Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	ELECTRICAL MACHINES
COURSE CODE	:	BEF 24103
PROGRAMME	:	BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	JUNE 2015/ JULY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) (i) Name the Flux *A* and Flux *B* as depicted in **Figure Q1(a)**

(2 marks)

(ii) Explain the differences between Flux *A* and Flux *B*

(2 marks)

(b) An electromagnet with circular cross-section as shown in **Figure Q1(b)** has a tightly wound coil with 1000 turns. The inner and the outer radii of the magnetic core are 10cm and 15cm, respectively. The length of the air-gap is given as 1.5mm. The injected current *I* into the coil is 5*A* and it produces a flux density (*B*) of 2.5 *Tesla* in the air-gap (no fringing effect).

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

(2 marks)

(ii) Discover the relative permeability of the magnetic material of the core μ_r

(1 mark)

(iii) Predict the total reluctance $\mathcal{R}_{total}$ of the magnetic core and air-gap

(2 marks)

(c) **Figure Q1(c)** shows a simple application of electromagnetic concept in crane. The core of the crane is made of silicon steel, for which the *B-H* relationship is given as:

$$B = 6.1643(1 - e^{-H/300})\ Tesla$$

It has a uniform cross-sectional area of $0.2m^2$ and a mean path length of 6m. Coils 1, 2, and 3 carrying 5*A*, 10*A*, and 2*A*, respectively in the directions as depicted in the figure. Coils 1 and 2 have 350 and 750 turns, respectively. In order to carry the load as shown in the figure, a minimum flux of 1 *Weber* need to be established in the core. Analyse the number of turns of coil 3 so that the crane has enough minimum power to carry the load.

(11 marks)

Q2 (a) (i) Define the meaning of ferromagnetic material which is commonly used as transformer's core

(2 marks)

(ii) Excitation current flowing in primary circuit of a transformer can be principally expressed by **two (2)** types of current. Explain it

(2 marks)

(b) **Figure Q2(b)** shows a core-type 100kVA, 3.3kV – 415V, three-phase power transformer.

(i) Arrange the connection at the primary windings in delta Δ and secondary windings in star Y. The neutral is to be solidly grounded

(2 marks)

(ii) Determine the phase current flowing in secondary winding I_a and primary winding I_{AB} if a 3-phase delta-connected load of 50kW, 415V, 0.8 power factor lagging is connected across the secondary

(3 marks)

(c) **Figure Q2(c)** shows a per-phase power system consisting of 300kVA, 6.35kV – 3.18kV, power transformer supplies two loads (Load 1 and Load 2) through a feeder (FD). The transformer is connected to a 50 Hz power source through a cable (CBL). Ratings of other components are given in the figure.

(i) If the loads draw rated currents at rated voltage, investigate the voltage level that should be supplied at the power source

(6 marks)

(ii) Analyse the voltage regulation of the power transformer at rated condition

(3 marks)

(iii) Evaluate the overall efficiency of this power system

(2 marks)

Q3 (a) Sketch and label the magnetisation curves (flux versus magnetomotive force) for transformer and induction motor. Explain the dissimilarity between theses curves.

(4 marks)

(b) As an electrical engineer, you have been assigned to select a proper rating of a 3-phase 415V, 50Hz 4-poles induction motor that to be used as stirrer in a fish pond. The full-load output torque that should be considered in this case is 600Nm. Assumed the motor having the power factor of 0.80.

(i) If the slip and the efficiency of the induction motor is to be assumed as 3% and 90%, respectively, determine the minimum power rating of the induction motor and the magnitude of the current drawn by the motor

(4 marks)

(ii) Construct the power triangle of this motor based on its input powers

(2 marks)

(c) A 415V, 50Hz, Y-connected, 8-pole induction motor is rated at 25HP. The per-phase equivalent circuit components data are given as follows:

Stator circuit:
$R_1 = 0.44\Omega$, $X_1 = 1.25\Omega$
Rotor circuit:
$R_2 = 0.40\Omega$, $X_2 = 1.25\Omega$
Magnetising circuit:
$R_C = 350\Omega$, $X_M = 27\Omega$

For a slip of 3%, analyse the starting current of this motor.

(10 marks)

Q4 (a) (i) List **two (2)** types of rotor on the synchronous machine construction

(2 marks)

(ii) Explain the procedure to start a synchronous motor using damper windings method

(3 marks)

(b) A 3-phase Y-connected synchronous motor has the following specifications: 150kW, 415V, 50Hz, 4-pole, power factor 0.9 leading. This motor is to be operated by controlling the system frequency with a solid-state drive from 20Hz to 50Hz. The motor parameters are synchronous reactance of 1.2Ω and a negligible armature resistance. The rotational losses are also to be ignored.

(i) Determine the range of the operating motor speeds

(2 marks)

(ii) Determine the induced voltage, E_A of the motor at rated conditions

(3 marks)

(c) A motor-generator set consisting of a synchronous motor driving a synchronous generator. The motor has 10-pole and supplied by electrical line with frequency of 50Hz. If the synchronous generator is designed to produce 3-phase output with frequency of 150Hz, evaluate the number of poles for the generator.

