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Design and Implementation of an IoT-Based Industrial Parameters Monitoring System Using ESP32

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Abstract : Industrial environments require continuous monitoring of critical parameters such as gas leakage, temperature, humidity, flame presence, and illumination to ensure operational safety and prevent hazardous incidents. Traditional monitoring systems often rely on manual inspection or wired infrastructure, which may limit real-time accessibility and rapid response. This research presents the design and implementation of an Internet of Things (IoT)-based industrial parameters monitoring system that enables real-time detection and remote monitoring of environmental conditions. The proposed system integrates multiple sensors including an MQ-series gas sensor for detecting combustible gases, a flame sensor for fire detection, a DHT11 sensor for measuring temperature and humidity, and an LDR sensor for monitoring ambient light intensity. These sensors are interfaced with an ESP32 microcontroller, which serves as the central processing unit of the system. The ESP32 collects sensor data, processes the readings, and compares them with predefined threshold values to identify abnormal environmental conditions. The processed data are transmitted through the built-in Wi-Fi module of the ESP32 to a web-based monitoring dashboard that enables users to visualize real-time system parameters using a computer or smartphone. When hazardous conditions such as gas leakage or flame detection occur, the system is capable of generating alerts to notify users and enable immediate corrective action. Experimental implementation of the prototype demonstrates reliable monitoring of environmental parameters and effective real-time visualization through the IoT dashboard. The results indicate that the proposed system provides a cost-effective, scalable, and efficient solution for industrial safety monitoring. The integration of IoT technology with multi-sensor monitoring enhances situational awareness and improves the ability to detect potential hazards in industrial environments. Future improvements may include cloud-based data analytics, mobile application integration, and advanced predictive monitoring capabilities to further enhance industrial safety and operational efficiency.

IndexTerms **- Internet of Things (IoT), Industrial Monitoring System, ESP32 Microcontroller, Gas Leakage Detection, Flame Detection**

I. INTRODUCTION

The rapid transformation of industrial systems in the twenty–first century has been largely driven by the emergence of Industry 4.0, which represents the integration of digital technologies into traditional industrial operations. Industry 4.0 emphasizes the use of cyber-physical systems, cloud computing, big data analytics, and intelligent automation to improve productivity, efficiency, and safety in industrial environments. One of the core components of Industry 4.0 is the ability of machines and devices to communicate with each other through interconnected networks, enabling real-time data exchange and intelligent decision-making. As industries increasingly adopt smart manufacturing practices, the need for advanced monitoring and control mechanisms has become more critical. Among the enabling technologies supporting Industry 4.0, the Internet of Things (IoT) plays a significant role in transforming conventional industrial infrastructures into intelligent systems. IoT refers to a network of interconnected devices embedded with sensors, software, and communication capabilities that allow them to collect and exchange data over the internet. In industrial environments, IoT-based monitoring systems enable the continuous collection of data from machines, equipment, and environmental conditions. These systems facilitate predictive maintenance, process optimization, and enhanced safety by providing accurate and timely information to operators and decision-makers. In industrial automation, IoT technology allows sensors and microcontrollers to monitor various parameters such as temperature, humidity, gas concentration, flame detection, and illumination levels. By integrating these sensing devices with wireless communication technologies, industrial operators can monitor system conditions remotely through web platforms or mobile applications. Such capabilities significantly reduce the need for manual supervision and improve operational efficiency. Moreover, IoT-based monitoring systems can automatically trigger alerts when abnormal conditions are detected, thereby preventing potential accidents and equipment failures. Another critical aspect of modern industrial systems is the need for real-time monitoring. Industrial environments often involve hazardous processes and volatile substances that require constant observation to ensure safe operation. Traditional monitoring methods typically rely on manual inspection or isolated control systems that may not provide immediate feedback during emergencies. Real-time monitoring systems address this limitation by continuously collecting sensor data and transmitting it to a centralized platform where it can be analyzed instantly. The integration of microcontrollers such as ESP32 with Wi-Fi communication enables rapid data transmission and remote access to industrial parameters. Consequently, real-time monitoring systems play a crucial role in improving safety, minimizing downtime, and enhancing the reliability of industrial operations. Industrial environments are often exposed to multiple hazards that can threaten both human safety and operational stability. Many industrial facilities handle flammable gases, combustible materials, and high-temperature processes, which significantly increase the risk of accidents if not monitored properly. Despite advancements in automation, several industries still rely on conventional monitoring methods that are limited in their ability to provide continuous and remote supervision. One of the major risks in industrial settings is gas leakage, particularly in facilities where liquefied petroleum gas (LPG) or other combustible gases are used. Even a minor leakage can lead to dangerous situations, including explosions and fire outbreaks, if it remains undetected for an extended period. Early detection of gas leakage is therefore essential to prevent catastrophic incidents and ensure workplace safety. Another critical concern is the occurrence of fire accidents, which can result from electrical faults, overheating machinery, or combustible gas accumulation. Fires in industrial environments spread rapidly and may cause severe damage to equipment, infrastructure, and human life. Without an efficient fire detection system, identifying and controlling such incidents becomes extremely difficult. In addition to gas leakage and fire hazards, environmental parameter instability also poses challenges in industrial operations. Parameters such as temperature, humidity, and illumination levels directly affect the efficiency and reliability of industrial processes. For example, excessive heat or humidity can damage sensitive equipment and affect product quality in manufacturing environments. Therefore, maintaining stable environmental conditions is crucial for ensuring optimal industrial performance. The lack of an integrated monitoring system capable of detecting multiple parameters simultaneously often results in delayed responses to hazardous situations. Traditional monitoring systems may also require physical presence for inspection, which increases the risk to personnel and reduces operational efficiency. Hence, there is a strong need for a smart monitoring system that can continuously track industrial parameters, transmit real-time data, and generate immediate alerts when abnormal conditions are detected. The primary aim of this research is to develop an efficient and reliable industrial monitoring system that utilizes IoT technology for real-time observation of critical environmental and safety parameters. The specific objectives of this study are as follows:

1. **To design a multi-sensor monitoring system** capable of measuring key industrial parameters such as gas leakage, flame detection, temperature, humidity, and light intensity using appropriate sensors integrated with a microcontroller.
2. **To implement real-time Wi-Fi based data transmission** using the ESP32 microcontroller, enabling remote monitoring of industrial parameters through internet-based platforms.
3. **To develop an automated alert mechanism** that activates warning signals such as buzzers or notifications whenever the monitored parameters exceed predefined safety thresholds, thereby improving industrial safety and response time.

