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Intelligent Desk Lamp with Real-time Environmental Sensing for Enhanced Energy Efficiency and User Interaction

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Abstract: With the rapid advancement of electrical technology and the growing demand for a more convenient and efficient lifestyle, an intelligent desk lamp has become a vital component of modern living. However, the functionality of most desk lamps currently available in the market is primarily restricted to basic flexible light control. This paper introduces an intelligent desk lamp control system that, like many existing products, enables flexible lighting control. The distinguishing feature of the proposed system is its capability to perform real-time detection of surrounding human presence, natural light levels, and other environmental parameters to enhance energy efficiency. Specifically, the desk lamp automatically turns off when no one is present and activates only under low natural light conditions. Additionally, the system can be operated via an infrared remote control and displays time and date parameters on an LCD screen.To enhance data processing speed, the system employs the STC89C51 chip as the primary control unit in the hardware circuitry. The well-designed circuit structure integrates the main control microprocessor with an LCD1602 display, a clock chip, an LS5V photosensitive sensor, and a pyroelectric infrared sensor. This configuration facilitates seamless communication with infrared remote control devices, ensuring the overall efficiency of the hardware system.

Keywords: Intelligent desk lamp; STC89C51 single chip microcomputer; ray detection; infrared remote control.

1. Introduction

The development of science and technology and electronic technology can promote the progress of society greatly [1-3]. With the increasing variety of electronic products, the level of various electronic products in the market is not uniform, and some electronic products do not meet the current needs of people's life. The intelligent lamp system to be studied in this paper is also a milestone product in the development and progress of electronic technology. Its appearance and continuous strong performance are all benefited from the development of electronic technology. In this continuous development process, electronic technology, microprocessor chip production technology, integrated circuit technology and a series of other technologies all have the characteristics of intelligent lamp system. It has played a huge role in promoting the improvement. At present, the development direction of science and technology is moving towards the direction of high intelligence, especially the most outstanding research and development and application performance of microprocessor chip. The shape and volume of this kind of microchip are shrinking, but the density of the basic components and semiconductor devices integrated inside are getting

higher and higher, and the circuit form is becoming more and more complex, which makes the microprocessor chip be able to achieve more High performance, at the same time, the development of automatic control technology will get the hardware foundation[3-6]. After decades of development, the main control microprocessor has been able to achieve 32-bit data processing ability. At present, the widely circulated STM32, ARM7 or ARM9 microprocessor chips are based on the cortex architecture, which can execute instructions in a single cycle, and the main frequency speed of the chip has been greatly improved, which can ensure that the intelligent lamp system can be collected. The system can recognize and process the signal quickly, and output the ideal result for users. In the process of project design, after consulting the extensive materials in the library and Internet, it can be found that in the selection of the main control processor of intelligent lamp system, there are two types of main control devices, i.e. microprocessor chips such as microcontroller and PLC programmable controller. These two different types of main control devices have been widely used in the field of production and life. The main application of the intelligent lamp system with PLC as the core of the main control is in the industrial environment. Because of the noise interference, radiation or high temperature and humidity in the industrial environment, the unprotected microprocessor chips such as single chip microcomputer cannot work normally, and only rely on the PLC controller with stronger anti-interference performance for control. Among them, the main application scenario of the intelligent lamp system, which takes the microprocessor chip such as MCU as the core of the main control, is some civil occasions or individual users. These users are in good environmental conditions, without so many environmental factors interference, so the intelligent lamp system has not so high requirements for the anti-interference performance of the main control chip.

In recent years, the intelligent table lamp has been gradually popularized in the market with various styles. Therefore, it has a good development prospect for the necessary daily necessities of intelligent table lamp [6-9]. Although the intelligent table lamp has not developed more perfectly and has not possessed more practical functions, it has a good sales market. According to a journal of Electronic Science, there is a research and development achievement of intelligent lamp system on the market at present. The researchers of this product say that in the aspect of internal hardware circuit, in order to improve the high-speed operation speed of intelligent lamp system for external data, they use the arm type CPU with multi-core coexistence as the main control, and work in parallel through multiple CPU cores, so that Many intelligent functions of the intelligent lamp system have been developed, which has a very fast response to external signals. With the launch of this product, the average price of many table lamps on the market has been lowered, so the prospect of intelligent table lamps is still very good.

2. Scheme Design of Intelligent Table Lamp

Before the design of the hardware circuit and software system of the intelligent lamp system, in order to realize each functional module more conveniently, it is necessary to design the overall implementation scheme of the intelligent lamp system and the implementation scheme of each functional sub module. Because STC89C51 is the main control core, each functional sub module is between the main control microprocessor. There is signal interaction. In order to realize the main control function of STC89C51, the reset circuit and crystal oscillator circuit in the figure need to be connected with STC89C51 single chip. The function of other modules is: the human body detection module is used to detect whether there are people around the table lamp. If there are no people around the table lamp, the human body detection module will output the low level to the pin of 51 single chip microcomputer. At this time, the microcontroller detects that the pin is in low power level, and turns off the light; the light detection circuit is used to realize the function of detecting the light intensity around the table lamp; the RTC clock module is used to generate real-time time time and date; the DS1302 clock chip circuit is used to realize the function of Beijing time timing; the hx1838 infrared integrated receiver circuit is used to realize the function of remote control, and the user uses the infrared remote control.The controller sends control instructions to realize the wireless control of the table lamp; the LCD1602 LCD circuit is used to realize the function of high-definition display of parameters. The single-chip microcomputer realizes the display of characters by

controlling the light and of the lattice in the internal LCD lattice, which is the main function of each module.

