ISSN 2616-5767 Vol.6, Issue 11: 43-50, DOI: 10.25236/AJETS.2023.061107

Design of Intelligent Curtain

Guifa Yao[1,#], Maorong Gu[2], Yafei Chen[3,#], Yadi Chen[4,c,*], Huifang Chen[1,5,a,*], Shuzhu Tian[1,b,*]

[1]Guangdong Lingnan Institute of Technology, Guangzhou, 510663, China
[2]Qingyuan Technician College, Qingyuan, 511515, China
[3]Boston University, Boston, 02215, USA
[4]The University of New South Wales, Sydney, 2052, Australia
[5]Guangxi Normal University, Guilin, 541004, China
[a]chenhf_1968@163.com, [b]2652399240@com, [c]3515249849@qq.com
[#]These authors contribute equally
[*]Corresponding author

Abstract: *Since the 21st century, with the continuous development of science and technology, smart household appliances have gradually entered people's vision and are being sought after globally. Smart curtains are also one of them. However, the price of smart curtains is not very high compared to the functions they can achieve. The main problems with smart curtains are high energy consumption and poor comfort. Starting from practical issues, this article mainly studies the use of light control and manual infrared remote control to control the opening and closing of curtains, in order to improve their use economy. According to the design requirements, this study used a light sensing module, a time module, and a low-cost 89S52 to construct a small control system. The hardware and software designs were completed, and the design results were simulated using PROTUES. Based on this, PCB design, software debugging, and hardware circuit debugging were carried out to simulate the operation of curtains, verifying the rationality of the system design scheme and the completeness of system functions.*

Keywords: *Automatic control; Intelligent curtain; Circuit design; Electric machinery*

1. Overall Scheme Design

1.1 System Overview

The entire intelligent curtain system is basically based on the STC89S5 microcontroller as the core unit, combined with resistors, capacitors, crystal oscillators, and various other photoelectric units, forming a more comprehensive microcontroller small management system. And other functions, such as display function, clock function, automatic keyboard function, infrared remote control module, etc., are also carried out around a small management system of a microcontroller. The display function uses a 1602 LCD, which can represent seconds, minutes, and seconds, including basic signals such as time identification and real-time lighting intensity of the control module; The circuit of the clock module uses the DS1302 chip. After initialization is completed, it will immediately start automatic operation and undergo real-time calculation to determine the current time. Therefore, users only need to use the microcontroller to complete the real-time reading and processing of the clock signal; The light control module is composed of the light intensity measurement circuit, of which the main electrical components are the Photoresistor and the analog digital conversion chip ADC0832. The analog quantity of light intensity is converted into specific figures through corresponding conversion, so that it can be used in the control circuit as a judgment basis and displayed; The curtains use a stepper motor as an alternative to simulate practical application scenarios, and an LED light is added as a clear indicator to visually observe whether the curtains are currently open or closed; This design also has 5 buttons for manual control and mode conversion time setting as input control information devices. Due to the difference in standard light intensity between curtain opening and closing in the light control mode, there is a button for adjusting the time for verification and setting; The infrared remote control module controls the opening and closing of curtains using an infrared remote control. Finally, the power supply adopts a 5V power supply selected based on the most commonly used power supply standards.

