A Smart Monitoring and Alerting System for Mining Workers

D.SHIRISHA
siri.ammi@gmail.com

Assistant Professor, Dept Of ECE, Siddhartha Institute of Technology and sciences, Ghatkesar Mandal, Rangareddy Dist, Telangana, India.

ABSTRACT: Industrial safety is one of the main aspects of industry specially coal mine industry. Underground mining hazards include suffocation, gas poisoning, object fall, roof collapse and gas explosion. So air quality and hazardous event detection is very important factor in mining industry. This system provides a wireless sensor network for monitoring real time situation of underground mines from base station. It provides real time monitoring of harmful gases like CO, CH4 and LPG and also temperature. The main reason for death of miners is that, due to any reason miners falls down and loses consciousness also proper treatment is not provided them at that time. To overcome this problem the system provide emergency alert to the supervisor if person fall down by any reason. And also location of the person using RFID Technology. Some workers are not aware for safety and they are not wear helmet. An IR Sensor was used to successfully determine whether a miner has removed his helmet or not. The system uses Zigbee technology for transmission of data from underground mine to base station. There is alert switch at mines and base station for emergency purpose.

***Keywords**: Zigbee, MEMS, RFID.*

INTRODUCTION

Hazard Evaluation Methodology for Computer-Controlled Mine Monitoring/Control Systems:

A methodology for identifying safety hazards inherent in underground monitoring and control equipment will be given. Under a US Bureau of Mines contract, a methodology has been developed for determining the inherent design items that affect safety hazards. Though serious consideration has already been given to the normal intrinsic safety and explosion-proof characteristics of a system, the problem may be the system itself rather than the more immediately noticeable system components. In monitoring or controlling items located in underground coal mines, the hardware reliability of a system is seldom recognized as a potential safety hazard. As a result of the developing methodology, a set of design guidelines has been developed to ensure that known system design difficulties can be identified from the outset for designers of new mine monitoring/control systems. This technique could prove valuable to other system design engineers as well. Coal is a prime source of energy in India. Coal is the key contributor to the Indian energy scenario 51% of the current total commercial energy needs is made by coal.

There are mainly two methods for extracting the coal from earth- surface mine and underground mine. Most of surface mines are open pit or open cast mine. The surface mine are entirely open and operated from the surface of the earth. The advantages of surface mines are high productivity, low operating cost and good safety condition. Most of the coal is extracted using surface method. In case coal is very deep from surface underground method is used. The underground mines are supported or unsupported mines. In supported method used artificial pillars for support of the opening. Supported mining methods are often used in mines with weak rock structure. The artificial supports are does not available for unsupported mining method. Unsupported methods are used in those areas where strong rock structure available. Underground coal mining involves a higher risk than surface mining due to the problems of ventilation and potential for collapse. The maximum accident occurs in underground mines.

In mining industry worker safety is very important issue. Every year, thousands of miners die in accidents and many more get injured, especially in the processes of coal mining and hard rock mining. The main reasons of accidents are gas or dust explosions, gas intoxications, improper use of explosives, electrical burn, fires, collapsing of mine structures, rock falls from roofs and side walls, flooding, workers stumbling/slipping/falling, or errors from malfunctioning or improperly used mining equipment. In coal mine use of personal protective equipment like helmet, shoes etc. are not proper and proper arrangements were not there to check if the person is wearing personal protective equipment or not [2]. The proper supervision for worker wear the protective equipment is very important factor for consideration. Underground mines are very dark so any miners are fall unconscious because of suffocation or falling of structure, supervisor don't known about her health condition and proper treatment is not provided her in time. The main reason for miner death is harmful gases explosions. In coal mines carbon monoxide, methane, LPG gases are existing and they are very harmful for human body. The proper supervision and proper communication is very important requirement of mining industry. The smart helmet provides a real time monitoring of harmful gases, person fall detection and miner wear the helmet or not. The harmful gases like carbon monoxide, LPG, Methane and also temperature are monitor using this system. The wired communication network is not so effective because when natural calamity or a roof fall occurred, wired network is damages, so it is very difficult and costly to reinstall the entire system. In wired network technology installation and maintenance cost is very high. The effective solution for communication from base station to underground mine is Zigbee wireless network. In Zigbee technology mesh topology provide a long distance wireless communication network.

LITERATURE SURVEY

Hazard Evaluation Methodology for Computer Controlled Mine Monitoring/Control Systems: A methodology for identifying safety hazards inherent in underground monitoring and control equipment will be given. Under a US Bureau of Mines contract, a methodology has been developed for determining the inherent design items that affect safety hazards. Though serious consideration has already been given to the normal intrinsic safety and explosion-proof characteristics of a system, the problem may be the system itself rather than the more immediately noticeable system components. In monitoring or controlling items located in underground coal mines, the hardware reliability of a system is seldom recognized as a potential safety hazard. As a result of the developing methodology, a set of design guidelines has been developed to ensure that known system design difficulties can be identified from the outset for designers of new mine monitoring/control systems. This technique could prove valuable to other system design engineers as well.

