UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	ELECTRICAL MACHINES
COURSE CODE	:	BEF 24103 / BEV 20803
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) The dimensions of a ferromagnetic core with a depth of 7 cm and relative permeability of 1500 are shown in **Figure Q1(a).** The air gaps on the left and right sides of the core are 0.07 cm and 0.05 cm, respectively. Due to fringing effect, the effective areas of both air gaps are increased 5% larger than their physical size. The number of turns of coil wrapped around the centre leg of the core and the current injected to the coil are 400 turns and 1 A, respectively.

(i) Examine all reluctances.

(8 marks)

(ii) Analyse the flux in each leg of the core.

(4 marks)

(iii) Predict the magnetic flux density in both air gaps.

(2 marks)

(iv) Propose **TWO (2)** method to reduce eddy current loss in ferromagnetic core.

(2 marks)

(b) A single phase power system is connected with 100 kVA, 14/2.4 kV transformer through a feeder impedance of 38.2 + j140 Ω. The transformer's equivalent series impedance referred to its low voltage side is 0.12 + j0.5 Ω. The load on the transformer is 90 kW at 0.85 PF lagging and 2300 V.

(i) Examine the voltage at the power source of the system.

(5 marks)

(ii) Identify the voltage regulation.

(2 marks)

(iii) Predict the transformer efficiency.

(2 marks)

Q2 (a) (i) Explain briefly **FOUR (4)** types of AC electrical machines.

(4 marks)

(ii) State **THREE (3)** methods of speed control of induction motor.

(3 marks)

(b) A 440 V, 50 Hz, six pole, Y-connected induction motor is rated at 75 kW. The equivalent circuit parameters are

$R_1 = 0.082\ \Omega$	$R_2 = 0.070\ \Omega$	$Slip = 4\ \%$
$X_1 = 0.19\ \Omega$	$X_2 = 0.18\ \Omega$	$X_M = 7.2\ \Omega$
$P_{F\&W} = 1.3$ kW	$P_{core} = 1.4$ kW	$P_{misc} = 150$ W

(i) Draw the equivalent circuit of the induction motor.

(2 marks)

(ii) Examine the line current.

(4 marks)

(iii) Analyse the stator and rotor power factor.

(3 marks)

(iv) Formulate the induced torque and load torque.

(4 marks)

(v) Justify the stator copper loss, air gap power, power converted, output power and overall efficiency.

(5 marks)

Q3 (a) (i) List **TWO (2)** common approaches to supply DC power source to the field circuit on the rotor of a synchronous generator.

(2 marks)

(ii) Outline **FIVE (5)** steps or procedures to determine induce voltage parameter of a synchronous generator.

(5 marks)

(b) A 480 V, 200 kVA, 0.8 power factor lagging, 50 Hz, two-pole, Y-connected synchronous generator has a synchronous reactance of 0.25 Ω and an armature resistance of 0.03Ω. Its friction and windage losses are 6 kW, and its core losses are 4 kW. The field circuit has a dc voltage and maximum I_F of 200 V and 10 A, respectively. The resistance of the field circuit is adjustable from 20 Ω to 200 Ω. The Open Circuit Characteristic (OCC) of this generator is shown in **Figure Q3(b)**.

(i) Predict the field current when the generator is running at no load and full load condition using OCC in **Figure Q3(b).**

(2 marks)

(ii) Calculate the internal induced voltage at full load condition.

(4 marks)

(iii) Investigate the input power of the generator.

(5 marks)

(iv) Formulate the speed in rpm, the torque applied and the efficiency of the generator.

(3 marks)

(c) A 415 V, 50 Hz, six-pole and Y-connected synchronous motor operated at maximum operation, draws 80 A from the line supply at 0.9 power factor leading and 85% efficiency. Analyse the maximum output torque of this motor.

(4 marks)

Q4 (a) Explain why a DC motor should not be started by applying directly its rated voltage across the armature terminals.

(5 marks)

(b) Sketch the torque-speed characteristics for both shunt and series DC motors.