II. Literature Review

Anitha et al. (2023) developed an Internet of Things (IoT)-enabled air pollution monitoring system designed to measure and analyze environmental air quality in real time using gas sensors. The proposed system integrates multiple sensing modules capable of detecting harmful gases and particulate pollutants in the atmosphere. The sensors are connected to a microcontroller that collects environmental data and transmits it through wireless communication to a cloud-based monitoring platform. The system enables continuous monitoring and visualization of pollution levels through a web interface, allowing users to access real-time environmental information remotely. The authors emphasize the importance of low-cost sensor technologies for environmental monitoring in urban and industrial areas where air pollution poses serious health risks. Their findings demonstrate that IoT-based monitoring systems provide efficient and scalable solutions for environmental surveillance. The research highlights the potential of sensor networks and IoT platforms in improving environmental management and supporting data-driven decision-making for pollution control.

Gupta (2025) proposed an IoT-based intelligent safety system aimed at monitoring industrial hazards such as gas leakage, fire outbreaks, and environmental irregularities in industrial facilities. The system integrates multiple sensors including gas detection sensors, flame sensors, and temperature monitoring devices connected to a microcontroller-based control unit. Data collected from these sensors are transmitted through an IoT communication network to a remote monitoring platform where the parameters can be analyzed in real time. The system includes an automated alert mechanism that activates alarms and warning notifications whenever abnormal conditions are detected. The study emphasizes the importance of integrating safety monitoring technologies within industrial environments to reduce accidents and improve operational security. Experimental evaluations showed that the proposed system can quickly detect hazardous conditions and generate immediate alerts, thereby minimizing response time during emergencies. The research contributes to the development of intelligent industrial safety frameworks and demonstrates the effectiveness of IoT technologies in enhancing workplace safety.

Kiruthika and Umamakeswari (2019) designed an IoT-based air quality monitoring system for indoor environments to ensure healthy living and working conditions. The system utilizes various environmental sensors to measure parameters such as temperature, humidity, and concentrations of harmful gases present in indoor spaces. These sensors are connected to a microcontroller that collects environmental data and transmits it to an IoT cloud platform where it can be monitored in real time. The proposed system enables users to access air quality information through web or mobile interfaces, allowing them to take preventive measures when pollution levels exceed acceptable limits. The authors highlight that poor indoor air quality can significantly affect human health, productivity, and comfort. Therefore, continuous monitoring is essential for maintaining safe environmental conditions. The study demonstrates that IoT-based sensor networks provide an efficient and cost-effective approach for indoor environmental monitoring and contribute to the development of smart buildings and intelligent environmental management systems.

Kodali and Greeshma (2018) proposed an IoT-based industrial plant safety system designed to detect gas leakage in industrial environments. The system integrates gas sensors with an embedded microcontroller platform capable of detecting hazardous gas concentrations and transmitting the data to an IoT monitoring platform. The authors developed a real-time monitoring mechanism that allows industrial operators to track gas levels remotely through internet-based applications. When gas concentrations exceed predefined safety thresholds, the system automatically triggers alarms and notifications to alert personnel about potential risks. The research emphasizes the significance of early gas leakage detection in preventing industrial accidents, explosions, and environmental hazards. Experimental testing demonstrated that the proposed system could accurately detect gas leakage and provide rapid warning signals, thereby reducing response time during emergencies. The study highlights the advantages of IoT-based safety monitoring solutions, including real-time data accessibility, remote supervision, and improved industrial safety management.

Kodali et al. (2018) developed an industrial process monitoring system based on the ESP32 microcontroller to enable real-time monitoring of industrial parameters. The system utilizes various sensors to measure environmental and operational conditions such as temperature, humidity, and other process variables. The ESP32 microcontroller serves as the central processing unit, collecting sensor data and transmitting it through Wi-Fi connectivity to a remote server for monitoring and analysis. The authors highlight the advantages of ESP32, including low power consumption, integrated Wi-Fi capabilities, and high processing performance, which make it suitable for IoT-based industrial applications. The system enables continuous monitoring of industrial processes and allows operators to access operational data remotely through web-based platforms. Experimental evaluation demonstrated that the proposed system provides reliable data transmission and efficient monitoring of industrial parameters. The study emphasizes the role of IoT-enabled embedded systems in improving industrial automation, operational efficiency, and predictive maintenance.

Lu et al. (2024) proposed a smart air monitoring system based on IoT technology that integrates multiple MQ-series gas sensors with the ESP32 microcontroller. The system is designed to monitor air quality by detecting gases such as carbon monoxide, methane, and other environmental pollutants. Sensor readings are processed by the ESP32 microcontroller and transmitted to a cloud-based monitoring system where real-time air quality data can be analyzed and visualized. The study focuses on the application of IoT technologies in environmental monitoring and smart city infrastructures. The authors highlight that the use of multiple gas sensors improves detection accuracy and enables comprehensive monitoring of air pollutants. The proposed system also allows users to access environmental data through remote interfaces, enabling timely responses to hazardous conditions. Experimental results demonstrated the reliability and effectiveness of the system in detecting variations in air quality, indicating its potential for large-scale environmental monitoring applications.

Morchid et al. (2024) developed an IoT-enabled fire detection system designed to enhance monitoring and early detection of fire hazards in various environments. The proposed system integrates flame sensors and environmental sensors with IoT communication technologies to continuously monitor the surrounding conditions. Sensor data are transmitted to a cloud-based monitoring platform where they are analyzed in real time to detect abnormal patterns associated with fire outbreaks. The system incorporates automated alert mechanisms that notify users or emergency services when fire risks are detected. The authors highlight the importance of early fire detection in minimizing property damage, environmental loss, and threats to human life. The research demonstrates how IoT-based monitoring solutions can significantly improve fire safety by enabling remote surveillance and automated risk detection. The proposed system also supports scalable deployment in smart buildings, industrial environments, and agricultural monitoring systems where fire hazards pose significant risks.

