Zig-Bee and Wi-Fi basedMine Safety Application

Kumari Archana*, Abdul Wasay Mudasser

Department of Electronics and Communication Engineering
Lord's Institute of Engineering and Technology, Hyderabad

Abstract- Real time monitoring of process parameters inside the underground or open cast mines in a reliable manner is a technical challenge for the mine industry. Real time monitoring can provide accurate information about different critical mining parameters like rise in humidity and temperature, presence of dangerous gases, presence of light etc. This monitoring can also pave way for the safety of the miners. Conventional wired communication has severe drawback regarding real time monitoring. This paper develops an ARM based embedded system which monitors the critical parameters inside the mine and transmits the data in wireless manner for better monitoring and visualization.

Index Terms- ARM, Mine Safety, Temperature, Humidity

I. INTRODUCTION

In mining industry, safety of human life is the primary concern. Negligence in the safety guidelines can damage the high quality equipments, hamper production or can cause loss of human life. To avoid any types of unwanted phenomena all mining industry follows a standard guideline. Underground mining was in existence at Rajapura-Dariba in 13th century BC in India. So India has some of the oldest mines of the world. Several legislations have been administrated by Director General of Mine Safety in India [1]. In India large scale mechanization of all mines is not possible due to varying geo mining conditions, low grade and scattered deposits and high cost of imported machinery. Traditional coal mine monitoring systems tend to be wired network systems, which play an important role in coal mine safe production. With continuous enlarging of exploiting areas and extension of depth in coal mine, many laneways become monitoring blind areas, where are lots of hidden dangers. Moreover, it is inconvenient to lay cables which are expensive and consume time [5]. So in this critical scenario, wireless mode of communication is a reliable option. Wireless mining communication networks transport data, voice, and video, supporting applications that are essential to efficient and safe mine operations.

This paper develops a wireless application which will sense different physical parameter inside the mine and transmit them in wireless medium to the outside world for a better monitoring and control. ARM microcontroller is used for the purpose of monitoring, control and wireless communication.

II. LITERATURE REVIEW

Different researchers have developed different embedded system for mine safety. This section reviews some of the state of art embedded system developed for mine safety.

J. Song et.al [5] developed a wireless sensor node based automatic monitoring system for coal mine safety. T Maity et.al [4], developed zigbee based monitoring system for coal mines. D. Bhattacharjee et.al [3], developed wireless sensor node with different sensors embedded in the node. L. K Bandopadhaya et.al [2], developed wireless information and safety system for mines.

III. ARM BASED EMBEDDED SYSTEM DESIGN

The ARM (Advanced RISC Machine) is a 32-bit microcontroller created by a consortium of companies and manufactured in many different kind of versions. And it is widely used in modems, cell phones, cameras, personal audio, pagers, and many more embedded high end applications. The LPC2148 is a low-power Complementary metal-oxide-semiconductor (CMOS) 32-bit microcontroller used the enhanced RISC architecture. Through executing powerful instructions in a single clock cycle, the LPC2148 achieves throughputs approaching 17 MIPS sustained 25 MHz permit the system designer, to optimize power consumption versus processing speed, operating Voltage range for this microcontroller is - 4.5V - 5.5V.

Xbee module with LPC2148

Low power Xbee 802.15.4 and extended range Xbee PRO 802.15.4 use the IEEE 802.15.4 networking protocol for fast point to multipoint and peer to peer networking. The Xbee module has low power output of 1mW and the range of Xbee module is up to 100ft (30m) and the range of Xbee Pro is up to 1 mile (1.6km). The interface rate is 115.2 kbps. The Xbee modules work at the 2.4 GHz frequency. Xbee modules have the ability to transmit Digital, PWM, Analog or Serial RS232 signals wirelessly. To communicate over UART or USART, three basic signals namely, RXD (receive), TXD (transmit), GND (common ground) are needed. These modules use direct sequence spread spectrum configuration. Figure 1 shows the interfacing circuit of Zigbee module and ARM-7 microcontroller.

