The design and application of an experimental system for measuring and controlling hypoxia in animal culture

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Abstract: An experimental system with intelligent control function was developed to observe the survival of animals under low oxygen conditions, Using advanced high - performance single - chip microcomputer control technology. A high precision digital temperature sensor DS18B20, oxygen electrochemical sensor and humidity sensor are used to form the information data acquisition module, Three key parameters can be collected in real time for recording and display. The upper and lower threshold values of the parameters can be set, and the system can automatically adjust the parameters within the set range. System design is mainly used to detect the oxygen concentration in the incubator, display and control the test data, set oxygen concentration of the box. Through the management software to realize the historical data display and detection. The instrument measuring circuit is universal and can be realized by adjusting the parameters of the different gas sensing elements. The parameters meet the design requirements after circuit test.

1. Introduction

In the agricultural, industrial, and immunology, microbiology, pharmacology medical field, it is often necessary to study the effects in temperature, humidity, O_2 concentration and intensity, because the growing development of animals usually were effected by the different concentrations of these parameters. For a long time, in the domestic and foreign ,white rats, dogs and so on was usually used to carry out experimental study in the simulation of the different parameters of the incubator. The culture box generally requires good temperature dynamic performance, in the whole space region, the survival results are reproducible, the training process is mild, the long-term operation reliability is higher, the intelligent concentration control, can produce the best training conditions in the varied environment temperature. The investment of scientific research funds in medical colleges and small research centers is weak, and it can be solved by the design of an intelligent hypoxic incubator system which is suitable for our medical laboratory environment.

The experimental system has the function of automatic control of oxygen concentration that can observe the survival of animals in hypoxia condition at any time. The circuit uses advanced high performance single chip microcomputer control technology with high precision digital temperature sensor DS18B20, O_2 electrochemical sensor and other components of information data acquisition module, which can collect key parameters for recording, display real-time. The system can set the parameters of the threshold and adjust the parameters in the set range. It is a precise measurement and control system on temperature, O_2 concentration, which is the most close to the living environment of animals. Design parameters exceed the limits of automatic alarm. It realized the system unattended. This system has the function of intelligent control, which can guarantee the high precision of parameter measurement and control, and can realize the wireless transmission data to the management center or the personal platform. In this paper, the design and implementation of the oxygen concentration detection and control circuit based on AT89S51 MCU is proposed. Electrochemical reactive sensor first turn the sensor signal of oxygen concentration into current signal, voltage signals after amplified by regulating transfer to single chip microcomputer AT89C2052, then serial port output and LED display after A/D conversion [1]. Also can use the

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embedded list/so converter asynchronous serial communication signal is converted into 485 network signal, through the LAN or the Internet cable network transmission, in order to achieve remote monitoring purposes.

2. Implementation plans

Control core uses SCM AT89S51 of high performance to price ratio, the temperature sensor using high precision digital temperature sensor DS18B20 (Dallas company in the United States), capacitive type humidity sensor HS1101 as humidity sensor (French); electrochemical type oxygen sensor ME3- O_2 gas sensitive oxygen sensor (Zhengzhou Wei Sheng Electronic Technology Co., Ltd) was selected. The three parameters are displayed in real time, and the data is transmitted to the control center. Give an alarm When the parameters to achieve the setting value and automatically open the corresponding electromagnetic valve to add nitrogen to adjust the parameters of incubator that set in advance.

3. Design scheme

3.1 The hardware system block diagram

Measuring system include single chip microcomputer, sensor, AD conversion circuit, display circuit and control circuit, etc.

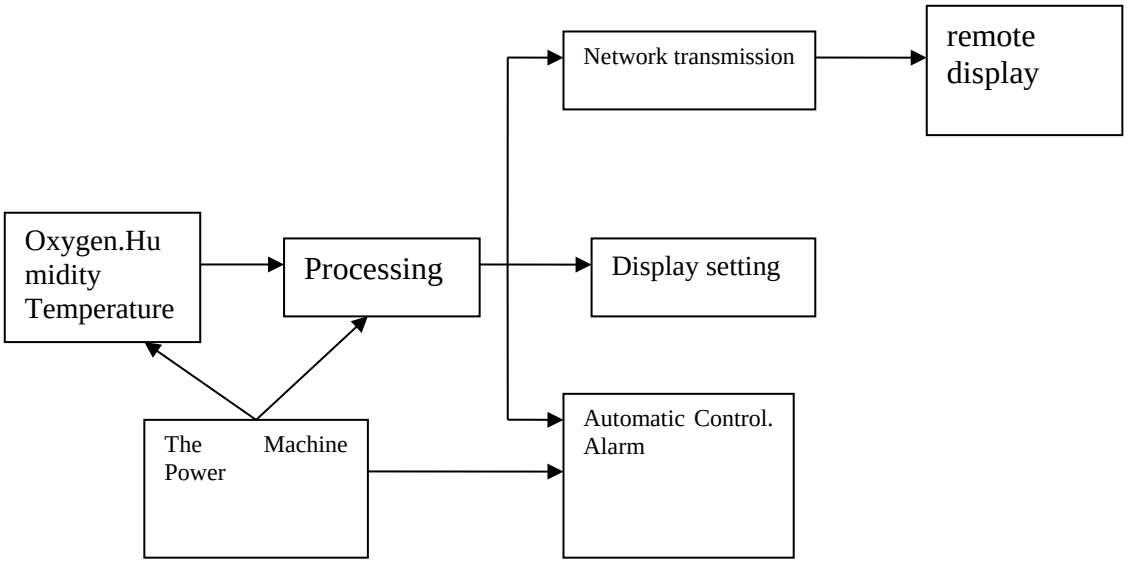

Fig.1. The overall design scheme

3.2 The principle and structure system

(1) Oxygen detection disposal cell for signal collection, conversion, amplification, outputs a voltage signal is easy to detect.

