The design of temperature and humidity control system in multi incubators based on single-chip microcomputer

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Abstract: hatching systems requiring high control accuracy of temperature and humidity. Particularly temperature, small temperature change will significantly affect hatching time and hatching rate. This article design the hardware circuit based on the SCM. Using digital single bus temperature sensor DS18820 to improve accuracy of temperature measurement, using HM1500 to build frequency detection circuit of humidity inside the incubator, design the output control circuit based on photoelectric coupler TLP521, power-driven IC ULN2803 and relay.

Keywords: Incubator; SCM; temperature and humidity; temperature sensor

I. INTRODUCTION

Hatching refers to the development of eggs in vitro's stage, it is through the external conditions (such as temperature, humidity, ventilation) effect, make the process of eggs into chickens. Hatching will direct impact the rate of hatchability, chick survival rate and performance of growth. So we want to control the requirements for external conditions such as temperature, humidity, ventilation during all stages.

This system select the temperature and humidity inside the incubator as a major controlled object, and implementing agencies such as heating system, humidification systems, cooling fans, turning motors as a means of control. Incubator control system as shown in Figure 1, System process is: Single-chip microcomputer process and operate the sampling data of temperature and humidity signal from temperature and humidity probe. According to the need to issue a driving signal, realize heating, humidification, fans stirring, turn the eggs, hatch opening of door control, to ensure that the needs of the development of embryo in egg.

II. THE HARDWARE CIRCUIT DESIGN OF THE SYSTEM

We design the hardware circuit first, including detection circuit of temperature and humidity, control circuit of temperature and humidity, data display circuit, keyboard interface circuits, communications circuits according to the design parameters of the system requirements.

A. The design of main control unit

This system use AT89S52 as main control unit (MCU) which produced by Atmel Company, it is a low-power, low voltage, high-performance 8-bit single-chip microcomputer, with a 8KB programmable and erasable read only memory; it uses the technology of high density non-volatile memory technology, and the output pin and instruction compatible with MCS-51. It widely used in industrial control and embedded systems due to its low price, reliable performance and strong anti-interference ability. There is no need to expand the memory because the amount of collecting data is not particularly large of the control system, and the 8K programmable Flash memory of SCM to meet your needs.

AT89S52 as a lower computer is responsible for collecting environmental parameters within the incubator, for various values of temperature and humidity inside the incubator to fuzzy operation, output control signal drives the implementation bodies, enabling real-time control over the parameters inside the incubator. In addition, each MCU pass
the data of temperature and humidity inside the incubator to the upper PC through serial communication interface.

![Control System Diagram](image)

**Figure 1** The control system diagram

### B. The design of detection circuit to sensor signal

#### 1) The acquisition of temperature signal

The system selects the temperature sensor DS18B20. DS18B20 is an intelligent temperature sensor produced in United States DALLAS, measuring range from -55°C to +125°C, accuracy up to 0.0625°C. DS18B20 can directly read out by the measurement of temperature, its field temperature directly transmission to "single bus" of digital signal, only needs one line of information reading or writing compared with the traditional measurement component just as thermal resistor. It allow a signal cable to hook up multiple DS18B20 under the single bus work, which greatly simplifies wiring, improved reliability, reduced costs, particularly suitable for long-distance multi-point temperature measurement and control system. The acquisition circuit of temperature signal as shown in figure 2.

The bits of the temperature conversion result for DS18B20 can be determined by the software program, you can direct the output of 9 to 12-bit digital signal, and the default value is 12 bit. DS18B20 able to meet the needs of control system, required up to about 1 second of time for a temperature collecting in the incubator control system.

![Temperature Acquisition Circuit](image)

**Figure 2** The acquisition circuit of temperature signal

#### 2) The acquisition of humidity signal

This system uses a humidity sensor HM1500, HM1500 is relative humidity sensor based on patents humidity sensitive capacitance, which design and product in HUMIREL Company of France. It contains bridge oscillators consisting of humidity sensitive capacitance, low-pass filter and amplifier, can output DC voltage signal of a linear relationship with the relative humidity, measurement range is 0%~100%RH, the output voltage range of +1V~+4V, the measurement accuracy of ±3%RH, sensitivity to +25mV/RH, the temperature coefficient of ±0.1%RH/°C, the response time of 5s. HM1500 has wet performance, high sensitivity, fast response, wide measuring range, high reliability, long term stability and ease of use, small and so on.

