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Advanced Safety Monitoring System for Coal Mines Using IOT

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Abstract:- The Coal Mine Safety and Monitoring Project revolutionizes safety practices in coal mining through its innovative approach, leveraging modern technology for real-time monitoring and cloud-based systems. By continuously tracking critical parameters such as temperature, humidity, gas concentration, and miners' heart rates, potential hazards are swiftly identified, allowing for proactive interventions. Utilizing cloud-based platform, data collected from sensors is seamlessly transmitted and analysed in real-time, enabling immediate responses to mitigate risks and ensure miners' safety. This initiative represents a significant advancement in safety protocols, not only minimizing the risk of accidents but also enhancing operational efficiency and productivity within coal mines. By providing a comprehensive framework for safety enhancement, this project sets a new standard for the industry, prioritizing the well-being of miners while contributing to overall sustainability and success in the coal mining sector.

Keywords:- *Heart Rate Sensor; ESP 32;MQ2 Gas Sensor;DHT11 Temperature and Humidity Sensor; Thing Speak.*

I. INTRODUCTION

The Mining Sector is known for its inherent hazards, with a variety of serious health risks. Therefore, safety and security are paramount in the mining business. To prevent accidents, the mining industry implements several essential precautions. Increases in temperature, humidity, and methane gas leaks constantly pose a threat to cause accidents in underground mines. To enhance underground mine safety, a dependable communication system between underground mine workers and the stationary ground mining system is crucial. The most frequent mining hazards include ground collapse, subsidence, fault reactivation and fissures, mine water rebound, acid mine water drainage, mine gas emissions, and combustion. The Internet of Things (IoT) is a collection of devices connected to the internet. The implementation of IoT varies significantly on a large scale. The parameters monitoring the health of workers and their surrounding environment can be observed via IoT systems.

In this paper, we present a novel approach to enhance coal miner safety through the implementation of a smart alerting system. Leveraging the capabilities of the ESP32 microcontroller, coupled with sensors such as the DHT11 for monitoring temperature and humidity levels and the MQ2 for detecting potentially dangerous gases, our system aims to provide real-time monitoring and early warning alerts in coal mining environments.

This project employs a platform known as Thing-Speak to construct such a system. Thing-Speak is a platform that exhibits data collected from multiple sources. In this instance, the source is the ESP32, which offers inputs for linking various sensors and operates according to the given code. The code was crafted using the C programming language. This system monitors Gas, Heart rate, and Temperature. Buzzers are used by this system to alert the user in case of any irregularities to the admin and workers. The IoT-based Coal Mine Safety Monitoring and Alerting System can precisely and instantly mirror the dynamic situation of underground workers to the ground computer system. Furthermore, the integration of email alert functionality provides an additional layer of responsiveness to the system. Upon identifying critical thresholds of temperature, humidity, or gas levels, immediate email alerts are activated, informing the assigned personnel to take immediate action and ensure the safety of miners.

II. METHODOLOGY

The methodology employed in designing and implementing the coal miner safety and alerting system revolves around integration of ESP32 microcontroller and IOT.

The hardware setup involves connecting the DHT11 sensor to the ESP32 microcontroller for measuring temperature and humidity, MQ2 sensor for detecting gas levels and KY039 for detecting the heartbeat. We ensured proper wiring and connections, as well as a stable power supply to all components while considering environmental hazards typically encountered in mining operations. The ESP32 microcontroller is programmed to initialize and read data from the DHT11 Humidity and Temperature sensor, MQ2 gas sensor and KY039 Heart rate sensor. Logic is implemented to continuously monitor sensor readings and trigger alerts if safety thresholds are exceeded, such as high temperatures or gas levels.

Additionally, the ESP32's Wi-Fi capabilities are utilized to establish an internet connection for data transmission.

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In terms of ThingSpeak integration, we must first create an account on the ThingSpeak IoT platform and create a new channel which is dedicated for storing sensor data. The ESP32 is then configured to send sensor data to ThingSpeak at regular intervals using ThingSpeak's API key, facilitating real-time data monitoring and analysis. For email alert setup, an SMTP email service is set up to allow programmatically sending emails from the ESP32 microcontroller. Code is written to trigger an email alert when safety thresholds are breached, with relevant sensor data included in the alert and the buzzer activates to warn the mine staff. The system is thoroughly tested in controlled environments and ensured proper functionality and reliability.

