

Using Zigbee Integrated Alerting and Coal Mine Safety Monitoring System

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Abstract: *The coal mine safety system replaces traditional coal mine safety which is wired system. This monitoring system for coal mines based on ZIGBEE wireless sensor network. Because of this there is important development in coal mine safety production which is safe. Apart from this it is unsuitable to lay the cables in life which is costly and consumes more time. To solve this ambiguity there is need of design and development of coal mine safety using WSN. Because of this there is improvement in the production safety and reduces accident. The purpose of this project is to propose a solution suitable to mine wireless communication, safety monitoring, and give proof to further study.*

Keywords: Wireless sensor Network, Zigbee, LPC2148.

1. Introduction

In the last few years for almost every country has one aspect that is environmental care. In last decades, without any control, accidents in industries has been increasing. So current situation in industries is more hazardous. Recently, for monitoring and control of environmental parameter in hazardous environment, modern industries requires instrumentation. Because human safety and property losses are important to maintain in industrial environment.

There are five hazardous factor which causes risk accident as fire, gas leakage, radiation and high temperature source, environmental elements combustible material due to the combined effects of all hazardous environment industrial accidents are occur. In coal mine industries existing monitoring system uses cable network. Due to explosion in hazardous environment especially in coal mine, sensor & cables damaged completely. It could not provide the information which is helpful to rescue search and detection of events. Because of the accident there is loss of human life. So the main scenario of this project is to improve the safety of humans.

Due to variety of work & complexity of mine environment disasters of coal mine happen. So it is more important to monitor mine working environment. Currently coal mine uses cable network for the transmission of environmental parameters such as methane, carbon monoxide, temperature & humidity & so on. So in this project we used the WSN rather than cable network. Here we used Zigbee as a WSN.

2. Wireless Sensor Network

Sometimes wired network cannot be established or not suitable so that time Zigbee as a WSN can penetrate walls[1]-[5]. The improvement in wireless communication technology made it possible to lay the communication network by keeping the communicating node at the required spots and switching the transmitter between them. With great usefulness and important features a wireless network is necessarily used in coal mines where it is not possible to establish a network. Also in case of hazardous environment, cave-ins or in the explosion the wire may get damaged

making the whole network useless. So to avoid the drawback of wired network the wireless network is used. With large operating node even though solid object such as walls and in the mines the most suited technology is WSN.

Today Zigbee is used for formation of many communicating network. In environment such as homes & hospitals, for the number of purpose where there are many sensors are used[6]-[9]. For creating good environment these sensors are installed at many places. The Zigbee system is used to find explosion location by observing the signal strength obtained from nodes.

3. Aim of Project

- 1) A zigbee network controlled automatic system has been developed for assisting the rescue workers.
- 2) A coal mine system which replaces the traditional coal mine monitoring system which tend to be wired network system.
- 3) The underground system also collects temperature, humidity of coal mine through sensor nodes in mine.
- 4) To check the presence of methane gas inside the mine.

4. Review of Literature

In the hazardous environment, industrialized accident occur. Due to which consequence may be very serious and it causes loss of environment, property and life. For moral, legal, & financial reasons hazardous environmental safety & security is more important wireless sensor network in industrial site, the deployment of distributed point source where the dangerous parameters used, produced and stored is described seven characteristics, fundamental aspects for estimating and emission method were identified[10]. For measurement of temperature using Virtual Instrumentation is by Automatic Process Control in many industries [11]. This paper shows agricultural environment monitoring system for monitoring information related to the outdoors production of agriculture environment using WSN technology [12].

This research shows survey study of need related with long term stewardship & environment monitoring[13]. The aim of this paper is consideration of design for monitoring of the

detection of hazardous parameter using system on chip[14]. In the wireless communication during emergencies is important for survival for example during accident traditional wired communication system is not reliable which is needed wireless radio system [15].

The field of electronics gives a very good performance and this is realized using zigbee technology guided by 802.15.4 PAN. WSN replaces existing non standard technologies. The Zigbee operates in 868MHz band at a data rate of 20kbps in Europe, 2.4GHz ISM band worldwide at a 250kbps, 914MHz band at 40Kbps in USA. Table 1 shows comparison of different transmission media.

Table 1: Different transmission technology

Characteristics	Infrared	RF	Bluetooth	Zigbee
Expansion	Low	Low	Medium	High
Data rate	38Kbps	4800bps	1Mbps	250Kbps
Power Consumption	Low	Medium	Medium	High
Controlled units	1	1	7	254
Distance	15m	50m	100m	100m

5. System Overview

In this paper we have proposed improved wireless communication system for mines specially to the coal mines workers to update the underground section in coal mines to the to the ground section and send the message to the Administrator that is authorized person immediately. Here the system is divided into the two parts :

- 1) Ground section acts as a base station
- 2) Underground section.

