Design of DC Power Supply Control System Based on Single Chip Microcontroller

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Keywords: MCU; Power supply; Output voltage; control

Abstract: the traditional DC power supply system is usually to control the output voltage according to the difference between the output voltage value and the benchmark value of the power supply, which is difficult to achieve and easy to be affected by the parameters, resulting in low control accuracy. This paper presents a power supply output voltage control method based on single chip microcomputer. SCM selects a cost-effective STC89C52 SCM, and the output voltage is collected through a voltage sensor. The voltage signal is transmitted to the SCM via the A/D converter. The LCD screen uses RT12864 and is connected with a single chip microcomputer. The single chip control results are transmitted to the RT12864 LCD for display. A / D conversion circuit is used to convert the output piezoelectric signal collected into a digital signal. The power supply output voltage is controlled by the single chip microcomputer controlling the A/D conversion circuit. The experimental results show that the proposed method has high control precision and robustness.

1. Introduction

With the development of computer and communication technology, the modern information technology revolution has provided a broad prospect for the development of power electronic technology, and at the same time has put forward higher requirements for power supply. The error caused by ordinary power supply during operation obviously affects the accuracy of the entire system and may cause many adverse consequences when used. Designing a voltage control method with sTable voltage and high precision of output voltage is an important issue in related fields. In recent years, people have constantly sought out power supply output voltage control solutions. The most commonly used method is to continuously collect power supply output voltage values, and control the output voltage based on the difference between power supply output voltage values and reference values. The operation is difficult and the accuracy is low. A power supply output voltage control method based on single chip microcomputer is proposed.

2. Control Method of Output Voltage of Power Supply Based on Single Chip Microcomputer

2.1 Circuit Design of Single Chip Microcomputer

In this paper, single-chip computer is used to control the output voltage of power supply. For the whole system, the circuit design of single-chip computer is very important. In order to ensure the calculation ability and control performance and save the design cost, STC89C52 single chip computer with high cost performance ratio is selected. The system circuit diagram is shown in Figure 1.
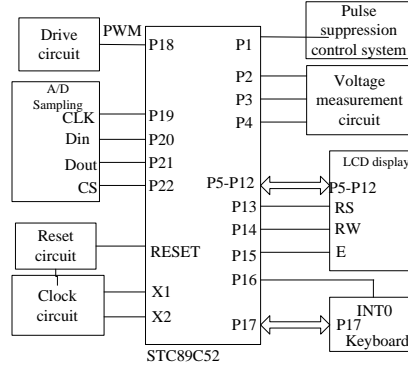
Fig. 1 Circuit Diagram of Single Chip Microcomputer

STC89C52 is an 8 bit microprocessor with low energy consumption and high performance. TLC2543 chip is selected as AD conversion chip. It is a 12 bit AD converter with short conversion time and only needs 10 mu s. It contains 11 analog input channels. It has high precision and the maximum error is only (+1 LSB).

2.2 Output Voltage Measurement Circuit Design

The output voltage is collected by a voltage sensor. The voltage sensor consists of five terminals, two of which are primary terminal ($\pm$TH), two of which are secondary terminal, and their ($\pm$TH) terminals are connected with (+12V) working voltage in turn, and the B terminal is the signal output terminal. The resistor Ra is connected in series with the measured voltage and the original terminal of the sensor. The series resistor Ra is:

$$R_a = \frac{U_c}{I_{in}} - R_0 \tag{1}$$

In formula (1), R_a is series resistance, U_c is measured voltage, I_{in} is rated input current and R_0 is original internal resistance of the sensor are used. The series resistance power is:

$$P_c = U_c \times I_{in} \tag{2}$$

On the basis of the above analysis, the voltage measurement circuit is designed. As shown in Figure 2, IN + is connected with the output terminal of the voltage sensor, and the measured voltage signal is transmitted to the single chip computer via A/D converter.
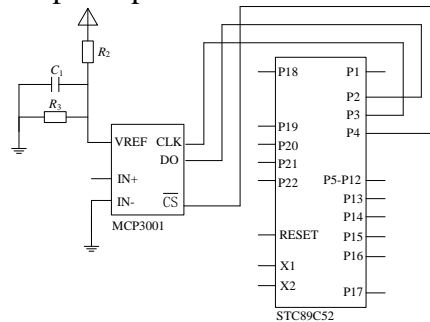

