

# Design of Remote Fire Automatic Alarm System Based on Zigbee Technology and TC35i Module

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## **Abstract**

*In order to realizing double function of monitoring home interior fire danger and automatic SMS alarm by using Zigbee networking technology, we propose the remote fire automatic alarm system based on Zigbee chip CC2530F256 and GSM wireless communication module TC35i. And on this basis, we give a detailed description of components selection, hardware design and software design of the system. The system testing results demonstrate that this system has good stability and response precision, anti-interference ability, which easy to be extended and applied.*

**Keywords:** *Zigbee technology; CC2530F256; TC35i; Remote fire automatic alarm system*

## **1. Introduction**

The gas leak and no one at home are regularly happening in residents' home life. It is very easy to cause huge casualties and property losses when fire occurred. Therefore, in order to avoid these unnecessary damages, we should be able to need some indoor detecting fire alarm systems. When fire danger could cause some possible damages to user, these systems will be able to automatically send SMS messages, so as to lead user can timely take appropriate measures to avoid unexpected danger.

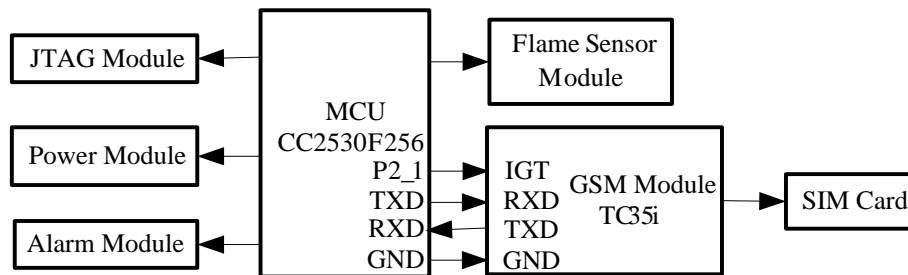
In recent years, with the development of sensor technology, computer network technology and modern communication technology, the real-time monitoring of fire danger and remote automatic alarm has becoming a reality.

Firstly, the alarm terminal equipment can realize unmanned real-time monitoring of fire danger by using the most advanced sensing devices (infrared thermal imager), aiming to quickly and effectively discover the hidden fire danger, and to eliminate fire danger in initial stage. Secondly, the fast and the effective remote automatic SMS alarm can be realized by using mobile communication system (GSM system), which can improve the response speed of fire danger alarm and utmost protect the user's safety life and property [1-2].

In view of this, we design a kind of remote fire automatic alarm system which based on Zigbee system-on-chip CC2530F256 and GSM wireless communication module TC35i in this paper. And this system can accomplish dual function of indoor fire danger information monitoring and remote alarm message automatic transmission in the actual family application. Besides, in this paper, we also expound the system components selection, hardware design and software design and so on, aiming at realizing system transplanted of fire danger information on Z-stack protocol stack in future. Thereby, we can lay a solid foundation for multipoint fire danger information real-time acquisition and wireless transmission with using Zigbee networking technology.

## **2. Overall Design of System**

The high-precision and remote fire automatic alarm system is composed by Zigbee system-on-chip CC2530F256, GSM wireless communication module TC35i and related peripheral circuits. And its overall design structure block diagram is shown in Figure 1.



**Figure 1. Overall Design Structure Block Diagram of Remote Fire Automatic Alarm System**

Among them, MCU CC2530F256, JTAG module and power module are collectively referred as CC2530F256 main control module.

The function of remote fire automatic alarm system can be divided into two parts. The first part is the monitoring of fire danger information, which is mainly realized by Zigbee system-on-chip CC2530F256 and flame sensor module. And the second part is the automatic transmission of remote alarm message, which is mainly realized by GSM wireless communication module TC35i.

Therefore, the operational principle of remote fire automatic alarm system is expressed as follows. Firstly, when the fire danger is happening, the flame sensor module can convert fire signal into voltage signal through its peripheral conditioning circuits, aiming at transferring it to system-on-chip CC2530F256 and achieving collection of fire danger information. Secondly, according to the flame sensor module, the system-on-chip CC2530F256 could send a voltage signal through the common I/O port to enable GSM wireless communication module TC35i enter into a work state. And then, this system can send corresponding AT command through serial port to control automatic alarm message, leading to a designated number of mobile phone and realizing automatic alarm of fire danger information.