South Africa is known for its extensive and diverse mineral resources and large mining industry [1]. Supervisors are held responsible for all injuries sustained under their supervision, and should therefore be aware of potentially risky situations [1]. The problem addressed in this paper was the improvement of a mining helmet in order to ensure more safety awareness between miners. When working with noisy equipment, being aware of one's surroundings can sometimes be challenging [2]. In the mining industry miners tend to remove some of their safety gear because the gear is too heavy, warm or uncomfortable to work with. However, miners generally do not remove their helmets. Presently mining safety helmets only have the purpose of protecting the miner's head against potential hazardous bumps. The safety helmets do not have any technology added to it to let miners know when a fellow miner has encountered a hazardous event. Therefore the purpose of the project described in this paper was to modify an existing mining safety helmet to make the helmet even safer by adding a wireless sensor node network. The task was extended to designing the system small enough to fit into the safety helmet and last long enough while running on battery power. A further challenge was to modify the helmet without changing its physical structure. The added weight had to be kept to a minimum. A mining helmet needs to be modified to improve miner safety by adding intelligence to the helmet. When a miner removes his helmet he needs to be warned. If an object falls on a miner even when wearing his helmet he can become unconscious or immobile. The system must determine whether or not a miner has sustained a life-threatening injury. These two events are

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 13
October 2017

defined as hazardous events. Thirdly, dangerous gases need to be detected and announced. In the area of mining technology, real-time monitor and control of mine hazard are more complex. Mine safety modules are configured to communicate to ground control or a central station. A real critical issue in mines is hazardous gases. Systems used in a mine can create intense vibrations and increase the level of hazardous gases such as CO, SO2, NO2 and particulate matter. The working conditions can be very noisy and miners don't watch each other constantly. Miners tend to stay in groups and will be no more than 5 meters (m) from each other. A warning system needs to be incorporated that will warn miners within a 5 m radius that a miner is experiencing a hazardous event. This system needs to process and transmit the event within 1 second (s). These systems measure the environment around the miner with gas sensors and are then used to implement evacuations. These do not alert the miner at all or only alert the miner in an audible way.

HARDWARE SYSTEM

In system construction, it mainly consist of two part namely as software part and hardware part.

In this Hardware part having two sections one is Helmet section, another one is Monitoring section.

HELMET SECTION:

The intelligent security system consists of a helmet, which is mounted with the sensor circuits. The transmitter section has a microcontroller which receives input from various sections like gas sensor, collision sensor, and helmet remover IR sensor and in certain case when dangerous event occurred then helmet transfer alert towards ZIGBEE. RFID reader reads various tags in the coal mine to identify the location of miner. For the simplicity to demonstrate, here in this project, four different locations are chosen and corresponding information is given through controller with the help of tags. The collision sensor, helmet remover and gas sensors will sense the corresponding parameters

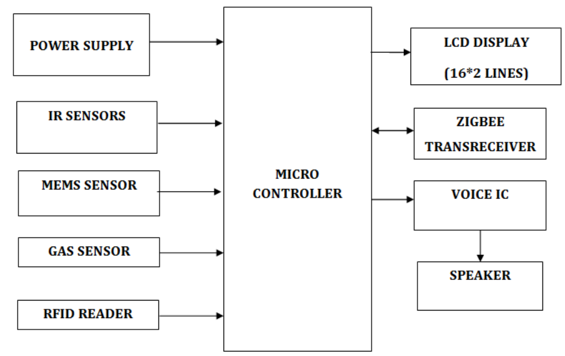

Fig.1. Helmet section Block diagram

MONITORING SECTION:

In this monitoring section we are having ZIGBEE Receiver for data receiving and that will be displayed in PC.

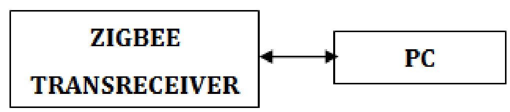

Fig.2. Monitoring section Block diagram

Hardware Requirements

Micro controller: This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, Pull up resistors (if needed) and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

ARM7TDMI: ARM is the abbreviation of Advanced RISC Machines, it is the name of a class of processors, and is the name of a kind technology too. The RISC instruction set, and related decode mechanism are much simpler than those of Complex Instruction Set Computer (CISC) designs.

Liquid-crystal display (**LCD**) is a flat panel display, electronic visual display that uses the light

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 13
October 2017

modulation properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock.