ThingSpeak Cloud platform allows Real-Time data Monitoring from any remote areas from any device with an active Internet Connection. Data shown on the Cloud platform can be used to analyze the situation furthermore.

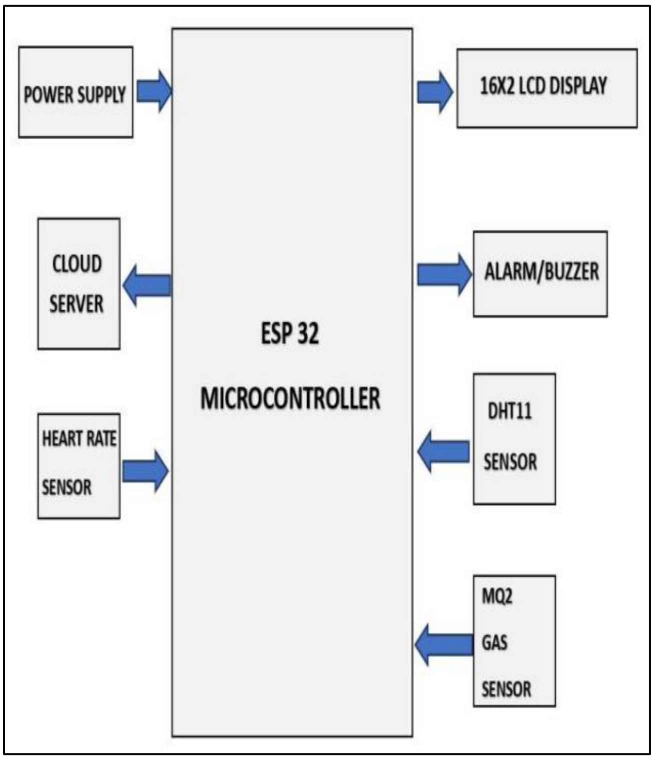

Fig 1 Block Diagram of Advanced Safety Monitoring System for Coal Mines Using IOT

III. COMPONENTS

➢ *KY039 Heart Beat Sensor*

In Figure 2, we observe the KY-039 heartbeat sensor module, also known as the KY-03 pulse sensor, is a small, portable device that detects a person's pulse or heartbeat. It consists of an LED and a photodiode attached to the back of the finger. The LED emits light through the finger, and the photodiode measures the light reflected from the skin. When blood moves, the amount of light changes, which can be detected as a pulse. A red LED flashes with each pulse.

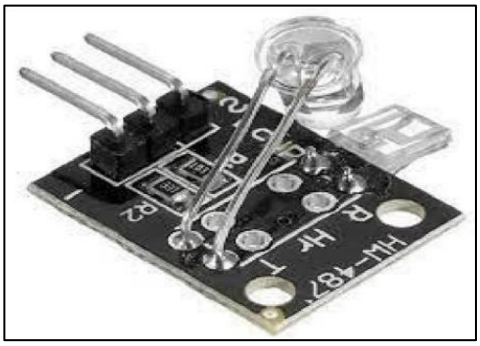

Fig 2 KY039 Heart Beat Sensor

➢ *ESP32-Node MCU*

The ESP32 microcontroller, a multifunctional embedded system, acts as the cornerstone of our project. Its low-power functionality ensures energy-efficient usage, vital for extended operation in mining environments. Equipped with built-in Wi-Fi and Bluetooth capabilities, the ESP32 enables smooth communication with sensors and the GSM module, facilitating remote surveillance and management. Moreover, its substantial processing power permits real-time data analysis, optimizing safety alerts based on miners' health parameters. Flexible GPIO pins allow effortless integration with a variety of sensors, providing adaptability and versatility to different mining conditions.