### 3. Hardware Design of System

#### 3.1. CC2530F256 Main Control Module

The core chip of remote automatic fire alarm system is CC2530F256 microprocessor which belonging to TI company. And it is also conforming to Zigbee standards. The CC2530F256 microprocessor can facilitate formation of its own wireless communication network through combination of Z-Stack protocol stack developed by TI company, which can provide user with a complete and powerful Zigbee solution [3]. At the same time, compared to traditional 51 series single chip, its internal development resources are very rich. The CC2530F256 main control module circuit is shown in Figure 2.

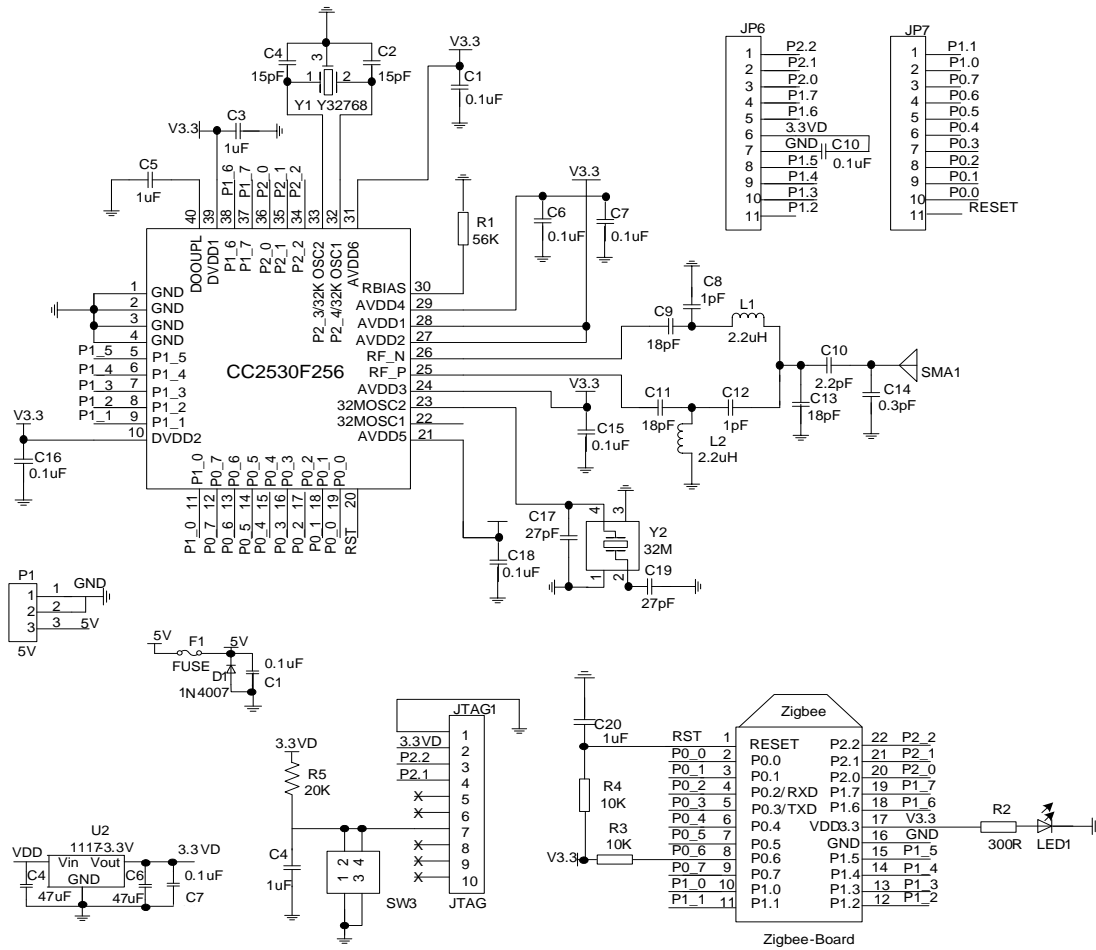
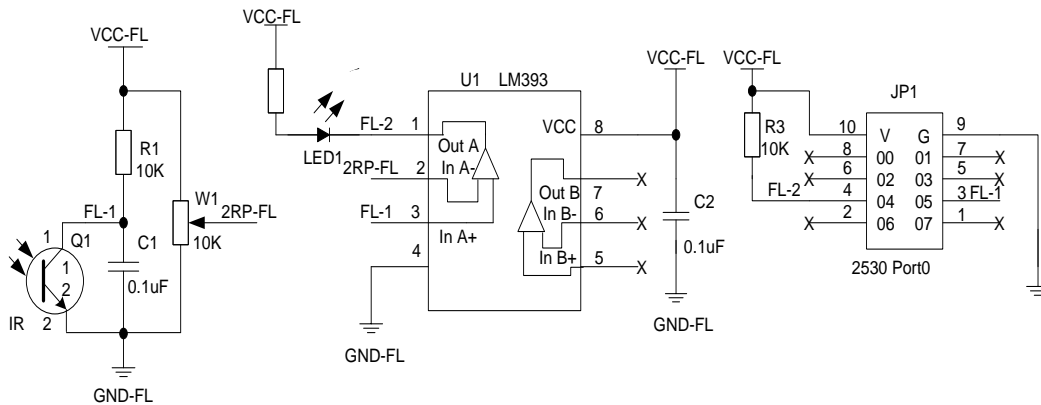