Sarkar et al. (2024) presented an ESP32-based gas detection system integrated with the Blynk IoT platform for real-time monitoring and safety management. The system employs gas sensors to detect the presence of hazardous gases and transmit the collected data to a cloud-based application through the ESP32 microcontroller. The Blynk platform allows users to monitor gas concentration levels through a mobile interface, providing real-time visualization and notifications. The system also includes an automated alert mechanism that activates alarms when gas concentrations exceed predefined safety limits. The authors emphasize that integrating IoT platforms with embedded sensor systems significantly improves the accessibility and responsiveness of safety monitoring systems. Experimental testing demonstrated that the proposed system can effectively detect gas leaks and provide immediate alerts to users, thereby reducing the risk of accidents. The study highlights the potential of IoT-enabled gas monitoring systems in enhancing safety in residential, commercial, and industrial environments.

III. Proposed System Architecture

The system architecture is organized into multiple functional layers to ensure efficient monitoring and management of environmental conditions. The sensing layer is responsible for collecting environmental data from different monitoring zones using various sensor modules. In the developed prototype, multiple sensors are deployed to measure critical parameters such as gas concentration, flame detection, temperature, humidity, and light intensity. A gas sensor module is installed near the microcontroller board to detect combustible gases such as LPG or methane and continuously monitor gas concentration levels.

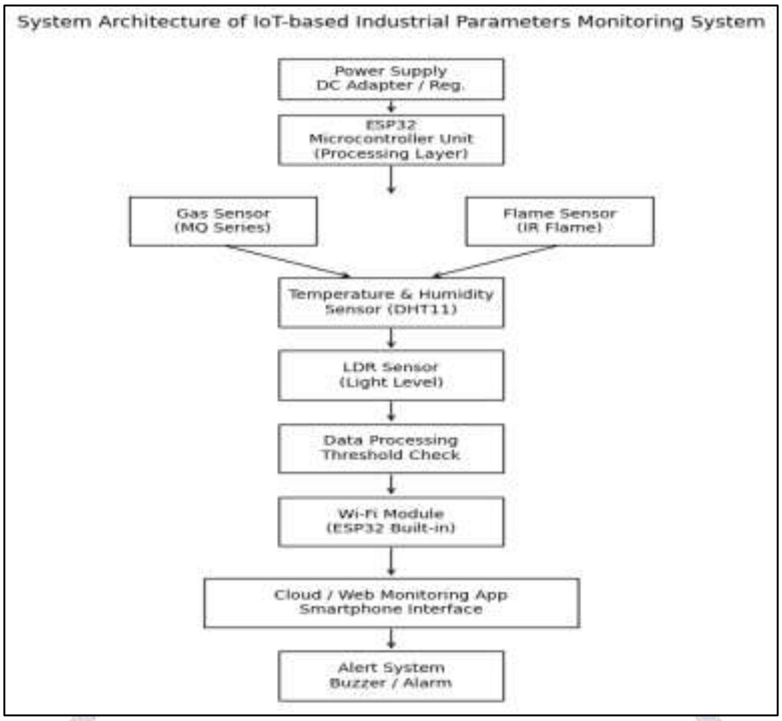

Figure 1: System architecture

A flame sensor module is placed in one of the monitored areas to detect infrared radiation emitted by flames and immediately notify the system when fire activity is detected. A temperature and humidity sensor module is used to measure environmental temperature and relative humidity levels to maintain environmental stability and detect abnormal temperature variations. Additionally, an LDR sensor module monitors ambient light intensity by varying its resistance based on the incident light. Each sensor module includes an onboard comparator circuit with adjustable sensitivity through a potentiometer and indicator LEDs to display sensor activity. The processing layer consists of the ESP32 microcontroller, which acts as the central controller of the system and processes signals received from all connected sensors through its GPIO pins. The ESP32 executes firmware developed using the Arduino programming environment to analyze sensor readings and compare them with predefined threshold values in order to determine whether the environmental conditions are safe or hazardous. When abnormal conditions such as gas leakage or fire detection occur, the microcontroller activates warning mechanisms and transmits alert information to the monitoring platform. The communication layer facilitates wireless transmission of sensor data using the built-in Wi-Fi module of the ESP32, enabling the processed environmental data to be transmitted to a remote monitoring platform through the internet. This allows users to observe system parameters remotely through smartphones or web-based dashboards without requiring wired communication links. The system is powered through a regulated DC power supply connected via a DC jack, which provides stable voltage to the ESP32 microcontroller and all sensor modules to ensure reliable system operation. The user interface and alert layer enables operators to monitor environmental conditions in real time through a smartphone or web-based monitoring interface. When sensor readings exceed predefined threshold values, the system generates alerts to notify users about potential hazards such as gas leakage, fire detection, or abnormal environmental conditions, while indicator LEDs on the sensor modules provide visual confirmation of sensor activity during system operation.

IV. Hardware Design

The hardware design of the proposed industrial parameters monitoring system consists of multiple sensing modules integrated with an ESP32 microcontroller to monitor environmental conditions in real time. The system is developed as a prototype mounted on a wooden base board where different sensors are connected to the microcontroller through jumper wires and a soldered circuit board. The hardware architecture is designed to detect important industrial parameters such as gas leakage, flame presence, temperature, humidity, and ambient light intensity. These parameters are continuously monitored and transmitted to a remote monitoring interface through the ESP32 microcontroller using wireless communication. The complete hardware system consists of the following main components: ESP32 microcontroller development board, flame sensor module, LPG gas sensor module (MQ-5), DHT11 temperature and humidity sensor module, LDR sensor module, power supply unit, buzzer alert system, and the supporting circuit components mounted on a base platform.

