Design of Watt-hour Meter Based on Radio Frequency Identification Technology

Jianjun Xu, Linlin Dong, Lianwei Zhang

Department of Electrical Information Engineering, Northeast Petroleum University, Daqing, 163318, P.R. China

Abstract

This paper based on the IC card prepayment Watt-hour meter, the design of prepayment Watt-hour meter based on RFID. Through the ADE7756 electric energy measurement module for electric energy acquisition, acquisition of electrical energy into pulse, in the PIC18F4680 MCU pulse count, and thus calculate the user's electricity. Interface circuit of RF reading and writing chip, energy metrology module and master control module are given. At last, application the anti-interference technology in the operation of Watt-hour meter system for perfect.

Keywords

RFID; Watt-hour meter; module.

1. Introduction

In the modern world, the IC card prepayment Watt-hour meter's model of first payment after use has fundamentally solve d the problem of the arrears of electricity. But the metal part of such an IC card bayonet is exposed to the outside, when the IC card is inserted into power meter, multiple contacts must work simultaneously in order to achieve the integrity of data transmission. However, The metal part's incapacity of waterproof, moisture proof and anti-friction will bring users a great inconvenience in long-term use [1-2]. In order to solve the above problems, this paper has designed prepayment Watt-hour meter based on RFID. Through communication between the radio frequency card and the single-chip the radio frequency identification technology, users' purchased electric energy is stored in the Watt-hour meter, then t begin to provide electric energy for users. It has solved problem of electric power department's charging difficult and stealing electricity and met the demand of society.

2. The system structure and working principle of Watt-hour meter based on RFID.

2.1 System Structure

The management system of prepayment Watt-hour meter based on RFID is consisted of Watt-hour meter, electric management center and radio frequency card. Through this medium of radio frequency card, the power purchased from the electric power department and the users' information is sent to the Watt-hour meter. The system of prepayment Watt-hour meter based on RFID is consisted of the following parts: RFID Watt-hour meter, RF reading and writing device, RF card and management system of prepayment Watt-hour meter. System structure is shown in Figure 1.

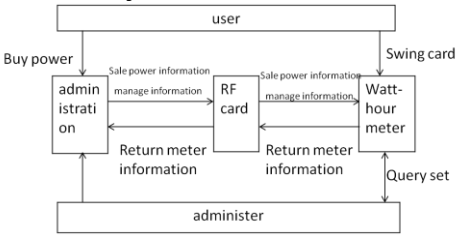

Figure 1. The composition of system.

2.2 Working Principle

1.Before using ,users should purchase electric energy in the electric power management department and deposit the purchased electric energy and users' information into the RF card together,these information will be inputted into computer system of the electric power department.

2.When users swipe electric energy stored RF card on the Watt-hour meter, its reading and writing chip will check the legality of the RF card, after successful authentication,the Watt-hour meter starts to read information in the RF card and will prompts to supply power for users if there are sufficient electricity, The Watt-hour meter system will write users' information in the E2PROM of SCM and will supply power for users simultaneously[3].

3.The Watt-hour meter adopts a sliding scale mode to measure electricity, the used electricity is stored in the E2PROM, the memory unit store once when electricity reach one degree. The accuracy of electric measurement is 0.01 degrees.

4.The Watt-hour meter management system collects the power situation of the Watt-hour meter working for users continuously. After treatment, the electric department management system will give three lists. (1)The electricity is less than 10 degrees indicating that the user on the Red List;(2)The electricity is 0 degrees indicating that the user on the Yellow List;(3)When is abnormal, it indicates that the user on the Black List. At the same time, the management department sends out the instruction information to he Watt-hour meter system in the net. When the Watt-hour meter has ensured that the user is on the Red List, the Watt-hour meter alerts to remind user to charge while providing power yet; When has ensured that the user is on the Yellow List, the Watt-hour meter starts audible and tips alarm, at the same time, it stops provide power for the user and exit the user card, the Watt-hour meter is on standby mode; When the user is on the Black List, the electric department will stop supplying power immediately and check it.

5.If users want to stop the use of electricity, they only need to move the RF card near the working scope of the Watt-hour meter again which will write its remained electricity into the RF card, the buzzer sounds to alert the user has completed the task after completion. the Watt-hour meter cuts relay immediately,then the power supply is stopped.

