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*Research Article*

# Smart Safety Helmet in Coal Mining Using Arduino

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**Abstract:** The Coal mining industry is very important for the nation's economy. The Need for coal is high nowadays. Coal plays a vital role in generation of electricity, steel and cement production. Nowadays thousands of miners lose them from mining accidents each year mainly from underground coal mining. Coal mining is considered much more dangerous than hard rock mining. Most of the deaths occur in developing countries such as India, Argentina, Armenia and rural parts of developed countries. Keeping this in mind we design a helmet for the safety of mine workers. In our system we are detecting dangerous gas such as methane and carbon monoxide, collision and temperature and humidity in underground area and nRF24L01 are used for transferring collected values. To save mine workers life in underground mining smart helmets have been developed. The sensors are connected to a microcontroller which is place in underground coal mining areas which detects the value and sends through RF transmitter to receiver which is placed in the helmet. The helmet also consists of microcontroller, buzzer and LCD display. The dangerous gases, collision and temperature parameters are detected using gas sensors and temperature sensor and if the collected values of sensors are compared with limit, if its greater than the buzzer in the helmet gives alert signal as well as turns on the LCD and shows the status. The status of the gas sensor, collision sensor and humidity sensor values are transmitting to the mine workers by the RF transmitter to the RF receiver which is located in the helmet. By transmitting that detected information from the sensor to the miners' helmet we can give warning so they can take safety precautions.

**Keywords:** ATmega328 Microcontroller, Sensors, RF Transmitter, RF Receiver, Buzzer, LCD Display.

## 1. Introduction

The necessary part of coal mining is safety. The safety of mine workers is the primary objective in underground coal mining industry. To avoid mining accidents every mining industry follows some basic rules and some precaution. The main reasons for coal mining accidents is collapsing. The collapsing accidents of coal mining are not always that much danger. Immediate rescuing help lot of mine worker's life. Communication is very important in the mining industry. To provide safety in coal mining area, a good communication method must be there.

Wired communication in underground mining is costly and also not so effective in communicating. Wireless communication in the underground mining is costless and also so effective in communicating with each other. To avoid unnecessary risk such as gas sensor and temperature sensor help us to take necessary steps during coal mining. During hazardous or dangerous condition, buzzer in the mine workers helmet gives a signal to the workers to avoid such things communication is done between mining peoples, before doing anything they need make sure that they are safe.

Due to cost of wired communication, it makes communication in underground mines so expensive as well as supporting expenses is higher in wired connection. In wireless connection, low cost RF transmitter and receiver are used and also it does not affect anything. The main goal is to reduce the number of casualties and helping the injures for mine workers or taking precautions with the help of smart sensors (Gas, Collision, Temperature) and RF component are used to execute the project and also ATmega328 microcontroller, ATmega328 microcontroller and buzzer are used in implementing this project. RF module which is used in this project is NRF24L01 RF transmitter and receiver. The performances of our system was tested successfully.

## 2. Literature Survey

In 2016, Pranjal Hazarika and his co-workers proposed the development of smart safety helmet for mining people. The helmet is fit out withMQ3 and MQ4gas sensor. The gasses sensed by using sensor. The X-Bee which is connected with the helmet is used to transmit the information to the control room, the microcontroller in the control room initiates an alarm signal when methane and carbon monoxide gas is in critical level. It is very useful technique in mining industries because of its ability, cheap in cost and stable.

In 2018, Rohith Revindran and his co-workers has implemented the smart helmet for safety in mining to help the miners. The wireless sensor network (WSN) can be implemented to keep a check on people who are at work. Distance Vector Routing (DVR) based routing protocol. Whenever threshold value is more than the force sensor, the helmet in the mote sends a trouble message by the saved route to the room manager. To check the status of rooms the Graphical User Interface (GUI) gives the centre to supervise all the mine workers. It takes the instant and the required take actions.

In 2016, C.J. Behr and his co-workers developed a smart helmet in order to detect hazardous in mining industry. The primary types of danger are air moisture, helmet removal and collision. This software used Contiki operating system to calculate the measured values to control the detecting sensors. When mine worker put the helmet on the head in order to determine successfully and Infrared sensor is used. This system can be used to determines the miners blood pressure and heart rate and the gas values of mine workers as well.

In 2018 Akshunya Mishra, Samayammalhotra, Suchitra, Pallavichoudekar and H.P. Singh proposed a project that can be used on helmets of these underground coal mine working people and would supervise some major hazards criterion found in the mine working people in real time. It contains humidity and temperature(lm35) sensor. These sensors would give the measurements of methane and sulphur oxide. In this project will find these criterion, analyse them in real time and help the ground control and the miners about condition by using a buzzer.

In 2014 Shabina. S proposed a brilliant sensing and alerting system. In this they using radio frequency and wireless sensor network to detect the temperature, pressure, humidity and gases measurements. Using these two technologies together a smart helmet is designed. The wireless sensor network contains many sensors senses mine worker's environment. The radio frequency technology is used to locating system and also used to locating the mine workers. This proposed system provides the safety and good wireless connection inside the underground mining areas.

