International Journal of Scientific Research in Engineering & Technology
Volume6, Issue4 (July-August 2026), PP: 159-161.
https://www.doi.org/10.59256/ijsreat.20260604018
www.ijsreat.com ISSN No: 2583-1240

IOT-Based Coal Mine Monitoring and Alert System using STM32F446RE

Andiboyina Vijaya Sri[1], Tamada Devi Sri Chandrika[2], Saragadam Deepa Sahasra[3], Siyyadri Gireesh Kumar[4], Korra Avila[5]

[1]*Assistant Professor, Department of ECE, Dr. Lankapalli Bullayya College of Engineering, Andhra Pradesh, India.*
[2,3,4,5] *Department of ECE, Dr. Lankapalli Bullayya College of Engineering, Andhra University, India.*

To Cite this Article: *Andiboyina Vijaya Sri[1], Tamada Devi Sri Chandrika [2], Saragadam Deepa Sahasra[3], Siyyadri Gireesh Kumar[4], Korra Avila[5], "IOT-Based Coal Mine Monitoring and Alert System using STM32F446RE", International Journal of Scientific Research in Engineering & Technology, Volume 06, Issue 04, July-August 2026, PP:159-161.*

Abstract: *Coal mining is a high-risk industrial activity due to the presence of hazardous gases, fire hazards, and unstable environmental conditions that can endanger the lives of workers. Conventional monitoring systems often lack continuous real-time monitoring, remote accessibility, and efficient worker identification, reducing their effectiveness in preventing accidents. This paper presents an **IoT-Based Coal Mine Monitoring and Alert System using the STM32F446RE microcontroller** to enhance safety in mining environments. The proposed system integrates multiple sensors, including the MQ-4 methane gas sensor, MQ-7 carbon monoxide sensor, DHT11 temperature and humidity sensor, and KY-026 flame sensor, to continuously monitor environmental conditions. An EM-18 RFID reader is employed for worker identification and attendance tracking, while a DS1307 Real-Time Clock (RTC) module provides accurate event timestamping. When any monitored parameter exceeds predefined safety limits, the system activates a buzzer to alert nearby workers immediately. Furthermore, a WE10 Wi-Fi module enables real-time transmission of sensor data to a cloud-based IoT dashboard, allowing remote monitoring, data visualization, and historical analysis. Experimental results demonstrate that the proposed system effectively detects hazardous conditions, provides timely alerts, and supports remote supervision, thereby improving worker safety and operational efficiency. The proposed solution is cost-effective, scalable, and suitable as a prototype for future smart mine safety applications.*

Keywords: *Internet of Things (IoT), STM32F446RE, Coal Mine Safety, Environmental Monitoring, RFID, Gas Sensors, Embedded Systems, Cloud Monitoring.*

I. INTRODUCTION

Coal mining is one of the most hazardous industrial activities due to the presence of toxic gases, fire hazards, high temperatures, and poor ventilation. Underground mines often contain combustible gases such as methane (CH_4) and toxic gases such as carbon monoxide (CO), which can lead to explosions, suffocation, and severe health risks if not detected at an early stage. Ensuring the safety of mine workers requires continuous monitoring of environmental conditions and rapid response to hazardou s situations.

Traditional mine safety systems mainly rely on manual inspections or standalone monitoring devices. These approaches are time-consuming, provide limited real-time information, and often fail to deliver immediate warnings during emergency situations. In addition, many existing systems do not support remote monitoring or efficient tracking of workers inside mining areas, making rescue operations more difficult during accidents.

Recent advances in Embedded Systems and the Internet of Things (IoT) have enabled the development of intelligent monitoring systems capable of collecting, processing, and transmitting real-time environmental data. IoT technology allows sensor information to be accessed remotely through cloud platforms, enabling supervisors to monitor mining conditions continuously and take preventive actions before hazards become critical.

This paper presents an **IoT-Based Coal Mine Monitoring and Alert System using the STM32F446RE microcontroller**. The proposed system integrates multiple environmental sensors, including the MQ-4 methane gas sensor, MQ-7 carbon monoxide sensor, DHT11 temperature and humidity sensor, and KY-026 flame sensor, to continuously monitor the mining environment. An EM-18 RFID reader is incorporated to identify workers and record their entry and exit, while a DS1307 Real-Time Clock (RTC) module provides accurate timestamping of events. A buzzer is used to generate immediate alerts whenever hazardous conditions are detected.

