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Design of Intelligent Drop Fuse

Xiaomin Qin [1*], Yujian Tang [1]

[1] *Beijing Smart-chip Microelectronics Technology Ltd., Changping District, Beijing 102200, China*

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Abstract

This paper introduces the design of an intelligent drop fuse. This study analyzes the system composition of intelligent drop fuse and introduces the hardware and software design principles, architecture, and implementation method of intelligent drop fuse. This design mainly applies to the intelligent fuse terminal in the station area, which is used to monitor the position signal of the drop fuse in real time, report the fuse drop state information, and effectively shorten the fault location and troubleshooting time, so as to reduce complaints and provide services. The wireless communication module implements a weighted random back-off transmission algorithm, which can determine the transmission time and priority of data according to the urgency of data in the process of data transmission, avoid data collision, and ensure the arrival of data as much as possible.

Keywords: Intelligence; Fuses; Distribution Network; Internet of Things Technology; Real Time Monitoring.

1. Introduction

With the construction and development of cities, there are more and more functional requirements for the construction of distribution network automation. While meeting high reliability, more functions need to be integrated. The essence of intelligent construction of distribution networks is to use modern technical means to monitor the line electric energy signal of distribution networks in real time and use network technology to complete the remote control of opening and closing of distribution switches so as to ensure the safe and reliable operation of the distribution network. On the basis of intelligent distribution networks, the concept of distribution Internet of things is proposed [1-3]. Distribution Internet of things is a new power network form produced by the deep integration of traditional industrial technology and Internet of things technology [4, 5]. Through the comprehensive interconnection, interworking and interoperability between distribution network equipment, realize the comprehensive perception, data fusion and intelligent application of distribution network, meet the needs of lean management of distribution network and support the rapid development of energy Internet. It supports the construction of an intelligent distribution network in the new generation power system [6].

Promoting the application and development of distribution Internet of things technology is of great significance to the construction of a new generation of power systems. In terms of application form, the application of distribution Internet of things has the characteristics of terminal plug and play [7], extensive interconnection of equipment [8], comprehensive state perception [9], application mode upgrading [10], rapid business iteration [11], efficient utilization of resources, and so on [12].

* Corresponding author: 330502449@qq.com

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Both the smart grid and the smart distribution network and the distribution Internet of things emphasize the intelligent operation, real-time perception, and online monitoring of power grid equipment and devices. Therefore, the intelligent upgrading of traditional power devices is urgent. In many distribution network devices, fuses are an important member. From the development history of electrical products, fuses have been produced and used for more than 100 years, and even the earliest protection equipment in the power system has always shown excellent protection characteristics in the power system [13–15]. Because it has the advantages of simple structure, safe and reliable action, fast breaking circuit, low price, and current limiting capacity, the fuse is widely used in power protection. With the development of industry and the power industry, new requirements are constantly put forward for fuses, which promotes the development of fuses. Under the premise of the continuous improvement of the requirements of the urban power grid, fuses have exposed many problems and many potential safety hazards, which cannot meet the needs of safe, humanized, and intelligent power grid construction in the new era [16, 17]. For products that urgently need to effectively monitor the state of drop fuse, find out the hidden dangers of drop fuse in time, and carry out maintenance and management in advance.

Therefore, this study proposes to develop an intelligent drop fuse core board, which is applied to the intelligent fuse terminal in the station area. Combined with the collection module of the drop fuse, it can intelligently upgrade the traditional drop fuse. Based on this design, the drop fuse can be monitored in real time, which provides a basis for fuse condition monitoring and reliability maintenance, and has important research significance.

2. Composition of Intelligent Fuse System

The architecture of intelligent fuse system is shown in Figure 1.

