AHSANULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of Electrical and Electronic Engineering

Course No.: EEE-2211

Course Title: Measurement and Instrumentation.

Project Name: Heart Rate Measurement.

Submitted by:

MD. Mainul Hasan

E-mail: mainul_sakin@yahoo.com

Abu Raihan Chowdhury.

Sadbi Ahmad Sanam.

E-mail: sadbi.sanam@gmail.com

Sec: C, Group-07

Year: 2nd, Semester: 2nd.

Group Members	Student's ID
1.	12-01-05-107
2.	12-01-05-130
3.	12-01-05-146

Working Principle

<u>**Theory:**</u>

This project is based on the principle of **Photoplethysmography (PPG)** which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. **Transmittance** and **Reflectance** are two basic types of photoplethysmography.For this project we used the reflectance PPG. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector. As the light doesn't have to penetrate the body, the reflectance PPG can be applied to any parts of human body. In either case, the detected light reflected from or transmitted through the body part will fluctuate according to the pulsating blood flow caused by the beating of the heart.

The PPG signal has two components, frequently referred to as **AC** and **DC**. The **AC** component is mainly caused by pulsating changes in arterial blood volume, which is synchronous with the heart beat. So, the **AC** component can be used as a source of heart rate information. This **AC** component is superimposed onto a large **DC** component that relates to the tissues and to the average blood volume. The **DC** component must be removed to measure the AC waveform with a high signal-to-noise ratio. Since the useful AC signal is only a very small portion of the whole signal, an effective amplification circuit is also required to extract desired information from it.

<u>**Circuit Operation:**</u>

There are two circuits used in this project 1) Signal Processing Circuit 2) LCD Display Circuit.

1) Signal Processing Circuit:

The sensor used in this project is **TCRT5000**, which is a reflective optical sensor with both the infrared light emitter and phototransistor placed side by side and are enclosed inside a leaded package so that there is minimum effect of surrounding visible light. Connecting the **Enable** pin to 5V of **ARDUINO** will turn the IR emitter LED on and activate the sensor. A fingertip placed over the sensor will act as a reflector of the incident light. The amount of light reflected back from the fingertip is monitored by the phototransistor.

The output (V_{SENSOR}) from the sensor is a periodic physiological waveform attributed to small variations in the reflected IR light which is caused by the pulsating tissue blood volume inside the finger. The waveform is, therefore, synchronous with the heart beat. This weak signal

contains a lot of noise superimposed on the useful AC signal which is then thoroughly filtered a series of signal processing circuits via a **Quad OP-AMP LM324N**.

The signal is first passed through a RC high-pass filter (**HPF**) to get rid of the DC component. The cut-off frequency of the HPF is set to 0.7 Hz. The next stage is an active low-pass filter (**LPF**) that is made of an Op-Amp circuit. The gain and the cut-off frequency of the LPF are set to 101 and 2.34 Hz, respectively. Thus the combination of the HPF and LPF helps to remove unwanted DC signal and high frequency noise including 50 Hz mains interference, while amplifying the low amplitude pulse signal (AC component) 101 times. The output from the first signal conditioning stage goes to a similar HPF/LPF combination for further filtering and amplification. So, the total voltage gain achieved from the two cascaded stages is 101*101 = 10201. The two stages of filtering and amplification converts the input PPG signals to near **Transistor –transistor Logic (TTL)** pulses and they are synchronous with the heart beat.

A 10K potentiometer is placed at the output of the first signal conditioning stage in case the total gain of the two stages is required to be less than 10201. An **LED** connected to the output of the second stage of signal conditioning will blink when a heart beat is detected. The final stage of the instrumentation constitutes a simple non-inverting buffer to lower the output impedance. This is helpful if an ADC channel of a microcontroller is used to read the amplified PPG signal. The output is then connected to Digital Pin 8 of **ARDUINO UNO**. The microcontroller measures the frequency of the PPG signal and returns the value of heart rate in BPM. The frequency (f) of these pulses is related to the heart rate (BPM) as,

*Beats per minute (BPM) = 60*f*

The following is the programming code to calculate the Heart rate:

