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# An Automatic Thermal Control for a Greenhouse Using Network Remote Control System

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**Abstract:** For the purpose of integrating the value of agriculture and lowering the cost of production expenses, a modern farming industry equipped with a remote automatic controlling system via the internet and a web camera is proposed in this study. In this study, the image of a plant will be forwarded to a server using a USB and a Web Cam. That image will be transported to a client using a TCP/IP protocol. Additionally, the green house will be equipped with a thermal detector, a water-spraying unit, a fan, a heating unit and a sunlight-proof unit. The control center will send the command to these units via RS232/RS485 protocol to engage them. The control system will also automatically detect current temperature in the greenhouse. The appropriate service, including sunlight-proof, ventilation and water-spraying, will be performed when the temperature has risen appropriately. The heating unit will also be actuated when the temperature in the greenhouse has fallen. The status of the green house shown on the server will be forwarded to the client via a TCP/IP protocol. The system mentioned above will be used to develop a remote monitoring interface via a TCP/IP protocol. Results reveal that the temperature for a greenhouse can be controlled online at the specified range of temperature using various heating/cooling strategies. Besides, the user will be able to monitor the plant online without going on site. Consequently, the expenses of the plant's production will be effectively lowered while the quality of plant will be greatly improved.

**Key words:** Sprinkler, PC-based, crop, sunlight-proof, agriculture, ventilation

## INTRODUCTION

In evaluating crop production, the importance of interaction between plants in determining the structure of plant communities is widely recognized (Grime, 1979; Aarssen, 1983; Tilman, 1988; Keddy, 1989; Grace and Tilman, 1990). However, it has often been difficult to demonstrate the effects of these interactions (Strong *et al*., 1984; Connell, 1990). Therefore, attention has tended to focus on studies within the greenhouse (Gibson *et al*., 1990). Moreover, to avoid the influence climate has on crops, a plastic greenhouse is compulsory (Montero *et al*., 1985; Lopez *et al*., 2006). The cares of various crops such as tomatoes, strawberries, cucumber and melons have been tried to raise in the greenhouses using thermal heating systems with water as a storage medium. It has been seen that temperature plays an essential role in agriculture reproduction, particularly in cueing seasonal crops (Jebari and Hamza, 1990).

Various methodologies such as heating and cooling techniques using cooling fans as well as solar equipment have been addressed (Roberts *et al*., 1976; Papadakis *et al*., 1992; Pardossi *et al*., 2004). However, a thermal control system that keeps the greenhouse at a steady temperature is rare. Therefore, there is interest in promoting an agricultural technique using an automatic thermal control system. An automatic control of greenhouse climate using a fuzzy interface system has been constructed (Sriraman and Mayorga, 2004). However, the operation of the fuzzy interface system is inflexible which shall be manipulated within the greenhouse. To lower the cost of manpower, a remote online monitoring/control system for a greenhouse is obligatory. In this study, a remote automatic thermal control system in conjunction with a heating bulb, a sunlight-proof, a ventilation fan and a water-sprinkling device via a network and a web camera shown in Fig. 1 is established. A PC-based control system is constructed using a VB interface in both the sever PC and the client PC via the RS232/RS485 protocol. Moreover, there is a great advantage for the remote online discrete monitoring/control system used in multiple greenhouses simultaneously by login to the sever PCs via a client PC. Consequently, to demonstrate the automatic thermal monitoring/control system, a greenhouse model in conjunction with growing potted plant is assessed.

