

# Smart Industrial Safety Monitoring Using WSN And GSM Alert System

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## Abstract:

This paper presents the design and implementation of a Smart Industrial Safety Monitoring System using Wireless Sensor Network (WSN) technology integrated with a GSM alert mechanism. Industrial environments are highly prone to hazards such as overheating, fire outbreaks, gas leakage, and abnormal environmental conditions, which may lead to equipment damage and safety risks for workers. The proposed system continuously monitors critical parameters including temperature, smoke levels, and light intensity using appropriate sensors. The collected data is processed by a microcontroller and compared with predefined safety thresholds. Whenever any parameter exceeds the permissible limit, the system automatically triggers an alert through a GSM module to notify responsible personnel via SMS. Additionally, a relay mechanism is incorporated to disconnect power to critical equipment during emergency conditions to prevent further damage. The developed prototype provides a low-cost, reliable, and real-time industrial monitoring solution that enhances operational safety, reduces human intervention, and minimizes potential industrial accidents.

**Keywords — Industrial Safety, Wireless Sensor Network (WSN), GSM Module, Sensors of Smoke Detection Temperature Monitoring, Relay Protection System, Real-Time Monitoring.**

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## I. INTRODUCTION

Industrial safety has become one of the most critical concerns in modern manufacturing environments due to the increasing use of hazardous materials, heavy machinery, and high-temperature processes. Industrial accidents caused by gas leakage, overheating, fire outbreaks, and

electrical faults can result in severe equipment damage, financial loss, and risk to human life. According to global industrial safety reports, improper monitoring and delayed detection of abnormal environmental conditions remain major contributors to industrial disasters. Therefore, real-time monitoring systems have become essential for ensuring safe and efficient industrial operations.

Wireless Sensor Networks (WSNs) have emerged as an effective solution for environmental and industrial monitoring applications. Akyildiz et al. (2002) described WSNs as distributed sensor systems capable of sensing, processing, and transmitting environmental data efficiently. Due to their low power consumption, scalability, and flexibility, WSNs are widely used in industrial automation and safety monitoring systems. The use of wireless communication eliminates complex wiring structures and enables remote supervision of critical parameters.

Gas leakage is one of the primary causes of industrial accidents, especially in chemical plants and oil refineries. MQ-series gas sensors are commonly used for detecting combustible gases due to their sensitivity and cost-effectiveness. Studies by Kumar and Singh (2018) demonstrated that microcontroller-based gas detection systems can effectively reduce response time during hazardous gas leakage conditions. Similarly, temperature monitoring plays a vital role in preventing overheating and fire incidents. Excessive temperature rise in industrial equipment can lead to malfunction or explosion if not detected in time.

GSM-based communication systems have been widely adopted for remote alerting purposes. Mazidi et al. (2008) highlighted the effectiveness of integrating microcontrollers with GSM modules for sending automated SMS notifications during abnormal conditions. GSM technology offers reliable long-distance communication and ensures that responsible personnel receive alerts instantly, regardless of their location. However, many existing monitoring systems focus only on sending alerts and lack automatic protective mechanisms such as power disconnection.

Recent research efforts have attempted to combine embedded systems with safety automation features. (2008) emphasized the importance of anomaly detection techniques in wireless sensor networks for industrial monitoring. Although these systems improve detection accuracy, integration with automatic relay-based shutdown mechanisms is often limited.

Considering the limitations of existing systems, there is a need for a compact, low-cost, and integrated industrial safety solution that combines real-time sensing, wireless communication, remote alerting, and automatic protective action. The proposed Smart Industrial Safety Monitoring System addresses these requirements by integrating a PIC16F877A microcontroller, gas and temperature sensors, RF-based wireless communication, GSM alert system, and relay-based power control into a unified framework.

The primary objective of this research is to develop a reliable and efficient monitoring system capable of detecting hazardous industrial conditions in real time and initiating immediate preventive action. By combining Wireless Sensor Network technology with GSM-based communication and automated relay control, the proposed system enhances industrial safety, minimizes human intervention, and reduces the risk of large-scale accidents.

