

IoT Based coal mine safety monitoring and controlling

Maheswaran U

Assistant Professor
Department of Electronics and
communication engineering
Rajalakshmi Institute of Technology
Chennai-600 124

Bhuvaneeshwaran V

UG Student
Department of Electronics and
communication engineering
Rajalakshmi Institute of Technology
Chennai-600 124

Hemanathan M

UG Student
Department of Electronics and
communication engineering
Rajalakshmi Institute of Technology
Chennai-600 124

Jawahar K

UG Student
Department of Electronics and
communication engineering
Rajalakshmi Institute of Technology
Chennai-600 124

Abstract—Many coal miners are concerned about their safety in the workplace. Within subsurface mines, poor ventilation exposes workers to toxic gases, heat, and dust, which can lead to sickness, injury, and death. With the aid of an ARM controller, this work proposes a concept for an Internet of things (IoT), wireless sensor network (WSN) that can track temperature, humidity, and gas in an underground mine. This device uses a low-power, less-cost Arduino UNO, Node MCU, DHT11 sensor, gas sensor, fire sensor to detect fire and send an alarm, and LDR to detect light depending on light levels. Conventional coal mineshaft observing frameworks are regularly wired organization frameworks that assume a significant part in guaranteeing coal mineshaft security. With the ceaseless extension of mining zones and profundity in coal mineshafts, numerous laneways have become visually impaired territories with various secret risks. Furthermore, laying cables, which is costly and time-consuming, is inconvenient. To address the issues, a coal mine safety monitoring system based on a wireless sensor network and the Internet of Things, which can increase the monitoring level is created. Many micro-sensor nodes with small volumes and low costs make up an IoT and wireless sensor network

Keywords—*Arduino UNO, Node MCU, ThingSpeak, Internet of things, sensors*

1. PROLOGUE

The Internet of Things (IoT) is a set of devices (things) that communicate with one another over the internet. On a wide scale, IoT implementations are diverse. Research in Europe the Internet of Things Cluster categorizes the most important IoT devices. Smart houses, smart transportation, and smart homes are only a few examples of smart applications, smart energy, business, health, and smart cities as a whole. The IoT is a ground-breaking breakthrough in which all sensor data is stored in the cloud and easily accessed from there. This advancement also includes sensors and actuators for collecting data and transmitting it over the internet. We use the cloud not only to store data, but also to analyse, collect, and visualize it. Such a new technology can be used in a variety of IoT applications, such as agriculture, health, and smart homes, to improve the efficiency of existing systems. Petroleum products are earth's natural resources that aid in the generation of energy and serve a variety of other

purposes. Coal could be a non-renewable resource that can't be simply replaced by humans; there are frequent coalmine mishaps occurring within the mines; diggers are golf stroke their lives at risk by working within the coal mines; and sometimes, they lose their lives in the coal mines. The majority of these mishaps occur as a direct result of outdated hardware and wired facilities, resulting in catastrophic failures. Spillage of noxious gases in coal mines poses grave dangers to the excavators working underground. Light is necessary in underground coalmines to carry out their work; they can't leave the mine if there isn't enough lighting, which can damage mineworker's vision due to working in a low-light setting. In this work, the issues were addressed by reviewing all of the data collected by the sensors that were used, and the monitoring was completed using the ThingSpeak platform. It is feasible to regulate each mechanically and manually. The microcontroller used in this project is the Node MCU.

2. LITERATURE SURVEY

Yongping Wu and Guo Feng [13] use the Bluetooth wireless transmission system to track coal mines. Bluetooth technology would develop a popular power efficient, cheaper wireless air interface and controlling software opening framework as a single global short-range wireless communication standard. This paper discusses the context of Bluetooth technology's growth, as well as the technological features and layout of the protocol stack, and proposes solutions for the wireless communication of Bluetooth host controller interface (HCI) in development convolution. Simultaneously, the device employs mature CAN bus technology and has realised the integration of wired and wireless data. device of transmission The biggest challenge with this device is that Bluetooth is a short-range wireless technology that makes cabling difficult. The cabling is broken while a catastrophe or a roof disintegrate occurs. As a result, traditional communication systems are unreliable and have a short lifespan. The construction and maintenance of the equipment became difficult due to the rasping climate in the mine.