## 3. Proposed Methodology

This project has two section. They are transmitter section and receiver section. The transmitter section consists of ATmega328 microcontroller, collision sensor, MQ5 gas sensor, humidity sensor and RF transmitter. In receiver section, ATmega328 is interfaced with buzzer, LCD Display and RF receiver.

The transmitter section is placed in the underground mining areas. In transmitter section, collision sensor, MQ5 gas sensors and humidity sensor are interfaced with ATmega328 microcontroller and then ATmega328 microcontroller connected with RF transmitter. The humidity sensor, gas sensor and collision sensor collect information and send it to receiver section through RF transmitter.

The receiver section is placed on the person's helmet. In receiver section, buzzer and LCD display is interfaced with ATmega328 microcontroller and RF receiver also connected with ATmega328 microcontroller. The transmitted information from RF transmitter is received by using RF receiver. If the detected values are higher than pre-defined limit, then buzzer gives warning signal and LCD display shows status. The advantage of placing transmitter section on the underground mining areas, we can know gases level and temperature level of that transmitter section placed area before we can go in there. The another advantage we don't need sensors to be placed in every individual person's helmet.

## 4. Architecture Diagram

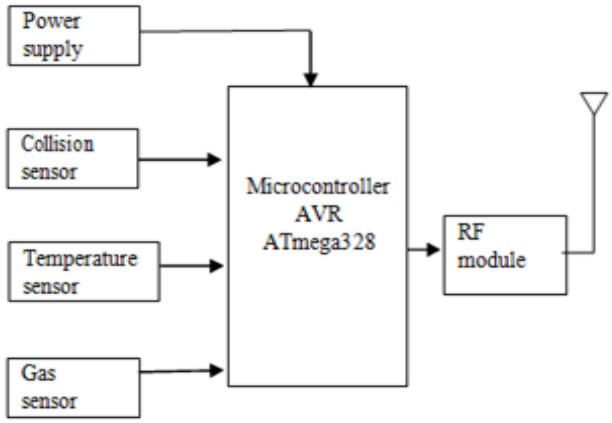


**Figure 1.** Transmitter Section

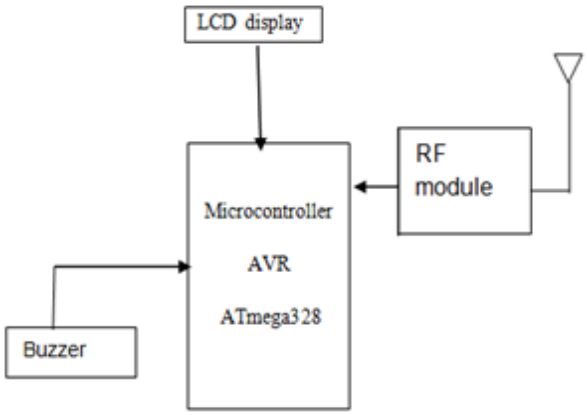


**Figure 2.** Receiver Section

## 5. Hardware Description

### 5.1. Transmitter Section

#### 5.1.1. Humidity Sensor

To detect humidity and temperature Humidity sensor is used. This device is electronic and it will measure the humidity in the environment where it present and Will convert the findings into electric signal. This device works by detecting changes that alter electrical currents or temperature in the air.

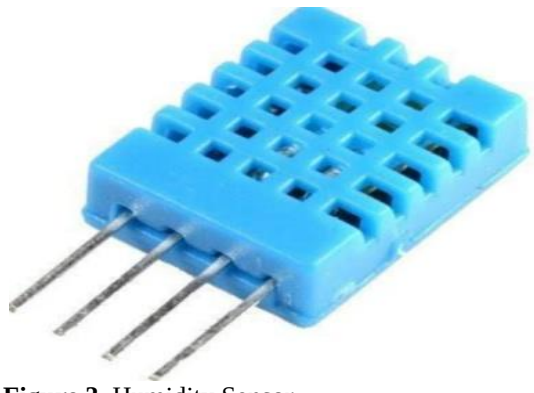

**Figure 3.** Humidity Sensor

**5.1.2. Gas Sensor**

The MQ5 Gas sensor is used to detect H2, LPG, CH4, CO and alcohol. The gas sensor contains steel exoskeleton under that sensing element is housed. The potentiometer is implemented to lower the delicacy of the sensor. This MQ5 sensor ranging from 100ppm to 3000ppm. Sensor identifies the gas by measuring voltage. Each gas as its unique voltages. By measuring the current discharge, we can determine the concentration of the gas can gas.

**Figure 4.** Gas Sensor

**5.1.3. Piezoelctric Sensor**

To detect collision in the underground mining we take pressure sensor. In our projects for gauging the pressure sensing, we have used the piezoelectric sensor. These expedient usages piezoelectric effect in orderto quantify the variation in surrounding temperature, varying pressure, acceleration, by transforming into an alternate charge which culminate to an electrical charge. The prefix piezo means “press” in Greek. They are also rummage-sale quality performance and process control.

