



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** IX **Month of publication:** September 2026

DOI: <https://doi.org/10.22214/ijraset.2026.84911>

www.ijraset.com

Call: ☎ 08813907089

E-mail ID: ijraset@gmail.com

Design and Implementation of a Fail-Safe IoT-Based Real-Time Health Monitoring System for Comatose Patients Using ESP32

Leena Chaudhari¹, Swaraj Kharmale², Harsh Kapse³, Sameeksha Rokade⁴

Department of Electronics and Telecommunication Engineering, Bharati Vidyapeeth's College of Engineering, Lavale, Pune, India

Abstract: Continuous observation of vital parameters is indispensable for comatose patients, who are unable to notify caregivers of any abnormality. Standard intensive care unit configurations are characterised by accuracy, yet they remain expensive and immobile, and cannot easily be transported. This work presents a cost-efficient, IoT-enabled system that provides real-time patient monitoring using an ESP32 microcontroller and a set of biomedical sensors. The monitor measures heart rate and blood oxygen saturation with a MAX30102 sensor, body temperature with a DS18B20 sensor, and performs electrocardiography and electroencephalography monitoring with an AD8232 amplifier and an AD620 analog amplifier, respectively. In addition, the proposed prototype includes a power management subsystem that switches automatically from mains supply to a backup battery source. The monitor operates over two communication networks: Wi-Fi, which connects the device to the Blynk IoT cloud application, and GSM, which delivers short message alerts through a SIM800L module. This arrangement enables live monitoring and notification of abnormalities, and early testing showed high stability and efficiency of the prototype in terms of data acquisition, alert delivery and visualisation on an OLED interface. The proposed system offers a low-cost, portable and scalable solution suitable for both hospital-based and home-based monitoring of comatose patients.

Keywords: IoT healthcare, coma monitoring, ESP32, biomedical sensors, GSM alerts, power reliability, real-time monitoring.

I. INTRODUCTION

Since comatose patients do not wake up and cannot show discomfort, regular monitoring of their vital parameters throughout the day is important in order to prevent conditions such as cardiac arrest, hypoxaemia, hyperthermia or neurological dysfunction. Standard intensive care unit monitoring systems provide accurate results, but they are expensive and heavy, and they require permanent supervision. Such characteristics complicate the use of intensive care devices at home. Thanks to the development of Internet of Things technologies, affordable health monitoring devices with a variety of sensors are now available for continuous measurement of health parameters, with remote access through cloud services. However, modern health monitoring devices suffer from being too dependent on a single channel of communication and a single power source. In an emergency, such dependencies may prove dangerous and even fatal, since a coma implies a critical condition in which any delay in diagnosis is unacceptable. For this purpose, the present work proposes a reliable real-time health monitoring device based on an ESP32 microcontroller, which combines data received from several sensors. The developed solution provides power reliability through power redundancy and uses two types of communication network, namely Wi-Fi and GSM.

II. LITERATURE REVIEW

A. IoT-Based Healthcare Monitoring Systems

Abdulmalek et al. highlight the role of the Internet of Things in healthcare, focusing on systems that use cloud platforms and biomedical sensors for real-time monitoring [1]. These solutions emphasise wearable devices and low-power controllers for remote supervision. However, they mainly target general health monitoring and lack support for the continuous, multi-parameter monitoring required for comatose patients.

B. IoMT Architectures for Real-Time Monitoring

Almarzouki et al. propose an Internet of Medical Things wearable system capable of transmitting electrocardiogram, SpO₂ and motion data in real time [2]. While effective for remote monitoring, the system depends on stable internet connectivity and lacks electroencephalogram integration and offline alert mechanisms. These limitations reduce its suitability for coma monitoring, which requires reliable communication and comprehensive physiological sensing [5], [6].

III. PROBLEM STATEMENT

Patients in a coma are incapable of expressing their distress; it therefore becomes imperative to monitor their vital signs very closely, because even minor alterations in heartbeat, oxygenation, temperature or electrical impulses in the brain can indicate severe problems requiring urgent measures.

Although intensive care unit monitors are accurate, they are expensive and immobile and necessitate regular attention. Internet of Things based devices are less intrusive, but they generally lack integration of multiple parameters, rely on a single medium of communication, lack a power backup and have poor real-time alerting capabilities.