## **II. LITERATURE REVIEW**

Industrial safety monitoring has been an active area of research due to increasing industrial automation and associated risks. Several researchers have proposed systems using wireless communication, embedded controllers, and sensor technologies to enhance workplace safety.

Wireless Sensor Networks (WSNs) have been widely adopted for real-time environmental monitoring. Akyildiz et al. highlighted that WSNs provide scalable and energy-efficient solutions for distributed sensing applications. WSN-based monitoring systems enable remote data acquisition, reduced wiring complexity, and improved flexibility in industrial environments.

Gas detection systems using MQ-series sensors have been extensively studied for leakage detection in industrial and domestic environments. Researchers have implemented microcontroller-based gas monitoring systems capable of detecting LPG, methane, and other combustible gases. However, many of these systems are limited to local alarms and do not provide remote notification capabilities.

Temperature monitoring systems using thermistors and semiconductor sensors have also been proposed for industrial equipment protection. Excessive temperature is one of the major causes of machinery failure and fire hazards. Previous works demonstrate that integrating temperature sensors with microcontrollers enables continuous monitoring and threshold-based alert systems.

GSM-based alert mechanisms have gained popularity due to their reliability and wide network coverage. Several studies implemented GSM modules to send SMS alerts during abnormal conditions. These systems reduce emergency response time and allow remote supervision. However, many existing GSM-based systems lack wireless sensor integration and automatic machine shutdown features.

Some recent works combine embedded systems with relay control mechanisms for automated power disconnection during hazardous situations. Although such systems improve safety, they often rely on wired sensor networks, which limit scalability and installation flexibility.

Despite significant advancements, most existing solutions focus either on monitoring or alerting, but not both integrated with automatic shutdown and wireless communication. Therefore, there is a need for a compact, low-cost, and fully integrated system that combines WSN technology, GSM alerts, real-time monitoring, and relay-based automation.

The proposed Smart Industrial Safety Monitoring System addresses these limitations by integrating:

- Wireless Sensor Network (RF-based communication)
- GSM-based SMS alert system
- Multi-parameter sensing (Gas, Temperature, Light)
- Automatic relay-based power disconnection

This integrated approach enhances industrial safety, minimizes human intervention, and ensures rapid emergency response.

### III. PROPOSED SYSTEM ARCHITECTURE

The proposed Smart Industrial Safety Monitoring System is designed to continuously

monitor critical industrial parameters and provide real-time alerts during hazardous conditions. The architecture integrates Wireless Sensor Network (WSN) technology with GSM communication and automatic relay-based control for enhanced industrial safety.

The system is divided into two major units:

1. Sensor (Transmitter) Unit
2. Control and Alert (Receiver) Unit

Both units communicate wirelessly using RF modules, ensuring flexibility and ease of installation in industrial environments.

#### A. Overall System Design

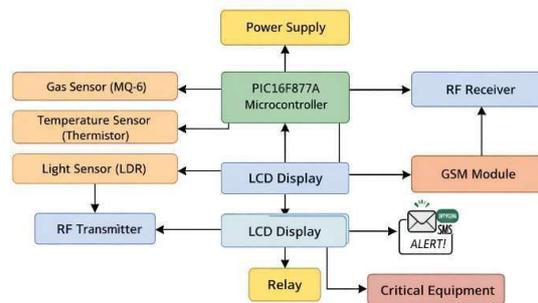


Fig. 1: Block Diagram of Smart Industrial Safety Monitoring System

The block diagram illustrates the functional relationship between sensors, microcontroller, wireless communication modules, GSM module, relay unit, and display system.

#### B. Processing and Control Unit

The processing unit is built around the PIC16F877A microcontroller. It performs analog-to-digital conversion of sensor signals and compares the obtained values with predefined threshold limits. The controller executes a continuous monitoring algorithm to ensure real-time detection of abnormal conditions.