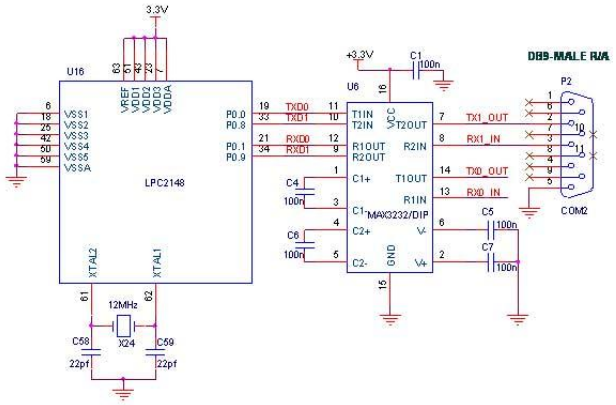
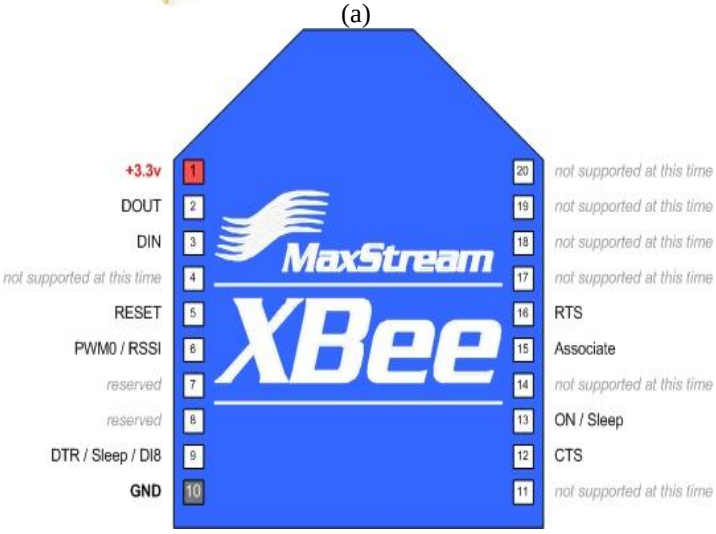


Figure 1: Interfacing circuit of Zigbee and ARM-7

(a)



(b)

Figure 2: (a) XBee Module (b) Pin out of XBee module

IV. Embedded System For Safety of Mines

Temperature Sensor

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ºC). The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. For LM35, the scale factor is 0.01V/°C meaning the nominal output voltage is 250mV at 25°C and 1.000V at 100°C. It does not require any external calibration or trimming. The most important characteristic of the LM35 is that it draws only 60µA from its supply and produces a low self heating capability. The general equation used to convert from the output temperature to temperature is Temperature (°C) = Vout * 100 °C/V

Methane and CO Gas Sensor

MQ-4 is suitable for sensing natural gas and presence of CH_4 concentrations in the air. It can detect natural gas concentrations anywhere from 200 to 10000ppm. This sensor has a high sensitivity and fast response time. The sensing element is comprised of a metal oxide semiconductor layer formed on an alumina substrate of a sensing chip together with an integrated heater. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to gas concentration. The sensor MQ-7 has high sensitivity to carbon monoxide. The detecting range of this sensor is 20 ppm - 2000 ppm of carbon monoxide. The resistivity of this sensor depends on the concentration of the gas. Its resistance varies from 2k-20k ohms. One special property of this sensor is that the heater coil is given pulsating power supply. For 60 sec the heater is given 5 volt supply and for the next 90 sec it is given 1.4 volt supply. The sensor MQ-4 has high sensitivity to Natural Gas and Methane (CH4) and has small sensitivity to alcohol and smoke. The detecting concentration of this sensor is from 200 ppm – 10000 ppm for Natural gas and Methane. The sensor resistance varies from 10k – 60k ohms. These sensors (MQ-4 and MQ-7) are composed by micro Al2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater which are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components.

Measurement of Light Intensity

The TSL235R light-to-frequency converter is a three pin integrated circuit which combines a silicon photodiode and a current-to-frequency converter on a single monolithic CMOS integrated circuit. Output is a square wave (50% duty cycle) with frequency directly proportional to light intensity (irradiance-Ee) on the photodiode. The digital output allows direct interface to a microcontroller or other logic circuitry. The device has been temperature compensated for the ultraviolet-to-visible light range of 320 nm to 700 nm and responds over the light range of 320 nm to 1050 nm. Higher resolution and accuracy is obtained using frequency measurement. Frequency measurement provides the additional benefit of averaging out random or high frequency variations (jitter) resulting from noise in the light signal. Resolution is limited mainly by available counter registers and allowable measurement time. Frequency measurement is well suited for slowly varying or constant light levels and for reading average light levels over short periods of time. Integrating the accumulation of pulses over a very long period of time, can be used to measure exposure (the amount of light present in an area over a given time period). Under test condition of Ee = 430 µW/cm2 for the monochrome light of wavelength λp = 635 nm, the output frequency varies from 200 kHz to 300 kHz for different intensity of light.

Transmitter and Receiver System

Figure 3 shows the block diagram of receiver and transmitter section of the embedded saftey application.

