Meerut Institute of Engineering and Technology

Session: 2023- 2024

PROJECT REPORT
ON
HEALTH MONITORING SYSTEM USING ECG AND PPG TECHNIQUE

BACHELOR OF TECHNOLOGY

COMPUTER SCIENCE AND ENGINEERING

(INTERNET OF THINGS)

Submitted To-

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DECLARATION

We hereby declare that the project entitled – "Health monitoring system based on ECG and PPG Technique" which is being submitted as Major Project in department of Computer Science and Engineering (IOT) to Meerut Institute of Engineering and Technology, Meerut (U.P.) is an authentic record of our genuine work done under the guidance of Asst.Prof. "Ajay Kumar Sah" of Computer Science and Engineering, Meerut Institute of Engineering and Technology, Meerut.

HARSHIT SINGHAL
TUSHAR GUPTA
KANISHKA MEHROTRA
SHAGUN TYAGI

Date: 12/12/2023
Place: Meerut

CERTIFICATE

This is to certify that major project report entitled – "Health monitoring system based on ECG and PPG Technique" submitted by "Harshit Singhal, Kanishka Mehrotra, Shagun Tyagi, Tushar Gupta" has been carried out under the guidance of Asst.Prof. "Ajay Kumar Sah" of Computer Science andEngineering, Meerut Institute of Engineering and Technology, Meerut. This project report is approved for Major Project (KCS753) in 7TH semester in "Computer Science and Engineering (Internet of Things)" from Meerut Institute of Engineering and Technology, Meerut.

Supervisor
Asst.Prof.
AJAY KUMAR SAH
Date: 12 DEC 2023

ACKNOWLEDGEMENT

We express our sincere indebtedness towards our guide Asst.Prof. “Ajay Kumar Sah” of Computer Science and Engineering, Meerut Institute of Engineering and Technology, Meerut for his valuable suggestion, guidance, and supervision throughout the work. Without his king patronage and guidance, the project would not have taken shape. We would also like to express our gratitude and sincere regards for his kind approval of the project. Time to time counselling and advises.

I would also like to thank to our HOD Prof. “Vikas Srivastav”, Department of Computer Science and Engineering (Internet of Things), Meerut Institute of Engineering and Technology, Meerut for his expert advice and counselling from time to time.

We owe sincere thanks to all the faculty members in the department of Computer Science and Engineering for their kind guidance and encouragement time to time.

HARSHIT SINGHAL
SHAGUN TYAGI
TUSHAR GUPTA
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Date: 12 DEC 2023

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INTRODUCTION

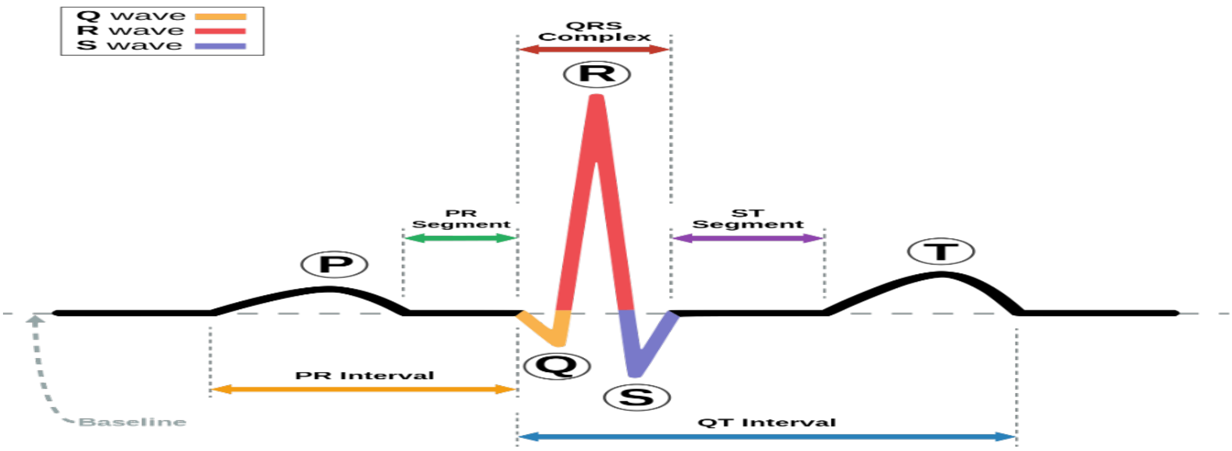
In recent years, the field of healthcare has witnessed significant advancements in technology, leading to the development of innovative systems for monitoring and managing individuals' health. One such breakthrough is the Health Monitoring System, which incorporates Electrocardiogram (ECG) and Photoplethysmography (PPG) techniques. This system plays a pivotal role in continuous and non-invasive monitoring of vital signs, enabling timely detection and intervention for various health conditions.

In conclusion, the Health Monitoring System using ECG and PPG techniques represents a significant advancement in healthcare technology. Its ability to provide continuous and non-invasive monitoring offers numerous benefits in terms of early detection, personalised healthcare, and improved overall well-being. As technology continues to evolve, these systems are likely to become more sophisticated, contributing to a paradigm shift in how we approach and manage individual health.

ECG TECHNIQUE

An electrocardiogram (ECG) is one of the simplest and fastest tests used to evaluate the heart. Electrodes (small, plastic patches that stick to the skin) are placed at certain spots on the chest, arms, and legs. The electrodes are connected to an ECG machine by lead wires. The electrical activity of the heart is then measured, interpreted, and printed out. No electricity is sent into the body.

Natural electrical impulses coordinate contractions of the different parts of the heart to keep blood flowing the way it should. An ECG records these impulses to show how fast the heart is beating, the rhythm of the heart beats (steady or irregular), and the strength and timing of the electrical impulses as they move through the different parts of the heart. Changes in an ECG can be a sign of many heart-related conditions.

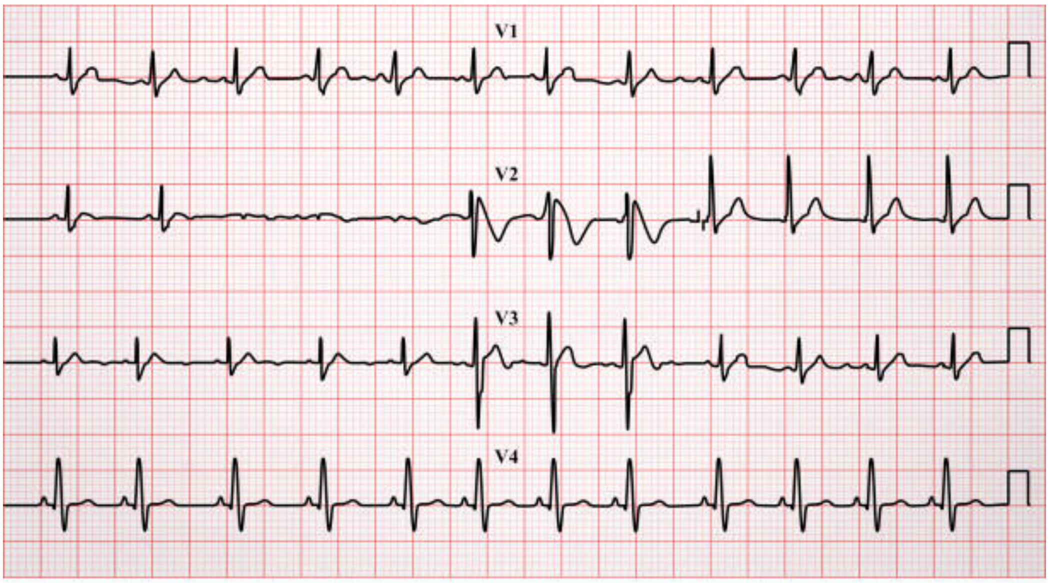


Principle of ECG

The basic principle of the ECG is that stimulation of a muscle alters the electrical potential of the muscle fibres. Cardiac cells, unlike other cells, have a property known as automaticity, which is the capacity to spontaneously initiate impulses. These are then transmitted from cell to cell by gap junctions that connect cardiac cells to each other.

