iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** V **Month of publication:** May 2025

DOI: https://doi.org/10.22214/ijraset.2025.71663

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

IoT Based Patient Health Monitoring System Using ESP32 and Blynk App

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Abstract: With the continuous evolution of Internet of Things (IoT) technologies, healthcare systems are experiencing a shift toward smart, real-time patient monitoring solutions. This paper introduces a cost-effective and portable health monitoring system based on the ESP32 microcontroller, integrated with the Blynk platform for remote access. The system is designed to track essential health metrics such as heart rate (monitored using a pulse sensor), body temperature (measured by LM35 or DS18B20 sensors), and blood oxygen saturation (detected via an SpO_2 sensor). All collected data is wirelessly sent to the cloud using Wi-Fi, allowing healthcare professionals to monitor patient health remotely through the Blynk app.

The application interface offers real-time data visualization and sends immediate alerts when abnormal values are detected. Due to its scalability and ease of use, the system is suitable for both home care and clinical use. Testing confirms the reliability of sensor outputs and stable cloud connectivity. This approach not only reduces the need for manual health checks but also ensures continuous observation, improving care for elderly and chronically ill patients.

Keywords: Internet of Things, ESP32, Remote Health Tracking, Real-Time Monitoring, Blynk Application, SpO_2 Sensor, Temperature Monitoring, Pulse Sensor.

I. INTRODUCTION

A. IoT-Based Health Monitoring System Overview

The healthcare sector is experiencing a transformative shift with the integration of Internet of Things (IoT) technologies. Traditional patient monitoring methods often demand constant physical presence and manual observation, which can delay critical responses and elevate medical expenses. To overcome these limitations, IoT-enabled health monitoring solutions have gained prominence by offering continuous, remote tracking of vital physiological data.

This paper presents an efficient and scalable health monitoring system built using the ESP32 microcontroller and the Blynk IoT platform. The system incorporates various biomedical sensors to measure essential health parameters, including:

- Pulse sensor – for heart rate measurement
- Temperature sensor (LM35 or DS18B20) – for detecting body temperature
- SpO_2 sensor – for monitoring blood oxygen saturation levels

Collected data is wirelessly transmitted to the cloud via Wi-Fi, enabling healthcare providers to access real-time health updates through the Blynk mobile application. The application features a user-friendly interface that delivers instant alerts in response to abnormal values, facilitating timely medical intervention.

This solution is especially advantageous for:

✔Elderly individuals requiring continuous monitoring
✔ Patients with chronic conditions such as cardiovascular diseases or diabetes
✔ Post-surgical patients to reduce the risk of hospital readmission
✔ Individuals in remote or medically underserved regions

B. Key benefits of the system include

- Continuous, real-time monitoring for early detection of health anomalies
- Reduced medical expenses by limiting unnecessary hospital visits
- Enhanced accessibility through cloud-based remote access
- Intuitive, mobile-friendly interface via the Blynk platform

II. PROBLEM STATEMENT

A. *Challenges in Traditional Healthcare Monitoring Systems*

In conventional healthcare setups, individuals suffering from chronic conditions, elderly patients, and those recovering from surgery often need constant tracking of vital health parameters like heart rate, body temperature, and oxygen saturation (SpO_2). However, traditional approaches encounter several obstacles:

1. Constraints of Manual Monitoring
   - Limited Continuous Observation: Medical staff cannot provide round-the-clock supervision for every patient, which may result in delayed reactions during emergencies.
   - Costly and Inconvenient Hospital Visits: Regular hospital appointments are not only expensive but also particularly burdensome for patients in rural areas or those with mobility limitations.

2. Absence of Immediate Alert Systems
   - Undetected Health Fluctuations: Sudden and severe health changes, such as spikes in pulse or temperature, may go unnoticed without real-time monitoring.
   - No Automated Emergency Warnings: Many systems do not include features that instantly notify medical personnel or caregivers of critical health events.

3. High Expenses Associated with Medical Devices
   - Unaffordable Advanced Equipment: High-quality health monitoring devices are often priced beyond the reach of most individuals and smaller healthcare facilities.
   - Reliance on Manual Data Entry: In several under-resourced regions, hospitals still depend on handwritten records, increasing the risk of data errors and delayed diagnoses.

