A

PROJECT REPORT

ON

ECG Sensor Automation with Automatic Emergency triggers

Submitted by

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Under the Guidance of

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Sanjay Bhokare Group of Institutes, Miraj

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CERTIFICATE

This is to certify that **Miss. Aishwarya Dadaso Patil** of B.Tech. At Sanjay Bhokare Group of Institutes, Miraj has satisfactorily completed the project work entitled **"ECG Sensor Automation with Automatic Emergency triggers"** in partial fulfillment for award of Bachelor of Technology Degree in Electronics and Telecommunication Engineering by Dr. Babasaheb Ambedkar Technological University, Lonere in the year 2022-2023.

Guide
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Acknowledgement

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Miss.Aishwarya Dadaso Patil

Contents

Abstract

Remote ECG monitoring systems are becoming commonplace medical devices for remote heart monitoring. In recent years, remote ECG monitoring systems have been applied in the monitoring of various kinds of heart diseases, and the quality of the transmission and reception of the ECG signals during remote process kept advancing. However, there remains accompanying challenges. This report focuses on the three components of the remote ECG monitoring system: patient (the end user), the doctor workstation, and the remote server, reviewing and evaluating the imminent challenges on the wearable systems, packet loss in remote transmission, portable ECG monitoring system, patient ECG data collection system, and ECG signals transmission including real-time processing ST segment, R wave, RR interval and QRS wave, etc. This paper tries to clarify the future developmental strategies of the ECG remote monitoring, which can be helpful in guiding the research and development of remote ECG monitoring.

In this mobile era, design and development of a continuous remote ECG Monitoring System will be of immense help to modern healthcare. Deploying telemedicine/telecare principles, the developed system suggests a feasible solution for continuously monitoring the post-operative conditions of cardiac patients. When the product developed is small in size and exhibits user-friendly operations the patients will feel more comfort in carrying them. Thermopile phone technology which has gained tremendous popularity when used as an inter-link between the patient and the physician will be a familiar platform for both of them. Our paper proposes the design of a real time, low cost portable wireless ECG acquisition system which we implement through the common mobile phone and high end recorder. An Alarm system with a notification mechanism is an added benefit to alert both the physician and the patient in case of any abnormalities.

List of Figures

Chapter 1

INTRODUCTION

1.1Basic information of ECG monitoring system.

The electrocardiogram (ECG) test is developed to monitor the functionality of the cardiovascular system. Nowadays, numerous attention have been given to the accurate and early detection of heartbeat anomalies in real-time to prevent complications and take necessary measures. This paper proposes a robust real-time binary classification for ECG signals to detect possible anomalies. We implement an initial detection phase right where ECG data is collected through lightweight deep learning analysis. We evaluate the system on two widely used datasets, PTB and MIT-BIH datasets from PhysioNet. Our experiments suggest using artificial neural network (ANN) algorithms for their superior performance over other machine learning algorithms with accuracy up to 99.3%. Furthermore, we implemented our system on a Raspberry Pi B+ representing an ECG patch to collect and process ECG signals and detect any abnormalities using the proposed ANN model. To create a scalable system, we stream the data in real-time using Apache Kafka and MQTT to keep records of patients' ECG data and use it for further analysis to identify causes and support medical diagnosis. The system notifies healthcare providers when abnormalities are detected.

An ECG monitoring system using ESP32 and AD8232 with a GSM module is a device that allows for the continuous measurement of a patient's heart rate and rhythm. It is an important tool for healthcare professionals in the diagnosis and treatment of various heart conditions.

The system consists of an ESP32 microcontroller, an AD8232 analog front-end (AFE) module, and a GSM module. The AD8232 is a low-power, single-lead electrocardiogram (ECG) front-end that can detect and amplify the electrical signals generated by the heart. The ESP32 microcontroller processes the signals and transmits the data to the GSM module, which can then send the data to a remote server or mobile device for analysis and monitoring.

The system is typically attached to the patient's chest using adhesive electrodes, and it continuously records and transmits ECG data in real-time. The GSM module allows for remote monitoring and analysis of the data, making it ideal for use in ambulatory care settings or for patients who need to be monitored outside of the hospital.

Overall, an ECG monitoring system using ESP32 and AD8232 with a GSM module is a powerful tool for the diagnosis and treatment of heart conditions, providing real-time monitoring and analysis of a patient's heart rate and rhythm.

1.2Objectives

- Design and develop a functional ECG monitoring system using ESP32 and AD8232 with a GSM module.

- Implement a user-friendly interface for data visualization and interpretation.

- Integrate real-time ECG data transmission to a remote server or mobile device via the GSM module.

- Test the accuracy and reliability of the system in detecting and transmitting ECG signals.

- Evaluate the system's performance and identify potential areas for improvement.

- Develop a basic algorithm for analyzing ECG data and detecting abnormal heart rhythms.

- Develop a plan for scaling up the system to handle larger amounts of data or multiple patients.

LITERATURE REVIEV

1) The objective of the work was to make a simple wireless one channel limited (3-lead) home electrocardiogram (ECG) transmission system for home and ambulance use. The wireless ECG monitoring system significantly improves the quality of life of the cardiac patients, reflected primarily in the permanent monitoring. In case of an accident, an immediate alarm is being transmitted to the physician. A long-term monitoring facilitates the capturing of sporadic events and therefore is an important contribution for the improvement of the therapy and, consequently, for the health of the patients. The task has been accomplished by Bluetooth technology, ECG detector and personal computer as monitor.
Published in: 2009 1st International Conference on Wireless Communication, Vehicular Technology, Information Theory and Aerospace & Electronics Systems Technology

2) Sudden and unexpected death due to heart failure is a major cause of mortality among middle aged and elderly people. An efficient heart monitoring system can find out the malformation of heart conditions and that can also be helpful in diagnose at critical ambience. Sometimes the distance between patients and doctors is the main barrier that people do not have access to quality health services and thus having trouble for their regular health examine. IoT-based healthcare monitoring system is one of the manifested application areas in medical science. As a significant access in diagnose heart disease ECG observing system is widely used. In this paper, a progressive method for ECG monitoring system based on Internet of Things (IoT) has been proposed. In this study, a system is designed to frequently monitor the Electrocardiogram (ECG) signal collected from patient's body using wearable sensors and the data is stored into the database which can be accessed by authorized personnel only. When any malformation is found an automatic email is sent to the users and doctors for analyzing about the critical conditions of the patients and provides emergency health assistances. In order to verify the authenticity of this system tests have been implemented on several patients and the report shows that, this system is dependable and efficient for collecting real time ECG data which can be very helpful in diagnose heart diseases. This IoT-based low cost device can be reliably used to reduce the risk of disability and mortality rate due to cardiovascular diseases.
Published in: 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT)

Chapter 3

METHODOLOGY

3.1 Introduction:-

Intensive research was devoted to improve the efficiency of processing and analysis of ECG signals to achieve high diagnostic accuracy. During the processing phase, advanced information technologies are carried out through the development of diverse algorithms and intelligent techniques, such as analysis, modification, and synthesis applied to ECG signals to recognize and identify its significant components, with the purpose of discovering diagnostic information. These include, but are not limited to signal quality assessment, ECG signal classification, heartbeat detection and delay correction, peak detection, and training. Processing ECG signals is challenging due to their special characteristics, such as dynamicity, noise vulnerability, and inconsistency among individuals. Therefore, the optimization and development of ECG signal processing techniques has attracted research interest.

3.2Working Details:-

The ECG (Electrocardiogram) is a non-invasive diagnostic test that assesses heart rhythm and function through a recording of the **electrical activity of the heart** that occurs with each heartbeat. This electrical activity is recorded from the patient's body surface and is drawn on a paper using a graphical representation or tracing, where different waves are observed that represent the electrical stimuli of the atria and ventricles. The device with which the electrocardiogram is obtained is called an **electrocardiograph**. The normal rhythm of an ECG is formed by a P wave, a QRS complex and a T wave. To interpret an electrocardiogram, the presence of these waves, their shape and duration, as well as the ST segment (time that elapses between the end of depolarization and the beginning of repolarization of the ventricles, measures less than 1 mm, if it is greater than 1 mm it indicates infarction or ischemia).

The P waves allow us to know the time between the heartbeats; it is represented as a straight line between the lowest and the highest point. The T wave represents the small perceptible beat after the first and marks the end of the heartbeat. The time elapsed between one and the other must be fairly regular throughout the entire test, if on the contrary, during the test we see that the elapsed time is variable, this indicates an irregularity in the heartbeat.

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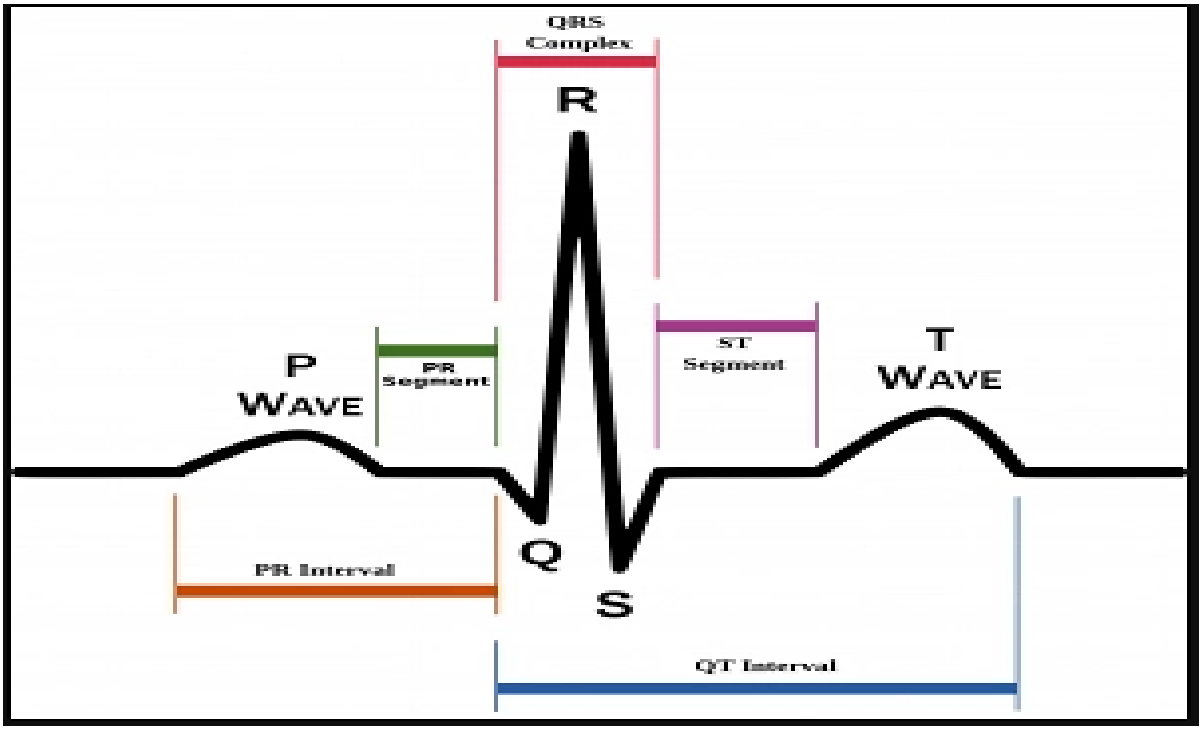


Fig. Schematic diagram of normal sinus rhythm for a human heart as seen on ECG

We suggested a system that comprises of an ECG sensor that measures an ECG signal from the patient using electrodes linked to the ECG board through normal electrode wires. The data was transferred to the ESP32 controller, which processed it before sending it to the IoT Cloud Platform. The data was then transmitted through WIFI to the user's phone. We'll need an IoT platform to publish the data to the IoT Cloud. So Ubidots is however one platform that provides a platform for programmers to capture sensor data and transform it into usable information. The Ubidots platform allows any Internet-enabled device to submit data to the cloud, which transforms sensor data into information that is useful for corporate decisions, machine-to-machine interactions, and educational research, resulting in increased global resource economization. It allows us to incorporate the power of the Internet of Things into our study in a simple and cost-effective manner. Its promising application platform will offer interactive, real-time data visualization; The proposed work's functioning principle is depicted in (Figure1). The AD8232ECG sensor is attached to the ESP32 controller. All of the remaining components, as well as the electrodes, are arranged in an assembly box the voltage regulator is provided a 12v switched mode power supply (SMPS) because it will only provide the required voltage to the ESP32 controller The ESP32 controller will operate at a voltage of 3.3v. The ESP32 controller will run on a 3.3v power supply. The electrodes are put on the patient's chest, and the patient's heart beats are obtained in analogue form. As a result, the AD8232 ECG sensor is used to transform the data into digital form for efficient transmission. The collected digital data is then provided to the ESP32 controller, which responds on the signal based on embedded C language instructions. The signals are then connected to Ubidots, an IoT platform, which displays the ECG signal. It analyses the ECG data to determine any heart issues. If the heartbeat rate exceeds a particular threshold (abnormal condition), the Ubidots platform sends an SMS message to the doctor or opens the Ubidots platform, alerting him to the patient's condition.

