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A SMART SAFETY HELMET FOR DETECTING HAZARDOUS EVEVTS IN MINING INDUSTRY

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ABSTRACT

A smart safety helmet has been designed which can detect hazardous and abnormal events in the mining industry. In this paper, we have considered three main types of hazards such as air quality, helmet removal, and collision. The first thing is to detect whether any poisonous gas(Carbon Dioxide (CO_2),Hydrogen (H_2),Hydrogen Sulphide (H_2S),Oxygen (O_2),Methane (CH_4), Nitrogen (N_2), Nitrogen Dioxide (NO_2),Sulphur Dioxide (SO_2) is present in the work place. If present, it will measure and display the concentration level of the gas to the control room. The second event is to ensure that the miner is wearing the helmet. If not, the miner will be alerted by means of alarm and a message (Wear Helmet) will be displayed in the LCD screen. The third hazardous event is described as an event when miner is struck by any object against the head with a force exceeding a value of 1000 on the HIC (Head Injury Criteria). MEMS (Micro Electro Mechanical Sensor) are used to measure the acceleration of the head and the HIC is calculated in software. The layout of the visualisation software was completed. Tests were successfully conducted to calibrate the MEMS. PCB's were designed and a prototype board is developed. The whole software development is done based on C# programming language in order to control the sensors involoved and to do the calculations with the measured values.

KEYWORDS: Arduino; MEMS; IR sensor; Zigbee; Max 232.

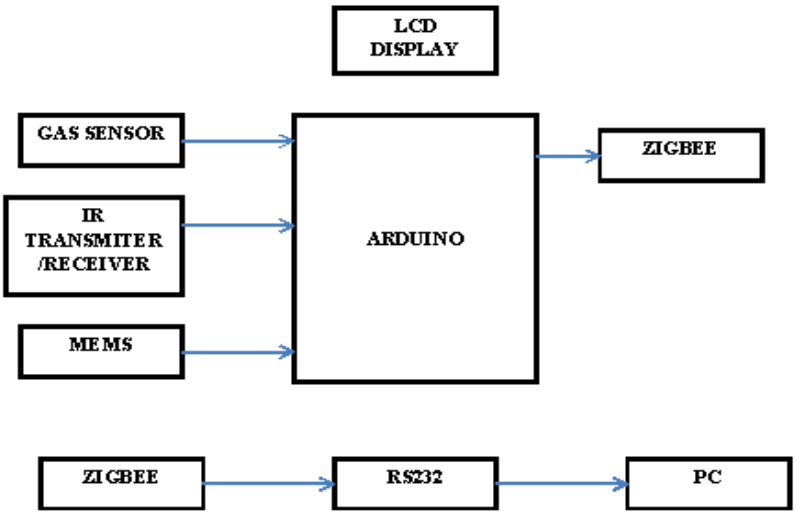
INTRODUCTION

The Mining industry in India is a major economic activity which contributes significantly to the economy of India. The GDP contribution of the mining industry varies from 2.2% to 2.5% only but going by the GDP of the total industrial sector it contributes around 10% to 11%. Even mining done on small scale contributes 6% to the entire cost of mineral production. Indian mining industry provides job opportunities to around 700,000 individuals.

