Department of Electronic & Telecommunication Engineering
University of Moratuwa

Module EN2091 - Laboratory Practice and Projects

HEART ECG MONITOR

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ABSTRACT

A gadget that can show a real-time electrical reading of the human heart is called a heart ECG monitor. We are planned to create a tool that uses electrodes to capture 3-lead ECG signals for the lab project in EN1091 module.

A suitable device should be used to show the signal. Given that the electrical impulses generated by the human body are generally of low magnitude, We have applied our analog electronics expertise to enhance signal quality while amplifying the necessary signals. We have to construct an analog front end that accepts data from the ECG probes and outputs a clean waveform of the ECG.

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1 INTRODUCTION

An electrocardiogram (ECG) is a quick test that can be used to examine the electrical activity and rhythm of your heart. The electrical signals that your heart beats out each time it beats are picked up by sensors that are affixed to your skin. A machine records these signals, and a doctor examines them to see whether they are odd.

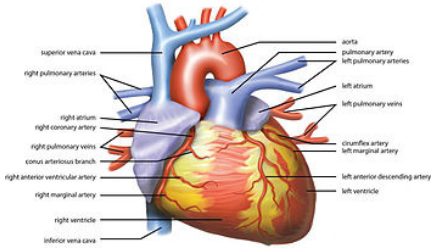


Figure 1 — Human Heart

Any doctor, including your general practitioner, who suspects you may have a cardiac condition may request an ECG, including a cardiologist. A medical expert with the necessary training can do the test at your GP's office, a clinic, or a hospital. Despite having a similar name, an echocardiogram, which is a scan of the heart, is not the same as an ECG.

1.1 Problem Description

In the human body, Heart is a main part. It's like the CPU in the human body. The heart will control all activities of a human by sending a pulse to the brain and the parts. If a difference in the heart pulse (heart rate) then it may cause death also. (Heart rate or pulse is the process of generation of the internal electrical signal.)
So, we need to monitor the heartbeat rate regularly, So that we need to know the pulse rate of the internal electrical signal.
A gadget that can show a real-time electrical reading of the human heart is called a heart ECG monitor. A suitable device should be used to show the signal. Given that the electrical impulses generated by the human body are generally of low magnitude, We have applied our analog electronics expertise to enhance signal quality while amplifying the necessary signals. We have to construct an analog front end that accepts data from the ECG probes and outputs a clean waveform of the ECG.

1.2 Problem validation

We have checked our problem and whether the needs are valuable or not. So that we have found some of the main uses and diagnoses using the ECG heart monitor. To help identify and keep track of heart abnormalities, an ECG is frequently used in conjunction with another test. It can be used to explore heart-related symptoms such as dizziness, shortness of breath, palpitations (suddenly detectable heartbeats), and chest pain.
An ECG can help detect:

1. arrhythmia.
   - where the heart beats too slowly, too quickly, or irregularly coronary heart disease – where the heart's blood supply is blocked or interrupted by a build-up of fatty substances
2. heart attacks
   - where the supply of blood to the heart is suddenly blocked
3. cardiomyopathy
   - where the heart walls become thickened or enlarged

A series of ECGs can also be taken over time to monitor a person already diagnosed with a heart condition or taking medication known to potentially affect the heart.

1.3 Motivation for selection

There are a lot of ECG Heart monitoring devices using the digital circuit. Sometimes when we use the ICs they will be expensive and we need to program them using the correct algorithms. When we compare the Analog circuit with the digital circuit that is quite simple and we can build them easier. At the same time if our filter circuit is not enough we can increase the order of the filters easily rather than change the ICs in the digital circuits.

1.4 Solutions

The electrocardiogram (ECG)- provides a general picture regarding the electrical activity of the heart, recording the electrical changes that take place at the surface of cardiac myocytes at different moments of the cardiac cycles.The device used for recording the ECG is called an electrocardiograph. The main components of an electrocardiograph are:

1. the signal acquisition system- includes the electrodes and the cables

2. the amplification and signal filtering system used to amplify the relatively small potentials collected by the electrodes (in the order of mV) and to limit the artifacts.

3. the signal charting system displays the ECG trace either on a millimeter paper or a screen.

1.5 Constrains

The constraints are :

* we need a small digital circuit than an analog circuit, Because we need to display the conditions of the heartbeat pulse as values rather than explain them in the signal
* We couldn't able to find the IC with the correct sampling rate
* Only the users, If they have personal oscilloscope then they can use. Otherwise, they can't use

1.6 Reasoning

We have analyzed the available ECG monitors. Then we came to a conclusion, most of them are available with the digital circuit. Some of the few with analog circuits. Then we planned to make an ECG monitor with an analog circuit.

1.7 Innovative Rating

Our system is not a completely new model. There already exists a system, which works using digital filters. But here we develop an analog system. Compared to the digital system, our system is quite different as our system is less expensive and uses low power. In addition to this we are providing the output signal more accurately (We can increase accuracy by increasing the order of the filter).

2 DESIGN

2.1 List of components used Budget

Item	Quantity	Unit price	Total price
LM4562NA	2	200	400
TL072	4	100	400
Resistors	32	1.5	48
100nF Capacitors	10	10	100
22uF Capacitors	6	60	360
Power regulator	2	150	300
LED	1	5	5
Switch	1	12	12
Enclosure		7800	7800
PCB	1	1000	1000
Powerup cable and others		1500	1500

