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Intelligent greenhouse control system Design

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ABSTRACT: *Parameters such as temperature, humidity and light intensity are important factors affecting the growth of crops in the greenhouse, and the real-time remote monitoring and integrated management of the crop growth environment can improve the yield. With the continuous development of the Internet of Things technology and the popularization of greenhouse technology, the real-time monitoring of the growth environment of crops has become possible. In order to realize the intelligent and information management of greenhouse, this system uses sensor detection technology, AT89C51 single chip, USR-TCP232-T2 serial port to Ethernet module, Web server and Android application mobile front end of the greenhouse remote control system. By analyzing the data in the database, the temperature, humidity and light intensity in the greenhouse are automatically controlled. At the same time, the Web server pushes real-time monitoring, alarm and other information to the mobile terminal, making the Internet of Things technology play an important role in the greenhouse production. Ensure that the environment in the greenhouse is suitable for the growth of crops, create favorable conditions for the high yield, efficient and scientific management of crops, and reduce unnecessary economic losses.*

KEY WORDS: *sensor, single-chip microcomputer, Web server, Android*

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I. Introduction

With the improvement of living standards, people's demand for fresh vegetables is increasing. Greenhouse plays an important role in solving the problem of people's vegetable basket and promoting the adjustment of agricultural structure. Traditional greenhouse planting only uses a thermometer to collect the temperature in the greenhouse, and the management of humidity and light intensity can only be controlled by the change of weather. This kind of artificial operation wastes manpower, and has no scientific management, which has great limitations on the growth environment control of crops in greenhouse. Therefore, a cheap, intelligent, accurate measurement of the data of the greenhouse control system is needed.

It is very important to create a very suitable environment for crops, which is inseparable from scientific management. Scientific management can reduce the impact on the growth of crops, and make greenhouses rely less and less on the external environment. The shorter the growth cycle of crops, the more yield and the economic benefits. Using modern sensor technology, computer, automation, communication technology combined application for the modern greenhouse control system provides a lot of options and solutions [1]. Since China's economic boom, the growing population has at the same time brought the problem of the rapid decline of arable land. An important reason for the reduction of available arable land is soil pollution. So reducing soil pollution and increasing the arable land area is of great strategic significance.

For the development of agriculture, due to the differences in geography, the development situation at home and abroad is not the same, but the development of greenhouses is the same, the development and utilization of greenhouses have to be said to be a very good way. Greenhouses can use the land throughout the year, doubling its income. The material demand used in greenhouses is very important. Only reasonable and powerful materials can be planted in the season when greenhouses cannot breed crops at room temperature.

However, the study of cash crops began earlier in some developed countries abroad. At the beginning, it was a relatively simple device, with a not intelligent development method. By the end of the 1980s, due to the development of distributed control system and sensors, free networking has been widely developed, especially the development of high-performance computer technology, so that the information collected by sensors can be quickly analyzed quickly, and intelligent analysis can be realized, to help people make scientific judgments. Thus, the greenhouse can present a large-scale development, especially towards the direction of intelligent development.

Foreign countries not only make the traditional agriculture presents the characteristics of modernization, but also apply the current high technology to the field of greenhouse planting. For example, the

application of ZigBee technology, database technology and supercomputer can already be well used in the development process of greenhouse. The most important intelligent control is long-distance, automatic control. The construction of information management and communication platform in the network platform can realize that the situation of the greenhouse can be seen in real time as long as there is the network, which can control the situation in the greenhouse more effectively, and realize the treatment of emergencies is more scientific and reasonable.

Microelectronics and automatic control technology corresponding to modern computer technology are booming, such development makes the market to greenhouse temperature and humidity and light control system become more detailed and accurate become a trend. Therefore, the greenhouse is also constantly improved with the requirements of the market, so that the greenhouse in many aspects have also made progress in advance.

(1) Intelligent technology. The greenhouse needs the best growing environment on the computer as a vague dynamic data. Because the process of greenhouse crops is very complex, the growth cycle is relatively long. Due to various reasons, there are many uncertainties about the control of greenhouses. The most important thing is to take into account the safety of temperature crops, including the market, technology, talent, and equipment, so no management cannot be achieved for the time being.

(2) Distributed system structure. In the previous relatively outdated temperature control system, there was mainly a host terminal as the control center of the whole greenhouse. Then, the control adjustment of each subsystem is realized through this host. But this control method is relatively simple or even too crude. Due to the rigid system mode and poor reliability is gradually abandoned. The distributed system of this system is just like the parallel connection of the circuit, with low coupling between each subsystem, easy to detect system faults, and good scalability.

(3) Multi-factor control mode. Use a variety of controls to manage the control in the system greenhouse, so that the subsystems can cooperate with each other, so as to achieve the multi-functional control effect.

(4) Integration of human intelligence system. In the greenhouse, each subsystem will affect each other, cooperate and restrict each other. In the future, the development trend of greenhouse control system is to combine the manager and system of greenhouse with each other, so as to realize a highly integrated human-machine intelligent system.