Thus, performing crucial functions such as coma surveillance becomes rather challenging, because of the necessity for uninterrupted operation and consistent communication. This problem calls for an inexpensive, mobile and reliable device that is able to monitor numerous parameters simultaneously, function consistently and maintain uninterrupted communication. This task is fulfilled by an ESP32 microcontroller with an integrated array of sensors, two media of communication, namely Wi-Fi and GSM, and a power-switching mechanism.

IV. PROPOSED METHODOLOGY

A. System Overview

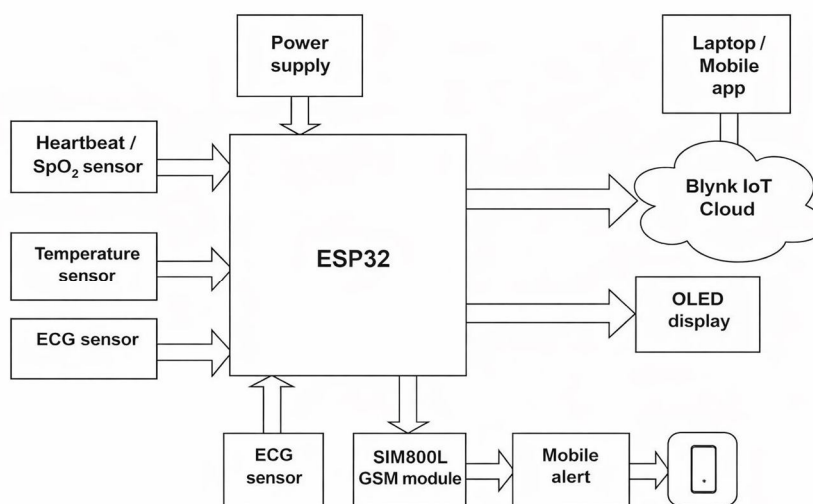


Fig. 1 System overview of the proposed fail-safe IoT-based health monitoring system

The system represents a complex IoT-based health monitoring device built from four subsystems: the sensor block, the ESP32 microcontroller, the communication subsystem and the power management unit. The first block contains the MAX30102 sensor for heart rate and SpO₂, the DS18B20 sensor for temperature, the AD8232 module for electrocardiogram signals and the electroencephalogram signal path based on an AD620 circuit. The devices are connected to the ESP32 processor using I²C, ADC and UART interfaces. Data acquisition is implemented by constantly sampling the sensors at appropriate rates to allow real-time monitoring of physiological parameters. Noise reduction is achieved using simple signal processing techniques, such as moving average and low-pass filters.

The processed results are then compared with medical threshold values in order to detect abnormalities. Once a parameter exceeds the safe level, the condition is regarded as critical and warnings are triggered, either locally or through a remote connection. Two communication methods are used in the design: Wi-Fi, through the Blynk IoT cloud platform, and GSM, through a SIM800L module, for transmitting short message notifications.

Another important feature of this system is the way in which power management has been carried out in order to ensure that the system operates without interruption. The power management subsystem uses a two-cell lithium-ion battery source together with a TP5100 charger and an MP1584 voltage regulator. These automatically alternate between the mains supply and the battery, which ensures constant operation regardless of any power failure.

