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Intelligent Helmet for Coal Miners with Voice over Zigbee and Environmental Monitoring

A. Geetha

Bharath University, India

Abstract: A cost effective ZigBee based wireless mine supervising system with voice over ZigBee (VoZ) is presented here.Here we design a smart helmet, which enable the helmet as a mobile sensor node of ZigBee wireless sensor networks, gathering parameters the temperature, humidity and illumination level of underground environment and will alert the central management unit in case of abnormal condition. We also design a voice transmission system, based on the same low-rate ZigBee networks. So with environmental monitoring, the miners can communicate with control centers or with other miners through wireless speech communication.

Key words: Voice over ZigBee (VoZ) · Coalmines · Wireless Sensor Nodes · Environmental Monitoring

INTRODUCTION

Coal as an important source of energy in industrial production, it plays a pivotal role in the national economy. Coal mine incidents were unpredictable and it has many factors the event of an accident, not only causes huge economic losses, but a direct threat to the safety of miners. In order to ensure the safety of underground mine operations, installation of environmental monitoring in the roadway to detect environmental parameters is very important. In recent years, LED miner's helmet is extensively deployed in large and medium-sized coal mines for their flexibility of light weight and low power. Meanwhile ZigBee based wireless sensor networks are recently investigated due to their remote environment monitoring capabilities. Such a network can easily collect sensor data and transmit them in radio frequencies. Combining these two advantages we design a smart new helmet, which enable the helmet as a mobile node of ZigBee wireless sensor networks, gathering parameters from underground timely and quickly. Moreover miners can also exchange information from control centre through wireless speech communication. It is convenient for centralized management to build real-time surveillance on environment parameters, so potential safety problems can be avoid by early-warning intelligence.

Underground Wireless Network Design

Technology of Zigbee: The ZigBee Protocol is the only international standard wireless sensor network protocol in existence, catering to the specific needs of low-power, low-cost, low maintenance monitoring and control systems with talks of using it in sensor networks. Direct sequence spread-spectrum at 2.4 GHz (ISM), 915 MHz (the United States) and 868 MHz (Europe) is applied in industrial, scientific and medical frequency band.

Structure Diagram of Network: As shown in Figure 1, the system consists of smart helmet, wireless stations and cable network [1]. Wireless base station is a gateway between Zigbee wireless network and cable network. Miner's smart helmet is used as mobile wireless sensor

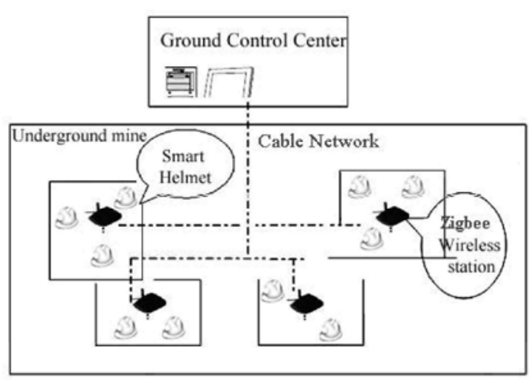

Fig. 1: Structure of the system

Corresponding Author: A. Geetha, Bharath University, India.

network node which is composed of rechargeable battery, LED lamp and ZigBee communications module. So intelligent helmets could collect production parameters timely and transmit to wireless base station. Control unit can send speech instruction to miners through ZigBee networks andminers can also receive calling from others working at different coal phase smoothly through smart helmets. It is a good Monitoring Mine Safety System both under normal circumstances and unexpected accident.

Hardware Implementation

Hardware Design of the System: As shown in Figure 2, helmet unit is composed of microcontroller (PIC24FJ64GB106), Zigbee communication module, temperature sensor (lm35), humidity sensor (HIH5030), light sensor (LDR), MIC amplifier, voice amplifier, voice codecs circuit (Si3000), LED and keypad.

As shown in Figure 3, control unit is composed of microcontroller (PIC24FJ64GB106), Zigbee communication module, temperature sensor (lm35), humidity sensor (HIH5030), light sensor (LDR), MIC amplifier, voice amplifier, voice codecs circuit (Si3000), LCD and keypad.

The sensors available in the helmet collect the temperature and humidity information and send this information to control unit. Low rate ZigBee is used for wireless data transmission. When the control center decides the parameters are abnormal then they can make a call to the coal miner through the same ZigBee module. Similarly the miner can communicate with other miners via wireless voice communication. Also, the light sensor sensing the light intensity and gives it to the controller. Based on the light intensity the controller automatically adjusts the LED light of the helmet.

