

Design Wireless Multi-sensor Fire Detection and Alarm System Based on ARM

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Abstract- The system uses nRF2401 for short-range wireless communications, GPRS for long-distance wireless communications, ARM9 for center console, Wireless Multi-sensor Fire Detector for node, and BP algorithm is used for judging the probability of fire. Wireless Multi-sensor Fire Detector is formed of the low-power electrochemical carbon monoxide sensor, photoelectric smoke detector and semiconductor temperature sensor. BP algorithm program is embedded in the S3C2440A ARM. The samples of BP algorithm were derived from the fire detection standard room of the State Key Laboratory of Fire Science of China. Center console uses Em GIS(embedded GIS) to show where the fire break out and uses GPRS to transmit SMS to the fire command center. The system is low false alarm rate, low cost, fast response and convenient to install.

Key words- ARM9; Multi-sensor fire detector; Em GIS; nRF2401; GPRS; BP algorithm

I INTRODUCTION

Fire brings great harm to the country's economic and social stability, detecting the location of a fire timely and accurately is an effective way to prevent or mitigate lose. The current fire detection and alarm system use the two bus for connecting Smoke temperature composite fire detector and central console. It has anti-interference, high reliability, etc., It has been widely used in society and played an important role in Socio-economic, national security. But it is high cost, design, construction and maintenance is complex. So people invented the wireless fire detection and alarm system. Recently, wireless fire detection and alarm system has been rapid development. Has Emerge in the wireless temperature, smoke, smoke temperature composite fire detection and alarm system. The most influential wireless fire detection and alarm system is invented by ITI Company in the United States. The system uses temperature detectors and photoelectric smoke detectors to for the nodes, the central monitoring and alarm center is composed of the CS-4000, a computer and a printer. The communication distance of the system in open space is 600 meters, the working frequency is 319.5MHz, the life of temperature detector is 2 years when using 9V lithium battery for power supply, the life of photoelectric smoke detector is 6.5 years when using two 3V lithium batteries for power supply. This technology currently is the world's most advanced wireless alarm technology. However, the high cost of such a system is not conducive to universal

application in the society and it use single parameter to judge whether a fire breaks out, which causes high false alarm rate of fire. To solve these problems, developing a universal wireless fire detection and alarm system which has low cost and low false alarm rate is very meaningful. Therefore, we must R&D a special system like the Wireless Multi-sensor Fire Detection and Alarm System Based on ARM. The center console of this system is made up of the ARM9, GIS software, nRF2401 and GPRS modules; Wireless Multi-sensor Fire Detector is formed of low-power microcontroller, three kinds of sensors and nRF2401 module. The structure diagram of this system is shown in Fig.1. This paper is organized as follows. In section 2, hardware design, include design the hardware of the wireless multi-sensor fire detector and the center console. In section 3, software design, include design the software of the wireless multi-sensor fire detector and the center console. The conclusion is made in section 4.

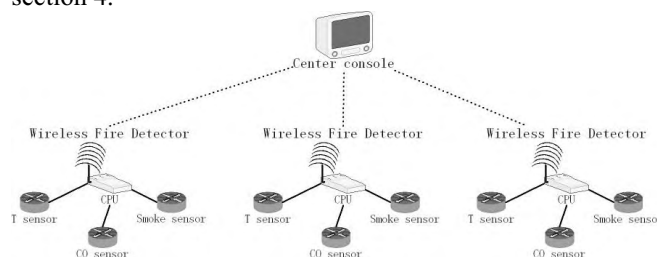


Fig.1 The Structure diagram of Wireless Multi-sensor Fire Detection and Alarm System Based on ARM

II HARDWARE DESIGN

The hardware of this system includes wireless multi-sensor fire detectors and center console. Wireless multi-sensor fire detector is used for collecting, processing, sending and receiving data, which consists of the MSP430 microcontroller, temperature sensor, CO sensor, smoke detector, signal amplifier and power, etc.; Center console is used for receiving and sending data, according to received data, query Em GIS database and display the location of the fire on the map of the building, and finally through the sound and light to alarm, at the same time, use the GPRS module to send SMS to the fire command center. It consists of ARM9 panel, GPRS module and alarm etc.

