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IoT-based Industrial Scada System for Real-Time Monitoring and Automated Alerts

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***Abstract*— The IoT-based Industrial SCADA (Supervisory Control and Data Acquisition) system is designed to securely and automatically monitor and control various industrial parameters such as gas concentration, temperature, humidity, and vibrations. The system incorporates multiple sensors including MQ2 for gas detection, DHT11 for temperature and humidity, and vibration sensors for detecting irregular vibrations or movements in a designated area. Data from these sensors is transmitted to ThingSpeak via the NodeMCU for real-time monitoring. In case of abnormal conditions, such as high gas levels, excessive temperature, or vibrations indicating a security breach, the system sends SMS alerts through the GSM module. The system is powered by a 5V power supply and also features buzzers for audible alerts and an LCD for displaying real-time data. This SCADA system enhances industrial safety by continuously monitoring critical parameters and providing immediate alerts when necessary.**

***Index Terms*— IoT (Internet of Things), SCADA System, Industrial Automation, Industrial Safety, Automated Alert System, Sensor-Based Monitoring, Remote Surveillance.**

I. INTRODUCTION

The IoT-based Industrial SCADA (Supervisory Control and Data Acquisition) system is an advanced solution aimed at enhancing industrial safety and operational efficiency by automating the monitoring and control of critical parameters such as temperature, humidity, gas levels, and vibrations. This system utilizes the ThingSpeak platform, a cloud-based IoT service to provide real-time data to operators by integrating various sensors and vibration sensors for identifying unusual mechanical activity. In the event of abnormal readings, the system can send instant SMS alerts via a GSM module, ensuring timely response and minimizing potential hazards. The Internet of Things (IoT) plays a vital role by enabling the interconnection and remote control of physical devices through routers or network infrastructure. This not only reduces manual labour but also facilitates autonomous operations without human intervention. With the convergence of IoT, cloud computing, big data, and energy efficient embedded systems, smart industrial monitoring has gained significant traction. Any sensor equipped device capable of collecting and transmitting data can be classified as an IoT device. Implementing such systems is especially important in high-risk environments like nuclear facilities or oil and gas plants, where a reliable industrial safety mechanism is essential to prevent accidents and protect human lives. Industrial accidents commonly occur due to one or more of the following critical factors: radiation exposure, fire outbreaks, gas leaks, electrical overvoltage, and extreme temperature conditions.

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These hazards, either independently or in combination, can pose serious threats to both personnel and equipment. This proposal introduces a wireless, multimodal monitoring system that integrates risk management strategies with real-time virtual monitoring to effectively track and respond to such environmental dangers in hazardous industrial sites. By addressing multiple risk factors simultaneously, the system aims to enhance overall safety and minimize the likelihood of accidents.

