EE321 Exam 4
Spring 2010

Notes**: You must show work for credit.**

Trigonometric identities are towards the back of Exam 5.

1.) 20 pts. An induction machine stator winding produces an MMF of the form

$$F_s = 100\cos(100t + 4\phi_{sm})$$

where ϕ_{sm} is measured in the CCW direction (as normal). The mechanical rotor speed is 200 rad/s in the CW direction. What is the speed and direction of the rotor MMF as viewed from the rotor.

2.) 20 pts. Consider a two-phase induction machine. Suppose the stator and rotor variables are transformed to the synchronous reference frame in which

$$\mathbf{f}_{qds}^{e} = \mathbf{K}_s^e \mathbf{f}_{abs}$$

$$\mathbf{K}_s^e = \begin{bmatrix} \cos\theta_e & \sin\theta_e \\ \sin\theta_e & -\cos\theta_e \end{bmatrix}$$

$$\mathbf{f}_{qdr}^{e} = \mathbf{K}_r^e \mathbf{f}_{abr}$$

$$\mathbf{K}_r^e = \begin{bmatrix} \cos(\theta_e - \theta_r) & \sin(\theta_e - \theta_r) \\ \sin(\theta_e - \theta_r) & -\cos(\theta_e - \theta_r) \end{bmatrix}$$

where θ_e is the position of the synchronous reference frame, $d\theta_e / dt = \omega_e$, and the referred rotor flux linkage equations may be expressed:

$$\boldsymbol{\lambda}'_{abr} = L'_{rr} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \mathbf{i}_{abr} + L_{ms} \begin{bmatrix} \cos\theta_r & \sin\theta_r \\ -\sin\theta_r & \cos\theta_r \end{bmatrix} \mathbf{i}_{abs}$$

Express the rotor flux linkage equations in the synchronous reference frame.

(extra paper for problem 2)

3.) 20 pts. Consider a 3-phase singly-fed induction machine in which there is no leakage inductance (stator or rotor) or stator resistance. For this machine, starting with the phasor equivalent circuit and the phasor expression for torque (torque in terms of $\tilde{I}_{as}$ and $\tilde{I}_{qr}^{'}$) derive an expression for torque in terms of V_s, ω_e, ω_r, and $r_r^{'}$.

4.) 20 pts. Consider a 3-phase wye-connected machine with the following parameters: $r_s = 72.5\ m\Omega$, $L_{ls} = L_{lr}^{'} = 1.32$ mH, $L_M = 20.1$ mH, $r_r^{'} = 41.3\ m\Omega$, and $P = 4$. A balanced 3-phase voltage source with of 460 V l-l rms amplitude and 60 Hz frequency is applied to the machine. Assuming L_M is infinite, what is the a-phase rms stator current into the machine if the rotor is blocked. Not assuming L_M is infinite, with rated voltage and frequency, what is the a-phase rms stator current into the machine under no-load conditions.

5.) 20 pts (2 pts each). Short Answer

a.) Of the types of induction machine control strategies we discussed, which one would be most appropriate for a hybrid electric vehicle application?

b.) Of the types of induction machines we discussed, which is the most appropriate for wind power generation?

c.) Which of the four types of induction machines models we discussed would be most appropriate to predict transient behavior?

d) Name two advantages of maximum-torque-per-amp control over voltz-per-hertz control.

e) Name two advantages of volts-per-hertz control over maximum-torque-per-amp control.

f) Name two reasons why the induction machine model does not yield as accurate predictions of machine performance as the brushless dc machine model does for that machine.

g) Would our phasor equivalent circuit work if the amplitudes of the phase voltages were unequal?

h) Why is the ratio of voltage over frequency held constant in volts-per-hertz control?

i) Could you have a machine with a three-phase stator and a two-phase wound rotor (i.e., would it work)?

h) When determining machine parameters using the blocked rotor test, why is a reduced electrical frequency used?