ABSTRACT

With the recent inventions and advancements in high flux density and high performance, permanent magnets like neodymium-boron iron and samarium cobalt Permanent Magnet Synchronous Motor (PMSM) came into existence. Permanent magnet (PM) motors became very popular due to their simple structure, efficiency, robustness and high torque/size (or weight) ratio. One of the most popular control methods of three phase motor drive systems, well developed during the last decade, is Field Oriented Control (FOC), usually realized with a digital Pulse Width Modulation (PWM) controller in rotating, direct-quadrature coordinate space. PMSM is widely used in industrial servo applications due to its high performance characteristics. However, torque pulsations are present in PMSM due to inverter switching, cogging, flux harmonics and errors in current measurement. These torque pulsations result in periodic speed ripples and torque ripples, which restrict its wide acceptance as servo drives. For applications that require precise tracking, the machine should be free of torque ripples. Field oriented vector controlled PMSM drive affords improved dynamic response and minimum torque ripples, and requires a constant switching frequency for working. In order to minimize the torque ripples, many methods are proposed in literature. These methods can be classified into two types, one based on proper motor
design and the other based on active control schemes. There are instances where proper motor design is not sufficient to achieve the required level of torque ripple reduction. For such instances, active torque control schemes play a vital role in minimizing the torque ripples. The major challenge is to develop a new active torque control scheme to minimize the torque ripples so as to suit the application requirements.

The main objective of the proposed research is to develop a new active torque control scheme to minimize the torque ripples in PMSM driven by field oriented control. The thesis investigates the results of the developed active torque control schemes by reduction in Torque Ripple Factor (TRF) expressed as a percentage.

The following two instantaneous FOC techniques operating at constant torque, namely, Iterative Learning Controller (ILC) in combination with Hysteresis Pulse Width Modulation (HPWM) and ILC in combination with Space Vector Pulse Width Modulation (SVPWM) respectively are proposed to reduce torque ripples in PMSM.

These two techniques are simulated under different load conditions using the SIMULINK under MATLAB and the results are presented and compared. The results of the simulation show that the ILC with SVPWM based field oriented control of PMSM has lesser torque ripples in comparison
with ILC with HPWM based field oriented control of PMSM, and all the existing methods.

Artificial Neural Network (ANN) Controller with SVPWM based FOC of PMSM operating at constant torque has been proposed to reduce torque ripples. The proposed ANN consists of feed forward network structure, composed of one input layer, one output layer and three hidden layers. The structure of three hidden layer having three neurons gives satisfactory results. The input layer accepts the present torque error and previous torque error as inputs. The output of the ANN controller is used to control the torque. The design, analysis, and simulation of the ANN controller with SVPWM based FOC of PMSM is simulated using SIMULINK under MATLAB. The results of simulation of the ANN with SVPWM based FOC of PMSM shows that the proposed ANN with SVPWM based FOC of PMSM is superior to the existing methods.

Furthermore two instantaneous FOC techniques operating at constant torque, namely, Fuzzy Logic Controller (FLC) with HPWM and FLC with SVPWM respectively are proposed to reduce torque ripples in PMSM.

The inputs to the FLC are torque error and change in torque error and the output is torque limit. Each of the inputs and output contains seven membership functions with 49 rules. The design, simulation and analysis of the proposed systems, namely, FLC with HPWM based FOC of PMSM and
FLC with SVPWM based FOC of PMSM respectively are done using SIMULINK under MATLAB. The result of the simulation shows that the proposed FLC with SVPWM based FOC of PMSM has the least TRF of 1.75% which is less than all the proposed methods.

The experimental verification is done for FLC with SVPWM based FOC of PMSM in FPGA controller SPARTAN 3A DSP. The results of the simulation are validated with the experimental results in PMSM prototype.