Table 1 — Budjet

Total Cost is 11 925 LKR

2.2 Product Architecture

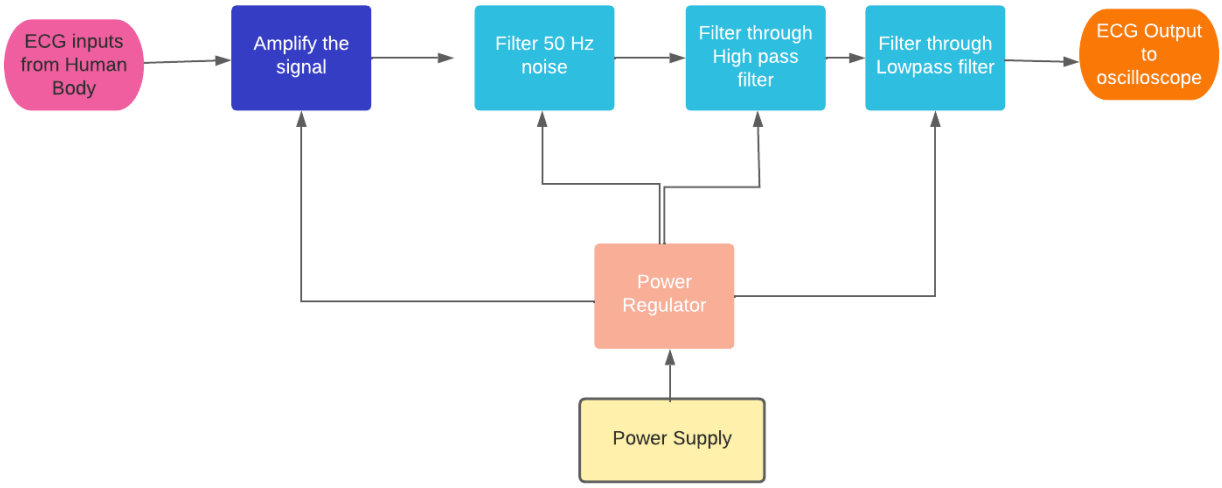


Figure 2 — Product Architecture

2.3 Circuit Diagram

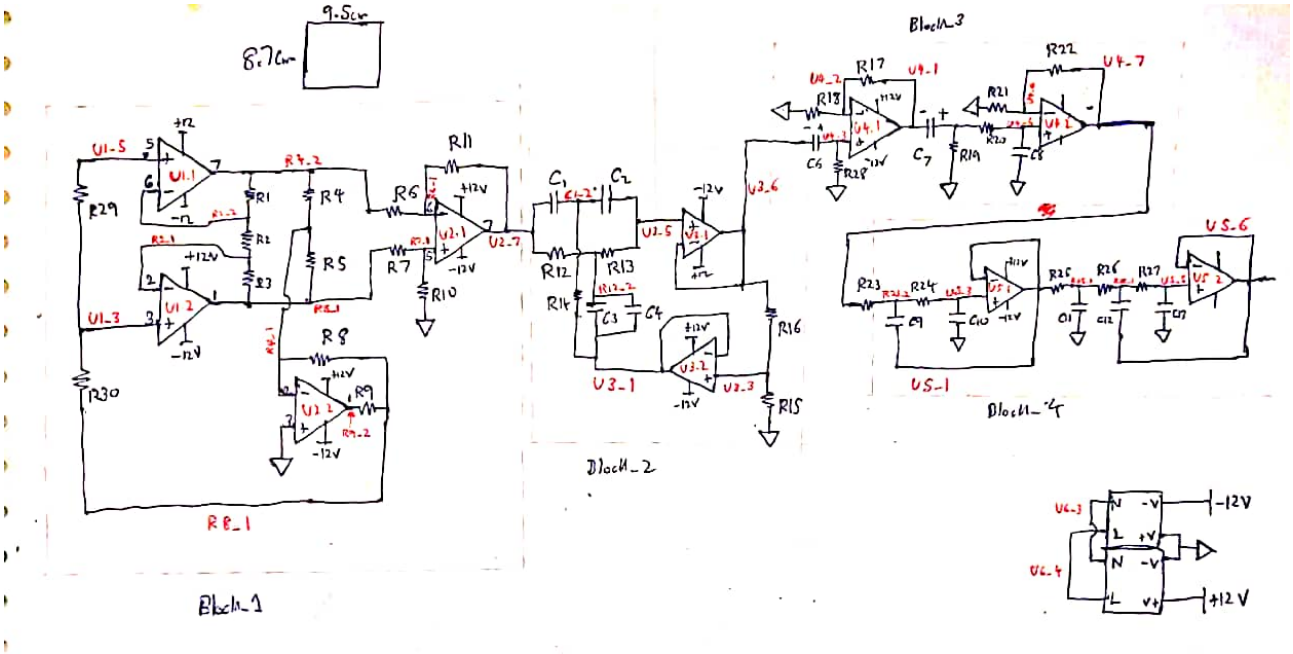


Figure 3 — Circuit Diagram Hand drawn

