

# Robot Based Wireless Monitoring and Safety System for Underground Coal Mines using Zigbee Protocol: A Review

Sachin M. Ledange, Swarup S. Mathurkar

**Abstract—** - Safety of a person is primary concern in any industry especially in underground coal mining industry. Underground communication is necessary to monitor underground environmental parameter such as temperature, Humidity, toxic gas etc. and take necessary actions accordingly to avoid any types of hazard. In this paper a robot based wireless monitoring and safety system for underground mines using wireless communication protocol zigbee is proposed, which will take the data of environmental parameters of underground mine using different sensors and send the data to control room using zigbee. This whole system will be placed on a robot which is operated by remote. Use of wireless robot will reduce the human intervention in security system and will improve the safety.

**Index Terms—** wireless, protocol, robot, coal mine, sensor, zigbee

## I. INTRODUCTION

Safety is one of the main aspects related to industries specially the mining industry. In the underground coal mines, human safety is most important thing which need to look. To avoid any types of unwanted phenomena all mining industry follows some basic precaution and rules. Communication is the main key factor for any industry today to monitor different parameters and take necessary actions accordingly to avoid any types of hazards. In recent years, disasters in coal mine occur frequently, which lead to great loss of possession and life. The accidents happening in coal mine are due to the complexity of mine environment and the variety of work condition of coal mine, so it is necessary to monitor mine working environment. To avoid loss of material and damaging of human health, protection system as well as faithful communication system is necessary inside the underground mines. To increase both safety and productivity in mines, a reliable communication must be established between workers, moving in the mine, and a fixed base station or control room. Inside mines, the wired communication system is not so effective. The reliability and long life of conventional communications systems in harsh mining environments has always been a problem. Inside mines due to uncomfortable situation the installation cost as

well as maintenance cost is high for wired communication networks. It is very difficult to reinstall the wired communication system inside mines, after a landslide or damage due to any reason. Due to roof fall, if by any means some workers trapped inside mines, to maintain the continuity of the communication system is very much important to know the actual position and condition of the trapped workers. To monitor other parameters during this condition it is very much necessary to maintain the communication system as usual. Accordingly, development of mine monitoring system to accurately detect temperature, pressure, flammable and poisonous gas and to track underground miners and vehicles on real-time has significant meaning to safety production and rescue of coal mine disaster.

A good communication system must be set between mine workers and Remote Control room, for this wired network communication is inefficient in underground mining areas. For the successfully wireless data transmission, Zigbee can be properly utilized. This wireless communication system is going to be design by considering all the environmental parameter inside underground mines. It can sense temperature, humidity, fire, gas as well as vibration inside mines. Therefore the proposed system will be giving a very good solution for most of the problems faced in mine accidents. Wireless system is cost effective and useful than wired safety system.

## II. LITERATURE REVIEW

Coal is a rich source for electricity in India, so safe production of coal is very important. There are different other research ideas proposed by different people on wireless communication for underground coal mines.

In a work presented by Y.P.Zhang and G.X.Zheng, a hybrid tunnel radio propagation model consisting of the free space propagation and the modified waveguide propagation is proposed. But using this radio communication inside mines has some disadvantages. When radio signals are transmitted diffraction, attenuation, multipath and scattering are often presents and Detroit the signal strength and quality [1].

N.chaamwe, H. Jiang designed a network called chain type wireless underground mine sensor network which consists of three kinds of sensor nodes: sensing nodes, cluster head nodes and a base station deployed on both sides of the

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tunnel at regular intervals to monitor the underground environment and locate the miners [2].

A wireless surveillance and safety system for mine workers based on zigbee designed by Tanmoy Maity and Partha Sarth Das .The design proposed a cost effective, flexible solution of underground mine workers safety. A module of MEMS based sensors are used for underground environment monitoring and automatic progression of measurement data through digital wireless communication technique is proposed with high accuracy, smooth control and reliability [3].

In one of studies related to wireless communication in mines , A new decision making approach to coal and gas outburst prediction with multisensory information fusion is proposed. Two of the multisensory information fusion method- neural network and the Dempster-Shafer evidence theory were taken into account and the improved combination rules in fuzzy sets was given for decision fusion. But, those communication methods having specific technology lacks in practical application in underground mines [4].

Some of the researcher developed, a rescue system for coal mine workers using different sensors based on GSM and RF-PRO. They designed MEMS based sensors network used to monitor the environmental parameters of underground mine area and sends all sensed data to ARM 7 processor. The same information is send to remote location by GSM and RF PRO [5].

Mr. Kumarsagar, R.T.Patil design a monitoring system for coal mine safety based on MSP430. This system utilizes low power, cost effective microcontroller MSP430, a temperature sensor, humidity sensor, smoke detector, gas sensor for sensing the mine climate parameter and a wireless zigbee trans receiver for remote sending of data at central unit. The microcontroller used in this system MSP430 is ultra-low power controller which is reduces power consumption [6].

