Abstract

The presence of VSCs on the stator and rotor terminals of Double-Inverter fed Wound Rotor Induction Machine (DI-WRIM) drives add to the power handing capability and control flexibility of the drive. However, due to the stator and rotor VSCs, the control and implementation complexity as well as the harmonic content of the drive is also increased. This thesis deals with the minimization of control and implementation complexity and, the harmonic content in the DI-WRIM drives.

To minimize the control and implementation complexity, the DI-WRIM drive is modelled and controlled as '2' virtual SQIMs. In the proposed modelling and control technique of DI-WRIM as '2' virtual SQIMs, the stator and rotor side controllers are identical to conventional FOC based SQIM drives. Thus, to control the DI-WRIM drive, two FOC based SQIM drives can be directly connected to the stator and rotor terminals of the WRIM, with some external communication. The '2' virtual SQIMs must produce a common torque in the air-gap and hence, the '2' virtual SQIMs are coupled using a common medium of coupling and this medium is the load angle between the stator and rotor currents. The feasibility of the proposed modelling and control technique is presented through extensive experimental results.

Unlike in SQIM drives, the harmonic source on the rotor side of the DI-WRIM also contributes to the ripple, along with the stator side harmonic source. This ripple is superimposed on the stator and rotor, fundamental fluxes and currents and, the generated torque. Thus, the harmonic model of the DI-WRIM drive is presented, in this thesis. Similar to the ripple analysis of SQIM drives, the torque ripple and current ripple in DI-WRIM is formulated in terms of the stator and rotor flux ripples, which are estimated from their respective sides. To facilitate the open-loop estimation of torque ripple and current ripple, a rotor position (speed) independent transformation technique is also proposed, to transform the estimated flux ripples to a single flux oriented reference frame. One important aspect of the harmonic analysis is that the interaction of stator and rotor flux ripples, which form current and torque ripple, is dependent on the mode of operation of WRIM. Therefore, stator-rotor PWM combinations, formed using the available PWM techniques, are proposed to reduce the torque and current ripple. Apart from the torque and current ripple in DI-WRIM, the variation of switching loss in the stator and rotor VSCs, due to the variation of stator and rotor power factors, is also analyzed. Based on the analysis, stator-rotor PWM combinations are also proposed to solely reduce switching loss and to reduce both current ripple and switching loss, along with flux sharing schemes between stator and rotor sides. The proposed PWM combinations, which are dedicated to reduce torque ripple, current ripple and/or switching loss, are independent within each other and does not majorly effect the other ripple.

The topology of DI-WRIM resembles the topology of Double-Inverter fed Open-End Winding Induction Machine (DI-OWIM) drive. In the DI-OWIM drive, each of the two stator winding terminals are connected to two individual VSCs, with isolated dc-link. The two VSCs are switched such that a 3-Level

Neutral Point Clamped (3L-NPC) converter is emulated on the stator terminals of the OWIM, in terms of the phase voltage. Thus, the ripple in the OWIM is similar to that of a 3L-NPC converter fed SQIM (3L-SQIM). This resemblance of DI-OWIM in DI-WRIM is explored to develop Equivalent 3L (EQ-3L) stator-rotor PWM combinations such that, a 3L-NPC converter is emulated in the air-gap of the WRIM, in terms of the quadrature axes flux ripples. With the proposed EQ-3L PWM combinations, the torque ripple in DI-WRIM is equivalent to the torque ripple in 3L-SQIM drive and it is further reduced when compared to stator-rotor PWM combinations formed using available PWM techniques.

The proposed modelling and control technique, combined with the proposed stator-rotor PWM combinations, can be a solution towards high performance DI-WRIM drive.