Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	ELECTRICAL MACHINES
COURSE CODE	:	BEJ 20403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION		1. ANSWER ALL QUESTIONS
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.**
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) Name and describe the features of the **FIVE (5)** types of generators.

(5 marks)

(b) All generators are driven by a source of mechanical power, which is usually called the prime mover of the generator. List **FOUR (4)** potential prime mover of DC generator.

(4 marks)

(c) A 2300 V, 500 kVA, 0.80 power factor (PF) lagging, 60 Hz four-poles, Y-connected synchronous generator has a synchronous reactance of 1.20 Ω and an armature resistance of 0.10 Ω. At 60 Hz, its friction and windage losses are 20 kW, and its core losses are 5 kW. The field circuit has a DC voltage of 230 V, and the maximum I_F is 10 A. The resistance of the field circuit is adjustable over the range from 23 Ω to 100 Ω. The Open Circuit Characteristic (OCC) of this generator is shown in **Figure Q1(c)**.

(i) Calculate the internal generated voltage, $\boldsymbol{E_A}$ of this machine at rated conditions.

(6 marks)

(ii) Determine the required field current to make V_T equal to 2300 V when the generator is running at rated conditions.

(3 marks)

(iii) If this machine is operating at rated conditions, determine the input torque, $\boldsymbol{\tau_{APP}}$ that must be applied to the shaft of this generator.

(7 marks)

Q2 (a) Explain, using phasor diagrams, what happens to a synchronous motor as its field current is varied.

(4 marks)

(b) A 2400 V, 60 Hz, 800 hp 0.85 PF leading six-poles Y-connected synchronous motor has a synchronous reactance of 1.5 Ω and negligible armature resistance. Ignore its friction, windage, and core losses for the purposes of this problem.

(i) If this motor is initially supplying 800 hp at 0.85 PF lagging, determine the magnitudes and angles of $\boldsymbol{E_A}$ and $\boldsymbol{I_A}$.

(6 marks)

(ii) Based on **Q2(b)(i)**, sketch the phasor diagram of this motor.

(4 marks)

(iii) Calculate the torque that this motor is producing, $\boldsymbol{\tau_{ind}}$ and the maximum possible induced torque for this motor, $\boldsymbol{\tau_{ind,max}}$.

(5 marks)

(iv) If the magnitude of the internal generated voltage, $|\boldsymbol{E_A}|$ is increased by 20 percent, determine the new magnitude of the armature current and its new PF.

(6 marks)

Q3 (a) Explain the purpose of brushes and rotor in a DC motor.

(4 marks)

(b) List out and describe **THREE (3)** types of losses in a DC motor.

(6 marks)

(c) A 50 hp, 250 V, 1200 r/min, DC shunt motor given in **Figure Q3(c)** with compensating windings has an armature resistance of 0.06 Ω. Its field circuit, $R_{adj} + R_F$ has a total resistance of 50 Ω, which produces a no-load speed of 1200 r/min. There are 1200 turns per pole on the shunt field winding.

(i) Find the induced torque when the input current is 150 A and 250 A.

(10 marks)

(ii) Plot the torque-speed characteristic curve of the motor by using the result obtained in **Q3(c)(i)**. Analyze your findings.

(5 marks)

Q4 (a) Explain and state the equations for voltage regulation, VR and efficiency, η of a DC generator.

(6 marks)

(b) Describe the difference between DC generators and DC motors.

(4 marks)

(c) A 155 kW, 430 V, 300 A and 1600 rpm separately excited DC generator has a magnetization curve given in **Figure Q4(c)**. The generator's characteristics are:

$$R_A = 0.06\ \Omega \qquad R_F = 57\ \Omega \qquad R_{adj} = 0\ to\ 200\Omega$$

$$V_F = 500\ V \qquad N_F = 1500\ turns\ per\ pole$$

(i) Sketch and label the equivalent circuit of the generator.

(4 marks)

(ii) If the adjustable resistor is set to 63 Ω and the prime mover is moving at 1300rpm, calculate the generators' no-load terminal voltage.

(2 marks)

(iii) Calculate the terminal voltage if a 210 A load is connected to its terminal considering the armature reaction at this load is 330 AT and the prime mover is moving at 1300 rpm. Assume the generator does not have compensating winding.