T. Aresh Kumar and K. Sambasiv Rao design a integrated mine safety monitoring and alerting system using zigbee and CAN bus. In this, they use CAN bus along with zigbee technology to reduce the cost and increase the speed of communication between base station and synchronize node [7].

### III. UNDERGROUND PARAMETER MEASUREMENT

An underground coal mine over the year has been known for its danger from explosion, fire and landslide etc. It is very important for coal mine worker to work safely and effectively inside underground mine. This is possible if there are suitable conditions present inside mines. Suitable conditions include proper temperature, humidity, Oxygen level etc. When work is in progress inside underground mines, there is always possibility of changes in the atmosphere of mines. Sometimes if temperature rises suddenly may cause fire, sometimes humidity increases leads to uneasiness in environment or sometimes vibration will occur or sometime harmful gases like methane may explode. So it is necessary to have continuous monitoring on parameter like temperature, humidity, gaseous, vibration etc. present inside the underground mines.

#### A. Temperature measurement

Suitable temperature is one of the most important condition inside underground mines. It is important for coal mine worker to have proper temperature to work safely and effectively inside the mines. During working hour due to drilling or blasting inside mines, new surfaces are get opened up which may cause increase or decrease in temperature, so it is very much important to monitor temperature inside the mines. Lots of technologies have been developed for temperature measurement .Thermocouple, RTD, Thermistor, LM series sensors etc. can be used to measure the temperature changes inside the mines.

#### B. Humidity Measurement

Humidity generally defined as the amount of water vapor present in the environment. Humidity can be divided into Absolute humidity and Relative humidity. Absolute humidity is the amount of water vapor present in the specific volume of air. And Relative humidity is the ratio of moisture in air to the maximum amount of moisture that air can hold. It is required to know the humidity inside the mines as it can affects chemical, physical and biological conditions of underground mines. The amount of water vapor in air can affect human comfort as well as physical processes inside the mines.so it is useful to have track on humidity inside the mines. Different sensors can be employed to measure humidity inside mines. There are sensors which are based on capacitive effect, some humidity sensors are polymer based. Sensors like SYSH220, HSM-20G etc. are good humidity sensors.

#### C. Gas Detection

Toxic and harmful gases like methane, carbon monoxide may be present in the surfaces of underground coal mines. During working hour, due digging or blasting of coal, methane or other harmful gas can explode and cause dangerous accidents. It is difficult to stop the emission of such harmful gases, but we can save the lives of coal worker by evacuating them, if such accidents occur. So it is important to detect these gases during digging of coal. Different sensors like MQ4, MQ5, TGS2611 etc. can be used to detect methane in underground coal mines.

#### D. Vibration measurement

This is one of the critical measurements in a underground coal mines. Tremor can be felt because of landslide or because of minor earthquake so it is very much important to know the suitable value for allowable vibration inside underground mines .There are various sensor available which effectively measure the vibration. Sensors like Tilt sensor, Accelerometer sensor can be very useful in underground coal mines.

### IV. PROPOSED MONITORING SYSTEM

The proposed monitoring and safety system of underground coal mine will be divided into two section.

**A. Transmitter section**

Transmitter section will be in underground mine mounted on a wireless robot and with the help of wireless communication protocol zigbee, it will send the necessary data to the receiver section which will be in control room where we analyze the data and take necessary action according to it. Transmitter section consists of sensor network which senses the respective environmental

parameter and gives to microcontroller for further operation. This sensing operation can be made in a specific time intervals according to need. Proper sensor need to be selected which are favorable to the environment inside underground coal mine. Such as, temperature sensor should be selected, which is capable of sensing temperature variation from 0°C to 50°C, which is a general temperature range present inside underground coal mine.

