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Design and implementation of fuzzy PID DC motor control system based on STM32

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***Abstract*—In view of the traditional PID DC motor speed control in the actual use of the process of the parameters of the regulation method is more complex, and can not achieve self-adaptation, in order to further tap the application potential of brushless DC motor, by studying its structure and working principle, a fuzzy PID DC motor control system based on STM32F407 is designed. By analyzing the speed control system of the PID DC motor, the speed of the DC motor can be adaptive controlled and displayed, the PWM control signal can be generated by the STM32 controller, and the speed can be measured by the Houle signal, combined with PID control algorithm to improve the robustness and adaptive ability of the control system, this design makes the system run more stable and improves the ability of anti-jamming.**

Keywords—STM32, fuzzy PID, DC motor speed regulation, PWM

Among many types of motors, brushless DC motors have higher use value compared with brushless DC motors and AC motors because of their fast dynamic response ability, good speed regulation performance and relatively long service life [1-2]. In the system control algorithm, the relevant personnel at home and abroad have done a lot of research, put forward IP controller instead of PI regulator, call internal model control algorithm, adaptive PID algorithm and so on. On this basis, this paper comprehensively studies the fuzzy PID DC motor control system based on STM32, using STM32 and DC motor special integrated control chip to realize the control, to ensure that the controller structure is simple, fewer peripheral devices, the use of fuzzy PID control algorithm in the control strategy, more cost-effective.

I. THE CONSTITUTION OF DC MOTOR CONTROL SYSTEM

The basic structure of DC motor control system is shown in Fig 1.

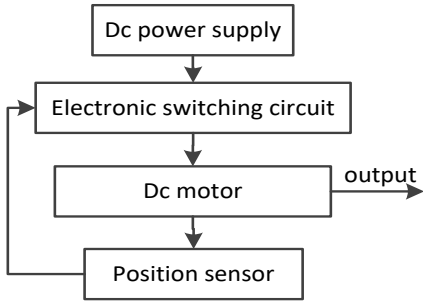

Fig. 1 DC motor control system

The system is mainly composed of electronic switching circuit, motor, position sensor and power supply. The main function of the position sensor is to effectively detect the position effect of the magnetic pole of the rotor.

When a certain stator winding is communicated with electricity, the interaction between the current and the magnetic pole magnetic field of the rotor will generate torque and drive the rotation of the rotor. Then, the position sensor enables the position of the magnetic pole of the rotor to transform the electrical signal. Electronic switching circuit is also known as electronic reversing circuit, its role is to realize the position sensor to the rotor position detection, after processing the detection results, according to the corresponding logic coding to achieve output. Control of fuzzy PID DC motor.

Generally, the cascade speed control system is used in the speed control system. PID control is relatively simple and the speed control is more accurate. However, due to the fixed PID parameters and the simple signal processing, the real-time speed control is low and can not be used in the nonlinear system. So fuzzy control is used to improve the adaptive ability of the system. Fuzzy control uses fuzzy reasoning and fuzzy language to list control rules, realizes fuzzy calculation, and finally removes ambiguity to obtain accurate control quantity. It belongs to intelligent control mode and has strong adaptability [3]. The structure of fuzzy PID DC motor control system is shown in Fig 2.

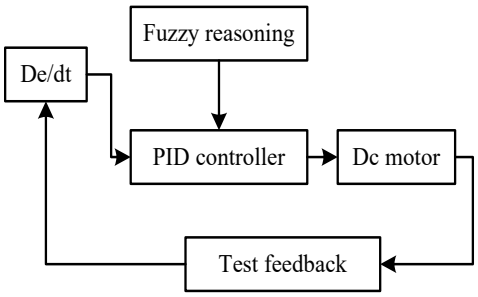

Fig. 2 Block diagram of fuzzy PID DC motor control system

Fuzzy control input language variables include E (k) and Ec (k), which belong to 7 fuzzy self, mainly including PB, PM,PS, Z, NS, NM, NB.