3.3:- Technical Specifications of ECG sensor

- Analog type output
- Operating voltage: 3.3V DC
- Low current consumption: 170 uA
- Noise rejection at 60Hz: 80dB
- High gain (G = 100), with DC current blocking
- Integrated Right Leg Amplifier (RLD)
- RFI filtering
- Shutdown pin
- Electrode input: Mini Plug 3.5mm
- Configurations: 2 or 3 electrodes

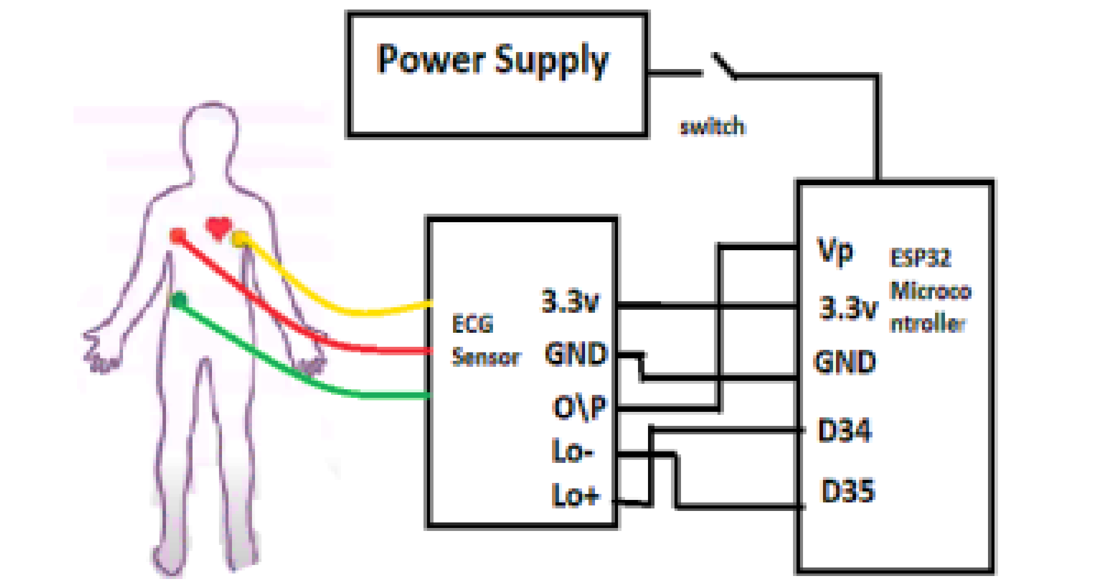


Fig. 1: Circuit\Block Diagram

Simultaneously, the buzzer and LED sound an alarm to alert the caretaker to the patient's status. The ECG sensor utilized is a low-cost circuit that measures the heart's electrical activity. This electrical activity of the heart is recorded as an ECG (Electrocardiogram) and shown as an analogue readout. Because the ECG signal we obtained was noisy, we used an Op-amp, the AD8232, to quickly obtain a clean signal from the PR, QT, and ST intervals. The AD8232 is utilized to measure additional bio-potential measuring signals as well as signal conditioning for ECG. In the presence of noise, it is meant to magnify the bio-potential signal. There are nine connecting pins and wires on the AD8232 Op-amp. Other connectors include LO+, LO-, OUTPUT, 3.3V, and GND, which are required to use the Op-Amp with an Adriano. This board also includes three lead electrodes: RA (Right Arm), LA (Left Arm), and RL (Right Leg) (Right Leg). The electrodes are put at a specific spot on the body to get an ECG signal since the required cardiac frequency can only be obtained at that location. The AD8232 ECG Sensor is connected to the ESP32 development kit. The AD8232 is powered by the ESP32 module, which provides 3.3V. The AD8232's output pin will be an analog signal. The VP pin of the ESP32 is then linked to this pin. Similarly, the AD8232's LO and LO+ are wired to ESP32's pins D3 and D2, respectively.

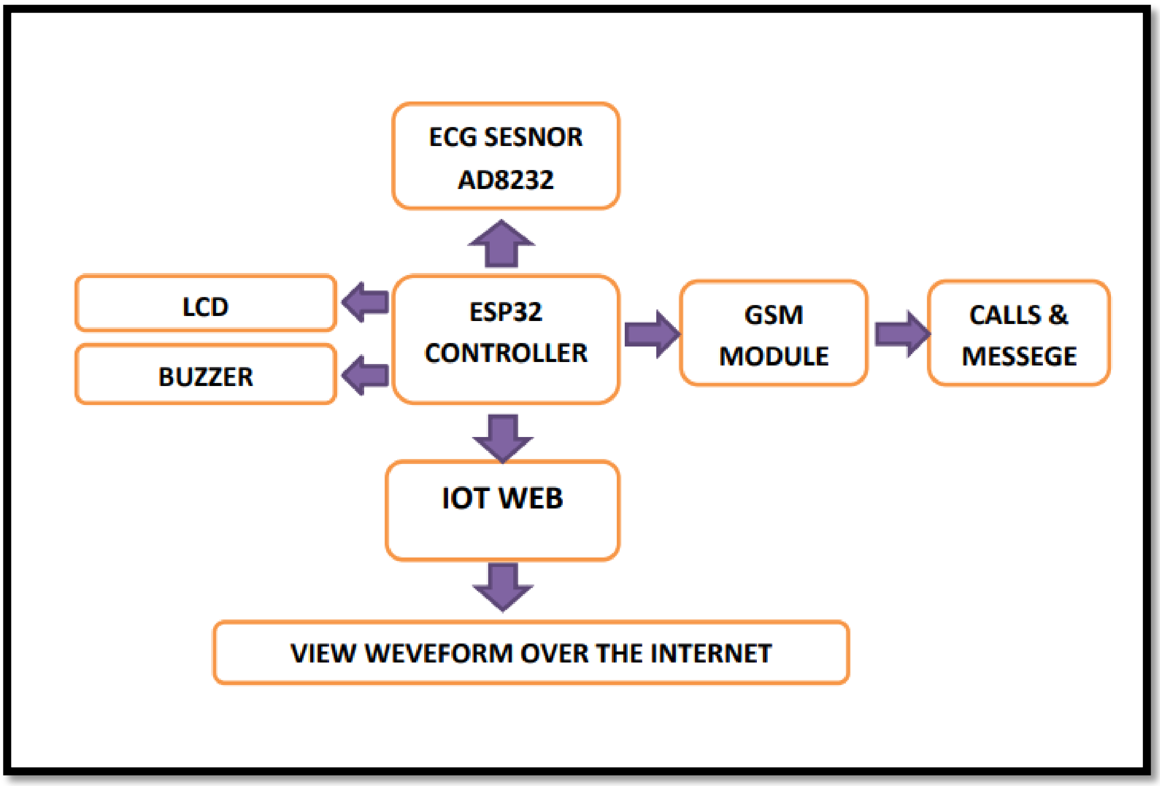
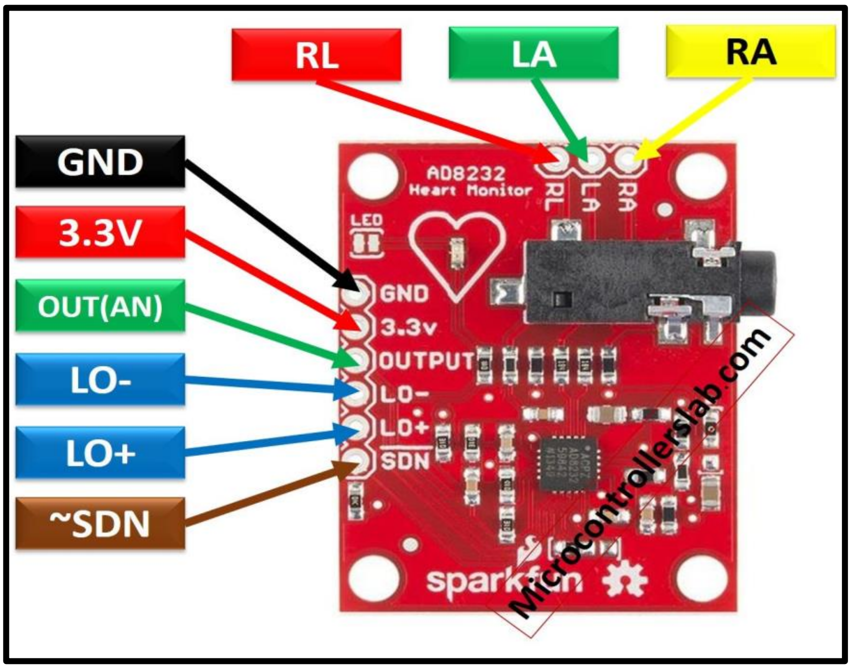


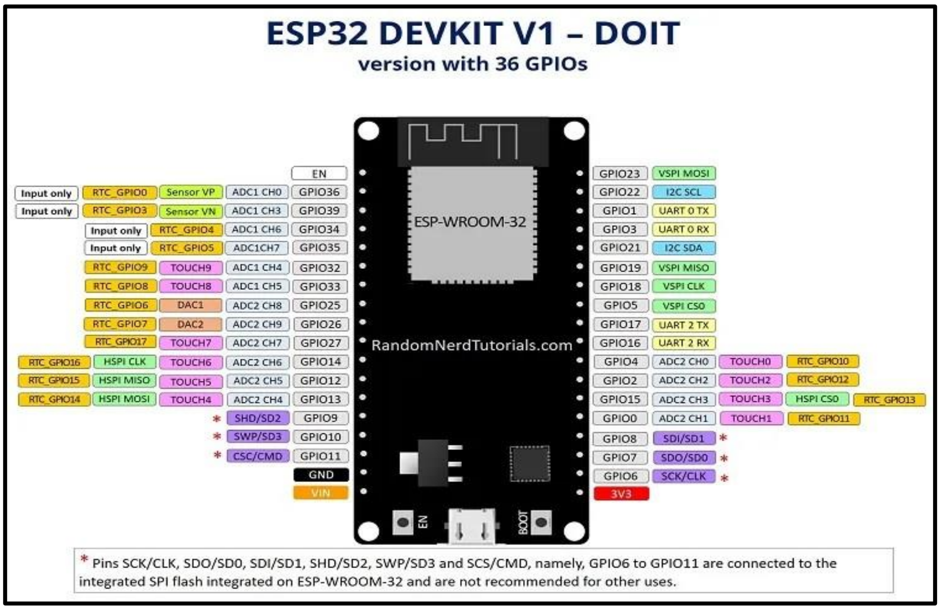
Fig. Block Diagram of ECG Monitoring

3.4 Hardware Details:-

1. AD8232 ECG Sensor: The AD8232 is a single-lead, heart rate monitor front-end that can measure heart rate or ECG signals. It can be used to monitor a patient's heart rate and detect abnormalities in the ECG signal.

