# Design and Prototype Implementation of Health Monitoring Device

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***Abstract*** — The rapid evolution of the Internet of Things (IoT) is prompting us to expand our horizons and explore the potential to connect virtually anything and everything in our world. Leveraging advancements in technology and sensor capabilities, various sectors are embracing this new paradigm to enhance the quality of life. With a concerning number of lives lost daily due to inadequate and untimely medical assistance, there is a pressing need for innovative solutions. IoT technology has emerged as a powerful tool in addressing this challenge by interconnecting medical resources and delivering reliable and efficient patient care. In this endeavor, we present a healthcare project aimed at addressing the current healthcare challenges facing society. Our project focuses on developing a system for continuous patient monitoring in hospital settings or within the comfort of their homes. Utilizing NodeMCU, we have devised a health observation system capable of monitoring both ECG and body oxygen levels. The primary objective of our project is to create a compact, lightweight, cost-effective. By continuously monitoring patients, our solution aims to provide timely intervention and overcome existing healthcare challenges.

## 1. Introduction

The advancements in semiconductor technology have revolutionized healthcare by enabling the development of Remote Health Monitoring Systems, which extend the scope of traditional hospital setups. These systems facilitate the monitoring of a patient's vital signs remotely, overcoming the limitations of older hospital-based detection systems that relied on large, power-intensive circuitry. Modern sensors and microcontrollers are now smaller, faster, and more energy-efficient, making these systems both practical and cost-effective. Despite the availability of several remote health monitoring solutions in recent years, challenges persist, particularly in **developing countries**. The high cost of subscription-based service models connectivity often restrict access. Our design includes a prototype to cater to these needs which measure important body parameters for timely detection. The increasing demand for accessible, affordable, and efficient healthcare services**,** especially in areas with limited healthcare facilities, highlights the need for innovative solutions. A key focus is enabling early detection of health issues and providing individuals with easy access to their health data, ultimately addressing systemic challenges in the healthcare sector.

## 2. Literature Review

The authors in [1] proposed a cost-effective and robust IoT-based health monitoring system designed to address critical challenges in remote healthcare monitoring, particularly for patients in rural or underserved areas. The system leverages 6LoWPAN (IPv6 over Low-Power Wireless Personal Area Network) to ensure scalable and low-power communication, integrating sensors that measure parameters such as heart rate, body temperature, blood pressure, and ECG signals. The collected data is processed locally and transmitted wirelessly to a central monitoring station, enabling real-time monitoring. Alerts and notifications are sent to healthcare professionals or caregivers when critical thresholds are exceeded, allowing prompt intervention in emergencies. Although the system emphasizes scalability and user-friendliness, the study highlights energy consumption as a major drawback due to the computational and data transmission requirements, limiting its applicability in areas with restricted power access. Despite this, the system shows great promise for real-time remote health monitoring.

The authors in [2] proposed a cost-effective and robust IoT-based health monitoring system designed to address critical challenges in remote healthcare monitoring, particularly for patients in rural or underserved areas. The system leverages 6LoWPAN (IPv6 over Low-Power Wireless Personal Area Network) to ensure scalable and low-power communication, integrating sensors that measure parameters such as heart rate, body temperature, blood pressure, and ECG signals. The collected data is processed locally and transmitted wirelessly to a central monitoring station, enabling real-time monitoring. Alerts and notifications are sent to healthcare professionals or caregivers when critical thresholds are exceeded, allowing prompt intervention in emergencies. Although the system emphasizes scalability and user-friendliness, the study highlights energy consumption as a major drawback due to the computational and data transmission requirements, limiting its applicability in areas with restricted power access. Despite this, the system shows great promise for real-time remote health monitoring. proposed a cost-effective and robust IoT-based health monitoring system designed to address critical challenges in remote healthcare monitoring, particularly for patients in rural or underserved areas. The system leverages 6LoWPAN (IPv6 over Low-Power Wireless Personal Area Network) to ensure scalable and low-power communication, integrating sensors that measure parameters such as heart rate, body temperature, blood pressure, and ECG signals. The collected data is processed locally and transmitted wirelessly to a central monitoring station, enabling real-time monitoring. Alerts and notifications are sent to healthcare professionals or caregivers when critical thresholds are exceeded, allowing prompt intervention in emergencies. Although the system emphasizes scalability and user-friendliness, the study highlights energy consumption as a major drawback due to the computational and data transmission requirements, limiting its applicability in areas with restricted power access. Despite this, the system shows great promise for real-time remote health monitoring.

