1) A 3-phase surface-mount permanent magnet synchronous machine has a peak phase current rating of I_{peak}. (34 pts)

a) Assume you have a machine in which currents are controlled. If there is only stator copper loss (no core loss or friction/windage loss), and you can apply arbitrarily large phase voltage, draw the **maximum** torque you can obtain from the machine as a function of rotor speed. Express the torque in terms of the I_{peak}, Poles, and λ_m.

b) If, in addition to copper loss, you had loss which results from time-changing flux density in the machine, explain where the majority of the loss would occur, stator or rotor? (Assume sinusoidal flux density waveforms with no harmonics).

2) A 3-phase induction machine is connected to a 377 rad/s utility and is driven mechanically to the operating point shown in the Figure 1. Assume all reference angles used for the machine analysis are defined positive in the counter clockwise direction. For the operating condition shown in Figure 1, complete Table 1 and Table 2. (33 pts)

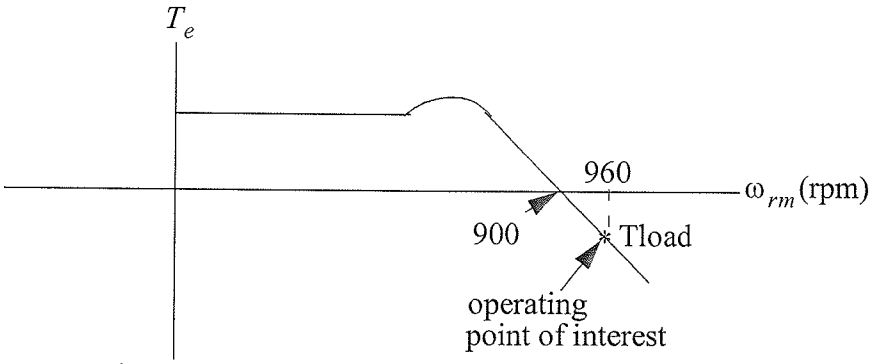

Figure1: Torque/speed curve of induction machine.

Table 1:

	actual (abc) variables	stationary reference frame $\omega = 0$	rotor reference frame $\omega = \omega_r$	synchronuous reference frame $\omega = \omega_e$
frequency of stator currents				
frequency of rotor currents				

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Table 2:

	Velocity and Direction of the Stator MMF	Velocity and Direction of the Rotor MMF
Viewed From Observer on Stator		
Viewed from Observer on Rotor		

3) A non-salient, 3-phase wound-rotor synchronous machine is connected electrically to the utility power system. The rotor shaft is connected to a dynamometer that is operated under a torque-control mode - i.e. it maintains a fixed input torque that is a negative value. The synchronous machine is operated as a generator. The rotor speed is 377 rad/sec. Assume that stator currents are defined positive into the machine. The field winding is initially set to a minimal value that maintains synchronism with the utility. (33 pts)

a) Is δ positive or negative? Explain.

b) As the field current increases, does the steady-state δ increase or decrease? Explain.

c) Assume the field is adjusted so that only reactive power is being provided to the utility. Draw the two potential phasor diagrams showing the relationship between $\tilde{V}_{as}$, $\tilde{I}_{as}$, and $\tilde{E}_{as}$. Neglect stator resistance.

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