DC Motor Detection and Protection Based On Bipolar PWM Drive

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Abstract. Based on the analysis of a DC motor driven by bipolar pulse width modulation (PWM), a detection method is proposed to protect the motor drive circuit from short circuit and multiple current sampling. The circuit uses a multiplexer to control four power transistors, in which the power transistors on the same side are in complementary conduction mode, and the current points are sampled at the same point. The root mean square value, the blocking current value and the short-circuit current value are taken respectively. The driving circuit is protected in different places through the three different types of current values mentioned above. Compared with the traditional bipolar PWM drive circuit, this circuit can avoid the short circuit of power transistor, and can better protect the current and prevent the driving circuit and motor from burning down.

1. Introduction

Brushless dc motor refers to a small power dc motor with electronic commutation, also known as commutator motor, commutator motor, dc motor without commutator. Structurally equivalent to a reverse-mounted dc motor, its armature is placed on the stator, the rotor is a permanent magnet. Its armature winding is multiphase winding, generally three phase, can be connected into a star or triangle. Each phase winding is connected to a transistor switch in an electronic commutator circuit.

The rotor shaft of brushless dc motor is equipped with rotor position detector, tachometer generator and photoelectric pulse encoder. The output signal of the rotor position detector controls the electronic commutator to realize the commutation of the motor, that is, the conduction and cutoff of transistors in the electronic commutator are determined by the output signal of the rotor position detector. The output signal of the tachometer generator is used for speed feedback. The signal from the photoelectric pulse encoder is sent to the CNC device. For position feedback. There are many types of rotor position detector, but the output signal waveform is three-channel square wave.

Brushless direct mechanical and electrical machine driving mode according to different categories can be divided into a variety of driving modes, they have their own characteristics. According to the driving waveform:

Square wave drive, this driving mode is convenient to realize, easy to realize the motor without position sensor control;
Sinusoidal drive, this driving mode can improve the motor operation effect, so that the output torque is uniform, but the implementation process is relatively complex. At the same time, this method has SPWM and SVPWM (space vector PWM) two ways, SVPWM effect is better than SPWM.

Brushless dc motor has the advantages of simple structure, reliable operation, convenient maintenance, high conversion efficiency of dc motor and easy speed regulation. It is widely used in industrial instrumentation, production equipment and medical instruments. However, the single polarity of the drive circuit will make the brushless motor torque fluctuation large, low speed when the stability is poor, slow start, slow braking, not suitable for the occasions of booster. Therefore, a bipolar drive circuit is created to solve the above problems. Bipolar circuit, however, because of the four power tube in a cycle is conducting in turn, leads to power tube is very easy to enter the dead zone, and then burned the drive circuit, this study proposes a modified bipolar drive protection circuit, by using the principle of multi-channel selector control, at the same time, only conducting a pair of power tube, and in the case of a current value is too large, will trigger the selector output different voltage value to protect the driver circuit.

2. Principle of dual - polarity pulse - width modulation drive mode

Bipolar PWM drive mode only a connection as shown in figure 1, the two diagonal power tube of the same signal amplitude, phase, the same as Q4 and Q1 at the same time conduction and closed at the same time. However, Q2 and Q3 of h-bridge are in the complementary conduction mode. In order to prevent the straight-through phenomenon of Q1 and Q2, or Q3 and Q4, dead zone time is generally required.

![Figure 1. Bipolar pulse width debugging driver circuit](image)

FIG. 2 time sequence diagram of a power tube in a bipolar pulse modulation scheme over a period. The dual-polarity pulse width modulation drive mode is actually a cycle of four power tubes simultaneously on and off. When PWM on a device, the drive voltage of both ends of the motor is positive, and when PWM is off, the drive voltage of both ends of the motor is negative. When the duty ratio of PWM is 50%, the motor remains at rest; when the duty ratio of PWM is greater than 50%, the motor is forward; when the duty ratio of PWM is less than 50%, the motor is reversed. In fact, when the PWM duty ratio is 50%, the motor is not stationary. But in situ jitter, which can effectively overcome the static friction force of the motor, so that the motor at low speed in a stable, quick start, sensitive response, suitable for a good dynamic performance.
3. Improved bipolar pulse width debugging drive circuit

In this paper, a circuit for protection of bipolar drive is proposed. The specific circuit diagram is shown in FIG. 3.

As shown in figure 3, IC8 (microprocessor) will output PWM waves which control the motor speed. When at rest, IC8 will output PWM waves of 50% duty cycle. This PWM wave is connected to IC6 (data selector). When the PWM wave is at high level, 1B/2B/3B/4B in IC6 is output to 1Y/2Y/3Y/4Y, so that Q1/Q4 leads and Q2/Q3 closes. When PWM waves are low level, 1A/2A/3A/4A in IC6 is output to 1Y/2Y/3Y/4Y, so that Q2/Q3 leads and Q1/Q4 closes. Therefore, the function of IC6 is utilized to realize interlock of Q1/Q4 and Q2/Q3, which leads in turn in a cycle, but does not burn the drive circuit. If forward transmission is required, the duty ratio of PWM wave is increased to 50%. If inversion is required, the duty ratio of PWM wave is less than 50%. The truth table for IC6 (data selector) is shown in figure 4 below. When G is high, all output is low. When A/B is the input is low,
select the level of the output A channel. When A/B input is high, select the level of the output B channel.

![Figure 4. IC6 truth table](image)

When the drive circuit drives the motor to rotate, current sampling is conducted through R1. Here, three current values are sampled at the same point, respectively the effective current value, the blocked current value and the short circuit current value. When the motor current is greater than the effective current value, IC8 will control the PWM duty ratio to reduce the current current value. When the motor current is greater than the value of the blocked current, IC6 will be triggered to make all its output low level, protecting the driving current. When the motor current is greater than the short circuit current, the IC8 will directly control the brake to prevent the motor from losing control.

4. Conclusion
The dc motor and protection method based on the bipolar PWM drive proposed in this paper has solved the problem of burning through the same side conduction of the dual-polarity drive circuit and provided three current feedback protection methods. Even if the microprocessor program runs away, it will not burn down the drive circuit due to the existence of data selector.

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