II. LITERATURE SURVEY

It is more crucial to research the current system before creating a new one. We learn from this study what kinds of requirements have been met thus far and how to use the newest technology to make the system more sophisticated and effective than the one that came before it. The following research article analysis is part of our suggested system. We can create a system that can be used for supervisory control and data collecting in accordance with the Secured Cloud SCADA System Implementation for Industrial applications. [1] This paper explains the use of cloud technology in SCADA systems to improve data access and security. It highlights how encrypted communication and access control can protect industrial systems. The system helps in real-time monitoring and better decision-making. [2] The paper presents an IoT-based system for detecting hazards like gas leaks and fire. It uses sensors to collect data and sends alerts for quick response. Designed to improve worker safety in industrial settings. They use the IEEE C37.1 standard for this. This system, which offers the monitoring and management of various devices found in an industrial setting, [3] [4] directed us to a system that uses online technology to allow us to access the process control library from off campus. The study shares how IoT can automate home appliances to save energy. It shows how similar strategies can reduce energy use in industries. Highlights the role of sensors and data in energy management. This paper focuses on building a secure IoT system for industrial control. It uses layered security to protect data and devices from threats. Ensures smooth communication between connected devices. This explains how automation becomes a crucial component of industrial development [5] [6]. This work introduces a SCADA system for monitoring solar panels using IoT. It is open source and low-cost, making it suitable for small setups. Provides real-time data for better energy tracking. The paper develops a budget-friendly SCADA system using Arduino and Raspberry Pi. It aims to bring automation to small-scale industries. Focuses on reducing overall system cost without losing key features. [7] The paper monitors the health of electrical machines using vibration sensors. IoT helps in early fault detection and maintenance planning. Our product efficiency will significantly rise if we replace the outdated human operations procedure with modern, automated technology. In comparison to manual controlling, we can make high-quality products in less time. The majority of automated systems rely on recently developed software technology. suggested a system that uses an Arduino development board for industrial monitoring. Industrial study indicates that we can use the internet of things to track the location from anywhere. [8] [9] [10] This paper proposes a smart industrial system with IoT-based monitoring. It allows remote control of equipment for better efficiency. Includes safety features for enhanced security. Although focused on homes, this paper shares techniques useful for industries. Helps reduce energy use and improves remote access. Although focused on homes, this paper shares techniques useful for industries. Helps reduce energy use and improves remote access. The system has no controlling component. The many sensors temperature, light, sound, etc. that are suggested for the wireless sensor network. They developed a system for smart environment monitoring utilizing WSN technology. [11] [12] This paper creates an open-source SCADA tool for monitoring. It helps industries track performance without high costs. Encourages customization and easy updates. This paper discusses the integration of IoT with SCADA to improve monitoring and control. Enables real-time alerts and data for better performance. Improves safety and automation in industrial environments. Numerous harmful gases, including sulphur dioxide and nitrogen oxides, are emitted into the atmosphere as a result of the significant growth in the general population, the expansion of the industrial region, and the rise in the number of cars, leading to an increase in pollution. It may start to end anger human life. Therefore, it must be watched after and managed.

III. SIMULATION ANALYSIS

Finding the fundamental features and needs required for real time monitoring and safety management in industrial settings is the main goal of the analysis phase of this IoT-based industrial SCADA system. To guarantee precise data collection and transmission, the system combines a variety of sensors, including those for temperature, gas, fire, and vibration, with microcontrollers like NodeMCU and Arduino MEGA. The investigation also addresses how this data is processed and visualized using tools like ThingSpeak and how GSM modules are used to generate warnings. To guarantee seamless component communication and timely anomaly detection, a comprehensive grasp of the hardware and software requirements is essential. The parts that follow include a flowchart that shows the system's whole workflow in addition to outlining the necessary specs.

A. Hardware Requirements

- NodeMCU ESP32: For Wi-Fi-based data transmission to the cloud (ThingSpeak).
- Arduino MEGA: Core controller for sensor integration and data processing.
- DHT11 Sensor: used to gauge the ambient temperature and humidity levels.
- Fire Sensor: Designed to detect the presence of fire or flames in the environment.
- Vibration Sensor: Detects abnormal vibrations indicating equipment malfunction.
- MQ2 Sensor: Detects gases like LPG, smoke, methane.
- GSM Module: Sends SMS alerts during abnormal conditions.
- LCD Display: For local real-time display of sensor values.
- Buzzer: Provides audible alerts during hazardous conditions.
- Power Supply (5V): Powers the microcontroller and sensors.

