Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2015-16 (2.0 hours)

EEE305 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. The major dimensions and parameters of a radial field, 12-slot, 10-pole surface mounted permanent magnet machine shown in Figure 1 are listed in TABLE 1. By specifying appropriate approximations, answer the following questions.

a. Assuming the permanent magnets are full arc (180^o) and $\mu_r = 1$, calculate the magnetic loading *B* and list possible ways to increase the magnetic loading *B*. **(6)**

b. If the allowable peak no-load lamination flux density is 2 T, choose a suitable stator tooth width (t_w) and comment on the result. **(4)**

c. For the same peak no-load lamination flux density stated in Q1.b, choose a suitable stator yoke thickness (d_c) and comment on the result. **(4)**

d. Calculate the electric loading *Q* if the total Ampere-Turns for the 3-phase windings are *NI* = 1000A. List the limiting factors for increase in electrical loading *Q*. **(4)**

e. Calculate the electromagnetic torque using the previously obtained electrical loading *Q* and magnetic loading *B*. **(2)**

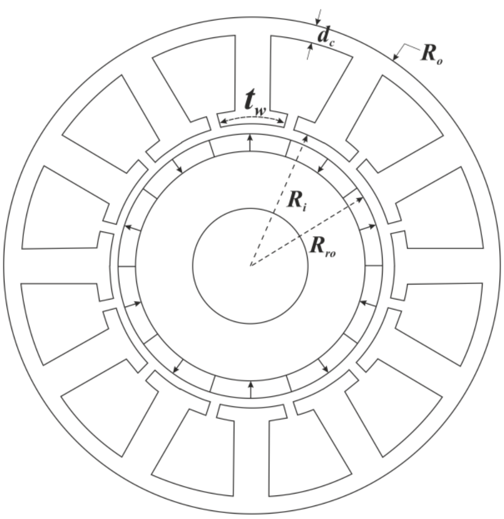

Figure 1

TABLE 1

Slot number (N_s)	12
Pole number ($2p$)	10
Stator outer radius (R_o)	50 mm
Stator inner radius (R_i)	28.5 mm
Active axial length (L_a)	50 mm
Air-gap length (L_g)	1 mm
Rotor outer radius (R_{ro})	27.5 mm
Magnet thickness (L_m)	3 mm
Magnet remanence (Br)	1.2 T

2. A 4-pole surface mounted permanent magnet machine has 15 stator slots (N_s) and the following dimensions:

Rotor outside diameter (D) =30 mm
Rotor active length (L) = 80 mm
Stator slot area (A_s) = 30 mm^2/slot
Magnet pole arc (α) = 140^o (elec.)
Effective airgap (l_g) = 1.0 mm
Magnet recoil permeability (μ_r) = 1.1

The magnet material has the B-H characteristic shown in Figure 2.

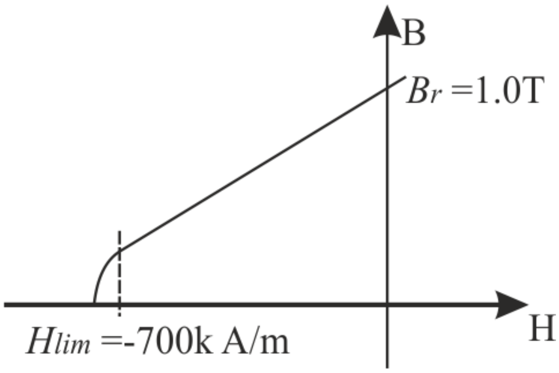

Figure 2

a. If the winding has a current density of J = 8 A/mm^2 and a packing factor of 0.5, calculate the magnet thickness required to obtain a power output of 600 W at 5000 rpm. **(6)**

b. List possible ways to improve the open-circuit airgap flux density. **(3)**

c. Check whether the magnet will be demagnetised at three times the full-load torque. **(6)**

d. Sketch the difference between reversible and irreversible demagnetizations. **(3)**

e. Explain the influence of temperature on the irreversible demagnetization for both Ferrite and NdFeB permanent magnets. **(2)**

3. **a.** Derive general expressions for the winding pitch-factor, K_p, and the distribution-factor, K_d, for both fundamental and n-th EMF harmonic components. **(6)**

b. By employing coil vectors, determine the coil connections that yield a maximum winding factor for a 3-phase, 12-slot, 14-pole permanent magnet machine with double layer, concentrated windings. **(4)**

c. Repeat Q3.b for a 3-phase, 12-slot, 14-pole permanent magnet machine with single layer, concentrated windings. **(3)**

d. Explain the main advantages and disadvantages of a single layer winding. **(4)**

e. Describe the main differences between concentrated winding and distributed winding and explain their merits and disadvantages. **(3)**

4. **a.** Derive an expression for the slot leakage inductance per-unit length, for a slot shown in Figure 3 (a) with N number of turns, specifying any assumptions which need to be made. Please note full marks will not be given if appropriate assumptions are not specified.

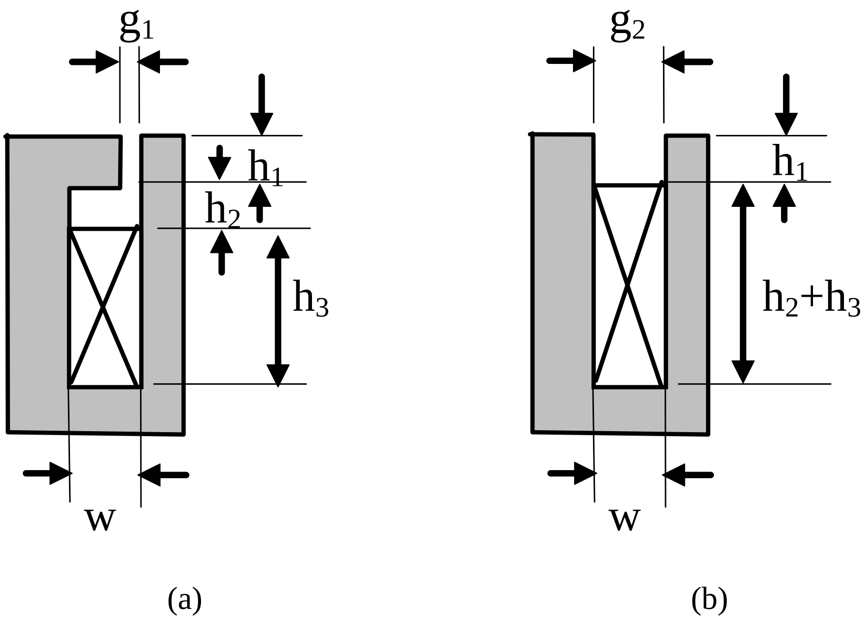

Figure 3 **(6)**

b. For large wind power generators and hydroelectric generators, it is often preferred to employ open slots, as shown in Figure 3(b). Calculate the difference in winding slot-leakage inductances between Figures 3(a) and 3(b). **(4)**

c. State the advantages and disadvantages of the slot configurations shown in Figures 3(a) and 3(b). **(6)**

d. List possible ways to increase winding inductances and state their limitations. **(4)**

GJL/JBW