International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Implementation of Wireless Sensor in Coal Mine Safety System using ZigBee

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Abstract - *This paper designs a monitoring system for coal mine safety based on ZigBee wireless sensor network. In this project there are two sections. The first section is underground section and another section is ground section. In underground section the sensors will be sense the more environment conditions such as temperature, gas etc., and this information is send to the micro-controller. micro-controller displays this information in the LCD and sends through ZigBee transmitter. In ground section ZigBee receiver take that information and that information send to PC with the help of serial communication converter TTL. Which can improve the level of monitoring production safety and reduce accident in the coal mine? ZigBee technology provides a direction for scientists who commit to solve the safety monitoring problems of coal mine. The purpose of this study is to propose a solution suitable to mine wireless communication, safety monitoring, give a proof to the further study.*

***Key Words*: Gas sensor, Fire sensor, temperature sensor, Coal mine safety, ZigBee wireless sensor network.**

1. INTRODUCTION

In underground coal mines, generally helmets with minimal protection and LED lighting are used because of their light weight and power efficiency. Nowadays, with evolving VLSI technology and development of efficient embedded systems, it has become possible to design a smart, compact and efficient electronic system which can be embedded into these helmets to provide better security without sacrificing on weight and power consumption requirements of them. Human protection has been an major issue ever since the humanity started mining materials from the underground coal mines. But due to earth acting as a natural obstruction in wireless communication and fragile nature of electronics, use of modern embedded systems has been limited in the underground coal mines [1-3]. Zigbee technology was proposed for this purpose, which has several advantages like use of globally acceptable frequency range for wireless communication between the sensors and ground control. However, the major drawback is that it suffers from lack of range underground and lack of infrastructure available for it [4,5]. In [6], the authors proposed a system that uses two sensor modules (temperature sensor and Gas sensor) to monitor the aforementioned hazardous parameters in real time and feeds their data to the micro-controller. The micro-controller then analyzes these parameters and compares it with a set range, and sets off the buzzer in case any of the parameters are exceeding it. This system is convenient for the ground control as it can be used for real time surveillance of the staff as well. The use of a compact humidity & temperature sensor ensures a lightweight and power efficient circuit while the use of RF module helps in wireless communication between staff and ground control. With the use of micro-controller, it has also become possible to design smart lighting system for easy recognition in low-to-no light conditions which may occur in underground coal mines using various intensities and colors of modern RGB LEDs.

In this paper, a safe Coal Mine Monitoring system which replaces the traditional coal mine monitoring systems which tend to be wired network systems. This play an important role in coal mine safe production. With continuous enlarging of exploiting areas and extension of depth in coal mine, many lane ways become monitoring blind areas, where are lots of hidden dangers. Moreover, it is inconvenient to lay cables which are expensive and consume time. In order to solve the problems, we designed a coal mine safety monitoring system based on wireless sensor network, which can improve the level of monitoring production safety and reduce accident in the coal mine. Further prevent the hazardous situation inside the coal mines.

2. HARDWARE IMPLEMENTATION

The overall block diagrams of transmitter and receiver sections of the real time coal mine monitoring system are shown in figure 1 and figure 2.

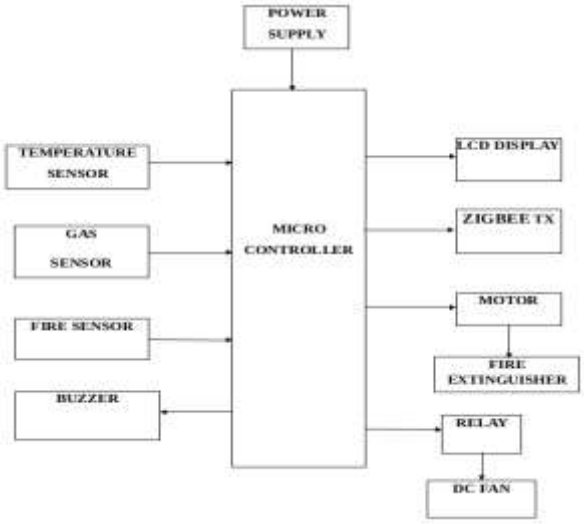

Fig -1: Block diagram of Transmitter section.