(2 marks)

(c) A 240 V, 1500 rpm DC shunt motor draws a current of 65 A during half-load operation. The rotational losses are 1500 W at rated power output. The armature circuit resistance and the field circuit resistance are given as 0.05 Ω and 120 Ω, respectively.

(i) Analyse the efficiency and torque of the motor under rated condition.

(10 marks)

(ii) Calculate the speed of the motor if the load is reduced so that the motor draws 75 A while the motor flux remains unchanged.

(6 marks)

(iii) Predict the speed of the motor as in **Q4(c)(ii)** with the same condition **EXCEPT** that the flux is decreased by 10% instead of remained constant.

(2 marks)

– END OF QUESTIONS –

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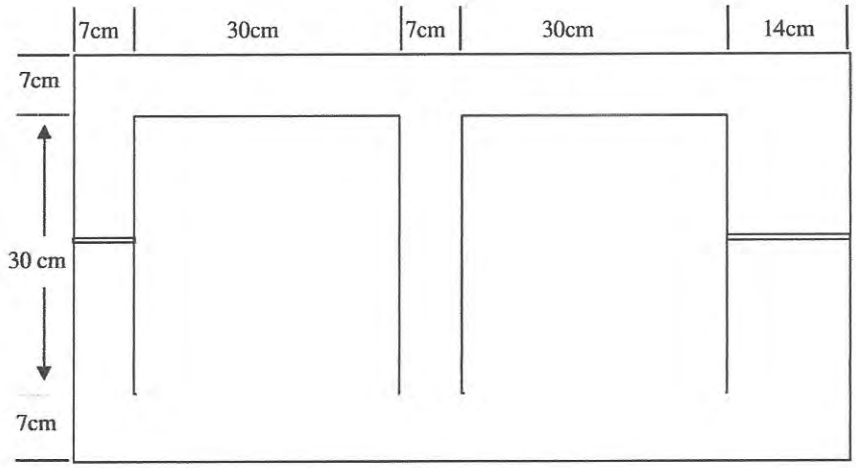

Figure Q1(a)

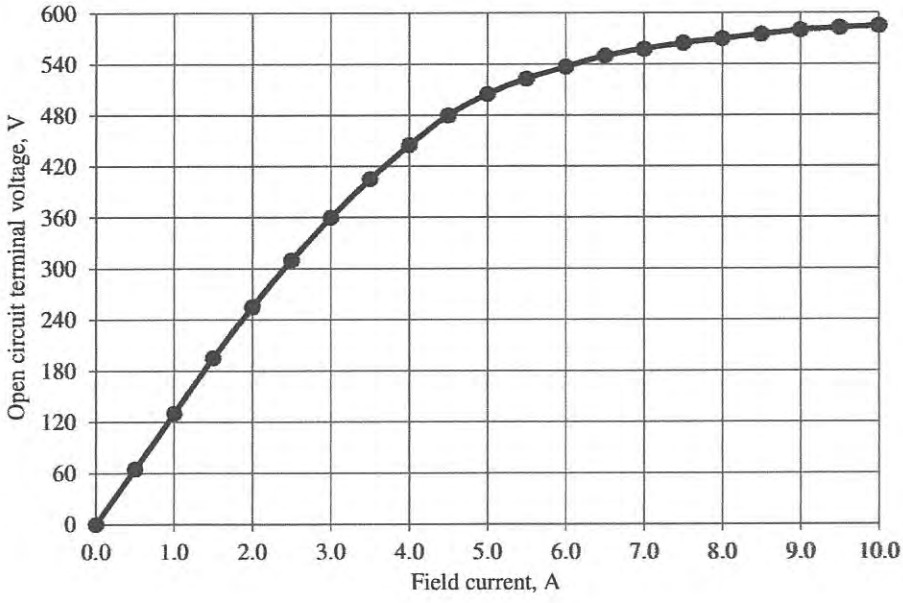

Figure Q3(b)