(3 marks)

(d) A 80KVA, 400V, 0.8 PF-lagging Y-connected synchronous generator has a negligible armature resistance and a synchronous reactance of 1.2 per-unit. The generator is connected in parallel with a 50Hz, 400V infinite bus that is capable of supplying or consuming any amount of real or reactive power with no change in frequency or terminal voltage.

(i) Point out the synchronous reactance of the generator in ohms

(2 marks)

(ii) Investigate the internal generated voltage, E_A of the generator at rated conditions

(3 marks)

(iii) Suppose that the generator is initially operating at rated conditions. If the internal generated voltage, E_A is decreased by 25%, analyse the new armature current value

(2 marks)

Q5 (a) (i) List **four (4)** losses component of DC machines

(2 marks)

(ii) Explain **two (2)** methods to control the speed of a non-permanent magnet DC motor

(2 marks)

(b) A 200V shunt DC motor is supplied by a full-load line current of 90A. The armature resistance and field resistance are given as 0.06Ω and 115Ω, respectively. The total brush-contact voltage drop is 1.5V with the friction and core losses of 550W.

(i) Sketch and label the appropriate equivalent circuit of the shunt DC motor

(2 marks)

(ii) Point out the efficiency of the motor at full-load operation

(7 marks)

(c) A separately excited DC motor operating at 1200rpm has a load current of 80A, a terminal voltage of 240V and an armature resistance of 0.13Ω.

(i) Analyse the developed torque

(4 marks)

(ii) If the load torque is double at same excitation, predict the motor speed in rpm

(3 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER/SESSION : II/ 2014/ 2015
COURSE NAME : ELECTRICAL MACHINES

PROGRAMME : BEV
COURSE CODE : BEF 24103

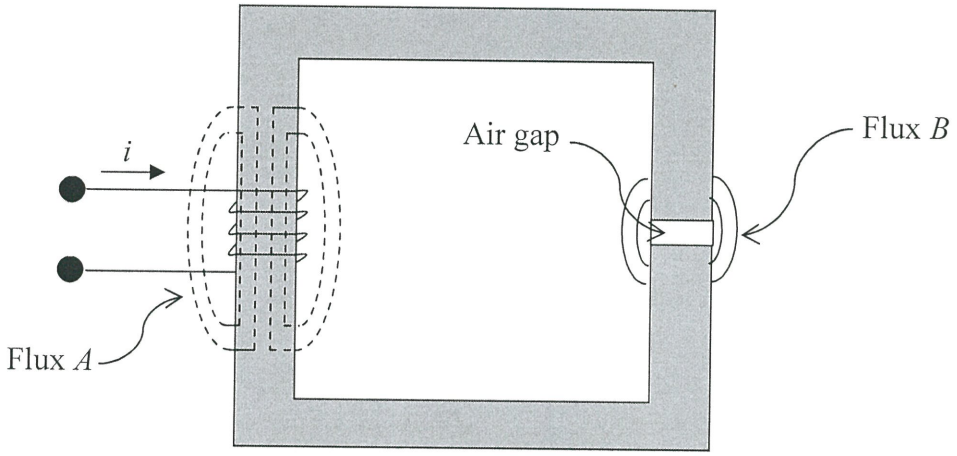

FIGURE Q1(a)

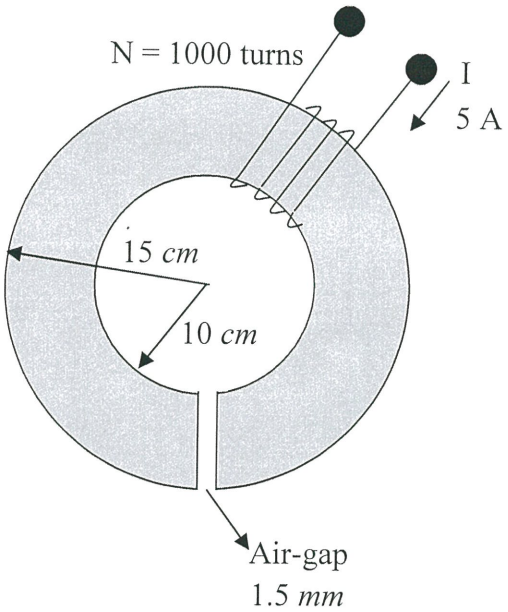

FIGURE Q1(b)