B. System Workflow

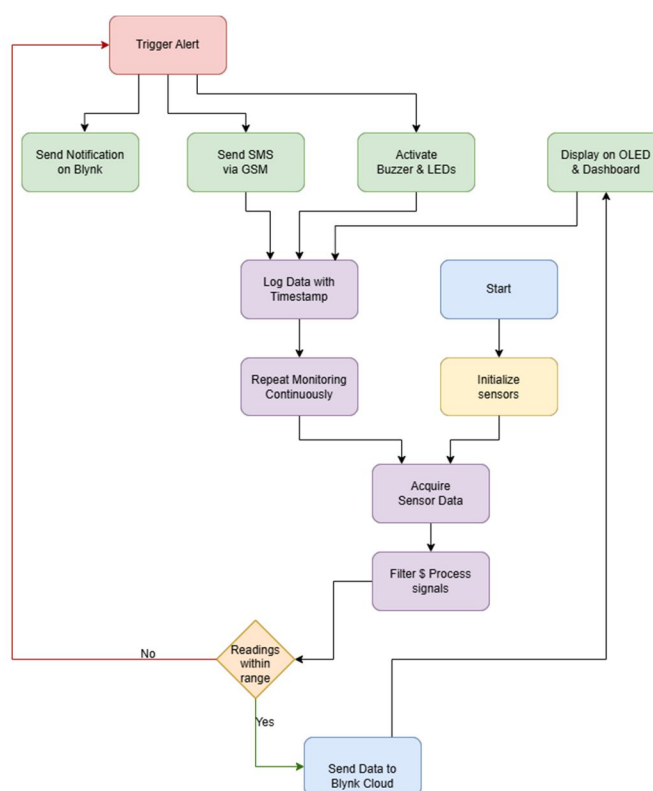


Fig. 2 System flow of the monitoring and alerting process

The overall system operates in a continuous loop, as follows.

- 1) Initialise the sensors and communication modules.
- 2) Acquire physiological data from the sensors.
- 3) Apply filtering and preprocessing.
- 4) Compare the values with the threshold limits.
- 5) If the readings are normal, send the data to the cloud dashboard.
- 6) If the readings are abnormal, trigger the alerts over Wi-Fi and GSM and sound the buzzer.
- 7) Log the data with a timestamp obtained from the real-time clock.
- 8) Repeat the process continuously.

V. IMPLEMENTATION AND EXPERIMENTAL SETUP

A. Implementation

For the hardware prototype, the following components were integrated: biomedical sensors, the ESP32 processor, communication equipment and a power management module. The sensor set consists of a MAX30102 sensor for heart rate and SpO₂, a DS18B20 sensor for temperature measurement, an AD8232 module for measuring the electrocardiogram and an AD620 circuit for acquiring electroencephalogram signals. To provide communication, display and timekeeping capabilities, a SIM800L GSM modem, an SSD1306 OLED display and a DS3231 real-time clock were used.

The project was developed using the Arduino integrated development environment, making use of the appropriate libraries for the sensors and communication modules. The firmware operates in a loop, constantly collecting data from the sensors, performing calculations and sending information to the OLED screen. Alerts are raised by the GSM modem, which sends short messages using AT commands, while the ESP32 manages all operations in real time.

Power supply management is crucial to the project in order to ensure proper operation. A two-cell lithium-ion battery is used to provide energy to the whole system, together with a TP5100 charger and an MP1584 step-down voltage regulator. Switching between the primary supply and the backup battery is carried out automatically.

During the testing procedure, the system operated for thirty to forty minutes without any interruption caused by switching the power source. All tests produced the same conclusions, namely steady voltage levels, reliable operation of the ESP32 and a trouble-free OLED display.

B. Summary of Implementation

These observations demonstrate that the key components, namely the supply, the microcontroller and the display, function properly. This provides assurance of the sound foundation on which the whole system has been built. The next stage is the integration of the remaining biomedical sensors and communication devices into the system.

VI. RESULTS AND DISCUSSION

Experiments were performed on the system in order to determine its efficiency in terms of the accuracy of the sensors used, their response time, the data transmission between nodes and the availability of power. A variety of physiological parameters, including heart rate, SpO₂, temperature and electrocardiogram waveforms, were detected and visualised in real time.

A. Sensor Output and Measurement Results

The system successfully interfaced with the biomedical sensors and produced stable outputs under normal conditions.

- 1) *Heart Rate and SpO₂ (MAX30102)*: Heart rate readings were observed in the range of 70 to 95 bpm under resting conditions, and SpO₂ values were measured between 96 per cent and 99 per cent. The readings remained stable when the finger was properly placed on the sensor.