II. Overall design

As the hardware control system of the system, the main function is to collect data from the sensor, use the USR-TCP232-T2 module to convert the serial port data to Ethernet data, transfer the data collected by the MCU to the remote Web server, the MCU can receive the control information from the Web server in real time, and raise or lower the port of the MCU. Mobile applications can also request relevant data from the web server to monitor the greenhouse in real time. So the "heart" of this system is the web server. It is the interaction center between mobile terminal and hardware data, and the mobile terminal sends the necessary control signal. For the microcontroller control system, how to accurately obtain and identify the control signal is its core task. The "left and right arm" of this system is the sensor, which is the primary part of single chip microcontroller measurement and temperature and humidity environment control, but also is the key part of single chip microcontroller measurement and control.

2.1 Design requirements

Design a Web-based greenhouse environmental monitoring and control system. Design requirement:

1. Requirements for each index of greenhouse (light intensity, temperature and humidity) for real-time measurement and then in conversion, by 51 single-chip microcomputer sensor acquisition temperature and humidity, light parameters serial port to ethernet module uploaded to the remote server, can request through the mobile terminal remote server data on the current temperature value, humidity value and light.
2. Single-chip microcontroller control and conversion system. After collecting the growth environment parameters of the crops in the greenhouse, it turns to the Ethernet module and uploads them to the Web server through serial port. At the same time, it can receive the control signal from the Web server in real time, make a correct judgment, and open the exhaust fan, sprinkler switch and other switches in the greenhouse.
3. The Web server control system. It receives the data from the data uploaded by the microcontroller in real time and stores it in the database, and monitors the online mobile terminal and pushes the alarm information to the mobile terminal. The control personnel of the greenhouse can set relevant parameters on the web server, such as the temperature and humidity that are most suitable for crop growth, illumination, etc.
4. Mobile terminal. It can obtain data from the server for display, monitor the real-time push from the server side, the system is stable, and can set the upper and lower limits of the parameters in the system.

2.2 Overall system scheme

The system uses the STC89C51 as the control core in the greenhouse, calculate and analyze the collected temperature and humidity and light signals, and then upload the analyzed data to the Web server, then the Web server will immediately store the received data in the established MySQL database, and then make corresponding operations according to the upper and lower limits of the parameters set in the system. The Web server can also be connected to multiple mobile terminals, the mobile terminal requests the server data for display, and the microcontroller can be controlled in real time through the Web server. The overall design structure diagram of the system is shown in Figure 2-1.

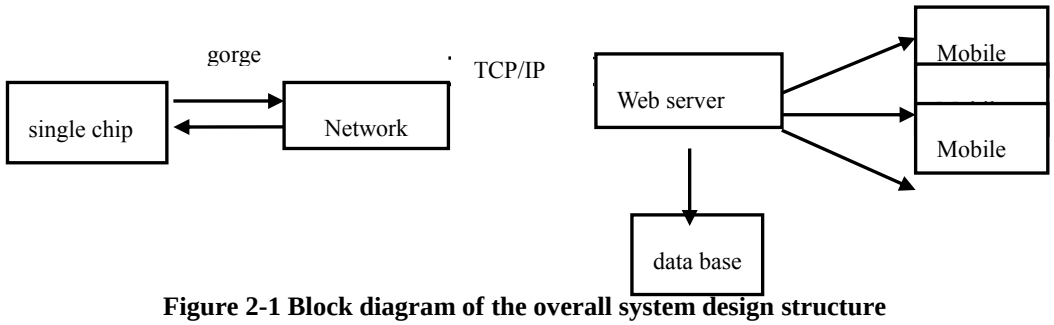

Figure 2-1 Block diagram of the overall system design structure

III. System hardware design

3.1 Main control module

The single controller used in the hardware master control module in the system is the control core of the whole hardware system, which can control the surrounding control switch and sensor coordination work, so as to complete the predetermined function. MCU is a kind of integrated circuit chip microchip, which is a miniature multi-function computer system composed of high-speed processor, program memory, timing counter and various input and output parts.

3.1.1 Scheme selection

Scheme 1: STC12C5A60S2 single-chip microcomputer. STC12C5A60S2 Single chip microcomputer is a single clock high performance single chip microcomputer, the low power consumption, high speed, strong anti-interference and other characteristics make it 8-10 times [2] higher than the traditional 8051 model single chip microcomputer speed. The internal 10-bit A / D conversion reset circuit is suitable for strong interference situations. But its programming is more complex, more suitable for the replication of the system.

Scheme two: AT89C51 micro. AT89C51 Is a multi-functional single-chip microcomputer produced by ATMEL company, it is simple to develop, internal integration of multiple memory and program memory, its internal control bus is stable, simple structure, strong versatility, with a complete command system.

The technology and development time options that need to be met in the integrated system.

3.1.2 STC89C51 SU function

STAC89C51 Is a typical single chip microcomputer kernel, with only 1 kernel of high-performance clock circuit, such a structure compared to other multi-clock cycle circuit, a single chip microcomputer clock cycle will improve the operation speed of 8 times. The voltage of the normal operation of the MCU can be maintained at about 3.3v-5v, and the possibility of power loss will be analyzed when the normal operation of the MCU is stored in the storage every time. Single chip computer also provides low power supply test, in the use of single chip computer is also very safe, save electricity. Used to store data and tables in the tablet. STC89C51 Microchip ROM storage can greatly improve the storage flexibility of programs, and support multiple changes and rewriting of the internal space.