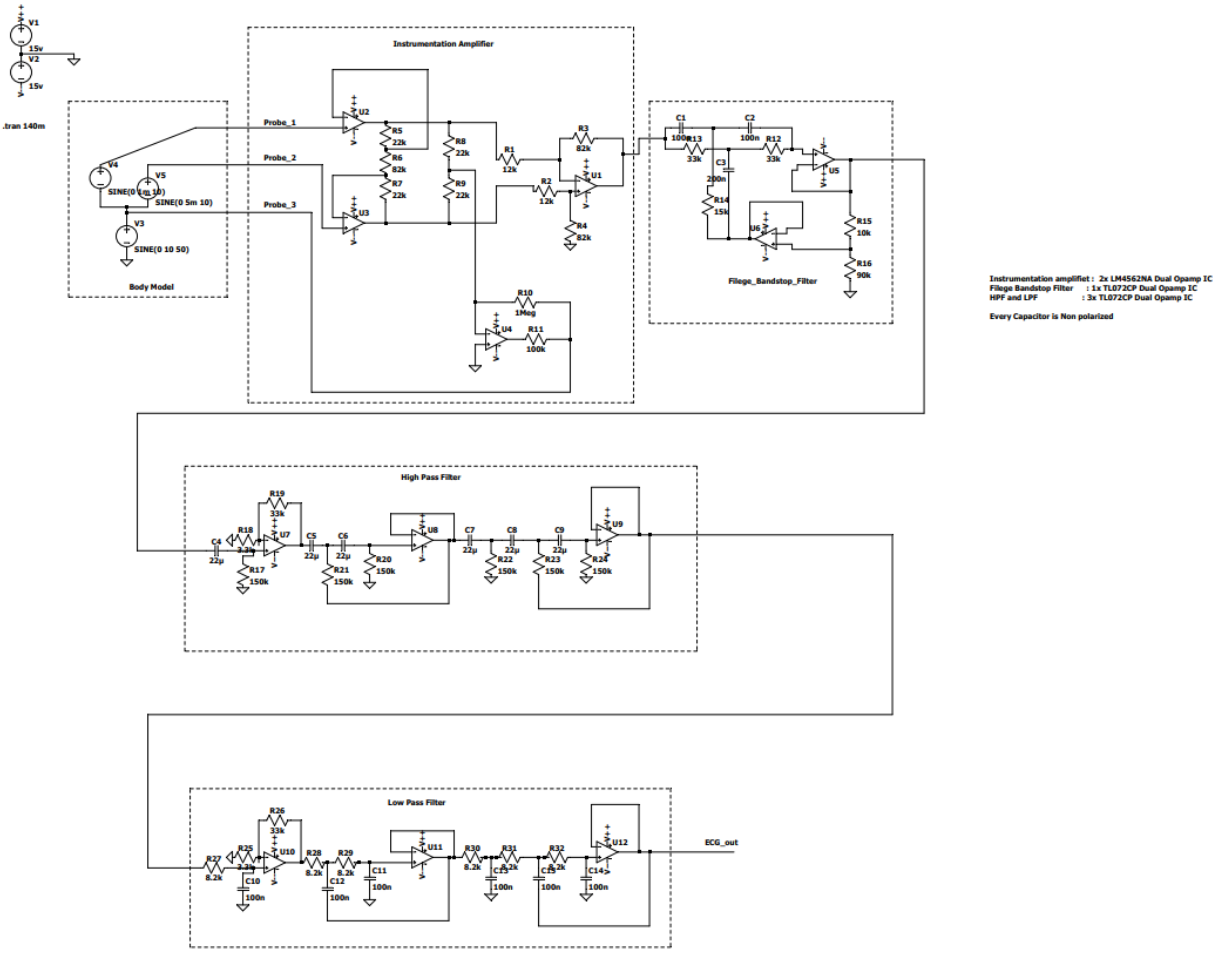


Figure 4 — Full Simulation LTspiece

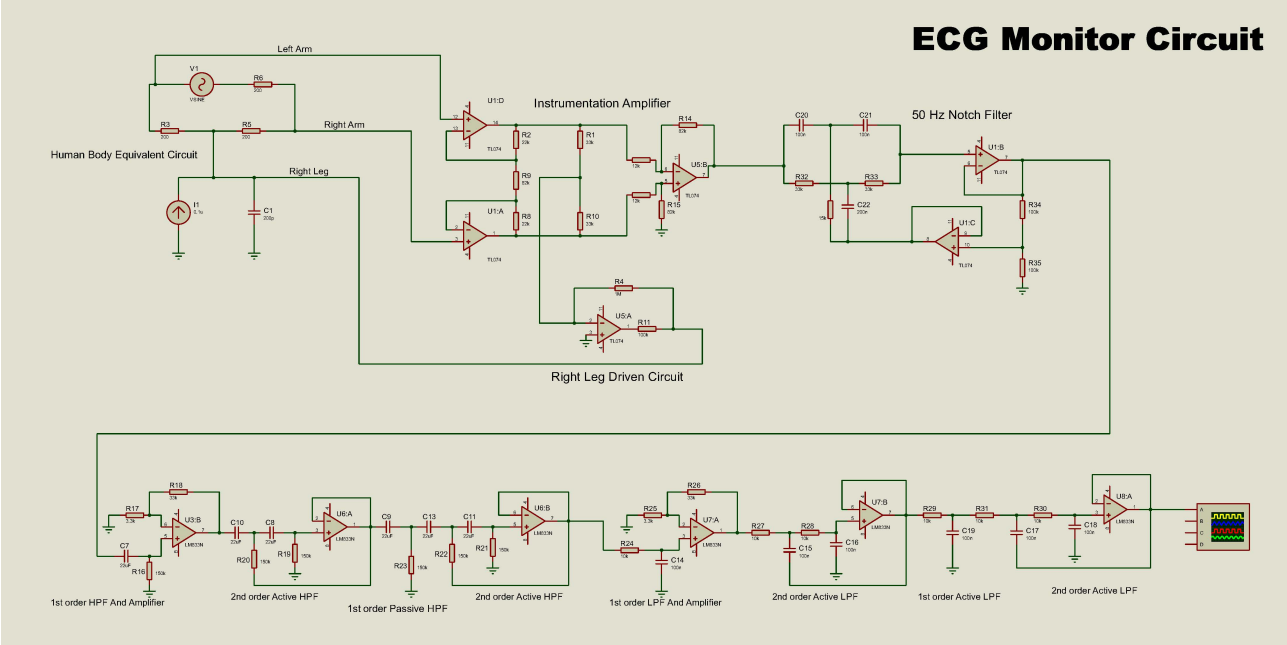


Figure 5 — ECG Circuit Proteous

2.4 PCB Design

The schematic of the circuit was drawn first and the PCB was designed accordingly using Altium.

