

ESP32 IoT-Based Heart Attack Detection & Heart Rate Monitoring System

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Abstract—This project demonstrates an Internet of Things-based Heart Attack Detection & Heart Rate Monitoring System that uses an ESP32 controller to measure critical human health metrics in real time. The device measures heart rate (BPM) and blood oxygen saturation (SpO₂) using a pulse oximeter sensor. The electrical activity of the heart is monitored by an AD8232 ECG sensor module in order to identify anomalies. To measure body temperature, a temperature sensor is incorporated. The ESP32 microcontroller processes the gathered data, which is then shown on an LCD I2C display for local monitoring. The system transmits the health data to the Thing-Speak cloud platform for remote monitoring and data analysis after connecting to the internet via Wi-Fi. A buzzer and red LED alarm system are triggered whenever any parameter exceeds the safe limit. This technology aids in early health problem detection and ongoing patient monitoring. It can be used at home or at a hospital and is inexpensive and portable. The suggested method uses IoT technology to increase healthcare accessibility.

Index Terms—AD8232 ECG sensor, Thing-Speak cloud, LCD I2c, MAX30102, ESP32 controller.

I. INTRODUCTION

Smart healthcare monitoring systems have been made possible by the Internet of Things' (IoT) explosive growth. Vital signs include body temperature, blood oxygen level (SpO₂), heart rate (BPM), and ECG signals must be continuously monitored in order to diagnose health issues early. This project introduces an ESP32-based Internet of Things health monitoring system that uses sensors

like a temperature sensor, an ECG sensor (AD8232), and a pulse oximeter (MAX30100/MAX30102) to measure critical health data. For remote monitoring, the gathered data is transferred to the cloud using Thing Speak and shown on an LCD I2C display [1].

A buzzer and red LED alert are triggered whenever any parameter exceeds the safe limit. To enhance patient care and

monitoring systems, the healthcare sector is progressively implementing contemporary technologies [2]. Conventional health monitoring techniques necessitate regular hospital stays and medical personnel's personal observation. The identification of serious medical disorders may be delayed by this time-consuming procedure. As a result, smart healthcare systems that make use of contemporary electronics and communication technology are becoming increasingly crucial. Real-time data gathering, Monitoring and analysis are made possible by the Internet of Things (IoT), a potent technology that links physical objects to the internet [3].

II. OBJECTIVES

This project's primary goal is to create an Internet of Things (IoT)-based health monitoring system that can continually track critical human health metrics in real time. The system uses suitable biomedical sensors coupled to an ESP32 microcontroller to measure blood oxygen saturation (SpO₂), heart rate (BPM), ECG signals, and body temperature [4]. Another goal is to transfer the measured health data over Wi-Fi to a cloud platform like Thing Speak for remote

monitoring, as well as to show it locally on an LCD I2C display.

The initiative also intends to deliver early warning signals by turning on a red LED and buzzer when the health metrics exceed the typical safe limits. In an emergency, this enables medical professionals or caretakers to act quickly[5]. Both home healthcare monitoring and hospital settings can benefit from the system's affordable, portable, and user-friendly design.

III. BLOCK DIAGRAM

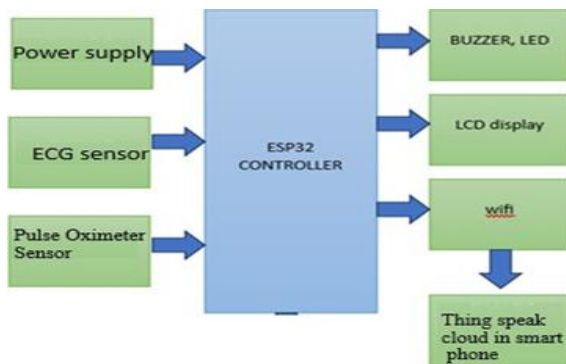


Fig.1. Block diagram of proposed system

3.1. Working Process

Using sensors and an ESP32 controller, the Internet of Things-based health monitoring system continuously gathers, processes, displays, and transmits patient health data. When the ESP32 microcontroller is turned on and linked to the Wi-Fi network, the system starts working. As the primary controller, the ESP32 controls communication with the cloud platform and reads data from all of the linked sensors. First, the patient's heart rate (BPM) and

blood oxygen saturation (SpO₂) are measured by the pulse oximeter sensor. These numbers are crucial markers of cardiovascular and respiratory health [6]. The AD8232 ECG sensor module simultaneously keeps an eye on the heart's electrical activity and generates ECG data that can be used to identify abnormalities or irregular heart rhythms.

