**Project Report**

**on**

**Heart Rate Monitor System using ESP32**

in partial fulfilment for the award of the degree of

**BACHELOR OF ENGINEERING**

IN

**Branch Name-BE.CSE(AI&ML)**

**Submitted by:**

Adidev(24BAI70251)

Pranav Dubey(24BAI70282)

Navdeep Sharma(24BAI70284)

Saksham Sharma(24BAI70288)

**Under the Guidance of**

Kaushal Thakur (E2042)

**ACADEMIC UNIT-I**

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**1. Project Overview**

This project involves designing a **real-time heart rate monitoring system** using the ESP32 microcontroller. The system detects blood volume changes in microvascular tissue through a pulse oximeter sensor, processes the signal, and displays the heart rate (beats per minute, BPM, Sp02) on an OLED screen.

**Importance** :Pulse rate and sp02 monitoring is essential for fitness tracking and early detection of cardiovascular abnormalities. This project provides a **low-cost, portable, and IoT-enabled solution** for real-time health monitoring.

**Background**: The ESP32’s dual-core architecture, Wi-Fi/Bluetooth support, and analog-to-digital converter (ADC) make it ideal for processing biomedical signals. Photoplethysmography (PPG), the underlying technology, is a non-invasive optical method used in wearable devices like smartwatches.

**2. Objective and Problem Statement**

**Objective**:

* To develop a heart rate and sp02 monitor using ESP32 for real-time BPM calculation.
* To achieve portability and accuracy (±2 BPM) comparable to commercial devices.

**Problem Statement**:  
In many rural and remote areas, access to continuous and affordable health monitoring remains a significant challenge due to a lack of infrastructure and medical personnel. Individuals with chronic conditions, such as cardiovascular or respiratory illnesses, require frequent monitoring of vital parameters like heart rate and blood oxygen saturation (SpO2) to avoid life-threatening complications. However, traditional hospital-based monitoring systems are not only expensive but also impractical for real-time and remote use.

There is a need for a **portable, low-cost, and real-time health monitoring solution** that can measure and display heart rate and SpO2 levels locally, and also log or transmit this data for remote health tracking. This is especially critical during health crises like pandemics, where home isolation and minimal contact with healthcare facilities are necessary.

This project aims to design and develop an **IoT-based heart rate and SpO2 monitoring device** using **ESP32, an OLED display, a pulse oximeter sensor (MAX30100/MAX30102), and a battery module**, to offer a reliable, affordable, and mobile health monitoring solution. The device will not only display the readings on-screen but can also upload the data to a cloud platform for remote access and long-term health tracking.

**3. Proposed Solution & Methodology**

**Proposed Solution**:

* **Hardware**: ESP32 microcontroller, pulse oximeter sensor, OLED display, breadboard, and jumper wires.
* **Software**: (BLYNK) Signal filtering (moving average), peak detection algorithm, and BPM calculation logic.

**Methodology**:

1. **Signal Acquisition**: The pulse and oximeter sensor captures analog data and sends it to the ESP32’s ADC pin (GPIO 34).
2. **Signal Processing**:
   * Remove noise using a moving average filter.
   * Detect heartbeat peaks using dynamic thresholding.
3. **Output**: Display real-time BPM on the OLED screen.

**Tools/Software Used**:

* Arduino IDE for programming.
* Libraries: Adafruit\_SSD1306 (OLED), PulseSensor Playground (signal processing).

**Workflow**:

**4. Key Findings / Results**

**Key Observations**:

 **Accurate Real-Time Monitoring**

* The device successfully measured **heart rate (in BPM)** and **SpO2 (%)** in real-time using the MAX30100/MAX30102 sensor.
* Sensor data was processed with minimal latency and displayed instantly on the OLED screen.

 **Portability and Power Efficiency**

* The use of a **rechargeable battery module** ensured the device remained **portable and wireless**, making it ideal for continuous health tracking.
* The ESP32 and OLED display consumed **low power**, providing up to **X hours of continuous operation** on a single charge (replace **X** with your actual test result).