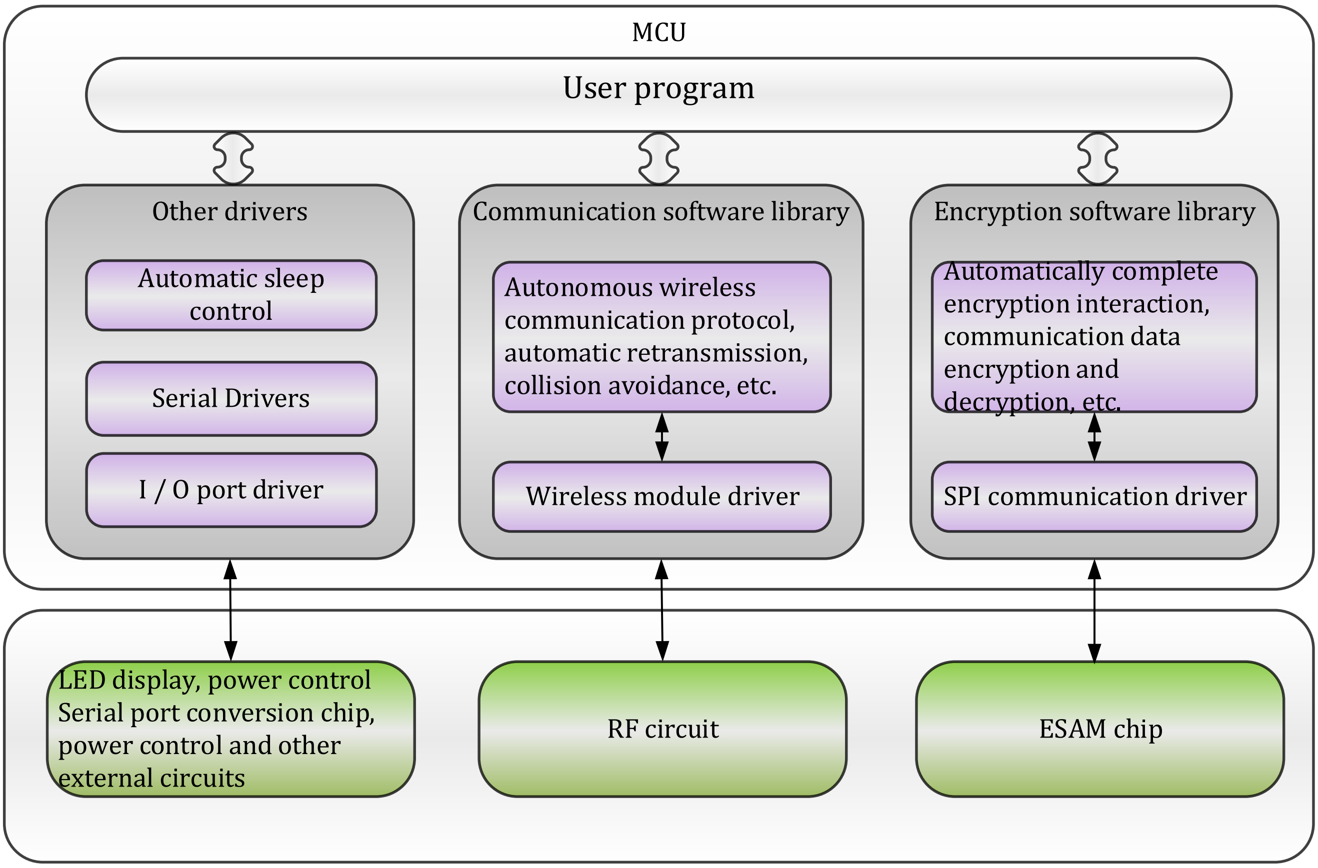

Figure 1. Architecture diagram of intelligent drop fuse system

Drop fuse collects the information of drop fuse through GPIO, and encrypts the collected information through ESAM security unit. It is sent to the fusion terminal wirelessly through the RF circuit, so as to realize the timely upload of drop fuse information.

