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Design of DC Motor PID Control System Based on STM32 Single Chip Microcomputer

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Abstract

The rotational speed of DC motors is an extremely important control quantity in the industrial production control process. With the improvement of industrial standards, the demand for speed control of DC motors in industrial production is also increasing day by day. Therefore, it is necessary to control the speed of DC motors. The paper conducts in-depth research, mainly introducing the characteristics and speed measurement methods of DC motors. The related concepts and principles of PWM pulse width modulation technology, the application of PWM in the speed control method of DC motors, the related concepts of PID and the control algorithm of PID are also researched in regards to control of DC motors based on single chip microcomputers and the incorporation of PID control into the system design. PID control is the most widely used and universal control method because of its simple structure, reliable operation, good stability, and easy adjustment. PID control algorithms have become the classic control method in industrial process control systems. The experiment proves that the PID algorithm can also be adopted for the DC motor speed control, so that the motor speed is stable and has quick response times. At the same time, the motor also has constant torque speed regulation characteristics.

Keywords

STM32,DC Motor,PID,PWM,Speed Control Systerm.

1. Introduction

Based on the DC power supply, DC motor, stm32f4 development board, rotary encoder and L298N drive module, this paper studies and designs the DC motor PID speed regulation system of stm32F4 single chip microcomputer. It is programmed on the programmable controller to change the duty ratio of PWM (the duty ratio of PWM can be changed by pressing the key to adjust the speed) to drive and control the DC motor. The rotary encoder used for DC motor speed detection feeds back the speed reading compared with the initial value to STM32 MCU, then calculate the speed deviation, and use PID algorithm to make the motor speed stable at the output setting value, reduce the DC motor error speed regulation, make the DC motor output speed more accurate, and finally make the DC motor PID control system achieve the following performance indicators: good control accuracy, low steady-state error, timely response, high working efficiency, low energy loss.

2. Materials and methods

2.1 Overall structure of system hardware

In this paper, STM32, which core is cortex-m4, is selected as the core control device of DC motor PID speed control system. [10] STM32 single chip development board as a programmable development board program control rotary encoder and L298N drive board, L298N drive board and

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DC motor are connected to drive DC motor, incremental rotary encoder and DC motor are connected to detect the speed of DC motor. As shown in Figure1, the physical

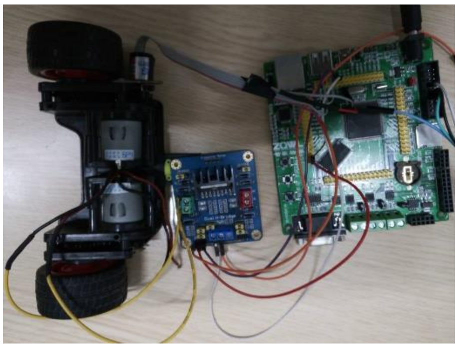

Figure1 schematic frame of the system

This system is a PID closed-loop speed control system of DC motor based on stm32f4 single chip microcomputer. The rotary encoder converts the measured rotational speed signal of DC motor into electrical signal and feeds it back to stm32f4 development board. The STM32 single chip microcomputer development system will get the deviation of rotation speed by comparing the set rotation speed of DC motor with the feedback speed signal, and then get the deviation of rotation speed control by incremental PID operation. [10] The PWM duty cycle is modified so that the voltage difference between the two ends of the armature of the DC motor changes to meet the purpose of the set speed output, so as to achieve the goal of DC motor speed regulation accuracy.

2.2 Generation and output of PWM based on stm32

PWM (except timer6 and timer7) can be generated by stmf4 timer. The PWM generated by general timer is generally more than 4 channels, and the PWM generated by Timer1 and timer8 can be more than 7 channels. Now a PWM output is generated through ch1 of timer 14. In addition, several registers are used to assist timer 14. The three registers are (timer14 – ccmr1) capture or compare mode register, (timer14 – CCR) capture or compare register and (timer14 – Ccre) capture or compare enable register. After timer 14 and GPIO clock are turned on, configure gpiof9 and select multiplexing function as gpioaf9 (timer 14) output. Timer14? Ccmr1 is used to set timer14? Ch1 as PWM output mode. At last, modify timer14? CCR1 to control the duty cycle of PWM, so as to control timer14? Ch1 to output PWM through GPIO pin.

2.3 Drive scheme of DC motor

As shown in Figure 2, it is the driving circuit diagram of L298N DC motor module. The circuit diagram includes eight triodes, each of which constitutes one H-bridge driving circuit, so the circuit includes two H-bridge full bridge driving circuits, which can drive two DC motors.

