Research on ZigBee-based Agricultural Intelligent Automation Water-saving Technology

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Abstract

In recent years, the integration of modern electronic technology will undoubtedly accelerate the process of agricultural production technology reform and innovation. It has incalculable benefits and advantages. It can not only manage agricultural production in an all-round intelligent and unmanned manner, but also save a lot of manpower and material resources. , It can also provide the most beneficial biological conditions and environment for the growth and reproduction of crops, which can greatly increase the total amount of agricultural production, and on the other hand, reduce agricultural costs at the same time, so as to improve the technology of agricultural production as a whole , The total production volume is increased and the overall economic efficiency is improved. As we all know, water resources are a necessary condition for the survival of human beings, animals and plants. Drought and insufficient water utilization are important factors that restrict my country's agricultural production and life. In terms of total water resources, China has a unique advantage. However, the per capita share of water resources in my country is very low and ranks relatively low in the world. The main reason for this is the pressure of the huge population base. In the field of agricultural irrigation, my country is still in the stage of artificial irrigation. People generally use water resources inefficiently, and the phenomenon of wasting water resources is not uncommon, which has greatly affected the development of my country's agriculture. This article aims at ZigBee wireless communication technology, combined with GPRS remote control technology, powered by solar clean energy, and built a set of intelligent automatic crop water-saving irrigation system, which can realize real-time monitoring of soil temperature and humidity, air temperature and humidity, and farmers You can flexibly set your own irrigation scheme according to the types of crops and your own needs to provide the most suitable living and growth environment for crops, which can greatly ensure the healthy growth and production of crops. At the same time, the system uses sprinkler irrigation. , To increase the utilization rate of water resources to more than 90%, which also guides the development trend of agricultural irrigation in China in the future. Water saving in agricultural irrigation provides a feasible solution.

Keywords*: Agricultural irrigation, ZigBee, water saving system.*

I. Technical Concept and Application

With the expansion of the research scope of electronic information and communication technology, and the emergence and rapid development of mobile terminals such as mobile phones, tablet computers, and notebook computers, more and more short-range wireless communication technologies have been developed, which greatly reduces The complexity of wired communication, which is widely used including Bluetooth, wireless local area network, infrared data communication technology IrDA and ZigBee communication technology[1].

In the field of power consumption, Bluetooth and wireless LAN power consumption are relatively large, IrDA and ZigBee power consumption are relatively small, of which the wireless LAN bandwidth is excellent, the communication distance is the largest, the communication distance between Bluetooth and IrDA is small, and the ZigBee wireless communication technology power consumption Very low, and the transmission distance is about 10-75m, in the middle position, the cost is very low, and there are many nodes. Considering comprehensively, the agricultural intelligent automatic irrigation system in this article is very suitable for short-range controlled irrigation using the ZigBee wireless sensor network protocol[2-5].

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1.1 Introduction to ZigBee Technology

When it comes to a short-range, low-complexity, low-power, low-cost, high-reliability, high-security, and large network capacity wireless communication technology, we will think of ZigBee, a two-way wireless communication technology, which is A new communication technology that has been proposed and widely used in recent years. Because ZigBee technology has many advantages, it has now been widely used in agricultural automation, industrial control, automobiles, medical auxiliary control, consumer electronic equipment and other fields. The application is to realize and improve the characteristics of automation and remote control of control, which meets the needs of access to the network and wireless control of small and inexpensive devices[4].

Although ZigBee communication technology belongs to short-range communication, it is different from GPRS, GSM and other long-distance wide-area wireless communication technologies. Its communication distance range is between several meters and tens of meters. Although it belongs to a personal area network, it can be expanded to expand the wireless communication network[5]. The coverage area is enlarged, the construction of nodes is simple and fast, and it is convenient to use. Compared with GSM and GPRS base stations, the cost of ZigBee base stations is much lower.

ZigBee is the commercial name of the IEEE 802.15.4 technology. This protocol has been widely used in various fields in recent years. The entire protocol is complete, and the processor required for configuration is also very inexpensive, which greatly reduces the use of cost.

In terms of protocol stack, ZigBee communication technology has advantages that cannot be ignored. The ZigBee protocol stack is composed of five parts, namely the physical layer, data link layer, network layer, application convergence layer, and high-level application specifications. Its protocol stack is compact and concise, and its implementation requirements are not high, and low-configuration chips enable Its cost has dropped to a large extent[6-8] .

