Ref No. : Ex/PG/EE/T/128A/2024

Master of Electrical Engineering, 1st Year 2nd Semester Examination, 2024

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) What are the salient features of an AC servomotor? **4+6+8=18**

(ii) Derive the mathematical model of an armature controlled DC servomotor for speed control.

(iii) A DC Servomotor must accelerate from rest to 35 m/s in 3.5 seconds. The rotating mass has a moment of inertia of 4.5 kg-m2. The load toque and the frictional torques are 18 N-m and 1.2 N-m respectively. The damping co-efficient is 0.05 N-m-s. The torque constant is 120 N/A. Determine the required current just before the acceleration ends.

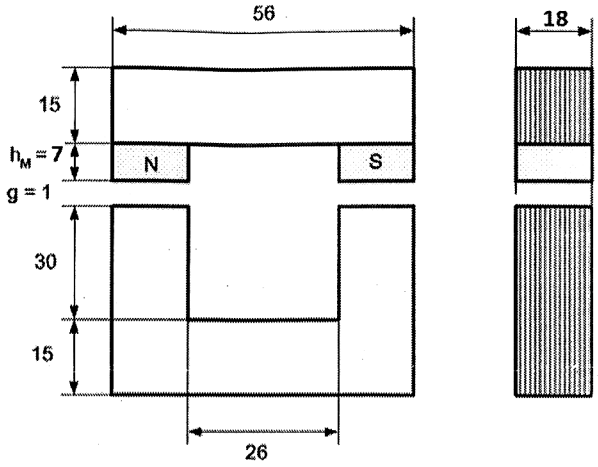
2. (i) Explain demagnetization curve and intrinsic demagnetization curve of permanent magnets. **8+8=16**

(ii) How the demagnetization curve and the recoil lines are approximated?

3. A simple stationary magnetic circuit is shown in the following figure. There are two Vacomax sintered 225 HR Sm_2Co_{17} PMs with minimum value of B_r = 1.02 T, minimum value of H_c = 750 kA/m, temperature coefficients α_B= -0.030%/°C and α_H= -0.18%/°C. at 20 < υ_{PM}<120 °C. The height of the PM is 7 mm and the air gap thickness g = 0.8 mm. The U-shaped and I-shaped ferromagnetic cores are made of a laminated electrotechnical steel. The width of the magnets and cores is 18 mm. Calculate the air gap magnetic flux density, air gap magnetic field strength, the useful energy of the PMs and normal attraction force per two poles at: (a) υ_{PM} = 20 °C and (b) υ_{PM} = 90 °C. The MVD in the laminated core, leakage and fringing magnetic flux can be neglected. **16**

[Turn over

PART - I



4. i) What is armature reaction in a PMDC machine? Is it detrimental for the PM? **6+10=16**

ii) Design the armature and field of a PMDC commutator motor of cylindrical construction with a slotted rotor rated at: Pout = 25 kW, V = 200 V, and n = 3500 rpm. The useful magnetic flux density cannot exceed 0.25T for the PM used. The efficiency at rated load should be a minimum of η = 86%. The motor has to be designed for continuous duty. Assume air gap flux density to be 0.35 T and line amp-conductor to be 18,000.

5. i) Discuss different rotor constructions of PMSM motor. **6 +10=16**

ii) Derive the flux density in the direct axis and quadrature axis of at least two of such constructions.

PART-II.

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

6.	a) Using the model equations of a BLDC machine, show that BLDC motor is inherently stable for speed control applications. (CO3)	8
	b) Explain how speed and position feedback can be taken in a BLDC motor Drive system. (CO2)	8
7.	a) Explain how BLDC motors can be driven with the help of unidirectional current control technique. (CO1)	6
	b) Deduce the expression of induced EMF and torque in a BLDC machine. Sketch the emf and ideal current waveforms for any one phase.(CO4)	10
8.	a) Draw and explain the schematic diagram of VSI fed BLDC drive system fed from a single phase ac supply. (CO3)	10
	b) Explain commutation torque ripple in a BLDC machine. Using model equations, show how the commutation torque ripple can be reduced. (CO2)	6
9	a) With the help of block diagrams, explain how a Buck converter can be used for speed control of BLDC motor. (CO2)	8
	b) Draw and explain the block diagram of a buck converter fed switched reluctance motor (SRM) drive system with four semiconductor switches for four stator windings. (CO4)	8
10	a) Show how a switched reluctance motor (SRM) can be driven with eight semiconductor switches having four stator windings. Also explain its merits/demerits over the four switch scheme for the same motor. (CO3)	10
	b) Using block diagram, show how speed sensor less operation can be achieved for a buck converter fed BLDC motor drive schemes. (CO1)	6