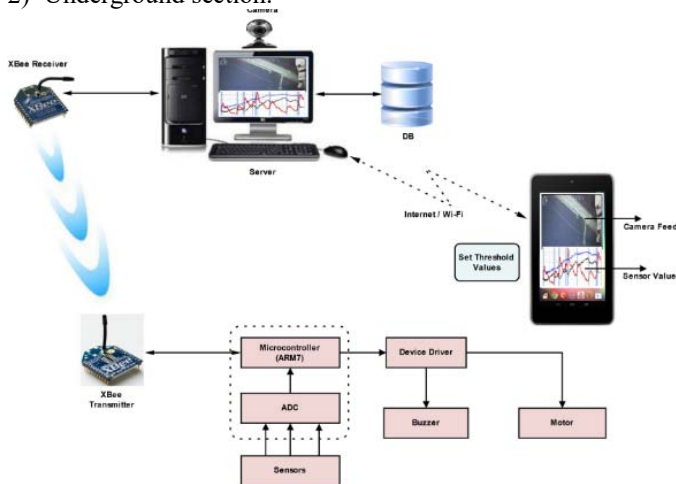


Figure 1: Design of system

The Underground section includes controller, the number of sensors that includes humidity sensor, temperature sensor, vibration sensor and gas sensor. This also includes the device driver, Buzzer and motor, Zigbee transceiver.

The Ground section includes administrator PC which acts as a server, Zigbee transceiver and there is one GUI which is running on android application.

6. Design and Proposal of the Project

A. Underground Section

In the underground section the numbers of physical parameters are observed by the respective sensor. In the underground section there are gas sensor, humidity sensor, temperature sensor and vibration sensor. Te output from this sensor is directly connected to the ADC of the ARM. There is no need of connecting signal conditioning circuit because output never exceeds from 5V. The number of people in the coal mine is observed. During the hazard all the information from sensor is send to the ground section. Information related to the safety measure as wearing helmets of oxygen etc. will be given to the worker. So that they can save their life.

If any of the received parameter is beyond the ultra limit then Buzzer is ON giving warning to the people. The output from sensor is converted into the digital format and sent to the ground section through Zigbee transceiver.ion is connected to each other through the Wi-Fi.

B. Ground Section

In the ground section the Zigbee transceiver receives the information and sends that information to the server. There is one Graphical user interface created by Neatbeans platform. On this we can set the threshold values and control the input sensor and output devices. There is another GUI running on android application of administrator created by eclipse software. There surrounding of server is captured by web camera and it is also send continuously on the android application from the precaution point of view. The server and android application.

7. Design of Hardware

1) Temperature sensor

In this system we used temperature sensor as a thermistor. The name thermistor is formed by thermal resistor which is a temperature sensitive resistor. This thermistor detects small change in temperature. The change in small change in temperature. The change in temperature is measured by change in resistance of the device. Here it may be noted NTC thermistor has a resistance of about 10kΩ and 100kΩ at 50⁰C to 150⁰C. It is connected to PIN no 13 that is P0.28.

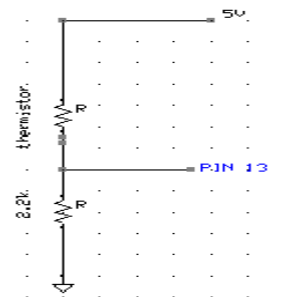


Figure 2: Circuit diagram of temperature sensor

2) Humidity

The amount of water vapor is expressed in terms of humidity. Here we used SY-HS-220 humidity sensor. This module converts the relative humidity to the output voltage. In daily language humidity is normally taken to mean relative

humidity. Relative humidity is defined as the ratio of partial pressure of water vapor to saturated vapor pressure at prescribed temperature. Humidity sensor is on pin no 15 that is P0.30.



Figure 3: Humidity sensor

3) Gas sensor

In hazardous environment, there are number of toxic gases are present which causes accident. In coal mines, methane, carbon monoxide are present. So for the detection of these gases MQ6 sensor is used in this project. This sensor has a fast response. It is a stable sensor and have a long life. It requires simple drive circuit. This sensor is used in gas leakage detection of equipments in industry and suitable for detection of LPG, iso-butane, propane, LNG. MQ6 is interfaced to the one pin of LPC 2148.