1.2 Introduction to Wireless Sensor Network (WSN) Technology

The wireless sensor network can be summarized by three parts: the sensor module part, the processing module part and the communication module part. It refers to the use of a large number of sensor nodes to collect information such as the environment that people need to collect, and process it. After the module is processed, it uses wireless communication to transmit the useful information needed to the information collector, so as to achieve the purpose of converting the actual environmental information into useful data information for human use and processing[9]. It should be pointed out that the information flow in the wireless sensor network is two-way. The main one is for the sensor node to transmit the collected information to the upper computer, and on the other hand, it is convenient for the upper computer to control the sensors and Arrange data exchange and transmission for the sensor nodes to perform tasks[10]. In addition, when the entire wireless sensor network covers a larger area, the data collected by the sensor may not be directly transmitted to the host computer. The information collected by the distant node can use the neighboring node as the sink node for indirect transmission. To the host computer, finally realize the state of information aggregation[11].

1.3 Brief introduction of GPRS Technology

The emergence of GPRS remote wireless communication technology is aimed at enhancing the support capability of GSM network for data services and ensuring the sustainable development of GSM technology. General Packet Radio Service, its abbreviation is GPRS, which is General Packet Radio Service. It is not an independent network structure, but a secondary network superimposed on GSM. It adds PCU, SGSN and GCSN, which can make GSM

from 2G. Upgrade to 2.5G.

In terms of channel coding, GPRS uses four different channel coding methods. According to different environmental requirements, different coding methods are used and different wireless speeds are used. Whether this technology can exert its maximum potential depends on the system software that matches it. Hardware supporting facilities[12].

GPRS remote communication technology has many advantages. It can ensure that it is always online, fast to log in, has a high transmission speed, can switch freely, and is billed according to the traffic used. When the user's mobile device is turned on and attached to the network At that time, users can take advantage of GPRS's "packet advantage" to maximize the data transmission utilization rate, and the login time is within three seconds, which is doubled compared with the traditional login time, and the file transfer rate is also very high. A large degree of improvement can basically meet the requirements of users for browsing web pages and using social software, and can also meet the parallel situation of user voice transmission and data transmission at the same time.

II. Design of Intelligent Automatic Irrigation System

Whether the functions of the system can be implemented well is directly related to the quality of the hardware platform[13]. Choosing an appropriate and reasonable chip plays a vital role in the overall system. In this paper, according to different functional nodes, different hardware foundations are carefully selected, and the combination and arrangement of various nodes in the system are carried out in a modular manner, including ZigBee communication modules, GPRS communication modules, sensor modules, solar battery modules, water pump control modules, etc. And so on, and carried out the circuit design of each unit respectively.

2.1 ZigBee Communication Module

Nowadays, there are many manufacturers in the ZigBee radio frequency transceiver manufacturing industry, with the basic requirements of low overall cost, low development difficulty, and short cycle[14-16]. We chose the GB2530 wireless microcontroller produced by Xiamen Okamoto Electronic Technology Co., Ltd., as shown in Figure 1. GB2530 is a wireless module produced by CC2530 and CC2591. Its appearance is small, only 28mm*16mm*2.2mm, and its performance is very superior. The peripherals are relatively easy and simple, and it is easy to use. The antenna adopts a 2.4g built-in gain antenna. The gain is 3db, the measured maximum distance can reach 600m, and all of its leads can be external ports, which provides a great deal for users[17].

Convenient, eliminating the need for debugging RF and related complicated work. Many advantages allow us to choose GB2530-5 to embed the system more quickly, reduce development costs, and shorten development cycles. GB2530-5 has very low power consumption when working in the system. The working voltage is 2V-3.6V. It has 5 different operating modes. The above-mentioned many advantages make it widely used in the society, and it is also very suitable for being used in the society. Selected as the chip of the intelligent automatic irrigation system in this article[18].

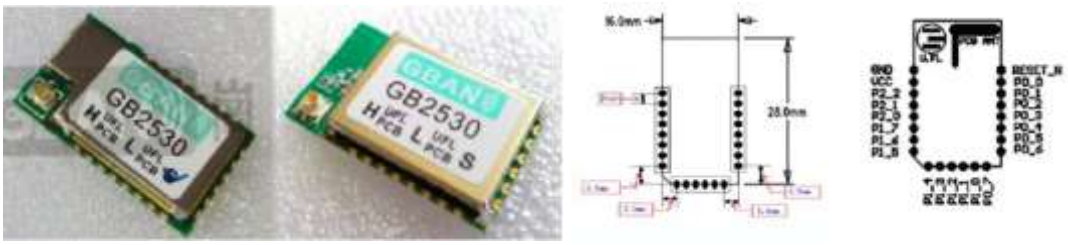

Figure 1. ZigBee wireless communication module

In terms of ZigBee power supply, we use the C6219 power chip with high accuracy and low noise, which has low output noise, low input and output voltage difference, high ripple suppression, and the turn-on time is very short[19]. The voltage limiter foldback circuit of the XC6219 series can provide short-circuit protection for the output pins and the current limiter. The output voltage can be set by laser trimming, ranging from 0.9V to S.OV, with an interval of 50 millivolts. The XC6219 series is an LDO voltage regulator chip that uses CMOS production technology. Low ESR ceramic capacitors can be used [y, which can not only reduce the cost, but also improve the output stability and have excellent transient response. With the high ripple suppression of the wide frequency band, it can better ensure the stable operation of the circuit, and the XC6219 series has the CE function, which can reduce the power consumption by stopping the chip operation. The ZigBee power supply circuit diagram is shown in Figure 2.

