Photovoltaic Greenhouse Load Control Based on Phase Change Thermal Storage Method

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Abstract. Aiming at the problem of unstable grid connection of photovoltaic power source, an in-situ consumption strategy was proposed, and a photovoltaic energy and phase change energy storage method was proposed to provide energy for greenhouse loading. Design an agricultural greenhouse power supply system with complementary solar energy and phase change thermal storage materials, including constant temperature control center, detection circuit, input circuit and display circuit. It could be seen through software programming and simulation analysis that phase change and photovoltaic combined energy supply could meet the load demand of agricultural greenhouses, it provided a reference for the local consumption of photovoltaic energy.

Keywords: Load Control, Phase Change Heat Storage, Photovoltaic Greenhouse

1 Introduction
As a clean renewable energy source, solar energy was gradually increasing in agricultural greenhouses, and energy optimization in greenhouses was also important [1]. Based on the energy supply needs of greenhouses, distributed energy and other forms of energy were combined to form a supply. Can system [2-4]. Compared with the traditional energy supply, the phase change heat storage has the advantages of large heat storage per unit volume and small temperature change during the heat release process, which was gradually valued by researchers [5-8]. These studies mainly focused on the selection of phase change materials. And performance [9-10]. In this paper, solar energy and phase change thermal storage systems were used for energy supply in agricultural greenhouses. The control system was used to detect the load and parameters in the greenhouse, so that solar energy and phase change energy storage could work together to control the energy consumption of agricultural greenhouses in real time.

2 System Design

2.1 System Design
Using solar renewable energy, we design an agricultural greenhouse energy supply system that
complements the use of solar energy and phase change thermal storage materials. The system uses solar energy and phase change hot water tank reactors to provide constant temperature conditions to compensate for the instability of solar energy supply and to ensure the stability of the control system for agricultural greenhouse energy. The specific system design is shown in Figure 1.

Fig 1. system overall design block diagram

2.2 Load Combined Energy Supply System
The energy supply system of the agricultural greenhouse adopts photovoltaic energy supply and phase change energy supply combined energy supply mode. The phase change energy storage device mainly uses the principle that the phase change material has small temperature fluctuation during the phase change process, and provides constant thermal energy for the agricultural greenhouse. The phase change energy storage device is selected according to the load of the system, and the phase change material pair is as shown in Table 1.

| Specifications | Phase change temperature point (°C) | Latent heat (kw.h/cbm) | Phase change material type | Maximum operating temperature (°C) |
|----------------|-------------------------------------|------------------------|---------------------------|----------------------------------|
| water          | 0                                   | 40                     | Inorganic                 | 100                              |
| NaCl           | 5                                   | 33                     | Inorganic                 | 75                               |
| Decylene       | 15                                  | 37                     | organic                   | 85                               |
| Paraffin       | 35                                  | 60                     | organic                   | 100                              |
| Calcium chloride hexahydrate | 55 | 42 | organic | 100 |

The daily warm water is generally around 30 °C, and the boiling point of hot water is 100 °C. The paraffin wax is selected as the research material, and the paraffin wax performance is stable. Although the thermal conductivity is small, the heat transfer can be enhanced by adding metal powder to the paraffin. ability. The phase change heat storage device can effectively compensate for the contradiction between the intermittent and unstable solar power supply and the need for continuous stable energy in the greenhouse.

Solar collector heating mode, solar energy supply system is mainly composed of solar photovoltaic panels, circulation system and greenhouse load. The solar photovoltaic panels collect heat and then transfer it to the greenhouse through the circulation system. The excess energy is stored in the battery during the day and released at night.

When the measured temperature of the phase change thermal storage system is lower than the lower limit of the greenhouse temperature, the solar collector is supplied to the greenhouse load by the circulating pump; when the measured temperature of the phase change thermal storage system is
greater than the upper limit of the greenhouse temperature, the supply of energy to the greenhouse is stopped. When the energy storage is not enough when it is rainy or night, the utility power is used to supply greenhouse energy.

2.3 Agricultural Greenhouse Thermostatic Control System
The constant temperature control system mainly uses the sensor to monitor the greenhouse temperature, controls the valve through the single-chip microcomputer, and constructs a reasonable operation mode to control the heating system, the energy storage system and the circulation system. Each module is debugged by programming, including temperature acquisition module, keyboard control and liquid crystal display module for input and reading of commands and auxiliary motor drive module, and then all modules are jointly debugged. Control system core STC89C52 single-chip microcomputer, temperature acquisition is DS18B20 sensor, using software and hardware to combine with each other, driving the whole system circuit to work according to the predetermined way, to achieve the purpose of constant temperature control.

3 System Hardware Circuit Design

3.1 Hardware Circuit
In the minimum system, the system rated voltage is 5V, the crystal oscillator circuit pins are XTAL1 and XTAL2, which are independent operation input and output inverting amplifiers, internal clock mode, crystal oscillator frequency 1.2~12MHz. In this paper, a 12M quartz crystal is used, and the size of the two capacitors is 20pF.

Reset circuit, because the capacitor voltage can not be changed when power is on, the negative pole of the capacitor is directly connected to RESET, the voltage is applied to the resistor, and the chip is reset. The parallel connection between the two ends of the capacitor is a reset button. When the reset button is not pressed, the circuit will be automatically reset when the power is turned on. When the push button is pressed, the RST side will become a high level. When the RST is in The working time of the high level exceeds 20ms, and the microcontroller is effectively reset.

The liquid crystal display circuit uses an LCD1602 liquid crystal display. LCD1602 liquid crystal is also called character type liquid crystal. The display module is a dot matrix display module. The display point is 5×7. It can display Arabic numerals, English letters and custom symbols including Chinese symbols. The data transmission method is serial transmission.