The electrical impulses spread through the muscle cells because of changes in ions between intracellular and extracellular fluid. This is referred to as action potential. The primary ions involved are potassium, sodium, and calcium. The action potential is the potential for action created by the balance between electrical charges (positive and negative) of ions on either sideof the cell membrane.

When the cells are in a resting state, the insides are negatively charged compared to the outsides. Membrane pumps act to maintain this electrical polarity (negative charge) of the cardiac cells. Contraction of the heart muscle is triggered by depolarisation, which causes the internal negative charge to be lost transiently.



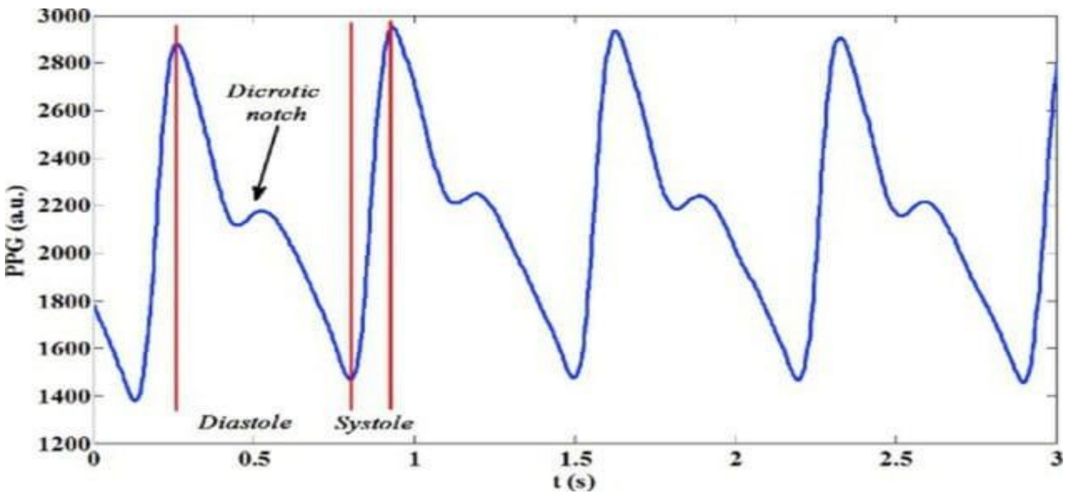
PPG TECHNIQUE

Photoplethysmography (PPG) is a simple optical technique used to detect volumetric changes in blood in peripheral circulation. It is a low cost and non- invasive method that makes measurements at the surface of the skin. The technique provides valuable information related to our cardiovascular system. Recent advances in technology have revived interest in this technique, which is widely used in clinical physiological measurement and monitoring.

Principle of PPG

A Photoplethysmogram (PPG) is an optically obtained Plethysmogram that can be used to detect blood volume changes in the microvascular bed of tissue. A PPG is often obtained by using a pulse oximeter which illuminates the and measures changes in light absorption. A conventional pulse oximeter monitors the perfusion of blood to the dermis and subcutaneous tissue of the skin.With each cardiac cycle the heart pumps blood to the periphery.

The PPG Waveform



PPG shows the blood flow changes as a waveform with the help of a bar or a graph. The waveform has an alternating current (AC) component and a direct current (DC) component development board. Also provided on this board are RA (Right Arm), LA (LeftArm), and RL (Right Leg) pins to attach and use your own custom sensors.

USES OF PPG AND ECG TECHNIQUE

- Clinical Physiological Monitoring
- Blood Oxygen Saturation
- Blood Pressure
- Cardiac Output
- Heart Rate
- Respiration
- Vascular Assessment