ISSN 2616-5767 Vol.6, Issue 11: 43-50, DOI: 10.25236/AJETS.2023.061107

1.2 System Block Diagram

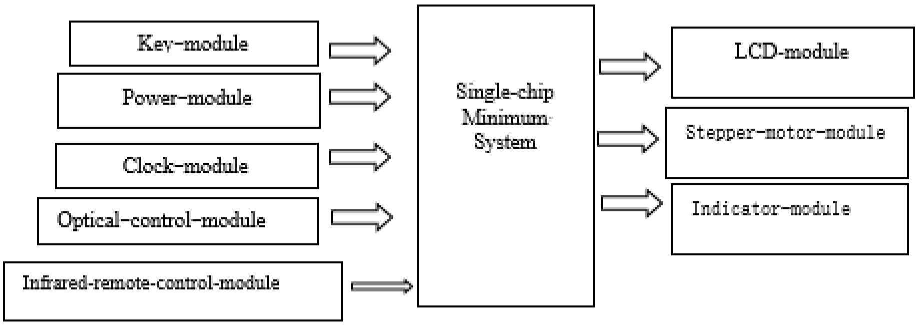

Figure 1: System Block Diagram

2. Hardware Circuit Design of Each Module

2.1 Minimum System Circuit

The minimum system of STC89s52 is shown in Figure 1. The entire minimum system consists of three parts: crystal oscillator circuit, reset circuit, and power circuit[1].The crystal oscillator circuit includes two 30pF capacitors C2 and C3, as well as a 12M crystal oscillator X1. The function of capacitors here is the oscillation function, mainly to assist in simpler oscillation of crystal oscillators, with a value range of 15-33pF. The value of a crystal oscillator can also be 24M, and the higher the value of a crystal oscillator, the faster the operating speed of a single chip or microcomputer. When designing circuits, the closer the crystal oscillator part is to the microcontroller, the better[2].When the microcontroller control system is still working or the program runs away due to the working environment, you can manually start running from scratch by pressing the reset button on the keyboard[3].The reset circuit consists of a 10uF polar capacitor C1 and a 10K resistor R3. By utilizing the stable and non deformable characteristics of capacitor voltage, it can be known that when the system is powered on, the RESET pin will generate a high level, and the duration of maintaining this high level is determined by the system's RC value. Properly combining the values of RC can ensure reliable reset.The last part is the power supply, which uses 5V USB for direct power supply. It can be powered by devices such as mobile phone chargers, computer USB ports, and mobile power supplies.In addition, in addition to the three main components of the microcontroller's smallest system, several peripheral circuits have been added[4].Due to the open drain output of the P0 port of STC89C52, a 10K resistor R1 is connected to the P0 port, allowing it to be used as a regular I/O port. In this design, the P0 port is used as the data port for the LCD[2-7].It is particularly important to note that for pin 31 (EA), when connected to high voltage, the microcontroller starts executing from the internal ROM's 0000H after resetting; When connected to a low battery level, reset and execute directly from the external ROM's 0000H [cited by Zhang Minju. Design and Research of MSC-51 Single Chip Microcomputer Learning Board [J] China New Communications 2012-11-05Since our program is stored inside the microcontroller, EA needs to be connected to a high level to ensure that the microcontroller reads the program from within and executes it.

