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Fast Modelling, Torque-Ripple-Reduction and Fault-Detection Control of Switched Reluctance Motors

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A thesis submitted in fulfilment of the requirements for the degree of
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Contents

Abstract

As the world moves towards a cleaner and greener future, electrical machines for various industrial purposes and transport applications have gained a lot of attention. Permanent magnet synchronous machines (PMSMs) are usually the solution for electric vehicle (EV) applications thanks to their high efficiency, compactness and high-power density. On the downside, although the price of rare-earth materials has recovered close to historical levels, concerns still remain and the questions on the environmental sustainability of these materials have also been raised, which has encouraged the researchers to consider rare-earth-free machines.

The switched reluctance machine (SRM) is one of the competitive alternatives, thanks to the simple and robust construction, high reliability and inherent fault tolerance capability. However, it has a bad reputation when it comes to torque ripple and acoustic noise. And the highly nonlinear characteristic brings much difficulty to routine design purposes and machine optimisation.

Therefore, some of the above mentioned problems are addressed - a torque-ripple-reduction, reliable and low-cost system of SRMs is presented in this thesis. Firstly from the modelling point of view, a combined magnetic equivalent circuit (MEC) and finite element (FE) model of SRMs is developed for fast characterization the nonlinear behavior. Secondly from the control point of view, various torque-ripple reduction techniques are implemented and compared. Moreover, a minimal current sensing strategy with enhanced fault-detection capability is proposed and validated experimentally. It requires two current sensors, to replace the phase current sensors, with no additional devices for fault detection, to achieve a more

compact and low-cost drive. Finally from the reliability point of view, an interturn short-circuit fault detection method and a rotor position estimation approach are investigated and validated experimentally, which leads to a more reliable system.