#include <FreqMeasure.h> //frequency measure library header file

#include <LiquidCrystal.h> // LCD Display library header file

LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup() {

  Serial.begin(57600);

  lcd.begin(2, 16);   // set up the LCD's number of columns and rows:

  lcd.setCursor(0, 0);   // set the cursor to column 0, line 1

                // (note: line 1 is the second row, since counting begins with 0):

   lcd.print("Welcome");

```arduino
  lcd.setCursor(0, 1);        // set the cursor to column 0, line 2

    lcd.print("Place ur finger");



  delay (10000);              //Allow user to adjust finger for 10s and then start reading

  lcd.clear();              //Clears LCD Screen

  FreqMeasure.begin();       //Starting frequency measure

}

  int a[3];  //initialising variables

  double sum=0;

  int count=0;

  int count1=0;

  double value=0;

  double sum2=0;

void loop()

{ lcd.setCursor(0, 1);// set the cursor to column 0, line 1

  // print the number of seconds since reset:

  if (FreqMeasure.available())

  { sum = sum + FreqMeasure.read();// average several reading together

    count = count + 1;

    Serial.println(count);    //for arduino serial monitor (ctrl+shift+m)

    if (count > 15)

    {

      double frequency = F_CPU / (sum / count);
```

```
double BPM=(frequency*60);

Serial.println(frequency); //for arduino serial monitor (ctrl+shift+m)

Serial.println(BPM);     //for arduino serial monitor (ctrl+shift+m)

a[count1]=BPM;

sum = 0;

count = 0;

count1++;

if (count1>1)

{

  for(int i=0;i<3;i++)

{sum2+=a[i];}


Serial.println(sum2/2);

FreqMeasure.end();

  lcd.print(sum2/2);

  lcd.print(" BPM");

  delay(10000);

  lcd.clear();

  lcd.print("The End");

  }

 }

}
```

2) LCD Display Circuit:

The LCD Display Circuit consists of nothing but wires connecting the ARDUINO to a *2x16 LCD. The code to display the resulting heart rate in BPM has been explained in the above program. The connections of the circuit are given in the circuit diagram section.*

Equipments:

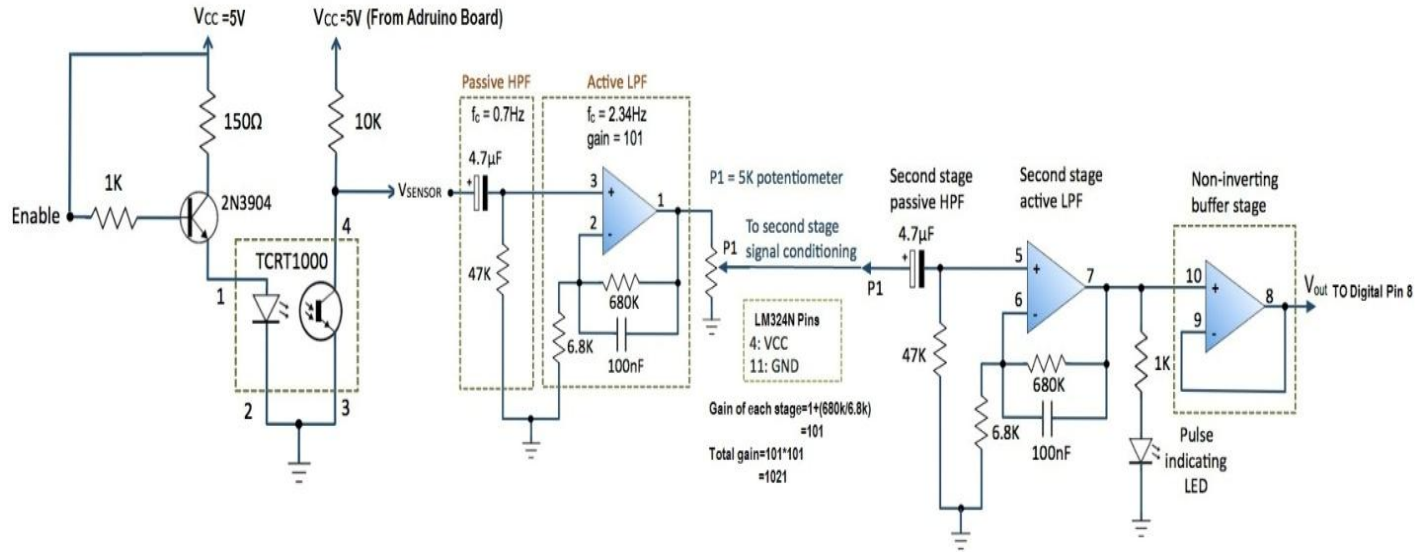| SN	Item	No.
1	LM324N(Op-amp)	1
2	1k ohm	2
3	150 ohm	1
4	10k ohm	1
5	6.8k ohm	2
6	680k ohm	2
7	47k ohm	2
8	4.7uf	2
9	100nf	2
10	TCRT5000(Sensor)	1
11	LED(red)	1
12	Wire(male)	
13	Varo Board	1
14	2N3904(BJT)	1
15	10k ohm pot	1
16	LCD(Display) (16*2)	1
17	Arduino UNO	1
18	USB Cable	1
19	Power Supply (7-12V)	1