#### C. Alert and Protection Unit

The alert mechanism is implemented using a GSM module. When any parameter exceeds the

permissible safety limit, the microcontroller sends AT commands to the GSM module to transmit an SMS alert to authorized personnel. Simultaneously, a relay driver circuit is activated to disconnect power supply to critical industrial equipment, thereby preventing further damage or hazards.

#### D. Display and Power Supply Unit

An LCD module is used to display real-time sensor readings and system status. The system is powered through a regulated DC supply consisting of a step-down transformer, rectifier, filter capacitor, and 7805 voltage regulator.

### IV. METHODOLOGY

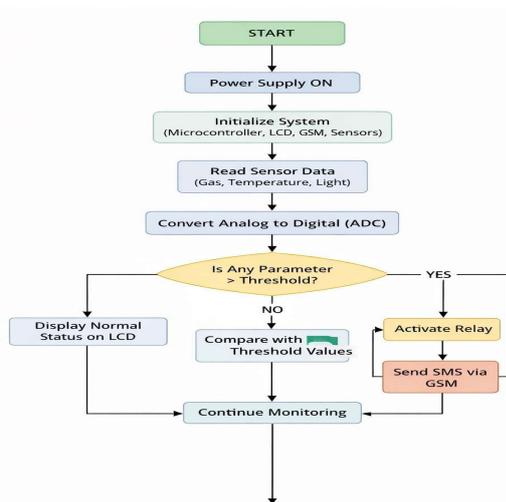


Fig. 2: Flowchart of Proposed System Methodology

The methodology of the proposed Smart Industrial Safety Monitoring System is based on continuous environmental sensing, data processing, threshold comparison, and emergency response activation. The system operates in a cyclic monitoring loop to ensure real-time detection of hazardous industrial conditions.

Initially, the power supply unit provides regulated DC voltage to all system components. After initialization, the PIC16F877A microcontroller configures the sensors, GSM module, RF communication module, and LCD display.

The gas sensor (MQ-6), temperature sensor (thermistor), and light sensor (LDR) continuously

monitor environmental parameters. The analog signals generated by these sensors are converted into digital form using the internal Analog-to-Digital Converter (ADC) of the microcontroller.

The digital sensor values are then compared with predefined threshold limits stored in the microcontroller program. If the measured values remain within safe limits, the system continues normal monitoring and displays real-time readings on the LCD.

However, if any parameter exceeds its threshold value, the controller immediately activates the relay circuit to disconnect power to critical industrial equipment. Simultaneously, the GSM module is triggered using AT commands to send an SMS alert to authorized personnel, informing them about the detected hazard.

After executing the alert and protection mechanism, the system returns to monitoring mode and continues the process in a loop. This methodology ensures rapid detection, automatic protection, and remote notification under emergency conditions.

### V. CIRCUIT DIAGRAM

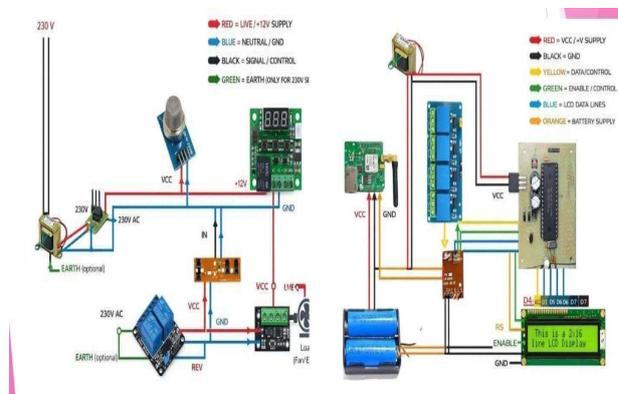


Fig. 3 Circuit Diagram of Smart Industrial Safety Monitoring System

Fig. 3 illustrates the complete circuit diagram of the proposed Smart Industrial Safety Monitoring System. The circuit consists of a regulated power supply unit, sensing modules, PIC16F877A

microcontroller, RF communication module, GSM module, relay driver circuit, and LCD display unit.