Yogendra S Dohare and Tanmoy Maity [12] develop a Low Power WSN-based monitoring and hazard minimizing system for coal mines beneath ground level. A power efficient, cost-effective wireless sensor network based on the Zigbee protocol is used in this system to provide an intelligent surveillance and protection unit for coal mines beneath ground level. The device is made up of many nodes that are connected wirelessly. This network is simple to install in underground mines and provides underground coal miners with an efficient surveillance and safety device. It enables real-time data exchange among miners and ground stations, especially with the use of top security wireless sensor nodes. Since this equipment is installed in the mine, problems will occur when the mining machine is out of the system. The device only monitors the environmental conditions of underground mines, not the health of miners.

Pranjal Hazarika[7] discusses the use of protective helmets by coal miners. A CH₄ and CO gas sensor is included in this helmet. This sensing element senses the gas, and measured data is wirelessly transmitted to the control station through a Zigbee wireless module attached to the helmet. When the concentration of methane or carbon monoxide gas exceeds a critical level, a controller in the control station activates an alarm, keeping the plant and its employees safe by avoiding an impending accident. This device is incapable of detecting a person's fall or whether or not the miner is wearing a helmet.

Tanmoy Maity and Partha Sarathi Das [9] use Zigbee technology to build a wireless monitoring and safety device for workers in the mine. This device aims to provide a cost-effective and adaptable solution for the safety of underground mine workers. A microcontroller is used to collect data and make decisions, after which mine workers are notified via alarm and voice system. The voice based notification system including a speaker and a microphone transforms the collected information into a digital signal and communicates wirelessly with the ground control station. For the short-distance communication between the miner's equipment and the ground control station, a ZigBee based short-range wireless network, is used to notify relevant departments.

Valdo Henriques and Reza Malekian [10] implemented a lightning protection unit with wireless sensor networks. This framework illustrates how to design and install a prototype safety system in a mine using wireless sensor networks to create a safety system that monitors the characteristic environmental conditions of the mine. Electronic circuitry was used in the electronics, with a microcontroller serving as the primary processing device. There is also a graphical user interface. Although the radio used in this design works well on the city/walkie-talkie system, multiple identical sensor nodes can be added to further enhance the device. The master/slave topology is converted to a mesh network. You can use Digi Mesh (a proprietary technology developed by the ZigBee module manufacturer) to configure an intelligent mesh network. As a result, the sensor node may be outside the range of the collection node, but the data can still flow

from the last sensor node to the collection node. A node can pass information via an intermediate sensor node, as long as the sensor node can communicate with another sensor node. This increases the contact radius in the shaft.

Zhenzhen Sun [11] investigated a DCS mine observation unit. The RS485 bus architecture braces multipoint and two-way communication and relies on the RS485 bus. As a result, popular 8-bit microcontrollers can be used to create this form of monitoring device. It benefits from a clear circuit layout and low costs. However, because of the master-slave system. The network structure's reliability is difficult to ensure. Furthermore, data transmission distance is reduced due to low real-time reliability.

3. PROPOSED METHOD

The proposed work includes gas sensors, a light based resistor (LDR sensor), a temperature sensor, gas sensor, and humidity sensor, a buzzer, and a fire sensor and a LED light. We attach all of the sensors to Arduino UNO and node MCU. To begin, we must first build an account in the Platform for ThingSpeak.

The ESP866 (NODEMCU) and Arduino IDE should be initialized first in the proposed model. The gas and flame sensors are attached to the ESP8266's analogue (A0) and digital (D5) pins, respectively. Every 15 seconds, this node MCU will collect data from the ambience through the sensor and will transmit it to Thingspeak cloud. The ESP8266 is connected to the buzzer and LED, which will activate when the reference value is exceeded. Where there is a lack of light, the LED automatically senses it based on the light level. Via ThingSpeak, the warning message will be sent immediately to the monitoring station and mobile phone. The person in charge of monitoring should first sign up for the app and then log in to access the Thingspeak page. Thingspeak is an open-source cloud that has been used to save parameter values since the beginning. When logging in, one can see the most recent temperature, humidity, and gas level results. This will aid the monitoring individual in making the best decision possible based on the past. The proposed system allows the environment condition of the coal mine to be tracked 24 hours a day, seven days a week from anywhere in the world.