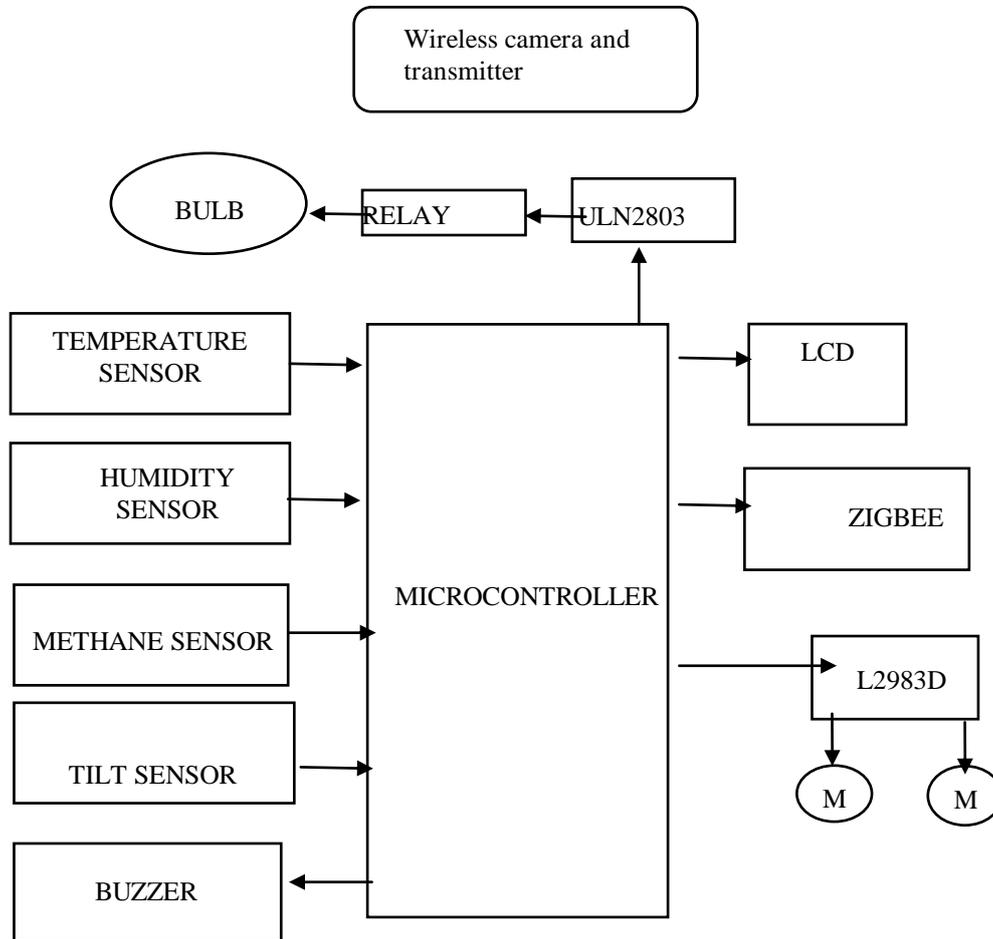


Fig 1. Transmitter Section of proposed system

Transmitter section consists of microcontroller, temperature sensor, humidity sensor, methane sensor, tilt sensor, buzzer, LCD, Driver ICs and Zigbee trans receiver. Environmental parameter data of underground coal mine is send to receiver side through zigbee. Bulb is connected to the transmitter section through relay which is drive by ULN 2803.As transmitter section is mounted on wireless robot, DC motors are required drive by L2983D motor driver IC. On wireless robot, wireless camera transmitter is mounted nearby bulb. Wireless camera will give live view of underground coal mine.

**B. Receiver section**

Receiver section is in control room which consists of microcontroller, zigbee trans receiver, PC for output and wireless camera receiver. Environmental parameter data from transmitter side zigbee is received by receiver side zigbee. And zigbee will send this data to microcontroller through which it will give to PC for display of data. Wireless robot can be controlled by zigbee from control room itself or by using RF module .For that one keypad for movement of robot is connected to the microcontroller in control room. The receiver section can be assemble on PCB.

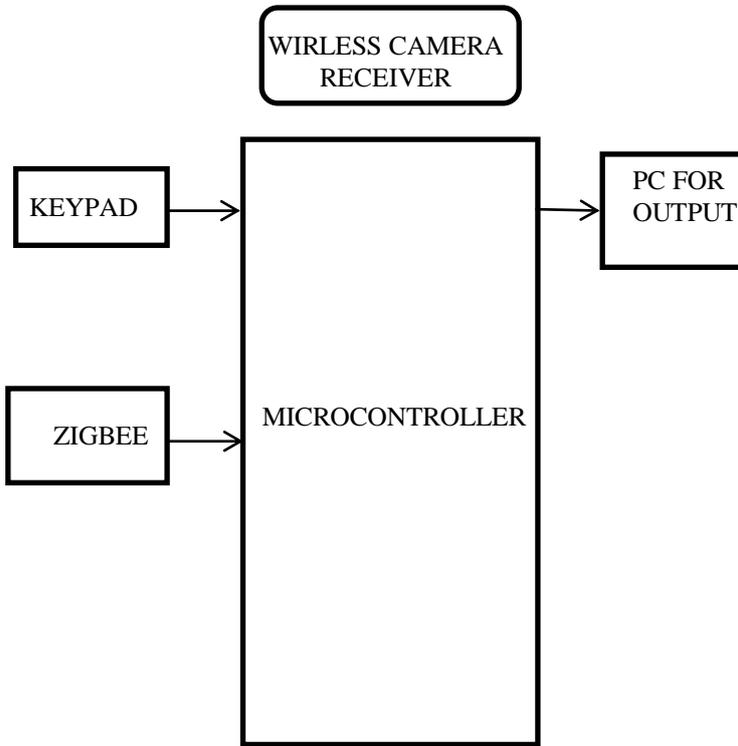


Fig 2. Receiver section of Proposed System

## V. CONCLUSION

The old traditional wired and wireless underground coal mine security system can be effectively replaced by this robot based wireless monitoring and safety system. This system is reliable and cost effective than wired safety system. This system also reduces the human intervention due to use of wireless robot operated from control room. This system is the best solution for complex mine environment as it will combine the low power, low cost zigbee based high frequency data transmission technology with small size sensors. This system will provide proper communication between control room and underground workers and will reduce the accidents.

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