Co2 sensor:

They are used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, i-butane, propane, methane, alcohol, Hydrogen, smoke. The surface resistance of the sensor Rs is obtained through effected voltage signal output of the load resistance RL which series-wound. The relationship between them is described:

Rs\RL = (Vc-VRL) / VRL

Fig.3. Co2 sensor

IR Tx and Rx:

Transmitter and receiver are incorporated in a single housing. The modulated infrared light of the transmitter strikes the object to be detected and is reflected in a diffuse way. Part of the reflected light strikes the receiver and starts the switching operation. The two states – i.e. reflection received or no reflection – are used to determine the presence or absence of an object in the sensing range.

This system safely detects all objects that have sufficient reflection. For objects with a very bad degree of reflection (matt black rough surfaces) the use of diffuse reflection sensors for short ranges or with background suppression is recommended.

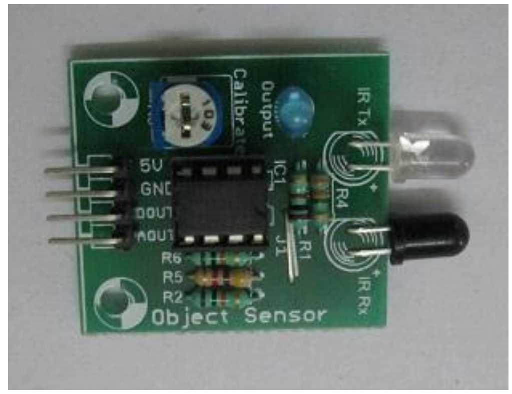

Fig.4. IR sensor

ZIGBEE:

Zigbee modules feature a UART interface, which allows any microcontroller or microprocessor to immediately use the services of the Zigbee protocol. All a Zigbee hardware designer has to do in this case is ensure that the host's serial port logic levels are compatible with the XBee's 2.8- to 3.4-V logic levels. The logic level conversion can be performed using either a standard RS-232 IC or logic level translators such as the 74LVTH125 when the host is directly connected to the XBee UART. The X- Bee RF Modules interface to a host device through a logic-level asynchronous Serial port. Through its serial port, the module can communicate with any logic and voltage Compatible UART; or through a level translator to any serial device.

Data is presented to the X-Bee module through its DIN pin, and it must be in the asynchronous serial format, which consists of a start bit, 8 data bits, and a stop bit. Because the input data goes directly into the input of a UART within the X-Bee module, no bit inversions are necessary within the asynchronous serial data stream. All of the required timing and parity checking is automatically taken care of by the X-Bee's UART.

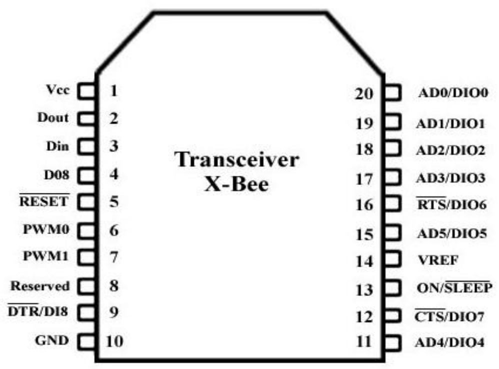

Fig.5. ZIGBEE pin diagram

RFID:

Radio Frequency Identification (RFID) is a silicon chip-based transponder that communicates via radio waves. Radio Frequency Identification is a technology which uses tags as a component in an integrated supply chain solution set that will evolve over the next several years. RFID tags contain a chip which holds an electronic product code (EPC) number that points to additional data detailing the contents of the package. Readers identify the EPC numbers at a distance, without line-of-sight scanning or involving physical contact. Middleware can perform initial filtering on data from the readers. Applications are evolving to comply with shipping products to automatically processing transactions based on RFID technology RFID Reader Module, are also called as interrogators. They convert radio waves returned from the RFID tag into a form that can be passed on to Controllers, which can make use of it. RFID tags and readers have to be tuned to the same frequency in order to Communicate. RFID systems use many different frequencies, but the most common and widely used & supported by our Reader is 125 KHz.

Fig.6. RFID Reader

MEMS:

Micro-Electro-Mechanical Systems (MEMS) is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through micro fabrication technology. While the electronics are fabricated using integrated circuit (IC) process sequences (e.g., CMOS, Bipolar, or BICMOS processes), the micromechanical components are fabricated using compatible "micromachining" processes that selectively etch away parts of the silicon wafer or add new structural layers to form the mechanical and electromechanical devices. MEMS promises to revolutionize nearly every product category by bringing together silicon-based microelectronics with micromachining technology, making possible the realization of complete systems-on-a-chip. MEMS is an enabling technology allowing the development of smart products, augmenting the computational ability of microelectronics with the perception and control capabilities of micro sensors and micro actuators and expanding the space of possible designs and applications.