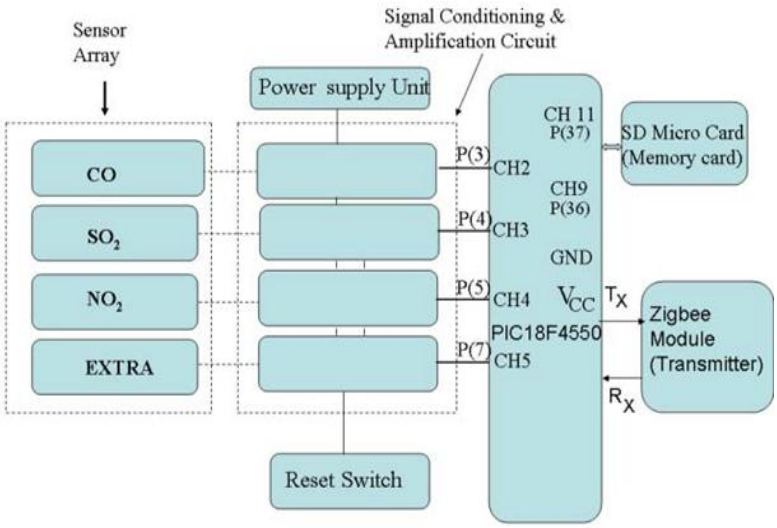
A mining helmet needs to be modified to improve miner safety by adding intelligence to the helmet. When a miner removes his helmet he needs to be warned. If an object falls on a miner even when wearing his helmet he can become unconscious or immobile. The system must determine whether or not a miner has sustained a life-threatening injury. These two events are defined as hazardous events. Thirdly, dangerous gases need to be detected and announced.

The most important part of any type of industry is safety. In the mining industry safety and security is a first aspect of all. To avoid any types of unwanted conditions, every mining industry follows some basic precaution. Communication is the most vital key factor today, to monitor different parameters such as poisonous gas continuously using s, gas sensor and IR sensor and MEMS sensor to take necessary actions accordingly to avoid any types of hazardous conditions and gives an alert using buzzer. To achieve safety in underground mines, a suitable communication system must be created between workers, moving in the mine, and a fixed base station. The wired communication network technology system will be not so effective. Under the mines due to uncomfortable situation the installation cost as well as maintenance cost is high for wired communication networks. For the successfully wireless data transmission, in this work a low cost zigbee is utilized in routers. A cost effective based wireless mine supervising system with early-warning security system on hazardous gases in mining area is proposed.

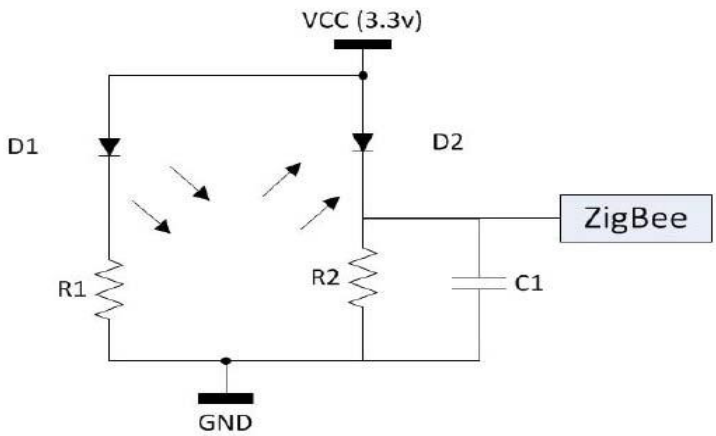
BLOCK DIAGRAM



Functional Block Diagram



Circuit Diagram



Hardware Design

The prototype board is designed around the Arduino to accomplish the above mentioned system requirements. The hardware section is divided into subsections as follows:

(1) Arduino

(2) Max 232

(3) Power supply unit.

(4) Alarm

(5) Gas sensor

(6) IR sensor

(7) MEMS sensor

(8) Zigbee

(1) Arduino

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDIUSB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

(2) Max 232

In telecommunications, RS-232 is a standard for serial binary data interconnection between a *DTE* (Data terminal equipment) and a *DCE* (Data Circuit-terminating Equipment). It is commonly used in computer serial ports.

Many modern devices can exceed this speed (38,400 and 57,600 bit/s being common, and 115,200 and 230,400 bit/s making occasional appearances) while still using RS-232 compatible signal levels.

Details of character format and transmission bit rate are controlled by the serial port hardware, often a single integrated circuit called a UART that converts data from parallel to serial form. A typical serial port includes specialized driver and receiver integrated circuits to convert between internal logic levels and RS-232 compatible signal levels.