6.When the Watt-hour meter is providing electricity for users, its system will not recognize other RF cards, two RF cards cannot be used simultaneously on an Watt-hour meter, the other RF card can be swiped to use only when the Watt-hour meter stops supplying electricity for former user.The normal operating range of the Watt-hour meter's reading and writing modules is 0-10cm,so when there is a RF card passing over surface of the Watt-hour meter, it will not trigger the Watt-hour meter work if does not reach the effective distance .

7.A card can be used on different RF Watt-hour meter, one RF Watt-hour meter also can be used by many RF cards, but one meter matches one card once time.

8.In the process of electricity, if power outages, the backup battery will input the used electricity in E2PROM for storage automatically. After electrifying, The Watt-hour meter will continue to provide on the basis of the energy saved before. on the situation of power outrage, if users do not want to use electricity when electrified, they can swipe the RF card on the Watt-hour meter's working area again to cancel electrifying, then the Watt-hour meter is on standby mode and waiting to work for the next user.

3. The hardware design of RFID Watt-hour meter

The hardware system of Watt-hour Meter Based on Radio Frequency Identification Technology is mainly consisted by the following modules: the led modules, electricity measurement module, the RF reading and writing module, the RF card, the encrypted module, the communication module, clock module and so on. Hardware structure is shown in Figure 2.

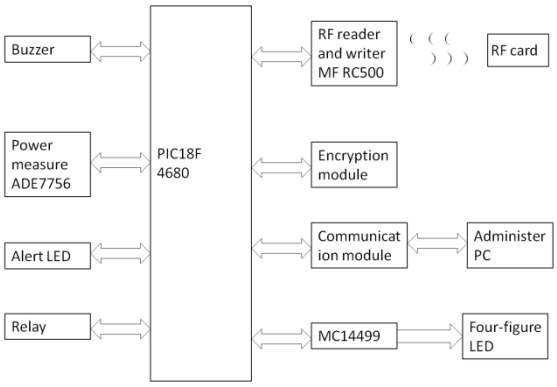

Figure 2. Design of the hardware structure.

This paper has chosen the PIC18F4680 SCM. As the core the design, PIC18F4680 links other modules together, forming the system of prepayment Watt-hour meter based on RFID. The main task of ADE7756 electricity measurement module is to measure electricity of the Watt-hour meter and to transform the collected current and voltage by multiplier [4],and finally convert electric energy into the form of pulse to calculate the power. MF RC500's RF reading and writing module communicates with the SCM by serial mode.

3.1 Design of RF Interface Module

MF RC500 is a non-contact type dedicated reader chip basing on ISO14443A which is designed by Phillips .It is the bridge to communicate between SCM and RF card, the key portion of wireless communication[5].The circuit diagram of MF RC500 and SCM interface is shown in Figure 3.MF RC500的D0-D7(Multiplexing line of data and address)is connected with RD0-RD7 of the PIC. The address Latch enable port of MF RC500, ALE, is linked with the PIC. MF RC500's Pin A0 and Pin A1 are given +5 voltage, Pin A2 is connected to the ground. The Pin NWR(Reading),NRD(writing) and NCS(chip select) is connected with MF RC500's RE0,RE1,RE2 of SCM respectively. Its Interrupt request port is connected with PIC and INT1.

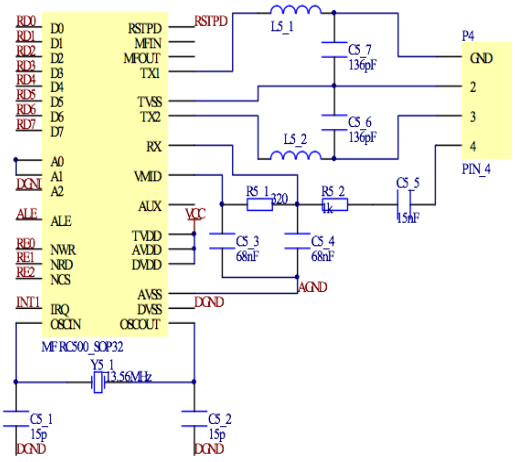

Figure 3. The interface circuit of MF RC500 and SCM.