2.1 Design of Wireless Multi-sensor Fire Detector

Wireless multi-sensor fire detector mainly consists of

MCU, 4-way analog switches, temperature sensor, CO sensor, smoke detector and wireless communication modules (**Fig.2**). MCU use ultralow-power microcontroller MSP430F149, which is the industry's ultralow-power MCU, low supply-voltage range: +1.8 V ~ +3.6 V, The current consumption of real-time clock is only 0.1 μ A in standby mode and 280 μ A (1MHz) in active mode, from the sleep to wake up to the normal work only takes 6 μ s, it also has 8-channel 12-bit A / D, 16 \times 16-bit hardware multiplier. The 4-way analog switch use MAX4678, it can be a single power supply (+2.7 V ~ +11 V), temperature sensor use MAX6608, it is a low-power and analog output temperature sensor, operating voltage can be as low as 1.8V, operating current: 15 μ A, the accuracy: $\pm 0.7^{\circ}\text{C}$. Smoke Detector is composed of an infrared light emitting diode and an infrared light receiver diode. CO sensor use 4CO-500, the sensitivity: $0.07 \pm 0.015\text{mA/ppm}$, the resolution: 1ppm, it has a high linearity and good stability and so on. Power is monitored by MCU's built-in A / D Acquisition. RS232 interface chip use SP3220, it is a low-power RS232 driver chips, the supply voltage: +3.3 V ~ +5 V, low-power current consumption: 1 μ A, in low-power state, it can still transmit data. Wireless data transmission module use low-power nRF2401 module, the module power supply voltage: 1.9 - 3.6V, in the standby mode only 1 μ A, emission current is 12.3mA, receive current is 11.3mA. And each chip can be set 40-bit address through software, the built-in CRC error correction, error detection circuit and hardware and agreement, the development of software is very easily. Using the 3.7V, 2000mAH lithium battery as power supply, in order to extend the service life, when MSP430F149 set in LPM3 mode, in this mode, work current is about 16 μ A, the service life is about 5 years. Monitoring power supply is necessary in order to facilitate the maintenance of the power, the results will be transmit through a wireless network to center console, if the power supply voltage is too low ,the alarm will in time inform the management staff to replace the battery. Its structure is shown in **Fig. 2**.

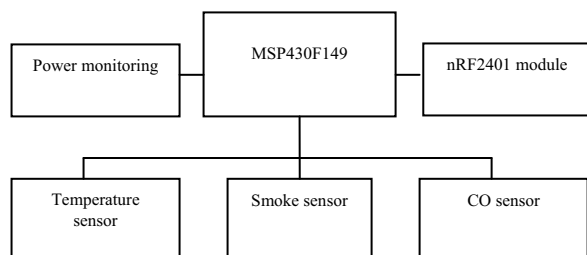


Fig.2 The Structure diagram of Wireless Complex Fire Detector

2.2 Design of Center Console

The Center console is used for receiving and transmitting data, according to received data, inquiry the GIS database and show location of the fire in the map of the building, at the same time, alarm through the sound,

light and GPRS module. It consists of ARM9 board, GPRS module, nRF2401 module and alarm, etc., It is shown in **Fig.3**.

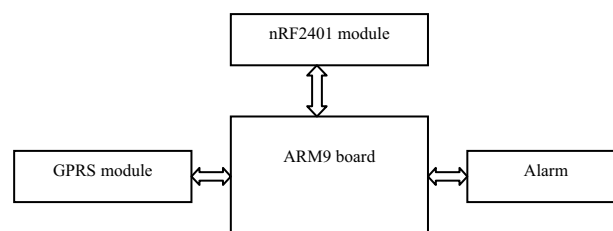


Fig.3 the Structure Diagram of Center Console

2.2.1 ARM9 board

ARM9 board consists of Samsung's S3C2440A, 3.5 inch TFT, 64M SDRAM, 64M Nand Flash, 2M Nor Flash and four interfaces, etc, It is shown in **Fig.4**. S3C2440A is a cost-effective, low-power microcontroller solution in a small form factor. 3.5 inch TFT is LCD touch screen, is used for display the location of the fire. Nor Flash memory is used for BIOS; Nand Flash is used for installing the operating system WinCE5.0.

