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Orchard Weather Station Based On SCM

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ABSTRACT:

In this design, STC15F2K60S2 single-chip microcomputer is used as the main control unit. Based on intelligent cloud technology, the data are collected by DHT11 temperature and humidity module, ABS (Acrylonitrile Butadiene Styrene) wind speed sensor, soil hygrometer detection module and GY-30 light intensity module connected to the single-chip microcomputer, and the Wi-Fi module is used to upload the data to the upper computer for real-time monitoring, so as to realize the operation of raising and lowering the temperature, adding and removing humidity, and supplementing light in the orchard. In the intelligent mode, the single chip microcomputer will compare the collected data with the threshold, then, feedback and adjust some parameters that exceed the set threshold. The design adopts the combination of the upper computer automatically generates date points by using the Gizwits platform. The circuit design of the lower computer uses Altium Designer 19, and the MCU programming uses KEIL 4. After assembly and debugging, all functions meet the design requirements.

Key words: Orchard, Meteorological station, Single-chip microcomputer, Gizwits, Sensor

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1. INTRODUCTION

In orchards, if the relative humidity in the air is low, the fruit trees will have more water and need more water [1-6]. In a sense, the lower the relative humidity in the air, the better for fruit trees to grow. If the humidity in the air is too high, it can prevent evaporation and thus affect the ripening of the fruit. And it is easy to cause the spread of pests and diseases, resulting in the decline of yield and quality. The relative humidity of the air naturally cannot be too low. Because the relative humidity in the air is too low, it will cause the air to be dry, thus affecting the growth of fruit trees. Especially in hot weather, when the soil is short of water, the effect is more pronounced. Therefore, we should not only adjust the humidity in the air, but also adjust the temperature accordingly, so that the fruit trees can be in a relatively comfortable temperature and humidity environment. The right temperature also plays a role in photosynthesis. However, natural disasters usually destroy the temperature and humidity environment of fruit trees so as to affect the fruit trees cannot develop normally [7-8].
This design is aimed at the environmental inspection needs of the orchard design of a single-chip based orchard weather station. First of all, we need to design the function of the system by viewing the reading materials and relevant literature. After the function setting is completed, the appropriate hardware is selected by comparison, and then the hardware circuit is designed, and then the software is designed. After the design of hardware and software is completed, the actual welding is completed, the burning of the program is completed, and the test of the whole system is finally completed to ensure the normal operation of the system.

2. SYSTEM REQUIREMENT ANALYSIS AND OVERALL SCHEME DESIGN

The system needs to transmit the collected data to the upper computer. The network architecture is consistent with the architecture of the Internet of Things, including the perception layer, network layer and application layer [9]. The perception layer is composed of microcontroller and sensor [10]. The network layer consists of intelligent cloud platform, which is responsible for communication and data storage of terminal devices in the wide area network. The application layer consists of Gizwits mobile APP and Gizwits web page virtual equipment. The system network architecture is shown in Figure 1.

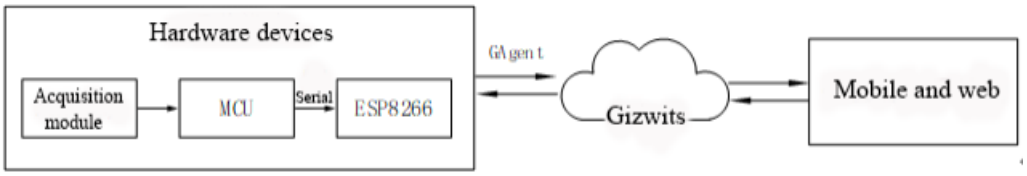

Fig. 1 System network architecture

Cloud platform is an essential part of the development of Internet of things projects, so it has received the attention of major technology companies. In recent years, the number of companies participating in the development of cloud platform in China has risen rapidly. *Gizwits* Internet of Things Development Company is one of them. Compared with cloud platforms launched by Alibaba, Baidu, China Mobile and other companies, *Gizwits* platform is more convenient to use, not only realizing the function of data calculation, processing and storage, but also providing one-stop intelligent hardware development function [11]. When developing hardware devices, users only need to set corresponding data points according to their own project requirements and select the main control chip used by hardware devices to automatically generate device basic code and supporting APP software DEMO. Moreover, *Gizwits* provides multi-level cloud data services and SDK for each development link for developers. Enables users to achieve complex functions of remote control through simple basic operations.

3. SYSTEM HARDWARE DESIGN AND IMPLEMENTATION

The hardware of the system consists of single-chip microcomputer control center, sensor acquisition unit, remote transmission and control unit, display unit, execution unit, alarm unit, power supply unit and key unit. The hardware composition of the system is shown in Figure 2. The control center uses STC15F2K60S2 microcontroller, which is the central hub of the whole system. It is responsible for the analysis, processing and sending of sensor data, and issues execution commands to the execution unit to drive LED (Light Emitting Diode) alarm unit to alarm and remind. The sensor acquisition unit consists of DHT11 temperature and humidity sensor, soil moisture sensor, light intensity sensor and wind speed sensor. The remote transmission unit adopts ESP8266-01S communication module, which is responsible for transmitting environmental parameters and circuit control state to Gizwits platform, and receiving instructions from Gizwits to realize remote communication between hardware devices and Gizwits platform. Display unit adopts IIC (Inter-Integrated Circuit) interface 0.96 inch OLED (Organic Light-Emitting Diode) display screen. The execution unit is mainly simulated by relays. The alarm unit uses red LED to alarm, and the power supply unit is equipped with the corresponding power cord for the DC power source of DC-005 model to power the device. The key unit is a patch-encapsulated four - pin key.