Fig. 2 Voltage measurement circuit

2.3 Realization of LCD

In this paper, RT12864 LCD screen is selected to connect it with single chip computer. P5-P12 interface of single chip computer and RT12864 LCD DB5-DB12 interface are connected together, P13 and RS are connected, P14 and RW are connected, P15 and E are connected, and the control results of single chip computer are transmitted to RT12864 LCD for display.

2.4 A/D Conversion Circuit Design

The AD conversion circuit is described in Figure 3, which is mainly responsible for converting the collected output voltage and electrical signals into digital signals.
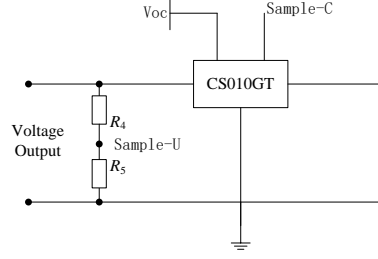

Fig. 3 AD conversion circuit

2.5 Power Supply Output Voltage Control

2.5.1 Output Voltage Control Process

The output voltage and electric signal are continuously converted by TLC2453 chip controlled by single-chip computer. According to the voltage value obtained, the voltage is adjusted by the single-chip computer control system, and the power supply feedback loop is obtained to control the output voltage to be sTable at a given value. When the output voltage exceeds the given value, the MCU will make timely judgment, turn off the driving signal and stop the power output. The output voltage V_0 is:

$$V_0 = V_U \times \left(R_b + R_c \right) / R_c \qquad (3)$$

Among them, V_0 is the sampling voltage, R_b, R_c is the sampling divider resistance.

2.5.2 MCU Control System Design

When the power supply is described by the first order transfer function, the structure of the output voltage closed-loop control system is described by Fig. 4.
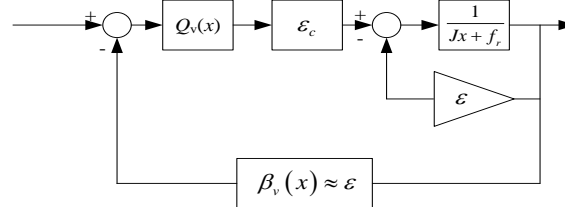

Fig. 4 Structure diagram of power supply voltage closed-loop control system

In Figure 4, β_v is the voltage feedback coefficient; ε and ε_c are signal dynamic model coefficients; J is the moment of inertia; f_r is the coefficient of friction. Firstly, the dynamic model coefficient of the signal is estimated, and then PI regulator is used as voltage feedback regulator $Q_v(x)$. Finally, the parameters δ_p and δ_i of the regulator are obtained, and the output voltage control of the power supply is realized. Assuming that a step power disturbance signal ΔP^* appears during the steady operation of the power supply, the power supply output voltage must conform to the PI regulator's non-hyper-steady error.

The transfer function of the system output part and the control part with the load power can be obtained:

$$W_{du}(x) = \frac{-\lambda m x}{x^2 + \left(m + n\delta_p S_k \right) x + n\delta_i S_k} \qquad (4)$$

$$W_{dt}(x) = \frac{m\lambda\delta_p x S_k + n\lambda\delta_i S_k}{x^2 + \left(m + n\delta_p S_k \right) x + n\delta_i S_k} \qquad (5)$$

The output voltage of power supply can be controlled by the parameters of the voltage feedback regulator. The single chip microcomputer control system is robust and can effectively improve the output voltage control accuracy of power supply.