We design the humidity data acquisition circuit using pulse oscillation circuit in order to improve the sensitivity and linearity of the system, and reduce the costs of data acquisition circuit and other factors, as shown in figure 3. It can compose of multiple harmonic oscillation circuit when place the humidity sensor in the oscillation circuit, the output signal of the oscillation frequency is:

$$f = \frac{1}{(R_c + R_i)C \ln 2} = \frac{1}{0.7(R_c + R_i)C}$$

Duty cycle: \( q = \frac{R_c}{R_c + R_i} \)

![Humidity Acquisition Circuit](image)

**Figure 3** The acquisition circuit of humidity data
We should adjust the potentiometer making \( R_f = R_i \) in figure 3 in order to get the square-wave signal. Convert the changes of humidity sensitive capacitance to the inversely proportional frequency signal (square wave signal) through the oscillation circuit inside the humidity sensor, then input the square-wave signal to T1 pin of AT89S52, timer/counter 0 work in the count way, timer/counter 2 work in the fixed cycle way. With this kind of measurement frequency measured by square wave signal frequency measuring the frequency of the square wave signals by measurement of frequency, which also measure the relative humidity in the air. We can obtain the relationship between the frequency of the output square wave and humidity measurements by analyzing the typical values of relative humidity and the typical values the voltage frequency.

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\text{RH}_a = -0.0767f + 565.1
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C. The design of serial communication interface circuit

The upper computer is PC machine, and the lower computers are multiple single-chip computers that spread out in different incubator, slave to more than one distribution at different incubator, and this constitutes a multiple machine communication system, as shown in figure 4. The collecting, processing of data in incubator, and driving-related institutions, implementation of control on the scene by single-chip computers. The upper computer transmits control instruction to the lower computers at a fixed time. It must be level translation to complete the communication with PC and single-chip microcomputer. This system uses MAX232 produced by the MAXIM Company to completed level translation.

D. The design of heating control circuit

The temperature and humidity signal inside the incubator input to the single-chip computers, dealt with a program and get the temperature and humidity value of the system. This value will be compared with the set value, and fuzzy operation. The single-chip computers control temperature and humidity control equipment based on the result of the operation. There are large number of functional components in the incubator control system, these functional components including high-power electric wire, agitated hot fan motor, increase humidity step motor, air door driving step motor stepping motor and turn the eggs step motor. These part have a strong interference signal when startup and shutdown, because its power is large. Isolating the driving ways of photovoltaic coupler + Darlington + relay to control these high power modules in order to effectively drive and control of these parts. The control signals issued by the single-chip computers first to drive Darlington ULN2803 by photovoltaic coupler TLP521, Then drive reliable relay by Darlington. Finally indirectly control these features by a relay.

Using 4 sets of heat resistance wires, and each set of resistance wire power 200W of the design because the incubator is larger. These resistance wires are distributed over the four sides in the incubator and installing agitated hot air fan behind the resistance wire. P2.0~ P2.3 output of high and low level signal of single-chip microcomputer control turn-on and shut-off of the four groups of resistance wire. Composed of a total 5 heating condition: no heat, little heat, medium heat, large heated, fully heated. Since the turn-on and shut-off moments of resistance wire will have a greater interference signal, the system Achieve electrical isolation of working circuits and control circuits through connecting photovoltaic coupler TLP521 to SCM output. Since the output power of TLP521 is 150mW, it unable to drive the relay. So connecting power driver IC ULN2803 behind TLP521 to drive SRD-05VDC-SL-C, the relay control turn-on and shut-off of heating resistance wire. The heating control circuit as shown in figure 5.
III. CONCLUSION

This article analyses the control object on the basis of the characteristics of temperature and humidity incubator, design the hardware circuit based on the SCM. Experimental results show that the system to achieve accuracy of temperature can be up to ± 0.1°C, accuracy of humidity up to ± 5%. You can implement distributed control of multiple incubator using a upper. The system cost low, it is appropriate for the needs of medium hatchery.

REFERENCES
