

# Research On Application Of Dynamic Matrix Control Algorithm In Temperature And Humidity Control System

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## Abstract

This paper introduces the composition and working principle of a temperature and humidity control system .The system is composed of AT89C51 single chip microcomputer .The principle of DMC is studied,and research on the DMC algorithm applied to the temperature and humidity control system is given too .The design of hardware and software are introduced .It shows that the system with DMC algorithm has many advantages than with PID.

## 1 Introduction

Warehouse, greenhouse and other places need to have a certain temperature and humidity environmental,so temperature and humidity control system is a must. Control algorithm is the key to determine the accuracy and effect of control. PID control has the characteristics of simple algorithm, easy implementation and strong robustness. Now PID is a widely used control algorithm. But the Classical PID control is unable to meet the control requirements obviously. Improved PID algorithm (such as gearshift integral PID) can improve the control performance,but it is a control algorithm which based on the mathematical model precisely ,if the mathematical model is not correct, it must be unable to meet the technological requirements, and even can't play a role. Predictive control is a new type of computer optimal control algorithm based on model, Receding horizon optimization and feedback correction, Suitable for the control is not easy to establish accurate mathematical model and more complex industrial production process, and has broad application prospect in the industrial process control <sup>[1]</sup>. In this paper, the dynamic matrix control algorithm (DMC) is applied to the temperature and humidity control system. DMC is one of the most widely used predictive control algorithms. It use the system step response sequence as the object model, the model is convenient, and the algorithm has good robustness.

## 2 Hardware Composition and Operational Principle of Control System

### 2.1 Hardware Components

Temperature and humidity are two strong coupling variables, the influence of temperature on humidity in many occasions is greater than the effect of humidity on temperature, and the humidity changes much more slowly than the temperature, So they can be decoupled by compensation. By compensation, Temperature and humidity variables can be controlled as a single variable<sup>[2]</sup>. The hardware composition diagram of the control system is shown in Figure 1.

### 2.2 Temperature and Humidity Sensor

SHT11 temperature and humidity sensor using SMD (LCC) surface patch package form, the interface is very simple, pin name and the arrangement of the order as shown in figure 2.

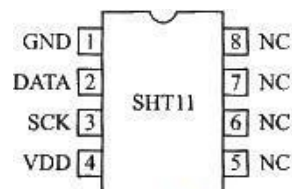


Fig.2 SHT11 pin diagram

The temperature and humidity sensor SHT11 integrated temperature sensing, humidity sensing, signal conversion, A/D conversion and heater and other functions integrated into a chip which inner structure is shown in Figure 3. This chip includes a capacitive polymer humidity sensitive element and a temperature sensitive element gap material, they input temperature and humidity into electric signal than amplify and into a 14 bit A/D converter, At last, the digital signal is output through the serial digital interface. SHT11 in the factory, will be calibrated at a constant temperature or humidity environment, the calibration coefficients are stored in the calibration. In the measurement, the calibration coefficient will automatically calibrate the signal from the sensor. In addition, SHT11 is also integrated with a heating component, the heating component can be connected to the temperature of SHT11 increased by about 5 degrees Celsius, while the power consumption will be increased. This function

is to compare the temperature and humidity values before and after heating, to verify the performance of the two sensors. Humidity measurement range of SHT11 is 0~100%RH, temperature measurement range is -40~+123.8°C, Accuracy of humidity measurement is  $\pm 3.0\%$  RH, Accuracy of temperature measurement is  $\pm 0.4$  °C.

SHT11 communication with the microcontroller through the Serial digital interface, Need to use the MCU general I/O port simulation of the communication timing. MCU control the SHT11 through 5 bit command code which means as shown in Table 1.

command code	Meaning
00011	Measuring temperature
00101	Humidity measurement
00111	Read internal status register
00110	Write internal status register
11110	reset
Others	retain

Table I Control command code

### 2.3 Operating Principle

According to the set value and the actual value of the microcontroller to calculate the deviation, and calculate output by DMC algorithm ,After decoupling, drive actuator to achieve temperature and humidity control by optical coupler .System MCU using AT89C51, optical coupler using MOC3061, 8279 keyboard/ display interface which used to data entry and function selection., Function keys include: Time and temperature, humidity setting ; Temperature, humidity and error display ; Control parameter setting ; Numerical increase or decrease; and Run, pause, reset , etc. The serial port of the single chip microcomputer is extended by MAX485 chip, To realize the remote control of the host machine to the remote spot [3].