1 ESP32 MICROCONTROLLER

The ESP32 microcontroller is the central processing unit of the proposed monitoring system. It is a low-cost, low-power system-on-chip developed by Espressif Systems specifically for Internet of Things applications. The ESP32 used in the prototype is based on the ESP-WROOM-32 module and operates using a dual-core 32-bit Tensilica Xtensa LX6 microprocessor with a maximum clock frequency of 240 MHz. The microcontroller includes integrated Wi-Fi and Bluetooth communication capabilities which allow the system to transmit sensor data to remote monitoring platforms. The ESP32 development board includes several additional components such as a USB-to-UART interface, voltage regulator, flash memory, and GPIO pin headers for interfacing with external sensors. The board supports 34 programmable GPIO pins which can be configured for digital input, digital output, analog input, and communication interfaces. It also includes a 12-bit analog-to-digital converter with multiple channels for reading analog signals from sensors. Additional communication interfaces supported by the ESP32 include SPI, I2C, UART, and I2S which enable flexible communication with peripheral devices. In the proposed system, the ESP32 receives signals from all connected sensor modules, processes the data using embedded firmware developed in the Arduino IDE environment, compares the sensor readings with predefined threshold values, and transmits the monitoring data through Wi-Fi communication to a remote smartphone or web monitoring interface.

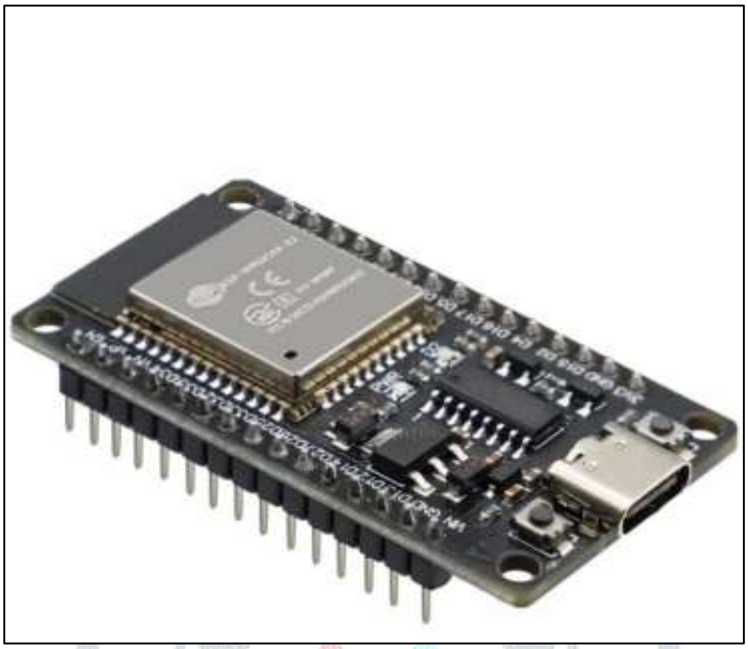

Figure 2: ESP32 Microcontroller

2 **FLAME SENSOR MODULE**

The flame sensor module is used in the system to detect the presence of fire or high-temperature zones. This sensor works by detecting infrared radiation emitted by flames. Typically, flames emit infrared radiation within a wavelength range between approximately 700 nm and 1100 nm, which can be detected by the sensor’s infrared photodiode. The flame sensor module used in the prototype contains a photodiode sensing element along with supporting electronic components such as resistors, capacitors, a comparator circuit (LM393), and an adjustable potentiometer. The comparator circuit processes the signal generated by the photodiode and compares it with a predefined threshold value to determine whether a flame is present. When the detected infrared radiation exceeds the threshold level, the sensor generates a digital signal that is transmitted to the ESP32 microcontroller. The module typically operates with a working voltage between 3.3V and 5V and supports both analog and digital output signals. The sensor has an approximate detection angle of 60 degrees and can detect flame sources within a distance of up to around 3 feet depending on environmental conditions. The onboard potentiometer allows adjustment of sensor sensitivity so that the detection range can be calibrated according to the application environment.

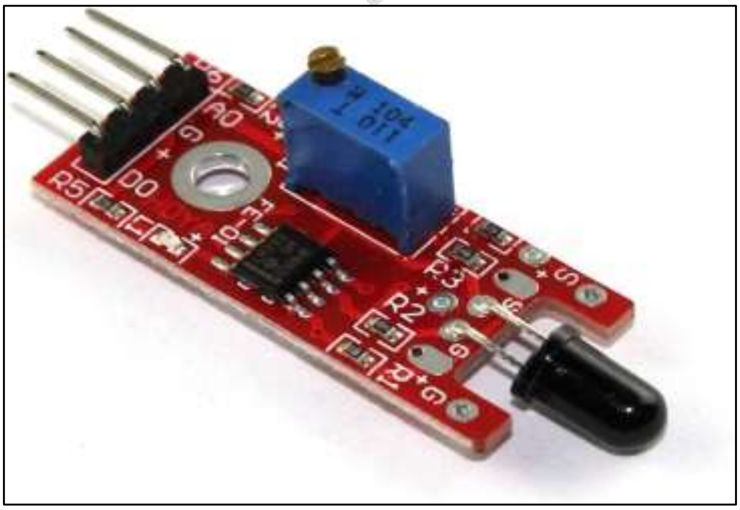

Figure 3: Flame sensor module

3 LPG Gas Sensor Module (MQ-5)

The LPG gas sensor module is used to detect the presence of combustible gases such as liquefied petroleum gas (LPG), propane, methane, and isobutane in the surrounding environment. The sensor module used in the prototype is based on the MQ-5 gas sensing element. The MQ-5 sensor operates using a semiconductor sensing material made of tin dioxide (SnO_2). The electrical resistance of this material changes when exposed to combustible gases. When the concentration of gas increases, the resistance of the sensing element decreases, resulting in a measurable change in output voltage. This variation in voltage is interpreted by the microcontroller to determine the presence of gas leakage. The MQ-5 module provides both analog output and digital output signals. The analog output corresponds to the gas concentration level, while the digital output is triggered when the gas concentration exceeds a predefined threshold. The module includes an onboard potentiometer that allows adjustment of the sensitivity level. An indicator LED on the module also provides visual confirmation when gas is detected. Gas sensors are particularly important in industrial and domestic environments where LPG leakage can cause serious accidents. The sensor used in this system helps detect gas leakage quickly and triggers an alert before the gas concentration reaches dangerous levels.

