Robot based Wireless Monitoring and Safety System for Underground Coal Mines using ZigBee

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Abstract :

Safety of a person is primary concern in any industry especially in underground coal mining industry. Today safety of miners is a major challenge. Miner's health and life is vulnerable to several critical issues, which includes not only the working environment, but also the prolonged effect of it. Mining activities release harmful and toxic gases in turn exposing the associated workers into the danger of survival. This puts a lot of pressure on the mining industry. To increase the productivity and reduce the cost of mining along with consideration of the safety of workers, an innovative approach is required. Communication plays an important role in surveillance and safety for any industries especially in underground coal mining industry. There is a need to develop active communication network in underground mine to quickly detect the underground environmental conditions and accurately provide necessary instruction to mine worker to evacuate if any danger occur. Underground communication is required to monitor underground parameter such as temperature, humidity, toxic gas etc. and take necessary actions accordingly to avoid any types of hazard. In this paper a design is proposed which is made of different sensors which will senses the environmental parameter in underground mines and this parameter data is send to the control room using wireless communication protocol zigbee.

Zigbee is cost effective wireless communication protocol useful for wireless transmission of data. A whole design is placed on a robot which is wireless operated by remote control. Due to use of wireless robot, it will reduce the human intervention in security system and will improve the safety. So this report proposed a low cost zigbee based wireless monitoring system of underground coal mine placed on robot for better safety in underground coal mine.

Keywords — *wireless, communication, protocol, robot, coal mine, sensor, zigbee.*

I. INTRODUCTION

Coal is the largest source of energy for the generation of electricity worldwide, as well as one of the largest industry which provides employment to the people. Coal is extracted from the ground by coal mining. Underground mining produces more coal than that on the ground level. Also the quality of underground coal in very good in order to produce amount of electricity .Underground coal mining is very popular around the world for coal extraction but also is one of the dangerous place to work. This is because of lack of safety measurement, complex environment and lack of communication.

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 needs 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 systems 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.

Underground mining operations prove to be a risky venture as far as the safety and health of workers are concerned. These risks are due to different techniques used for extracting different minerals. The deeper the mine, the greater is the risk. These safety issues are of grave concern especially in case of coal industries. Thus, safety of workers should always be of major consideration in any form of mining, whether it is coal or any other minerals.

Underground coal mining involves a higher risk than open pit mining due to the problems of ventilation and potential for collapse. However, the utilization of heavy machinery and the methods performed during excavations result into safety risks in all types of mining.

Coal has always been the primary resource of energy in India, which has significantly contributed to the rapid industrial development of the country. About 70% of the power generation is dependent on it thus; the importance of coal in energy sector is indispensable. But the production brings with it the other byproducts, which proves to be a potential threat to the environment and the people associated with it. In lieu of that the present work is a sincere attempt in analyzing the graveness and designing a real time monitoring system of detection by using the zigbee technology. Zigbee is low cost effective wireless communication protocol which is suitable for underground coal mine environment.

II. LITERATURE REVIEW

A wireless sensor network (WSN) consists of hundreds or thousands of low cost nodes which could either have a fixed location or randomly deployed to monitor the environment. It is formed by hundreds or thousands of motes that communicate with each other and pass data along from one to another. Many researchers have proposed the application of wireless sensor network in underground mining, as they are more prone to accidents due to rock weaknesses and the presence of toxoids gases [1]. Only various causes of disaster in underground coal mines are discussed in [1]. Therefore, there has been an interest in applying this WSN technology to Monitor underground mines environment in real-time and choosing an efficient routing protocol to increase lifetime of the WSN [2-3]. The sensor nodes, fixed on the wall do not allow the expansion of network in his system's technology can be applied in underground coal mines in order to improve real-time monitoring safety system at low cost. Each node is able to sense various environment parameters and communicate these values to nearby nodes and transmit to ground monitoring center. In 2000, Laura *et al* proposed a wireless mines communication solution based on wireless LAN which provides wireless and real-time connection with full coverage from underground mine to the enterprise information system [4]. However this system requires large bandwidth and a more power consumption. A hybrid wireless network topologies along with heterogeneous communication protocols to support high and low bandwidth applications is also proposed in [5] without proper practical and testing results in underground mines. To overcome the shortcomings of wired systems, a two leveled network architecture for the wireless sensor network is proposed under an integrated monitoring system, combining wireless sensor network and existing wired monitoring system [6]. It discusses only the topology generation algorithm and monitoring mechanism for the system. Again, a low power consumption WSN is proposed based on the low energy adaptive clustering hierarchy protocol in [7]. One of the schemes for coal mines environment monitoring system is proposed based on Zigbee [8]. During acquiring data, nodes communicate with sinks by radio. Sinks send data received from the WSN to substation by CAN (control area network) bus. Similarly in the paper by Yu Li-min *et.al*. design a mine's safety system based on the Zigbee wireless sensor network for underground coal mines. The sensor nodes will send the collected data to an embedded network controller based on ARM kernel through multi-hop method and then the controller receives the data and sends it to the ground PC by the conversion of Zigbee protocol to Ethernet protocol [9]. The paper evaluated the performance of wireless sensor network for underground mine's safety monitoring system based on Zigbee technology via simulation using software ns-2. The system consists of large number of sensor nodes that organize themselves into a multi-hop routing wireless network [10].

