Real-Time ECG Monitoring System Using AD8232 Sensor and Arduino UNO for Biomedical Applications

B. A. V. N. Hasini[1], Mekala Varun[2], N. V. S. Sanjana[2], Abburi Sai Keerthi[1],
Sai Mani Deepika Somayajula[2] and Gayathri Ramaswamy[2]

[1]*Department of Electronics and Communication Engineering, Amrita Vishwa Vidyapeetham, Bengaluru-560035, Karnataka, India*

[2]*Department of Computer Science and Engineering, Amrita Vishwa Vidyapeetham, Bengaluru-560035, Karnataka, India*

Keywords: ECG Monitoring, AD8232 Sensor, Arduino UNO, Real-Time Signal Processing, Biomedical Signal Acquisition, Cardiovascular Health, Noise Filtering, Wearable Health Monitoring.

Abstract: The increasing prevalence of cardiovascular diseases necessitates the development of accessible and cost-effective solutions for continuous electrocardiogram (ECG) monitoring. This study presents a real-time ECG monitoring system utilizing the AD8232 ECG sensor interfaced with an Arduino UNO microcontroller to measure and analyze the electrical activity of the heart. The AD8232 sensor, equipped with integrated signal conditioning capabilities, extracts, amplifies, and filters bio-potential signals while mitigating noise interference, ensuring accurate ECG readings. The Arduino UNO serves as the primary processing unit, facilitating data acquisition and transmission for real-time visualization. The ECG signal is displayed using a serial plotter or the Processing IDE, enabling immediate observation and analysis. The hardware implementation involves a structured integration of the AD8232 sensor with the Arduino UNO, accompanied by a comprehensive circuit diagram for ease of replication. This system provides a reliable and cost-efficient approach to real-time ECG monitoring, offering potential applications in remote healthcare and early cardiac anomaly detection.

1 INTRODUCTION

Cardiovascular diseases (CVDs) are accountable for some of the major causes of death in the world and are a main hindrance to public health. The covert character of the diseases necessitates that they be continuously monitored and diagnosed early to allow timely intervention and improved patient outcomes. As the prevalence of cardiac diseases increases, so does the need for novel and lower-cost methods of real-time monitoring of cardiac electrical activity. Standard electrocardiogram (ECG) monitoring methods are largely limited to clinical settings, which limits accessibility and results in a lag in detection of potential abnormalities.

The Wireless ECG Monitoring System, developed employing the AD8232 Sensor interfaced with the Arduino UNO, meets this fundamental requirement with the help of contemporary electronic parts to provide an economical, convenient, and accessible solution for live electrocardiogram monitoring. The system attempts to balance traditional healthcare practices and emerging technological innovations, thereby ensuring continuous monitoring accessible to various socio-economic classes. This is congruent with the overall objective of encouraging preventive healthcare practices and combating the incidence of cardiovascular diseases.

At the center of the system is the AD8232 ECG sensor, a small and versatile chip that is capable of capturing, amplifying, and filtering the heart biopotential signals. The sensor is paired with the Arduino UNO microcontroller, which amplifies and sends the signals for graphical representation. The ECG signals are visible in real time by the users on a serial plotter or the Processing IDE, which provides an easyto-use interface for heart activity analysis. Furthermore, the wireless design of the system greatly enhances its portability, making remote monitoring feasible in many settings, from home health care to community health care projects.

Hasini, B. A. V. N., Varun, M., Sanjana, N. V. S., Keerthi, A. S., Somayajula, S. M. D. and Ramaswamy, G.
Real-Time ECG Monitoring System Using AD8232 Sensor and Arduino UNO for Biomedical Applications.
DOI: 10.5220/0013892900004919

In *Proceedings of the 1st International Conference on Research and Development in Information, Communication, and Computing Technologies (ICRDICCT'25 2025) - Volume 3*, pages 113-118
ISBN: 978-989-758-777-1

Aside from its technological innovation, the system serves the interests of society since it enables individuals to take an active role in the management of their cardiovascular health. Continuous monitoring that enables the identification of abnormalities early on can greatly minimize the risks of heart diseases and enable timely medical intervention. The cost-effectiveness and reproducibility of the system make its principle a suitable solution for mass application, especially in developing regions. By integrating real-time ECG monitoring with wireless communication, this system is a paradigm shift in healthcare from reactive treatment to proactive health maintenance. Not only does it improve patient autonomy, but it helps towards the larger vision of accessible and preventive healthcare for everyone.

