IoT in Mines for Safety and Efficient Monitoring

G. Prabhakar Reddy
Department of ECE
St. Martin's Engineering College Technology,
Hyderabad, India

M.Vijaya Lakshmi
Associate Professor, Department of ECE,
St. Martin's Engineering College Technology,
Hyderabad, India

***Abstract*— In this paper we are designing an IoT (Internet of Things) monitor, a safety measures for mine workers which is most essential in underground mining areas. In this project, the system is build using different sensors network based on MEMS used to monitor the surroundings parameters of underground mine place and drives all sensed parameters/values to /values to ARM7 based Microcontroller Unit (MCU). The MCU unit is used to build a completely automated evaluating system with high accuracy, smooth control and reliability. When a critical conditions is detected alert is given by the system and the same statistics is communicated to webserver by initiating ESP8266 module based on Wi-Fi communication. The detected variations in the values are displayed on webserver page that makes easier for the underground control center to monitor and to take essential instantaneous action to prevent severe damage.**

***Index Terms*— IoT, MCU, Wireless Sensors Network (WSN), MEMS, Wi-Fi, PC, Webserver.**

I. INTRODUCTION

The primary factor in running any industry successfully is to ensure the safety of person working that work area. Underground mining industry comes to the same category, where each and every parameter such as methane gas, high temperature, fire accidents and so on has to monitor regularly. Every mining industry follows some basic precautions to avoid any type of unwanted phenomena. In this paper we are considering above mentioned situations and also monitoring mine workers activities e.g. Fall Detector that states workers position. A major improvement is to implement internet of things in collecting and plotting parameter and sensor values to web servers.

Designing of IoT systems in Mines for Safety and Efficient Monitoring is based on wireless sensor network can be sensible and correctly redirect dynamic condition of workers in the underground areas to data servers and can be monitored regularly using web applications and servlets in computer system. The hybrid underpass radio propagation model comprising of the free space propagation and the modified waveguide propagation is proposed. However, using popular radio communication inside underground mines has some drawbacks. Though radio signals are transmitted, attenuation, diffraction, multi-path and scattering are frequently very serious. Therefore wireless communication is the important need today for the fast, flexible safety, accurate and production method in underground mines and we are using IEEE802.11 Wi-Fi wireless communication protocols to record the sensed parameters to data center or webservers.

There are diverse added research ideas proposed by different people on wireless communication. In a network called chain-type wireless underground mine sensor network (CWUMSN) is recently proposed which consists of three kinds of sensor nodes: sensing nodes, cluster head nodes, and a base station installed on both sides of the passageway at consistent intervals to monitor the underground environment and locate the miners. An innovative decision-making method to coal and gas outburst prediction with multisensory information fusion is proposed.

This IoT system is planned by bearing in mind all these factors i.e. it can measure temperature, sense pressure, fire, gas, humidity, as well as Persons Fall. Thus the intended system is giving a very good solution for most of the difficulties challenged in mine calamities.

An efficient communication system must be set between mine workers and Remote Base Station For this wired network communication is inefficient in underground mining areas. Thus we are selecting a wireless network system built on Radio Frequency communication at 2.4 GHz (ESP8266-01 Module is a Wi-Fi Trans-Receiver module which offers easy to use RF links at 2.4 GHz) that enable us to put sensed data into web server.

II. EXPLANATION OF THE SCENARIO

The proposed system is divided into two sections. Firstly is a wearable device that will be attached/tagged to the body of the Mine Workers. The suitable design for this wearable is a safety helmet.

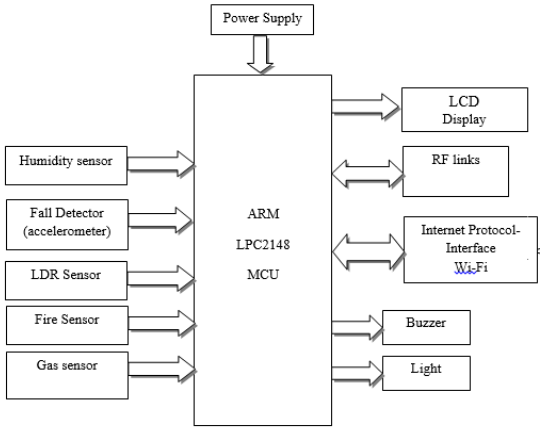


Fig 1 Interfacing Block Representation of Wearable Device.

ISSN: 2278 – 1323

The device is build using sensor module consisting of some sensors that processes real-time underground parameters like natural gas release and concentration, humidity, fire and light, temperature, miner physical positon. Excess natural gas concentration is meant for the harmful gases like Carbon-monoxide, Methane, Butane and Propane.

