

# Wireless Surveillance And Safety System For Mine Workers Using ZigBee

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**Abstract:** Mining safety is one of the major concerns over the many decades. The loss of human health, resources increases as mining progress. The proper channel of communication in the mines was not established till now. They still using old, wired telephonic communication for the purpose of communication to the base station which leads to loss manpower sometime. This project addresses a cost-effective, flexible solution for underground mine workers safety and established faithful communication system inside the underground mines.

**Index Terms** - Arduino Uno, ZigBee, LM35, MQ2, DHT11.

## I. INTRODUCTION

Engineers have worked for a long time for the safety of human resources. They developed many advanced new technologies to warn surface monitoring station before any threatening situation happens. Many hazardous disasters take place inside mines such as fire, leaking of gases and flooding.

IEEE 802.15.4 ZigBee global standard protocol defined for low-power, low-rate, and cost-effective wireless sensor network is developed for automation and wireless environment monitoring. Many applications have been designed based on the ZigBee 2003, ZigBee 2006 version of the device such as building automation, security systems, remote control, and smart energy metering. The ZigBee standard utilizes of IEEE 802.15.4 standard and that combinations are made a complete stack.

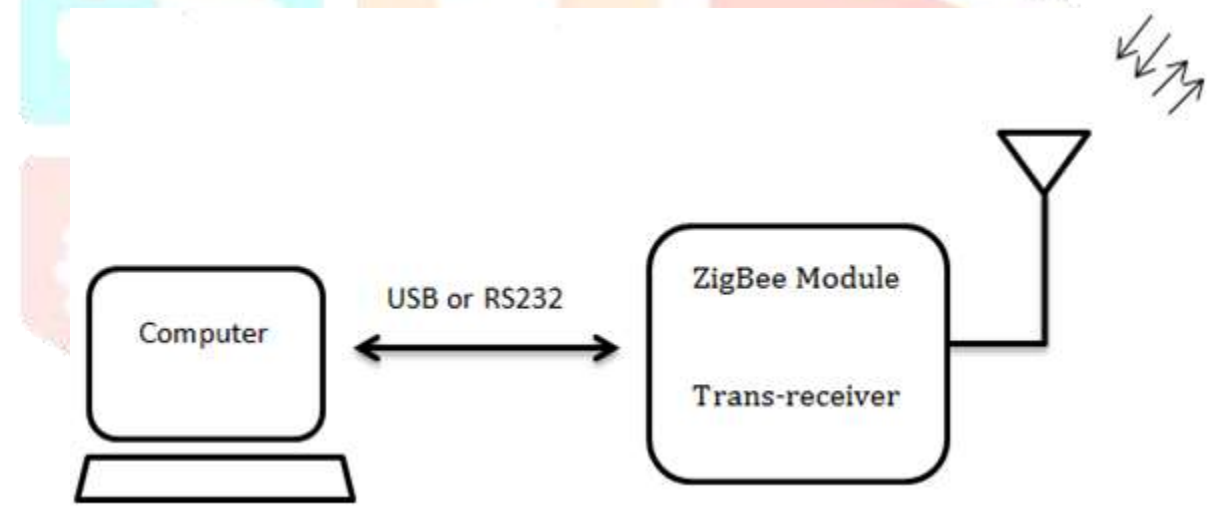
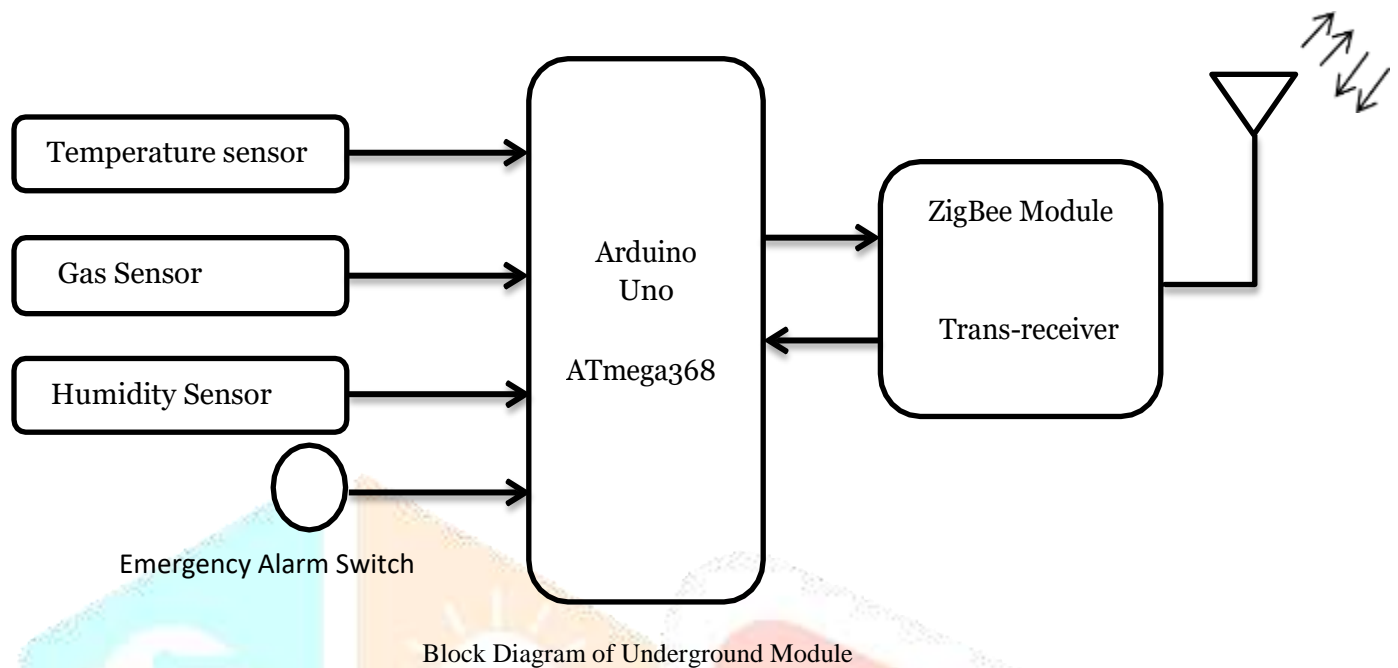
Coal mine safety monitoring system based on wireless sensors can timely and accurately reflect a dynamic situation of staff in the underground regions to ground computer system. In this project, MEMs based sensors have been used to sense environmental parameters such as temperature to detect fire, humidity to detect flooding and methane gas to detect leakage of organic harmful gases. The parameters are sensed, analyzed and processed before transmission. If any of the mentioned factors exceeds the specified limits, then workers inside the mines are warned through indicators as well as sound. The parameters are then transmitted through ZigBee.