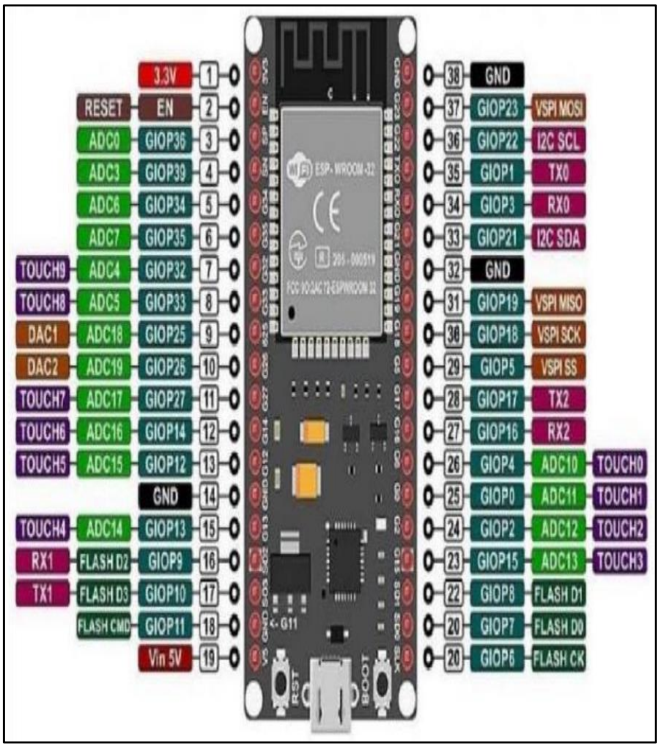

Fig 3 ESP32 Microcontroller

➢ *DHT11 Temperature & Humidity Sensor*

The DHT11 Temperature & Humidity Sensor employs a calibrated digital signal output to provide accurate readings of temperature and humidity. Its advanced technology ensures consistent reliability and stability over time, making it suitable for diverse applications. When

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integrated with microcontrollers, it offers rapid response times and cost-effective performance, making it an ideal choice for projects requiring precise environmental monitoring and control. Additionally, its compact design and low power consumption further enhance its versatility and usability in various settings

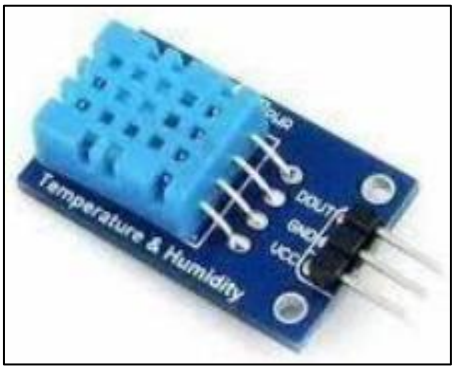

Fig 4 DHT11 Temperature & Humidity Sensor

➢ *MQ2 Gas Sensor*

The MQ-2 is a semiconductor gas sensor that detects smoke and flammable gases. It's also known as a Chemiresistor because the gas detection is based on the change of resistance of the sensing material when the gas comes into contact.

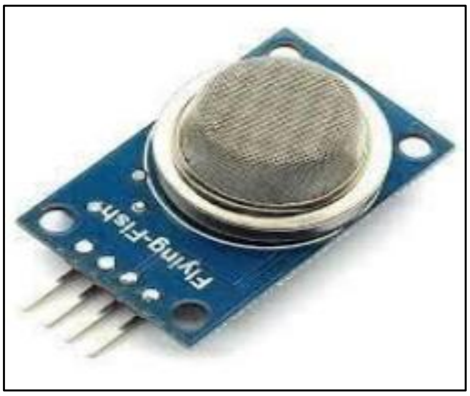

Fig 5 MQ2 Gas Sensor

➢ *LCD*

Described in Figure 6, a serial computer bus serves as a compact interface utilized to connect lower-speed peripheral integrated circuits (ICs) to processors and microcontrollers. In our project, this bus plays a crucial role in facilitating the connection between the LCD display and the ESP32 microcontroller.


Fig 6 LCD Connected to ESP32

➢ *Buzzer/Alarm*

A buzzer, also known as a beeper, is an audio signalling device that produces a buzzing or beeping sound when an external voltage is applied. A 5V signal is given as input when the alarm is required.


Fig 7 Buzzer

➢ *12V Adapter*

The 12V adapter, also known as a 12-volt power supply, plays a critical role in converting AC mains power into a stable DC voltage of 12 volts. This essential electrical device serves as a power source for various electronic devices and appliances that rely on a 12-volt supply to operate efficiently. Its widespread use spans across numerous applications, making it indispensable in modern electronics and technology.

