Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2011-12 (2.0 hours)

EEE202 Electromechanical Energy Conversion

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. **a.** With the aid of a suitable diagram, derive an expression for the force developed on the voice coil of a loudspeaker, and explain the operation of the device. **(8)**

b. Show how the mechanical components of the loudspeaker may be modelled by electrical equivalents and how the system may be represented by an electrical equivalent circuit. Ignoring the damping, give the equivalent circuit values for the loudspeaker parameters below: **(8)**

Radial field flux density (B):	0.8T
Voice coil diameter (D):	50mm
Number of turns on voice coil (N):	100
Voice coil resistance:	8Ω
Voice coil self inductance:	100μH
Mass of combined coil and cone:	25g
Radial compliance of suspension spring:	1000N/m

c. State an expression for the mechanical resonant frequency in terms of the equivalent circuit values and calculate the mechanical resonant frequency of the loudspeaker in part b. **(4)**

2. **a.**

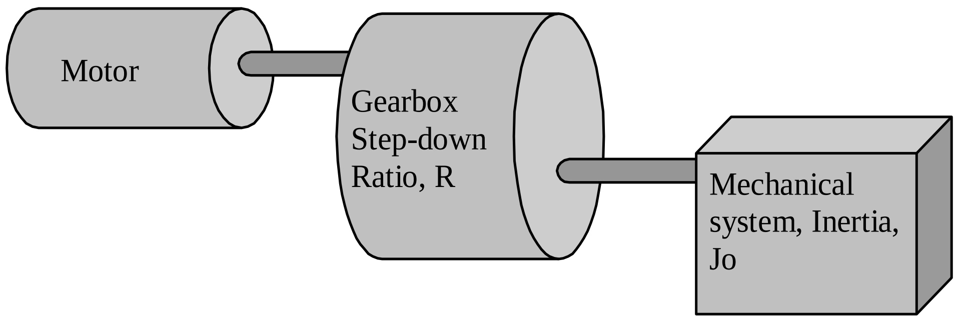

Figure 1

With reference to figure 1, show how the inertia of the load (Jo) will be reflected back to the motor. **(6)**

b. A permanent magnet servo motor is used to drive a portable centrifuge, through a 1:2 gearbox, which steps the motor speed up to the required centrifuge load speed of 4000rpm. Given the motor data at the end of the question, and that the centrifuge load is dominated by its inertia of 0.1kgm, calculate the motor current required to accelerate the centrifuge from standstill to full speed in 4 seconds under constant acceleration. **(3)**

c. In order to maintain the separation of the samples in the centrifuge, the load has to be decelerated back to standstill in 1 second under constant deceleration. Given that the entire cycle (including operation in part b) lasts for 10 seconds, draw the profile of the current drawn by the motor **(3)**

d. Calculate the voltage requirement of the supply, and sketch the voltage profile applied to the motor. **(2)**

e. Calculate the average power dissipated over the full cycle in the motor windings **(2)**

f. What problem could be encountered if the supply was connected directly to the motor at standstill. **(4)**

MOTOR DATA:

Winding resistance = 0.1Ω

Motor inertia= 0.2kgm

Motor back emf constant = 1.6 Vs rad^{-1}

3. **a.** Give the approximate equivalent circuit for a three-phase induction motor, explaining what each component represents. Show how the locked rotor test may be used to calculate some of the motor parameters in the equivalent circuit. **(8)**

b. The following readings were taken during a locked rotor test performed on a 6-pole, 415V, 3-phase, 50Hz, star-connected induction motor.

Line voltage = 80V,   Line current = 20A, Input power = 2.0kW

The stator resistance was measured at 0.4Ω per phase.

Find the maximum mechanical load torque which it is safe for the motor to drive, such that the motor will not stall under the worst-case supply conditions, given that the 50Hz supply to the motor is prone to voltage drops of up to 20%. **(12)**

4. **a.** With the aid of suitable diagrams explain how a variable reluctance stepper motor operates in half stepping mode. Give the advantages of half stepping over full stepping operation **(8)**

b. A student was using a stepper motor in his final year project to move a small computer controlled robot arm. The student noticed that when the arm was moving slowly, the system behaved well, however when the student tried to increase the speed of the arm above a certain speed, the system stalled. Explain what is happening with the system, and suggest a way of making the robot arm move at the required speed. **(8)**

c. Briefly describe one disadvantage of a variable reluctance stepper motor and show how this may be overcome. **(4)**

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