2 RELATED WORKS

Sangeethalakshmi K. et al. 2023 develop an IoT-based realtime health monitoring system. Methodology uses an ESP32, sensors, a mobile app, and GSM for continuous monitoring. Results ensure reliable patient management by healthcare professionals. Future work includes advanced sensors, better UI, and scalability.

Sadad et al. 2023 proposed an efficient ECG image classification using a lightweight CNN with an attention module and IoT. Results show high accuracy with reduced computation, improving real-time processing. Future work includes advanced attention mechanisms and expanding the IoT framework.

Xu et al. 2020 introduced a framework for ECG, utilizing small, capable devices for sensing, processing, and communicating. Integrates sensors and embedding devices for secure data transmission. Shows the feasibility of using IoT for secure and efficient ECG monitoring. Future work could focus on enhancing security measures and improving scalability.

Yeh et al. 2021 integrated IoT-based ECG monitoring with deep neural networks for remote healthcare. Results showed improved accuracy and efficiency in heart condition classification. Future work aims to enhance robustness with diverse data and advanced algorithms.

Hasan et al. 2020 introduced an ECG device using Blynk app for heart disease diagnosis. It enables real-time ECG data collection, transmission, and alerts for abnormalities. Future work includes advanced ML for predictive analytics and monitoring more vital signs.

Obaidur et al. 2022 developed ECG device for rural healthcare in Bangladesh. It uses IoT sensors, microcontrollers, and cloud computing for remote heart monitoring. Future work includes adding health parameters, improving security, and expanding coverage.

Gawsalyan et al. 2022 introduced ANNet, real-time detection in wearables of IOT. Using LSTM and MLP, it ensures power-efficient processing of ECG features. Future work aims to improve robustness to artifacts and adaptability across demographics.

Morello et al. 2022 developed an IoT-based ECG monitoring system for cardiac diagnosis in smart cities. It demonstrated effective real-time detection of cardiac issues. Future work includes improving accuracy, scalability, and integrating machine learning for better diagnostics.

O. Ankireddypalli et al. 2024 present a piezoelectric-powered smart irrigation system for urban sustainability. Footstep energy powers irrigation based on real-time soil moisture data, reducing water use by 30%. The system ensures reliable automation, and future enhancements include cloud integration and machine learning for efficiency.

Adithi et al. 2019 develop a low-cost robotic mapping system using an ultrasonic sensor. The robot scans a 180-degree area and plots real-time radar maps. It efficiently detects motion via Bluetooth control. Future work includes GPS tracking and wireless communication.

M.Shyam et al. 2024 presented an health monitoring system wearables. It collects and transmits real-time vital signs securely. Results confirm accurate monitoring. Future work focuses on enhanced security and remote care.

Pradeep et al. 2017 propose an IoT-based sustainable water management system for rural areas. They analyze water scarcity issues in Gudipadu Cheruvu and design an automated distribution and storage system. The results demonstrate effective regulation of water usage. Future improvements include enhanced scalability and real-time monitoring.

M.Tejaswi et al. 2023 discuss the implementation of IoT-based precision agriculture for optimizing farming operations. They use a NodeMCU, DHT11, and soil moisture sensor to develop an automated watering system. The results show improved water management and increased crop yields. Future enhancements include advanced AI-driven analytics for better decision-making.

Ramaswamy et al. 2023 present a brain tumor detection model using a modified Link-Net with SE-ResNet152, achieving 99.2% accuracy. Future work focuses on improving feature fusion and integrating additional pre-trained models.

Ramaswamy et al. 2022 also propose an Optimized Gradient Boosting model for Type-2 Diabetes Mellitus detection, achieving 94.5% accuracy. Future improvements include additional clinical features and advanced ensemble techniques.

3 METHODOLOGY

3.1 Components Used

The implementation of the Wireless ECG Monitoring System utilizes the following hardware components (table 1):

Table 1: Components Used.