- The power supply section includes a 230V AC input, step-down transformer, rectifier, filter capacitor, and voltage regulator to provide regulated DC voltage to all components. The MQ-6 gas sensor, temperature sensor, and light sensor are interfaced with the analog input pins of the PIC16F877A microcontroller.
- The RF transmitter and receiver modules enable wireless data communication between sensing and control sections. The GSM module is connected through UART communication for transmitting SMS alerts using AT commands.
- A relay module is interfaced with the microcontroller through a driver circuit to control external industrial loads such as fans or machinery. The 16×2 LCD display is connected in 4-bit mode to display real-time sensor values and system status.
- The entire circuit is designed to ensure continuous monitoring, automatic alert generation, and protective shutdown during hazardous industrial conditions.

## VI. IMPLEMENTATION

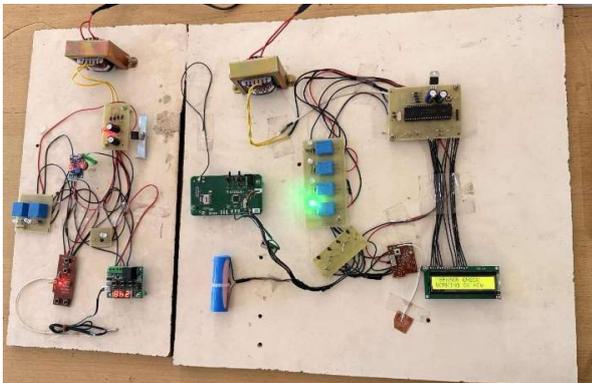


Fig.4 Hardware Prototype of Smart Industrial Safety Monitoring System using gsm alert system

The proposed Smart Industrial Safety Monitoring System was implemented using the PIC16F877A microcontroller programmed in Embedded C using MPLAB IDE. The MQ-6

gas sensor, thermistor, and LDR were interfaced with the analog input pins of the microcontroller. The internal ADC module was used to convert analog sensor signals into digital values.

Wireless communication between sensing and control sections was achieved using RF transmitter and receiver modules. The GSM module was interfaced using UART communication to transmit SMS alerts through AT commands. A relay driver circuit was used to control external industrial loads during abnormal conditions.

The complete hardware prototype was developed and tested under controlled environmental conditions to verify real-time monitoring and alert functionality.

## VII. ACKNOWLEDGMENT

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## VIII. RESULTS

The developed system was tested for different environmental conditions including gas leakage simulation, temperature increase, and light intensity variation. The system successfully detected abnormal conditions and responded accordingly.

When gas concentration exceeded the predefined threshold, the GSM module sent an SMS alert within 5–10 seconds. Similarly, during high temperature conditions, the relay

was activated to disconnect the load. The LCD display showed real-time sensor readings continuously.

The experimental results confirm that the system provides reliable real-time monitoring, wireless communication, and automatic protective action. The performance aligns with the findings of Akyildiz et al. (2002) and Rajasegarar et al. (2008), who emphasized efficient anomaly detection in wireless sensor networks.

### IX. GRAPHICAL REPRESENTATION



Fig.5 Functional Overview of the Proposed Smart Industrial Safety Monitoring System.

### X. CONCLUSION

This paper presented a Smart Industrial Safety Monitoring System using Wireless Sensor Network and GSM alert mechanism. The system integrates multi-parameter sensing, wireless communication, GSM-based remote alerting, and automatic relay-based protection into a compact architecture.

The implementation demonstrates that real-time hazard detection and emergency response can be achieved effectively using embedded

systems. Compared to conventional manual monitoring methods, the proposed system improves response time, enhances safety, and reduces industrial risk.

The developed prototype validates the practical feasibility of integrating WSN and GSM technologies for industrial safety applications, as supported by previous research works (Akyildiz et al., 2002; Mazidi et al., 2008).

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