Fig 8 12V Adapter

IV. IMPLEMENTATION AND RESULTS

To implement the integration of sensors with the ESP32 microcontroller, the first step is to ensure a stable power supply for all components. A suitable power source, such as a battery or a regulated power supply, is connected to the ESP32 and the sensors. Once the power supply is established, the sensors, including the DHT11 for temperature and humidity, the MQ2 Gas Sensor for gas concentration, and the Heartbeat Sensor, are connected to the GPIO pins of the ESP32. For convenience in connecting

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the sensors a daughter board for ESP32 can be used which has its own voltage regulation for safety. Each sensor is configured to provide analog or digital output, depending on its specifications and interface requirements. The ESP32 microcontroller is programmed to initialize communication with each sensor and read the data they provide. The Sensors are connected to ESP32 module pins as shown in the figure.

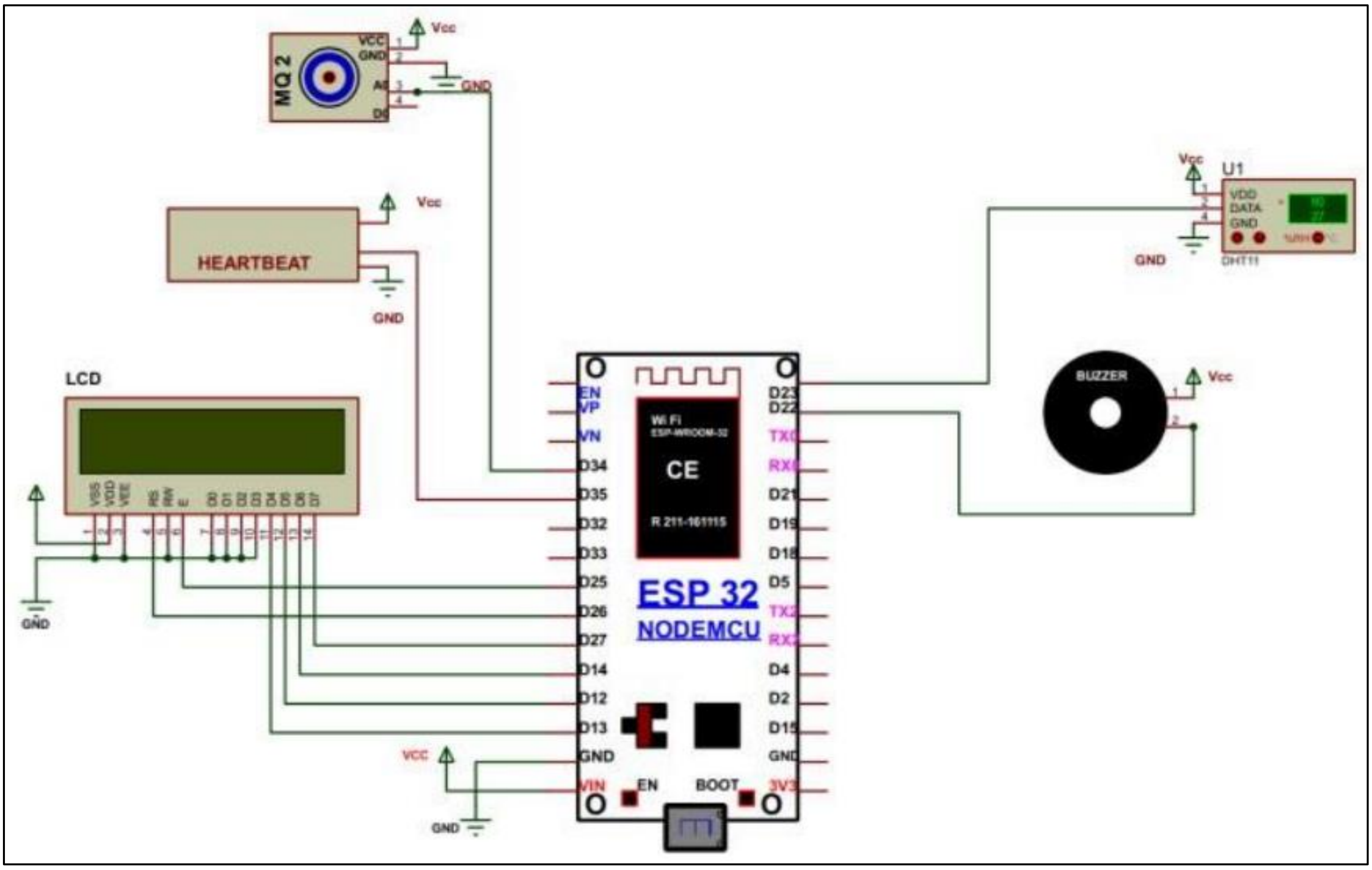

Fig 9 Experimental Setup of Advanced Safety Monitoring System for Coal Mines Using IOT