3. Experimental verification

3.1 Robust analysis

The experimental analysis of the proposed system is carried out. Because the robustness of the single chip control system determines the effectiveness of the control method, this section focuses on the analysis of the robustness of the single chip control system. The robustness of the single chip microcomputer control system is that the performance or index of the control system remains unchanged under the condition of other parameters. The closed-loop frequency feature of power supply is the embodiment of the tracking performance of the single-chip microcomputer control system, and the perturbation frequency feature is the embodiment of the anti-interference ability of the single-chip microcomputer control system. This section verifies the robustness of the single-chip control system under the condition that the circuit parameter characteristics change $\pm$ 30. When the circuit resistance changes $\pm$ 30, the closed-loop frequency characteristics of the single-chip microcomputer control system have no significant changes in the low frequency, medium frequency and high frequency segments, and the load frequency characteristics of the entire process are basically unchanged, indicating that the resistance changes will not affect the single-chip microcomputer control system, and the single chip control system is robust. high.

3.2 Control Results Testing

In order to verify the control performance of this method more effectively, a more easily observed step wave voltage is introduced. Figure5 describes the power supply output voltage and ladder wave voltage waveform before control, the upper waveform is the power supply output voltage waveform, and the lower waveform is the ladder wave voltage waveform. Figure 5 shows that the peak voltage value of power supply output voltage is higher, and the waveform sine difference ladder wave voltage fluctuates to some extent.
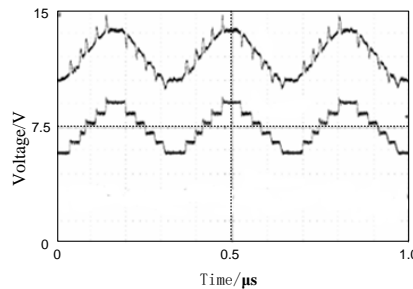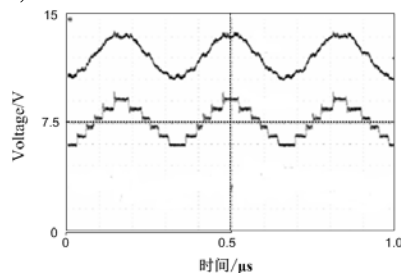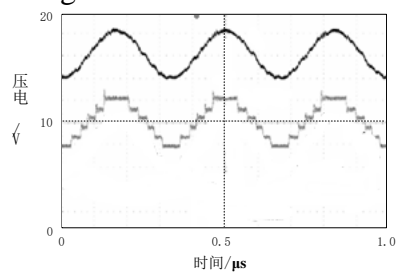

Fig. 5 Voltage waveform before control

In the experiment, the Jacoby matrix method is used as a comparison to carry out experimental tests. For the voltage waveform shown in Figure 5, these two methods are used to control the voltage waveform, and the control results are described in Figure 6.

(a)Method of Jacoby matrix   (b)Proposed Method

Fig. 6 Comparison of control results between two methods

Analysis of Figure 6 shows that when the Jacoby matrix method is used to control the output voltage and step wave voltage of the power supply, the high frequency peak voltage of the output voltage is basically eliminated, and the sinusoidal degree of the output voltage and step wave voltage is not good. When the method is used to control the output voltage and step wave voltage of the power supply, the peak voltage of the output voltage is completely eliminated, and the output voltage and the step wave voltage are also eliminated. The step-wave voltage has a good sinusoidal degree, and has the least influence on the amplitude and phase of step-wave voltage.

4. Conclusion

In this paper, a control method of output voltage of power supply based on single chip computer is proposed. The design block diagram of DC power supply system, voltage control monitoring circuit and A/D conversion circuit are given. The control principle is analyzed and the experiment is carried out. The results show that the control accuracy and robustness of the proposed scheme are higher than those of the traditional control method of output voltage of DC power supply system.

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