Design and Implementation of Mine Personnel Vital Signs Monitoring Terminal Based on WSN Network

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Abstract - For domestic mine poor working conditions and market demand for mine personnel monitoring of characteristic parameters information, the paper presents a WSN-based mine personnel vital signs monitoring terminal which used to collect body temperature, pulse and other physical characteristic parameters. The entire monitoring system is composed of miners characteristic parameters monitoring terminal and monitoring center computer. miners characteristic parameters monitoring terminal is developed based on embedded core processor ARM7 and embedded uClinux operating system platform, which uses WSN wireless network to send miners characteristic parameters data to the monitoring center computer. Monitoring center computer can be used to view miners physical characteristic parameters data, and provides a important support for the protection of the lives of mines personnel safety and accident rescue.

Index Terms – WSN, physical characteristic parameters, wireless network, mine.

I. Introduction

Coal is an important national resources. Coal mining is mostly underground, at the same time the circumstance of the coal production is worse. The high temperature and humidity, high concentrations of dust, high concentration of flammable and poisonous gas, coupled with poor ventilation, make a threat to the healthy of the mine personnel, and even to their live. With the complex of the mine structure, when an accident happened, we usually can't get the information of the mine personnel. This brings huge difficulties to the mine rescue, also delays the best opportunity of the rescue, at last make a horrible consequence.

As our country pay more attention to the coal mine, the insurance for the lives of workers becomes the most important. With the development of the communication and computer technology, the monitoring of the mine personnel vital signs becomes possible. This paper presents a mine personnel vital signs monitoring terminal based on WSN network. Through the terminal, vital signs parameters information is collected, the monitoring center computer can monitor mine personnel vital signs information with WSN network in real time, providing a guard to the safety of mine personnel and a support to the rescue of the accident.

II. WSN Network Technology

Wireless Sensor Network(WSN), is consists of a large number of low-cost micro-sensor nodes in the monitoring area, which is a self-organization multi-hop network system, formed by a wireless communication method, and its purpose is collaborate perception, acquisition and processing the information of sensing target which is covered by network, and send the information to the observer. Sensors, sensing target and the observer constitute the three elements of the wireless sensor network[1]. A typical sensor network consists of sensor node, sink node, Internet or communications satellite, task management node and other parts. Sensor nodes are deployed in the monitoring area randomly, this process can be achieved by artificial embedded, aircraft sow and rocket catapult. Node constituted network by a self-organizing form. Each node can collect data and transfer data to the sink node by multi-hop routing. It also can be used in the same way send the information to each node. Sink node connect to Internet or communication satellite directly, achieving communication between the task manager node and sensor by Internet or communication satellite. Users make configuration and management to sensor network through the management nodes, then release monitoring tasks and collect monitoring data.

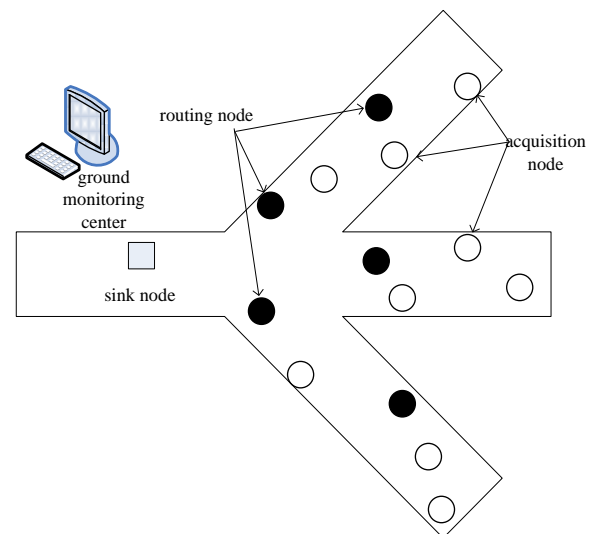## III. Design of Mine Personnel Vital Signs Monitoring System