## 3 Software Design of Control System

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#### 3.1 Control Algorithm

DMC algorithm includes three parts: prediction model, Receding horizon optimization ,feedback correction[4]. Prediction model :Get sampled data by test controlled object step response  $a_i$  ( $i=1,2,\dots,N$ )to Parameters of prediction model in DMC algorithm. By using the unit step response model of the object and the increment of the given input control, we can predict the future output value of the system .Receding horizon optimization: the control increment of the M sampling period from a moment is determined by the optimization criterion, so that the output value of the system in the next P time is as close as possible to the expected value. In theory, it can be recalculated every M M sampling period, and then the M controlled quantity take effect on the system on the M sampling period respectively after K time .But during this period, Model error and random

disturbance may cause the system output to be far away from the desired value. In order to overcome this shortcoming, we can take the Real time control increment in optimal solution( $\Delta u(k)$ )for the actual control increment( $u(k) = u(k-1) + \Delta u(k)$ ).To the next moment ,A similar optimization problem is proposed to find out  $\Delta u(k+1)$ .This is "rolling optimization".

Feedback correction: After applying  $U(k)$  to the controlled system in  $KT$  moments, in  $(K+1)T$  moments we can collect the actual output which Compared with the predicted value of the system output based on the model. Due to the model error, disturbance, weak nonlinearity and other uncertain factors in the actual process, predicted values generally deviate from the actual value, that is, there is a prediction error. If the feedback correction is not carried out in a timely manner, further optimization will be based on the false .So the DMC algorithm is used to predict the future output error of the system based on the real-time prediction error , corrected open loop predictive value every moment in the future.

In a word, DMC algorithm is composed of three parts, which are prediction, control and correction. DMC algorithm is an incremental algorithm. Whether the model has error, it can always adjust the output to the expected value and does not produce static difference. For the step form of the disturbance, the algorithm can always make the system output back to the original set state.

The flow chart of DMC algorithm is shown in Figure 4.

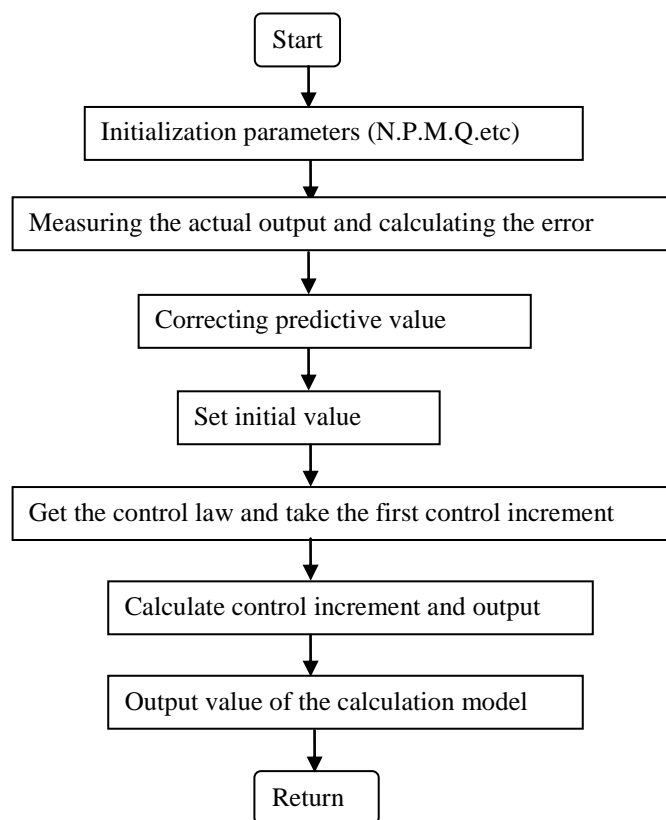


Fig.4 Flow chart of DMC

### 3.2 Decoupling Control of Temperature and Humidity

The temperature and humidity decoupling diagram is shown in Figure 5,  $R_1, R_2$  are Decoupling link and Determined by experiment,  $0 < R_1, R_2 < 1$ , After decoupling control the system output as:

$$U_T = (1 - R_1) \times C_T + R_1 \times C_H$$

$$U_H = (1 - R_2) \times C_H + R_2 \times C_T$$

### 3.3 System software design

Figure 6 shows the principle diagram of the main program of the system software. Design system software on 89C51 single chip microcomputer, The main program includes initialization, display panel management and subroutine calls. DMC algorithm and decoupling using subroutine, Sampling period through the AT89C51 timer T0 and software to achieve.