Components	Description
Arduino UNO	A microcontroller board based on ATmega328P, used for reading sensor data and processing signals.
USB Power Cable	Provides power supply to the Arduino board from a computer or adapter.
Pulse Sensor	Optical sensor that detects heartbeat by measuring blood flow variations through green light absorption.
AD8232 Heart Rate Monitor	An analog front-end module that extracts, amplifies, and filters ECG signals for accurate heart activity monitoring.
LM35 Temperature Sensor	A precision temperature sensor that outputs a voltage proportional to temperature in °C, used for body temperature measurement.
16×2 LCD Display	A character-based display used to show ECG readings, heart rate (BPM), and temperature in real time.
Connecting Wires	Essential for establishing connections between various components and the Arduino board.
Potentiometer	Used to adjust the contrast of the LCD display for better visibility.
LED	Provides visual indications, such as power status or alerts for abnormal ECG readings.

3.2 Software Used

The system employs the following software tools for coding, visualization, and data processing:

- Arduino IDE 2.0.3 – Used for coding, editing, and uploading the program onto the Arduino microcontroller.
- Processing IDE – Employed for graphical user interface (GUI) visualization of the ECG signals.

3.3 Technical Aspects

- Pulse Sensor: The Pulse Sensor works by emitting green light (550 nm) onto the user's finger and detecting the level of reflected light using a photo sensor. Green light is absorbed by oxygenated hemoglobin in arterial blood, allowing pulse to be detected by sensing changes. Illumination and photo sensor levels persist while the system detects heartbeat pulses precisely.

- LM35 Temperature Sensor: The LM35 is a low-voltage, high-accuracy centigrade temperature sensor produced by Texas Instruments. It is a voltage-output temperature sensor that is linearly proportional to temperature in degrees Celsius (°C). Specifically, this sensor does away with the requirement for external calibration, with ±0.5°C accuracy at room temperature and ±1°Cover its full operating range of -55°C to +155°C.

- Arduino UNO: The Arduino UNO is a microcontroller board based on the ATmega328P. It features:

    - 14 digital input/output pins (6 can be used as PWM outputs)
    - 6 analog inputs
    - 16 MHz ceramic resonator
    - USB connection, power jack, ICSP header, and reset button The board is capable of operating via a USB connection, an AC-to-DC adapter, or a battery.

- AD8232 Heart Rate Monitor: The AD8232 sensor is a cost-effective solution that was specifically intended to monitor cardiac electrical activity. It is utilized to acquire and amplify biopotential signals, thereby producing an analog ECG output that is employable for real-time monitoring.
- 16×2 LCD Display: A 16×2 LCD is capable of showing 16 characters on one line and a

total of two lines at its command. It shows every character in a 5×7 pixel matrix and can show 224 unique characters and symbols. The LCD module has two registers:

- Command Register: Stores commands and instructions given to the LCD.
- Data Register: Holds the data (characters) to be displayed.

The LCD facilitates on-screen visualization of ECG data and other system parameters.

4 SYSTEM DESIGN

The design of the system of the ECG Graph Monitoring project using the AD8232 ECG Sensor and the Arduino platform involves the integration of heterogeneous hardware components, such as the Arduino UNO board and the AD8232 ECG Sensor, and software code in order to monitor and present ECG signals. The system design is divisible into three main components: the hardware configuration, the signal processing, and data presentation.

4.1 Hardware Setup

Hardware setup is done by plugging the AD8232 ECG Sensor into Arduino UNO board. AD8232 sensor detects electrical activity of the heart and provides an analog signal. Pins of the sensor, such as: These pins are connected to corresponding pins on the Arduino for proper signal acquisition. Additionally, the sensor pads are placed at specific body locations (Right Arm, Left Arm, and Right Leg) to ensure optimal signal detection. The connections are made using a breadboard for ease of prototyping. Figure 2 shows the hardware setup. The Table 2 shows Pin descriptions.

Table 2: Pin Descriptions.

Pin Name	Description
GND	Ground connection
3.3V	Power supply.
OUTPUT	Analog ECG signal output.
LO-	Lead-off detection pin
LO+	Lead-off detection pin.

4.2 Circuit Diagram

The connections between the AD8232 ECG Sensor, Arduino UNO, and external components are shown in the below diagram. The Arduino is programmed to read the analog signal from the AD8232 sensor using the analogRead() function. The obtained signal is then processed to detect any lead-off condition, indicated by the symbol"!". If a lead-off condition is detected, the system notifies the user by displaying a blue line. Figure 1 shows the circuit diagram.