4. Inadequate Remote Health Monitoring Options
   - Limited Integration and High Costs: Many IoT health monitoring solutions either do not support cloud connectivity or require costly proprietary systems, reducing their practicality.
   - Healthcare Gaps in Remote Areas: Individuals in geographically isolated regions face barriers such as poor medical infrastructure and lack of access to specialists.

III. BASICS AND BACKGROUND

A. *Internet of Things (IoT) in Healthcare*

The Internet of Things (IoT) describes a network of smart devices connected via the internet that gather, transmit, and process data. In the medical field, IoT technology enables **Remote Patient Monitoring (RPM)**, minimizing the necessity for frequent hospital visits. Major advantages include:

- Instant data sharing for quick medical responses.
- Automated notifications in case of abnormal health metrics.
- More affordable compared to traditional health monitoring setups.

B. *ESP32 Microcontroller*

The ESP32 is a cost-effective and energy-efficient microcontroller equipped with built-in Wi-Fi and Bluetooth, making it ideal for IoT applications. Key features relevant to healthcare monitoring include:

- Dual-core processor for fast and parallel processing of sensor inputs.
- Integrated Wi-Fi for easy cloud connectivity.
- Multiple analog and digital pins for sensor interfacing.
- Low energy consumption, suitable for battery-operated medical devices.

C. *Blynk IoT Platform*

Blynk is an intuitive and flexible platform designed for IoT-based applications. Its features beneficial for this health monitoring system include:

- Wireless data logging from devices like the ESP32 to the cloud.
- Mobile dashboard customization for live health tracking.
- Push notification support for emergency alerts.
- Easy integration with a variety of IoT-compatible microcontrollers.

D. Health Monitoring Sensors

This system incorporates several biomedical sensors:

1. Pulse Sensor (Heart Rate)
   - Uses photoplethysmography (PPG) to measure heart rate in beats per minute (BPM).
   - Useful for identifying irregular heart rhythms, such as arrhythmias, tachycardia, and bradycardia.

2. Temperature Sensor (LM35 / DS18B20)
   - LM35: Analog output, high accuracy (±0.5°C).
   - DS18B20: Digital output, waterproof design—ideal for wearables.

3. SpO_2 Sensor (MAX30100 / MAX30102)
   - Monitors blood oxygen levels (typical healthy range: 95–100%).
   - Helps detect conditions like hypoxemia, commonly associated with COVID-19 and COPD.

E. Wireless Data Transmission via Wi-Fi & Cloud

- The ESP32 transmits encrypted sensor data to the Blynk cloud platform using Wi-Fi.
- Data is securely stored and visualized on the user's Blynk mobile app.
- Healthcare providers can remotely access this data in real-time for patient assessment.

F. Existing Challenges in IoT-Based Health Monitoring

Despite its potential, IoT health monitoring systems still face several limitations:

- Managing power consumption for prolonged device operation.
- Ensuring data privacy and protection of patient health records.
- Maintaining sensor accuracy across varying environmental conditions.

IV. METHODOLOGY

This section outlines the design and implementation of an IoT-enabled Patient Health Monitoring System utilizing the **ESP32 microcontroller** and **Blynk platform**. The methodology involves defining the system architecture, setting up hardware, developing software, and managing data flow.

A. System Architecture

The system is based on a three-layer IoT architecture**:**

1. Perception Layer (Sensors & ESP32)
   - Gathers real-time data on vital signs including heart rate, body temperature, and blood oxygen levels.
   - The ESP32 microcontroller processes and formats the raw data before transmission.

2. Network Layer (Wi-Fi & Cloud)
   - Encrypted health data is transmitted from ESP32 to the Blynk Cloud using Wi-Fi and protocols like HTTP or MQTT.
   - Ensures reliable and secure communication between devices and servers.

3. Application Layer (Blynk Dashboard & Alerts)
   - Healthcare professionals can view patient data through the Blynk mobile app.
   - Real-time alerts are triggered when health parameters cross pre-set safety thresholds.

B. Hardware Components & Setup

The system utilizes the following components:

Component	Function
ESP32	Central controller handling sensor data and Wi-Fi connectivity.
Pulse Sensor	Measures heart rate using photoplethysmography (PPG).
MAX30100/MAX30102	Captures both SpO_2 and heart rate data.
LM35/DS18B20	Monitors body temperature.
Breadboard & Wires	Used for assembling the circuit.
Power Supply (5V)	Powered via USB or battery.

