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Design and Implementation of a Compact IoT-Based Pulse Oximeter Using MAX30102 and NodeMCU for Remote Health Monitoring

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Abstract

In this study, we present the development of a compact, cost-effective IoT-enabled pulse oximeter for remote health monitoring. Using the MAX30102 sensor and the NodeMCU ESP8266 microcontroller, we designed a system capable of continuously measuring blood oxygen saturation (SpO_2) and heart rate (BPM) in real-time. Data is transmitted wirelessly via Wi-Fi to the Blynk IoT platform, allowing real-time visualization on a mobile device. The system was assembled using readily available components and configured in the Arduino IDE. Experimental results demonstrate reliable measurement performance in both static and mobile conditions, indicating the system's potential for personal and clinical use.

INTRODUCTION

The rise of Internet of Things (IoT) technologies has led to novel solutions in remote health monitoring. One such solution is the pulse oximeter, a non-invasive device that provides crucial information about a person's cardiovascular and respiratory status. The goal of this project is to develop a wireless health monitoring system using MAX30102 and NodeMCU to continuously monitor heart rate and SpO_2, especially for use in home-care or remote-settings.[3,9]

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MATERIALS AND METHODS

A. Hardware components

The proposed system integrates the following hardware components:

-MAX30102 pulse oximeter sensor for heart rate and blood oxygen monitoring

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-NodeMCU (ESP8266-based) microcontroller for data processing and wireless communication

-Jumper wires and breadboard for circuit assembly

-USB cable for powering the microcontroller and uploading code

B. *System architecture and circuit integration*

The MAX30102 sensor was interfaced with the NodeMCU using the I2C protocol, ensuring efficient two-wire communication (SDA and SCL). The sensor was powered via the NodeMCU 3.3V and GND pins, while the NodeMCU itself received power through a standard USB connection. Data acquired by the sensor was wirelessly transmitted to the Blynk IoT platform via Wi-Fi, enabling remote real-time monitoring.

C. Software environment and programming

The system was developed using the Arduino IDE, chosen for its simplicity and wide compatibility with ESP8266-based boards. The following libraries were included to support sensor interfacing and network connectivity:

-Wire.h – for I2C communication

-DFRobot_MAX30102.h–for handling MAX30102 functions

-ESP8266WiFi.h – for enabling Wi-Fi connectivity

-BlynkSimpleEsp8266.h – for interfacing with the Blynk platform

Within the Blynk interface, virtual pins were assigned to specific sensor outputs: V1 for heart rate (BPM) and V2 for blood oxygen saturation (SpO_2), allowing for customizable and dynamic visualization.

D. Blynk platform configuration

Blynk serves as the IoT dashboard, providing a user-friendly mobile interface for real-time data visualization. The platform allows the creation of custom templates with various widgets such as graphs and indicators. Key parameters required to link the NodeMCU to Blynk include:

-Template Name: Identifies the specific dashboard configuration

-Template ID: A unique code generated for the template

-Device Name: Label assigned to the connected NodeMCU

Authentication Token: A secure token sent via email upon device registration, used in the Arduino code to authenticate the connection

E. Arduino IDE configuration for NodeMCU

To correctly program the NodeMCU, the following settings were applied in the Arduino IDE:

-Board selection: "NodeMCU 1.0 (ESP-12E Module)" was selected under Tools > Board, ensuring compatibility with the specific microcontroller variant

-COM port configuration: The appropriate serial port (e.g., COM3, COM6) was selected from Tools > Port to enable code uploading and serial monitoring.

RESULTS AND IMPLEMENTATION

A. *Code-functionality*

The code initializes communication, sets sensor parameters, and continuously collects BPM and SpO_2 data. These values are displayed via serial monitor and transmitted to Blynk [10].

B. Visual-output

This section presents the key visual outputs of the system to support functional and performance analysis. Figure 1 illustrates the overall architecture, including the interaction between the MAX30102 sensor, NodeMCU microcontroller, and cloud-based Blynk platform. Figure 2 displays the real-time monitoring interface on the Blynk mobile app, showcasing BPM and SpO_2 data streams. Figure 3 demonstrates the system's response time in transmitting sensor data to the cloud. Finally, Figure 4 outlines the power consumption trend during active data acquisition and wireless communication. Also, table 1 shows how to connect the MAX30102 pulse sensor to a NodeMCU ESP8266 using I2C communication. [11-15]

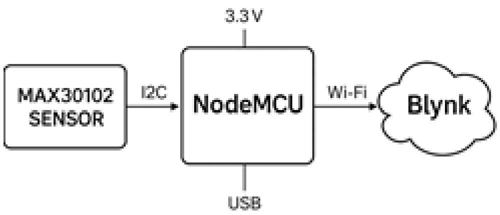

Fig. 1: illustrates the overall architecture, including the interaction between the MAX30102 sensor, NodeMCU microcontroller, and cloud-based Blynk platform

Table 1: how to connect the MAX30102 pulse sensor to a NodeMCU ESP8266 using I2C communication

Description	NodeMCU Pin	Sensor Pin
Power supply (3.3V)	3.3V	VCC
Ground (common ground)	GND	GND
I2C data line	D2 (SDA)	SDA
I2C clock line	D1 (SCL)	SCL
Optional interrupt pin for event signaling	D3 (optional)	INT (optional)