Figure 2. CC2530F256 Main Control Module Circuit

### 3.2. Flame Sensor Module

The flame sensor module of this remote fire automatic alarm system is an IR type sensor. It is based on sensitive characteristics of the infrared flame, which using a special infrared receiver tube to detect the flame. The working principle of the flame sensor module is stated as follows. In the first place, the integrated infrared flame detector will convert external infrared light intensity variations into voltage changes, and reflect as numerical changes within 0~255 range through A/D converter. When the infrared light is stronger, then the numerical value is smaller. Otherwise, when the infrared light is weak, then the numerical value is greater. In the next place, we take flame sensor signal terminals as input end of the voltage comparator, and compare with a reference voltage. In result, when the flame sensor detect fire danger information in a certain distance range, we can obtain a low voltage which from voltage comparator output. At length, the voltage comparator output is imported into CC2530F256 microprocessor general pin P0\_4 for corresponding processing according to the voltage change. The flame sensor module circuit is shown in Figure 3.



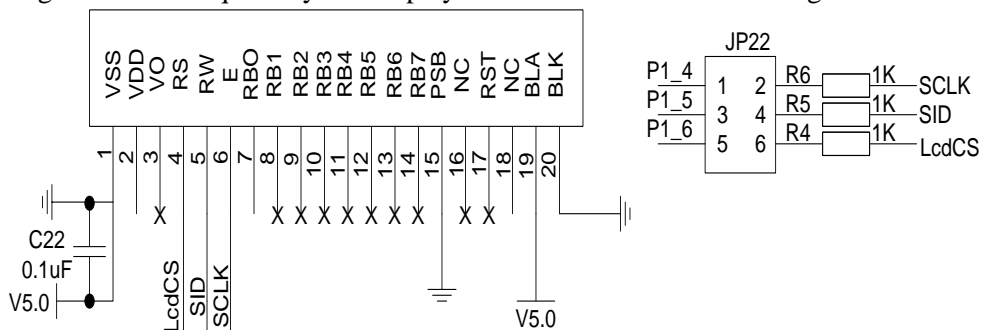
**Figure 3. Flame Sensor Module Circuit**

### 3.3. TC35i Module

A new industrial grade GSM module TC35i which produced by SIEMENS company is selected for this remote fire automatic alarm system. The connection between TC35i module and CC2530F256 microprocessor is simple and convenient. And it is easy to realize serial data transmission and reception through respectively connection of CC2530F256 microprocessor serial port transmission interface TXD and serial port reception interface RXD with the RXD and TXD serial port of TC35i module [4]. Simultaneously, in order to realize the control of CC2530F256 microprocessor to TC35i module, the IGT pin can be used as a trigger pin for TC35i module. When the flame sensor does not detect flame, we can allow CC2530F256 microprocessor general pin P2\_1 to output high level into the IGT pin by programming, so that the TC35i module doesn't work. Conversely, when the flame sensor could detect flame, we can also allow CC2530F256 microprocessor general pin P2\_1 to output low pulse with greater than 100 ms and duration of level drop without more than 1 ms into the IGT pin by programming, so that making the TC35i module to work. Then we will be able to realize SMS automatic alarm of the fire danger information [5].

