Real Time Ecg and Heart Rate Detection and Display

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***Abstract*—This project presents an ECG and Heart Rate Monitoring System developed to continuously monitor the electrical activity of the human heart and accurately measure heart rate using sensor-based technology. The system is designed to provide a reliable, low-cost, and portable solution for real-time cardiac monitoring in both clinical and home environments. An ECG sensor module is used to acquire real-time cardiac signals from the human body through electrodes placed at specific positions on the skin. These electrodes detect the small electrical impulses generated during each heartbeat. The captured analog signals are transmitted to the ESP32 microcontroller, which serves as the central processing unit of the system.**

The ESP32 is selected for its high processing capability, low power consumption, and built-in Wi-Fi and Bluetooth features that enable wireless data transmission. Since raw ECG signals are highly sensitive to noise, motion artifacts, and external interference, appropriate filtering and signal conditioning techniques are applied to obtain clean and accurate waveforms.

After filtering, key parameters such as heart rate and waveform characteristics (including the P wave, QRS complex, and T wave) are extracted for analysis. These parameters help in assessing heart function and identifying irregularities. The processed data can be displayed on an LCD or serial monitor and can also be transmitted wirelessly to a mobile device or web-based monitoring platform for remote observation. The system can be enhanced with alert mechanisms to notify users in case of abnormal heart rate conditions such as tachycardia or bradycardia.

Overall, this project offers a compact, efficient, and cost-effective solution suitable for healthcare monitoring, fitness tracking, and remote patient care applications.

***Index Terms*—ESP32 Microcontroller, ECG System.**

I. INTRODUCTION

Electrocardiography (ECG) is a widely used medical technique for monitoring the electrical activity of the human heart. The ECG waveform provides important information about heart rhythm, heart rate, and possible cardiac abnormalities. Continuous monitoring of heart signals plays an essential role in early diagnosis and prevention of heart diseases. With the advancement of embedded systems and biomedical sensors, portable health monitoring devices are becoming increasingly popular. Traditional ECG systems are usually bulky and expensive, making them less accessible for everyday personal health monitoring. To overcome these limitations, modern technologies such as microcontrollers, wearable sensors, and wireless communication have enabled the development of compact and low-cost monitoring systems. These systems allow users to monitor vital parameters such as heart rate and ECG signals in real time.

In this project, a Real Time ECG and Heart Rate Detection System is developed using an ESP32 microcontroller, Sparkfun Bio-Hub heart rate sensor, and AD8232 ECG sensor module. The ECG sensor captures electrical signals generated by the heart, while the heart rate sensor measures the pulse rate using optical sensing techniques. These signals are processed by the ESP32 controller to determine the heart rate and visualize ECG waveforms.

The measured data is displayed locally on a 16×2 I2C LCD display, providing immediate feedback to the user. In addition, the ECG signal is transmitted wirelessly via Bluetooth communication to a mobile application for graphical visualization and remote monitoring.

The system is designed to be portable, cost-effective, and easy to use. It can be applied in healthcare monitoring, fitness tracking, and remote patient observation. By combining embedded technology with biomedical sensors, the project demonstrates a practical solution for real-time heart monitoring. Uses cost-effective embedded hardware components.

II. LITERATURE SURVEY

The literature survey focuses on reviewing existing technologies and research related to ECG monitoring systems, heart rate detection, biomedical sensors, and wireless health monitoring systems. Over the past few decades, significant developments have occurred in biomedical engineering, enabling the design of compact and portable healthcare devices. Traditional ECG systems were mainly hospital-based and required expensive equipment, while modern research emphasizes portable and wearable monitoring devices using microcontrollers and IoT technologies.

Several studies have focused on improving signal acquisition techniques, filtering methods, and real-time monitoring solutions. Sensors such as ECG modules and optical heart rate sensors have been widely used to measure physiological parameters accurately. Recent developments integrate wireless communication technologies such as Bluetooth, Wi-Fi, and IoT platforms to transmit health data to mobile devices or cloud servers.

Researchers have also explored the use of embedded systems like Arduino, ESP32, and Raspberry Pi for health monitoring applications. These systems help reduce the cost and complexity of medical monitoring devices while maintaining reliable performance. However, challenges such as signal noise, electrode placement issues, and real-time data visualization remain areas of ongoing research.

The literature survey highlights the evolution of ECG monitoring systems from traditional hospital-based equipment to modern portable and wireless monitoring devices. Traditional ECG machines provide accurate results but are expensive, bulky, and limited to clinical environments. Recent advancements in embedded systems and biomedical sensors have enabled the development of compact monitoring systems.

Technologies such as IoT, wireless communication, and sensor-based monitoring have improved the accessibility and efficiency of healthcare devices. Microcontrollers like ESP32 allow real-time processing and wireless transmission of physiological data. Sensors such as MAX30102 and AD8232 enable accurate measurement of heart rate and ECG signals.

