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Working Principle and Signal Detection of Position Sensors in New Energy Vehicle Drive Motors

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Abstract: As the core feedback unit of the drive motor, the position sensor's failure will directly lead to motor control inaccuracy, abnormal power output, or even system shutdown, posing a serious threat to driving safety. Based on the National Vocational College Skills Competition's New Energy Vehicle Technology event, this paper combines the motor drive control simulation teaching platform. Starting from the installation position and function, structure and working principle, as well as common measurement methods of the motor speed sensor in the 2020 BYD Qin drive system, it provides solutions for students majoring in new energy vehicle technology or practitioners in the automotive maintenance industry.

Keywords:Position sensor; Drive system; New energy vehicle technology; BYD Qin;Automobile maintenance

1. Introduction

With the global automotive industry transitioning towards new energy sources, new energy vehicles have garnered widespread attention and rapid development worldwide. According to data from the China Association of Automobile Manufacturers, China's production and sales of new energy vehicles exceeded 13 million units in 2024, accounting for 70% of the global share, maintaining its position as the world leader for ten consecutive years. The rapid development of new energy vehicles not only demonstrates a commitment to environmental protection and sustainable development but also highlights significant technological innovation and industrial upgrading.

Among the many critical components of new energy vehicles, the drive motor is one of the core components, directly affecting the vehicle's power performance and driving experience. Li Jie and others combined the characteristics of dual-winding permanent magnet fault-tolerant motors, based on a sliding mode observer using data from two sets of windings, proposed a new method for diagnosing and fault-tolerant control of position sensor faults in dual-winding permanent magnet fault-tolerant motors. This method can effectively diagnose and ensure fault-tolerant operation of open circuit, jamming, and offset faults in system position sensors, enhancing the reliability of the system. In terms of technological breakthroughs, Huaxuan Sensing Technology Co., Ltd.'s developed 'a high-precision automotive-grade low-installation magnetic reluctance resolver suitable for high-speed motors' has been awarded an 'internationally advanced' level evaluation certification. This technology successfully solved the problem of low precision of position sensors in new energy vehicle high-speed motors, significantly improving the maximum speed and control accuracy of motor products, laying the foundation for cost reduction and efficiency improvement of motor systems, and promoting the progress of comprehensive domestication of sensors in new energy vehicles. Therefore, in-depth research on the working principle and signal detection of new energy vehicle drive motor position sensors is of great practical significance for enhancing the performance and safety of new energy vehicles.

Based on the above status quo, This paper, guided by the competition requirements, uses the 2020 BYD Qin drive system motor speed sensor as the research object, systematically elaborating on its installation location and function, structure, and working principle, while also detailing common measurement methods. The aim is to build a comprehensive knowledge system for students majoring in new energy vehicle technology and provide practical fault diagnosis and repair solutions for professionals in the automotive maintenance industry, thereby promoting the deep integration of new energy vehicle technology talent cultivation and industry practice.

2. Measurement Principles and Methods

The drive motor of new energy vehicles serves as the power core of the vehicle, operating based on the law of electromagnetic induction. Taking a common permanent magnet synchronous motor as an example, when three-phase symmetrical AC is fed into the stator windings, it generates a rotating magnetic field. According to the right-hand rule and Ampere's force law, this rotating magnetic field interacts with the magnetic field produced by the permanent magnets on the rotor, generating electromagnetic torque that drives the rotor to rotate. In the BYD Qin, the permanent magnet synchronous motor achieves efficient and stable power output through precise control of the current in the stator windings, ensuring good performance under different operating conditions.

The stator windings are divided into three types: excitation winding, detection winding S (outputting a sine signal), and detection winding C (outputting a cosine signal). The angle between detection winding S and detection winding C is 45° (Note: This may vary depending on different drives). Since the rotor is elliptical, the gap distance between the windings and the rotor changes as the rotor rotates. Therefore, by passing an alternating current through the excitation coil, different corresponding output powers are generated in detection winding S and detection winding C. The ECU can detect the position of the drive motor rotor based on the differences between these output powers. Even when the rotor is stationary, this position can still be detected.

3. The motor speed sensor measurement on the teaching platform

On the motor drive control simulation teaching platform, the drive motor speed sensor is installed at the rear of the motor shaft. The drive motor speed sensor has a total of 4 terminals, namely motor encoder power+, motor encoder power-, motor encoder A signal, and motor encoder B signal.We can measure the speed sensor voltage and waveform on the motor drive control simulation teaching bench using a multimeter and oscilloscope, and determine whether the speed sensor is functioning properly.

3.1 Measurement of power supply voltage

Voltage measurement is a common method for detecting analog signals. It involves measuring the voltage output from a sensor to determine the rotor position. For example, using a Hall effect sensor, as the rotor rotates, its magnetic field periodically affects the Hall element, causing corresponding changes in the Hall voltage. By detecting changes in the Hall voltage, the rotor's position and rotation angle can be determined. In practical applications, a voltmeter or voltage acquisition module is usually connected to the sensor's output end to convert the voltage signal into a digital signal, which is then transmitted to the motor controller for processing.

Locate the motor encoder measurement port in the measurement area, insert the two probes of the multimeter into the motor encoder power supply + and motor encoder power supply - respectively for voltage measurement, with the reference value of the voltage signal being 5V,as shown in Figure 1.

Figure1. Power supply voltage signal measurement

3.2 Measurement methods for waveform signals

Count the number of pulses from the encoder within a fixed time interval, and estimate the speed by calculating the ratio of the pulse count to the number of pulses per revolution of the encoder.

Locate the motor encoder measurement port in the measurement area, connect the oscilloscope's red probe to the motor encoder's A/B signal, and connect the black probe to the motor encoder's power supply negative (-) to measure the motor encoder signal waveform.

The standard waveform of the motor encoder is a 5V square wave. When the depth of the accelerator pedal is changed, the frequency of the measured waveform will also vary,as shown in Figure 2.

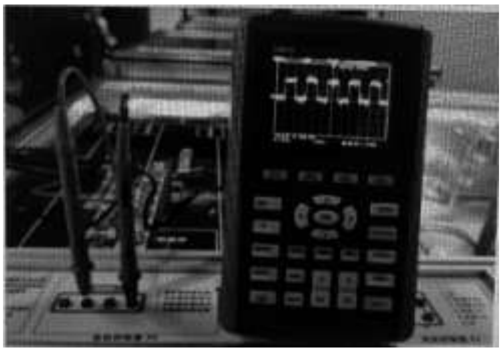

Figure 2. Measurement of A/B signals of motor encoder

4. Conclusion

This paper systematically elaborates on the working principle of position sensors for new energy vehicle drive motors, emphasizing their core role in real-time monitoring of rotor position and speed to ensure efficient motor control. By analyzingthe signal generation mechanisms of power supply. voltage and motor encoders, future development requires the integration of new materials and intelligent algorithms to advance sensors toward higher precision and integration, thereby facilitating performance upgrades in new energy vehicle electric drive systems.

5. References

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