3.1.3 Min. system circuit of SCM

The minimum system is composed of reset circuit, crystal shock circuit and data memory. STC89C51 The circuit diagram of the minimum system is shown in Figure 3-1.

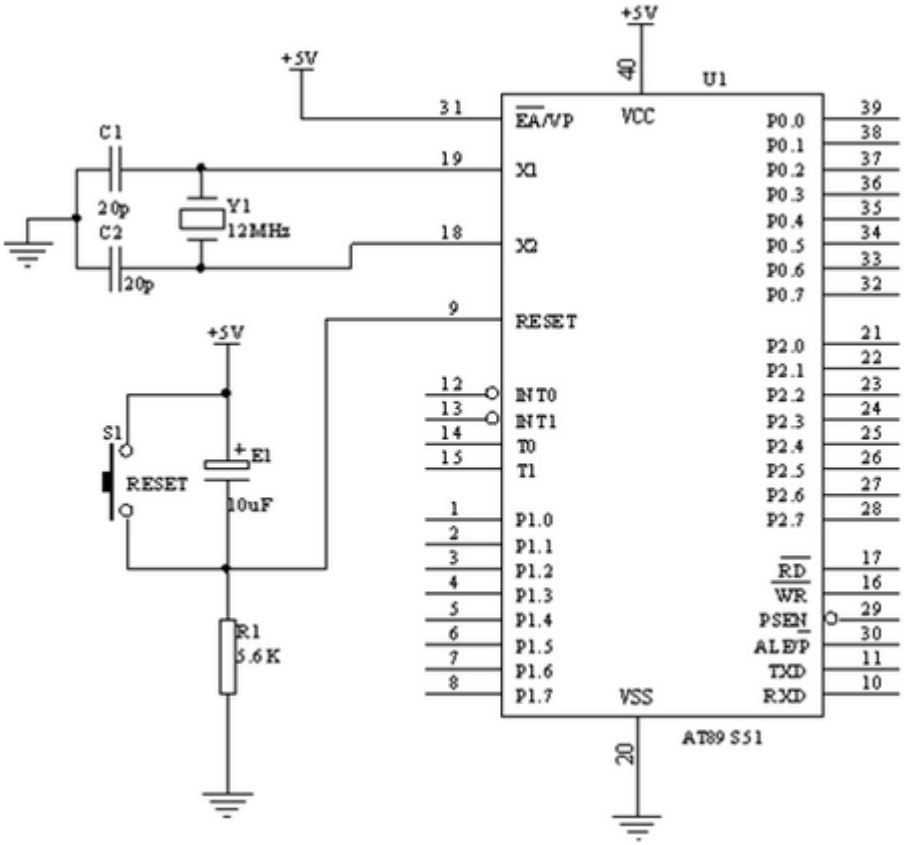

Figure 3-1 Circuit diagram of STC89C51 SCM minimum system

3.2 The transmission module

The data collected by the microcontroller from the sensor needs to be uploaded to the remote server. The microcontroller itself does not have the function of uploading the data to the Internet, but only through the serial port RTX and TXD, so it is necessary to convert the data of the serial port through the network module.

3.2.1 Scheme selection

Scheme 1: ESP 8266 Wi-Fi communication. ESP8266 Is a low cost, small size encapsulation Wi-Fi chip, its ultra-low energy consumption technology in the actual production medium to the wide application, ESP8266 can realize network can also be connected to the Internet, ESP8285 is with 1 MiB built-in flash memory ESP8266, allows to connect to Wi-Fi single chip equipment connected to the ESP8266 Wi-Fi wireless network, realize remote network control function.

Scheme 2: USR-TCP232-T2 serial port to Ethernet module. USR-TCP232-T2 module realizes the transmission of TCP data from the serial port information to Ethernet network port, without the need to care about the internal conversion details, and the internal module fast is to convert the serial port information into TCP / IP protocol information. Serial port is TTL level data, Ethernet is network data packet, and transmission mode is transmitted to the Internet by TCP, UDP or HTTP protocol. Parameters can be set through built-in web settings, one once. The module is directly connected to the Internet to transmit data to the remote server, with TCP reliable transmission, can realize real-time monitoring and secure transmission. However, many modules are used to realize the networking.

Based on the above comparison, scheme 2 is suitable for data transmission between microcontroller and Web server.

3.2.2 Introduction of the USR-TCP232-T2 module

The overall function of USR-TCP232-T2 is shown in Figure 3-6, with the advantages of a small footprint, low power consumption and high stability. TCP / IP mode is the main transmission protocol of USR-TCP232-T2 in this system. After the user equipment is connected to T2 module, the serial data is packaged through internal circuit to analyze the data packet after mode selection. The parsed data is then set into a data format that can be transmitted on the Internet. When connecting, this network module is designed in TCP Client mode, which means that chip and network module are customer service terminals. When connecting the remote

server, the IP and port number of the server should be set. The IP and port number will be encapsulated in the packet during the data protocol conversion.