In order to detect fever or other unusual bodily conditions, the temperature sensor also takes the patient's body temperature. The ESP32 controller continuously reads and processes the sensor data. Following processing, the measured data are shown

on the LCD I2C display, enabling real-time local monitoring of the health parameters by the patient or a caregiver in close proximity. The patient's present state of health is clearly shown on this display[7]. The ESP32 then transmits the gathered health data to the Thing Speak cloud platform via its integrated Wi-Fi module. In order for medical professionals or family members to remotely monitor a patient's health from any location over the internet, the cloud platform archives the data and presents it graphically.

Additionally, the system has an alert system. The technology automatically turns on a buzzer and red LED if any of the health parameters—such as body temperature, heart rate, or oxygen level—exceed the safe limit. In order to facilitate prompt medical assistance, this alert promptly notifies the user or caregiver[8]. Through this procedure, the technology improves patient safety and healthcare administration by offering remote access to health data and continuous, real-time monitoring.

IV. EXISTING SYSTEM

In traditional healthcare systems, distinct medical instruments are typically used in hospitals or clinics to assess patient health metrics including temperature, heart rate, oxygen level, and ECG. Medical personnel must be present to manually check and record the data on these devices. Doctors are unable to remotely monitor a patient's health in real time because the majority of current devices are not internet-connected. The difficulty of constant monitoring, particularly while patients are at home, is another drawback of traditional methods. It can be costly and time-consuming for patients to regularly attend hospitals for check-ups. Sudden health issues, such as an irregular heartbeat or low oxygen levels, can go undiagnosed until they worsen[9]. Additionally, standard monitoring equipment are not appropriate for personal health monitoring because they are frequently large, expensive, and non-portable. Additionally, they don't have automated alert systems that can tell caretakers right away when unusual circumstances arise. A smart, linked, and real-time health monitoring system is required as a result of these constraints.

4.1. Drawbacks

1. **No Continuous Monitoring:** Conventional health monitoring systems typically only take patient parameters when they are in the hospital. It is challenging to continuously monitor vital indicators in these systems.
2. **Lack of Remote Access:** Physicians and caregivers are unable to remotely monitor patients' health under traditional systems[10]. Only the hospital or clinic has access to the data.
3. **Manual Data Recording:** A lot of current systems require medical personnel to manually record patient data, which could result in mistakes and delays in diagnosis.
4. **High Cost of Medical Equipment:** The majority of conventional medical monitoring instruments, like oxygen monitors and ECG machines, are costly and unaffordable for individual usage at home.
5. **Bulky and Non-Portable Devices:** Patients find it challenging to use unconventional monitoring equipment outside of medical institutions because it is often bulky and fixed in hospitals.
6. **No Automatic Alert System:** When health metrics surpass acceptable limits, current systems do not automatically send out notifications, which could cause an emergency reaction to be delayed.
7. **Limited Data Storage and Analysis:** Long-term analysis and tracking of health issues are challenging because traditional systems do not keep patient health data in cloud platforms.

V. PROPOSED SYSTEM

Using an ESP32 microcontroller, the suggested system is an Internet of Things- based health monitoring system that continuously tracks important health metrics and transmits the information to the internet for remote access. Blood oxygen saturation (SpO₂) and heart rate (BPM) are measured by a pulse oximeter sensor in this system, and the AD8232 ECG sensor module captures the electrical activity of the heart. Body temperature is measured using a temperature sensor. The ESP32 controller serves as the system's central processing unit and processes all of the sensor data [11].

Users can monitor the health metrics locally by seeing the measured values on an LCD I2C display.

Simultaneously, the ESP32 uses its integrated Wi-Fi module to connect to the internet and uploads the data to the Thing Speak cloud platform for remote monitoring and analysis.

