

# Greenhouse Temperature and Humidity Intelligent Control System

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*Abstract:* - The article based on embedded database of greenhouse temperature and humidity control system intelligent. Put forward by embedded database system set up in an ideal environment for data greenhouse temperature and humidity control, greenhouse crops in the process of growth under control. To address the growth of greenhouse crops in the process of temperature and humidity controlled environment is not ideal, at the same time improve the efficiency of control and cost-effective system. The article focuses on the structure of the control system, hardware, software design and system control strategy. The control system has a simple hardware structure, cost-effective, easy to use and maintenance, temperature and humidity data, and other advantages of good stability.

*Key-Words:* - Embedded database, Temperature and Humidity, Control ; data filtering, Greenhouse, Microcontrollers

## 1 Introduction

With embedded Microcontrollers technology, intelligent control system is to develop in the direction. The database is the decision-making intelligent control system's core, is the intelligent control foundation. It needs to store a lot of expertise and examples, but also to constantly update and add real-time data. In order to ensure that greenhouse environment in normal agricultural production and high efficiency, improve the quality and quantity of agricultural products, reducing the labor intensity and energy conservation, the need for greenhouse environment in the temperature and humidity control. Middle-and-low grade products currently in control of the greenhouse there are still some technical problems: generally used only for a single set of temperature and humidity control. As the day of crops on the environment of temperature and humidity requirements not the same, users must frequently adjust the controller settings, it is very difficult to meet the requirements of modern agricultural production. Development of a group of existing greenhouse, low prices and reliable system of temperature and humidity intelligent control system is necessary.

The greenhouse environment is the non-linear, the distribution parameter, time-variable, the long delay, the multivariable coupling and plurality of controls object system. In the greenhouse cultivates the different crops to need the different habitat. Establishes the greenhouse environment embedded database system's goal in the greenhouse temperature and humidity control system to lie in: (1) experiences

the expert with user's actual need unifies, nimble and the automatic production suits the specific cultivation object the monitoring strategy; (2) has not provided the cultivation crops which regarding the system the expert experiences, the user may through control system's use operation the way independently establishes the monitoring database, and long-term preservation; (3) the monitoring strategy data which establishes has been possible to carry on the optimization and the revision regarding the system by the user. In the present greenhouse control, on the one hand the plant culture environment expert experiences the software study serious lag in the greenhouse hardware technology development, simultaneously the greenhouse user tried to find out the plant culture experience is unable to enter the control system promptly, this research is helpful to this question solution.

## 2 Design of an Embedded Database

In analyzed had the greenhouse temperature and humidity control environmental data and in the database system technology present situation foundation, has designed the crops habitat embedded database. In the design process, utilizes the example parameter - pattern recognition method, summarizes the known data relations semiempirical rule. Will have the basis example parameter - pattern recognition method to the part unknown certain characteristic forecast function. The preliminary study result indicated: This kind of embedded database's research technique has the application

value to the greenhouse temperature and humidity control system's research. Uses the close coupling technology, introduces the expert system tool in the database management system, used the embedded database system administration expert system knowledge library, the design has developed the crops habitat database system. Proposed this embedded database system's design proposal, has completed the agronomist knowledge expression and the management and in the relational database expression and the memory. The embedded database system of this control system makes up as shown in Figure 1.

## 2.1 The Establishment of an Embedded Database

Database applications in the temperature and humidity intelligent control system, is of great significance, the most important thing is to accumulate data in order to facilitate the control of crop growth of the overall situation for analysis. In the control system embedded in the database, the data from the following table: the object stored data table, kept the collection of real-time data on temperature and humidity information table, set the storage temperature and humidity data sheet information.

### 2.1.1 Object Information Tables

Object Information tables to be used to store information in the control of greenhouse crops in the current target information and data, the table by the name of crops, the growth cycle, from the time when features such as field crops and composition.

### 2.1.2 Real-Time Temperature and Humidity Data Tables

Real-time temperature and humidity data tables used to store the scene node send real-time data from the scene, long-term accumulation of data to users for analysis. The table by date, temperature, humidity and time in four fields is composed, namely recorded in the corresponding period per hour delivery from the temperature and humidity information, and other field composition.

### 2.1.3 Set Temperature and Humidity Data Table

Table set temperature and humidity of a system to be used to store crops in the greenhouse temperature and humidity in the ideal setting. The table dates from 24 hours a day, every hour in the set temperature, humidity, and other fields of settings.

