Research on Coordinated Control of Dual Motors Based on DSP

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Abstract: In order to save energy and reduce emissions, improve the ecological environment and achieve sustainable development, the research and development of electric vehicles has become a common consensus in all countries in the world. As the core component of electric vehicles, the requirements for drive motors are getting higher and higher. The control strategy of the dual-stator motor is based on the mature vector control method of the traditional PMSM. The two sets of three-phase windings are transformed at the same time by rotating coordinate, and the vector control under the dual synchronous rotating coordinate is realized through separate decoupling; the control system uses TMS320F28335 as the control core, equipped with The dual stator motor vector control system makes full use of chip resources to realize the functions of rotor position detection, two-winding current and voltage acquisition and IGBT drive at the same time to complete the torque control of the two stator windings. It is verified by experiments that the control system meets the requirements of electric vehicle power system, with simple structure and strong practicability.

1. Introduction

Among the commonly used various types of electric vehicle drive motors, PMSM stands out because of its excellent performance, and more and more are used as traction motors for drive systems. Among them, the application of dual-stator PMSM can well solve the problem of insufficient average load rate of the motor. The two stators can work together to meet the demand for large torque, and the single-stator operation ensures a higher load rate of the system [1].

In order to overcome the problem of poor voltage control ability and low overall coordination, this paper studies the method of dual-motor coordinated control of electric vehicle systems based on DSP (digital signal processor, microprocessor). The specific method of the dual-motor coordinated control of the electric vehicle system based on DSP is to analyze the coordinated control circuit of the dual-motor of the electric vehicle system based on DSP, and then increase the coordinated control ability of the dual-motor according to the circuit analysis result. The innovation of this article is to add PWM (Pulse Width Modulation) buffers in the two areas of the dual motors to improve the ability of the dual motors to coordinate the transformer and the entire electric vehicle system, and achieve coordinated control of the electric vehicle system through these two methods, so that the system can work stably and coordinately [2].

2. DSP-based electric vehicle system dual-motor coordinated control circuit analysis

The dual-motor system control circuit of the electric vehicle system based on DSP is mainly composed of two areas, namely the driving area and the control area. The driving area is composed of power supply and reverse circuit. The power supply of the driving area uses the high-voltage DC current of
the high-power integrated electrolytic capacitor of the flyback switching power supply. The inverse

circuit is to ensure that the dual-motor system control circuit of the electric vehicle system has the
functions of an inverter drive and a protection circuit.

2.1. Application of switching power supply to adjust load

The control area is based on the dual-motor microprocessor of the electric vehicle system, which
transmits high-voltage and issued instructions to the system's dual-motor coordination system for
real-time signal transmission, improves the system's dual-motor coordinated control capability, and
ensures the dual-motor of the electric vehicle system Carry out stable coordination work [3]. The
specific electric vehicle system dual-motor coordinated control circuit is shown in Figure 1:

![Figure 1 Electric vehicle system dual-motor coordinated control circuit](image)

The power supply of the electric vehicle system dual-motor coordinated control circuit drive area is
mainly composed of switching power supply and DSP power supply. Switching power supply includes
switching power supply chip TB6806, stabilizing transformer, shunt regulator TL422 and optical lotus
coupling NC4442.

2.2. Use shunt regulator to stabilize input voltage

The shunt regulator TL422 is connected to the dual-motor coordinated control circuit of the electric
vehicle system through the secondary side and the primary side. There are a total of 4 coils on the
secondary side of the shunt regulator, and each coil plays a different role. The first and second coils
are opposite to the primary coils, which can stabilize the voltage output by the dual-motor coordinated
control circuit. The receiving voltage of the first coil is 15v, and the second receiving voltage is 30v.
According to the delivered voltage value, the corresponding coil is carried out. If the input voltage
does not meet the requirements, it will automatically change to 30v voltage and then output. The third
coil and the fourth coil are the same as the primary coil. The third coil accepts the stable voltage
output by the first and second coils, and provides electrical energy for the microprocessor. The fourth
coil is to extract part of the voltage to provide energy for the TB6806 chip. Ensure that the input
voltage and output voltage of the dual-motor coordinated control circuit of the electric vehicle system
are the same to maintain the normal operation of the electric vehicle system.

3. Coordinated control of dual motors with PWM buffer

In order to increase the dual-motor coordinated control capability of the electric vehicle system, this
paper adds a switching power supply DSP power supply and an inverter circuit to the dual-motor
coordinated control circuit of the electric vehicle system, and adds a PWM buffer to the dual-motor
coordinated control circuit.

PWM is an analog control method of pulse width adjustment. The working basis of PWM is the
on-time of the transistor to make the working voltage of the power supply stably transmit, and the
digital signal output of the microprocessor is used to strengthen the control of the corresponding circuit. Applying to this article is to strengthen the dual-motor coordinated control capability of the electric vehicle system on the basis of DSP power supply, circuit switching power supply and inverter circuit. This buffer zone is between the driving area and the control area of the dual-motor coordinated control circuit of the electric vehicle system. The function of the buffer zone is to interrupt the current in the driving area of the dual-motor coordinated control circuit of the electric vehicle system in advance, so that the current in the control area is turned on in advance. In order to allow the corresponding current to execute the corresponding command, this article performs coordinated control on the analog control method of applying pulse width adjustment to the buffer area. Make the electric vehicle system dual-motor coordinated control circuit to complete the commutation of the current in the drive area and the control area. The length of the connection between the drive area and the control area is the commutation time. The current commutation diagram is shown in Figure 2:

![Figure 2 Current commutation diagram of buffer area](image)

In Figure 2, the c+ switch and b– switch conduct current conduction; after the current enters the driving area of the dual-motor coordinated control circuit of the electric vehicle system, the c+ switch is turned off, and the a+ switch conducts the current conduction and enters the electric vehicle system dual-motor. In the coordinated control area, the c+ switch is turned off after a delay, and the pulse width adjustment method is used to transition the current from the drive area until the current in the buffer area of the dual-motor coordinated control circuit matches the input current of the control area, and the transition behavior ends.

