



Intelligent Mining: A Monitoring and Security System for Coal Mine Workers

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ABSTRACT: This paper introduces an intelligent remote monitoring system based on zigbee. The system consists of two parts- The ground system and the underground system. The underground system consists of the sensor network that senses the environmental parameters and transmits this data to the ground system via zigbee modules. The function the system implements includes data collection, analysis, management, alarm display and control. This system provides real time, reliable and robust monitoring. Consequently, it ensures safety and stable operation.

KEYWORDS: Zigbee, Sensor network, Coal Mine Security System, System Security.

I.INTRODUCTION

Economy majorly depends on country's natural resources which mainly include agriculture, forestry, fisheries and extraction of minerals through mining. In this paper we are concentrating mainly on underground coal mines and how the toxic gases therein can be monitored in order to control the mining operations while keeping a check on the health and safety of workers at the same time. Underground mine environment is very complex. It is seen that, the various environmental parameters of mine, such as methane, carbon monoxide, other toxic gases, temperature, oxygen, etc. are not monitored. In coal mines, the major emission is of methane. The methane released during and after mining operations is called Coal mine methane (CMM). The concentration of methane if passed through a certain range with oxygen, it can be ignited easily with the presence of an ignition source which create a violent methane explosion that may propagate in the presence of combustible coal dust. Hence, environment surrounding mine worker should be continuously monitored. If the conditions become unfavorable for working, mine worker be alerted to leave the place. 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.

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 in real time has significant meaning to safety production and rescue of coal mine disaster.

II.SYSTEM MODEL AND ASSUMPTIONS

The developed system can be divided into two sections. First is an underground management section which contains the hardware circuit that will be attached with the body of the mine workers. This may be preferably fitted with the safety helmet of the workers and the other is the monitoring management section i.e the ground level section.

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Figure below shows the typical structure of the mine. The shaft connects multiple drifts, coal mining is in the drifts, and the coal from every drift is transported to the ground through the shaft. Explosion-proof lighting and sensor array nodes are located in the shaft and the drifts for lighting and real-time monitoring of the underground environment. In order to fully reflect the communication network structure of the mine, an underground power line communication network model is established according to the mine's structure shown in Figure below. In this model, the layout of actual mine shaft and drifts works as the backbone of the communications network, and the explosion-proof lightings and sensor nodes are the power line communication terminal nodes, they build a complex tree structure of underground power line communication network. This network model accurately describes the actual network of the underground structure, can be used as the subject for further networking network analysis.

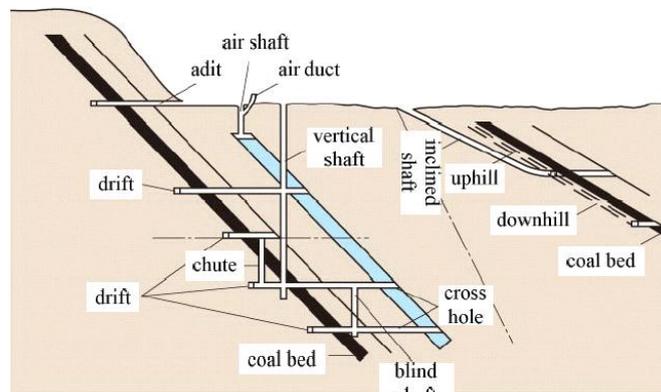


Fig 1. Structure of mine.

The circuit has a sensor module consisting of some MEMS based sensors that measures real-time underground parameters like temperature, humidity and gas concentration. A gas sensor is meant for the harmful gases like methane and carbon-monoxide. A microcontroller is used with the sensors to receive the sensor outputs and to take the necessary decision. Once temperature or the gas concentration is more than the safety level preprogrammed at microcontroller, it decodes beep alarms and sends a message to the authorized person and carries out control system mechanism.

In this system we use three sensors i.e temperature sensor, gas sensor and humidity sensor, the sensor senses the respective data and sends it to the ARM controller, the data is digitized by the ADC's on the board. According to the sensed data values decision is taken based on the sensor value and the threshold values. If the value exceeds the threshold buzzer is activated and a message is sent to the authorized person to take further actions.