## 2.2 Management of the Embedded Database

When the embedded database based on the greenhouse temperature and humidity control systems to intelligent user, the system will give users with a dialogue environment, choice of applications, applications and its application, and people lose the new application requirements. Knowledge of database management software that reasoning machine the user to answer, automatic control, expand and update the knowledge base of knowledge, in accordance with the requirements of users to search the data suitable match for the greenhouse environment of temperature and humidity control. Embedded database control system in use, and control process, through the acquisition of new input data in the embedded database already exists and the object of the distance between, to judge whether they are the same or similar. New users will lose the same or similar object to the embedded database, which will be rounded down to different objects, make embedded database system more perfect, more universal.

## 3 Systematic Scheme

The control system embedded database in the ideal temperature and humidity data from agricultural experts to study the growth of crops ideal temperature and humidity data. In control, in accordance with the system measured temperature and humidity data and storage of agricultural experts of different crops to provide the ideal data to control greenhouse in the object (in this system in the sunroof, heater, fan and water facilities in first class) The operation, so that the greenhouse temperature and humidity values in the best state of crop growth. Is the automatic control system to a year in the value of the temperature and humidity inside the greenhouse. According to users within the greenhouse cultivation of crops in this type of control system of importation of agricultural experts from the experience of temperature and humidity data (in every hour of time to the temperature and humidity values in a year), temperature and humidity control system in accordance with the temperature in the database system Humidity data in the smart control greenhouse temperature and humidity. In addition, the system in controlling greenhouse temperature and humidity within the same time, automatically record the actual environment of the greenhouse temperature and humidity values as data preservation, the future agricultural experts to develop a more reasonable crop growth temperature and humidity data, the next cycle as the ideal value, Make the system better able to control greenhouse temperature

and humidity, for the crops to provide the best temperature and humidity of the environment.

### 3.1 The Systematic Hardware Makes Up

According to the functional and technical indicators schematic diagram of system hardware design structure shown in Figure 2, as was the object of all motor control, Electromagnetic valve, Electromagnetic switches, etc.- electrical equipment, and the controller use of the environment and relatively poor, in order to improve the control system The reliability, output controller interface using solid state relays, solid state relays contain

This module uses the microcontrollers internal FLASH memory, enables the controller both online to revise in 1 year the random number of days 1 hour temperature and humidity ideal setting value, and can in the record greenhouse each hour average temperature and the average humidity value, moreover the request power failure data does not lose. The controller must record the data are many (in for 1 year, daily 24 hours, each hour has a temperature and humidity setting value, but must record in 1 year each hour greenhouse temperature and humidity mean value). If uses each data 1 byte (i.e. 1B), altogether needs  $365 \times 24 \times 1 = 8760$  B. The data automatic input storage modules, completes the data test result saves according to the specific form in the corresponding

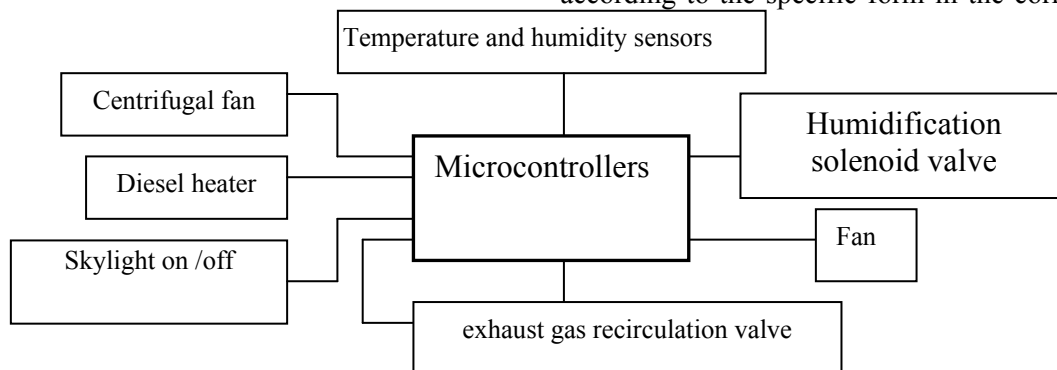


Fig.2, Schematic diagram of systematic hardware structure

photoelectric isolation and SCR, it has good effects of segregation, the strong and weak, for electrical isolation, a further SCR Can reduce the power of the weak-interference, improve system reliability.

#### 3.1.1 Input Module

This module's major function is passes to the greenhouse in temperature and humidity data the computer. The traditional load module is by temperature, the humidity sensor, the special-purpose amplifier and ADC is composed. What because they process is the simulated signal, is disturbed easily the influence which and floats warm, creates the precision and the reliability is not high. Adopt the advanced integrated transducer of digital temperature and humidity in the input subsystem of this system. Its most major characteristic is the direct output digit quantity, does not need the signal amplifying circuit and ADC. Moreover it uses "a main line" the system, may receive, the transmission data in a data line, and may hang meets many sensors, the microcontrollers distinguishes through the difference different sensor serial number measures the temperature and humidity spot one by one.