The authors in [3] proposed a real-time wireless health monitoring system that integrates mobile devices for continuous health tracking. The system employs wireless sensor technology to measure vital parameters such as heart rate, body temperature, and blood pressure. These sensors are connected to a mobile device, which acts as a processing and communication hub. The collected data is transmitted to healthcare providers or stored in a centralized cloud-based system for analysis and long-term record maintenance. The system provides real-time alerts to medical personnel when abnormalities are detected, enabling immediate intervention. The study emphasizes the portability and user-friendliness of the system, making it suitable for patients in remote or underserved areas. However, challenges such as energy consumption, data security, and the reliability of wireless communication are highlighted as areas for further improvement. This system showcases the potential of mobile devices in delivering cost-effective and efficient healthcare solutions for real-time monitoring.

The authors in [4] proposed a wireless fetal heartbeat monitoring system utilizing ZigBee and the IEEE 802.15.4 standard to address the challenges in continuous fetal monitoring. The system uses wireless sensor technology to measure fetal heartbeat data and transmit it wirelessly to a monitoring unit. ZigBee technology ensures low-power consumption and reliable communication over short distances, making the system efficient and suitable for use in hospital and home environments. The collected data is processed in real-time, allowing for the early detection of fetal abnormalities and enabling timely medical intervention. The study highlights the scalability and portability of the system, which can operate efficiently in environments with limited power resources. While the system demonstrates promise for enhancing prenatal care, the authors identify potential challenges in maintaining data reliability and minimizing interference in wireless communication, suggesting the need for further research to improve performance and expand functionality.

The authors in [5] suggested a smart device integrated with an Android application to monitor and alert users about their health conditions using the Internet of Things (IoT). The system combines various sensors to measure vital health parameters such as heart rate, body temperature, and blood pressure. The data is wirelessly transmitted to an Android device, which serves as a user-friendly interface for real-time monitoring. Alerts are generated and sent via notifications or SMS to caregivers or medical professionals when critical thresholds are breached, enabling prompt medical intervention. The system is cost-effective and portable, making it suitable for individual users and healthcare facilities. While emphasizing the importance of IoT in healthcare, the authors highlight challenges like power consumption, data security, and reliability in wireless data transmission, suggesting the need for improvements in these areas. This study demonstrates the potential of IoT-based health monitoring systems in enhancing personalized healthcare.

## 2.1 Similar Industrial Products

The comparison highlights various features and applications of remote health monitoring systems, showcasing their strengths and limitations in different scenarios. Philips HealthSuite Monitoring System integrates wearable sensors, cloud storage, and AI-driven analytics to provide continuous patient monitoring and predictive diagnostics, making it suitable for hospitals and clinics. However, its high cost and the technical expertise required for operation render it less suitable for small-scale deployments or individual users. Similarly, Tytocare Remote Health Examination Kit offers an all-in-one solution with tools like a stethoscope, otoscope, and thermometer, designed for home use and telemedicine applications. While user-friendly, its limited sensor capabilities and reliance on high-speed internet restrict its use in rural or underserved areas.

iHealth Wireless Vital Monitoring System provides affordable wireless devices for monitoring parameters like blood pressure, glucose levels, and heart rate, offering an intuitive mobile app for real-time tracking. Despite its appeal for personal use, it lacks scalability and does not address the needs of multi-patient monitoring or more complex healthcare setups. Medtronic Remote Patient Monitoring System, on the other hand, targets chronic disease management and hospital settings with advanced devices for monitoring ECG, oxygen levels, and other critical

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parameters. However, its high cost and dependence on specialized hardware limit accessibility for smaller healthcare facilities or individual users. Lastly, HealthPatch by VitalConnect offers a lightweight, wearable biosensor for ambulatory and post-operative care, capable of monitoring vital signs like heart rate and respiratory rate. Despite its potential, short battery life and reliance on continuous wireless connectivity are significant challenges.