4) Vibration Sensor

In the hazardous environment sometimes vibrations are created. So to sense this vibration and to avoid accidents and to save life of humans, vibration sensor is used over here. This vibration sensor directly gives digital output. And it has sensitivity adjust model. When the output valid signal is high then LED goes out. It has adjustable sensitivity. Vibration detection range is wide, non-directional. Working voltage is 5V DC.

5) Controller

In this project we used the 32 bit ARM7TDMI which is the member of Advanced Risk Machine (ARM). The ARM offer high performance for very low power consumption at a price. There are two types of architecture one is Reduced Instruction Set Computer (RISC). The ARM architecture uses RISC principle because of instruction set and related decode mechanism. It is much simpler than those of Microprogrammed CISC [16]. This simplicity feature results in a high instruction throughput and good real time interrupt response from small and cost effective chip. Pipelining is implemented so that all the parts of processing and memory system can operate continuously. While one instruction is being executed its successor is being decoded and third instruction is fetched from memory [17]. The ARM7TDMI processor employs a unique architectural strategy known as a THUMB which makes it ideally suited to high volume application with memory restrictions or applications where code density is an issue [18].

We used LPC2148 of NXP semiconductor which shows following features:

1. 16/32 bit ARM7TDMI Microcontroller.
2. 40KB of an On-chip Static RAM and 512 KB of an on-chip flash program memory
3. In-system/In-Application programming via On-chip Boot loader software.
4. Two 10bit ADC provide total 14 analog input with 2.4µsec conversion time.

5. Single 10bit DAC provide Variable analog output.
6. Multiple serial interfaces including 2 UART, two fast I2C bus, SPI with buffering and variable length capabilities.
7. Vectored interrupt controller with configurable priorities and vector addresses [19]

6) Zigbee

Zigbee is a new wireless technology guided by the IEEE 802.15.4 Personal Area Networks Standard. It is primarily designed for wide ranging automation applications. It currently operates in 868 Mhz band at a data rate of 20kbps in Europe, 914 Mhz band at 40Kbps in USA and 2.4Ghz ISM band worldwide at a maximum data rate of 250kbps. The Zigbee specification operates in 2.4 Ghz radioband- the same band as 802.11b standard, Bluetooth, microwave & some other devices. It is capable of connecting 255 devices. Range of transceiver is 30-70m in urban areas and 1 to 1.5km in outdoor i.e line of sight. The transceiver has an on-chip antenna & it operates at a frequency of 2.4 Ghz [20]. Zigbee technology is slower than 802.11b but it consumes significantly low power [21]. Here a pair of Zigbee module is used one to transmit data and another to receive the data.

7) Buzzer

Whenever the toxic gases, temperature, humidity and vibration crosses its threshold level then buzzer is ON for alerting the people present in coal mines.

8) Power supply

In this we used ARM as a controller which requires 3.3V Power supply. So the 230V ac is fed to the step-down transformer. The output of this is given to the bridge rectifier. The output is given to the filter capacitor. The capacitor used here is 1000µf capacitor. The output of this filter is then applied to the regulator. Here we used LM7812 and LM7805. For other modules power is regulated by variable regulated supply.

8. Software Design

The software platform used for software designing is as follows-

- A. Keil microvision 4
- B. Flash program utility

C. Keil microvision 4

Window based software development platform is microvision 4. It consists of robust and modern editor with project manager and make facility tool [17]. For developing the embedded applications it consists of different tools such as C/C++ compiler, macro assembler, Linker, locator, Hex file generator. Microvision 4 provides Integrated Development environment for the development process of embedded applications. Keil can be used to create source files automatically compile, link and convert using option set with an easy to use user interface. And finally simulate or perform the debugging on the hardware with the access to C variables and memory. KIEL Greatly simplifies the process of creating and testing an embedded applications [18].

D. Flash program utility

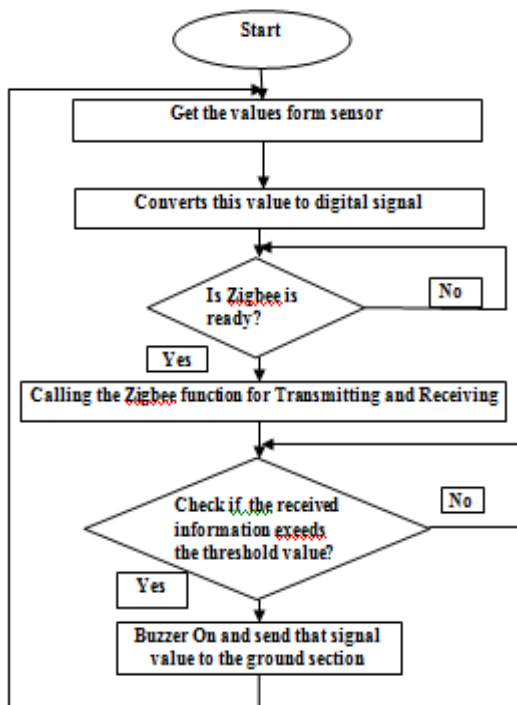
For downloading the application program into ROM Flash program utility tool is necessary. The program code generated in C language after processing produces object

code in hex form. It is referred as. hex file. To burn this hex code in the Flash ROM of the controller the facility is provided with Kiel microvisison 4. For programming with the older versions the same task is completed with the help of software called Flash Magic[18].