#### 3.1.2 Data Storage Module

storage space.

#### 3.1.3 Control Output Module

Controller control object more wetting electromagnetic valve, electrical sunroof open, sunroof, organs, fan, heater, furnace blower and exhaust gas recirculation (EGR) heat exchange electromagnetic switch], for the eight output solid state relays (A backup, in order to expand the new control object), solid state relay by 5V. In order to improve the reliability of in control output modules include Electro-optical coupler, with the former level after level of contact between no electricity. A transistor array drive relay, the circuit more tidy.

#### 3.1.4 Reveal the Module

Of the control system of LCD display module is mainly used to show the system to control and monitor the state. As the need to display Chinese characters and graphics, the system uses an LCM 240128 graphics LCD module. The liquid crystal display module is a cost-effective liquid crystal display module that can easily carry out a variety of characters and graphics display. The liquid crystal display module with the character generator inside, you can work in the way of graphics and text, this

software can be set up to achieve. It is mainly used to show the system on-line monitoring of the results. Use little one common interface of controller as data line, regard every control signal line of LCD as respectively with another interface of six the units. The specific content of the show: shows the current time, real-time data on temperature and humidity, temperature and humidity set of data and equipment charged with the current state of the show, as well as temperature and humidity control of the process curve, and so on.

### 3.1.5 Clock Module

Controllers at a pre-determined ideal temperature and humidity values and ideals, according to the current time control, so controllers require accurate clock. Clock module in the use of special clock chip, it is a kind of built-in crystal, I<sup>2</sup>C bus interface to support the high-precision real-time clock chip. The series chip clock to ensure accuracy of  $\pm 4$ ppm, that is, the error is less than two minutes. The chip built-in battery, a built-in rechargeable battery, in a case full of power can take the time to ensure that the internal clock for more than one year. Has selected high accuracy clock chip module, had guaranteed the overall system has the accurate clock.

### 3.2 Control System Software

The control system software includes the following modules: initialization module, display modules, keyboard processing module, data acquisition modules, data-processing module, the decision-making control module, real-time clock module and communications modules. Data format choice: In order to reduce data storage space, we collected the temperature and humidity data for a number of treatments, in order to save data storage space. The database system based on the principle of independence, separation of data from the procedure, the establishment of an embedded database management module specialized management.

### 3.3 Cycle Control Cycle

In view of the greenhouse temperature and humidity greater inertia, and crops on the temperature, the reaction time is not sensitive wetlands, and most of control object (such as the furnace, sunroof, etc.) cannot be frequent opening and closing, the controller to control the cycle Five minutes. Delay Module waiting for a cycle of five minutes, during this period to measure and display the current temperature and humidity values.

### 3.4 Process Control

Control module choose state of exporting according to temperature and humidity input state of data arrived to gather. Control module procedure, according to temperature and humidity set point data (The data from agricultural experience datum of expert) that establish among them control system this entirely. While controlling, control the operation which is accused of the target compared with experience data according to the measurement result according to the control strategy, so that the temperature and humidity of the greenhouse is in the peak that a certain crops grow.

### 3.5 Sampling Data Filtering

Control system used in the actual environment, there is always a variety of signal interference, in order to interfere with these signals and improve the reliability of the data collection system requires the use of sampling data filtering technology. As the signal interference of very short duration, so the digital signal acquisition, the re-collection, in a row until two or more of the same sample, as the only effective input signal. If the result of sampling many times always changes is deemed that it is invalid to sample. In meeting the requirements of real-time, if the adjacent signal acquisition process between the insertion delay the procedure, they can inhibit a wide pulse, anti-jamming effect will be even better.

In the development of the system, through theoretical analysis, as well as the actual experimental data analysis, the control system of filtering data used to determine the filtering process increases fuzzy arithmetic average of the composite filter data filtering method, was a very good filtering effect. And the sampling data used to control the data obtained in the previous average value, because the arithmetic average of seeking to use division, and in addition to the process of losing some of the data. The specific method is to sample data obtained after the first data filtering, for a set of data and to determine the number for the control of the data, of course, in the process need to control the first set of data Multiplied by the number and data. After the system test, confirmed the use of such data can be satisfied with the effect of filtering and high reliability of the system.