In TCP Client mode, a heartbeat packet will be sent at regular intervals inside the module. The heartbeat packet can be sent to the remote server or to the microcontroller serial port device to monitor the long connection to prevent the connection from disconnecting. The module can also send a registration package when connected to the remote server side to identify the data source device and prevent other malicious devices from making the system more secure when the module is TCP Server.

3.3 Temperature and humidity measurement module

3.3.1 Scheme selection

Scheme 1: Thermistor is adopted. Thermistor is the use of different temperature induction of the induced current and voltage, through the circuit A / D conversion into digital signal, single chip processing digital signal need to deal with more parameters, the circuit is complex, the scalability is poor [3].

Scheme 2: Adopt wet sensitive capacitor. Wet sensitivity capacitor is the use of humidity sensing in the air, the electrical signal into data signal, it has the corresponding fast, high sensitivity, integrated high [4].

Scheme 3: Use DHT 11 temperature and humidity sensor. DHT 11 integrates the detection of temperature and humidity at the same time. In DHT 11, the wet capacitor is used to detect the humidity, and the thermistor is used to detect the temperature, which has the advantages of scheme 1 and Scheme 2. At the same time, the measured signals are converted into digital signals, which is conducive to the data collection and data conversion. DHT 11 is easy to use, small size, high precision and wide range of application.

In comparison, Scheme 3 is more suitable for the selection of temperature and humidity sensors in this design system.

3.3.2 Introduction of the DHT 11

DHT 11 is a composite sensor that combines temperature and humidity for packaging and collection at the same time. Its internal signal is the calibrated digital module acquisition and temperature and humidity measurement. The sensor has a wet resistance element and an NFCT temperature measurement element, which is stored in the calibrated 0 TP memory in the DHT 11 program. The original uses single line serial transmission to make the transmission reach more than 25 meters, the system integration is small, small occupation volume, and is suitable for temperature and humidity detection on multiple occasions. DHT 11 uses single-line data transmission to shorten the communication time to 4ms, and the data transmission size reaches 80 bytes, of which the first 40 bytes are the temperature data, and the last 40 bytes are the humidity data. When DHT 11 is in low consumption mode, it will send the end signal after the host is powered on, and then send the response signal without the end signal sent to the MCU, it will not actively conduct temperature and humidity acquisition. After collection, DHT 11 switches to low speed mode, and the communication process of DHT 11 is shown in Figure 3-2.

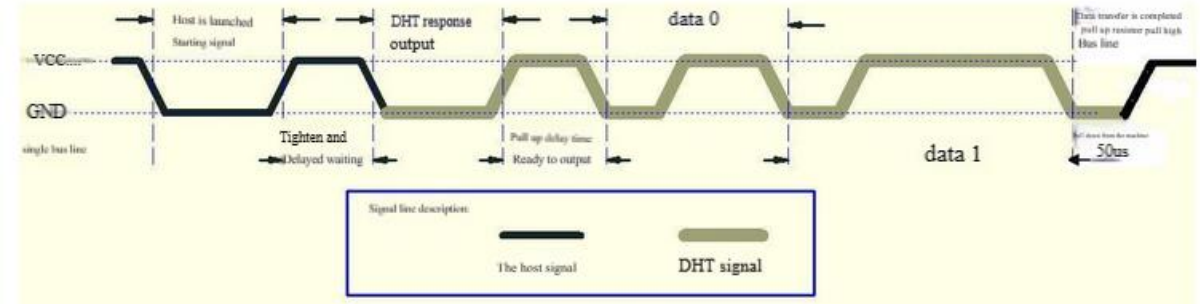

Figure 3-2 The communication process of the DHT 11

3.4 Light measurement module

3.4.1 Light intensity

The light intensity refers to the degree to which an object is illuminated by light, which is based in Ix (l Lux), that is, the ratio of all the light intensity on the surface of an object to the area illuminated. The intensity of light will change with the season. For example, in summer, the light intensity can reach 60000 ~ 1000000 lx, while the light intensity in winter is 10000 ~ 20000 lx.

3.4.2 Scheme selection

Scheme 1: Light sensor TSL2561. In the current complex lighting environment, the brightness of the display screen can be adjusted at any time can effectively reduce the consumption of power supply. It can be used in many places of society. The main features of the chip are as follows: it can be programmed to control the critical

value up and down, and the signal can be interrupted at any time.
Scheme two: the so-called photoresistor is a kind of resistor made by using the photoelectric effect. In relative darkness, the resistance ranged from 1 to 10 M Ohm. But if the resistance is illuminated with strong light, the resistance value is only a few hundred euros. Even if the human eye can feel the change in light, it will lead to this change in resistance value.
Scheme 3: the illumination module GY-30. Through this module to change the modulus to the converted circuit, direct digital output, relatively speaking, the peripheral circuit is relatively simple. Suitable for almost all kinds of electronic device displays,
In summary, select Scheme III.

3.4.3 GY-30 light metering intensity circuit
GY-30 chip contains five pins, respectively VCC connected to 5V voltage, SCL pin connected to P1.6 chip for data output, SDA pin connected to P1.7 pin for data input, ADDR and GND, the GY-30 optical intensity circuit diagram is shown in Figure 3-3.