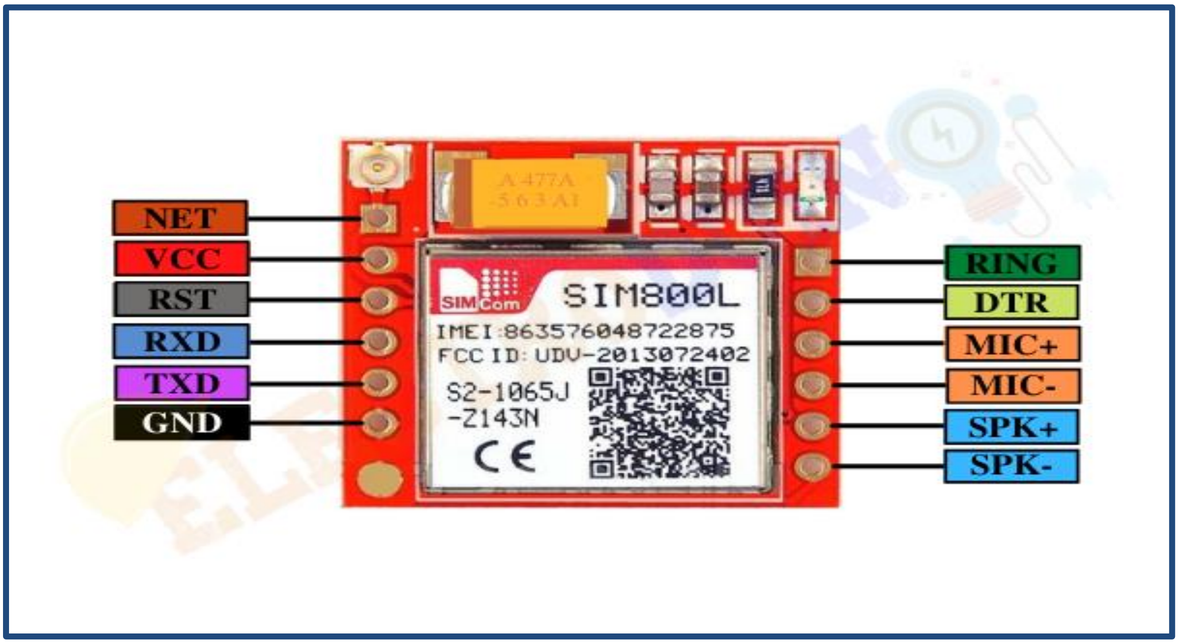


2. ESP32 Development Board: The ESP32 is a popular microcontroller that has built-in Wi-Fi and Bluetooth capabilities, making it an excellent choice for IoT applications. It can be programmed using the Arduino IDE, making it easy to use for beginners.

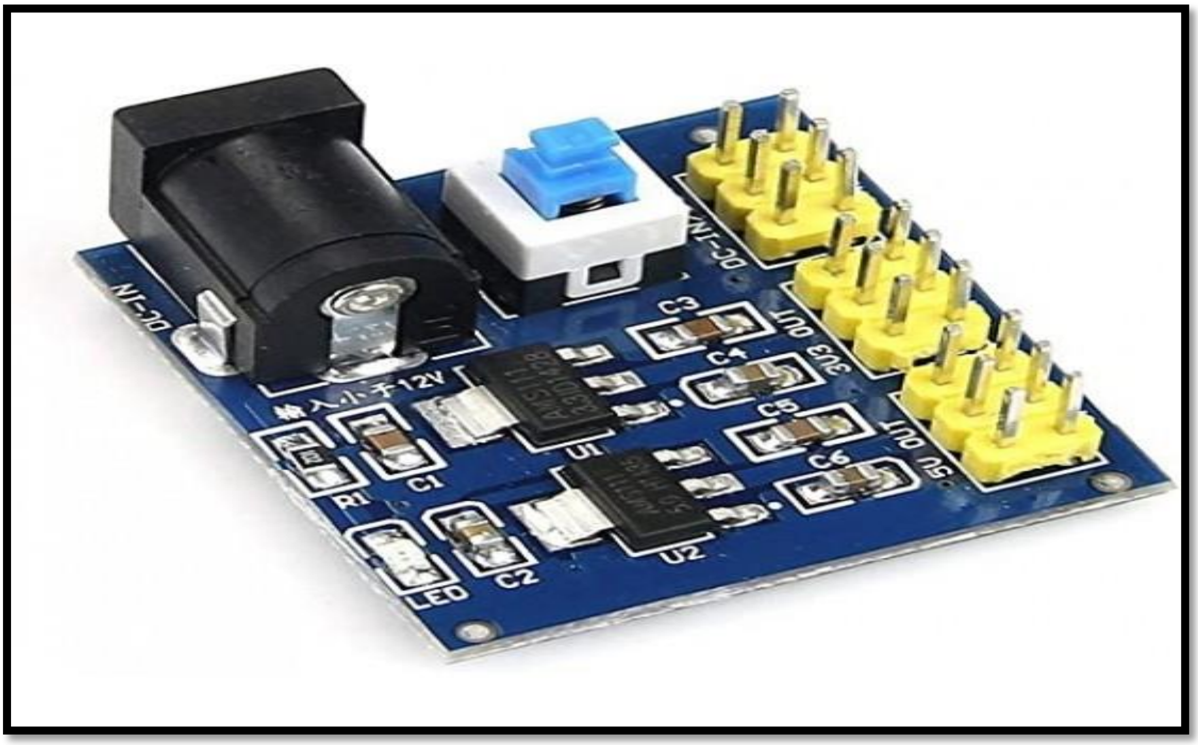


3. SIM800L GSM Module: The SIM800L is a quad-band GSM/GPRS module that allows the ECG monitoring system to send SMS alerts to the caregiver or

physician in case of any abnormal ECG readings or heart rate fluctuations. It can be used to transmit the ECG signal to a remote server for further analysis and storage.

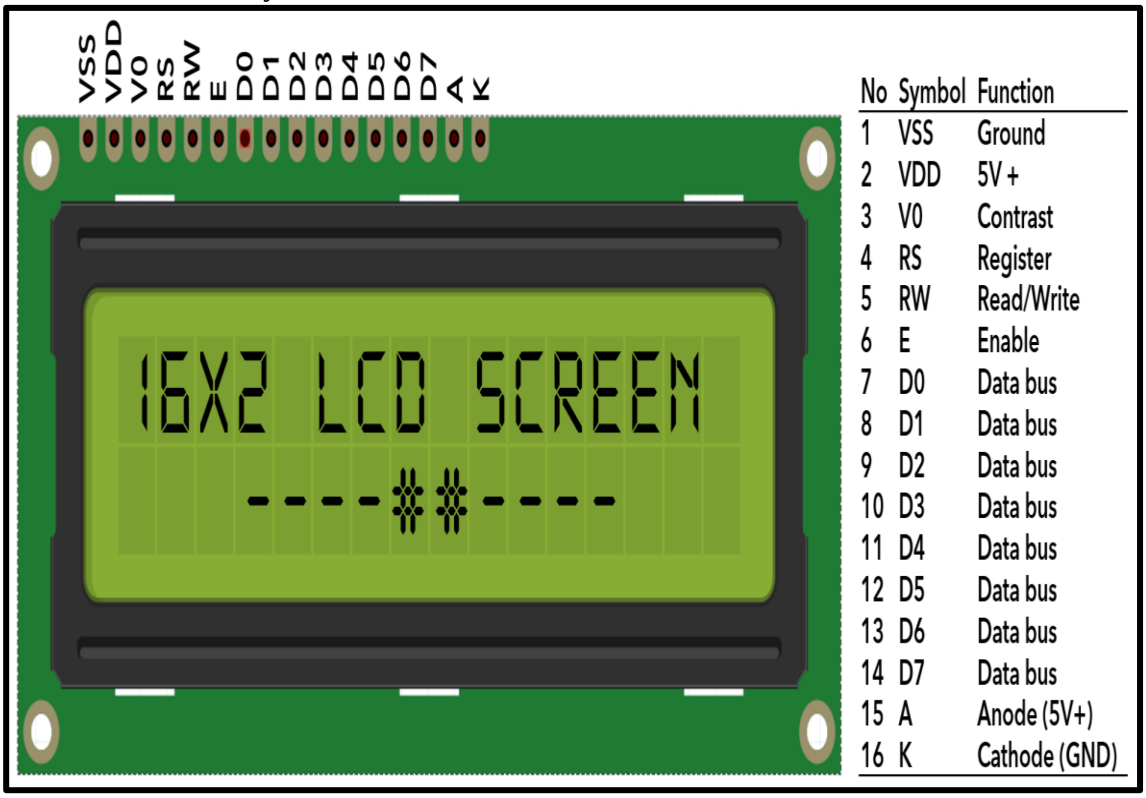


4. Power Supply: The ECG monitoring system requires a stable power supply to operate. A DC power supply with a voltage range of 5V to 12V can be used to power

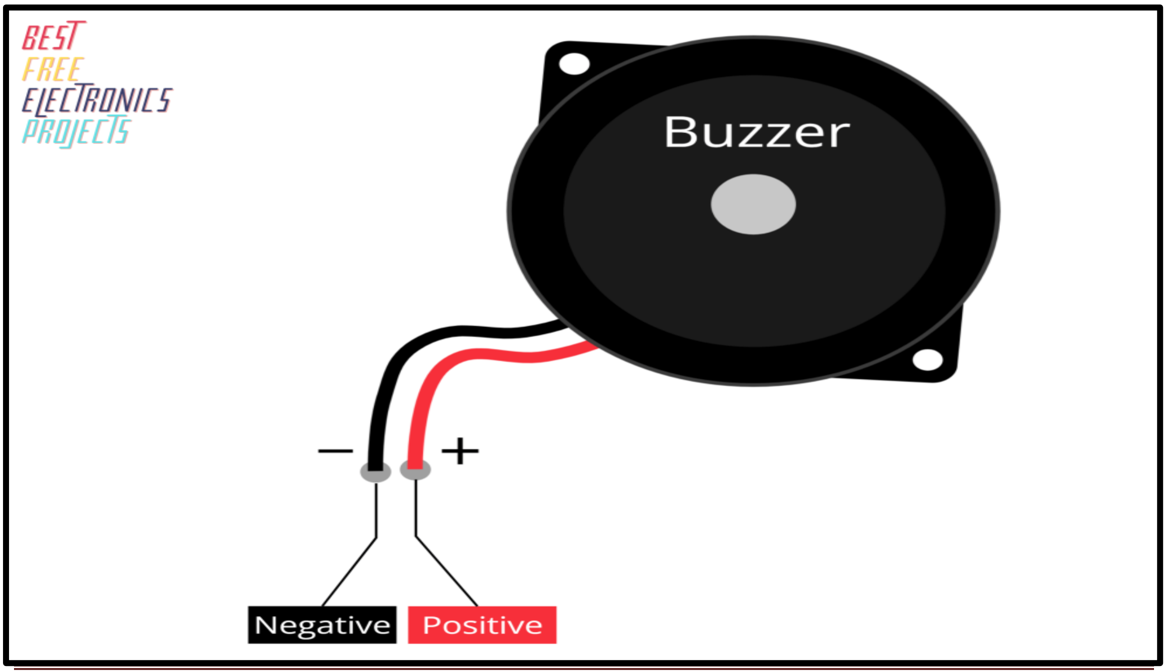


the system.

