UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2012/2013

COURSE NAME	:	ELECTRIC MACHINES AND DRIVES / ELECTRICAL MACHINES
COURSE CODE	:	BEE 4123 / BEX 42403 / BEF 24103
PROGRAMME	:	BEE / BEF
EXAMINATION DATE	:	JUNE 2013
DURATION	:	2 ½ HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) Explain clearly the differences between fringing flux and leakage flux.

(4 marks)

(b) An electromagnet of rectangular cross-section shown in Figure Q1(b) has a tightly wound coil with 500 turns. The inner and the outer radius of the magnetic core are 10 cm and 12.5 cm, respectively and its thickness being 2 cm. The length of the air-gap is 1 mm. If the current, I in the coil is 3 A and produces a flux density, B of 1.2 T in the air-gap (no fringing effect), determine:

(i) The magnetic field intensity in the magnetic core, H_c and in the air-gap, H_g

(ii) The relative permeability of the magnetic material of the core, μ_r

(iii) The total reluctance, $\Re_{total}$ of the magnetic core and air-gap

(7 marks)

(c) The toroidal (circular cross section) core shown in Figure Q1(c) is made from cast steel. Its magnetization curve as shown in Figure Q1(d),

(i) Calculate the coil current required to produce a core flux density of 1.2 tesla at the mean radius of the toroid

(ii) Determine the core flux, in Wb. Assume uniform flux density in the core

(iii) If a 2-mm-wide air gap is made in the toroid (cross A-A'), determine the new coil current required to maintain a core flux density of 1.2 T. Assume fringing effects of 5%

(14 marks)

Q2 (a) Draw the connection of transformer for short circuit test and open circuit test together with their necessary meters.

(6 marks)

(b) A 5500 kVA 240/13.8 kV single-phase transformer has a values of the excitation branch, R_c=2500 Ω and X_m=250 Ω referred to the primary of the transformer. The short circuit test performed on the high-voltage side of the transformer and the data recorded are as follows:

$$V_{SC} = 550 \text{ V} \quad I_{SC} = 20 \text{ A} \qquad P_{SC} = 450 \text{ W}$$

(i) Determine the type of the transformer.

(ii) Determine the values of series impedance R_{eq} and X_{eq}.

(iii) Draw the equivalent circuit referred to the high voltage side of the transformer. Label all the components correctly.

(iv) Determine the full-load voltage regulation at 0.8 lagging power factor.

(v) Determine the output power of the transformer.
(vi) Determine the core loss and copper loss of the transformer.
(vii) From result (b)(vi),explain the relationship between the values of the excitation branch and the results.

(19 marks)

Q3 (a) Sketch and explain briefly power flow diagram of an induction motor.

(8 marks)

(b) A 3 phase, 450V, 50Hz, 4 pole, Δ-connected induction motor has the following parameter referred to the stator.

$$R_1 = 0.15\Omega$$
$$X_1 = 0.6\Omega$$
$$X_m = 35\Omega$$
$$R_2 = 0.35\Omega$$
$$X_2 = 0.6\Omega$$

The rotor is running at 1450 rpm and the rotational loss is 1800W. Based on the information given,

(i) Draw the equivalent circuit.
(ii) Find the stator current, I_1.
(iii) Calculate the power factor, *pf.*
(iv) Input power, P_{IN}.
(v) Stator copper loss, P_{SCL}.
(vi) Air gap power, P_{AG}.
(vii) Converted power, P_{CONV}.
(viii) Output Power, P_{OUT}.
(ix) Calculate the induced and load torque.
(x) Determine the value of external resistance required in each phase of the rotor when the maximum torque occurs at the starting point.

(17 marks)

Q4 (a) Sketch and explain the principle operation of a 3-phase, 2-pole DC excited synchronous motor.

(5 marks)

(b) A three-phase wye-connected synchronous motor has specifications as follow:

Line Voltage = 415 V, 50 Hz	Armature Resistance, R_A = 0.3 ohms
Power Factor = 0.8 leading	Synchronous Reactance, X_S = 4 ohms
Output Power = 20 Hp	Friction and Windage Losses = 15 kW
Pole = 2	Core Losses = 20 kW

Based on Figure Q4(b) and information given, answer the following questions.

(i) Sketch and label a single-phase equivalent circuit of synchronous motor.

(ii) By considering the related factor, estimate the value of three-phase copper losses, P_{copper} and armature current, I_A at unity power factor and full-load condition.

(iii) Calculate the required value of three-phase internal generated voltage, E_A and identify the required field current, I_F.

