Assessment of steady-state losses in electrical drives

Giampaolo Torrisi, Dr. Sebastien Mariethoz, Prof. Roy Smith
Automatic Control Laboratory – ETH Zurich

Introduction

Field Oriented Control
Dynamic performance
Constant nominal flux
Non-optimal for losses
Model with linear inductances
Sufficient for basic control
A non-linear model for the inductances is necessary to optimize losses

Induction Motor modeling

Model with linear inductances

\[
\dot{x} = A_x x + B_u u + A_{s1}\omega_e x + A_{r1}\omega_e x \\
\dot{x} = \left[ \begin{array}{c} \dot{\psi}_{r1} \\ \dot{i}_{sd} \\ \dot{i}_{sq} \end{array} \right] \\
u = \left[ \begin{array}{c} u_{sa} \\ u_{sb} \end{array} \right]
\]

Requires an accurate model

• Unavailable from manufacturer
• Theoretical Jiles-Atherton relations
• Experimental evaluation

Experimental test for saturation

Experimental set-up

Inductances with saturation effect

Steady-state optimal currents

Optimization of stator currents

Inductances with saturation effect

Steady-state power losses


Improvements in efficiency

Losses as a function of the torque


Future work

• Real-time control of stator currents to achieve dynamically theoretical savings
• Capability to optimally control varying loads known in advance
• Take into account hysteresis and iron losses

Motor on test: Baldor EM3546, 750 W - 1 hp, 115 V, 60 Hz, 2 pole pairs. Nominal Torque = 2.073 Nm