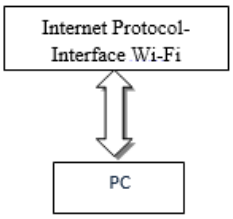


Fig 2 Wi-Fi links Miner's wearable and IoT web Server

We use an ARM7 based microcontroller which is important in processing instructions given as a firmware. The MCU sense the change in physical parameters and process them to convert into digital form. The conversion can also be from analog data or an interrupt in data signal or a digital signal. If temperature exceeds a safety level pre-programmed at microcontroller, alert is sent to ground station controller make sense of, alarms the speaker interfaced with MCU. If the measured humidity value is more than the safety limits at microcontroller; it alerts with alarms. Likewise when gas concentration crosses threshold limit MCU decodes siren alarms. When a working person falls down for any reason fall sensor will alert by alarm to nearer areas and also to ground control section through Wi-Fi repeaters. Light sensor helps in setting PWM controlled torch lamp, which senses depending on the light intensity. Fire Sensor helps in stopping fire accidents and rapid spreading by detecting fire and feed alert to main station that helps in taking essential precautions. LCD display interfaced will show all the parameters like temperature, humidity etc., on wearable device.

ESP8266 is interfaced to the Module to send sensor data to the server in a regular intervals, and also sends the same to local ground monitoring station through Wi-Fi repeaters.

III. HARDWARE DESCRIPTION

A. *SENSOR*

1) Temperature Sensor (LM35):

A Linear LM35 is used to record temperature at constant interval of time. It is an accurate temperature sensor with an output voltage linearly proportional to Centigrade temperature. The analog voltage to digital sample data conversion is handled by LPC2148 and the obtained digital value will be sent on the LCD display connected to LPC 2148.

2) MEMS Accelerometers (ADXL335):

The ADXL335 is a low power whole 3-axis accelerometer with signal conditioned voltage outputs. Product processes acceleration with a minimum full-scale range of ±3 g. This sensors can measure the static acceleration of gravity in tilt-sensing device, and also as dynamic acceleration consequential from vibration, shock, or motion. X-axis is connected with controller and continuously checks that 'g' value change.

3) Humidity Sensor:

This sensor will give analog output proportional to relative humidity, the amount of water vapor in the air. The humidity sensor HSM-20G is of resistive type. It is an analog humidity and temperature sensor that outputs analog voltage respects to relative humidity and temperature

4) Fire sensor:

Fire sensor will sense heat radiations in surroundings. The sensor is used to detect any trace of fire and it will give interrupt signal as soon as it detects Fire in underground regions. It works on the principle of IR rays or Heat radiation detection.

5) MQ-4 Semiconductor Sensor for Natural Gas

For detection of most natural gases like Methane, also to Propane and Butane which are the major toxic gases in underground coal mines this gas sensor interfaced. It has 6 pins; 4 of them are used to bring signals and other 2 are used for supplying heating current.

6) Light sensor (LDR):

. Light sensor helps in setting PWM controlled torch lamp, which senses depending on the light intensity. If the working area is dark then LDR activated circuit will turn ON the torch lamp arranged to wearable device. PWM usage helps the system to have good battery backup.

