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"SIRASTRANA"-A Smart Helmet for Air Quality and Hazardous Event Detection for the Mining Industry

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***Abstract*: -- A smart helmet has been developed that is able to detect 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 HIC (Head Injury Criteria). An accelerometer was used to measure the acceleration of the head and the HIC was calculated in software. This paper presents the undertaken design detailing solutions to issues raised in previous research. Main objective to give the correct and clean breathing averment at any hazardous or toxic environment.**

Index Terms: Air quality,Mining,Safety,ZigBee, Wireless sensor Networks.

I. INTRODUCTION

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 . 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 . 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 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

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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. These systems warn miners, but when a miner is obstructed or injured, an external input is required from ground control.

II. RELATED WORK

Hazard Evaluation Methodology for ComputerControlled 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 minesthe hardware reliability of a system is seldom recognized as a potential safety hazard. Because ofthe 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 aswell.

III. PROPOSED METHOD

A smart helmet has been developed that is able to detect of hazardous events in the mines industry. The mining safety helmets only have the purpose of protecting the miner's head against potential hazardous bumps. 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. A smart mining helmet was developed that is able to detect three types of hazardous events such as danger level of hazardous gases, miner helmet removing, and collision or impact (miners are struck by an object). It had been shown in fig 1(a) and fig 1(b).

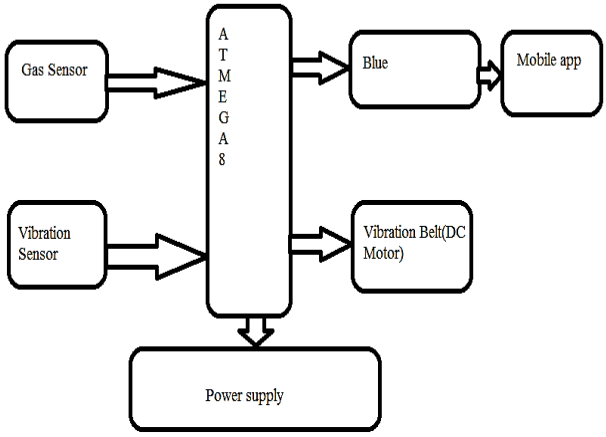

Fig. 1(a). Block Diagram

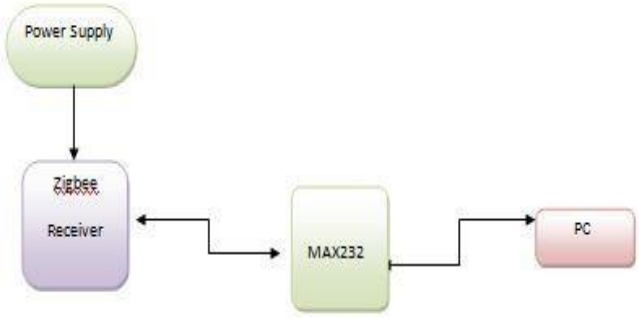

Fig. 1(b). Supervisor

A. ArduinoUno

Arduino Uno is a microcontroller, the central controller for the whole unit of smart cart. Arduino Uno based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and a reset button. The board can be programmed with Arduino Software (IDE). The board can operate on an external supply from 6 to 20 volts. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The ATmega328 has 32 KB flash memory. It also has 2 KB of SRAM and 1 KB of EEPROM.

B. Air PollutionSensor

Air pollution from coal mines is mainly due to emissions of particulate matter and gases include methane (CH4), sulphur dioxide (SO2), and oxides of nitrogen (NO2), as well as carbon monoxide (CO). From different studies, it is well known that when human being comes in contact these chemicals/pollutants it could have adverse effect on their health. MQ-2 gas sensor is used to detect hazardous gases, it

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has high sensitity to Propane, Butane and LPG, also response to Natural gas. The sensor could be used to detect different combustible gas, especially Methane, it is with low cost and suitable for different application.

C. Helmet RemovalSensor

For detecting the removal of the helmet a few different approaches were considered. The comparison, advantage, and disadvantage of the proposed approaches in the literature was reported in [1]-[11]. For this study, the IR beam-based helmet remove sensor technique was considered better among other available techniques such as a switch, analogue distance sensor, and digital distance sensor. The IR beam can be designed to use low amounts of power. An off-the-shelf IR distance detector was used for this application. The IR sensor was designed to send a constant signal from the one side of the helmet to the other side with thecircuit.