III.PROPOSED SYSTEM

The proposed system consists of two section A.Transmitter section and B.Receiver section. Transmitter section is in underground coal mines while receiver section in control room.

A. Transmitter Section

Block diagram of transmitter section consists different sensor such as gas sensor MQ2, temperature and humidity sensor DHT11 and tilt sensor ADXL335. Xbee module is present to send the sensor information to the receiver section which is in control room. LCD for displaying values of temperature and humidity. Motor driver IC L293D is required to drive DC motors .All these components are controlled by auduino. Wireless audio video camera transmitter is independent mounted on robot.

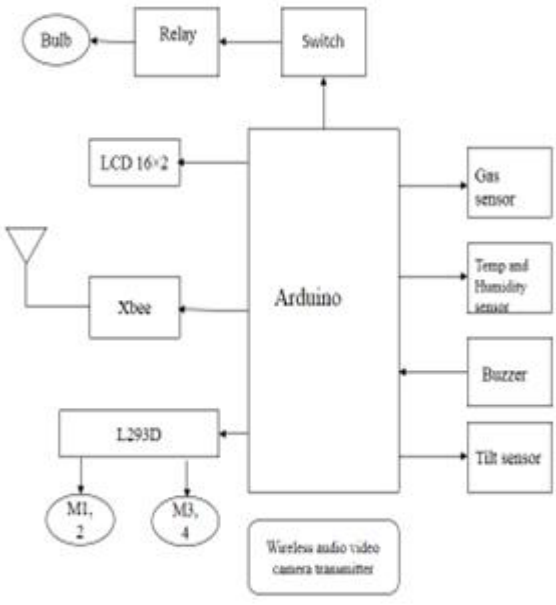

Fig. 1 Block Diagram of Transmitter Section

B. Receiver Section

Receiver section consists of Xbee module to receive sensor data and to control the movement of robot. Keypad is to move robot to required direction and PC is to display the necessary data. Wireless audio video camera receiver is connected to PC for video surveillance of underground coal mines.

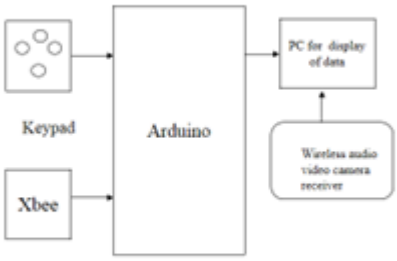

Fig. 2 Block Diagram of Receiver Section

IV. EXPERIMENTAL ANALYSIS

By interfacing all the components with proper arrangement, transmitter section get designed. All these components are controlled by arduino mega. Different sensor forms sensor unit along with other component are placed on land rover robot which is wirelessly operated from control room by remote control.

This transmitter section is powered by DC batteries. 12 v battery is given to the sensor unit and to the arduino mega for environment sensing operation and independent 9v battery is given to the DC motors for movement operations .Again wireless audio video camera is powered by 9 Dc battery.