Our project aims to address these limitations by providing a cost-effective, scalable, and energy-efficient IoT-based remote health monitoring prototype system. Unlike existing high-end systems, our design emphasizes accessibility and affordability, particularly for rural and underserved regions. Future advancements will focus on integrating renewable energy solutions like solar power, utilizing AI-driven analytics for personalized monitoring, and leveraging edge computing for low-latency, secure data processing. By prioritizing modularity and energy efficiency, our system strives to redefine the landscape of remote healthcare monitoring, ensuring it meets the diverse needs of individual users and healthcare facilities alike.

## 3. Development of IoT system using different sensors

The development of an IoT-based healthcare system involves integrating various sensors to monitor, collect, transmit, and analyze patient health data in real time. These systems are designed to provide timely insights into a patient's condition, enabling early detection of abnormalities, remote monitoring, and improved access to healthcare services. In the context of healthcare, sensors play a crucial role in capturing physiological parameters such as heart rate, blood pressure, body temperature, oxygen saturation (SpO2), and ECG signals. These sensors are interfaced with a microcontroller, such as an ESP8266, which processes the collected data locally. For wireless communication, protocols like Wi-Fi, Bluetooth, or ZigBee are used to transmit the data to a remote server or cloud-based platform, ensuring seamless connectivity between the patient and healthcare providers. The processed data is then visualized on user-friendly platforms such as mobile apps or web dashboards, allowing caregivers and medical professionals to monitor patient health in real time. Alerts and notifications are triggered if the data indicates critical conditions, facilitating prompt medical intervention. The system also focuses on addressing challenges like energy efficiency and scalability. Techniques such as power optimization and modular sensor designs are implemented to ensure prolonged operation in resource-constrained environments, such as rural areas. Data security is another critical aspect, with encryption protocols and secure authentication mechanisms protecting sensitive patient information. By leveraging IoT technology and diverse sensors, the healthcare system aims to bridge the gap between patients and medical care, making it accessible, cost-effective, and efficient, especially for underserved populations.

## 4. Hardware Illustration of the proposed system

Fig.1 represents the architecture diagram. With the help of this architecture, every sensor is connected with node MCU pins. The power supply is given to the node MCU by USB which is connected with PC.

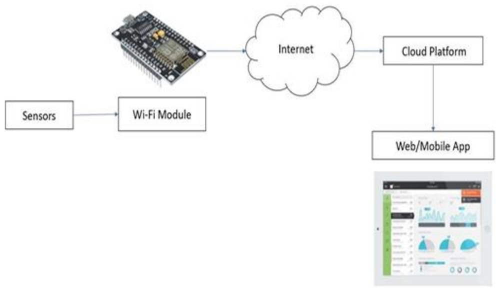



Fig.1. The proposed model architecture of the IoT system

Table 1.

| Sensor 1 | Sensor 2 | Sensor 3 |
|---|---|---|
| NodeMCU ESP 8266 (Board combines 8266 with WiFi) | MAX30102 (Pulse Oximeter Sensor) | AD8232 (ECG Sensor) |

Sensors integrated in the system

## 5. Circuit Diagram

The circuit diagram of our proposed system is given below. The diagram represents the connection of the sensor and how the connection will be done.