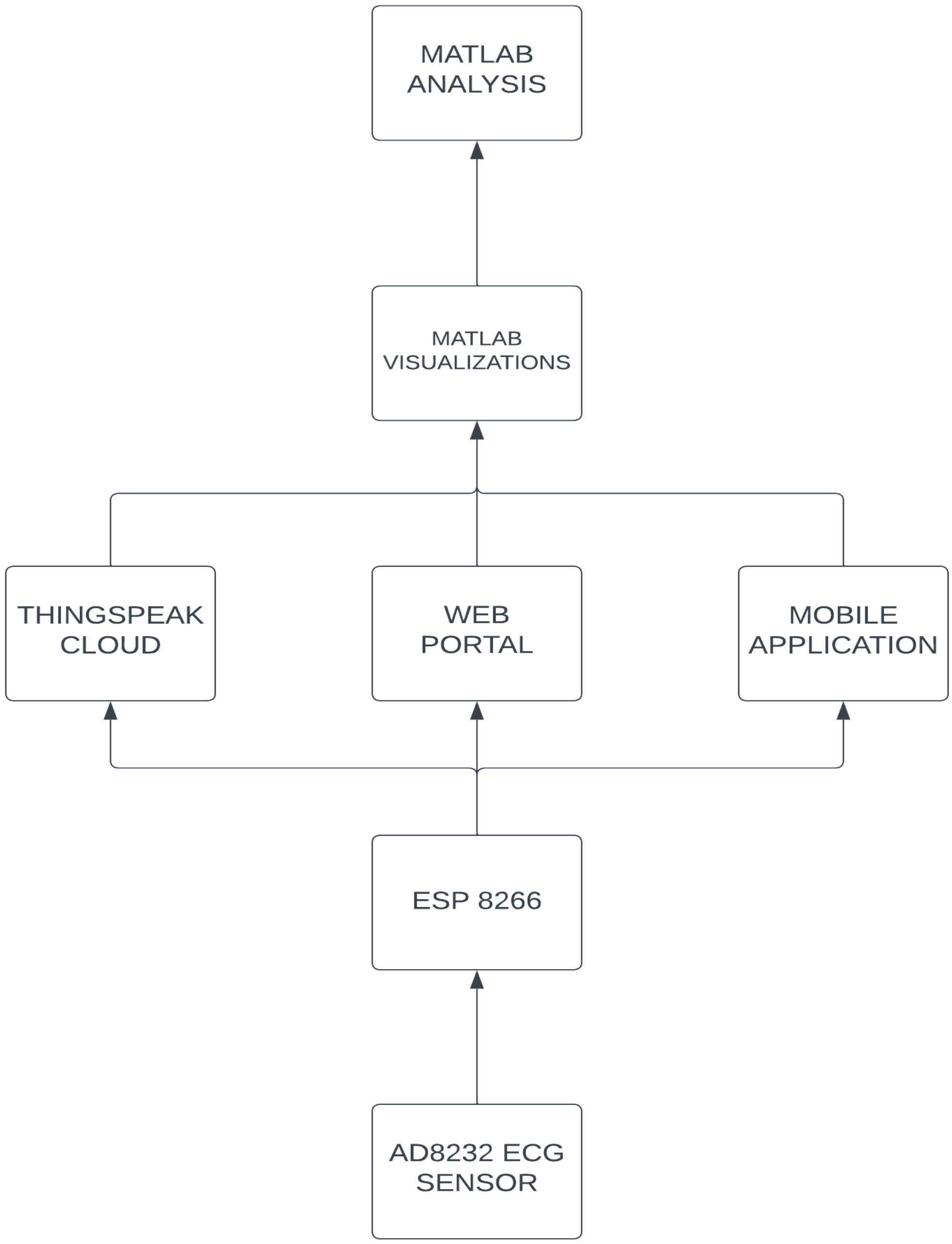
COMPONENTS REQUIRED

- MAX30100
- AD8232 ECG SENSOR
- NODEMCU ESP8266
- Connecting Wires
- 5V Charger or Power Bank
- Display
- Breadboard

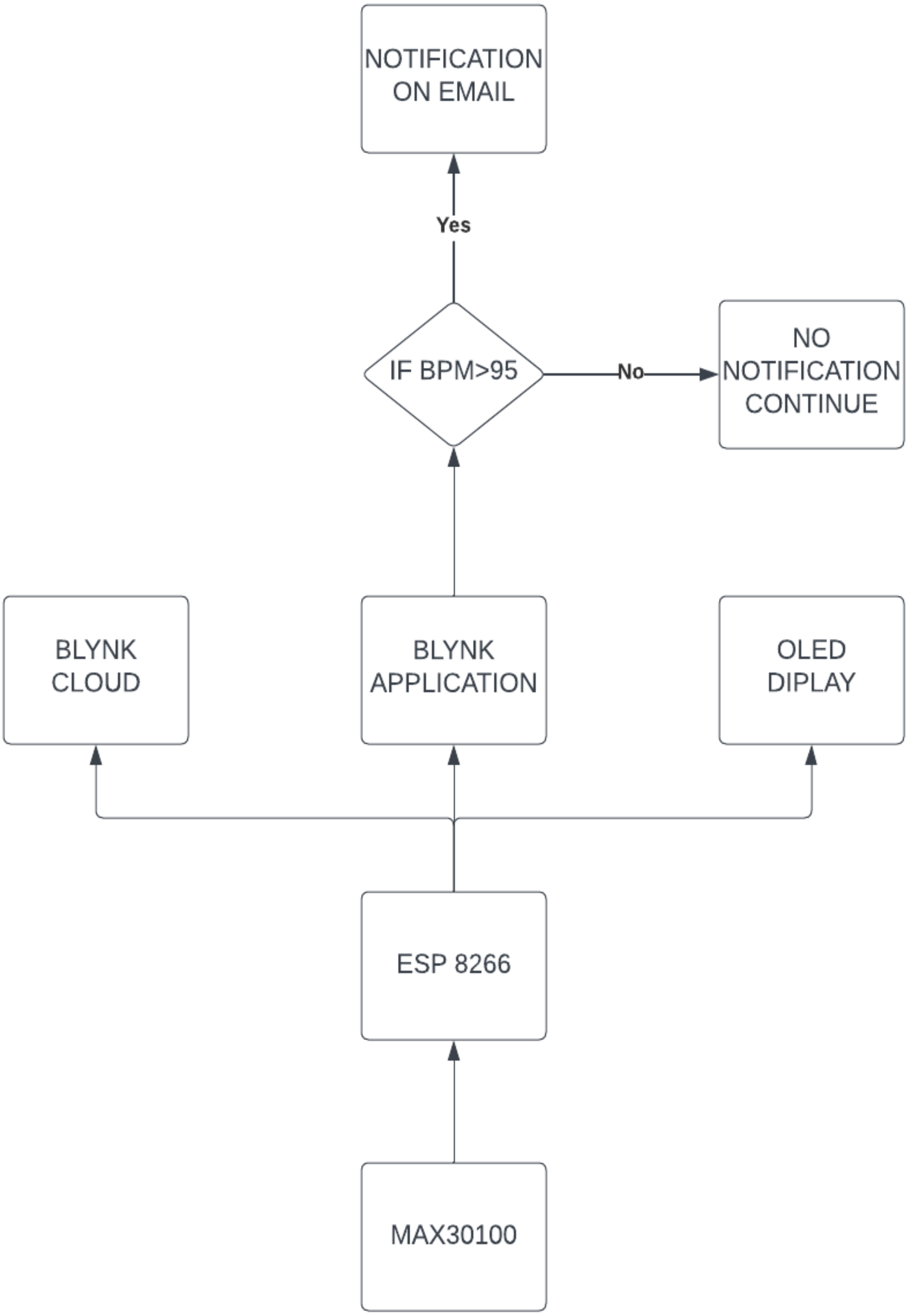
TECHNOLOGY USED

- ARDUINO IDE
- WINDOW OS
- ECG Technique
- Thingspeak
- PPG Technique
- Database- Firebase
- Blynk
- Application- Flutter
- MATLAB Visualization
- MATLAB Analytics