The formula for calculating fuzzy PID parameters of DC motor control is:

$$Kp=Kp+\Delta Kp \qquad (1)$$

$$Ki=Ki+\Delta Ki \quad (2)$$

$$Kd=Kd+\Delta Kd \quad (3)$$

The fuzzy PID control system can automatically adjust PID parameters, and firstly determine ΔKp. If ΔKp > 0, it indicates that the motor responds quickly[4]. The simulation results of fuzzy PID are shown in Fig.3.

It can be seen from the figure that the adjustment time of fuzzy PID is smaller than that of traditional PID, which can effectively improve the adjustment time of the system and has relatively good stability[5].

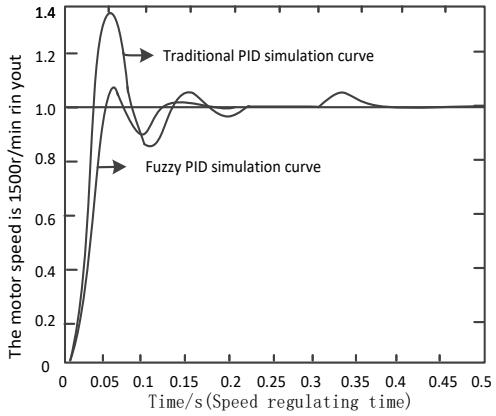

Fig. 3 Fuzzy PID simulation result

II. Motor control system design

A. System structure

In this system, the PC is used as the upper computer, and commands are sent through SCI system interrupt to monitor the system in real time. The control system uses STM32 processor to control the motor speed and Hall element to detect the rotor position. DSP can correct the control speed of upper computer and realize closed-loop control of motor speed[6]. The structure of DC motor control system is shown in Fig 4.

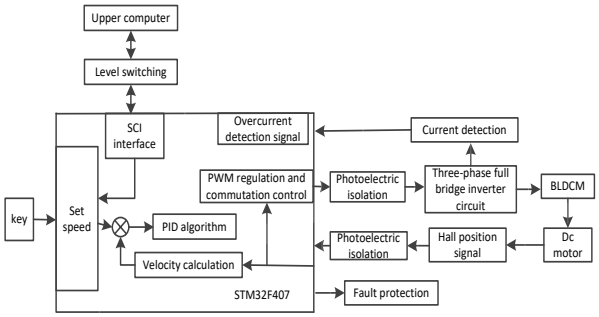

Fig 4 DC motor control system structureB Hardware design

The STM32 controller judges the current position of the motor rotor through the feedback signal of Hall sensor, controls the on-off of the switch tube in the three-phase bridge drive circuit, and carries out reversing operation. The continuous change of on-off of the switch tube drives the rotor to rotate[7]. The start and stop, acceleration and deceleration, and positive and negative rotation of the motor can be controlled by the upper computer or the key circuit. The controller adjusts the PWM duty ratio speed through the PID control algorithm for closed-loop control to realize the stable operation of the motor speed, so that the speed adjustment process is rapid and stable.

B. Hardware design

Through STM32 to complete the PID control algorithm required by the system, generate PWM pulse width digital signal, but also to achieve real-time communication with the host computer to complete other control functions. The main circuit of DC motor control system is shown in Fig 5. Motor DC bus signal to real-time current monitoring, avoid motor overcurrent failure.

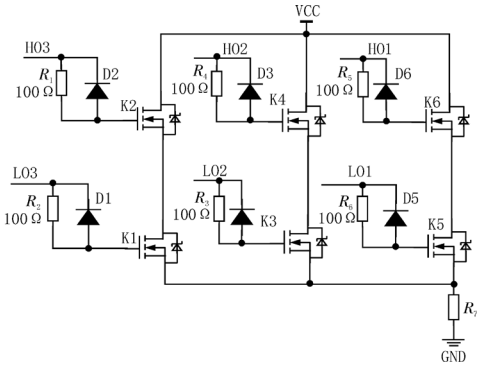

Fig. 5 Main circuit of DC motor control system

The driving circuit of DC motor is composed of three IR2110S and three-phase full-bridge inverter circuit. IR2110S has undervoltage protection function and is provided with external protection port. The external circuit can realize overcurrent protection. At the same time, the 120-degree motor is used in the system circuit to detect the position, and the Hall signal is transmitted to STM32 through the optical coupling. When the motor rotates, STM32 generates the corresponding PWM signal according to the received Hall signal to control the on-off of the MOSFET, so as to control the motor reversing and calculate the speed of the motor.