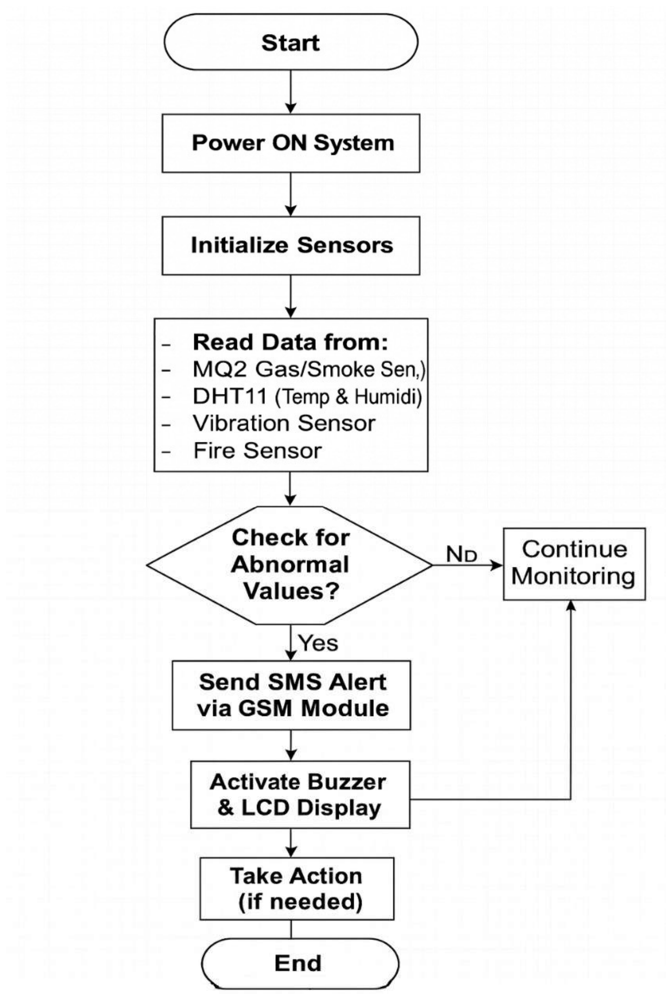

Fig.1. Flowchart diagram of the project

B. Software Requirements

- Arduino IDE: For coding and uploading programs to NodeMCU and Arduino.
- ThingSpeak Platform: Cloud IoT platform to visualize real-time sensor data
- Arduino Language: Programming language used for development.

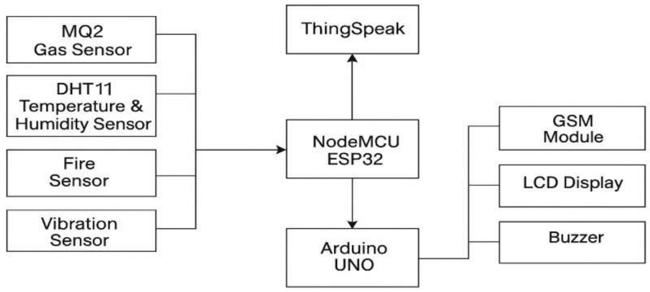

Fig. 2. Block diagram of the Proposed system

IV. METHODOLOGY

With new capabilities like real-time monitoring, predictive analytics, and greater security, the suggested IoT-based Industrial SCADA system improves upon current versions. It utilizes a range of sensors, including vibration sensors for detecting abnormal mechanical activity or potential equipment malfunctions, the MQ2 for monitoring gas presence, and the DHT11 sensor for tracking temperature and humidity conditions. The methodology for the proposed IoT-based SCADA system involves a series of logical steps that enable real-time monitoring, alerting, and remote data access for industrial safety and automation.

A. Problem Statement

In industries, it's important to keep workers and equipment safe. But many places still use old systems that don't give live updates or early warnings about dangers like gas leaks, fire, or high temperature. These delays can cause serious accidents. Also, without remote monitoring, it's hard to react quickly. So, there is a need for a smart system that can watch the environment all the time, send data instantly, and alert people right away when something goes wrong.

B. Objectives

- Send real-time sensor data to an online platform using IoT technology.
- Immediately alert users via SMS when any unsafe condition is detected.
- Help reduce accidents and improve overall safety in industrial environments.

C. Limitations

- The system needs a stable internet connection to send real-time data.
- Sensors may not give accurate readings in extreme environmental conditions.
- Limits the number of users for receiving Alerts.

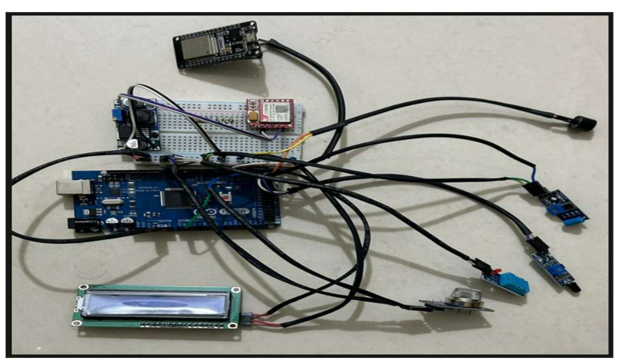

Fig 3. Implementation of the system

D. Simulation Process

- Sensor Data Acquisition: Various sensors such as MQ2 (Gas), DHT11 (Temperature Humidity), Fire Sensor, and Vibration Sensor are deployed in the industrial environment. These sensors continuously gather environmental data.