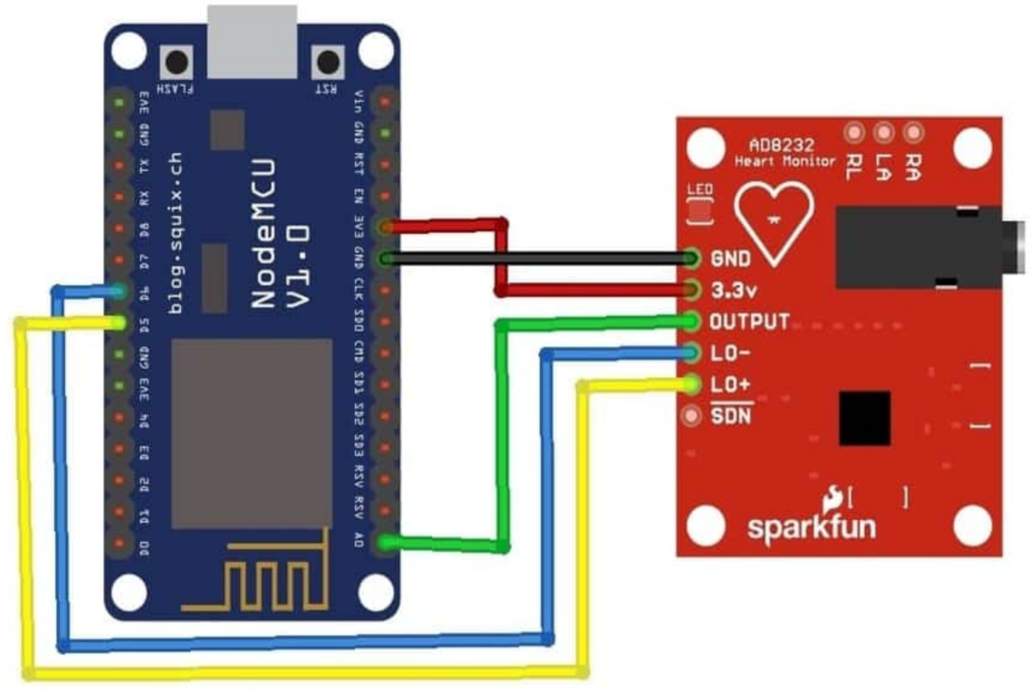
BLOCK DIAGRAM OF ECG



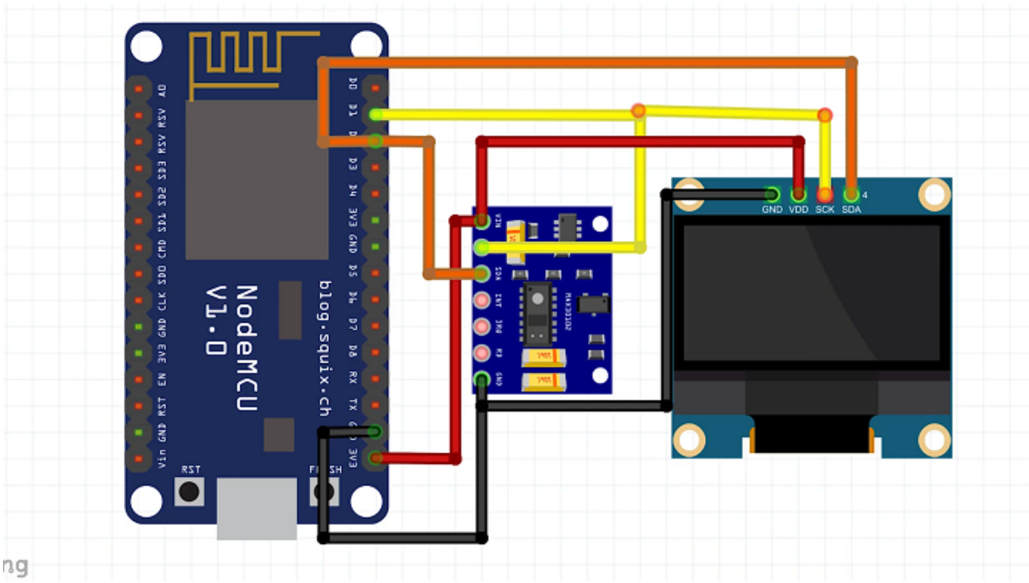
<u>BLOCK DIAGRAM OF PPG</u>



CIRCUIT DIAGRAM OF ECG

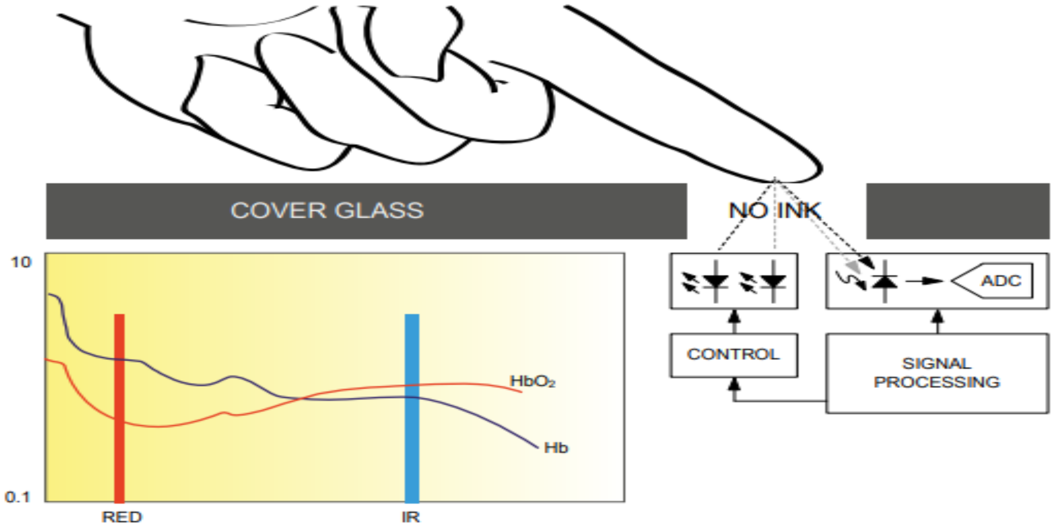


<u>CIRCUIT DIAGRAM OF PPG</u>



MAX 30100

The MAX30100 is an integrated pulse oximetry and heart rate monitor sensor solution. It combines two LEDs, a photodetector, optimised optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals



The MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to always remain connected.

Features of MAX 30100

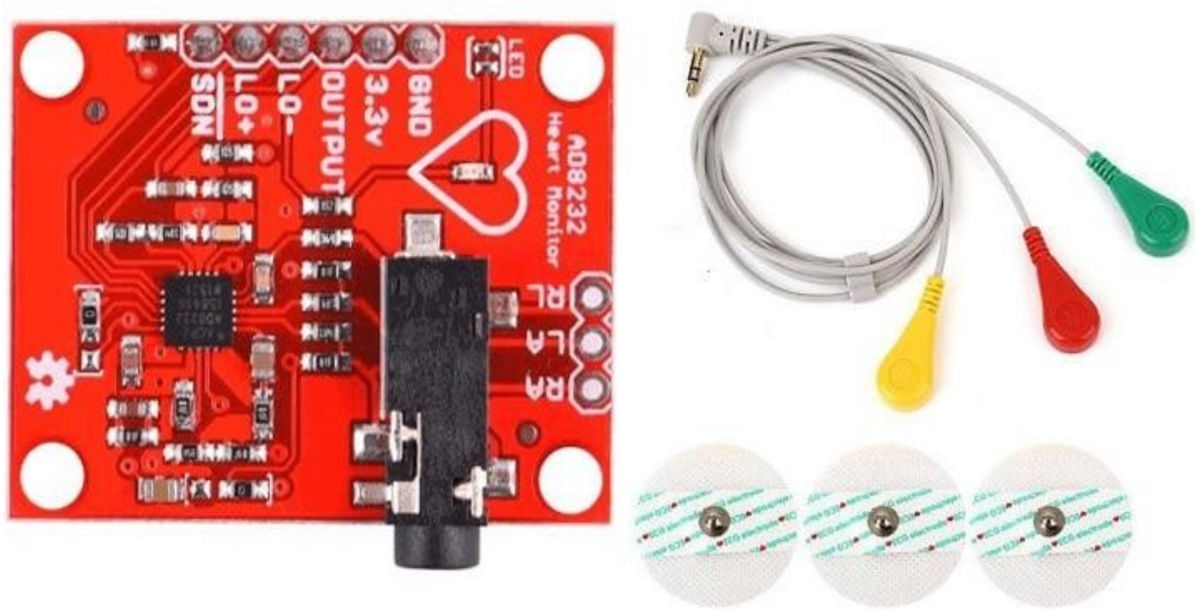
- Complete Pulse Oximeter and Heart-Rate Sensor Solution Simplifies Design
  - Integrated LEDs, Photo Sensor, and High-Performance Analog Front -End
  - Tiny 5.6mm x 2.8mm x 1.2mm 14-Pin Optically Enhanced System-in-Package

- Ultra-Low-Power Operation Increases Battery Life for Wearable Devices
  - Programmable Sample Rate and LED Current for Power Savings
  - Ultra-Low Shutdown Current (0.7µA, typ)

- Advanced Functionality Improves Measurement Performance
  - Integrated Ambient Light Cancellation
  - High Sample Rate Capability

AD8232 ECG SENSOR

This sensor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analogy reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op-ampto help obtain a clear signal from the PR and QT Intervals easily.