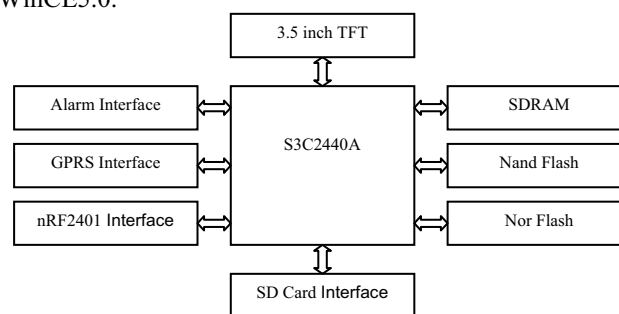


Fig.4 the Structure Diagram of ARM9 Board

2.2.2 GPRS module

General packet radio service (GPRS) is a packet switching technology for GSM networks. It's an advanced data transmission mode that does not require a continuous connection to the Internet, as with a standard home modem. Instead, GPRS uses the network only when there is data to be sent, which is more efficient. The &GSM Association& believes using GPRS will enable users to send and receive data at speeds up to 117 kbps, more than two times faster than with traditional home modems.

In this design, Siemens MC55 embedded module is used for GPRS module, it supports GPRS & GSM network modes, The hardware interface uses standard RS232 serial port, through which transmits AT commands to the GPRS module, you can control the GPRS module easily.

2.2.3 nRF2401 module

nRF2401A is the Industry's smallest, lowest cost,

lowest current consumption and low voltage supply 2.4GHz RF transceiver. It provides global wireless equipment vendors with global 2.4GHz transceiver technology at the price and complexity of lower frequencies. The nRF2401A is a highly integrated component for wireless communication manufactured in an ultra modern 0.18 μ m CMOS process. The entire transceiver including all inductors and filters is integrated in a single chip that gives the lowest cost solution to the end user. The only external components needed to make a complete RF system are a crystal and a resistor.

In this design, wireless data transmission module use low-power nRF2401 module, the module power supply voltage: 1.9 - 3.6V, in the standby mode only 1 μ A, emission current is 12.3mA, receive current is 11.3mA. And each chip can be set 40-bit address through software, the built-in CRC error correction, error detection circuit and hardware and agreement, the development of software is very easily.

III SOFTWARE DESIGN

Software design, include wireless multi-sensor fire detector program design and center console software design. Wireless multi-sensor fire detector software is mainly responsible for collecting, processing, transmitting and receiving signals. Center console software design, including transplantation of the embedded system, Em GIS software, the serial communication program, GPRS communication program and alarm program.

3.1 Wireless Multi-sensor Fire Detector Program Design

Wireless multi-sensor fire detector acquires power supply voltage, smoke density, CO density and temperature signals, then uses artificial neural network algorithm (BP algorithm) to judge whether a fire breaks out. If there is a alarm signal, then transmit data to the center console. The detector also receives voltage detection signal, when receives a voltage detection signal, then acquires the voltage and transmit it. The flow-chart shown in **Fig.5**.

3.2 Center Console Software Design

As shown in **Fig.6**, the wireless transmission program will receive the fire alarm signal and transmit it to the center console through the serial program; center console uses Em GIS software to show the location of the fire broke out, at the same time, open the alarm and the indicator light begin to flash. The center console control GPRS module through the serial port to transmit alarm SMS. In **Fig.6**, the dotted line is stand for the process of

receiving alarm signal, Solid line is stand for the process of transmitting alarm signal.

