

IOT-Based COPD Monitoring System

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Abstract:- Chronic Obstructive Pulmonary Disease (COPD) requires continuous monitoring to prevent severe health complications. This project presents an ESP32-based IoT COPD Patient Monitoring and Oxygen Control System that monitors vital parameters such as blood oxygen saturation (SpO₂), heart rate, and ECG signals using MAX30102 and AD8232 sensors. The collected data is displayed on an OLED screen and uploaded to the cloud for remote monitoring through a webpage. A GPS module provides real-time location tracking, while a GSM module sends emergency alerts with patient information and location details. A servo-controlled oxygen valve automatically regulates oxygen supply, improving patient safety and healthcare support.

Key words: COPD, IoT, ESP32, ECG Monitoring, Cloud-Based Healthcare, GSM and GPS, Automatic Oxygen Control.

1. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a long-term respiratory disease that affects airflow in the lungs and makes breathing difficult. Continuous monitoring of vital signs is essential to prevent serious health complications and provide timely medical assistance. This project presents an ESP32-based IoT COPD Patient Monitoring and Oxygen Control System that monitors blood oxygen saturation (SpO₂), heart rate, and ECG signals using MAX30102 and AD8232 sensors. The system displays real-time data on an OLED screen, uploads information to the cloud, tracks patient location using GPS, sends emergency alerts through GSM, and automatically controls oxygen supply using a servo motor.

Recent studies have demonstrated that the integration of Internet of Things (IoT) technology into healthcare has significantly improved the monitoring and management of patients with chronic respiratory diseases. IoT-enabled systems equipped with sensors such as pulse oximeters, heart rate monitors, temperature sensors, and ECG modules

facilitate continuous monitoring of vital parameters and enable real-time transmission of patient data to cloud platforms for

remote access by healthcare professionals. Furthermore, the incorporation of wireless communication technologies, including Wi-Fi, GSM, and GPS, has enhanced emergency response by supporting instant alerts and real-time patient location tracking. These developments have reduced the need for frequent hospital visits while enabling timely medical intervention and improving the overall quality of patient care [1]–[5].

Several researchers have also focused on automated oxygen therapy systems that regulate oxygen delivery according to the patient's blood oxygen saturation (SpO₂) level. Kumar et al. [1] demonstrated the effectiveness of cloud-connected IoT health monitoring using ESP32, while Sharma and Singh [2] proposed a smart oxygen monitoring system for continuous SpO₂ surveillance. Patel et al. [3] integrated GSM and GPS technologies to provide emergency alerts and patient location tracking, whereas Verma et al. [4] developed an automated oxygen control system capable of regulating oxygen flow based on sensor readings. More recently, Thomas et al. [5] presented a comprehensive respiratory care system incorporating SpO₂ monitoring, ECG acquisition, GSM alerts, and GPS tracking for chronic respiratory patients. Although these systems provide valuable healthcare support, most existing solutions either focus only on patient monitoring or on oxygen regulation and often lack portability, affordability, or complete integration of essential features.

Motivated by these limitations, the proposed IoT-based COPD monitoring system aims to provide a low-cost, portable, and comprehensive solution for continuous respiratory care. The system integrates real-time health monitoring, cloud connectivity, automatic oxygen supply control using a solenoid valve, GPS-based location tracking, GSM-enabled emergency notifications, and battery-powered operation within a single platform. By combining these functionalities, the proposed system offers an efficient and practical solution for continuous monitoring and timely intervention, thereby improving the safety and quality of life of patients with Chronic Obstructive Pulmonary Disease (COPD) [1]–[5].

2. PROPOSED SYSTEM

The proposed "IoT-BASED COPD MONITORING SYSTEM" continuously monitors the patient's health and provides automatic oxygen support when required. The ESP32 microcontroller collects data from the MAX30102 (SpO₂ and pulse rate) and AD8232 (heart rate and ECG) sensors. The measured values are displayed on an OLED display and uploaded to the cloud for remote monitoring. A GPS module tracks the patient's location, while a GSM module sends emergency alerts to caregivers. When the SpO₂ level falls below a predefined threshold, the ESP32 automatically activates a solenoid valve connected to the oxygen cylinder. The system is powered by a rechargeable lithium-ion battery with a 5V boost converter, making it portable, reliable, and suitable for home healthcare.

