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IOT Based Wireless Safety System for Monitoring the Physiological and Environmental Variables of Mine Workers.

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Abstract*: The coal mining is essential as well as a risky venture. The miners working here need to handle the extreme environmental condition and the physiological hazardous without specialized examination. A continuous monitoring of the environmental change and the physiological variables is needed in order to enhance the condition for people and the equipment. A Continuous monitoring of the environmental gases and the physiological variables is the major challenge and need to be followed for safety of workers working in mine. This paper present the design and the implementation of real time monitoring device to measure the physiological variables and the gases present in the mining. The proposed system consists of physiological variables, ECG signal, respiratory activity, body temperature, fall detection and also the environmental gases. The sensors will be embedded throughout the T-shirt to measure the variables. The device will monitor the real time data and wireless communication network will be provided by using Wi-Fi link module. By using IOT it is easy to upload the data on the web server and it also provides data security.

Keywords: Coal mine safety, Sensors, Wi-Fi link, Gas monitoring, wireless communication

I. INTRODUCTION

Coal mining is a risky venture. Hundreds of mining workers has lost their lives in mining accidents, all over the world. Prime concern is of safety in coal mining. Main consideration lies in the improvement of safety issues of workers, whether it is coal mining or other minerals. 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. The worker working in coal mine has shift wise working schedule. The shifts are so plan that the workers should not be exposed to gases for longer time.

A periodic health checkup of the miners is mandatory. 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, vomiting are 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 the human health. With contact below zero temperature can cause hypothermia.

As a precaution a continuous real time monitoring of oxygen saturation, gases present in environment, heart rate and ambient temperature is important. The real time monitoring system helps in measuring the physiological variables and the environmental variables which may cause health issues to the workers. When the value of gases present in environment changes, this affects the change in the respiratory rate of the worker, an alarm is set and a first aid team is rushed to the worker suffering from this.

II. LITERATURE REVIEW

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

In 2016, Pablo Aqueveque, Christopher Gutierrez, Francisco Saavedra, Esteban J. Pino, Anibal s. Morales, Eduardo Wiechmann, they 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 media and the sensed data was transferred to the monitoring unit through the Wi-Fi link [1].

In 2018, Ivan Alfonso, Camilo Gomez, Kelly Garces Jaime Chavarriaga proposed a optimization methodology for the deployment of wireless sensor networks to monitor gases in underground coal mining. They proposed two stage approaches for minimizing deployment costs and maximizing WSN lifetime [2].

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 [3].

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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 of sleep quality is important as inadequate amount of sleep may lead to fatigue and higher risk of accidents [4].

In 2016, Pranjal Hazarik 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 Zig-bee module. The system was monitored in labview. An alarm is triggered when the gas concentration reaches beyond the critical level; this saves the plant and the workers from major accidents [5].

In 2016, Bo Cheng, Shuai Zhao, Shangguang Wang and Junliang Chen proposed a mash-up middleware for coal mine, the main purpose of their work is to develop a lightweight mash-up for mine monitoring and controlling. This makes it trouble free to use and install. They also proposed OSGI based uniform devices access framework. They created graphical user interface of different physical sensor using the visualization technique [6].

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 the 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 [7].

In 2018, Ruipeng Tong, Yanwei Zhang Pengcheng Chi, Cunlizhai Meng Shhi and Suruixu they proposed a theoretical framework for analysis of unsafe behavior characteristics of coal miner. The data analysis result provides the data support and management basis for safety management [8].

In 2018, Akshunya Mishra, Sakshan Malhotra, Ruchira Pallavi Choudekar, 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 [9].

From 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 fall detection of worker when affected by the surrounding and the buzzer is set on when the value reaches above the threshold value.

III. SYSTEM DESIGN

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

The architecture of the proposed system is shown below:

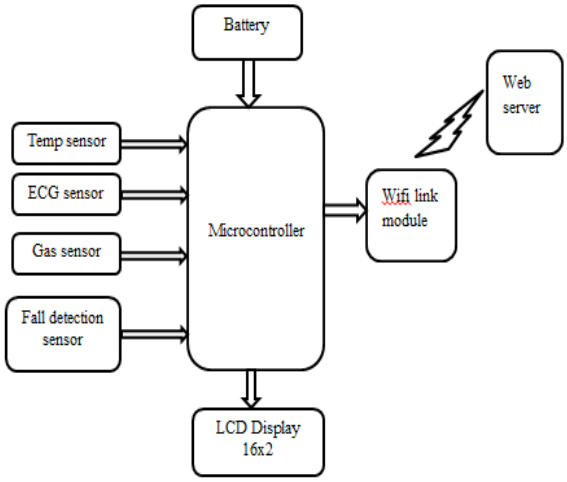


Fig. (i) Transmitter unit.