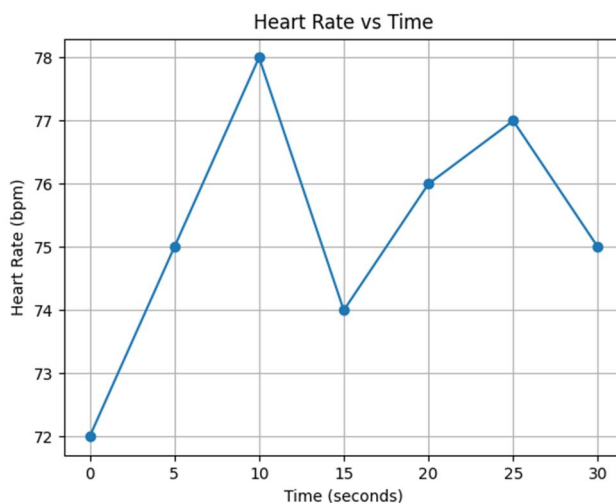


Fig. 3 Heart rate measured over time

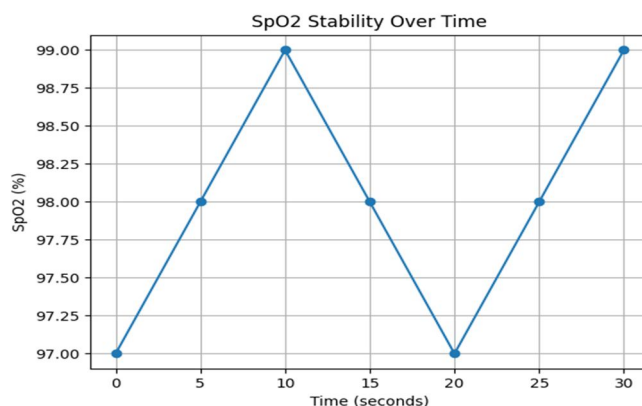


Fig. 4 SpO₂ concentration measured over time

- 2) *Temperature Measurement (DS18B20)*: Temperature readings ranged between 36 °C and 37 °C, which is consistent with normal body temperature. The sensor provided a stable digital output with minimal fluctuation.

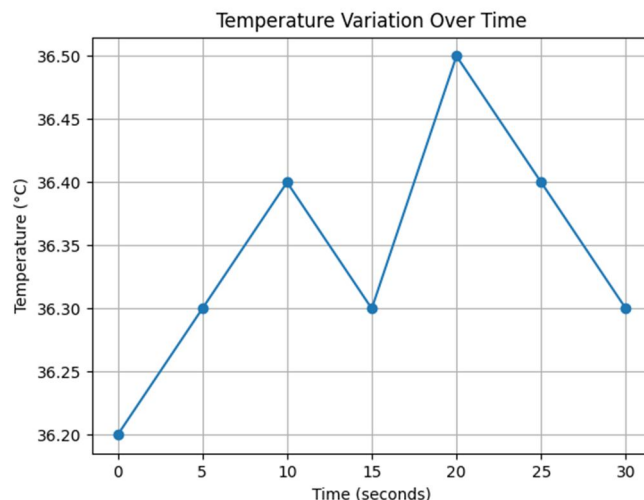


Fig. 5 Temperature variation over time

- 3) *ECG Signal Acquisition (AD8232)*: Clear electrocardiogram waveforms were observed, including recognisable peaks corresponding to heart activity. Minor noise was present because of movement, which is expected in real-time acquisition.

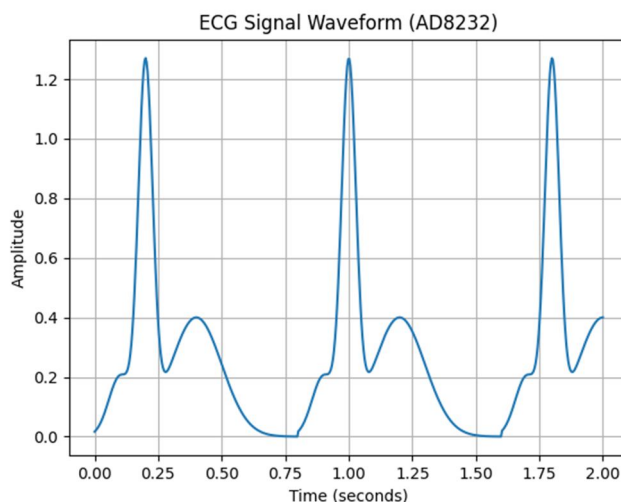


Fig. 6 Electrocardiogram signal waveform acquired with the AD8232 module

TABLE I
SUMMARY OF SENSOR READINGS

Parameter	Expected Range	Observed Range	Remarks
Heart rate (bpm)	60–100	70–95	Stable readings
SpO ₂ (%)	95–100	96–99	Accurate
Temperature (°C)	36–37.5	36–37	Minimal variation
ECG signal	Normal waveform	Clear waveform	Slight noise present

B. GSM Alert System Performance

The short message alerts sent through the SIM800L GSM module were delivered successfully, taking an average time of three to five seconds. The system was also able to operate successfully without Wi-Fi, which confirms that the dual communication approach works effectively to ensure the delivery of alerts.

