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Design of Incubation Environment Detection System Based on STM32 Single-chip Microcomputer

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Abstract

This design focuses on the "Incubation Environment Detection System" and proposes a system that uses STM32 microprocessor as the microprocessor controller. It can collect real-time temperature and humidity data in the incubation room to obtain the hatching status of chicks. During the system's operation, it can control the temperature and humidity of the incubation room through fans and incandescent lamps. When the system detects that the temperature and humidity parameters in the incubation room exceed the warning value, it will immediately start the fan for cooling and dehumidification. When the temperature is too low, it will control the temperature through incandescent lamps. The system will display the system data through a high-definition LCD screen, and at the same time, the data can be sent to a mobile APP for display through a WIFI module. This system is dominated by STM32 microprocessor chips in terms of core control, and corresponding driver circuit parts have been designed according to the requirements of various expected functional indicators. In order to facilitate the optimization and improvement of the design results, this graduation project underwent operational debugging. Through extensive testing work, defects were identified and analyzed for optimization. Ultimately, this model of incubation environment detection and control system can operate efficiently and meet the expected functional requirements.

Keywords

STM32 Microprocessor; Temperature and Humidity Detection; Wireless Network Communication.

1. Introduction

This project aims to develop an incubation environment detection and control system. We will conduct research and design on it, proposing the topic of "Incubation Environment Detection System". We will conduct research and analysis on a large number of related products on the market, and focus on transplanting some mature research and development solutions. We will organize the core design points of its software and hardware and integrate them into this project for use. When designing this system, it is necessary to analyze and study its development process in order to understand the important information such as the technical characteristics and user groups of incubation environment detection and control systems in various historical periods [1-5]. Through this technical background analysis method, the design content and functional requirements of various indicators of this project can be determined. The entire development process of incubation environment detection and control systems has gone through multiple stages of electronic science and technology, from the electronic tube era in the 1960s and 1970s to the overall microprocessor era today. Designers have implanted various advanced technologies into the software and hardware of incubation environment detection and control systems, so that the core technical level of incubation environment detection and control systems can gradually increase with the assistance of these technologies,

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Through the research on various excellent design results of incubation environment detection and control systems at home and abroad, it can be known that in the development of incubation environment detection and control systems for so many years, the continuous increase in the user group of this device, due to the high market sentiment, will inevitably feedback to research and development companies and developers, in order to invest more energy in continuing research and upgrading incubation environment detection and control systems. For incubation environment detection and control system related products on the market today, the overall digital characteristics have already been achieved, and no enterprise or researcher will design traditional analog electronic architecture incubation environment detection and control systems anymore, because this has been completely eliminated by the market, The current mid to high end performance incubation environment detection and control systems on the market all use 32-bit cores as the main control core, which are implanted into the software and hardware layers of the incubation environment detection and control system. Paired with high-performance peripheral circuit modules, they can achieve various indicators that meet the needs of the public. This most popular design method has significant advantages and convenience. In order to meet the needs of the user population, continuous improvement and upgrading work is needed. If it is a pure analog circuit architecture, significant changes need to be made to the connection relationships and device indicators parameters in the circuit, while digital structures only require program code modifications from a software perspective, and only a small amount of changes are needed to complete the improvement and optimization of the incubation environment detection and control system. The, This type of R&D solution has gained widespread recognition in the field of incubation environment detection and control system design. At the same time, this type of R&D solution can minimize the cost of each design, as it rarely requires component replacement and only requires changes in software code. Moreover, the debugging of program code can only be done on computer software, saving a lot of manpower and material resources. [6-11]

This paper reviewed relevant research materials on incubation environment detection and control systems. Recently, a technical literature publication recorded the research and design of incubation environment detection and control systems by the University of Liverpool. A research and development team from the university announced its breakthrough research and development results to the outside world. Based on the technology of ordinary incubation environment detection and control systems in the market, a parallel working quad core ARM was developed The processor is implanted into the core of the hardware architecture, and the developer claims that the highlight of this architecture is that it changes the drawbacks of previous single core processors and greatly improves the efficiency of the incubation environment detection and control system. The research and development focus of this incubation environment detection and control system in China has mainly been on high-end products. In the past, low - and medium performance products had stronger market competitiveness. However, with the continuous improvement of market demand for product use, the performance of low - and medium performance products is increasingly unable to meet the current situation. Therefore, related enterprises and research groups from some universities in China are focusing on high-performance products, using higher end main control chips and algorithm processes to upgrade the incubation environment detection and control system.

