M.E. ELECTRICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM 2025

SUBJECT: SMALL MACHINES, INCREMENTAL MOTION DEVICES AND ACTUATORS

Time: Three Hours | Full Marks: 100 (50 for part I)

Use a separate Answer-Script for each part

PART - I

Answer Question No. 1 and any two from the rest.

1. (i) Write down the special features of DC servo motors. **4+14=18**

(ii) Obtain the closed-loop transfer function for the positional servo system shown in the following figure. Assume that the input and output of the system are the input shaft position and the output shaft position respectively. Assume the following numerical values for system constants:

- r = angular displacement of the reference input shaft, radians
- c =angular displacement of the output shaft, radians
- θ = angular displacement of the motor shaft, radians
- K_1= gain of the potentiometric error detector = 24 / pi volts/rad
- K_p= amplifier gain= 10 volts/volt
- e_a= applied armature voltage, volts
- e_b=back emf, volts
- R_a = -winding resistance = 0.2 ohms.
- L_a= -winding inductance, negligible
- i_a=armature-winding current, amperes
- K_b = emf constant = 5.5 x 10^{-2} volts-sec/rad
- K = torque constant 6 x 10^{-5} N-m/ampere
- J_m= of inertia of the motor 1 x 10^{-5} kg-m^2
- b_m = viscous-friction coefficient of the motor, negligible
- J_L= moment of inertia of the load = 4.4 x 10^{-3} kg-m^2
- b_L= viscous-friction coefficient of the load = 4x10^{-2} N-m/rad/sec
- n=gear ratio N_1/N_2= 1/10

2. (i) What is recoil permeability? Explain with proper diagram. **4+4+8=16**

(ii) What is Ballistic coefficient of demagnetization? What are the parameter it depends on?

(iii) With suitable assumptions determine the operating point for magnetization on the surface of a PM with an armature.

3. (i) Short notes on demagnetization curve and intrinsic demagnetization curve of permanent magnetic materials. **6+10=16**

PART - I

3. ii) Find the main dimensions of a PMDC commutator motor of cylindrical construction with a slotted rotor rated at: Pout = 50 W, V = 110 V, and n = 4000 rpm. The useful magnetic flux density cannot exceed 0.22T for the PM used. The efficiency at rated load should be a minimum of η =0 .6. The motor has to be designed for continuous duty. Assume air gap flux density to be 0.35 T and line current density to be 7500A/m

4. i) Write down the key features of an actuator. **4+4+8=16**

ii) What are the advantages of electrical actuators?

iii) Assuming that a two-phase servomotor has a linear torque-speed curve such that the no-load speed is ω_s rad/sec and the stall torque is T_s N-m, find the maximum motor-shaft output power Pima watts. If T_s = 0.0353 N-m and ω_s = 418.9 rad/sec (4000 rpm), what is the maximum power output P_{max} and at what frequency does it occur?

PART-II.

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

6. a) Compare the characteristic features of BLDC machine with cage type induction machines for vehicular applications. (CO2) 8

b) Derive the emf and torque equations of a BLDC machine and show that BLDC motor is inherently stable for speed control applications. (CO3) 8

7. a) Explain how BLDC motors can be driven with the help of unidirectional current control technique. (CO1) 6

b) Sketch the emf and ideal current waveforms for any one phase of BLDC machine. 5+5
Explain the methods to take speed and position feedback in a BLDC motor Drive system. (CO4)

8. a) Draw and explain the schematic diagram of VSI fed BLDC drive system fed from a single phase ac supply. (CO3) 10

b) Comment on the types of semiconductor switches that can be used in a BLDC drive system. (CO2) 6

9 a) Explain with block diagrams the buck converter fed CSI based scheme for speed control of BLDC motor. (CO2) 8

b) Draw and explain how a buck converter can be used in a switched reluctance motor (SRM) drive system with four semiconductor switches for four stator windings. (CO4) 8

10 a) Draw and explain the scheme of a switched reluctance motor (SRM) drive system with six semiconductor switches having four stator windings. Also explain its merits/demerits over the four switch scheme for the same motor. (CO3) 10

b) Explain how current feedback can be taken for a SRM drive system. (CO1) 6