C. Power System Performance

The power source changes automatically from the switched-mode power supply to the battery supply without any interruption, through the use of 1N5822 diodes. This arrangement was faster and more reliable than relay switching and is therefore recommended for critical applications.

D. Real-Time Performance Using FreeRTOS

FreeRTOS ensures that several processes, such as reading sensor data, updating the display and communicating with external devices, are performed simultaneously and without any delay.

E. Overall System Performance

The system is capable of providing continuous data acquisition, real-time processing and reliable GSM notification, together with fault tolerance arising from the two communication channels and the power redundancy.

F. Discussion

The results of the tests indicate a reliable system for monitoring multiple vital signs, which performs well at a lower cost than conventional systems. FreeRTOS allows several tasks to be managed concurrently, while the power circuit ensures smooth operation through the diode-based switching mechanism. In the case of poor connectivity, the GSM module provides a backup channel. Minor limitations remain, such as electrocardiogram noise and the positioning of the sensors, which could be addressed during future development stages.

VII. CONCLUSIONS

This paper has described the development of an Internet of Things based health monitoring system for comatose patients, using an ESP32 microcontroller and several biomedical sensors. The system provides continuous monitoring of heartbeat, SpO₂, body temperature and the electrocardiogram, and it has been designed with reliable power management based on automatic switching through diodes.

The use of FreeRTOS allows multitasking to be implemented so that data are processed in real time. Alerts have been configured over both Wi-Fi and GSM networks, so that the user can receive notifications in any scenario. The experimental results show reliable operation of the developed system. Overall, the proposed monitoring system is compact and cost-effective and can be used both in hospitals and at home.

VIII. FUTURE WORK

The system has the potential for greater performance and a wider scope of application in the future. Specifically, incorporating additional parameters such as non-invasive blood pressure measurement, respiration rate estimation and blood glucose level monitoring can provide a more comprehensive analysis of the health status of the patient [3], [4], [7], [8].

Furthermore, making the device wearable rather than stationary will make it comfortable enough for continuous use while maintaining mobility. In terms of signal processing, methods such as Kalman filtering or adaptive noise cancellation can be used to eliminate motion artefacts in electrocardiogram and electroencephalogram data, thus enhancing their reliability.

Finally, developing a dedicated application for portable devices will help users to visualise their data more efficiently and to manage alerts more effectively.