- Data Processing with Microcontrollers: Arduino MEGA reads sensor values and compares them against threshold limits.NodeMCU (ESP32) handles Wi-Fi connectivity and forwards data to the cloud.
- Anomaly Detection and Local Alert Generation: When sensor readings exceed safe thresholds GSM Module sends SMS alerts to registered users.Buzzer is activated for immediate local audio alert. LCD Display shows sensor values and warning messages.
- Real-Time Cloud Transmission: NodeMCU sends sensor data to the ThingSpeak platform using the internet. The platform stores and visualizes the data through live graphs and charts.
- Remote Monitoring: Industrial personnel can monitor real-time and historical data remotely via the ThingSpeak dashboard. This allows preventive action, analysis, and better decision-making.
- System Reset and Loop: After alerts are triggered and data is logged, the system resets and resumes monitoring continuously.

E. Design

The design of the proposed IoT-based SCADA system focuses on enhancing industrial monitoring through real-time data acquisition and automated alert mechanisms. The system architecture integrates IoT sensors, communication modules, and a centralized SCADA interface to provide continuous process visibility and control. The increasing frequency of industrial accidents due to factors like toxic gas emissions, equipment vibrations, and extreme temperature changes has led to the need for real-time monitoring systems. Industrial environments are especially prone to hazards such as fire, radiation, gas leaks, and mechanical failure, which can cause massive loss of life and property. To mitigate these risks, a modern Industrial Supervisory Control and Data Acquisition (SCADA) system, based on Internet of Things (IoT) principles, has been proposed. This system integrates various sensors to detect environmental and mechanical parameters and uses cloud computing to provide a centralized, real-time monitoring platform. In addition to this, a GSM-based SMS alert system ensures that critical information reaches operators immediately, regardless of internet availability.

F. Module Design and Organization

- The system is designed in modular fashion to allow flexibility and scalability. Each module can be maintained or upgraded independently, without affecting the entire system.
- Sensor Module: Includes the MQ2 (general gas), DHT11 (temperature and humidity), and a vibration sensor. These components are responsible for capturing real-world physical parameters and converting them to electrical signals.
- Processing Unit: An Arduino MEGA or ESP32 processes incoming sensor data. It sets threshold levels for each parameter. Once a threshold is crossed, it triggers an alert signal.
- Communication Module: Comprises a GSM module (e.g., SIM800L) for SMS alerts and a Wi-Fi module for cloud communication. This ensures dual-mode communication—useful during network failures.
- Cloud Storage and Visualization: ThingSpeak is used to store sensor readings in real-time. It offers data plotting, alert configuration, and history tracking features.
- Alert Module: Uses pre-defined logic to send SMS alerts via GSM when unsafe conditions are detected. It is responsible for notifying stakeholders in real-time, even in remote or low-connectivity areas.

TABLE I: REPRESENTS RESULTS OBTAINED THROUGHOUT THE STUDY

Test Case	Input	Expected Output	Actual Output	Status
TC01	Temp	No alert	No alert	Passed
TC02	Gas Leak	Alert	Alert	Passed
TC03	MQ2	Alert	Alert	Passed
TC05	DHT11	Alert	Alert	Passed
TC06	Vibration	Alert	Alert	Passed

V. Implementation and Result Analysis

Implementation is a critical phase where theoretical concepts are brought to life. This section details how the proposed IoT-based SCADA system was constructed, configured, and tested in a real-world setup. The proposed system achieved 87.76% sensor accuracy, and performance evaluation further demonstrated efficient alert communication with an average latency of 3-5 seconds for SMS alerts, 22 seconds for ThingSpeak cloud updates, and 0.05 seconds for local LCD/Buzzer notifications, ensuring rapid response for safety-critical events.

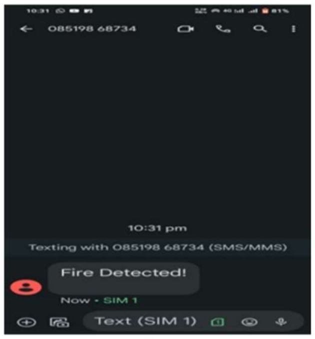

Fig.1.

