Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	ELECTRICAL MACHINE
COURSE CODE	:	BNR 35603
PROGRAMME CODE	:	BND
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) Name the main components of induction motor and explain briefly their usage.

(2 marks)

(b) Define slip speed and slip. Gives the rotor frequency (f_r) of an induction motor if the synchronous freqeuncy is given as 50 Hz, and the rotor is locked and rotates at 4% slip

(6 marks)

(c) A 415 V, 50 Hz, Y-connected, 4-pole induction motor is rated at 20 horse power (HP). Its per phase equivalent circuit component data are given as:

Stator circuit:
$R_1 = 0.44\ \Omega$, $X_1 = 1.25\ \Omega$

Rotor circuit:
$R_2 = 0.40\ \Omega$, $X_2 = 1.25\ \Omega$

Magnetizing circuit:
$R_C = 350\ \Omega$, $X_M = 27\ \Omega$

The motor mechanical losses and core losses are 262 W and 150 W, respectively. For slip of 3%, determine:

(i) the motor's stator, rotor and starting current;

(9 marks)

(ii) the efficiency of the motor;

(4 marks)

(iii) The induced torque and load torque of this motor

(4 marks)

Q2 (a) Explain briefly how to determine the synchronous reactance of a three-phase generator.

(6 marks)

(b) A three-phase, 200 kVA, 400 V, 50 Hz alternator has a per phase armature resistance and synchronous reactance of 0.1 and 0.2 Ω respectively. Determine induced emf when the machine is delivering a rated current at unity power factor. Draw the phasor diagram of the given alternator.

(4 marks)

(c) A 480 V 200 kVA 0.8 power-factor-lagging, 60 Hz two-pole Y-connected synchronous generator has a synchronous reactance of 0.25 Ω and an armature resistance of 0.03 Ω. At 60 Hz, its friction and windage losses are 6 kW, and its core losses are 4 kW. The field circuit has a dc voltage of 200 V, and the maximum I_F is 10 A. The resistance of the field circuit is adjustable over the range from 20 to 200 Ω. The OCC of this generator is shown in **Figure Q2(c)**.

(i) Determine the field current required to make terminal voltage, V equal to 480 V when the generator is running at no load.

(1 mark)

(ii) Determine the internal generated voltage of this machine at rated conditions.

(4 marks)

(iii) Determine the field current when the generator is running at rated conditions.

(3 marks)

(iv) Determine the power and torque supplied by the prime mover.

(5 marks)

(v) Determine the efficiency of the generator at rated load.

(2 marks)

Q3 (a) Explain why a synchronous motor does not have a starting torque. Give **ONE (1)** method to start up a synchronous motor.

(4 marks)

(b) A 460-V, 200-kVA, 0.80-PF-leading, 400-Hz, six-pole, Y-connected synchronous motor has negligible armature resistance and a synchronous reactance of 0.50 per unit. Ignore all losses.

(i) Determine the speed rotation of this motor.

(1 mark)

(ii) Determine the output torque.

(2 marks)

(iii) Determine the internal generated voltage at rated condition.

(7 marks)

(iv) Determine the maximum possible output power when the armature current are the same in **Q3(b)(iii)**.

(1 mark)

(c) A plot of I_A versus I_F for a synchronous motor is called as a synchronous motor v curve, for the obvious reason that is shaped like the letter V.

(i) Draw and label clearly the synchronous motor v curve corresponding to different real power levels.

(4 marks)

(ii) Based on your drawing in question **Q3(c)(i)**, label where is the minimum armature current, lagging and leading power factor occurs.

(3 marks)

(iii) Explain, the relationship between I_F and I_A to determine either the reactive power is being supplied to or by motor.

(3 marks)

Q4 (a) A terminal characteristic of a machine is a plot of the machine's output quantities versus each other. For a motor, the output quantities are shaft torque and speed, so the terminal characteristic of a motor is a plot of its output torque versus speed.

(i) Draw and label clearly the speed-torque characteristic of a series and shunt DC motor.

(3 marks)

(ii) Based on your drawing in question **Q4(a)(i),** explain clearly the main disadvantages of DC series motor as can see from the speed-torque characteristic.

(2 marks)

(iii) Suggest **ONE (1)** solution to avoid the problem stated in question **Q4(a)(ii)** to happen.

(1 mark)

(b) A 50 hp, 250 V, 1200 r/min, DC shunt motor with compensating windings has an armature resistance which including the brushes, compensating windings, and interpoles of 0.06 Ω. Its field circuit has a total resistance $R_{adj}+R_F$ of 50 Ω, which produces a no load speed of 1200 rpm. There are 1200 turns per pole on the shunt field winding as shown in **Figure Q4(b)**.