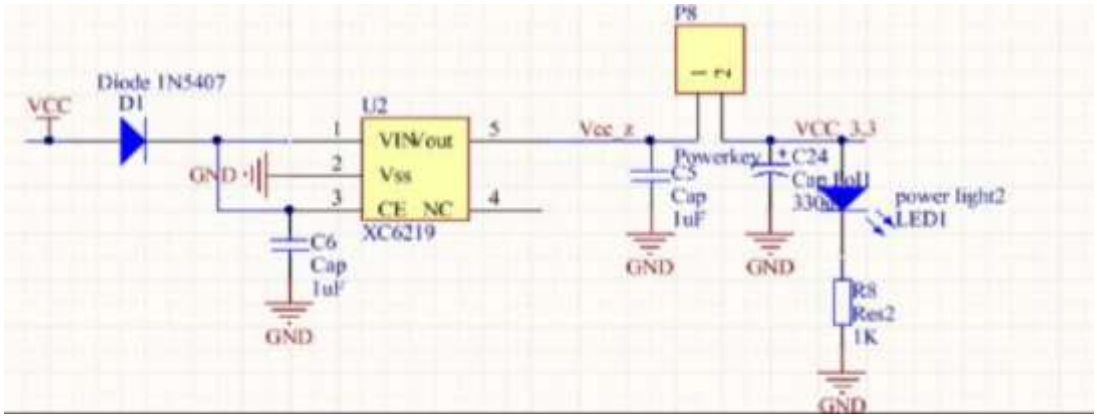

Figure 2. ZigBee power supply circuit diagram

2. 2 GPRS Communication Module

In terms of GPRS communication module chip selection, the advantages and characteristics of all parties are integrated, and the SIM900A chip is selected as the system in this article. The SIM900A chip has excellent performance. Its size is compact and its size is relatively small, only 24*24*3mm[20]. It is packaged using SMT technology, which is convenient for customers to process and produce, and its power consumption is relatively low. In standby mode, Its current is less than 18 mA. When in sleep mode, the current is less than 2 mA. The power supply range is between 3.2V and 4.8V, which is relatively wide. It supports SM/GPRS900/1800MHz, and supports enhanced rate and full rate. , Half-rate speech coding, while supporting echo suppression algorithms. The chip has very powerful performance. It uses the ARM926EJ-S architecture to realize that customer applications can be built in. It is a single-core solution based on STE and is widely used in various industries and fields, including vehicle tracking systems, power monitoring systems, and wireless POS machines. Wait. In this article, by using 5G network, data can be transmitted to the server, wireless connection can be realized, without the limitation of transmission distance, as shown in Figure 3, the hardware schematic diagram and the hardware PCB board produced, the red frame part is the GPRS module[21-24] .

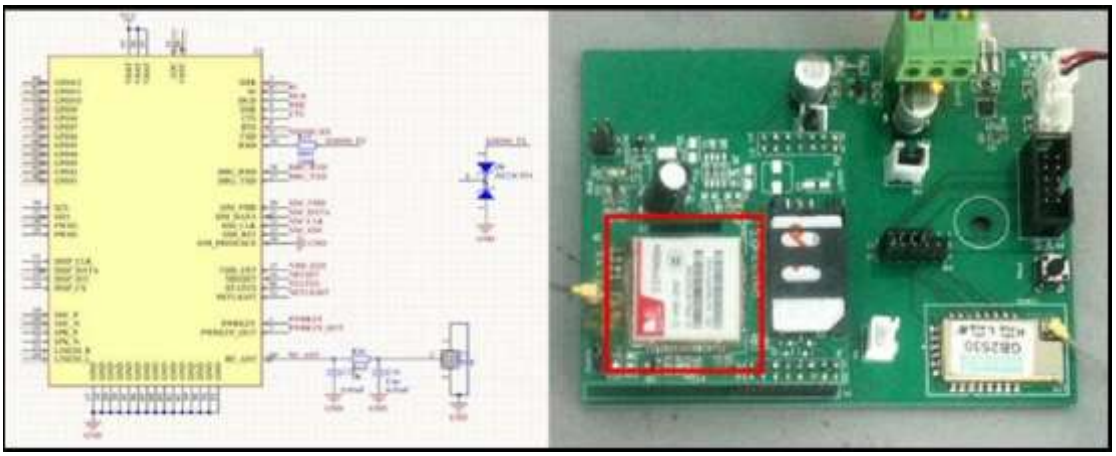

Figure 3. GPRS module circuit schematic diagram and PCB board hardware circuit

2. 3 Sensor Module

By consulting related literature, we know that the two main factors that affect vegetation growth, reproduction and maturity are the temperature and humidity of the environment. Therefore, we chose to add a temperature and humidity sensor to the system, and according to the needs of the crop growth environment and the customer's If required, other types of sensors can be added to the system in subsequent work groups. The temperature and humidity sensor is mainly used in the collection of temperature and humidity information data in the surrounding environment of crop growth, and by analyzing and processing the collected data, formulating reasonable irrigation plans and tasks, as transmission instructions, and then realizing Actual irrigation control[25].