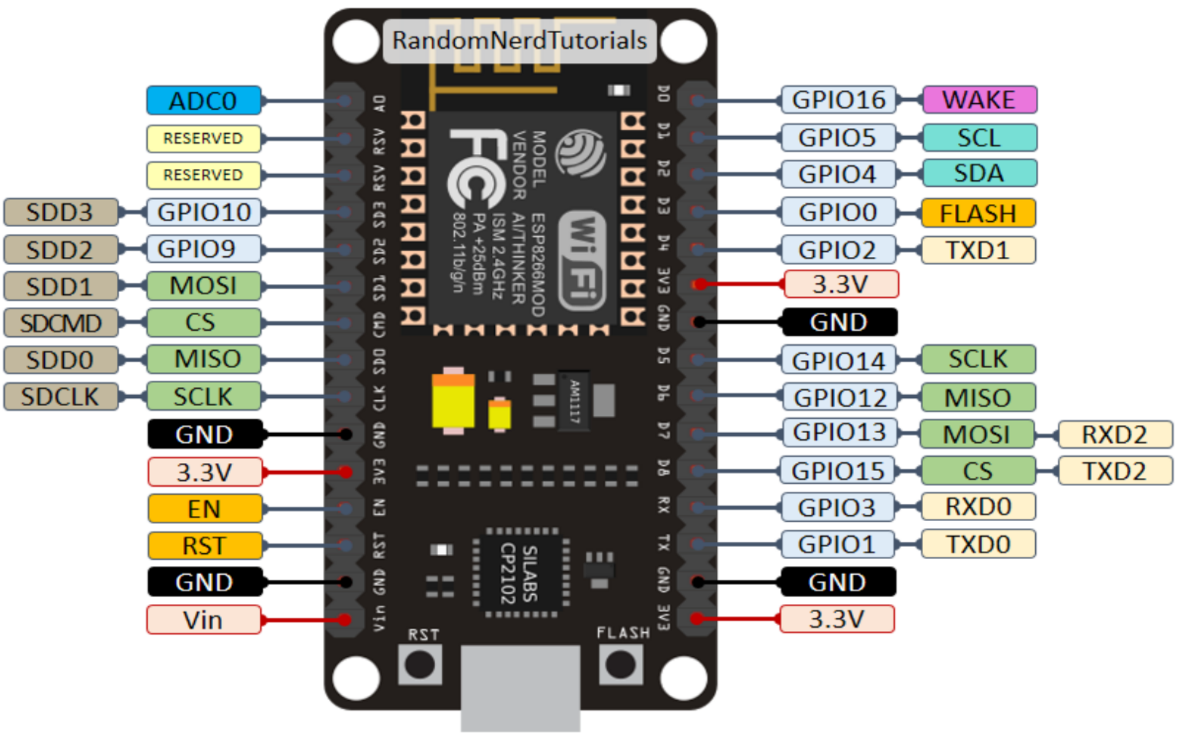


The AD8232 is an integrated signal conditioning block for ECG and other biopotential measurement applications. It is designed to extract, amplify,and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement.

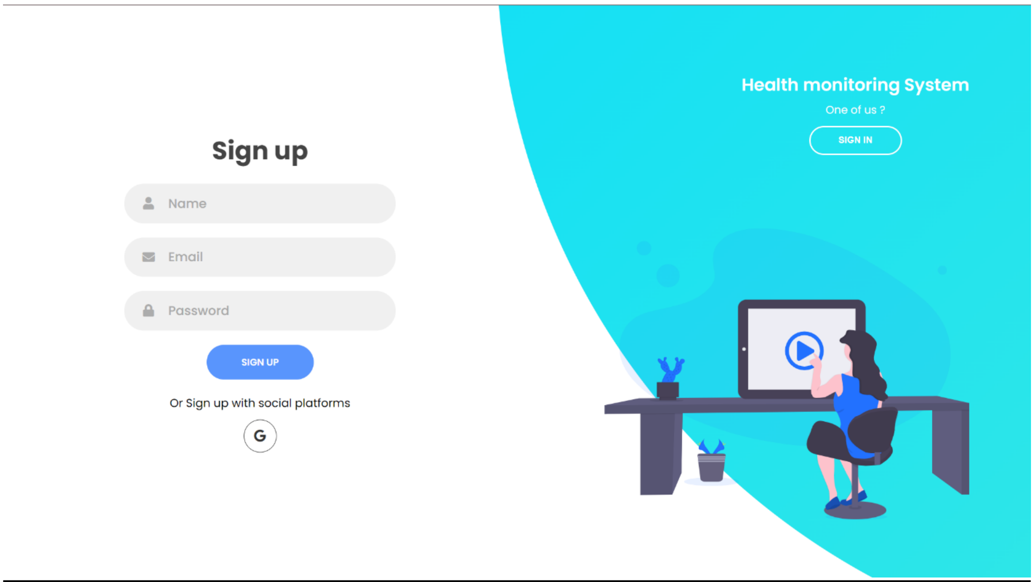
The AD8232 module breaks out nine connections from the IC that you can solder pins, wires, or other connectors to SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other.