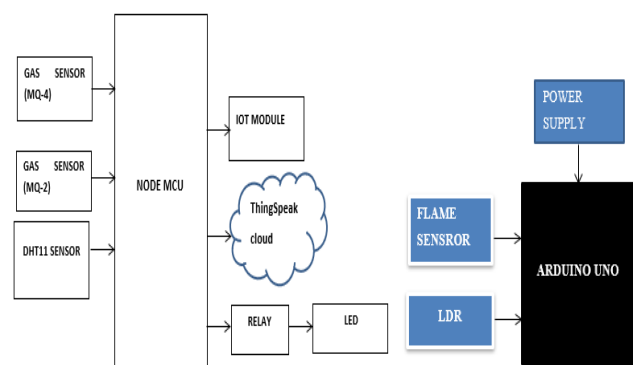


Fig.1 shows the model of proposed system

Gas sensor:

The mq2 gas sensor is used here, specifically in the use of the mq2 sensor. It has a high sensitivity and responds quickly. A gas sensor is made up of four pins, three of which are used. GND is connected to GND, and VCC is 3.3v. A0 is an analogue pin that is connected to the analogue pin of the Node MCU. This sensor is capable of detecting gas leaks in factories as well as combustible smoke.

Fire sensor:

This is the place to be. In coal mines, a fire sensor is used to detect fire. A fire sensor is made up of four pins, three of which are used. The analogue pins A0, GND, VCC, A0 are related. GND is attached to GND on the analogue pin of the Node MCU. The VCC supply voltage is 3.3 volts.

Node MCU:

As a gateway, the Node Micro Controller Unit (Node MCU) is used. It has an integrated Wi-Fi module that sends sensor information to the cloud for retrieval and further processing. The main reason we chose Node MCU is that the sensors we'll be using in our project only have digital pins and only one analogue pin is needed. As compared to other microcontrollers/processors like Arduino and Raspberry Pi, it uses less power (3.3v) and is less expensive. Ultrasonic sensors, gas sensors, temperature sensors, and an infrared sensor are all attached to the Node MCU. All of the values have been linked and are being sent to the Cloud server.



Fig.2 Node MCU – ESP8266

LDR sensor:

The A0, GND, and Digital pins of an LDR sensor are coupled to the ground pin of the Node MCU board. The power supply of the sensor supply is 3.3v, and the sensor's ground pin is connected to the ground pin of the Node MCU. Node MCU digital pin to LDR sensor digital pin .

ThingSpeak:

ThingSpeak is an open-platform for Internet of Things (IoT) application development and analytics. It has API for storing and retrieving statistics from matters over the Internet or a Local Area Network over HTTP protocol. ThingSpeak cloud platform can be used for applications like processing the sensor data from different networks, carrying out different analytics on the acquired data, location based applications and internetworking of different smart verticals. ThingSpeak was first introduced by i/o Bridge in 2010 as an IoT application support service. ThingSpeak also includes support for MathWorks' MATLAB numerical computing tools, allows users of

ThingSpeak cloud platform to simulate and analyze uploaded data through MATLAB. ThingSpeak and MathWorks, Inc. have a close working contact. In reality, the ThingSpeak documentation is absolutely embedded into the MathWorks MATLAB documentation website, with registered MathWorks consumer debts serving as valid user credentials at the ThingSpeak cloud website. ThingSpeak.com terms and privacy policy are laid between the customer and MathWorks.

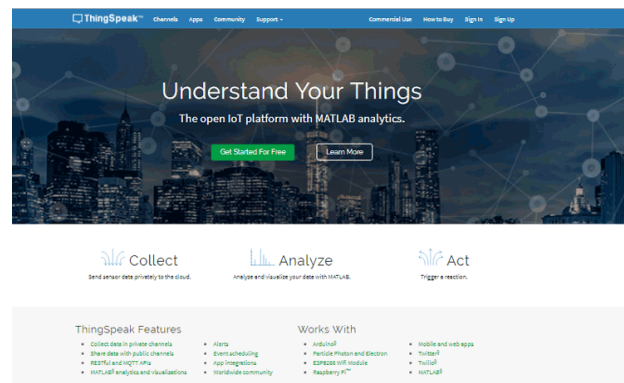


Fig.3 Picture of ThingSpeak

Arduino UNO Microcontroller:

The Arduino Uno is an open-source version of ATmega328P microcontroller development board designed by Arduino.cc. It consists various digital and analog (I/O) pins which can be used for interfacing various expansion boards, memory devices, sensors and actuators. The Arduino development board holds 14 advanced I/O pins out of which 6 pins are used for PWM applications. The 6 simple I/O sticks are programmable through a kind B-type USB link utilizing the Arduino IDE software. The source of power for the board is drawn by an USB cable or from an external 9-volt battery. The functionality of Arduino UNO is almost similar to that of the Arduino Nano and Leonardo microcontrollers. The equipment reference configuration is accessible on the Arduino site under a Creative Commons Attribution Share-Alike 2.5 permit. A few renditions of the equipment have format and creation records accessible also.



