ABSTRACT

The main aim of the thesis is to investigate the issues related to BLDC motor performance, various control techniques for torque ripple mitigation and analyze the effect of speed on the commutation torque ripple with 2-ΦO of the BLDC motor drive and present the closed-loop speed control of brushless dc (BLDC) motor with the two-phase operation(2-ΦO), two-three-phase operation (2-3ΦO) and three-phase operation(3-ΦO) using different control techniques to obtain improved motor performance with reduced torque ripple.

For this, first of all, the analysis of closed-loop control of BLDC motor with the conventional six-step control is investigated and the various conditions responsible for the production of commutation torque ripple are studied in detail. The effect of motor speed on the torque ripple is analyzed based on the commutation logic for the three-phase inverter circuit acting as an electronic commutator. The simulation of the six-step control with 2-ΦO is performed using MATLAB®/SIMULINK. The behavior of phase current on the motor torque is observed under varied speed and load conditions. The detailed results of this technique are used for the comparison with the proposed 3-ΦO of the BLDC motor. As this method directly uses the hall signal output to energize the three stator winding with no current or voltage control, the dynamic response is poor and leads to a high torque ripple deteriorating the motor performance.

Secondly, to improve the motor performance by providing a commutation logic for the 3-Φ VSI, a conventional 2-ΦO of BLDC motor speed control with hysteresis current control technique(HCCT) is discussed and modeled with an inner current control loop and outer speed loop using MATLAB®/SIMULINK. The closed-loop control of BLDC motor when operated in 120° conduction mode develops quasi square wave current in phase with the trapezoid back emf leads to finite torque ripple in the commutation region with only two phases conducting at any time. The closed-loop speed control of the BLDC motor drive is validated by experimental results. This technique provides improved performance of motor than conventional six-step control.

To overcome the drawback of increased torque ripple with the two-phase operation(2-ΦO), a modified direct torque control approach with a two-three-phase operation (2-3ΦO) is developed. A modified twelve-step direct torque control (MTSDTC) with ONPWM and

PWMON control with two-phase conduction control in conduction region and zero switching concept in commutation region is developed. This is incorporated by selecting the appropriate voltage vectors from the lookup table developed for each method. The developed method reduces the switching losses along with the elimination of dead band which needs much attention in conventional six-step direct torque control (SSDTC)and twelve-step direct torque control(TSDTC) technique. The simulation of all the DTC techniques is performed in MATLAB®/SIMULINK. The simulation results demonstrate reduced torque ripple as compared to conventional 2-3ΦO with TSDTC at varied speed and loading conditions leading to the smooth operation of the drive. The closed loop speed control is achieved with the proposed technique with the real motor speed following the reference speed. A comparative analysis of the conventional DTC techniques with the developed MTSDTC ONPWM and PWMON is provided to prove their effectiveness. The proposed work is validated by experimental results.

A novel control technique for 3-ΦO of BLDC motor drive is proposed using modified sinusoidal pulse width modulation (MSPWM) technique with only one PI controller and fewer computational steps. This technique provides three-phase sinusoidal stator currents instead of quasi square wave currents in synchronism with the trapezoid back emf reducing the stator copper losses. The proposed technique also provides a higher DC bus utilization as compared to conventional six-step control. This control technique is investigated using MATLAB®/SIMULINK. The simulation results prove that the torque ripple with the proposed technique is reduced up to 50% as compared to the conventional six-step operation of the motor thus improving the motor performance at varied speed and loading conditions. This method also provides the closed loop speed control with the measured motor speed following the reference speed. A comparative analysis of the torque ripple of the proposed work with the conventional six-step operation is provided to prove its effectiveness. The proposed work is validated by experimental results.