To enable remote supervision, the system employs a WE10 Wi-Fi module that transmits real-time sensor data to a cloud-based IoT dashboard. This allows authorized personnel to monitor environmental conditions, receive alerts, and analyze historical data from any location. The integration of sensing, worker identification, alert mechanisms, and cloud connectivity provides a comprehensive, low-cost, and scalable solution for improving mine safety.

The proposed system aims to reduce the risk of mining accidents by providing continuous environmental monitoring, early hazard detection, real-time alerts, and remote accessibility. It serves as an effective prototype that demonstrates how embedded systems and IoT technologies can significantly enhance safety and operational efficiency in coal mining environments.

II. MATERIAL AND METHODS

Materials

The proposed IoT-based coal mine monitoring and alert system is developed using embedded hardware and sensing modules to monitor environmental conditions and improve worker safety. The main components used in the system are listed below:

- **STM32F446RE Nucleo Board:** Acts as the central processing unit, acquiring sensor data, processing information, and controlling all peripherals.
- **MQ-4 Gas Sensor:** Detects methane (CH_4) gas concentration in the mining environment.
- **MQ-7 Gas Sensor:** Measures carbon monoxide (CO) levels to identify toxic gas leakage.
- **DHT11 Sensor:** Monitors ambient temperature and relative humidity.
- **KY-026 Flame Sensor:** Detects the presence of fire or flame hazards.
- **EM-18 RFID Reader and RFID Tags:** Used for worker identification and entry/exit logging.
- **DS1307 Real-Time Clock (RTC):** Provides accurate date and time information for event timestamping.
- **16×2 LCD with I2C Module:** Displays real-time sensor readings and system status.
- **WE10 Wi-Fi Module:** Transmits sensor data to a cloud-based IoT dashboard for remote monitoring.
- **Buzzer:** Generates an audible alarm whenever hazardous conditions are detected.
- **Breadboard and Jumper Wires:** Used for circuit prototyping and hardware interconnections.

Procedure Methodology

The proposed system follows a continuous monitoring approach for detecting hazardous conditions in coal mining environments. Initially, the STM32F446RE microcontroller initializes all connected peripherals, including sensors, communication interfaces, LCD display, RFID reader, RTC module, and Wi-Fi module.

The DHT11, MQ-4, MQ-7, and KY-026 sensors continuously acquire environmental data such as temperature, humidity, methane concentration, carbon monoxide concentration, and flame detection. The analog sensor outputs are converted into digital values using the internal Analog-to-Digital Converter (ADC) of the STM32 microcontroller, while digital sensors communicate through GPIO interfaces.

The collected sensor data are processed and compared with predefined threshold values. If any parameter exceeds its safe operating limit, the controller immediately activates the buzzer to alert nearby workers. Simultaneously, the abnormal condition is displayed on the LCD screen.

For worker monitoring, each employee carries a passive RFID tag. When the tag is scanned by the EM-18 RFID reader, the unique identification number is transmitted to the STM32 through UART communication. The DS1307 RTC module provides the current date and time, enabling accurate logging of worker entry and exit records.

To enable remote supervision, the processed sensor data and RFID information are transmitted through the WE10 Wi-Fi module to a cloud-based IoT dashboard. The dashboard displays real-time environmental parameters, worker information, and alert notifications, allowing supervisors to monitor mine conditions from remote locations.

The overall methodology integrates environmental sensing, embedded data processing, RFID-based worker identification, local alert generation, and cloud-based monitoring into a single intelligent safety system. This integrated approach improves accident prevention, enhances worker safety, and supports real-time decision-making in coal mining operations.

III.RESULT

The proposed IoT-Based Coal Mine Monitoring and Alert System was successfully implemented using the STM32F446RE microcontroller and tested under different operating conditions. The system continuously monitored environmental parameters, including methane concentration, carbon monoxide level, temperature, humidity, and flame detection.

The MQ-4 and MQ-7 gas sensors successfully detected methane and carbon monoxide gases. When the measured gas concentration exceeded the predefined threshold values, the STM32 microcontroller immediately activated the buzzer and displayed a warning message on the 16×2 LCD.

The DHT11 sensor continuously measured temperature and humidity, and the obtained readings were displayed locally on the LCD as well as transmitted to the cloud dashboard through the WE10 Wi-Fi module. The flame sensor accurately detected the presence of fire and generated an immediate alert.

The EM-18 RFID reader successfully identified registered RFID tags and recorded worker entry and exit information along with timestamps obtained from the DS1307 Real-Time Clock module. This information was also uploaded to the IoT dashboard for remote monitoring.