After the introduction of the history and other contents of this incubation environment detection and control system in the previous text, the main content of this project will be established [12-15]. This paper intends to design an incubation environment detection and control system, using STM32 microprocessor developed by STMicroelectronics as the main controller. The graduation project will adopt the system module segmentation method to divide the overall framework of the incubation environment detection and control system into multiple driving circuit parts. This detection system can detect and control various parameters of the incubation environment during operation, and continuously monitor the temperature and humidity values in the air through its high-performance temperature and humidity sensors. In order to achieve a suitable temperature environment in the incubation room, high-power LED is also needed The lamp beads are used for illumination to maintain the stability of environmental parameters. In order to improve the system's human-computer interaction performance, a WIFI interface is also configured in this project, allowing users to view work data through the mobile APP interface and remotely control it.

2. System Scheme Design

The historical development process and current domestic and international development status of the incubation environment detection and control system have been introduced in the previous text, and each expected functional indicator requirement has been determined. Next, the system development plan will be designed based on each content. This paper will use the system module segmentation method to reasonably divide the system as a whole, generate the STM32 microprocessor minimum system and driver circuit, and form the overall system architecture in the figure. Next, each functional sub circuit will be designed. In order to achieve high-precision detection of temperature and humidity parameters in the incubation room environment, this project uses the DHT11 temperature and humidity sensor to construct a detection circuit. It can accurately collect temperature and humidity parameters in the environment in less than 0.1 seconds, convert them into digital signals, and send them to the microprocessor for use.

In order to enable users' mobile apps to interact with the incubation system for operational data, this project uses the ESP8266 WIFI module to construct a wireless communication circuit. It allocates a UART serial port to build the communication circuit externally, allowing the microprocessor to drive it through a two-wire port. In order to control the temperature parameters inside the incubation room, this project uses a high-power LED lighting device for temperature control. As the microprocessor cannot directly drive high-power devices, a temperature control circuit in the form of a digital level interface is configured.

In order to display the working data generated by the incubation room control system clearly, this project uses an LCD1602 dot matrix screen to construct a display circuit. The microprocessor will send the operating data in string form to the LCD screen through a high-speed communication interface for display. In order to handle high humidity and high temperature situations, this project uses a DC fan to construct a processing circuit, and a microprocessor can control the opening and closing of the circuit through high and low digital level signals.

3. System Scheme Design

The various functional indicators of the incubation environment detection and control system have been established in the previous text. In order to meet these functional requirements, the STM32 microprocessor is selected for control in this graduation project, configured as the core control part of the system. The software program design of the STM32 microprocessor will be implemented through C language, and its internal code storage performance can reach 512 KByte, which can meet the application requirements of this incubation environment detection and control system. The core module of the STM32 microprocessor adopts an ARM type central processing unit, which is equipped with timers, bus managers, interrupt triggering resources, memory, and various functional pins on its periphery, thus achieving the overall functional architecture of this STM32 microprocessor.

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The general function of the clock circuit is for the STM32 microprocessor to provide accurate 12MHz clock frequency signals, enabling the STM32 microprocessor to complete instruction execution under clock control. This paper uses three basic components to design the clock circuit, using a high stability passive crystal oscillator as the clock source, and combining two 30pF small capacity capacitors to connect it to the two pins of the crystal oscillator, thus forming the crystal oscillator circuit framework in the figure. The two ends of the crystal oscillator are connected to the XTAL1 and XTAL2 pins of the STM32 microprocessor respectively to achieve connection with the STM32 microprocessor.

The main function of the reset circuit is to provide a reset level signal for the efficient operation of the STM32 microprocessor. The principle structure used in this graduation project is shown in the following figure. Through three devices, a 10k resistance resistor and a 10uF capacitor are connected in series to form a charging circuit for the capacitor. A mechanical button is also connected to both ends of the capacitor to form a short-circuit control. During operation, the resistor fully charges the capacitor, causing the RST terminal to form a low level. When the button is pressed, the capacitor is short circuited, causing the RST terminal to form a high level. The RST pin of the STM32 microprocessor can achieve a reset operation in a high level state, while it can stably run program instructions in a low level state.

The DHT11 sensor from Dallas company is selected to design the temperature and humidity detection module, which is driven by software and hardware sub modules to achieve the effect of collecting the temperature and humidity of the incubation room environment. The DHT11 temperature sensor is the most suitable one in terms of performance indicators and price level. In terms of completing the temperature and humidity detection function, the DHT11 temperature sensor needs to be combined with the external hardware driving circuit structure of its module to complete it. During the working process, the DHT11 temperature and humidity sensor can have the operating effect of 1% RH humidity resolution and 0.5 degree temperature resolution. When configured in this incubation environment detection and control system, it can be driven by only one GPIO pin of STM32 microprocessor to achieve the measurement of temperature and humidity parameters. Temperature and humidity detection can bring about a power consumption parameter of about 40 milliwatts, which improves the performance. The power consumption index of the incubation environment detection and control system.

