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Impact of Position Sensor Faults on the Control Performance of PMSM Drives

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Abstract: High-performance control of Permanent Magnet Synchronous Motors (PMSMs) relies heavily on accurate rotor position and speed information, typically provided by rotary sensors such as resolvers, incremental encoders, or absolute encoders. This information is essential for transforming stator currents into torque and flux components, enabling efficient motor control. However, the system's performance can degrade significantly when sensor faults occur, such as signal loss, drift, or voltage-induced deviations.

Resolvers are commonly used due to their robustness, but they come with increased complexity and cost. Their signals require digital conversion and advanced signal processing to extract rotor position information. Moreover, the accuracy of these sensors is sensitive to design tolerances and manufacturing variability.

To address these challenges, this paper introduces a fault diagnosis and fault-tolerant control (FTC) strategy for PMSM drives with salient poles, which aims to maintain system reliability in the presence of sensor faults. The proposed method integrates a standard vector control approach with virtual (sensorless) estimators, allowing the system to continue operating across the full speed range even during sensor failure. The fault detection mechanism compares measured rotor speed with a delayed version of the same signal, identifying anomalies without the need for additional hardware.

Although sensorless control methods typically do not match the accuracy of physical sensors like resolvers, the proposed approach ensures that position estimation errors remain within acceptable limits, thus avoiding excessive torque ripple and current distortion. This makes the method particularly effective for applications where cost, space, or fault tolerance are critical concerns.

The novelty of this work lies in its software-based solution that ensures uninterrupted motor operation, offering a practical and scalable alternative to hardware redundancy. This contribution represents a significant step forward in enhancing the robustness and reliability of PMSM control systems in fault-prone environments.

Keywords: fault-tolerant control, sensor fault, fault diagnosis, Observers, PMSM.

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