(iv) Sketch and label phasor diagram of the motor at unity power factor and full-load condition.

(v) Compute the motor efficiency, η_m at unity power factor and full-load condition by considering copper losses, P_{copper} effect.

(vi) Determine the maximum torque, τ_m at unity power factor and full-load condition by considering copper losses, P_{copper} effect.

(vii) Determine the maximum torque, τ_m at 0.8 leading power factor by considering copper losses, P_{copper} effect.

(viii) Sketch and label phasor diagram of the motor at 0.8 leading power factor.

(20 marks)

Q5 (a) Sketch and explain briefly equivalent circuit of shunt DC motor with its starting resistor in order to avoid any excess current.

(8 marks)

(b) A 50hp, 250V, 1200r/min dc shunt motor with compensating windings has an armature resistance of 0.06Ω. Its field circuit has a total resistance $R_{adj} + R_F$ of 50Ω, which produces a no-load speed of 1200r/min. There are 1200turns per pole on the shunt field windings.

(i) Find the speed of this motor when its input currents are 100A, 200A, and 300A

(ii) Plot the torque-speed characteristics of this motor at all conditions calculated from (i) and

(iii) List three (3) methods to control the speed of the motor

(17 marks)

- END OF QUESTION -

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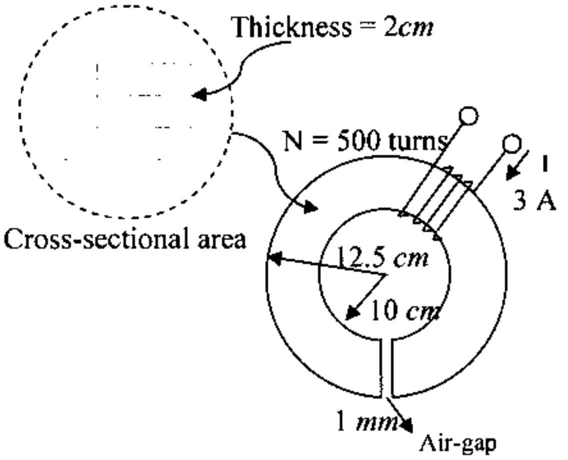

FIGURE Q1(b)

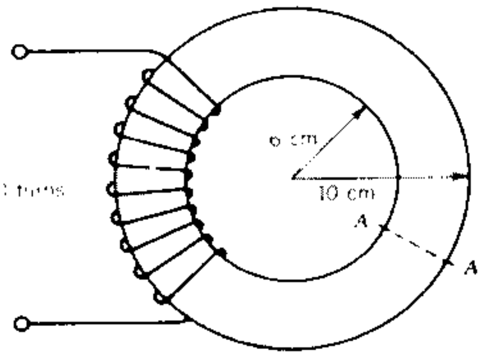

FIGURE Q1(c)

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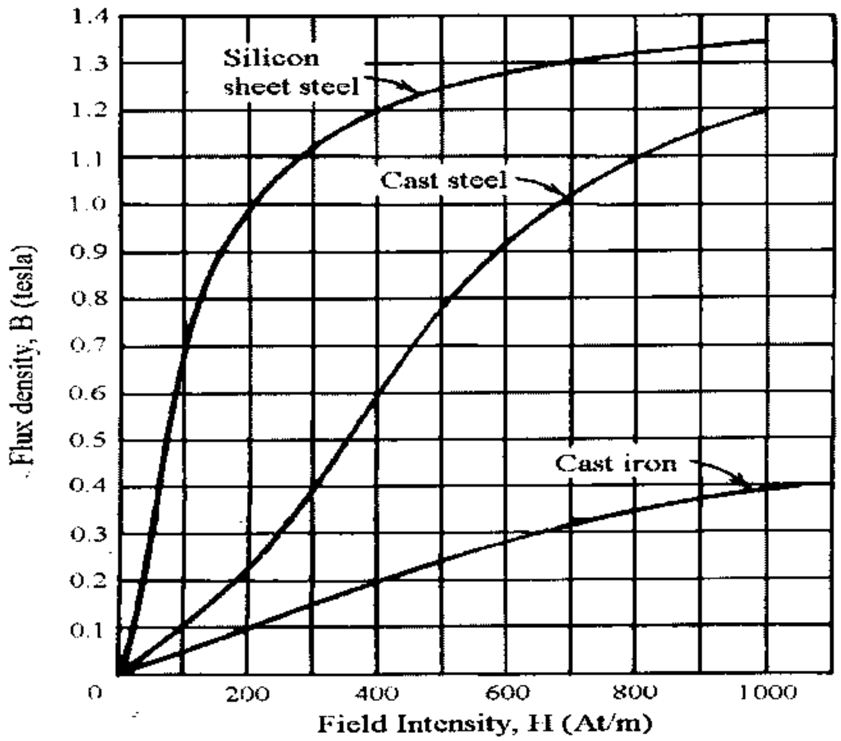