The DHT11 temperature and humidity sensor has a total of 3 functional pins, of which OUT is used to implement functional control. In this graduation project, it is configured as a component of a single bus interface. According to the circuit structure provided in the official information of the DHT11 temperature and humidity measuring device, the hardware circuit of the DHT11 temperature and humidity sensor is divided into two parts: the power supply circuit and the hardware interface circuit. Firstly, it needs to be powered by a+5V DC voltage. The+5V DC voltage is connected to the VCC pin of the DHT11 temperature and humidity sensor, and then the GND pin is directly connected to the digital ground to achieve power supply for the sensor. Next, the hardware interface circuit connects the PB1 pin of the STM32 microprocessor to the DO pin of the temperature and humidity sensor.

Based on the design of the expected requirements for this type of incubation environment detection and control system mentioned above, it is necessary to achieve the performance of WIFI wireless communication, The ESP8266 WIFI module is a good choice for implementing WIFI wireless communication functions. This type of WIFI wireless communication sensor requires hardware circuits to enable its internal circuit module architecture to start working. The ESP8266 core processor is an important part that determines the performance bottleneck of this WIFI wireless communication. Due to the compact appearance of the incubation environment detection and control system in this graduation project, there is an upper limit on power consumption characteristics. This ESP8266 WIFI module requires VCC voltage for power supply, and the energy consumption in working state is around 0.1W. It has low power

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consumption characteristics and can meet the performance requirements of this type of incubation environment detection and control system.

Below, we will conduct research and development on the power supply circuit, microprocessor interface circuit, and other parts of the ESP8266 WIFI module. The WIFI communication module used in this graduation project is packaged in DIP and has external ports such as RXD and TXD. With the UART interface link, the WIFI wireless communication sensor can be driven and controlled at the hardware level, The data transmission and reception of the ESP8266 WiFi module need to be achieved through its high-performance serial interface. At the hardware level, the key task of designing its driver circuit is to dock its UART serial port. In terms of the UART interface of the STM32 microprocessor, it consists of the multiplexing function of two pins, PA10 and PA9. PA10 is used to receive data output from external serial devices, and PA9 is used to output data from other serial devices. Based on the differences in the functions of these two pins, this project connects the PA10 pin of the STM32 microprocessor to the TXD pin of the ESP8266 WiFi module, and the PA9 pin to the RXD pin of the ESP8266 WiFi module. In terms of power supply,+3 is used. Use a. 3V DC regulated voltage to power the VCC of the ESP8266 WiFi module, and connect the+3.3V DC regulated power supply network to the VCC pin of the ESP8266 WiFi module.

A photosensitive sensor can convert the strength of surrounding light into electrical levels and analog voltage signals through its core processing, allowing users to sense changes in light at the electrical level. Compared with components such as photoresists that are often used to achieve light detection targets, photosensitive sensors can also achieve high-precision acquisition of light intensity. During normal operation, photosensitive sensors have the function of fast acquisition and conversion.

This paper will use a photosensitive sensor as the core part to achieve the detection of light brightness. Through the manipulation of the GPIO pin of the STM32 microprocessor, the light intensity detector's light detection function will be realized. This project refers to a large number of excellent design schemes and designs the circuit topology structure in the following figure. It uses a+5V DC voltage for power supply. In order to improve the stability of the power supply, a decoupling capacitor is connected to the ground on this pin to achieve efficient noise filtering effect. In terms of the output signal reading function, this project uses its AO digital signal pin, which outputs an analog voltage signal. The PB9 pin of the STM32 microprocessor is configured as an analog-to-digital conversion function at the software level and directly connected to the AO pin to complete the light filtering. Strength testing.

The implementation of the DC fan drive circuit requires the combination of the GPIO pins of the STM32 microprocessor. From a software perspective, the input-output pins are configured as PWM signal interfaces to enable the DC fan to interface with the STM32 microprocessor at both hardware and software program levels. Due to the very weak PWM wave power output by the STM32 microprocessor, it is not enough to drive the DC fan to rotate. Therefore, a power amplification part must be configured to amplify the GPIO pins of the STM32 microprocessor. According to the circuit structure in the figure, a high-power MOSFET drive tube is selected for this project, and its gate is connected to the PB9 of the STM32 microprocessor The pin absorbs the pulse signal output by the pin, amplifies it with sufficient power, and sends it to the DC fan connected to its source pin, so that a large current is sent to drive the DC fan.

In order to achieve heating of the incubation room temperature, this project uses an incandescent lamp as the heating device, and assigns the PB7 pin of the microprocessor as the driving port, which is connected to the gate pin of the MOSFET driving tube to increase the power of the driving signal, so that the incandescent lamp can work.

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4. Physical Production and Installation

In order to verify the various design results, this project has configured a running debugging phase and selected high-performance components to construct a physical circuit board. Based on the design results of the hardware circuit in the previous text, the physical appearance structure in the diagram is constructed through the connection relationship of the components, including the STM32 microprocessor minimum system and driver circuit. This type of research and development solution can facilitate the inspection process. Through the test results presented by the physical circuit board, problems and faults can be easily found, and continuous improvement and optimization can be carried out. This is a classic research and development method in current microprocessor control systems, which can greatly promote the progress of research and development design.

