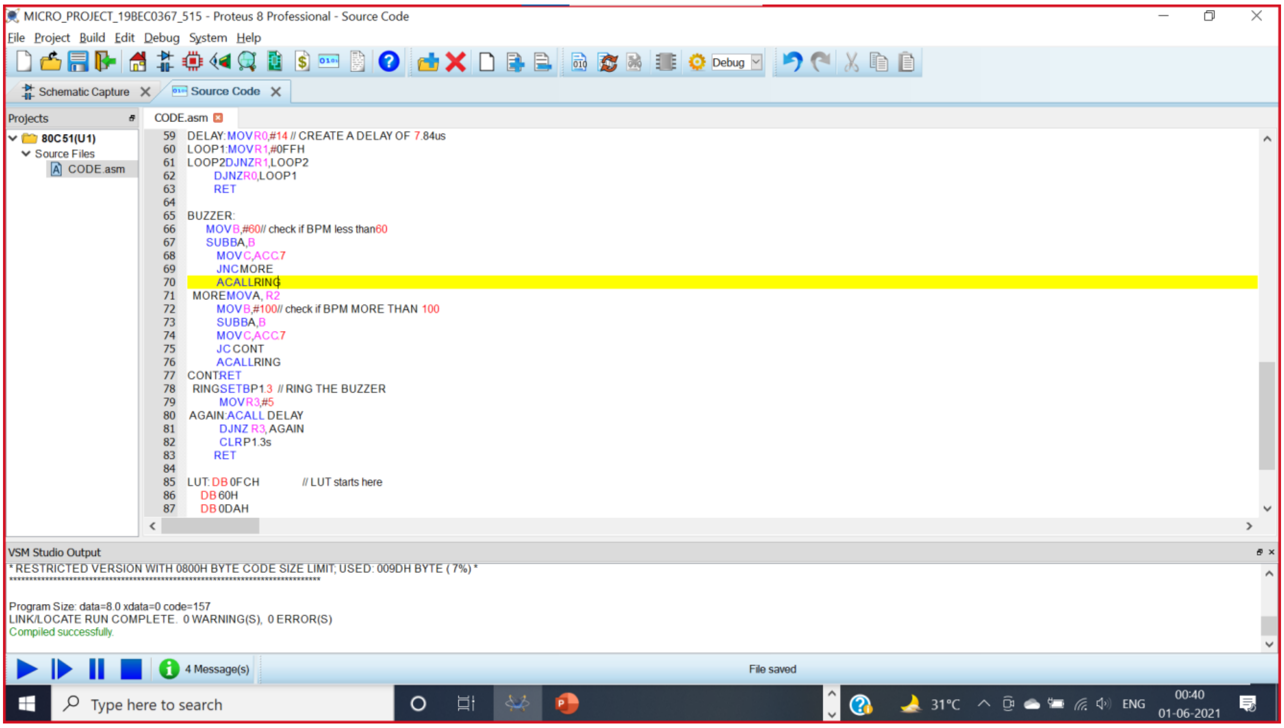
OUTPUT FOR 32 BPM-(buzzer rings)

