Mems Sensor And Zigbee Module Over The Helmetof Mine Workers

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Abstract

This paper addresses an economical, supple, continuous monitoring system of underground mine workers' protection and security. A module of MEMS based sensors are used for monitoring underground parameters as per the requirement of the user and automating sequence of measuring data through digital wireless communication system is projected with high precision, soft control and reliability. A microcontroller based system is used for collecting and storing data and making decision accordingly, based on which the mine worker is informed through different alarm tone as well as voice system. The voice system with both microphone and speaker, converted into digital signal and successfully communicate wirelessly with the ground control centre computer system(ccc). The communication system is reliable based on ZigBee. This is used for transmission between the hardware circuit fitted with the mine workers and the ground control centre computer system through some routers.

Keywords*: Wireless, mines' safety, zigbee, protection, security.*

1 Introduction

Safety is the most vital part of any type of industry. Negligence in the safety part may cause damaging of high quality equipment hampering of production or may cause loss of human life also in extreme cases. In the mining industry safety and security is a fundamental aspect of all. To avoid any types of unwanted phenomena all mining industry follows some basic precaution and phenomena. Communication is the most vital key factor today, to monitor different parameters continuously and to take necessary actions accordingly to avoid any types of hazards related to production, security, managing of human resources. To avoid loss of material and damaging of human health, security and safety system as well as reliable continuous faithful communication system is essential in the interior of the underground mines. To enhance security, safety and productivity in underground mines a reliable communication system must be established between workers, moving in the mine, and a fixed base station. The communication network must not be interrupted at any moment and at any condition. Inside underground mines, the wired communication network system is not so effective. 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. If due to some reason any wire of the communication network damages, it may cause temporary interruption of the continuous process or may cause a long term break down of the system.

Due to roof slide, if by any means some workers trapped inside mines, it is very much required to maintain the continuity of the communication system. It 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 underground mine disaster.

Coal mine safety monitoring system based on wireless sensor network can timely and accurately reflect dynamic situation of staff in the underground regions to ground computer system. A hybrid tunnel radio propagation model consisting of the free space propagation and this radio communication inside mines has some disadvantages. When radio signals are transmitted, diffraction, attenuation, multi-path and scattering are often very serious. So wireless communication is the burning need today for the rapid, precise, flexible, safety process in underground mines.

There are different other research ideas proposed by different people on wireless communication. In a network called chain-type wireless underground mine sensor network (CWUMSN) is recently proposed which consists of three kinds of sensor nodes: sensing nodes, cluster head nodes, and a base station deployed on both sides of the tunnel at

regular intervals to monitor the underground environment and locate the miners. A new decision-making approach to coal and gas outburst prediction with multi-sensor information fusion is proposed in. Two of the multi-sensor information fusion methods- neural network and the dempster-shafter evidence theory. But, those communication methods having specific technology lacks in practical application in underground mines.

For the successfully wireless data transmission, in this work the ZigBeespecification is utilized. There has been increased interest in the ZigBee standard, in particular for building automation and industrial controls since its release in 2004. Though the specification was available publicly in 2005, people prefer using this standard among different wireless protocol for diversified applications. In an agent-based wireless local positioning system with ZigBee technology is proposed, mainly for factory level applications. A cost effective ZigBeebased wireless mine supervising system with early-warning intelligence on methane, temperature, humidity in mining area is proposed in Again, another article presents the development of a system integrated to a ZigBee network to measure the whole human body vibration, for the persons exposed to vibratory environment. ZigBee specification is incorporated by many manufacturers in their devices because of its low power consumption and decreasing development cost.

2 Description of the scheme

The developed system can be divided into two sections. First is a 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 also which should be mandatory in the premises of any underground mines. The circuit has a sensor module consisting of some MEMS based sensors that measures real-time underground parameters like temperature, humidity concentration of different gases, vibration inside mines etc. Gases like methane and carbon-monoxide etc. cause harmful for workers. Some of the gases are toxic and some are inflammable. A microcontroller is used with the sensors to receive the sensor outputs and to take the necessary decision. The microcontroller can store data's as required by the user for maintaining of records.

Once temperature is more than the safety level preprogrammed at microcontroller, microcontroller decodes beep alarms through the headset speaker connected with controller. Again, once the measured humidity value is more than the safety level preprogrammed at microcontroller, it decodes different type of beep alarms. Similarly when gas concentration crosses the safety level, microcontroller decodes siren alarms. In all such cases, this will send an alarm through an urgent message and alarm sound to the ground control terminal through zigbee. For the voice CODEC the low size, low power,CMX639is used which is a continuously variable slope delta modulation (CVSD) digital voice communication systems. With its robust and selectable coding algorithms, 8kbps to 128kbps data/sampling rates, supported internal clock signals makes it versatile. It has analog input interface with encoder that connects the microphone and microcontroller and also an analog output interface with decoder that connects speaker/headset and microcontroller. Communication through these encoding and decoding of voice and alarm signals is effectively established with the help of microcontroller. The microcontroller data is transmitted through two separate boards i.e. ZigBee transmission module to the data collector or receiver module. The microcontroller used here is PIC 16F877A with 20MHz operating frequency. It has five I/O ports, eight A/D input channels and 368 bytes data memory.

the data receiving terminal of zigbee XB_RX and data transmitting terminal XB_TX are cross connected to the microcontroller corresponding transmitter and receiver terminals TxD and RxD respectively .If the structure of UART (Universal Asynchronous Receiver Transmitter) system is completed, sending and receiving signal is possible using ZigBee, after installing necessary software.The RESET pin of Zigbee is used to provide an optional reset facility of user through a reset button. A transistor is used for this purpose.