FIGURE Q1(d)

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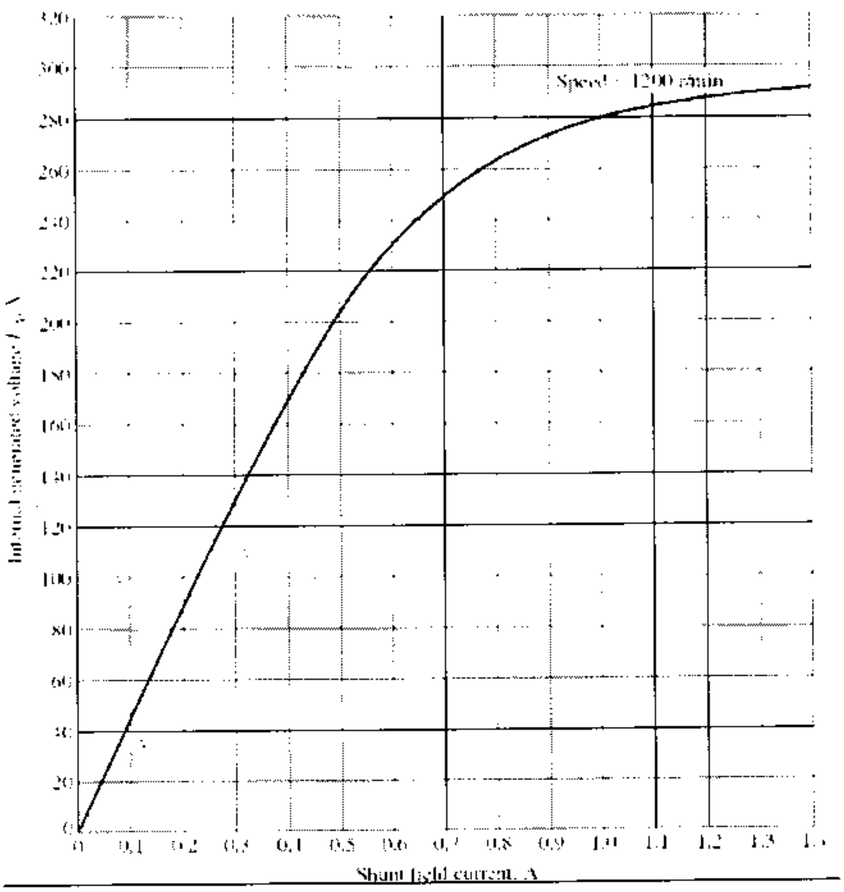

FIGURE Q4(b)

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Formulae

Magnet:

$$\mu_0 = 4\pi \times 10^{-7}\ H/m$$

Synchronous machine:

$$P_{conv} = \tau_{ind}\omega_m = 3E_A I_A \cos\gamma$$

$$P = \frac{3V_\phi E_A \sin\delta}{X_S} \qquad \tau_{ind} = \frac{3V_\phi E_A \sin\delta}{\omega_m X_S}$$

Induction motor:

$$P_{conv} = 3I_2^2 R_2\left(\frac{1-s}{s}\right) \qquad P_{AG} = 3I_2^2 \frac{R_2}{s}$$

$$\tau_{ind} = \frac{P_{AG}}{\omega_{sync}} \qquad \tau_{load} = \frac{P_{OUT}}{\omega_m}$$

$$\tau_{ind} = \frac{3V_{TH}^2\ R_2/s}{\omega_{sync}\left[\left(R_{TH} + R_2/s\right)^2 + \left(X_{TH} + X_2\right)^2\right]} \qquad s_{max} = \frac{R_2}{\sqrt{R_{TH}^2 + \left(X_{TH} + X_2\right)^2}}$$

DC motor:

$$E_A = K\phi\omega \qquad \tau_{ind} = K\phi I_A$$

$$P_{conv} = E_A I_A = \tau_{ind}\omega_m \qquad I_F^* = I_F + \frac{N_{SE}}{N_F} I_A - \frac{\Im_{AR}}{N_F}$$

$$\omega = \frac{V_T}{K\phi} - \frac{R_A}{(K\phi)^2}\tau_{ind}$$