(3) Power supply unit

All electronic circuits need a power source to work. For electronic circuits made up of transistors and/or ICs, this power source must be a DC voltage of a specific value. A battery is a common DC voltage source for some types of electronic equipment especially portables like cell phones and iPods. Most non-portable equipment uses power supplies that operate from the AC power line but produce one or more DC outputs.

(4) Alarm

An alarm is a signalling device, usually electronic, typically used in automobiles, household appliances such as a microwave oven, or game shows. It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise).

(5) Gas sensor

A gas detector is a device that detects the presence of gases in an area, often as part of a safety system . This type of equipment is used to detect a gas leak or other emissions and can interface with a control system so a process can be automatically shut down. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals.

(6) IR sensor

Infrared transmitter is one type of LED which emits infrared rays generally called as IR Transmitter. Similarly IR Receiver is used to receive the IR rays transmitted by the IR transmitter. One important point is both IR transmitter and receiver should be placed straight line to each other.

(7) MEMS sensor

MEMS accelerometers are one of the simplest but also most applicable micro-electromechanical systems. They became indispensable in automobile industry, computer and audio-video tech-nology. This seminar presents MEMS technology as a highly developing

industry. Special attention is given to the capacitor accelerometers, how do they work and their applications. The seminar closes with quite extensively described MEMS fabrication.

(8) Zigbee

ZigBee is suited for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection.

SIMULATION RESULTS

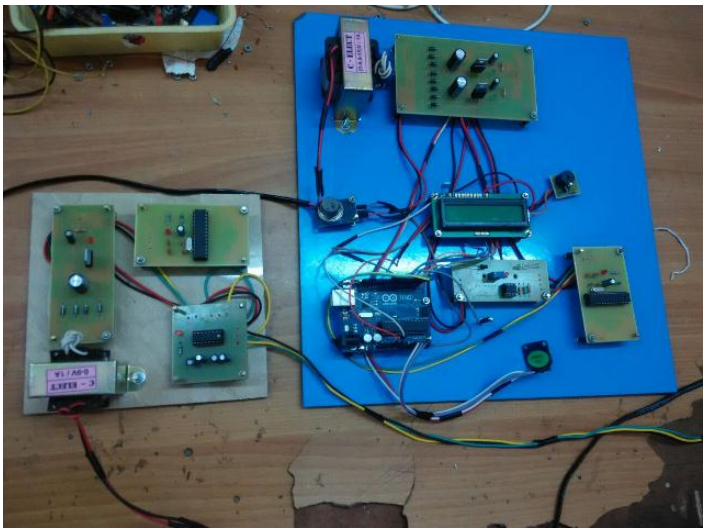


Fig 1: Transmitter and Receiver section.

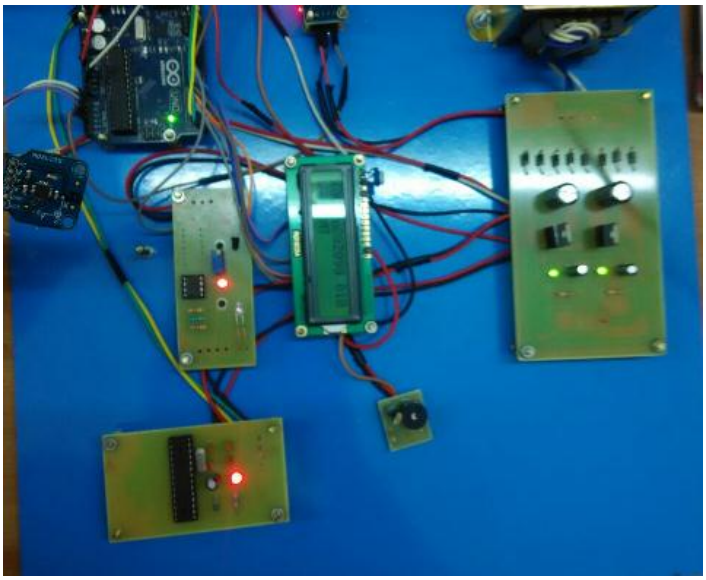


Fig 2: Transmitter Section.