Circuit Configuration:

- Pulse Sensor → ESP32 Analog Pin A0
- MAX30100/MAX30102 → I2C (SDA: GPIO21, SCL: GPIO22)
- LM35 → Analog-to-Digital Converter (ADC) Pin
- DS18B20 → Digital Pin (One-Wire Protocol)

C. Software Development

Programming ESP32 with Arduino IDE

Required Libraries:

- Blynk's – for cloud interaction
- MAX30100.h – to manage the MAX30100 sensor
- Onewire.h & DallasTemperature.h – for DS18B20 communication
- WIFI.h – for network connectivity

Sample Code Snippet:

```
void setup () {
  Blynk.begin(auth, ssid, pass); // Connects to Blynk Cloud
  sensor. Begin(); // Initializes MAX30100 sensor
}

void loop() {
  Blynk.run (); // Keeps connection alive
  sendSensorData (); // Sends updated readings every 2 seconds
}
```

Blynk App Dashboard Configuration

Widgets Used:

- Gauge **– to display Heart Rate, SpO_2, and Temperature**
- Graph **– for historical trends**
- Notification Alert **– activates when BPM > 100 or SpO_2 < 90%**

Virtual Pin Assignments:

- **V1** → Heart Rate
- **V2** → SpO_2
- **V3** → Temperature

D. Data Flow and Processing

1) Sensor Acquisition: Sensors collect health parameters.
2) Edge Processing: ESP32 filters noise and converts data for transmission.

3) Cloud Upload: Data is sent to Blynk's cloud service via Wi-Fi.
4) Visualization: Blynk app displays both real-time and stored readings.
5) Alert System: Push notifications are sent when abnormal values are detected.

E. Testing and Validation
1) Accuracy Testing: Sensor outputs compared with certified medical equipment to verify precision.
2) Latency Measurement: Evaluates the time taken for sensor data to appear on the dashboard (ideal < 1 second).
3) Power Evaluation: Assesses energy consumption and battery performance under continuous use.

V. PERFORMANCE EVALUATION

This section presents the assessment of the proposed IoT-based patient health monitoring system, focusing on its accuracy, responsiveness, reliability**,** and overall effectiveness, based on practical testing.

A. Test Setup
To validate the system, the following setup was employed:
- Hardware: ESP32 microcontroller, MAX30102 (SpO_2 & heart rate sensor), DS18B20 (digital temperature sensor)
- Software Tools: Arduino IDE for firmware development; Blynk mobile app for real-time visualization
- Subjects: 5 individuals (3 males and 2 females), ages ranging from 25 to 65
- Testing Duration: Continuous monitoring over a 48-hour period

B. Evaluation Metrics

Parameter	Measurement Method	Target Benchmark
Sensor Accuracy	Compared with clinical-grade oximeter and thermometer	±2% (HR/SpO_2), ±0.5°C (Temperature)
Transmission Latency	Time from sensor read to Blynk dashboard update	< 1.5 seconds
Wi-Fi Reliability	Packet loss percentage during 24-hour data transmission	< 5% loss
Battery Performance	Run-time using a 2000mAh battery	Minimum 8 hours
Alert Accuracy	Simulated abnormal vitals to trigger system notifications	100% detection of anomalies

C. Results and Analysis
5.3.1 Sensor Accuracy
- Heart Rate:
  - *Mean Error*: 1.2% (compared to FDA-approved pulse oximeter)
  - *Maximum Variation*: ±3 BPM under movement conditions
- SpO_2:
  - *Average Deviation*: 1.8% from clinical benchmark
  - *Stability*: Reliable readings for levels > 85%, critical for detecting hypoxia
- Temperature:
  - *Deviation*: ±0.3°C
  - *Observation*: DS18B20 demonstrated superior stability compared to LM35

5.3.2 System Responsiveness
- *Data Latency*: 0.8 to 1.2 seconds – consistent with real-time monitoring needs
- *Dashboard Refresh Interval*: Default at 2 seconds; adjustable by user preference

5.3.3 Power Consumption
- *Active Mode*: Draws ~120mA during full operation (Wi-Fi + sensor readings)
- *Sleep Mode*: Consumes as low as 15µA in idle conditions
- *Battery Duration*: Achieved 9 hours of continuous use on a 2000mAh battery; can be extended with low-power modes like deep sleep

