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Implementation of Asset Management System Based on Wireless Sensor Technology

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Abstract: RFID technology is regarded as one of the top ten key technologies in the 21st century, which has extensive application prospect in various fields, including asset management, public safety and so on. Through analyzing the current problems existing in asset management, this paper proposes to apply RFID technology in device management to effectively improve the level of automation and informatization of device management, and designs the scheme of equipment monitoring system based on 433 MHz RFID electronic tag and reader. The hardware part of monitoring system consists of the RFID sensor terminals attached in the device and the readers distributed in each monitoring site. The reader uploads the information collected by tag to the backend server and the management system, so as to allow managers and decision makers to understand the usage rate and location of the experimental instruments and to provide managers with a scientific basis for decision making, which effectively solves the relatively backward status quo of current device management level. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Optical communications, RFID, Electronic tag, Instrument management, Wireless sensor technology.

1. Introduction

In order to meet the requirements for long-range data transmission of space optical communication, it is necessary to maximize the transmission power and conversion efficiency of emitted light [1]. The characteristics of fiber lasers are very valuable resources for space optical communication, such as high peak power, good beam quality and short pulse-width etc. But because of its relatively low repetition frequency, it is difficult to achieve the requirements of high-rate communication [2-5]. At a given average power of the light, PPM (Pulse Position Modulation) can achieve a high data transfer rate with a small laser pulse repetition frequency, which makes up for the shortcomings of the fiber laser. It also has the advantages of high power utilization, high transmission efficiency and anti-jamming ability etc. which makes it widely used in the field of laser communication. So PPM technology based on fiber lasers will become a focus in space optical communication [6].

RFID is the abbreviation of Radio Frequency Identification, it is a new automatic identification technology, which make target conduct non-contact identification track and bidirectional data communication by electromagnetic induction and electromagnetic transmission mode and rises in the 1990s, Compared with a magnetic stripe, laser barcode, fingerprints, optical character, and other automatic identification technology, RFID has the signal strong penetrating power, non-contact reading and writing, identification distance is distant, strong environmental adaptability, large capacity of information storage, data can be adapted, encryption performance is good, long service life and other advantages[7-8]. From the perspective of communication industry, the demand for RFID applications originates directly from the development of communication technology, which belongs to communication market development between equipment. The direct result of the development of communication technology is a structure which is more complex and more powerful communication system, therefore, fundamentally the great opportunity exists in combination of RFID and WSN (wireless sensor network) [11].

In recent years, with the popularization of higher education, both the total assets and the financial investment of China's universities have reached a rather high level. According to related statistics, up to 2011 all kinds of colleges and universities in China have a building area of 780,760,000 square meters (including the independent non-proprietary use), an increase of 34.72 million square meters over the previous year; the total value of teaching and research equipment is 255.5 billion yuan, an increase of 27.6 billion yuan over the previous year, and the annual increase reaches 12.1 % [9]. How to greatly enhance asset management, improve service efficiency of device and raise automation and informatization of device management is becoming an urgent problem.

This paper proposes to combine RFID technology and WSN (wireless sensor network) technology, which is helpful to solve this problem. RFID and WSN technology provide basic data, such as temperature and location of device, for device monitoring system. The system comprehensively uses the target search and positioning technology based on sensor nodes and RFID, supported by database and data mining technology, and uses unique self-adaptive network communication structure, to achieve all-around data support of device management, which facilitates the manager to conduct statistics query and control equipment flow, so as to meet requirements like convenience, fastness, safety, efficiency and so on.

2. System Design

System design scheme is shown in Fig. 1.

1) RFID sensing terminal collects status information of device by sensor technology;

2) Data is transmitted to the side of reader through RFID communication channel;

3) After receiving the data collected by the terminal, the reader conducts processing and calculation on the data to a form that is familiar to people and then sends the data to communication interface;

4) Multi-path communication interface receives the data sent to management platform, and then transmits to the management platform in corresponding forms like serial port, wired network and WIFI network based on relevant data packet format [17-19].

3. Module Design of System

3.1. Design of Temperature Sensor Module

After studying some widely used temperature sensors on the market, a relatively popular smart temperature sensor is selected instead of traditional analog integrated temperature controller. Smart temperature sensor can output temperature data and associated temperature control quantity to adapt to a variety of microcontrollers. Furthermore, it implements its function by software on the basis of hardware, and its functionalization degree depends on the development level of software. Common smart temperature sensors are AD7416 and DS18B20.