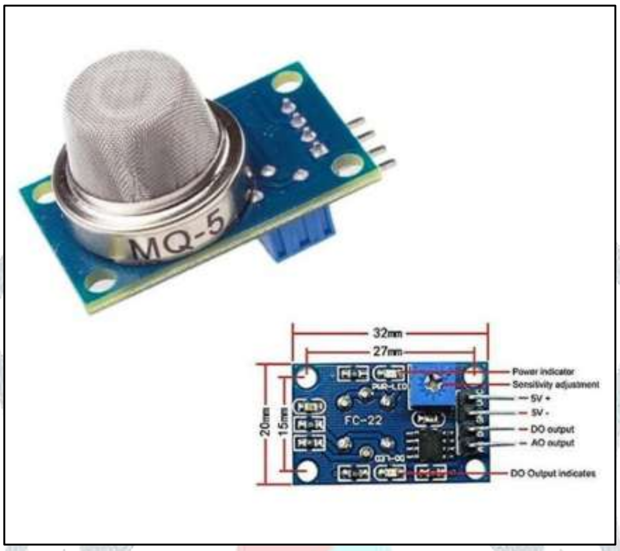

Figure 4: LPG Gas Sensor Module (MQ-5)

4 DHT11 Temperature and Humidity Sensor

The DHT11 sensor module is used to measure environmental temperature and relative humidity conditions in the monitored area. The sensor integrates a humidity sensing element and a thermistor to measure these environmental parameters. The humidity sensing element consists of two electrodes separated by a moisture-holding substrate. When water vapor in the air is absorbed by the substrate, ions are released which increase the conductivity between the electrodes. This change in electrical resistance corresponds to the relative humidity level of the environment. The temperature measurement is performed using an NTC thermistor whose resistance changes with temperature variations. An internal microcontroller within the DHT11 sensor processes the analog signals from the sensing elements, converts them into digital values using analog-to-digital conversion, and transmits the calibrated digital data to the ESP32 microcontroller. The DHT11 sensor operates within a temperature range of 0°C to 50°C and a humidity range of 20% to 90% relative humidity. It provides digital output signals and typically produces one measurement reading per second. Because the sensor is factory calibrated, it does not require additional calibration circuits for normal operation.

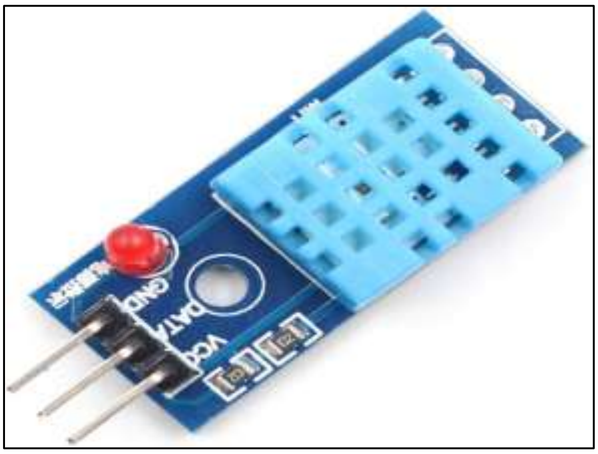

Figure 5: DHT11 sensor

5. LDR Sensor Module

The LDR sensor module is used to measure ambient light intensity in the monitoring environment. The sensing element of the module is a light dependent resistor or photoresistor whose resistance changes based on the intensity of incident light. When exposed to bright light, the resistance of the LDR decreases significantly, allowing more current to flow through the circuit. Conversely, when the environment becomes darker, the resistance increases and the current flow decreases. This change in resistance is converted into an electrical signal which can be interpreted by the microcontroller. The LDR sensor module used in the prototype includes an LM393 comparator circuit that converts the analog voltage signal into a digital output signal based on a threshold value. The module also includes an adjustable potentiometer that allows users to set the threshold light intensity level at which the digital output is triggered. The module typically operates with a supply voltage between 3.3V and 5V and provides both analog output and digital output signals. Indicator LEDs on the module display the power status and detection status of the sensor.

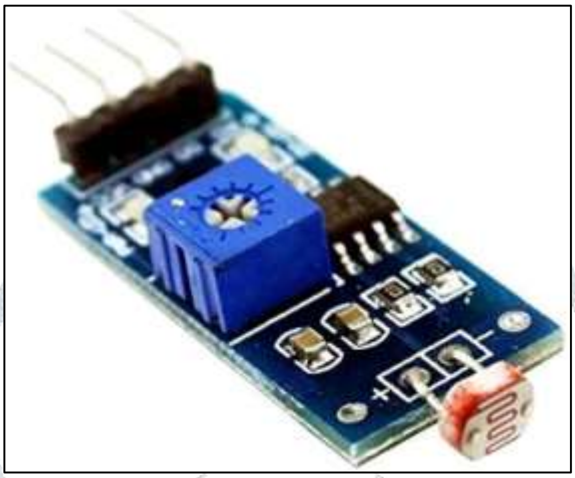

Figure 6: LM393

4.6 Power Supply Unit

The power supply unit provides stable electrical power to the entire monitoring system. In the developed prototype, an external DC power adapter is used as the primary power source. The power input is connected through a DC jack mounted on the circuit board. The system operates using regulated voltage levels required by the ESP32 microcontroller and sensor modules. The ESP32 microcontroller operates at 3.3V, while some of the sensor modules operate at 5V supply voltage. Therefore, voltage regulation circuits are used to convert the input supply voltage to appropriate levels for different components. Proper voltage regulation and grounding ensure stable system performance and prevent electrical noise or voltage fluctuations that may affect sensor accuracy.

4.7 Hardware Integration and Prototype Implementation

The complete hardware prototype of the proposed monitoring system is assembled on a base platform where all sensor modules are connected to the ESP32 microcontroller through jumper wires and soldered connections. The sensors are arranged in separate monitoring areas to simulate industrial parameter monitoring zones. Each sensor module includes indicator LEDs that display active detection signals during operation. The gas sensor, flame sensor, temperature and humidity sensor, and LDR sensor continuously monitor environmental conditions and transmit their signals to the ESP32 microcontroller. The ESP32 processes these signals and transmits the monitoring data to a remote smartphone interface through Wi-Fi communication. When abnormal environmental conditions are detected, the system triggers warning alerts to notify the user.

