Design of Motor Controller New Energy Vehicle Based on DSP

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Abstract. For the AC Induction Motor (ACIM) has the characteristics of simple structure, high power factor and high overload rate, the drive controller of the new energy vehicle induction motor is researched and designed. According to the d-q axis coefficient model of induction motor, the controller model of induction motor based on vector control is constructed. The controller consists of Digital Signal Processor (DSP) TMS320F28035, power drive circuit, control circuit and current detection circuit. The digital signal processor (DSP) TMS320F28035 produced by TI is the core of the whole control system. With the help of more precise digital vector field oriented control (FOC) algorithm, DSP enhanced PWM (EPWM) module is used to generate high precision flexible space vector pulse width modulation (SVPWM) signal this allows the motor to maintain high efficiency over a wide range of speeds.

1. Introduction
In recent years, the energy crisis and environmental pollution have become more and more serious. The electric energy-driven new energy vehicles have zero emissions and the use of low cost is increasingly accepted [1]. The performance of the controller as the core device of the controller directly determines the efficiency of the car, so the introduction of efficient control algorithms to research and develop high-quality motor control systems has extremely important practical significance. AC induction motor (ACIM) has higher durability than permanent magnet synchronous motor (PMSM) switched reluctance motor (SRM) [2]. Higher reliability and low overload cost are widely used in new energy vehicles [3].

In this paper, by analyzing the principle of AC induction motor and Field Oriented Control (FOC) [4], the overall architecture of the system is designed based on the demand analysis. The system uses the DSP chip TMS320F28035 developed by Texas Instruments for motor control as the core chip of the controller, and on this basis, the software and hardware system design of the controller is completed. The hardware system mainly includes a minimum system, power module, driving module, detecting module, and digital-analog input and output module. The software system includes driving module, detecting module, and driving protection module. Finally, in order to verify whether the AC induction motor controller meets the design specifications, a 3KW induction motor is used as the control object to complete the system and each unit test and the stability test of the system, the test results show that the system functionality, stability, reliability meet the design requirements.
2. FOC Vector Control Algorithm

Field Oriented Control (FOC), also known as vector control, uses a variable frequency drive control method that controls the output voltage of the inverter and frequency control of a three-phase AC motor. Since the simple control of V/Hz strategy has some limitations on performance [5], in order to achieve better dynamic performance, this design adopts the FOC control system configuration to control induction motor. This control is based on projections which transform a three phase time and speed dependent system into a two coordinate (d and q coordinates) time invariant system. These projections lead to a structure similar to that of a DC motor control. The overall framework of the system is shown in the Fig 1.

![Figure 1. FOC vector control frame diagram](image)

3. HARDWARE DESIGN

3.1. DSP Control Circuit

The motor control system is given by Fig 2 including DSP control circuit, three phase inverter, human-machine interface circuit and detection module. This paper choose TMS320F28035 as main control unit. The DSP control system can generate corresponding PWM signals to make the motor work normally through sampled phase currents from the inverter.

![Figure 2. Motor control system structure diagram](image)
3.1.1. System power circuit. The required voltage 5V, 3.3V, 1.8V during system operation, However, the bus voltage of the system is DC72V, so this design uses a DCDC power supply with UC2845 as the core to provide DC72V to DC12V switching power supply for the system, and use the 7805 and TPS767D318 dual-line power supply to power the DSP core and other peripherals. In order to ensure the stability of the system. This design does not use the on-chip VREG voltage and directly uses an external power supply to power the DSP core.

3.1.2. Current detection circuit. The controller needs to collect the phase current of the motor in real time when controlling the motor which puts high requirements on the real-time and accuracy of current sampling. This system selects the current sampling circuit composed of linear Hall and op amp to detect the AC current of -300A to +300A. The current signal collected by the Hall sensor is converted into a voltage signal, and the voltage is modulated by an arithmetic unit and input to the AD sample module of the DSP. The current detection circuit is as the Fig 3 follows:

3.1.3. Accelerator pedal circuit. This design uses a 4-wire electronic accelerator pedal design commonly used in automobiles and the controller provides 12V working voltage. After inputting to the DSP by processing the pedal output signal In order to prevent accidents caused by false triggering of the throttle, the system introduces a hardware protection mechanism. The A/D circuit simultaneously collects two acceleration signals of the pedal output. The acceleration signal is collected only after a specific one of the signals reaches the design value. In the opposite case, the system is unresponsive to the acceleration signal.

3.1.4. Quadrature encoder pulse circuit. Control of induction motors requires real-time monitoring of the rotor position is calculated rotor flux position. So the corresponding position sensor is needed to detect the position of the rotor. This design selects the incremental quadrature encoder. The encoder can output two-phase pulse sequence with 90° phase difference. Then the system can know the rotation direction of the motor according to the order of the two groups of pulse sequences, and the QEP module inside the DSP. The received pulse is multiplied by 4 so that the resolution of the encoder can be increased without increasing the number of gratings of the encoder disc.

3.2. Drive circuit and Three Phase circuit
When the motor starts or is under high load, the phase current of the motor will become very large. This system uses multiple MOSFETs in parallel to increase the output current of the controller. Here, the power MOSFET selects IXFA4115 and select IR2127 as the driver chip and integrate overcurrent protection. The W phase circuit of the driver is shown in Fig 4:
4. TEST RESULT ANALYSIS
The designed circuit schematic is drawn into the PCB by EDA software as shown in Fig 5. This design designs the control circuit and the drive circuit into two PCBs, wherein the drive board uses an aluminum substrate to enhance heat dissipation. Next, the soldered control board and driver board are assembled and placed in a custom heat sink and connected to the motor and other peripherals as shown in Fig 6a. The program is downloaded to the chip and tested by the JTAG emulator via Code composer studio (CCS). When the system is running normally, the oscilloscope is used to observe the signal output of the controller. As shown in Fig 6b, a pair of complementary waveforms of the W phase is displayed, and the duty ratio and the rotational speed of the motor also change in real time as the acceleration signal changes.
5. Conclusion
The text addresses the market demand for new energy automotive motor controllers. Developed a high-power induction motor controller based on the DSP platform and introduced FOC advanced algorithm. Through a large number of experiments and loading tests, the controller can operate stably under various complicated working conditions. The controlled motor runs smoothly, with low noise, low vibration, quick response and high efficiency. At the same time, the controller can adapt to different powers by adapting different parameters.

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