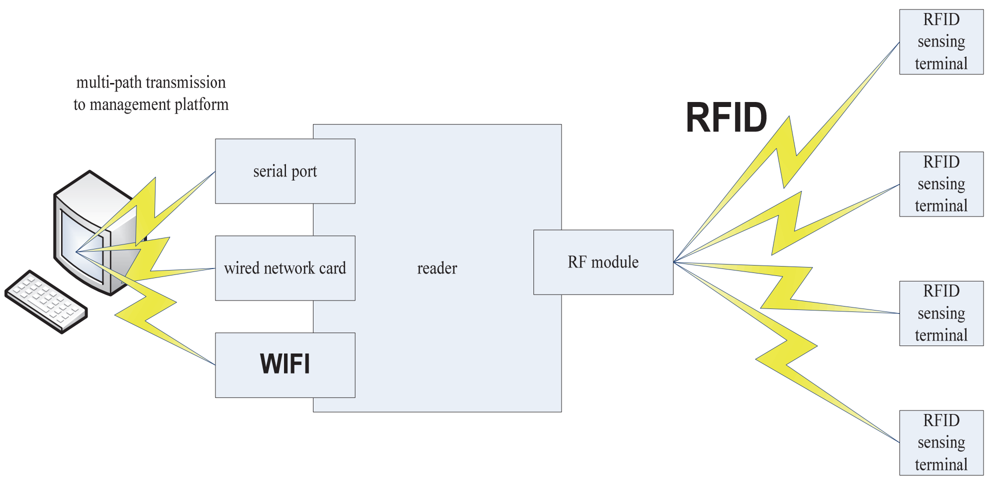

Fig. 1. System structure.

AD7416 is the analogy devices company monolithic integrated temperature monitoring system manufactured by American analogy devices company (ADI). Its interior contains a band gap temperature sensor and 10-bit AD converter, which can transform induction temperature into digital signal of 0.25 ℃quantized interval and used to compare with the temperature point set by users. The temperature sensor can be widely used environmental temperature monitoring in data acquisition system, industrial process control, the battery as well as the personal computer system and son on.

The DS18B20 type single intelligent temperature sensor was manufactured by Dallas Semiconductor Company, which belongs to an intelligent temperature sensor of new generational adaptive microprocessor intelligent temperature sensor. Unlike traditional thermistor temperature sensor, it can directly be read out measured temperature, and according to actual requirements through simple programming in the realization of 9 and 12-bit numerical values reading and writing mode, it can respectively within 93.75 ms and 750 ms turn temperature values into 9 and 12-bit digital quantity. DS18B20 digital temperature sensor wiring is convenient, which can be applied to various occasions after packaging. Wear resistance and crashworthy, small size, easy to use, packaged in various forms, it is suitable for all kinds of small space equipment digital temperature test and control field, which is the main characteristic of DS18B20.

DS18B20 internal structure is mainly composed of four parts: a 64-bit lithography ROM, temperature sensor, nonvolatile temperature alarm triggers TH and TL, configuration register, which is presented in Fig. 2.

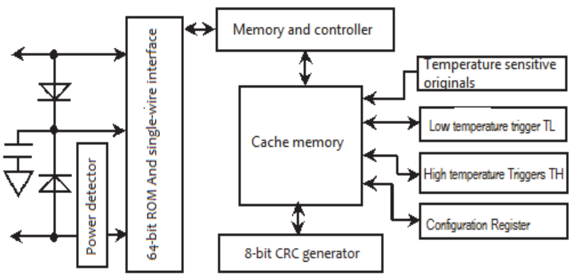

Fig. 2. DS18B20internal structure diagram.

1) The 64-bit serial number in the lithography ROM is well lithography before delivery; it can be seen as the DS18B20 address sequence code. The arrangement of 64-bit lithography ROM is: the initial 8-bit (28H) is the product type label, the following 48-bit is the DS18B20 own serial number, the last 8-bit is the above 56-bit cyclic redundancy check code (CRC=X8+X5+X4+1). The effect of Lithography ROM is to make each DS18B20 are different from each other, so it can realize the purpose of a bus that connect multiple DS18B20.

2) The temperature sensor OF DS18B20 can be completed on the temperature measurement, exemplifying 12-bit transformation, using 16-bit sign-extended binary complement sign reading form supply, expressed in the form of 0.0625℃/LSB, where S is the sign bit.

The major factors of this topic are the size of chip hardware, marketing cost and the serial bus of data transmission. Compared the two sensors, DS18B20 has simpler structure, parasitic power, 3 pins, small hardware overhead and smaller volume; device cost has more dominant advantage (AD7416 is about 12 yuan, and market price of DS18B20 is around 5 yuan); data transmission applies the single bus connection which is qualified with simple line, convenient expansion and simpler compile program, compared to other bus connection. After comparison tests, DS18B20 is selected as the temperature sensor of this project.