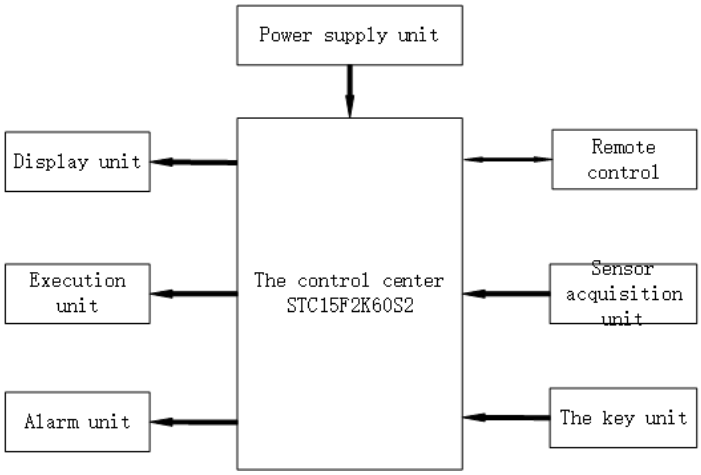

Fig.2 system hardware composition

1. SCM system

Single chip microcomputer as the main control device of the whole system, select the appropriate single chip microcomputer can help the whole system in the execution, can improve the overall efficiency of the system. At

the same time, the choice of cost-effective MCU can improve the popularity of the system.
STC15F2K60S2 microcontroller packaged by LQPF44 is adopted in this design. The encapsulation mode is patch type, which can effectively reduce the position occupied in the system. The microcontroller is a new generation of 8051 microcontroller produced by STC [12]. External crystal oscillator and reset circuit can be eliminated. With large capacity in-chip EEPROM, a total of 8 channels 10 bit high-speed ADC, internal with high precision R/C clock (±0.3%), ±1% temperature wave (-40℃~+85℃), temperature wave ±0.6%(-20℃ ~+65℃), the maximum frequency can reach 28MHZ, support program encryption after transmission, anti-interception. The connection diagram is shown in Figure 3, and the physical diagram is shown in Figure 4.

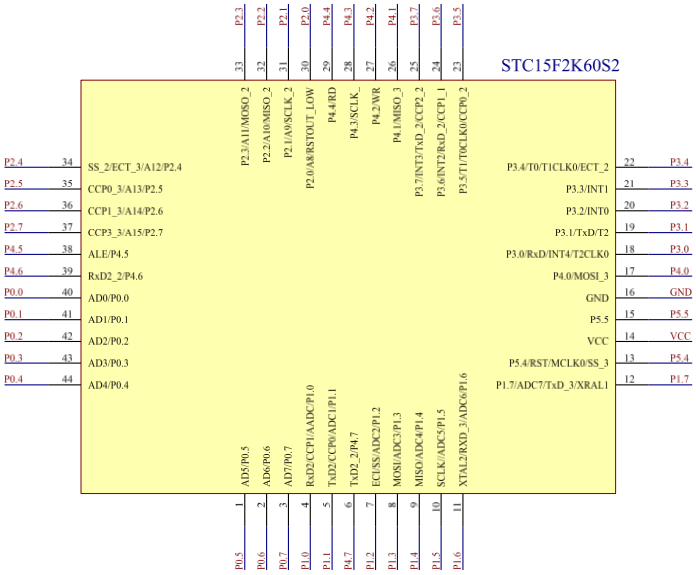

Fig.3 The connection diagram

Fig.4 The physical diagram

2. Sensor unit

The sensor unit is used to detect temperature and humidity in the air, soil temperature and humidity, light intensity and wind speed. The excellent design of the sensor circuit is the basis for the normal operation of the whole system. Therefore, it is necessary to select appropriate sensors for detection. The system uses DHT11 to detect air temperature and humidity, GY-30 to measure light intensity, and the wind speed detection sensor is used to detect wind speed. Wind speed detection sensor is used to detect wind speed [13]. The design is described below.

(1) DHT11
DHT11 digital temperature and humidity sensor is a composite temperature and humidity sensor with calibrated digital signal output [14]. It adopts special digital module data acquisition technology and temperature sensor to

ensure the product's high reliability and stability of long life [15]. The sensor consists of a resistive humidity sensor and an NTC temperature sensor, and is connected to an 8-bit high-performance microcontroller. Therefore, this product has the advantages of excellent quality, ultra-fast response, strong anti-interference ability and extremely high-cost performance [16]. The connection of the sensor, on the basis of the positive and negative power supply connection, only need to connect the data transmission interface with the I/O port of the MCU can achieve the transmission of temperature and humidity data, the design of the connection for the P2.4 pin of the MCU. The circuit connection diagram is shown in Figure 5 below, and the physical diagram is shown in Figure 6 below.