According to its own characteristics and requirements, this system uses DHT11 temperature and humidity sensor, which has a small number of sensor interfaces and uses a single-wire communication method, which saves chip resource costs. The temperature and humidity sensor DHT11 is a composite sensor that contains a calibrated digital signal output. This temperature and humidity sensor has high accuracy and stability, and it has a long service life and a good Long-term stability, this is mainly because it uses dedicated temperature and humidity sensing technology and digital module acquisition technology, the calibration operation of the sensor is completed in a harsh laboratory, which makes this transmission Sensibility has a very high cost performance. The typical circuit schematic diagram is shown in 4.

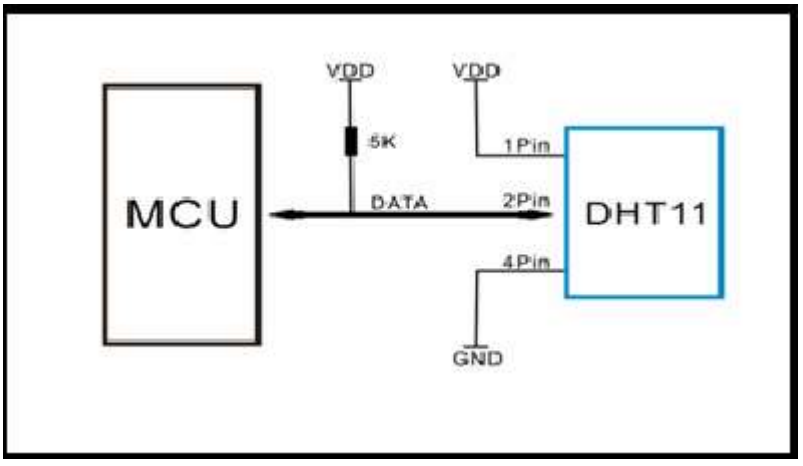

Figure 4. DHT11 sensor circuit schematic diagram

2. 4 Solar Power Supply Module

Considering that the automatic irrigation system in this article is in the growing environment of crops, it is very time-consuming and labor-intensive to replace the battery, and for the purpose of saving costs, this system creatively uses solar panels for all power supply sources, not only to a large extent In the long run, the cost of power supply will be reduced, which saves manpower and material resources. In addition, solar power supply can ensure long-term uninterrupted energy supply for the system, and solar power supply is also an important factor. An environmentally friendly and sustainable power supply method improves the automation of the system[26].

The solar panel used in this article can provide a voltage of 6V and a power of 6W, and the power of the device used is only about 1W, which can completely ensure that the system can work normally for 24 hours during the day, night, and rainy weather. In short, the use of solar power as the power supply method of the irrigation system is a future development trend, and it is also a very meaningful reform and innovation. The CN3065 chip used in the solar charging part of the irrigation system, as shown in Figure 5 (left), is the physical picture of the solar panel, and Figure 5 (right) is the schematic diagram of solar power supply.