V. Methodology

The methodology of the proposed IoT-based industrial parameters monitoring system describes the systematic procedure adopted for the development, implementation, and operation of the monitoring framework. The methodology integrates both hardware and software components to ensure continuous monitoring of environmental conditions and timely detection of hazardous situations in industrial environments. The system utilizes multiple sensors connected to an ESP32 microcontroller to measure parameters such as gas concentration, flame presence, temperature, humidity, and light intensity. The collected sensor data are processed by the microcontroller and transmitted to a remote monitoring interface through wireless communication. The system operation begins with the initialization of hardware and software components. During this stage, the ESP32 microcontroller configures the input and output pins connected to various sensor modules including the MQ-5 gas sensor, flame sensor, DHT11 temperature and humidity sensor, and LDR module. At the same time, the Wi-Fi communication module integrated within the ESP32 establishes a connection with the available wireless network to enable data transmission to the remote monitoring platform. The firmware of the monitoring system is developed using the Arduino Integrated Development Environment. The Arduino IDE provides an open-source platform for writing, compiling, and uploading programs to microcontroller boards. The programming language used in this environment is based on C and C++, which allows efficient development of embedded system applications. The development process involves writing the program code, compiling the code to detect errors, and uploading the compiled firmware to the ESP32 microcontroller. Once the program is uploaded, the microcontroller continuously executes the monitoring algorithm to collect and process sensor data.

To simplify the interaction between hardware components and the microcontroller, several software libraries are used within the Arduino environment. The Wi-Fi library enables the ESP32 to connect to wireless networks and transmit sensor readings to cloud or web-based monitoring platforms. The DHT sensor library is used to obtain temperature and humidity data from the DHT11 module, while the serial communication library allows monitoring of sensor outputs and debugging through the serial monitor interface. These libraries provide predefined functions that reduce programming complexity and improve the reliability of system operation. The algorithm implemented in the system defines the logical sequence of operations performed by the microcontroller during the monitoring process. The algorithm operates in a continuous loop that repeatedly reads sensor values, processes the data, and evaluates environmental conditions. The monitoring process begins with the acquisition of real-time sensor readings. The ESP32 microcontroller collects analog and digital signals from the sensors and converts them into numerical values that represent environmental parameters such as gas concentration, temperature, humidity, flame detection, and light intensity.

After acquiring the sensor data, the microcontroller compares the measured values with predefined threshold limits stored within the program. These threshold values represent safe operating conditions in the industrial environment. If the sensor readings remain within the acceptable limits, the system continues normal monitoring operations. However, if any parameter exceeds the defined safety threshold, the system identifies the situation as potentially hazardous. When abnormal conditions such as gas leakage or fire detection are identified, the system activates the alert mechanism by triggering a buzzer alarm. The buzzer provides an immediate audible warning in the monitored environment, allowing personnel to respond quickly to the detected hazard. At the same time, the ESP32 microcontroller transmits the sensor readings and system status information to a cloud server or web-based monitoring interface through the Wi-Fi communication module.

The transmitted data are displayed on a remote web dashboard where users can monitor environmental conditions in real time. The monitoring interface provides visualization of sensor data through graphical displays and parameter values, allowing operators to observe system behavior and detect abnormal patterns. Remote accessibility of monitoring information improves operational efficiency and enhances safety in industrial environments.