ZigBee is a very reliable, low-range wireless technology and uses IEEE 802.15.4 Specification. This specification is a very modern, robust radio technology built on over 40 years of experience by IEEE.

## II. PROPOSED SYSTEM

The proposed system is divided into two sections. First one is the hardware circuit that will be attached to the body of the mine workers. This may be preferably fitted with the safety jacket of the workers also. The circuit has a sensor module consisting of some sensors that measure real-time underground parameters like temperature, humidity and hazard gas concentration. Hazard gases are the gases which have less oxygen content. A microcontroller is used with the sensors to receive the sensor outputs and to take the necessary decision. Once temperature, humidity and hazard gas level are more than the safety level preprogrammed at microcontroller, it alarms through the headset speaker connected with the controller. Different sensors values are displayed in the LCD of base a station. An alarm through buzzer is given when the sensor levels exceed the threshold levels. In all such cases, this will send an alarm through an urgent message and alarm sound to the ground control terminal through ZigBee. In control station, the information is received by ZigBee transceiver and the status of the sensors is monitored in the LCD.

**BLOCK DIAGRAM:**



Block Diagram of Base Station

**III. RESULT AND ANALYSIS**

The prototype for wireless surveillance safety system for mine workers is implemented and tested using temperature, humidity and gas sensor. The sensing system module was implanted in the wearable jacket of mine workers and data acquisition for each sensor is explained in the following sub-sections.

**Temperature measurement**

Temperature sensor LM35 is able to measure the temperature in the range of  $-55^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$  as per the specification mentioned by the manufacturer. The resolution of the sensor is  $10\text{mV}/^{\circ}\text{C}$  and with an accuracy of  $0.05\text{V}/^{\circ}\text{C}$  at  $25^{\circ}\text{C}$ . The DC power required for the operation of this sensor is 4 to 30V. In this project, the DC voltage of 12V is used in the temperature sensing circuit. For various

temperatures the experiment is conducted and the sensor output voltage is recorded. These values are represented in table 1. With this prototype up to 60°C of temperature experiment is conducted. It is observed from the tabular data, the sensor output voltage is linearly varying with the temperature and shown in fig 1.

