Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2011-12 (2.0 hours)

EEE6140 Machine Design

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. For the radial-field, 4-pole, 12-slot, surface-mounted permanent magnet machine shown schematically in Figure 1, the major dimensions and parameters are listed in Table 1, (full marks will not be given if the appropriate approximations are not specified)

a. Derive the general expression for airgap flux density on load and on open-circuit **(6)**

b. Calculate the magnetic loading **(3)**

c. Calculate the tooth flux density and comment on the result **(3)**

d. Calculate the back-iron flux density and comment on the result **(3)**

e. Calculate the electric loading if the total ampere turns for the 3-phase windings are NI=5000A. **(2)**

f. Calculate the electromagnetic torque **(3)**

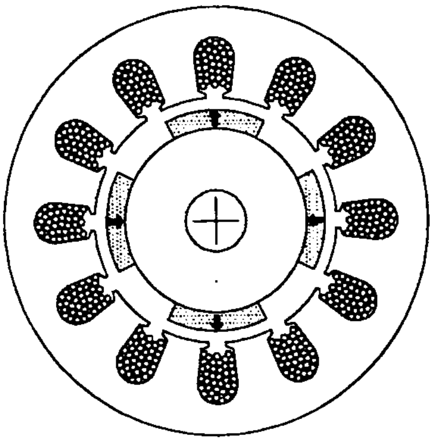

Figure 1

Table 1

Stator outside diameter	D_o	100 mm
Stator inner bore diameter	D_i	60 mm
Airgap length	l_g	1 mm
Magnet thickness	l_m	5 mm
Magnet pole arc	α	120 deg. Elec.
Magnet remanence	B_r	1.2 T
Magnet recoil permeability	μ_r	1
Tooth width	w_t	7 mm
Back-iron thickness	d_c	12 mm
Active axial length	L_a	50 mm

2. **a.** For a permanent magnet brushed DC motor, derive the torque constant K_T and the EMF constant K_E. (full marks will not be given if the appropriate approximations are not specified). **(6)**

b. Sketch typical torque-speed characteristics of a permanent magnet brushed DC motor when supplied from different DC voltages. For a given motor, what limits the maximum torque which can be achieved and why? **(5)**

c. Explain, with the help of a diagram, the reversible and irreversible demagnetisation phenomena in NdFeB magnets when the temperature is increased from room temperature to an elevated temperature and then reduced to the room temperature again. **(6)**

d. Explain why the irreversible demagnetisation, which is caused by the temperature rise in rare-earth magnets, is usually much more serious than that in ferrite magnets? **(3)**

3. **a.** Derive general expressions for the winding pitch-factor, K_p, and the distribution-factor, K_d, for both fundamental and n-th harmonic emf components. **(10)**

b. Show that the skew factor can be derived from the winding distribution factor. **(4)**

c. A concentric winding which is distributed in the slots over one pole pitch in a machine having evenly spaced slots, as shown in Figure 2. Derive its expression of winding factor for the fundamental and the n-th harmonic components and calculate its value for the fundamental component. **(6)**

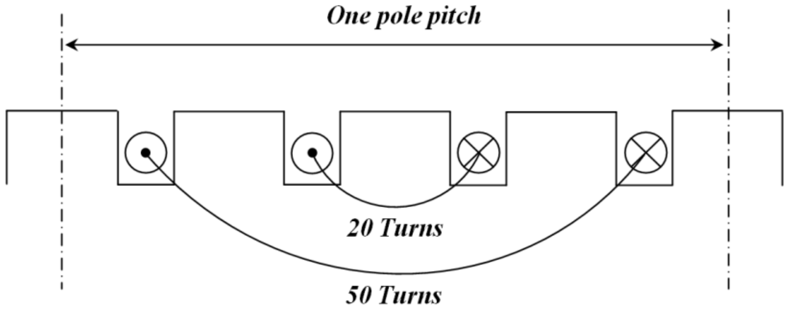

Figure 2

4. For a slot shown in Figure 3, specifying any assumptions which need to be made (Full marks will not be given if the appropriate assumptions are not specified)

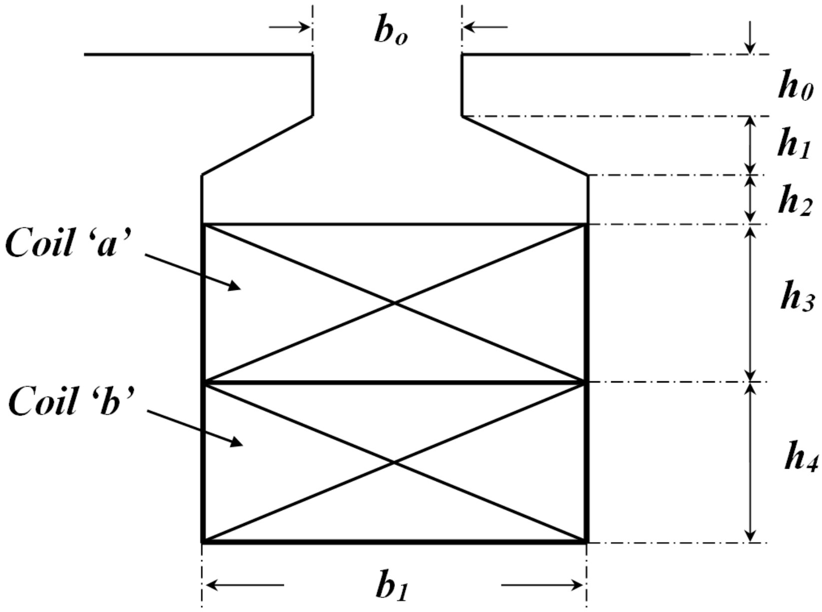

Figure 3 (Numbers of turns in the slot for coil "a" and coil "b" are N_a and N_b respectively)

a. Calculate the coil slot leakage inductance per-unit length for coil "a" **(5)**

b. Calculate the coil slot leakage inductance per-unit length for coil "b" **(4)**

c. Calculate the mutual inductance per-unit length between coils "a" and "b" **(7)**

d. List possible ways of reducing the slot leakage **(2)**

e. If this slot is part of an induction motor, discuss how the slot inductance may affect the motor performance, and why? **(2)**

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