Design of PLC Automatic Water and Fertilizer Integrated System in Greenhouse

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Abstract. In this system, the soil moisture content is collected by the FDS soil moisture sensor, and the pH value in the soil is collected by the soil in situ EC meter. The collected moisture and EC values are transmitted to the PLC and displayed through the touch screen display. The automatic mode or manual mode is selected through the touch screen, and the humidity and pH value are set in different modes to realize automatic watering of the proportional fertilization pump. The overall scheme, circuit diagram and program of the system designed in this paper have been designed and implemented after many times of debugging.

1. Introduction
With the modernization of agriculture and the continuous advancement of irrigation technology, automated agricultural equipment has been promoted. In China, greenhouse cultivation is an important farming method to increase the yield of crops. However, in greenhouse cultivation, most of the areas use traditional fertigation methods to fertilize crops. This traditional fertigation not only consumes a lot of material and financial resources, but also causes serious waste, low utilization rate and rising pollution index. Therefore, in this context, based on the status quo of agricultural development in China's greenhouses, the research on the design of integrated greenhouse water and fertilizer integrated systems was launched.

2. Overall structure of the system
The integration of water and fertilizer has great significance for improving resource utilization, environmental protection, and saving manpower and material resources. The water and fertilizer integration system based on PLC includes four parts: water source, first hub system, network system and pipeline system. The overall structure of the system is shown in Figure 1.

a). The choice of water source. Only water quality meets the needs of irrigation, and can provide water for crop growth before it can be used as a water source, for example: rivers, lakes, reservoirs, etc.

b). Have a complete set of first hub system. Pumps, filter devices, fertilization devices, leakage protectors, pressure and flow detection devices, fertilization systems, automation control devices, etc. are the control centers of the entire system, responsible for the correct operation of the entire system, flow monitoring and adjustment, they are known as the first hub system.

c). Establish an IoT system. The realization of water and fertilizer automation requires a detailed understanding of soil moisture, weather conditions, and fertilizer requirements for crops, so that irrigation can be carried out in a timely and appropriate amount. Therefore, the environmental detection system, the soil moisture collection system, the automatic irrigation system, and the radio valve control system are constructed into a network system.
d). Establish a continuous and complete pipeline system. According to the location of the soil and water source, establish appropriate main, dry, support, and wool pipelines and corresponding pipeline control valves.

![Figure 1. Overall structure of greenhouse automatic water and fertilizer integrated system in greenhouse](image)

3. Principles for system design compliance
The water and fertilizer integrated system designed in this paper is applied to the crops in the greenhouse, and the growth characteristics of the crops and the environment in the greenhouse should be considered. Therefore, the system design should follow the following principles:

a). The principle of modularization: the whole system of water and fertilizer integration is refined into one module, and it is not easy to make mistakes in the design process, and it is also convenient for subsequent failure modification.

b). Practical principle: The designed system should be able to adapt to the planting environment in the greenhouse, meet the irrigation and fertilization needs of various crops in the greenhouse, and at the same time, the operating system should be simple and easy to understand, and convenient for users to operate.

c). Safety principle: The soil moisture collection system and environmental monitoring system in the Internet of Things system will not cause the set parameters, the programmed procedures, and the collected soil public opinion information due to power failure, voltage instability, bad weather, etc. Missing.

d). Stability principle: Dynamic monitoring devices are set up in the system to ensure safe and stable operation of the system.

4. Hardware system overall plan
The design of the automatic water and fertilizer integrated hardware system mainly consists of two parts. The first part, based on the wireless network acquisition and monitoring system, achieves the collection of soil moisture content, nutrient element content, temperature, illumination and other data in the greenhouse, and then transmits the data to the control center as the basis for the operation of the water and fertilizer irrigation system. The second part, the main system of water and fertilizer irrigation, this part is designed with programmable logic controller PLC, which can not only be operated locally in the control room of the greenhouse, but also can be used to water and fertilizer through a computer connected to the Internet at any other place. The integrated system performs remote operations.
The overall structure of the hardware system is shown in Figure 2. The system is mainly composed of three parts, namely PLC control part, computer room data center and soil moisture collection system.