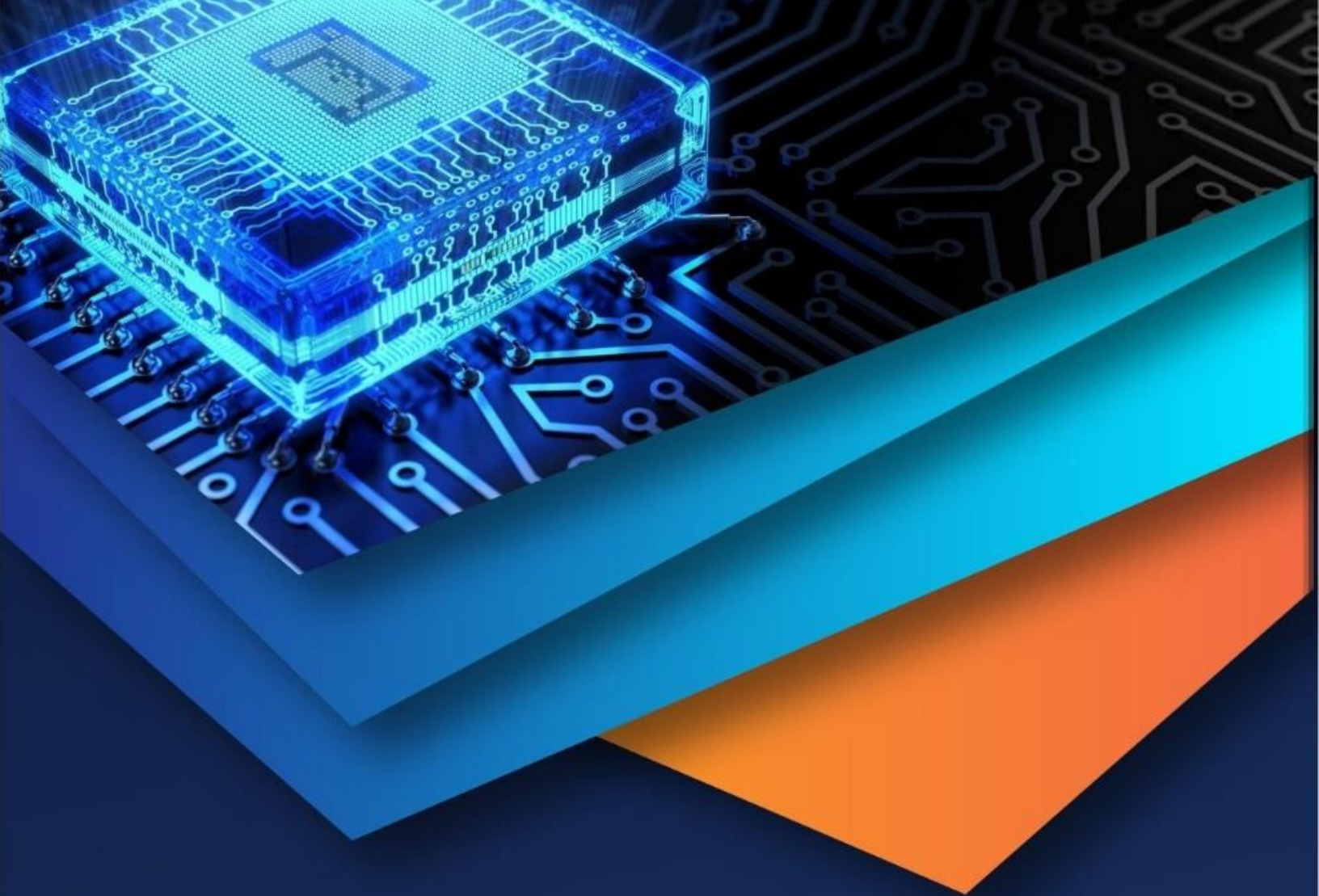
IX. ACKNOWLEDGMENT

The authors wish to thank the Department of Electronics and Telecommunication Engineering, Bharati Vidyapeeth's College of Engineering, Lavale, Pune, for providing the laboratory facilities and guidance required for the development and testing of this prototype.



REFERENCES

- [1] S. Abdulmalek, A. Alharthi, Z. Alshammari, et al., "IoT-based healthcare monitoring system towards improving quality of life: a review," *Sensors*, vol. 22, no. 15, pp. 1–19, 2022.
- [2] H. Z. Almarzouki, M. Alsharekh, M. E. Ahmed, et al., "An Internet of Medical Things (IoMT)-based model for real-time monitoring using wearable devices," *IEEE Access*, vol. 9, pp. 167777–167788, 2021.
- [3] Y. H. Li, C. T. Lin, and S. C. Lee, "Real-time cuffless continuous blood pressure estimation using ECG and PPG," *IEEE Journal of Biomedical and Health Informatics*, vol. 24, no. 6, pp. 1901–1910, 2020.
- [4] X. Ding, B. P. Yan, Y.-T. Zhang, et al., "Pulse transit time-based continuous cuffless blood pressure measurement: extension and evaluation," *Scientific Reports*, vol. 7, no. 1, p. 11507, 2017.
- [5] R. Uddin, S. Hasan, and M. Rahman, "Real-time remote patient monitoring: a review," *Applied Sciences*, vol. 14, no. 2, pp. 123–138, 2024.
- [6] H. L. Yimer, F. Cunico, and A. Giorgi, "IoT-based coma patient monitoring system," *arXiv preprint arXiv:2402.01034*, 2024. [Online]. Available: <https://arxiv.org/abs/2402.01034>
- [7] M. S. Tanveer and M. K. Hasan, "Cuffless blood pressure estimation from ECG and PPG using waveform-based ANN-LSTM network," *IEEE Transactions on Instrumentation and Measurement*, vol. 67, no. 9, pp. 2161–2171, 2018.
- [8] M. M. R. K. Mamun, R. Hossain, and A. Khatun, "Cuffless blood pressure measurement using linear and non-linear methods," *Sensors*, vol. 22, no. 9, p. 3342, 2022.
- [9] S. Patel, P. Rao, and N. Kumar, "IoT-based smart ICU patient monitoring system using Wi-Fi and GSM," [publication details to be completed].



10.22214/IJRASET



45.98



IMPACT FACTOR:
7.129



IMPACT FACTOR:
7.429



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24*7 Support on Whatsapp)