## 4 Control Strategy

In the control system, control strategy is the heart of the system. As temperature and humidity control of the process control parameters and control targets more, and the control of large differences in the nature of targets, and the control parameters and

control targets implicated each other, the use of conventional digital PID algorithm, Dahlin algorithm or fuzzy algorithms are more difficult, And because it is difficult to establish control parameters, control results may not necessarily ideal, it adopted the original analog operators approach - a ping-pong back to poor control. This method of program is simple, imitating the operator operation, temperature and humidity control at control points to close objects to a certain low-value (adjusted) were opened, the cycle work. System can be set according to the ideal of smooth curves of intelligent control temperature and humidity of the greenhouse environment. In control, according to the system of measurement data are stored and the results of experts on different crops to provide the ideal data to intelligent control object of the operation, so that the greenhouse temperature and humidity values in the best state of crop growth. The whole temperature control module control of the state divided into three: GT (T) temperature is higher than set, EQ (T) temperature is set and LT (T) less than the temperature settings, the humidity control, control is also divided into three Of state: GT (H) and humidity is greater than set, EQ (H) and the humidity is set LT (H) and humidity is less than set. Temperature and humidity measurements of the relationship between state and expressions are as follows:

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IF      TMEA < TSET - ΔT THEN
TSTATUS=LT (T) ; The temperature is less than
the value set
IF      TMEA > TSET - ΔT AND TMEA <
TSET + ΔT THEN TSTATUS=EQ (T) ; The
temperature is equal to the value set
IF      TMEA > TSET + ΔT THEN
TSTATUS=GT (T) ; The temperature greater than
the value set
IF      HMEA < HSET - ΔH THEN
HSTATUS=LT (H) ; The humidity is less than the
value set
IF      HMEA > HSET - ΔH AND HMEA <
HSET + ΔH THEN HSTATUS=EQ (H) ; The
humidity is equal to the value set
IF      HMEA > HSET + ΔH THEN
HSTATUS=GT (H) ; The humidity greater than
the value set
TSTATUS The current temperature、HSTATUS
The current humidity、TMEA : Temperature
measurements、TSET: Setting temperature、
Δ T : The current temperature tolerance、
HMEA: Humidity e measurements、HSET :

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Setting humidity、ΔH: The current humidity tolerance。

## 5 Conclusion

In this paper, through embedded control system for greenhouse-related technology research, a practicality and high levels of greenhouse technology embedded intelligent control system, including systems architecture, systems software and hardware design. This article focuses on practical research. The aim is to design a highly practical and technical level of greenhouse intelligent embedded control systems. The use of manual analogue system of control and improve the reliability of control. The adoption of the output corresponding to a set of equipment for the handling of state control, and simplifies the operation and control procedures, so that control is easy to implement, so that a reliable system operation, equipment control systems to avoid a state of conflict. At the same time, this control system can also be used for other automatic control temperature and humidity environment, with better prospects. Its temperature and humidity information embedded database storage and graphics display to users for further analysis of the greenhouse temperature and humidity of history is of great significance and practical value. It is the alternative to the traditional way to control temperature and humidity control system ideal greenhouse.

### References:

- [1] strom K J , Wittenmark B. Computer Controlled Systems -Theory and Design[ M]. U. S : Prentice -Hall ,1994 pp.107-110
- [2] Edward C, Luczak. Designing Expert Systems Using a Database Design Method[DB/OL]. <http://www.ghg.net/clip/download/documentatio>n.
- [3] SHEN Jin, SONG Jing-ling, WANG Xiangyou, BAI Xueyuan, CHENG Weidong. An All-digital Temperature Measuring System Used in Grain Barns [J]. Transactions of The Chinese Society of Agricultural Machinery, 2001.Vol.32 No.2 ( 89~ 91) cnki:ISSN:1000-1298.0.2001-02-026
- [4] LIU Xiao-dong; ZHANG Jie; BAO Jun-peng; ZHAO Jun-jun. The Design and Implementation of a Platform for Agriculture Expert System [J]. Application research of computers, 2002 Vol.19 No.5 ( 79-81 ) cnki:ISSN:1001-3695.0.2002-05-026
- [5] SHU Di-qian ,LIU Hong-cai ,WU Bao-lian, WANG Jing, ZHENG Fu-jian ,HUANG

Cheng-yang. Intelligent adaptive control for a group of cover annealing furnaces [J]. Acta Automatica Sinica, 1991, 17 (2): 207 ~ 214  
cnki:ISSN:0254-4156.0.1991-02-010

- [6] F. B. Bastani, I.-L. Yen, and S. Kim, "Highly reliable relational control programs for robust rapid transit systems", in 6th IEEE Int. Symp. on High Assurance Systems Engineering (HASE 2001), Oct. 22-24, 2001, pp. 65-74.
- [7] PENNING de VRIES, FWT. Simulation of plant growth and crop production[M]. Center for Agriculture, 1982
- [8] Sigrimis N A, Arvanitis K G, Pasgianos G D. Synergism of high and low level systems for the efficient management of greenhouses[J]. Computers and Electronics in Agriculture 2000, 29: 21- 39.
- [9] L. Wang and G. Yang, "Study on Sunlight Greenhouse Temperature and Humidity Fuzzy Control System", Nature and science, 2005, 3(1).