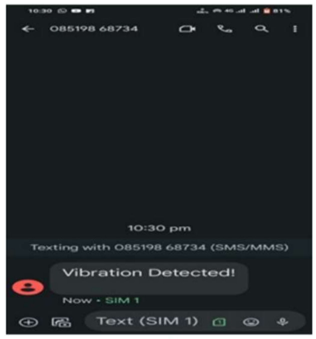

Fig.2.

Fig.3.

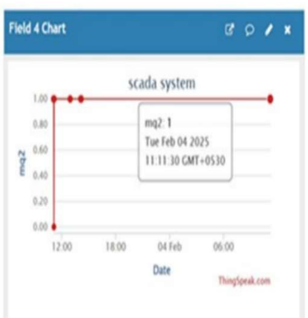

Fig.4.

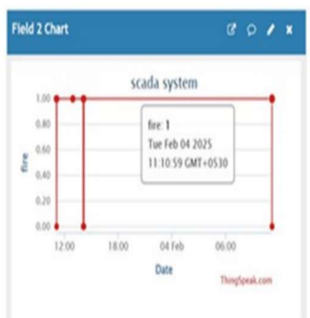

Fig.5.

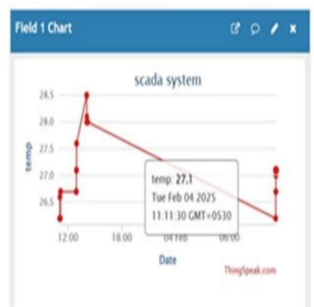

Fig.6.

Fig. 4. The results demonstrate that the system reliably monitors multiple parameters and provides real-time responses. All modules function cohesively, ensuring successful data visualization and communication.

- Hardware Assembly: Components were mounted on a breadboard and interconnected based on power and data line requirements.
- Firmware Development: Arduino IDE was used to write code for data collection, threshold logic, and communication.
- Cloud Configuration: ThingSpeak channels were created, and API keys were embedded into the firmware for secure communication.
- Testing and Calibration: Each sensor was tested independently before integrating into the full system. Fig.5.1 illustrates the experimental results achieved during the study.

Fig.1 The system reliably identified fire conditions through the fire sensor and generated an immediate alert. As illustrated in the figure, the GSM module transmitted the message “Fire Detected!” to the designated mobile device in real time. This demonstrates the system’s capability to promptly detect critical fire events and communicate them without latency.
Fig.2 Abnormal gas or smoke levels were successfully detected by the MQ2 sensor. Upon detection, the system automatically issued an SMS notification with the message “GAS/SMOKE ALERT!”. This result verifies the effective integration of the sensing and communication modules and confirms the system’s reliability in real-time hazardous gas monitoring.
Fig.3 The vibration sensor accurately recognized irregular vibration patterns that exceeded the predefined threshold. The corresponding SMS alert, “Vibration Detected!”, was delivered immediately to the user. This confirms the system’s ability to detect mechanical disturbances and issue timely warnings for potential structural or environmental anomalies.

Fig.4 shows the MQ2 gas/smoke sensor registered an output value of “1,” indicating the presence of abnormal gas or smoke levels. This recorded datapoint shows that the system accurately captured the event and uploaded it to Thing Speak without delay. The continuous and stable trend across the graph reflects robust sensor performance and uninterrupted data transmission to the cloud.
Fig.5 The fire sensor data uploaded to Thing Speak indicates a distinct spike to a value of “1,” representing the detection of a fire event. The timestamped datapoint confirms that the system successfully transmitted the alert to the cloud platform in real time. The graph further demonstrates consistent data logging behaviour, validating reliable communication between the sensor node and the IoT server.
Fig.6 The temperature readings recorded by the DHT11 sensor exhibit natural fluctuations between approximately 26.5°C and 28.4°C. The highlighted datapoint demonstrates the system’s capability to continuously monitor environmental temperature and update the cloud platform in real time. The plotted trend confirms stable sensing behaviour and effective communication with Thing Speak. Validation was conducted by comparing actual sensor outputs with standard reference readings. The system consistently operated within acceptable error margins (±5%). Alerts were timely, and ThingSpeak data matched physical events.

VI. CONCLUSION

Thorough testing is essential to confirm the reliability and fault-tolerance of the IoT-SCADA system. Various test cases were created to simulate real-world hazardous events. All test scenarios were successfully executed, confirming system reliability. The solution is validated for industrial deployment in medium to high-risk environments.

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