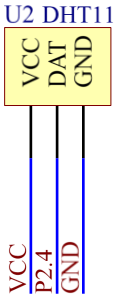

Fig.5 DHT11 Connection diagram

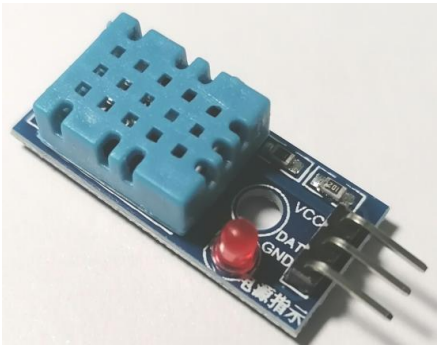

Fig.6 DHT11 Real figure

(2) Soil moisture sensor

Soil moisture is one of the main factors affecting crops, so the detection of soil moisture is very important. The system uses soil moisture sensor to detect soil moisture [17], and nickel plating on its surface improves the induction zone and conductivity, prevents corrosion after contact with soil, and improves the service life [18]. Stable operation, with fixed bolt hole, easy to fix, and with LM93 comparison chip, stable operation [19]. The sensor has two pins connected to the comparator module, and then the comparator will output analog signals and digital signals through comparison. The module integrates four pins, which are VCC pin connected to the positive pole of the single chip microcomputer, GND pin connected to the negative pole of the single chip microcomputer, DO pin output 1, 0 digital data. This design does not use this pin, AO pin port is the analog signal output terminal connected to the ADC pin of the single chip microcomputer, this design is connected to the P1.1 port. The circuit connection diagram is shown in Figure 7, and the physical diagram is shown in Figure 8.

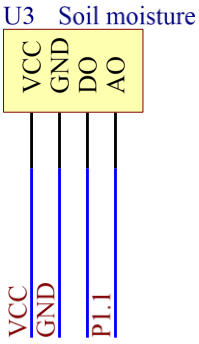

Fig.7 Soil moisture sensor connection diagram

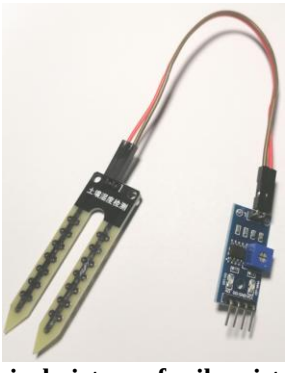

Fig.8 Physical picture of soil moisture sensor

(3) GY-30

In the orchard, crops can supply oxygen through photosynthesis, reducing carbon dioxide concentrations and further keeping them in their proper environment. The system uses GY-30 digital optical module as the light detection module. The power supply voltage of the module is 5V, and the spectral range of detection is similar to that of human eyes. The module has little dependence on light source and can detect multiple light sources. In low current shutdown, played a good role in protection. On the basis of high power supply, low power supply and enabling high connection, it is necessary to connect the clock line and data line with the microcontroller.

The chip used is BH1750, which is a digital optical intensity sensor integrated chip [20][21]-[22]. The module is easy to be controlled by single chip microcomputer. The circuit connection is shown in FIG. 9 and the physical figure is shown in FIG. 10.

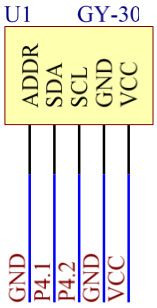

Fig.9 GY-30 circuit connection diagram

Fig.10 GY - 30 real figure

(4) Wind speed sensor

In orchards, different conditions with and without wind will affect the flow of air and the temperature and humidity inside the orchards. To test the wind speed can effectively reflect the environmental status of the orchards. The wind speed sensor selected in this design is composed of a small DC brush motor and a three-cup rotary wind cup [23]. When ventilating, the three-cup wind cup will be driven to rotate so that the motor can generate voltage. The single-chip microcomputer will convert the voltage to a/D, and then calculate the wind speed through the calculation formula F(m/s) = 0.027*V (MV). The wind speed sensor has high precision and wide measuring range. When connecting, the positive pole is connected to the ADC of the processor, and the negative pole can be grounded. The circuit connection diagram is shown in Fig.11 and the physical is shown in Fig.12.