3. BLOCK DIAGRAM

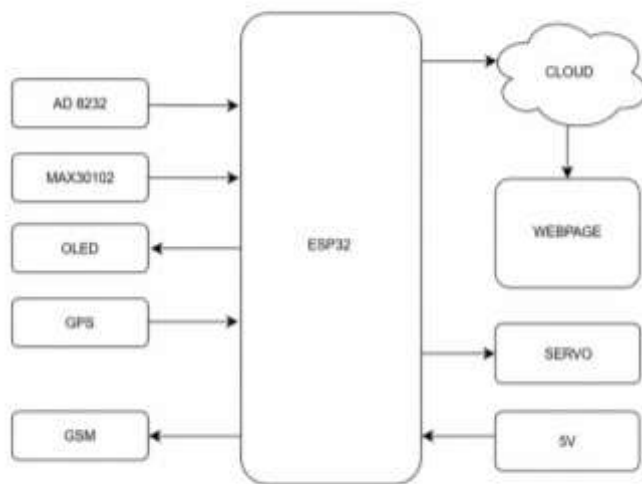


Fig-1: Block diagram

The block diagram of the proposed ESP32-based IoT COPD Patient Monitoring and Oxygen Control System consists of an ESP32 microcontroller connected to a MAX30102 sensor, AD8232 ECG sensor, OLED display, GPS module, GSM module, cloud platform, and a servo-controlled oxygen valve. The MAX30102 measures SpO₂ and heart rate, while the AD8232 monitors ECG signals. The ESP32 processes the collected data and displays it on the OLED screen. Patient data is uploaded to the cloud for remote monitoring through a webpage. The GPS module provides location tracking, and the GSM module sends emergency alerts. The servo motor automatically regulates oxygen flow based on SpO₂ levels.

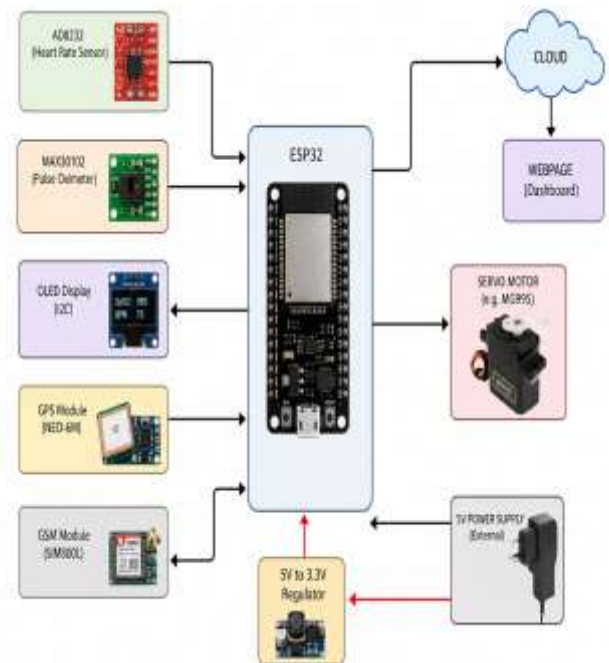


Fig-2: Pictorial Representation Of Block Diagram

4. CONTENTS

The existing system mainly provides manual oxygen therapy and basic patient monitoring. It requires continuous supervision by healthcare staff and does not support automatic oxygen control, cloud-based remote monitoring, GPS tracking, or GSM emergency alerts. This can delay emergency response and reduce the efficiency of patient care for COPD patients.

ESP32 Microcontroller:

The ESP32 is the main controller of the COPD monitoring system. It collects data from sensors, processes health information, controls the oxygen valve, connects to Wi-Fi, and uploads real-time data to the cloud for remote monitoring.

MAX30102 Sensor:

The MAX30102 sensor measures blood oxygen saturation (SpO₂) and heart rate. It continuously monitors the patient's vital signs and helps detect abnormal oxygen levels that may require immediate attention.

AD8232 ECG Sensor:

The AD8232 ECG sensor monitors the electrical activity of the heart. It provides real-time ECG signals and helps identify abnormal heart conditions during patient monitoring.

NEO-6M GPS Module:

The GPS module tracks the patient's real-time location. During emergencies, it provides accurate location coordinates that can be shared with caregivers and medical personnel.

SIM800L GSM Module:

The SIM800L GSM module sends SMS alerts to family members, caregivers, or healthcare providers when abnormal health conditions such as low oxygen levels or irregular heart rate are detected.

OLED Display (I2C):

The OLED display shows real-time patient information such as SpO₂ level, heart rate, ECG status, GPS status, and system alerts, allowing easy local monitoring.

Servo Motor:

The servo motor controls the oxygen valve automatically. When the patient's oxygen level falls below a predefined threshold, the servo adjusts the valve to increase oxygen supply.

Oxygen Cylinder and Valve:

The oxygen cylinder provides medical oxygen to the patient. The valve regulates oxygen flow and is automatically controlled by the servo motor based on SpO₂ readings.

Wi-Fi Connectivity:

The ESP32 uses Wi-Fi to transmit patient data to the cloud platform. This enables remote monitoring through a webpage or mobile device from any location.