Fig.4 Arduino UNO

DHT-11 sensor:

A temperature and moisture sensor complex with an adjusted advanced sign yield is remembered for the DHT11 Temperature and Humidity Sensor. This sensor can be interfaced with any of the 8-bit general purpose microcontroller and it includes a resistive-type mugginess

estimation part and a NTC temperature estimation segment, giving amazing performance, fast reaction, hostile to obstruction capacity, and at a cheap cost. It guarantees high dependability and great long-haul solidness by utilizing an elite computerized signal-obtaining method just as temperature and dampness detecting innovation.

4. RESULT AND DISCUSSION

Experimental setup:

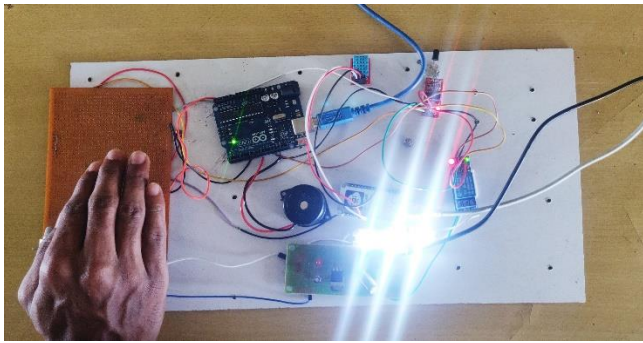


Fig.5 Setup of coalmine safety system

The sensors values are collected by Node MCU, are sent to ThinkSpeak. Buzzer and fire sensor are connected to Arduino UNO and the buzzer gives alert when fire sensor senses heat or high temperature.

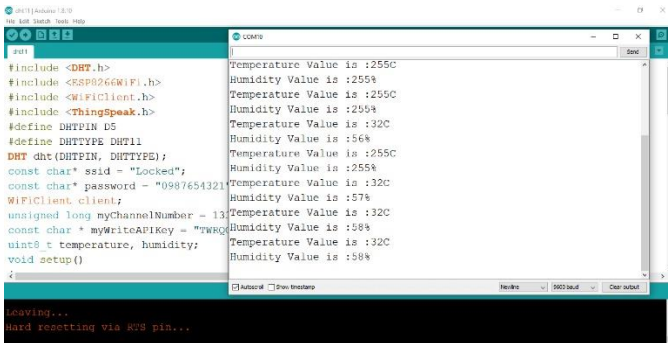


Fig.6 shows the values and the message displayed on the screen

The level of gas, temperature and humidity are displayed in the monitor.

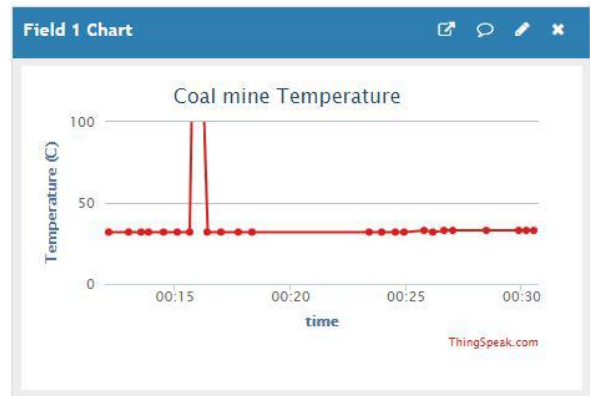


Fig.7 shows temperature vs time graph

In the mining process, this will be used to gauge the temperature. The graph's performance will change as the temperature rises.

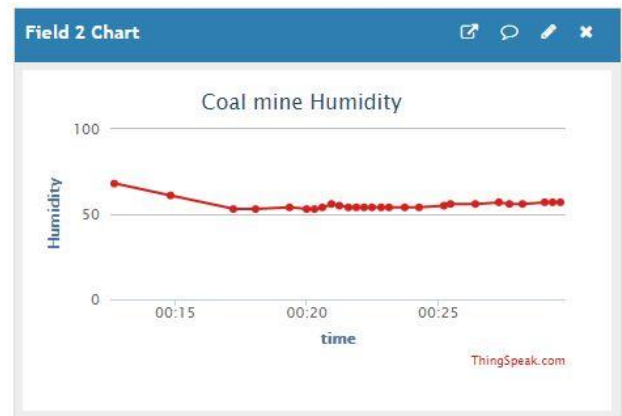


Fig.8 shows the humidity vs time graph

From this simulation result, sensor will measure and report moisture and air temperature. According to the moisture, the output will be varied.