(i) Find the speed of the motor when the input current is 100 A.

(3 marks)

(ii) Find the speed of the motor when the input current is 300 A.

(3 marks)

(iii) Plot the torque-speed characteristic of this motor.

(7 marks)

(c) A series-connected DC motor has an armature resistance of 0.5 Ω and field winding resistance of 1.5 Ω. In driving a certain load at 1200 rpm, the current drawn by the motor is 20 A from a voltage source of 220 V. The rotational loss is 150 W. Analyse the output power and efficiency.

(6 marks)

- **END OF QUESTIONS –**

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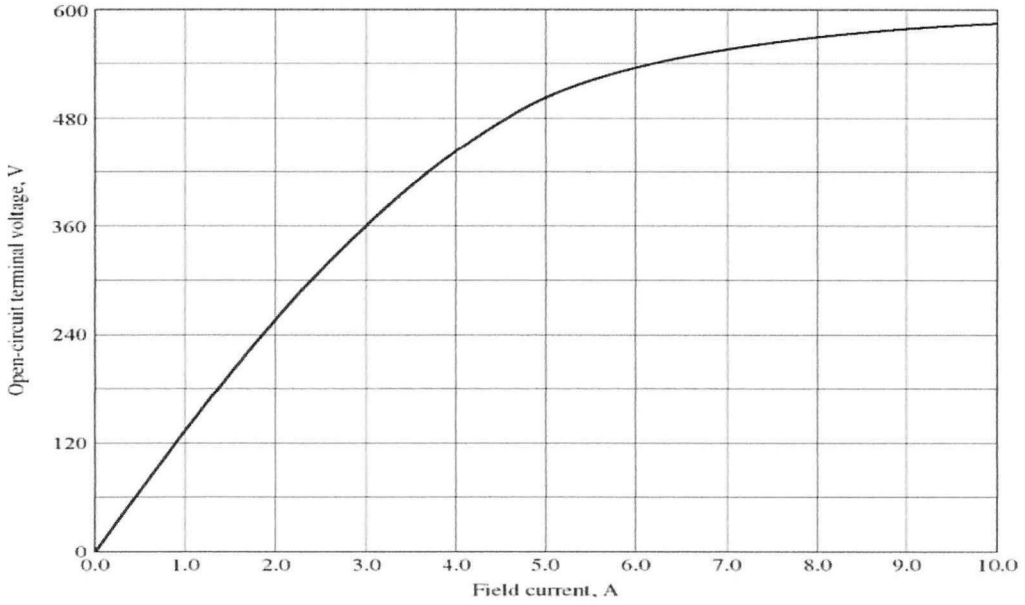

Figure Q2(c)

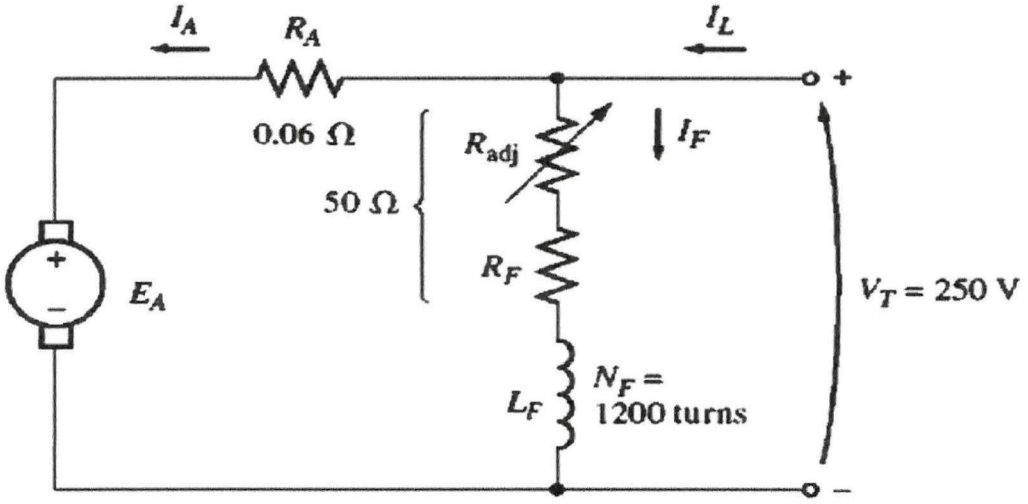

Figure Q4(b)