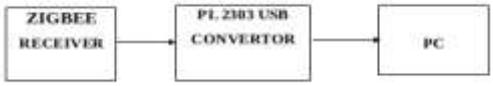

Fig -2: Block Diagram of Receiver section

The components used in the hardware design of the present work has been tabulated in table 1.

S. No	Name	Quantity
1	LM35 temperature sensor	1
2	Fire sensor	1
3	MQ-6 gas sensor	1
4	PL2303 USB	1
5	Arduino Uno	1
6	Buzzer	1
7	Relay	1

1) Temperature Sensor: The LM35 sensor is used for sensing the temperature. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in oC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 oC temperature rise in still air. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every o C rise/fall in ambient temperature, i.e., its scale factor is 0.01V/ ^{o}C.

Fig -3: Gas Sensor Module

2) Gas sensors: Gas sensor measures the concentration of gas in its vicinity. Gas sensor interacts with a gas to measure its concentration. Each gas has a unique breakdown voltage i.e., the electric field at which it is ionized. Sensor identifies gases by measuring these voltages. The concentration of the gas can be determined by measuring the current discharge in the device. MQ-6 gas sensor has been used in this work which has high sensitivity to Propane, Butane and LPG, also response to Natural gas. The sensor could be used to detect different combustible gas, especially Methane, it is with low cost and suitable for different application.

Fig -4: Fire Sensor Module

3) Fire sensor: The Fire sensor is used to detect fire flames. The module makes use of Fire sensor and comparator to detect fire up to a range of 1 meter. Typical Maximum Range is 1 m and the input +5V DC. It consists of LED with 3 pin easy interface connector.

4) Buzzer: Buzzer is considered to be an indicator, which indicates something is happening in the circuit, it is quite useful to identify problem in any system. If a **detector** detects fire or gas, or some abnormal changes occur in the temperature, then **alarm** sounders operate to warn the people in the coal mine of the possible danger and that they need to evacuate.

5) Arduino Uno: The Arduino Uno is a micro-controller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the micro-controller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not

use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

Fig -5: Aurdino Uno

6) Relay: A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current. The heart of a relay is an electromagnet (a coil of wire that becomes a temporary magnet when electricity flows through it). Relay is a switch it on with a tiny current and it switches on another appliance using a much bigger current. As the name suggests, many sensors are incredibly sensitive pieces of electronic equipment and produce only small electric currents. But often we need them to drive bigger pieces of apparatus that use bigger currents. Relays bridge the gap, making it possible for small currents to activate larger ones. That means relays can work either as switches (turning things on and off) or as amplifiers (converting small currents into larger ones). Relays are also used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal.

Fig -6 Relay Module

8) ZigBee: ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio needing low rates of data transfer. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. ZigBee is a low-cost, low-power, wireless mesh networking standard. First, the low cost allows the technology to be widely deployed in wireless control and monitoring applications. Second, the low power-usage allows longer life with smaller batteries. Third, the mesh networking provides high reliability and more extensive range.

Fig -7: Zigbee Module

3. SOFTWARE IMPLEMENTATION

In the present work, the programming of Arduino Uno microcontroller has been done in Embedded C language. The pseudocode is given below:

include SoftwareSerial header

Initialize mySerial

include LiquidCrystal header

Initialize lcd

Define temp A0

Define gas A1

Declare fire1=8, motor=9; fan=10;

Function setup()

{

set lcd.begin to (16,2)

Input pinMode is fire1

output pinMode is motor

output pinMode is fan

Set Serial.begin(9600)

Set mySerial.begin(9600)

}

Function loop()

{

Set temp_out equal to analogRead(temp)

```
assign temp_out as temp_out*0.48
Set gas_out equal to analogRead(gas)
set fire_out equal to digitalRead(fire1)
clear lcd
Set lcd Cursor(0,0)
print lcd output as (“T:”)
lprint temp_out on lcd
Set lcd Cursor(8,0);
print lcd output as(“G:”);
print gas_out on lcd
set lcd Cursor(0,1)
print lcd output as(“F:”);
print fire_out on lcd
Print Serial(“T:”)
Serial print(temp_out)
Serial print(\t)
Serial print(“G:”)
Serial print(gas_out)
Serial print(\t)
Serial print(“F:”)
Serial println(fire_out)
mySerial print("T:");
mySerial print(temp_out);
mySerial rint("\t");
mySerial print("G:");
mySerial print(gas_out);
mySerial print("\t”);
mySerial print("F:");
mySerial println(fire_out);
set delay to 1000
if temp_out is greater than 40; then
        digitalWrite(fan, HIGH)
        mySerial println(“FAN ON”)
else if gas_out is greater than 50; then
        digitalWrite(fan, HIGH);
        mySerial println(“FAN ON”);
else if fire_out is equal to Zero; then
        digitalWrite(fan, HIGH);
        digitalWrite(motor, HIGH);
mySerial println(“FAN ON”);
mySerial println(“MOTOR ON”);
else
        digitalWrite(fan, LOW);
        digitalWrite(motor, LOW);
        mySerial.println("NO PROBLEM");
end
end
```