The service interaction diagram of drop fuse is shown above. After the acquisition equipment is short circuited, the fuse will fuse automatically, and the fuse status data will be uploaded to the collection equipment. The collection equipment uploads the data to the fusion terminal and finally to the master station. It is convenient to quickly locate the fault location and strengthen the real-time performance of fault emergency repair.

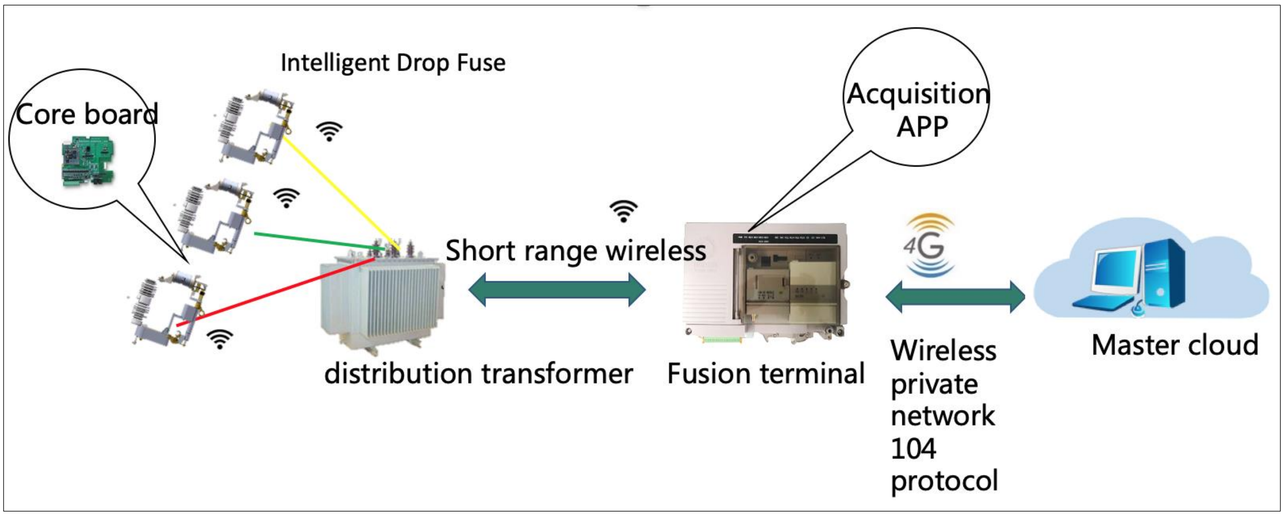

Figure 2. Intelligent fuse service interaction diagram

3. Hardware Design of Intelligent Fuse System

3.1. Hardware Design Principle

The hardware of intelligent drop fuse is divided into power supply unit, main processor, power consumption control circuit, RF circuit, ESAM safety unit circuit and external interface. The power supply unit supplies power to all units; The power consumption control unit receives the instruction from the main processor to control the power supply of RF circuit and ESAM safety unit; The main processor completes RF circuit drive, ESAM safety unit drive, serial port drive, I2C drive and GPIO control; I2C and serial port interface complete communication with external equipment; GPIO completes the control of external equipment and the collection of switching value information.

