Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech(EE)/SEM-2/CAM-204B/2011

2011

CONTROL OF ELECTRICAL DRIVES

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer any *five* questions. 5 × 14 = 70

1. a) What is steady state stability in electric drives ? Derive the condition of stability. 2 + 5

   b) What is load equalization ? Discuss the method to determine the moment of inertia of the flywheel required for load equalization. 2 + 5

2. a) Explain the quadrennial diagram of electric drives with a suitable example.

   b) A drive has the following parameters :

   J = 10 kg-m^2 , T = 100-0.1N N-m positive load torque. T_1 = 0·05 N-m where N is the speed in rpm.

   Initially the drive is operating in steady state. Now it is to be reversed. For this motor characteristic is channged T = –100-0.1N N-m. Calculate the time of reversal.

   c) Obtain the expression of the energy loss during the starting conditions of the *dc* shunt motor drive under constant load. 5 + 5 + 4

3. a) With the help of relevant torque-speed characteristics discuss dynamic braking of induction motor.

   b) A 500V, 45kW, 600 r.p.m. d.c. shunt motor has full load efficiency of 90%. The field resistance is 200 ohm & armature resistance is 0·2 ohm. The field current is maintained constant. Armature reaction & brush drop may be neglected. Calculate the rated armature current & hence, find the speed under regenerative braking at which machine develops an electromagnetic torque equal to the rated torque.

      i) Regenerative braking : no external resistance

      ii) Dynamic braking : external resistance of 2.6 ohm inserted. 6 + 8

4. a) Explain the chopper fed *dc* motor drive with the help of relevant circuit and torque speed characteristics.

   b) The speed of a 220V, 3.73kW, 1000 rpm *dc* shunt motor is controlled by a single phase full-converter. The *ac* supply is 240V, 50 Hz. A vary large inductance is connected in series with the armature. Assume the motor & converter to be lossless. The motor emf constant is 1.9 V.s/rad. For a speed of 1000 rpm & rated motor current, detemine

      i) the firing angle

      ii) the r.m.s. value of the supply current & thyristor current

      iii) the supply power factor.

5. a) Explain the static Kramer method employed for speed control of three phase induction motor drives.

   b) The rotor of a 4-pole, 50Hz, 3-phase IM has resistance of 0·2 ohm per phase and runs at 800 rpm. If the load torque remains unchanged, calculate the additional rotor resistance that will reduce its speed by 15%. Neglect stator impedance.

   c) For a three-phase induction motor drive show that

$$T = \frac{2T_m}{(s/s_m + s_m/s)}$$

   where symbols bearing the usual meaning. 4 + 5 + 5

6. a) A synchronous motor connected to an infinite bus bar is driving a load corresponding to its rated capacity, with a torque angle of 30°. If the load is suddenly increased to $\sqrt{2}$ times the rated load, determine whether or not the drive is stable.

   Calculate the maximum additional load that can be thrown suddenly on the shaft of the motor without affecting the stability of the drive.

   b) A motor having a suitable control circuit develops a torque given by the relationship $T_m = a\,\omega + b$, where a, b are positive constants. This motor is used to drive a load whose torque is expressed as $T_L = c\,\omega^2 + d$, where are some other positive constants. The total inertia of the rotating masses is J. Determine the relations amongst the constants a, b, c and d in order that the motor can start together with the load and have an equilibrium operating speed. 7 + 7

7. a) Assuming steady state stability of the drive system, derive an expression for the speed of the induction motor driving a load torque proportional to some power of the speed, when the supply voltage falls by certain percentage. If an induction motor, having a rated slip of 4% and s_{maxT} of 20% drives a constant load torque, determine the slip at which motor will run when the supply voltage falls by 20%.

b) Show that for an induction motor having negligible stator resistance & load torque, the acceleration time t_s from standstill to a slip s is given by the following expression :

$t_s = J\omega_{ms} / T_{max} [1 - s^2 / 4s_m + s_m / 2 \log_e (1 / s)]$.

8 + 6

8. a) A 250V dc shunt motor has an armature resistance of 0·05 Ω and with rated field excitation has a back emf of 245V at a rated speed of 1200 rmp. It is coupled to an overhauling load with a torque of 200 N.m. Determine the lowest speed at which the motor can hold the load by regenerative braking.

b) Find the expression of the speed of the dc shunt motor drive under transient conditions of dynamic braking.

c) The following parameters are given for a separately excited *dc* motor :
240V, 0·75kW, 500 rpm, r_a = 7·6 Ω . L_a = 0·06 H,
C = 4·23 V.s/rad, J = 0·14 kg.m^2 .
Assume that load inertia = the motor inertia. Find the transfer function indicating the natural frequency of oscillations and damping ratio. Also find the speed response to a constant torque corresponding to a step change of 50V in input voltage using exact and approximate transformation. 5 + 4 + 5