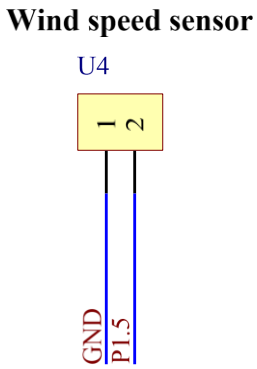

Fig.11 Wind speed sensor connection diagram

Fig.12 Physical drawing of wind speed sensor

3. Communications unit

The choice of communication module is related to the speed and convenience of communication between the upper computer and the lower computer. Here, the design chooses ESP8266-01S as the communication module. This module is a Wi-Fi module, which improves the convenience of transmission to a certain extent [24]. At the same time, it has rich communication interfaces to communicate with external devices [25]. Module adopts DIP-8 package, optimized PCB antenna, each pin name is marked, simple connection. Good storage condition, high temperature resistance. Low standby power. Because the rated voltage of the module is 3.3V. Therefore, the voltage needs to be stabilized to 3.3V by 1117-3.3V voltage regulator circuit when connecting. In connection, on the basis of positive and negative power supply connection, No. 2, no. 6 and No. 7 are jointly connected with the output end of the voltage regulator circuit. No. 8 is the serial port sending pin and No. 4 serial port receiving pin are respectively connected with the P3.1 and P3.0 ports of the single chip microcomputer to realize the serial port communication with the single chip microcomputer, and establish a connection with the upper computer. Its circuit connection diagram is shown in Fig.13. The physical diagram is shown in Fig.14.

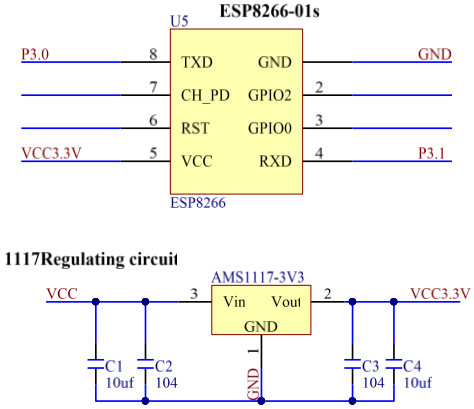

Fig.13 ESP8266 Circuit and connection diagram

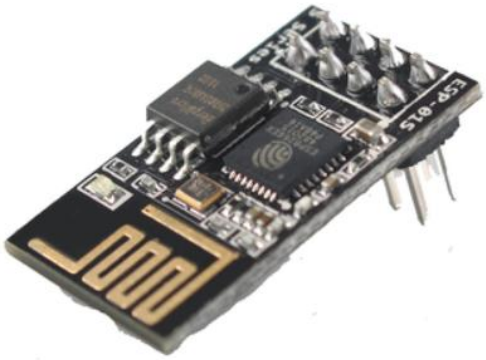

Fig.14 ESP8266 Real figure

4. Display unit

In this design, OLED is used as the Display unit, OLED (Organic Light-emitting Diode), also known as Organic Electroluminescence Display. OLED is a kind of current-type organic light-emitting device, which is caused by the injection and recombination of carriers, and the luminous intensity is proportional to the injected current [26]. It has been widely used because of its characteristics of light and light, energy saving and so on. The connection mode of this module is simple. On the basis of the positive and negative connection of power supply, only pin no. 3 and Pin No. 4 need to be connected with P2.0 and P2.1 of the single chip microcomputer. The circuit connection diagram is shown in Fig.15 and the physical diagram is shown in Fig.16.

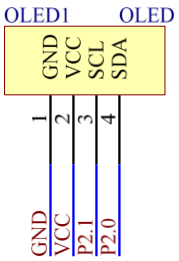

Fig.15 OLED connection diagram

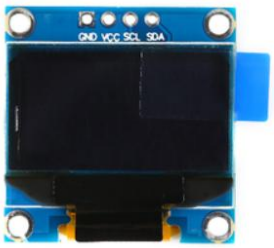

Fig.16 OLED real figure

4. SOFTWARE DESIGN

The software design part of this design mainly uses C language to realize in Keil uVision4, in which the function program to be designed and realized is divided into main program design and realization and subroutine, and the program design of main function is the program design of main function. Subroutine design includes DHT11 subroutine design, GY-30 subroutine design and OLED subroutine design.

1. SCM main program design

After the device is powered on, the OLED, internal AD, BH1750, serial port 1, serial port 2, and timer 1 are initialized first. In order to make the relay work normally, the fourth pin of P0 is strongly pulled up and pulled down. Secondly, the data state is stored in the structure sent to the Gizwits for Gizwits initialization. After the initialization, in the big loop of while (1), the network configuration keys are scanned from front to back to determine whether network configuration is needed, and the network data is sent to ESP8266 through the serial port. Then it is to collect the data of the sensor. If it is in intelligent mode, it will judge the collected data. If it exceeds the set threshold, red LED warning will be given and automatic adjustment will be made. Finally, the four keys s1-S4 are scanned to determine whether the commands in the keys need to be executed. Finally, the loop is returned to the beginning of while (1). The program flow diagram is shown in Figure 17.