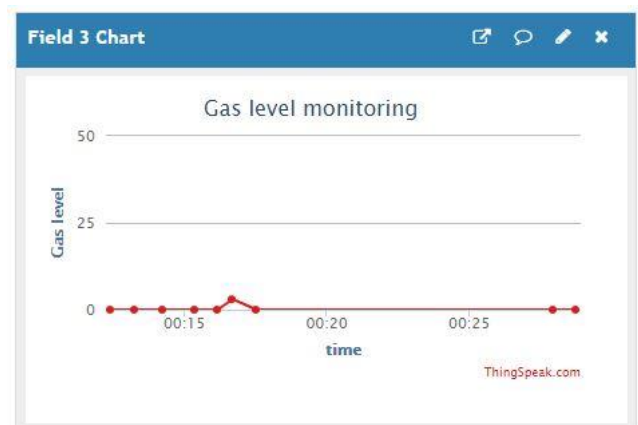


Fig.9 represents the gas level

In the mining process, the gas sensor senses or tests poisonous gas. The graph's production can change depending on the gas level.

5. CONCLUSION

Today, maintaining mining operations requires ensuring the safety and well-being of staff and properties. The use of Arduino, Gas Sensor, Temperature, and Humidity Sensor in the production of coal mining security for employees continues to monitor the safety of mining and update information to the IoT site. The workers' protection is ensured when they use this method.

REFERENCES

1. Boddu, R., Balanagu, P., & Babu, N. S. (2012). Zigbee based mine safety monitoring system with GSM. *International Journal of Computer & Communication Technology*, 3(5), 63-67.
2. Liu, T., Wei, Y., Song, G., Li, Y., Wang, J., Ning, Y., & Lu, Y. (2013, December). Advances of optical fiber sensors for coal mine safety monitoring applications. In 2013 International Conference on Microwave and Photonics (ICMAP) (pp. 1-5). IEEE.
3. Sheela, A. S., & Jerlin, R. N. Coal mine workers smart safety nursing security system.
4. Nakirekanti, M., Prasad, R. M., Mahammad, E., Narsimha, R. K., & Khalandar, B. D. (2017). Coal mining safety monitoring system. *International Journal of Mechanical Engineering and Technology*, 8(12), 542-550.
5. Marjani, M., Nasaruddin, F., Gani, A., Karim, A., Hashem, I. A. T., Siddiq, A., & Yaqoob, I. (2017). Big IoT data analytics: architecture, opportunities, and open research challenges. *IEEE Access*, 5, 5247-5261.
6. Pranjali Hazarika, "implementation of safety helmet for coal mine workers", 1st IEEE International Conference on Power Electronics Intelligent Control and Energy Systems, pp. 1-3, 2016
7. S. Wei, L. Li-li, "Multi-parameter Monitoring System for Coal Mine based on Wireless Sensor Network Technology", Proc. International IEEE Conference on Industrial Mechatronics and Automation, pp 225-27, 2009.
8. Maity, T., Das, P. S., & Mukherjee, M. (2012, March). A wireless surveillance and safety system for mine workers based on Zigbee. In 2012 1st International Conference on Recent Advances in Information Technology (RAIT) (pp. 148-151). IEEE.
9. Henriques, V., & Malekian, R. (2016). Mine safety system using wireless sensor network. *IEEE Access*, 4, 3511-3521.
10. Feng, X., Qian, J., Sun, Z., & Wang, X. (2010, September). Wireless mobile monitoring system for tram rail transport in underground coal mine based on wmn. In 2010 International Conference on Computational Aspects of Social Networks (pp. 452-455). IEEE.
11. Dohare, Y. S., Maity, T., Paul, P. S., & Das, P. S. (2014, July). Design of surveillance and safety system for underground coal mines based on low

- power WSN. In 2014 International Conference on Signal Propagation and Computer Technology (ICSPCT 2014) (pp. 116-119). IEEE.
12. Wu, Y., Feng, G., & Meng, Z. (2014, May). The study on coal mine using the Bluetooth wireless transmission. In 2014 IEEE workshop on electronics, computer and applications (pp. 1016-1018). IEEE.