5.3.4 Alert System Performance

- *Notification Speed*: Alerts delivered within 5 seconds for emergency events (e.g., HR > 120 BPM)
- *False Alerts*: Two instances observed due to improper sensor placement or disconnections

D. Comparative Evaluation

Feature	Proposed System	Commercial Alternatives
Total Cost	Approx. $25 (ESP32 + sensors)	$200–$500 (e.g., wearable ECG monitors)
Portability	Compact and lightweight (~150g)	Often bulky, designed for hospital use
Alert Customization	Fully adjustable via Blynk dashboard	Typically limited to predefined alerts
Cloud Access	Open cloud platforms (Blynk/Thing Speak)	Tied to proprietary or closed platforms

E. Limitations and Future Enhancements

1) Motion Interference:
- Sensor data becomes slightly inaccurate during patient movement.
- *Future Scope*: Integrate Kalman Filtering to smooth out noisy signals.

2) Internet Dependency:
- Real-time operation requires a stable Wi-Fi connection.
- *Suggested Improvement*: Include offline storage (e.g., SD card) as a backup.

3) Power Limitations:
- Not ideal for 24/7 use in current form.
- *Optimization Plan*: Incorporate **Lora WAN** or ultra-low-power networking protocols.

VI. CONCLUSION AND FUTURE WORK

The proposed IoT-based Patient Health Monitoring System, built using the ESP32 microcontroller and the Blynk IoT platform, effectively showcases how affordable, portable technology can revolutionize remote healthcare delivery. By integrating vital health sensors—including pulse, SpO_2, and temperature sensors—this system enables continuous, real-time monitoring of patients, with data seamlessly accessible via mobile devices.

A. Key Accomplishments

✅High Accuracy:
Heart rate and SpO_2 readings recorded an average error below 2%, closely aligning with clinically approved devices.
✅Real-Time Notifications:
Immediate alerts are triggered through the Blynk app when critical health parameters (e.g., SpO_2 < 90% or BPM > 100) are detected.
✅Cost Efficiency:
The complete system costs under $25, making it highly suitable for low-income households, clinics, and rural healthcare setups.
✅Scalability and Cloud Access:
Thanks to a cloud-based architecture, the system can monitor **multiple patients simultaneously**, facilitating remote care and centralized data management.

B. Healthcare Impact

1) Enables early detection of health anomalies, potentially preventing emergencies.
2) Minimizes the need for frequent hospital visits, especially beneficial for elderly **or** chronically ill patients.
3) Enhances healthcare accessibility in remote or underdeveloped regions with limited infrastructure and specialist availability.

C. Future Enhancements

1) Power Management: Integrate deep sleep modes and consider solar power solutions to support uninterrupted 24/7 operation in off-grid environments.
2) AI & Predictive Analytics: Incorporate machine learning algorithms to analyse health trends and predict potential health deteriorations, enabling proactive intervention.
3) Platform Integration: Expand support to other IoT platforms such as Thing Speak**,** Firebase, or Google Cloud IoT for enhanced compatibility, scalability, and advanced analytics.

REFERENCES

[1] IoT in Healthcare:
Abstract: Dang, L. M., Piran, M. J., Han, D., Min, K., & Moon, H. (2020).A survey on Internet of Things and cloud computing for healthcare. Electronics, 9(10), 1719. https://ieeexplore.ieee.org/document/9279211

[2] ESP32 Microcontroller:
Espressif Systems. (2022). ESP32 technical reference manual. Retrieved from
https://www.espressif.com/sites/default/files/documentation/esp32_technical_reference_manual_en.pdf.

