

Design of Intelligent Window Control System based on Single Chip Microcomputer

Luyao Jiang^{1, a}, Xinhong Zhu^{1, b} and Xing Wang^{2, c}

¹School of Economics and Management, Chongqing University of Posts and Telecommunications, Chongqing400065, China

²Guangzhou Guangdong Core Semiconductor Technology Co., Ltd510555, China

^achunglooyo@163.com, ^b529873043@qq.com, ^c2564153676@qq.com

Abstract

In recent years, with the renewal of communication and automation technology, smart home has slowly entered our life, among which, the research of intelligent window came into being. Although there are many kinds of smart windows now, there are still many shortcomings, so it is necessary to study better intelligent window potential. Design of the smart window system using STM32 single-chip, one of the smart home application is the smart window. The system has the functions of automatic window closing, automatic window opening, temperature alarm and so on. In the early stage of hardware selection, read the data manual of the chip, ensure that all components voltage is normal, the circuit schematic drawing, completed the hardware circuit construction. The system uses a variety of sensors, by the single-chip computer to calculate and process the information, when the environmental conditions are different, can automatically control the window state. The sensor selects temperature and humidity sensor, smoke sensor. The motor adopts DC motor. By Keil programming, writing the program, testing the physical object, the system realizes the following functions: when the combustible gas and smoke in the room exceed the preset value, the smoke sensor transmits the collected signal to the single chip microcomputer, and the single chip microcomputer drives the motor to realize window opening, exhaust work, red light flashing, buzzer sound. When rain occurs, the sensor detects humidity. After the single chip microcomputer processes the signal, drives the motor, closes the window, the buzzer works, and the blue diode is switched on. After that, the outside humidity will be judged independently every other time, and the window will be opened when it is lower than the set value. In addition, the temperature can be detected. When the temperature exceeds the standard, the buzzer will work, in line with market and household needs, has broad application prospects.

Keywords

smart home, smart window, single chip microcomputer, sensor.

1. Introduction

The development and progress of smart home related technology make people have higher standards for family living environment and quality of life. Specifically lies in the home home intelligence, automation, as well as car safety and comfort. The automation equipment now provides great convenience for our daily life. The intelligence of windows is a very important step in smart home. Traditional windows do not have the function of automation, encountered overheating, rain, smoke, theft when the need to manually switch windows, very inconvenient. Intelligent window is based on automatic control technology, which combines sensor technology, PC machine technology and mobile communication technology to process all kinds of environmental information collected and control the switch of the form in real time. The

intelligent window is developing in the direction of multi-function to meet different environmental conditions, greatly expanding its application scope, and also making certain requirements for integration. An intelligent window system is designed, the most important part of which is STM32 single chip microcomputer, and many sensors and other modules are connected to the periphery. The data is judged and processed by single chip microcomputer, the DC motor is driven, and the window switch is automatically completed.

2. Current Status of Research

2.1. Status of Research Abroad

Smart home combines a variety of technologies, its earliest application is in architecture, among which the United States has many intelligent products. Families in nearly 100 communities in Singapore have adopted a "windows intelligent system ", MINGARDI is the first company to produce linear window opener for industrial use, and their product design is more humanized, intelligent, automated and can be applied to various environmental conditions, easy to use. Its window opener adopts push rod structure with long stroke and large thrust. It has simple shape, stable operation, automatic and manual mode, corrosion resistance and long service life. Are widely used in automatic door and window control system, Italian TOP company's series of products are suitable for all kinds of open windows, inside windows, skylights and shutters, rack window opener system, maximum thrust up to 800 Newton, maximum travel 1000 mm, and has the function of self-alignment rotation motion.[1]In order to pursue the comfortable indoor environment, the multi-function of intelligent window has become the research hotspot. British SE company's automatic window ventilation system products achieve the function of saving air conditioning electricity, maintaining a healthy and comfortable indoor environment, isolation of harmful radiation.