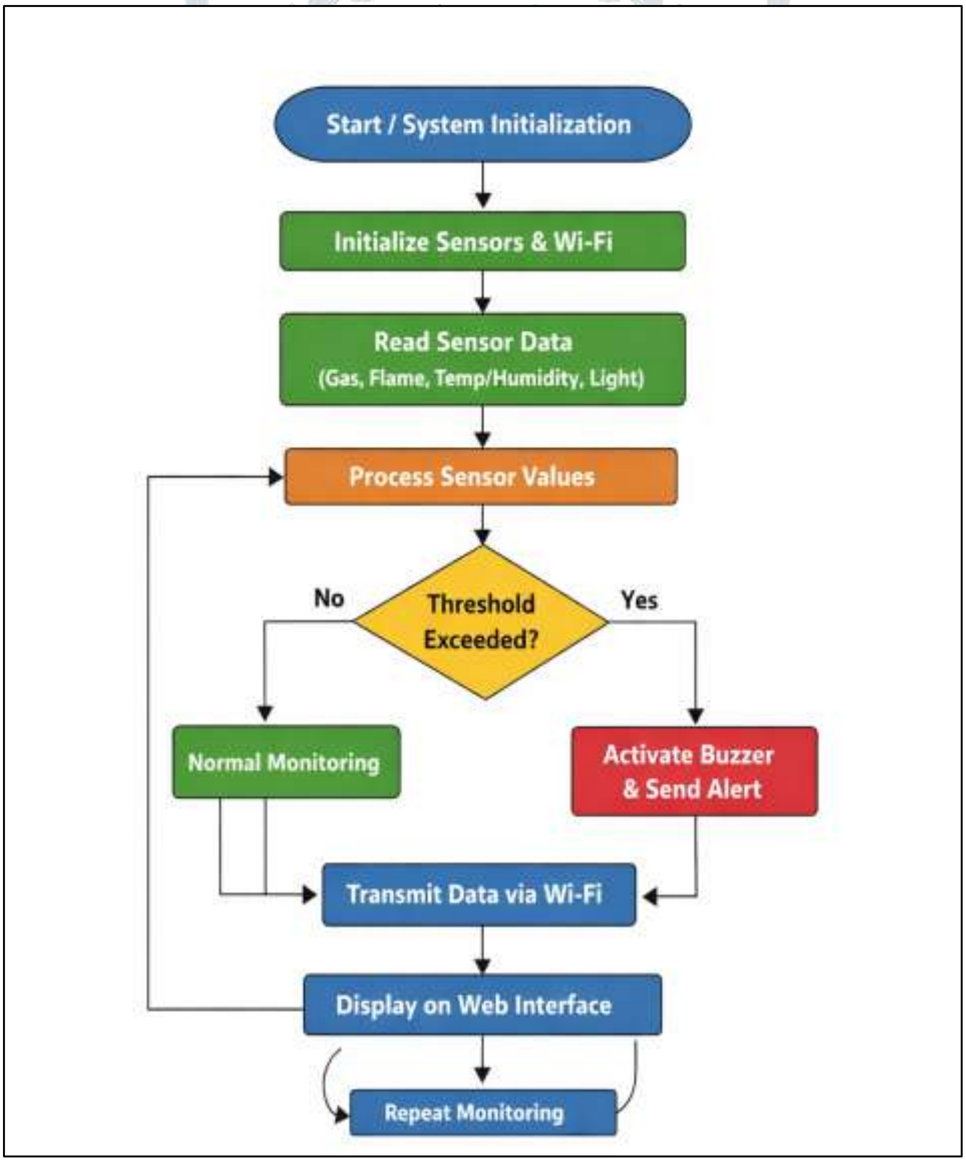

Figure 7: Flowchart

VI. Experimental Setup

The system is designed to monitor multiple environmental parameters in real time using a combination of sensors integrated with an ESP32 microcontroller. The hardware components are mounted on a prototype board to demonstrate the operational functionality of the monitoring framework and to simulate industrial environmental monitoring conditions. The central processing unit of the system is the ESP32 development board, which functions as the primary controller responsible for collecting sensor data, processing the readings, and transmitting the information through Wi-Fi communication to a remote monitoring interface. The ESP32 module is equipped with integrated wireless communication capabilities and multiple general purpose input and output pins, enabling seamless integration with various sensor modules used in the system.

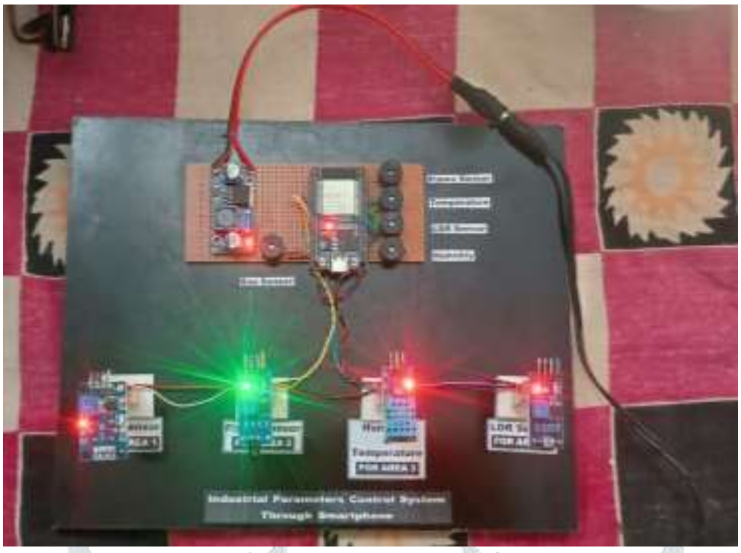

Figure 8: Experimental setup

The system incorporates several sensing modules to monitor different environmental parameters. A gas sensor module is installed to detect the presence of combustible gases such as liquefied petroleum gas, methane, and propane. The sensor operates by measuring changes in electrical resistance caused by variations in gas concentration within the surrounding environment. When the gas concentration exceeds predefined safety limits, the monitoring system identifies the abnormal condition and initiates warning indicators. A flame sensor module is integrated to detect the presence of fire or high-intensity infrared radiation emitted by flames. This sensor operates within a wavelength detection range of approximately 760 nm to 1100 nm, allowing it to detect flame sources within a limited distance. The flame sensor provides output signals that are interpreted by the microcontroller to identify potential fire hazards. Environmental conditions such as temperature and humidity are monitored using a DHT11 temperature and humidity sensor module. The DHT11 sensor contains a thermistor for temperature measurement and a capacitive humidity sensing element for detecting relative humidity levels.

The sensor provides digital output signals which are transmitted directly to the ESP32 microcontroller for processing and monitoring. In addition, the system incorporates an LDR sensor module to measure ambient light intensity. The resistance of the light dependent resistor changes according to the amount of incident light falling on its surface. As the intensity of light increases, the resistance decreases, allowing the system to detect variations in illumination levels. This feature enables monitoring of environmental lighting conditions and detection of sudden changes in light intensity. Each sensor module is connected to the ESP32 microcontroller through jumper wires, forming a compact embedded monitoring network. The sensors are positioned on the prototype board to represent different monitoring zones, as indicated by the labeled sections such as Area 1, Area 2, Area 3, and Area 4.

This configuration demonstrates how the monitoring system can be expanded to observe multiple locations within an industrial environment. The entire system is powered through a regulated direct current power supply that provides stable voltage to both the microcontroller and sensor modules. Light emitting diodes integrated within the sensor modules indicate operational status and sensor responses during experimental testing. The prototype demonstrates the practical implementation of a multi-sensor IoT monitoring platform capable of detecting hazardous conditions such as gas leakage, fire occurrence, abnormal temperature and humidity levels, and variations in illumination. The system is designed to transmit real-time monitoring data to a smartphone or web-based interface, enabling remote supervision of industrial environmental conditions and facilitating rapid response to potential industrial hazards.

VII. Results and Discussion

The output of the proposed industrial parameters monitoring system is visualized through a web-based dashboard that provides real-time monitoring of environmental conditions detected by the connected sensors. The dashboard interface displays key parameters such as temperature, humidity, ambient light intensity, gas concentration level, and flame detection status. These parameters are continuously transmitted from the ESP32 microcontroller to the monitoring platform using Wi-Fi communication, enabling users to observe system conditions remotely through a computer or smartphone interface.