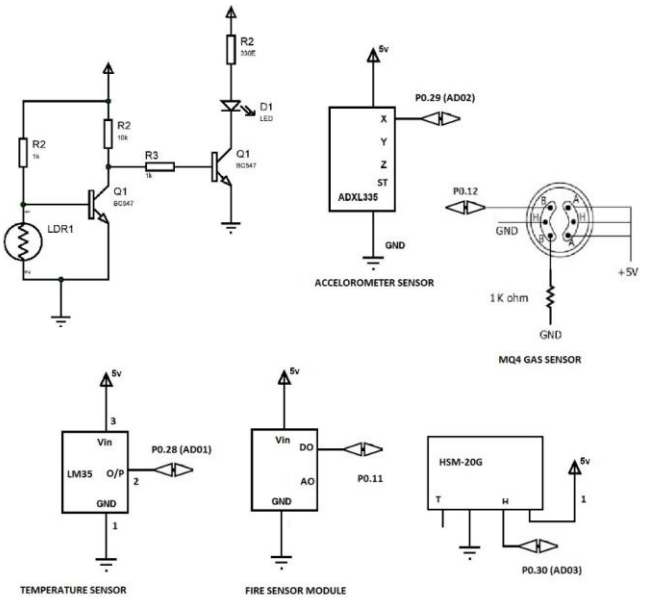


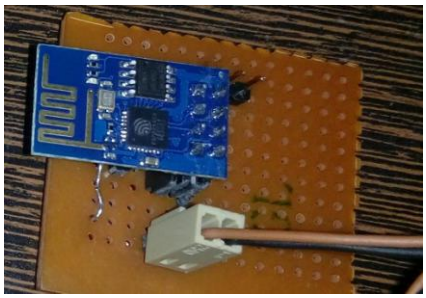
Fig 3 Sensors in Sensor Network

B. *ESP8266 MODULE*

The updating web data through ESP8266 modem when interfaced with microcontroller or PC is much simpler as compared with Ethernet module since ESP is a SoC and Integrated TCP/IP protocol stack. AT firmware is provided with easy to use command set with which it can be configured or operated at various Baud Rate (Supported 9600, 115200 or

ISSN: 2278 – 1323

57600). Plain Text may be sent through the modem by interfacing only three signals of the serial interface of modem with microcontroller (TxD, RxD and GND). In this scheme RTS and CTS signals of serial port interface of ESP Modem are connected with one another. The transmit signal of serial port of microcontroller is connected with of the serial interface receive signal (RxD) of ESP Modem while receive signal of microcontroller serial port is connected with transmit signal (TxD) of serial interface of ESP Modem.



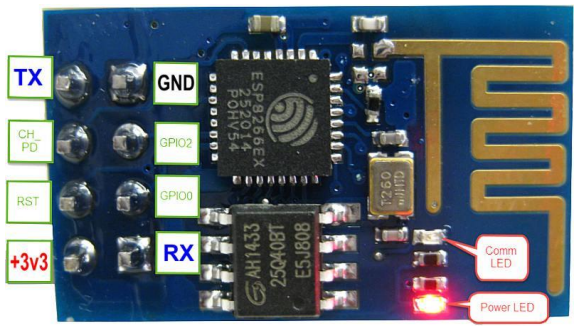


Fig 4 ESP8266 Module

C. *LCD INTERFACING*

Here we have interfaced a character based 16x2 LCD for displaying information regarding different parameters like Temperature, Humidity etc.

Fig 5 LCD with Sensor Information

IV. SOFTWARE DESCRIPTION

The core firmware is developed for Bare Metal microcontroller and flashed to internal rom. Firmware is written Embedded C language. And whole project is designed keil product development tools such as keil IDE, armcc cross-compiler for ARM controllers. Phillips Flash loader for burning firmware to ROM. HyperTerminal used as serial port client for purpose of debugging hard-software effectively.

A. *About Keil IDE*

Keil is free software that solves many of the pain points for an embedded programmer. This is an integrated development environment (IDE) software that integrated a text editor to write, a compiler to compile it and convert source code to hex files

B. *About HyperTerminal*

The HyperTerminal tool is used to monitor Serial Ports in PC. Terminal software is mainly used for initial setup of Wi-Fi module, i.e. to update setting or updating AT firmware for ESP module provided from manufacture. It also helpful in debugging the functionalities of prototype of our project. Thus at the Remote station the collected data from Wi-Fi Receive is displayed as mentioned in the Results section.

V. RESULTS

A. *PROTOTYPE PICTURES*

The Overall system's results are given in this section. The LPC2148 Evolution Board which is shown in below figure is heart of all functionalities in miner module i.e. Monitoring, Processing collected data and taking necessary action based on the limits given for individual sensors.

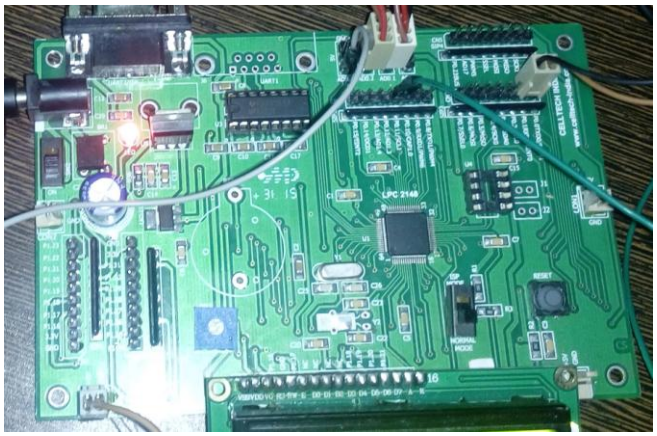


Fig 6 LPC2148 Evolution Board

In the following Figure all sensors and modules are connected to form the first prototype of our proposed system.

