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Wireless Safety System for Mines

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***Abstract* – Wireless communication networks provide the potential for the extension of the wireless network in areas that could have never been imagined. One such potential application is Underground Mine Communication System based on Wireless Communication Networks. The mine tunnels are long and narrow. They employ hundreds of mining personnel working at any point of time under extreme conditions. It is a fact that the underground mining operations involve a high level of risk. Hundreds of miners die from mining accidents every year. To ensure the safety of workers and perform co-ordination of tasks, a communication and location sensing system is one of the more important infrastructures that need to be deployed. This system is expected to deliver satisfactory performance in terms of communicating and performing location estimation in routine and rescue operations. The current state-of-the art communication technology used in underground mines is challenged by various limitations. Communication and tracking systems in underground mines is an area that has not been actively researched as contemporary surface based systems.**

In the present paper a solution for communication and locating the person using ZigBee technology is presented. The electrodes placed on the miner's body picks up the ECG and on analysis identify the cardiac problems, in case of emergency the message is sent from miner's unit to the Master unit. The paper describes the application, implementation and advantages of the proposed system.

***Keywords* – ZigBee, RFID, mine communication, miner tracking, mine disasters.**

I. INTRODUCTION

Underground mines are characterized by tough working conditions and hazardous environments. They require a fool-proof mine-wide communication system for smooth functioning of mine workings and ensuring better safety. Proper and reliable communication systems not only save the machine breakdown time but also help in immediate passing of messages from the vicinity of underground working area to the surface for day-to-day normal mining operations as well as for speedy rescue operations in case of disaster. Therefore, a reliable and effective communication system is an essential requisite for safe working for maintaining requisite production and productivity of underground mines.

Most of the existing systems generally available in underground mines are based on line (wired) communication principle, hence these are unable to withstand in the disaster conditions and difficult to deploy in inaccessible places. Therefore, wireless communication is an indispensable, reliable, and convenient system and essential in case of day-to-day normal duty or disaster situations.

The wireless communication systems used on surface cannot be applied straightaway in underground mines due to high attenuation of radio waves in underground strata, besides presence of inflammable gases and hazardous environment. Non-symmetric mine topology, uneven mine structure, and complex geological structures put further hindrance on the way of communication.

The options for communication signaling in underground mine include through the wire (TTW), through-the-earth (TTE), and through-the-air (TTA). All these communication means are tried with their own advantages and disadvantages. But, wired communication prevailed for several years. The following types of phones are used in underground mines: (i) magneto type, (ii) sound powered, (iii) bell signaling system, (iv) paging, (v) dial, and (vi) dial and page.

These methods are having their own limitations. With the advent of latest electronic devices, micro controllers and improvement in the communication technologies has led to the design and implementation of latest communication devices, that can provide maximum safety apart from withstanding the harsh mine environment was made possible. The leaky feeder cable is one such technology. This leaky feeder cable "leaks" the radio signal in or out along its length, thus creating a continuous coverage area along the tunnels in which the cable is strung. The coaxial cable has regular openings in the outer shield, which permit RF energy to enter or leave the cable. It can receive and transmit signals down its entire length. Wherever a mine desires communications, it installs leaky feeder cable down the entries. Leaky feeder cables cannot transport radio signals for indefinite distances. There is *attenuation* in the cable itself and there is the continual radiation of RF energy through the openings in the outer shield. Therefore, a mechanism that periodically boosts the strength of the RF signal is required. Amplifiers are electronic components periodically inserted in the cable to boost the signal by increasing its amplitude. In addition to transporting the RF signal, the center conductor of the cable also carries the DC power (typically 12 volts) for the amplifiers.

With the limitations, recently ZigBee based communication paved its way into mine communication. The ZigBee system can also be used to provide the RFID capability into the system.

II. HARDWARE METHODALOGY

In the present paper a mine wide communication methodology is designed and developed to suit the requirements of present day situations. The block diagram of the developed system is shown in Fig.1. The block diagram consists of three basic building blocks:

i) Master unit
ii) Slave unit and
iii) Miner unit

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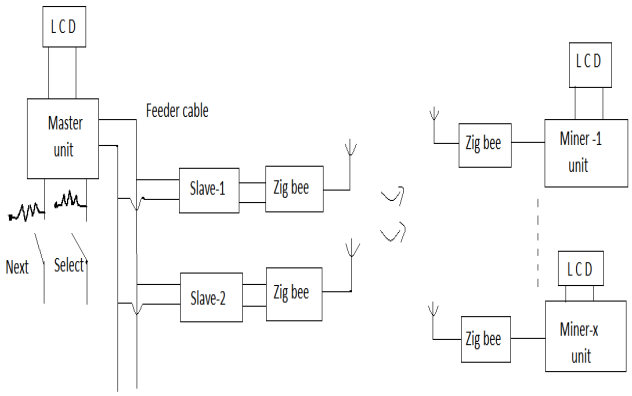

Fig.1. Block diagram

The operation of the total system is as explained below:

The master unit is responsible for all operations. By using the "NEXT" and "SELECT" switches, the operator can select the desired miner ID. The selection process can be monitored on LCD, once the desired miner ID is selected; the "SELECT" button is pressed. Then the master unit first transmits the miner ID through RS485 two wire communication system, to all the slave units, which are located in the mine strategically, so that the signal can be spread to each and every sector of the mine. In the present demonstration only two slaves are provided due to paucity of funds.