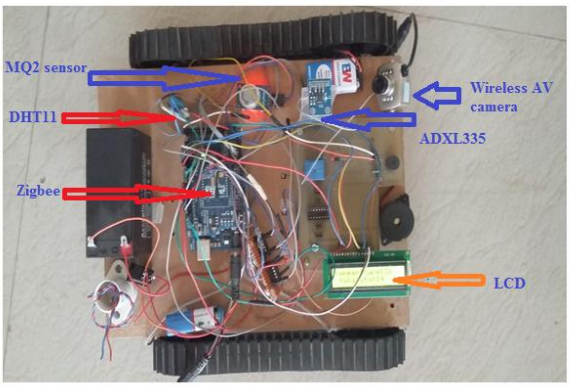

Fig. 3 Transmitter Section

In receiver section Keypad and Xbee S2 model is interfaced to the auduino Uno in order to receives sensor data and to control the movement of robot. Xbee module not only will receive the sensor data from the transmitter section but also will control the movement of robot. Keypad will move the robot to the required directions. This receiver section is connected to PC where we can monitor the sensing data and take the necessary action by analyzing it. With the help of wireless camera we can easily move the robot.

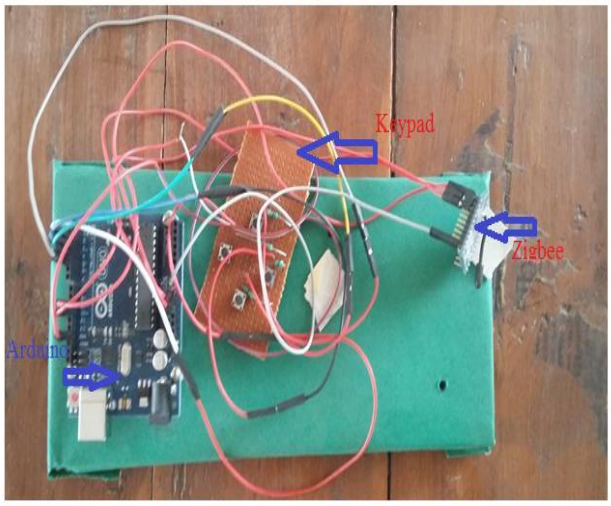

Fig.4 Receiver Section

The environmental parameter data from transmitter section in received in control room and can be monitored on COM port of arduino as

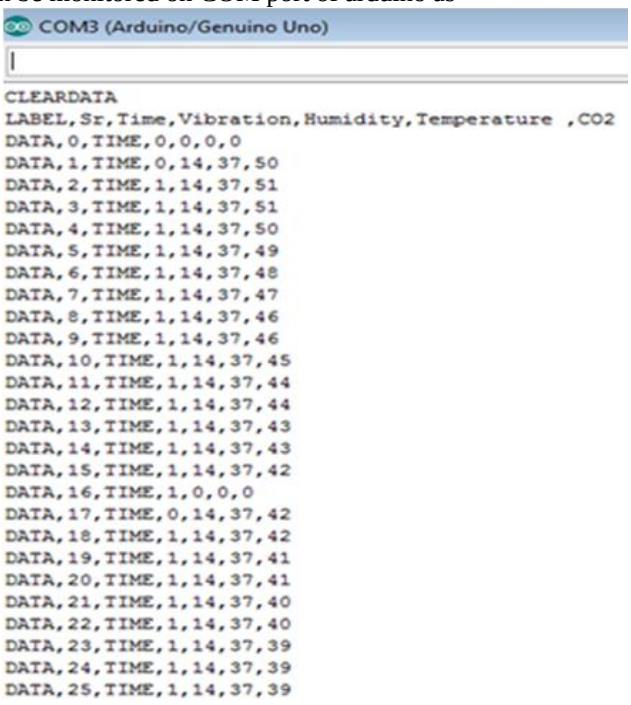

Fig 5 Different Sensors Value using Arduino IDE Software.

V. CONCLUSIONS

The study on real time monitoring of toxic gases, variation in temperature, humidity and acceleration present in underground mine has

analyzed using wireless sensor network. A real time monitoring system is developed to provide clearer and more point to point perspective of the underground mine. This system is displaying the parameters on the LCD at the underground section where sensor unit is installed as well as on the monitoring unit; it will be helpful to all miners present inside the mine to save their life before any casualty occurs. Buzzer triggers when sensor values crosses the threshold level. This system also stores all the data in the computer for future inspection. From the experiments and observations, the following conclusion can be drawn:

1) The proposed robot will give a good application based device for the mining safety.

2)This system will combine the low power, low cost ZIGBEE and Arduino advantages with modern age small size sensors.

3) Traditional mine security system can be effectively replaced by the surveillance and safety robot proposed in report.

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