



IOT Based Industrial Environmental Monitoring System

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Abstract: Industrial environments often involve hazardous operating conditions such as the presence of flammable or toxic gases, excessive temperature, smoke, fire risks, and poor air quality. These factors pose serious threats to worker safety, equipment reliability, and environmental health. Conventional monitoring systems largely depend on manual inspection or standalone safety devices, which are inefficient, prone to human error, and incapable of providing real-time remote monitoring. To overcome these limitations, this project proposes an IOT-Based Industrial Environmental Monitoring System using ESP32. The proposed system continuously monitors critical environmental parameters including gas concentration, temperature, humidity, smoke or flame presence, and air quality using multiple sensors such as MQ-series gas sensors, DHT11 temperature and humidity sensor, smoke/flame sensor, and MQ-135 air quality sensor. The ESP32 microcontroller acts as the central processing unit, acquiring sensor data, processing it in real time, and transmitting it wirelessly to an IoT cloud platform using built-in Wi-Fi functionality. The monitored data is visualized on a cloud dashboard, enabling real-time remote monitoring and historical data analysis. When any environmental parameter exceeds predefined safety thresholds, the system automatically generates alerts and notifications, allowing rapid response to hazardous conditions. The proposed system is cost-effective, scalable, and easy to deploy, making it suitable for applications in manufacturing industries, chemical plants, warehouses, power stations, and research laboratories. With further enhancements such as advanced analytics and mobile application integration, the system can be extended to support predictive safety and smart industrial monitoring in accordance with Industry 4.0 concepts.

Key Words: IOT, ESP32, Industrial Safety, Environmental Monitoring, Gas Detection, Air Quality Monitoring.

I. INTRODUCTION

Industrial safety and environmental monitoring have become major concerns in modern industries due to the increasing risk of hazardous conditions such as gas leakage, fire accidents, excessive temperature, humidity fluctuations, and air pollution. Continuous monitoring of these environmental parameters is essential to ensure worker safety, protect industrial equipment, and maintain efficient industrial operations. Conventional monitoring systems mainly rely on manual supervision and periodic inspections, which may result in delayed detection of dangerous situations and increased operational risks.

The rapid development of the Internet of Things (IoT) has enabled the creation of smart monitoring systems capable of real-time sensing, data processing, and remote communication. IoT technology allows various sensors and embedded devices to connect through the internet, enabling continuous environmental monitoring and instant alert generation. These intelligent systems improve industrial safety by providing accurate, automated, and remote monitoring capabilities.

This paper presents an IoT-Based Industrial Environmental Monitoring System using ESP32, designed to monitor critical environmental parameters in industrial environments. The proposed system integrates multiple sensors such as the MQ-2 gas sensor, MQ-135 air quality sensor, DHT11 temperature and humidity sensor, and smoke/flame sensor with the ESP32 microcontroller. The ESP32 processes the sensor data and transmits it to an IoT cloud platform through Wi-Fi communication for real-time monitoring and analysis.

Whenever any environmental parameter exceeds predefined safety limits, the system generates immediate alerts, allowing quick preventive action to reduce industrial hazards. The proposed system offers several advantages including low cost, real-time monitoring, remote accessibility, reduced human intervention, and improved reliability. The implementation of this system supports the concept of Industry 4.0 by integrating embedded systems, wireless communication, cloud computing, and IoT technologies into industrial safety applications.

The developed system provides an efficient, scalable, and intelligent solution for industrial environmental monitoring and contributes toward safer and smarter industrial environments.

II.MATERIAL AND METHODS

Materials

The proposed IoT-based industrial environmental monitoring system consists of hardware and software components used for sensing, processing, communication, and cloud monitoring.

Hardware Components

- **ESP32 Microcontroller** – Used as the main processing and communication unit.
- **MQ-2 Gas Sensor** – Detects combustible gases and gas leakage.
- **MQ-135 Air Quality Sensor** – Monitors air quality and harmful pollutants.
- **DHT11 Sensor** – Measures temperature and humidity.
- **Smoke/Flame Sensor** – Detects smoke and fire conditions.
- **Power Supply Unit** – Provides regulated power to the system.
- **Wi-Fi Network** – Enables wireless communication with the cloud platform.

