Control Circuit design of permanent magnet synchronous motor control system based on DSP

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Abstract: This paper introduces the design and implementation of hardware circuit of permanent magnet synchronous motor Servo Controller Based on DSP. In this scheme, TMS320F28335 is used as the control core, and DRV8312 is used as the three-phase motor driver chip. The main control circuit, communication circuit, drive circuit, current feedback circuit and protection circuit are designed in detail. The reliability of the control circuit is verified by experiments, and the servo control of PMSM is realized.

1. Introduction
Permanent magnet synchronous motor has many advantages, such as simple structure, high efficiency and low loss. Compared with DC motor, it has no commutator and brush, so it has high reliability. However, compared with asynchronous motor, permanent magnet synchronous motor has some disadvantages such as high cost and complex control. Compared with common synchronous motors, Permanent magnet synchronous motor (PMSM) needs no excitation device, and has simple structure and high efficiency. With the progress and development of motor control technology, power electronics technology and computer technology, vector control technology of permanent magnet synchronous motor has attracted wide attention of scholars at home and abroad. Compared with other control systems, the permanent magnet synchronous motor control system using vector control technology has higher precision, larger speed range and better dynamic performance. Permanent magnet synchronous motor has been widely used in aerospace, electric vehicles, robots, industrial driving devices and other fields.[1,2]

In order to obtain better control effect, the permanent magnet synchronous motor servo system with digital control technology has been widely used[3]. TMS320F28335 digital signal processor is a TMS320C28X series processing chip produced by TI Company, which is equipped with floating-point processing unit and is specially designed for motor control. Compared with the previous fixed-point DSP, F28335 has the advantages of high performance, low cost, low power consumption and high peripheral integration.

The main control chip of the control circuit designed in this paper adopts TMS320F28335, and the three-phase motor driver chip adopts DRV8312. The main control circuit, communication circuit, driving circuit, current feedback circuit and protection circuit are designed and analyzed in detail. The control circuit can control the position, speed and output torque of the permanent magnet synchronous motor in real time, meet the requirements of high performance and high precision.
2. System composition

The servo control system in this paper is mainly used to control permanent magnet synchronous motor. The position, speed, and current of the motor can be controlled by servo closed-loop control. The composition block diagram of servo control system is shown in Figure 1. It can be seen from Figure 1 that this servo system is mainly composed of: DSP main control circuit, driving circuit, position detection circuit, voltage detection circuit, current feedback circuit, protection circuit, communication circuit, and PMSM.

The main control chip of the controller adopts TMS320F28335 produced by TI company, and PWM signals are generated by EV module of DSP and input to DRV8312 chip. After conditioning and amplifying the PWM signals, DRV8312 chip transmits them to the three-phase full-bridge inverter circuit, thus generating the three-phase AC current needed by permanent magnet synchronous motor and driving the motor to move.

3. Circuit design

3.1 DSP master control circuit

The main control circuit of DSP includes: DSP chip power supply circuit, clock circuit, reset circuit, JTAG interface circuit, and extended memory circuit.

This paper selects LM2596 voltage regulator chip and input DC28V to generate DC12V. Select MP1482 voltage regulator chip, and input DC12V to generate DC5V. DC5V generates DC3.3V through LD1117DT33 module. Two different reference voltages, 3.3V and 1.9V, are required for the normal operation of DSP28335. 3.3V is used as the power supply voltage for Flash and I/O ports, and 1.9V is used as the core power supply voltage. In this design, DC5V generates 1.9V and 3.3V through TPS767D301.

The 30MHz active crystal oscillator is used as the external clock, and the signal is multiplied by the PLL in DSP to get 150MHz. As shown in fig. 2, compared with the passive crystal oscillator, the active crystal oscillator does not need the internal oscillator of DSP, and the signal quality is good, and the connection mode is relatively simple, without complicated configuration circuit\(^{(4)(5)}\).
3.2 Drive circuit

DRV8312 is a digital motor control chip produced by Texas Instruments, which is a high-performance, integrated three-phase motor driver with advanced protection system. The efficiency of the driver can reach 97%. The designed driving circuit is shown in Figure 3.

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Fig. 2 clock circuit of dsp28335

The reset circuit uses a special reset chip TPS3823-33/SOT-23, which is supported by the microprocessor to ensure the reliable reset of DSP chip. Active low reset, 1.1 V-5.5V input, threshold voltage of 2.93V, minimum power supply voltage of 1.1V, maximum power supply voltage of 5.5V, operating temperature range of the device is -40℃ to 85℃.

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Fig. 3 reset circuit
3.3 Current sampling circuit

Current sampling circuit is one of the key modules of the whole control system. Whether the sampling is accurate or not is related to the accuracy and response speed of the whole control algorithm, which is very important for the control system. There are two main sampling methods of three-phase current at stator side of motor: resistance sampling and Hall sensor. Three-resistance sampling method is adopted in this circuit. It is converted into voltage signal by signal conditioning circuit and sent to DSP for processing.

3.4 Communication circuit

The DSP28335 processor provides three SCI interface modules, namely SCIA, SCIB, and SCIC, and each SCI module has a receiver and a transmitter. The receiver and transmitter of SCI each have a 16-level FIFO (First In First Out first in first out) queue, and they all have their own independent enable bit and interrupt bit, which can work in half-duplex or full-duplex mode. The driver module SCIA corresponds to GPIO28/29. SCIB corresponds to GPIO18/19. SCIA interface is configured as RS422, which is used to communicate with the upper computer, as shown in fig. 5. SCIB interface is configured as RS485 for receiving encoder angle information, as shown in fig. 6. ADM2682E can realize the function of isolated RS422, and has strong anti-interference ability and its own isolated power supply. The ADM2486BRWZ transceiver has a data rate of 20.0Mbps, a power supply current of 3ma and 16 pins.
4. Experiment
DSP reads the angle value of encoder and adopts FOC control algorithm. Under torque mode, the three-phase current waveform of motor is shown in Figure 7, and the curve relationship between torque output and mechanical angle under different torque commands is shown in Figure 8, which achieves ideal results.
5. Conclusion
For the control circuit of permanent magnet synchronous motor, this paper uses TMS320F28335 of TI Company as the main control chip, and the motor drive uses integrated DRV8312 chip. Through the experimental results, it can be seen that this scheme can realize the servo control of permanent magnet synchronous motor, and with the appropriate algorithm, the expected control goal can be achieved.

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