Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.TECH(EE)/SEM-1/PEM-102/2011-12

2011

ELECTRICAL MACHINE ANALYSIS

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) Prove that $T_e = -\frac{\partial W_{fld}}{\partial \theta}$ with φ is constant and show therefrom $T_e = -\frac{1}{2}\varphi^2 \frac{dR}{d\theta}$ with φ is constant.

   b) Derive the expression of torque for a doubly excited machine and explain the significance of each term.

   7 + 7

2. a) Draw the Kron's primitive machine model of a single phase transformer.

   b) What is the significance of quasi-static winding ?

   c) Derive the expression of torque for the Kron's primitive machine. 3 + 3 + 8

3. Stationary circuit variables are given by v_{as}, v_{bs} and v_{cs} and are to be referred to the following reference frames :

   a) The stationary two axes reference frame having axes α and β.

   b) The arbitrarily rotating reference frame having axes d and q.

   Derive the transformation and inverse transformation matrices for both of the cases. Also write the matrices if the axes of the reference frames interchange their positions.

   Why are the axes of the reference frames chosen in quadrature ?

4. a) Develop a mathematical model of DC Series Motor.

   b) Draw the open loop block diagram of the machine.

   c) Also draw the block diagrams for a step change in input voltage and load torque. Write corresponding transfer functions. 3 + 4 + 7

5. A three phase star connected balanced symmetrical stationary circuit containing resistances, inductances and mutual inductances of same value is to be referred to arbitrary reference frame. Derive the corresponding equations and draw the transformed circuits.

6. Derive the Parks voltage equations for a 3-ph synchronous machine. Use suitable notations for the variables and show their corresponding transformation as required during derivation.

7. Mention the system / machines for which following reference frames are chosen and also mentions the reasons : 5 + 5 + 4

   a) Stationary reference frame

   b) Arbitrarily rotating reference frame

   c) Synchronously rotating reference frame.

8. Answer any *two* of the following : 2 × 7

   a) Show that

$$ {}^{x}K^{y} = \begin{bmatrix} \cos(\theta_y - \theta_x) & -\sin(\theta_y - \theta_x) & 0 \\ \sin(\theta_y - \theta_x) & \cos(\theta_y - \theta_x) & 0 \\ 0 & 0 & 1 \end{bmatrix} $$

   when y would be the reference frame to which variables are being transformed and x is the reference frame from which variables are being transformed.

   b) Show that for inductive elements of stationary reference frame referred to an Arbitrarily rotating reference frame can be modelled as $V_{qdos} = \omega\lambda_{dqs} + p\lambda_{qdos}$.

   c) Show that the torque of an induction motor can be expressed as $T_e = \frac{3}{2}\frac{P}{2} L_M \left(i_{qs} i'_{dr} - i_{ds} i'_{qr}\right)$.

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