The cloud-based IoT dashboard received real-time sensor data without significant delay, allowing continuous monitoring of environmental conditions and worker activity. The complete system operated reliably throughout the testing period, demonstrating stable communication between sensors, the microcontroller, and the cloud platform.

IV. DISCUSSION

The experimental results demonstrate that the proposed system effectively integrates environmental monitoring, worker identification, and IoT-based remote supervision into a single embedded platform. Continuous monitoring of methane, carbon monoxide, temperature, humidity, and flame conditions enables early detection of hazardous situations, thereby improving work er safety.

The integration of RFID technology enhances personnel management by maintaining accurate entry and exit records, which can be valuable during emergency rescue operations. The use of the WE10 Wi-Fi module and cloud dashboard enables supervisors to monitor mine conditions remotely, improving response time and operational efficiency.

Compared with conventional monitoring systems that rely on manual inspection or standalone devices, the proposed system provides real-time data acquisition, instant alert generation, and remote accessibility. The STM32F446RE microcontroller efficiently handles multiple sensors and communication modules while maintaining reliable system performance.

Although the prototype demonstrated satisfactory performance, the system has certain limitations. The accuracy of low-cost gas sensors is influenced by environmental conditions and periodic calibration is required. Future improvements may include industrial-grade gas sensors, GPS-based worker tracking, AI-based hazard prediction, and automated ventilation control to further enhance the reliability and scalability of the system.

V.CONCLUSION

This paper presented an IoT-Based Coal Mine Monitoring and Alert System using the STM32F446RE microcontroller to improve safety in coal mining environments through continuous environmental monitoring and real-time hazard detection. The proposed system successfully integrates MQ-4 and MQ-7 gas sensors, a DHT11 temperature and humidity sensor, a KY-026 flame sensor, an EM-18 RFID reader, a DS1307 Real-Time Clock module, and a WE10 Wi-Fi module into a single embedded platform. The developed system effectively detects hazardous gases, abnormal environmental conditions, and fire hazards while providing immediate local alerts through a buzzer and LCD display. In addition, RFID-based worker identification enables accurate entry and exit monitoring, improving personnel management during emergency situations. The IoT-based cloud dashboard facilitates real-time remote monitoring and data visualization, allowing supervisors to access critical information from any location.

Experimental evaluation demonstrated that the proposed system operates reliably, provides timely hazard detection, and enhances overall mine safety. The integration of embedded systems and IoT technology offers a cost-effective, scalable, and efficient solution for monitoring coal mine environments. Future enhancements may include the use of industrial-grade sensors, AI-based predictive analytics, automated ventilation control, GPS-based worker tracking, and standalone IoT gateways to further improve system accuracy, reliability, and scalability for real-world mining applications.

REFERENCES

1. S. Madakam, R. Ramaswamy, and S. Tripathi, "Internet of Things (IoT): A Literature Review," Journal of Computer and Communications, vol. 3, no. 5, pp.164–173, 2015.
2. STMicroelectronics, STM32F446RE ARM Cortex-M4 Microcontroller Datasheet, Geneva, Switzerland, 2023.
3. STMicroelectronics, STM32CubeIDE User Manual, Geneva, Switzerland, 2023.
4. Hanwei Electronics, MQ-4 Methane Gas Sensor Technical Datasheet, Zhengzhou, China, 2022.
5. Hanwei Electronics, MQ-7 Carbon Monoxide Gas Sensor Technical Datasheet, Zhengzhou, China, 2022.
6. Aosong Electronics, DHT11 Temperature and Humidity Sensor Datasheet, Guangzhou, China, 2022.
7. EM Microelectronic, EM-18 RFID Reader Module Datasheet, 2022.
8. Maxim Integrated, DS1307 Real-Time Clock (RTC) Datasheet, San Jose, CA, USA, 2021.
9. Right-Tech IoT Platform, Cloud-Based IoT Dashboard Documentation, 2024.
10. N. Kushalnagar, G. Montenegro, and C. Schumacher, "IPv6 over Low-Power Wireless Personal Area Networks (6LoWPAN): Overview, Assumptions, Problem Statement, and Goals," RFC 4919, Aug. 2007.
11. K. Ashton, "That 'Internet of Things' Thing," RFID Journal, June 2009.
12. M. A. Razzaque, M. Milojevic-Jevric, A. Palade, and S. Clarke, "Middleware for Internet of Things: A Survey," IEEE Internet of Things Journal, vol. 3, no. 1, pp. 70–95, Feb. 2016.