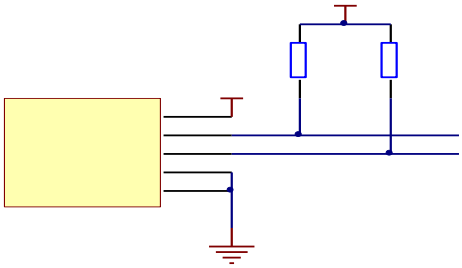

Figure 3-3 GY-30

IV. System software design

4.1 Overall idea of system software design
Design a reliable and stable system is not separated from the strong hardware support and software cooperation. In modern society, software can replace many hardware tasks to complete [5]. Even the software can make some complicated circuits simple.
This design hardware programming is STC89C52 SU, composed of main program, temperature and humidity, illumination acquisition subroutine, and alarm control modules. Web server programming using Java language including MySQL database, etc. Mobile terminal programming under the main Android system environment, mainly uses the HTTP network request framework, DB Utils do database. Request after a package is easy to use, all the picture request using the most original Http URL Connection package good request method. Parsing Json string data using Json.

4.2 System master control program
4.2.1 Web Server programming
The hardware programming of the system is mainly used to collect data and upload it to the server, receive the control signal and make the corresponding control. The mobile terminal programming is mainly to view the data and analysis data in the web server database, receive the alarm information, and also send the control information to control the microcontroller. After the web server starts, the microcontroller will automatically connect to the remote server, connected from the sensor detection data, and then from the web server to the database, monitor the parameters at the same time, if not normal, notify the mobile terminal, if no mobile terminal connection, the web program to handle, microcontroller will make action after receiving the web program. The Web program opens the push connection at the same time to realize multiple connections on the mobile terminal. When there is a mobile terminal login connection, the web program will log the login information on the mobile terminal, and each interface request will be recorded. The web program will also assign permissions to the mobile terminal. The Web server programming process is shown in Figure 4-1.

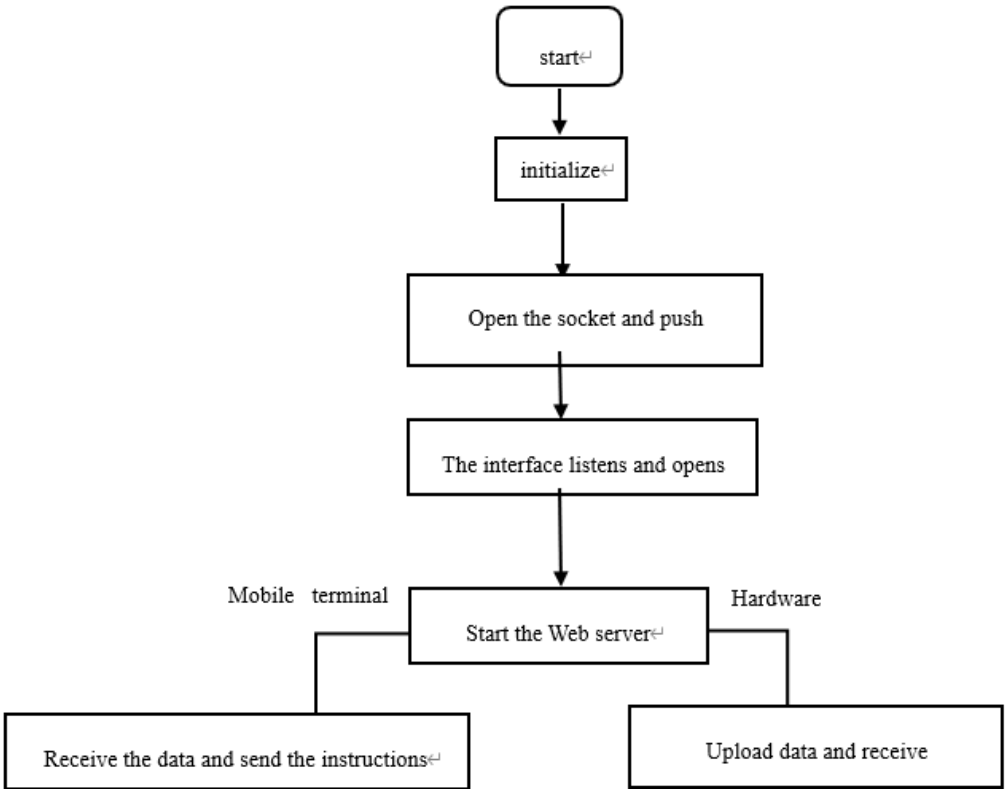

Figure 4-1 Web server programming

4.3 Hardware master program

The hardware program is in the MCU, mainly including temperature acquisition, humidity collection, light intensity acquisition, alarm and control module. The hardware master control program design is shown in Figure 4-2.

