A WIRELESS SURVEILLANCE OF MINING WORKERS AT HIGH ALTITUDE

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Abstract—Miners working at high altitude must handle extreme climatic and physiological hazards and hence the monitoring of the mining workers is highly essential. Extreme environment conditions are detrimental for human health. The non-invasive sensors of the proposed system are embedded all throughout a T-shirt to achieve a functional device and maximum comfort for the users. The device is able to continuously monitor the heart rate, the position of the miner and measuring out the gas level, humidity level in the mining area. Proper monitoring and communication is possible between the miners, monitoring site and the rescuing team with the help of zigbee module.

Index Terms—Coal mine safety, Heart rate sensor, MEMS sensor, Gas sensor, Humidity sensor, Zigbee transceiver.

I. INTRODUCTION

Coal mining is a risky venture. Mining is one of the most important activities at high altitude. Hundreds of mining workers has lost their lives in mining accidents, all over the world. Prime concern is of safety in coal mining. The workers need to undergo extreme climatic and physiological changes when working in coal mine. The environment in the coal mine includes the toxic gases which are harmful when in contact with it for longer time. A long time expose to the toxic gases can produce change in respiratory system causing arrhythmia and hyperventilation. If not treated adequately it may also lead to severe pulmonary brain edema, Migraine, lack of energy, shortness of breath during exercise, lack of appetite, and vomiting characteristics of acute mountain sickness (AMS) and usually this symptom begins after 4 to 8 hours in this environment. The temperature has its own effect on human health. With contact below zero temperature can causehypothermia.

The miners spend long periods living at high altitude, and working extended hour-shifts exposed to extreme weather conditions. The worker working in the coal mine has a shift wise working schedule. The shifts are so planned that the workers should not be exposed to gases for a longer time. A periodic health checkup of them iners is mandatory. Inaddition, Occupational

Safety and Health programs currently used in mining sites only consider a periodical medical examination on a once-per year basis to assess the health condition of the staff. This medical evaluation allows to detect risk factors and define the groups that require medical assistance to the miners.

High altitude can cause fatigue and lower productivity. Also, it can increase the risk factors for health problems and reduce the sleep quality of the mining workers. This last physiological disorder can cause daytime sleepiness and restless nights, increasing the probability of suffering a work accident. As a precaution a continuous real time monitoring of the position of the worker, gases present in environment, heart rate and humidity are important. When the value of gases present in environment changes, this affects the change in the respiratory rate of the worker, a buzzer is set and the message is sent to the monitoring station and from there the messages are forwarded to the rescuing team to provide the first aid to the miners.

Fig. 1. Mining operations at high altitude

II. LITERATUREREVIEW

Many works have been carried out in monitoring coal mine gases and physical variables.

In 2015, Esteban J. Pino, Astrid Domer De la Paz and Pablo Aqueveque proposed a system to measure the sleep quality of workers. They present a noninvasive sleep evaluation device based on the pressure sensor. This device when installed at the mining facilities provides the respiration frequency, body movements (BMs), time in bed (TB), apnea events and the sleep depth. Measuring sleep quality is important as inadequate amounts of sleep may lead to fatigue and higher risk ofaccidents.

In 2016, Pablo Aqueveque, Christopher Gutierrez, Francisco Saavedra, Esteban J. Pino, Anibal s. Morales, Eduardo Wiechmann, implemented a system to continuously monitor and measure the physiological variables of the workers at high altitude. The physiological variables included were electrocardiogram, respiratory activity and the body temperature and ambient humidity. They used Bluetooth as a communication medium and the sensed data was transferred to the monitoring unit through the Wi-Fi link.

In 2016, PranjalHazarik designed a safety helmet for workers. The helmet was embedded with the methane and CO gas sensor. The gas sensor senses the data and transmission of the data is done by using the Zig-bee module. The system was monitored in the labview. An alarm is triggered when the gas concentration reaches beyond the critical level; this saves the plant and the workers from major accidents .

In 2017, Mohd Anas, Syed Mohd Haider, Prateek Sharma proposed the gas monitoring system they implemented a system to monitor the real time gases. They also stated the different gases present in the coal mine environment and the effects of the gases. The permissible limit of the gases is also stated in their work.