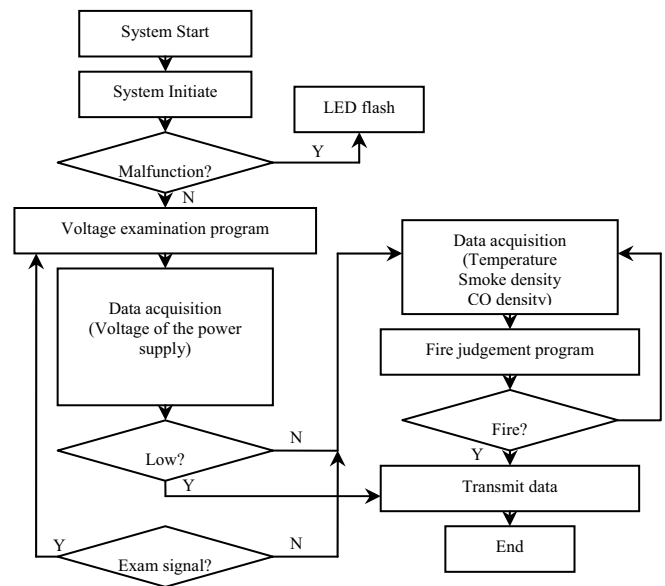


Fig.5 Flow-Chart of Wireless Multi-sensor Fire Detector software design

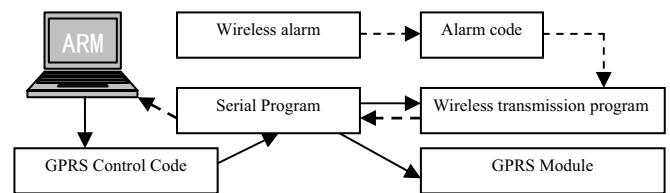


Fig.6 Flow-Chart of Center Console Software

The process of center console software design, as follows:

- A. Installed Windows CE5.0 as operating system. Windows CE5.0 is a simple, efficient and multi-tasking operating system, which can be cut. It has its own system structure with independent development of the kernel and device driver model. It has the key part of Windows NT and Windows9X and supports more than 1400 most frequently used Win32 API, using EVC (Embedded Visual C++4.0), embedded software applications can be developed rapidly. The process of installing Windows CE5.0 as follows: (1) Division; (2)Install boot loader; (3)Install Eboot; (4)Install the kernel image of Windows CE5.0;
- B. Using EVC (Microsoft Embedded Visual C++4.0) develop Em GIS software. Through Em GIS software, compare the signals that store in ARM9 board with the signals that the wireless module receives, shows the alarm type and the location of the fire broke out in the map; Em GIS software requires concise code, high reliability, small space storage; In order to improve system run speed, we have to store

map data in a SD card;

- C. Compiling serial communication program. ARM9 through the serial port to transmit AT commands to GPRS module to transmit alarm SMS, however, there is no MSComm control in Windows CE5.0, so have to use Win32 API function to realize serial communication by writing class Cserial, open the serial port function: OpenPort (LPCTSTR Port, int Baudrate, int DataBits, int StopBits, int Parity, LPDATAARRIVEPROC proc = NULL, DWORD userdata = 0), ReadPort (char * data, int length) as a function of reading serial, WritePort (char * data, int length) as a function of writing serial; this function can be used to write AT commands to serial port and operate GPRS module;
- D. Compiling GPRS module control procedures. Making fire alarm signals and the corresponding location signal to embedded in a text message and transmits it to the fire department or management personnel, Writing Class CGPSSer to control GPRS module, AT + CMSS command is stand for transmit SMS from the memory, gprsSendMessage (CString strNum, CString strCon) as a function of transmitting SMS;
- E. Compiling alarm control procedures. Alarm control procedures is used for controlling alarm light and alarm, we have specially compile alarm drivers and the alarm control category, the function Led (Bool status) to control lights OFF, the function Alarm (Bool status) to control alarm opening and closing.

IV CONCLUSION

This system use ARM9 board for the center console, use nRF2401 module for wireless communication, use GPRS module for remote alarm. Develop Em GIS software for this System specifically, which not only can shows the location of the fire broke out, but also can control the GPRS remote alarm module. Compared with traditional fire detection alarm system, the system saves a lot cost of hardware and improves the efficiency of the fire detection alarm. It not only can make up for the limitations of wired fire detection system, when use in ancient buildings, temples, museums, etc., but also in family homes, villas, etc., the system will has wide applicable market and prospects.

ACKNOWLEDGEMENTS

The study was conducted under the Project 08010302203 supported by S&T research project of Anhui Province. The authors would like to thank Mr. Shixing Liu and Mr. Jianxiang Zhu for their helps during the design.

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