## 4 Experimental Results and Analysis

The temperature control of a certain temperature and humidity field is verified, and the unit step response curve is obtained as shown in Figure 7. Obviously, the transient response of the DMC algorithm and the temperature and humidity decoupling is better than that of the conventional PID control.

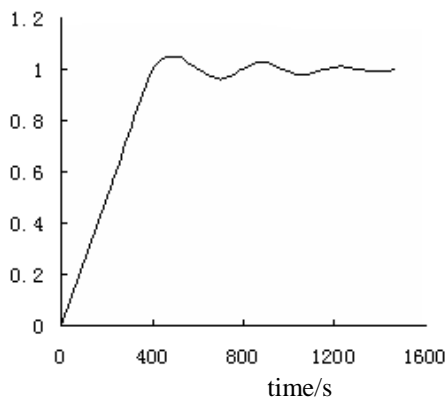


Figure (a) PID Control chart

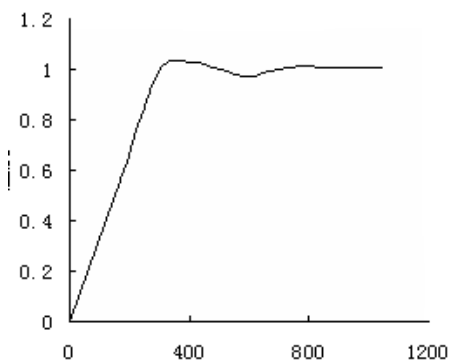


Figure (b) DMC Control chart

Fig.7 unit step response curve

## 5 Conclusion

Temperature and humidity control system using DMC algorithm, can improve the dynamic and static characteristics of the system evidently. The sensor adopts SHT11, strong anti-interference ability, using the single chip microcomputer as the control device, low cost, high reliability.

## References

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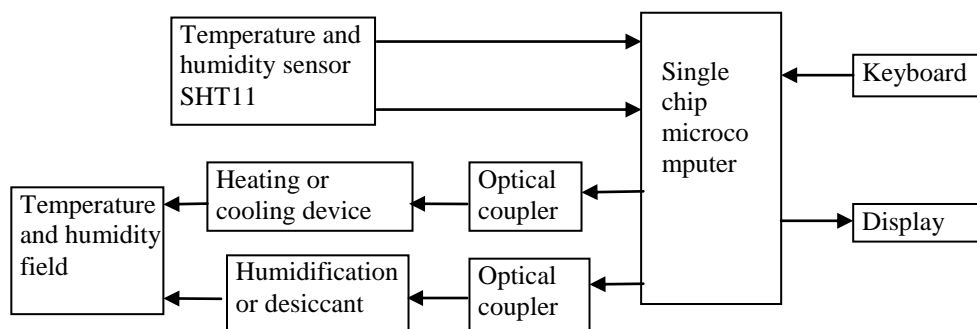


Fig.1 the hardware composition diagram of the temperature and humidity control system