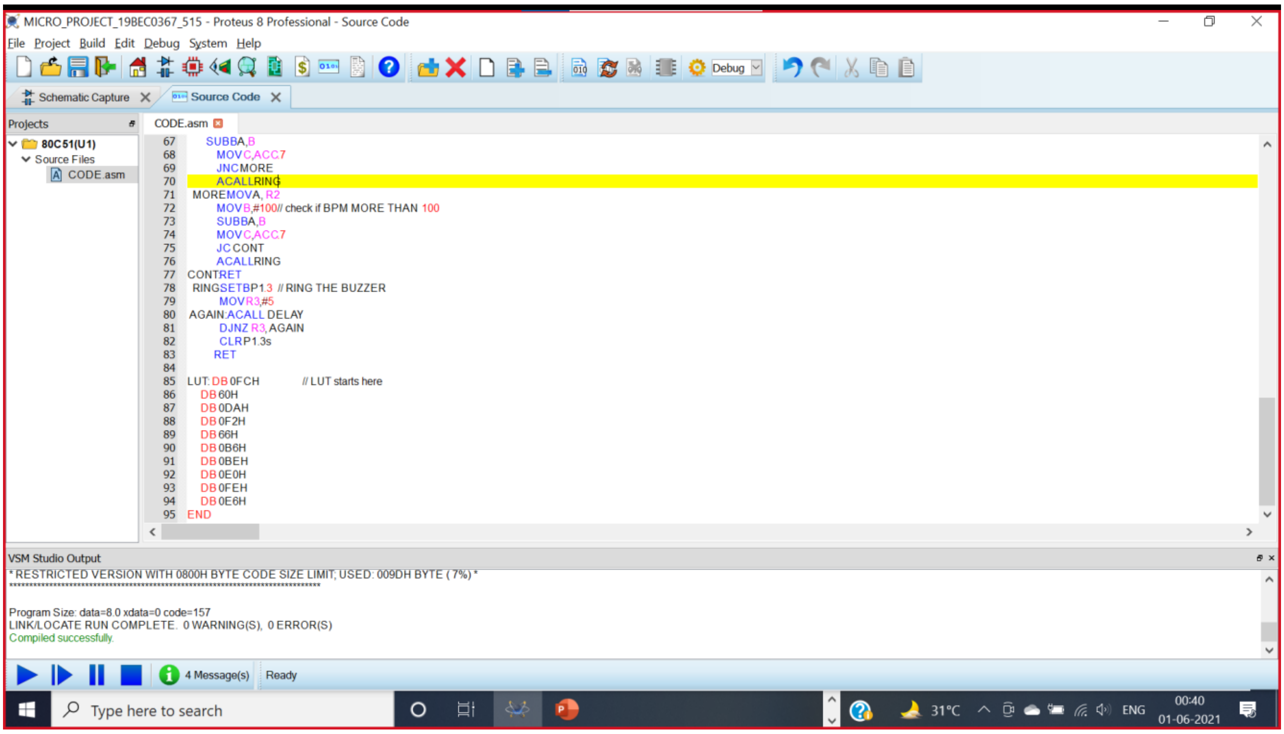


Code screenshots-






MICRO_PROJECT_19BEC0367_515 - Proteus 8 Professional - Source Code
File Project Build Edit Debug System Help
Schematic Capture
Source Code
Projects
80C51(U1)
Source Files
CODE.asm
DELAY:MOVR0,#14 // CREATE A DELAY OF 7.84us
LOOP1:MOVR1,#0FFH
LOOP2DJNZR1,LOOP2
DJNZR0,LOOP1
RET
BUZZER:
MOVB,#60// check if BPM less than60
SUBBA,B
MOVC,ACC7
JNCMORE
ACALLRING
MOREMOVA, R2
MOVB,#100// check if BPM MORE THAN 100
SUBBA,B
MOVC,ACC7
JC CONT
ACALLRING
CONTRET
RINGSETBP1.3 // RING THE BUZZER
MOVR3,#5
AGAIN:ACALL DELAY
DJNZ R3, AGAIN
CLRP1.3s
RET
LUT: DB 0FCH // LUT starts here
DB 60H
DB 0DAH
VSM Studio Output
* RESTRICTED VERSION WITH 0800H BYTE CODE SIZE LIMIT; USED: 009DH BYTE (7%) *
Program Size: data=8.0 xdata=0 code=157
LINK/LOCATE RUN COMPLETE. 0 WARNING(S), 0 ERROR(S)
Compiled successfully.
4 Message(s)
File saved
Type here to search
31°C
ENG
00:40
01-06-2021


MICRO_PROJECT_19BEC0367_515 - Proteus 8 Professional - Source Code
File Project Build Edit Debug System Help
Schematic Capture
Source Code
Projects
80C51(U1)
Source Files
CODE.asm
SUBBA,B
MOVC,ACC7
JNCMORE
ACALLRING
MOREMOVA, R2
MOVB,#100// check if BPM MORE THAN 100
SUBBA,B
MOVC,ACC7
JC CONT
ACALLRING
CONTRET
RINGSETBP1.3 // RING THE BUZZER
MOVR3,#5
AGAIN:ACALL DELAY
DJNZ R3, AGAIN
CLRP1.3s
RET
LUT: DB 0FCH // LUT starts here
DB 60H
DB 0DAH
DB 0F2H
DB 66H
DB 0B6H
DB 0BEH
DB 0E0H
DB 0FEH
DB 0E6H
END
VSM Studio Output
* RESTRICTED VERSION WITH 0800H BYTE CODE SIZE LIMIT; USED: 009DH BYTE (7%) *
Program Size: data=8.0 xdata=0 code=157
LINK/LOCATE RUN COMPLETE. 0 WARNING(S), 0 ERROR(S)
Compiled successfully.
4 Message(s)
Ready
Type here to search
31°C
ENG
00:40
01-06-2021