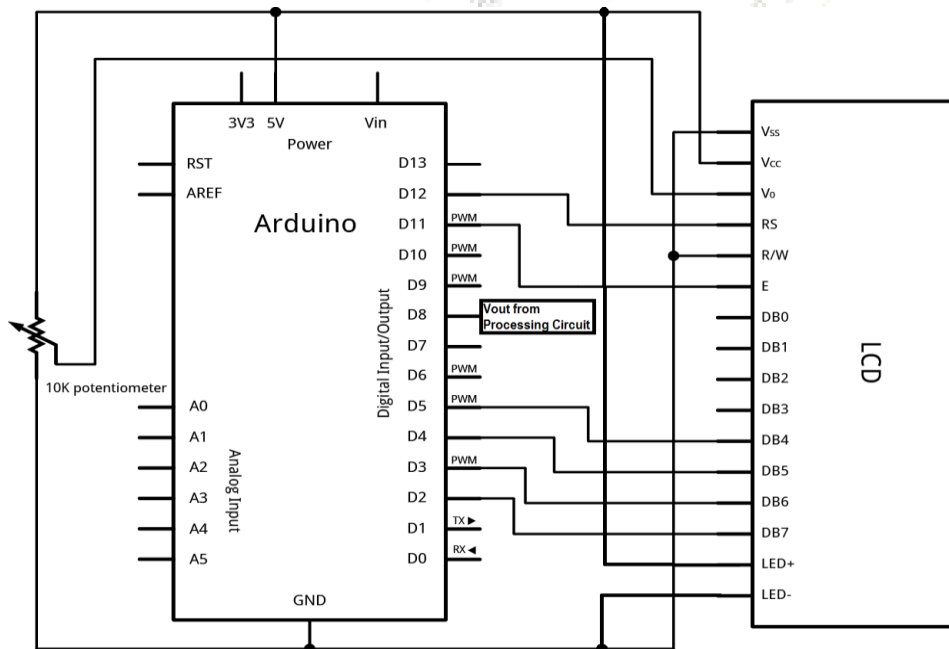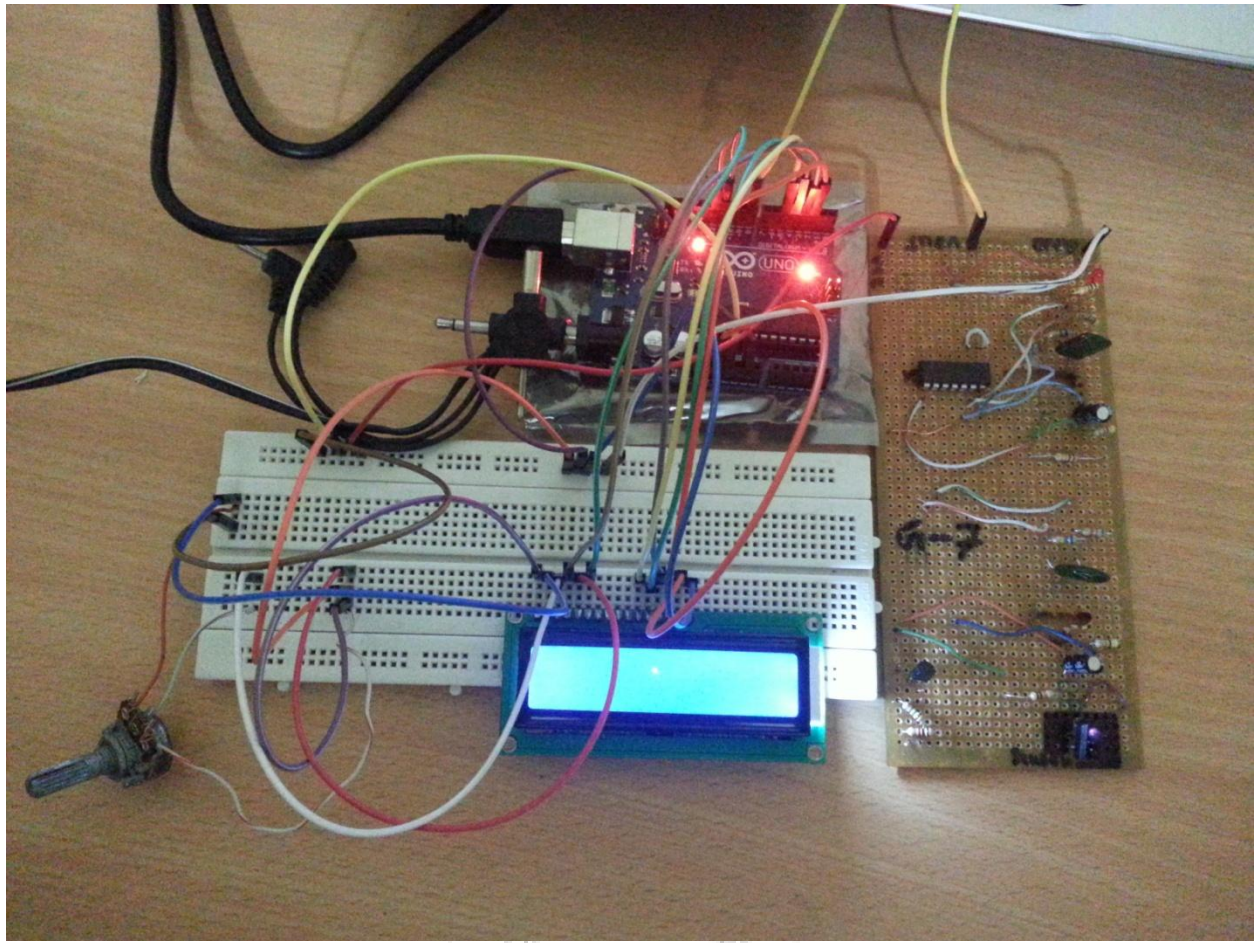