Fig. 1   System composition

Figure 1 is the composition of the mine personal vital signs monitoring system. It can be divided into underground data acquisition and transmission part and ground monitoring part[2]. Underground data acquisition and transmission part is made of mine personnel vital signs acquisition nodes and

routing nodes. Acquisition nodes which is mine personnel vital signs monitoring terminal is responsible for the mine personnel vital signs data collection and carried by mine personnel. Routing node which is on the mine roadway bracket at regular intervals constitute a transmission network, which is responsible for organizing multi-hop and sending vital signs data collected by acquisition nodes to the sink node. The role of the sink node is to achieve the data transmission between the transmission network and ground monitoring system. It is a gateway node between the systems. Ground monitoring center can view real-time information of mine personnel vital signs, and can analyze, inquiry, forward the information of mine personnel vital signs. The core of the entire system is the mine personnel vital signs monitoring terminal, which is responsible for acquisition, processing and sending information of mine personnel vital signs.

IV. Hardware Design of Vital Signs Monitoring Terminal

The mine personnel vital signs monitoring terminal hardware mainly includes embedded processor module, a storage unit, power supply, clock, Zigbee wireless transmission module[3], sensor module and conditioning circuit. The hardware block diagram is shown in Figure 2.
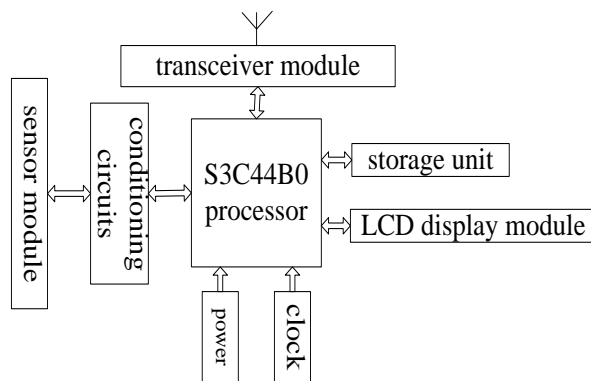

Fig. 2   Hardware block diagram

Embedded processor module which work in mine tunnel should have a low power consumption and strong data processing capabilities, meanwhile it should have the ADC section in order to facilitate access analog signal which collected by various types of sensor. By comparison we select the Samsung ARM7 S3C44B0 microprocessor. S3C44B0 microprocessor chip integrate ARM7TDMI core, take the 0.25um CMOS manufacturing process and integrate rich peripheral function modules on the basis of the ARM7TDMI core basic functions in order to design embedded application at low-cost. Increasing 8KB Cache in the basis of ARM7TDMI; Expanding memory controller (FP/EDO/SDRAM control, chip select logic) in external part; LCD controller(256-color STN) with an LCD-dedicated DMA channel; Two general-purpose DMA channels, two DMA channel with external the request pin; Two UART with a handshake protocol, one SIO; One multi-master IIC bus controller; One IIS bus controller (used to control audio); Five

PWM timer and an internal timer; Watchdog timer; 71 general-purpose programmable I / O ports, eight external interrupt sources; Power control modes: normal, low, sleep and stop; 8 way ADC with 10-bit; RTC(real time clock) with calendar function; Integrating PLL clock generator on chip[4].

The wireless transceiver module using single chip RF transceiver nRF2401, working in 2.4 ~ 2.5GHz ISM band, which integrate frequency synthesizer, power amplifier, crystal oscillator and modulator and other functional modules on chip. Output power and communication channels can be configured by programming. Chip power consumption is very low. When the launching power is -5dBm, the operating current is 10.5mA, and the receiving operating current is only 18mA. DuoCeiverTM technology can make the nRF2401 use the same antenna to simultaneously receive data from two different channels. The nRF2401 is applicable to a variety of wireless communication.