Cloud Platform:

The cloud platform stores patient health data, system logs, and monitoring records. It provides real-time access to health information and supports long-term data analysis.

Web Monitoring Dashboard:

The web dashboard displays live patient parameters, including oxygen level, heart rate, ECG data, and system status. It allows healthcare providers to monitor patients remotely.

Emergency Alert System:

The emergency alert system generates instant notifications and SMS alerts whenever critical health conditions are detected, ensuring timely medical intervention and improved patient safety.

5. CIRCUIT DIAGRAM

The circuit consists of an ESP32 connected to the MAX30102, AD8232, OLED display, GPS, and GSM modules. The ESP32 monitors the patient's vital signs and uploads data to the cloud. When the SpO₂ level becomes low, it activates the solenoid valve, supplying oxygen from the oxygen cylinder automatically.

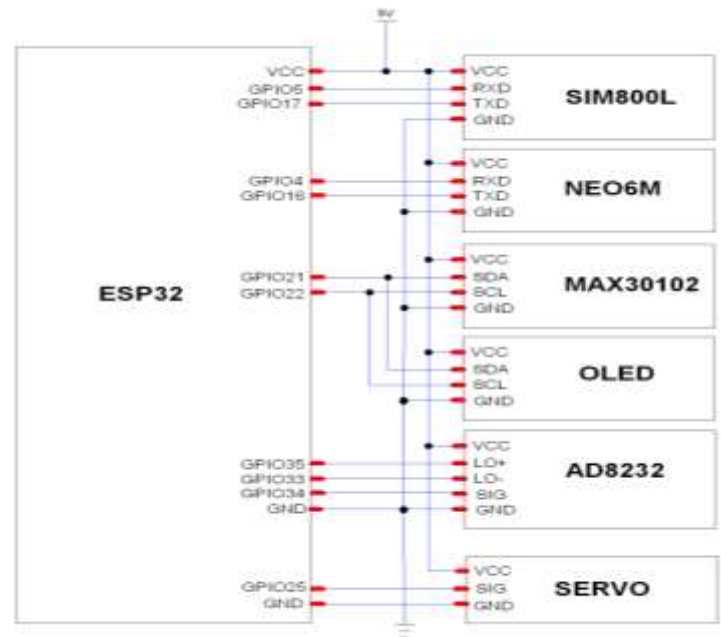


Fig-3: Circuit diagram

The system is designed to provide a portable and intelligent healthcare solution for COPD patients. It continuously monitors the patient's respiratory and cardiac health, enabling early detection of abnormal conditions. The collected health information is stored for future medical analysis, allowing doctors to evaluate the patient's condition over time. The system supports remote healthcare by enabling caregivers to access patient information from any location. It also provides emergency notifications to ensure a quick response during critical situations. The battery-powered design makes the device suitable for home care and outdoor use, while its compact structure improves portability. By integrating IoT technology with automated healthcare functions, the system reduces the need for continuous manual supervision, improves treatment efficiency, minimizes emergency risks, and enhances the overall quality of life for COPD patients.

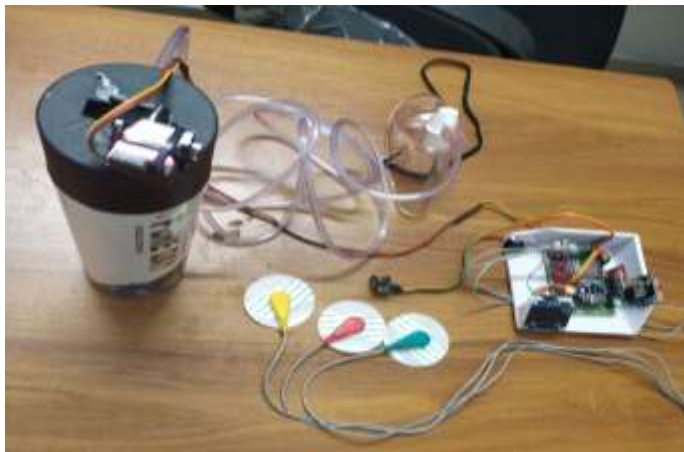
6. WORKING

The proposed COPD Patient Monitoring and Oxygen Control System is centered around the ESP32 microcontroller. The MAX30102 sensor measures SpO₂ and heart rate, while the AD8232 sensor monitors ECG signals. An OLED display shows real-time patient data locally. The NEO-6M GPS module provides location tracking, and the SIM800L GSM module sends emergency SMS alerts when abnormal conditions are detected. The ESP32 uploads health data to the cloud for remote monitoring through a webpage. A servo motor and solenoid valve work together to control oxygen flow automatically. The entire system operates using a regulated 5V power supply.

