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PROACTIVE SHIELDING OF COALMINE(R) USING CONNECTED DEVICES AND IOE(T)

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ABSTRACT:

A smart helmet has been developed that is able to detect of hazardous events in the mines industry. In the development of helmet, we have considered the three main types of hazard such as air quality, helmet removal, and collision (miners are struck by an object). The first is the concentration level of the hazardous gases such as CO, SO2, NO2, and particulate matter. The second hazardous event was classified as a miner removing the mining helmet off their head. An IR sensor was developed unsuccessfully but an off-the shelf IR sensor was then used to successfully determine when the helmet is on the miner's head. The third hazardous event is defined as an event where miners are struck by an object against the head with a force exceeding a value of 1000 on the Head Injury Criteria. An accelerometer was used to measure the acceleration of the head and the HIC was calculated in software. The layout of the visualisation software was completed, however the implementation was unsuccessful. Tests were successfully done to calibrate the accelerometer.

Keywords:*IR,MEMS,ZIGBEE,RFID,Gas.*

INTRODUCTION

In recent years, harvesting technology has played an important role in the area of mine applications. The literature on mines technology is available but very limited. Nutter, et al. proposed a methodology for identifying safety hazards inherent in underground monitoring and control. They also designed potential safety hazard equipment. They developed methodologies based on analytical electronics and computer based hardware/software systems [6]-[8]. Kock, et al. developed the technology in terms of health, safety, and productivity for the South African coal mining industry. They also investigating the coal interface detection (CID), productivity, communication channels (infrared, power line, optical fibers, and radio) [9]. Misra et al. presents a case study for mines. They reviewed on communication techniques such as through the wire (TTW), through the air (TTA), and through the earth (TTE) [10]. Forooshani, et al. presents a compressive survey of wireless propagation in tunnels and underground mines with a focus on current wireless channel modeling, technologies, and applications [11]. The Internet-of-Things, where all devices are

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smart and interconnected, are increasingly being used in more industrial applications [12], [15], and it is therefore also a principle that can make a difference in mining safety with smarter equipment. The literature also shows that despite some attractive solutions; very few have been implemented and tested in the real-world, identifying the existence of a gap between theory and real world application at scientifically accepted level. In this paper smart helmet in compliance with IEEE 21451 standards is presented. It has various advanced features such as fast response time low, portability, and low cost with precisely acceptable accuracy. In recent years, harvesting technology has played an important role in the area of mine applications. The literature on mines technology is available but very limited. Nutter, et al. proposed a methodology for identifying safety hazards inherent in underground monitoring and control. They also designed potential safety hazard equipment. They developed methodologies based on analytical electronics and computer based hardware/software systems [6]-[8]. Kock, et al. developed the technology in terms of health, safety, and productivity for the South African coal mining industry. They also investigating the coal interface detection (CID), productivity, communication channels (infrared, power line, optical fibers, and radio) [9]. Misra et al. presents a case study for mines. They reviewed on communication techniques such as through the wire (TTW), through the air (TTA), and through the earth (TTE) [10]. Forooshani, et al. presents a compressive survey of wireless propagation in tunnels and underground mines with a focus on current wireless channel modeling, technologies, and applications [11]. The Internet-of-Things, where all devices are smart and interconnected, are increasingly being used in more industrial applications [12], [15], and it is therefore also a principle that can make a difference in mining safety with smarter equipment. [5] discussed about a project, in this project an automatic meter reading system is designed using GSM Technology. The embedded micro controller is interfaced with the GSM Module. This setup is fitted in home. The energy meter is attached to the micro controller. This controller reads the data from the meter output and transfers that data to GSM Module through the serial port. The embedded micro controller has the knowledge of sending message to the system through the GSM module. Another system is placed in EB office, which is the authority office. When they send "unit request" to the microcontroller which is placed in home. Then the unit value is sent to the EB office PC through GSM module. According to the readings, the authority officer will send the information about the bill to the customer. If the customer doesn't pay bill on-time, the power supply to the corresponding home power unit is cut, by sending the command through to the microcontroller. Once the payment of bill is done the power supply is given to the customer. Power management concept is introduced, in which during the restriction mode only limited amount of power supply can be used by the customer. The literature also shows that despite some attractive solutions; very few have been implemented and tested in the real-world, identifying the existence of a gap between theory and real world application at scientifically accepted level. In this paper smart helmet in compliance with IEEE 21451 standards is presented. It has various advanced features such as

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fast response time low, portability, and low cost with precisely acceptable accuracy.

