DEPARTMENT OF ELECTRICAL ENGINEERING, INDIAN INSTITUTE OF TECHNOLOGY DELHI

EEL203: ELECTROMECHANICS

TIME –TWO HOURS ***MAJOR TEST*** ***MAXIMUM MARKS-300***

Q.1. (a) In a hybrid stepper motor, a step angle of 1.8° is required. Calculate its design data in terms of number of phases, number of steps per revolutions, number of stator teeth, number of rotor teeth. **[20]**

(b) A switched reluctance motor with 8 stator poles and 6 rotor poles has a stator pole arc of 23° and rotor pole arc of 27°. The aligned inductance is 110mH and unaligned inductance is 10mH. Saturation can be neglected. Calculate the instantaneous torque when the rotor is 15° before the aligned position and the phase current is 25A. Compute the phase current for developing a torque of 20Nm. Neglect fringing. **[20]**

(c) A 3-phase, 1.5 kW, 4-pole, 1500 rpm permanent magnet brushless dc motor is fed from a VSI (an Electronic Commutator) which DC link voltage is 300 V and DC link current is 6 A. Calculate (i) the back emf, and (ii) the torque developed by the motor running at 1500 rpm. Given, the winding resistance per phase is 1.25 ohms/phase. **[20]**

(d) A 220V, 50Hz, 2-pole, universal motor operates at a speed of 7500 rpm on full load and draws a current of 4 A. The motor parameters are: R_a=2.25 Ω, X_a=13.75 Ω, R_s=0.25 Ω and X_s=11.25 Ω. Determine (i) the power factor, and (ii) efficiency, if the rotational loss is 10W. **[20]**

(e) A three-phase, 400 V (line), 50 Hz, 4-pole, star connected, synchronous reluctance motor has an X_d=25 ohms/phase, X_q=5 ohms/phase and negligible R_s. This motor is driving a load of 30 Nm at 1500 rpm. Calculate (i) the armature current, and (ii) the power factor. **[20]**

Q.2. A three-phase, 415V, 40kW at 0.8 pf lagging load is to be supplied from a three-phase 11kV, 50Hz ac mains. A Δ-Y connected three phase transformer is used between the ac mains and the load. Find the primary and secondary line and phase currents, primary and secondary line and phase voltages, kVA rating and its turn's ratio. **[40]**

Q.3. A 120 V DC shunt motor takes 2 A at no load and 7 A from a DC source when running on full load at 1200 rpm. The armature resistance is 0.8 Ω and the shunt field resistance is 240 Ω. Calculate (a) rotational power loss, (b) the no load speed, (c) the output power, and (d) the efficiency. **[40]**

Q.4. A 25 kVA, 400V, Δ-connected, 3-phase, synchronous generator draws a field current of 5 A to maintain the rated armature current under short-circuit condition. For the same field-current, the open-circuit voltage is 360 V. Determine (a) the synchronous reactance of the generator if its winding resistance is negligible. What are its voltage regulations when the generator delivers the rated load at (b) 0.8 pf lagging, (c) unity power factor and (d) 0.8 pf leading at rated terminal voltage? **[40]**

Q.5. A star-connected, 15 hp, 208 V (line), 3-phase, 2-pole, 60-Hz squirrel-cage induction motor has following equivalent-circuit parameters per phase referred to the stator: R_1 = 0.3Ω, R_2 = 0.3 Ω, X_1 = 0.41Ω, X_2 = 0.41Ω. Neglect shunt branch in the equivalent circuit. (a) Calculate the starting current and starting torque for this motor when connected to a 208V, 60 Hz, 3-phase AC source. (b) Moreover, calculate the starting current and starting torque for this motor when connected to an 80V (line), 20 Hz, 3-phase AC source. **[40]**

Q.6. A 0.375 kW, 230V, 50 Hz capacitor start single-phase induction motor has the following constants for the main and auxiliary windings (at starting): Z_m= (12.50+j15.75) ohms (main winding), Z_a=(24.50+j12.75) ohms (auxiliary winding). (a) Determine the value of the capacitance to be added in series with the auxiliary winding to obtain maximum starting torque. Compute (b) AC mains currents and (c) the ratio of starting torques with and without added capacitance in the auxiliary winding circuit when operated from a 230V, 50 Hz, AC supply. **[40]**

*****BEST OF LUCK*****