![Hardware system schematic](image)

**Figure 2.** Hardware system schematic

### 5. Module control program design

The control part of the system is mainly divided into three modules: soil moisture collection system, PLC control and actuator. The soil moisture collection module includes FDS-100 model soil moisture sensor and 2265FS model farm soil in situ salinity meter, which is responsible for the soil. The water content and salt ion content are measured. The PLC control includes the controller of the Omron CP1H series and the touchable display screen. It is responsible for receiving the data, moisture and EC value parameters transmitted by the acquisition module through RS485, and executing according to the ladder diagram and data pair. The mechanism controls and executes the output device including the solenoid valve and the pump motor, which is responsible for irrigation of the farmland.

In this paper, the motor Y start, automatic control mode and manual control mode in the actuator are described in detail. In addition to the analog input of the FDS-100 model humidity sensor and the soil in situ EC meter, the other inputs and outputs are digital. Therefore, the anti-interference energy required by the system is realized by the programming controller. The system uses the programming software CX-P to compile the ladder diagram to realize the control of the actuator motor and solenoid valve.

| Enter device name        | Button | Input point |
|--------------------------|--------|-------------|
| Startup button           | SB1    | 0.00        |
| Stop button              | SB2    | 0.01        |
| Automatic mode           | SB3    | 0.02        |
| Manual mode              | SB4    | 0.03        |
| Manual start             | SB5    | 0.04        |
| Output device name       | Relay  | Output point|
| Electromagnetic valve    | KM1    | 100.00      |
| Motor star connected     | KM2    | 100.01      |
| Motor triangle connected | KM3    | 100.02      |
| Solenoid valve indicator | L1     | 100.03      |
| Manual display light     | L2     | 100.04      |
| Automatic display light  | L3     | 100.05      |

### 6. Automatic irrigation mode

In the automatic irrigation mode, the PLC controller can compare the moisture and EC value transmitted by the sensor with the suitable crop growth set by the verified data, that is, the comparison
between the detected value and the set value, when the detected value is low. At the set value, the solenoid valve is activated and the actuator performs the corresponding irrigation and fertilization. The flow chart of this mode is shown in Figure 3.

**Figure 3.** Automatic irrigation flow chart

![Automatic irrigation flow chart](image1)

The function of the control circuit of the automatic irrigation mode: press the button 0.02, the system selects to enter the automatic mode, and the automatic mode display lamp L3 lights up. At this
time, the motor has already started the star triangle, and the signal transmitted by the sensor through RS485 is put into the 200 channel. The fixed parameter is placed in the 201 channel. When the value of the 200 channel is less than the value of the 201 channel, the solenoid valve KM1 works, that is, the actuator starts to operate, and the ladder diagram of the automatic irrigation mode is as shown in FIG. 4.

7. Manual irrigation mode
In the manual irrigation mode, the system has the function of manually setting the opening time of each solenoid valve. When the irrigation system requires pressing the manual mode button, the solenoid valve is closed, the corresponding indicator light is on, and the motor is started in the star triangle. Then observe the value collected by the sensor, press the start button, set the irrigation time, the solenoid valve works, when the irrigation time arrives, stop the irrigation, the solenoid valve is disconnected. The flow chart of this mode is shown in Figure 5.

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**Figure 5. Manual irrigation mode flow chart**

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**Figure 6. Manual irrigation mode ladder**
Function of the control circuit of the manual irrigation mode: press the button 0.03, the system selects to enter the manual mode, the motor performs the star-delta start, the manual mode indicator L2 lights up, then presses the manual start button 0.04 to set the irrigation time on the touch display. The solenoid valve KM1 is activated, the solenoid valve indicator L1 is lit, and the actuator performs corresponding work. When the set time is up, the solenoid valve is closed and the motor is stopped. The ladder diagram of the manual irrigation mode is shown in Fig. 6.

8. Summary
This paper introduces in detail the hardware and software design ideas of PLC-based automatic water and fertilizer integration system. Completed the task of designing the greenhouse automatic water and fertilizer integrated system in the greenhouse. The design of this paper adopts the combination of hardware and software. It has certain difficulty, but it has very powerful functions. It has great practicality in agriculture and can be widely used in greenhouses and orchards.

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