9. Design Flow

Flow chart for the underground section is shown following Fig. The system consists of very simple process:

1. Send the values from sensor to the LPC2148.
2. Display the values on LCD
3. Check whether the ZigBee is ready.
- If it is ready then call ZigBee function.
- If it is not ready then check until it is ready.
4. Check whether the values from Sensor exceeds the Limit If yes then Buzzer is on.

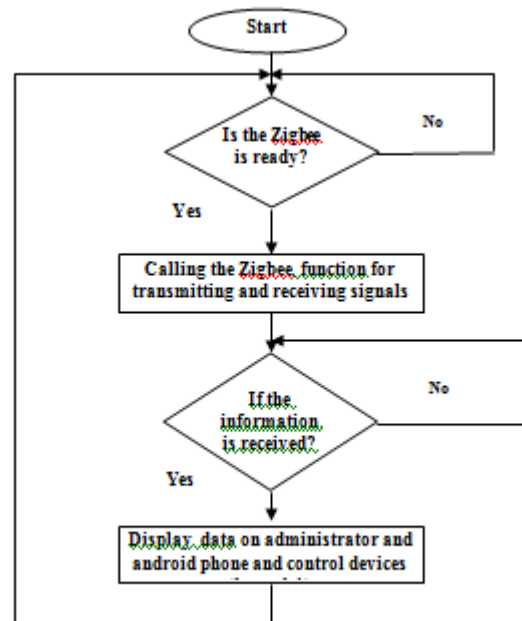


Flowchart 1 for Mining section

Flow chart for Ground Section is shown in the Flowchart 2

It Consist of the following procedure

1. Check whether the ZigBee is ready.
2. Send the Values form sensor to the LPC2148.
3. Display the values on the LCD.



Flow-chart 2 for Monitoring Section.