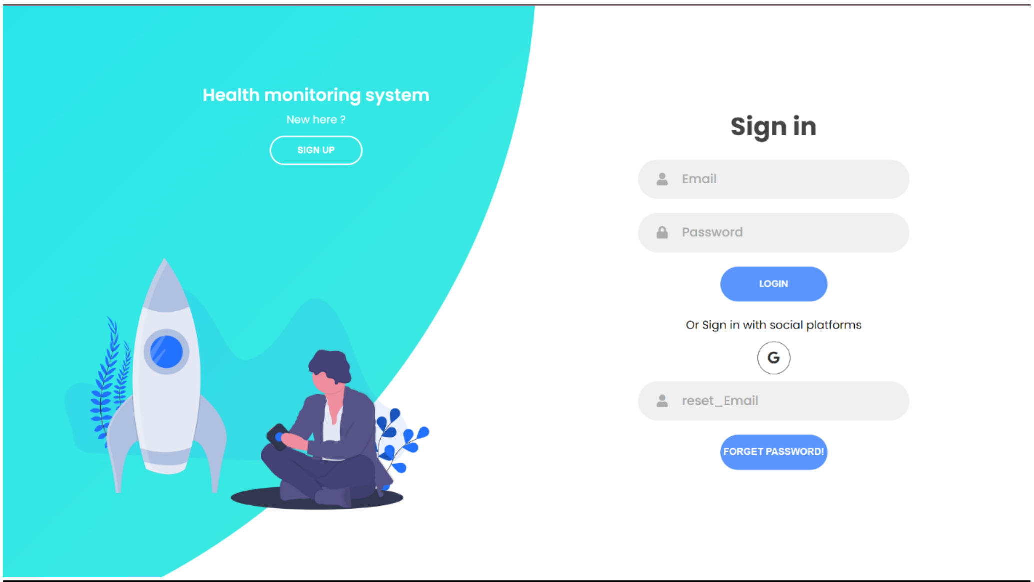
<u>NODE MCU8266</u>

The NodeMCU ESP8266 is a low-cost microcontroller board that isdesigned for IoT (Internet of Things) projects. It is based on the ESP8266chip and comes with built-in Wi-Fi connectivity, making it an ideal platform for building IoT applications. The NodeMCU ESP8266 board is Arduino-compatible and can be programmed using the Arduino IDE (Integrated Development Environment) or using Lua scripting language. It has a built-in USB-to-serial converter that makes it easy to program and communicate with the board. The board also features GPIO pins, which can be used to connect sensors, actuators, and other peripherals. Additionally, it has built-in support for MQTT (Message Queuing Telemetry Transport), which is a lightweight messaging protocol that is commonly used in IoT applications. Overall, the NodeMCU ESP8266 board is a powerful and versatile platform for building IoT projects, and itslow cost and easy-to-use design make it accessible to hobbyists andprofessionals alike.