4.3 Signal Processing

If the incoming data is valid, the system processes the analog signal to calculate the heart rate (BPM). This is achieved by measuring the time interval between successive peaks in the ECG waveform. The BPM value is then sent to the connected computer for further visualization.

4.4 Data Visualization

The processed data, including the ECG waveform and BPM, is transmitted from the Arduino to a computer using a serial connection. On the computer side, a Processing sketch is employed to receive and visualize the data in real time. The Processing sketch performs the following tasks:

- Reads incoming data from the Arduino.
- Plots the ECG waveform dynamically using the line() function.
- Displays the BPM periodically on the screen

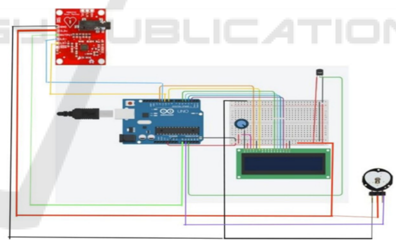

Figure 1: Circuit Diagram.

5 RESULTS AND EVALUATION

ECG Graph Monitoring project with the AD8232 ECG Sensor and Arduino aims to create a cost-effective system for monitoring and analyzing the electrical activity of the heart. The AD8232 ECG Sensor is employed to capture the heart's electrical signals, which are then processed and displayed using an Arduino microcontroller. The project offers an accessible solution for individuals to observe and analyze their ECG signals at home, enabling early detection of potential heart-related issues. The system utilizes a simple circuit connection between the

AD8232 sensor and Arduino, making it user-friendly for electronics enthusiasts and beginners. The real-time ECG data is visualized on the Arduino's serial plotter or Processing IDE, providing a graphical representation of the heart's electrical activity.

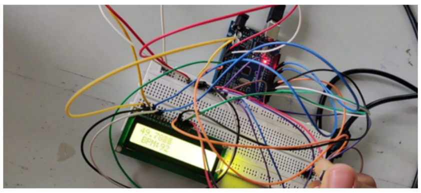

Figure 2: Hardware Setup of the ECG Monitoring System.

Inference: By implementing this project, individuals can gain insights into their heart's health and potentially identify irregularities or abnormalities in the ECG signal. The system's affordability and simplicity make it an accessible tool for personal health monitoring. It serves as a valuable educational project for learning about ECG signals, sensor interfacing, and Arduino programming. While the project provides a useful monitoring tool, it's important to note the disclaimer in the article, emphasizing that the AD8232 module used is not a medical device and is not intended for medical diagnosis or treatment. Users should consult healthcare professionals for accurate medical assessments and diagnoses. Figure 3 shows the inference result and figure 4 shows the graphical user interface.

Circuit Diagram: The connections between the AD8232 ECG Sensor, Arduino UNO, and external components are shown in the below diagram. The Arduino is programmed to read the analog signal from the AD8232 sensor using the analogRead() function. The obtained signal is then processed to detect any lead-off condition, indicated by the symbol"!". If a lead-off condition is detected, the system notifies the user by displaying a blue line.

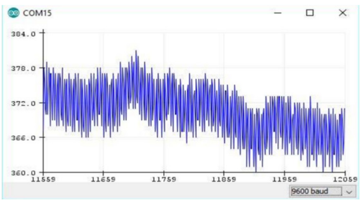

Figure 3: Inference Results from the ECG Monitoring System.

Figure 4: Graphical User Interface Displaying Real-Time ECG Signals.

6 CONCLUSIONS

The AD8232 ECG Sensor and Arduino-based ECG Graph Monitoring project is an inexpensive and simple method of continuous monitoring of cardiac health. With the use of minimum-cost hardware along with open-source software, the system allows to detect cardiac ailments in an early stage, thus helping to stem the global problem caused by cardiovascular diseases. Its application ranges from urban areas, where it allows for regular monitoring, to rural areas that do not have easy access to healthcare facilities, and it can serve as a first-line diagnostic tool. The open-source nature of the project encourages innovation, which results in further advancement in affordable healthcare technology.