### 3.4. Liquid Crystal Display Module

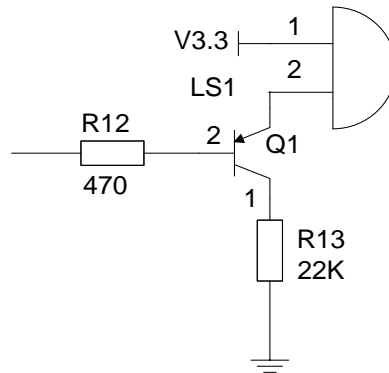
The remote fire automatic alarm system chooses FYD 128\*64 monochrome screen as its liquid crystal display module. And it is connected with parallel interface of CC2530F256 microprocessor, so that the SPI bus is indirectly controlled to complete driving work. The Liquid Crystal Display module circuit is shown in Figure 4.



**Figure 4. Liquid Crystal Display Module Circuit**

### 3.5. Alarm Module

The remote fire automatic alarm system selects a piezoelectric passive buzzer as its alarm module. When flame sensor does not detect the flame, we can control CC2530F256 microprocessor pin P2\_0 to output high level by programming, so that the buzzer does not work. On the contrary, when the flame sensor could detect the flame, we can control CC2530F256 microprocessor pin P2\_0 to output low level by programming. And then, we drive buzzer to achieve automatic sound alarm function for fire danger information. The alarm module circuit is shown in Figure 5.



**Figure 5. Alarm Module Circuit**

#### 4. AT Instruction

In GSM network, GSM short message service is the only service that does not require end-to-end path establishment. It uses store and forward mechanism, and provides secure two-way services. Meanwhile, it can still guarantee stable transmission when terminal equipment goes out of scope or shutdown. Therefore, the short message can be a convenient and reliable transmission for corresponding alarm information [6-7].

TC35i module can provide command interface according to GSM07.05 and GSM07.07 standards. Then, TC35i module will achieve the short message sending and receiving control through writing AT command to serial port. At present, the TC35i module supports three modes. Respectively, they are Block mode, Text mode and PDU mode. Among them, PDU mode is the most widely used, and has been sought after by domestic mobile operators, not only can support the English text message transmission, but also can support the Chinese text message transmission [8-9].

This paper takes the PDU mode as an example to send short message. When the flame sensor detects flame and causes TC35i module to enter working state, we can do the following three things. First, by programming, we can let CC2530F256 microprocessor to send AT instruction "CMGF=0 AT" into TC35i module for selecting PDU mode. If SMSC (SMS center) number is 8613800532500, the receiver number is 8618254010381, and the message content is "fire alarm". And then, by programming, we can let CC2530F256 microprocessor to send AT instruction "CMGS=24 AT" into TC35i module for setting information length as 24. Last, the PDU string sent by TC35i module is ">08 91 68 31 08 50 23 05 F0 11 00 0D 91 68 81 52 04 01 83 F1 00 08 00 70 6B 70 7E 62 A5 8B 66 FF 01 24".

According to AT specification, the above SMS message content is explained as follows.

- 08: The length of the SMSC address information is 8 bytes.
- 91: SMSC address format (TON/NPI) with international format number (Add "plus" in front).
- 68 31 08 50 23 05 F0: The SMSC address is 8613800532500, and making up into an even number by filling "F".
- 11 00: Fixed prefix of target address.

- 0D: The target address is a hexadecimal number with 13 digit capacities.
- 91: Destination address format (TON/NPI) with international format number (Add "plus" in front).
- 68 81 52 04 01 83 F1: The target address is 8618254010381, and making up into an even number by filling "F".
- 00 08 00: Fixed suffix of target address.
- 70 6B 70 7E 62 A5 8B 66 FF 01: UCS-2 code for user information "fire alarm".
- 24: The length of user information "fire alarm" is 24 bytes.

## 5. Software Design of System

The software of remote fire automatic alarm system is based on embedded IAR workbench for 8051 V8.10 version which belongs to IAR Systems company. In this version, it includes integrated development environment, C/C++ cross compiler, project manager, linker, assembler and C-SPY debugger. So this software version will be a better developing platform for CC2530F256 microprocessor.

The software of remote fire automatic alarm system which based on C language programming uses a modular design thought, and it is mainly consists of two core parts. Namely, they are monitoring program of fire danger information and automatic sending program of remote alarm message. The flow chart of system software design is shown in Figure 6.