Both the slave1 and slave-2 (all the slaves in the practical situations) receives this information and all the slaves re-transmit the miner ID through the ZigBee modules interfaced to the respective slaves. All the miner units, which are in receiving mode receives this information, and matches the ID which is already embedded in the miner unit. The matched miner unit responds and provides an acknowledgement to the nearest slave unit. The slave unit on reception of acknowledgement from miner unit immediately provides this information to master unit along with the slave address.

The master unit on reception of miner ID acknowledgement displays on the LCD indicating that the miner is located in the vicinity of the slave from which the information has been received. If there is no response from any one of the slaves, it indicates that the miner is not in the mine. With this basic communication technique, it is possible to locate the miner, where he is in the entire mine.

Apart from this basic communication between Master and miner units through slave units an emergency protocol can also maintained. In the present project the emergency protocol is maintained by using ECG of the miner.

The ECG of the miner is recorded using electrodes placed on the thoracic region of the miner. The signal thus acquired is amplified and processed to identify the R-wave. The R-R interval is indirectly proportional to the heart rate. If the R-R interval is too high, the heart rate is too low indicating the brady cardia, similarly if the R-R interval is too low, the heart rate is very high, indicating the tachy cardia situation. Both the situations are very dangerous and immediate attention is needed. After identifying the situation, the software generates an emergency warning audio signal, so that the nearby miner can provide immediate attention. Apart from providing the warning, the miner unit immediately transmits message to the Slave unit, which in turn retransmits the message to the master unit. Where the master unit display this on the LCD, along with the miner I D and the location where the miner is, that is Slave vicinity. This way the field staff can take care of the situation by providing the necessary assistance.

The block diagrams of master unit, slave unit and miner unit are shown independently in the following figures

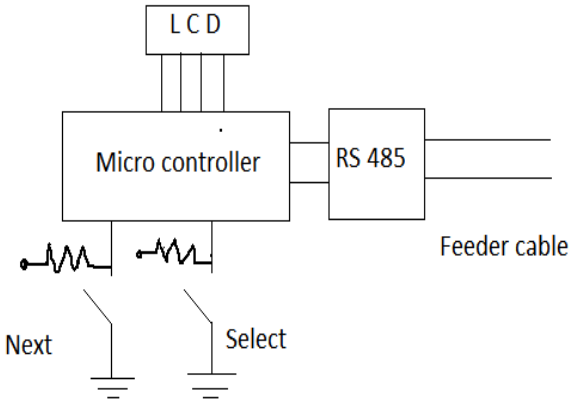

Fig.2. Master Unit

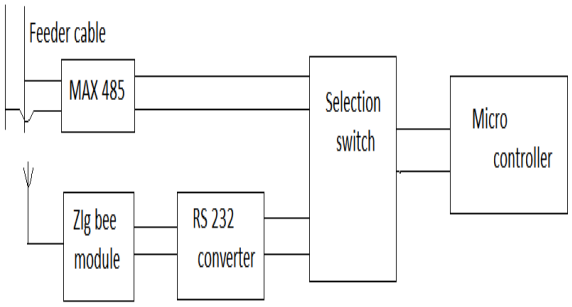

Fig.3. Slave Unit

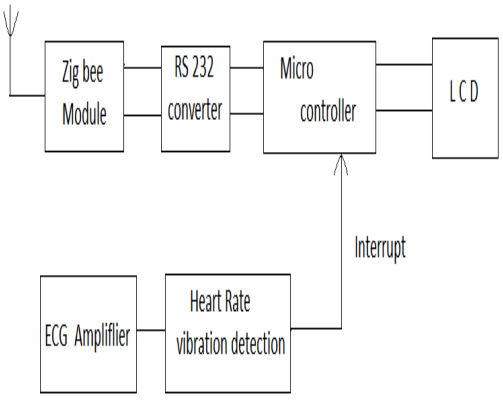

Fig.4. Slave Unit

In the present work, simple 89C52 microcontroller has been used, in practice any high end microcontroller can be used with suitable modifications.

III. CONCLUSIONS

In the present project a cost-effective and viable solution is provided for the miners in their working environment. Though the developed system is working satisfactorily as per the features it has been developed for, it can be extended further. The micro controller can be of high end, so that the power saving sleep modes can be used. Even, the high end other features can also be incorporated, without much difficulty. The system can be further extended to transmit the messages to the selected miner or to a group of miners on selection. It can also be further extended by considering the other vital physiological parameters to protect him to the maximum possible extent.

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