Despite these advancements, challenges such as signal noise, electrode placement issues, and system reliability still require further research. The proposed system addresses some of these limitations by providing a low-cost, portable, and wireless ECG monitoring solution.

III. PROPOSED SYSTEM

The proposed system introduces a portable and real-time ECG and heart rate monitoring device based on embedded system technology. The system uses an ESP32 microcontroller as the main processing unit to collect and analyze physiological signals from sensors.

In this design, the AD8232 ECG sensor module is used to detect the electrical activity of the heart through two copper electrodes attached to the human body. These signals are amplified and filtered by the ECG module before being sent to the microcontroller for further processing.

The Sparkfun heart rate sensor measures the user's pulse rate using optical sensing technology. It detects blood flow changes through infrared light and calculates the heart rate in beats per minute (BPM).

The ESP32 processes the sensor data and displays the heart rate value on a 16×2 LCD display. The LCD provides real-time visual feedback for the user. Additionally, the ECG waveform data is transmitted wirelessly using the Bluetooth module.

A mobile application receives the Bluetooth data and plots the ECG waveform graphically. This allows the user to observe heart activity in real time on their smartphone.

The system also includes a mode switch that allows the user to toggle between ECG monitoring mode and heart rate monitoring mode.

Advantages of Proposed System

- Low cost compared to hospital ECG machines
- Portable and lightweight design
- Real-time heart rate monitoring

• Wireless ECG waveform transmission via Bluetooth
• LCD display for instant results
• Easy to operate and user-friendly
• Suitable for home healthcare monitoring
• Can be extended for IoT health monitoring systems

The proposed system provides an efficient and affordable solution formonitoring heart activity, making it suitable for healthcare applications, fitness monitoring, and remote patient observation.

3.1 Block Diagram

The block diagram represents the functional structure of the ECG and heart rate monitoring system. It illustrates how different hardware components interact to perform signal acquisition, processing, and output display.

At the core of the system is the ESP32 microcontroller, which acts as the central processing unit. The ESP32 receives input signals from the sensors and processes them to generate meaningful output.

The AD8232 ECG sensor module captures electrical signals from the heart through electrodes attached to the body. These signals are amplified and filtered before being transmitted to the ESP32.

The Sparkfun heart rate sensor measures the user's pulse rate using optical sensing technology. It detects changes in blood flow and converts them into digital signals that can be processed by the microcontroller.

A mode switch is connected to the ESP32 to allow users to select between ECG monitoring mode and heart rate monitoring mode.

The processed heart rate values are displayed on the 16×2 LCD display, providing real-time feedback to the user. At the same time, ECG waveform data is transmitted through Bluetooth communication to a mobile application for graphical visualization.

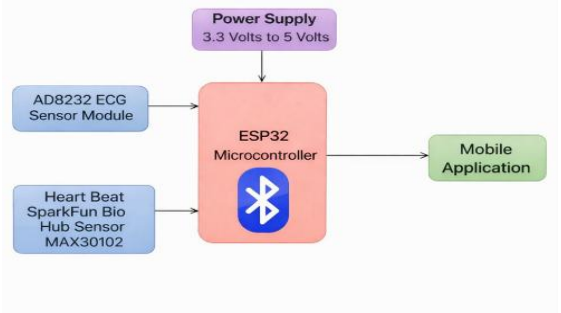

Figure1: Block diagram ofReal Time ECG and Heart Rate Detectionsystem

The block diagram demonstrates the flow of information from input sensors to processing units and finally to output devices.

3.1.1flow Diagram

The flow diagram illustrates how information moves through the system from input to output. The process begins when the system is powered on and the ESP32 microcontroller initializes all connected components, including sensors, LCD display, and Bluetooth communication.

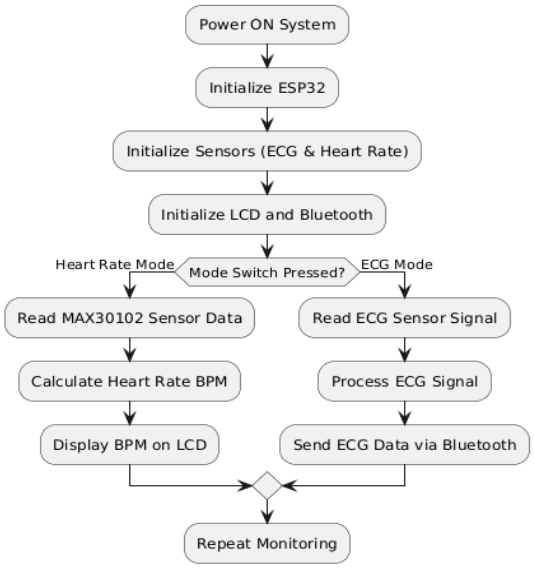

Figure1.1: Flow diagram ofReal Time ECG and Heart Rate Detection system

After initialization, the system continuously checks the state of the mode switch. If the switch is set to heart rate monitoring mode, the ESP32 reads pulse data from the Sparkfun sensor. The microcontroller processes the sensor data and calculates the heart rate in beats per minute. The calculated value is then displayed on the LCD screen.