2.2. Status of Domestic Research

The domestic intelligent window starts late, in recent years the modernization degree is higher and higher, the people living standard becomes better. This industry combines with modern information and electronic technology update, with a variety of functions of the window emerging. But at present, the penetration rate of intelligent windows in China is still relatively low, because the propaganda of manufacturers is not enough, and people's understanding of products is insufficient, which to some extent affects the popularity of intelligent windows. Beijing Tuhui United Technology Co., Ltd.'s products hide the appearance, it uses a small material size, very narrow border, can receive more light, has a good sealing, with waterproof function. But smart windows still have a lot of demand and potential in the domestic market. Even in this case, foreign enterprise manufacturers see its huge market vacancy and invest in the industry of intelligent window to promote the development of intelligent window in China.

3. Overall Design

Choose suitable sensor and main control chip, build hardware platform and debug, mainly include 6 parts: sensor and signal processing part, central processing unit with STM32F103C8 as the core, alarm circuit, display module, indicator light circuit, motor drive circuit. Write system control program, adjust software and hardware related operation, and carry out simulation test.

3.1. Functional Analysis

The quickening pace of life, the improvement of people's livelihood and the rise of modern science and technology require the development of modern home towards automation and intelligence. For the more common windows in life, it is hoped that the windows can

independently adjust the switching state under different conditions. Especially when rain, wind and other bad conditions, how to adjust accordingly. Needs analysis - goal setting - functional structure sub-multi-programme generation-programme evaluation[2]. In order to top down [3]Conceptual design method to clarify the conceptual design process of intelligent window. Let the intelligent window can independently judge whether to open windows according to different temperature and humidity, and the toxic gas concentration is too high to automatically close and alarm exhaust function. the smart window design target tree is shown in figure 1.

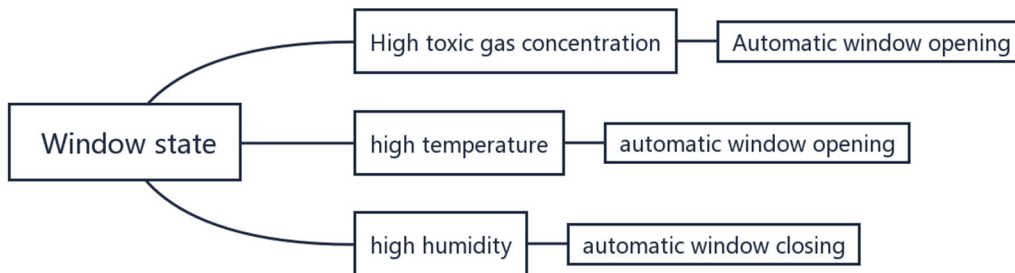


Figure 1. Intelligent Window Design Target Tree

3.2. Module Architecture

STM32 single chip microcomputer is used in the whole system to collect data with sensors, the display screen feedback the information that needs to be displayed, the motor drives the window to control, and the buzzer completes the alarm work. Among them, the most important is the signal conversion, and how to convert the voltage to concentration, how to communicate between devices, how to send and receive data. This requires the study of IIC protocols, MCU ADC functions and so on. It is possible to work independently between parts, easy to operate and find problems, and the specific modules involved are shown in Figure 2.

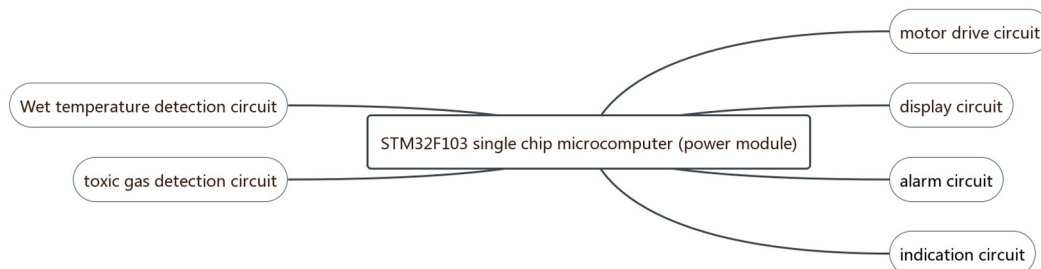


Figure 2. Overall programme diagram

3.3. Hardware Design

This section mainly carries on the hardware part design and each part circuit uses the device elaboration. and the design drawings are given, and the circuit diagram drawn is shown in figure 3.

