Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2009-2010 (2 hours)

Machine Design 3

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.** For a radial-field electrical machine, with the aid of schematic diagram of stator lamination, show the effect of increasing the machine radial dimensions on electric loading, output power and torque.

(i) When all major radial dimensions are increased by a factor K. **(7)**

(ii) When the slot depth is kept constant but other major radial dimensions are increased by a factor K. **(6)**

b. Show schematically the variation of electric load against machine diameter. **(3)**

c. What is the influence of number of poles on the machine design? **(4)**

2. **a.** Derive an expression for the coil inductance per-unit length, for a slot shown in Fig.1, specifying any assumptions which need to be made (Full marks will not be given if the assumptions are not specified). **(10)**

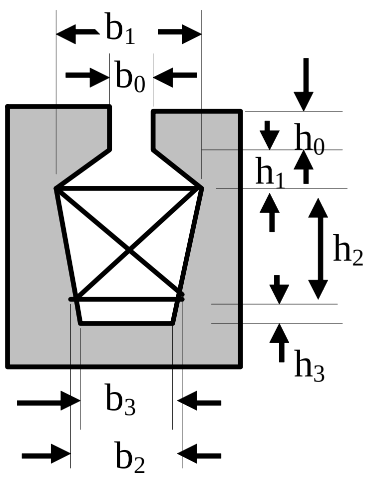

Figure 1

b. Suggest possible ways of increasing the winding inductance in the slot. **(4)**

c. Use coil emf vectors to determine the coil connections for a 3-phase, 9-slot, 8-pole permanent magnet motor which has a non-overlapping concentrated windings. Discuss the advantages and disadvantages of this type of winding layout. **(6)**

3. Derive the following two equations for airgap open-circuit flux density and minimum magnet length to avoid irreversible demagnetisation, which are often used in the design of surface-mounted permanent magnet machines. List all the assumptions that are made in the derivation.

a. Open-circuit airgap flux density produced by the magnets:

$$B_g = \frac{B_r}{\frac{A_g}{A_m} + \mu_r \frac{L_g}{L_m}}$$

(8)

b. Minimum magnet length to avoid irreversible demagnetization of magnets:

$$l_{m(\lim)} = -\frac{NI}{H_{\lim}} - \frac{B_r}{\mu_0 H_{\lim}} \times \left(l_g \frac{A_m}{A_g} \right) - \mu_r l_g \left(\frac{A_m}{A_g} \right)$$

(8)

where B_r, $H_{\lim}$ and μ_r are the remanence, critical coercivity and recoil permeability of the magnets and NI is the external demagnetising mmf. A_g and L_g are the cross-section area and length of airgap, respectively, and $A_{m,}$ and L_m are the cross-section area and length of magnet, respectively.

c. Describe the methods of enhancing the magnetic loading in permanent magnet machines and their constraints. **(4)**

4. **a.** Derive general expressions for the airgap field distributions produced by a single-phase winding and a three-phase winding in a cylindrical electrical machine, respectively. Describe the characteristics of the airgap field produced by the single-phase winding and the three-phase winding. **(12)**

b. Derive expressions for the corresponding airgap winding inductances for both single-phase and three-phase windings. **(8)**

ZQZ