D. Wireless Transmission

ZigBee was created to be a low power, low data rate and a low-cost device. ZigBee has all the same benefits as a Wi-Fi system. ZigBee is based on the IEEE 802.15.4 standard [13]. A ZigBee module is also more useful for creating larger mesh networks than Bluetooth and is therefore the better option when routers and access points cannot be implemented. In [3] all the components are attached to the safety helmet with Velcro. Some of the components are placed inside the helmet, while this helps to protect the components from bumps and gasses, this can result in electronics being embedded into the head of a miner if a seriously hard bump is experienced. In [4] ZigBee modules are the chosen wireless chip because its signals can penetrate walls and work very well in mines. Wireless or more specifically Wi-Fi, is sometimes used in mines, but it needs cabling throughout the mine to the routers, that can be 0damaged [13].

IV. RESULTS

The helmet removal test was done using Ir sensors used in our project by using different sizes, shapes and different colors sensor given satisfactory and 100% results is obtained as shown in figure 3 and all various kinds of testing done during performance test of helmet sensor program done in Arduino controller done using digital pins run very well displayed helmet value on PC as well as send to receiver using zigbee communication 9600bits/sec to a range of nearly 10mts with line of sight and without line of sight at constant 5v.

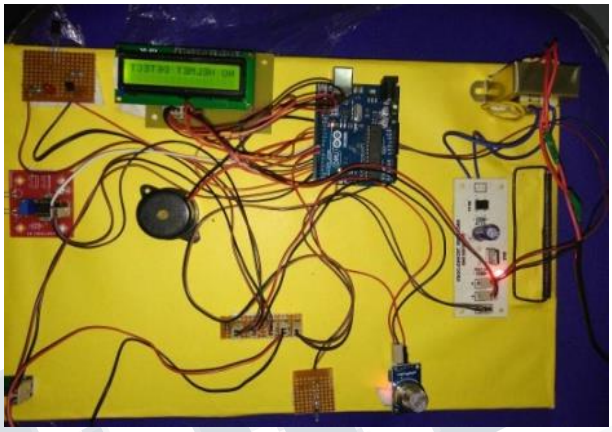

Fig. 3. No helmet detected

Gas sensor in our project used is MQ-2 measures a wide range of gases like LPG, CO2, also alcohol this sensor has been tested under extreme condition of high and low chemical and dangerouspoisonous which are hazardous for human health. The sensors values are accurate when tested and proceeds and results are displayed on PC as shown in Fig:4(b), Fig:4(a) represents the design of this idea.

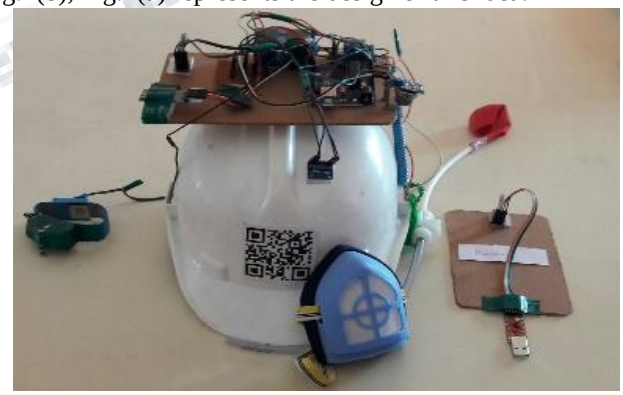

Fig. 4(a) Smart helment

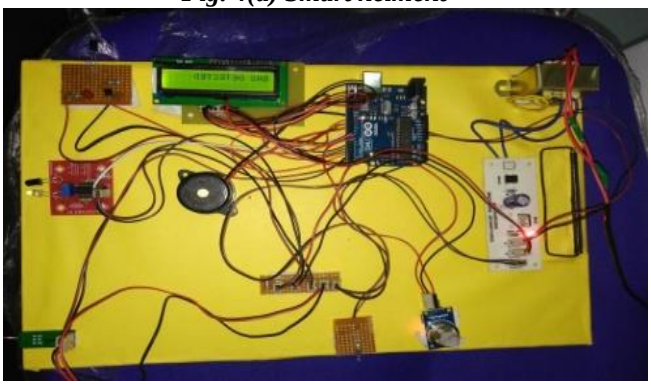

Fig. 4(b): Hazardous Gases are detected.

V. CONCLUSION

A smart mining helmet was developed that is able to detect three types of hazardous events such as danger level of hazardous gases, miner helmet removing, and collision or impact (miners are struck by an object). The hazardous events were classified as a miner removing the mining helmet off their head. An off-the-shelf IR sensor was then used to successfully determine when the helmet is on the miner's head. Another 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 HIC (Head Injury Criteria). An accelerometer was used to measure the acceleration.

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