In order to accurately control the buffering time of the buffer area of the dual-motor coordinated control circuit of the electric vehicle system, this paper uses a formula to calculate the current phase change time difference between the driving area and the control area of the dual-motor coordinated control circuit.

\[
\begin{align*}
\frac{d i_a}{dt} &= \frac{u_d + e_a + e_b - 2e_c - i_R}{3L} \\
\frac{d i_b}{dt} &= \frac{2u_d + e_a + e_b - 2e_c - i_R}{3L} \\
\frac{d i_c}{dt} &= \frac{u_d + 2e_a + e_b - 2e_c - i_R}{3L}
\end{align*}
\]

In the formula (1), \(i_a, i_b\), and \(i_c\) are the average currents of each current in the circuit and time period. In a PWM period \(t\) with \(d\) as the duty cycle, the rate of change of the current of each phase in the two equivalent circuits is \(d i_a, d i_b, \text{ and } d i_c\) are the three motors in two areas. The peak voltage, \(U_a, U_b, U_c\) are the equivalent voltage values of the three motors in two areas. Because the buffer current of the dual-motor coordinated control circuit of the electric vehicle system satisfies the formula (2), the formula (1) can obtain the change rate of the variable phase current within a period \(T\) of the analog control method of pulse width adjustment. The formula is as follows:
4.2. Experimental process

(1) Change the control circuit of the dual motor of the electric vehicle system of the TS545846 control chip into the drive area and the control area, and add the power switch, DSP switching power supply and inverter circuit designed in this article in the drive area;

(2) Add a buffer area to the driving area and control area of the dual-motor coordinated control of the electric vehicle system, and set an analog control circuit for pulse width adjustment in the buffer area;

(3) The new DSP-based dual-motor coordinated control circuit of the electric vehicle system and the dual-motor of the traditional electric vehicle system will work for one cycle at the same time, and the two-motor coordinated control situation of the two electric vehicle systems will be updated and recorded in real time;

(4) The DSP-based dual-motor coordinated control method of the electric vehicle system is compared with the method of literature [4] and literature [5], and two experimental indicators of voltage transmission time and circuit coordination ability are established.

4.3. Analysis of experimental results

Voltage transmission time: When the buffer phase change time difference is lower, the voltage transmission time is shorter, that is, more voltage values are delivered in the same time.

The comparison results of the two methods are shown in Figure 3:
According to the experimental results in Fig. 3, it can be seen that the dual-motor coordinated control capability of the DSP-based electric vehicle system is stronger. The same electric vehicle power station inputs the same voltage of the two electric vehicle systems. The DSP-based electric vehicle system studied in this paper. The dual motors completed the voltage transmission in a short time, and the voltage value delivered to the user did not change. However, the transmission process of the method in [4] took 3 hours longer than the method studied in this paper, and the method in [5] and the voltage value received by the user has been reduced by nearly half. So in summary, the DSP-based dual-motor coordinated control method of the electric vehicle system studied in this paper is better.

Circuit coordination ability: When carrying out the coordinated control of the dual-motor circuit of the electric vehicle system, the coordination ability within the circuit is the main indicator of the robustness of the verification method. The method in this paper adds a PWM buffer, which can coordinate the drive area of the control circuit and the voltage transmission mode of the control area.

The comparison result of the two methods is shown in Figure 4:
In Figure 4, compared with literature [4] and literature [5] without PWM buffer, the method in this paper has a higher degree of current control in the drive area and control area, and can realize the voltage control of the buffer. The circuit coordination ability is strong and can be applied in practice.

5. Conclusion

In order to solve the problems of system delay, current static difference caused by parameter deviation, system instability, etc., the improved PMSLM deadbeat current predictor is used here, which is based on two-step prediction and compensation system delay, without affecting tracking. Under the accuracy condition, assuming that the motor speed and parameters remain unchanged during the four sampling periods, the voltage and current vectors of adjacent periods are used to represent the parameter disturbance and back-EMF component at the current moment, which is designed by this. Finally, on the DSP control system experimental platform, the current and speed tracking experiment results when the system parameters have deviations at a given current and speed are completed. The results show that the method has strong robustness to disturbances caused by system parameter deviations, and thus has good performance. Current and speed control performance.

References

[1] Fan Shougao, Shan Chunxian, Chen Jingfang. Brushless DC motor speed control system design based on TMS320F28335 [J]. Communication Power Technology, 2017, 34(3): 34-37.
[2] Gu Mingliang, Lin Qing. Design of DC servo system based on TMS320F2812 [J]. Application of Automation, 2015(7): 98-99.
[3] Gao Feng, Shi Hongliang, Mao Chunhua. Multi-processor communication method based on TMS320F2812 serial port[J]. Information and Communication, 2016(6): 37-38.
[4] Lu Degang, Du Zeyuan, Zhang Heng, et al. Research on PWM modulation method modeling of brushless DC motor[J]. Micro & Special Motor, 2017, 45(9): 60-63.
[5] Zhang Tong, Du Xiao, Zhang Yaping, etc. Pulse signal parameter measuring instrument system design based on TMS320F2812 [J]. Journal of Yibin University, 2017, 17(6): 1-5, 14.
[6] XU Zhichao, SONG Chao, LIU Junxia. A short circuit fault diagnosis method for DC voltage converter based on neural network. Journal of Physics: Conference Series. Volume: 1486; Issue: 2; Article number: 022002.