3.2. Design of RF Module

In this project, communication mode of 433 MHz high frequency link is adopted between sensing terminal and reader, and the applied chip is CC1100 chip. CC1100 chip is developed and manufactured by CHIPCON Company. It is a wireless RF chip used to achieve low-cost, short-range wireless communication. Performance can be improved by turning on the forward error correction option integrated in the modem [10].

Taking active electronic label for example, a complete module structure is mainly composed of wireless radio frequency module, antenna, microcontroller (MCU), sensor, power supply module. The hardware structure diagram is shown in Fig. 3.

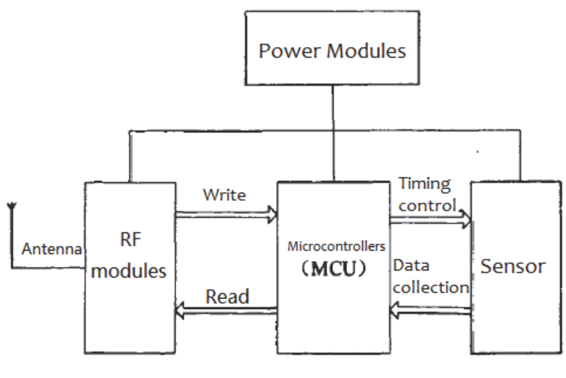

Fig. 3. Sensor label structure.

After the electronic label electrifying, first, wireless RF module and sensor were initialized, complete, transmit-receive address, transmit-receive frequency, transmission power, wireless transmission rate, wireless transceiver mode, and the length of the CRC verification and effective data length and other information setting of RF transceiver in RF chip. Then Microcontroller transmit data that the sensor regularly collected to RF chip via the communication interface, and RF chip sent again via the transmission mode.

Semi-active RFID temperature sensor label VarioSens Basic, The American Gentag announce that they have already designed, applied for patent and successfully tested a temperature sensing circuit, European Union Bridge project that GabrieleIsola and Fabrizio Bertuccelli involved in has developed with semi-active RFID tags with temperature sensor, support EPC C1G2/IS018000.6C standard, can be used for fresh food, frozen food, medicine storage, distribution and sales.

It is famous for communication line terminal of TekVet's RFID livestock tracking system, which allows investors and producers immediately confirm the location of the cattle through the network, meanwhile, the cow's temperature can be real-time monitored, the cattle health situation can be understood at any time. At present, TekVet is still in the study of sensor system which can monitor blood pH (PH value) and the heartbeat. The Atlanta HotHead Sports company and Identec strengthen cooperation with GE Sensing and Cavist company, will launch a RFID football helmet, the temperature information will be delivered to trainers or other staff.

This topic between sensor terminal and reading and writing device is applied 433 MHz high frequency link communication mode, the chip select CC1100 chip, which is presented in Fig. 4. CC1100 chip is researched and manufactured by CHIPCON Company, which is used to achieve radio frequency chips that implement low-cost short-distance wireless communication. By turning on forward error correction options which integrated on the modem, we can improve the performance. CC1100 is specially designed for low power wireless applications, the RF transceiver working at 315 MHz, 433 MHz, 868 MHz and 915 MHz ISM (industrial, scientific and medical) and SRD (short range device) frequency band, which also can be set up through software programming frequency band 300 MHz to 348 MHz, 400 MHz to 464 MHz and 400 MHz to 928 MHz. CC1100 interiorly also integrates a highly configurable modem, the modem supports different modulation formats, its data transfer rate is up to 500 Kb/s. CC1100 can provide packet handling, data buffering, burst data transmission, clear channel assessment, link quality indication and electromagnetic with hardware support.

