

## The Design of Smart Windows Which can automatically close in Rainy Days Based on Single Chip Computer

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**Keywords:** STC89C51 single chip computer; FC-37 raindrop sensor; ULN2003 stepping motor; LCD1602 liquid crystal; close windows in rainy days.

**Abstract:** In the design of smart windows which can automatically close in rainy days, STC89C51 single chip computer control technology is the core of the control system. The FC-37 raindrop sensor is used as the raindrop acquisition component to collect rainfall value through ULN2003 stepping motor. The automatic window closing in rainy days is realized by comparing the collected rainfall value with the pre-set rainfall value of the system. At the same time, the LCD1602 liquid crystal is used to display the detected rainfall value and set the rainfall value. This design includes contents of scheme selection, the introduction to hardware and circuit design, the introduction to software and program design, as well as the system debugging process. The design is achieved from the perspectives of hardware and software programming. Contents on hardware include the introduction of main components, as well as the design and analysis of circuits in each unit. These circuits include the key circuit, the LCD1602 display circuit, the reset circuit, the crystal oscillator circuit and the motor drive circuit. Software programming includes the introduction of programming software and the idea of programming design. The structure and function of circuits in each unit are also designed and realized separately. The software uses the C language to pre-set the rainfall value, and compares it with the detected rainfall value to realize the automatic opening and closing of windows.

### 1. Introduction

China in the 21st century is a world power with scientific and technological information. The products of new Internet technologies can be seen everywhere in China. They make people's daily life more colorful and greatly improve the efficiency of life. Traditional windows need people to open and close, which is a troublesome thing for most people. According to this demand, smart windows appear.

Smart windows can make people's lives more comfortable and safe. For example, in rainy days, when people are not at home or forget to close the windows, rainwater will flow into their houses and cause damage. The problem can be easily solved by using smart windows with raindrop sensors which can detect rainwater value. Some people tend to sleep with open windows at night; but the temperature is too low at night and they may get a cold. Smart windows with temperature and humidity sensors can detect temperature and close themselves to ensure owners' health. There are many kinds of smart windows, such as smart windows that can detect noise, smart windows that can detect harmful gases, and smart windows that can detect wind speed.

Smart windows have a very broad market in China, because they have flexible functions and simple wiring, which can be easily recognized and used. These windows have not been popularized in China. They can be widely used in various living environments, and can promote the development of smart home. It is believed that in the future, smart windows will be installed and applied in all households.

## **2. The Overall Design Scheme**

### **2.1 Overall design of the system**

The design of smart window closing in rainy days mainly adopts single chip computer control technology as the core, which consists of a power module, a driving module of raindrop stepping generator, a sensor detection module, a display module and an A/D analog-digital conversion module. The smart window closing can detect rains. Data collected by the raindrop sensor is displayed on the LCD screen, and the window is automatically open and close according to the detected rainwater value.

### **2.2 Scheme selection**

#### **2.2.1 Main control chip**

This smart window closing design uses the STC89C51 single chip with strong functions as the main control chip, and uses STC89C51RC chip as the core of this system. All functions needed in this design can be accomplished by the STC89C51 single chip computer.

STC89C51 single chip computer has a complete set of step-by-step operation system. It has a rich instruction system with logical place operation functions. STC single chip computer has the characteristics of on-line application programming. Its operation speed is 8 to 12 times faster than that of traditional single chip computers. The most important thing is that it is easy to debug; it can be said that the single chip computer is of high quality and low price. The STC89C51 single chip computer can download burning programs through the serial port; it can be easily used and is very suitable for beginners.

#### **2.2.2 Sensors**

Nowadays, science and technology are very developed; the field of sensors also makes huge progress. Now sensors are widely used in various fields. There are many kinds of raindrop sensors. The FC-37 raindrop sensor is selected for this design. The FC-37 raindrop sensor can detect rainwater value through the impact of raindrops. It has excellent antioxidant performance and strong conductivity. It also has small size and simple installation procedures. So the FC-37 sensor is very suitable for this design.