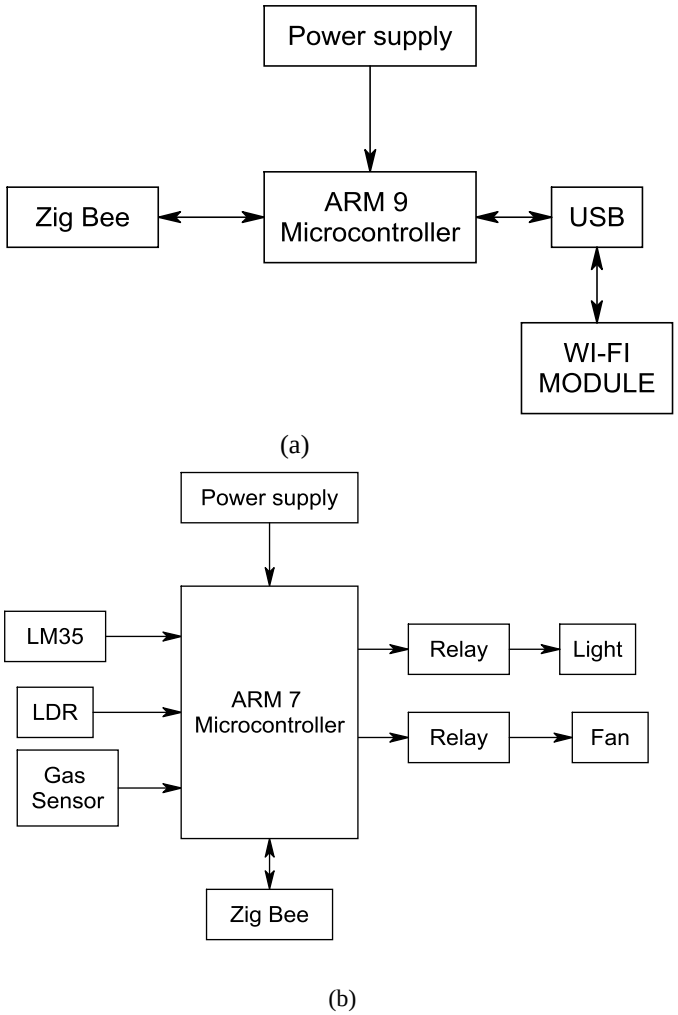


Figure 3: (a) Receiver Section (b) Transmitter Section

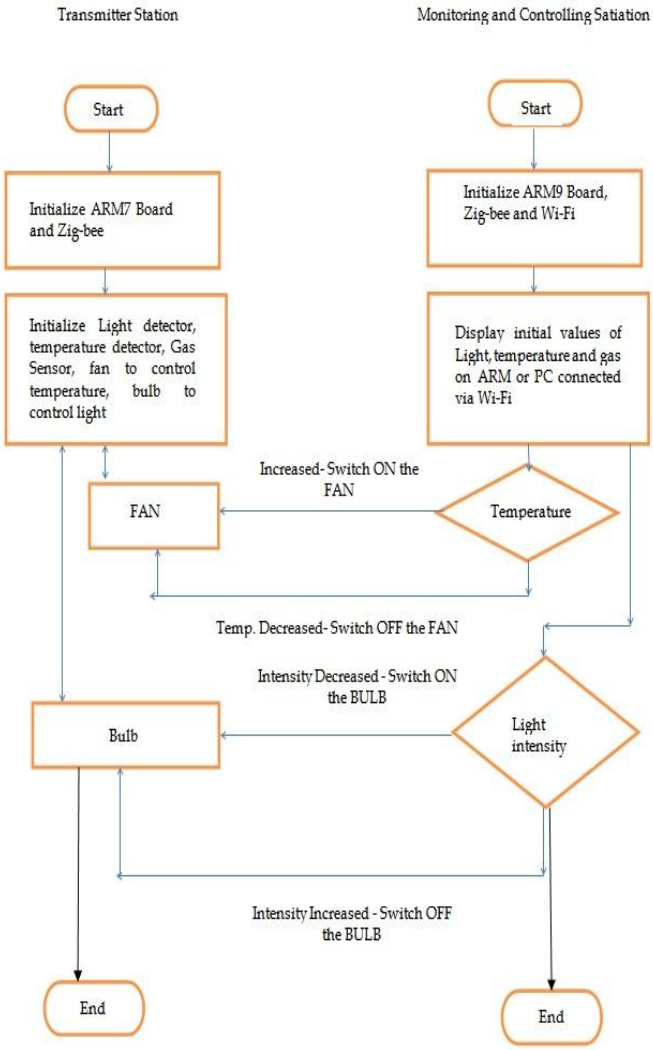


Figure 4: Flow chart for coal mine safety monitoring and control

The transmitter section is deep inside mine and sensors are connected to the microcontroller for data acquisition and subsequent control. The temperature sensor (LM35) measures the temperature inside the mine, gas sensors (MQ-4 and MQ-7) detect the presence of methane (CH_4) and carbon monoxide (CO) and LDR detects the light intensity respectively. If the temperature is above a permissible limit then the relay connected in the output port of ARM-7 actuates the fan unit to cool down the temperature. Simillarly if the light intensity is low then the relay connected to the output port of ARM-7 actuates the light bulb to provide proper light.The display unit displays the current reading of temperature, light intensity and presence of gas (in ppm). Simultaneously the microcontroller sends the data via Zigbee to the base station stationed outside the mine in a secured location. The receiver section receives the value of temperature, light intensity and gas sensor reading (ppm). The basic flow chart for operation of the embedded system is shown in figure 4.

