Motor Speed Measuring Device Based on Mcu

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Abstract: A hardware circuit and software design method based on AT89S51 MCU and using JK-8002C Hall sensor technology to measure motor speedis introduced in this paper. Under the premise of ensuring the correct measurement results, the accuracy of the measurement should be improved as much as possible. At the same time, the design should highlight its own characteristics, namely product design, to ensure the practicality and economy of the device itself.

Keywords: AT89S51; JK-8002C; motor speed; practicality

1. Introduction

The MCU is a technology with great development potential. The most influential one is the MCS-51 series MCU. Its modular structure is typical and its application is flexible. It has been adopted by many large companies. This makes the 8051 series of single-chip products occupy a very important position in the domestic and foreign single-chip applications. With the development of materials science, some materials with magnetic sensitivity, photosensitive properties, and Hall effect and piezoelectric effect have been made into various types of sensors. They automatically detect the various and non-electrical quantities of the motor. Among them, the Hall switch sensor is widely used in the field of measuring motor speed due to its small size, maintenance-free performance, good dynamic performance and long service life. The speed is an important parameter to judge whether the motor works normally, and it is also one of the important physical quantities that affect the performance of the motor. This technique is used in this design to convert the motor speed signal into an output pulse signal. The frequency of the pulse signal is proportional to the motor speed. When the pulse period or frequency is measured, the speed value can be obtained.

2. Overall Design

In this paper, the Hall switch JK-8002C is used as the sensor, and the MCU is used as the core chip to measure the rotation speed of the low speed DC motor. The device should include sensors and peripheral circuits, integrated voltage regulator circuits, microcontrollers and keyboard display circuits, etc., as well as related applications. Figure 1. shows the overall design of the system.

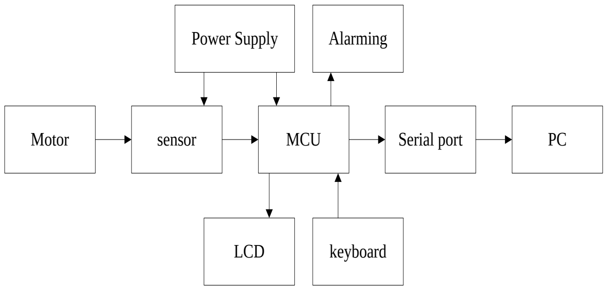

Figure 1. Overall system block diagram

3. Hardware Circuit Design

3.1. Regulated Power Supply Module Design

In the design of the regulated power supply module, the 220V mains is first reduced to 12V by the small transformer, and the 12V regulated power supply module is reduced to 5V, and then connected to the single-chip system. The output of the 7805 is +5V. The capacitor C1 at the input is used to filter out the ripple. The capacitor C2 connected to the output can improve the transient effect of the load and make the circuit work stably.

C1 and C2 are preferably tantalum capacitors with small leakage current. If electrolytic capacitors are used, their values should be 10 times the values in the figure, which are 3.3μF and 1μF.

As shown in Figure 3., it is the pin of CW7805, where 1, 2, and 3 are input, ground, and output, respectively.

Its characteristic parameters are Vi=10V, Io=500mA, Vo=4.8~5.2V. According to the requirements of the system, Vo should be 5V.

3.2. MCU and Eripheral Circuit Design

The MCU used in this design is AT89S51, which is a low-power, high-performance CMOS 8-bit MCU with the following features: 40 pins, 4k Bytes Flash on-chip program memory, 128 bytes of random access data memory (RAM), 32 external bidirectional input/output (I/O) ports, 5 interrupt priority levels, 2 layers interrupt nesting interrupt, 2 16-bit programmable timing counters, 2 full-duplex serial communication ports, see Gate dog (WDT) circuit, on-chip clock oscillator.

(1) Reset circuit

The button reset mode is used to facilitate resetting when the system is faulty during debugging of the MCU. And in the actual work of the system, when the fault occurs when the single chip microcomputer is working, it is unreasonable to disconnect the power supply at random, so the button is reset, and no power-on reset is required. When the reset operation is performed, a reset signal is provided when the system is powered on, and the reset signal is cancelled after the system power supply is stabilized. For the sake of reliability, after the power supply is stabilized, the reset signal is cancelled after a certain delay to prevent the jitter caused by the power switch or the power plug splitting process from affecting the reset. Figure 2. shows the reset circuit diagram of the system.

