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Sensorless Control of Induction Motors for Industrial Applications

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ABSTRACT

This research has been carried out by A.C.S. Wijayatilake for the fulfillment of M.Phil. degree at the University of Peradeniya. This postgraduate program was conducted by the Department of Electrical and Electronic Engineering at University of Peradeniya in collaboration with the Royal Institute of Technology Sweden. Financial assistance was given by Swedish International Development Cooperation Industry.

The objective of this research is to select a suitable speed sensorless algorithm for implementing in a vector controlled induction motor drive system. This research is a part of the project which is being carried out at University of Peradeniya to design a low cost vector controlled variable speed drive system for local industry.

At present the vector control technique is widely used for high performance induction motor drives where knowledge of motor speed is essential. Normally, tachogenerators or optical encoders are used to measure the rotor speed. However, these speed sensors impair the ruggedness, reliability and simplicity of the induction motor. In this regard, many kinds of field oriented algorithms without speed sensors have been proposed. However, many researchers interested on the theoretical analysis rather than evaluating their suitability for being used in an actual drive system. Since many algorithms are depending on machine parameters, changes in temperature and saturation levels of the machine vary the steady state and dynamic operation of the drive system. In addition to that the behavior of sensorless techniques and their limitations should be well known when implemented in a commercial drive system. This research presents comprehensive theoretical analysis followed by experimental determination of the characteristics of few selected senorless

algorithms in order to evaluate their suitability to be implemented in a commercial drive system.

At the beginning of this thesis basic theoretical background and design of vector controller is discussed briefly. This thesis presents the theoretical description of seven leading sensorless algorithms: Rotor flux based MRAS, EMF based MRAS, Reactive power based MRAS, Luenberger Observer based method, High frequency signal injection method, Neural Network based method and modified Indirect Field Orientation method. The design considerations of different controllers associated with each technique is discussed here. Performance of each method is evaluated through simulations using SIMULINK software. Based on the simulation results, three best performing algorithms are selected and implemented in DSPACE DS1102 DSP system which has 32 bit floating point TMS320C31 processor. The implementation problems and remedial measures are comprehensively discussed. The experimental results clearly indicate that any of the tested speed sensorless algorithm does not perform equally at all operating points. All algorithms exhibit poor speed regulation at low speeds and some of them are unstable at low speed and/or at speed reversal operations. Experimental performance comparisons of implemented algorithms are presented and this comparison can be used as a guide line to select speed sensorless algorithms for a particular applications. The conclusion is that all sensorless techniques discussed here can not be generally adapted to all applications since they exhibit poor performance at different speed regions as well as different operating modes such as regenerating mode. Hence, analyzed speed sensorless algorithms are

application specific and should be selected critically considering the speed and load profile of the particular application.