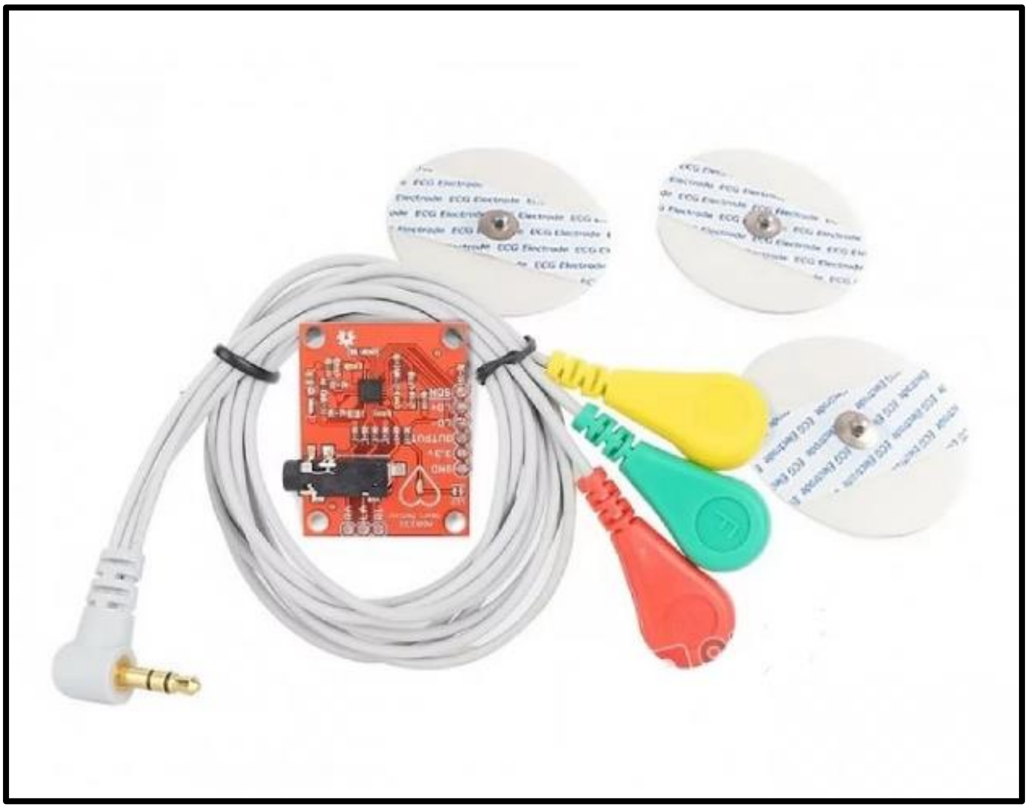
5. LCD Display: An LCD display can be used to display the heart rate and ECG readings in real-time. This allows the caregiver or physician to monitor the patient's condition more easily.



6. Buzzer: A buzzer can be used to provide audio feedback to the caregiver or physician in case of any abnormal ECG readings or heart rate fluctuations. This can help to alert the caregiver or physician to potential issues more quickly.



The AD8232 ECG sensor requires two electrodes to be attached to the patient's body to detect the ECG signal. Typically, one electrode is attached to the right arm and the other electrode is attached to the left leg.



3.5 Software Details:-

To develop an ECG monitoring system using an ESP32 and an AD8232 sensor with software details using the C programming language, the following steps can be followed:

Set up the Development Environment: Install the Arduino IDE and ESP32 board support packages. Also, install the necessary libraries such as the AD8232 library and the GSM library.

Configure the ADC: The ESP32 has a built-in ADC that can be used to read the analog signal from the AD8232 sensor. Configure the ADC using the appropriate ESP32 libraries to read the ECG signal.

Configure the GSM Module: The GSM module can be configured to send SMS alerts to the caregiver or physician in case of any abnormal ECG readings or heart rate fluctuations. Configure the GSM module using the appropriate GSM library.

Initialize the AD8232 Sensor: Initialize the AD8232 sensor by setting the appropriate pin configurations and filter settings. Use the AD8232 library to initialize the sensor.

Read the ECG Signal: Use the ADC to read the ECG signal from the AD8232 sensor. The signal can be filtered and amplified using analog circuitry if necessary.

Display the ECG Signal: Display the ECG signal in real-time using an LCD display. Use the appropriate libraries to interface with the LCD display.

Calculate the Heart Rate: Calculate the patient's heart rate by analyzing the ECG signal. Use the appropriate algorithms to calculate the heart rate and display it on the LCD display.

Send SMS Alerts: Send SMS alerts to the caregiver or physician in case of any abnormal ECG readings or heart rate fluctuations. Use the GSM library to send SMS alerts.

Implement Buzzer Feedback: Use the buzzer to provide audio feedback to the caregiver or physician in case of any abnormal ECG readings or heart rate fluctuations. Use the appropriate libraries to control the buzzer.

Implement User Interface: Develop a user interface to allow the caregiver or physician to configure the system and view the patient's ECG readings and heart rate. Use the appropriate libraries to develop the user interface.

Overall, the software for an ECG monitoring system using an ESP32 and an AD8232 sensor with the C programming language involves configuring the hardware components, reading the ECG signal, analyzing the signal to calculate the heart rate, displaying the ECG signal and heart rate, sending SMS alerts, providing audio feedback, and developing a user interface for configuration and monitoring purpos

LIBRARIES:-

3.6.1 AD8232 library:-

To use the AD8232 sensor in an ESP32-based ECG monitoring system, you need to install the AD8232 library in the Arduino IDE. Here are the steps to install the library:

Step 1: Open the Arduino IDE and go to Sketch > Include Library > Manage Libraries.
Step 2: In the Library Manager dialog, search for "AD8232".
Step 3: Select the "AD8232" library and click Install.
Step 4: Wait for the installation to complete and click Close.

Once the library is installed, you can include it in your Arduino sketch using the following statement:

Copy code
```
#include <AD8232.h>
```

With this library, you can use the functions provided by the AD8232 library to communicate with the sensor and obtain ECG data. The library includes functions to read the ECG waveform and heart rate, as well as to adjust the gain and frequency response of the sensor. You can refer to the library documentation for more details on the available functions and their usage.

3.6.2 SIM800L library:-

To use the SIM800L GSM module in an ESP32-based ECG monitoring system, you need to install the SIM800L library in the Arduino IDE. Here are the steps to install the library:

Step 1: Open the Arduino IDE and go to Sketch > Include Library > Manage Libraries.
Step 2: In the Library Manager dialog, search for "SIM800L".
Step 3: Select the "SIM800L" library and click Install.
Step 4: Wait for the installation to complete and click Close.

Once the library is installed, you can include it in your Arduino sketch using the following statement:

```
#include <SIM800L.h>
```

With this library, you can use the functions provided by the SIM800L library to communicate with the GSM module and send SMS or make calls. The library includes functions to set up the GSM module, send AT commands, and read the response from the module. You can refer to the library documentation for more details on the available functions and their usage.

3.6.3Liquid Crystal library:-

To use an LCD display in an ESP32-based ECG monitoring system, you need to install the Liquid Crystal library in the Arduino IDE. Here are the steps to install the library:

Step 1: Open the Arduino IDE and go to Sketch > Include Library > Manage Libraries.
Step 2: In the Library Manager dialog, search for "LiquidCrystal".
Step 3: Select the "LiquidCrystal" library and click Install.
Step 4: Wait for the installation to complete and click Close.

Once the library is installed, you can include it in your Arduino sketch using the following statement:

```
#include <LiquidCrystal.h>
```

With this library, you can use the functions provided by the LiquidCrystal library to communicate with the LCD display and display information. The library includes functions to set up the display, print text, and move the cursor. You can refer to the library documentation for more details on the available functions and their usage.

Chapter 4

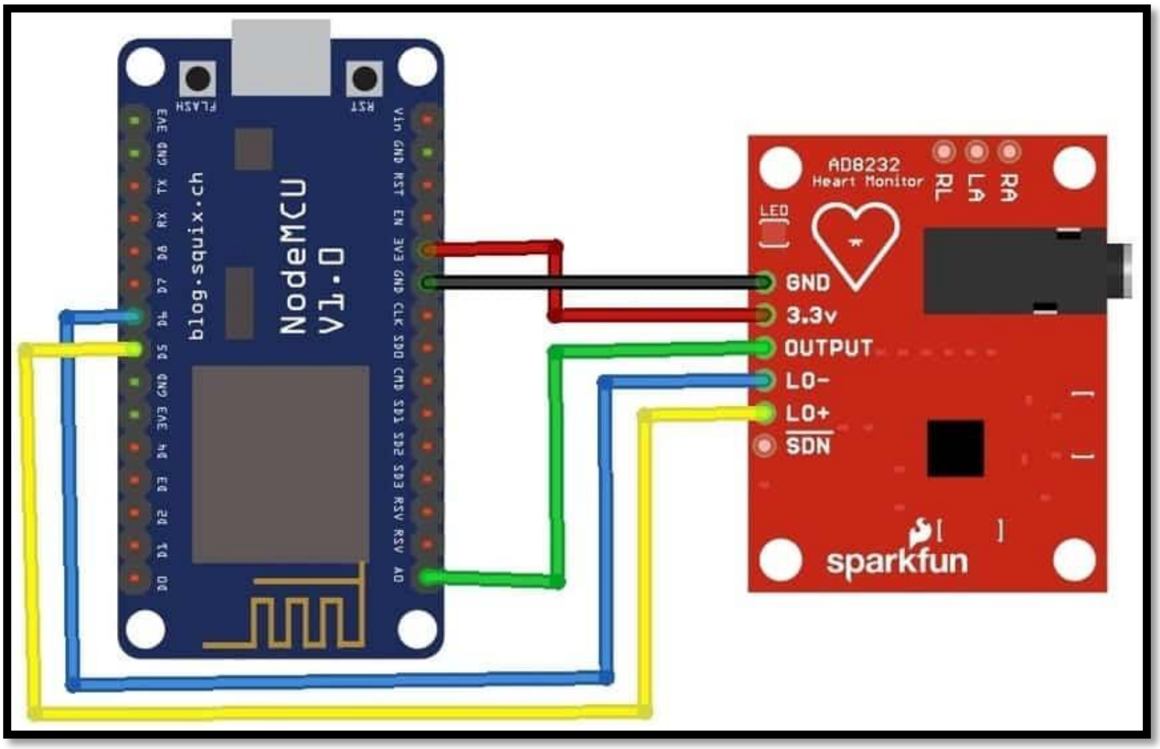
EXPERIMENTS

4.1 Experiments details:-

1. Connect the ESP32 development board to a breadboard and connect the power supply to it.

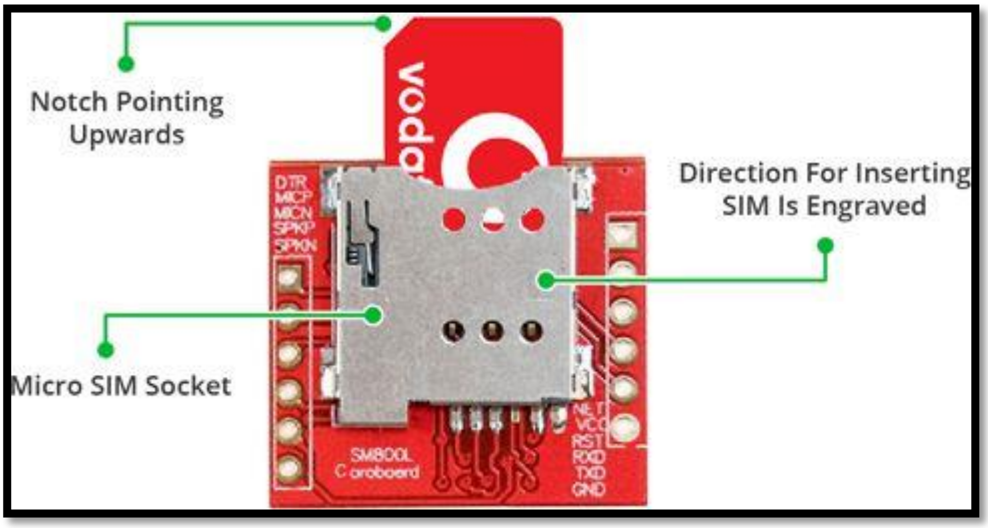
4. Connect the AD8232 sensor module to the breadboard and connect its power and ground pins to the power supply and ground respectively.