5.1. Proposed System Advantages

1. **Real-Time Health Monitoring:** The suggested system continuously tracks vital health indicators in real time, including body temperature, heart rate, SpO₂, and ECG signals.
 2. **IoT-Based Remote Monitoring:** Physicians and caregivers may keep an eye on patients' health from any location by sending health data via Wi-Fi to the Thing Speak cloud platform[12].
 3. **Automatic Alert System:** This system allows for prompt action in emergency scenarios by sounding a buzzer and turning on a red LED when any health parameter deviates from the normal range.
 4. **Low-Cost Solution:** The system is affordable and appropriate for home healthcare monitoring because it makes use of inexpensive parts including ESP32, sensors, and an LCD display.
 5. **Compact and Easy to Use:** Patients can use the device at home or in remote locations without the need for complicated medical equipment because it is small and portable.
- Cloud Data Storage:** The Thing Speak cloud stores the measured health data, which aids in long-term trend analysis and patient health record maintenance.
6. **Better Healthcare Accessibility:** By utilizing IoT technology, the system enables ongoing monitoring and early health issue detection, enhancing patient safety and healthcare services.

VI. PROBLEM STATEMENT

Continuous monitoring of critical health markers, including body temperature, heart rate, blood oxygen saturation (SpO₂), and ECG signals, is crucial for early medical problem diagnosis in contemporary healthcare systems. Traditional patient monitoring systems, on the other hand, are mostly found in hospitals and necessitate ongoing medical personnel supervision. These devices are frequently costly, heavy, and unsuitable for ongoing patient monitoring at home or in isolated locations[13]. As a result, when irregularities arise, people with heart-related issues, respiratory disorders, or other chronic conditions might not receive prompt medical

attention.

VII. LITERATU REREVIEW

- To secure mobile information-centric networks, Rathee et al. (2020) [12] presented at rust management framework. In order to guarantee dependable communication in distributed systems, their work concentrated on enhancing security and trust among network nodes. This study emphasizes the significance of secure data transmission, which is essential for IoT-based healthcare applications that need to safeguard private patient data.
- Hassen et al. (2020) [13] created a home hospitalization system that combines cloud, fog, and Internet of Things technology. Their technology lessens the strain on hospitals while enabling remote patient monitoring at home. The study showed that integrating IoT devices with fog and cloud computing can speed up data processing and increase the effectiveness of healthcare services.
- Islam et al. (2020) [14] created an intelligent healthcare monitoring system in an Internet of Things setting to gauge vital signs including body temperature and heart rate. For real-time monitoring, they stemsent data to a cloud platform via sensors linked to microcontrollers. According to their research, IoT- based systems can offer early health problem diagnosis and ongoing patient monitoring. • In a similar vein, Acharya and Patil (2020) [19] created an Internet of Things-based healthcare monitoring kit that incorporates several sensors to measure various aspects of patient health. For remote monitoring by physicians and caregivers, the system transmits gathered data to a cloud platform. Their research demonstrated that IoT technology can offer a practical and affordable healthcare monitoring solution.

VIII. HARDWARE DESCRIPTION

8.1 ESP32Microcontroller

The system's primary controller is the ESP32. It gathers sensor data, interprets it, shows it on the LCD, and then uses WiFi to post it to the Thing

Speak cloud platform[14].



Fig.2. ESP32 controller

With built-in antenna switches, RF baluns, power amplifiers, low-noise receive amplifiers, filters, and power management modules, the ESP32 is highly integrated. ESP32 reduces the need for printed circuit boards (PCBs) while adding invaluable capability and diversity to your applications. Bluetooth chip and hybrid Wi-Fi.

8.2. Pulse Oximeter Sensor (MAX30102)

The MAX30102 is a highly integrated sensor that measures heart rate (HR) and blood oxygen saturation (SpO2). It uses a photodetector in conjunction with a red and infrared LED to precisely track heart rate and pulse oximetry. This sensor is perfect for wearable health monitoring devices because of its small form factor and low power consumption. Because it uses I2C communication, integrating it with microcontrollers like Arduino or Raspberry Pi is made easier[15]. The MAX30102 is frequently found in fitness trackers, smartwatches, and medical monitoring devices due to its excellent accuracy and efficiency. For more accurate readings, ambient light rejection is also supported.