If the switch is set to ECG monitoring mode, the ESP32 reads the analog ECG signal from the AD8232 sensor module. The microcontroller processes the signal and sends the ECG data through Bluetooth communication to a mobile application.

The system continuously repeats this process, enabling real-time monitoring of heart activity. The data flow diagram helps visualize the logical sequence of operations performed by the system.

IV. OUTPUTS

Graphical Visualization of ECG Output

Displaying Heart Rate Output

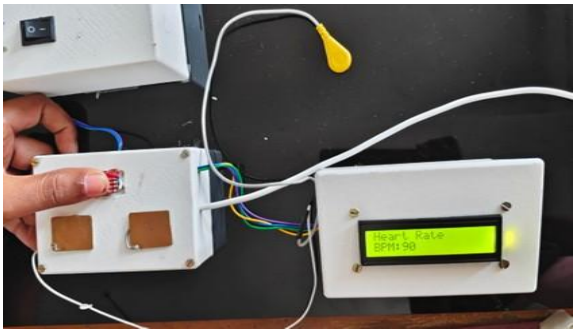

Figure2: Outputs

V. CONCLUSION

The Real-Time ECG and Heart Rate Detection and Display System has been successfully designed and implemented using biomedical sensors and an embedded microcontroller platform. The system is capable of monitoring heart activity by detecting ECG signals and measuring heart rate in real time.

The ECG sensor module is used to capture the electrical signals generated by the heart, while the MAX30102 sensor measures the pulse rate through optical sensing technology. These signals are processed by the ESP32 microcontroller and displayed on the LCD screen. The system also transmits ECG waveform data through Bluetooth communication to a mobile application for graphical visualization.

One of the major advantages of the proposed system is its low cost and portability compared to traditional hospital ECG machines. The use of compact sensors and a microcontroller allows the system to be easily used for personal health monitoring.

The system also provides real-time monitoring, enabling users to observe heart rate and ECG signals instantly. Wireless data transmission allows ECG waveforms to be visualized on a smartphone, making the monitoring process more convenient.

Although the system provides basic cardiac monitoring functionality, it can be further enhanced by integrating additional features such as cloud-based data storage, abnormal heart rate alerts, and IoT connectivity for remote patient monitoring.

Overall, the proposed system demonstrates an effective and affordable solution for monitoring heart activity using modern embedded system technology. It can be used for healthcare monitoring, fitness applications, and educational demonstrations in biomedical engineering projects.

REFERENCES

[1] Digital thermometer and its applications (online). Available at: https://www.elprocus.com/digital-thermometers

[2] Jeremy Booth, "A short history of blood pressure measurement", Proceedings of the Royal Society of Medicine, Vol. 70, 1977.

[3] Engineering and technology history wiki (online). Available at: https://ethw.org/EKGs_and_EEGs.

[4] Richard C. Alkire, Dieter M. Kolb, Jacek Lipkowski, “Bioelectrochemistry: Fundamentals, Applications and Recent Developments”, Somerset, NJ, US: John Wiley & Sons, 2013.

[5] Jan S. Jørgensen MD, Volker König PhD, Karin FaisstMD, Albert Huch MD & Dr Renate Huch MD, “Limitations of forehead pulse oximetry”, Journal of Clinical Monitoring, 11, pages253–256 (1995).

[6] S.U. Rani A. Ignatious, B.V. Hari, V.J. Balavishnu, “IoT Patient Health Monitoring System”, Indian Journal of Public Health Research and Development, vol. 8, pp. 1329 – 1334, October 2017.

[7] N.S. Palkhede, S.D. Mali, M.S. Shelar, “IoT Based Patient Monitoring”, International Journal of Trend in Scientific Research and Development (IJTSRD), Vol. 2, pp. 971 – 975, May 2018.

[8] D. S. R. Krishnan, S. C. Gupta and T. Choudhury, "An IoT based Patient Health Monitoring System," 2018 International

Conference on Advances in Computing and Communication Engineering (ICACCE), Paris, 2018, pp. 01-07.

[9] R. A. Rahman, N. S. A. Aziz, M. Kassim and M. I. Yusof, "IoT-based personal health care monitoring device for diabetic patients," 2017 IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), Langkawi, 2017, pp. 168-173.

[10] M. Malathi, Dr. Preethi, “IoT Based Patient Health Monitoring System”, International Journal of Engineering Research & Technology (IJERT), Vol. 7, 2019.

[11] S. Gupta, S. Kashaudhan, D.C. Pandey, “IoT Based Patient Health Monitoring System”, International Research Journal of Engineering and Technology (IRJET), Vol. 4, March 2017, pp. 2316 - 2319.

[12] J. Wan, M.A.A.H. Al-a wlaqi, M. Li, M. O’Grady, X. Gu, J. Wang, N. Cao, “Wearable IoT Enabled Real-Time Health Monitoring System EURASIP Journal on Wireless Communication and Networking, 2018.