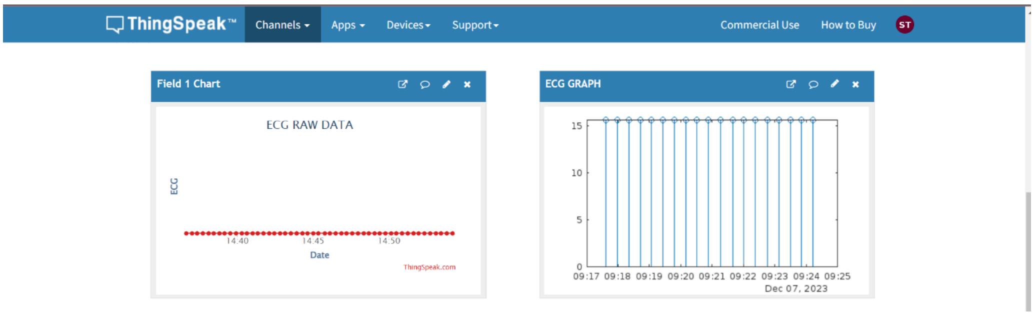


WEBSITE PORTAL FOR ECG

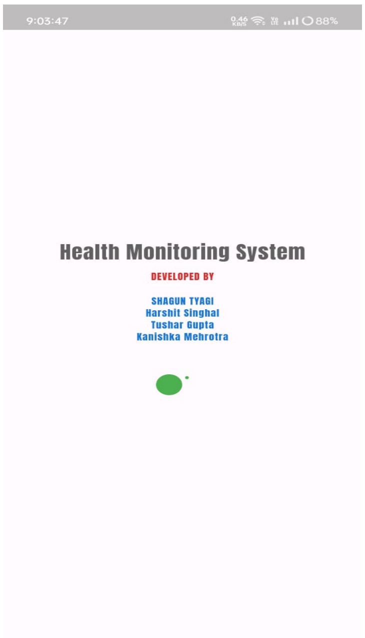


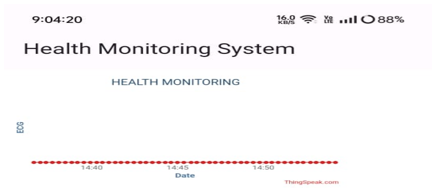


THINGSPEAK CLOUD FOR ECG

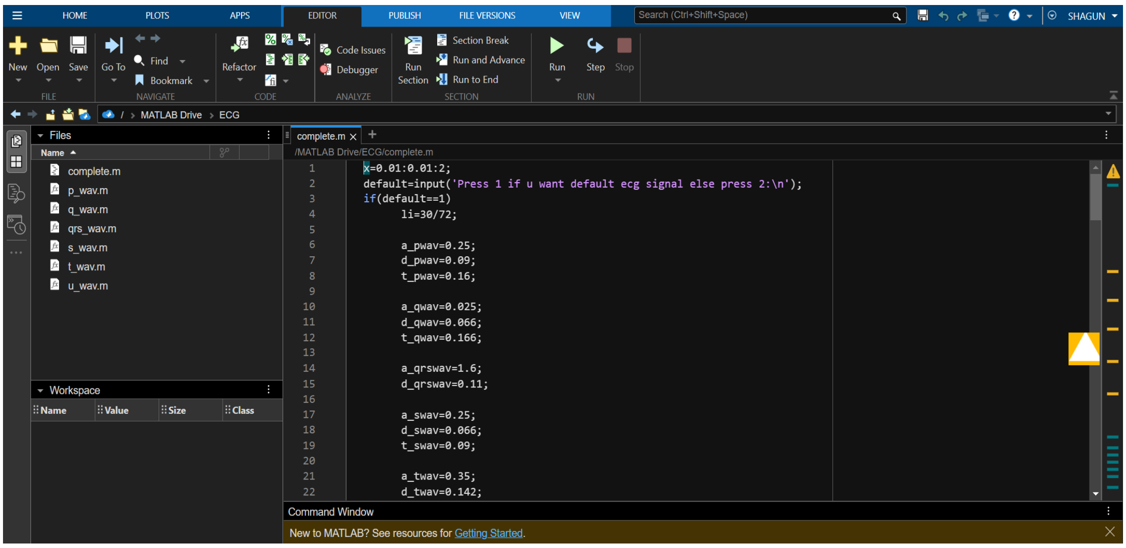


MOBILE APPLICATION FOR ECG

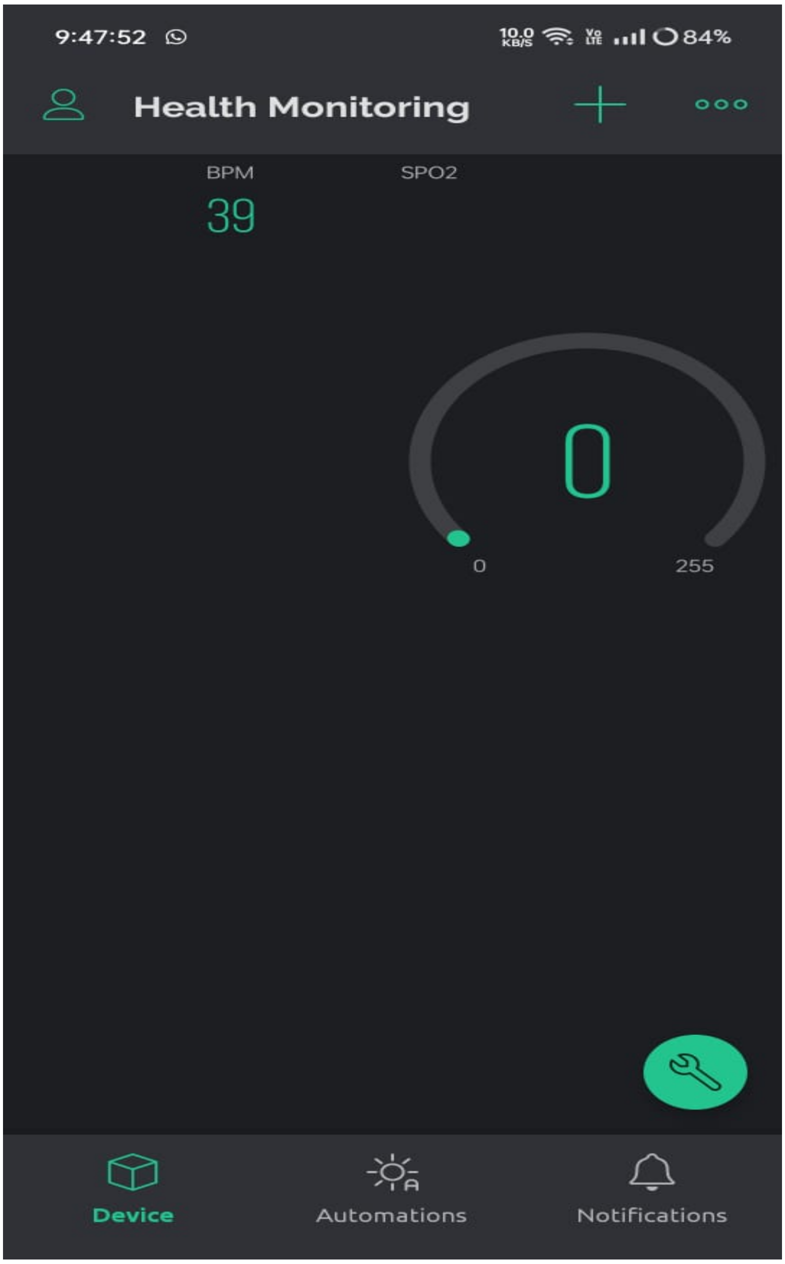




MATLAB ANALYSIS FOR ECG GRAPH ANALYSIS



<u>APPLICATION FOR PPG</u>



CODE FOR ECG MODEL

```
#include <WiFi.h>

// WiFi settings
const char* ssid = "GNXS-2.4G-CB5A1B";
const char* password = "Shagun@098";

// ThingSpeak settings
const char* server = "api.thingspeak.com";
const char* apiKey = "I9N3ZCBRPCUL52P2";

// AD8232 ECG sensor pin
const int ecgPin = A0;

void setup() {
  Serial.begin(115200);

  // Connect to WiFi
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(1000);
    Serial.println("Connecting to WiFi...");
  }
  Serial.println("Connected to WiFi!");
}

void loop() {
  // Read ECG sensor data
  int ecgValue = analogRead(ecgPin);

  // Create ThingSpeak URL with API key and data
  String url = "/update?api_key=";
  url += apiKey;
  url += "&field1=";
  url += String(ecgValue);

  // Connect to ThingSpeak
  WiFiClient client;
  if (client.connect(server, 80)) {
    Serial.println("Connected to ThingSpeak!");
    client.print(String("GET ") + url + " HTTP/1.1\r\n" +
                 "Host: " + server + "\r\n" +
                 "Connection: close\r\n\r\n");
    Serial.println("Data sent to ThingSpeak successfully!");
    client.stop();
  } else {
    Serial.println("Failed to connect to ThingSpeak.");
  }
```

```
  delay(10000); // Wait 10 seconds before sending next data
}
```

CODE FOR PPG

```
#define BLYNK_TEMPLATE_ID "TMPL3rdCxgU3o"
#define BLYNK_TEMPLATE_NAME "Health Monitoring"
#define BLYNK_AUTH_TOKEN "DT1eOL37Kz6Ea3oPNnX1eCq_XDyKz0X_"
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#define BLYNK_PRINT Serial
#include <Blynk.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include "Wire.h"
#include "Adafruit_GFX.h"
#include "OakOLED.h"

#define REPORTING_PERIOD_MS 1000
OakOLED oled;

char auth[] = "DT1eOL37Kz6Ea3oPNnX1eCq_XDyKz0X_";             // You
should get Auth Token in the Blynk App.
char ssid[] = "B.D ENTERPRISES 2.4G";
// Your WiFi credentials.
char pass[] = "02052003";

// Connections : SCL PIN - D1 , SDA PIN - D2 , INT PIN - D0
PulseOximeter pox;

float BPM, SpO2;
uint32_t tsLastReport = 0;

const unsigned char bitmap [] PROGMEM=
{
0x00, 0x00, 0x00, 0x00, 0x01, 0x80, 0x18, 0x00, 0x0f, 0xe0, 0x7f, 0x00,
0x3f, 0xf9, 0xff, 0xc0,
0x7f, 0xf9, 0xff, 0xc0, 0x7f, 0xff, 0xff, 0xe0, 0x7f, 0xff, 0xff, 0xe0,
0xff, 0xff, 0xff, 0xf0,
0xff, 0xf7, 0xff, 0xf0, 0xff, 0xe7, 0xff, 0xf0, 0xff, 0xe7, 0xff, 0xf0,
0x7f, 0xdb, 0xff, 0xe0,
0x7f, 0x9b, 0xff, 0xe0, 0x00, 0x3b, 0xc0, 0x00, 0x3f, 0xf9, 0x9f, 0xc0,
0x3f, 0xfd, 0xbf, 0xc0,
0x1f, 0xfd, 0xbf, 0x80, 0x0f, 0xfd, 0x7f, 0x00, 0x07, 0xfe, 0x7e, 0x00,
0x03, 0xfe, 0xfc, 0x00,
0x01, 0xff, 0xf8, 0x00, 0x00, 0xff, 0xf0, 0x00, 0x00, 0x7f, 0xe0, 0x00,
0x00, 0x3f, 0xc0, 0x00,
0x00, 0x0f, 0x00, 0x00, 0x00, 0x06, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00,
0x00, 0x00, 0x00, 0x00
};

void onBeatDetected()
{
    Serial.println("Beat Detected!");
```

```
    oled.drawBitmap( 60, 20, bitmap, 28, 28, 1);
    oled.display();
}

void setup()
{
    Serial.begin(115200);
    oled.begin();
    oled.clearDisplay();
    oled.setTextSize(1);
    oled.setTextColor(1);
    oled.setCursor(0, 0);

    oled.println("Initializing pulse oximeter..");
    oled.display();

    pinMode(16, OUTPUT);
    Blynk.begin(auth, ssid, pass);

    Serial.print("Initializing Pulse Oximeter..");

    if (!pox.begin())
    {
         Serial.println("FAILED");
         oled.clearDisplay();
         oled.setTextSize(1);
         oled.setTextColor(1);
         oled.setCursor(0, 0);
         oled.println("FAILED");
         oled.display();
         for(;;);
    }
    else
    {
         oled.clearDisplay();
         oled.setTextSize(1);
         oled.setTextColor(1);
         oled.setCursor(0, 0);
         oled.println("SUCCESS");
         oled.display();
         Serial.println("SUCCESS");
         pox.setOnBeatDetectedCallback(onBeatDetected);
    }

    // The default current for the IR LED is 50mA and it could be changed
by uncommenting the following line.
     //pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

}

void loop()
{
    pox.update();
```

```
    Blynk.run();

    BPM = pox.getHeartRate();
    SpO2 = pox.getSpO2();
     if (millis() - tsLastReport > REPORTING_PERIOD_MS)
    {
        Serial.print("Heart rate:");
        Serial.print(BPM);
        Serial.print(" bpm / SpO2:");
        Serial.print(SpO2);
        Serial.println(" %");

        Blynk.virtualWrite(V0, BPM);
        Blynk.virtualWrite(V4, SpO2);

        oled.clearDisplay();
        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0,16);
        oled.println(pox.getHeartRate());

        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0, 0);
        oled.println("Heart BPM");

        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0, 30);
        oled.println("Spo2");

        oled.setTextSize(1);
        oled.setTextColor(1);
        oled.setCursor(0,45);
        oled.println(pox.getSpO2());
        oled.display();

        tsLastReport = millis();
    }
}
```

