Implementation of Smart Safety Helmet for Coal Mine Workers

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***Abstract*—This paper presents implementation of safety helmet for coal mine workers. This helmet is equipped with methane and carbon monoxide gas sensor. This sensor sense the gas and the data is transmitted to the control room wirelessly, through a wireless module called X-Bee connected with the helmet. When the methane or carbon-monoxide gas concentration is beyond the critical level, controller in the control room triggers an alarm and keeps the plant and the workers safe by preventing an upcoming accident.**

Keywords—Smart Safety Helmet; Gas Sensor; X-Bee

I. INTRODUCTION

Demand of coal as energy resources is always important and significant. But thousands of people have lost their lives in mining accidents, all over the world. In their article Jing change, Qinggui Cao & Yonjige Yang listed 100 of major mining accident which had taken place from 2001-2010 [1]. As most of the coal mines in North East region of the country are still in primitive state, the mining accidents here are also very frequent. The main reason is these accidents occur due to the presence of methane and carbon monoxide gas in theses mines. These gas are colorless, odorless and is undetectable by human sensors [2]. The key to controlling such accidents is the prediction of outburst by implementing sensors and microcontrollers and to generate an alarm system before critical atmospheric level. A continuous monitoring is necessary which again requires some effective and accurate sensing system. Several technique are adopted to sense the presence of these poisonous gas, among them use of semi conductor type gas sensor is very much effective. These sensors can be mounted in the coal mine area [3]but some time these create some problems in mining too. Accidental damage of the sensor device often took place. Another technique is the use of robot [4]. These robot are effective but for country like India where industrialists are not much concerned about the safety of the workers, we cannot imagine about a robots. However, there is another way of getting effective and low cost solution of sensor implantation. It is on the safety helmet of the coal mine workers. A smart safety helmet having sensor array to sense data and a wireless modem to transmit it [5].

II. BLOCK DIAGRAM OF HELMET

The block diagram of the helmet is given below:

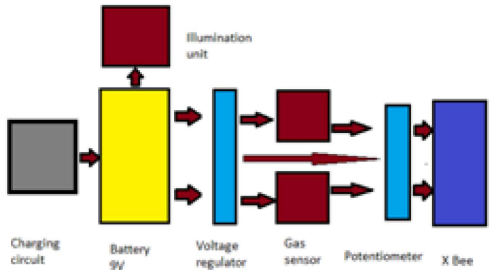

Fig. 1: Block Diagram of Smart Safety Helmet

III. DESIGNING OF HELMET CIRCUITRY

The helmet circuit is designed in Fritzing, a GUI used by electronic engineers for designing electronic circuit equipped with various features like bread board view, schematic view, PCB view and also auto routing

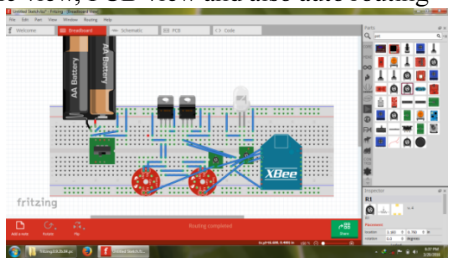

Fig. 2: Fritzing Designing of the Circuit

The voltage regulator 7805 and LM 351T are used for voltage regulation. MQ7 and MQ2 are used for sensing CH_4 and CO respectively. The X-Bee is of series 2, having a range of 2000 meter at the line of sight. The system power is made ON-OFF using a simple switch.

IV. DESIGNING OF HELMET IN AUTO CAD

The helmet is designed in Auto-CAD Inventor Fusion and is given in the Fig. below.