Next, the firmware for the ESP32 is developed using a programming environment such as Arduino IDE. The firmware includes logic to read data from each sensor at regular intervals, typically every few milliseconds. The readings from the sensors are then processed and formatted for display on an LCD screen. The LCD display is connected to the ESP32 microcontroller, and appropriate libraries are included in the firmware to initialize and control the display. The ESP32 firmware continuously updates the LCD display with the latest sensor readings, providing real-time monitoring of environmental conditions.

In addition to displaying data on the LCD screen, the firmware includes logic to trigger a buzzer alarm if any of the sensor readings exceed predetermined threshold values. For example, if the temperature exceeds 38°C, the humidity exceeds 85%, the heart rate exceeds 75 beats per minute, or the gas concentration exceeds 140 parts per million, the buzzer alarm is activated to alert personnel to potential safety hazards. The threshold values are configurable parameters that can be adjusted based on specific safety requirements and environmental conditions.

Furthermore, the ESP32 firmware is programmed to upload the sensor data to the ThingSpeak IoT platform for remote monitoring and analysis. ThingSpeak provides a cloud-based platform for storing, visualizing, and analyzing sensor data in real-time. The ESP32 is configured to establish a Wi-Fi connection to the internet and communicate with the ThingSpeak API using HTTP requests. The sensor data is formatted as JSON or CSV and sent to the appropriate ThingSpeak channel for storage and visualization. The ESP32 uploads the sensor data to ThingSpeak at regular intervals, typically every two minutes, to ensure timely monitoring of environmental conditions.

In summary, the implementation of the integration of sensors with the ESP32 microcontroller involves several key steps. First, the sensors are connected to the ESP32 and powered using a stable power supply. The ESP32 firmware is then developed to read data from the sensors, display the data on an LCD screen, trigger a buzzer alarm for threshold exceedances, and upload the data to the ThingSpeak IoT platform for remote monitoring and analysis. This comprehensive approach enables real-time monitoring of environmental conditions and enhances safety in various industrial applications, including coal mining.

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The integration of sensors with the ESP32 microcontroller forms the backbone of the implemented system, facilitating real-time monitoring of environmental parameters crucial for coal miner safety. The selection of sensors plays a pivotal role in capturing key environmental parameters. Among the sensors utilized are the MQ2 gas sensor, responsible for detecting hazardous gases such as methane and carbon monoxide; the DHT11 temperature and humidity sensor, for monitoring ambient conditions; and the KY039 heart rate sensor, essential for tracking miners' vital signs. These sensors are strategically positioned within the coal mine environment to provide comprehensive coverage and accurate data readings.

Initialization of the sensors and the ESP32 microcontroller is the first step in the working of this project. Upon powering up, the sensors undergo a calibration and initialization process to guarantee the accuracy and reliability of the collected readings. The ESP32 microcontroller is programmed to establish communication with each sensor, enabling the reception of real-time data. This process involves configuring the ESP32 to interface with the sensors through suitable protocols and data transmission methods, ensuring efficient data collection and processing.

Once initialized, the sensors commence data capture, focusing on parameters such as gas concentration, temperature, humidity, and heart rate. These readings are continuously monitored by the ESP32 microcontroller in real-time. To maintain operational efficiency and uphold safety standards, the ESP32 is programmed to conduct periodic checks for breaches in predefined threshold values. These threshold values serve as safety limits, beyond which immediate action is required to mitigate potential hazards and ensure the well-being of miners and the integrity of the coal mine environment.