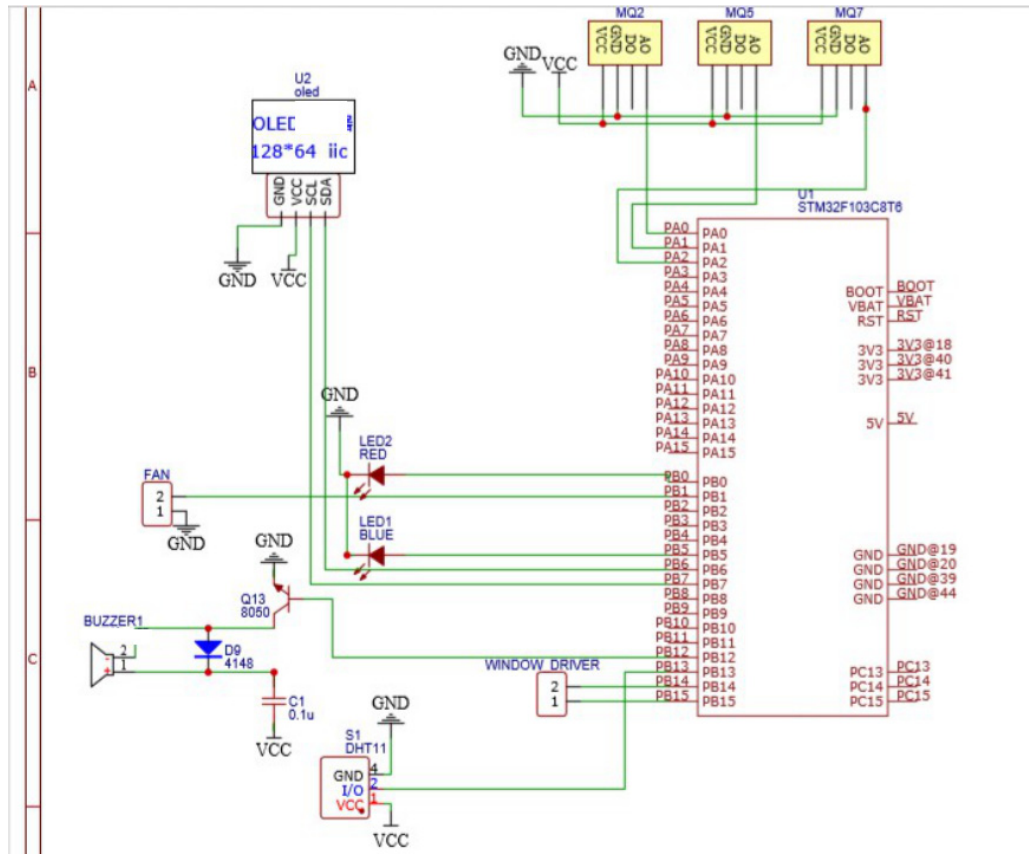


Figure 3. Schematic diagram of circuit

First: MCU minimum system part, with STM32F103C8 as the core, according to the functional requirements, reference device manual, around the STM32F103C8 development.

Second: sensor detection circuit, divided into toxic gas detection part and temperature and humidity detection part. MQ-2 adopted

Detect smoke concentration, DHT11 detect temperature and humidity.

3rd: display circuit, with 0.96 inch OLED module to complete the display function.

Fourth: the indication and alarm part, the indication part uses the light emitting diode, the alarm part uses the active buzzer module.

Fifth: the design of the drive part, with the transistor, diode, capacitance and other devices to drive the motor.

3.4. MCU Control Circuit

The number of single-chip computer bits used this time is 32 bits, A single chip computer in ARM series, High cost performance, To perform most of the required functions, With 48 pins, Frequency up to 72 MHZ, Strong computing power. And its program memory capacity is 64 KB,. Data memory capacity KB,20 Rich interface resources, Has 37 I/O, can extend many external functions. STM32F103C8 number of pins of the chip is 48. With 37 common interfaces, Mainly divided into PA, PB, PC three sets of ports. as shown in Figure 4.