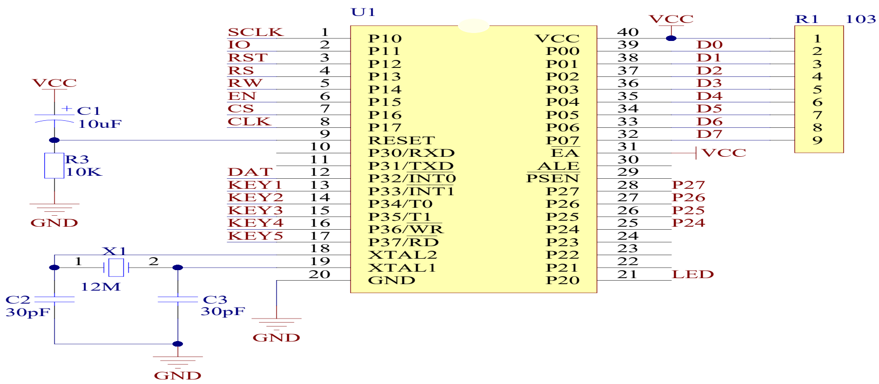

Figure 2: System module connection diagram

ISSN 2616-5767 Vol.6, Issue 11: 43-50, DOI: 10.25236/AJETS.2023.061107

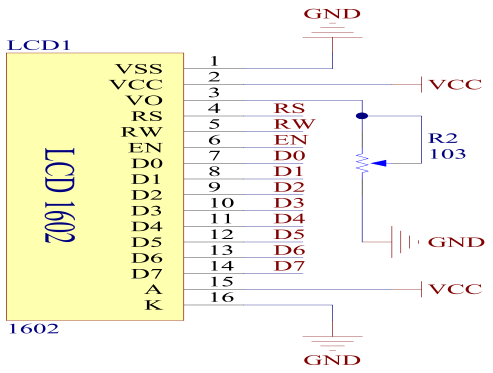

Figure 3: LCD module connection diagram

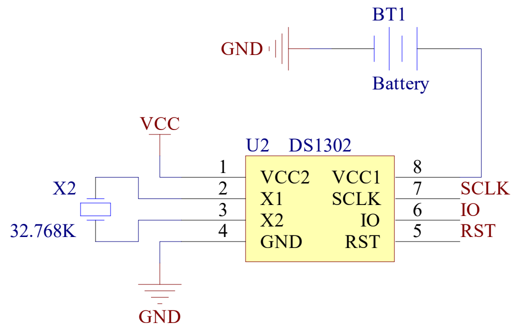

Figure 4: Circuit diagram of DS1302 module

2.2 LCD display module circuit

The circuit wiring of the LCD display module is shown in Figure2-5. Pin 1 and pin 2 are grounded, which is GND; The other is to connect to the power VCC, which is the power input position when the LCD screen is working. Pin 3 is connected to a 10K Potentiometer first, and then grounded. At the same time, the connected Potentiometer is adjustable. The contrast of the LCD can be adjusted by adjusting the Potentiometer. The pin is used to manage a control pin of the LCD display screen register, and the pin structure is connected to the P13 pin of the microcontroller. Pin 5 is a read and write control pin that manages the reading and writing of the LCD display screen, and it is also connected to the P14 pin of the microcontroller. Pin 6 is the enabling pin of the LCD display screen, connected to pin P15 of the microcontroller. From pin 7 to pin 14, the data/address eight bit bus pins of the LCD display screen are directly connected to the P0 port of the microcontroller. Final pins 15 and 16 are the backlight power pins of the LCD screen, which are directly connected to the VCC and GND of the system [8-14].

2.3 DS1302 module circuit diagram

The wiring circuit of the DS1302 module is shown in Figures 3-9. Pins 1 and 4 are connected to the power supply port of the circuit, which is VCC, while the other pin is grounded and directly connected to GND. These two pins are the power input pins for DS1302 operation. Pin 8 is connected with a 3V button battery, which is a Backup battery used to supply power to the clock chip. The main function of this backup battery is to ensure that after the DS1302 is connected to the main power supply, it can still continue to time. Pin 2 and pin 3 are connected to a 32.768K crystal oscillator. And this crystal oscillator is also specifically used to supply clock pulses to chips. Finally, pins 5, 6, and 7 are sequentially connected to the corresponding IO ports of the microcontroller for data transmission.

