Electronic circuit design of stepping motor based on 51 single chip microcomputer

Jianwei Jia1, Bo Xue2, Yimeng Wang3

1Nankai University Department of Microelectronic Engineering, Tianjin, China
2Physical college, University of Electronic Science and Technology of China, Chengdu, China
3College of the Arts, Guangxi University, Nanning, Guangxi, 530000

Abstract. With the development of automatic control system and the improvement of high-precision control requirements, stepping motor plays an increasingly important role in various automation equipment. The stepping motor control system designed in this paper takes STC89C51 as the core, LCM12864 as the display module, and eight independent keys as the control function keys. It realizes the start and stop state, speed and running distance, forward and backward control of the stepping motor, and adds Hall sensor to measure the speed of the stepping motor. Using SCM as the main control chip not only simplifies the hardware circuit, but also reduces the system cost. The system increases the interactive experience between people and machines, and maximizes the economic benefits, saves resources, and can be better applied to the actual daily life.

1. Design background

In our life, stepping motor is also called pulse motor. In 1920, step motor was invented. Thirty years later, the invention of transistors led to the use of stepping motors. Digital control becomes easier. Stepping motor has been widely used in a variety of mechanical control systems which require high performance of controllable random change. Stepping motor can be divided into hybrid type, variable reluctance type and permanent magnet type.

In real life, we can find the application of stepping motor everywhere. In particular, stepping motor is often used to control in various occasions which need the control of speed and position and the flexibility of completing various functions accurately. For example, stepping motor is one of the essential control components for 3D printers widely used in technology and manufacturing. Generally, there are four stepper motors installed on the printer, one for each x, y, Z axis and feeder. How to print out the desired shape and style requires accurate control of the speed, position and other factors affecting the stepper motor, which requires higher requirements for the control system of the stepper motor. The household fan can also be regarded as a stepping motor control system. By pressing the function button on the fan, you can control the start-up, customization, swing direction or fixed direction of the stepper motor, and the rotation speed of the fan blade determines the size of the wind speed. From this we can see that the normal operation of all parts of our life is inseparable from the stepping motor. Therefore, the stepping motor control system designed has excellent performance, simple operation and simple hardware circuit design, which are essential requirements.
2. **Basic Requirements**

This paper presents the design of a stepping motor control system with STC89C51 as the core chip. It is used to control the start rotation, stop, forward and backward, acceleration and deceleration of the stepping motor, and to set the running distance of the stepping motor. LCM12864 is used to display the start and stop of the motor, the forward and reverse rotation, the rotation speed of the motor, the display status of the preset distance and the actual rotation distance from the stepping motor. In this paper, 28byj-48 motor is selected, and the method of stepping motor drive is controlled by single chip microcomputer. Among them, the stepping motor is a controllable machine which converts the received electrical signal into angular displacement output.

When the driver receives the pulse signal from the main control chip, it drives the stepping motor to rotate at a fixed angle (called "step angle") in the set direction. And gradually turn in the same direction at the same angle. Therefore, the control of the running distance of the stepping motor can be realized by controlling the number of pulse groups sent by the main control chip. Using the time interval between each pulse signal, the speed of stepping motor can be changed. In particular, LCM12864 is added as the display, which can display the relevant rotation status and data of the stepping motor, and increase the visibility of the operating system.

3. **Electronic circuit of stepping motor based on 51 single chip microcomputer**

3.1. **General design**

The system is a stepping motor control system based on STC89C51. It is mainly composed of power circuit, independent key control circuit, Hall sensor speed measurement module, LCM12864 display module and stepping motor driver module. When pressing the external independent key, the MCU sends a pulse signal. The stepping motor driver drives the motor to rotate according to the function of the corresponding key, and displays the function of the current running state of the stepping motor on LCM12864. The rotation of stepping motor will also affect the output of Hall sensor, so as to calculate the running speed of motor.