2.4.1 PCB Schematic

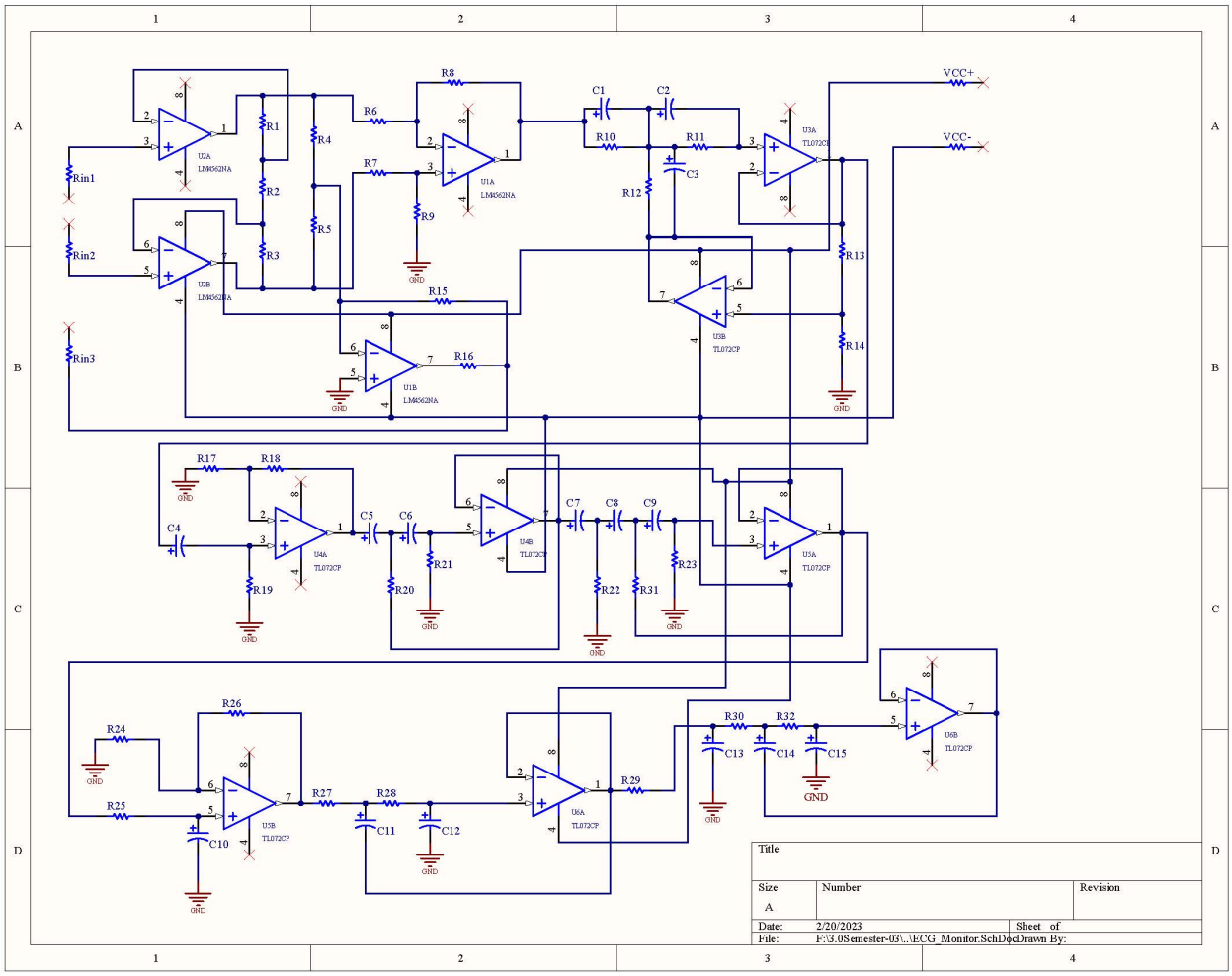


Figure 6 — PCB Schematic

2.4.2 PCB Design rules

* PCB length – 95 mm
* PCB width - 87 mm
* PCB clearance between two copper lines - 0.203 mm
* width of copper wire - 0.381 mm
* Hole size - 1 mm

2.4.3 PCB Footprint

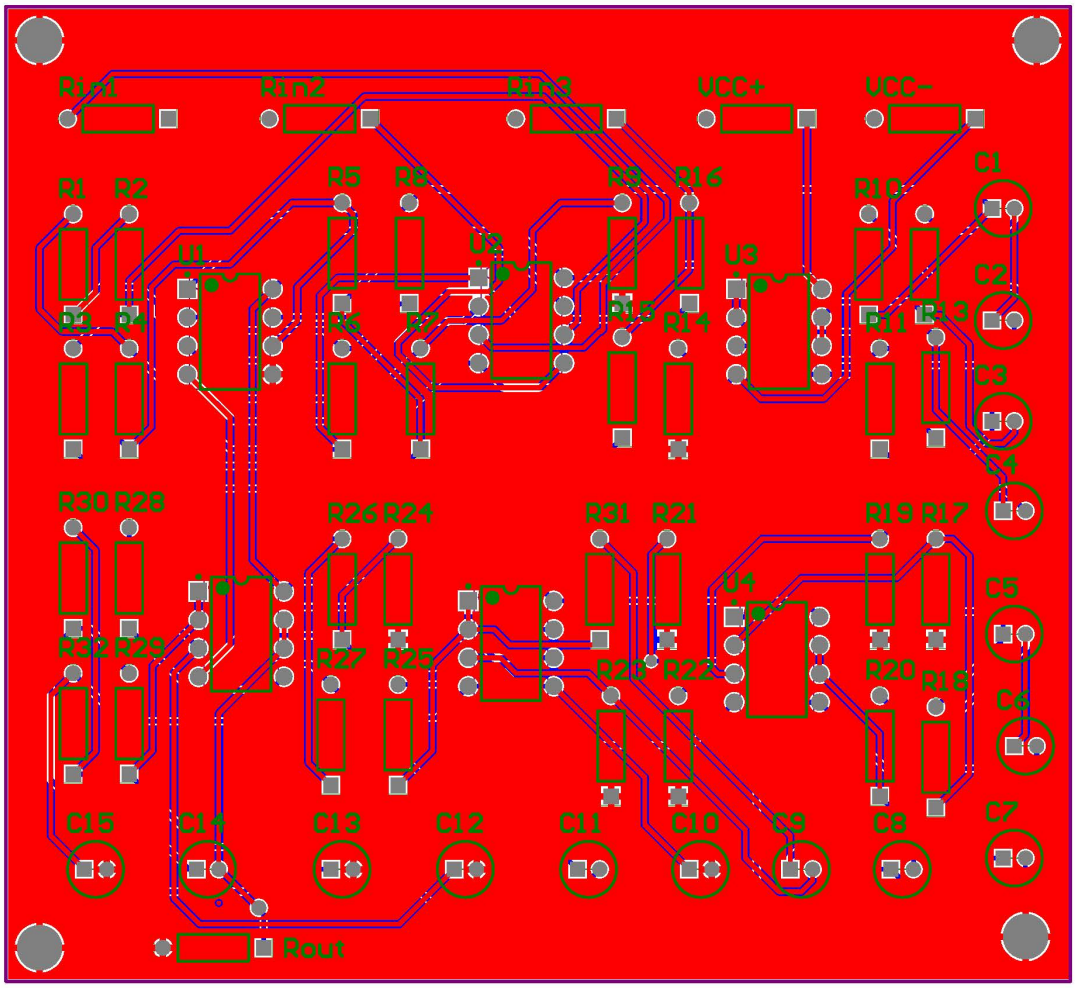
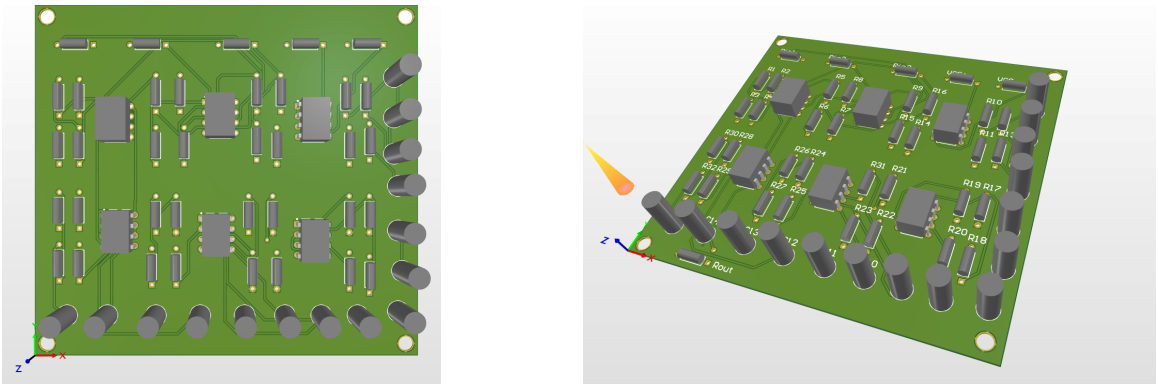