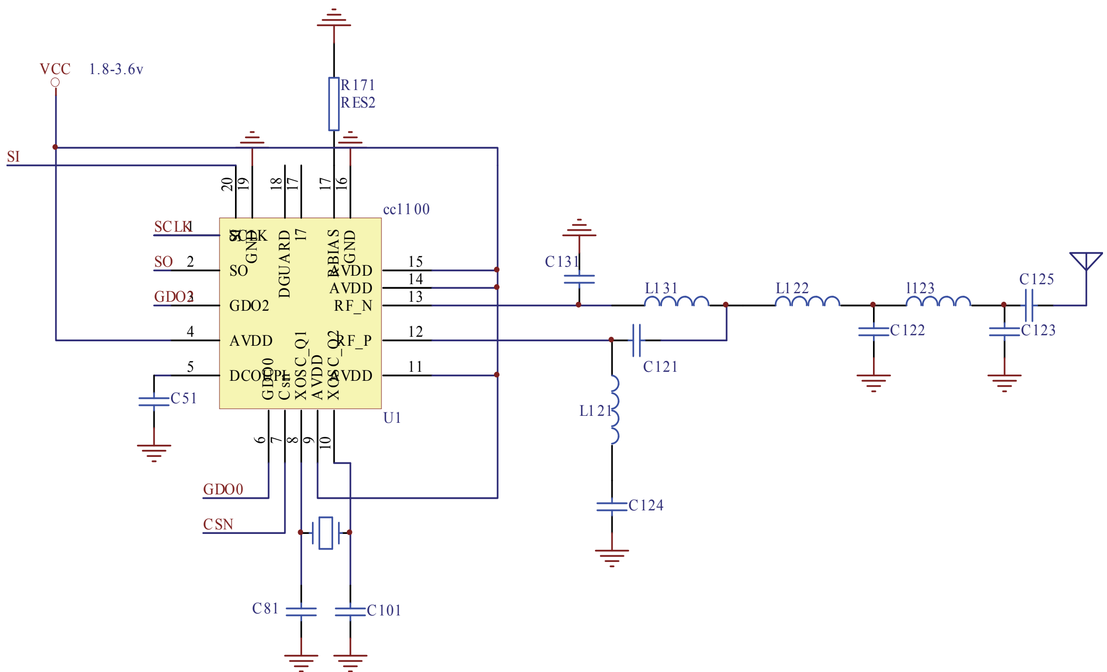

Fig. 4. CC1100 Application Circuit.

CC1100 is suitable for AMR automatic meter reading, electronic consumer products, RKE - two way remote keyless entry, low power telemetry, residential and building automatic control, wireless alarm and safety systems, industrial monitoring and control and wireless sensor network applications area and so on, which is presented in Table 1.

The CC1100 main product features as follows:

High sensitivity (-110 dBm/1.2 kb/S, 1 % packet error rate);

Lower current consumption (15.6 mA in the RX, 2.4 KBPS, 433 MHZ):

Programmable output power, all frequency bands provide 30.10 dBm output powers.

Very few external components: chip frequency synthesizer, and does not require an external filter or RF converter;

Table 1. Parameter of CC1100 application circuit component.

Element	Value	Description
C51	100 nF	The 100 nF decoupling capacitances of voltage regulator of digital part.
C81/C101	27 pF	Crystal load capacitance
C121/C131	6.8 pF	RF Balun/matching capacitance
C122/C123	12 pF	RF Filtering/matching capacitance
C124	220 pF	RF Balun DC Module capacitance
C125	220 pF	RF LC filtering DC Module capacitance
L121/L131	33 nH	RF Balun / matching capacitance
L122/L123	18 nH	RF LC filtering / matching capacitance
R171	56 K	The 56000 ohm resistances of internal partial current reference.
XTAL	26.0 MHz	26 MHz-27 MHz crystal

Support 2 FSK, GFSK and MSK modulation way;

Wide working voltage range that all can be work from 1.8 V-3.6 V, which can use battery power;

Many powerful digital characteristics, make use of cheap micro controller can get high-performance RF system;

The controller interface configures easier (4 SPI bus interface);

The flexible support of packet-oriented, synchronous word detection vocabulary of chip support, address check, flexible packet length and automatic CRC handling; In addition, there are many useful functions: automatic packages and unpacking of data, independent transmit/receive FIFO, idle channel assessment function, automatic wake-up function, RSSI function, automatical forward error correction (FEC), interleaved and albino function. These features are very suitable for wireless sensor networks [12-14].

3.3. Design of Control Module

Currently, there are many MCUs in the market, but considering the requirements of system, especially the requirement of low power, STC89C52 chip is chosen through the cost performance comparison of various chips. This microcontroller is the new microcontroller of high speed / low power / super anti-jamming promoted by STC, the instruction code is fully compatible with the traditional 8051 microcontroller, and 12 clocks / machine cycle and 6 clock / machine cycle can be arbitrarily selected. User application program space is 8 K bytes, and 512 bytes RAM is integrated on chip. Only simple peripheral circuits can implement the design of entire control module.