The threshold values set for the sensors are meticulously determined to reflect critical safety parameters within the coal mine environment:

- Temperature: 38°C
- Humidity: 85%
- Heart rate: 75 beats per minute (bpm)
- Gas concentration: 140 parts per million (ppm)

Upon detecting a breach in any of these threshold values, the ESP32 initiates a series of actions to ensure prompt response and effective mitigation strategies. Primarily, the ESP32 transmits the collected sensor data, alongside the alert status indicating the threshold breach, to the ThingSpeak IoT platform. ThingSpeak serves as a centralized repository for storing and analyzing sensor data, furnishing stakeholders with real-time updates on the coal mine's environmental conditions and facilitating informed decision-making.

Simultaneously, leveraging the Simple Mail Transfer Protocol (SMTP), the ESP32 triggers an email alert to designated recipients. This protocol facilitates seamless communication between the ESP32 and an email server, enabling the transmission of alert notifications to specified email addresses. The email alert serves as an additional communication channel, ensuring that relevant stakeholders are promptly informed of the safety hazard and can take immediate action as necessary.

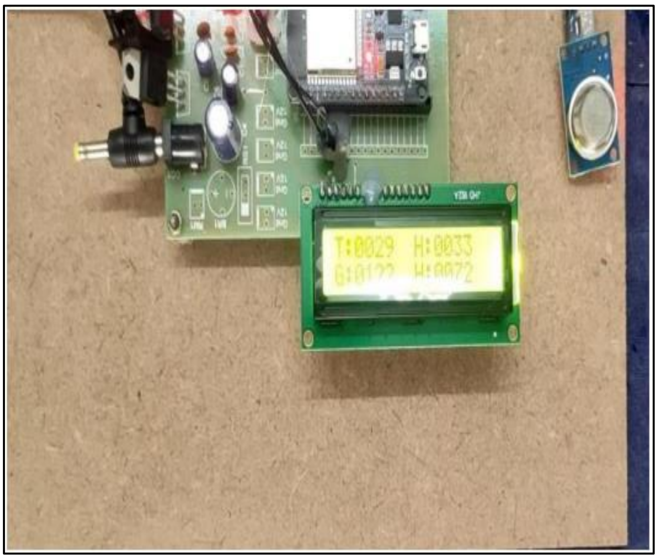

Fig 10 LCD Displaying Sensor Readings

Moreover, to provide an immediate warning signal within the coal mine, the ESP32 activates a buzzer alarm. This audible alarm serves as a critical safety measure, alerting miners and supervisors of the potential danger and prompting them to undertake necessary precautions and evacuation procedures, if required.

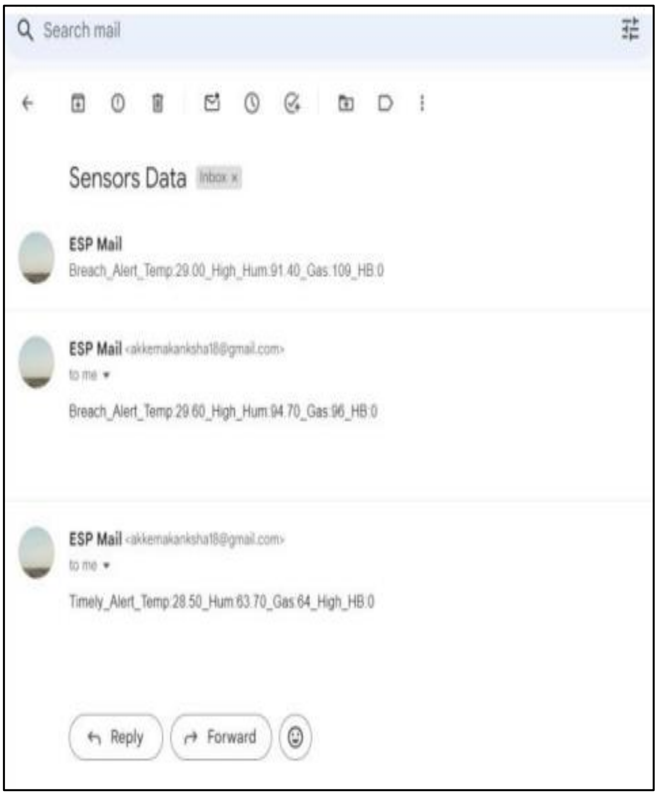

Fig 11 Email Alert Message

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In scenarios where the sensor readings remain within the predefined threshold values, the ESP32 continues to collect sensor data and updates the information on the ThingSpeak platform at regular intervals, typically every two minutes. This periodic data transmission ensures that stakeholders have access to up-to-date information about the coal mine's environmental conditions, facilitating proactive safety management.

