

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. $5 \times 14 = 70$

1. A doubly excited rotating machine has following parameters and variables :

$$r_s = 40\Omega \quad M_{sr} = 0.08 \cos \theta_r$$

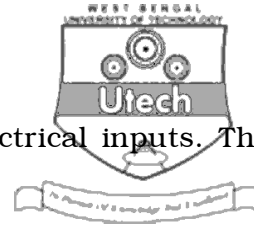
$$r_r = 2\Omega \quad i_s = 10\text{A d.c.}$$

$$L_s = 0.16 \text{ H} \quad i_r = 2\text{A d.c.}$$

$$L_r = 0.04 + 0.02 \cos 2\theta_r$$

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

- Derive the expressions for the instantaneous voltages applied to the stator and rotor winding.
- Obtain the expressions for the torque and corresponding electrical power.
- Repeat (a) and (b) if $\theta_r = 90^\circ$.



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

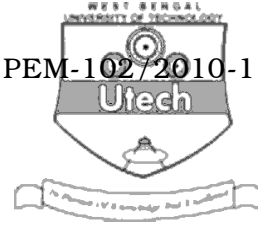
$$\lambda_1(i_1, i_2, x) = x^2 i_1^2 + x i_2$$

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

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,

$$\int_{qd0s}^y = {}^x K^y \int_{qd0s}^x$$
 show that ${}^x K^y = K_s^y (K_s^x)^{-1}$
 where x = reference frame to which variables are being transformed
 y = reference frame to which variables are being transformed.
- b) Derive the expression for ${}^x K^y$ in terms of space angle between the reference frames.
 - c) Prove that ${}^x K^y = ({}^y K^x)^{-1}$.



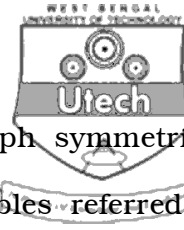
5. If K_s is defined as

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

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