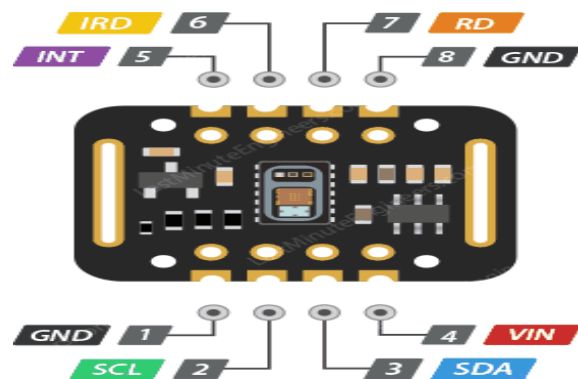


Fig.3. Pulse oximeter sensor

8.3 AD8232 ECG:

This sensor is an affordable board that measures the heart's electrical activity. This electrical activity can be produced as an analog reading and plotted as an electrocardiogram, or ECG. The AD8232 SingleLeadHeartRateMonitor functions as an op-amp to make it easier to get a clear signal from the PR and QT intervals because ECGs can be very noisy [16]. It is intended to extract, amplify, and filter tiny biopotential signals in noisy environments, like those produced by motion or distant electrode positioning. Pins, wires, or other connectors to the nine connections that the AD8232 module separates from the IC. Essential pins for using an Arduino or other development board to operate this monitor are SDN, LO+, LO-, OUTPUT, 3.3V, and GND. Additionally, this board has RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins for you to use and attach your own unique sensors. There is a small LED indication light that pulses in time with a heartbeat.

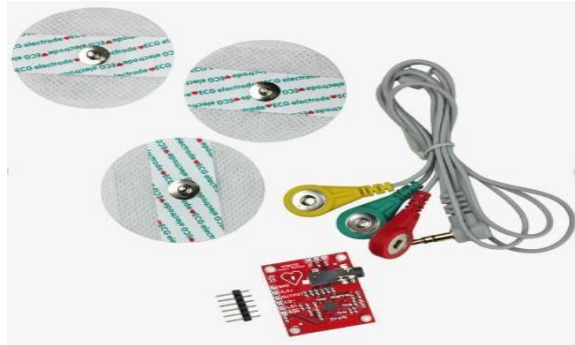


Fig.4. AD8232 ECG Sensor

8.4. LCD I2C Display:



Fig.5. LCD I2C module

One of the most popular electronic display modules for embedded systems and microcontroller-based projects is the LCD 16x2 display. Because it has two rows and can display 16 characters per row, a total of

32 characters can be displayed at once. This is why it is called 16x2. Electronic equipment frequently employ this kind of LCD to show text, sensor readings, and system status data. Liquid crystals are positioned between two layers of polarized glass in Liquid Crystal Display (LCD) technology, which is how the LCD 16x2 display operates [17]. The liquid crystals align in a way that either blocks or permits light to pass through when an electric current flows through them, creating characters and symbols on the screen.

8.5. 5V Mini Buzzer

TMB12D05-CLDZ-Electromagnetic active integrated buzzer-5V (12 x 7.5 mm). In electrical systems, audio indicators are parts or apparatuses that generate sound to deliver aural feedback, alerts, or cautions [18]. Numerous applications, including alarm systems, consumer electronics, automotive systems, medical devices, and more, depend on these sound-producing components.



Fig.6. Buzzer

IX. RESULTS AND DISCUSSION

Heart rate (BPM), blood oxygen saturation (SpO₂), ECG signals, body temperature, and other critical health indicators were effectively measured by the created IoT-based HMS using the ESP32 controller. The ESP32 microcontroller, which was linked to the sensors, gathered and processed the data in real time. The LCD I2C display showed the measured results, enabling the user to keep an eye on the health metrics locally. The AD8232 ECG sensor effectively recorded the electrical activity of the heart throughout testing, and the MAX30102 pulse oximeter sensor

gave accurate results for heart rate and SpO₂ levels. The ThingSpeak cloud platform received the collected data via the ESP32 Wi-Fi module[19]. There, the numbers were stored and shown graphically for remote monitoring.