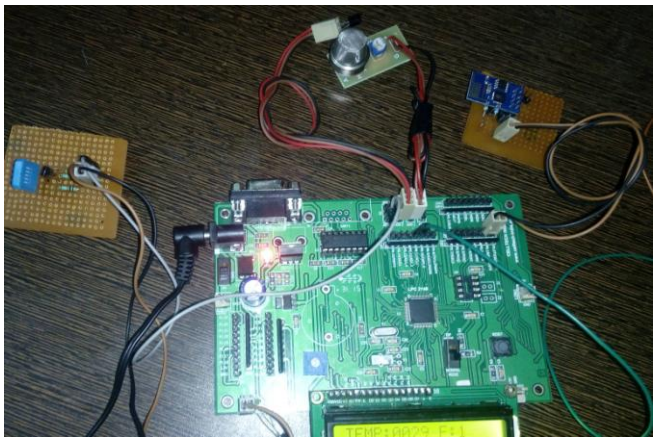


Fig 7 Overall Miners Module Hardware Setup

On detection of Abnormal activity at miner module the

ISSN: 2278 – 1323

core system sends alert based on the Interrupt source. A Fall Status indicates the steadiness of a miner. Various data is also record in regular intervals of time. This enables us to track the real time data at any given instance of time.

B. TEST CASES

The IoT server regularly collects the listed measured parameter and plots on graphs with reference of date they measured. Thingspeaks channel settings can be changed as per figure showed.

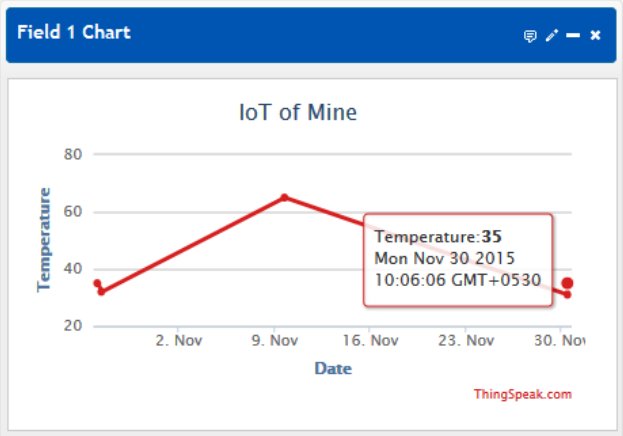


Fig 8 Temperature values plot on graph

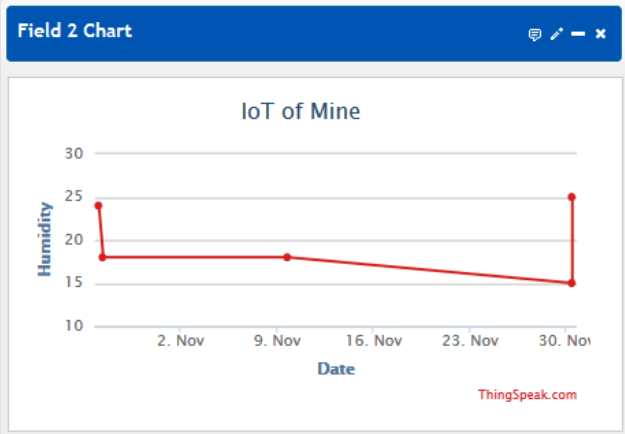


Fig 9 Humidity values plot on graph

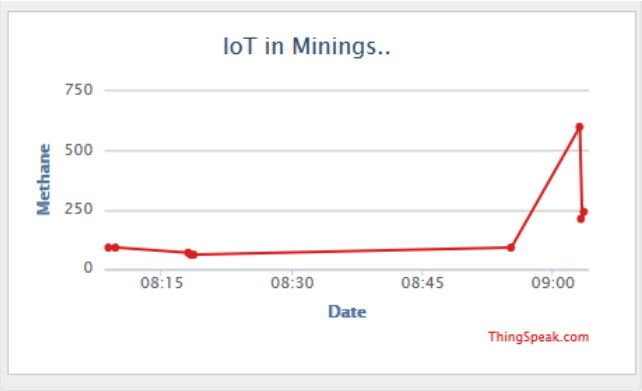


Fig 10 Graph plotting of Gases (Methane)

The above showed graphs reveals time-to-time updates of sensor parameters collected from the ground section nodes. Graph plotting of data easy in analyzing and monitoring. This data is displayed in pc that provides the complete information of workers and statistics of all the parameters.

The parameters log data can also be cleared to refresh unwanted overhead of maintaining huge data in the server as showed with listed options. Additional options enable to delete channel if unwanted.