Microelectronic integrated circuits can be thought of as the "brains" of a system and MEMS augments this decision-making capability with "eyes" and "arms", to allow micro systems to sense and control the environment. Sensors gather information from the environment through measuring mechanical, thermal, biological, chemical, optical, and magnetic phenomena. The electronics then process the information derived from the sensors and through some decision making capability direct the actuators to respond by moving, positioning, regulating, pumping, and filtering, thereby controlling the environment for some desired outcome or purpose. Because MEMS devices are manufactured using batch fabrication techniques similar to those used for integrated circuits, unprecedented levels of functionality, reliability, and sophistication can be placed on a small silicon chip at a relatively low cost.

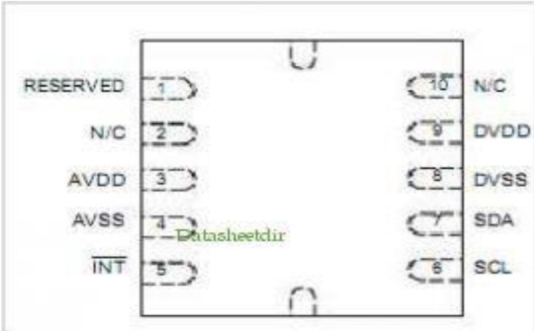

Fig.7. MEMS IC

Voice IC:

The APR33A3 device offers true single-chip voice recording, non-volatile storage, and playback capability for 40 to 60 seconds. The device supports both random and sequential access of multiple messages. Sample rates are user- selectable, allowing designers to customize their design for unique quality and storage time needs. Integrated output amplifier, microphone amplifier, and AGC circuits greatly simplify system design. the device is ideal for use in portable voice recorders, toys, and many other consumer and industrial applications.

• Single-chip, high-quality voice recording & playback solution

- No external ICs required

- Minimum external components

• Non-volatile Flash memory technology

- No battery backup required

• User-Selectable messaging options

- Random access of multiple fixed-duration messages

- Sequential access of multiple variable-duration messages

• User-friendly, easy-to-use operation

- Programming & development systems not required

- Level-activated recording & edge-activated play back switches

• Low power consumption

- Operating current: 25 mA typical

- Standby current: 1 uA typical

- Automatic power-down

• Chip Enable pin for simple message expansion

Fig.8. Voice IC module

CONLCUSION

As the system requirement and the required components can be easily made available this project can be implemented easily. It will provide the safety to coal miners and change the way of their working as well as system controlling the various environmental changes in mines. It has been presented the original design of the low power ZigBee wireless sensor system with an extremely reduced cost. It is reliable system with quick and easy installation. The system might be easily extended. With ZigBee wireless positioning devices, it will improve system scalability and extend accurate position of underground miners in future.

REFERENCES

[1] M. A. Hermanus, “Occupational health and safety in mining—status, new developments, and concerns,” *The Journal of The Southern African Institute of Mining and Metallurgy*, vol. 107, pp. 531-538, Aug. 2007.

[2] A.P. Squelch, “Virtual reality for mine safety training in South Africa,” *The Journal of The South African Institute of Mining and Metallurgy*, pp. 209-216, July 2001.

[3] C. Qiang, S. Ji-ping, Z. Zhe and Z. Fan, ZigBee Based Intelligent Helmet for Coal Miners,” *IEEE*

World Congress on Computer Science and Information Engineering (WRI 2009), 31 Mar. -2 April 2009, vol. 3, pp. 433–435, 2009.
[4] H. Hongjiang and W. Shuangyou, "The application of ARM and ZigBee technology wireless networks in monitoring mine safety system," *IEEE International Colloquium on Computing, Communication, Control, and Management (ISECS 2008)*, 3-4 Aug. 2008, Guangzhou, pp. 430–433, 2008.
[5] X. Liu, J. S. Huang and Z. Chen, "The research of ranging with timing over packet network for the mine safety application," *Journal of Networks*, vol. 7, no. 7, pp. 1054–1062, Jul. 2012.
[6] R. S. Nutter, "Hazard evaluation methodology for computer-controlled mine monitoring/control systems," *IEEE Trans. on Industry Applications*, vol. IA-19, no. 3, pp. 445-449, May/June 1983.
[7] R. S. Nutter, "A distributed microprocessor monitoring and control system for coal mines," *in Proc. 4th WVU Conf. on Coal Mine Electrotechnology*, Aug. 2-4, 1978.

Author profile

D.Shirisha is currently working as assistant Professor in ECE Department from Siddhartha Institute of Technology and sciences. She Received M.TECH from Sreyas Institute of Technology and sciences. She Received B.tech Degree from Aurora's Institute of Technology and Sciences. Her current research interest includes Analysis & Design of embedded System Design.