III. Software design

The upper computer monitoring interface of the motor control system software is written by VC, and the communication is realized by MS serial communication control and debugging command. The lower computer program mainly includes the main program design, speed detection program, PWM program, fuzzy control algorithm, serial communication program design, waveform generation program design, etc [8].

The fuzzy control algorithm program is the main part of the system software. The fuzzy reasoning idea is used to continuously detect the motor speed during the operation of the motor [9], so as to realize the adjustment of parameters. The design principle of fuzzy control program is shown in Fig 6.

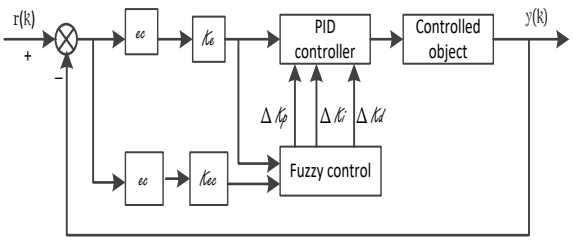

Fig. 6 Design principle of fuzzy control program module

The fuzzy PID algorithm is completed by a subroutine and called by the main program. The flow chart of the fuzzy PID DC motor control system program is shown in Figure 7.

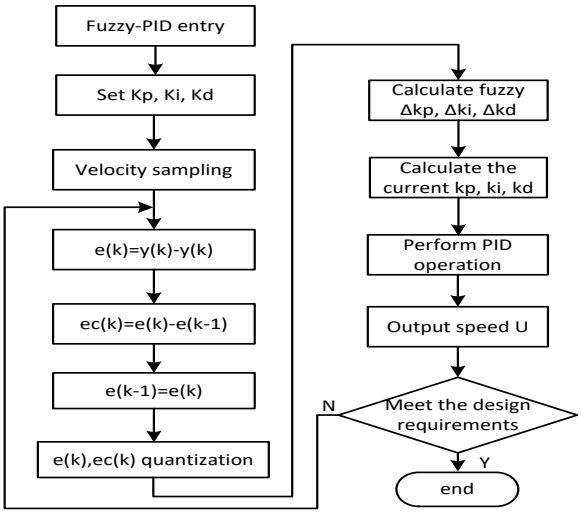

Fig. 7 Flow chart of fuzzy PID DC motor control system algorithm

The motor control system speed adjustment, hall signal acquisition interrupt, system protection and other functions are realized through the interrupt program. The main interrupt flow chart is shown in Fig 8.

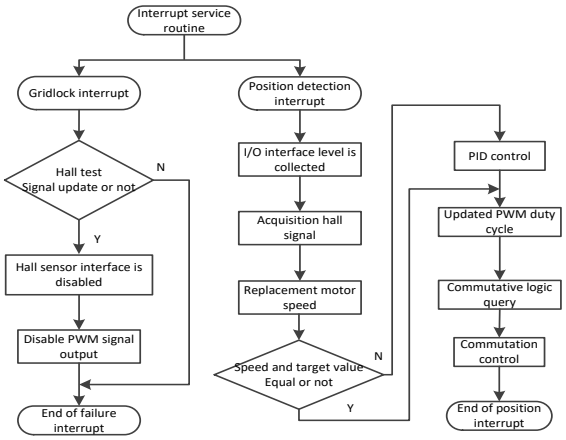

Fig. 8 Core control function terminal flow chart

The purpose of system management software is to read the motor running state data and control the motor running. The monitoring interface of upper computer can realize parameter and port setting, data collection, speed setting, etc., and real-time monitoring of speed curve [10].

IV. Conclusion

This system realizes the design of fuzzy PID DC motor control system based on STM32. The system mainly includes hardware circuit, software design, upper computer software interface and control system program design. The peripheral circuit of the control system is simple, the cost is low, the control precision of the system is higher, the system is reliable, and has strong robustness. Through the upper computer interface, the system can display the running state of the motor in real time and set the parameters, which greatly improves the convenience and economy.

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