Abstract of Ph.D. Thesis

"MTPA and MTPV Control Optimization Schemes for Double-Inverter fed Wound Rotor Induction Motor Drive"

Ms. Cheshta Jain (2017EEZ8154)

ABSTRACT

This thesis proposes torque optimization control schemes for a Double-Inverter fed Wound Rotor Induction Motor (DI-WRIM) drive, focusing on Maximum Torque per Ampere (MTPA) and Maximum Torque per Voltage (MTPV) strategies. Additionally, it provides an extensive analysis of the flux weakening region in DI-WRIM drives, an area that has yet to receive much attention in the existing literature. These MTPA and MTPV control schemes are designed to facilitate wide speed range operation of the drive.

Existing literature offers numerous PI-based and hysteresis-based control schemes for DI-WRIM drives. PI-based schemes are typically developed for machine models in various reference frames, including rotor flux-oriented, airgap flux-oriented, and stator/rotor current-oriented frames. Hysteresis-based control schemes, such as Dual-Direct Torque Control (DDTC) and Dual-Direct Current Control (DDCC), are also widely discussed.

Initially, the present research develops and integrates MTPA and MTPV control schemes with the PI-based control scheme in the rotor flux-oriented reference frame. The drive's operation is analyzed in the stator current plane for both the constant torque region (CTR) and the flux weakening region (FWR). Based on this analysis, an MTPA control scheme is developed to enable wide speed operation of the DI-WRIM drive. Further, the stability, sensitivity, and convergence analysis of the proposed MTPA scheme is presented with the primary aim to validate its efficacy and operational soundness. The influence of parameter variation is studied. Moreover, a comparative study of the proposed control with the existing control techniques is performed to highlight its advantages. This comprehensive approach ensures that the MTPA control scheme is robust, reliable, and effective across a wide range of operating conditions.

Subsequently, the flux weakening region is analyzed in the stator voltage plane, leading to the development of an MTPV control scheme. The performance of the MTPV control scheme is thoroughly demonstrated, particularly during variations in the DC link voltage.

To simplify the implementation of MTPA and MTPV control schemes, additional machine analyses are performed in airgap flux and stator/rotor current reference frames. This results in developing corresponding MTPA and MTPV control schemes suitable for these frames.

Further, in the airgap flux reference model, the torque components of stator and rotor currents, which are equal in magnitudes and opposite in nature, are controlled from their respective sides. This leads to large overshoots in the direct and quadrature axes currents and may also lead to instability. This problem is solved by implementation of an improved FOC scheme in the airgap flux reference frame.

Finally, MTPA/MTPV control schemes are tailored for integration with the DDCC scheme. These control schemes are analyzed, simulated using MATLAB Simulink, and experimentally verified on both symmetric and asymmetric DI-WRIMs, demonstrating their effectiveness and practical applicability.

The MTPA/MTPV control, in general, minimizes the machine current for a given torque reference. This ability to maximize machine torque with a restricted source voltage and inverter current capability increases the performance of electro-mechanical systems, e.g., traction, wind energy, and industrial systems. As a result of optimizing the torque to ampere ratio, the motor efficiency that can be achieved is almost as high as that can be achieved using the minimal active losses optimization criterion.