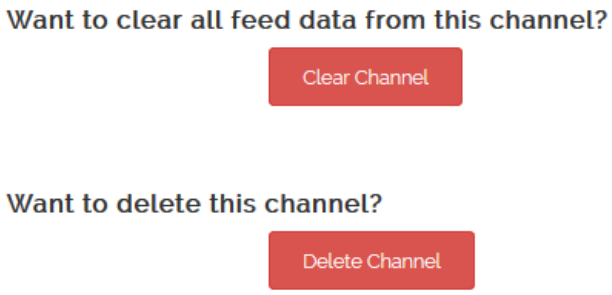


Fig 11 Channel setting with clear channel data and Delete channel from server

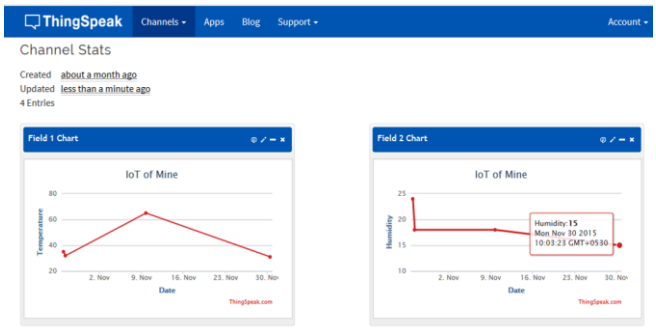


Fig 12 IoT Webserver Monitoring section Screen

VI. CONCLUSIONS

The present underground Mines system can be productively substituted by this IoT safety system proposed in this paper. This IoT system enclosed the utmost Key and major feature of currently deployed mine workers safety. Since this system is made of low power Wi-Fi module and control lamp with PWM technique, proportion of power consumption is lowered, which is significant for any device that is powered by battery. Additional safety can be delivered to data servers and maintained accurate information of mines.

REFERENCES

[1] E. K. Stanek, "Mine Electrotechnology Research: The Past 17 Years", IEEE transactions on industry applications, vol. 24(5), pp 818-19, 1988.

[2] S. Wei, L. Li-li, "Multi-parameter Monitoring System for Coal Mine based on Wireless Sensor Network Technology", Proc. International IEEE Conference on Industrial Mechatronics and Automation, pp 225-27, 2009.

[3] Y.P. Zhang, G. X. Zheng, J. H. Sheng, "Radio Propagation at 900 MHz in Underground Coal Mines", IEEE transactions on antennas and propagation, vol.49(5), pp. 752-62, 2001.

ISSN: 2278 – 1323

[4] S. Jin-ling, G. Heng-wei, S. Yu-jun, "Research on Transceiver System of WSN Based on V-MIMO Underground Coal Mines", Proc. International Conference on Communications and Mobile Computing, pp 374-378, 2010.

[5] N. Chaamwe, W. Liu, H. Jiang, "Seismic Monitoring in Underground Mines: A case of Mufulira Mine in Zambia Using wireless Sensor Networks for Seismic Monitoring", Proc. IEEE international Conference on Electronics and Information Engineering, vol. 1(V1), pp 310-14, 2010.

[6] X. Ma, Y. Miao, Z. Zhao, H. Zhang, J. Zhang, "A novel approach to Coal and Gas Outburst Prediction Based on Multi-sensor Information Fusion", Proc. IEEE international conference on automation and logistics, pp 1613-18, China 2008.

[7] C. Qiang, S. J. Ping, Z. Zhe, Z. Fan, "ZigBee Based Intelligent Helmet for Coal Miners", Proc. IEEE World Congress on Computer Science and Information Engineering, pp. 433-35, 2009.

[8] D. Koenig, M. S. Chiaramonte, A. Balbinot, "Wireless Network for Measurement of Whole-Body Vibration", J. Sensors, vol. 8, pp. 3067-81, 2008. [11] http://www.mxcom.com, accessed June, 2011.

[9] http://www.citeseerx.ist.psu.edu/viewdoc/download, accessed August 2010.

[10] http:// www.MaxStream.net , accessed June, 2011.

BIOGRAPHIES

G.Prabhakar Reddy received his B.Tech degree in Electronics and Communication Engineering from MITS Affiliated to Jawaharlal Nehru Technological University (Hyderabad) and he is currently pursuing M.Tech in Embedded Systems (ES). His research Interest includes Embedded Systems and Internet of Things.

M.Vijaya Lakshmi received her B.Tech degree in Electronics & Communication Engineering from GPREC, Kurnool in 2000, and Masters in Electronics & Communication Engineering from JNTU, Hyderabad in 2009. Presently, she is working as Associate Professor in ECE department in St. Martin's Engineering College, Hyderabad. Her Area of interest are Wireless sensor networks and Embedded Systems.

ISSN: 2278 – 1323