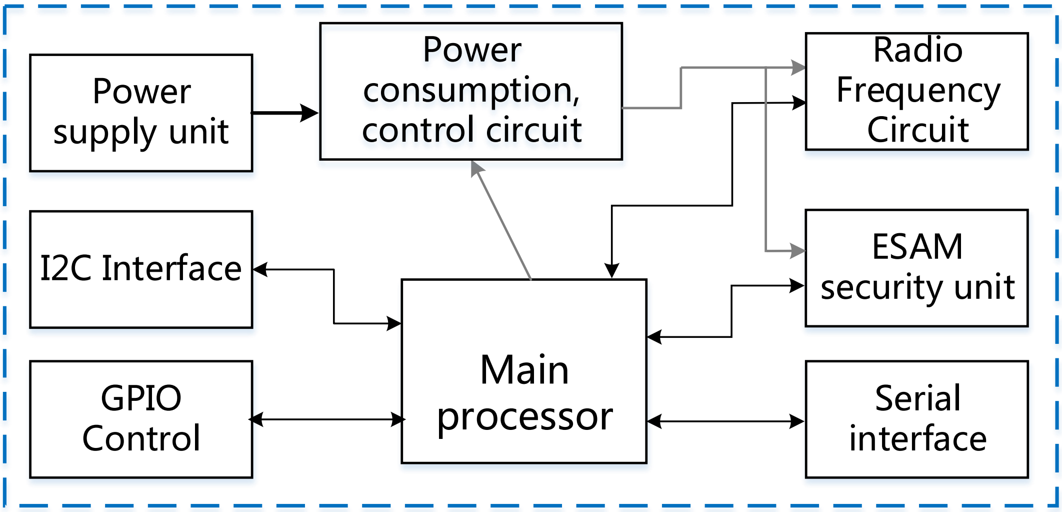

Figure 3. Framework diagram of intelligent fuse hardware system

3.2. Hardware Design

The specific hardware design of intelligent drop fuse is as follows:

- ***Power supply unit:*** it is composed of LDO and filter capacitor to complete equipment power supply and power filter.
- ***Main processor:*** it is composed of scm325 and its peripheral circuits to realize the functions of processor cold start, RC circuit reset and crystal oscillator oscillation signal generation.
- ***Power consumption control circuit:*** it is composed of RF driver and RF antenna to transmit and receive RF signals.
- ***RF circuit:*** small wireless RF implementation circuit.

- ***ESAM security unit circuit:*** it is composed of ESAM chip and its peripheral circuit. It communicates with MCU through SPI to realize data encryption and decryption.
- ***External interface circuit:*** realize external communication, equipment control and switching value information acquisition of serial port, I2C, GPIO, etc.

4. Software Design of Intelligent Fuse System

4.1. Principle of Software Design

The software is divided into application layer and driver layer. The application layer is mainly realized by users, including the judgment logic of alarm or fault, the application layer data of communication, communication protocol, etc.; The driver layer completes the sleep wake-up control, small wireless communication protocol stack, various peripherals and hardware devices. The overall software framework is shown in the figure below:

The software driver layer completes the core board software library of wireless communication, security encryption and basic driver. The wireless interaction process adopts random back-off mechanism to ensure the arrival of data as much as possible. The security chip driver and encryption and decryption process are encapsulated into the software library, and only simple interfaces such as initialization, data sending and receiving, encryption and decryption and sleep are reserved to facilitate users' rapid secondary development.

