Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/M.Tech (EE)/SEM-1/PEM-102/2010-11

2010-11

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 doubly excited rotating machine has following parameters and variables :

$r_s = 40\Omega$ $M_{sr} = 0 \cdot 08 \cos \theta_r$

$r_r = 2\Omega$ $i_s = 10\text{A d.c.}$

$L_s = 0 \cdot 16 \text{ H}$ $i_s = 2\text{A d.c.}$

$L_r = 0 \cdot 04 + 0 \cdot 02 \cos 2\theta_r$

θ_r is the space angle between coil axes. The rotor is revolving at a speed of 100 rad/sec. Find the following :

a) Derive the expressions for the instantaneous voltages applied to the stator and rotor winding.

b) Obtain the expressions for the torque and corresponding electrical power.

c) Repeat (a) and (b) if θ_r = 90°.

2. An electromechanical system has two electrical inputs. The flux linkages may be expressed as

$\lambda_1(i_1, i_2, x) = x^2 i_1^2 + x i_2$

$\lambda_2(i_2, i_2, x) = x^2 i_2^2 + x i_1$

Derive the expressions of the following :

a) Field energy, $W_f(i_1, i_2, x)$

b) Co-field energy, $W_c(i_1, i_2, x)$

c) Force, $f_e(i_1, i_2, x)$.

3. a) Obtain the expression for the electrical torque of the Kron's primitive machine.

b) Show that no torque is produced by interaction between the current and flux on the same axis.

c) What is quasi-static coil ? What is its significance ?

4. a) For transformation between two reference frames, $f^y_{qd0s} = {}^xK^y\ f^x_{qd0s}$

show that ${}^xK^y = K^y_s \left(K^x_s\right)^{-1}$

where x = reference frame to which variables are being transformed

y = reference frame to which variables are being transformed.

b) Derive the expression for ${}^xK^y$ in terms of space angle between the reference frames.

c) Prove that ${}^xK^y = \left({}^yK^x\right)^{-1}$.

5. If K_s is defined as

$f_{qd0s} = K_s f_{abcs}$ and $f_{abcs} = K_s^{-1} f_{qdos}$ where

$$K_s = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos\theta & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) \\ \sin\theta & \sin\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right) \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}$$

Prove the following :

a) $(K_s)^T = (K_s)^{-1}$

b) $f_{as}^2 + f_{bs}^2 + f_{cs}^2 = f_{qs}^2 + f_{ds}^2 + f_{0s}^2$ where $f \equiv v, i, \lambda$

6. a) Derive the Park's voltage Equations for a 3-ph round rotor non-salient poly type synchronous machine. Use suitable notations for the variables and show their corresponding transformations as required during derivation.

b) Why is the rotor reference frame preferred for the analysis of the Synchronous machine compared to the other reference frames ?

7. a) Develop the Time-domain Block diagram of a Armature controlled Permanent magnet DC motor.

b) Derive the dynamic equations.

c) Derive the transfer functions for armature current and speed of the motor.

d) Derive the time domain equation for armature current if load torque is zero.

8. a) Derive the equivalent circuits for a 3-ph symmetrical Induction motor with all circuit variables referred to arbitrarily rotating reference frame. Also show the transformations and write all corresponding voltage equations.

b) Derive the expression of torque in terms of transformed variables referred to arbitrarily rotating reference frame.