The driving circuit of the LCD1602 liquid crystal panel is composed of one row driver and two column drivers, so the 1602 liquid crystal panel is also spliced into two independent 64×64 liquid crystal screens, each of which has 512×8-bit display data RAM. The signal received by the chip is passed to CS1 and CS2 to drive the circuit on the left half of the screen.

The temperature sensor circuit uses the temperature sensor DS18B20. The sensor's measurement temperature is at least 45 °C, up to 125 °C, and when measuring objects in the range of -10 °C ~ 85 °C, the floating range is 1°C, the sensor can support the "one line is the bus" transmission mode, can improve anti-interference, working voltage 5V.

3.2 System Hardware Test
System hardware testing mainly detects whether the circuit has open circuit, virtual soldering, wrong component wiring, and circuit design errors.

In order to detect whether the component is misaligned or not, the physical map is compared with the schematic circuit, and each component is tested one by one to see if it can correspond to the real object. If there is a missing physical object or there is no way for the schematic to correspond to the physical map, it needs to be re-examined in time, and the actual effect can be achieved by repair welding or modifying the direction of the component.

The digital multimeter is used for the detection of short circuit, open circuit and virtual welding. The digital multimeter is hit into the position of the diode, and then the two pens are touched together.
If the device is in the on state, the multimeter will give a warning, otherwise there is no sound. In this way, according to our actual detection situation, whether the line is faulty can be measured by whether the multimeter makes an audible sound.

4 System Software Part Design

4.1 Program design

Initialize with the main function void main() temperature and assign parameters according to design requirements. After the initialization, the system will enter the reading temperature. If the temperature is high, the system will reduce the temperature through the circulation system. Otherwise, the system will supply the greenhouse energy through the combined energy supply system. The main program flow chart is shown in Figure2.

![Flow chart of the main function](image_url)

**Fig 2.** Flow chart of the main function

The temperature acquisition program, after the temperature sensor is converted, is the analog quantity, not the actual temperature value, so you need to write a program to simply process the data. Because the accuracy of this program is 0.0625, the number after the decimal point can be multiplied by 0.0625, and the non-integer is rounded off. Only the first decimal place after the decimal point is retained, so that the actual value of the ambient temperature is obtained. The accuracy reaches 0.1 °C.

The judgment of the temperature first determines whether the temperature is below the set value. If it is, then the sensor will save the complement of the temperature, and then add the first bit to the eighth bit, thus becoming the original code. After processing, the temperature of the DS18B20 will be copied to the MCU, stored in the memory of the MCU, the Hex code stored last time before the RAM, and then the Hex code is converted to the BCD code, and then the decimal places in the BCD code are respectively Ten bits are stored in the memory, and after the conversion is completed, the temperature end program is read.

Temperature transfer debugging process: Initialization is successful at the beginning and the slave responds. However, when reading the temperature, the data readout is all 0xff, indicating that the slave does not respond, or the slave does not send data to the bus, and the transmission timing is considered to be problematic because the command used is no problem. Can be successful once, the second time is wrong. The second initialization failed.

There is a problem with the data transmission. The read data is 0x50, 0x05. After re-modifying the timing delay, the correct temperature data can be obtained, but the correct temperature reading is obtained under the condition of the breakpoint setting. At full speed, communication is not possible,
that is, the slave does not send data to the bus or the slave does not receive data. Generally, the situation is that the temperature conversion is not completed, because during the temperature conversion process, the bus is not responded to, the data is sent to the bus, and the debugging is extended for a long time. However, the extension time is too long, the compiler crashes, and the temperature is adjusted to get the correct value. The solution adopted is to use the timer, then turn on the temperature, and after a while, read the temperature.

LCD1602 displays the program. The programming is that the LCD display writes the address you want to display by command, and then writes the data in order, and after displaying the first address, the following will be automatically incremented by 1.

4.2 Simulation Debugging

For static debugging, first check the interface, check the physical object, check whether the connection of the circuit board is wrong, and find out the errors in the installation and connection by visual inspection, and then modify it. Secondly, find the relevant chip data, mainly the interface between LCD1602 and MCU, especially to observe the interface of LCD I/O corresponding to LCD. Finally, the simulation check, after the simulation run, check whether the program is written correctly, whether the LCD screen is blooming, whether the chip used is properly used, and then the next step can be debugged. The schematic diagram of the constant temperature control system is shown in Figure3.

The software runs and debugs, and the programming software loads the preliminary debugging program into the main module through the support of the compiler. The debugging steps include:

1) Single step: Each time the system runs only one command, after executing this command, it returns to the monitoring program.

2) Line: It can be started from any address and guarantees fast and error-free operation.

3) Point operation: can arrange breakpoints at any position, and immediately return to the monitoring program when a breakpoint is encountered.

Query and modify the memory and the contents of the register. By debugging the subroutine, you can find the infinite loop and address error.

Through simulation analysis, it can be seen that the combined energy supply of phase change energy storage and photovoltaic energy supply can meet the energy demand of agricultural greenhouses and provide a reference for photovoltaic local consumption.

5 Simulation and Conclusion

1) The intelligent control system can control the coordinated supply of phase change energy storage and photovoltaic energy supply;

2) According to the daily temperature, paraffin is selected as the phase change energy storage material, and the heat exchange capacity is enhanced by adding metal powder in paraffin, and the phase change heat storage device can effectively compensate the intermittent and unstable solar power supply and the greenhouse. The need to continuously stabilize the contradiction between energy.
Fig3. Schematic diagram of the constant temperature control system

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