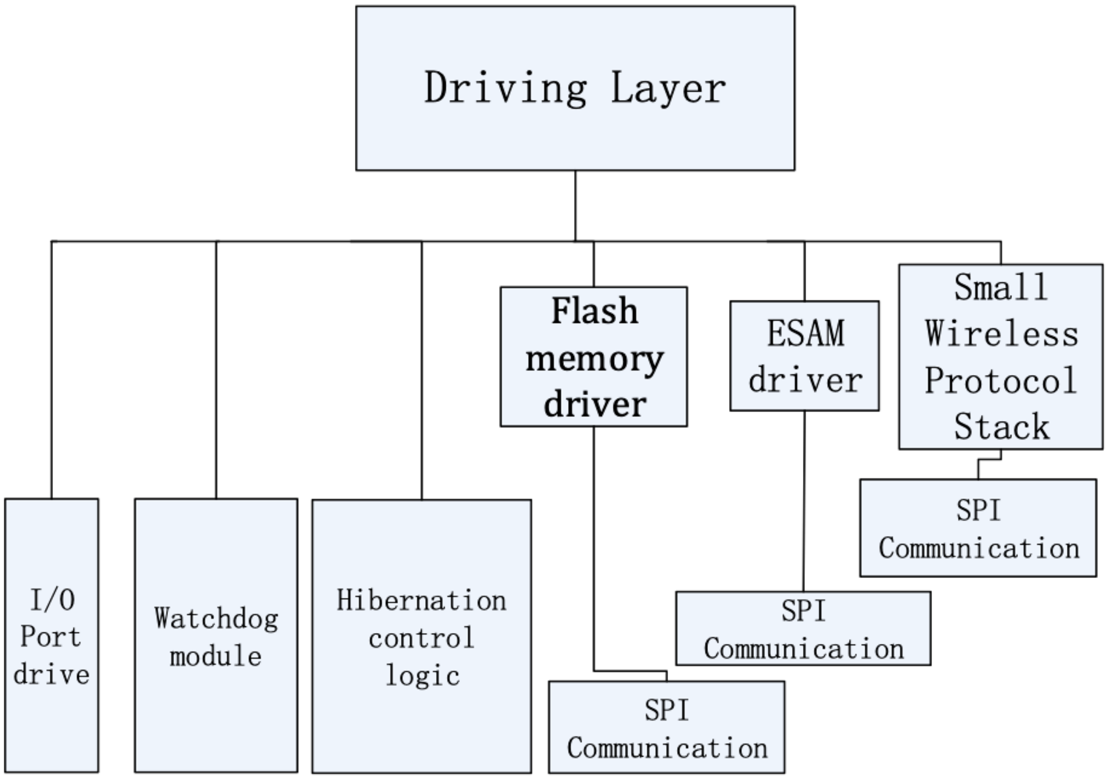

Figure 4. Module division diagram of drive layer

4.2. Specific Design of Software

The software is divided into sleep wake-up control module, wireless communication module and ESAM module. The wireless communication module implements a wireless communication software processing method based on weighted random back-off mechanism, which can determine the transmission time and priority of data according to the urgency of data in the process of data transmission. Software structure is classified according to function level:

1) Sleep wake-up control module: use RTC module to sleep and wake up regularly, so that the module can only run at the necessary time, so as to reduce power consumption. On the basis of RTC peripherals, the module realizes the timed wake-up function. Before the program runs, initialize the module first. When sleep starts, configure the time point of next wake-up, and then sleep.
2) Wireless communication module: the wireless communication protocol using random back-off mechanism is realized to avoid data collision in the air and ensure data arrival. The software module drives the RF chip based on SPI peripherals. Firstly, it completes the initialization of the wireless communication module. When receiving data, it reads the data in the RF chip through SPI. When sending data, it first determines the air data. If there is

no data in the current air, it will send the data immediately. If there is data in the current air, Delay a random length of time, and then repeat the determination step. The weighted random back-off transmission algorithm implemented by the wireless communication module sets the minimum idle time T1, which is the maximum data transmission time in the communication network; T2 is 2*T1; T3 is the sum of T2, maximum message sending time and message response time. Before sending general data, first monitor for a period of time. If there is no data within a certain period of time T2, it can be sent. When sending general data continuously, the packet data directly needs an interval of time T2, so that emergency data can be sent first within T2, so as to ensure the priority of sending emergency events, If general data cannot be transmitted or transmission fails, it will be delayed for a random period of time n * T2, n is a random positive integer, and the upper limit of value is determined by the amount of general data in the communication network; Before sending emergency data, continue to monitor. If you hear an idle time of T1 within T3 time, send it. When sending emergency data continuously, there is no need for an interval between the two packets of data. If the transmission fails, it will be delayed for a random time n * T1, n is a random positive integer, and the upper value limit is determined by the amount of emergency data in the communication network. The emergency data sending process is shown in the figure:

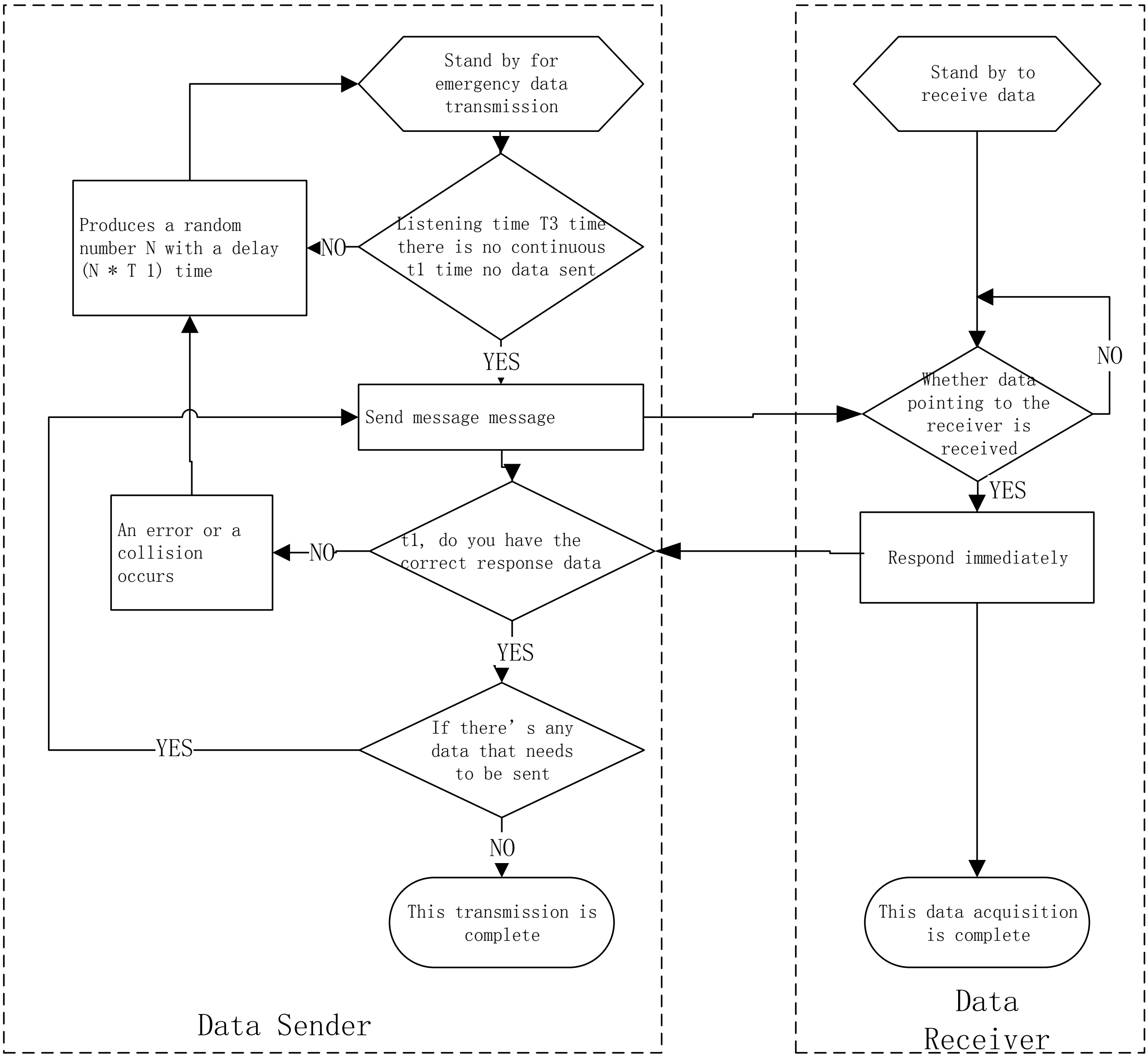

Figure 5. Module division diagram of drive layer

3) ESAM module: complete data encryption and decryption. The software module is based on the driver of hardware encryption chip. Firstly, the initialization of ESAM encryption module is completed, and then the data transmission and reception is realized through the transceiver function.

The software design flow chart is shown in the figure below.