Software Components

- **Arduino IDE** – Used for programming the ESP32 microcontroller.
- **IoT Cloud Platform (ThingSpeak/Blynk)** – Used for real-time data visualization and remote monitoring.
- **Embedded C Programming** – Used for sensor interfacing and data processing.

Methods

The proposed system continuously monitors industrial environmental parameters using multiple sensors connected to the ESP32 microcontroller. Each sensor collects real-time data related to gas concentration, temperature, humidity, smoke/fire presence, and air quality.

The ESP32 processes the sensor readings and compares them with predefined threshold values. If any parameter exceeds the safe limit, the system immediately generates alerts and sends warning notifications to the IoT cloud platform. Under normal conditions, the monitored data is periodically updated to the cloud for remote observation and analysis.

The system operates through the following steps:

1. Initialization of ESP32 and sensors
2. Establishment of Wi-Fi connection
3. Continuous acquisition of sensor data
4. Processing and conversion of sensor readings
5. Comparison with threshold values
6. Alert generation during abnormal conditions
7. Cloud data transmission for remote monitoring

The integration of IoT technology enables real-time monitoring, remote accessibility, and rapid response to hazardous industrial conditions, thereby improving industrial safety and operational efficiency.

III.RESULT

The proposed IoT-Based Industrial Environmental Monitoring System was successfully designed and implemented using ESP32, multiple environmental sensors, and cloud-based monitoring technologies. The system continuously monitored industrial safety parameters such as temperature, humidity, gas leakage, air quality, and flame detection in real time.

The DHT11 sensor accurately measured temperature and humidity values from different rooms, while the MQ-2 and MQ-6 gas sensors effectively detected smoke and LPG gas leakage conditions. The MQ-135 sensor monitored air quality levels and detected harmful gases present in the environment. The flame sensor successfully identified fire conditions and triggered immediate safety actions.

The ESP32 microcontroller processed the sensor data efficiently and transmitted the monitored values to the IoT dashboard through Wi-Fi communication. Real-time monitoring was achieved successfully using the web dashboard, where all sensor values, room status, gas conditions, and actuator status were displayed continuously.

Whenever abnormal conditions were detected, the system generated instant Telegram alert notifications to ensure remote safety monitoring. During gas leakage detection, the servo motor automatically rotated to close the gas valve, while the buzzer alarm was activated for emergency warning. Similarly, when fire was detected, the system immediately triggered alert notifications and activated the buzzer alarm.

The experimental outputs demonstrated that the developed system provides accurate sensing, fast response time, reliable wireless communication, and efficient real-time industrial safety monitoring. The proposed system improves industrial safety, reduces manual supervision, and provides a low-cost smart monitoring solution for industrial environments.