4. EXPERIMENTS

The complete project implementation is shown in Figure 8. The detection results for fire, temperature and gas are shown in Figures 9, 10 and 11, respectively. Disasters are common in coal mine due to the complexity of its natural Environment. These frequent disasters bring huge loss of possession and life. Therefore, the safe production of coal in the mine is inevitable. The system adopted a ZIGBEE wireless technology to build wireless sensor networks, realized real-time surveillance with early-warning intelligence on methane, temperature, humidity in mining area to reduce potential safety problems in coal production.

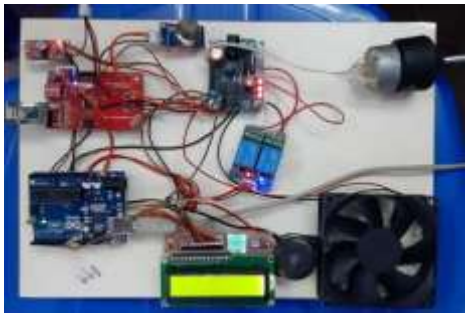

Fig -8: The Real Time Coal Monitoring System

Fig -9: Gas detection output

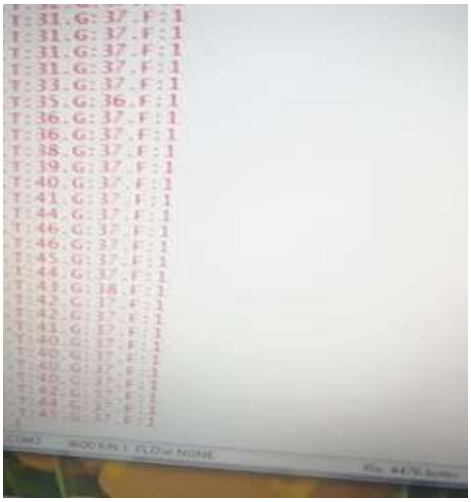

Fig -10: Temperature detection output

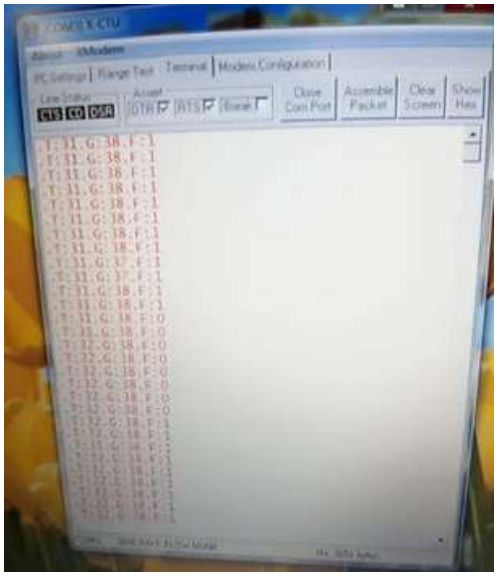

Fig -11: Fire detection output

5. CONCLUSION

The proposed real time coal mine monitoring system has been successfully implemented and tested using the arduino Uno micro-controller. The system adopted a ZigBee wireless technology to build wireless sensor networks, realized real-time surveillance with early-warning intelligence on methane, temperature, humidity in mining area to reduce potential safety problems in coal production. This system will greatly help in reducing future dangers caused in the coal mines, which will give proper rescue and avoid many human deaths. The compact and efficient design ensures the practical implementation of the system. The system can be changed as per the conditions of the coal mines by simply editing the software which makes it more flexible to various coal mine environments.

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BIOGRAPHY

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