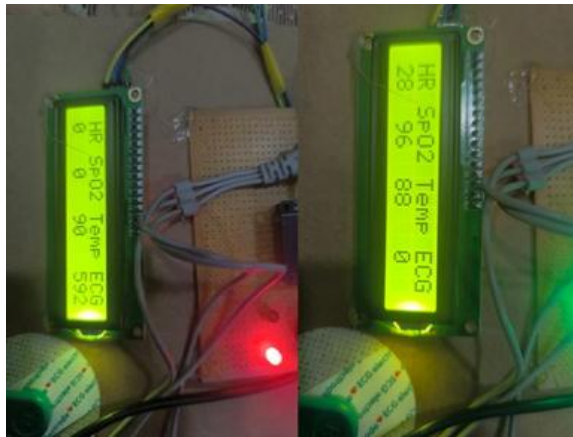


Fig.7.IoT based health monitoring system

Additionally, the device used a red LED and buzzer to illustrate an efficient alarm mechanism. The alarm system promptly notified the user or caregiver when the measured data, such as low SpO₂ or an aberrant heart rate, exceeded the predetermined safe limits. The findings demonstrate that the suggested system can offer real-time updates both locally and remotely while continually monitoring patient health status. The system worked well for remote patient surveillance and home healthcare monitoring since it was inexpensive, dependable, and simple to set up. Overall, the findings demonstrate that combining IoT technology with biological sensors can greatly enhance healthcare monitoring systems by facilitating ongoing observation, early anomaly identification, and improved patient care[20].

X. ADVANTAGES

- Monitoring health in real time
- IoT-based remote monitoring
- Early identification of cardiac anomalies
- Portable and inexpensive
- Simple to use

XI. APPLICATIONS

- Monitoring patients remotely
- Health monitoring systems in hospitals
- Systems for home healthcare
- Monitoring elderly patients
- Monitoring wellness and fitness

XII. CONCLUSION

An effective and affordable method of continually monitoring critical health metrics like SpO₂, heart rate, ECG signals, and body temperature is provided by the Internet of Things-based ESP32 health monitoring system. Real-time remote monitoring and data analysis are made possible via the Thing Speak cloud. This approach can greatly aid in the early identification of health problems and prompt medical intervention, enhancing patient safety and the effectiveness of healthcare. The ESP32 controller-based IoT-based health monitoring system offers a practical and efficient way to continuously monitor critical health metrics. Using the proper biomedical sensors, the system effectively measures body temperature, heart rate (BPM), blood oxygen saturation (SpO₂), and ECG signals. The ESP32 microcontroller processes the gathered data, which is then shown on an LCD I2C display for local monitoring.

The solution allows physicians and caregivers to remotely monitor patient health in real time by sending health data to the ThingSpeak cloud platform through the integration of Wi-Fi and IoT technology. Additionally, the device has an LED alert mechanism and buzzer that alerts users when health metrics surpass safe limits, assisting in the early identification of possible medical problems. The suggested system is affordable, portable, and user-friendly, making it appropriate for both hospital

settings and home healthcare monitoring. It offers ongoing health monitoring and lessens the need for frequent hospital stays, which is particularly helpful for elderly patients and those with chronic illnesses. Overall, the study shows how IoT technology may enhance healthcare services by offering dependable and intelligent patient monitoring options.

XIII. FUTURE ENHANCEMENTS

Even if the suggested system monitors health effectively, there are a number of ways to improve its functionality and performance going forward. Adding more medical sensors to monitor more health factors for a more thorough health analysis, such as a respiration rate sensor, blood

pressure sensor, or glucose monitoring sensor, is one potential improvement. The creation of a mobile application that can deliver notifications, provide real-time patient health data, and make it simple for doctors to access medical records from cellphones is another advancement. Incorporating GPS technology to track patients' locations during emergencies is another way to improve the system. This would be especially helpful for elderly people or patients who need special care.

In order to evaluate the gathered health data and anticipate possible health problems before they become serious, machine learning or artificial intelligence algorithms may be used in the future. Additionally, the device can be made more compact, wearable, and battery-operated so that patients can use it comfortably for extended periods of time. The system will become more sophisticated, dependable, and appropriate for contemporary smart healthcare applications as a result of these improvements.

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