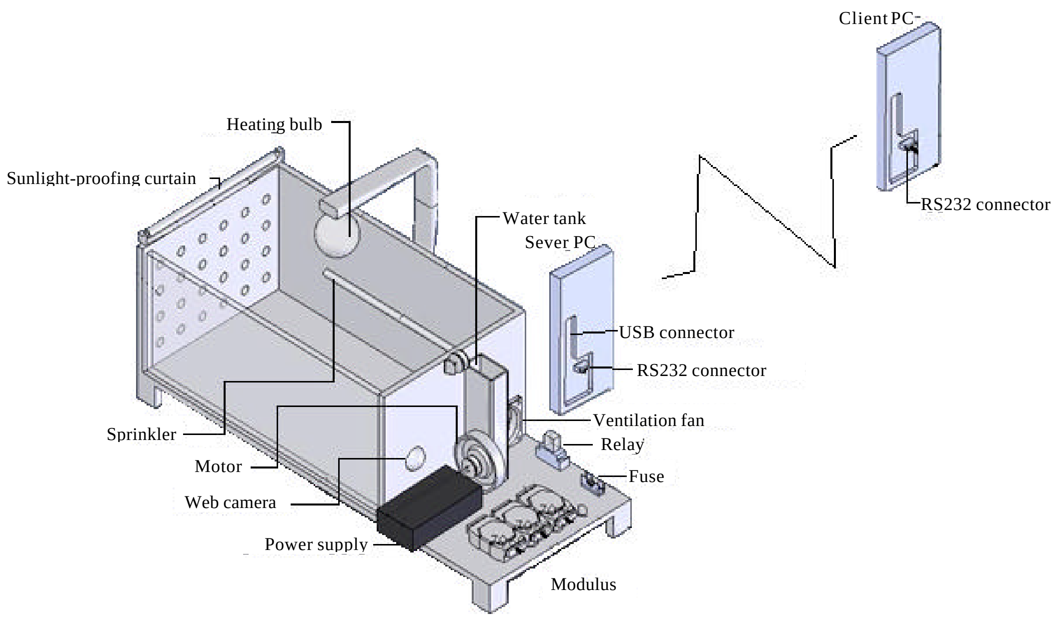


Fig. 1: A remote automatic thermal control system used in a greenhouse

## A PC-BASED TEMPERATURE CONTROL SYSTEM

An automation system used in an industrial, agricultural and an aquatic environment to reduce manpower is prominent. As indicated in Fig. 2, to increase crop production, a remote automatic thermal control/sunlight-proof/ventilation fan/water-sprinkling system using two VB interfaces (one for the sever PC and the other for the client PC) to manipulate greenhouse temperature via a network and a web camera (Tse and Chan, 2003; Mustafa *et al*., 2007) is established.

As indicated in Fig. 3, three kinds of system modulus (7060D, 7520 and 7011D) are applied to the remote monitoring/control system. Because there is a serious decay of the signal for a RS232 protocol traveling over a long distance (15 m), a new protocol (RS485) in which the effect of signal decay is trivial for long-distance transportation is recommended. Here, the module 7520 is a protocol transfer device from a protocol RS232 to RS485 (Chiu, 2008; Chiu *et al*., 2008). A commend emitted from the sever PC will be sent to the other modulus via the RS232/RS485 converter. A thermal detector made out of a thermocouple is embedded in a greenhouse to detect the temperature of the greenhouse via the module 7011D in which the analogue signal of the temperature will be transformed to the digital signal of the electric voltage.

The hardware of the thermal control/ventilating/ watering system will be actuated by the 7060D and 7011D modulus's DI/O (digital input and output) that is emitted from a sever PC via a 7520A module (a protocol translator from RS232 to RS485). Similarly, the status of the online temperature will be sent back from the module 7011D via an A/D converter. As indicated in Fig. 4, online control of the greenhouse temperature, a PC-based control logic using a temperature-detecting feedback system in conjunction with a heating device/a ventilating fan/a watering device, is performed.

As indicated in Fig. 3, the heating bulb will be actuated when the temperature detected inside the greenhouse is below 25°C. The motor for stretching the sunlight-proof curtain will be actuated if the temperature is between 28 and 30°C. Both the fan and the sunlight-proof motor will be started up if the temperature increase is $30<T<33$°C. Moreover, all the devices including the fan, the sunlight-proof motor and the watering system will be actuated simultaneously when the temperature of the greenhouse rises above 33°C. On the other hand, all the heating and cooling devices will keep working till the greenhouse temperature is $25<T<28$°C. Consequently, the thermal detecting system will continuously detect the temperature of the greenhouse and perform the related actions during the thermal controlling process.

As indicated in Fig. 5 and 6, the user can monitor online the current temperature of the greenhouse. The manual heating can also be performed by clicking the heating button to actuate the heater via the VB dialogue on the PC sever and the PC client.

