EEL841 Solid-state Controllers for Drives
Major Test

Date and Time : 4/5/2010 8:00-10:00 hrs
Venue: II-337
Max marks: 50

1. Short Questions: **(8 x 3 =24 marks)**

A. Traction DC drives are normally single phase DC drives although they are of more than 50 kW capacity. Why?

B. Commutation overlap will be observed in an AC-DC converter only if both source inductance and load inductance are present. Is this always TRUE? Justify.

C. Can a PMSM be used to drive loads above base speed? If not, why? If yes, how?

D. A multi-stack variable reluctance stepper motor has 3 stacks with 12 teeth on the rotor and stator. What will be the step angle? If a pulse of 1 kHz frequency is sequentially feeding all the stator stacks, what will be the speed of rotation of the motor?

E. A switched reluctance motor will have constant torque operating characteristics until base speed and constant power characteristics until twice rated speed. Is this always TRUE? Justify.

F. Mention one practical application each for the following drives: (i) LCI fed synchronous motor drive (ii) Universal motor (iii) Switched reluctance motor (iv) variable reluctance stepper motor (v) DC series motor (vi) PMBLDC motor

G. Can a slip energy recovery scheme, with two thyristor converters –one each on the rotor side and grid side of the slip-ring induction motor, be operated on all 4 quadrants of speed-torque plane? Explain.

H. A 220 V DC shunt motor has R_a=0.2Ω and $I_{no\text{-}load}$ = 2.5 A when running at 1400 rpm. Determine its speed while taking 60 A current from the mains, if armature weakens the field flux by 3%

2. A synchronous motor drive fed by an LCI has the following name-plate details: 10 MW, 3-phase, 11 kV, Y connected, 60 Hz, 6 pole, UPF. The parameters are Xs=12Ω and sub-transient reactance = 3Ω; Rs is negligible. The filed is controlled to maintain constant flux below base speed and armature voltage is frozen at rated value above base speed. The drive operates at a constant commutation lead angle of 60°. (a) calculate the margin angle (γ), torque, terminal voltage, when the motor is operating at 1200 rpm drawing rated armature current. (b) If the current is restricted to rated value and a minimum margin angle of 10° is to be maintained for successful commutation, calculate the maximum speed at which the motor can operate. (Relevant formulae 3-ph converter Vdc = 1.35 V Cosα ; source inductance drop= $(3/\pi)\omega L_s I_d$; Cosα- cos(α+μ) =Vdc*6.28/(3 Vm) where Vm = line to line voltage peak) **(8 marks)**

3. A 1 hp, 125 V, 1500 rpm separately excited DC motor is controlled by a buck chopper whose frequency and input voltage are 500 Hz and 180 V respectively. Ra=0.8 Ω La=3 mH. Back emf constant=0.763 V.sec/rad. The motor is to be run at rated torque at 300 rpm with a maximum torque pulsation of 2%. Is this chopper suitable for this application? Justify your answer by proper calculations. If not, suggest a suitable frequency of operation for the chopper. **(6 marks)**

4. A 415 V, 4-pole, 60 Hz, 170 kW, 1780 rpm, Δ connected, 3-phase cage induction motor has R_1=0.060, L1=0.638mH, Lm=23.3mH, R_2'=0.0302, L_2'= 0.957mH. The motor is to be driven from a CSI with rotor frequency controlled at rated value. Maximum output power is to be limited to 85% of the rated value. Motor friction, windage and core losses are about 4 kW and can be assumed to be fairly constant. Load characteristics are such that $T_L = \omega_m^2/32$ N-m. Determine the maximum values of motor speed, inverter frequency and rms motor line current, fundamental line to line motor terminal voltage at maximum power output. State any assumption made. **(7 marks)**

5. 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)**