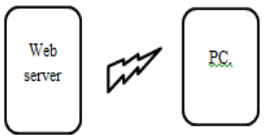


Fig. (ii) Monitor unit.

Fig.1. Block Diagram of the system.

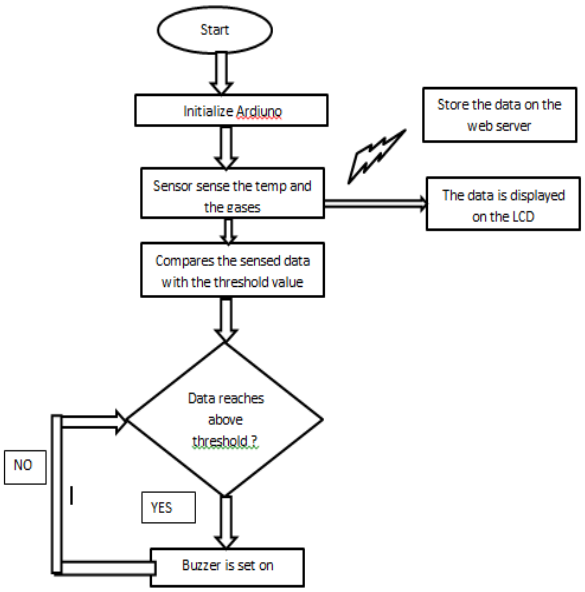
The system consists of two units:

i) Transmitter unit.
ii) Monitor unit.

In the transmitter unit all the main data processing carried out. We use four sensors, Temperature sensor, Gas sensors, Heart beat sensor, fall detection sensor. The temperature sensor used in this system is (LM35) which continuously monitor the environmental temperature. The graphical representation of this data is shown on the PC with date and time.

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 is the MQ5 and MQ7 sensor which is used to measure the methane and CO contain in the environment. When the methane contain increase beyond the safe value then this may affect the health of the worker and may cause shortness of breath, dizziness, Migraine, vomiting. The ECG sensor is used to continuously measure the heart activity. Graph is plot in accordance with the sensed data.

The system flow is 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 Wi-Fi link module. The Wi-Fi network contains SOC and integrated with TCP/IP protocol stack. It gives the network access to any microcontroller. Using this, real time health status reporting to the monitor unit is possible.

The Think-speak application can be loaded onto the PC and also in mobile. In the monitoring stage (PC) makes possible to show the physiological and environmental parameters and shows the plots and report the health status. For periodic record of analysis and control, the system allows to store the data.

IV. HARDWARE DESCRIPTION

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A. ATmega16A

It is a low power 8 bit microcontroller, with high performance. It has high endurance nonvolatile memory, 512kb of EEPROM, 1kb of internal SRAM. It provides software security with programming lock. It also has flexible two 8 bit and one 16 bit timer/counters. It provides with the JTAG interface. It has 8 channels, 10 bit ADC. To balance the power consumption it has power saving modes. The power supply to the controller is given through the 12v battery.

B. Gas Detectors

In the proposed system MQ5 and MQ7 gas sensor is been used.

MQ5: This sensor is used to sense the methane contain 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 MQ5 sensor can be used to measure various gases like LPG, Methane, hydrogen and carbon monoxide. It requires 5v power supply and has detecting concentration from 200-10000ppm.

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

C. Wi-Fi Module Esp8266

The communication in this system is carried out by this module. The Esp8266 is a microchip full with TCP/IP stack and is a low cost chip. It allows device to connect to the Wi-Fi and has a built in flash. It comes under the type of 32bit microcontroller. It has 32kb instructions and 80kb user data memory. It has 16 GPIO pins.