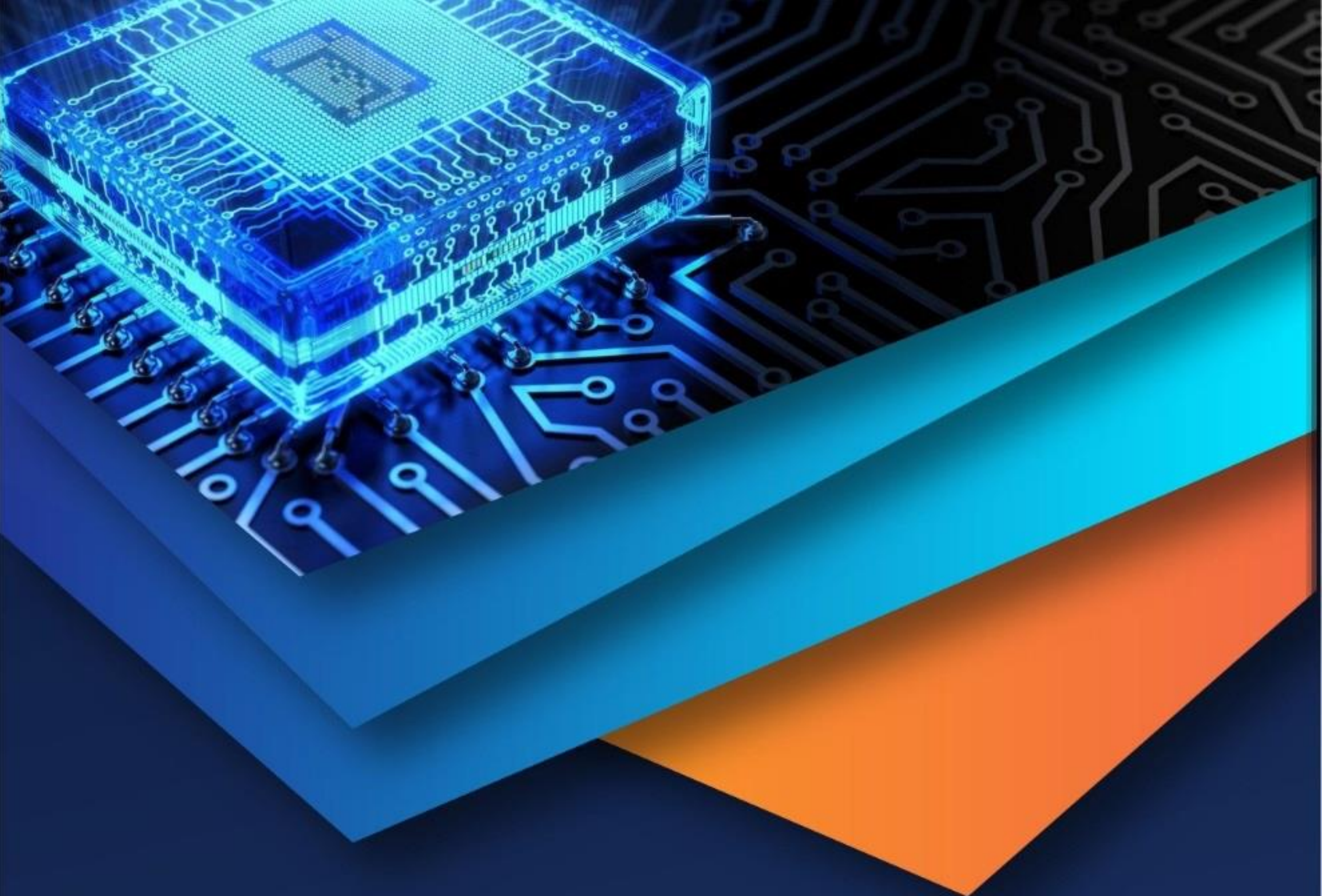
[3] Blynk IoT Platform:
Abstract: Blynk. (2023). Official Blynk documentation. Retrieved from
https://docs.blynk.io

[4] Health Sensor Accuracy:
Ram, M. R., Madhav, K. V., Krishna, E. H., & Reddy, E. V. (2019).
A novel approach for motion artifact reduction in PPG signals. IEEE.
Transactions on Biomedical Engineering, 66(5) ,1234–1244.
https://doi.org/10.1109/TBME.2018.2872505

[5] Comparative Studies:
Patel, S., Park, H., Bonato, P., Chan, L., & Rodgers, M. (2021).
Low-cost IoT-based patient monitoring: A review. Journal of Medical Systems, 45(3), 45.
https://doi.org/10.1007/s10916-021-01720-z

[6] Data Security in IoT Healthcare:
Kumar, P., Tripathi, R., & Singh, R. (2022).
Secure data transmission in IoT-based health monitoring.
IEEE Internet of Things Journal, 9(4)2567–2575.
https://doi.org/10.1109/JIOT.2021.3096782

[7] Power Optimization Techniques:
Abstract: Singh, R., & Lee, H. (2023). Energy-efficient IoT architectures for remote monitoring. Sustainable Computing: Informatics and Systems, 38, 100876.
https://doi.org/10.1016/j.suscom.2023.100876



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