3.4. Power Module

As shown in Fig. 5, working voltage is 5 V, but the working voltage of CC100 ranges between 1.9 V-3.6 V. The module will burn if the voltage is more than 3.6 V. So the recommended voltage is around 3.3 V. Except for the power VCC and ground terminal, all the remaining pins of CC1100 can be directly connected to I / O port of ordinary 5 V microcontroller without level conversion. The regulator module of ASM117 outputs +3 V, which can regulate the VCC of microcontroller for the application of CC1100. Furthermore, in order to make the tag be more convenient for test, three AA batteries are applied to supply power for microcontroller.

At last, The principle diagram of electronic label control module is shown at Fig. 6.

4. Design of Software System

4.1. Design of Sensor Control Software

As shown in Fig. 7, after completing Rf module initialization, through ds_reset () function reset temperature sensor.

Using read_temp () function to read the temperature value will be transmitted to iso_18000-7 _stack_push () function to compress the temperature data into data packets.

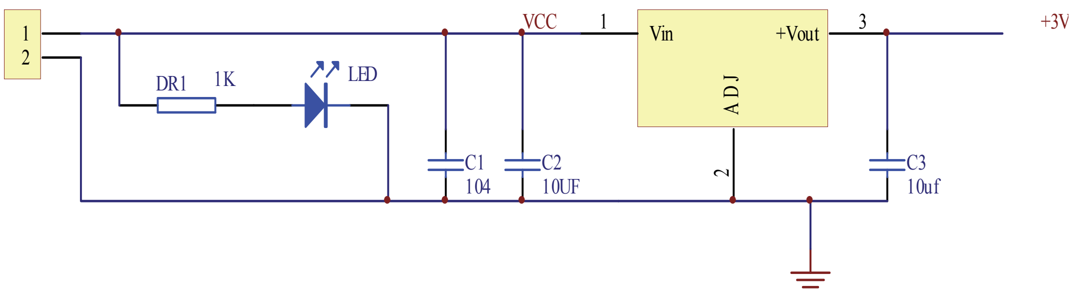

Fig. 5. ASM117 stable voltage circuit.