The 128M SDRAM memory and 256M FLASH memory is used for storage unit.

The sensor module is composed by temperature sensor and pulse sensor. Temperature sensor use digital temperature sensor DSl8B20 from Dallas Semiconductor company. Its external interface is simple, only three pins, pin 1(GND) connect to ground and pin 2 (DQ) used to transfer data and pin 3 (VDD) used to supply power(optional). By counting the number of clock cycle experienced by low temperature coefficient oscillator during counting door opened, DSl8B20 measure temperature. Counting gate opening period is determined by the high temperature coefficient oscillator. All data which through the DQ port read and write start from the least significant bit. The communication of DSl8B20 rely on a single line port and must establish the ROM operation agreement firstly in order to control and memory operations. One of its operation process is: initialize DSl8B20(send reset pulse), send the ROM function command ,send the memory operation command and process the data.

HK-2000A integrating pulse sensor produced by the Hefei Huake Electronic Research Institute is used. HK-2000A integrate sensing element (PVDF piezoelectric film), sensitivity temperature compensation components, temperature sensing element and signal conditioning circuit in the sensor using highly integrated process. It use the piezo principle to collect signal, the analog signal output, the output pulse signal in synchronization with the pulse fluctuations, each pulse fluctuations output a positive pulse. The specifications of HK-2000A pulse sensor are as follows: power supply voltage: 3V to 12V DC; pressure range: -50 to +300mmHg; the acceptable maximum overload: 100 times;output high voltage: greater than VCC-1.5V; output low level voltage: less than 0.2V. Its characteristics are: high sensitivity, strong anti-jamming performance, more overload, better consistency, stable, reliable performance and long work time. The connection of HK-2000A pulse sensor is simple with the only white, red, black three lines. The black line connect to ground, red line connect to DC power, white line output collected pulse signal which can be input directly to I/O ports, processor judge the variation of the pulse based on

the high and low of the input voltage.

The power module supply use two 5V batteries, through AMSl117 3.3 and AMSl117 of 1.8 transformer chip, 3.3V and 1.8V voltage are getted which used to power for the chip-on-board, peripherals, and the core.

V. Software Design

The software of mine personnel vital signs monitoring terminal include operating system and applications two major part. Operating system selects the mainstream Embedded uClinux which include bootloader, kernel image files of uClinux and file systems[5].

uClinux is an excellent version of embedded Linux, derived from Linux 2.0/2.4 kernel, followed most characteristics of Linux. It is embedded Linux operating system designed specifically for the CPU without MMU (memory management unit) and a lot of small work has been done for embedded systems. It is typically used for little memory or Flash embedded operating system. Under the guarantee of the GNU General Public License, running uClinux operating system, users can use almost all of the Linux API function. After cutting and optimization, it forms a highly optimized, compact code embedded Linux. It has many advantages such as small size, stability, good portability, excellent networking capabilities, comprehensive support for various file systems, as well as API functions and so on.

A. System Migration

The bootloader is a small piece of code running before uClinux operating system[6]. It can combine system hardware and software, guide the uClinux embedded Linux kernel, load linux kernel into RAM from the flash to implement and update blob, the kernel and ramdisk online at the command line; It also can view and modify physical address space directly at the command line. Vital signs monitoring terminal select mature Blob as the bootloader. Blob is a powerful bootloader. It follows the GPL and the source code is completely open. Blob can be used both simple debugging and start the Linux kernel.

Linux2.4 kernel is used for uClinux, it uses graphical kernel configuration interface, adding system support for ARM7 processor, using the cross-compiler tool chain arm-elf-gcc as compiler. Command operation of the system is as follows.

$> Make menuconfig / / configure the kernel
$> Make dep / / create dependencies
$> Make zImage / / compiler

The compiler generate elf format uClinux kernel image file. Kernel file burn into flash through Blob command line.