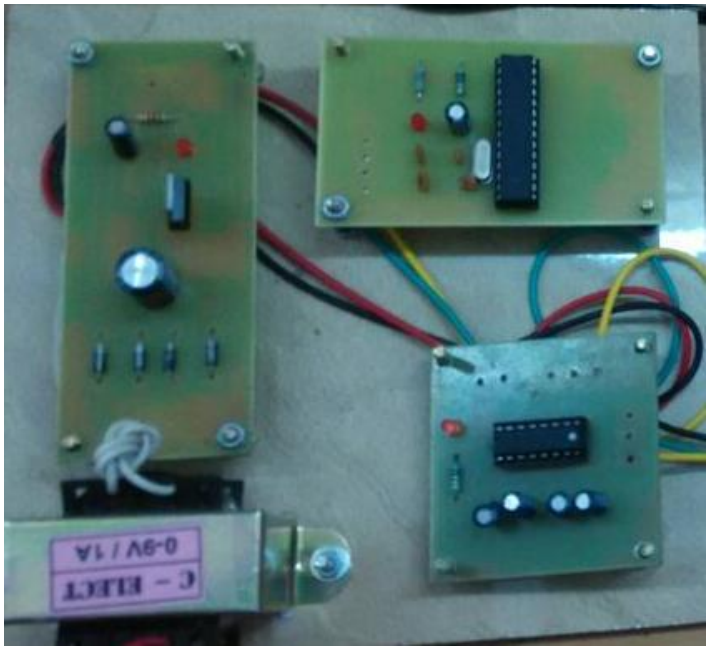


Fig 3: Receiver section.

In fig 1. In PC the transmitting data is given to R2IN of MAX232 through transmitting pin of 9 pin D type connector which converts the RS232 level to 5v TTL/CMOS level. The R2OUT pin is connected to receiver pin of the microcontroller. Likewise the data is transmitted and received between the microcontroller and PC or other device vice versa.

In fig 4. Infrared transmitter is one type of LED which emits infrared rays generally called as IR Transmitter. Similarly IR Receiver is used to receive the IR rays transmitted by the IR transmitter. One important point is both IR transmitter and receiver should be placed straight line to each other.

The transmitted signal is given to IR transmitter whenever the signal is high, the IR transmitter LED is conducting it passes the IR rays to the receiver. The IR receiver is connected with comparator. The comparator is constructed with LM 358 operational amplifier. In the comparator circuit the reference voltage is given to inverting input terminal. The non inverting input terminal is connected IR receiver. When interrupt the IR rays between the IR transmitter and receiver, the IR receiver is not conducting. So the comparator non inverting input terminal voltage is higher then inverting input. Now the comparator output is in the range of +5V. This voltage is given to microcontroller or PC and led so led will glow.

When IR transmitter passes the rays to receiver, the IR receiver is conducting due to that non inverting input voltage is lower than inverting input. Now the comparator output is GND so the output is given to microcontroller or PC. This circuit is mainly used to for counting application, intruder detector etc.

Fig 4: Helmet with IR sensor in the front.

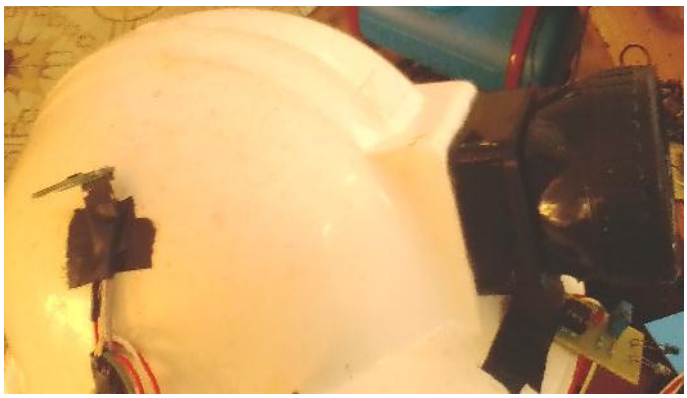


Fig 5: MEMS sensor fitted on the right side of the helmet.