3.2 Electric Energy Metering Module

MF RC500 is a non-contact type dedicated reader chip basing on ISO14443A which is designed by Phillips .It is the bridge to communicate between SCM and RF card, the key portion of wireless communication[5].The circuit diagram of MF RC500 and SCM interface is shown in Figure 3.MF RC500的D0-D7(Multiplexing line of data and address)is connected with RD0-RD7 of the PIC. The address Latch enable port of MF RC500, ALE, is linked with the PIC. MF RC500's Pin A0 and Pin A1 are given +5 voltage, Pin A2 is connected to the ground. The Pin NWR(Reading),NRD(writing) and NCS(chip select) is connected with MF RC500's RE0,RE1,RE2 of SCM respectively. Its Interrupt request port is connected with PIC and INT1. ADE7756 is introduced by ADI(Analog

Devices Inc， Abbreviation is ADI) which has designed a RF prepayment Watt-hour Meter of high-precision and low-cost with it. It is the production of ADE7755 improved version.ADE7756 is a kind of high-accuracy energy metering integrated circuit with serial interface and pulse output. It contains two second-order $\sum \Delta ADC$, a reference voltage source, a temperature sensor and all signals processing function required by the active power and the active electric energy.

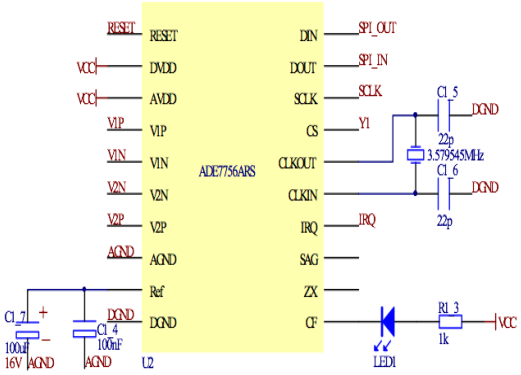

Figure 4. The interface circuit of ADE7756 and SCM.

The interface circuit of ADE7756 and SCM is shown in Figure 4 ,the SCM reads and writes contents of the ADE7756 via the SPI serial mode.(1)When it is in reading operation, SCM sends read and write commands to ADE7756's register first,ADE7756 starts to interpret after receiving the commands, and finally outputs the desired data via DOUT.(2)When it is in writing operation, SCM sends a write command,ADE7756 starts to interpret after receiving the command and inputs the desired data via DIN.SCM can read other information stored in ADE7756 through the SPI interface, such as temperature, sample waveform data and so on.

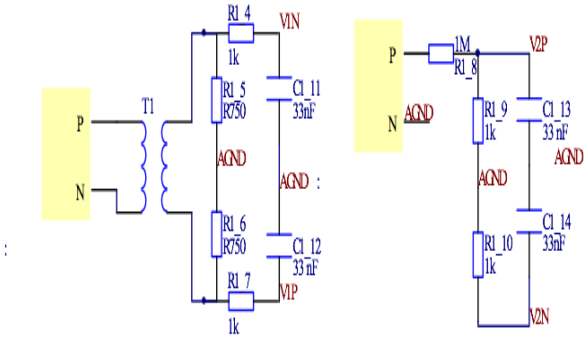

Figure 5. current and voltage acquisition.

As shown in the left of Figure 5. Current signal equals current in the circuit-under-test to small current according to mutual proportion via current transformer, the small current is sent into port $V1P$ and $V1N$ of ADE7756 as current input channel after conditioning and filtering. As shown in the right of Figure 5.The voltage sampling signal is linked to port $V2P$, $V2P$ of ADE7756 after resistor divider network.

4. Software design of RFID Watt-hour meter

4.1 Design of Main Program Design

Initialize the PIC18F4680 SCM, put function Task Trigger (&current Task) and Process Task() into the main program, execute Task Trigger(&current Task) first and then get into function Process Task().