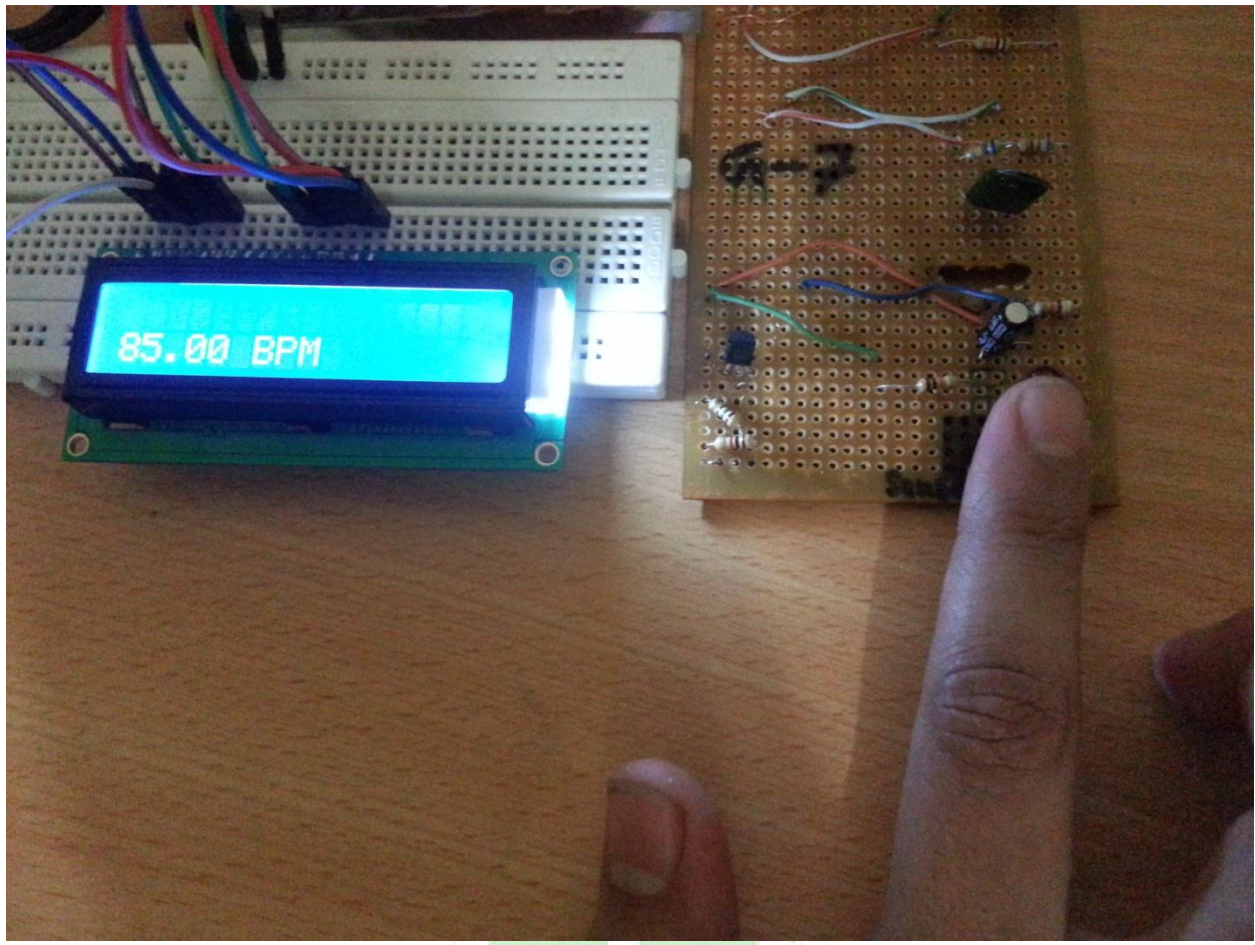# Circuit Diagram

