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Position Sensorless Advanced Control Techniques of Synchronous Reluctance Motor and Permanent Magnet Synchronous Motor

By

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ABSTRACT

This thesis introduces various modern control techniques with different sensorless schemes for the synchronous reluctance motor (SynRM) and permanent magnet synchronous motor (PMSM). Firstly, the mathematical principles of the system modeling are highlighted. Then, based on these principles, the general mathematical modeling of the nonlinear Synchronous motors (SMs) are investigated. By exploiting the form equations of nonlinear modeling of SMs, the nonlinear and linear modeling of SynRM, and linear modeling of PMSM are concluded. A fair comparison between the field-oriented control (FOC), finite control set current predictive control strategies (FCS-CPC), and novel strategy for finite control set speed predictive control (FCS-SPC) of the nonlinear SynRM are investigated and discussed.

In these control strategies, the rotor position and speed measurement are necessary which achieved by an incremental encoder. This encoder gives a good position and speed signal, at the expense of increased noise, increase cost, extra complexity, and decreasing the reliability due to the hazard of damage. As a result, to overcome the drawbacks associated with position/speed transducers, sensorless techniques are proposed for the SynRM and PMSM. The extended Kalman filter (EKF) is used to estimate the position and speed for both motors and decrease the total harmonic distortion

(THD) of the output currents. A robust sensorless speed predictive control of SynRM and PMSM based on EKF online estimation is investigated and compared with the conventional current predictive method. To decrease the computation burden the conventional FCS-CPC, a computationally efficient FCS-CPC is investigated and compared for the SynRM and PMSM. Furthermore, to increase the robustness of the proposed control strategies under parameter mismatches, online parameter estimation based on EKF is merged in the observer states. Different sensorless techniques have been investigated to SynRM and PMSM. Sensorless FOC based on high-frequency current injection is proposed for the SynRM. Sensorless control of PMSM based on the model reference adaptive system (MRAS) is investigated and discussed. The performances and feasibilities of the investigated strategies for SynRM have been validated with simulation results, while the control strategies for the PMSM are validated through experimental results. The results reveal the high robustness and reliability of the proposed strategies during different operating conditions.