LITERATURE SURVEY

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]. 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. 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

HELMET SECTION:

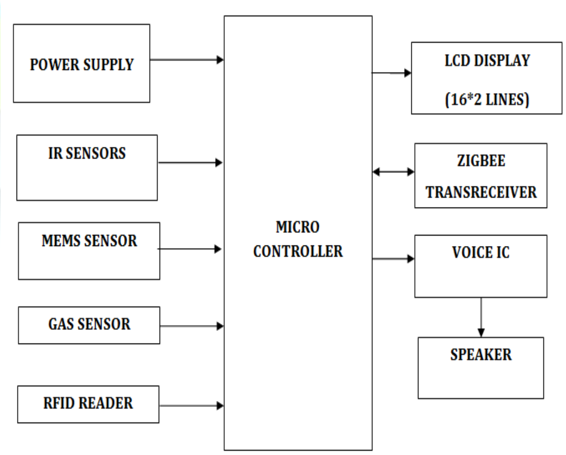

Fig.1:Block diagram

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MONITORING SECTION:

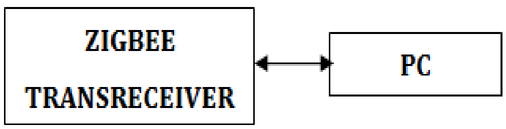

Fig.2Block diagram

METHODOLOGY

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)

It is a flat panel display, electronic visual display that uses the light 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

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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 isrecommended.

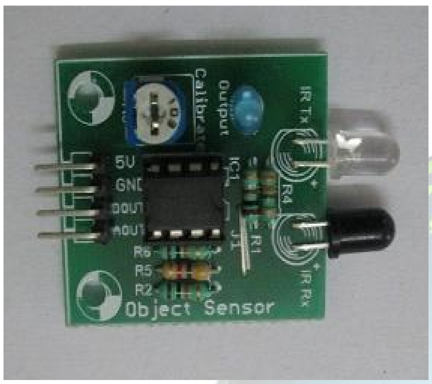

Fig.4: IR sensor

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 caseis 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.

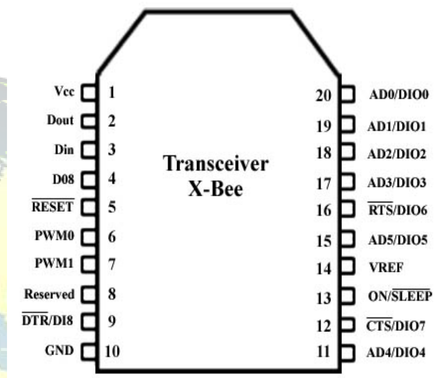

Fig.5: ZIGBEE pin diagram

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 technologyRFID Reader Module, are

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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

Tags are classified into two types based on operating power supply fed to it.

1. Active Tags
2. Passive Tags

Active Tags: These tags have integrated batteries for powering the chip. Active Tags are powered by batteries and either have to be recharged, have their batteries replaced or be disposed of when the batteries fail.

Passive Tags: Passive tags are the tags that do not have batteries and have indefinite life expectancies.

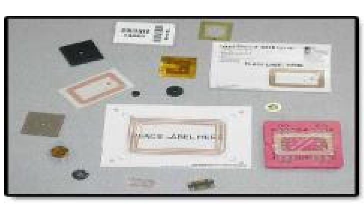

Fig.7: Different types of tags

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

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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.

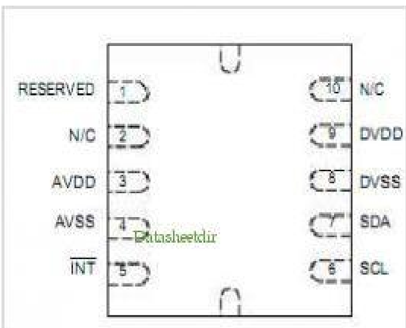

Fig.8: MEMS IC

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

• Chip Enable pin for simple message expansion

Fig.9: Voice IC module

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CONCLUSION

A smart mining helmet was developed that is able to detectthree types of hazardous events such as danger level ofhazardous gases, miner helmet removing, and collision orimpact (miners are struck by an object). The hazardous eventswere classified as a miner removing the mining helmet offtheir head. An off-the-shelf IR sensor was then used tosuccessfully determine when the helmet is on the miner'shead. Another hazardous event is defined as an event where miners are struck by an object against the head with a forceexceeding a value of 1000 on the HIC (Head Injury Criteria).An accelerometer was used to measure the acceleration of thehead and the HIC was calculated in software. The layout ofthe visualisation software was completed. Tests weresuccessfully done to calibrate the accelerometer. PCB's thatwere designed and made included a breakout board and aprototype board. A whole software implementation was done based on embedded c in order to do the control of themeasuring of sensors and of calculations done with themeasured values. The system was extensively tested in orderto determine whether or not the system works to therequirements. It was observed that the accelerometer shouldbe placed on the inside of the helmet and not on the plasticharness inside the helmet to compensate for the weightdifference. The accelerometer calibration was then modified tocorrectly calibrate the accelerometer.

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