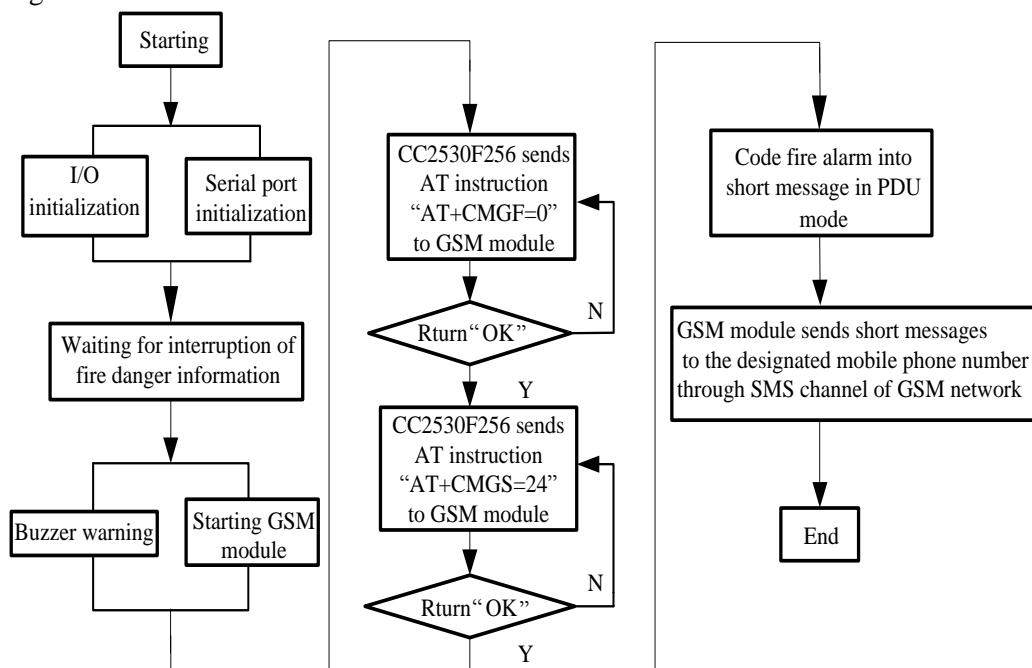


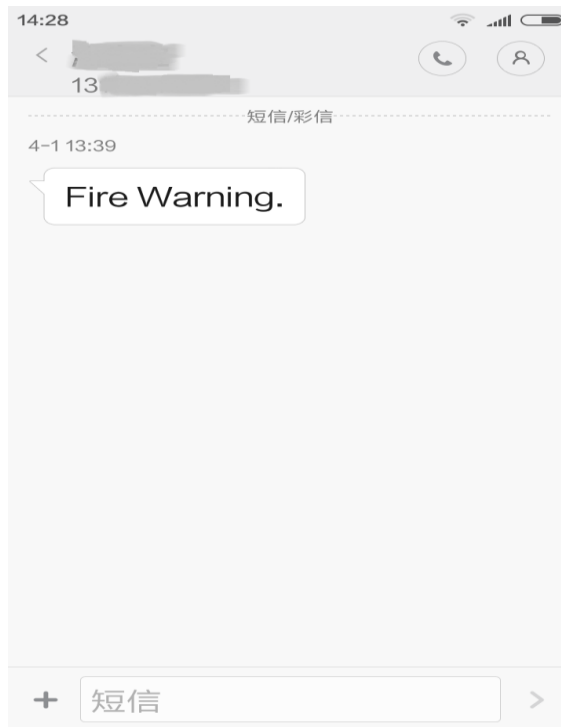
Figure 6. The Flow Chart of System Software Design

## 6. System Test

Under the laboratory environment, we carry out the system test through simulation of fire danger information. Finally, the test results are shown in Figure 7, and Figure 8.



**Figure 7. Transmission Process of Fire Alarm Short Message**



**Figure 8. Reception Result of Fire Alarm Short Message**

From Figure 7, and Figure 8, we find that this system has achieving the expected test results, and its operation is stable, with having a strong timeliness.

## 7. Conclusion

Combined with new requirements of modern family fire alarm, this paper introduces a remote fire automatic alarm system which based on Zigbee system-on-chip CC2530F256 and GSM wireless communication module TC35i. This system can complete dual function of indoor fire danger information monitoring and remote alarm message automatic transmission in actual family application. This makes the remote fire automatic alarm system having more intelligence and automation, and also makes this system's

alarm mode to be more timely and intuitive.

And then, the system test results show that this system has stable performance, reasonable structure design, low cost, quick response and high reliability and so on. Furthermore, this system can transfer fire danger information in GSM short message form, which making mobile phone user can directly receive corresponding alarm information. At the same time, this means that this system can preferably complete family fire alarm function, with having a very high practical value. As a result, this system will be able to get a wide range of application and development in the near future.

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