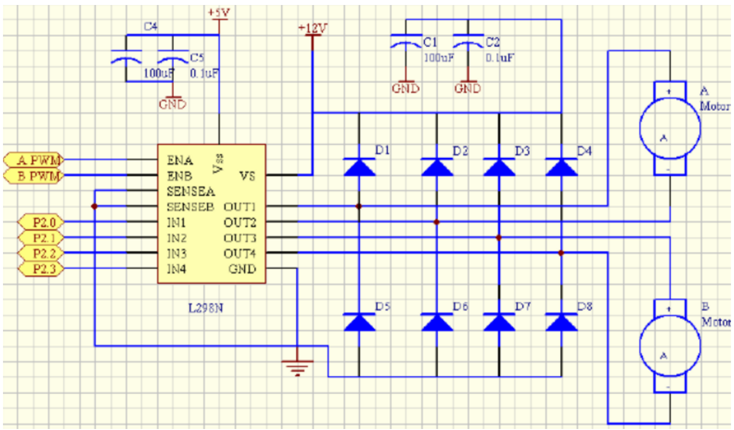

Figure 2 schematic diagram of DC motor drive circuit

The two-way H-bridge drive circuit of L298N DC motor driver module can drive two DC motors. Assume DC motor M1 and DC motor m2. The following is the scheme of driving DC motor M1.

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Provide 5V to 10V DC power to L298N motor drive board. Pin a and B of L298N motor drive module are connected to both ends of DC motor. After EA pin is enabled, the speed and direction of DC motor M1 can be driven by in1 and in2 input PWM wave signals through STM32 single chip microcomputer. If the input signal of in1 in2 is connected to high level and low level respectively, DC motor M1 will rotate forward. When the high and low levels of in1 and in2 input are exchanged, DC motor M1 will reverse. The method of controlling another DC motor is the same. If the signal pins in3 and in4 are connected to high and low levels respectively, the DC motor will rotate forward. In3, in4 signal input high and low levels are exchanged, then DC motor M2 reverses.

2.4 Design of principle framework of experimental system

As shown in Figure3: the STM32F4 microcontroller development board is a DC motor control system. After compiling the program through keil5 software on the computer, there is no error in compilation, so it can be downloaded to STM32 MCU. After supplying power to stm32f4 MCU development board and L298N motor drive module, the DC motor can be driven to run. The rotary encoder captures the pulse, obtains the rotation speed of DC motor, feeds it back to STM32 MCU. The MCU calculates the deviation between the speed feedback value and the speed setting value, and adjusts the PID value to stabilize the rotation speed of DC motor at the setting value.

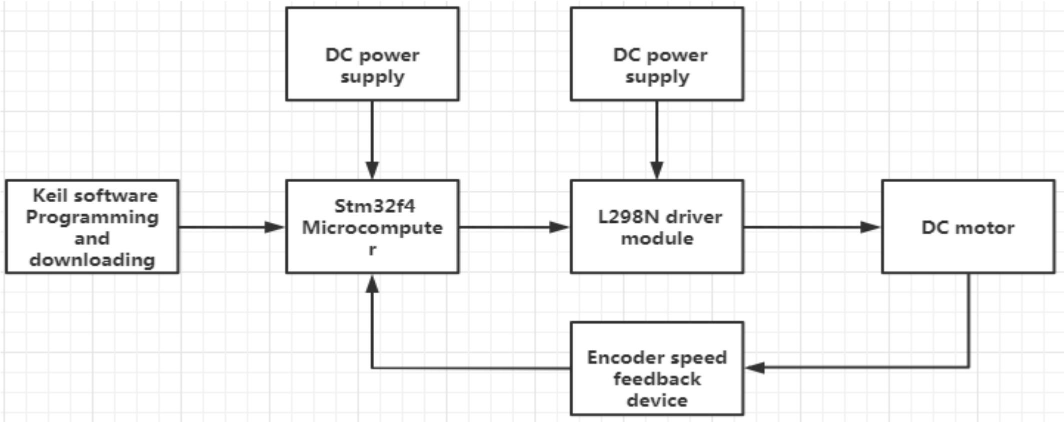

Figure3 schematic frame of the system

2.5 PID parameter setting to stabilize motor speed regulation

In this experiment, the process of setting PID parameters is to carry out pure proportional parameter control first, and gradually increase the proportional coefficient P until the speed feedback value has a certain overshoot, and the speed basically fluctuates up and down the set value, but at this time, the fluctuation amplitude of the speed up and down will be relatively large, and the stability error cannot be eliminated. From this point on, the integral control is added to gradually increase the integral coefficient. In this process, the fluctuation amplitude of the system speed is obviously reduced, and the steady-state error is also gradually reduced. Finally, when the integral coefficient is set properly, the system error becomes smaller and basically meets the requirements. The speed stability is close to the speed setting value to the maximum extent. However, due to the lack of differential control, only proportional integral control, the response speed of the system is relatively slow, and there is a lag phenomenon. At this time, set the differential time coefficient D, and fine tune the differential coefficient to make the system get better dynamic performance and faster response speed, thus completing the PID parameter setting of a group of speed, and the speed PID parameter setting method of other groups is the same.

