University of Saskatchewan
College of Engineering
EE 444.3: Electrical Machines II
Final Examination

Instructor: Dr. N. Kar December 20, 2002
Time: 3 hours
Note: Two sheets of handwritten formulas permitted.

Marks

20 1. The dimensions of electromagnet shown in Fig. 1 are in centimetre (cm) and the depth of the core and the armature is 5 cm. The coil has 1000 turns. Assuming that the permeability of the magnetic material is very large relative to air ($\mu_o = 4\pi \times 10^{-7}$ H/m) and neglecting the leakage flux and the fringing of flux at the air-gaps:

(a) Determine the required D.C. current in the coil to provide a total pull on the armature (supported by springs) of 50 N at an air-gap length of l=0.8 cm.

(b) If the coil is excited from an A.C. supply, what will be the current in this case?

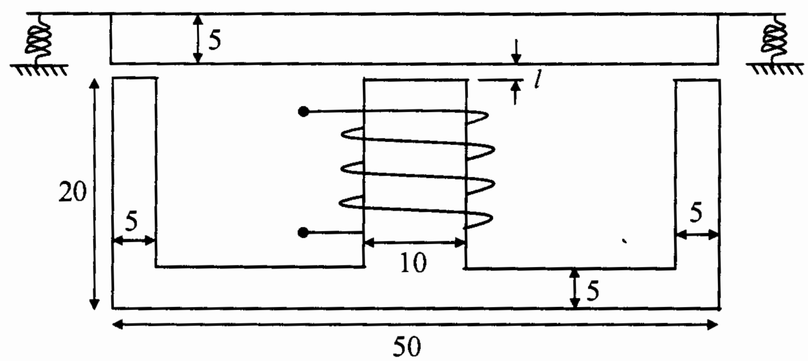

Fig. 1

20 2. Fig. 2 depicts a simple, single-phase, 4-pole reluctance motor. A current of 1A at 60 Hz is passed through its stator winding. Assuming a sinusoidal variation of inductance of this winding in terms of θ_r between the maximum value of 0.4 H and a minimum value of 0.1 H:

(a) Derive an expression as a function of time for the torque produced by this motor.

(b) Determine the value of the speed at which this motor will develop an average torque. What will be the maximum value of this average torque at this speed?

(c) What are the frequencies of the time varying components of the produced torque? What are the amplitudes of these components?

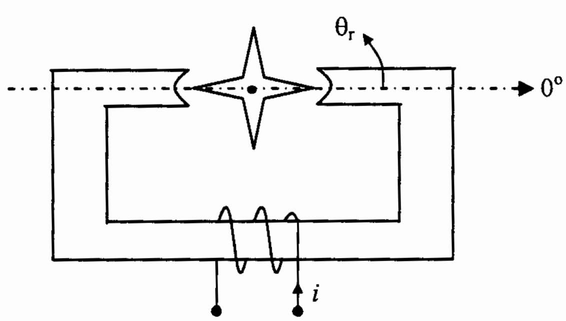

Fig. 2

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20 3. (a) What are the advantages and disadvantages of brushless dc motors compared to ordinary brush dc motors?

(b) A 460-V, 25-hp, 60-Hz, 4-pole, Y-connected, wound-rotor induction motor has the following impedances in ohms per phase referred to the stator circuit:

$R_1 = 0.641\ \Omega$ $R_2 = 0.332\ \Omega$
$X_1 = 1.106\ \Omega$ $X_2 = 0.464\ \Omega$ $X_M = 26.3\ \Omega$

i) What is the maximum torque of this motor? At what speed and slip does it occur?
ii) What is the starting torque of this motor?
iii) When the rotor resistance is doubled, what is the speed at which the maximum torque now occurs? What is the new starting torque of the motor?

15 4. (a) Neglecting the stator resistance, show that the active power output of a cylindrical-rotor synchronous generator connected to an infinite bus is given by

$$P = \frac{E_f V_t}{X_s} \sin\delta$$

(b) Describe the effect of the excitation on the synchronous generator performance using phasor diagram when the generator real power output, frequency and terminal voltage are constant.

25 5. A 2000-hp, 1.0-power factor, 3-phase, Y-connected, 2300-V, 30-pole, 60-Hz synchronous motor has a synchronous reactance of 1.95 Ω/phase. For this problem all losses may be neglected.

(a) Compute the maximum torque which this motor can deliver if it is supplied with power from a constant frequency source, commonly called an *infinite bus*, and if its field excitation is constant at the value which would result in 1.0 power factor at rated load.

(b) Instead of the infinite bus of part (a) suppose that the motor is supplied with power from a 3-phase, Y-connected, 2300-V, 1750-kVA, 2-pole, 3600-r/min turbine generator whose synchronous reactance is 2.65 Ω/phase. The generator is driven at rated speed, and the field excitations of the generator and motor are adjusted so that the motor runs at 1.0 power factor and rated terminal voltage at full load. The field excitations of both machines are then held constant, and the mechanical load on the synchronous motor is gradually increased. Compute the maximum motor torque under these conditions and the terminal voltage when the motor is delivering its maximum torque.

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