EEL745 Electrical Drives System
Major test

Date and Time: 4/5/2007 10:30 am -12:30 pm
Venue: II-325
Max Marks: 50

A. Multiple Choice Questions (**5 MARKS**) Wrong answers carry a penalty of **-0.5 mark.**

1. Which of the following motors will have the highest full-load speed for the same value of no-load speed
(a) Cumulatively compounded DC motor
(b) Differentially compounded DC motor
(c) DC shunt motor
(d) Level compounded DC motor

2. A Three-phase full-converter is feeding a separately excited DC motor drive (with closed loop control) under rated conditions with $\alpha = 35°$ If the load is decreased, and the motor is allowed to attain steady state
(a) the back emf will increase.
(b) The firing angle will increase automatically due to the action of closed loop
(c) Either of (a) or (b) will happen along with probably the current becoming discontinuous
(d) Cannot say anything.

3. The limitations of regenerative braking are
(a) Energy efficiency wise it is the poorest.
(b) It requires speeds greater than normal no-load speed
(c) If solid-state control is being used it needs a bidirectional converter
(d) All of the above
(e) Options (b) and (c)

4. When a salient pole synchronous motor connected to an infinite bus is working on 10% load and the field excitation is abruptly cut off
(a) it will continue to run in motoring mode normally
(b) it will start working as a generator
(c) it will stall
(d) Cannot say anything

5. In a squirrel-cage induction motor, if the thickness of the rotor bars is increased,
(a) it will affect the starting torque
(b) it will affect the starting current
(c) it will affect the power factor
(d) all of the above will be affected
(e) only (a) and (b) are correct.

B. Short Questions (**5 x 2 =10 Marks**)

1. The air gap in a synchronous motor is normally less than that of a 3-phase induction motor of comparable rating. State TRUE or FALSE and justify.
2. A multi stack variable reluctance stepper motor with 4 stacks and 9 rotor teeth will have a step angle of ---- degrees. If a pulse of 1 kHz frequency excites the stacks of the machine then the speed would be --------- rpm.
3. For a 1hp, 3-phase, 415 V, 50 Hz, 2-pole, 2950 rpm cage induction motor with Lm=100 mH, in which of the following two cases, the capacitor braking will be more effective and why? (a) 102 μF (b) 200 μF

4. A separately excited DC motor connected to a 220 V battery, is working under regenerative braking mode by means of a class B chopper, at constant excitation. If the duty ratio of the chopper is varied from 0.2 to 0.4, will the rate of reduction in speed with respect to time, increase or decrease? Justify your answer
5. Dynamic braking is more effective in ----------(shunt/separately excited) DC motor because---
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C. Long questions:

1. A motor equipped with a flywheel has to supply a load torque of 600 Nm for 12 sec followed by a no-load period long enough for the flywheel to regain its full speed. The maximum torque that can be delivered by the motor is 450 Nm. The motor has a rated slip of 4% while delivering the rated torque of 225 Nm with its no-load speed being 600 rpm. Assume that the speed-torque curve is linear in the region of interest. What should be the moment of inertia of the motor + flywheel together and what will be the minimum speed achieved? Derive any formulae used. **(7 Marks)**
2. A 200V, 60 A DC series motor has R_a=0.06 Ω and R_f=0.04 Ω respectively. The machine was run on no-load at 500 rpm, with field winding connected to a separate DC source, the following OCC was obtained.

I_f Amp	10	20	30	40	50	60	70
V_t Volts	53	98	125	142	153	162	168

The motor is controlled in regenerative braking by a chopper with an input voltage of 200V. Calculate (a) the motor speed for a duty ratio of 0.4 at motor braking torque equal to rated value. (b) Maximum allowable motor speed for a maximum allowable current and duty ratio of 60 A and 0.9 respectively. (c)Resistance to be inserted in series for motor to run at 800 rpm without exceeding an Ia of 60 A. The range of duty ratio of the chopper is 0.1 to 0.9. (d) the value of divertor resistance to be connected in parallel with the series field to run the motor at 800 rpm without exceeding Ia beyond 60 A. **(6 Marks)**
3. A 3-phase 15 kW, 415V, 50Hz, 6-pole, ~~960~~ 912 rpm Y connected induction motor gave the following test results under blocked rotor test: 200V, 50A,cosΦ=0.415. The motor drives a load having a constant torque of 175 Nm. (a) Estimate the possible reduction in voltage before the motor stalls assuming that the copper losses are equally divided between the stator and rotor. Neglect the magnetizing current. (b) Calculate the starting current and torque on DOL starting for this motor assuming that the motor is started on no-load. **(5 Marks)**
4. A 3-phase 400V 50 Hz 4-pole Y connected wound rotor induction motor has R_1=1.5Ω R_2'=2Ω x_1=x_2'=3Ω . If the motor is used for regenerative braking, determine (a) the maximum overhauling torque it can hold and the range of speed it can safely operate (b)the speed at which it will hold a torque of 50 Nm (c) the ratio of the maximum overhauling torque it can hold with a capacitive reactance of 2Ω inserted in each phase of the stator, to the max overhauling torque it can hold without a capacitor. **(5 Marks)**
5. A 1 MW 3-phase 6.6. kV, 50 Hz 6-pole delta connected UPF synchronous motor with R_s=0 and X_s=40Ω with a rated field current of 5 A is being controlled by a Voltage Source inverter with a constant v/f ratio. Calculate (a) torque and field current for rated armature current, half the rated speed and UPF. (b)Armature current and PF for regenerative braking operation at rated torque and half the rated speed with the field current being at rated value. (c) If the machine is operated at constant terminal voltage above base speed, calculate motor torque for 1500 rpm and 0.5 leading PF operation. What will be the field current under this operating condition? **(7 Marks)**
6. A 10/8 switched reluctance motor is to be operated at a speed of 12000 rpm. (a) What should be the frequency of pulses to each of the phases in the stator? (b) If the stator winding L_{max} and L_{min} are 10 mH and 125 mH respectively and the resistance is 4 Ohms, and the motor is being run at 500 rpm and excited by a 400 V DC supply, Derive an expression for the lead time (ahead of positive dL/dθ region) required while exciting every phase winding to obtain perceivable amount of torque. Also show when the main device should be turned OFF to ensure that the current is not carried by the stator winding in dL/dθ=0 or (-)ve region. The stator inductance profile is shown below. **(5 Marks)**

T_L = 12 Nm