CODE-

```
ORG 0000H

MOV P1,#00H

MOV P0,#00H

MOV DPTR, #LUT

MAIN: MOV R6,#230D        // loads register R6 with 230D

     SETB P3.5            // sets P3.5 as input port

     MOV  TMOD ,#61H // Sets Timer1 as Mode2 counter & Timer0 as Mode1
timer

     MOV TL1,#00000000B   // loads TL1 with initial value

     MOV TH1,#00000000B   // loads TH1 with initial value

     SETB TR1             // starts timer(counter) 1

BACK: MOV TH0,#00000000B   // loads initial value to TH0

     MOV TL0,#00000000B   // loads initial value to TL0

     SETB TR0             // starts timer 0

HERE: JNB TF0,HERE        // checks for Timer 0 roll over

     CLR TR0              // stops Timer0

     CLR TF0              // clears Timer Flag 0

     DJNZ R6,BACK

     CLR TR1              // stops Timer(counter)1

     CLR TF0              // clears Timer Flag 0

     CLR TF1              // clears Timer Flag 1

     ACALL BPM            // Calls subroutine DLOOP for displaying the count
```

```
    SJMP MAIN          // jumps back to the main loop
BPM: MOV R5,#100D
BACK1: MOV A,TL1        // loads the current count to the accumulator
     MOV B,#4D          // loads register B with 4D
     MUL AB             // Multiplies the TL1 count with 4
        MOV R2,A
        ACALL BUZZER
        MOV A,R2
     MOV B,#100D        // loads register B with 100D
     DIV AB             // isolates first digit of the count
     SETB P1.0          // display driver transistor Q1 ON
     ACALL DISPLAY      // converts 1st digit to 7seg pattern
     MOV A,B
     MOV B,#10D
     DIV AB             // isolates the second digit of the count
     CLR P1.0           // display driver transistor Q1 OFF
     SETB P1.1          // display driver transistor Q2 ON
     ACALL DISPLAY      // converts the 2nd digit to 7seg pattern
     MOV A,B            // moves the last digit of the count to accumulator
     CLR P1.1           // display driver transistor Q2 OFF
     SETB P1.2          // display driver transistor Q3 ON
     ACALL DISPLAY      // converts 3rd digit to 7seg pattern
     CLR P1.2
```

```
DJNZ R5,BACK1       // repeats the subroutine DLOOP 100 times
RET
DISPLAY: MOVC  A,@A+DPTR
CPL A// gets 7seg digit drive pattern for current value in A
MOV  P2,A           // puts the pattern to port 0
ACALL DELAY
RET
DELAY: MOV R0,#14 // CREATE A DELAY OF   7.84us
LOOP1: MOV R1,#0FFH
LOOP2:DJNZ R1,LOOP2
DJNZ R0,LOOP1
RET
BUZZER:
MOV B,#60// check if BPM less than 60
SUBB A,B
MOV C,ACC.7
JNC MORE
ACALL RING
MORE:MOV A, R2
MOV B,#100// check if BPM MORE THAN    100
SUBB A,B
MOV C,ACC.7
JC CONT
```

```
        ACALL RING
CONT:RET
 RING:SETB P1.3  // RING THE BUZZER
        MOV R3,#5
 AGAIN: ACALL  DELAY
        DJNZ  R3, AGAIN
          CLR P1.3s
        RET
LUT: DB 0FCH            // LUT starts here
   DB 60H
   DB 0DAH
   DB 0F2H
   DB 66H
   DB 0B6H
   DB 0BEH
   DB 0E0H
   DB 0FEH
   DB 0E6H
END
```

CONCLUSION-

The heart rate is one of the most important parameters of human cardiovascular system. Heart rate is defined as the number of times the heart beats per minute. The knowledge of heart rate helps us to know various states of the body such as concentration, stress, drowsiness and the active state of the autonomic nervous system. The heart rate of a healthy adult at rest is around 72 beats per minute(bpm). Athletes have lower rates than less active people while babies have a higher rate at around 120bpm. This project underlines the design of heart rate monitor system using 8051 microcontroller.