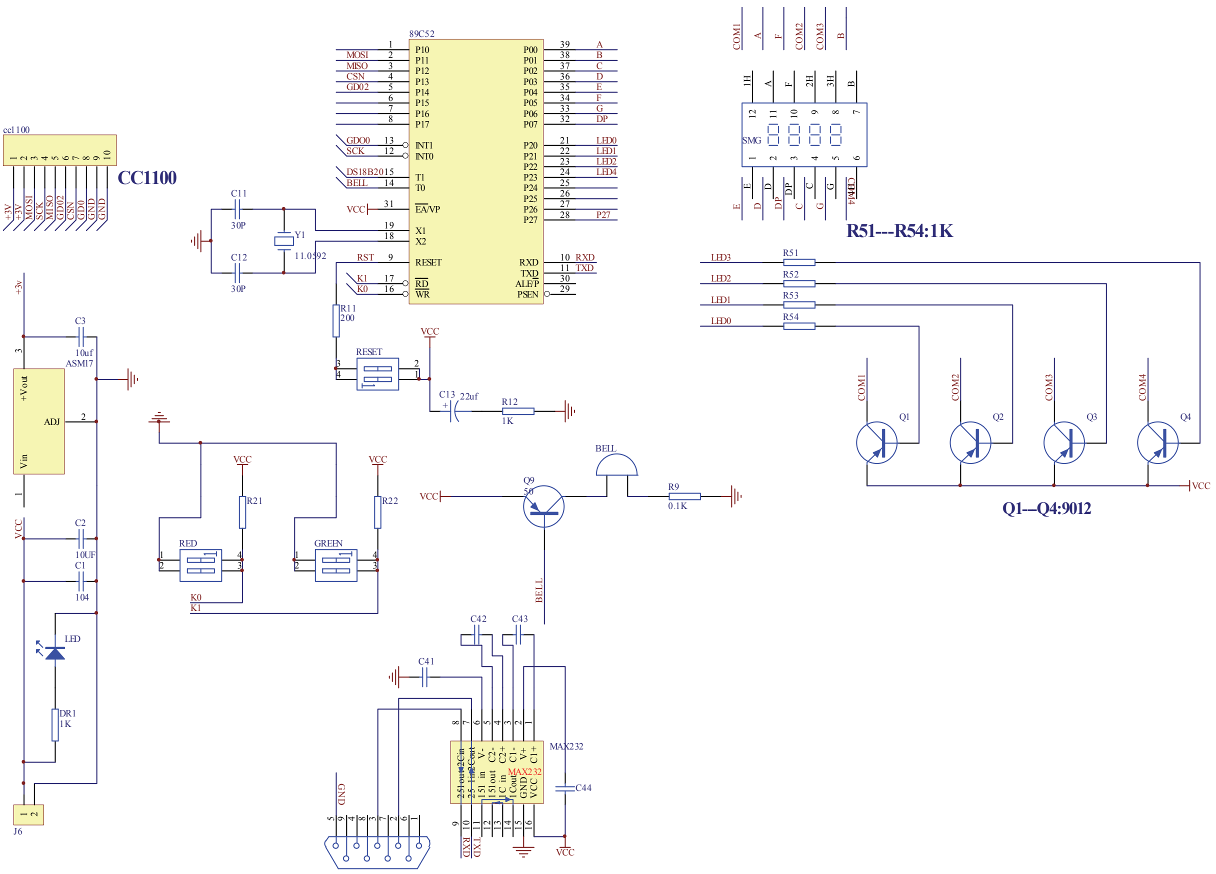

Fig. 6. The principle diagram of electronic label control module.

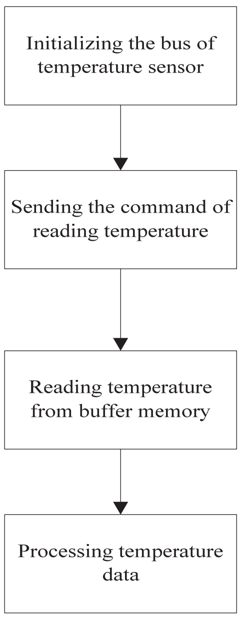

Fig. 7. Flow chart of sensor control software.

4.2. Design of RF Module Software

As shown in Fig. 8, first of all, the radio frequency module through SpiInit () function, output CC1100 clock line and chip selection line, make the chip selection CSN ultimately setting 1, the clock SCK setting 0.

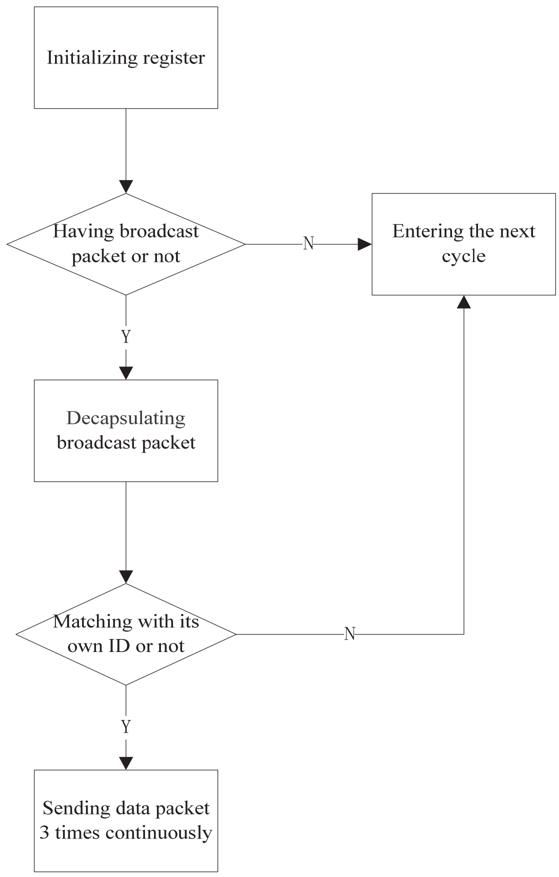

Fig. 8. Flow chart of RF module software.

After Initialization of the clock line, we need to reset the CC1100 register values to avoid CC1100 registers with residual configuration. Through RESET_CC1100 () function, transmitting RESET command to CC1100 chip, electrify the chip and reset registers values. When reset all register are set to the default value, reset the TEST cluster that also set to the default value and the user can change.

Through halRfWriteRfSettings () function will make write initial configuration write CC1100 corresponding register.

After configuring register, use halSpiWriteBurstReg () function configure sensing terminal transmission power. The sensing terminal transmission power configuration is 0 dm, increase the transmission distance.

After the completion of the initialization phase, through halRfReceivePacket function, we wait to receive command protocol that reader transmits.

By judging ID number is your current ID whether or not, transmit the corresponding data [15-16].

4.3. Process of Software Design

As shown in Fig. 9,

1) The control chip initializes sensor chip through single bus, and then sends command of collecting to the sensor chip.

2) The control chip initializes RF module via CS, SCK bus, to make RF module stay in the transceiver state.

3) Temperature sensor starts collecting temperature data of the surrounding environment.