Fig 1: Signal Processing Circuit

Fig 2: LCD Display Circuit

Project Image

Troubleshooting

1. In this project the Sensor part is very important. The use of **TCRT5000** simplifies the build process of the sensor part of the project as both the infrared light emitter diode and the detector are arranged side by side in a leaded package, thus blocking the surrounding ambient light, which could otherwise affect the sensor performance. We have also designed a printed circuit board for it, which carries both sensor and signal conditioning unit.
2. For making this device more sensitive we may use **MCP6004** IC, which has got four general purpose Op-Amps offering rail-to-rail input and output over the 1.8 to 6V operating range). But in our country these two types of opamp is rare, further they are costly.
3. The wire connection must be good otherwise the value will vary, even our device may not work.
4. If we set this device on the Project board, the value may differ. So we must try to make this project on **Varo board** or **PCB (Printed circuit board).**
5. For Arduino Uno, we must not connect a DC power supply with a rating between 7-12V and the supply current must not exceed 300mA as the Arduino has a built in IC voltage regulator of 5V.

Application

1. We can measure our Pulse by this device. Measuring our heart rate while working out is a simple and effective way to ensure that we are exercising most efficiently.
2. In the hospital for the serious patient we can use this device for measuring their pulse continuously via an oscilloscope giving the heart rate in BPM in real time.