Table 1: Relation between Temperature and Voltage across Sensor

Temperature	Voltage Across Sensor
25	0.24
30	0.29
35	0.34
40	0.39
45	0.46
50	0.49
55	0.54
60	0.59

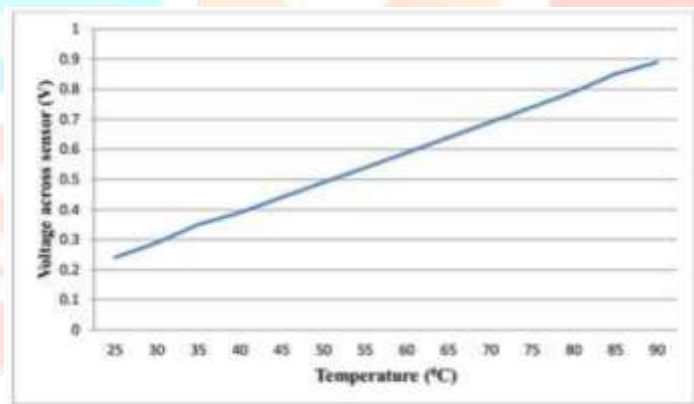


Fig 1 Relationships between Temperature and Voltage across sensor

Whenever there is a change in temperature the sensor is able to sense only 1°C change in temperature and the response time (settling time) of the sensor is about 20 microseconds. Hence after 20 microseconds only a steady state output voltage can be taken. Therefore input port of microcontroller connected to temperature sensor is programmed such that the values are recorded after every 20 microseconds only. The response graph of temperature sensor is shown in the fig 2.

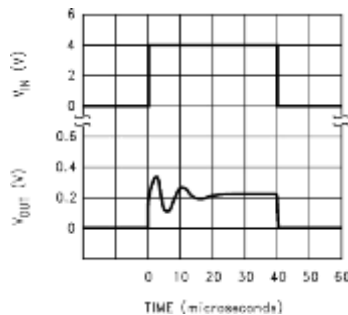


Fig 2 Start-Up Response

## Humidity measurement

The percentage humidity of ambience is measured by using hydrometer, which is costly and cannot be installed in wearable jacket. So, an indirect method of humidity measurement is adopted in this project.

For the humidity sensor DHT11, the %RH and corresponding output voltage are mentioned in data sheet [11] by the manufacturer are used, which are presented in the tables 2 and 3 at 37°C and 43°C.

Table 2: Relative Humidity and Voltage across sensor at 37°C

Relative Humidity (%)	Voltage across sensor(v)
25	1.00
30	1.21
35	1.40
40	1.54
45	1.79
50	2.00
55	2.21
60	2.41
65	2.59
70	2.79
75	2.99
80	3.15
85	3.40
90	3.61
95	3.75
100	4.01

Table 3: Relative humidity and Voltage across sensor at 43°C

Relative Humidity (%)	Voltage across sensor(v)
25	1.01
30	1.23
35	1.41

40	1.63
45	1.80
50	2.05
55	2.23
60	2.44
65	2.63
70	2.83
75	3.00
80	3.23
85	3.44
90	3.63
95	3.78
100	4.05

By using this tabular data the output voltage of the humidity sensor and the %RH are calculated or interpolated. The graph showing the relation between relative humidity and sensor voltage at 37°C and 43°C is shown in figure 3

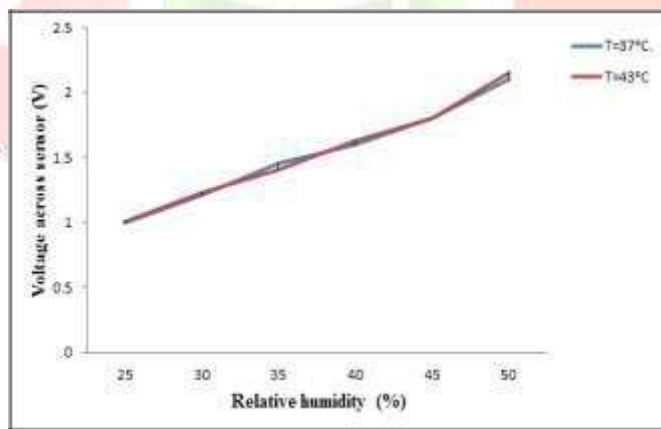


Fig 3: Relationships between Relative humidity and Voltage across sensor

### Detection of toxic gases

In mining areas normally, the toxic gases emitted are Carbon monoxide, methane, carbon dioxide, sulphur dioxide, nitrogen dioxide and hydrogen sulphide [6]. If human beings are exposed for long time to these toxic gases then they become unconscious which may lead to death. To prevent this effect, gas sensor MQ2 is used in this project to detect whether the toxic gasses are present or not.

If any toxic gases are sensed by the sensor, it is indicated with LED and also buzzer and same is also displayed on LCD. This information is also transmitted to the base station immediately. Hence the corresponding mine workers can come out of toxic gaseous area.

### Output obtained from the prototype unit

For the safety of mine workers, three parameter are measured they are temperature in the mining area, humidity and harmful gases. For temperature measurement, the temperature sensor LM35 is used in this prototype. For measuring humidity DHT11 in this prototype. For measuring harmful gases, gas sensor MQ2 is used in this prototype developed.