Figure 7 — PCB Footprint

2.4.4 PCB 3D Model



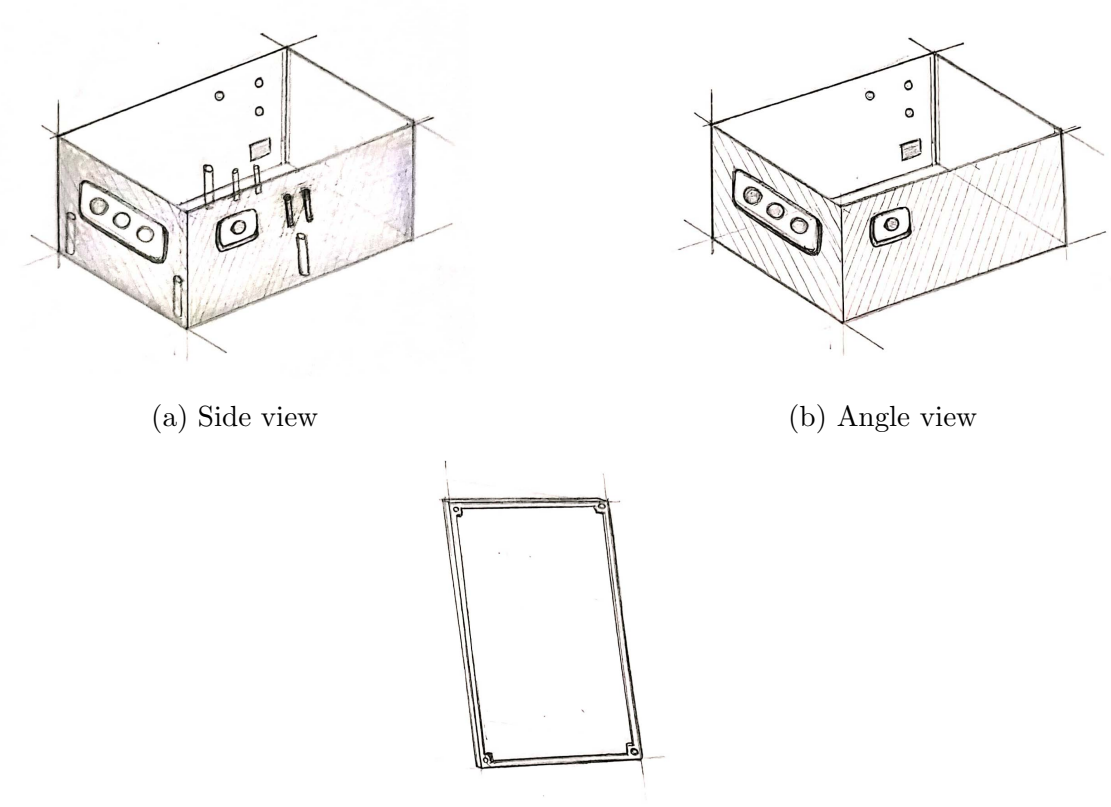
(a) (b)

Figure 8 — PCB 3D model

2.5 Enclosure Design

We have designed the enclosure using Solid works. The dimensions of our enclosure are 20 cm long, 12 cm wide, and 8 cm high. The top and bottom planes of the enclosure are 3 mm thick. The thickness of the other sides is 5 mm. Base casing and top casing are the two sections that make up our enclosure. On the top casing, 4 holes measuring 3 mm in diameter and 20 mm in depth are left for fastening two enclosure portions together.
Three spherical holes remain in one of the side planes for the injection of ECG inputs from the body, other spherical holes remain in another of the side plane for the exit of ECG output to the Oscilloscope. At the same time, there are two holes for indicator LEDs and .another square hole for the switch. To fix the circuit PCB, there are 4 holes on the Lid case that are 3 mm in diameter and 2.5 cm deep. and another 4 holes to fix the power regulator that is 3 mm in diameter and 2 cm deep.
The top shell has holes on one side for the LED and switch.