The XBee Modules used in the interfacing boards. It is lowcost, low-power, reliable 20 pin device that operates within the ISM 2.4 GHz frequency band. It has 30 to 100 meter data transmission capability with rate of 250,000 bps. XBee modules operate in five modes. When not receiving or transmitting data, the RF module is in Idle Mode. The RF module shifts into the other modes of operation under various conditions. In transmit mode serial data is received in the DI (data in) buffer and the data is stored in the DI Buffer until it can be processed. When the DI buffer is 17 bytes away from being full, by default, the module de-asserts CTS (high) to signal to the host device to stop sending data. CTS is re-asserted after the DI Buffer has 34 bytes of memory available.

Smaller size data or low baud rate can be selected to avoid this state of overflow. In receive mode valid RF data is received through the antenna. When RF data is received, the data enters the DO (data out) buffer and is sent out the serial port to a host device. Once the DO buffer reaches capacity, any additional incoming RF data is lost. If RTS(hardware flow control) is enabled for flow control, data will not be sent out the DO buffer as long as

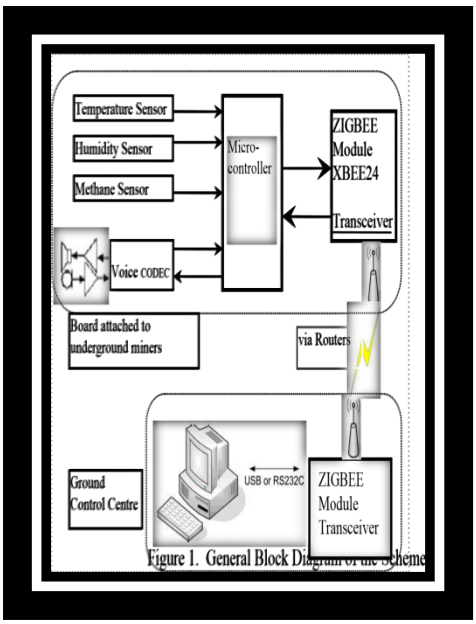
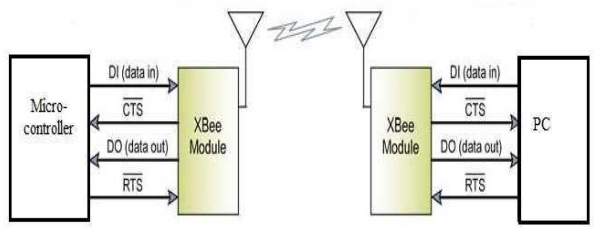


Figure 1. General Block Diagram of the Scheme

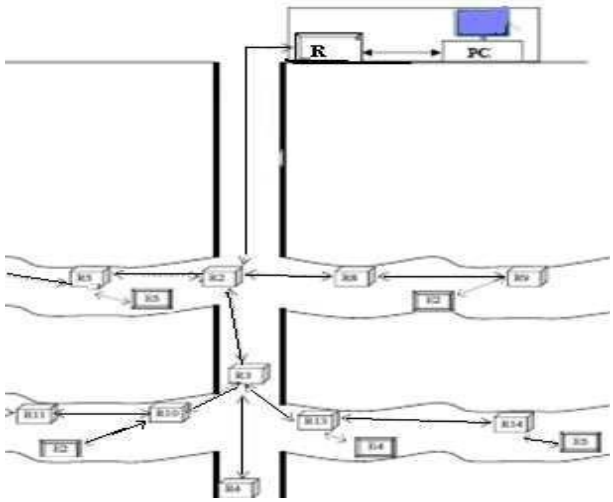
RTS is de-asserted. Sleep Modes enable the RF module to enter states of low- power consumption when not in use i.e. not transmitting/receiving data for the amount of time predefined by the ST parameter. To modify or read RF Module parameters, the module must first enter into Command Mode - a state in which incoming characters are interpreted as commands.

The programming requires the installation of X-CTU software and a serial connection to a PC. When communication occurs between two networked devices, each data packet contains a 'Source Address' and a 'Destination Address' field.

In case of underground specifically, because of the low resistance of earth material, the transmitting signal may be weak enough not to reach properly at the ground centre. So some more zigbees are required throughout the path as routers, which will act as receiver and transmitter in case of non-linear route inside mines. These routers are required to be fixed over the walls of the underground mines. One of the possible schemes applied for shaft mining is shown as an illustration in Fig.