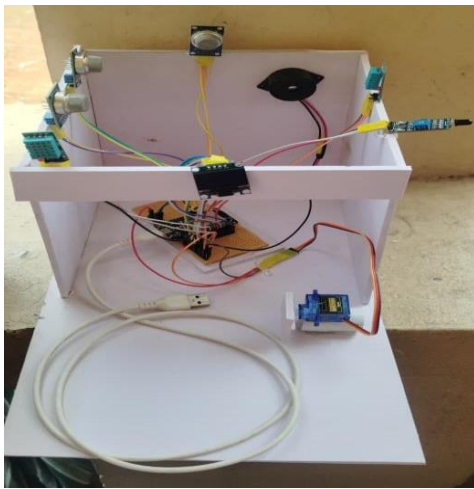


Fig: Hardware Prototype of the Proposed System

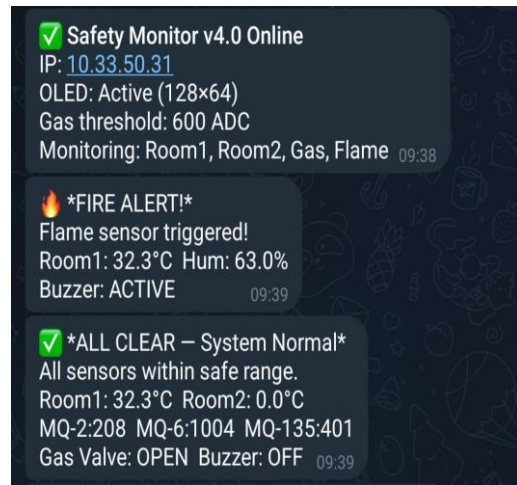


Fig: Real-Time Web Dashboard Monitoring Output



Fig : Telegram Notification for Fire Alert

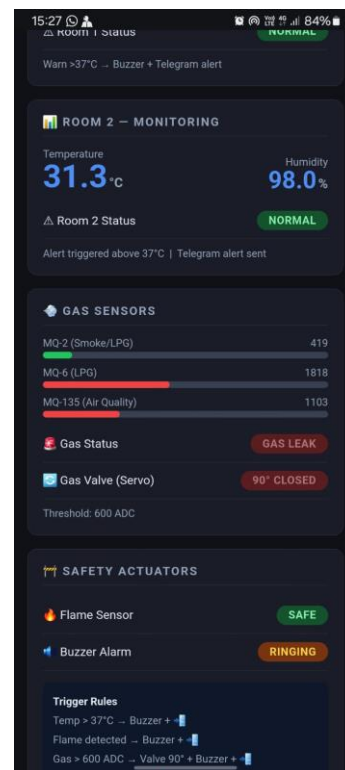


Fig : Telegram Notification for System Status Monitoring

IV.DISCUSSION

The IoT-Based Industrial Environmental Monitoring System demonstrates the effectiveness of integrating sensor technology, embedded systems, and IoT platforms for real-time industrial safety applications. The results obtained from the system show that continuous monitoring of environmental parameters such as gas concentration, temperature, humidity, smoke, and air quality can significantly improve the detection of hazardous conditions in industrial environments.

The use of the ESP32 microcontroller plays a crucial role in ensuring efficient data processing and reliable wireless communication. Its built-in Wi-Fi capability enables seamless transmission of sensor data to IoT cloud platforms, allowing remote monitoring and quick decision-making. The integration of multiple sensors ensures comprehensive environmental coverage, reducing the chances of undetected hazards.

During testing, the system performed reliably under both normal and abnormal conditions. It successfully identified gas leakage, fire, and air quality degradation without generating false alerts under stable conditions. This indicates that the threshold-based detection mechanism is effective for industrial safety applications. The quick response time of the system also ensures timely alert generation, which is critical in preventing accidents and minimizing damage.

However, the system has certain limitations. The accuracy of low-cost sensors such as MQ-series and DHT11 may vary depending on environmental conditions and calibration. Network dependency for cloud communication can also affect real-time data updates in areas with poor internet connectivity. Additionally, the system currently focuses on monitoring and alerting but does not include automatic control actions such as shutting down equipment.

Despite these limitations, the proposed system provides a strong foundation for smart industrial monitoring. It is cost-effective, scalable, and easy to implement in various industrial environments. With further improvements such as AI-based prediction, industrial-grade sensors, and automation integration, the system can be enhanced into a fully intelligent industrial safety solution aligned with Industry 4.0 standards.

V. CONCLUSION

The IoT-Based Industrial Environmental Monitoring System was successfully designed and implemented using the ESP32 microcontroller and multiple environmental sensors. The system effectively monitors critical industrial parameters such as gas leakage, temperature, humidity, smoke/fire presence, and air quality in real time.

The integration of IoT technology enables continuous data acquisition, wireless communication, and remote monitoring through cloud platforms. The system provides instant alerts whenever environmental conditions exceed predefined safety limits, thereby ensuring timely response and improved industrial safety.

The experimental results confirm that the system operates reliably with fast response time, accurate sensing, and stable cloud connectivity. It minimizes the need for manual supervision and enhances overall monitoring efficiency.

In conclusion, the proposed system offers a low-cost, scalable, and efficient solution for industrial environmental monitoring. It contributes to safer working conditions and aligns with modern smart industry and Industry 4.0 concepts

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