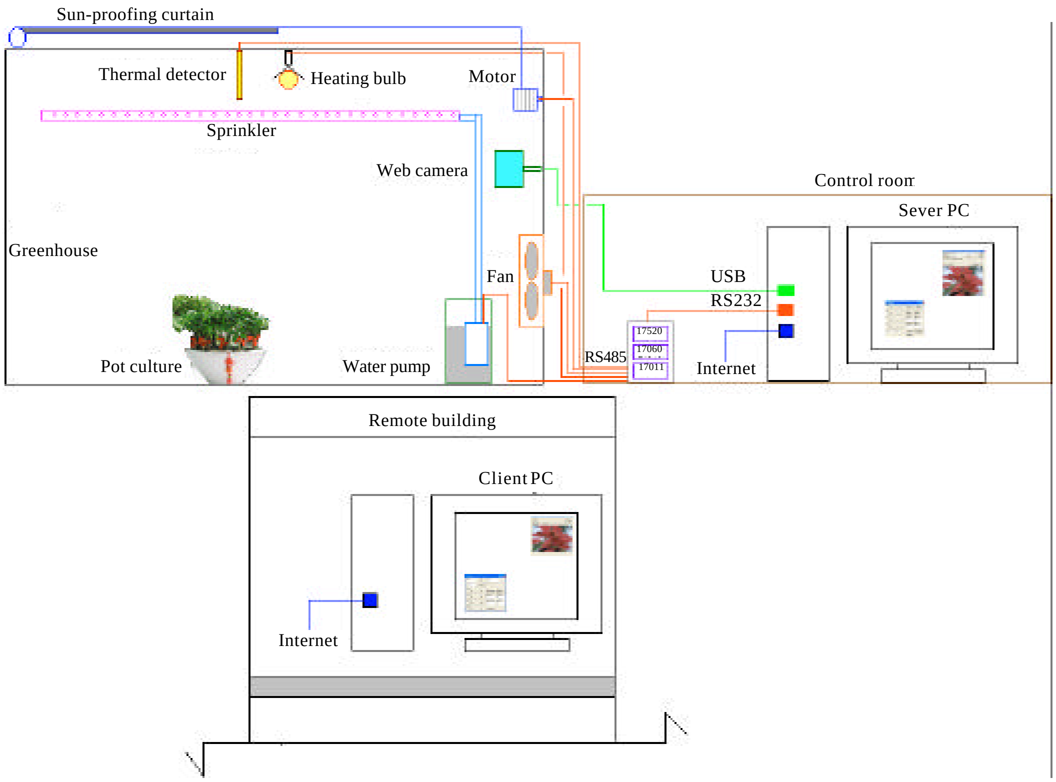


Fig. 2: A remote automatic thermal control/sunlight-proof/ventilation fan/water-sprinkling system