2.5.1 Enclosure sketch



(a) Side view

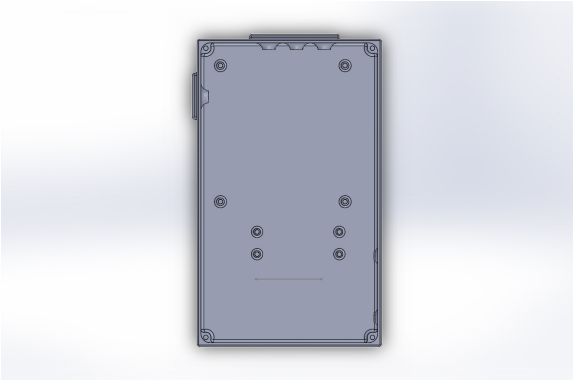
(b) Angle view

(c) LID view

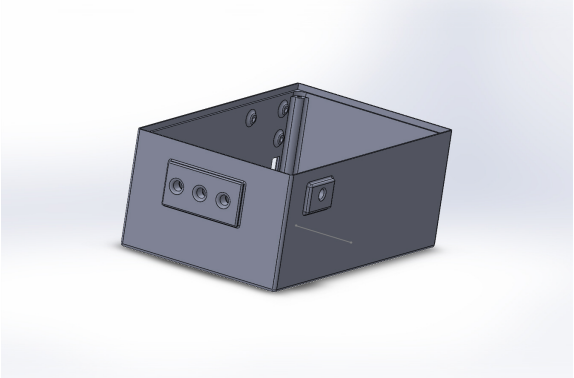
Figure 9 — Enclosure sketch

2.5.2 Enclosure Parts

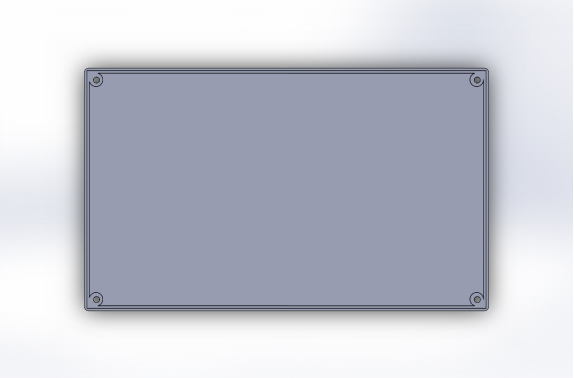
(a) Front view of Box



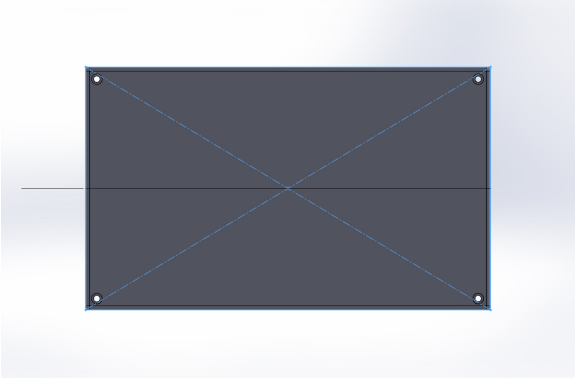
(b) Internal structures



(c) Side view



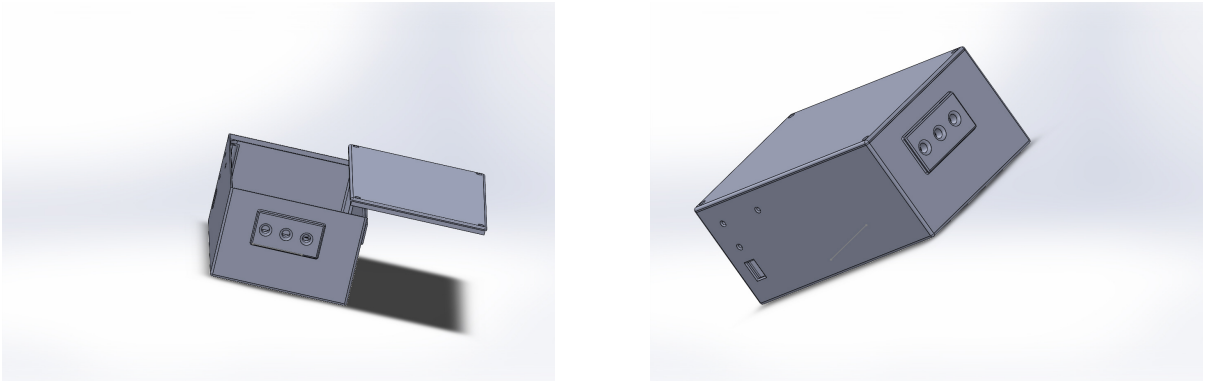
(d) Internal view of lid



(e) Top view of lid

Figure 10 — Enclousre parts

2.5.3 Enclosure Assembly



(a) Side view (b) Angle view

Figure 11 — Enclosure Assembly

2.6 ADC Design

2.6.1 ADC circuit sketch Design display

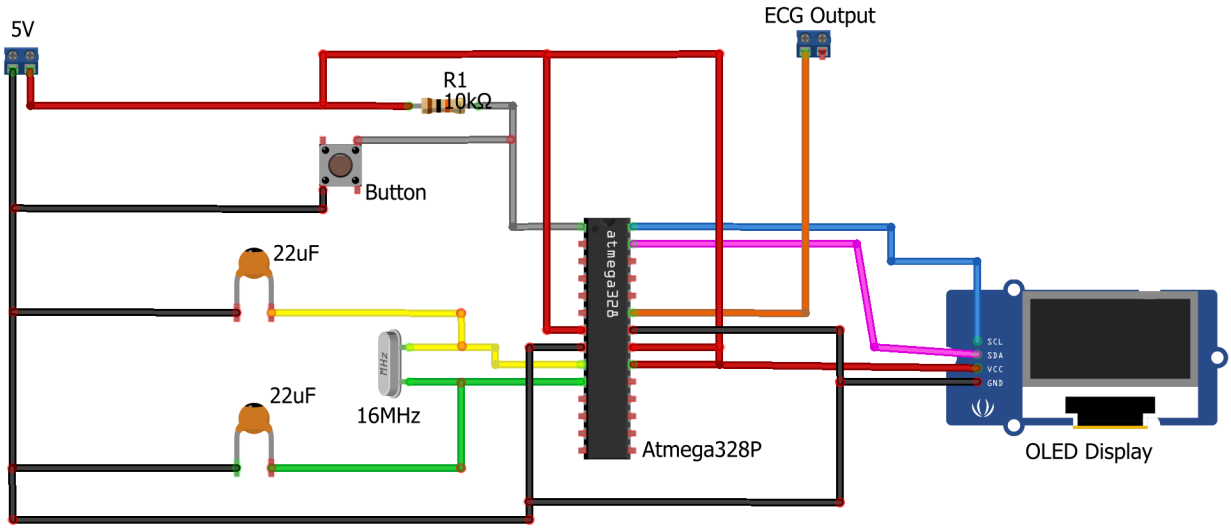


Figure 12 — Display Circuit Graphic

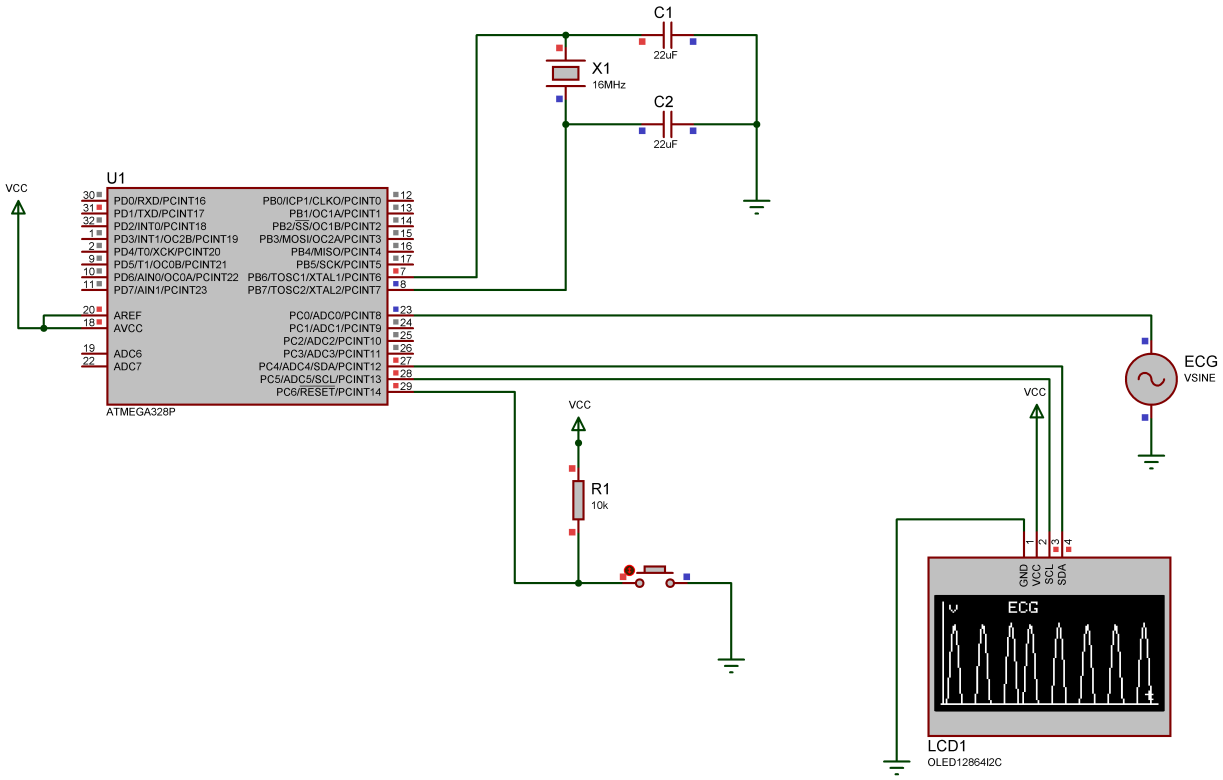


Figure 13 — Display Circuit Proteus

2.6.2 Components for ADC

Used

* Atmega328p
* 0.96 inch 128×64 OLED Display Module
* Crystal Oscillator
* 2× 22uF ceramic capacitors
* A 10k Ohm Resistor
* 240V to 5V convertor
* A Push Button

2.6.3 ADC Functionality

This circuit is to displays the output of ECG signal in the OLED display using Atmega328P microcontroller. The OLED display is 128×64 pixel. The output of ECG signal amplitude is about 4V is mapped to 64 Pixels. And used Pre-scaler is 2 which is minimum theoretically usable value in Atmega328p with external crystal oscillator 16MHz.Also it can be shown in simulation. But practically, output is aliasing when displaying ECG output which is less than 8Hz.This happen due to Pre-Scaler value is 8 which is practically usable value is not enough to sample the signal.

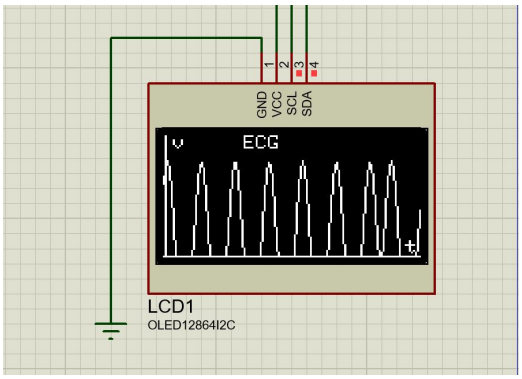


Figure 14 — ADC output

3 METHODOLOGY

3.1 Functionality description

* First up all we need to plug the device and on the switch in plug. Check the connectivity by Indicator LED.