The mine area and base station where there will be continuous monitoring sensors i.e. temperature sensor for detecting temperature, humidity sensor for detecting humidity, and gas sensor which is used to detect hazardous gases from coal mines. Data processing unit, Arduino Uno with micro controller (ATmega328) which is used to get all output data from the given three sensors, if the level of the output is more than the threshold level preprogrammed at microcontroller, it alarms and the sensor values are displayed in the LCD of the base station. In all such cases, this will send an alarm through ZigBee as a urgent message and alarm sound to the ground control terminal. In the base station, the information is received by ZigBee Trans-receiver and the system also enables the acknowledgement from the base station.

The Experimentation is conducted on four days at different time instants as shown in table 4.

Table 4: Relationship between actual and sensor value

Date	Time	Temperature (In degree Celsius)		Humidity (In %RH)	
		Sensor value	Actual Value	Sensor value	Actual value
3/03/2018	06:30 PM	34	33	31	29
5/03/2018	10:00 AM	30	31	31	26
10/03/2018	01:03 PM	36	36	32	28
16/03/2018	02:31 PM	30	29	49	51

During Experimentation, the outputs of the temperature sensor and humidity sensor are recorded as represented in the table 4. For checking the accuracy of the temperature sensor output, a digital thermometer is used to measure the temperature at the same time instants, those values are also are represented in the table 4.

For Humidity measurement, the data released by authorities of India Meteorological Department (IMD), Ministry of Earth Sciences, Government of India is adopted, the relative humidity in percentage during the time instants of experimentation are also shown in Table 4.

When the values are correlated with those of standard values like thermometer output and India meteorological department (IMD) data, the values generated by these sensors of the prototype are correlating with each other. Even though small error is there in %RH, this is mainly because of the following:

When the Experiment is conducted in the lab, the obtained %RH value of the sensor is specific and a % RH value from the India Meteorological Department (IMD) is the average value of the specific geographical area. So the error obtain by the sensor is inevitable.

Input port of micro-controller is connected to the temperature; humidity sensor is programmed such that it records the data, and transfers the data through ZigBee data to the base station .Transfer data to base station of humidity and temperature sensor is shown in fig 4.



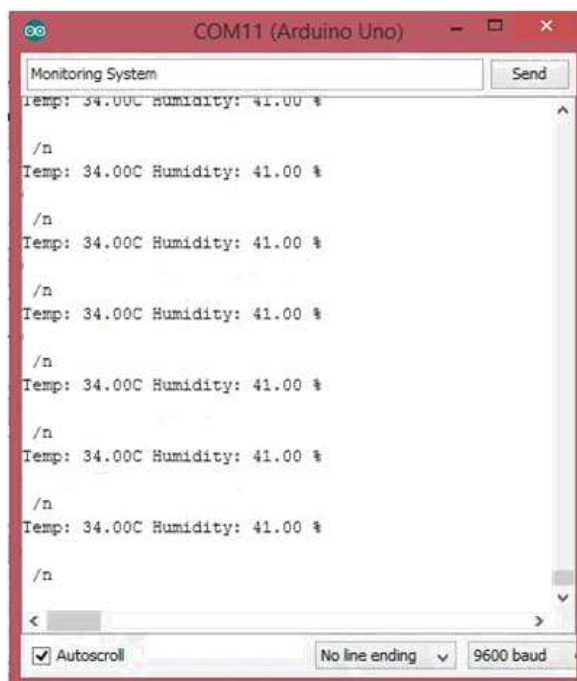


Fig 4. Different sensors value using Arduino IDE Software

#### IV. CONCLUSION

The proposed system developed and tested to demonstrate its feasibility and effectiveness. The present work, coal mine safety monitoring system based wireless sensor networks, and hardware and software design are describe in detail, this system can detect presence of toxic gases, temperature, humidity in underground mine. This prototype monitor three parameters (temperature, humidity and gas) under coal mine and alarm automatically, simultaneously displayed on the LCD when environment parameters are abnormal to exceed the threshold, which help improve the level of monitoring safety and reduce accident in the coal mine. The experiment conducted in the lab results are highly satisfactory, hence this can implemented in mining or industrial areas which are highly hazardous.

#### V. FUTURE SCOPE

Miniature sensors can be used for small and lighter prototype used in wearable jacket. Range of communication can be increased up to 1500 meters by replacing ZigBee with ZigBee pro in practical use. Advance gas sensor can be used to detect concentration, type of toxic gases present in the mine. DHT11 sensors can be replaced with DHT22 or other better sensors for better accuracy, precision and measurement range.

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