SEE 3433 TEST 1 2012 2013 SEM 2 Duration: 1 hour 30 minutes

Q1. Two windings one mounted on the stator and the other mounted on the rotor have self and mutual inductance of L_{11} = 4.5 H, L_{22} = 2.5 H and $L_{12} = L_{21}$ = 2.8 cos θ H, where $\theta = \omega_m t + \delta$ is the angle between the axis of the winding. Let the current in the first winding be denoted by i_1 and the current in the second winding by i_2. Derive an expression for the instantaneous torque as a function of the angular position θ in simplified form and find the time-average torque for the following conditions:

(a) $\omega_m = 0$, $\delta = 30°$, $i_1 = 2$ A and $i_2 = 0$ A [2 marks]

(b) $\omega_m = 0$, $\delta = 30°$, $i_1 = i_2 = 2$ A [2 marks]

(c) $\omega_m = 0$, $\delta = 30°$, $i_1 = 2$ A and $i_2 = 2\sin 20t$ A. [2 marks]

(d) $\omega_m = 0$, $\delta = 30°$, $i_1 = i_2 = 2\sin 20t$ A. [2 marks]

(e) $\omega_m = 20$ rad/s, $\delta = 30°$, $i_1 = 2$ A, $i_2 = 2\sin 20t$ A. [2 marks]

Q2. A magnetic circuit, including a movable plunger, is shown in Figure Q2. Assume that the permeability of the core is infinite and neglect leakage and fringing. The dimensions of magnetic circuit is a = 2.5 cm, b = 2 cm, d = 0.02 cm, w = 3 cm (width/thickness of the magnetic core) and numbers of turn of winding, N, is 500 turns.

(a) Derive an expression for reluctance of magnetic circuit in term of variable x. [2 marks]

(b) Write an expression for inductance of magnetic circuit. [2 marks]

(c) Derive an expression for field energy stored in the magnetic systems. [2 marks]

(d) If exciting current, i, is 5 A, calculate field energy stored at x = 2 mm. [2 marks]

(e) Derive an expression for the force acting on movable plunger. Calculate the force at x = 2 mm. [2 marks]

(f) If the armature of the movable plunger moves from open to closed position at constant current, I, as shown in the Figure Q2(g). Show that the electrical energy input is shared equally between field energy stored and mechanical work done. [2 marks]

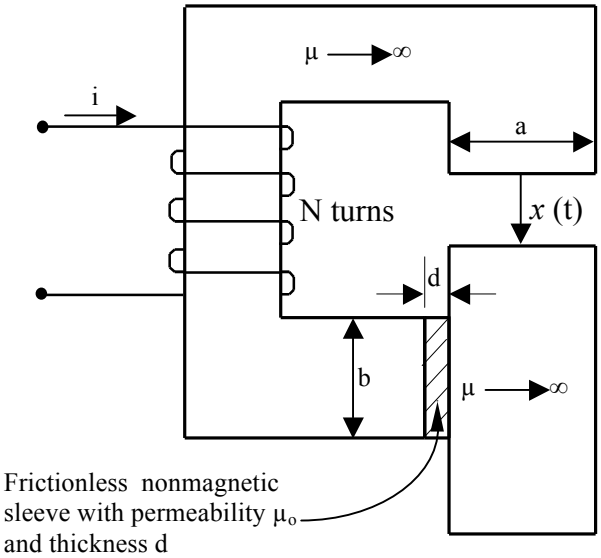

Figure Q2

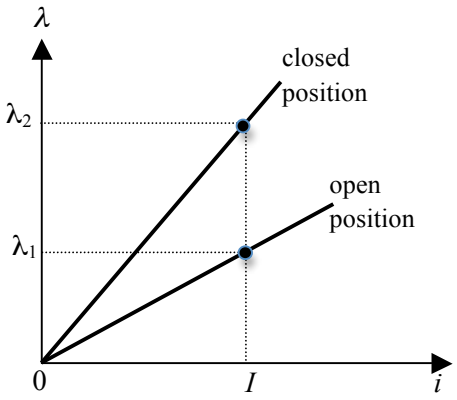

Figure Q2(g)

Q3. An eight pole DC machine has a lap winding of 400 turns. The flux per pole is 0.05 Wb.

(i) Determine the generated voltage, E_a, at the speed of 800 rpm. Also, determine the induced voltage for each turn.

[3 marks]

(ii) Determine the developed torque by the machine if the current through the turn is 5 A at the speed of 800 rpm.

[2 marks]

(iii) If conductors are available which are rated at 4 V and 10 A, determine the power rating of the machine.

[2 marks]

Q4. A self-excited dc shunt generator 11 kW, 110 V, 1100 rpm has armature resistance R_a = 0.1 Ω, shunt field winding resistance, R_{fw} = 82 Ω and R_{fc} can be adjusted from 0 Ω to 66 Ω. The magnetization characteristic curve at 1100 rpm is shown in Figure Q4.

(i) Draw a self-excited DC shunt generator. Label all resistances, voltages and currents.

[2 marks]

(ii) Determine the maximum and minimum values of the generated terminal voltage at no load. Draw on the Figure Q4. [3 marks]

(iii) Determine the value of the field control resistance, R_{fc}, required to generate rated terminal voltage of 110 V at no load. Draw on the Figure Q4.

[2 marks]

(iii) Determine the full-load terminal voltage for the value of field control resistance as determined in (ii). Neglect armature reaction effect. Draw on the Figure Q4.

[2 marks]

(iv) Determine the full-load terminal voltage for R_{fc} as in (ii). Assume that the armature reaction effect at the full-load is $I_{f(AR)}$ = 0.05 A. Draw on the Figure Q4.

[2 marks]

Your drawing on the Figure Q4 is a part of the solution. You have to submit Figure Q4.