2.4 Light intensity acquisition circuit

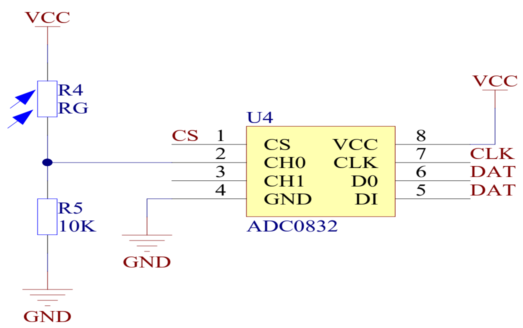

Figure 5: Light intensity acquisition circuit

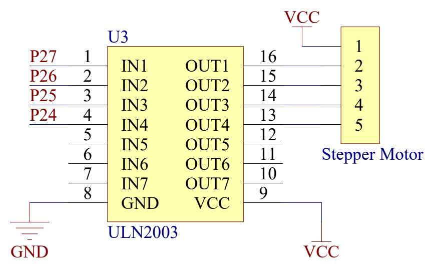

Figure 6: Motor drive circuit

The circuit wiring diagram of the light intensity acquisition module is shown in Figure 3-11. Pin 4 is grounded and connected to GND. Pin 8 is connected to the power VCC to provide power for the module to operate. Pin 2 is connected to the Photoresistor, and then connected to the 10K resistor. Pin 7 is used to transmit the clock signal. Pins 5 and 6 are used for transmitting data. Pin 1 is used to transmit chip selection signals [21-23].

ISSN 2616-5767 Vol.6, Issue 11: 43-50, DOI: 10.25236/AJETS.2023.061107

2.5 Motor drive module

A stepper motor refers to an open-loop controlled stepper motor component that can convert electrical pulse information into angular or even linear displacement information. Without considering overload, the rotational speed and stopping position of the stepper motor only depend on the frequency and number of pulses of the pulse signal itself, rather than changing with its load. [Cited from the design of an Lcd graphic display based on a microcontroller. "Internet Document Resources] (http://max.book118.)2019

When a pulse signal is input to the driver of the stepper motor, it will drive the stepper motor to rotate a fixed number of degrees in a predetermined direction, and this angle is called the "step angle". The speed of a stepper motor rotates and advances in a relatively constant manner, one by one. During the process of compromising the pole movement of the motor, the program can be used to adjust the number of pulses to achieve more accurate positioning.

Because the current directly transmitted through the IO port of the microcontroller is relatively weak, it cannot be relied on to directly drive the stepper motor to rotate. So add a Darlington array chip ULN2003 between the microcontroller and the stepper motor. This chip is produced by T1 Company in the United States and is characterized by low voltage resistance, high torque, and is used as a driving chip for stepper motors. The main characteristics of ULN2003 include high current gain, high working voltage, wide temperature tolerance range, and strong load capacity. It can be used in various situations that require fast and high-power driving.

The stepper motor drive circuit is shown in Figure 6

2.6 Key Input Module

We mainly use the keyboard to send instructions to the microcontroller. Standing in the position where the microcontroller and software design controlled by humans meet the design requirements, and then reading the current state pressed by the keyboard cannot complete the entire design work, and there are still many difficulties to be overcome. Otherwise, when using a keyboard to control the operation of a microcontroller, there is a possibility of incorrect operation or loss of control. In the most commonly used use of microcontrollers, one of the most commonly used methods is independent buttons, and the other is matrix buttons. These two methods each have their corresponding characteristics and properties. The wiring of the independent keyboard circuit here is relatively simple, and its program design is not very cumbersome and relatively simple. Independent keyboards are mostly used in relatively simple systems where the demand for hardware systems is not significant; However, there are significant differences between matrix keyboards and independent keyboards. Firstly, in terms of hardware systems, matrix keyboards are much more complex than independent keyboards, and at the same time, programming and computation are also relatively cumbersome. However, relatively speaking, it has its own unique advantages, and matrix keyboards also have advantages in saving port resources. Compared to matrix buttons, it is more suitable for some hardware systems that require many buttons. Secondly, the matrix mouse can also remove the "burrs" that occur during button processing. The most common method is usually the delayed repeated scanning method. The basic principle of this method is: because the time of the "burr" pulse is not long, it can only be measured in milliseconds. However, in normal working environments, when the key is pressed, it will be much longer than this time. Therefore, it must be determined whether the level remains in its original state after the microcontroller presses the detected key and adds some delay time. If it is determined to be yes, it will be considered a valid button, otherwise it will be a failure [20-22].