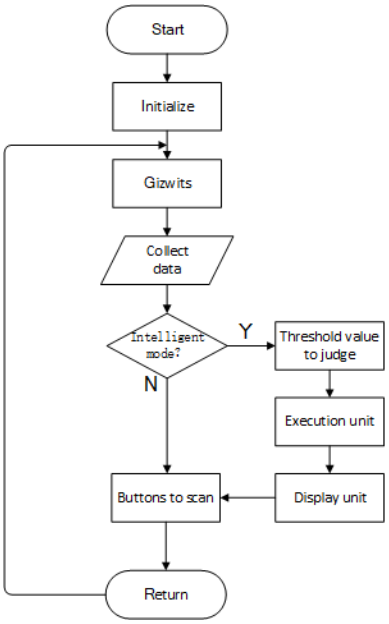

Fig.17 Main program flow diagram

2. Subroutine design

(1) DHT11 subroutine design

The DHT11 uses the single-bus protocol. The data port of the DHT11 is connected to the P2.4 port of the microcontroller. After the microcontroller completes the initialization, the microcontroller starts to obtain the temperature and humidity value of the DHT11, which includes the 8-bit humidity integer, 8-bit humidity decimal, 8-bit temperature point, 8-bit temperature point, and 8-bit check number. This design only takes its temperature and humidity 8-bit integer part, and then processes its data. The program flow diagram is shown in Figure 18.

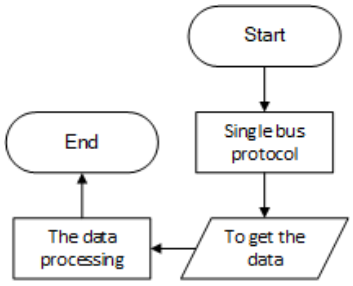

Fig.18 DHT11 Subroutine flow diagram

(2) GY-30 Subroutine design

The GY-30 light intensity sensor communicates with IIC protocol, and the microcontroller will first send it an initialization instruction of 0x01 to start its normal function of obtaining light intensity, and then continuously read and store the obtained light intensity value into BUF array, and then process it and finally return a light intensity value. The program flow chart is shown in Figure 19.

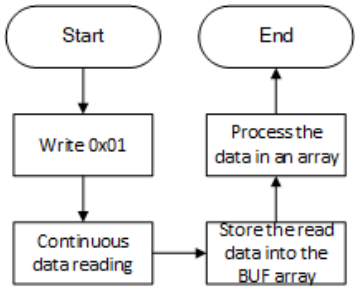

Fig.19 GY-30 Subroutine flow diagram

(3) OLED Subroutine design

OLED uses the four-legged IIC protocol for communication. Since the screen has memory line, it needs not only to initialize it but also to clear the screen after the single chip computer is powered on, otherwise THE OLED will remember the display mode before the power failure and the screen cannot be displayed normally. After that, the corresponding data OLED can display Chinese characters, numbers, symbols and images. This design mainly uses the first three parts, which respectively exist in the three arrays OF F8X16[], F6x8[][6] and Hzk[][32]. Among them, Chinese characters are the Chinese character BCD code needed in this design generated by the mold taking software. The program flow diagram is shown in Figure 20.

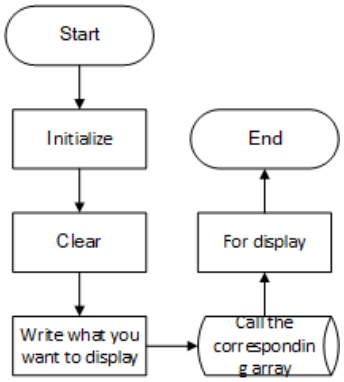

Fig.20 OLED Subroutine flow diagram

3. Gizwits implementation
(1) Gizwits configuration process

This design adopts AirLink mode connection of Gizwits platform for remote communication. The design principle is that first, the mobile APP (client 2) needs to connect to the wi-fi network (2.4g band) that meets the connection requirements. Then the orchard weather station equipment (client 1) will first press the button S5 and then the single chip microcomputer will send ESP8266 09 instructions, meaning that ESP8266 is in the receiving state, and then the mobile phone connected to Wi-Fi will be distributed through the DEMO. During network configuration, the mobile phone APP sends the wi-fi account password to ESP8266 in broadcast mode. After receiving the account password, the ESP8266 tries to connect. After the connection is successful, client 1 and client 2 are on the same LAN and can communicate with each other remotely. The configuration steps between Gizwits platform and weather station equipment are as follows：
1.Log in to the home page of Gizwits to create a device and select the communication mode. The communication mode of this design is Wi-Fi. Then set the corresponding data point and input the correct product key to download the packaged device control program of STC15F2K60S2. Data points required in this design include: read-only numerical air temperature, air humidity, soil humidity, light intensity and wind speed. Such data points can only be read from hardware devices and cannot be modified. Writable Boolean data increase temperature, lower temperature, increase humidity, decrease humidity, this data type allows users to remotely control the execution unit through the DEMO. The writable upper and lower limits of temperature and humidity allow users to remotely adjust the threshold of the meteorological station.
2.Through serial port burning module and software, burn Gizwits matching GAgent firmware to ESP8266.
3.Set S5 as the access button in the device control program generated by Gizwits, and record the changed program into the single chip microcomputer to complete the preparation before access to the network.
4.The ESP8266 communication module is controlled by the S5 button, and the network is configured for the ESP8266 communication module to achieve network communication.
5.After the ESP8266 communication module is successfully configured and connected to the network, the single chip microcomputer can transmit the collected data to the Gizwits platform and display it on the background webpage or mobile APP to achieve the purpose of remote detection. At the same time, the DEMO can also be used to issue control instructions to the hardware equipment, when the MCU will execute the specified operation after receiving the instructions. The intelligent cloud configuration process is shown in Figure 21.