(3 marks)

(iv) For **Q4(c)(iii)**, the terminal voltage is lower than the no-load terminal voltage calculated from **Q4(c)(ii)**. Examine the adjustment of field current, I_F and R_{adj} to raise for the terminal voltage to match the no-load terminal voltage.

(6 marks)

- END OF QUESTIONS -

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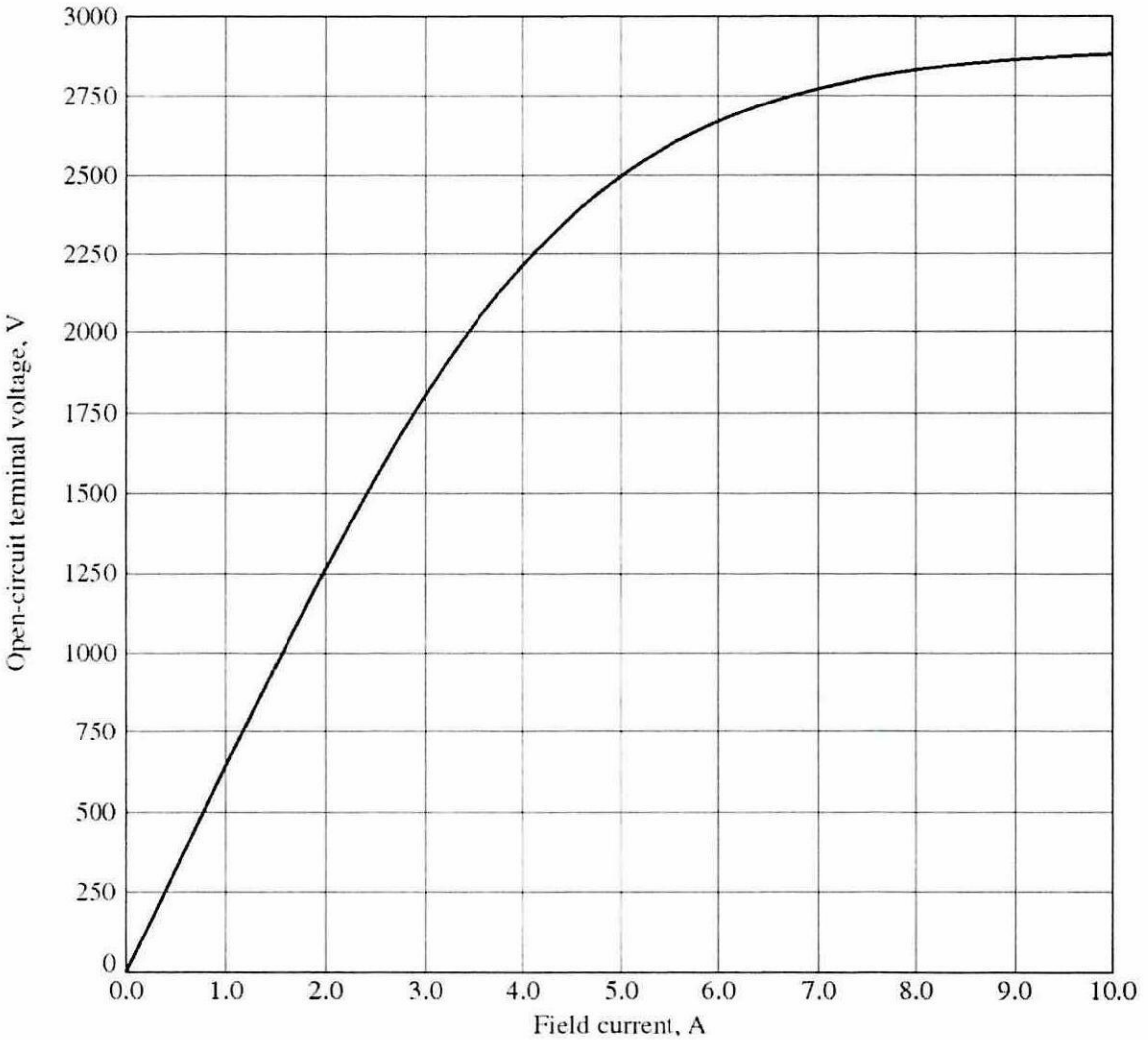