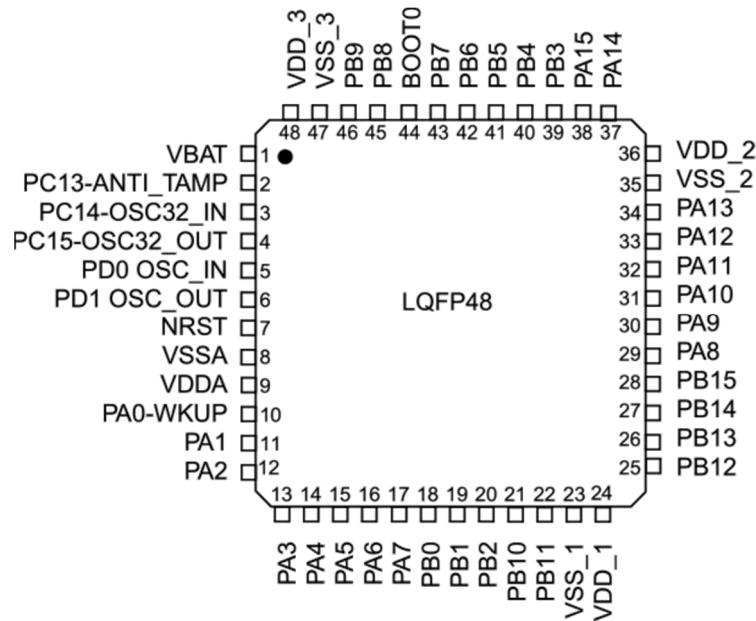


Figure 4. STM32F103C8 Pin distribution

3.5. Minimum System Circuit Design

The design is based on minimal systems, Peripheral motor, Sensors, The display screen is directly connected with the single chip microcomputer. Monolithic work, Power, clock, reset, etc. The power supply is the heart, The clock is the brain, Reset ensures that the system can be rerun when the circuit goes wrong. 3.3 V power supply is used in the power supply section. which contains a voltage conversion circuit. The clock part can use active or passive crystal oscillator, After 8M external crystal oscillator is divided and doubled, capable of the required clock frequency. The reset mode includes power-up reset and key reset, etc. A separate RC reset is used in this system, Easy reset, Easy to trigger. In addition, The minimum system can choose the mode of work, STM32 have Boot0 and Boot1 pins. When these two pins have different levels, The system will start in different places, Generally set to boot from the Flash, The data still exists after power down, Can also start from Ram, The advantage is that loading is fast, But when it goes down, The data will be lost. Download the program using St-link, can also be done using traditional Hex document burning.

4. Toxic Gas Detection Circuit

4.1. Design Ideas

The gas detection circuit uses MQ-2 combustible gas sensor, MQ-5 gas sensor, MQ-7 carbon monoxide sensor. The functions of this part of the circuit are: when the smoke and combustible gas exceed the standard, the single chip microcomputer receives the data collected by the sensor, and drives the motor, the window is closed, the exhaust fan starts to work, the alarm device starts, and the indicator light is on the red light. In addition, it can monitor the concentration of carbon monoxide and gas in the air in real time, prevent gas poisoning and protect human safety. For different kinds of gas, there are different gas sensors, which can be divided into electrochemical gas sensor, semiconductor gas sensor and contact combustion gas sensor, etc [4].

4.2. Gas Sensors

(1) MQ-2 flammable gas sensors

MQ-2 the sensor detects smoke, it converts smoke concentrations[5]It has two output modes, analog output and digital output. It has high sensitivity to smoke, adjustable accuracy and strong stability.

(2) MQ-5 gas sensors

Gas sensors are MQ-5 to detect gases such as gas and methane. it uses tin dioxide as the gas sensing material. when the gas concentration increases, the conductivity of the sensor will also increase. after a certain circuit conversion, the electrical signal corresponding to the gas concentration can be output.

(3) MQ-7 carbon monoxide sensor

MQ-7 carbon monoxide sensor is used to detect CO concentrations in mixtures of different gases.[6]Quick response.

5. Display Circuit

LCD LCD module brief introduction: the LCD luminescence is mainly done by backlight layer, need to light the whole part through a large number of LED lights, but the LCD can not be completely closed, there will be problems when showing black. because of the phenomenon of light leakage. LCD contrast is relatively low, can not light a single pixel point, screen response has a certain delay.

OLED module introduction: OLED is like a screen composed of countless small lights, OLED can directly turn off the black pixel area when displayed. achieve the effect of pure black, compared to liquid crystal display, it appears more light and thin, can bend, bright colors, high contrast. fast response and more energy saving. But the OLED material loss is faster and the resolution is lower[7]Easy to burn screen.