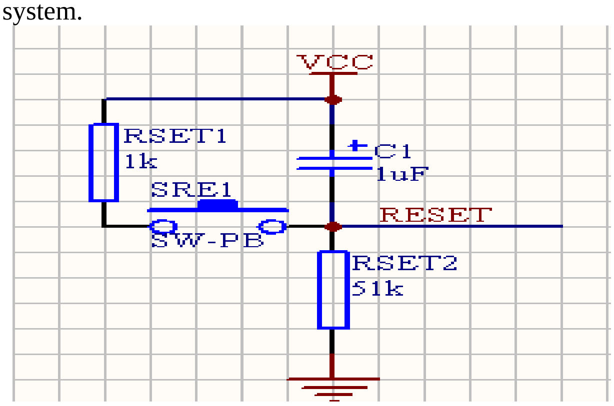

Figure 2. Minimum system reset circuit

(2) Clock circuit

The on-chip clock oscillating circuit is used to connect timing components to the pins of XTAL1 and XTAL2. The crystal has a frequency of 12MHz and the capacitance is 30pF. The clock circuit is shown in Figure 3.

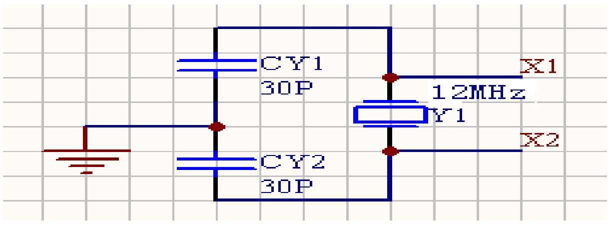

Figure 3. Clock circuit

3.3. LCD Module Design

The liquid crystal display module circuit is shown in Figure 4., where RS is connected to P2.5, P2.5 controls data or command selection; R/W is connected to P2.6 to control the selection of read or write commands; Connected to P2.7 for controlling the enable signal. The liquid crystal display module is a slow display device, so be sure to confirm that the module's busy flag is low before executing each instruction, indicating that it is not busy, otherwise the instruction will be invalid.

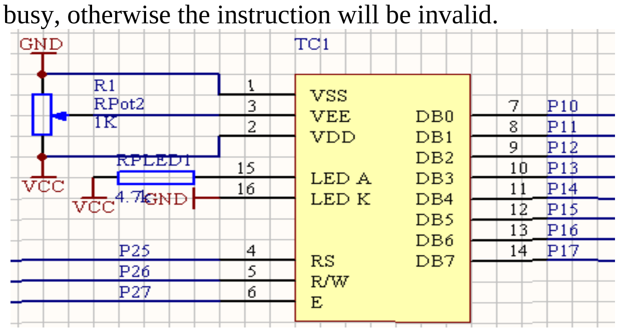

Figure 4. Interface between the microcontroller and the liquid crystal display

3.4. Serial Communication Circuit

As shown in Fig.5, the serial port communication interface circuit used in this design.

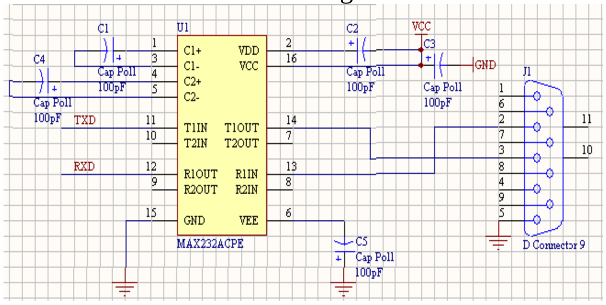

Figure 5. Serial communication circuit

3.5. Over-limit Alarm Module Design

As shown in Figure 6., the circuit design for the alarm section. When the speed is higher than a certain set value, or higher than a certain keyboard setting value, it will alarm. P0.0 is connected to the base input of the transistor. When P0.0 outputs a high level "1", the transistor is turned on, the piezoelectric buzzer is powered and sounds; when P0.0 outputs a low level, the transistor exits conduction. Status, buzzer stops pronunciation.

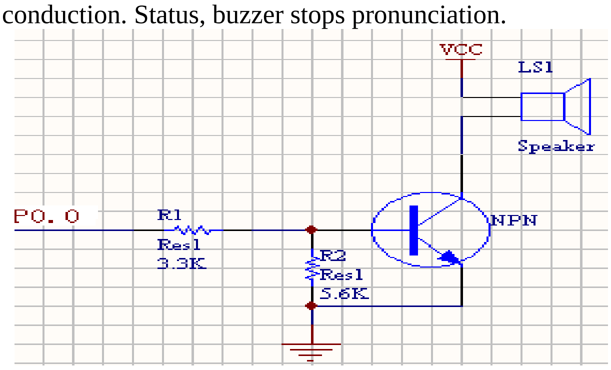

Figure 6. Alarm module design

4. System Software Design

4.1. System Overall Programming

The functions to be implemented by the system software are data display, alarm processing, key interrupt and serial communication. The modular design should be followed during the design of the software. The MCU programming language generally uses C language and assembly language. The C language is advantageous for large-scale programs, and is familiar to the C language itself, so the programming uses the C language. The system initialization is mainly based on the requirements of the program, to determine some settings of the interrupt enable register, counter, etc. Since the system uses counter T0 interrupt, serial communication interrupt and key interrupt, it is necessary to set the interrupt enable register to allow serial port interrupt, counter T0 interrupt and key interrupt, and other interrupts are prohibited.