* After that, glue the lead in the body and attach the input cables.
* Then Connect the output to the oscilloscope.
* After that, Switch ON the device
* Adjust the resistance.
* Display the ECG signal

3.2 Breadboard Implementation

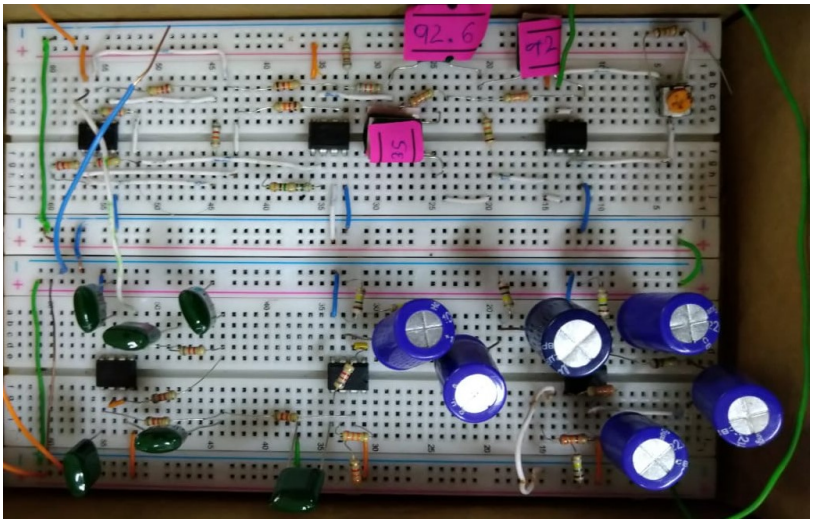


Figure 15 — Breadboard Implementation

3.3 PCB Implementation

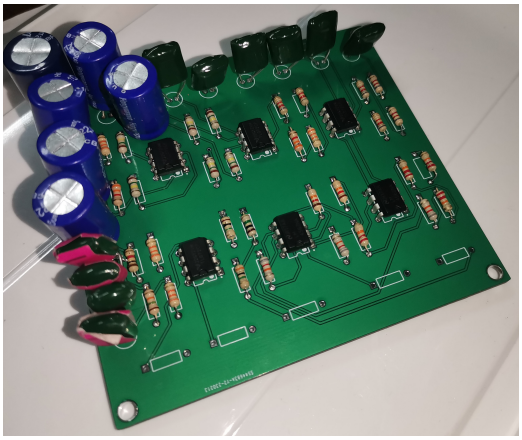


Figure 16 — PCB Implementation

3.4 Results

You have to Setup the device according to the instructions provided in the user manual.First up all we need to plug the device and on the switch in plug. Check the connectivity by Indicator LED.After that, glue the lead in the body and attach the input cables.Then Connect the output to the oscilloscope.And setup the oscilloscope.

After that we on the switch, then the device will be started to work. It get the ECG from the body and amplify it by 1000 times and filter the noises (include the noises by power supply also).And gives us a clear ECG as a output in the oscilloscope.

1. Product packaging: -

* Protection Styrofoam material will be utilized to carefully pack our item inside the box after it has been wrapped in bubble wrap and placed in a cuboid cardboard box. Our brand will be incorporated into the packaging, along with other details like the guarantee duration and the gadget characteristics. While being transported or sent, it will safeguard our equipment from abrupt shocks, vibrations, and harsh exterior environmental conditions.

* Appearance

Figure 17 — Packing Box

To ensure that the information printed on the package box is clearly visible to others, the package will be wrapped in transparent polythene. The box must be printed with information.

