Sensorless Control of a Matrix Controlled Variable Speed Double Fed Induction Machine

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Project Brief
Aims & Objectives

Sensorless control is a branch in power electronics which studies how machines can be controlled without the use of speed sensors such as encoders or tachogenerators. This project was aimed at the review and design of sensorless techniques to be applied on a variable speed Double Fed Induction Machine (DFIM) which is driven through a matrix converter. The angular speed and rotor angle estimates, output from the sensorless block are to be used for Stator Field Orientation (SFO) vector control of the DFIM.

Methodology
Tools & Prototype

Model Reference Adaptive System (MRAS) observer was chosen as the ideal sensorless technique when considering the experimental rig available. A vector control environment complete with MRAS (Figure 1) was simulated using Simulink©. The MRAS observer consists of two stator flux models (Figure 2) which are expressed mathematically as:

Voltage Model: $$\psi_{S_{\alpha\beta}} = \int v_{S_{\alpha\beta}} - R_S i_{S_{\alpha\beta}}\, dt$$

Current Model: $$\hat{\psi}_{S_{\alpha\beta}} = L_S i_{S_{\alpha\beta}} + L_O i_{R_{\alpha'\beta'}} e^{j\hat{\omega}_R t}$$

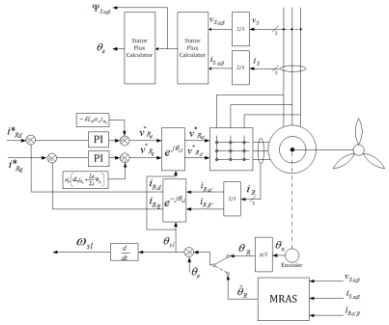

Figure 1 – SFO Vector Control for DFIM with MRAS

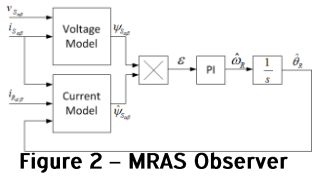

Figure 2 – MRAS Observer

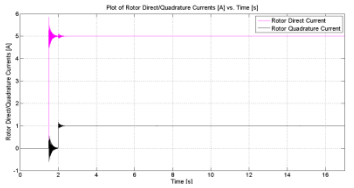

Figure 3 – Plot of Rotor Direct/Quadrature Currents [A] vs. Time [s]

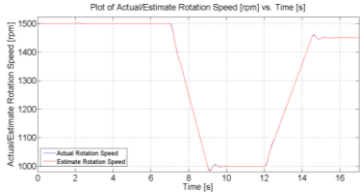

Figure 4 – Plot of Actual / Estimated Rotation Speed [rpm] vs. Time [s]

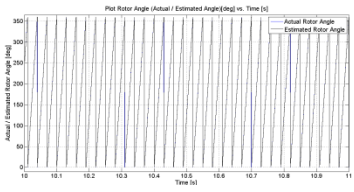

Figure 5 – Plot of Rotor Angles [degrees] vs. Time [s]

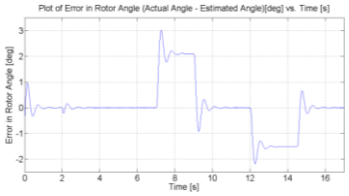

Figure 6 – Plot of Error in Rotor Angle [degrees] vs. Time [s]

Results & Conclusions
Results & Prototype

Results from the Simulink© simulation are shown in Figures 3-6. Vector control with the encoder angle is started at 0 s while machine shaft is driven at 1500 rpm. Ird = 5 A and Irq = 1 A reference currents are given at 1.5 s and 2 s respectively (Figure 3). MRAS observer is switched on at 2 s and can be seen to track the actual speed (Figure 4) while keeping the error in the estimated angle to a minimum (Figure 5-6). Maximum error in the angle for the period shown is 3° while tracking ramp.

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