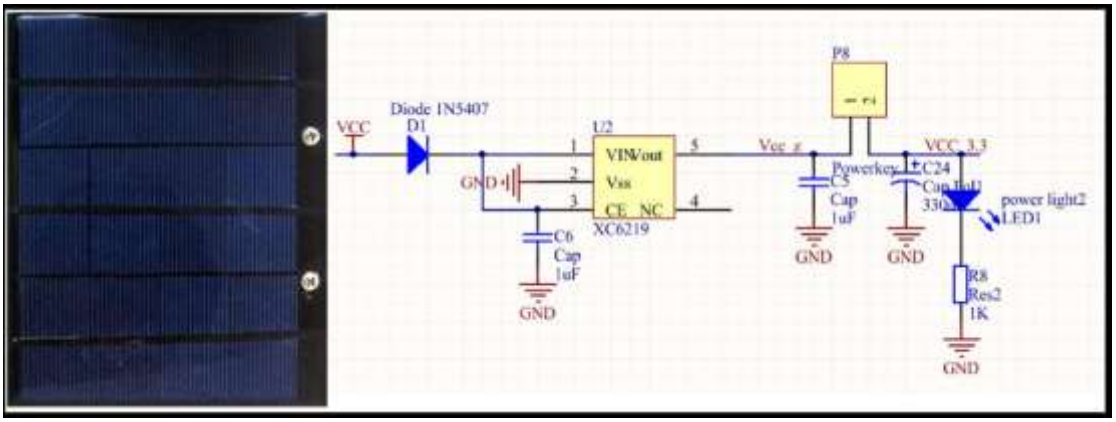

Figure 5. physical diagram and power supply schematic diagram of solar panels

2.5 Water Pump Control Module

In the driving circuit, this article uses the L9110 isolation circuit chip, which can effectively raise the 3.3V pulse to 12V to reach the standard pulse of the solenoid valve, thereby ensuring the normal switching and irrigation of the water pump. L9110 is a two-channel push-pull power amplifier special integrated circuit device designed for controlling and driving motors[27]. It can integrate discrete circuits into a single IC, thereby reducing the cost of peripheral devices and greatly improving the whole machine. Reliability. The L9110 chip has two TTL/CMOS compatible level inputs, which makes the chip's anti-interference ability very good, and its two output terminals can directly drive the forward and reverse movement and brake of the motor, with Strong current drive capability, peak current capability can reach 1.5-2.OA. In addition, the output saturation voltage drop of the L9110 chip is also relatively low, ensuring its safety and reliability when driving relays, DC motors and stepper motors. Due to its many advantages and cost-effectiveness, L9110 has a very wide range of applications in the circuit design and use of industries such as safe production, toy car motor drive, stepper motor drive and switching power tube. Use the L9110 isolation circuit chip as above to be used in the drive circuit. Because the switching power supply used in the boost part of the isolation circuit can provide a larger current, it can ensure that the solenoid valve works normally at the same time. The following figure 6 is a schematic diagram of the drive circuit[28].