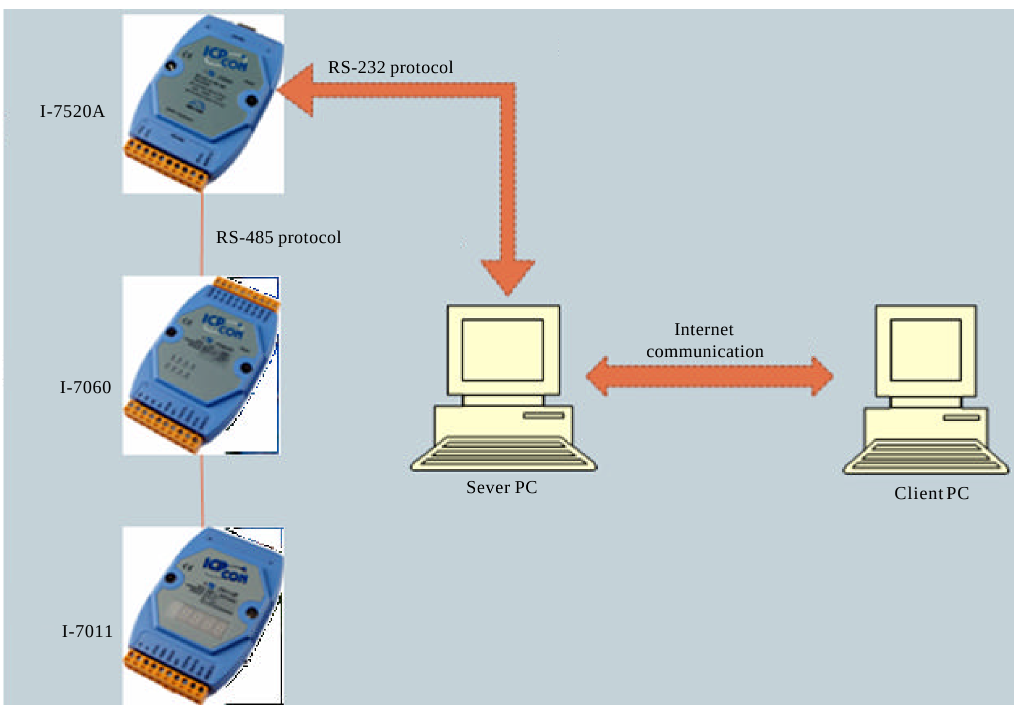


Fig. 3: Three kinds of modulus

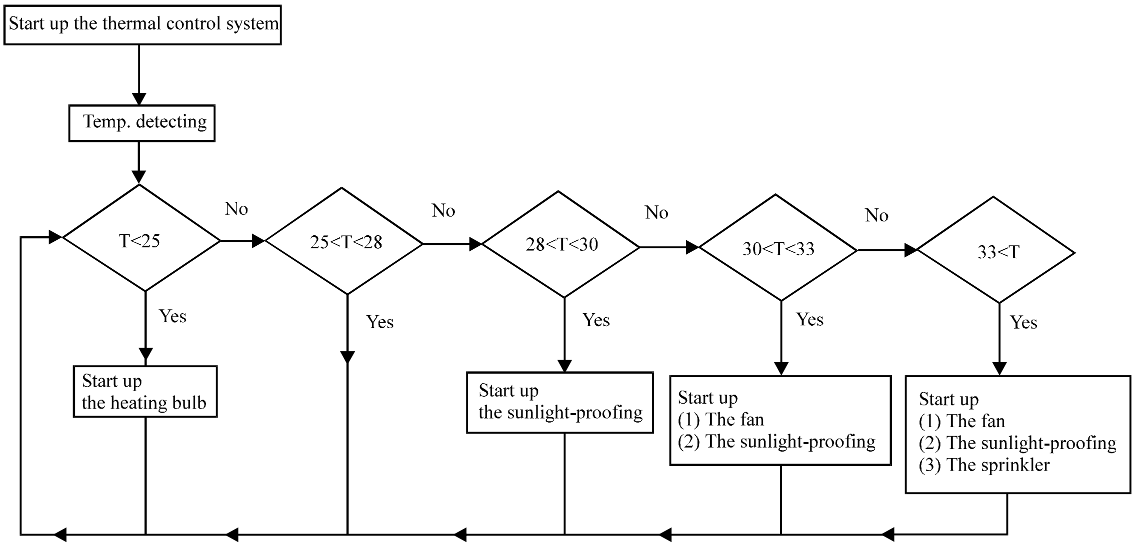


Fig. 4: A temperature-detecting feedback system built in a PC-based controller

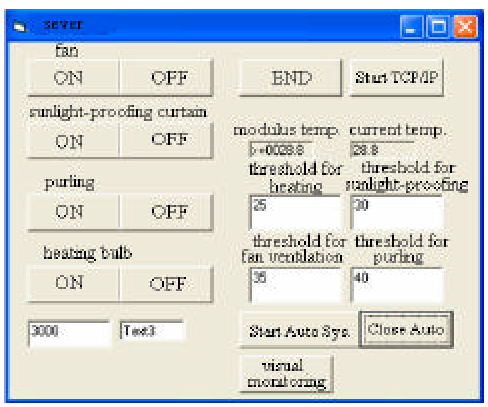


Fig. 5: Manual heating on the VB dialogue (PC sever)

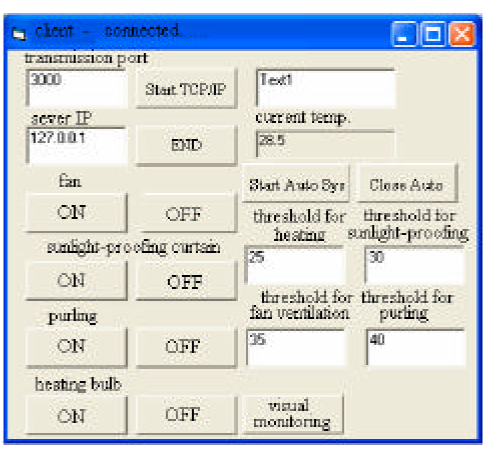


Fig. 6: Manual heating on the VB dialogue (PC client)

## A PC-BASED ONLINE MONITORING SYSTEM

To lower the cost of manpower for watering crops, a remote automatic watering system using a VB dialogue to trigger an electrical pump installed in a water tank via the RS232/RS485 and the TCP/IP protocol is established. As indicated in Fig. 7, the user can monitor the status of the crops via a web camera. As indicated in Fig. 8, manual watering can be performed by clicking the purling button of the VB dialogue on both PC sever and PC client.