(2) Processing unit to complete the AD conversion of the input signal, processing and displaying, serial port output and storage three aspects realization from the former one unit. The solenoid valve automatically opens to the nitrogen, when the oxygen concentration is overrun.

(3) The network transmission unit transfers the output of the serial port to the output of the network and transmits it to the network through the wire.

(4) The display unit is displayed after get data from the processing unit.

(5) The remote processing display unit will display the network data received from the network

transmission unit in real time.

(6) Alarm unit to complete the overrun concentration alarm task, the software controls the alarm value.

(7) The power supply unit completes the power supply to the whole system, and needs to be supplied to the oxygen detecting unit, processing unit, field unit and alarming unit.

3.2.1 Selection of oxygen sensor

ME3-O_2 type oxygen sensor based on the principle of electrochemical galvanic cell, using the electrochemical reduction and anodic oxidation process of the gas in the original battery to produce a current, and the current which generated by the gas electrochemical reaction is proportional to the concentration and follow the Faraday law. Thus, the concentration of the gas to be measured can be determined by measuring the magnitude of the current. It is widely suitable for industrial, mining and environmental protection, medical and other civilian areas of oxygen monitoring. Range 0-25% vol, maximum limit of measurement is 30% vol, a sensitivity of 0.15 ± 0.05 mA (in air), temperature range from - 20 ℃ to + 50 ℃, standard atmosphere pressure range ± 10%, response time ≤15s,.It is comply with the design requirements.

A/D conversion circuit ADC0809 with 8 bits A/D converter, 8 road multiway switch and microprocessor compatible control logic CMOS components. It is successive approximation A/D converter, which can direct interface with single-chip microcomputer. ADC0809 for analog input requirements: signal single polarity and voltage range is 0 to 5 v, if the signal is too small, must be enlarged. Input analog in the process of transformation should remain the same, if analog changes too fast, need to increase the sampling keeping circuit before input. Address input and control line: 4. ALE to address latch allow input line, the high level effectively. When the ALE line for high electricity at ordinary times, address latch and decoder will be A, B, C three address line address signal is latched, after decoding the selected channel analog input converter. A, B and C for address input line, used for gating IN0 - IN7 analog input all the way[3].

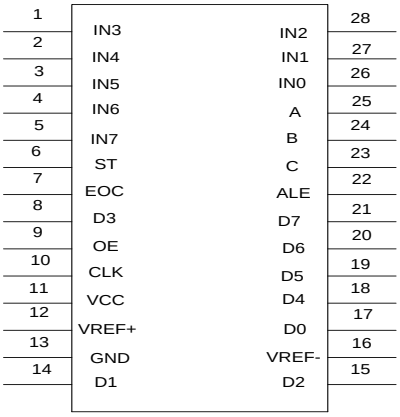

Fig.2. ADC0809 pin figure

3.2.2 The control unit

Control circuit adopts the electromagnetic valve (Nitrogen input control) automatic start and stop. Oxygen concentration was calculated by single chip microcomputer, which compared with the set value, if below the set value, placing the P2. 7 for the high level, control solenoid valve to open the work. If higher than the set value. P2. 7 for the low level, to close the solenoid valve.

3.2.3 Network transmission unit

One side of the RS485 / ILI45 serial port converter connect to the AT89S51 serial port and the other side connect a PC. The corresponding parameters are set up by using the software. The serial port parameters are matched with the 485 devices. Connection is established after parameter set. In this way, RS 485 communication serial port can be through the IP network and monitor the host's network interface for data communication, so as to remote network display [4].

3.2.4 Crystal oscillating circuit

Crystal oscillator circuit in a variety of instructions in the micro operation in time has a strict order, this micro operation time order is called timing sequence, MCU clock signal is used to provide a time reference for a variety of microchip chip. There are two ways to generate the 89c51 clock, one is the internal clock and the other is the external clock. The internal clock mode is that a crystal oscillator circuit connected to the outside of the single-chip microcomputer and an oscillator inside the single-chip microcomputer combine to produce clock pulse signal. The external clock mode is to introduce the external existing clock signal into the single-chip microcomputer. This mode is often used for multi-chip 89C51 MCU work at the same time, in order to facilitate the synchronization of each MCU, generally requires the duration of external signal high level is greater than 20ns. And the frequency is less than 12MHz square wave. For MCU with CHMOS process, the external clock shall be introduced by XTAL1 end, while XTAL2 end shall be suspended.

