Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2008-2009 (2 hours)

Electromechanical Energy Conversion 2

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 suitable diagrams, show how a loudspeaker works, and derive an expression for the force on the cone as a function of the current in the device.

(4)

b. Show how the device may be modelled by an electrical equivalent circuit, showing how to derive the component values in the proposed equivalent circuit.

(8)

A particular loudspeaker has the following parameters:

Radial field flux density (B):	1.0T
Voice coil diameter (D):	32 mm
Number of turns on voice coil (N):	100
Voice coil resistance:	140 Ohms
Voice coil self inductance:	172mH
Mass of combined coil and cone:	6 grammes

c. Given that the mechanics of the loudspeaker are dominated by the combined mass of the coil and cone, derive a simple equivalent electrical circuit for the device, and show that it has a resonant natural frequency of 50Hz.

(5)

d. Calculate the current drawn from the supply, when the voice coil is supplied with a 12Vrms voltage at 50Hz

(3)

2.

2. a. Explain the ratings of a servo motor (T_{max}, T_{stall} & n_{max}), giving their definitions and what mechanism within the motor governs the rating.

(6)

b. With the aid of suitable diagrams, explain the action of a commutator, and why it is necessary within a brushed dc motor.

(4)

c. In a manufacturing process, a robot arm is required to move through an angle of 150^o in 1 second before returning to the start. The arm accelerates at a constant rate for 0.5 seconds, then decelerates at a constant rate to stop at the required position.

- Draw a velocity / time graph for the movement.
- Calculate the maximum rotational speed of the arm.
- Given that the system inertia is $0.5kgm^2$, calculate the maximum torque required from the motor and sketch a torque vs time profile.
- Given that the motor constant is 100V / 1000rpm, calculate the maximum current required from the supply, and sketch a current vs time profile.
- The motor resistance is 0.1Ω, calculate the applied voltage, and sketch a voltage / time profile.

(8)

d. How many quadrants does the electronic drive which supplies the motor need to operate in?

(2)

3. a. Give the full stator equivalent circuit for an induction motor, labelling all components and giving an explanation of what each component is.

(9)

b. For a 3-phase, 415V, 2 pole induction motor (specification given below), calculate the starting torque and pull out torque, and sketch the torque speed curve for the motor, labelling the values calculated.

(7)

Motor Specification

2 Pole, 3 Phase, star connected, 415V, 50Hz, rated slip = 1%

$R_1 = 1\Omega$, $R_2' = 0.2\Omega$, $X_1 = 5mH$, $X_2' = 2mH$ all per phase.

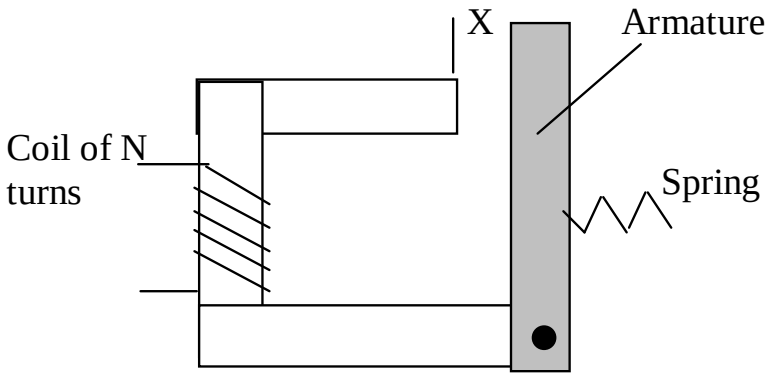
c. Sketch a suitable power electronic drive for an induction motor.

(4)

4. **a.** The figure below shows the configuration of a simple relay, in which the only significant reluctance is the airgap of length X, and cross sectional area A. Derive an expression for the coil inductance, and hence show the force on the hinged armature when the coil is carrying I amps is given by:

$$F = \frac{\mu_o A N^2 I^2}{2X^2}$$

(8)



b. For a particular relay, N=1000 turns, A=120mm^2 and X=5mm when the armature is in the fully open position and X=3mm when the armature is in the closed position. If the spring exerts a constant force of 3N, calculate the current required to close the relay and the current at which it will re-open.

(7)

c. Why are the two current levels not equal, and why is this effect desirable in the relay operation?

(5)

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