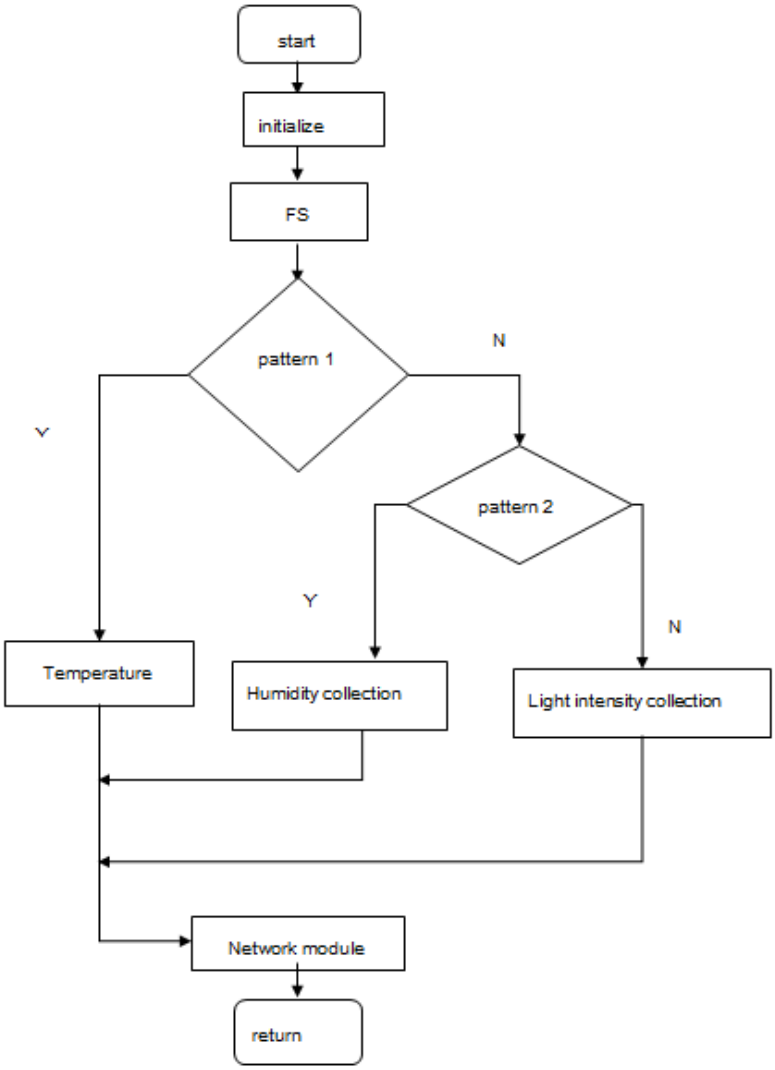

Figure 4-2 Hardware master programming

4.3.1. Design of temperature and humidity acquisition module

When the main program runs, it is first initialized with the AD transformation of DHT 11, and then the temperature is updated every second in the outage function. DHT 11 writes the data to the SU, and after 1s, the SCM processes the data. Converts the data into decimal numbers and sends the data to the web server. The temperature and humidity collection process is shown in Figure 4-3.

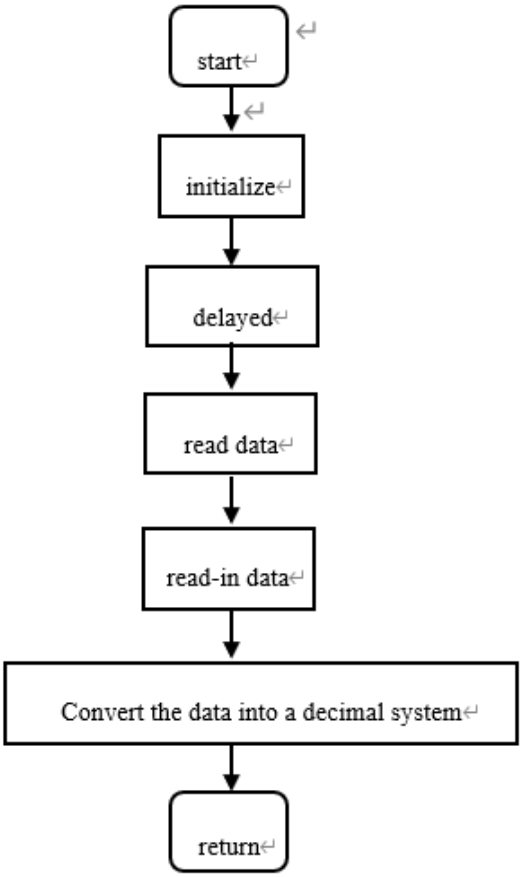

Figure 4-3 Temperature and humidity collection process

4.3.2 Light acquisition sub design

When the main program runs to the light acquisition function, the light acquisition subroutine is called: first, initialization, then the signal port is opened, and GY-30 writes data to the microcontroller. The specific light acquisition process is shown in Figure 4-4.