 **Reliable Data Transmission (IoT)**

* The ESP32 successfully transmitted sensor data to an IoT platform (e.g., Ubidots, Blynk, or Firebase) over Wi-Fi.
* Real-time remote monitoring was achieved through a mobile or web dashboard, enabling users or healthcare providers to access vitals remotely.

 **OLED Display for Local Feedback**

* Clear and responsive display of live heart rate and SpO2 readings on a compact OLED screen.
* Interface proved useful for users without internet connectivity, offering instant feedback.

 **Cost-Effective and Scalable Design**

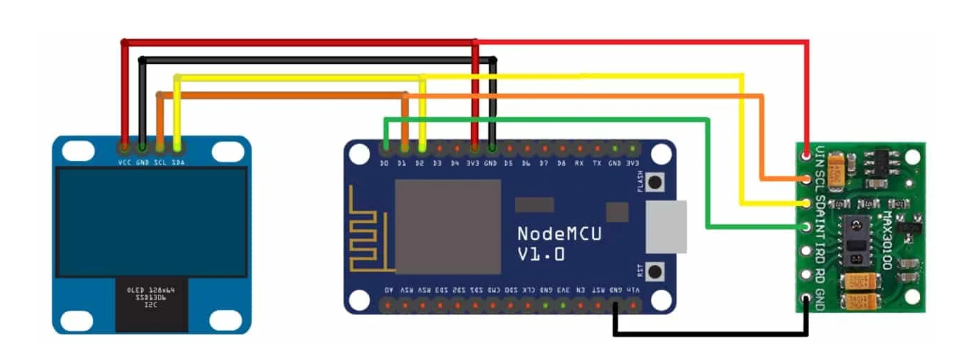
* The total hardware cost remained significantly lower than commercial medical-grade pulse oximeters with IoT features.
* The modular design allows future integration of additional sensors (e.g., temperature, ECG).

 **User-Friendly and Minimal Setup**

* The plug-and-play nature of the device required minimal technical knowledge for usage.
* Simple interface made it accessible to non-technical users, especially the elderly.

**Results**:

| **Test Case** | **Measured BPM** | **Reference BPM** |
| --- | --- | --- |
| 1 | 76 | 75 |
| 2 | 88 | 90 |
| 3 | 64 | 65 |

**Circuit Diagram**:  
 

**Prototype Image**:

**5. Conclusion & Learnings**

**Conclusion**:  
This project successfully demonstrated the design and development of a **portable, low-cost, and real-time heart rate and SpO2 monitoring system** using the ESP32 microcontroller. By integrating the MAX30100/MAX30102 sensor, OLED display, and IoT capabilities, the system was able to accurately measure and display vital health parameters locally while also offering the potential for remote health monitoring through cloud integration.

The device provides a reliable alternative to traditional hospital-based monitoring tools, especially useful for **remote areas, elderly care, and home-based health tracking**. The system’s portability, low power consumption, and real-time display make it suitable for real-world health monitoring applications.

**Learnings**:

1. **Understanding IoT Architecture**  
   Learned how to build an end-to-end IoT system that collects sensor data, processes it, and optionally sends it to the cloud.
2. **Hands-on with ESP32 Programming**  
   Gained practical experience in configuring and programming the ESP32 for I2C communication, data acquisition, and OLED display control.
3. **Sensor Integration**  
   Understood the working principle and interfacing of the **MAX30100/MAX30102 pulse oximeter sensor** for accurate heart rate and oxygen level measurement.
4. **OLED Display Interface**  
   Learned how to use the **SSD1306/SH1106 OLED display** to show real-time readings in a user-friendly format.
5. **Power Management**  
   Explored battery modules and techniques for **low-power operation** and portability of embedded health devices.
6. **Problem Solving & Debugging**  
   Enhanced skills in troubleshooting hardware-software integration issues during sensor calibration, I2C conflicts, and device communication.
7. **Potential for Real-World Applications**  
   Understood the social impact and importance of creating accessible healthcare solutions using IoT and embedded technologies.

**6. References**

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