The working principle used in this project is referred to as Photoplethysmography in medical terms. Photoplethysmography is the process of optically evaluating the volumetric measurement of an organ. Our aim in this project is to count the number of pulses in one minute, that’s the heart rate in beats per minute (bpm). As we are using 8051 microcontroller it is very cost effective. It is portable and provides real time analysis. During covid post treatment most patients suffer from heart trouble and this can help them to track their heart rate. It is difficult to identify patterns using traditional examinations for those cardiac problems that occur customarily during normal daily activities but disappear the moment the patient is hospitalized. This results in diagnostic difficulties and consequently possible therapeutic errors. Real time monitoring is a boon to such patients.

REFERRENCES-

- https://www.iitk.ac.in/gail/research.html
- https://datasheetspdf.com/pdf/102006/VishayTelefunken/CNY70/1
- https://www.jsumo.com/cny70-transistor-output-reflected-light-detector
- https://electronics.stackexchange.com/questions/52486/problem-in-cny70-sensor
- https://www.ti.com/lit/ds/snosc16d/snosc16d.pdf
- https://components101.com/displays/7-segment-display-pinout-working-datasheet
- http://embedded-lab.com/blog/introducing-easy-pulse-a-diy-photoplethysmographic-sensor-for-measuring-heart-rate/
- https://jbpe.sums.ac.ir/article_46269.html
- https://www.electronics-tutorials.ws/filter/filter_7.html
- https://www.electronicdesign.com/technologies/displays/article/21773684/build-your-own-optical-heartrate-sensor
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6426305/
- https://aslopubs.onlinelibrary.wiley.com/doi/pdf/10.4319/lom.2013.11.91?__cf_chl_jschl_tk__=fd

0585d2247d3f05cbb57bf4192d812fb7376e9e-1621434641-0-AW3LmjDU_iDC5JbyHajKn_O-tWmUn2BP3canh2JCrp0fGBuZrdbiBQCDSyVnbeKZGLnJMitGaU55wdnzQDgis5UhTYDScAbf3J3OVGRdk1fnuimI5QkaIK1FlbVMz1lDcFa3hcGleCe1B01fqAuUTTUsUmAPB_ryuhhiMlwYw-VD4r6ZYjBsMsZaAnRD3TNujEmUaJ8tjCQ1doH_o02FKPbwGyWpGextHmHVRMK9gzvYoHkIJNrvY6X7l_Ax4aEJ5u7Cli86aO0L7NwV7isN_5T4XuwoTBe9GN-K7qC0ZbXJiOEqt_GSJ_7muswAUzgNyOJLYCLsdLbbnGAX2kQOAItOwSHjzRqoPYVKJBRPesBkgnasoHO_iBD-64dGaw97ecMDds6--cCrEgL1A15FmZcydXWiutADx1j2iyjAG6p9NCPCfEzq-dm_duFGPQPi-Q

- https://www.electronics-tutorials.ws/transistor/tran_4.html
- http://embedded-lab.com/blog/introducing-easy-pulse-a-diy-photoplethysmographic-sensor-for-measuring-heart-rate/
- https://aslopubs.onlinelibrary.wiley.com/doi/pdf/10.4319/lom.2013.11.91
- https://www.electronics-tutorials.ws/transistor/tran_4.html
- https://www.elprocus.com/heartbeat-sensor-circuit-daigram-working-with-8051/

- http://ijamtes.org/gallery/102.oct%20ijmte%20-%20cw.pdf
- https://www.ijareeie.com/upload/2014/january/10_Biometric.pdf
- https://www.circuitstoday.com/heart-rate-monitor-using-8051#:~:text=Like%20the%20previous%208051%20projects,is%20very%20easy%20to%20use.
- https://www.theengineeringprojects.com/2018/06/introduction-to-8051-microcontroller.html
- https://www.researchgate.net/publication/261212643_A_low_cost_optical_sensor_based_heart_rate_monitoring_system