**5.1.4. Arduino Uno**

Arduino UNO is a microcontroller; it is the central controller for our system in transmitter section and also receiver section. Arduino UNO is based on ATmega328. The Arduino UNO comprises of 14 Digital pins such as input &output pins along with 6 analog inputs, a 16MHz Quartz crystal a Universal Serial Bus, a USB connection an, power jack and a button. Arduino UNO will be operated on an external supply from six to twenty volts. If we use RF module for this board is seven to twelve volts. The Arduino UNO is supplied with thirty male input output headers, during a dip thirty like configuration which might be programmed.


**Figure 5.** Arduino UNO

**5.1.5. RF Module**

In this project we used NRF24L01 RF module. It is designed to operate in 2.4GHz. Its capable of data transferring rate is 2Mbps. It has more power, higher range and simple to use radio frequency wireless transceiver module based on the popular NRF24L01.

The Output power of NRF24L01frequency channels, and SPI protocol is used in this RF module. Current consumption of NRF24L01 is very lesser at 9.0mA and an output power of -6dBand 12.3Mm in RX mode. To save the power the Built in Power Down and Stand by wide 2.4 - 2.5 Ghz.nRF24L01 is less expensive and modes are used. It is a easy to use rf module to do wireless communication using Arduino, raspberry Pi and other microcontrollers. Through a spi interface. It transferring distance is 800 meter in straight line and otherwise it transfers up to 100 meters. To communicate with each other, they need to be in the same channel.

### 5.2. Receiver Section

#### 5.2.1. Buzzer

A buzzer is used for audio warning. In our project we use buzzer for warning the mine workers. If detected value of sensor are higher than per defined value, then the buzzer is activated.

**Figure 6.** Buzzer

#### 5.2.2. LCD Display

The LCD is a Liquid Crystal Display which uses liquid crystals in its first form of performing. Light Emitting Diodes have many applications, as they can be often found in mobile phones, TV and computer screens.

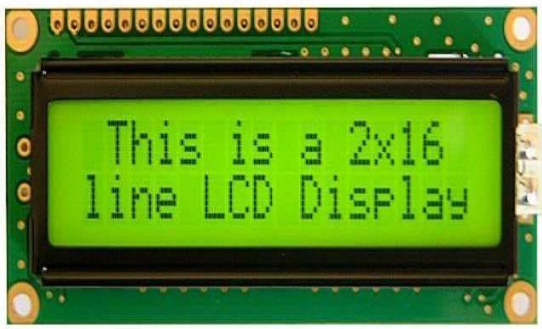


**Figure 7.** LCD Display

### 6. Result and Discussion

When the gas sensor MQ5 detects the gas level of the surrounding environment in the transmitter section, if it is high level of hazardous or dangerous gases then the transmitter section sends “GAS DETECTED” alert signal to helmet, then the helmet shows status on the LCD, as well as buzzer is activated.


**Figure 8.** Output of Gas Detection

When any object falls on the sensor then pressure sensor is detecting the fallen object pressure and then the RF module sends "LESS OR MORE THERSHOLD" signal to helmet, then the helmet shows status on the LCD, as well as buzzer is activated.

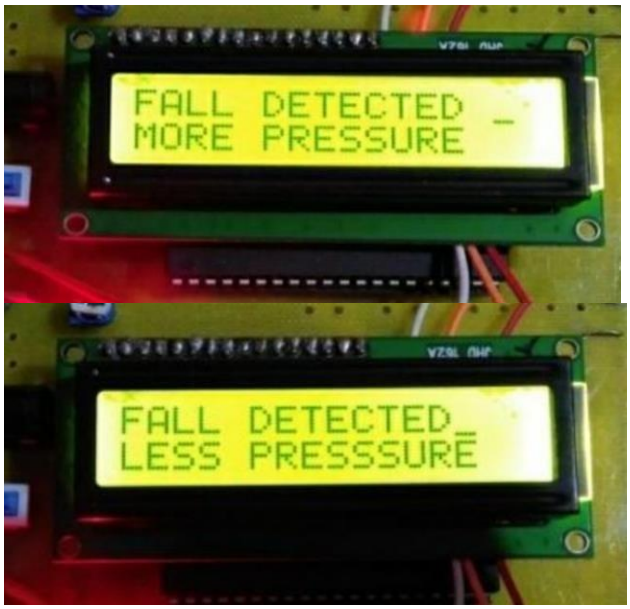


**Figure 9.** Output of Collision Detection

When the Humidity sensor detect the temperature and humidity of the environment if it is higher than pre-defined limit then transmitter section sends "HIGH TEMPERATURE" alert signal to helmet, then the helmet shows status on the LCD, as well as buzzer is activated.

## 7. Conclusion

A system is developed and collected the dangerous gases, pressure and temperature information and transferred to the person. With the help of the collected information available on the person helmet they will take precautions or rescue the mine workers. The safety is the top priority of all in mining industry by using our system we can achieve the safety of the mine workers. This project covered the first aspect of safety of the workers in the underground coal mining. This project is not only for coal miners, but also wherever the underground works are done by the workers. In the project Module NRF24L01 is used due to simple and cost effective. In future this project is to be sent to the control room or manager office using IOT and we are also going to add some new sensor to this system.

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