3.2. **Singlechip module**

Selection of this paper STC89C51 MCU is the core control chip. Fifty-one Single chip microcomputer is Eight 32 bit CPU I/O Port, two programmable T0 and T1, interrupt control system with five interrupt sources, single+ 5V Power supply. In the stepping motor control system designed in this paper, the P1 The interface is connected with an external independent key for function control; the step motor is connected to the P2 Port. In particular, the timer and external interrupt of single chip microcomputer are used to count the timer to determine which task blocks are executed to achieve the corresponding tasks.
3.3. Sensor module

Hall sensor is selected as the sensor module to measure the speed of stepping motor, as shown in the figure below. Use the 3144E Hall switch IC as shown in Figure 2.2. VCC is connected to the positive pole of the power supply, GND is connected to the negative pole of the power supply, do-ttl digital output is connected to the p3.3 port of the single chip microcomputer. When the hall sensor 3144E senses the magnetic field, the do sends an interrupt signal to the external interrupt 1 once. The integrated circuit uses Hall effect.

Figure 1. Circuit diagram of the minimum system of single chip microcomputer

Figure 2. 3144E Hall switch IC
The magnetic sensing circuit includes voltage regulator, Hall voltage generator, differential amplifier, Schmitt trigger, temperature compensation circuit and open collector output stage. The input is the magnetic induction intensity and the output is the digital voltage signal. When the sensor senses the magnetic field, the digital output is low and the signal lamp is on; if the magnetic field is not sensed, the digital output is high and the signal lamp is not on. The sensor has the characteristics of small volume, high sensitivity and fast response.

3.4. Display module

LCM12864 is used for LCD module. If the third foot V0 is not connected, the display is equipped with a potentiometer. In this case, the potentiometer on the back of the display must be adjusted to R1. The 18 pin Vout of LCM12864 can be connected or not in the suspended state.

LCM12864 with Chinese character library is selected as the display module. Because LCM12864 is a 128 * 64 lattice LCD module, each line can display 4 lines and 8 columns, 32 16 * 16 lattice Chinese characters in total. Each display RAM can display one Chinese character or two 16 * 8 dot matrix full height ASCII characters, that is, each screen can display up to 32 Chinese characters, or 64 American information exchange standard codes. The display module needs to display the start and stop status, rotation direction, speed gear, rotation speed, preset distance and actual running distance of the motor. Every time there is a new data change, the whole screen will be refreshed and reloaded to prevent garbled phenomenon.

3.5. Driver module

ULN2003 is used as the stepper motor driver in the stepper motor control system, and 28byj48 stepper motor with 1 / 64 reduction ratio is selected as the stepper motor. The stepping motor supplies + 5V power and is connected with the power supply of single chip microcomputer. The standard interface of stepper motor is equipped on the drive board of ULN2003. The A, B, C and D LEDs on the drive board indicate the working state of the four phase stepper motor. The frequency of LED flashing represents the speed of stepping motor drive. The in1, in2, in3 and in4 of the ULN2003 driver are respectively connected with the p2.0, p2.1, p2.2 and p2.3 ports of the single chip microcomputer, which sends pulse signals to control the rotation of the stepping motor.

3.6. Key module

The motor control system uses 8-bit independent keys to control the external functions. The key is connected with P1 port of single chip microcomputer, which is characterized by occupying I/O port line by itself, and each operation state button does not affect other I/O port lines.

Compared with matrix keyboard, the hardware configuration of independent key is flexible and the software architecture is simple. K1 is the motor start stop control key. The initial state of the motor is stop after power on. Press K1 to start the motor rotation, and then press the motor stop again. K2 is the motor rotation direction control key. After the motor starts to rotate, it is in the reverse state. Press K2, the motor starts to rotate forward, and then press the motor to reverse. K3 is the control key of adding and subtracting function, which controls whether the adding and subtracting function is to use and adjust the speed range, set the high position of the running distance or set the position of the running distance. K5 and K7 are function buttons. K6 and K8 are minus function buttons.

