Model Correction of Permanent Magnet Synchronous Motor based on Residual Compensation

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***Abstract*—This article takes permanent magnet synchronous motors as the research object, selects the vector control strategy of $i_d = 0$ to achieve speed and current dual closed-loop control, and focuses on the research of sensorless control strategy applied to permanent magnet synchronous motors. Using MRAS based on fixed axis $\alpha - \beta$ system to obtain speed and position information. At the same time, the feasibility of the proposed MRAS was demonstrated using the popov hyperstability theory. By designing appropriate algorithms to suppress current disturbances in the current loop, the ability to resist disturbances can be enhanced. Based on the above ideas, the interference of current and the observed electromagnetic velocity and angle will be discussed in MRAS. Then, design a current residual compensation scheme to compensate for current disturbance residuals in real time. The core parameters of residual compensation can be adjusted through the PI parameters of MRAS without any additional parameter adjustments.**

***Index Terms*—Permanent magnet synchronous motor, model correction, residual compensation.**

I. Introduction

Permanent magnet synchronous motor (PMSM), as the most prominent representative of permanent magnet motors, has continuously expanded its application fields due to its competitive advantages such as easy maintenance, high power density, good dynamic performance, and high reliability. In addition to CNC machine tools and household appliances, PMSM is also applied in fields such as wind power, aerospace, ships, and power systems. Due to the fact that PMSM excitation can be provided by permanent magnets, it eliminates components such as collector rings and brushes that are prone to faults in DC motors, achieving brushless operation. This not only simplifies the motor structure, but also improves the reliability of the motor. In addition, the development of computer related control technology and microprocessor technology, as well as the introduction of advanced methods such as Space Vector Pulse Width Modulation (SVPWM) and vector control, have made the prospects of PMSM development even brighter, and it has also received increasing attention in the field of motor control research. For vector control of PMSM, dual closed-loop control is usually used to regulate the motor current and speed. In this control method, the speed loop measures the motor speed to obtain the speed error signal, and uses the error signal as the input of the PI controller to adjust the current by outputting the current value. At the same time, the current loop measures the current value in the rotating coordinate system to obtain the current error signal, and uses this error signal as the input of the PI controller. After adjustment, the voltage value output by the PI controller is transmitted to the SVPWM module through coordinate transformation, and the motor speed is adjusted by changing the frequency of the three-phase voltage output by the inverter circuit. In this process, coordinate transformation requires the position information of the rotor to ensure that the rotor magnetic field and armature current are orthogonal, thereby maximizing the electromagnetic torque of the motor. Therefore, obtaining the speed and position information of the motor rotor becomes the key to vector control. In general, PMSM control systems use methods such as installing Hall sensors and photoelectric encoders to obtain rotor position and speed information. However, the working temperature range of mechanical sensors is limited and easily affected by noise. In some complex or harsh environments, such as humidity, high temperature, sandstorms, etc., sensors may experience abnormal operation, which can reduce the reliability of the entire system and lead to problems in the control system. Meanwhile, the installation of sensors will increase system costs, occupy more space, and limit the application and promotion of PMSM. Therefore, how to reduce or overcome the dependence of control systems on sensors has become one of the current research hotspots. In order to avoid potential issues with mechanical sensors during use and improve motor control performance, researchers have begun to delve into sensorless control technology. Position sensorless control technology refers to using the voltage and current signals of the motor to obtain the speed and position information of the rotor, thereby achieving vector control of PMSM. Compared to using sensors, sensorless control technology has its own advantages, such as relatively less wiring, lower production costs, more convenient operation and maintenance, and lower susceptibility to complex environments.