As shown in Figure 7., it is the system main program flow chart.

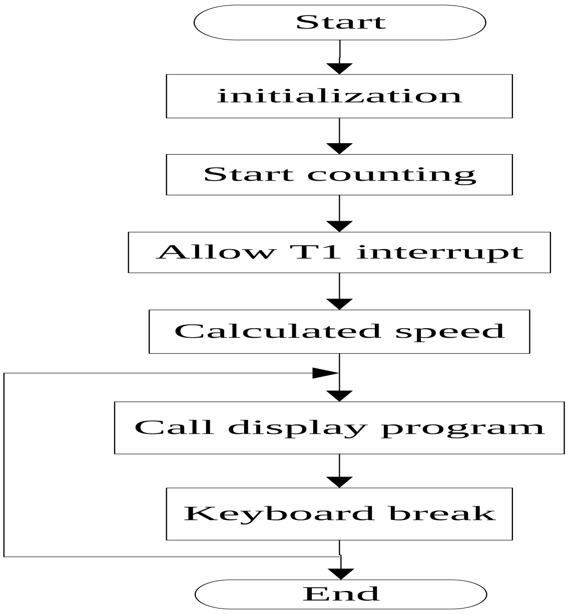

Figure 7. Main program flow chart

4.2. Steps to Enable the Timer/Counter

(1) Determine the working mode - by setting the TMOD register;
(2) Calculate the initial value of the count register as needed, and load the TMOD register;
(3) open the interrupt;
(4) Start the timer/counter by setting TR0 and TR1. Two liquid mixing and stirring devices such as

4.3. Keyboard Program Design Steps

(1) The program is controlled to scan the keyboard to determine whether there is a key closure.
(2) In order to ensure the correct identification of the key, debounce judgment must be made. One way to debounce is by software delay debounce. Just after the key is closed, a delay program is executed. After the level is stabilized, the state of the key is judged. If the key is still closed, the key is considered to be in a stable closed period, otherwise it is considered to be the jitter or interference of the key.
(3) Determine the location of the key by querying the I/O port line one by one.
(4) It is necessary to ensure that the primary closing of the key corresponds to only one process, and the method of waiting for the closing key to be released is used. That is, after waiting for the button to be released, the next key function operation is performed. Otherwise, pressing the key once may cause the same key operation to be performed multiple times in succession, which may cause an infinite loop.

4.4. Keyboard Subroutine Flow Chart

As shown in Figure 8., a flowchart of the keyboard subroutine.

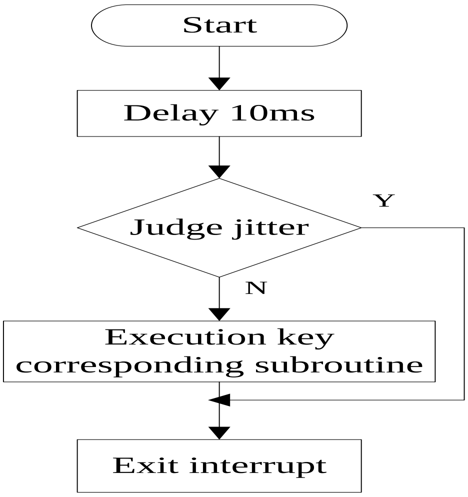

Figure 8. Keyboard subroutine flow chart

4.5. Specific Steps to Achieve Communication

(1) Determine the operation mode of Timer 2 - Program the TMOD register; (T1 is used as a timer, but it is used for internal timing in this design.)
(2) Calculate the initial value of Timer 2 - load TH2, TL2;
(3) Start timer 2 - TR2 is set to 1;
(4) determine the control of the serial port - programming SCON;
(5) When the serial port works in the interrupt mode, open the CPU interrupt and the source interrupt - program the IE register.

5. System Debugging

5.1. Hardware Debugging

(1) Voltage regulator circuit debugging
The system is powered by a +5V regulated power supply and requires a small AC component. In the debugging, the output of the 7805 can be measured by the oscilloscope, which meets the requirements of the system for the power supply voltage, and the voltage regulator circuit is debugged. It should be noted that the power supply must be separately commissioned before being added to the various components of the system. Because if there is a power failure in the prototype, the components will be damaged after power-on. The detection of the power supply includes: whether the voltage value is a symbol design requirement, whether the power supply lead line and the socket correspond, and whether the load capacity is strong.
(2) Single-chip debugging
Pressurization is greater than 5V during commissioning, causing the chip to burn out. Therefore, before plugging in the chip, power on for offline inspection, mainly checking whether the power pin and the ground pin on each chip socket are reversed. It should also be noted that the power supply voltage should be adjusted first, and the power supply line can be connected only after the power is turned off. The power supply can be used to burn a simple cycle program to the microcontroller, then plug the microcontroller into the board and power it on. At this point, use the oscilloscope

to observe the clock pulse of the ALE terminal of the microcontroller, the output waveform is stable, and the microcontroller works normally.