D. Heart Beat Sensor

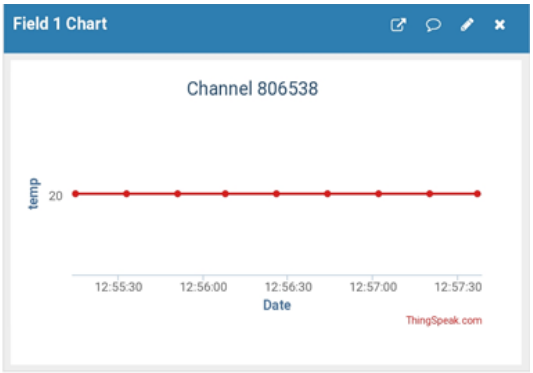
The ECG Electrode sensor is used to measure the heart rate of the worker. The electrode is also used to measure the irregularities in the heart rhythm called as arrhythmias. The heart rhythm test is also performed if the signs such as weakness or inability to work, dizziness, chest pain, shortness of breath, rapid pulse occurred in order to check the body functionality. It gives almost good accuracy data then the finger electrode.

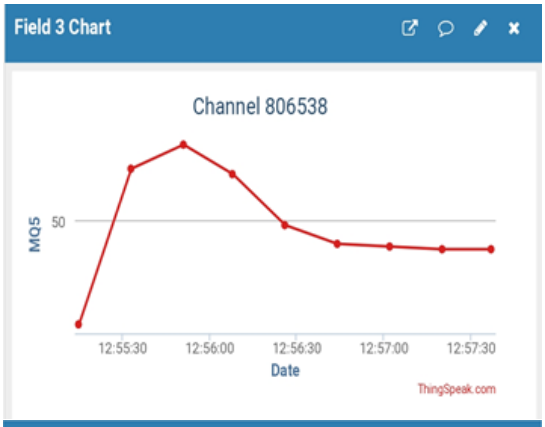
E. Fall Detection Sensor

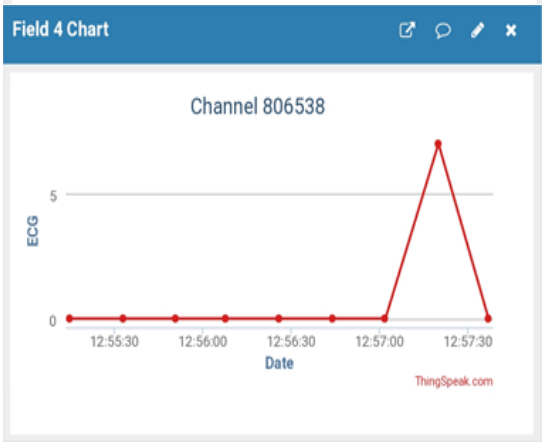
We have used ADXL335; it has 3 axis sensing and is small and low power device. It also has excellent temperature stability and can be used in cost sensitive application. The device measures the acceleration of gravity in tilt sensing.

V. RESULTS

The proposed system is tested and the output is shown in the graphical form using the think speak application. The data sensed by the sensor is processed and then send to the web server through the Wi-Fi link module. At the monitor unit the think speak application is installed onto the PC and here we can see the real time plots of each sensor. The think-speak application is very easy to use, just enter the channel ID and here you get your plots with the date and time information.







By Clicking on the peak point you will get date, time and value. The think-speak application helps to store the data. The data is uploaded through the web or can be uploaded through the device itself.

VI. CONCLUSION

This paper represents the hardware implementation of the real time monitoring the physiological and the environmental variables of the coal mine workers. We have focused on the design and implementation of the monitoring system to continuously monitor the gases and the physiological variables of the workers. The sensors are embedded on the T-shirt of the worker and the communication is done by using wireless network between the T-shirt and the monitoring unit. By using IOT it is easy to store the data. The Think-speak application helps us to show the graphical representation of each sensor. The alarm works correctly detecting any problems the worker is suffering. The system is tested and the results are obtained accordingly. This system mainly focuses on the safety of the workers thus by reducing the future accidents which can be caused by the sudden change in the measured variables.

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Gauri Suresh Dabhade is currently pursuing her PG degree in VLSI and Embedded system Design in AISSMS Institute of Information Technology, Pune. She has also completed her BE in Electronics and Telecommunication and diploma in E&TC. Her area of interest includes VLSI, Internet of Things, Embedded system design, programming in embedded C. She is doing research on IOT based Wireless Safety System for Coal Mine workers since 2018. She has also published 1 paper on Smart School security system for children's.

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