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Applications of Fractional Calculus for Modeling and Control of Electrical Machines

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ABSTRACT

Permanent Magnet Synchronous Machines (PMSM) are recently used in many electromechanical applications due to their high efficiency and great torque to current ratio. Due to these advantages, many of the research works are focusing on improving the PMSM drive performance. This thesis represents an attempt to introduce a PMSM drive with an improved and optimized performance at reduced cost using a sensorless speed estimation technique.

This work introduces a Fractional Order Field Oriented Control (FO-FOC) with a sensorless Model Reference Adaptive System (MRAS) for the Permanent Magnet Synchronous Motor (PMSM). In this work, the conventional integer controllers of the vector control method are replaced with the Fractional-Order PI (FOPIα) controllers. Particle Swarm Optimization technique (PSO) is employed to tune the gain, integration parameter and the fractional order parameter for each of the speed, current, and MRAS controllers to get the optimum values. The presented methodology is tested using MATLAB Simulink simulation and the results show improved performance of the field- oriented control technique by the employment of the fractional order controllers instead of the conventional integer at different operating points. Furthermore, the additional degree of freedom in the fractional controllers helps the PSO technique to get the optimum cost at a very low number of iterations compared with that of the integer one.

The results obtained in this work can be considered as a start point for applying online PSO tuning methodology within the drive algorithm taking advantage of the very fast optimization results obtained for the fractional order controllers.