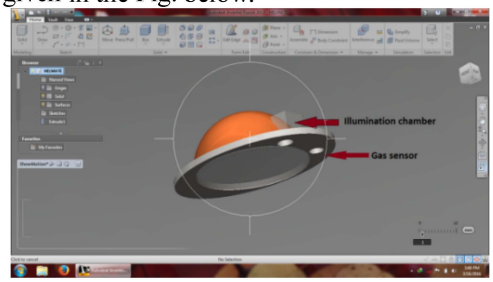

Fig. 3: AutoCAD Design of Smart Safety Helmet

As seen in the above Fig. a 3D image of the device is obtained as marked in the diagram sensor, X-Bee, and the other circuit component is kept in the helmet inside the illumination chamber. Gas sensor are kept vertically, facing the ground. While designing the helmet, safety norms are also followed and is made under Indian Standard Specification for Industrial Safety Helmets keeping the total weight of the helmet under 400 grams.

A. Experimental Setup

Fig. 4: Experimental Set up of Smart System

Before implementing the smart system on helmet, it is tested and the result is monitored experimentally. The experimental set up is portrayed in Fig. 4.

B. X-Bee Configuration

For a successful transmission the configuration of X-Bee module is most important. The transceiver module is configured using X-CTU software from Digi International. X-CTU is a multi-platform application that enables developers to interact with Digi- radio frequency (RF) modules through a simple-to-use graphical interface. It is an open source platform for configuring radio modules, having several features like range testing, spectrum analyzer, network scanning, checksum monitoring, packet data transmission.

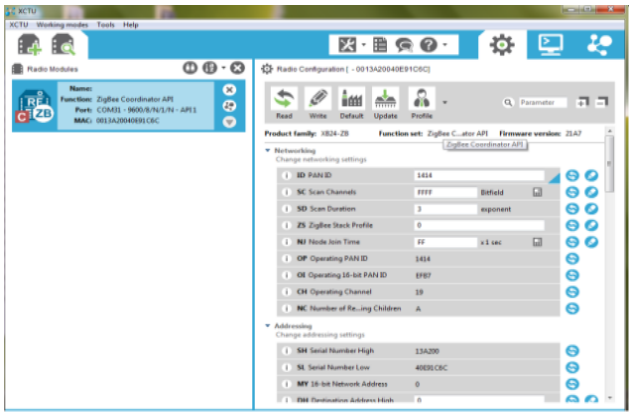

Fig. 5: X-Bee Configuration in X-CTU

In the experiment a single coordinator and the router are used. Both router and coordinator must have same PAN ID. Destination of router is the source address of coordinator. To save battery power X-Bee are set in cyclic sleep mode with pin awake configuration. Pin 2 and 3 of X-Bee is set to ADC mode to get analogue data from the sensor. Data Pull method is used to avoid the crashing problem of the coordinator. Each time an awake signal is received by the router X-Bee, it wakes up and give the data of analogue pin 2 & 3. After the data transmission it again goes to sleep mode. Data sampling rate (IR) is set to 5 second. Data is transmitted to the receiver in a maximum speed of 250kbps.

V. NETWORK TOPOLOGY

The system communicates in Mesh network using MAC protocol [6].The flow chart of the transmitter system is given next.

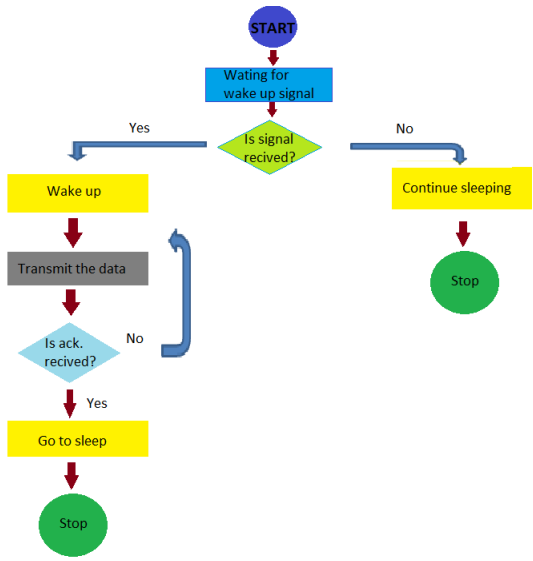

Fig. 6: Flow Chart of Router X-Bee

Each time the router is awaked by an awaking signal generated by the coordinator, the coordinator is asking for the data from router. This method is called pull method and is superior in those case where there are more number of router. This is because if two or more router is transmitted at the same time, coordinator is not able to fetch the data and may crash. In this system another important technique is used, called token passing. During transmission of data, router passes a token with the data to coordinator that data is transmitted. When the coordinator gets the token with the data it sends an acknowledgement signal to the router and stop sending awaking signal to that router. It then sends awaking signal to the next router and the process keeps continuing.