Through analysis, combined with the actual requirements, the final selection of OLED modules, there are common SPI interfaces and IIC.

Interface module, select the module of the IIC interface, it is simple to connect, easy to write programs. This design uses 0.96 inch OLED to complete the display function, the common 0 LED module has seven line system and four line system, this time uses four line system based on IIC protocol OLED screen. pin function is shown in Table 1.

Table 1. OLED Pin distribution

Pin definition	Pin function
GND	Connected to negative pole of MCU power supply
VCC	Connected to the power positive pole of MCU
SCL	Clock pin, connected to PB7
SDA	Data pin, connected to PB6

6. Intelligent Window Software Design

This design uses the single chip computer of ST company STM32F103C8, it interface resource is rich, function is complete, and memory is sufficient. Efficient implementation. The software part includes main program and subroutine. programming the peripheral drive circuit based on the standard library. The main program contains a number of judgment statements, the

system reset, will re-judge the state. system software to DHT11, MQ-2, OLED and other parts of the circuit management. The main function of the subroutine is to control the motor, the overall flow chart is shown in figure 5.

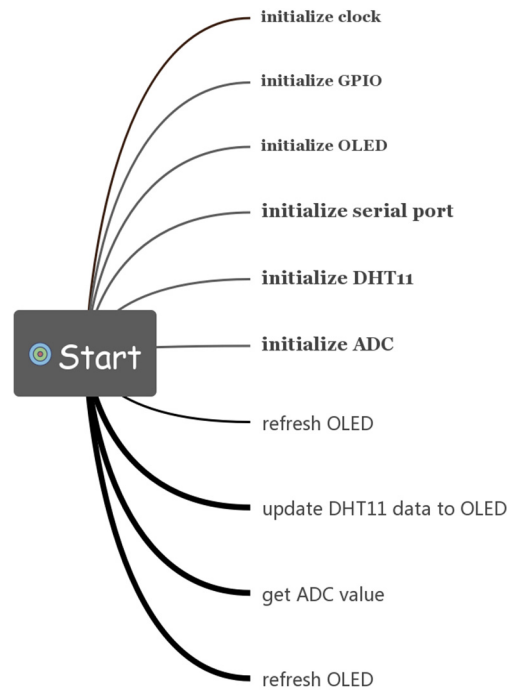


Figure 5. System design

7. Summary and Outlook

7.1. Key Work and Innovation

Design to STM32F103C8 single-chip microcomputer as the core, selected sensor accuracy is relatively high. The driving part of the motor adopts DC motor, the driving mode is simple and easy to control. The system can complete the switch window work in different scenarios, and has certain intelligence. When the external environment parameters are different, the sensor perceives the information, the single chip microcomputer makes the control and processing, the indicator lamp, the buzzer, the motor and so on will work. When the concentration of toxic gas is too high, it also has the function of exhaust fan. Design level of software, using Keil5 to develop, it is compatible with a variety of chips, debugging is also convenient. programming is based on the standard library provided by ST company. Through the standard library to directly operate registers, can simplify the development process, improve efficiency. Furthermore, the STM32F103C8 has large enough memory and rich interface resources to extend a variety of external functions. The data collected by the general sensor must be processed by the AD circuit, and the single chip microcomputer has its own ADC function. Therefore, there is no need to design another AD conversion circuit. In addition, the system clock frequency up to 72 MHz makes the single chip microcomputer operate fast. and the program is easy to modify and debug. Easy to develop.

7.2. Follow-up and Future Perspectives

This design of an intelligent window system, it can detect different kinds of gas concentration (carbon monoxide, gas, smoke, etc.), and can display the corresponding parameters to the screen. Under different conditions, can automatically make a judgment, and decide whether to switch windows. But the function of the whole system is not complete enough, the circuit of

manual switch window should be added to make it more humanized, in the contemporary society, people's life pursuit is higher, can add light adjustment function and anti-theft function on the basis of the original. A complete and multi-functional window, can be used in daily life, hotels, offices and other scenarios, the follow-up will optimize the program, make the window control more accurate, add more functions to the system, believe in the future, with multi-functional window system will appear in people's lives, and can be widely used.

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