5. Connect the output pins of the AD8232 sensor module to the analog input pins of the ESP32 development board.

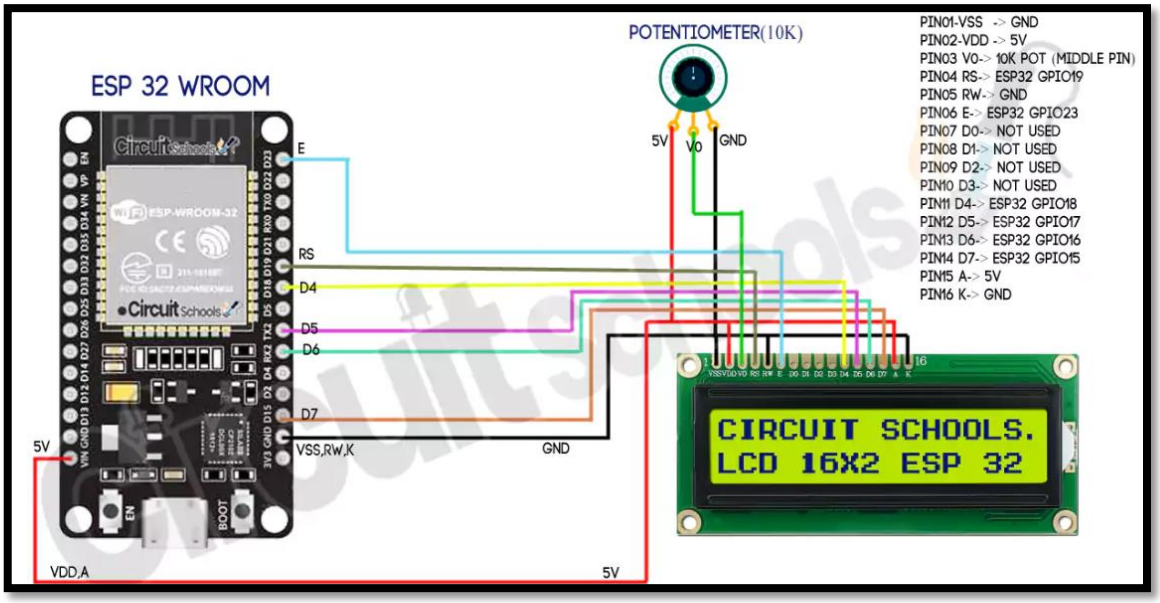


4. Connect the SIM800L GSM module to the breadboard and connect its power and ground pins to the power supply and ground respectively.

5. Connect the RX and TX pins of the SIM800L module to the RX and TX pins of the ESP32 development board.



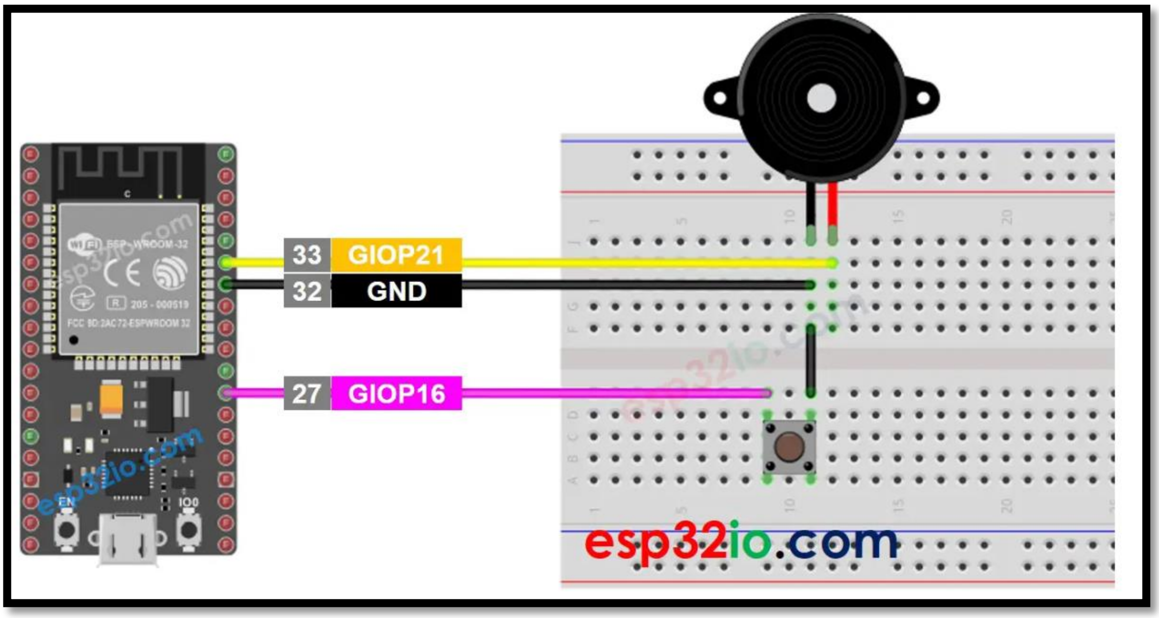
6. Connect the LCD display module to the breadboard and connect its power and ground pins to the power supply and ground respectively.



7. Connect the data pins of the LCD display module to digital output pins of the ESP32 development board.

8. Connect the buzzer to a digital output pin of the ESP32 development board.

9. Include the AD8232, SIM800L, and Liquid Crystal libraries in the sketch.
Write the code to set up the ADC and read the ECG signal from the AD8232 sensor module.



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10. Write the code to process the ECG signal and detect any abnormalities.

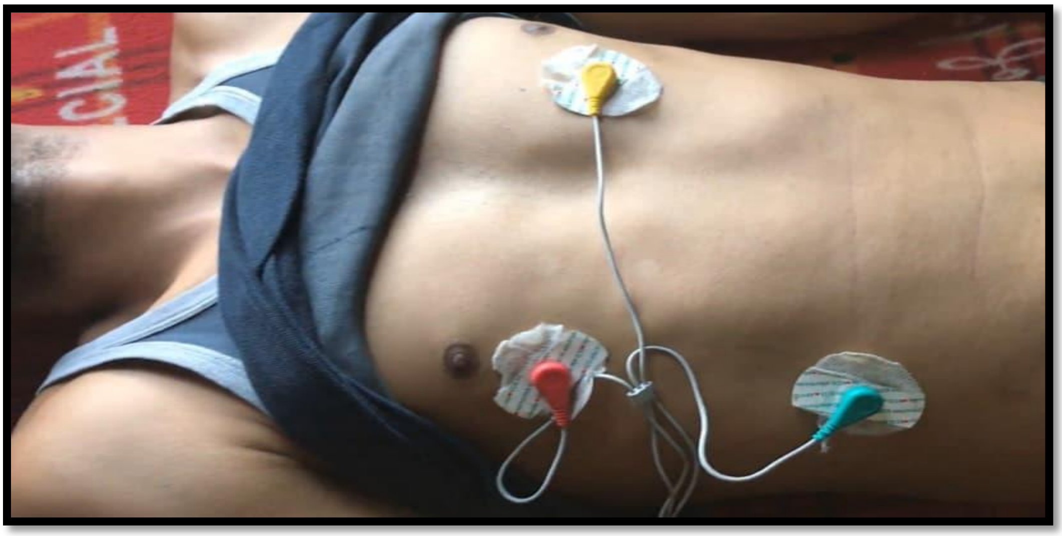
11. Write the code to display the ECG waveform and heart rate on the LCD display module.

12. Write the code to send an CALL to a designated phone number using the SIM800L GSM module if any abnormalities are detected.

13. Write the code to sound the buzzer if any abnormalities are detected.

14. Upload the sketch to the ESP32 development board using the USB cable.

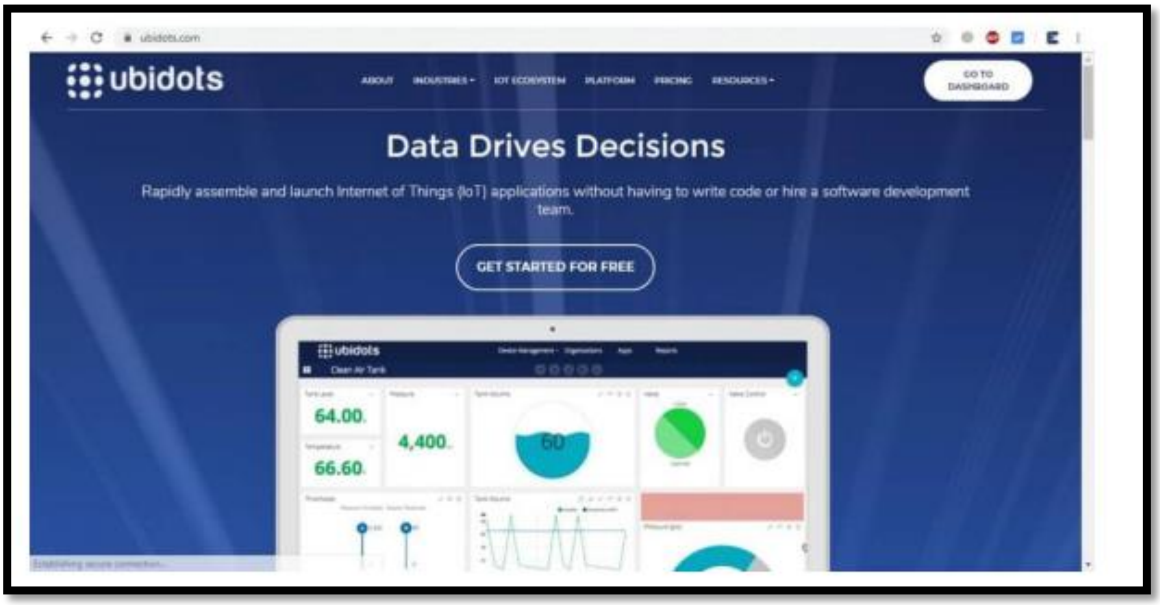
15. Connect the ECG electrodes to the patient's body and test the system.



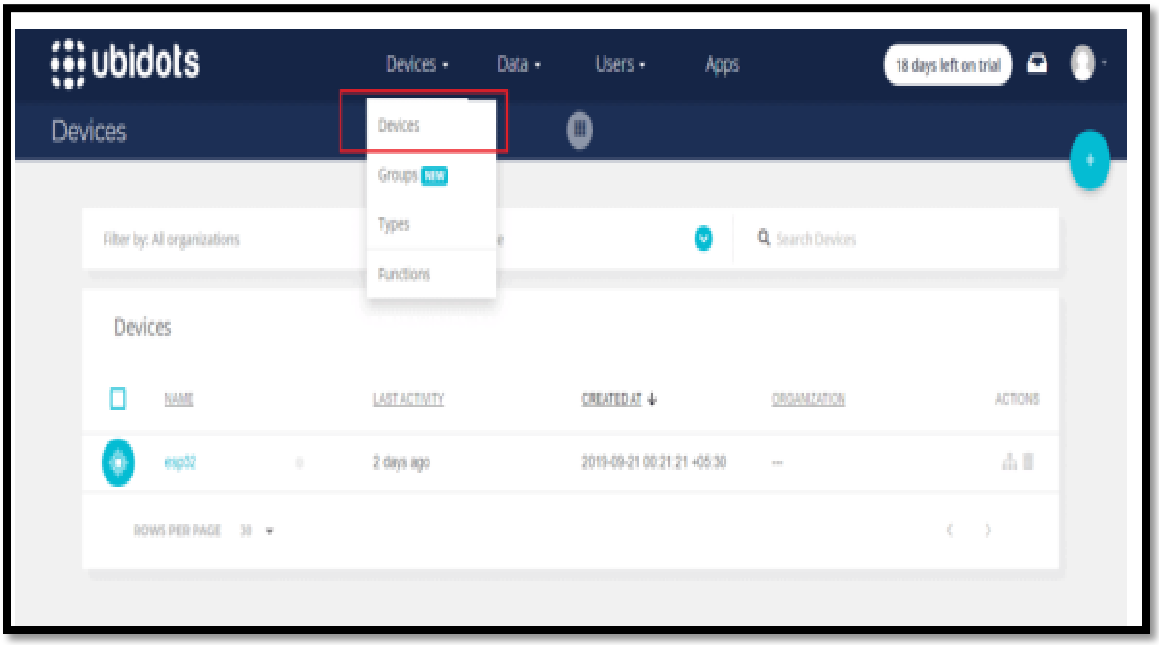
16.Send the data in ubidotes server to display online waveforn