#### **2.2.3 Motors**

The power element used in this design is a stepping motor. The reason is that, when opening and closing windows, it is necessary to rotate a fixed angle in the predetermined direction. Thus, the motor should have excellent start-stop and reverse response, while the stepping motor fully meets these requirements. The advantages of stepping motor are low price, convenient control, high utilization rates and good overload.

Stepping motor is also called as the pulse motor. It can realize open-loop control; the angular displacement is realized through transforming electric pulse signals through the stepping motor. In the absence of overload, the stepper motor controller is used to control the frequency and number of pulse signals to determine the rotation speed and rotation length; it is not disturbed by load changes. When the pulse signal is received by the driver, the stepping motor will be driven and rotate in a fixed direction and angle. One of the most important advantages of stepping motors is that they can be accurately controlled in open-loop systems. Open-loop control means that feedback information about location is not needed.

#### **2.2.4 Driver module of the electric motor**

The stepping motor can be selected from the selection of motors in 2.2.3. The motor drive module uses ULN2003A chip to drive the stepping motor. The ULN2003A chip has advantages of simple structure, low price and strong load capacity; no external power is needed to amplify the circuit.

The ULN2003A device has a series base resistance on each Darlington pair, so it can work

directly in 5V or 3.3V supply voltage through TTL or CMOS. ULN2003A devices provide solutions for many interface requirements, including solenoid valves, relays, lamps, small motors and LED. If the application requires input current which exceeds the capacity of a single output, parallel outputs can be arranged.

### **2.2.5 Working state display**

The LCD1602 liquid crystal is chosen to display the working state in this design. When controlled by the interface of a single-chip computer, the digital interface is adopted. The programming is simple and the operation is very convenient. It has high display quality and low power consumption. LCD1602 LCD display can display letters, numbers and other characters in English. It can display 32 characters in two lines and 16 characters in each line.

## **3. Hardware Design for Each Unit**

### **3.1 The reset circuit**

The reset circuit means to reset the values of registers in the single chip computer to the initial values. After the clock circuit starts to run, the high level of two machine cycles can be added outside the RST pin to reset the value. This design uses power-on reset. Its composition is to connect a 10K resistance to GND on the RST pin of the single-chip computer, and then connect a 22 $\mu$ F capacitor to VCC. In order to make the single chip computer work sTable, the RST terminal must have sufficient high levels.

### **3.2 The crystal oscillator circuit**

The crystal oscillator can be divided into active crystal oscillator and passive crystal oscillator. This crystal oscillator circuit uses 12M passive crystal oscillator, which is connected with a grounded 30pf ceramic capacitor at both ends to form a crystal oscillator circuit, so as to generate clock frequency and provide it to the single chip computer. Because 12M passive crystal oscillator is used, the single chip computer can work at the speed of 12M per second.

### **3.3 The key circuit**

The key circuit is a very important part in this single chip computer system. The keyboard can input commands to control the operation of the single chip computer. The key circuit is an one-to-one direct connection. One-to-one direct connection means that a key is directly connected with an I/O port. When the input level is high, the key is not pressed. When the input level is low, the key is pressed. This circuit has simple structure and can be used directly when the number of keys is small or the program is simple.

This design has six keys. P14 - p17 are connected to the P3 port of the single chip computer; P21 and P22 are connected to the P2 port. If keys are pressed, corresponding functions will be realized to ultimately achieve the control of the window.

### **3.4 The LCD1602 display circuit**

LCD1602 display circuit is the transmission to LCD1602 through the port P0 of the single chip computer according to the display program set in the ASCII code Table in programming.

This design sends instructions to LCD1602 through P0 pin. Information such as the amount of rainwater, the state of window, and the selection of window closure mode is presented on the screen in a very clear form. P 0.0 - P 0.7 are connected to pin 7-14 of LCD1602 to issue a series of instructions such as clearing screen and displaying displacement. The second (VDD) pin and the fifteen (back light positive role) pin are connected to VCC; the first (VSS) pin and the sixteenth (back light negative role) pin are grounded; the third (contrast adjustment end) pin can adjust the brightness of LCD1602.