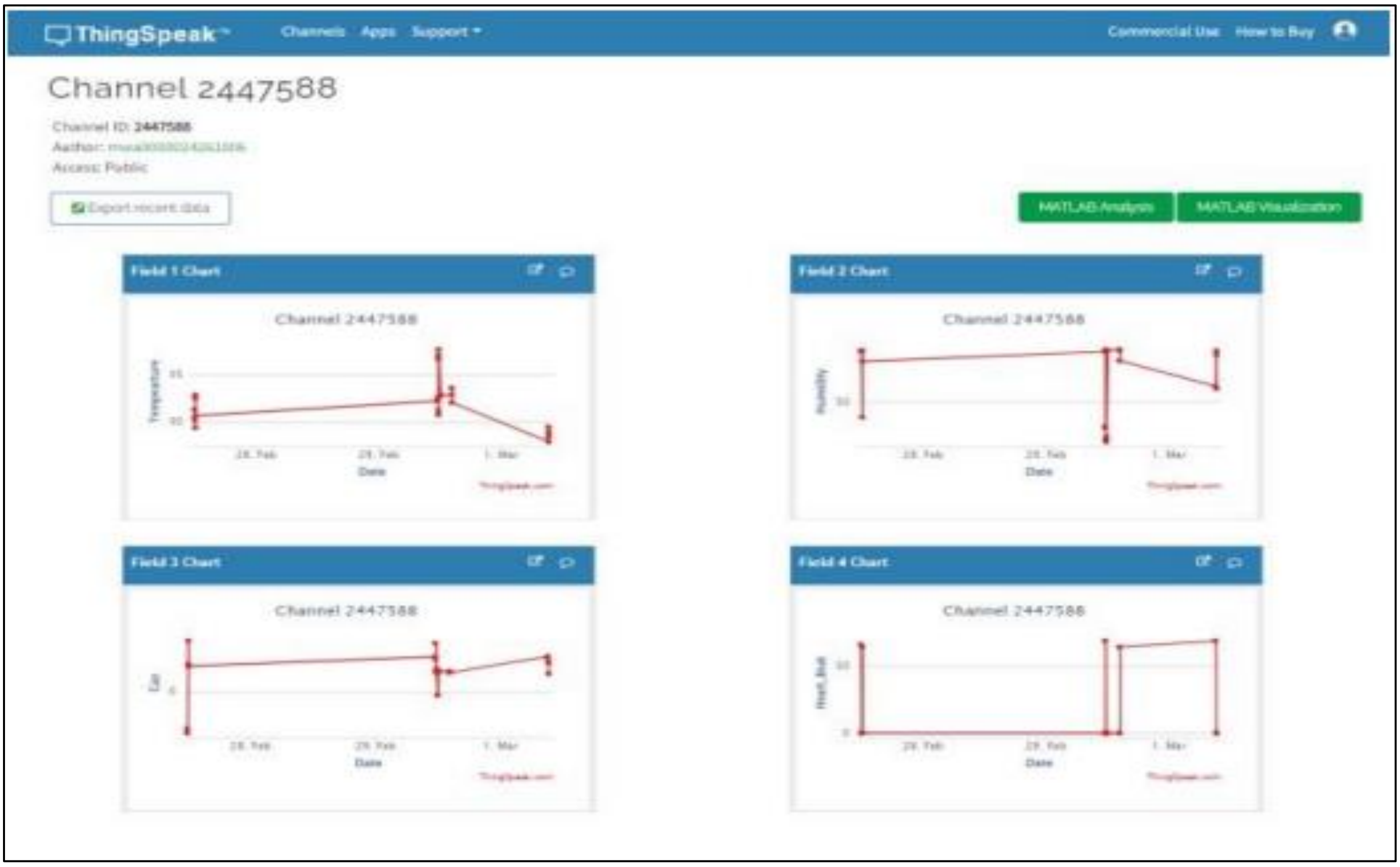

Fig 12 Graphs Showing Sensor Readings in Thing Speak Cloud

All the readings are visible in ThingSpeak website all the time and can be remotely monitored from anywhere in the world with ThingSpeak Account Login credentials or can be shared through a link after making the channel Public. Moreover, the data is visually represented in charts and can be done MATLAB analysis on the go.