In the future, wireless communication modules like Bluetooth or Wi-Fi can facilitate real-time remote monitoring with instant connectivity. In addition, integration of machine learning algorithms for autonomous ECG analysis can enhance predictive diagnostics, providing valuable insights into potential heart conditions. Integrations with healthcare experts could also be utilized to validate and calibrate the system for clinical use. With these enhancements, the project has immense potential to evolve into an advanced telehealth solution, facilitating proactive cardiac care in home and clinical settings.

REFERENCES

D. Hasan and A. Ismaeel, "Designing ECG Monitoring Healthcare System Based on Internet of Things Blynk Application", JASTT, vol.1, no. 3, pp. 106 - 111, Jul. 2020.

G. Xu," IoT-Assisted ECG Monitoring Framework with Secure Data Transmission for Health Care Applications," in IEEE Access, vol. 8, pp. 74586-74594, 2020.

G. Ramasamy, T. Singh, and X. Yuan, "Multi-Modal Semantic Segmentation Model using Encoder Based Link-Net Architecture for BraTS 2020 Challenge," Procedia Computer Science, vol. 218, pp. 732-740, 2023. doi: 10.1016/j.procs.2023.01.053.

G. Sivapalan, K. K. Nundy, S. Dev, B. Cardiff and D. John, "ANNet: A Lightweight Neural Network for ECG Anomaly Detection in IoT Edge Sensors," in IEEE Transactions on Biomedical Circuits and Systems, vol. 16, no. 1, pp. 24-35, Feb. 2022.

G. Ramasamy, P. B. Pati, T. Singh, and R. R. Nair, "A Framework for the Prediction of Diabetes Mellitus using Hyper-Parameter Tuned XGBoost Classifier," 2022 13th International Conference on Computing Communication and Networking Technologies (ICCCNT), Kharagpur, India, 2022, pp. 1-5. doi: 10.1109/ICCCNT54827.2022.9984315.

O. Ankireddypalli, A. Mouhitha, S. Gujjula and T. Somasundaram," Piezoelectric Footstep Energy Harvesting for Automated Garden Watering," 2024 Second International Conference on Networks, Multimedia and Information Technology (NMITCON), Bengaluru, India, 2024.

Pradeep, Preeja Narendran, Sreekanth Vinodini Ramesh, Maneesha. (2017). An Internet of Things (IoT) based Sustainable Water Management. 10.1109/GHTC.2017.8239320.

R. H., R. Adithi, M. Vinodhini and J. M. Oli, "2D Mapping Robot using Ultrasonic Sensor and Processing IDE," 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN), Vellore, India, 2019.

Rahman, M.O., Kashem, M.A., Nayan, A.A., Akter, M., Rabbi, F.,Ahmed, M. and Asaduzzaman, M., 2022. Internet of things (IoT) based ECG system for rural health care.

Rosario Morello, Filippo Ruffa, Ireneusz Jablonski, Laura Fabbiano,Claudio De Capua, An IoT based ECG system to diagnose cardiac pathologies for healthcare applications in smart cities, Measurement,Volume 190, 2022.

S. Thangam, M. Tejaswi and V. Supritha," Low Cost Precision Farming and Remote Monitoring Using Cloud", 2023 14th International Conference on Computing Communication and Networking Technologies ICCCNT, 2023, 2023.

Sadad, T.; Safran, M.; Khan, I.; Alfarhood, S.; Khan, R.; Ashraf, I. Efficient Classification of ECG Images Using a Lightweight CNN with Attention Module and IoT. Sensors 2023, 23, 7697.

Sangeethalakshmi K., Preethi Angel S., Preethi U., Pavithra S., Shanmuga Priya V., Patient health monitoring system using IoT, Materials Today: Proceedings, Volume 80, Part 3, 2023, Pages 2228-2231, ISSN 2214-7853,

T. S, N. D K, K. M. Shyam, M. C. K. Reddy and K. A. Sai, "IoTBased Health Monitoring System for Forbidden Patients," 2024 10th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2024.

Yeh L-R, Chen W-C, Chan H-Y, Lu N-H, Wang C-Y, Twan W-H, Du W-C, Huang Y-H, Hsu S-Y, Chen T-B. Integrating ECG Monitoring and Classification via IoT and Deep Neural Networks. Biosensors.2021