## RESULTS AND DISCUSSION

**Results:** As indicated in Fig. 9, the remote automatic thermal control/monitoring system using two VB interfaces (one for the sever PC and the other for the client PC) to manipulate the greenhouse temperature via a network and a web camera has been established. Before the client PC can be manipulated, based on the TCP/IP protocol, the sever PC shall be connected first by inputting the IP address and transport number in the client PC's dialogue.

To keep a greenhouse in an appropriate temperature range, several devices (a heating bulb, a ventilation fan, a sunlight-proof motor and a watering system) have to be actuated at various temperature ranges by setting the thresholds of the temperature on the VB dialogue of the sever PC. In the case shown in Fig. 5 and 6, a target temperature of 25~30°C has been preset in the program. The upper threshold for starting the heating bulb is 25°C. Similarly, the lower threshold to stretch the sunlight-proof curtain is 30°C. Likewise, the lower threshold to turn on

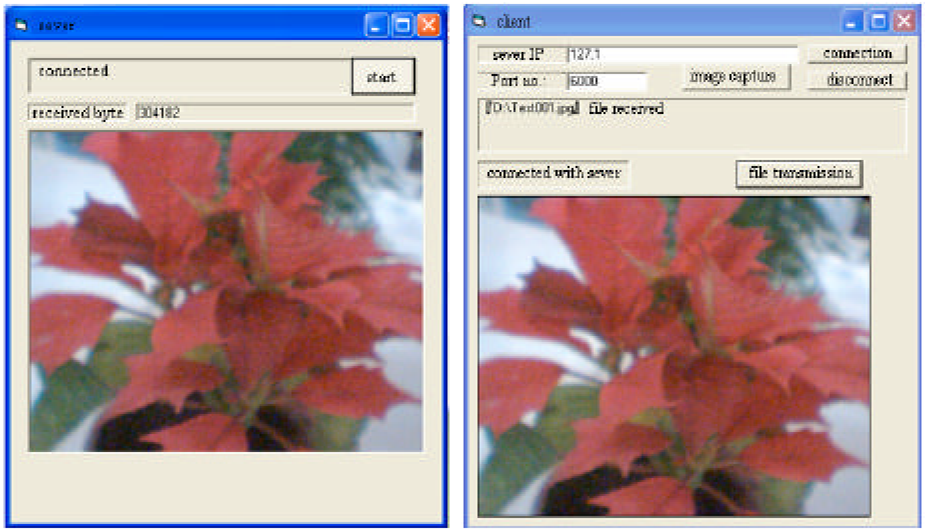


Fig. 7: An image of the crops in sever/client PC

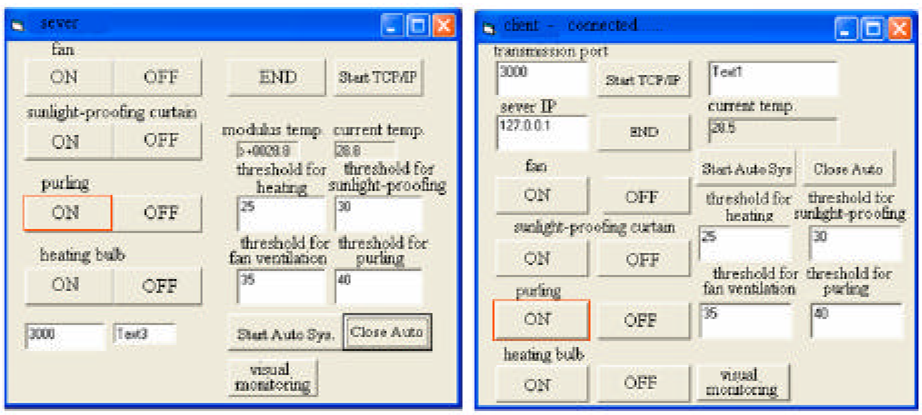


Fig. 8: Manual watering of the VB dialogue on pc sever/client

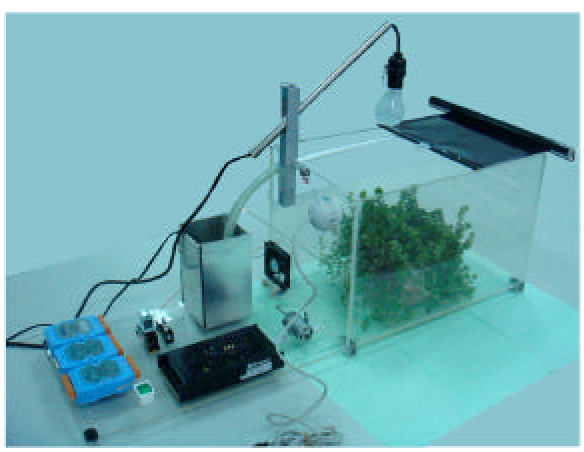

Fig. 9: A remote automatic thermal control/monitoring system using two VB interfaces

the ventilating fan is set at 35°C. Moreover, the lower threshold to actuate the watering system is 40°C.

As indicated in Fig. 5 and 6, in case of T<25 °C, the heating bulb will be turned on. Additionally, the motor for stretching the sunlight-proof curtain will be started when the temperature is 30<T<35 °C. Similarly, both the fan and the sunlight-proof motor will be started simultaneously if the temperature increase is 35<T<40°C. Moreover, the fan, the sunlight-proof motor and the watering system will be actuated simultaneously.

## DISCUSSION

The user can manipulate the thermal control in both PC sever and PC client. The status of the devices such as the heater, the sunlight-proofing motor and the watering pump will be transmitted to the PC client via a TCP/IP protocol. The command that is clicked in the PC client will be also transmitted to the PC sever to actuate the related devices. Moreover, the image of the greenhouse will be caught and sent to the PC sever using the USB protocol. The image will be then transmitted from the PC sever to the PC client via the TCP/IP. The user can remotely irrigate the crops by clicking the watering button of the VB interface.