Data can be continuously monitored using a hardware (microcontroller) Set up or by using Lab-View software.

A. Monitoring of Data using Lab View

Lab view is a Graphical user interface, a kind of simulator especially designed for instrumentation engineers by NI [5]. It consists of front panel and a block

diagram panel where the blocks are connected and all mathematical works are done. The Figure below shows the monitoring of sensor data using lab view software.

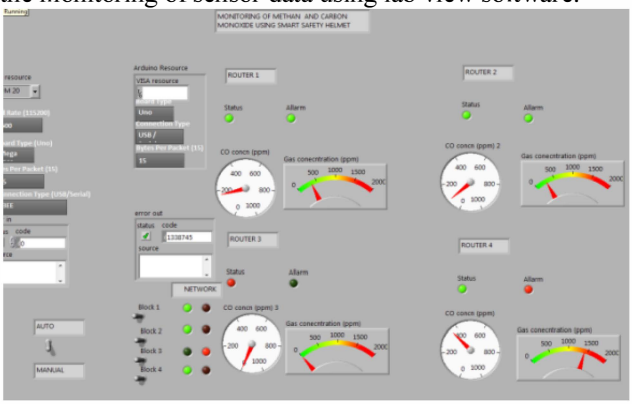

Fig. 7: Lab View Data Monitoring

As shown in the above Figure, in Lab view the data from different nodes are monitored continuously. There is one network indicator for each node, which indicates the presence or absence of router in the network. Router 3 is out of the range hence network indicator is red and no data is obtained from there. When Gas concentration is greater than the set point value it makes the alarm high as seen in the router 4.

B. *Monitoring of Data using Microcontroller*

Another effective and low cost technique of data monitoring is the use of microcontroller. Arduino mega is one of such solution [7]**.** X-Bee data can be continually in serial monitor of Adruino IED or in a liquid crystal display.

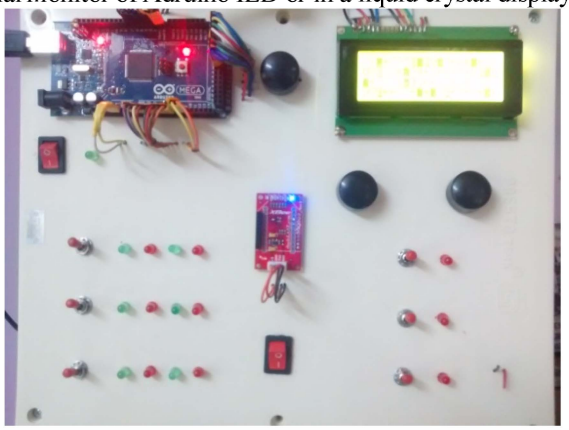

Fig. 8: Monitoring of Data in the Control Panel

The panel have switch to set the set point for CO & CH_4 concentration for each node separately. When the wireless data goes above set point it generates an alarm in the control room and also in the smart helmet remotely. Both auto and manual option are available. A network LED is provided to know whether the router is in the network or have gone out of range.

VI. CONCLUSION

Detection of an odorless and colorless gas is not an easy task, moreover some inaccurate device and improper sensor placement make the task more difficult. The smart safety helmet is going to be one of most effective and useful technique in mining industries due to its excellent sensing ability, low cost, good and reliable signal transmission. Also the system can be monitored in Lab–view and in a portable mini monitor panel, which gives the system versatility. Lab-view monitoring is more accurate but is little expensive due to the expense of the software. On the other hand, hand-held portable monitoring device is very cheap and good for monitoring few routers.

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