17. Setting up procedure to account open of Iot web.

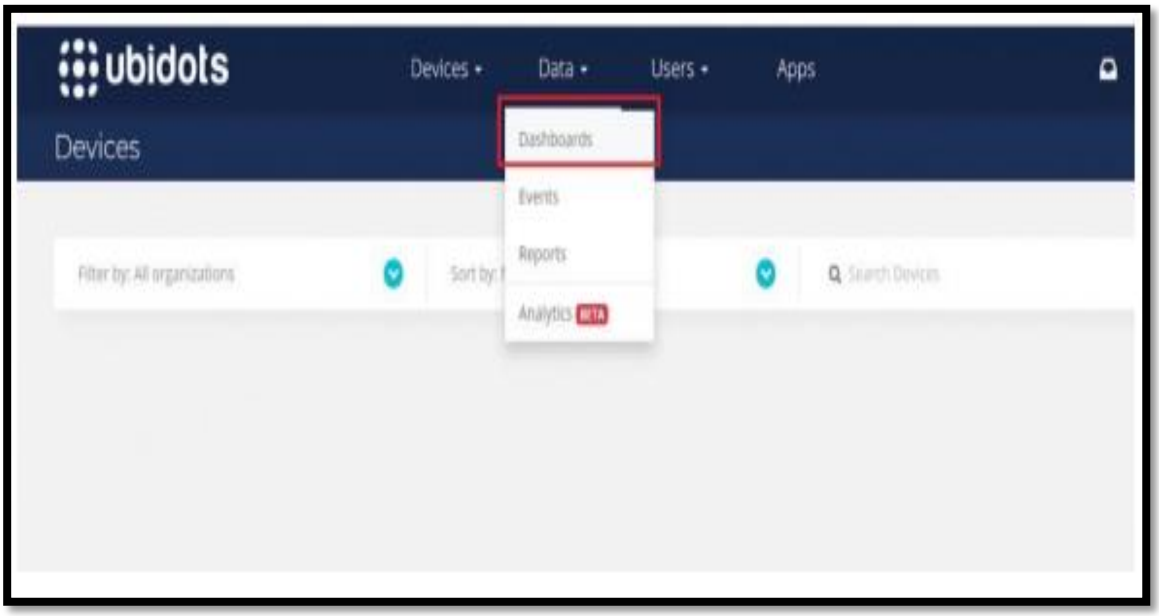
Step 1: Creating Ubidots Account Go to ubidots.com and create and account. You will get a trial period of 30 days.



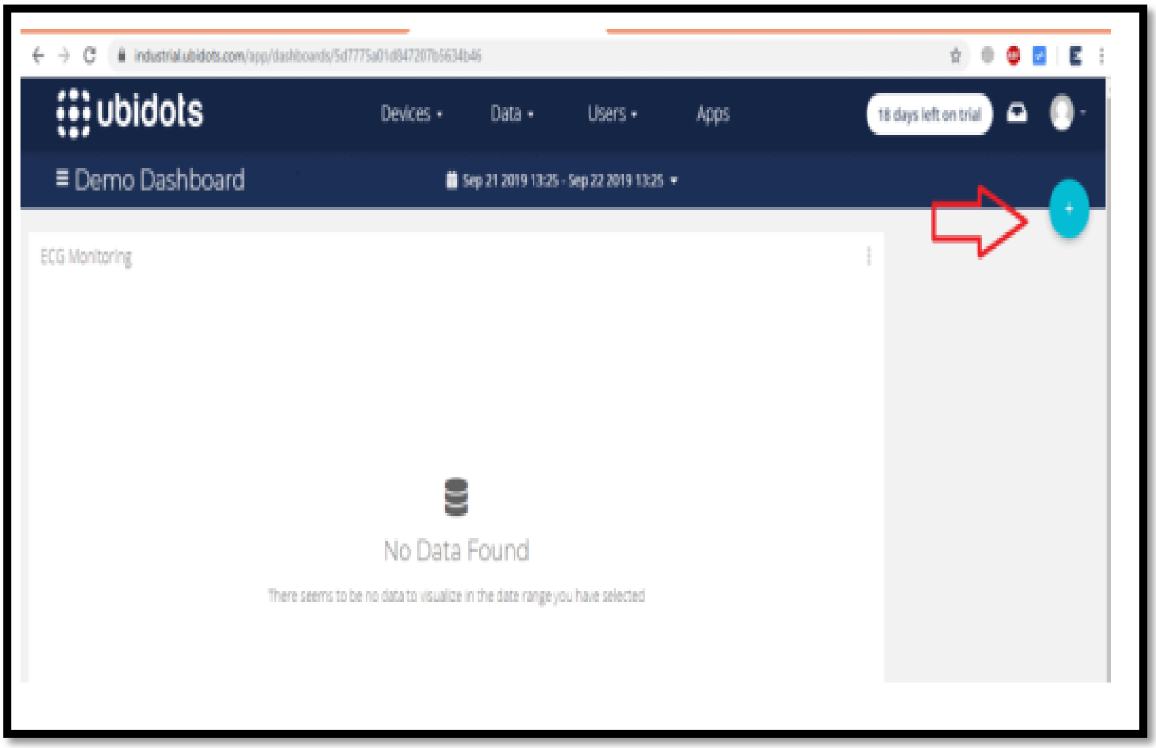
- Step 2: Creating Device & Adding Variables Now setup an Ubidots Device. To create it, go to the Devices section (Devices > Devices). Create a new Device with name esp32, Once the device is created, create a new variable by renaming the variabale to sensor.



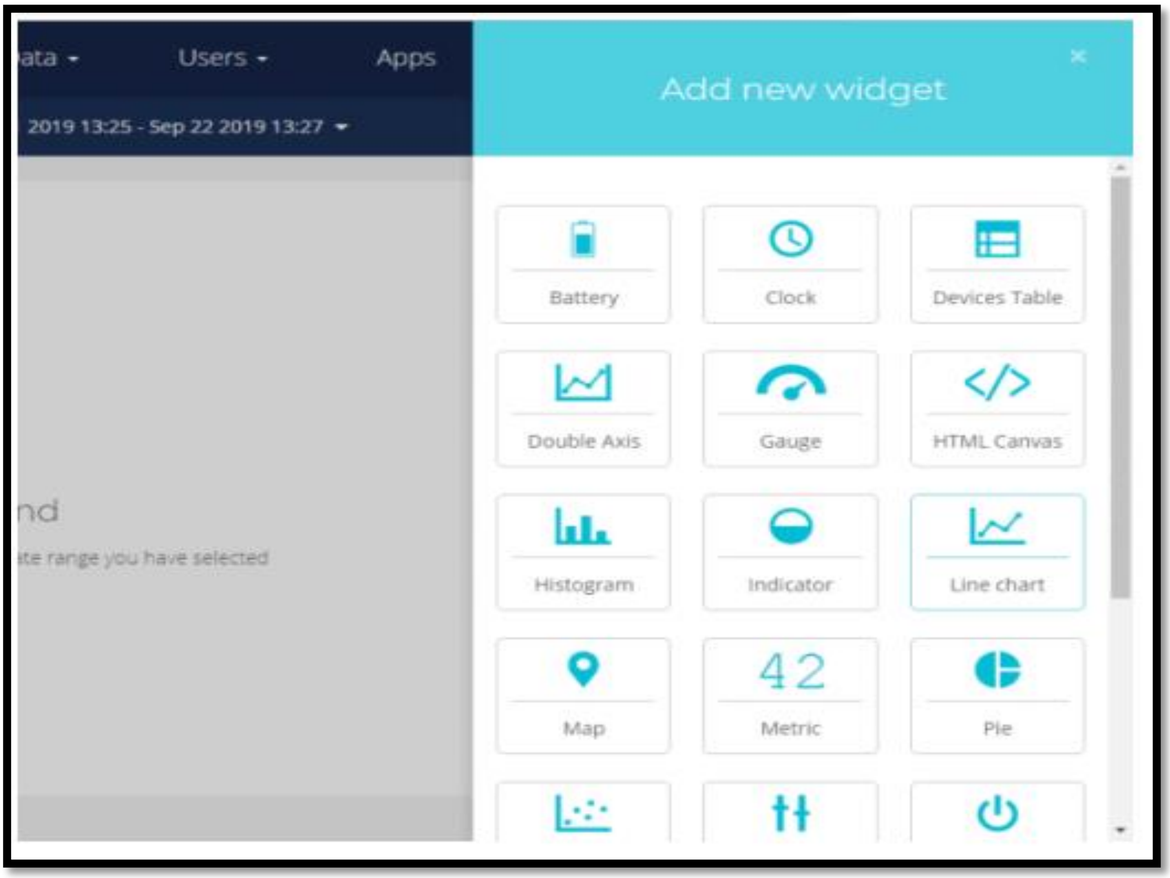
- Step 3: Creating Dashboards Let's setup an Ubidots' Dashboard. To create it, go to the Dashboard section (Data > Dashboard).

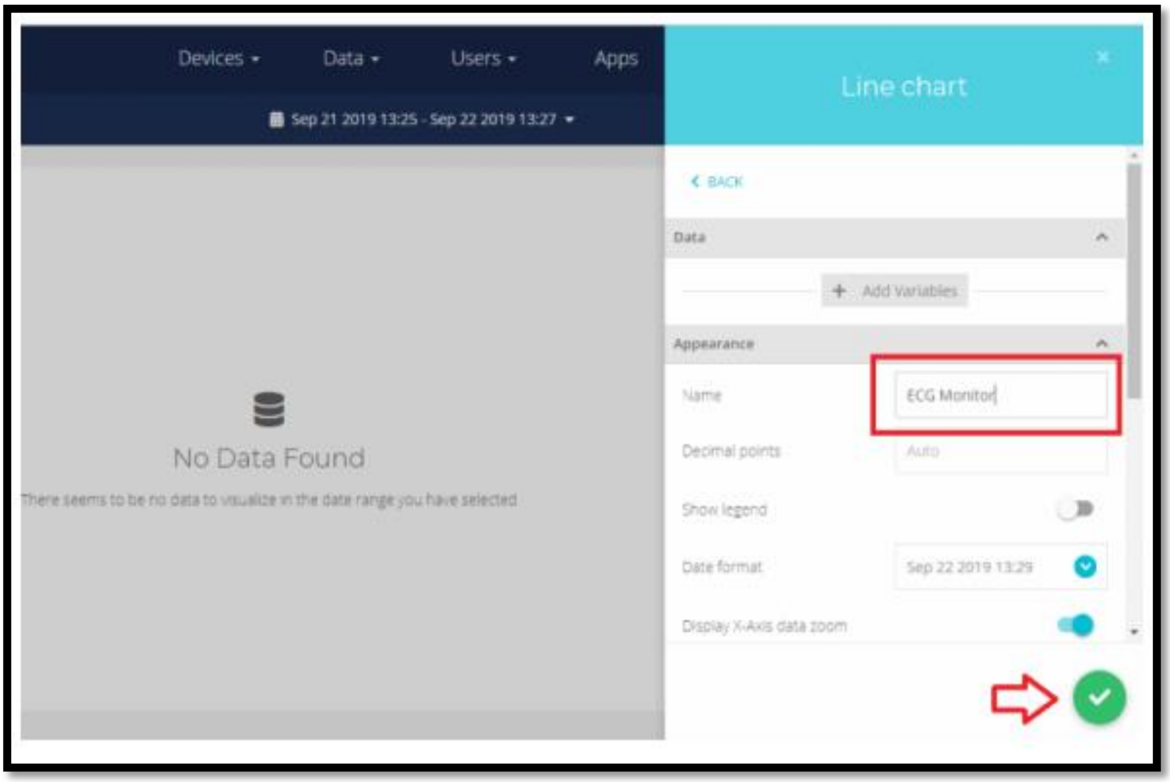


- Step 4: Adding New Widgets Click on the + sign in the right side and "Add new Widget", and select your widget. Now, Select the type of widget desired to be displayed. In my case, I choose
- the "Line Chart":