In order to drive the LCD display circuit, DS1302 clock chip circuit, light acquisition circuit, hc-sr501 pyroelectric sensor circuit and infrared remote control receiving circuit in the intelligent lamp system, and realize all the expected functional indexes, it needs to be realized by the powerful control function of the main control microprocessor. Figure 1 shows the STC89C51 single chip core. Outline structure of the sheet. In this paper, 4K flash can be used to store program code and 256 bytes RAM can be used to store variables. In terms of processing speed, the intelligent lamp system will use 12m high-speed crystal oscillator to provide clock signal for the intelligent lamp system. Because the STC89C51 single chip is a 12t processor, its single cycle instruction execution time is 1us.

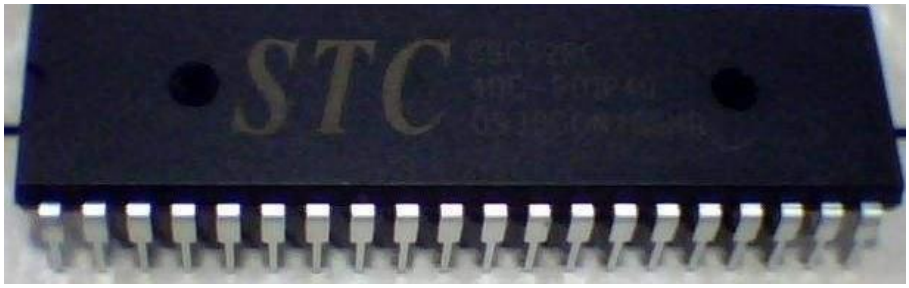


Figure 1: STC89C51 single chip microcomputer

Next, we will design each functional sub-circuit of this intelligent lamp system according to the design method of system block diagram, and the hardware system part will start to design the minimum system circuit first. According to the official data of STC89C51 single chip microcomputer, pin 9 of STC89C51 is a pin with reset function. Inputting high level to the pin can make it work normally, while inputting low level makes the program run again, thus realizing reset function (as shown in Figure 2).

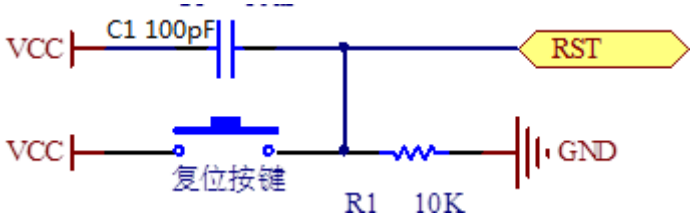


Figure 2: reset circuit design

When designing the clock circuit, the input frequency of the clock is mainly considered. According to the various intelligent functions to be realized by the intelligent lamp system, a clock signal with high frequency value is needed. According to the data consulted, the 12Mhz crystal oscillator is relatively stable, and its use needs to be matched with two 30pf capacitors in the figure to achieve the work (as shown in Figure 3).

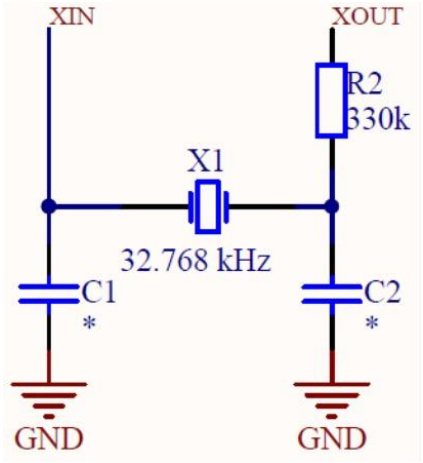


Figure 3: crystal oscillator circuit design

As shown in Figure 4 is the appearance of this LCD1602 LCD screen. In terms of working parameters, this LCD1602 display can display up to 32 characters at the same time. This level of performance, combined with its price of no more than 5-8 yuan, has a very high price performance ratio. Compared with the most popular LCD devices in the market, it can be found that LCD1602 LCD screen has the advantages of low current consumption, high LCD integration, controllable backlight, clear display characters, simple circuit structure, less scrambling phenomenon and simple driver program, etc., while the disadvantages of LCD1602 lattice screen are slow update speed, less display content and too many pins. There is no Chinese character library, too many pins of MCU are consumed and pictures cannot be displayed.