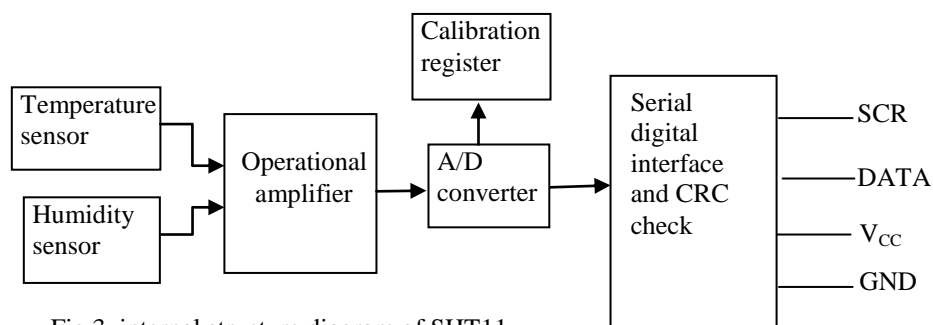


Fig.3. internal structure diagram of SHT11

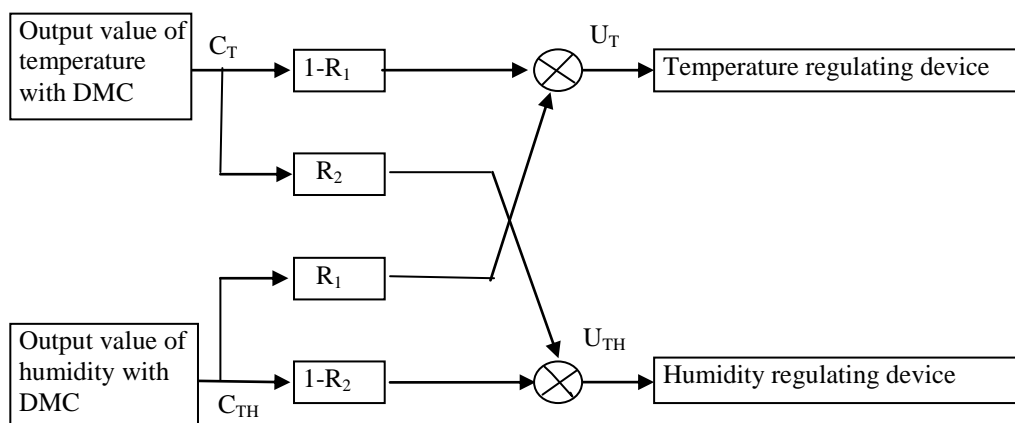


Fig.5 temperature and humidity decoupling diagram

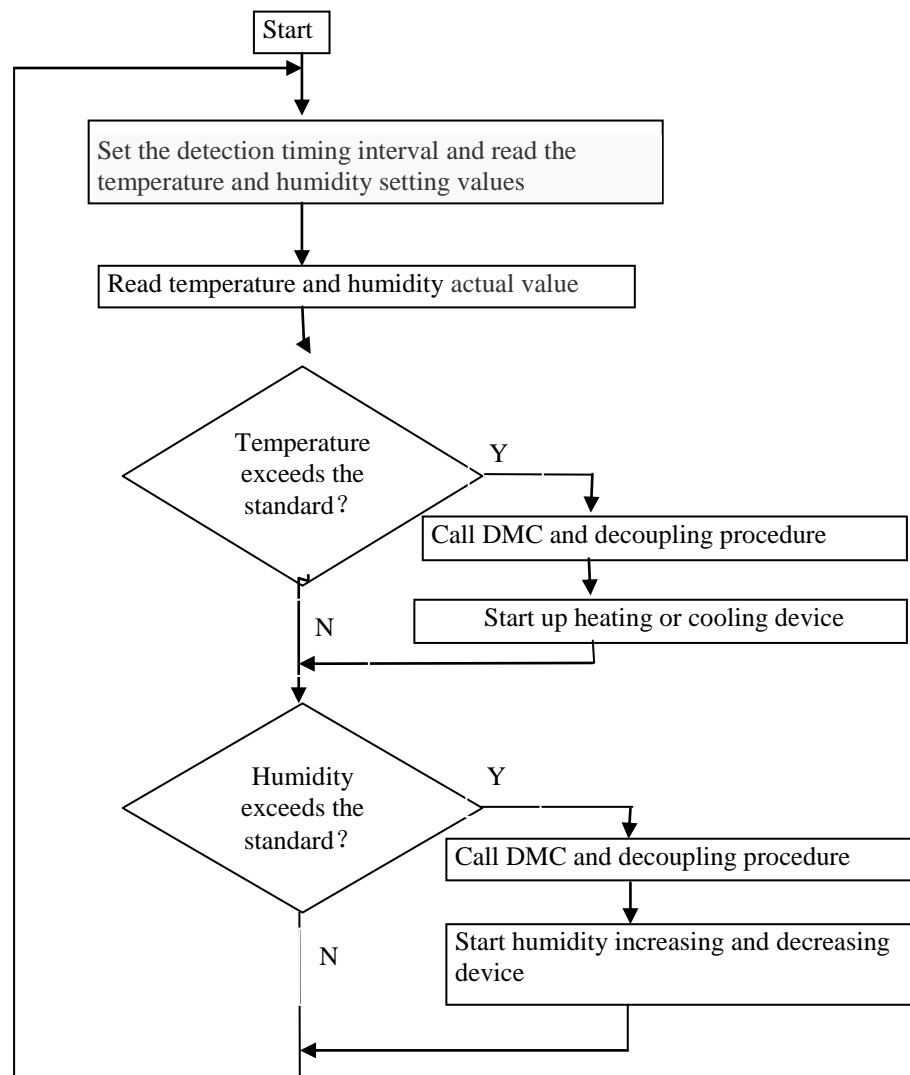


Fig.6 principle diagram of the main program