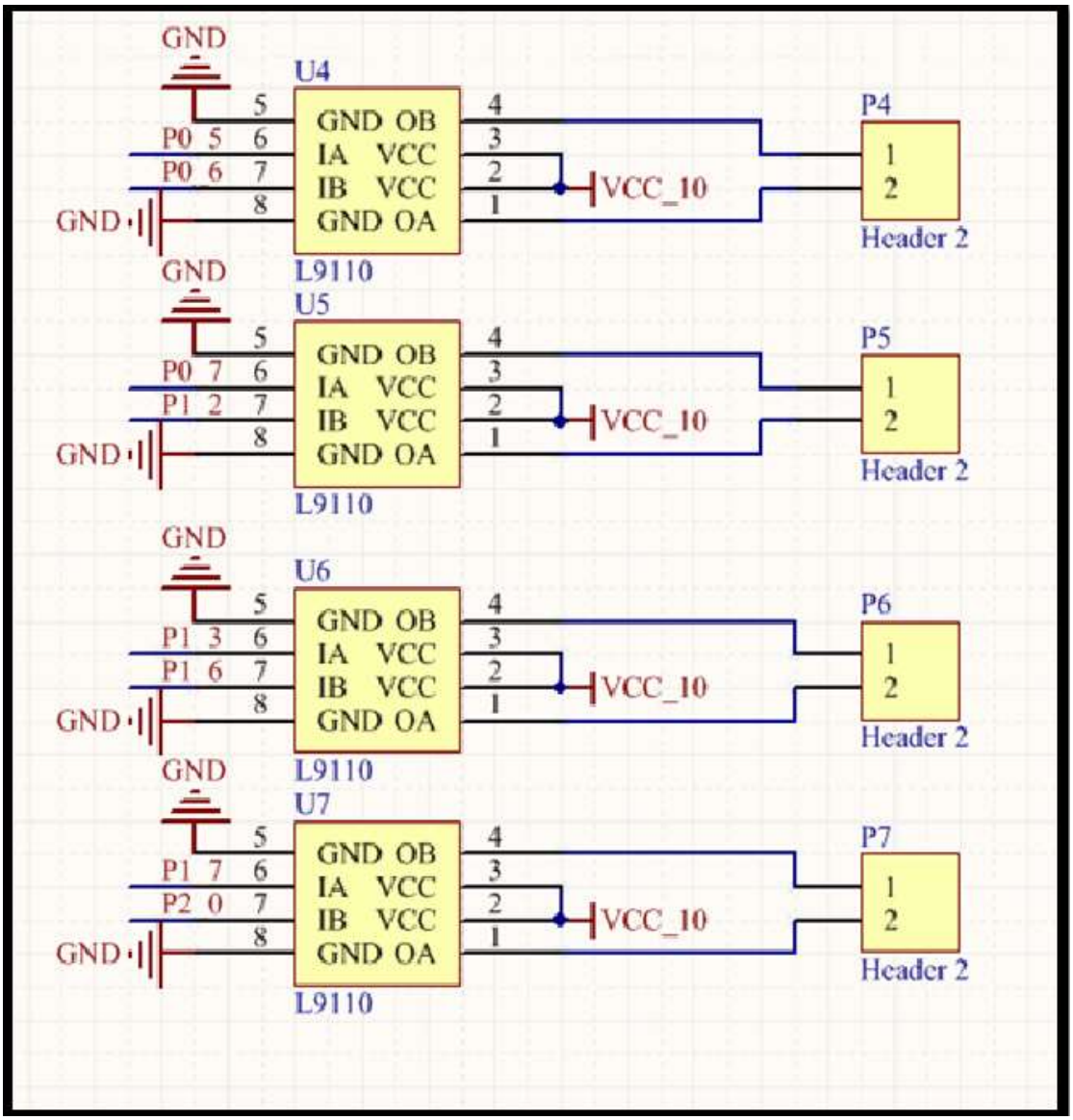

Figure 6 Schematic diagram of the drive circuit

III. Software Design Part of Automatic Water Saving System

Before the software design, we analyzed the current market's requirements for the functions and characteristics of the farmland irrigation system by consulting relevant agricultural irrigation documents, and combined with the ZigBee and GPRS wireless communication technology used in this article, we formulated the specific irrigation functions and characteristics that the system needs to achieve[29]. Find the key and difficult points of completing the software part, divide the entire software design part into modules, and complete the program writing and software design module by module.

3.1 Communication Protocol and Software Design

In order to reduce the overall power consumption of the system, the system needs to set the state of the terminal. When it does not need to work, the terminal enters the dormant state to save power. When it needs to work normally, the terminal must be awakened. Design and write the response message communication protocol, which can ensure the efficiency of the entire system and the safety of operation. This requires the system to design three

parts. The first part is the message at the convergence node. The processing part is used to process and analyze the information received at the sink node. The second part is the message processing part at the terminal, which is used to process the received information data at the terminal of the system. The third part is used For the design of the message format of the communication protocol. The following figure shows part of the software operation interface. Figure 7 is the software's simulated node distribution control interface， which can realize node status, set irrigation tasks, and restart tasks , And can realize the functions of starting task, stopping task, suspending task, continuing task and setting cyclic irrigation[30].

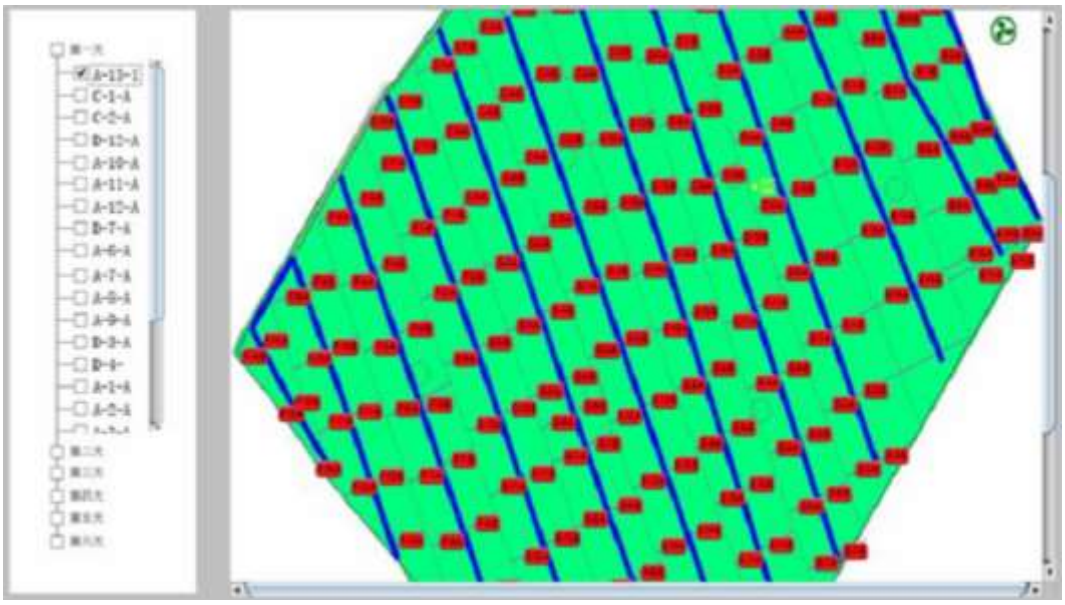

Figure 7. Analog node distribution control interface

3. 2 Headend Software and Communication Protocol

In terms of function discussion, the main function of the head-end node is to receive control command messages from the upper computer, and to return all the gathered information such as the status of the crop growth environment to the upper computer, which can ensure the stability of the entire system network, Forward the control instructions of the host computer to the terminal, and upload the temperature and humidity data to the server in real time. Due to the sleep mechanism of the terminal, in order to ensure the overall stability of the system, the head-end node forwards the received control instructions from the host computer to the terminal, Real-time transmission of the collected farmland temperature and humidity information data to the server, and the terminal sleep mechanism of this system can greatly reduce power consumption while ensuring the overall stability of the system sex.