Figure Q1(c)

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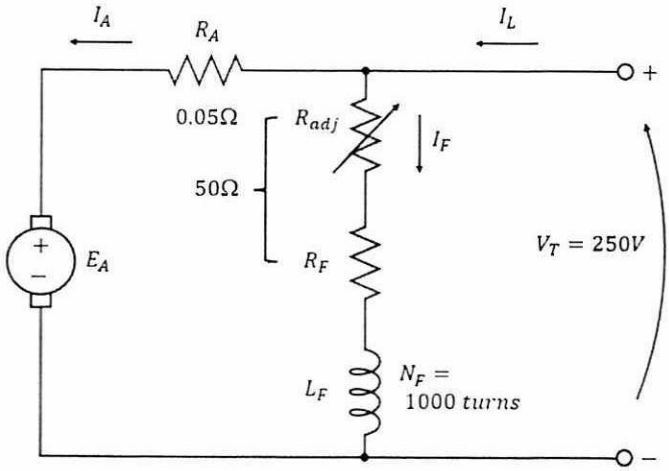

Figure Q3(c)

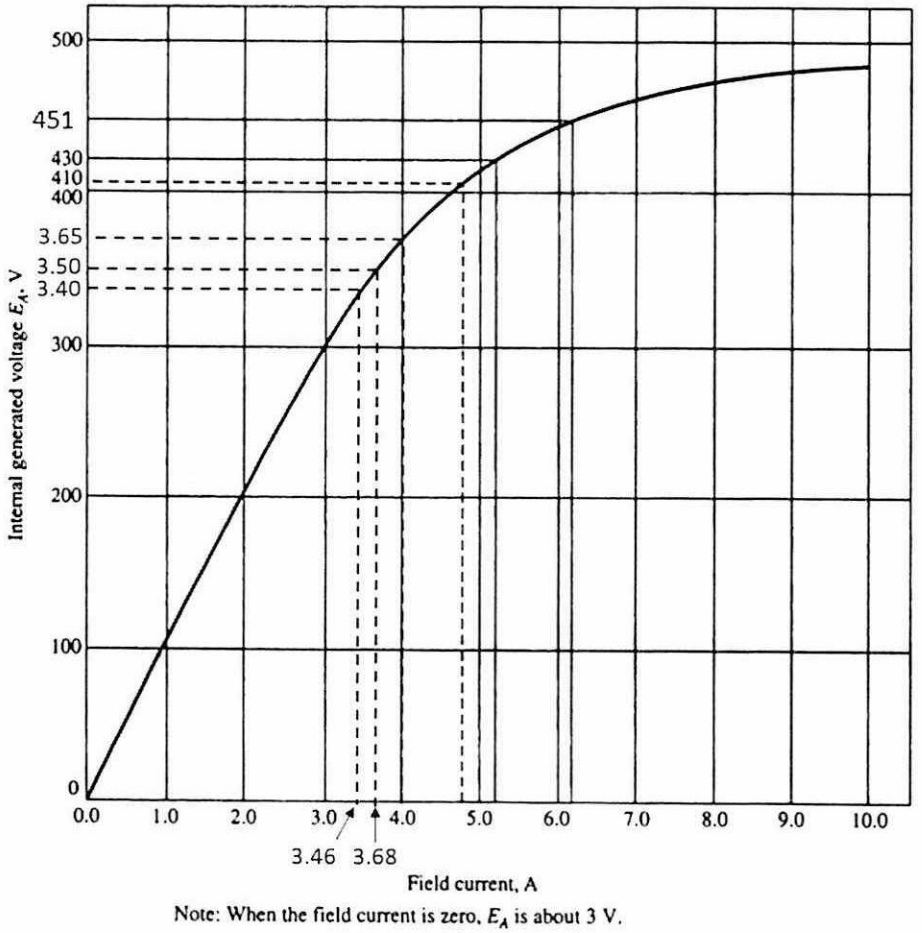

Figure Q4(c)