7. IMPLEMENTATION AND TEST RESULT

The proposed ESP32-based IoT COPD Patient Monitoring and Oxygen Control System was implemented by integrating the MAX30102, AD8232, GPS, GSM, OLED display, servo motor, and solenoid valve with the ESP32 microcontroller. The system continuously monitored SpO₂, heart rate, and ECG signals and displayed the readings on the OLED screen. Patient data was uploaded to the cloud for remote monitoring through a webpage. Emergency SMS alerts containing health status and location information were sent using the GSM module. The results showed accurate monitoring, reliable alert generation, successful remote access, and automatic oxygen control, improving patient safety and healthcare support.

The webpage dashboard displays the patient's health status in real time. It shows heart rate, blood oxygen saturation (SpO₂), respiration rate, and solenoid valve status. The system also provides a health review, a live monitoring graph, and a GPS location button for emergency tracking. This enables continuous remote monitoring and quick medical response for COPD patients.



8. ADVANTAGES

- 1. Continuous Health Monitoring** – Monitors vital parameters such as heart rate, SpO₂, and ECG in real time.
- 2. Automatic Oxygen Supply** – Provides oxygen automatically when the patient's oxygen level falls below a safe limit.
- 3. Early Emergency Detection** – Detects abnormal health conditions and generates alerts quickly.
- 4. Remote Monitoring** – Doctors and caregivers can monitor patient data from anywhere through the internet.
- 5. Instant Notifications** – Sends SMS alerts to family members or healthcare providers during emergencies.
- 6. Improved Patient Safety** – Reduces the risk of severe complications caused by low oxygen levels.
- 7. Reduced Hospital Visits** – Enables home-based monitoring, minimizing frequent hospital checkups.
- 8. Real-Time Data Display** – Shows health information instantly on the OLED display and cloud platform.
- 9. Location Tracking** – GPS helps locate the patient during emergency situations.
- 10. Low-Cost Healthcare Solution** – Uses affordable IoT components, making it suitable for home healthcare applications.
- 11. Lightweight Design** – Easy to carry, install, and use in homes, hospitals, and ambulances.
- 12. Transparent Monitoring** – Provides clear and real-time display of patient health data for patients, caregivers, and doctors.

9. APPLICATIONS

- 1. COPD Patient Monitoring** – Continuous monitoring of oxygen level, heart rate, and ECG signals.
- 2. Home Healthcare** – Enables remote monitoring of patients at home.
- 3. Hospital Patient Care** – Assists doctors and nurses in tracking patient health conditions.
- 4. Elderly Care Monitoring** – Provides health supervision for elderly individuals with respiratory problems.
- 5. Emergency Healthcare Systems** – Sends instant alerts during critical health conditions.
- 6. Remote Patient Monitoring** – Allows healthcare providers to monitor patients through cloud and web platforms.

7. Automatic Oxygen Management – Regulates oxygen supply automatically based on SpO₂ levels.
8. Ambulance and Emergency Services – Shares patient location using GPS for quick medical assistance
9. Rural Healthcare Applications – Supports healthcare services in remote and underserved areas.
10. Telemedicine Systems – Enhances online consultation and remote healthcare management.

10. FUTURE SCOPE

The proposed IoT-based COPD Monitoring System can be further enhanced by adding advanced features to improve healthcare services. Machine learning can be used to analyze patient data, identify health trends, and predict potential medical emergencies for better treatment planning. Video consultation and telemedicine integration will enable patients to communicate directly with doctors and receive remote diagnosis and treatment. Electronic Health Record (EHR) integration can automatically store patient data in hospital databases, making medical records easily accessible and reducing manual documentation. The system can also be connected to wearable devices such as smartwatches and fitness bands for continuous health monitoring. A portable smart healthcare kit can be developed by making the system compact and lightweight, allowing easy transportation and use in homes, ambulances, and outdoor environments. Voice assistant support can provide voice alerts and enable voice-controlled operation, making the system more accessible, especially for elderly patients. In addition, multi-patient monitoring can allow healthcare professionals to monitor several patients simultaneously through a centralized dashboard, improving hospital efficiency and patient care.

11. CONCLUSION

The IoT-Based COPD Monitoring System is an intelligent healthcare solution designed to improve the safety and quality of life of COPD patients. The system continuously monitors vital parameters such as SpO₂, heart rate, and ECG signals in real time. When oxygen levels fall below a predefined threshold, a solenoid valve automatically supplies oxygen from the cylinder. GSM and GPS modules provide emergency alerts and location tracking for rapid medical assistance. IoT technology enables cloud-based remote monitoring and data storage. The system is cost-effective, portable, reliable, and suitable for home healthcare, ensuring timely intervention and effective management of COPD patients.

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