When get into function Task Trigger(&current Task) first， The pointer of Process Task()is pointed to NO_Task(indicating no task).When a user wants to perform a task, it jumps from NO_Task(break);after executing the function Task Trigger(&current Task)in succession， gets into function Process Task(), The pointer of current Task points to the program which user want to

execute, after executing the task, it jumps out(break);the instruction jump from Process Task(); function backs to Task Trigger(&current Task)，executes Process Task()again，and then executes command of the user, jumps out of the function(break)after completing . This process is used repeatedly until the program end. The main program flow is shown in Figure 6.

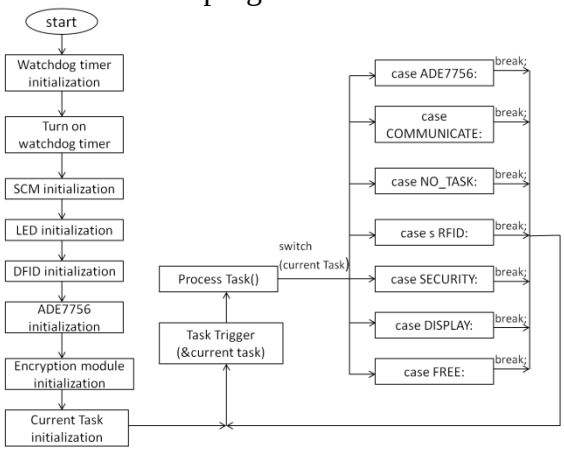

Figure 6. The main program flow.

As known from the figure, users should trigger RFID_request task execution first if they want to use RF reader module program, they should ensure that if the SCM is performing task before execution. The pointer of current Task will not on the NO_Task but on the RFID_request_task if there is no task. It will jump into the main circulating function again after jumping out of the current command, and then executes Task Trigger(&current Task)， to complete the requirements of users by entering Process Task()function in RFID_request.

4.2 MF RC500 and RF card verification

1. Reset answer

Request std or (Request all)command: read continuously or (read continuously). If there is a RF card is put into the working scope of MF RC500, (1)Request std instruction will read the information in the card constantly, repeat the above operation continuously after completing once to complete the task.(2)Request all instruction reads one card's information, thus preventing to read a card repeatedly. It reads to complete the task until a new RF card is put into working scope of MF RC500.

2. Anti-overlapping Instruction

When two or more than two Mifare are put into the scope of working scope of MF RC500, anti-collision mechanism is turned on. Since each RF card has different serial number, RF reader can only operate on one card, the remaining cards are in the standby state. If there are special circumstances take place, the electric department staff can set this meter to communicate with serial number of a known user's card. The effect of Anti-collision is to select a card in the overlapping cards.

3. Card Selection Instruction

After the anti-overlapping instruction, you must use this command to establish communication with the selected card.

4. The authentication operation instructions

Verify the validity of the card by ensuring whether the password of MF RC500's RAM matched that in the RF card, the validation is successful if it matched, otherwise fail.

5. Read, Write, Add number and Reduce number Instruction

The operations to read, write, add number and reduce number of the card.

6. Cease Instruction

The final process is to exit the RF card. The above are shown in Figure 7.

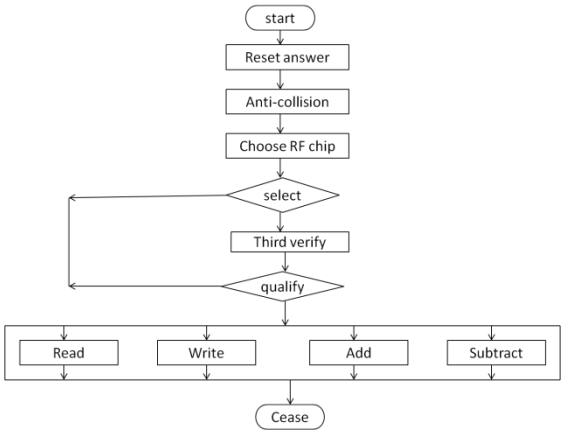

Figure 7. The main program flow MF RC500 and RF card verification process.

5. Conclusion

Radio Frequency Identification Technology has been a mainstream technology in 21st century, it has a high degree of security and information integration. The RF prepayment Watt-hour meter designed in this paper can communicate between RF card and the host PC of electric department. The results proved that the anti-interference ability of Watt-hour meter system is high, data transmission is safe, management of electric department is convenient and it has broad application prospects.

Acknowledgment

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