MATLAB ANALYSIS CODE

```
x=0.01:0.01:2;
default=input('Press 1 if u want default ecg signal else press 2:\n');
if(default==1)
      li=30/72;

      a_pwav=0.25;
      d_pwav=0.09;
      t_pwav=0.16;

      a_qwav=0.025;
      d_qwav=0.066;
      t_qwav=0.166;

      a_qrswav=1.6;
      d_qrswav=0.11;

      a_swav=0.25;
      d_swav=0.066;
      t_swav=0.09;

      a_twav=0.35;
      d_twav=0.142;
      t_twav=0.2;

      a_uwav=0.035;
      d_uwav=0.0476;
      t_uwav=0.433;
else
    rate=input('\n\nenter the heart beat rate :');
    li=30/rate;

    %p wave specifications
    fprintf('\n\np wave specifications\n');
    d=input('Enter 1 for default specification else press 2: \n');
    if(d==1)
        a_pwav=0.25;
        d_pwav=0.09;
        t_pwav=0.16;
    else
       a_pwav=input('amplitude = ');
       d_pwav=input('duration = ');
       t_pwav=input('p-r interval = ');
       d=0;
    end


    %q wave specifications
    fprintf('\n\nq wave specifications\n');
    d=input('Enter 1 for default specification else press 2: \n');
    if(d==1)
        a_qwav=0.025;
        d_qwav=0.066;
        t_qwav=0.166;
    else
       a_qwav=input('amplitude = ');
       d_qwav=input('duration = ');
       t_qwav=0.166;
       d=0;
```

```
end



%qrs wave specifications
fprintf('\n\nqrs wave specifications\n');
d=input('Enter 1 for default specification else press 2: \n');
if(d==1)
    a_qrswav=1.6;
    d_qrswav=0.11;
else
   a_qrswav=input('amplitude = ');
   d_qrswav=input('duration = ');
   d=0;
end



%s wave specifications
fprintf('\n\ns wave specifications\n');
d=input('Enter 1 for default specification else press 2: \n');
if(d==1)
    a_swav=0.25;
    d_swav=0.066;
    t_swav=0.09;
else
   a_swav=input('amplitude = ');
   d_swav=input('duration = ');
   t_swav=0.09;
   d=0;
end


%t wave specifications
fprintf('\n\nt wave specifications\n');
d=input('Enter 1 for default specification else press 2: \n');
if(d==1)
    a_twav=0.35;
    d_twav=0.142;
    t_twav=0.2;
else
   a_twav=input('amplitude = ');
   d_twav=input('duration = ');
   t_twav=input('s-t interval = ');
   d=0;
end


%u wave specifications
fprintf('\n\nu wave specifications\n');
d=input('Enter 1 for default specification else press 2: \n');
if(d==1)
    a_uwav=0.035;
    d_uwav=0.0476;
    t_uwav=0.433;
else
   a_uwav=input('amplitude = ');
   d_uwav=input('duration = ');
   t_uwav=0.433;
   d=0;
end
```

```
end

 pwav=p_wav(x, a_pwav, d_pwav, t_pwav, li);


 %qwav output
 qwav=q_wav(x, a_qwav, d_qwav, t_qwav, li);


 %qrswav output
 qrswav=qrs_wav(x, a_qrswav, d_qrswav, li);

 %swav output
 swav=s_wav(x, a_swav, d_swav, t_swav, li);


 %twav output
 twav=t_wav(x, a_twav, d_twav, t_twav, li);


 %uwav output
 uwav=u_wav(x, a_uwav, d_uwav, t_uwav, li);

 %ecg output
 ecg=pwav+qrswav+twav+swav+qwav+uwav;
 figure(1)
 plot(x, ecg);
```

CONCLUSION

In conclusion, a health monitoring system utilising ECG and PPG techniques holds significant promise in providing comprehensive and real-time insights into an individual's cardiovascular health. The integration of these technologies enables continuous monitoring, early detection of anomalies, and timely intervention, contributing to improved healthcare outcomes. Here are key points to consider:

- Early Detection of Cardiovascular Issues
- Continuous Monitoring & Real- Time Alerts
- User Empowerment & Engagement
- Remote Patient Monitoring
- Data- Driven Healthcare
- Integration with Healthcare Systems
- Challenges & Consideration
- Collaboration & Feedback

FUTURE SCOPE

The integration of ECG technology with the Internet of Things (IoT) can provide many benefits, including improved monitoring, diagnosis, and treatment of heart disease. Some potential future scopes of ECG techniqueusing IoT are:

1. Remote Monitoring: IoT-enabled ECG devices can allow patients to monitor their heart health remotely and send real-time data to healthcare providers. This can help to detect abnormalities early and prevent heart disease progression.
2. Personalised Medicare: IoT can be used to collect patient-specific data, such as lifestyle habits and genetic information, to develop personalised treatment plans for heart disease.

Overall, the integration of ECG technology with IoT can lead to more efficient and effective monitoring, diagnosis, and treatment of heart disease. By providing real-time data and personalized insights, IoT-enabled ECG devices can help to improve patient outcomes and reduce healthcare costs.

LITERATURE SURVEY/RESEARCH PAPERS

- The use of photoplethysmography for assessing hypertension | npj Digital Medicine (nature.com)
- Heart Rate Estimation From Wrist-Worn Photoplethysmography: A Review | IEEE Journals & Magazine | IEEE Xplore

- The accuracy of heartbeat detection using photoplethysmography technology in cardiac patients - ScienceDirect
- Heart Rate BPM Meter using Easy Pulse Sensor & Arduino (how2electronics.com)

- Photoplethysmography—new applications for an old technology: a sleep technology review | Journal of Clinical Sleep Medicine (aasm.org)
- 5.4.1: Circuit of pulse sensor HRM-2511E | Download Scientific Diagram (researchgate.net)

TARGET AUDIENCE

- Patients with Cardiovascular Conditions
- Fitness Enthusiasts
- Elderly Population
- Healthcare Professionals
- Telemedicine and Remote Monitoring Services

FUTURE UPDATE

- Enhanced Wearable Devices
- Artificial Intelligence Integration
- Interoperability with Health Platforms
- Mobile Health Apps
- Continuous Connectivity and Cloud Integration