FINAL EXAMINATION

SEMESTER/SESSION : II/ 2014/ 2015 PROGRAMME : BEV
COURSE NAME : ELECTRICAL MACHINES COURSE CODE : BEF 24103

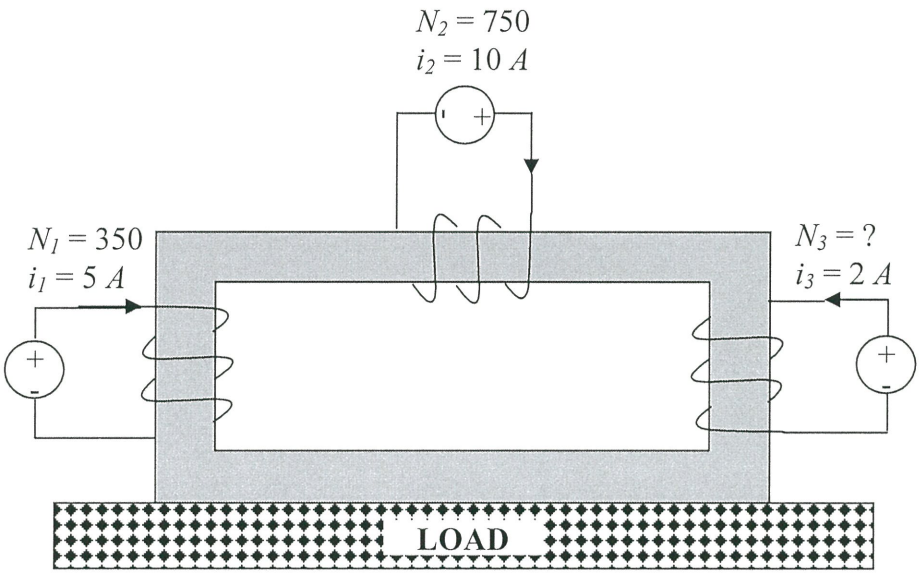

FIGURE Q1(c)

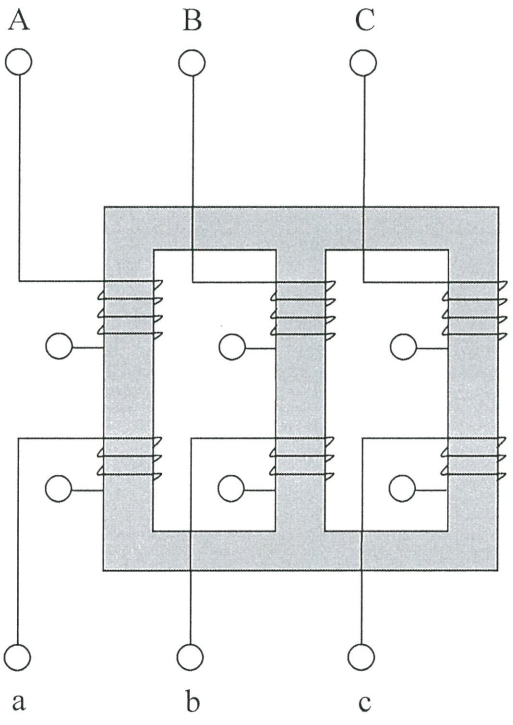

FIGURE Q2(b)

FINAL EXAMINATION

SEMESTER/SESSION : II/ 2014/ 2015 PROGRAMME : BEV
COURSE NAME : ELECTRICAL MACHINES COURSE CODE : BEF 24103

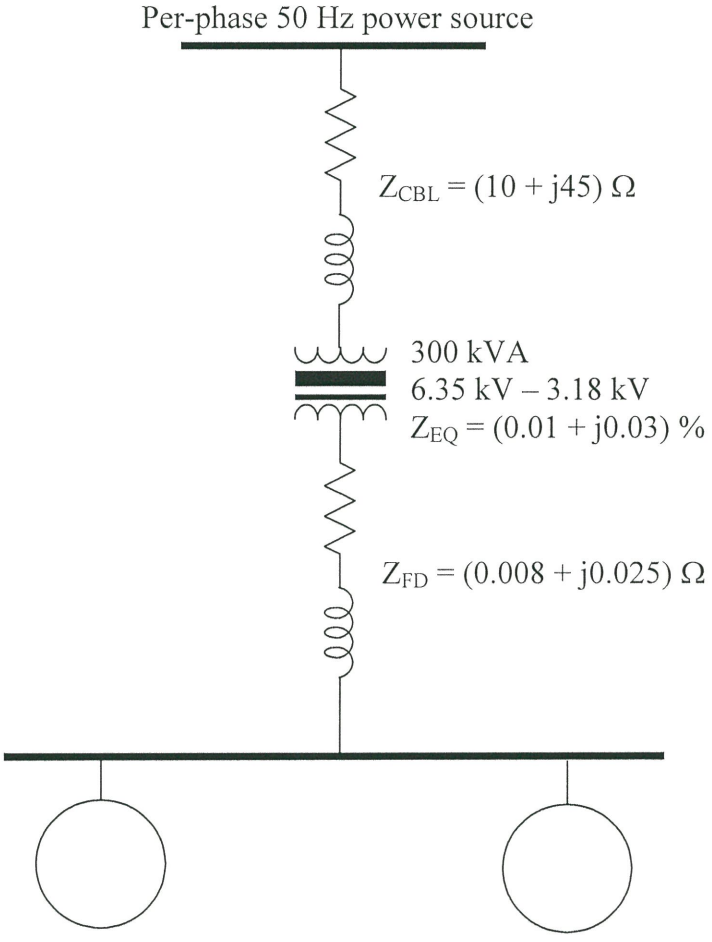

FIGURE Q2(c)