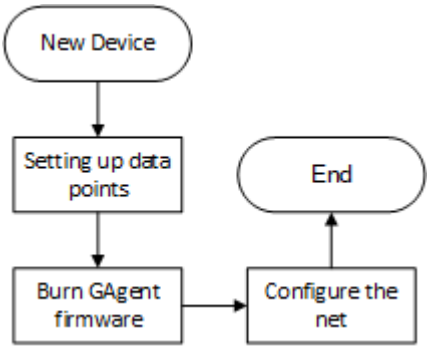

Fig.21 Gizwits distribution network flow chart

(2) GAgent firmware

GAgent is mainly used for data forwarding and is a data interaction bridge between device data, Gizwits and APP [27]. In this design, GAgent firmware is transplanted into wi-fi module through burner. After burning, Wi-Fi module and mobile APP can be connected to Gizwits server through Internet, so as to realize data interaction between equipment and Gizwits platform. This firmware mainly encapsulates MQTT protocol [28]. The communication protocol is consistent with MQTT communication protocol, which is suitable for the long time the device is online. In actual use, this design only needs to realize the communication with the serial port of the Wi-Fi module, and configure the Wi-Fi module to access the network. After successful configuration, it can directly access the Gizwits server, which is convenient for users to use.

(3) AirLink configure the net

This design adopts Airlink network access mode. When the mobile APP is connected to the router in the LAN, it enters the configuration network access mode after filling in SSID and password on the configuration interface [29]. During the configuration process, the mobile APP will continuously send UDP configuration packets, which are airborne packets, which store the SSID and password of the packaged Wi-Fi router [30]. At the same time, the hardware equipment must enter mode of distribution network, ESP8266 communication module will continue to collect the air bag, after get the packet ESP8266 module even on the router and successful package returned through a router configuration, phone APP will display the device configuration is successful and hardware project name registered in tact on the cloud and the current equipment online status. After the configuration, if the device is online, users can directly communicate with the hardware device. Users do not need to be on the same LAN as the hardware device. Airlink Figure 22 shows the process for configuring network access.

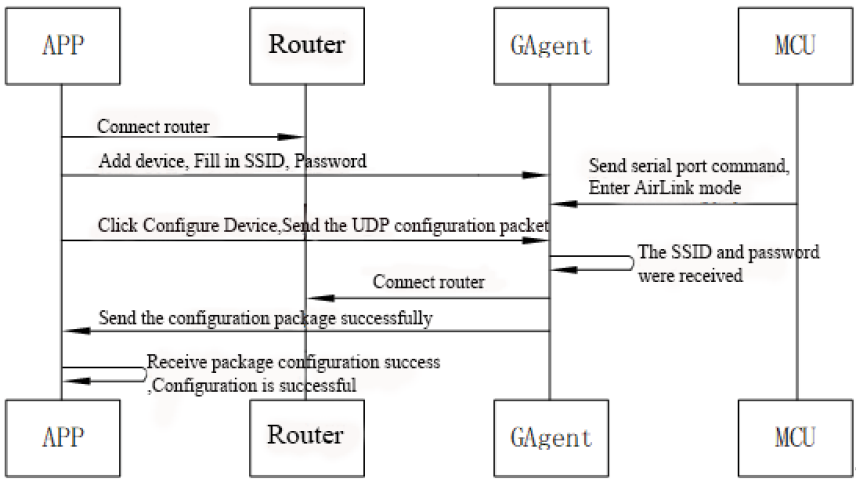

Fig.22 AirLink Configure the network access process

5. SYSTEM INTEGRATION AND DEBUGGING

1. Cloud platform data display

The software automatically generated by Twit Cloud includes web version simulation device and mobile phone APP software. When the device goes online, users can monitor the environment of the hardware device, set thresholds, and send execution commands through the web version or APP software. When using the web version simulation device, the user can directly view the communication log of the hardware device on the right side of the screen without exiting the current web page, which is easy to operate and convenient for communication debugging. The web device is shown in Figure 23. At the same time, the user can also use mobile phone APP, apps page more beautiful, more intelligent operation, once the variable state changes directly to the corresponding instructions, to carry on the remote control, mobile phone APP page as shown in figure 24.