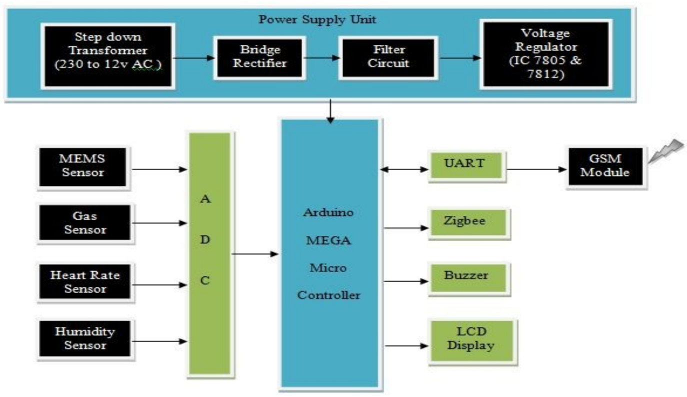
In 2018, Ramesh V, Gokulakrishnan V. J, Saravanan R and Manimaran R proposed a system to continuously monitor the physiological variables of the workers working at high altitude. They implemented a system which monitored the real time physiological variables of the workers at the high altitude. The whole system was monitored in lab-view.

In 2018, Akshunya Mishra, Sakshan Malhotra, RuchiraPallaviChoudekar, H.P.Singh proposed a system to measure the hazardous gases in the mine environment. They designed a smart, compact and efficient electronic system which is embedded into the helmet of the workers.

From the above review, we have included the idea of the safety of the workers working in the coal mine environment, we not only check the real time physiological variables but also the environmental parameters like gases and the humidity of the surrounding and the buzzer is set on when the value reaches above the threshold value.

III. SYSTEMDESIGN

The physiological monitoring system consists of sensors which are interface to the microcontroller.



The system consists of two units:

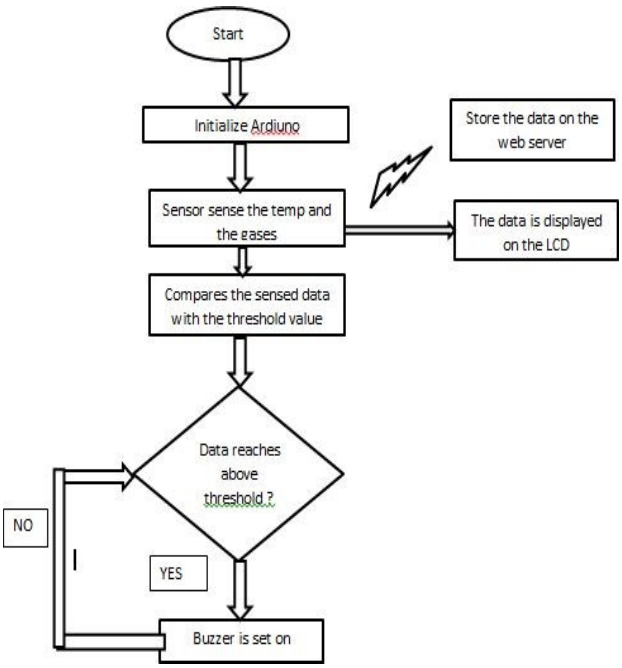
- Transmitterunit.
- Monitorunit.

In the transmitter unit all the main data processing carried out. We use four sensors, Humidity sensor, Gas sensors, Heart beat sensor, MEMS sensor. The humidity sensor is used to sense the moisture of the atmosphere of the underground coalmine.

The gases present in coal mine environment are harmful and may cause serious issues to the health of the worker when reached beyond the safety value. The gas sensors used here are the MQ2 and MQ7 sensor which is used to measure the methane and Carbon monoxide (CO) present in the environment. When the methane contains an increase beyond the safe value then this may affect the health of the worker and may cause shortness of breath, dizziness, Migraine, vomiting.

The system flow as follows:

The sensors are embedded on the T-shirt (first layer of clothing) they measure the physiological and environment variables. The communication between the monitoring unit and transmission unit is achieved by using the Zigbee module. The Zigbee module contains Zigbee router , Zigbee coordinator and integrated with TCP/IP protocol stack. It gives the network access to themicrocontroller.



IV. HARDWARE DESCRIPTION

Sensor Network:

Sensor network comprises several sensors to monitor the hazardous environment of the underground area.

A. GasDetectors:

In the proposed system MQ2 and MQ7 gas sensor is being used.