The intelligent incubation control system designed in this project uses a universal board to build the circuit, and connects various components through soldering to form the overall appearance architecture of the system. Due to the single-sided copper coating of the universal half, it can only be laid out on one side, and some component ports need to be connected through flying wires. The power supply voltage of the system adopts a single power supply+5V. In this project, a mobile phone charger is used to output+5V to achieve the power supply of the system. Then, the internal program code of the microprocessor starts running. Through the driving of various functional modules by the microprocessor, it is detected that the current temperature in the incubation room is 20 degrees Celsius and the humidity is 20% RH. The threshold values of the temperature and humidity parameters are set through the buttons. After pressing the setting button, the system enters the setting interface of the LCD1602 LCD screen, where the threshold values of various parameters can be set through the buttons. As shown in the figure, the temperature threshold is set to 41 degrees Celsius. Since the current ambient temperature is below 41 degrees Celsius, the microcontroller starts the LED light for heating.

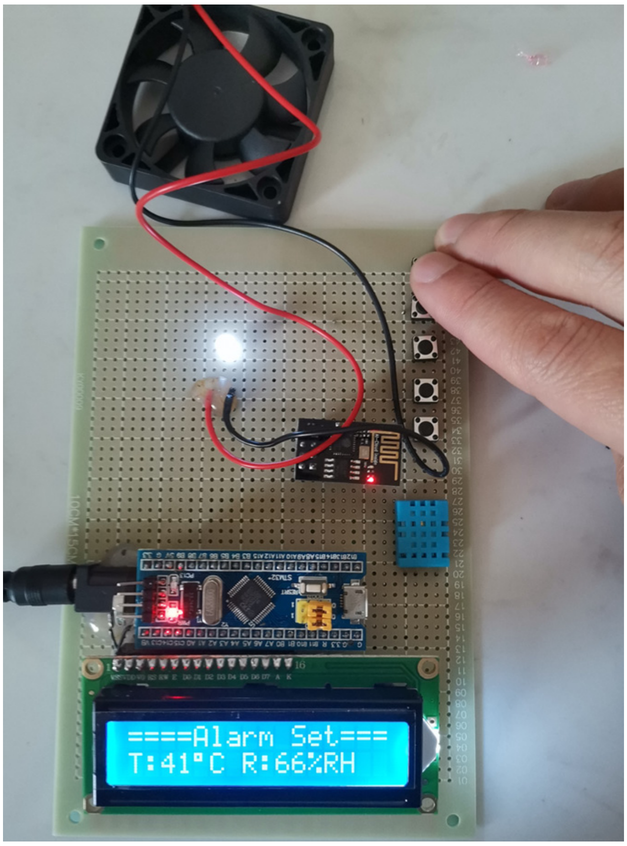

Figure 1. Physical operation demonstration diagram

5. Conclusion

The main task of this section is to summarize the design results of the incubation environment detection and control system. Based on the large amount of data and work phenomena obtained from the system debugging process in the previous section of the paper, all the functional indicators proposed at the beginning of the project have been perfectly implemented, enabling it to collect real-time temperature and humidity data in the incubation room and obtain the hatching situation of chicks. During the system operation, temperature and humidity control in the incubation room can be achieved through fans and incandescent lamps. When the system detects that the temperature and humidity parameters in the incubation room exceed the pre alarm value, the fan will be immediately started for cooling and dehumidification. When the temperature is detected to be too low, temperature control will be carried out through incandescent lamps. The system will display the system data through a high-definition LCD screen. At the same time, it can... Through WIFI The module sends data to the mobile app for display. In order to test the stable performance of this incubation environment detection and control system, this graduation project repeatedly tested and operated the research and development results. During the testing process, the system did not encounter any faults or crashes, and all functions were effectively executed. This is the goal pursued in this article. STM32 microprocessor was selected as the core part at the software and hardware level in this graduation project, which greatly increased the performance indicators of the incubation environment detection and control system to a certain extent. The various indicators of this incubation environment detection and control system have reached a high level. This is mainly due to the mature research and development plan as a foundation, and the STM32 microprocessor was used as the hardware system level The microprocessor chip is designed as the main control chip, and the powerful performance of this type of microprocessor determines that the incubation environment detection and control system can achieve very high system performance indicators. The incubation environment detection and control system designed in this paper adopts an excellent design scheme, which can clearly see the excellent performance of the system during the operation and testing stage. A perfect scheme can greatly reduce the probability of errors in the design work, so repeated testing can be carried out smoothly. This also shows that the great effort spent on the system scheme is worthwhile.

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