Xbee is used for real time communication of the undermine conditions wirelessly. The xbee send all the data to the ground base station on the receiver side, this data is sent continuously and the mines can be monitored for the safety of the workers.

A. Ground Unit:

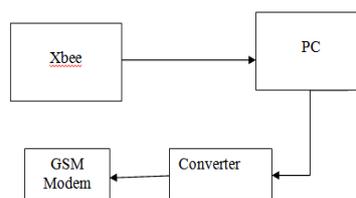


Fig 2: Ground Unit

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It is located at ground level outside the mine. The number of mining units developed will communicate with single monitoring unit.

B. Mining Unit:

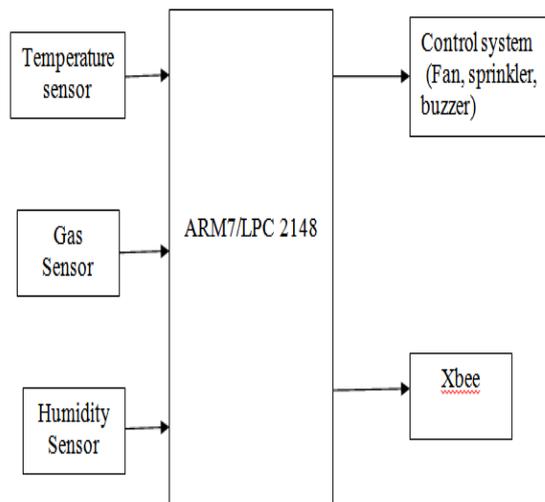


Fig 3: Mining Unit

The mining unit kit will be located in underground environment of the mine. It is nothing but sensor node of the systems. We can deploy number of mining units in different parts.

III. EFFICIENT COMMUNICATION

Communication is the vital part of this system, if the communication fails the entire system fails. Therefore a highly efficient wireless communication system is used here. ZIGBEE is a new wireless technology guided by the IEEE 802.15.4 Personal Area Networks standard. It is primarily designed for the wide ranging automation applications. It currently operates in the 868MHz band at a data rate of 20Kbps in Europe, 914MHz band at 40Kbps in the USA, and the 2.4GHz ISM bands Worldwide at a maximum data-rate of 250Kbps. The ZIGBEE specification is a combination of Home RF Lite and the 802.15.4 specification. The specification operates in the 2.4GHz (ISM) radio band - the same band as 802.11b standard, Bluetooth, microwaves and some other devices. It is capable of connecting 255 devices per network. Range of the transceiver module can be 30-70m in urban areas and 1- 1.5km in outdoor (LOS). The transceiver has an on-chip wire antenna and it operates at a frequency of 2.4GHz. The data received from the microcontroller is organized based on the ZIGBEE protocol standards and then modulated. The specification supports data transmission rates of up to 250 Kbps at a range of up to 30 meters. ZIGBEE's technology is slower than 802.11b (11 Mbps) and Bluetooth (1 Mbps) but it consumes significantly less power. Here a pair of Zigbee modules is used one to transmit the data from underground section and another to receive this data at ground or monitoring section.

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PARAMETER	BLUETOOTH	RFMODULE	ZIGBEE
Powerconsumption	Medium	Medium	Low
Units	7	1	254
Distance	10 m	50 m	30 m-100 m
TransferRate	1Mbps	4.8Kbps	256Kbps

These are the different topologies in which we can place our zigbee devices the most effective is the cluster tree topology

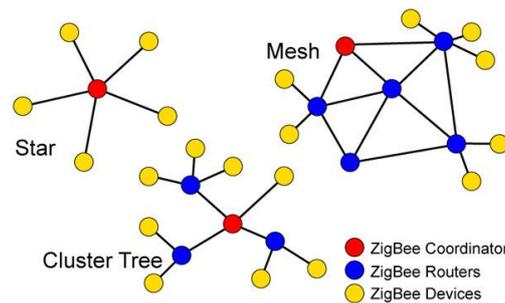


Fig. 4 Zigee Topologies

IV.SENSORS AND SECURITY

Temperature Sensor: The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

Humidity Sensor:These sensors convert humidity into output voltage. Based on a unique capacitive cell, these relative humidity sensors are designed for high volume, cost sensitive applications such as office automation, automotive cabinair control, home appliances, and industrial process control systems. They are also useful in all applications where humidity compensation is needed.