MQ2: This sensor is used to sense the methane contained in the coal mine environment. The gas concentration is determined when the gas sensor interacts with the gases. Each gas has its own breakdown voltage, this voltage then helps to identify the gases. The MQ2 sensor can be used to measure various gases like LPG, Methane, hydrogen and carbon monoxide. It consumes 5v power supply and has a range from 200-10000ppm.

MQ7: This sensor senses the carbon monoxide concentration in the environment. It has a high sensitivity to carbon monoxide in a wide range.Thedetecting range of this is 10-500ppmCO.

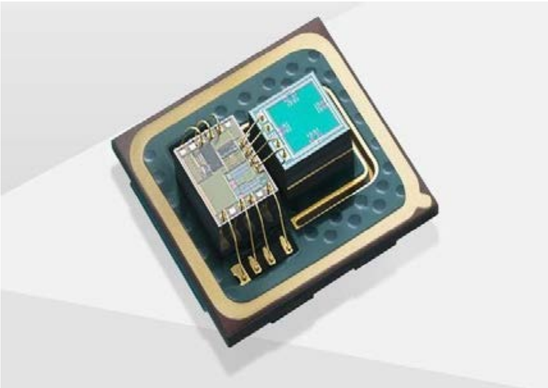
B. Humiditysensor:

Humidity is the amount of moisture content in the air. The humidity sensor HSM-20G is of resistive typewhich converts relative humidity

into standard voltage output.

C. MEMSSensor:

MEMS sensor is used to find out the position of the worker such as Standing, Sitting, Lying and mainly to find out the state of unconsciousness.



D. Heart RateSensor:

Heartbeat Sensor is an electronic device that is used to measure out the heart rate. When you are working out and sweating, the electrodes pick up the electrical signals by our heart beat, and that information is sent to the transmitter. The transmitter is typically the only part of the chest strap which is detachable. Inside is a microprocessor that records and analyzes heart rate from those electrical signals, as well as a battery and the chips needed for Zigbeeconnectivity.

Using Zigbee and a connected smartphone, the transmitter can consistently send heart rate data to you're a mobile device, which acts as thereceiver.

E. Zigbee module:

ZigBee is a low-cost, low-power, wireless mesh network standard which has been targeted at battery-powered devices in wireless control and in the monitoring applications. ZigBee delivers low-latency communication.

Fig 1:Front view of Zigbee

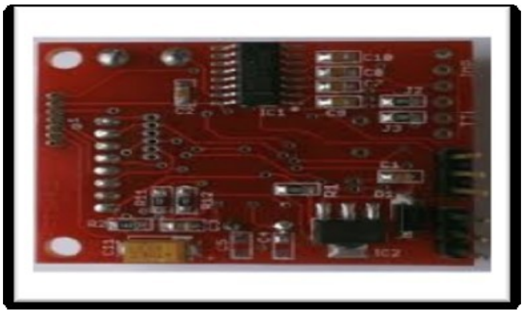


Fig 2:Back view of Zigbee

ZigBee devices are of three kinds:

ZigBee coordinator (ZC): The Coordinator forms the root of the network tree and bridges to other networks. There is accurately one ZigBee coordinator in each network since it is the device that started the network originally. It stores information about the network,and also acts as the trust center and repository for security keys.

ZigBee router (ZR): A router can act as anintermediate router, passing data on or from other devices.

ZigBee end device (ZED): It contains enough functionality to talk to either the coordinator or a router and at the same time it cannot relay data from other devices.

This relationship allows the node to be asleep thereby giving long battery life. A ZED requires a minimal amount of memory.

F. GSM:

GSM is a mobile communication modem which stands out for the global system for mobile communication (GSM). A GSM digitizes and reduces the data, then sends it through the channel with two different streams of client data.

V. SOFTWARE USED

Embedded-C:

C is the most widely used programming language

among all languages for the embedded Processors/controllers. Assembly is used mainly to implement those portions of the code where very high timing accuracy, size of code efficiency are prime requirements.

VI.CONCLUSION

This integrated design will replace the old-fangled way. The system works on any kind of mine environment, to ensure the safety of the mine workers. The traditional mine security system can be efficiently replaced by the surveillance and safety system.This paper gives a system related to safety and security of underground mines and the miners.

The system is most probably reliable, uninterrupted, economical and user friendly. A larger area and more depth inside hazardous underground mines are now easily monitored and accidents can be controlled in an efficient manner. The system generally combined the low power, low cost Zigbee based high frequency wireless data transmission technology. Proper monitoring and communication is possible between the miners, monitoring site and the rescuing team.

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