Most greenhouses consisting of low cost structures covered with plastic have no heating equipment (Perez-Parra *et al*., 2004). To improve winter vegetable production (Pérez-Parra *et al*., 2000), the greenhouse equipped with a heating systems proposed in this paper is necessary. Besides, for low-technology greenhouses without automatic thermal control system, earlier researches (Bailey and Chalabi, 1994; Lopez *et al*., 2002) needed to assess an optimal heating strategy in advance. Furthermore, various methodologies of heating and cooling techniques using cooling fans and solar equipment have been addressed (Roberts *et al*., 1976; Papadakis *et al*., 1992; Pardossi *et al*., 2004). However, they lacked a closed-loop thermal control system that keeps the greenhouse at a steady temperature. Moreover, without a remote vision monitoring and a thermal controlling online, the crop quality in above mentioned greenhouses will not be assured. Consequently, it has been shown that a remote control system used in dealing with a thermal control is highly efficient for the improvement of crop production.

## CONCLUSION

It has been shown that a remote control system in dealing with a thermal control is highly efficient for the improvement of crop production. Concerning a steady temperature in a greenhouse, a PC-based controlling logic using a temperature-detecting feedback system in conjunction with various heating/cooling devices is used. For saving manpower and lowering the cost of the manpower in irrigating the crops, a sprinkler in conjunction with a visual monitor using a VB dialogue to manually trigger a watering pump installed in a water tank via the RS232/RS485 and the USB protocol is established. Moreover, the remote automatic thermal control system using two VB interfaces (one for the sever PC and the other for the client PC) to manipulate the greenhouse temperature via a network and a web camera has been established using a TCP/IP protocol. It has been seen that crop quality will be assured online via the remote monitoring/control system. Therefore, modern agriculture will be moving into the high-tech realm. Furthermore, there is a great advantage for the remote online discrete monitoring/control system used in multiple greenhouses simultaneously by login to the multiple sever PCs via a client PC. Consequently, on the basis of the discrete PC-based control structure, it is easy to integrate another issue for control in this system.

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