4) The control chip detects whether the temperature data are legitimate, that is, whether they are beyond the maximum or minimum settings.

5) The temperature data are transmitted to the RF module by the control chip.

6) The RF module conducts hardware encapsulation on temperature data, which is package framing (adding header and trailer).

7) RF module sends the temperature data.

8) The program returns to the period of data code, and repeats the process of 1-7.

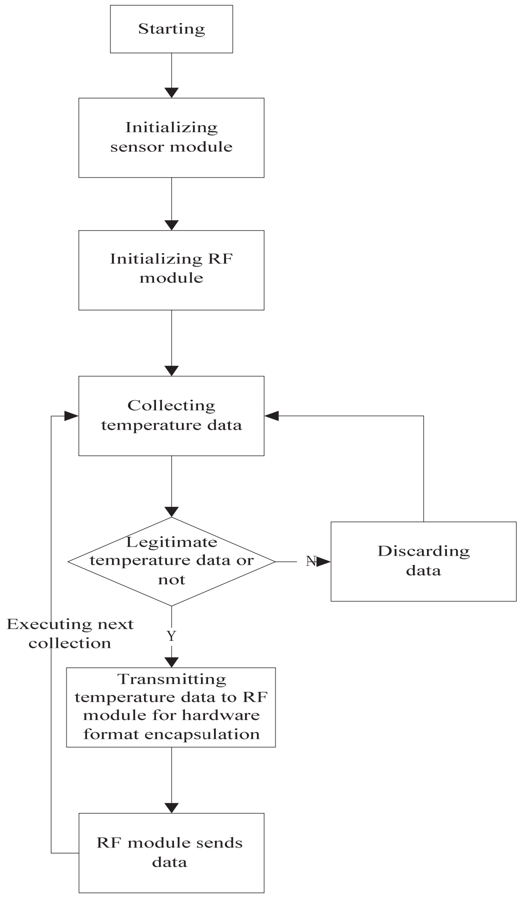

Fig. 9. Overall operational process.

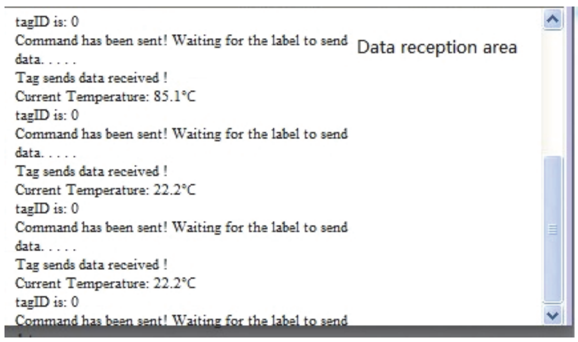

Fig. 10. Flow chart of RF module software.

5. Verification Test

5.1. Performance Test of Sensor

Being powered on, the RFID sensing terminal is copied into transceiver program. Sending terminal collects indoor air temperature, processes the data, and then sends it to the reader. After receiving the data, the reader converts the binary data by using binary to decimal conversion algorithm and transmits it to serial port program which displays the temperature data received through serial port, which is shown in Fig. 10.

5.2. Performance Test of RFID Electronic Tag

After debugging hardware, communication distance of the tags is tested. CC1100 chip is qualified with programmable transceiver power which is set by CCxxx0_PATABLE, which are 0 dBm, -30 dBm and 10 dBm respectively. The communication distance may vary by changing power of the sender and receiver. Assuming an electronic label as the sender and the other as the receiver, the sender transmits the temperature collected to the receiver. The sender is programmed to send data to the receiver every 200 ms, and the sender is fixed at a certain position while the receiver moves from near to far; when the receiver cannot receive the temperature, it can be determined that the distance of sender is beyond the communication range of the receiver. By changing the power of sender and receiver through programming, the communication distance of different power combinations can be determined. Experimental environment is as following: outdoor open space, free of obstacles, fine weather and electronic label with external antenna. The mean value of several tests is adopted, the transceiver distances measured by experiments are shown in Table 2, and the unit is in meter.

As can be seen from the results of the above table, the communication distance between RFID electronic tags can reach about 134.6 meters. Because of environmental factors, some of the test results may be affected, but the general results work as expected.

Table 2. Distance test of RFID tags.

Sending power \ Received power	10 dBm	0 dBm	-30 dBm
10 dBm	134.6	86.2	69.7
0 dBm	26.7	23.4	16.7
-30 dBm	8.6	11.4	6.3

This paper conducts debugging implementation to all communication instructions, and the specific implementation steps are listed as follows. Reader sends work commands to tags, and active tag conducts instruction parsing on the commands received from reader, and returns corresponding instruction data to the reader; after receiving tag data, reader directly sends it for serial display without any treatment. Through the serial data, tag is analyzed for whether it can correctly process, send and receive commands.