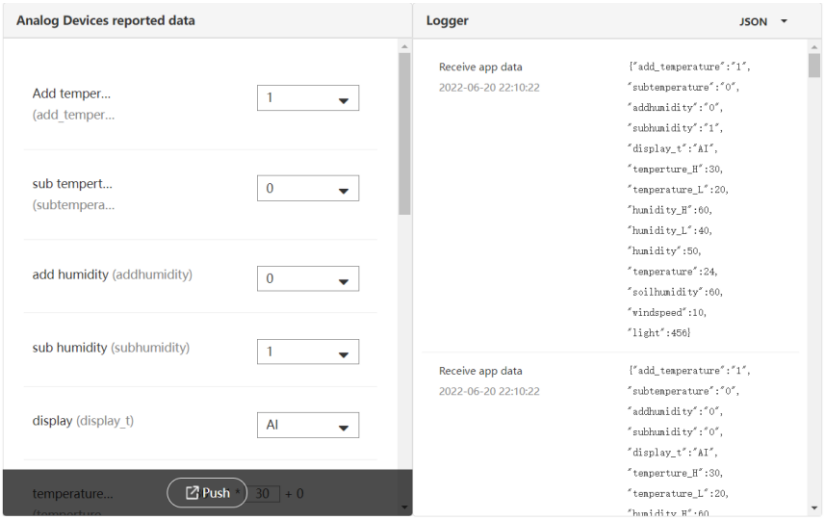

Fig.23 Web device

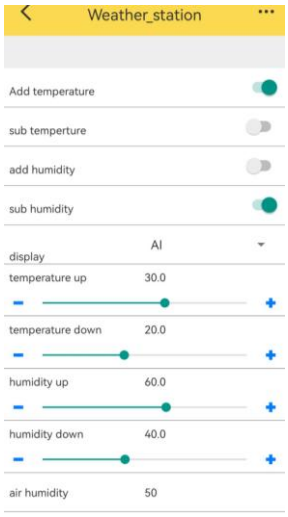

Fig.24 Mobile APP

2. Hardware debugging

The hardware debugging can test whether the circuit connection is correct and whether each module works normally, so as to avoid the influence of the wrong circuit on the subsequent joint debugging with the DEMO. This design hardware debugging process, mainly on the sensor data acquisition function, ESP8266 wireless communication module communication function, as well as the execution unit is normally available for testing.
The test of sensor data acquisition function is mainly to determine whether temperature, humidity, soil humidity, light intensity, wind speed and other data are within the measurement range, and whether the results meet the requirements of the design project. After testing, the data collection function of each sensor is normal and meets project requirements. Test results of sensor acquisition function are shown in Table 1.

Table (1) Sensor test results

Device	The name of the data	Range	Results	Whether normal
DHT11	Temperature	0-50℃	23℃	Normal
	Air humidity	0-99%RH	61%RH	Normal
Soil moisture sensor	Soil moisture	0-99%RH	42%RH	Normal
GY-30	Light intensity	0-65535Lux	1523Lux	Normal
Wind speed sensor	Wind speed	0-99m/s	9m/s	Normal

As the communication part of this design, whether ESP8266 is normal or not is related to whether it can be connected to Gizwits, so it is also necessary to debug the module. After the successful burning of ESP8266 firmware, plug it into the circuit board, and send the 0x09 instruction connected to ESP8266 through serial port 1 by pressing S5 microcontroller. Then connect the serial port 2 of the SCM to receive data at 115200 baud rates. The received data is ESP8266 log data. If the received log data is normal, ESP8266 is normal. The test results are shown in Table 2.

Table (2) TEST results of ESP8266

Device	Instruction	Whether the data is normal	Whether the device works properly
ESP8266	0x09	Yes	Yes

The executive function test of this design has four relays, so it is necessary to control these four relays respectively to check whether they can switch on and off normally, so as to judge whether the relay is normal. The test results are shown in Table 3.

Table (3) Relay test results

Device	Number	Normal number	Test case
Relay	4	4	All normal

3. Joint testing and effects

In the joint debugging of the design system, the upper computer and the lower computer are combined to test whether the data of the upper computer and the lower computer are synchronized, and whether the receiving and sending between instructions are normal.
The sensor joint test is mainly for real-time monitoring of temperature, air humidity, soil humidity, light intensity, wind speed and other data, and at the same time for real-time monitoring of temperature, air humidity, soil humidity, light intensity, wind speed and other data of upper computer and lower computer. Through the test, its temperature, air humidity, soil humidity, light intensity and wind speed are the same as the data of the DEMO, which is in line with the expected functions of the design. The test situation is shown in Figure 25.

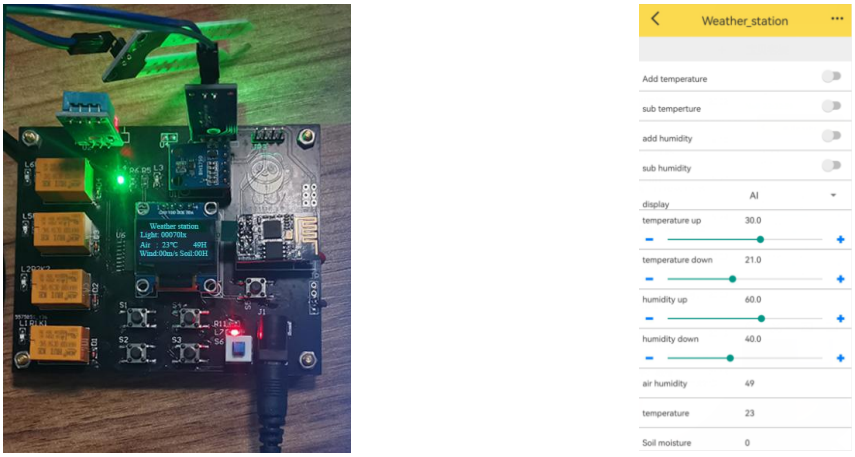

Fig.25 Sensor joint test diagram

In addition to the design of real-time sensor for collection, also can automatically adjust the parameters, is to collect data to adjust to the environment, within the scope of the required threshold, the threshold range can be set in the upper machine, also can undertake design in the next bit machine, under a machine mainly push the S2 in smart mode both threshold adjustment into the interface. In this case, S1 indicates select, S2 indicates plus, S3 indicates minus, and S4 indicates confirm and return. Threshold adjustment is shown in Figure 26.