V. Results And Discussion

Section IV describes the working of the mine safety application. The proposed architcture is modeled in the lab environment and section V shows the results. Figure 5 shows the prototype model of transmitter section which has to be placed deep inside the coal mine whereas figure 6 shows the prototype model of receiver station which has to be placed in a secured location outside the mine. Figure 7 shows the web based monitoring of embedded application.

Figure 5: Hardware unit of embedded safety application: coal mine station

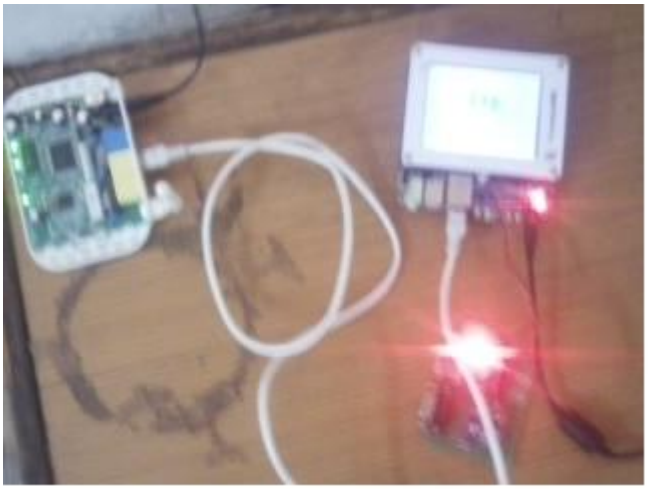


Figure 6: Hardware unit of embedded safety application: Base Station

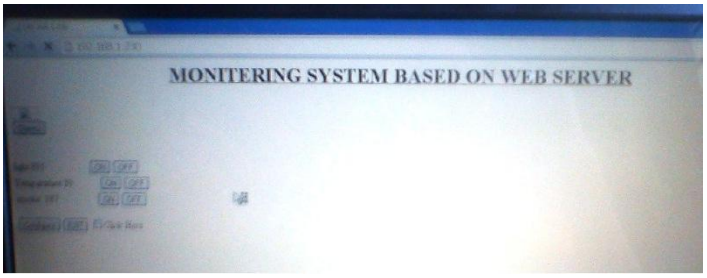


Figure 7: Web based monitoring of embedded application

VI. CONCLUSION

This paper develops a safety system for underground and open cast mines using wireless communication and microcontroller. Real time values of temperature, gas readings (in ppm) and light intensity is monitored inside the mine and is sent via a wireless media to a base station situated outside the mine, which eventually updates the current information in a local web server and updates the website.

As a future scope other sensors like pressure, humidity, dew sensors can be interfaced so that all total information can be gathered.

.

REFERENCES

[1] Director General of Mine Safety, Government of India, Ministry of Labour and Employment (dgms.net)

[2] L.K. Bandopadhyay et.al, "Wireless information and saftey system for mines,"Journal of Scientific and Industrial research, vol. 68, Feb 2009, pp. 107-117.

[3] Dipanjan Bhattacharjee et.al, "Design and development of wireless sensor node,"International Journal of Computer Science and Engineering, vol.2, no. 7, 2010, pp. 2431-2438.

[4] Tanmoy Maity et.al, "A wireless survailance and safety system for mine workers based on zigbee," Proc. 1st Int. Conf. Recent Advances in Infromation Technology, 2012,

[5] J. Song et.al, "Ä̈utomatic monitoring system for coal mine safety based on wireless sensor network," in Proc. 2011 Cross Strait Quad-Regional Radio Science and Wireless Technology Conference, 2011, pp. 933-936.

AUTHORS

Kumari Archanais pursuing her M.Tech degree in Embedded System and VLSI design in Dept. of Electronics and Communication Engineering, Lord's Institute of Engineering and Technology, Hyderabad, India.

Abdul Wasay Mudaseer is an Assistant Professor in Dept. of Electronics and Communication Engineering, Lord's Institute of Engineering and Technology, Hyderabad, India.

Correspondence Author – Kumari Archana, archanakmr085@gmail.com