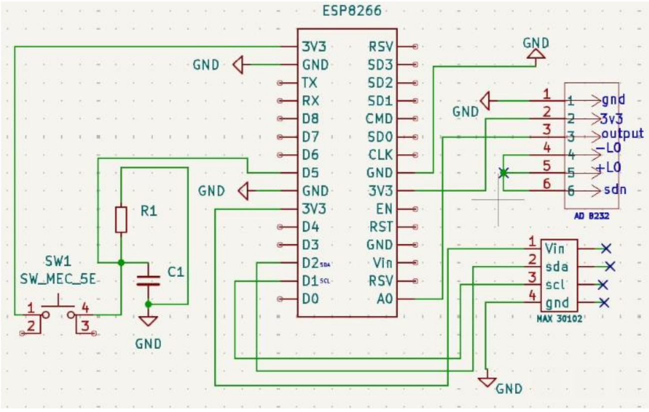


Fig.2. Circuit diagram of the proposed Prototype

## 6. Block Diagram of the proposed model

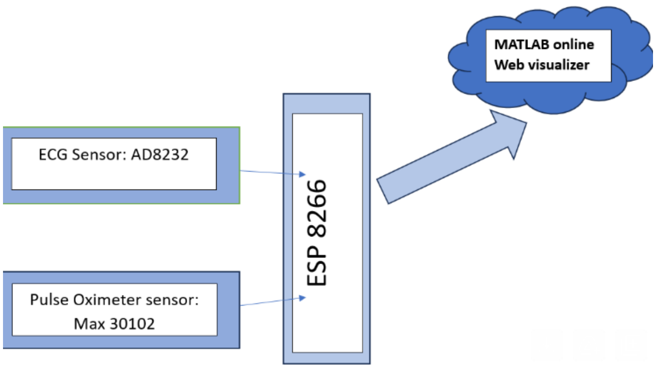


Fig.3. Block Diagram of the proposed model

## 7. Working Process

The project focuses on developing an IoT-based remote health monitoring system aimed at real-time tracking of vital health parameters, including ECG, oxygen saturation (SpO2). The system is built around the ESP8266 NodeMCU microcontroller, which serves as the central unit for sensor integration, data processing, and wireless transmission. Key components include the MAX30102 sensor for SpO2 monitoring and the AD8232 sensor for capturing ECG signals using Photoplethysmography (PPG).

The workflow begins with data acquisition from the sensors, which is processed by the NodeMCU. The processed data is transmitted wirelessly to a Firebase backend, which acts as a secure and efficient repository for storing and managing the collected data. Firebase enables real-time synchronization, ensuring seamless accessibility for monitoring and analysis purposes. Data visualization and further analysis are carried out using MATLAB, providing meaningful insights into patient health.

Currently, the system is in its prototyping phase and utilizes breadboards for circuit assembly. The design of a printed circuit board (PCB) is planned for the next phase, which will ensure a compact, robust, and deployable solution. The system is designed for low power consumption and supports continuous health monitoring, data logging, and scalability to incorporate additional sensors in the future. This project demonstrates significant progress toward developing accessible, cost-effective, and data-driven healthcare solutions.

Fig.4. Working on Platform (MATLAB).

Fig.5. Peak Values

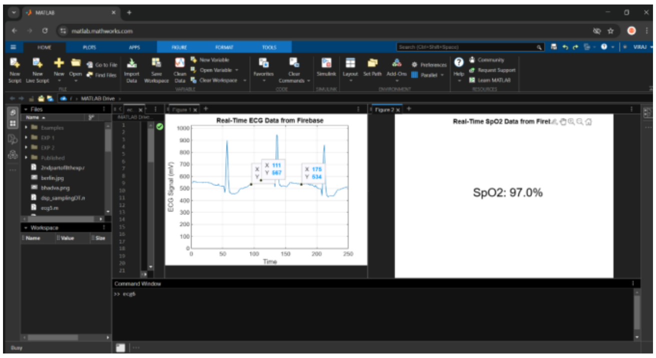
## 8. Results and Discussion

The proposed IoT-based health monitoring system successfully demonstrated its capability to measure and transmit key health parameters, specifically ECG signals and oxygen saturation (SpO2), in real time. Using the ESP8266 NodeMCU microcontroller, the system integrated sensors efficiently and transmitted data to the Firebase backend for secure storage and management. The collected data was further visualized and analyzed using MATLAB, providing a clear representation of the measured parameters and enabling insightful analysis.