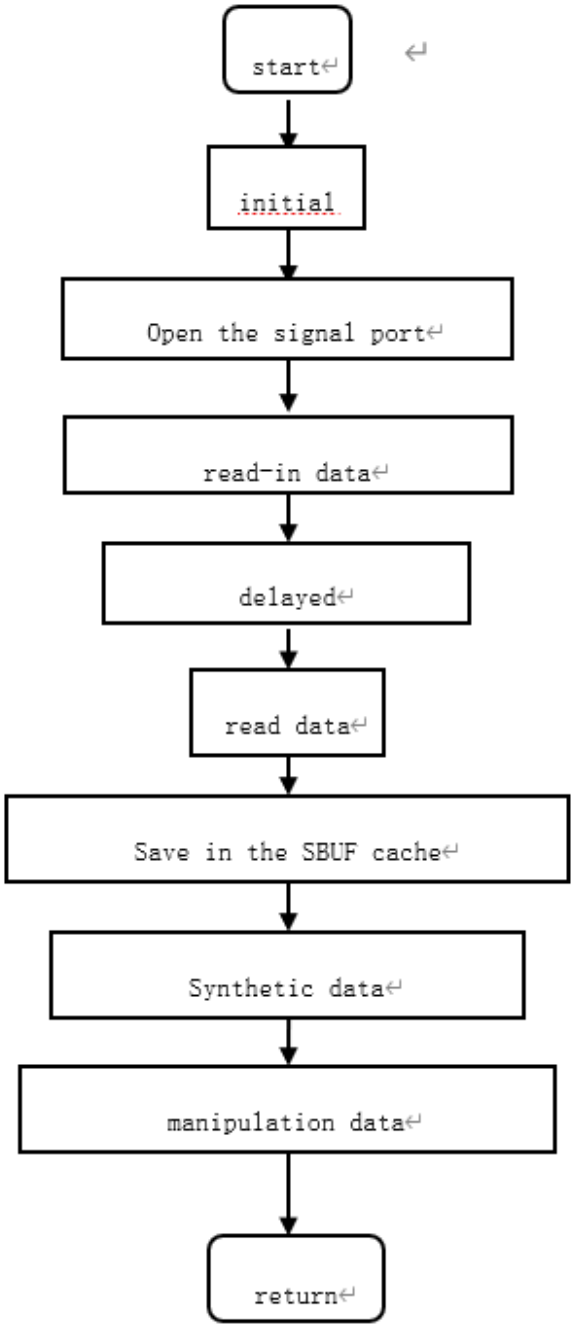

Figure 4-4 Process of illumination acquisition

4.4 Master control program design of the mobile terminal

The mobile terminal program is mainly developed on the Android system. As the display front section of the system, the mobile terminal mainly displays the temperature, humidity and light intensity in the greenhouse, receives the alarm information from the Web server, processes the alarm information, and controls the control system of the microcontroller by sending the control signal to the Web server. An SDK with JDK and Android is required in the Android running environment, and the Android application is suitable for environments above Android4.0. In addition to the compilation environment in the Android system, the third-party Jar package library class is also added to the system. The most important third-party library for network request is OKhttp3, which is a third-party framework designed by Chinese people with very powerful functions. This design uses the http request network in this system, and DB Utils does the database. The request has been encapsulated again, it is very easy to use, all the picture requests use the most original Http URL Connection wrapped request method. Parsing the Json string data was parsed using fast Json.

4.4.1 Mobile terminal programming

After entering the mobile application, you will first judge whether the system has logged in, and you will directly jump to the main interface. If you do not log in, you will enter the login interface and then enter the main interface. After entering the main interface, the program will load the data required by the UI initialization, and then display it. At the same time of entering the main interface, the system will start a service, and the service will monitor whether to start the WebSocket every minute. The WebSocket is a class that establishes a long connection with the Web server, and the service will always run. After the long connection is established, it will monitor the data reception. When the data is sent over, the corresponding data will be called and processed later.