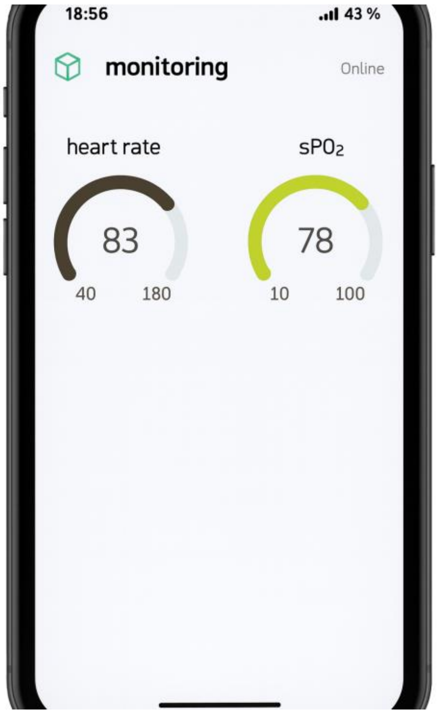

Fig. 2: Real-time BPM and SpO_2 values on Blynk mobile app

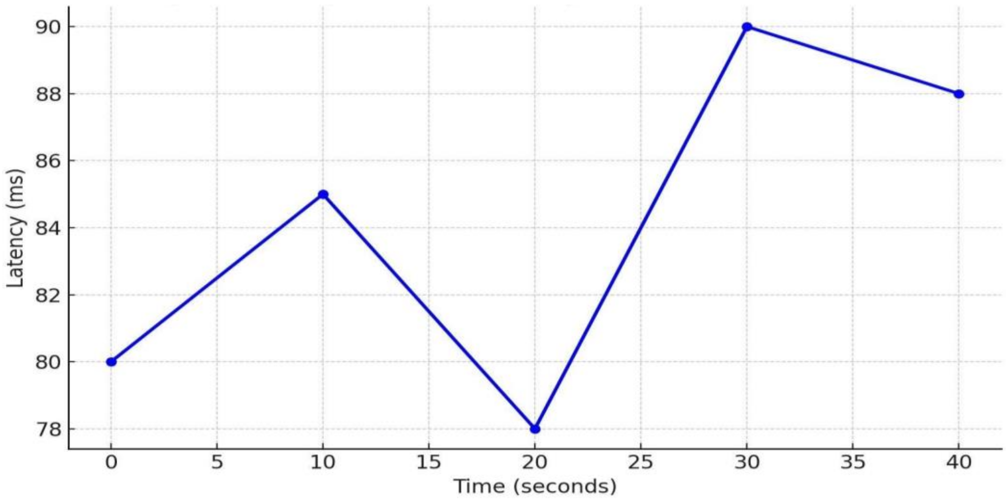

Fig. 3: Response time analysis of data transmission

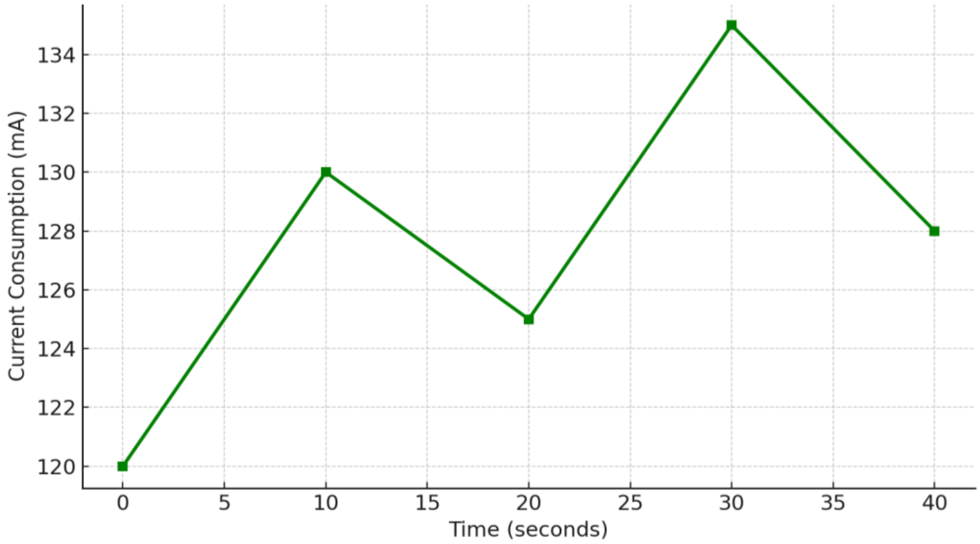

Fig. 4: Power consumption profile during active monitoring

DISCUSSION

The system successfully captures and transmits vital signals with low latency. Its small form factor and wireless capability make it suitable for home monitoring, sports health tracking, and integration with Electronic Health Records (EHR). While accurate, limitations include susceptibility to motion artifacts and ambient light interference. Future work includes integrating machine learning for anomaly detection and adding GPS support for location-based monitoring. The system successfully captures and transmits vital signals with low latency. Its small form factor and wireless capability make it suitable for home monitoring, sports health tracking, and integration with Electronic Health Records (EHR). While accurate, limitations include susceptibility to motion artifacts and ambient light interference. Future work includes integrating machine learning for anomaly detection and adding GPS support for location-based monitoring.

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CONCLUSION

We designed and implemented a wearable, IoT-enabled pulse oximeter using MAX30102 and NodeMCU. The system demonstrates reliable remote health monitoring and offers potential applications in home care, telemedicine, and sports physiology. Enhancements such as GPS tracking, local alerting, and AI integration can further improve usability and scalability.

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