In the design, due to the relatively small number of buttons required, there are only 5 buttons, and the corresponding control functions of different buttons are "mode conversion", "set time", "pause", "decrease", and "increase", so the design method of independent buttons was selected and used. The connection of the buttons is shown in Figure 7

ISSN 2616-5767 Vol.6, Issue 11: 43-50, DOI: 10.25236/AJETS.2023.061107

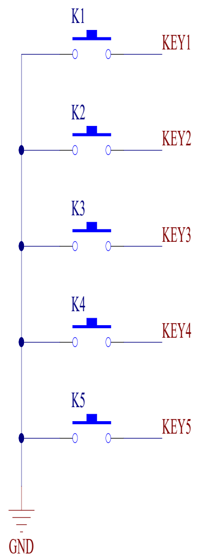

Figure 7: Button circuit

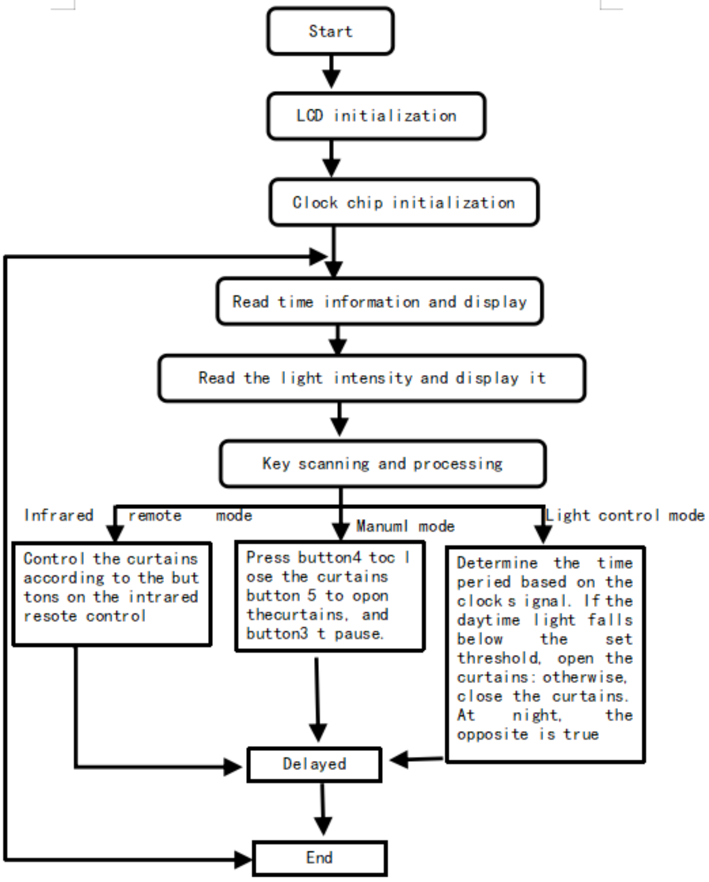

Figure 8: Main Function Flowchart

3. Infrared Reception

The researchers just use an infrared receiver head to receive the control signal generated by the infrared remote control, and then the microcontroller processes it before controlling the motor switch.

4. Software Design

4.1 Program flowchart design

4.1.1 Overall program flowchart design

The software design process of the intelligent curtain control system is shown in Figure 8. The first step is to initialize the LCD display LCD1601 and clock chip DS1302, followed by a cyclic scanning process. Firstly, the clock chip DS1302 is used to read the clock signal, input the clock data, and then present the obtained clock signal on the LCD1602 LCD screen. Then, the information about the intensity of light is read and sent to the LCD screen for display. Then it's the turn to scan the buttons. If any signal of button pressing is detected during this process, corresponding task processing will be carried out based on the different buttons pressed. Then, according to the received button signals, the researchers perform different modes of operation and select to operate the curtain switch control operation in different modes. If the manual control mode is selected, the curtains in the closed state will be opened by pressing the "On" button. If the "Off" button is pressed, the curtains in the open state will be closed, and if the "Pause" button is pressed, they will stop at any position; If it is in infrared remote control mode, the curtains are controlled according to the buttons on the infrared remote control. If light intensity control mode is selected, it is determined whether it is day or night based on the time signal received by the clock chip. Then, it is determined whether the light intensity in the current time period is higher than the initial set threshold. If it is higher than the threshold during the day, the curtains will be automatically closed. If it is lower than the threshold, the curtains will be opened. At night, it is the opposite. So far, the process of a loop is completed.