10. Result & Conclusion

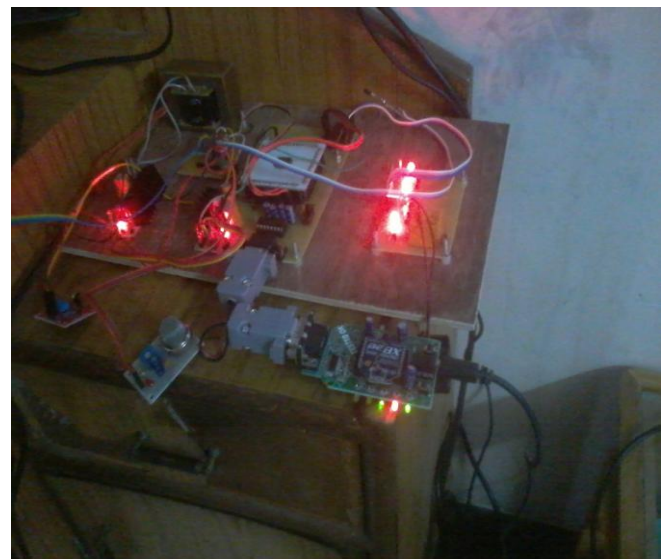


Figure 3: Hardware Underground section



Figure 4: Ground Section



Figure 5: Snapshot for Administrator Control

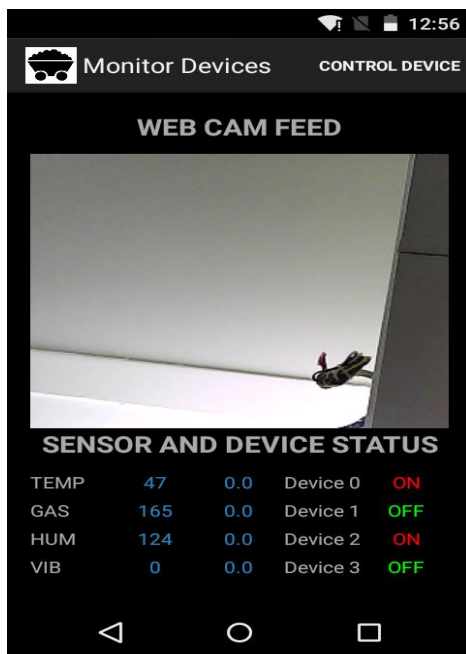


Figure 6: Snapshot of Web Camera Feed from Android Application

For Demonstration purpose we used the sensor. The gas sensor is more sensitive to the carbon monoxide but can sense methane, butane, LPG, hydrogen, smoke etc. We found more heating of sensor if operated for long time. The ZigBee communication is noise free. ZigBee and LPC2148 provides low power platform. More advanced version of controller like cortex-M3 can be used for more speed of execution and extreme low power consumption. With the use of sophisticated sensors, the system can work with more accuracy in real time. It can be modified in industrial monitoring as well.

References

- [1] H. Martín H, A.M. Bernardos, Bergesio, L. Tarrío. P, "Analysis of key aspects to manage Wireless Sensor Networks in Ambient Assisted Living environments, "International Symposium on Applied Sciences in Biomedical and Communication Technologies", Nov 2009. 1-8.
- [2] Ransom.S., Pfisterer, D., Fischer, S, "Comprehensible Security Synthesis for Wireless Sensor Networks", Proceedings of the 3rd international Workshop on Middleware for Sensor Networks, Leuven, Belgium, pp. 19–24 ,2008.

- [3] Hande Hande Alemdar , Cem Ersoy, "Wireless sensor networks for healthcare, A survey, Computer Networks", The International Journal of Computer and Telecommunications Networking , 54(15), (2010) 2688-2710
- [4] Yick, J., Mukherjee, B., Ghosal, D, "Wireless sensor network survey", Computer Networks. 52, (2008), 2292-2330.
- [5] Sun, Y. -, Qian, J. -, Wu, J. -, & Luo, Y., "Research on safety monitor system for underground unmanned roadway based on WSN", Chinese Journal of Sensors and Actuators, 2007, 20(11), 2517-2521
- [6] "Zigbee Alliance", ZigBee Specification, January 2008, (Rev. 17) [Online]. Available: <http://www.zigbee.org>
- [7] Xiao, H., Gong, Y., Ogai, H., Zhang, J., Zou, X., Ottawa, T., et al., "A data collection system in wireless network integrated WSN and ZIGBEE for bridge health diagnosis", Paper presented at the Proceedings of the SICE Annual Conference (2011), pp2024-2028.
- [8] Qian Zhang, Xiang-long Yang, Yi-ming Zhou, Li-ren Wang and Xi-shan Guo, "A wireless solution for greenhouse monitoring and control system based on ZigBee technology", Journal of Zhejiang University- Science A, 1584-1587, DOI 2007, 10.1631
- [9] Ge Bin; Li Huizong, "The research on ZigBee-based Mine Safety Monitoring System ", Electric Information and Control Engineering (ICEICE), International Conference, 2011, pp 1837 – 1840.
- [10] 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, pp225-27 , 2009 .
- [11] Chung, P.W.H. and Yang, S.H. (2003) „Safety analysis of process plant control systems based on model checking“, The Journal of Safety & Reliability, Vol. 23, pp.19 –34, 2013
- [12] S.C.S. Jucá, P.C.M. Carvalho and F.T. Brito, "A low cost concept for data acquisition systems applied to decentralized renewable energy plants", Sensors, 2011, vol.11, pp. 743-756 , 2011
- [13] Chung, P.W.H., Yang, S.H. and Edwards, D.W. (1999) „Hazard identification in batch and continuous computer-controlled plants“, Industrial & Eng. Chem. Research, Vol. 38, pp.4359 – 4371,2013
- [14] 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 , 2008 .
- [15] Y.P Zhang, G.X Zheng, J.H. Sheng "Radio Propagation at 900 Mhz in underground coal mine ", IEEE transactions on antennas and propagation, vol. 49(5), pp. 752-62, 2001
- [16] Andrew sloss, Dominic Symes, Chris Wright, ARM system Developer's Guide, 2004, Morgan Kaufmann, ISBN: 1-55860-874-5
- [17] Vaibhav Pandit, Prof U.A Rane, "Coal mine monitoring using ARM7 and ZigBee", IJETAE, 2012
- [18] MDK-ARM, KeilTM Tools By ARM, Keil0223-3\01.11J.S.
- [19] Zigbee Specification Document 053474r17, January 17, 2008, Zigbee Alliance.
- [20] MDK-ARM Keil™ Tools By ARM Keil0223-3\01.11JS
- [21] Steve Furber, ARM System-on-chip Architecture, secon Edition, 2000, Addison Wesley, ISBN 0-201-67519-6