(3) ACM1602 liquid crystal display debugging

When debugging the liquid crystal display portion, the insufficiency found is that the liquid crystal display is unclear in the dark. During the daytime experiment, it can be displayed by daylight, and the light source must be used at night, otherwise the displayed characters cannot be seen. Similarly, the connection between the liquid crystal part pin and the MCU pin is a plug and pin connection, which is prone to open circuit. It is not the LCD burnout. After the power is turned off, the LCD can be re-inserted and used again. At the same time, be careful not to press the metal frame, otherwise the conductive rubber will be deformed and cause failure. The displayed content is related to the program, and the display program is generally placed in the main program. Since the LCD can display two lines of characters, the first line is fixedly displayed, that is, the speed per minute during programming. The content displayed in the second line can be determined by the keyboard program, for example, the speed per second, the average speed per minute, and the alarm. Show and so on. However, during the debugging process, it was found that when the rotation speed is greater than 1860 rpm, the display will be wrong; the analysis shows that the error occurs during the shift of the count value, and the count is normal after the modification.

(4) debugging of the keyboard

During the keyboard debugging process, it is necessary to perform debounce judgment. That is, after the software delays, the level is stable, and then it is judged whether the key is still closed. There is still a key closure, in order to think that the button is in a stable closed period, the keyboard interrupt program is executed; otherwise it is considered to be the jitter or interference of the key, and the exit is interrupted. Make sure that the key closure of the key corresponds to only one process, and waits for the closure key to be released before processing. Otherwise, pressing the button once may cause the same key operation to be performed multiple times in succession, resulting in an infinite loop.

5.2. Software debugging

The debugging software used in the debugging of the single-chip microcomputer software is the Keil C51, a 51-series compatible single-chip C language software development system produced by Keil Software of the United States. The debugging methods commonly used during debugging are single-step mode and breakpoint mode, both of which are used during debugging.

The debugging method is important for programs that calculate the speed portion of the main program. This type of error is a static, fixed error that can be debugged with either single-step or breakpoint mode. According to the function of measuring the rotation speed, a set of test data is prepared in advance. When debugging, the data is written into the parameter buffer unit of the calculation program, and then the calculation is started from the calculation program to the end, and the operation result is compared with the correct data. After testing all the test data, no errors were found, so the debugging was successful.

The most difficult part of the whole program is the liquid crystal display part and the serial communication part. It should be noted that the ACM1602 LCD program needs to detect busy status. Therefore, in the software debugging, you must first mask the busy status command before you can simulate debugging. After completing the debugging of each module program, the full-speed breakpoint operation mode can be used for comprehensive debugging. The main work of this stage is to eliminate the errors left in the system to improve the dynamic performance and accuracy of the system. After the speed measurement index is realized, the software can be solidified, and then the cured program can be run. After successful, the system can be run offline. However, after offline, an abnormal situation was also found. The inspection found that the capacitor pins in the crystal oscillator circuit were not soldered properly, and the operation was not normal. After the pins were soldered, no fault occurred.

6. Conclusion

After testing, it is found that in the range of speed from 1 to 1000 rev / min, the sensor output pulse signal is very regular, so the system error is small and the precision is high. The motor speed measuring device based on single-chip microcomputer uses a Hall effect between a small magnetic steel and a sensor to output a series of pulse signals by the Hall sensor. The frequency of these pulse signals is proportional to the motor speed; Counter function, record the number of pulses per unit time, the motor speed can be calculated through the software program; the speed and other information is displayed through the liquid crystal module, which is intuitive; the function of the keyboard part is to set the upper and lower limits of the speed, when the speed The alarm is generated when the value is higher or lower than the set value; the function of direct communication with the PC is completed through the serial port; the whole circuit is regulated by the regulated power supply, and the small transformer can be directly connected with the 220V voltage to facilitate the test; therefore, The device basically completes the design task and meets the design requirements. The advantages of the device include: simple structure, small error, non-contact, maintenance-free, superior economy, and productization. It also has the ability to be developed.

The device can also be used in some industrial fields that require measuring the low speed of the motor, such as measuring the motor speed in electromechanical products such as generators, fans, washing machines, etc., and also as a measuring device in the motor speed control system.

There are still some shortcomings in the single-chip system. For example, the repeatability of the system is not good enough. In the future design, more attention should be paid to this aspect.

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