ISSN 2616-5767 Vol.6, Issue 11: 43-50, DOI: 10.25236/AJETS.2023.061107

4.1.2 LCD1602 LCD Program Design

Before displaying information, the LCD screen should first set a location and set the starting point for displaying information, for example, the design should be set in the first row and fifth column. After completing the coordinate determination work, the content of the display can be determined. When the LCD screen displays information, it follows the content one by one. For example, a string of numbers "123" displays first "1" in the hundreds, then "2" in the tens, and finally "3" in the tens. If a liquid crystal display screen is used to display a string of text, it also works the same principle, such as displaying "hello", which starts from the first letter "h" at the beginning, and then transmits the display bit by bit until the last letter "o" to complete this display task. It should be noted that every time a string or group of numbers is displayed, only one positioning is required at the beginning. In the following, every time a character is displayed, the LCD screen will automatically jump to the next position without the need for repositioning. Each character needs to be repositioned once again.

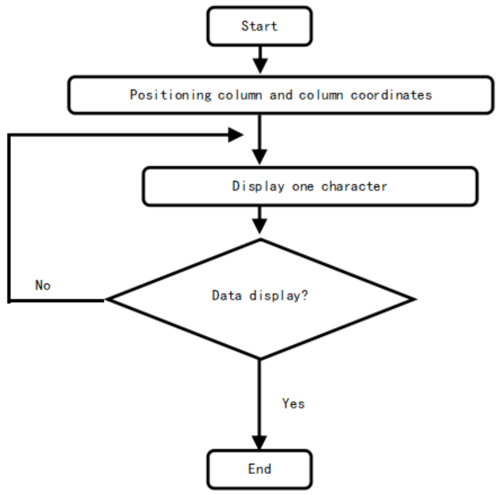

Figure 9: LCD Display Flowchart

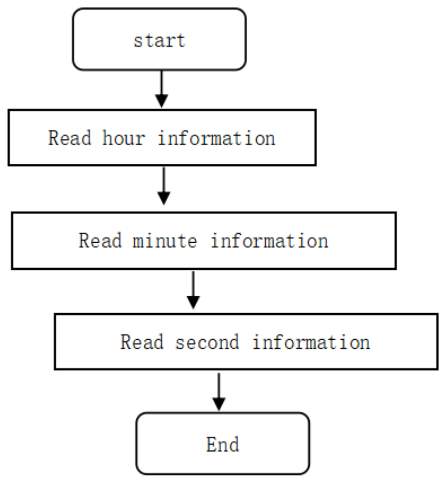

Figure 10: Flow Chart of Reading DS1302 Time Information

4.1.3 Reading Time Information of DS1302

The reason why the clock on the LCD screen continuously updates is because the microcontroller continuously reads and receives the clock signal extracted by the DS1302 clock chip, and then transmits it to the LCD screen for display. The main process of reading the clock signal read by the clock chip DS1302 is to first write the hour to the register address 0x85, and then continue reading the minute data. Then, in the same way, it writes the time information of the second hand to the register address 0x81. The flowchart for reading is shown in Fig.10[15-21].

4.1.4 Application of Light Sensing Module ADC0832

The role of ADC0832 in this design is to convert the analog quantity of received light intensity into digital quantity for use. The first step is to sample first. The sampling interval t, the sampling frequency is 1/t, and it will definitely be twice the highest frequency. The second step is to quantify, convert the sampled level into a digital quantity. In this design, the voltage range of the given lighting circuit is 0-5V, so the data received by ADC0832 should also be a value between 0-5V. For example, if a voltage of 2.5V is received, the order of magnitude that can be obtained when quantized into numbers is approximately 128. Because the 8-bit resolution corresponds to 256 levels, and each level corresponds to a voltage of 5/256=19.53mv, (128/256 * 19.53)=2.5V, the microcontroller knows that the order of magnitude is 128 by receiving 10000000, thus obtaining a voltage of 2.5V.

