Ref.No. EE/5/T/522C/2017(Old)

BACHELOR OF ELECTRICAL ENGINEERING(EVENING) EXAMINATION,2017

(5-th YEAR, 2nd SEMESTER)

ELECTRICAL MACHINE MODELLING & ANALYSIS

Time:3 hours Full Marks:100

(50 marks for each part)

Use separate Answer-script for each part

PART-I

Answer any three questions. Two marks for neatness. All symbols have their usual significance

1. a) Consider the operation of an electromagnetic relay shown in fig.1, where one winding is mounted on a stationary member of iron and a movable member of iron is attached to a wall of the relay by a spring on one side. Now show that the energy converted to mechanical form equals the area between the two magnetization characteristics (flux vs.mmf) respectively for the open position and closed position with respect to movement of the plunger. Assume the necessary parameters for the system concerned.

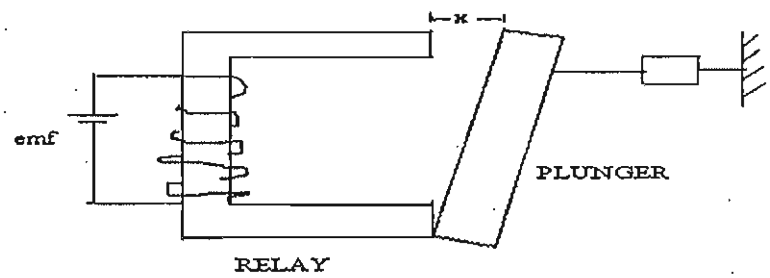

Fig.1

b) Derive the expression for mechanical force if the plunger shown in fig.1 is allowed to move an infinitesimal distance in the direction of magnetic force acting upon it. 8+8=16

2. a) Explain magnetostriction and its equation.

b) In an electromagnetic relay shown in fig. 1, the exciting winding has 1000 turns. The cross-sectional area of the magnetic core is 10 cm × 10 cm. The reluctance of the magnetic circuit may be assumed to be negligible. Also neglect fringing effects.

i) Find the coil inductance for an air-gap of x = 2 cm at both ends of the plunger. What is the field energy when the coil carries a current of 50 A? What are the forces on the plunger under these conditions?

ii) Find the mechanical energy output when the plunger moves in the direction of magnetic force acting upon it,from x = 2 cm to x = 1 cm at both ends of the plunger assuming that the coil current is maintained constant at 50 A.

Also, find the mechanical energy output if the flux linkage is maintained constant during plunger movement. 6+10=16

3. Describe, with the aid of flux and current diagrams, the construction and principle of operation of a single-phase reluctance motor. Assume that the magnetic flux and reluctance variations are sinusoidal. Assume the necessary parameters for the system concerned.

Also develop an expression for reluctance torque. 16

[Turn over

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4. Cross section of a cylindrical **solenoid magnet** is shown in fig.2; which shows the cylindrical plunger of mass 'M' kg. moves vertically in brass guide rings of thickness 't' meter and mean diameter 'b' meter. The permeability of brass is the same as that of free space. The plunger is supported by a spring whose elastance is 'K' newtons/m. Its un-stretched

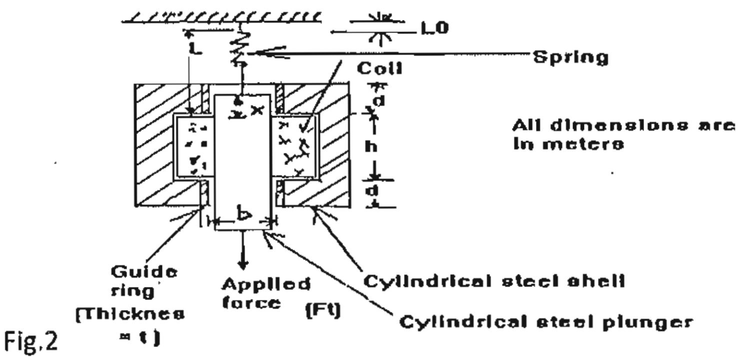


Fig.2

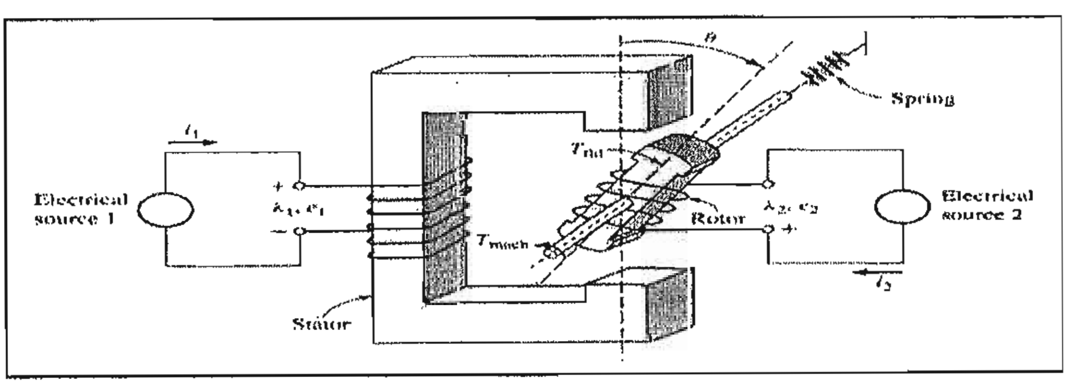
length is 'L_0'. A mechanical load force 'Ft' newtons is applied to the plunger from the mechanical system connected to it. Assume that the frictional force is linearly proportional to velocity and that coefficient of friction is 'p' newtons-sec/m. The coil has 'N' turns and a resistance of 'r' ohms. Its terminal voltage is 'v' volts and its current is 'i' Amps. The effects of magnetic leakage and reluctance of the steel are negligible.

i) Derive the **dynamic equations of motion** of the electromechanical system.

ii) Adjust this electromechanical system to have a stable quiescent point. Find the relations among the quiescent values of the terminal voltage, current, applied mechanical force, and displacement in terms of the spring constant 'K', the dimensions of the spring and magnet and the weight of the plunger.
Then linearize the differential equations for incremental operation around the quiescent point. 8+8=16

5. In an electromagnetic-energy-conversion-device shown in fig.3, if one winding is mounted on a stationary member of iron and another winding is mounted on the movable member of iron then obtain the expression for electromagnetic torque in this doubly excited rotational electromechanical energy converter. Assume the necessary parameters for the system concerned. Also derive expressions for the speed and the transformer emfs. 10+6=16

Fig.3



PART - II

Answer *any three* questions from this part.
Two marks are reserved for neat and well organised answer.

6. What do you mean by quasi-holononic reference frame? For a generalized machine having two layers of stator and rotor windings along the quasi-holonomic reference frame develop the impedance matrix. 16

7. a) Develop the voltage equations of a generalized machine in the non-holonomic reference frame. 8

   b) Establish the relation between the torque matrix and inductance matrix of the generalized machine in the rotating reference frame. 8

8. Developing the impedance matrix of a compound wound dc motor, derive the expression for current flowing through different branches. 16

9. Develop the impedance matrix of the Capacitor Motor from the generalized machine of the first kind and transform it into the symmetrical sequence axes. Hence draw the equivalent circuit of the motor. 16

10. What do you mean by bucking impedance of a transformer? Describe the methods of determining the bucking impedance between two coils of a three limbed core type transformer having a turns ratio 'n' when (i) the two coils are on the same limb and (ii) the coils are on different limbs. Discuss the limitation of the method, if any. 16