PE-2

August 2015 QE

Problem 1. 34 pts. Consider a 3-phase non-salient permanent-magnet ac machine. Starting from the machine *qd* voltage equations, the *qd* flux linkage equations, the *qd* torque equation, and expressions for input and output power, show that if voltage magnitude is of no concern and it is desired to achieve a certain torque, then power loss is minimized by placing all current into the *q*-axis (i.e. the *d*-axis current should be zero)

Problem 2. 33 pts. Consider a non-salient 3-phase synchronous machine with zero stator resistance. Recall that

$$v_{qs}^{r} = \sqrt{2} v_s \cos\delta$$

$$v_{ds}^{r} = \sqrt{2} v_s \sin\delta$$

$$T_e = \frac{3}{2}\frac{P}{2}\left(\lambda_{ds}^{r} i_{qs}^{r} - \lambda_{qs}^{r} i_{ds}^{r}\right)$$

Starting from the machine *qd* voltage equations and the *qd* flux linkage equations, derive an expression for steady state torque in terms of $v_s, \delta, i_{fd}^{'r}, P, L_{md}$, and L_d.

Problem 3. 33 pts. Consider an 8-pole 3-phase induction motor. The stator MMF is traveling at a mechanical speed of 500 rad/s CCW relative to the stator. The rotor MMF is moving at a mechanical speed 200 rad/s CW relative to the rotor. (a) What is the speed of the machine? (b) What is the absolute value of the radian frequency of the stator currents? (c) What is the absolute value of the radian frequency of the rotor currents? (d) Is the machine operating as a motor or as a generator?