The first clock DI of the ADC0832 chip is high level, the second and third clocks are channel selection, 10 represents channel selection 0, 01 represents channel selection 1, and from the third clock to the eleventh clock, 8bit data is received. From twelve to nineteen clocks, they are responsible for receiving the second data, comparing the data received twice, and outputting the data if the data received twice is the same.

4.1.5 ULN2003 drive stepper motor

The stepper motor has four phases (A-B-C-D). Firstly, the researchers define the four phase IO port connected to the stepper motor, and then define forward rotation, with the idea of A → B → C → D, and the sequence is that phase A is powered on and other phases are powered off; Power on phase B and power off other phases. The researchers Power on phase C again, and power off other phases; Finally, the D phase is powered on, while the other phases are powered off. The reverse rotation sequence is D → C → B → A, which is exactly the opposite of the forward rotation. By rotating power to each phase, the motor shaft rotates 360 degrees[22-22].

4.2 Summary of this section

This section solves the main problem of automatic control curtain design and is the focus of the entire article, mainly completing the LCD1602 LCD program design; Confirmed the time information for reading DS1302; The application mode of the light sensing module ADC0832 was selected, and the ULN2003 driving stepper motor was determined.

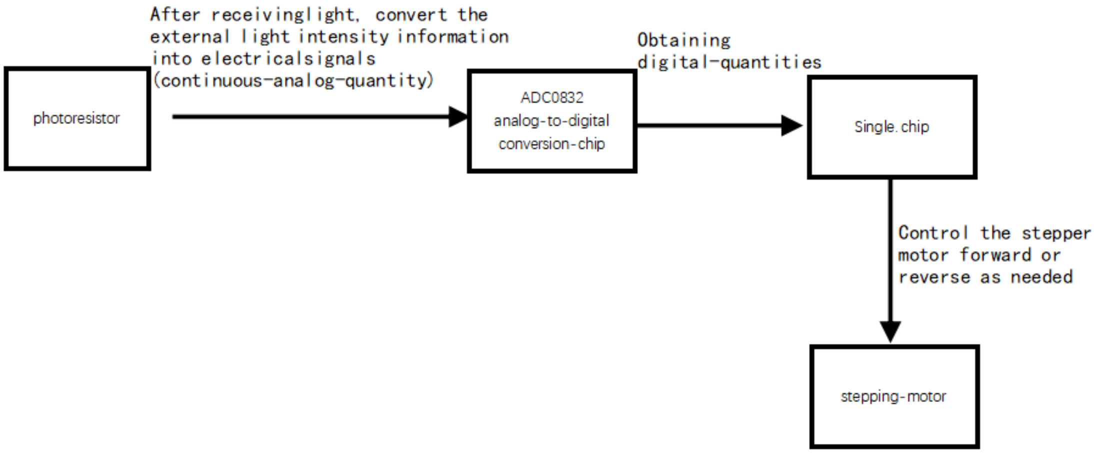

Figure 11: Control Flow Chart of Intelligent Curtain Light Detection Control Module

5. Summary and Outlook

In the process of completing system scheme design and product design, it is necessary to have the ability to effectively combine the content of many courses such as microcontroller basic principles, C language programming, analog circuits, and digital circuits for application. Based on consideration of design requirements and reasonable application, we have deepened our understanding of these related knowledge. In addition, in addition to completing project engineering design and conceptual planning according to engineering design requirements, there are also tasks such as analyzing and selecting product design functional modules, drawing schematic diagrams, designing and manufacturing PCB boards, completing programming, and debugging software and hardware. This provides experience and opportunities for further self-improvement in the future. Although the function of a microcontroller is constantly improving, its basic principles are relatively constant. So although the actual function of this design task will not be difficult to complete, it allows people to have a more comprehensive understanding and deepen the basic knowledge and application related to microcontroller design, and also enhances their awareness of completing microcontroller engineering design tasks. It is a great opportunity to transform basic knowledge into practical hands-on skills.

