Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2009-2010 (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.** Explain clearly the 3 rating parameters for brushed d.c. motors (T_{stall}, n_{max} and T_{max}).

Highlight what influences the rating and how this affects the motor operation. **(5)**

b. With the aid of an annotated diagram, show how a permanent magnet pole may become partially demagnetised within a brushed d.c. motor. **(4)**

c. i. Derive the equations for the operation of a wound field brushed d.c. motor, and explain how the motor may be operated from an a.c. supply. **(3)**

ii. Highlight any other factors which would affect the choice of voltage for the operation of the motor in part (i) on an a.c. supply. **(2)**

d. i. A 200V, 2-pole brushed d.c. shunt motor runs at 3000 rpm and takes an armature current of 28A when driving a certain load. The four field windings are all connected in series across the supply, and draw a field current of 7A. If the armature resistance is equal to 0.1Ω, find the load torque. **(3)**

ii. The four field coils are now connected all in parallel, and the machine is run as a series motor across a 250V supply. Calculate the new speed if the load torque remains the same. **(3)**

2. **a.** With the aid of a suitable diagram, show that for a linear, non-saturated magnetic system comprising of a coil carrying some current *I*, the energy stored in the magnetic circuit, *W*, is

$$W = \frac{1}{2} L I^2$$

(6)

b. For a particular simple relay shown as figure 1, $N = 1200$ turns, The cross sectional area $A = 100\text{mm}^2$, and airgap length $X = 5\text{mm}$ when the armature is in the open position, and $X = 2\text{mm}$ when the armature is in the open position.

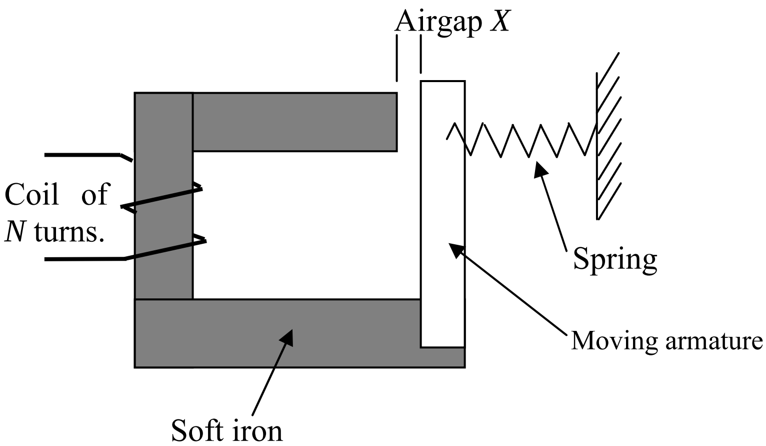

Figure 1 – Simple relay

If the spring exerts a constant force of 1Nm, calculate the current required to close the simple relay, and the current at which the simple relay will re-open. **(6)**

c. i. Why are the two current levels calculated in part 'b' above not equal? **(4)**

ii. Explain why this is desirable for correct operation of the device. **(4)**

3. **a.** With the aid of a diagram, give the approximate per-phase equivalent circuit of a 3-phase induction motor, explaining what each of the components represents, and how they relate to the motor. Also give the assumption made in enabling the approximate equivalent circuit to be formed from the classical equivalent circuit. **(7)**

b. Using the approximate equivalent circuit from part (a) as a starting point, derive an expression for the output torque of a 3-phase induction motor **(6)**

c. A locked rotor test is carried out on a 2-pole, 3-phase star connected induction motor, rated for 50Hz, 415V_{line} operation. At the rated motor current of 50A, the power input to the machine was measured to be 210W, with an applied phase voltage of 42V. Given that the winding resistance is measured at 0.01Ω per phase, calculate the maximum pull-out torque for the motor at rated voltage. **(7)**

4. **a.** A robot arm on a packaging machine has to swing through an arc of 150^{o} in 0.5 seconds following a triangular velocity profile. The load is connected to the motor through a 10:1 reduction gearbox, and that the total inertia of the gearbox and load presented to the motor shaft is $0.025kgm^2$ Given that the brushed servo motor constant, K, is 100V / 1000rpm and the winding resistance is 0.2Ω, ignoring any friction and the inertia of the motor, calculate:

i. The top speed of the motor **(4)**

ii. The maximum supply voltage and current required **(4)**

b. With the aid of a suitable quadrant diagram, show how the drive system may be required to operate in more quadrants than the motor is expected to operate in for this movement profile. **(6)**

c. Sketch a suitable power electronic drive circuit for this task, explaining how the drive will enable the motor to perform the required operation. **(6)**

DAS