The mainstream romfs in the uClinux operating system platform is selected as file system for vital signs monitoring terminal, including applications, configuration files and libraries.

B. Application Development

The software of mine personnel vital signs monitoring terminal need to complete mine personnel vital signs parameter data acquisition, retransmission, and command receiving. The software should include two data acquisition tasks: body temperature data acquisition task and pulse data acquisition task. After power on, firstly it complete the terminal system initialization. When the monitor detecting the acquisition command, it begin to do data collection. Data is sent to the routing nodes after the acquisition is completed. Routing node is responsible for collecting all of mine personnel vital signs parameter data from monitoring terminal and sending data to the sink node. Sink node submit data to the monitoring center computer. When the system does not have the data acquisition command, the system hangs acquisition task, start saving task, enters a power saving mode[7]. The software process of main program is shown in Figure 3.
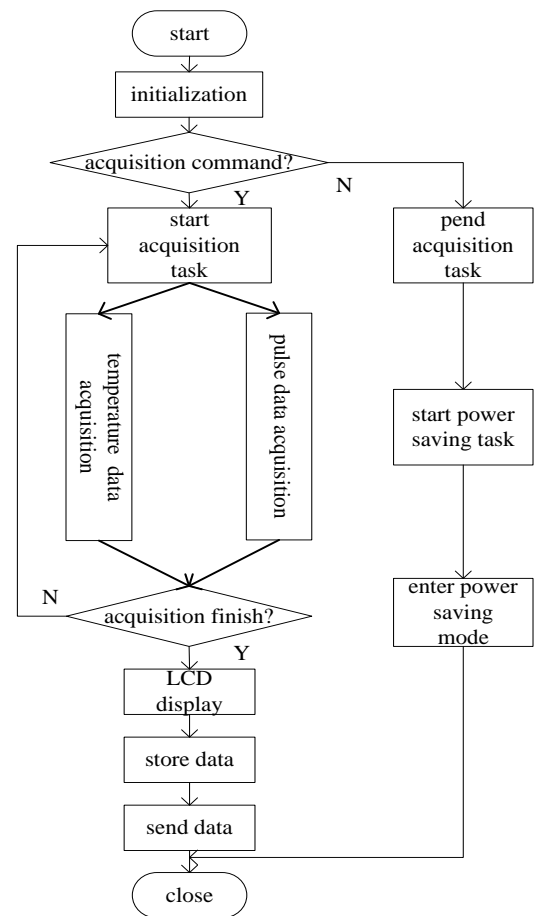

Fig. 3 The software flow chart of the personnel vital signs monitoring terminal

VI. The Experimental Results

The system can operate normally after the module testing and integration testing. Under simulated roadway environment, 6 Mine personnel's pulse and body temperature parameters are measured, and comparing with the actual data that monitor measured. Table 1 is the data.

The experiment shows that parameter error collected by the personnel vital signs monitoring terminal is very small, the computer in monitoring center can monitor the mine personnel vital signs information through WSN network in

real-time. Data transmission is stable and reliable. It provides an important basis for the protection of the lives and safety of mine personnel.

VII. Conclusion

It has been brought forward a design and implementation of mine personnel vital signs monitoring terminal based on WSN network, and a detailed description of the hardware and software of the system is given. ARM7 embedded processor has strong capability in computing, and provides an important safeguard for data collection and transmission. Its low power consumption is very suitable for underground environments.

TABLE I   Signs Parameters Monitoring Data

	Test value of pulse (times/min)	Actual value of pulse (times/min)	Error rate (%)	Test value of temperature（℃）	Actual value of temperature（℃）	Error rate (%)
1	67	67	0	37.0	36.6	1.1
2	71	72	-1.4	36.5	36.7	-0.5
3	62	61	1.6	36.8	36.8	0
4	63	63	0	36.5	36.5	0
5	73	74	-1.4	36.9	37.1	-0.5
6	78	78	0	37.1	37.2	-0.2

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