Acknowledgement

This work was supported by Grants from the research and practice of the school-level teaching and research project of Guangdong Lingnan Vocational and Technical College based on the training of teaching talents in the professional skills contest of electromechanical industrial robots (Project No.:JC202221)

References

[1] Run Maozhen. Research on the Effect of Corrosion Inhibitors on the Electrochemical Performance of Copper Friction [D]. Master thesis of Harbin Institute of Technology, 2011-06-01.
[2] Chen Ming. Graduation Design for the Department of Electronic and Electrical Engineering of

ISSN 2616-5767 Vol.6, Issue 11: 43-50, DOI: 10.25236/AJETS.2023.061107

Hunan Railway Science and Technology Vocational and Technical College [D]Http://www Worlduc c. 2016.
[3] Li Guojin, Hou Xuda, Hu Changlin. Design of Video Surveillance Terminal Based on ATmega128 and Zigbee [J] Automation and Instrumentation" 2012-01-25.
[4] Li Dong. Design of Ultrasonic Distance measuring equipment Based on AT89C51 [J].Internet Document Resources, 2016
[5] Li Guojin, Hou Xuda, Hu Changlin. Design of video surveillance terminal based on ATmega128 and Zigbee. Central South Proceedings of the 29th Academic Annual Conference of the Automation Society of Six Provinces (Regions), 2011-10-28.
[6] Wang Jin. Design of a temperature and humidity monitoring system based on a microcontroller Network. hops://www.sanbiaog. 2020.
[7] Li Ming. Design of Music box Player System. Daokebaba. Internet Document Resources http://www. Doc88.com. 2019.
[8] Jiang Li. Design of ultrasonic Distance measuring equipment based on AT89C51 Internet Document Resources. http://www.Worlducc. 2016.
[9] Zhang Qiang. Design and manufacture of ultrasonic Distance measuring equipment based on liquid crystal display Internet Document Resources. http://www. Doc88.com. 2019.
[10] Wang Qian. Design of LCD graphic display based on microcontroller Internet Document Resources http://max. Book118. com. 2015.
[11] Zhang Minju. Design of Campus Multipoint Temperature Monitoring System Based on Microcontroller [J] Wireless Interconnection Technology. 2013-09-15.
[12] Zhang Minju. Design and research of DISC-51 microcontroller learning board [J]. China New Communications. 2012-11-05.
[13] Li Ling. Home anti-theft alarm wireless central control system Internet Document Resources http://www. 360doc. com 2015.
[14] Chen Ye. Solar cell testing system. Internet document resources http://www. 360doc. com 2015
[15] Wang Min. Digital capacitance measurement instrument based on 51 microcontroller Internet Document Resources http://www. 360doc. com 2019.
[16] Wang Min. Design of an ICD graphic display based on a microcontroller Internet Document Resources http://max.book118. 2019.
[17] En Wen. Electronic music Box. Baidu Library. Internet Document Resources (http://wenku. Baidu. Com. 2012.
[18] Li Sheng. Design of a campus multi-point temperature monitoring system based on microcontroller Network (https://www. Xzbu Com). 2018.
[19] Chen Wen. Course Design of Microcontroller Application and Interface Technology Internet Document Resources (http://wenku. Baidu c) 2012.
[20] Home anti-theft alarm wireless central control system Internet Document Resources (http://www. 360doc Co). 2015.
[21] Rong Wang. Intelligent Home Appliance Control System. Baidu Wenku. "Internet Document Resources (http://wenku. Baidu c) 2012.
[22] Chen Zhongming. Extension of parallel IO for 80c51 microcontroller Network (https://www. wenku365). 2020.