- Company Logo and Product name
- mages of the final product
- Price of the product
- Warranty period
- Technical specifications
- How to fix our product

* Easiness of use

The user manual or technical guide will be included in the box with the item for ease of use. The majority of the time, visual representation will be used because it is simple for everyone to understand.

* Storage

Distributors won't have any storage space issues because our product is a compact, portable gadget.

* Promotion

We intend to create an illustrated tutorial or, if possible, an animated video presentation, and disseminate it via paid advertising options on social media.

2. Maintenance: -
   Six months of service warranty will be offered by your dealers. If you made your purchase online, the nearby service facilities will give your warranty servicing; users must provide their online purchase receipts to do so. By using these merchants, you can specify the items you want.You can submit any grievances, concerns with our product, and any other suggestions for improving our product on our website. It will be highly beneficial for us to further develop and enhance our product in a way that is both efficient and user-friendly.

3. Product Life cycle
   * Repair
     You can go to one of our service facilities in your neighborhood if you have any problems with our product. If it occurs before the promised time frame, the service will be free; otherwise, a fee will be charged. If the device doesn't function properly within the guaranteed time frame, they will check for problems and repair it; if not, we will give it to you as a refurbished device.

   * Disposal
     If the equipment is broken and you can no longer use it, dispose of it properly. If not, we advise our users to bring it to a nearby service center, where it will be properly disposed of using an E-waste management system.

4. Manufacturing
   * We have chosen to produce a predetermined number of goods—roughly 50 goods per day—and each good will be sent to a testing unit to see if it successfully passes all test cases before being sent to a packing unit.
   * Other products will be sent for re-examination.

5. Marketing and Sales
   * Through online shopping platforms such as e-bay, AliExpress, Alibaba, Daraz, Amazon etc
   * Advertising through social media platforms using online paid promotions in Facebook, Instagram etc.
   * Through electronic sales mediators (LG, SINGER, ABANS showrooms)
   * Using company's own web page customers can order for personal and for bulk as well.
     .

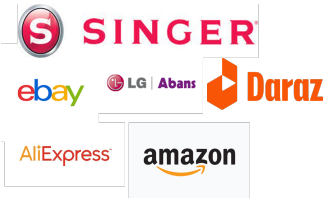


Figure 18 — Marketing Platforms

5 DISCUSSIONS

There were various challenges, which we had to face during the execution of this project. The obstacles we had to go through were stated follow.

* Considering the circuit and noise reduction part was very challenging
* Considering the size and the internal structure of our device will be more complex because of we need to fix the Oled screen stably and input,output and charging cables. Hence, we need to correctly calculate the size of holes and ports same time the total size of the enclosure.
* This is a non rechargeable. therefore we need to plug when we using and so we need the regulator part.
* Another main problem is the 50Hz noise by power sources.So,We need to build bandstop filter.
* We have use ICs(Amplifiers) so we need Plus and minus supply voltages to activate the ICs.So we need to use power regulator and step down the 230 V to 12V.
* When designing enclosure, There also difficulties with fixing the dimensions.
* When designing the PCB there were some difficulties because of the lack of experience in PCB designing. We had to learn and follow PCB design rules

6 ACKNOWLEDGMENT

We would like to thank each and every person who has helped us even in a very small manner in order to achieve good results in this project. We would like to specially thank Ms. Dinithi Fernando madam , Mr. Thilanka Udara sir , Mr. Sandun Ranasinghe sir & Dr. Sampath Perera sir, who were the Overall Supervisiors. They motivated us to learn the extra subjects required for this project ourselves.

At the same, We would like to specially thank Ms. Prabhani madam , Mr. Sahan & Ms. Amashi madam, who were the supervisiors. They also helped us in clearing our doubts and ambiguates regarding the project.

7 INDIVIDUAL CONTRIBUTIONS OF EACH GROUP MEMBER

Name	Index Number	.....Contributions.....
AMARASINGHE Y.E	200029B	Circuit Simulation(LTSpiece) Soldering Assembling
HAPUTHANTHRI H.H.A.M.	200207U	PCB Design Soldering Assembling
MANIMOHAN T.	200377M	Solidworks Report Slides(Demonstration) Soldering Assembling
SAIRISAN R.	200552V	ADC Simulation(Proteus) Soldering Assembling

Table 2 — Team Contributions

8 APPENDIX

Code for ADC part

```
 /* Created: 12/28/2022 12:07:06 AM
 * Author : RAJARETNAM SAIRISAN (200552V)
 */

#define  F_CPU 16000000
#include <avr/io.h>
#include <util/delay.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, -1);
const int numReadings = 128;
int readings[numReadings];
int readIndex = 0;

void setup() {
 /* Initial Codes for ADC 10bits converting */
  ADMUX=0x40;       //0b0100 0000    - for using external Voltage as reference.
  ADCSRA=0X81;      //0B1000 0111    - for enabling ADC conversion and Pre scaler is 2


  display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
  display.clearDisplay();
  display.display();
  Serial.begin(9600);

  for (int thisReading = 0; thisReading < numReadings; thisReading++) {
    readings[thisReading] = 0;
  }



}
```

```
void loop() {


  ADCSRA|=(1<<ADSC);                        // Starting conversion by setting 1 to ADSC r
  while( ((ADCSRA)&(0x10))==0);      //waiting for conversion complete
    _delay_ms(1);
    int sensorValue = ADC/4;
    readings[readIndex] = sensorValue;
    readIndex = readIndex + 1;

    if (readIndex >= numReadings) {
      readIndex = 0;
  }
    display.clearDisplay();

  //Axis
    display.setCursor(5,0 );
    display.println("v");
    display.setCursor(120,55);
    display.println("t");

  //Features of displaying LED
    display.setCursor(40, 0);
    display.drawLine(1,0 , 1, 63, WHITE);
    display.drawLine(0, 63, 127, 63, WHITE);
    display.setTextColor(WHITE);
    display.println("ECG");
    display.setTextColor(WHITE);


    for (int i = 0; i < numReadings - 1; i++) {
      int x0 = i;
      int y0 = 64 - (readings[i] / 4);
      int x1 = i + 1;
      int y1 = 64 - (readings[i + 1] / 4);
      display.drawLine(x0, y0, x1, y1, WHITE);
  }

  display.display();
  delay(10); //by adjusting delay to lower value we can acheive max sampling rate.
}
```

9 BIBLIOGRAPHY

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4. https://www.electronics-tutorials.ws/combination/analogue-to-digital-converter.html
5. https://www.alldatasheet.com/datasheet-pdf/pdf/241077/ATMEL/ATMEGA328P.html