In order to reduce the power consumption as much as possible, the internal clock is adopted in this system.

See figure 3 for the circuit diagram.

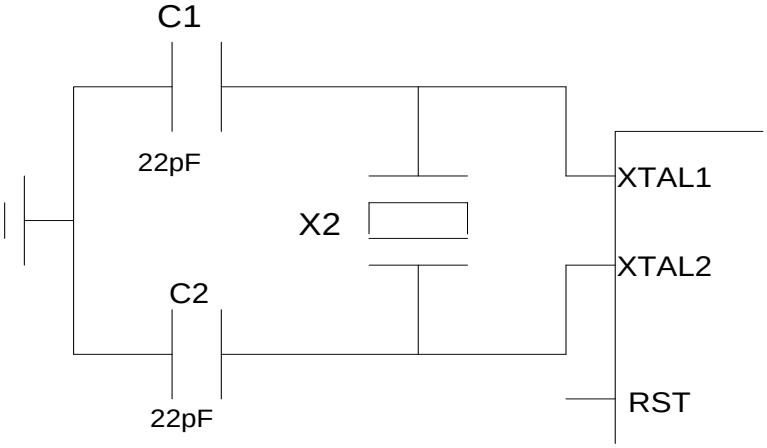

Fig.3. Crystal oscillator circuit diagram

3.2.5 Reset Circuit

Reset circuit is still an indispensable main component in the work of MCU, which must be in a certain state. The uncertainty of the level of the port line and the status of input and output may make the peripheral equipment misoperate and lead to serious accidents. Uncertain contents of some internal control registers (special registers) may lead to overflow of timer, interruption before the program starts, and random transmission of serial port to the peripheral to send data.

3.2.6 Reset circuit principle

In this design, the reset circuit adopts the power-on reset circuit and the manual reset circuit. If the switch is not pressed, the power-on reset circuit is the power-on reset circuit. At the moment of power-on, the voltage on the capacitor cannot be suddenly changed and the capacitor is in the state of charging (conduction), so the voltage of RST foot is the same as that of VCC.

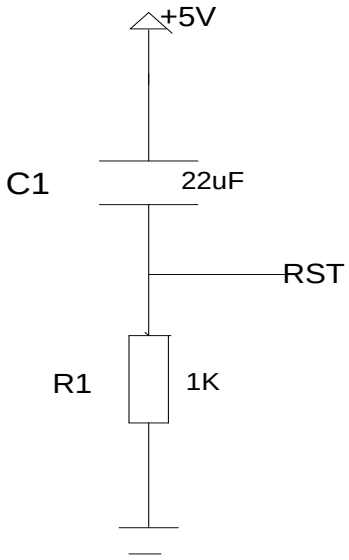

Fig.4.Power on reset circuit diagram

As the capacitor is charged, the voltage on the RST pin slowly drops. Select a reasonable charging constant, you can ensure that when the switch is pressed down is RST end has more than two machine cycles of the high level so as to make AT89C52 internal reset. When the switch is pressed down, it is the manual reset circuit of the button. The RST end is connected to the VCC power supply through the resistance, and the MCU reset can be realized through the voltage division of the resistance.

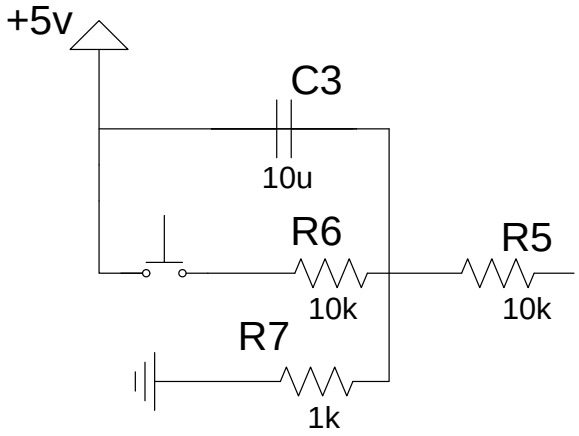

Fig.5 Reset circuit diagram

3.2.7 Software design structure

Software design mainly includes: design of the main program/child processes, preparation of the functional modules program, write soft/hardware debugging and demonstration. Mainly includes the following functional modules: 51 drivers, detection, liquid crystal display, the clock, keyboard, modulus conversion [5] ,software structure diagram.

3.2.8 The design of the main program module

The function of the main program implementation: Combined with the hardware realize each function of oxygen concentration detector. Mainly detection and display, time adjustment and show, data storage and features a subroutine call.

3.2.9 Design of analog to digital converter

The main function of the analog to digital conversion module is to convert the analog voltage signal into MCU to handle the digital signal, and send it to the microcontroller. Flow chart of

ADC0809 conversion is shown below.

4. Conclusion

According to the requirements of low oxygen concentration in animal culture, the hardware and software design realized the real-time monitoring and control of oxygen concentration, temperature and humidity display, and communication with the external PC, and realized data remote monitoring and recording. to realize the real-time tracking of oxygen concentration. The function of the system is basically realized.

Acknowledgement

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