Connections with XBee modules



Layout of zigbee modules (routers) in underground shaft mines

3 Data Transmission ThroughZigbee

The main characteristics of ZigBee network are simple implementation, low power consumption, low cost interface, redundancy of devices, high node density per physical layer (PHY) and medium access control layer (MAC). Besides, they allow the network to work with a great number of active devices. ZigBee is consisting of two terms of the PHY and MAC layers. ZigBee defines two kinds of devices: the Full Function Device (FFD) and the Reduced Function Device (RFD). The FFD has the function to coordinate the network and consequently has access to all other devices. The RFD is limited to a star topology configuration, not being able to work as a network coordinator, so it does not have all the protocol services. The FFD and RFD devices can operate in three different ways at the ZigBee standard as the ZigBee coordinator (ZC), ZigBee Router (ZR), or ZigBee End Device (ZED). The network layer supports three topologies: star, cluster tree and mesh as shown in Fig. 4. A star topology consists of a coordinating node and of one or more FFD or RFD which communicates with the ZC. At the cluster tree, the final devices can be associated to the network by the ZC and the ZR helping the increasing of number of nodes and the network scope. At the mesh topology, the FFD can distribute messages directly to other FFD. To enter the network, each device receives an address given by ZC or a ZR.

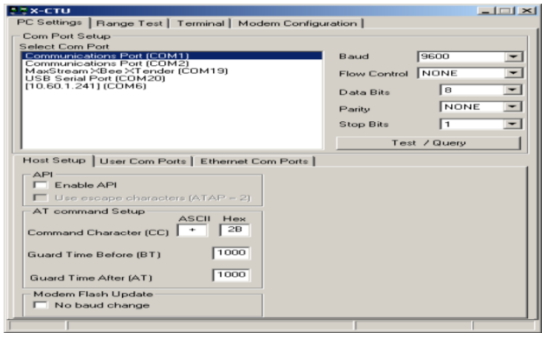
Different topologies of ZigBee network X-CTU is a windows-based application provided program

designed to interact with the firmware files and to provide a simple-to-use graphical user interface. Each of the four tabs there has a different function. PC Settings tab allows selecting the desired COM port and configuring that port to fit the zigbee settings.baudrate, type of flow control and no of bits are required to set before the operation. The Test / Query button is used to test the selected COM port and PC settings. A response is received if the communication between them is correct. The range test tab is used to verify the range of the radio link by sending a user-specified data packet and verifying the response packet is the same, within the time specified. Terminal tab accesses to the computers COM port with a terminal emulation program. This tab also allows to send and receive predefined assemble packet data or data in Hex and ASCII formats using suitable commands. A complete list of commands is available in the product manual. Terminal tab of the X-CTU software is also used to change the RF module's DL (Destination Address Low) parameter and save the new address to non-volatile memory. Modem Configuration tab is used to program the device firmware settings via a graphical user interface. It is also utilized to restore default parameter values of the RF module.

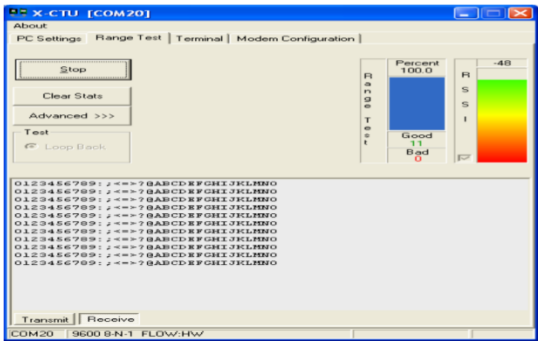
4 Data Management software

A software, developed here is to make an interactive, reliable monitoring and management of sensed data and alarm. The system software is made using Visual Basic which helps to form graphical user interface. It can display the parameters in the forms of bar chart, table and graphical display. Also, it generates and prints the reports of the parameters. The different environmental parameters received by the ground control PC are displayed in those manners in the LCD screen. The parameters include the temperature, humidity, concentration of methane and carbon monoxide gases etc. The computer stores the parameters in the hard disk and ground staff can choose any of the parameters for recording and replaying. When it is found that the parameters received have exceeded the limit set, the microcontroller will control the alarm buzzer to ring in time, and the computer at ground control centre also gives the alarm ring and the alarm pictures.

Based on the alarm received ground staff takes decision and establish voice communication with the underground workers. The safety department people are sent alarm. Respective control and safety measures are taken accordingly based on the continuous monitoring of situation and voice communication with underground people.



PC setting window for X-CTU software



Range Test between the transmitter and receiver XBEE24.

5 Conclusion

Traditional mine security system can be effectively replaced by the surveillance and safety system proposed in the paper. This paper gives a system related to safety and security of under-ground mines. The system is reliable, faithful, uninterrupted, economical and user friendly. A larger area and more depth inside hazardous underground mines are now can be covered and potential accidents can be controlled effectively. The system combined the low power, low cost Zigbee based high frequency wireless data transmission technology with modern age MEMES based small size sensors. The sensor and zigbee module can be preferably installed over the helmet of mine worker. Proper monitoring and conversation is possible between the workers and the ground staff which can help to take appropriate actions more rapidly and smartly. The system also can be easily extended with ZigBee wireless image transmission facility in future; it will improve scalability of underground environment and extend accurate position of miners.

XBEE module with antenna used as transmitter.

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