3. Results and discussion

3.1 Experimental results of DC motor PID control system design

As shown in Figure4 and Figure5, it is the low-speed control effect of DC motor. The experimental setting value is 160 pulses per 100ms motor, while the rotation speed of motor measured by encoder speed sensor is about 150 pulses per 100ms.

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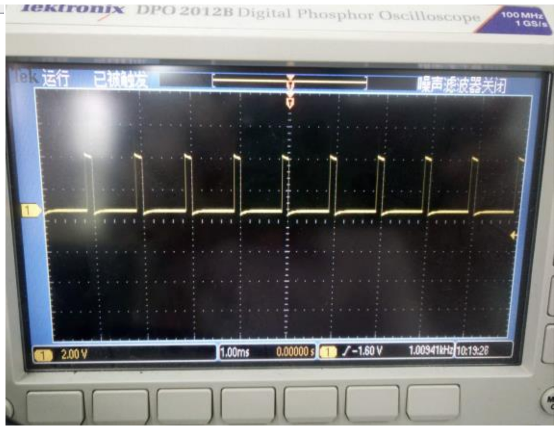

Figure4 low speed feedback of motor Figure5 low speed pulse

The following figures show the medium speed control effect of DC motor. The experimental setting value is 230 pulses per 100ms motor, while the motor speed measured by encoder speed sensor is about 210 pulses per 100ms.

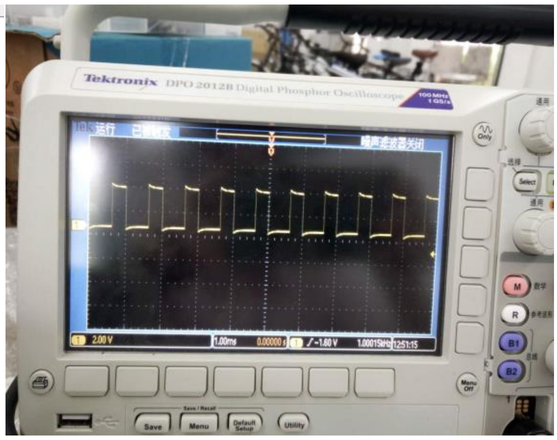

Figure6 medium speed feedback of motor Figure7 medium speed pulse

As shown in Figure8 and Figure9, the high-speed control effect of DC motor, the experimental setting value is 300 pulses per 100ms motor, while the rotation speed of motor measured by encoder speed sensor is about 280 pulses per 100ms.

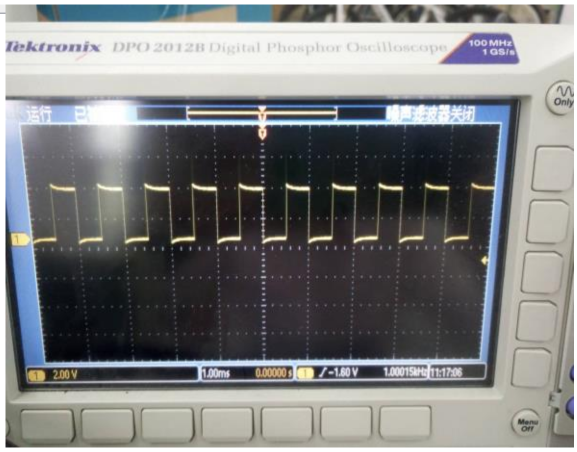

Figure8 high speed feedback of motor Figure9 high speed pulse

3.2 Analysis of the causes of experimental errors

There is a certain error between the speed setting value of this experiment and the actual speed feedback measurement value. The main reasons for the error are as follows:

1. The setting of PID parameters is not accurate enough, which will make the speed of DC motor unable to reach the set value.

2. The output current and voltage of DC power supply are not stable, and the fluctuation of voltage and current will also cause the speed error of DC motor.

3. If the rotary gear of the encoder and DC motor is too tightly clamped, the speed feedback of the encoder will be too small, and at the same time, it cannot be too loose. The tightness must be just right.

4. Conclusion

This paper designs a DC motor PID speed control system based on stm32f4 single chip microcomputer. [10] The single chip microcomputer is a stm32f4 development board with arm cortex -M4 core. The stm32f4 programmable controller programs the L298N drive board to drive the DC motor, changes the PWM duty ratio of DC motor drive and speed regulation, and the incremental PID algorithm makes the electric speed reach the speed setting value as much as possible. The research of this paper shows that the PID speed control system of DC motor has the advantages of fast response, small steady-state error, excellent stability, high control accuracy, low energy loss and high working efficiency. It has certain reference significance and reference value for the future research of DC motor speed control system. It can be widely used in various industrial fields that need DC motor to participate widely, such as port crane, elevator, mechanical grab, ship electric propulsion and other industrial application fields.

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