Gas Sensor:Sensitive material of MQ-6 gas sensor is SnO₂, which with lower conductivity in clean air. When the target combustible gas exist, the sensor’s conductivity is higher along with the gas concentration rising. Please use simple electro circuit, Convert change of conductivity to correspond output signal of gas concentration. MQ-6 gas sensor 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. Used in gas leakage detecting equipment’s for detecting of LPG, iso-butane, propane, LNG combustible gases. The sensor does not get trigger with the noise of alcohol, cooking fumes and cigarette smoke.

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GSM Modem: GSM/GPRS Modem-RS232 is built with Dual Band GSM/GPRS engine- SIM900A, works on frequencies 900/ 1800 MHz. The Modem is coming with RS232 interface, which allows you connect PC as well as microcontroller with RS232 Chip (MAX232). The baud rate is configurable from 9600-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in M2M interface. The onboard Regulated Power supply allows you to connect wide range unregulated power supply. Using this modem, you can make audio calls, SMS, Read SMS, attend the incoming calls and internet etc. through simple AT commands.

V. RESULT AND DISCUSSION

In the fig 5, it shows underground system. The values of the sensors are displayed on the miners unit and sent to the ground unit via Xbee.



Fig. 5 working of the underground system

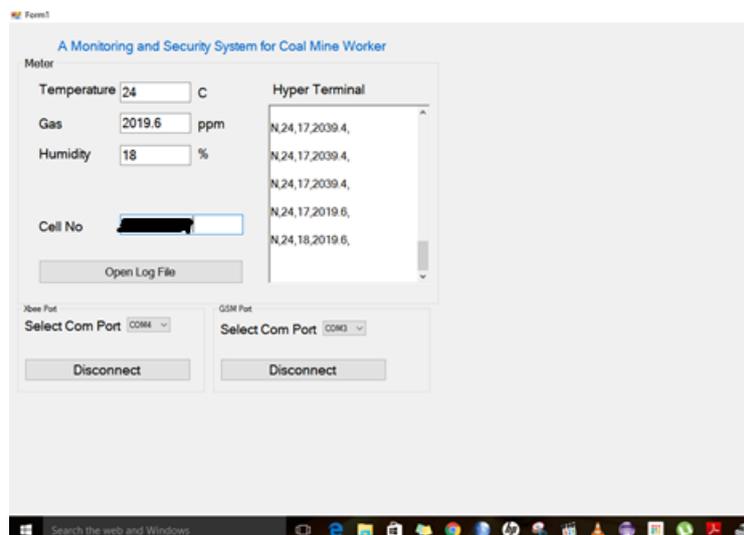


Fig. 6 Display on the ground system

In the fig 6, it shows the VB page designed for the ground section. The values are sent to ground section by the xbee and displayed.



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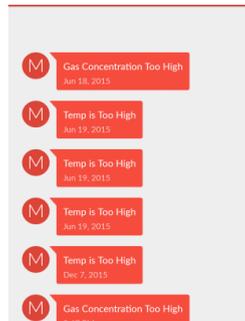


Fig .7Messages sent to the authorized number

In Fig 7, the message is sent to the authorized person in case of emergency via a GSM modem connected at the ground section.

VI.CONCLUSION

This article offers a fundamental study on the design and implementation of the remote network monitoring and security system of coal mine. In this work, we discussed the design and research of hardware architecture and software platform based on ARM microprocessor. The embedded microprocessor provides the needed flexibility and scalability. This system is based on the ZigBee wireless sensor network. The system makes full use of the low cost, low data rate and low power consumption characteristics. Installation and debugging of the monitoring system is simple to the manage stuff. This system includes functions like data collection, analysis, management, storage, automatic alarm, display and control.

This solution scheme and technology makes the hardware circuits easy to realize in practice, and ensures the monitoring system has higher viability in harsh environment.

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