V. CONCLUSION

In conclusion, the Integration of the ESP32 microcontroller, DHT11 sensor, and the implementation of ThingSpeak IoT platform has successfully fulfilled the research objectives of enhancing coal miner safety through real-time data monitoring. By leveraging these technologies, the project has effectively addressed the critical need for continuous monitoring of environmental conditions in coal mining operations. The system's ability to provide timely alerts through email and buzzer notifications when threshold values for temperature, humidity, and gas concentration are exceeded underscores its effectiveness in fortifying safety protocols. Moreover, the integration with ThingSpeak IoT platform has enabled remote monitoring and analysis, providing stakeholders with valuable insights for proactive decision-making. In achieving these objectives, the project has demonstrated its strengths in providing real-time monitoring, proactive alerts, and remote accessibility, thus contributing significantly to the advancement of coal miner safety in industrial settings. As future work, further enhancements could involve expanding sensor capabilities, refining data analytics algorithms, and optimizing communication channels, thereby continuing to advance coal miner safety and operational efficiency.

FUTURE SCOPE

Integration of more advanced sensors, such as noise or light sensors, to monitor additional parameters in the mining environment. The implementation of machine learning models could help predict potential hazards based on the sensor data, providing early warnings even before the threshold values are reached.

In addition to monitoring data on ThingSpeak IoT, performing real-time data analysis could identify trends and patterns, aiding in the prediction of potential issues. A mobile application could be developed for miners and supervisors, providing real-time updates, safety alerts, and health status of each miner.

The communication system could be improved to send alerts not only via email but also through other channels like SMS or push notifications. As the ESP32 microcontroller and sensors are battery-powered, exploring energy harvesting techniques could extend the battery life of these devices.

These future work and improvements hold the potential to significantly enhance safety standards, minimize the risk of accidents, and improve operational efficiency within coal mining operations.

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REFERENCES

[1]. Dr. Arockia Sahaya Sheela, R Nisha Jerlin ,"COAL MINE WORKERS SMART SAFETY NURSING SECURITY SYSTEM", International Research Journal of Modernization in Engineering Technology and Science, Volume:02/Issue:07/July 2020.

[2]. T. Thilagavathi,"INTERNET OF THINGS BASED COAL MINE SAFETY MONITORING AND ALERTING SYSTEM", Journal of Data Acquisition and Processing Vol. 38 (3),2023.

[3]. N.Sai Kiran reddy, V. Akhil sai, P. Sandeep kumaar, mrs. A. Sritulasi,"COAL MINE SAFETY MONITORING AND ALERTING SYSTEM USING IOT", Journal of Engineering Sciences, Vol 14,2023.

[4]. Jasmine Kavitha Sundar M, Rajesh R,"COAL MINE SAFETY SYSTEM".International Journal of Scientific Development and Research (IJSDR).Volume 5, Issue 4,2020.

[5]. A. H. Ansari, Karishma Shaikh, Pooja Kadu, Nikam Rishikesh,"IOT Based Coal Mine Safety Monitoring and Alerting System".International Journal of Scientific Research in Science, Engineering and Technology,2021,doi: https://doi.org/10.32628/IJSRSET2183188

[6]. M.Shakunthala, C.Raveena, B. Saravanan, "IOT Based Coal Mine Safety Monitoring and Controlling", Annals of R.S.C.B, ISSN:1583-6258, Vol. 25, Issue 4,2021.

[7]. T Mary Santhi Sri, K Kranthi Kumar ,"Design and development of coal mine safety system using wireless technology". International Journal of Research,2020, ISSN NO:2236-6124.

[8]. A. E. Forooshani, S. Bashir, D. G. Michelson and S. Noghanian , "A survey of wireless communications and propagation modelling in underground mines". IEEE Communications Surveys and Tutorials. vol. 15, no. 4, pp.1524-1545,2013.

[9]. Singh A., Singh U. K. and Kumar D,"IoT in mining for sensing, monitoring, and prediction of underground mines roof support". 4th International Conference on Recent Advances in Information Technology (RAIT) (pp.1-5),2018.