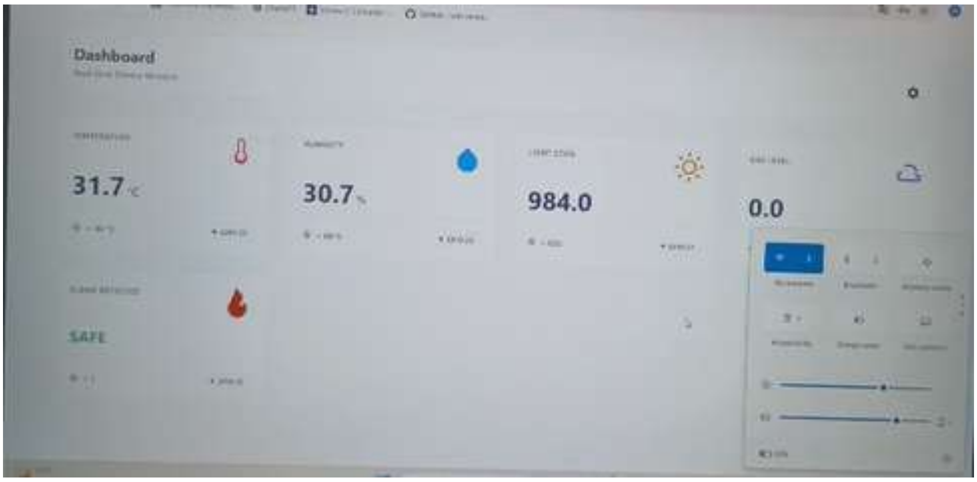

Figure 9. Real-time web dashboard displaying monitored industrial parameters including temperature, humidity, light intensity, gas level, and flame detection status.

As shown in the dashboard output, the temperature reading is displayed as 31.7°C, which represents the current environmental temperature measured by the DHT11 temperature sensor. The humidity level is displayed as 30.7%, indicating the relative humidity in the monitored environment. The light intensity value is shown as 984.0, which represents the analog output level from the LDR sensor module corresponding to the surrounding illumination conditions. The gas level indicator shows a value of 0.0, indicating that no combustible gas has been detected by the MQ-5 gas sensor at the time of monitoring. Additionally, the flame detection panel displays the status as "SAFE," confirming that no flame or fire has been detected by the flame sensor module.

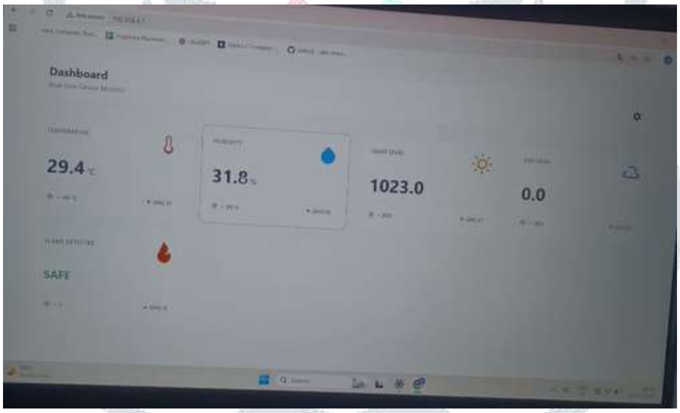

Figure 10. Real-time web dashboard displaying monitored industrial parameters including temperature, humidity, light intensity, gas level, and flame detection status.

The monitoring results of the proposed industrial parameters monitoring system are presented through a real-time web-based dashboard interface. The dashboard provides a clear visualization of environmental parameters collected from different sensors connected to the ESP32 microcontroller. The displayed parameters include temperature, humidity, ambient light intensity, gas concentration level, and flame detection status. These readings are continuously transmitted to the monitoring platform using Wi-Fi communication, allowing users to remotely observe the system status through a computer or smartphone interface. As illustrated in the dashboard output, the temperature value recorded by the DHT11 sensor is 29.4°C, representing the current environmental temperature within the monitored area. The relative humidity level is displayed as 31.8%, which indicates the moisture content present in the surrounding atmosphere. The light intensity measured by the LDR sensor module is shown as 1023.0, which corresponds to the analog sensor output representing the brightness level in the monitored environment. The gas concentration level detected by the MQ-5 gas sensor is indicated as 0.0, confirming that no combustible gas leakage is present during the monitoring period. Additionally, the flame detection indicator shows the system status as "SAFE," which confirms that no flame or fire has been detected by the flame sensor module. The dashboard interface includes visual icons and numerical indicators that allow operators to easily interpret sensor readings and evaluate environmental conditions. This real-time monitoring capability enables early detection of abnormal conditions such as gas leakage, fire occurrence, excessive temperature rise, or unusual lighting conditions. By continuously transmitting sensor data to the monitoring platform, the system enhances industrial safety and provides users with the ability to monitor environmental parameters remotely and respond promptly to potential hazards.

VIII. Conclusion

This study presented the design and implementation of an Internet of Things (IoT)-based industrial parameters monitoring system capable of monitoring critical environmental conditions in real time. The proposed system integrates multiple sensors including a gas sensor, flame sensor, temperature and humidity sensor (DHT11), and an LDR light sensor with an ESP32 microcontroller to continuously monitor parameters such as combustible gas leakage, fire detection, temperature, humidity, and ambient light intensity. The ESP32 microcontroller serves as the central processing unit that collects sensor data, processes the readings, compares them with predefined safety thresholds, and transmits the monitoring information to a web-based dashboard through Wi-Fi communication. The developed prototype demonstrates the capability of real-time monitoring and remote visualization of environmental parameters using a web interface accessible through computers or smartphones. The system effectively detects abnormal conditions such as gas leakage and flame presence and provides immediate alerts, thereby enhancing industrial safety and reducing the risk of hazardous incidents. Experimental testing and dashboard outputs confirm that the proposed system can reliably monitor environmental parameters and present them through a user-friendly monitoring interface. The results indicate that the integration of IoT technologies with embedded sensor systems can significantly improve monitoring efficiency and operational safety in industrial environments. The system offers advantages such as low cost, wireless communication capability, scalability, and ease of deployment. Furthermore, the modular architecture of the proposed system allows additional sensors and monitoring features to be integrated in the future. Future enhancements of the system may include the integration of advanced sensors with higher accuracy, implementation of cloud-based data analytics, incorporation of machine learning techniques for predictive safety analysis, and development of mobile application interfaces for enhanced monitoring and control. The proposed IoT-based industrial monitoring system therefore provides a reliable and scalable solution for real-time industrial safety monitoring and environmental parameter management.

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