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# MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

*(A constituent unit of MAHE, Manipal)*

## I SEMESTER M.TECH (POWER ELECTRONICS & DRIVES)

## END SEMESTER EXAMINATIONS, NOVEMBER 2019

## MODELLING AND ANALYSIS OF ELECTRICAL MACHINES [ELE 5172]

REVISED CREDIT SYSTEM

**Time: 3 Hours** **Date: 23 November 2019** **Max. Marks: 50**

**Instructions to Candidates:**

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

**1A.** Derive the expression for field energy in a singly excited linear motion system. Assume that core has linear magnetization characteristics. ***(05)***

**1B.** Prove that the electromagnetic torque developed in a doubly excited rotational system with symmetrical rotor is proportional to the derivative of mutual inductance with respect to rotor position. Assume that core has linear magnetization characteristics. ***(05)***

**2A.** Differentiate the terms Field energy and Co-energy in a nonlinear magnetic system. Also, derive the electromagnetic torque expression in a rotational system with nonlinear magnetic core. The flux linkage $\psi$, is related to exciting current $I$, as per the following expression

$I=(15-4\cos 4\theta)\ \psi^{3.8}$. ***(06)***

**2B.** Explain the concept behind the torque production in a singly excited salient pole machine. ***(04)***

**3A.** Calculate the total Field Energy in the magnetic system given in Fig.1, when the current of 15A through the coils reverses in 2 seconds.
The three magnetically coupled inductive coils connected in series, have the following data,
$L_1 = 0.2$ H; $L_2 = 0.15$ H; $L_3 = 0.13$ H
$k_{12} = 0.85$; $k_{23} = 0.23$; $k_{31} = 0.41$
Assume that core has linear magnetization characteristics.

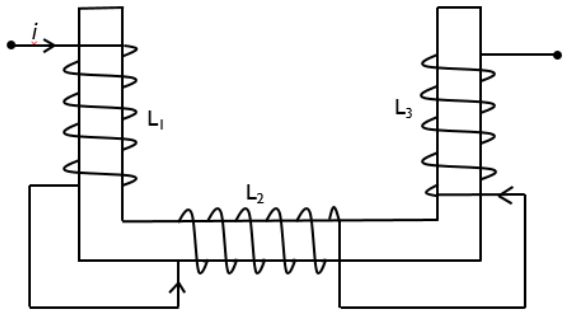


Fig.1 ***(06)***

**3B.** Calculate the torque developed by a 4 pole, 50Hz, 3-phase induction motor to accelerate from zero to steady speed in one second. Steady state slip-speed is 20rpm. Moment of inertia of rotor is 0.02kgm$^2$. Consider a load of 10Nm. Assume friction coefficient to be 1Nm/rpm ***(04)***

**4.** Consider a 3-phase, 3hp, 400V, 4-pole, 60Hz induction motor with the given dataset. **Using the given Simulink machine model**, simulate and analyse the dynamic responses of Stator current, Developed torque and Rotor speed for the following conditions.

1. Machine is started on No-load by applying full voltage (DOL starting) and full load-torque is applied after 1 second.
2. Star-Delta starting. Assume star-delta changeover at 0.5 second. Machine is fully loaded at 1 second.
3. Auto transformer starting with the voltage linearly increased from zero to rated voltage in one second. Assume that full load is applied at 1.5 seconds.
4. Machine is started on No-load by applying full voltage (DOL starting) and its speed is reversed after 1 second by phase sequence reversal (Plugging).

*Motor-data:*

*Magnetizing reactance, $X_m$=26.23Ω;*

*Leakage reactance of stator magnetic circuit, $X_s$=0.754Ω;*

*Leakage reactance of rotor magnetic circuit, $X_r$=0.754Ω;*

*Per phase resistance of stator winding, $R_s$=0.435Ω;*

*Per phase resistance of rotor winding, $R_s$=0.816Ω;*

*Moment of inertia of the rotor=0.089kgm$^2$;*

*Neglect friction.* ***(20)***