After completing the general terminal network, the serial port will be continuously scanned to obtain GPRS network information. Whenever information arrives and it is distinguished that it is not spam, the head office will read the content of the received information, combine it into the format of the control information in the figure above, and send the reply information to the host computer control software, And then notify the host computer management software to receive the control instruction information.

3.3 Terminal Software and Communication Protocol

Since the terminal is all powered by a battery, the terminal must adopt a regular sleep mode to save power, reduce power consumption, and save energy, so that the power supply and working time of the terminal can be extended

as much as possible. Therefore, it is impossible to send the control information directly to the terminal after the head office receives it. It must be stored first. After the terminal wakes up from sleep, it needs to send an inquiry message to the head office, so that the convergent head end will send it[31]. Control information, the terminal can be controlled after receiving the message. After receiving the control information, the terminal obtains the control information of the node. In order to prevent the motor in the terminal's solenoid valve from getting stuck, the terminal must determine whether the current control state is consistent with the current state of the solenoid valve. If they are consistent, no control action will be taken on the solenoid valve. If the two are inconsistent, corresponding control measures will be taken on the solenoid valve according to the control information. After judging the received control information, in order to enable the solenoid valve to have sufficient response time to the control information, the control information of the solenoid valve is collected with a delay of one second, and then transmitted to the head end, and finally the whole is realized. Normal operation[32].

IV. The Actual Environment Test of the Intelligent Automatic Irrigation System

The test environment in this chapter selects simulated farmland environment conditions, carries out actual outdoor system tests, tests the functions realized by the system, and explores the deficiencies and shortcomings of the system.

4.1 Test Environment

We chose a relatively open lawn on the campus to test the entire system. The hardware part of the entire test system includes two solenoid valves, a solar panel, a valve controller and a field controller node, and the overall hardware Combined together to form a sample small irrigation system. Considering that some crops have a certain height, we installed the battery panel and valve controller on the top of a one-meter-long metal rod, and encapsulated the valve controller and field controller nodes to prevent the outdoor environment from rainy weather. The resulting circuit damage. The distance between the field controller and the valve controller is set to 100 meters to test whether the entire system can operate normally under the condition of solar energy as a single power source, and complete the on-off control of the solenoid valve.

4.2 Temperature and Humidity Information Collection Test

In this section, an automatic irrigation system sample is formed by correctly assembling each module, and the temperature and humidity are tested in real-time experiments in the actual outdoor environment. After checking that the system is assembled correctly, the nodes are placed in the communication network, and the information collection terminal starts to monitor the environment. Information collection of temperature and humidity. The total length of the entire collection time period is 24 hours. The test starts at 6 o'clock in the morning and ends at 6 o'clock the next day. We set the temperature and humidity data to be collected every half an hour, and finally the collected temperature and humidity data is formed into a dotted line graph. , It can be seen from the temperature point line graph that the temperature peak is reached at about 14:00 in the afternoon of the day, and users can customize private irrigation schemes according to the data and the growth habits of crops[33-34]. It can be seen from the humidity dot-line graph that the humidity change during this day is not very large, and it is maintained at about 20%.