Figure 4: LCD1602 lattice screen module

In order to realize the display function of important parameters through LCD1602 LCD, the intelligent table lamp system needs to design the device in two layers of hardware and software. The hardware part includes two main parts: the peripheral circuit of the device and the bottom driver. In this part, the hardware peripheral circuit of LCD1602 LCD is designed firstly, and the circuit topology of LCD1602 LCD is designed according to the suggestions provided in relevant materials. STC89C51 single chip microcomputer will need to allocate 11 pins (P0 and p2.5-p2.7) to the DB parallel port, en, RW and RS of LCD1602 LCD screen, so that the data can be sent and received. After the VCC pin is applied with power, the voltage of about 1V is distributed to the V0 pin to adjust the contrast of LCD screen.

DS1302 has a high-performance timing structure inside, which can generate second beat under the action of clock signal, which is the basis for it to achieve high-precision timing. This intelligent lamp system uses this RTC chip (as shown in Figure 7) as the display part, which can bring the advantage of sending the time data with leap year automatic calculation function to the intelligent lamp system for use.

The expected design goal of this project includes the function of providing the time and date data generated by automatic operation to STC89C51 single chip computer for use, so this project chooses clock chip to realize the function. This function is mainly realized by GPIO pin of STC89C51 single chip computer to output high and low level data flow and send it to the real- time clock chip to work on the internal circuit of the device. The design of hardware peripheral circuit

will determine whether the software code can be smoothly transmitted between STC89C51 single chip computer and RTC chip, so as to complete high-quality time and date data generated by automatic operation. It can be used by STC89C51 single chip microcomputer. The external data input and output pins of the device are connected to the GPIO pins of STC89C51 single chip microcomputer, so that the design of the hardware peripheral circuit of DS1302 real-time clock chip is basically completed. On this basis, the software code will be designed to achieve the function of automatically generating time data.

This design also includes the function of collecting light parameters. Therefore, the light detection part needs to be configured in the internal hardware circuit and software driving process of this system. The main design point of this circuit is to ensure high-quality and high- precision light detection function. The main function of this project is to detect the light intensity. After consulting the information on the Internet, the system will use four pins of the light intensity detector to design the circuit. The intelligent lamp system will distribute the P1.7 pin of STC89C51 MCU to collect the output signal of the photosensitive sensor module, because the photosensitive sensor module The output signal is digital, so the do pin can be directly connected to P1.7 pin of STC89C51.The intelligent lamp system is to realize the function of detecting whether there are people around the intelligent lamp system. According to the reference materials and the experience accumulated during the University, some devices such as infrared tube sensor are the most commonly used. Among these devices, the pyroelectric red sensor model pyroelectric sensor has the most detailed information on the network, which can be easily found. This paper will use it and configure it into the internal hardware circuit of intelligent lamp system, and realize the function of detecting infrared ray of human body through the control of STC89C51 single chip microcomputer.

In order to ensure high-quality and high-precision detection of human body function, this part will connect hc-sr501 pyroelectric infrared sensor device with the peripheral resistance and capacitance network by Protel drawing schematic diagram. The level between STC89C51 single chip microcomputer and pyroelectric infrared sensor device pin is compatible with each other, only simple power supply and single chip microcomputer pin connection are needed. The driving circuit of hc-sr501 pyroelectric sensor only needs one bus to build. Its output signal is high and low level signal. The output data can be read by connecting the P1.6 pin of STC89C51 single chip microcomputer with the do pin of hc-sr501. In terms of power supply, it is directly driven by + 5V.In terms of the internal architecture design of hx1838 infrared integrated receiver, the R & D personnel mainly divided the device into several key parts in terms of hardware circuit, such as infrared receiver tube and amplifier, filter, mechanical structure and interface circuit, among which the infrared receiver tube is the core part, and the performance of this functional module determines the performance parameters of the whole infrared remote control transceiver module. In order to facilitate the user to realize the internal circuit control of the infrared integrated receiver through the single chip microcomputer, the R & D personnel lead out three pins for the user to control, so as to realize the function of receiving infrared remote-control signals.

The main function of hx1838 infrared integrated receiver circuit is to send the received infrared remote-control signal to STC89C51 single chip microcomputer. The circuit schematic diagram of the infrared remote controller receiver is composed of two parts: DC 5V voltage supply circuit and single line serial single chip microcomputer pin drive circuit, which can work stably in the DC voltage range of + 3.3-5v. This is mainly due to its internal it is a high-performance voltage stabilizing module, which can depressurize and stabilize the DC voltage of external power supply input and effectively filter the AC interference components carried in it. Because the intelligent lamp system designed in this project uses + 5V voltage for power supply, it can be directly applied to pin 3 of infrared remote-control transceiver module.

3. Conclusion

The advantages of this intelligent table lamp system are that it can fully achieve all the expected functional indicators, and the operation speed and performance parameters are higher than the

expected effect. In addition, in the aspect of human-computer interaction, it can display the important parameters of the intelligent table lamp system in the operation process through a high-definition display module. The user can very it is convenient to fully grasp the operation of the system according to the output parameters.

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