ZigBee Based Intelligent Helmet for Coal Miners

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Abstract

A cost effective ZigBee-based wireless mine supervising system is presented in this article. This scheme used intelligent helmets as voice terminal and ultra-low-power nodes of wireless sensor network.The programme adopted ZigBee wireless technology to build wireless sensor networks, realized real-time surveillance with early-warning intelligence on methane,temperature, humidity in mining area, and used speech communication to reduce potential safety problems in coal production.

1. Introduction

In recent years,LED miner's helmet are extensively deployed in large and medium-sized colal mines,for their flexibility of light weight and low power [1].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 by radio. 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 informations from control centre through wireless speech communication. It is convenient for centralized management to bulid real-time surveillance on environment parameters,so potential safety problems can be avoid by early-warning intelligence.

2. Underground wireless network design

2.1. 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. In a word it is perfect for the presented application.

2.2. Structure diagram of network

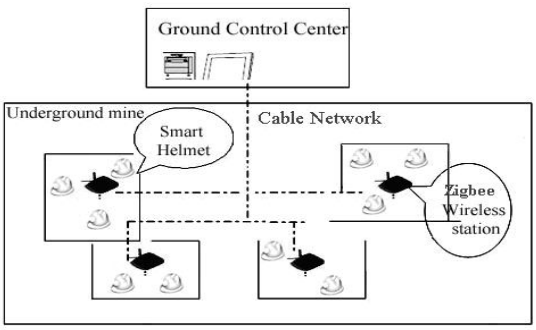

Figure 1. Structure of the system

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As shown in Figure 1, The entire system consists of smart helmet, wireless stations and cable network. Wireless base station is a gateway bewteen Zigbee wireless network and cable network.Miner's smart helmet is used as mobile wireless sensor network node which is composed of rechargeable battery,LED lamp and ZigBee communications module. So intelligent helmets could collect production parameters timely,then transmit to wireless base stations, finally upload the data to ground control center through communications cables. Monitoring Centre can send speech instruction to miners through underground networks, yet miners can also receive calling from others working at different coal face smoothly through smart helmets. It is a good Monitoring Mine Safety System both under normal circumstances and unexpected accident.

3. Hardware Implementation

3.1. Hardware design of the system

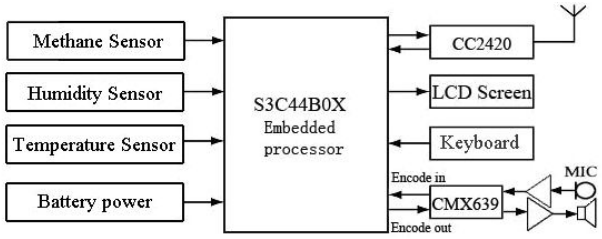

Figure 2. Structure of mobile data acquisition node

As shown in Figure 2,intelligent wireless helmet is composed of embedded processors(S3C44B0X), Zigbee communication module (CC2420), sensor modules, MIC amplifier, voice amplifier, voice codecs circuit (CMX639),LCD and keyboard.

S3C44B0X processor circuit is the core of system which collect temperature, humidity, gas concentration signals. CC2420 module transmitts ZigBee wireless to cable network; Once gas concentration is upper than 4%, CMX639 circuit decodes siren alarms. If dialing keyboard, the miner can hear request singal from his headset which compose ZigBee module and CMX639 codec circuit ,when ground centre house connected them in spare time, the two parties can talk easily as usual [2].

3.2. MCU S3C2410

The heart of all units is a hybrid chip S3C44B0X which is designed to provide hand-held devices and general applications . By providing a complete set of common system peripherals, the MCU contains all software for embedded operating systems such as μCOS-II and μCLinux etc.S3C44B0X is a ARM7TDMI core,low power,32-bit RISC microprocessor and highest frequency up to 64 MHz[3].

3.3. RF transceiver module

We chose CC2420 as RF module for it's main features: low power and lower cost,2.4 GHz RF chip supporting IEEE802.15.4 standard, need very few external components to ensure short-distance communication. ZigBee wireless communications equipment with this chip support data-rate up to 250 kbps, chip-speed up to 2 MChip/s, can compose multinode-to-multinode network rapidly [4].

As shown in Figure 3, RF circuit connect to S3C44B0X,with external amplifier and filter circuit supplemented voice communications.

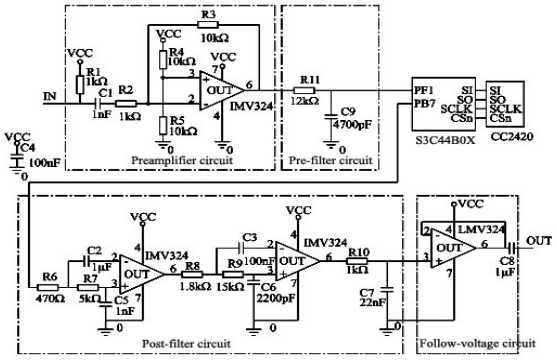

Figure 3. Schematic for interference of S3C44B0X

3.4. Temperature and Humidity Sensor Units

In temperature and humidity sensor module we use SHT11 which is a digital sensor designed to I^2C bus. SHT11's main features: temperature range of -40℃ ~ +85℃, relative humidity range of 0% ~ 100% RH; low-power,short response time, completely submerged,temperature measurement accuracy ± 0.4℃, humidity measurement accuracy of ± 3.0% RH. SHT11 can store factors in OTP memory preliminarily, after 14-bit A/D converter done, then send temperature and relative humidity values to I^2C bus [5].

3.5. Gas Sensor Unit

In Gas module we choose TP-I1A which is a low-power heat conduction gas sensor. The working principle is its resistance value fluctuate when gas concentration changes, the relationship is almost a linear one. TP-I1A is a high precision, low-power unit without heating circuit,the voltage is 6V, load resistance is 51 Ω, static power consumption is less than 210 mW, and working temperature range is -40℃ ~ +70℃ [6].

4. 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.

5. Acknowledgement

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