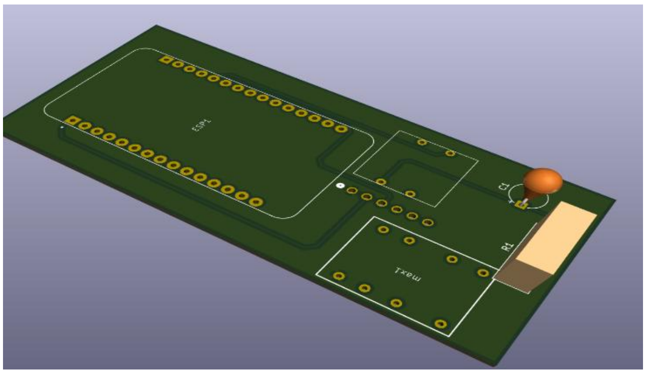
The AD8232 sensor provided accurate single-lead ECG waveforms, which were free from significant noise under controlled conditions. However, precise electrode placement was critical for obtaining reliable readings. The MAX30102 sensor effectively measured SpO2 levels but required stable conditions to avoid inaccuracies caused by ambient light or inconsistent sensor placement. Data transmission via Firebase was seamless, enabling real-time synchronization and ensuring that the system could handle continuous monitoring without interruptions.

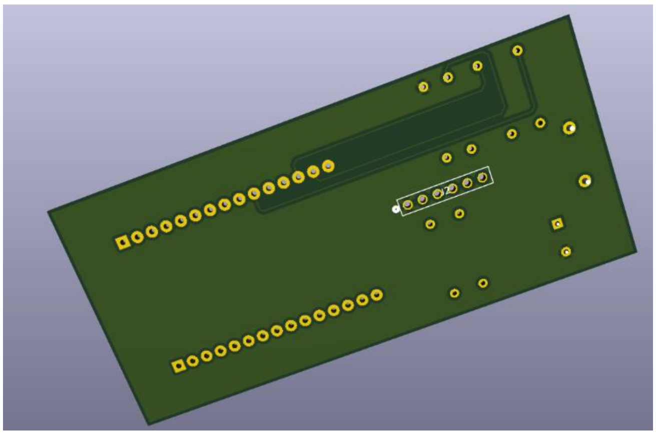
The breadboard-based prototype served as an effective proof of concept, although its bulkiness and lack of robustness highlight the need for a compact printed circuit board (PCB) in future iterations. Challenges included occasional inaccuracies in SpO2 readings due to environmental factors and the need for user-friendly sensor placement mechanisms to improve usability. Despite these limitations, the system proved to be a cost-effective and efficient solution for remote health monitoring.

This project underscores the potential of IoT technology to provide accessible and scalable healthcare solutions. Future improvements could involve the addition of more health parameters, integration of advanced data analytics for predictive insights, and the development of a robust PCB for practical deployment. The results demonstrate significant progress toward building a reliable, real-time health monitoring system with remote data accessibility




## 9. Proposed PCB Model





## 10. Conclusion

The development of the IoT-based health monitoring system successfully achieved its objectives of measuring and transmitting critical health parameters, specifically ECG signals and SpO2 levels, in real time. By utilizing the ESP8266 NodeMCU microcontroller, the system efficiently integrated sensors and facilitated seamless data transmission to a Firebase backend. The visualization and analysis of data through MATLAB further enhanced the system's capability to provide meaningful insights into patient health.

The project demonstrated the feasibility of creating a low-cost, accessible solution for remote health monitoring. While the prototype effectively validated the concept, challenges such as occasional inaccuracies in SpO2 measurements and the reliance on precise electrode placement for ECG readings highlighted areas for improvement.

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