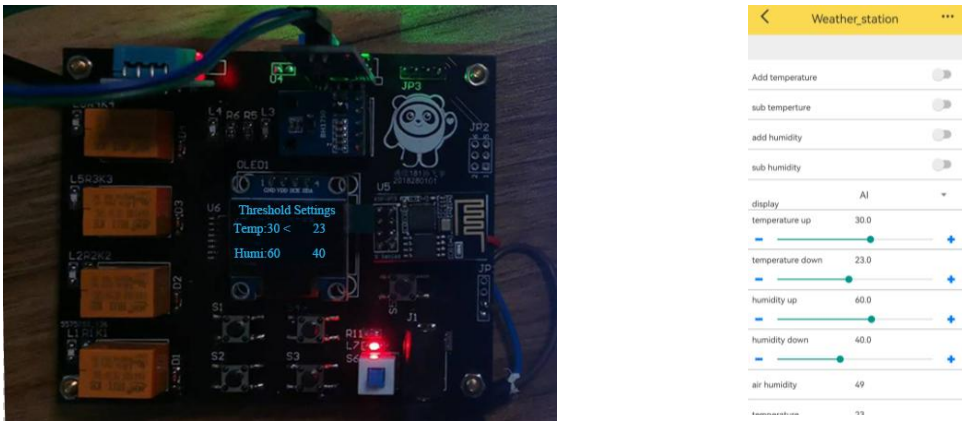

Fig.26 Threshold setting joint test

When the data exceeds the threshold, the red LED will light up for alarm, and the corresponding analog relay will give corresponding feedback. The green LED light is on in the normal range, and the test results are shown in Figure 25. Red LED alarm and relay feedback are shown in Figure 27.

Fig.27 Red LED alarm and relay feedback combined test

This design not only has intelligent mode and manual mode, in which four relays can be adjusted freely. However, in order to prevent unnecessary waste caused by user operation mistakes, conflict judgment is also written in the program, which cannot be turned on when humidifying, and cannot be turned on when heating. Both upper and lower computers can be adjusted. Relay control test is shown in Figure 28.

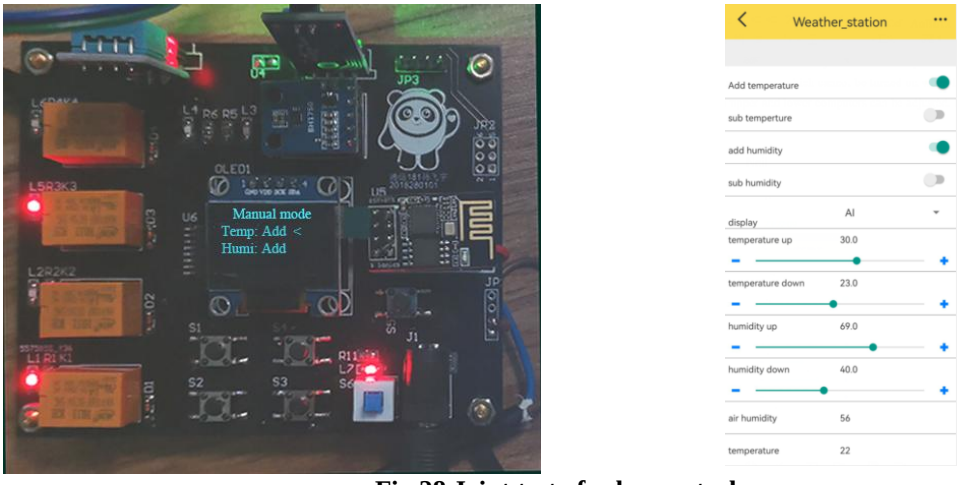

Fig.28 Joint test of relay control

6. Conclusion

This paper mainly discusses the orchard weather station based on SCM. It introduces the DHT11 temperature and humidity sensor, GY-30 light intensity sensor, ABS material wind speed sensor, soil hygrometer detection module, OLED display module, relay execution unit and intelligent cloud platform used in this design, realizing all-weather monitoring of the orchard meteorological environment. And can make real-time feedback to the orchard temperature, humidity environment, as well as its light, wind speed feedback to the user to make the adjustment as soon as possible. After testing, this experiment can replace the traditional weather station, and solve the market weather station is not convenient to carry, expensive and other problems. The design cost is low, and it is easy to carry to adjust the temperature and humidity environment in the air in real time, and transmit the important data those other orchards need to detect to the upper computer in real time. Users can also carry out some necessary control of the weather station through the upper computer. Its intelligent mode is also in line with the current direction of social development, and its networking characteristics can be well in line with the Internet era when everything is connected.

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