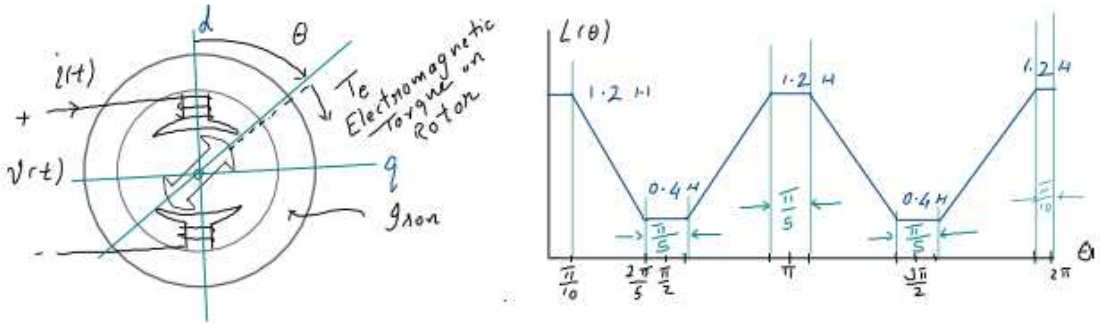
EE6303D DYNAMICS OF ELECTRICAL MACHINES
TEST 1 : 2020 MONSOON SESSION : 04-12-2020

Time : 2 Hours **Max. Marks : 15**

ANSWER ALL QUESTIONS

I. A Singly excited rotational electromechanical system and the approximate variation of coil inductance with Θ are shown below.



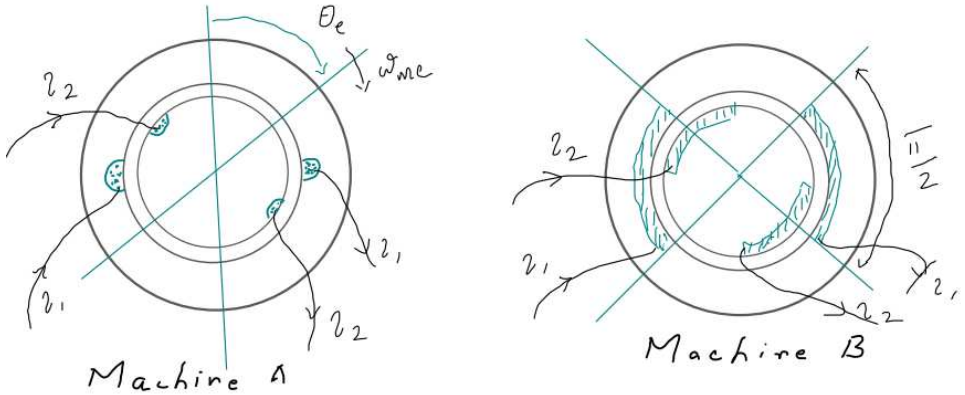
(a) An external agent holds the rotor fixed at θ = π/3. A DC Current source of value 15A is switched on to the coil. **What is the torque applied by the external agent** to keep rotor stationary? **What is the direction** of the applied torque? **Derive the expressions you use from basic principles.** (1 ½ Marks)

(b) An external prime mover drives the rotor at a speed of 1500 rpm and a DC current source of 10A is flowing in the coil. **Find and sketch the voltage** that appears across the DC Current Source **and the torque applied by the external prime mover**. **Mark salient values**, **period, frequency** etc in both sketches. (1 ½ Marks)

II. A smooth air gap machine, machine-A, with concentrated coils on stator and rotor is shown below. Diameter of the machine is 30cm, Length is 30cm, air gap is 2.5 mm and number of turns in the concentrated coil in stator and rotor is 300 turns. A similar machine with same dimensions, machine-B, but with 300 Turns distributed uniformly over an arc of π/2 radians (on one side) on both stator and rotor are shown below.

(a) **Derive expressions** for self-inductances of stator and rotor coils in both cases and **evaluate** the four values. (1 ½ Marks)

(b) The stator coil is driven by a 3A DC Current Source and the rotor coil is kept open. The rotor is rotated at 1500 rpm by an external prime mover. **Sketch** the voltage that appears across the rotor coil as a function of time and **mark its amplitude and time period** for Machine-A and Machine-B. **Derive the expressions you use**. (1 ½ Marks)



III. (a) **Draw** the symbolic sketch of a Primitive Commutator Machine and **state its V-I equation and Torque equation** after defining the parameters of the machine. **Explain how** the sign of speed emf entries is decided. (1 Mark)

(b) **Explain how** the commutation process was accounted mathematically in deriving speed emf and transformer emf contributions to the brush voltage (1 Mark)

IV. A 5HP. 240V, 127.7 rad/sec, 16.2 A, 2-pole DC Shunt Motor with R_F = 240Ω, R_a= 0.6Ω, L_F =120H, L_a= 0 H, M=1.8H, J= 3 kg-m^2, B=0 is running on no load. At t=0, the armature supply is reversed and a resistance of R is connected in series with the armature while the field continues to be energized from 240V DC. The supply to field and armature is switched off when the motor speed reaches zero.

(a) **Explain**, with the help of motor V-I equation and mechanical equation, **why** the motor **speed decreases first**. (½ Mark)

(b) **Show** that first order model of the motor can be used in solving this problem and set up the relevant differential equation. (1 Mark)

(c) **Solve** the motor differential equations and **obtain the value of R** if it is given that motor comes to a stop in 12 seconds. (1 ½ Marks)

(d) With this value of resistance R, **obtain time-domain expressions** for armature current, torque and speed for the time interval [0,12 sec] and plot them.(1 Mark)

V. (a) A DC Series Motor has following rating and parameters – 5 HP, 240V, 127.7 rad/sec, 2-Pole, R_F = 0.8Ω, R_a = 0.6Ω, L_a = 0.01H, L_F = 0.5H, M = 0.12H, J = 2kg-m^2, B = 0.03 N-m-s. The motor is running with a constant torque load at 1500 rpm**. Find the (i) armature current (ii) torque developed by the motor (iii) external load torque applied on the motor**. (1 Mark)

(b**) Prepare a linearized model in state space form** for this motor for analyzing small transients around the operating point given above. **Give the numerical values for state matrices.** If the motor voltage undergoes a small change, **predict the shape of transients** that will appear in motor current and speed using the A matrix of the linearized model. (2 Marks)

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