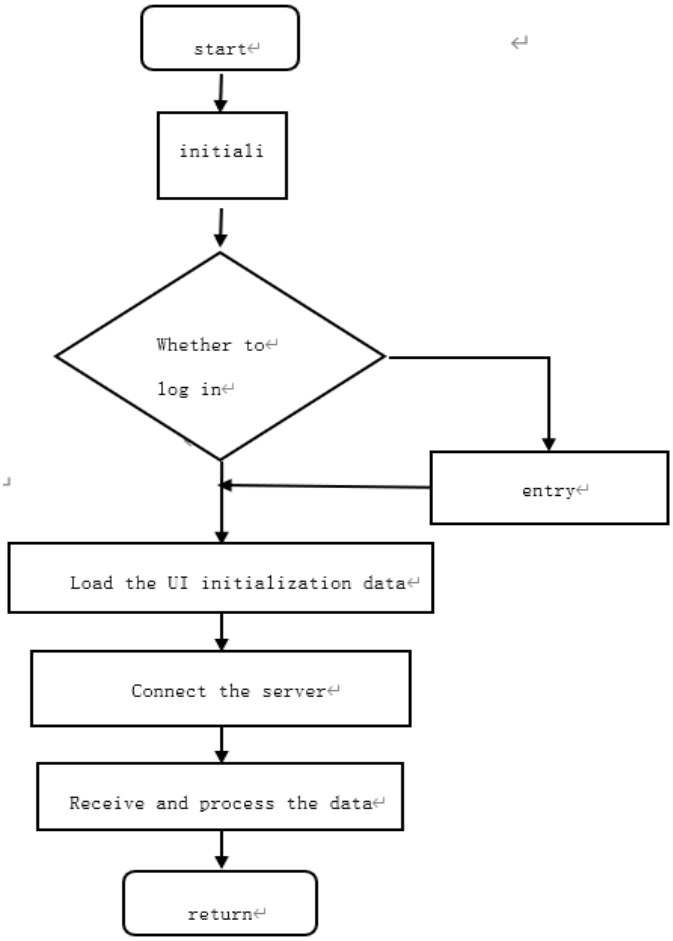

Figure 4-5 Flow chart of mobile terminal control

4.4.2 Main interface design of the mobile terminal

The main interface of the mobile terminal mainly displays the composition of real-time temperature, real-time humidity, real-time light intensity, emergency processing and viewing data. The current latest temperature of the real-time temperature display, the real-time humidity display is the latest humidity value, the real-time light intensity is the latest light intensity, and the emergency treatment is to open and close the alarm message when the Web service sends the alarm message. When the main interface is opened, the server will be automatically connected, and the connection to the server is successful.

V. System debugging and experiment

The system debugging in this system is divided into three parts, namely hardware debugging, Web server debugging and Android application debugging. In the hardware debugging, the minimum single-chip microcomputer module is first formed, and then each sensor is connected, and the serial port is transferred to the Ethernet module, debugging the correctness of data uploading and conversion. Through the network module, only one byte can be uploaded at a time, so when the Web server debugging, the data needs to be processed. Web server debugging requires building MySQL database, WebSocket push building, request interface addition, etc. Android Application debugging mainly includes project construction, UI adjustment, Socket IO push

debugging, and network request framework construction.

5.1 Commissioning of the hardware equipment

First of all, draw the PCB of the circuit board, through printing, heating carbon transfer, corrosion, make the circuit board after drilling, insert components for welding, in the welding process, the welding should ensure that the circuit is not virtual welding, copper wire no short circuit or open circuit, etc. Then the equipment should be connected, and the connection between each module should strictly follow the schematic diagram. For example, the Wi-Fi module works in the condition of 3.3V voltage condition, so it must be connected to the VCC end after the step-down to work normally. For microcontroller and Wi-Fi module communication, it is necessary to convert the high and low levels. The hardware PCB diagram is shown in Figure 5-1.

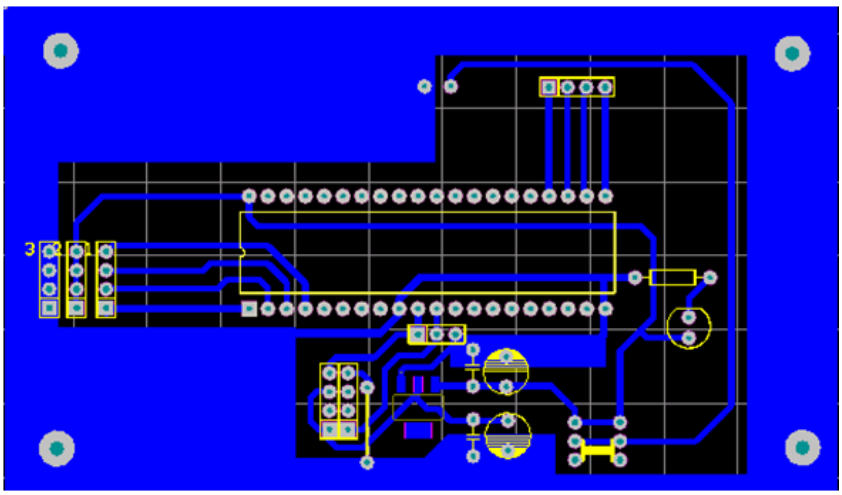

Figure 5.1 Hardware PCB diagram

5.2 Software debugging

The design software program is written in java and C language. Select the development board of STC89C51, as the carrier to debug the program of each peripheral module, and combine the debugging subprograms to complete the debugging of the whole design.

The debugging tools used in this design include: serial port debugging assistant, STC-ISP debugging tools, etc. The debugging steps of this design are as follows: first determine that the USR-TCP232-T2 module can be used, that is, communicate with the computer, and then determine that the microcomputer serial port works normally, the last step is to connect the SR-TCP232-T2 module and the microcomputer, and finally complete the mutual communication of each part.

VI. Summary

The system comprehensive use of microcomputer technology, Android development technology and other scientific knowledge, completed the single microcomputer-based control of temperature and humidity, light measurement, alarm, control, Web server remote construction, Java Web program design and Android mobile terminal development design. Involving hardware design, chip program development, Java Web server program development, Android application program development, complete the whole process of remote control of the Internet of Things. This design process is smooth to realize the whole process of mobile terminal interaction from Web server to hardware data, and control the remote device with the identification of simple data. The identification of data in the system through the account and password, by the user manually assigned account and password, to prevent malicious network attacks, make the system more secure. The system also adds a network interface and suasible sensor interface, which is possible for future expansion. TCP / IP protocol is used in the system for communication, and the whole system information transmission is more secure and reliable. Due to the limitation of personal ability, the function of the system is relatively simple, but the framework built in the system is suitable for large-scale software development, the scalability is good, in the future expansion, only need to be developed on the source program. In development, there are many functions that are not realized due to too many technologies involved, such as networking surveillance, video surveillance and other key technologies.

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