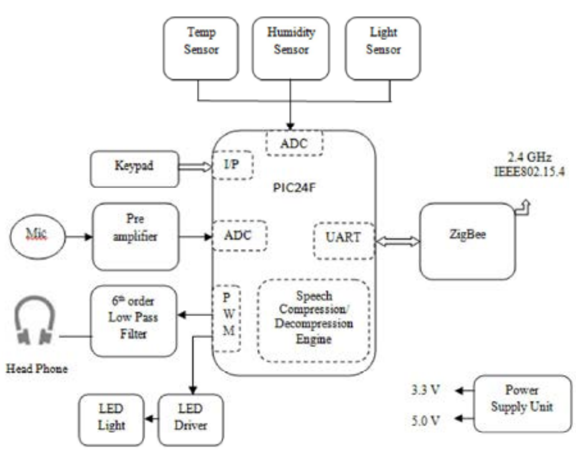

Fig. 2: Helmet unit

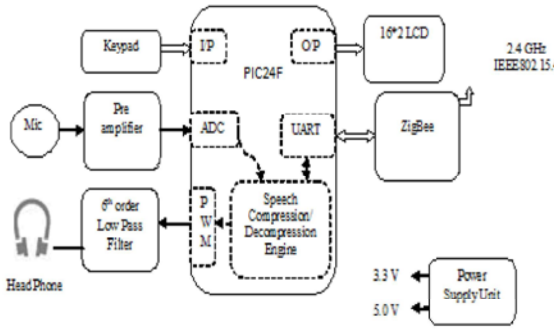

Fig. 3: Control unit

PIC24FJ64GB106 Microcontroller: PIC24FJ64GB106-I/PT is part of the PIC24FJ64 Series family with 64 KB Flash as a 16-Bit Microcontroller. It can sustain standard temperature ranges from -40°C to +85°C and has 53 I/O pins in a TQFP package. The main features are: Modified Harvard Architecture, 16 MIPS Operation at 32 MHz, Run, Idle and Sleep modes, Self-Reprogrammable under Software Control, On-chip LDO Voltage Regulator, USB v2.0 On-the-Go compliant and supports speech processing.

Voice Decoder: We chose Si3000 for voice communication because of its main features such as 84 dB ADC Dynamic range, 84 dB DAC Dynamic range, 4-12 kHz Sample rates, 30 dB Microphone Pre-amplifier, support for 32 ohms Headphones, 3:1 Analog Input Mixer, 3.3-5.0V Power Supply.

D. G.726 Voice Codec Algorithm: G.726 voice codec algorithm is used for compressing and decompressing the speech samples at transmitter and receiver sides respectively. Speech compression algorithm is used for reducing the bandwidth requirements during the time of transmission. ItsSampling frequency is 8 kHz and typical algorithmic delay of 0.125 ms, with no look-ahead delay.G.726 is a waveform speech coder which uses Adaptive Differential Pulse Code Modulation (ADPCM).

Humidity Sensor and Light Sensor: The HIH-5030 Low Voltage Humidity Sensors operate down to 2.7 V. It is designed specifically for high volume OEM (Original Equipment Manufacturer) users. With a typical current draw of only 200 ìA, the HIH-5030 is ideally suited for many low drain, battery operated systems. The HIH-5030 delivers instrumentation-quality RH (Relative Humidity) sensing performance in a competitively priced, solderable

SMD. We chose Light Dependent Sensor (LDR) which has features like wide spectral response, wide ambient temperature range and low cost.

Temperature Sensor: We use LM35 Precision Centigrade Temperature Sensors whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4°C at room temperature and ±3/4°C over a full -55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output and precise inherent calibration make interfacing to readout or control circuitry especially easy.

CONCLUSION

It has been presented the original design of the low power ZigBee wireless sensor system with an extremely reduced cost. It is reliable system with quick and easy installation. The system might be easily extended. With ZigBee wireless positioning devices, it will improve system scalability and extend accurate position of underground miners in future.

REFERENCES

1. Jong -ukLee, Euanchang Choi and Jaedoo Huh, Voice over ZigBee networks with environmental monitoring. 2011. IEEE International Conference on Consumer Electronics (ICCE).
2. Yu Li-min, Li Anqi, Sun Zheng and Li Hui,Design of Monitoring System for Coal Mine Safety Based on Wireless Sensor Network, 2008 IEEE, pp: 409-414.
3. Dongge Wen, Xin Yue, Haifeng Ma and Yantao Wang, Design of Coal Mine Gas Monitoring System Based on ZigBee", 2011 International Conference on Future Computer Science and Education, pp: 580-583.
4. Yang Dongxuan, Chen Van and Wang Kedong, "Design of Environmental Monitoring Node of Coal Mine Based on CC2530", 2010 International Conference on Computer Application and System Modeling, pp: 418-421.