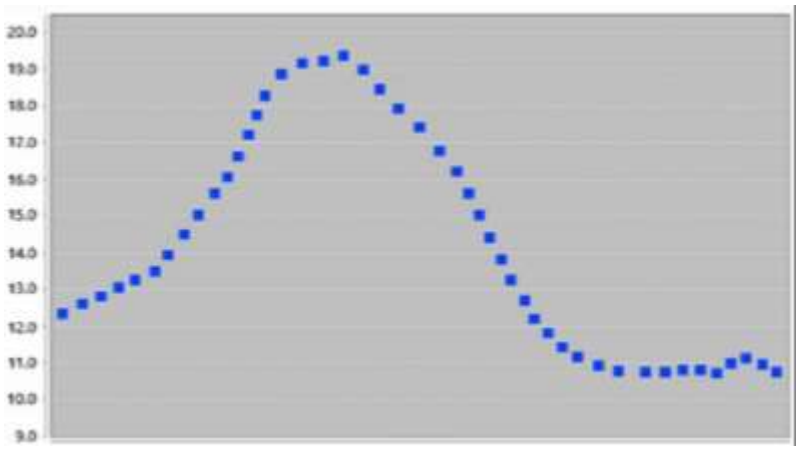

Figure 8. Temperature change point line diagram

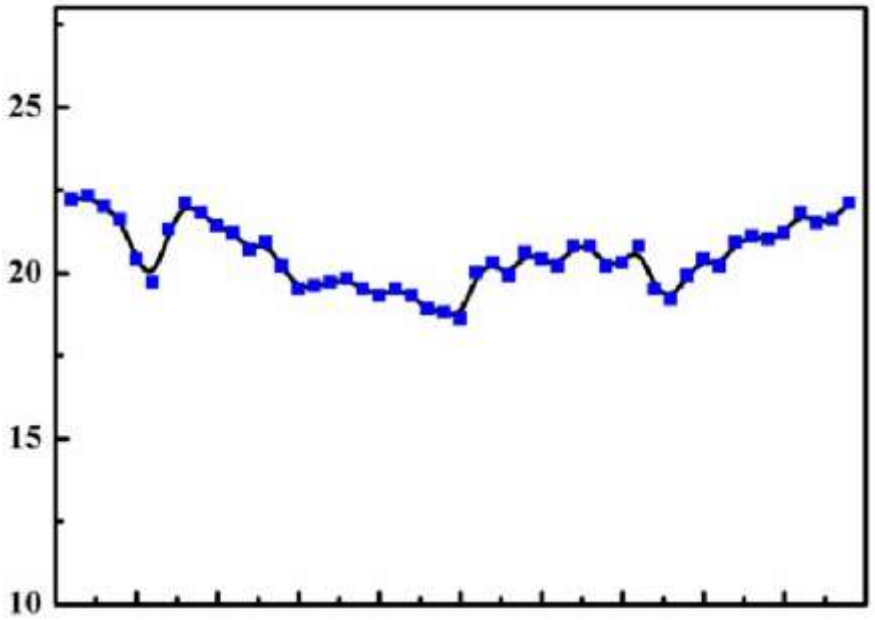

Figure 9. Humidity change point line graph

V. Work summary and Outlook

5.1 Summary of the Work Completed in this Article

Based on the survey and access to relevant agricultural irrigation data, this article analyzes the market demand for automated agricultural irrigation, specifically targeting at the current situation of water resource utilization and irrigation in my country, designed and built an intelligent automated agricultural irrigation system powered by solar clean energy, and successfully passed the actual Test and use in the environment. The irrigation system is a combination of ZigBee communication technology and GPRS communication technology. It can operate and control farmland irrigation on mobile terminals and upper computers. Sensor nodes scattered in the farmland can collect real-time temperature and humidity data of the crop growth environment. The collected temperature and humidity information is transmitted to the monitoring terminal, and the user can filter, filter and analyze the collected useful information to set the irrigation plan, and can also formulate irrigation tasks according to their own needs and the adaptation characteristics of the crops. Control commands can be sent to the actual growth environment of crops through the communication network, so as to finally realize the control of the irrigation of crops. At the same time, we have chosen solar charging to power the entire system, which reduces the need for

traditional automatic irrigation systems to replace batteries. The tedious and complex nature of the system saves manpower and material resources. At the same time, it is also a more environmentally friendly way, which is in line with the future trend of sustainable agricultural production in China, and it is also a measure of the degree of automation.

By consulting related literature and reports, we can deeply understand the current development status of agricultural automatic irrigation in China and the market demand for agricultural automatic irrigation systems, and understand the functions and characteristics of agricultural automatic irrigation systems that customers need to achieve, combined with the system designed and developed in this article , Formulate specific system functions and innovation points, analyze the difficulties and key points in the entire development process, consider the feasibility analysis of ZigBee and GPRS wireless communication technology, and then sort out the overall scheme design of the system and the functions that need to be implemented, and the system The materialization of the process is divided into processes and modularization, and each task plan is gradually completed.

5.2 Prospects for Future Work

In this article, it can be seen that the intelligent automated agricultural irrigation system in this article has high accuracy and practicability. It can automatically irrigate farmland, has a good degree of automation, and can collect the temperature of the growing environment of crops in real time. Humidity information, and users can set up and formulate farmland irrigation programs and tasks by themselves based on the collected information. It is highly intelligent, and the system can independently complete the irrigation of the entire farmland according to the irrigation plan and program settings. In addition, the irrigation system uses solar energy for power supply, which not only saves manpower and material resources, but also reduces economic costs and system consumption. It is also in line with the future development requirements and trends of China's agricultural sustainability and environmental protection. However, when the entire system was tested in the actual environment, there was a certain data packet drop situation, which may cause a node in the farmland to be unable to receive control commands for irrigation and to collect the temperature and humidity of the actual environment. Information, thereby affecting the control accuracy of the node. In addition, when the nodes are arranged, they are arranged according to human requirements. After the nodes are arranged, they cannot move on their own. The convenience of repair and replacement after a certain node is damaged or malfunctions has not been considered. Further steps are needed. The improvement and update.

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