4. Simulation and experimental results

First of all, LCM12864, timer 0, timer 1 and external interrupt 1 are initialized. In the whole step motor control system, the realization of each function is regarded as a task block. In the main function, only the timer timing is used to decide which task block to execute. The counting time of timer 0 is 2ms, and the corresponding tasks of 10ms, 20ms, 50ms and 100ms can be executed after counting 5, 10, 25 and 50 times; the counting time of timer 1 is 50ms, and the corresponding tasks of 200ms, 500ms and 1000ms can be executed after counting 4, 10 and 20 times. Among them, the task of 20ms is to scan each key to see if there is a key press, and if there is a key press, to complete the corresponding task
function; the task of 500ms is to calculate the actual running distance of the stepping motor; the task of 1000ms is to count the rotation speed of the stepping motor.

The actual running distance is displayed by serial port debugging. The setting distance is 179mm. When the actual running distance reaches 179mm, the stepping motor stops rotating.

Table 1. running distance test table

| Preset running distance (mm) | Actual displayed running distance(mm) | Absolute error (mm) | Relative error |
|-----------------------------|--------------------------------------|---------------------|----------------|
| 1 176                       | 177                                  | 1                   | 0.50%          |
| 2 59                        | 60                                   | 1                   | 1.69%          |
| 3 99                        | 100                                  | 1                   | 1.01%          |
| 4 1099                      | 1099                                 | 0                   | 0%             |
| 5 600                       | 604                                  | 4                   | 0.67%          |
| 6 255                       | 255                                  | 0                   | 0%             |
| 7 256                       | 259                                  | 3                   | 1.17%          |

According to the table, the average relative error is 0.72%, less than 5%. Because the program is designed to refresh LCM12864’s fixed UI every time the data is updated. Therefore, the reason for the error is that the screen swiping takes too much time, which leads to the difference between the two distances is not timely. Therefore, the error occurs when the actual display running distance is greater than the preset running distance.

5. Conclusion

This design system is mainly based on STC89C51 single chip microcomputer to control the start, stop, forward and backward, acceleration and deceleration control and running distance of stepping motor. LCM12864 is used to display the start/stop and forward/reverse state of the motor, the speed of the motor, and the preset distance and actual running distance of the stepping motor. Eight independent keys are used as function keys.

After the MCU is powered on and the program is downloaded, LCM12864 displays the fixed UI interface. At this time, the content displayed is the initial state of the stepping motor set in the program. When key K1 is pressed, the motor will run according to "on, reverse and speed 05” displayed in the LCD. Among them, "speed 05" represents that the initial speed of the set motor is five gears. Press the start / stop key again, LCM12864 shows "off", and the motor stops. Press the K2 key when the disc is running, the motor will change from the original initial reverse state to forward rotation, and LCM12864 will display "forward rotation". The speed shift must be changed when the motor is stopped. First press K3 key to adjust to 01 state, and then press k5-k8 function plus / minus key to change the rotation speed.

The setting of running distance can only be changed when the motor is stopped. Press key K3 to 02, and then press key k5-k8 to set the high position of the distance. Press K3 to 03, press k5-k8 to set the low position of the distance, and then press K1 to make the motor start to rotate. When the actual running distance is equal to the preset running distance, the motor stops rotating. It can also modify the rotation direction, rotation speed and running distance of the motor according to the above method after the single chip computer is powered on.

Reference:

[1] Cao Minggang. Research on stepping motor control system based on single chip microcomputer [J]. Digital technology and application, 2017,06:20 + 22

[2] Deng Lu. Research on linear motor control system based on Hall sensor [D]. Southeast University, 2017
[3] Alexandru Morar. Driver for 5-phase stepper motor pentagon connection with dedicated ICs[J]. Procedia Manufacturing, 2018, 22.
[4] YH Lee. Stepper motor motion control system design[J]. Equipment Manufacturing Technology, 2015, 2(6):31-41.