### **3.5 The stepping motor driving circuit**

Stepping motor is an open-loop control motor, so it cannot be directly connected to AC and DC

power supply; special circuit must be used to control the driver. In this design, the ULN2003 chip is used to drive the stepper motor, which amplifies the current through ULN2003, so that the driving voltage becomes 5V. The p30 - p33 are the signal input terminals, which are connected with the P3.0 - P3.3 interface of the single chip computer to drive, and need 10K pull-up and exclusion. Variable signals are processed by p30 - p33 and the motor rotation is controlled by 13-16 as output signals. GND of the No.8 pin of ULN2003 is in ground connection; No.pin 9 is connected to VCC.

## **4. System Debugging**

### **4.1 Hardware debugging**

#### **4.1.1 Key control module debugging**

There are six keys with different functions. They are the setting key, the adding key, the reducing key, the manual/automatic conversion key, the manual window opening key and the manual window closing key.

In debugging, the system shakes when closing and disconnecting the keys. It is due to the unstable logic level of the electric shock. The solution is software delay.

#### **4.1.2 LCD1602 display module debugging**

LCD1602 display module debugging is an important part; it reflects the driving status of each module. The LCD screen is not bright in debugging. There are several possible reasons, such as welding circuit problems, bad LCD screen and no power supply. After carefully checking with the multimeter, it is found that the reason is that the power line of the LCD screen is virtually connected, and it cannot provide voltage to the LCD screen. After welding the virtual welding place, the LCD screen can display information.

#### **4.1.3 Raindrop sensor acquisition module debugging**

Debugging of the raindrop sensor acquisition module is divided into three parts. The process includes the debugging when rainfall amount is less than the alarm value and the debugging when rainfall amount is greater than the alarm value. In the process of program debugging, it is needed to check whether the interface of raindrop sensor is well welded, and to wipe up the circuit board of raindrop sensor before the test.

#### **4.1.4 Stepping motor module debugging**

The stepping motor is controlled by the ULN2003A driver chip. After the circuit board is powered on by the USB power cord, the start button is pressed. The stepping motor can rotate in the set direction, and can rotate to a specified position. This module is welded correctly.

## **4.2 System function**

### **4.2.1 Functions realized by the system**

The system can detect the rainfall value through the single chip computer system, control the direction of stepping motor to open and close windows by judging the change of rainfall values, and control the stepping motor to open and close windows directly through function keys in the keyboard. When the detected rainfall value is lower than the set value of alarm, the stepping motor will turn to open the window. When the detected rainfall value is higher than the set value, the stepping motor will turn to close the window. The system can also display the rainfall value currently detected as well as the opening/closing state of windows through the LCD1602 liquid crystal display.

### **4.2.2 System function analysis**

The system is mainly composed of key circuits, the LCD1602 display circuit, stepper motor drive circuits, rain drop sensors, crystal oscillator circuits and reset circuits. First of all, the raindrop sensor is considered. The whole system needs to detect the raindrop value through the raindrop

sensor, then judge the rainfall value through the single-chip computer. Afterwards, it uses the single-chip computer to control the stepping motor to open or close the window. Secondly, the driving circuit of the stepping motor is used. The ULN2003A chip can better control the stepping motor, showing excellent control effect. The function of LCD display circuit is to display currently detected rainfall values and the opening/closing state of the window. The keys can adjust the rainfall alarm value and open or close the window directly. All these information can be displayed directly on the LCD screen.

## 5. Conclusion

In this design, the core of system control is the STC89C51 single chip computer. The rainfall value is detected by the raindrop sensor; the turning of motor is controlled by the change of rainfall value. The LCD1602 screen can continuously and steadily display rainfall values detected and the opening/closing state of windows. The stepping motor can be directly controlled by keyboard functional keys to open and close windows. The system of smart windows closing in rainy day based on a single chip computer is realized.

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