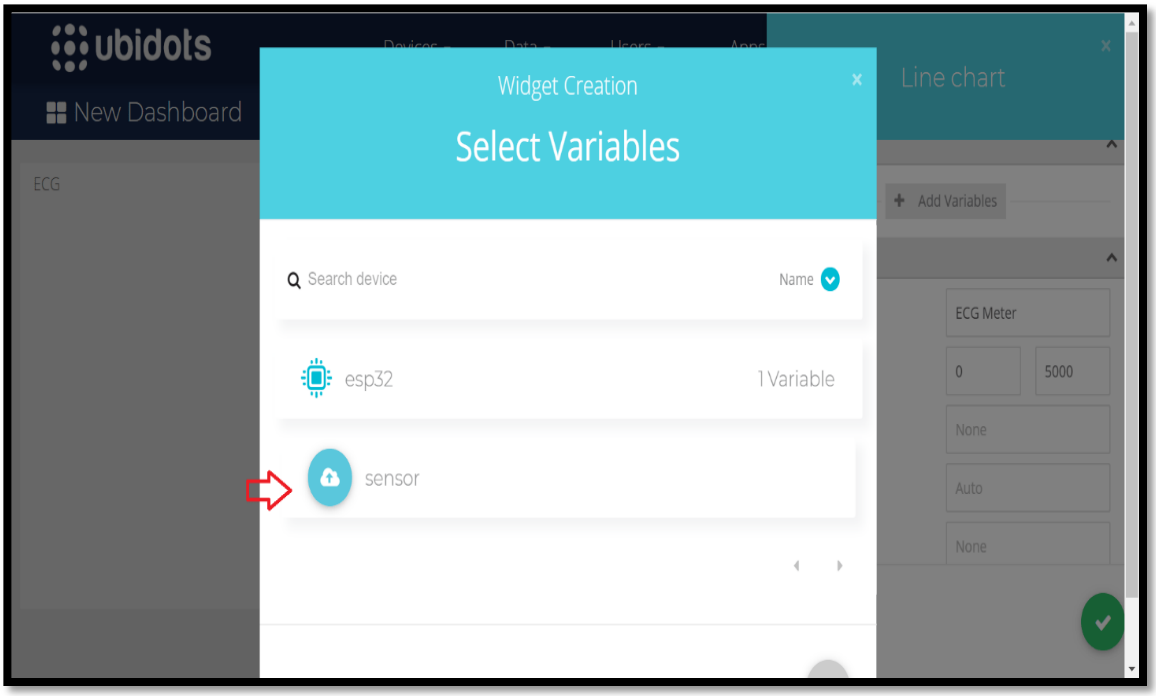


- Then, select the variable desired to display the data. Ubidots allows you assign a customize widget name, color, period of data to be displayed and much more. To finish the widget creation, press the green icon.





Select your previously created Device and Variables as shown in the figure below.



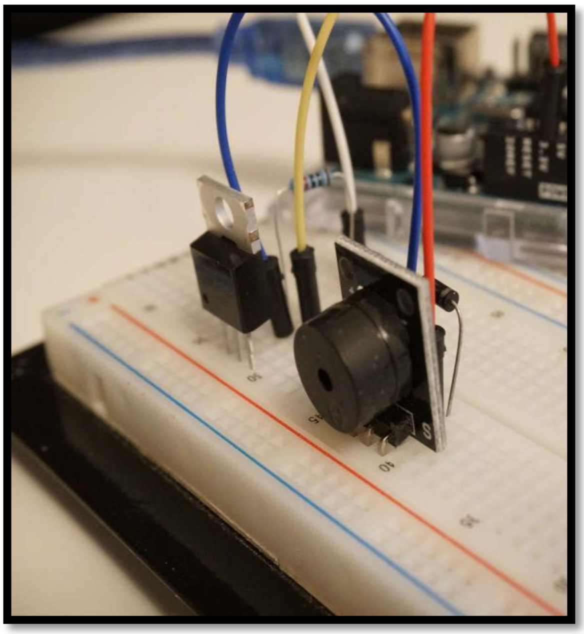
Display waveform and ECG value:

4.2 RESULT:-

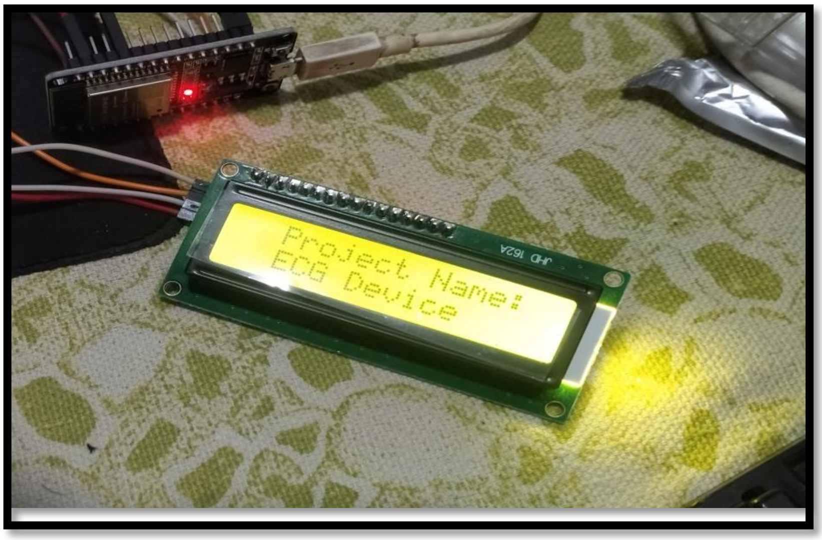
The ECG monitoring system should be able to read the ECG signal from the AD8232 sensor module and display the ECG waveform and heart rate on the LCD display module. If any abnormalities are detected, the system should sound the buzzer and send an SMS to a designated phone number using the SIM800L GSM module.

4.2.1. EMERGANCY CALL:

4.2.2. BUZZER:



4.2.3. HEART COUNT SHOWS ON LCD DISPLAY:



4.3.4. DISPLAY WAVE AND HEART ON UBIDOTS IOT WEB :

4.3 Application of project:-

Home Health Monitoring: Patients with chronic conditions like heart disease or arrhythmia can use this system to monitor their ECG signals at home and alert their doctors if any abnormalities are detected. This can help in early diagnosis and treatment of heart-related diseases.

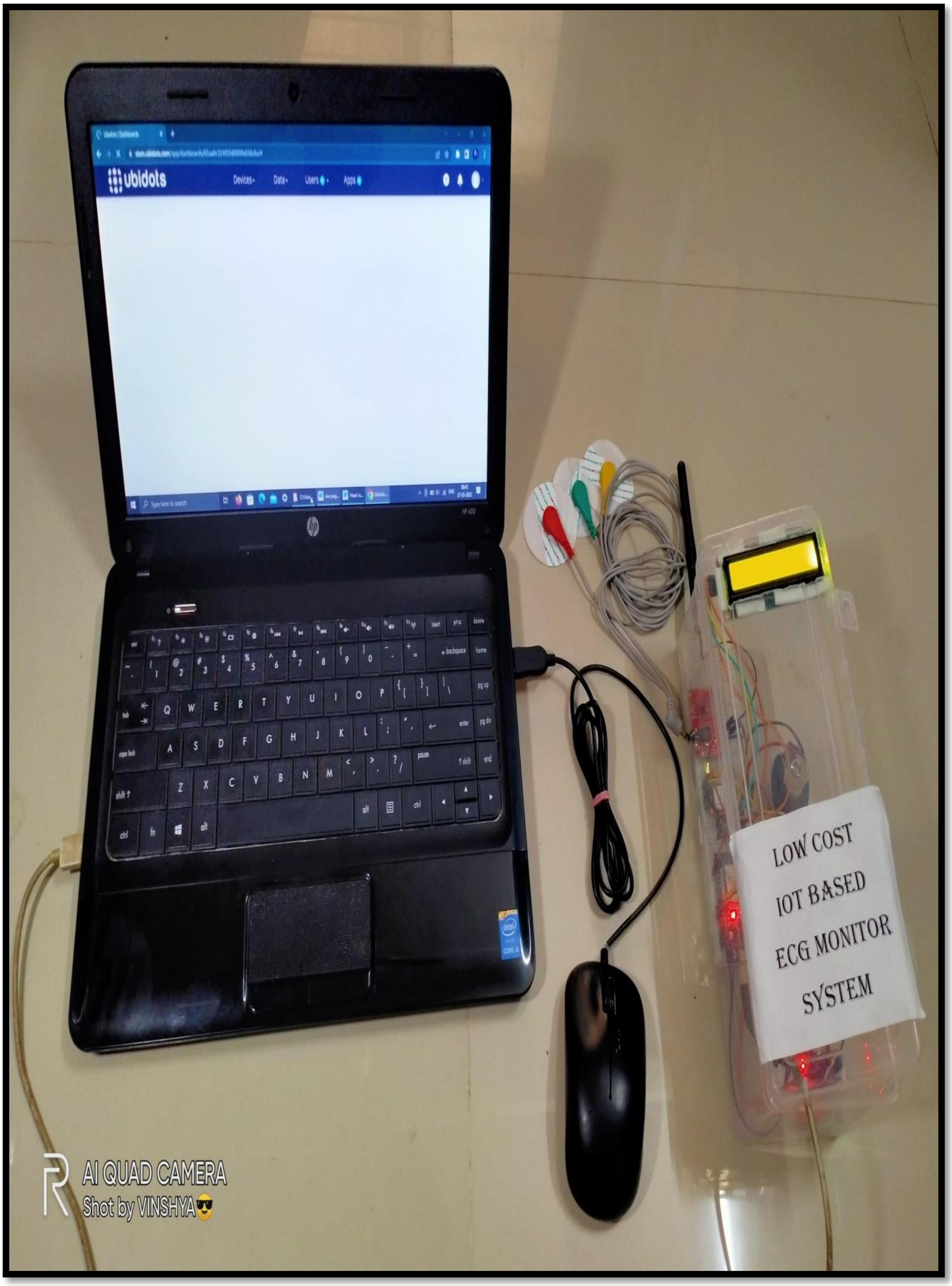
1. Hospital Patient Monitoring: The ECG monitoring system can be used to monitor the ECG signals of patients in hospitals and alert the medical staff if any abnormalities are detected. This can help in providing prompt medical attention and reducing the risk of heart-related complications.

2. Sports Performance Monitoring: The ECG monitoring system can be used to monitor the heart rate and ECG signals of athletes during training and competition. This can help in optimizing their training and performance and prevent any heart-related injuries.

3. Wearable Health Devices: The ECG monitoring system can be integrated into wearable health devices like smart watches or fitness trackers to monitor the ECG signals of users and provide real-time feedback on their heart health.

4. Research: The ECG monitoring system can be used in research studies to collect and analyze ECG signals of participants and gain insights into the functioning of the heart and its response to various stimulation.

4.4 Photo of Project:-



Chapter 5

CONCLUSION

In conclusion, an ECG monitoring system using an ESP32 and an AD8232 sensor with a GSM module like the SIM800L, an LCD display, and a buzzer is a powerful tool for monitoring heart health. This system can be used for home health monitoring, hospital patient monitoring, sports performance monitoring, wearable health devices, and research studies.

The AD8232 sensor captures the ECG signals, which are then processed by the ESP32 microcontroller. The LCD display and buzzer provide real-time feedback to the user, and the SIM800L GSM module enables remote monitoring of the ECG signals.