In fig 5. A MEMS sensor is used to measure the acceleration of the head and the HIC was calculated in software.

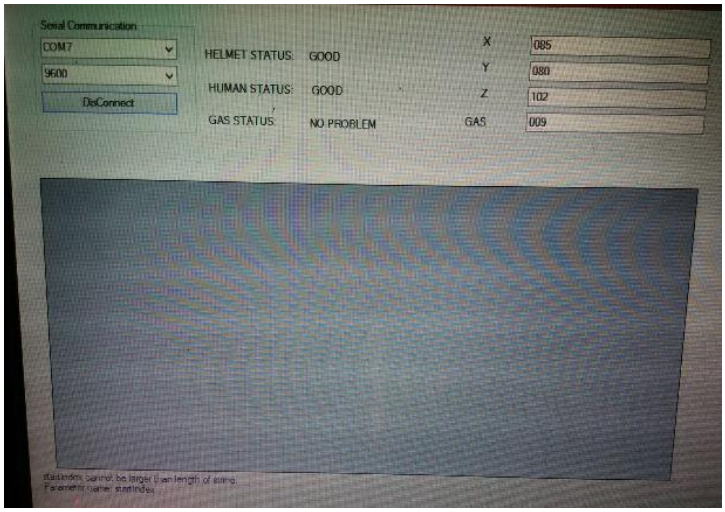


Fig 6: Output displayed in PC.

In fig 6.The results showed the data received and the corresponding system values.

CONCLUSION

A smart safety helmet has been designed which can detect hazardous and abnormal events in the mining industry. In this paper, we have considered three main types of hazards such as air quality, helmet removal, and collision. The first thing is to detect whether any poisonous gas(Carbon Dioxide (CO_2),Hydrogen (H_2),Hydrogen Sulphide (H_2S),Oxygen (O_2),Methane (CH_4),Nitrogen (N_2),Nitrogen Dioxide (NO_2),Sulphur Dioxide (SO_2) is present in the work place. If present, it will measure and display the concentration level of the gas to the control room. The second event is to ensure that the miner is wearing the helmet. If not, the miner will be alerted by means of alarm and a message (Wear Helmet) will be displayed in the LCD screen. The third hazardous event is described as an event when miner is struck by any object against the head with a force exceeding a value of 1000 on the HIC (Head Injury Criteria). MEMS (Micro Electro Mechanical Sensor) are used to measure the acceleration of the head and the HIC is calculated in software. The layout of the visualization software was completed. Tests were successfully conducted to calibrate the MEMS. PCB's were designed and a prototype board is developed. The whole software development is done based on C# programming language in order to control the sensors involved and to do the calculations with the measured values. The system was extensively tested in order to determine whether or not the system works to the requirements. It was observed that the MEMS should be placed inside the helmet and not on the plastic harness of the helmet to compensate for the weight difference. The MEMS calibration was then modified. A few aspects of the system can be

improved. Adding an external antenna would extend the range or improve the signal strength in order to allow for more human interference. The distance might still want to be limited as it would be impractical to warn miners that are too far away to find the miner who is experiencing a hazardous event. The processing speed of the system can be improved to allow for more accurate MEMS measurement. The IR sensor can be improved to work within the helmet by not triggering because of reflections. Node hopping can be implemented to allow transmissions to the supervisor or even a central control station. This can be done by adding stationary nodes that are programmed to only bounce any signal that is received. The system can be improved by adding more measuring devices to check the miner's blood pressure and heart rate. Gas concentrations can be measured as well. In future, it could also be considered if such modules can also be used for secondary services, such as localization of workers relative to each other.

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