Fig. 11 is to show ID command of tag is read to debug serial data. Three tags sent their ID information and temperature collected to the reader, and the tags can successfully complete the reading of ID instruction. Currently, all communication commands have passed the debugging in this way [20].

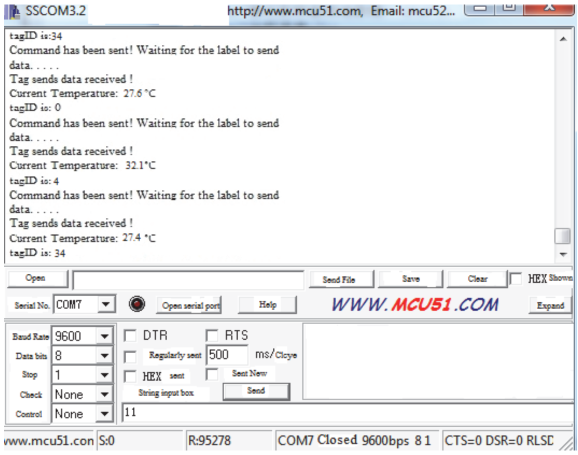

Fig. 11. Broadcast command of reader to read three tags.

5.3. Overall Test of System

The login screen of management software (designed by Wang Hongsheng, Xu Ye) is shown in Fig. 12. Before logging in the system, several sensor tags are placed on some laboratory equipment, and the reader is turned on to receive data. When the management software receives data uploaded by the reader, it can determine the equipment via ID, and then displays the result in the management module of device working status.

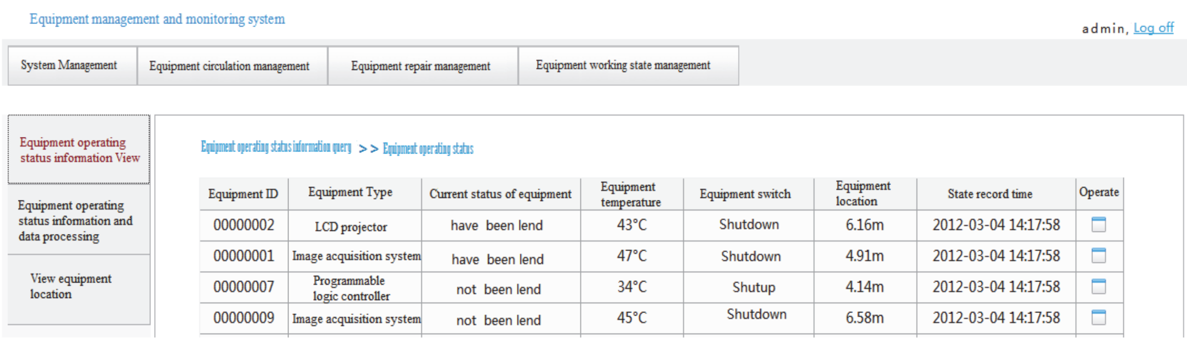

Fig. 12. Testing results of graphical software.

6. Summary and Outlook

RFID technology is the use of radio frequency to realize non-contact automatic identification technology, which is to enhance the level of social informatization, promote logistics automation and whole-coursing, enhance public security and other ways can produce great economic and social benefit. The research and design of topic is an exploration of the RFID technology, RFID sensor terminal of research and design, make it can be placed on equipment, and identify and monitor equipment. If later improved, it will have broad market prospects.

RFID technology is not just limited to the supply logistics, retail, etc., with the further development of the RFID radio frequency identification technology and marketization, it will play an important role in the many areas and many industries, so the RFID application in various fields are introduced in detail, show the significance of development of RFID at home and abroad.

This paper focuses on the design and research of RFID sensing terminal's hardware and software. DB18S20 sensor is applied as hardware, STC80C52 chip is used as controller chip to control the sensor, CC1100 chip that is popular in market is applied as RF chip, the frequency is at 433 MHz and the data collected by sensor is sent to RF module for transmission.

With the increasing demand for real-time monitoring and diversification of device status, this design will have more efficient sensor chip, such as pressure sensors, fans transmission sensor and a series of other sensing devices, to ensure smooth operation of the device. Software design can apply more efficient chips like ARM chips, to conduct multiple tasks. More researches and achievements in this area are left to be improved in the future work.

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