By detecting abnormalities in the ECG signals, this system can help in early diagnosis and treatment of heart-related diseases, provide prompt medical attention, optimize sports training and performance, and collect valuable data for research studies.

Overall, an ECG monitoring system using an ESP32 and an AD8232 sensor with a GSM module like the SIM800L, an LCD display, and a buzzer has the potential to improve the quality of healthcare and revolutionize the field of medical diagnostics

Chapter 6

FUTURE SCOPE

The future scope of an ECG monitoring system is vast and promising. Some of the potential areas of development and improvement are:

1. Artificial Intelligence Integration: With the increasing advancements in AI and machine learning, the ECG monitoring system can be integrated with AI algorithms to provide more accurate and efficient analysis of the ECG signals.

2. Cloud Integration: The ECG monitoring system can be integrated with cloud computing technology to enable remote access and monitoring of the ECG signals. This can provide doctors and medical staff with real-time data and insights into the patient's heart health.

3. Internet of Things (IoT) Integration: The ECG monitoring system can be integrated with other IoT devices and sensors to provide a comprehensive health monitoring system for patients.

4. Wireless Charging: The system can be developed with wireless charging capabilities to eliminate the need for physical charging.

5. Portable and Wearable Design: The system can be made more portable and wearable, allowing patients to carry it around with ease and comfort.

6. Improved Sensor Technology: Future developments in sensor technology can enable more accurate and reliable detection of ECG signals, leading to better diagnosis and treatment of heart-related diseases.

Chapter 7

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Journal reference:

Author(s) name, (Year of publication), “Title of paper”, *Title of journal (in italic)*, Volume No., Issue No., referred Page Nos.

For example: -

Sinha Shambhu, (2004) “Seismic Applications of Energy Dampers”, *Defense Science Journal*, Vol. 54, No. 1, pp. 73-83

Conference reference:

Author(s) name, (Year of publication), “Title of paper”, *Proceedings of (Name of conference)*, Place of conference, Paper No.

For example: -

Malu Girish and Murnal Pranesh (2012) “Comparative study of sliding isolation system for low frequency ground motion”, *Proceedings of 15th World Conference on Earthquake Engineering*, Lisbon, Portugal, Paper No. 4606

Book reference:

Author(s) name, (Year of publication), *“Title of book in italic”*, Edition No., Name of Publisher, City.

For example: -

Punmia B. C., Jain A. K. and Jain A. K. (2004) *“Theory of Structures”,* 12th Edition, Laxmi Publication, Delhi

Chapter 8

CERTIFICATE

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SANJAY BHOKARE GROUP OF INSTITUTES, MIRAJ

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Affiliated to MSBTE, Mumbai, DBATU, Lonere (Raigad) and Shivaji University, Kolhapur.

Tilak-Nagar, Miraj-Sangli Road, Miraj- 416 414

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IOT BASED ECG MONITORING SYSTEM WITH GSM MODULE

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ABSTRACT

This paper presents an IoT-based ECG monitoring system that utilizes the ESP32 microcontroller, AD8232 ECG sensor module, and SIM800L GSM module. The system enables real-time monitoring of a patient's ECG data and facilitates wireless transmission to healthcare professionals or caregivers. The ESP32 microcontroller serves as the central processing unit and is responsible for data acquisition, processing, and communication. The AD8232 ECG sensor module captures the patient's electrical signals and converts them into digital data. The ESP32 then processes the acquired ECG data, extracting relevant features and detecting abnormal cardiac patterns. The SIM800L GSM module utilizes the GSM network to transmit the processed ECG data to a remote server or healthcare professional. The data can be sent as text messages or through an internet connection, ensuring real-time monitoring and timely intervention. It provides healthcare professionals with real-time data, allowing them to monitor multiple patients simultaneously and provide prompt medical assistance when required. The system is cost-effective and scalable, making it suitable for individual patients and healthcare facilities. In conclusion, the proposed IoT-based ECG monitoring system using ESP32, AD8232, and SIM800L GSM module offers a reliable and efficient solution for remote patient monitoring. It enhances the quality of healthcare services, promotes early detection of cardiac abnormalities, and improves patient outcomes. Future enhancements can include integrating advanced analytics and machine learning algorithms for automated ECG analysis and predictive monitoring.

Keywords: IOT, ECG Monitoring, ESP32, AD8232, SIM800L GSM Module, Real-Time Monitoring, Remote Patient Care.

I. INTRODUCTION

In recent years, the Internet of Things (IoT) has transformed various industries, including healthcare, by enabling real-time monitoring, remote patient care, and improved healthcare services. One significant area of application within the healthcare domain is the monitoring of Electrocardiogram (ECG) signals. ECG monitoring plays a vital role in diagnosing and assessing cardiac health. However, traditional ECG monitoring systems are often limited in their accessibility, requiring patients to be physically present in healthcare facilities for monitoring and diagnosis.

To address these limitations, this paper presents an IoT-based ECG monitoring system using the ESP32 microcontroller, AD8232 ECG sensor module, and SIM800L GSM module. The proposed system aims to enable continuous ECG monitoring, remote accessibility, and real-time transmission of data to healthcare professionals or caregivers.

The ESP32 microcontroller serves as the heart of the system, responsible for data acquisition, processing, and communication. The AD8232 ECG sensor module is employed to capture the electrical signals generated by the patient's heart and convert them into digital data. The ESP32 processes the acquired ECG data, extracting relevant features and detecting abnormal cardiac patterns, providing valuable insights for healthcare professionals.

To enable remote monitoring and timely intervention, the system incorporates the SIM800L GSM module, leveraging the Global System for Mobile Communications (GSM) network. This allows the processed ECG data to be wirelessly transmitted to a remote server or healthcare professional. The data can be sent as text messages or through an internet connection, ensuring real-time monitoring and prompt medical assistance if required. The proposed IoT-based ECG monitoring system offers several advantages over traditional

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approaches. It allows patients to be monitored continuously, even outside of healthcare facilities, enhancing the quality of patient care.

II. METHODOLOGY

1. System Architecture-

The IoT-based ECG monitoring system comprises three main components: the ESP32 microcontroller, the AD8232 ECG sensor module, and the SIM800L GSM module. The ESP32 serves as the central processing unit, responsible for data acquisition, processing, and communication.

2. Data Acquisition-

The AD8232 ECG sensor module is connected to the patient's body to capture ECG signals. The module amplifies and filters the signals to ensure accurate data acquisition. The amplified analog signals are then converted into digital form using the ADC pins of the ESP32 microcontroller.

3. Signal Processing-

The acquired ECG data undergoes preprocessing and signal conditioning to remove noise and artifacts. Filtering techniques such as low-pass and high-pass filters are applied to eliminate unwanted frequencies.

4. Abnormality Detection-

The processed ECG data is analyzed to detect abnormal cardiac patterns and anomalies. The ESP32 compares the extracted features with predefined thresholds or uses machine learning algorithms for automated anomaly detection.

5. Wireless Communication-

The ESP32 establishes a connection with the SIM800L GSM module to enable wireless communication. The ESP32 utilizes the AT commands to configure the SIM800L module and establish a reliable GSM network connection.

6. User Interface-

The system can include a user interface, such as a mobile application or web-based dashboard, to display the ECG data, provide visualizations, and enable user interaction.

7. Implementation and Testing-

The IoT-based ECG monitoring system is implemented using the Arduino IDE or other suitable programming environments. The hardware components, including the ESP32, AD8232, and SIM800L modules, are integrated, and the necessary libraries and firmware are uploaded.

8. Performance Evaluation-

The performance of the system is evaluated based on parameters such as data accuracy, response time, power consumption, and reliability.

III. MODELING AND ANALYSIS

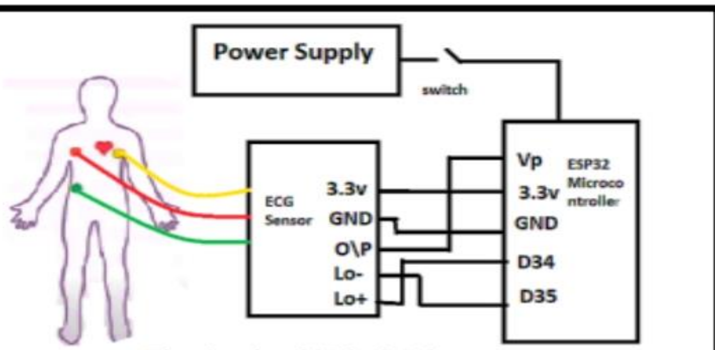

Fig. 1: Circuit\Block Diagram

Figure 1: Circuit diagrammatic modeling

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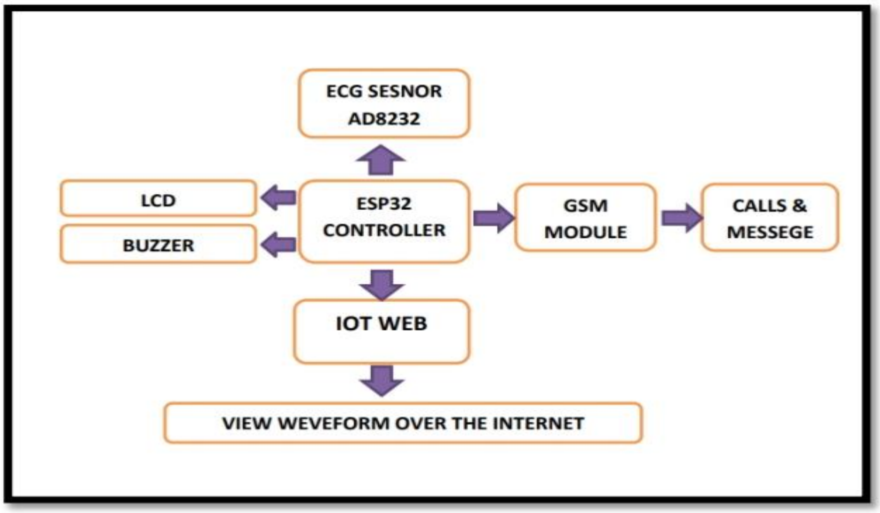

Figure 2: Block diagrammatic modeling

IV. RESULTS AND DISCUSSION

4.1 System Performance:

The system successfully captured ECG signals using the AD8232 ECG sensor module and achieved accurate data conversion with the ESP32 microcontroller. The signal processing algorithms effectively extracted relevant features from the ECG data, allowing for the detection of abnormal cardiac patterns.

4.2 Accuracy of Abnormality Detection:

The system's ability to detect abnormal cardiac patterns was evaluated through extensive testing and analysis. Comparative studies were conducted to compare the system's performance with traditional ECG monitoring methods.

4.3 Real-Time Monitoring and Remote Accessibility:

The system's real-time monitoring capabilities and remote accessibility were evaluated in practical scenarios. Healthcare professionals were able to remotely access the ECG data through the user interface, such as a mobile application or web-based dashboard.

4.4 User Experience and Feedback:

Feedback from healthcare professionals and caregivers who utilized the IoT-based ECG monitoring system was collected to assess user experience and system usability. Overall, the feedback was positive, with users appreciating the convenience and flexibility offered by remote monitoring.

4.5 Future Enhancements:

The results and discussion pave the way for future enhancements to the IoT-based ECG monitoring system. Integration of advanced analytics and machine learning algorithms could enable automated ECG analysis and predictive monitoring. This would provide more comprehensive insights into cardiac health and facilitate personalized healthcare solutions.

V. CONCLUSION

The system offers real-time monitoring, remote accessibility, and timely intervention, significantly improving the quality of healthcare services. The system's architecture allows for efficient data acquisition, processing, and wireless communication. The ESP32 effectively processes ECG data, extracting relevant features and detecting abnormal cardiac patterns. The SIM800L GSM module ensures reliable transmission of the processed data to healthcare professionals or caregivers. Through continuous monitoring and real-time data transmission, the system enables healthcare professionals to remotely monitor multiple patients and provide timely medical assistance. The system's scalability and cost-effectiveness make it suitable for both individual patients and healthcare facilities.

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