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M.E. DEGREE EXAMINATION, JANUARY 2006.

First Semester

Power Electronics and Drives

PE 1601 — MODELLING AND ANALYSIS OF ELECTRICAL MACHINES

(Regulation 2005)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Compute the energy stored in the air–gap of a single excited system where the system voltage is $10 \times \sin(314t)$ and current is $2 \times \sin(314t - \Phi)$ over a period of 3 seconds.

2. Show the non–linear magnetization characteristics of a doubly excited system and write the expression which relates energy and co–energy.

3. The stator currents for a three–phase rotating electric machine with symmetrical stator windings are $I_{as} = \sqrt{2}\ I_a \cos\omega_e t$, $I_{bs} = \sqrt{2}\ I_b \cos(\omega_e t - 2\pi/3)$, $I_{Lcs} = \sqrt{2}\ I_c \cos(\omega_e t + 2\pi 3)$, where the currents I_a, I_b, I_c are unbalanced. Comment on the total air–gap MMF due to the stator currents.

4. State whether for a three–phase salient pole synchronous machine the mutual inductances between the stator windings are a function of rotor position under dynamic conditions. Explain your answer.

5. Enumerate the merits of the application of reference frame theory to electrical machines.

6. Let the transformations matrix be defined as

$$\mathbf{Ks} = \begin{bmatrix} \cos(\theta - 2\pi/3) & \sin(\theta - 2\pi/3) & 1 \\ \cos(\theta + 2\pi/3) & \sin(\theta + 2\pi/3) & 1 \end{bmatrix}$$

State whether it would be possible to obtain f_{abcs} variables from f_{qds} variables.

7. State as least two different conditions when asymmetry exists in induction machines.

8. What is the purpose of performing frequency response test in electrical machines?

9. Compare the surface permanent magnet machine with the interior type.

10. What is the principle of self controlled operation in permanent magnet synchronous machines?

PART B — (5 × 16 = 80 marks)

11. (i) Consider the electro–mechanical system shown in Figure 11.(i). Assume the peak amplitude of the mutual inductance is L_{sr}. Then

  (1) express the mutual inductance

  (2) show the location of the north and south poles of the stator (N and S) and of the rotor (N and S) for positive i_1 and i_2 and
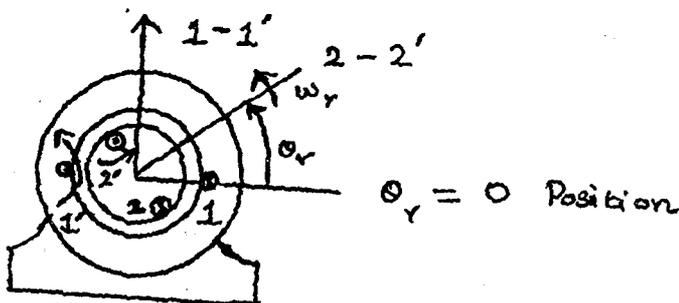
  (3) express the electro–magnetic torque T_e. (8)

Figure 11.(i)

  (ii) Derive the general expression for force in terms of co–energy of a doubly–excited electro–magnetic system. (8)

12. (a) Obtain the transient state voltage and torque equations of a d.c. shunt machine and also show the block diagram representation. (16)

Or

  (b) Derive the voltage equations of a three–phase synchronous machine in phase variable form. (16)

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13. (a) Discuss the reference frame theory in a step–by–step basis and show that how a three–phase symmetrical induction machine model is transformed into two–phase machine model. Draw also the equivalent circuit model of the transformed two–phase machine model with respect to synchronous reference frame. (16)

Or

(b) Obtain the dynamic model of the three–phase synchronous machine using Park's transformation. (16)

14. (a) Write short notes on :

(i) Standard machine time constants and

(ii) Derived machine time constants. (16)

Or

(b) Analyse the steady state operation of an unsymmetrical two–phase induction machine based on its equivalent circuit model. (16)

15. (a) Describe the construction and operating principle of interior permanent magnet synchronous machines. (16)

Or

(b) Perform the dynamic analysis of Switched Reluctance Motors based on its dynamic model. (16)

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