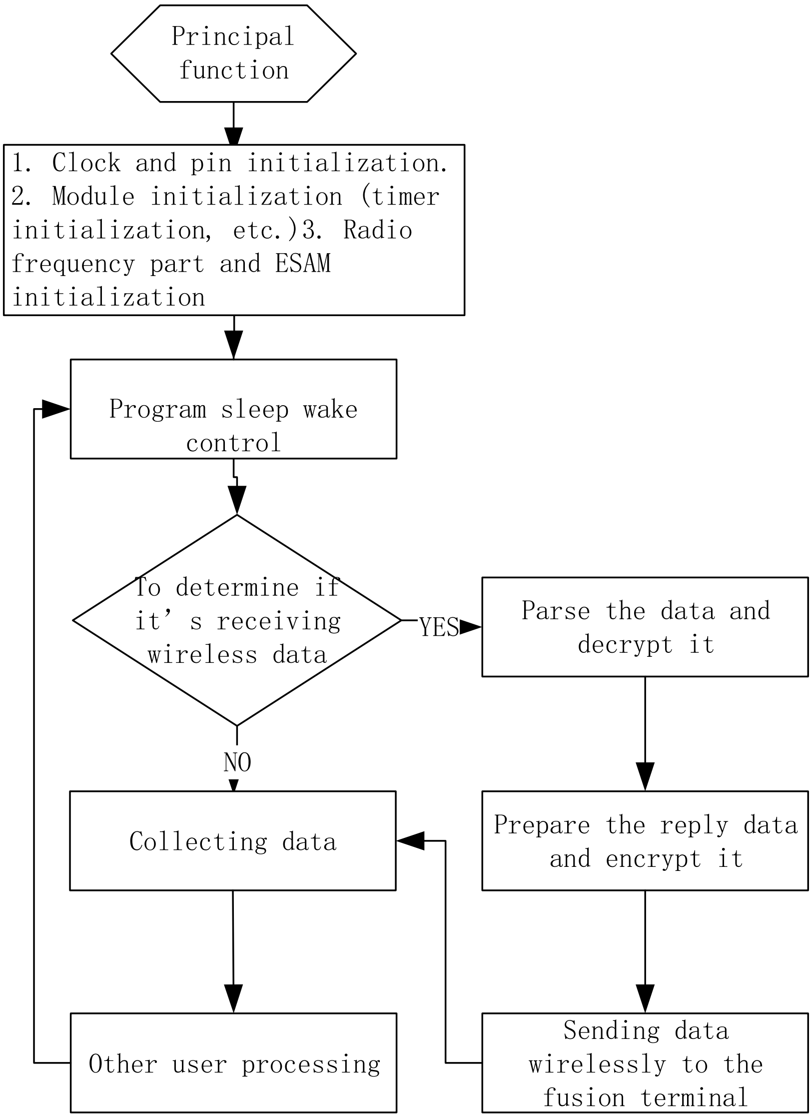

Figure 6. Software flow chart

5. Conclusion

This paper analyzes the hardware design and software design of intelligent drop fuses. The scheme is reasonable in terms of technical feasibility and cost, and uses hardware encryption to ensure data security. A random back-off mechanism is adopted in the wireless interaction process to avoid data collision and ensure data arrival. It is of great significance for intelligent drop fuses to monitor the condition of equipment and master its operation characteristics and change trend so as to improve the continuity and efficiency of power system transmission, reduce the equipment failure rate, and improve the reliability of the fuse.

6. Declarations

6.1. Author Contributions

Conceptualization, X.A. and Y.T.; methodology, X.A. and Y.T.; writing—original draft preparation, X.A. and Y.T.; writing—review and editing, X.A. and Y.T. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

Data sharing is not applicable to this article.

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6.5. Institutional Review Board Statement

Not applicable.

6.6. Informed Consent Statement

Not applicable.

6.7. Declaration of Competing Interest

The authors declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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