Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	ELECTRICAL MACHINES
COURSE CODE	:	BEJ 20403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS

INSTRUCTION

1. ANSWER ALL QUESTIONS
2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND 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 **SIX (6)** 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 2400 V, 1000 kVA, 0.85 power factor (PF) lagging, 50 Hz six-poles, Y-connected synchronous generator has a synchronous reactance of 1.4 Ω and an armature resistance of 0.15 Ω. At 50 Hz, its friction and windage losses are 25 kW, and its core losses are 15 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 20 to 200 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 2400 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 load is varied.

(4 marks)

(b) A 2500 V, 50 Hz, 1000 hp 0.85 PF leading four 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 1000 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 15 percent, determine the new magnitude of the armature current and its new PF.

(6 marks)

Q3 (a) Describe types of DC motors with description and its equivalent circuit.

(8 marks)

(b) Illustrate types of power loses of a DC motor with description

(4 marks)

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

(4 marks)

(d) A 30 hp separately excited DC motor is running initially at $V_A = 240\ V$, $I_A = 110\ A$ and $n = 1800\ rpm$, $R_A = 0.19\ \Omega$ supplying a constant-torque load while the field circuit is supplied with voltage, $V_F = 240\ V$ and $R_{adj} = 175\ \Omega$ and $R_F = 75\ \Omega$. The armature voltage, V_A can be varied from 120 to 240 V.

(i) Sketch the equivalent circuit of the motor with proper labels.

(2 marks)

(ii) Calculate the no-load speed of this separately excited motor when and V_A at 120 V, 180 V and 240 V. Assuming no armature reaction effect.

(4 marks)

(iii) Analyze the effect if the field circuit opened while the motor is running.

(3 marks)

Q4 (a) Differentiate DC generators and DC motors with description.

(5 marks)

(b) Explain voltage regulation, VR and efficiency, η of a DC generator.

(5 marks)

(c) A separately excited DC generator is rated at 172 kW, 430 V, 400 A and 1800 rpm. Its magnetization curve is shown in **Figure Q4(c)**. The generator's characteristics are:

$$R_A = 0.05\ \Omega \quad R_F = 20\ \Omega \quad R_{adj} = 0\ to\ 300\ \Omega$$

$$V_F = 430\ V \quad N_F = 1000\ turns\ per\ pole$$

(i) Sketch an equivalent circuit of the generator with proper labels.

(2 marks)

(ii) If $R_{adj} = 63\ \Omega$, and the prime mover is driving at 1500 rpm, calculate the generators' no-load terminal voltage.

(3 marks)

(iii) Calculate the terminal voltage if a 360 A load is connected to its terminal. Assuming the generator does not have compensating winding. Its armature reaction at this load is 450 $A.turns$. The prime mover is driving at 1500 rpm.

(4 marks)

(iv) For **Q4(c)(iii)**, the terminal voltage is lower than no-load terminal voltage calculated from **Q4(c)(ii)**. Investigate 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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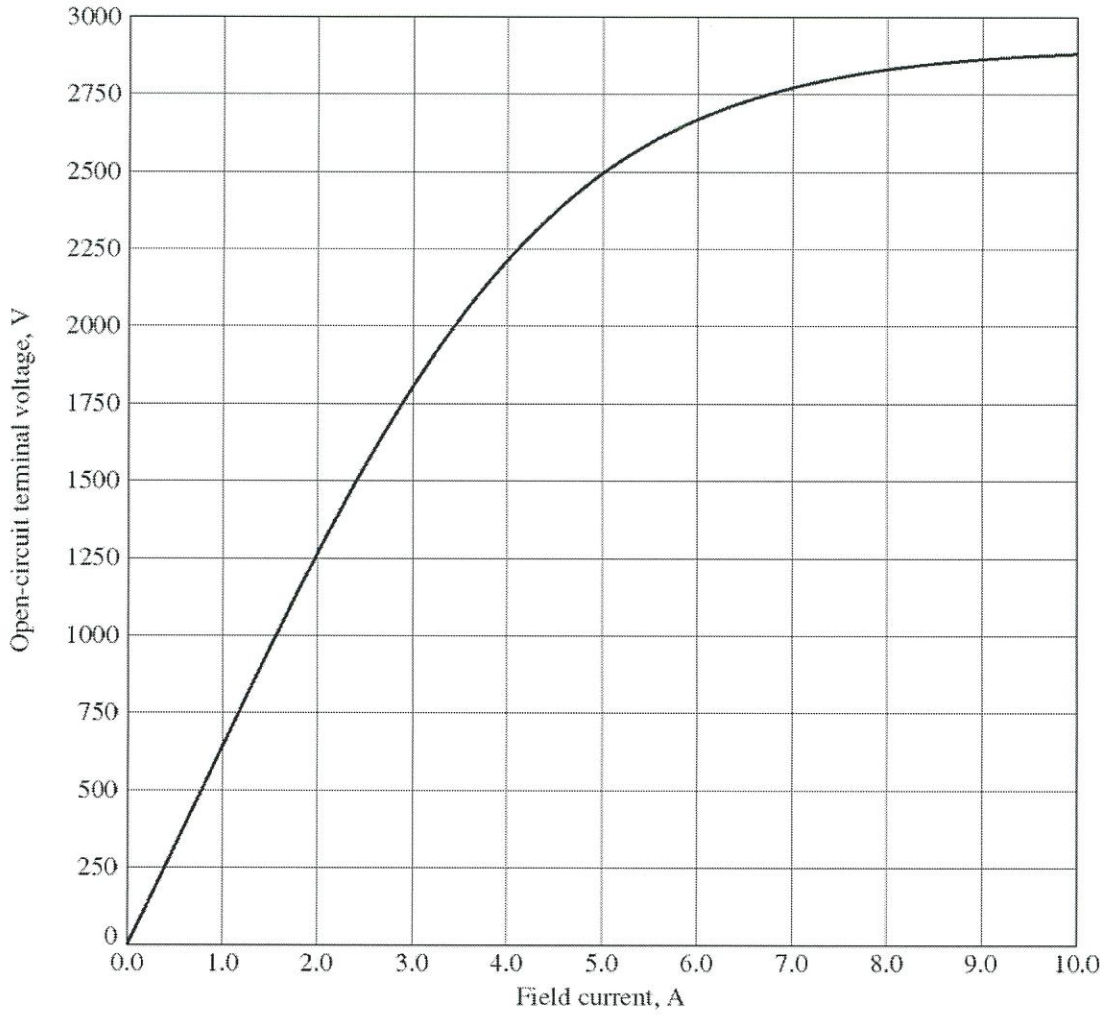

Figure Q1(c)

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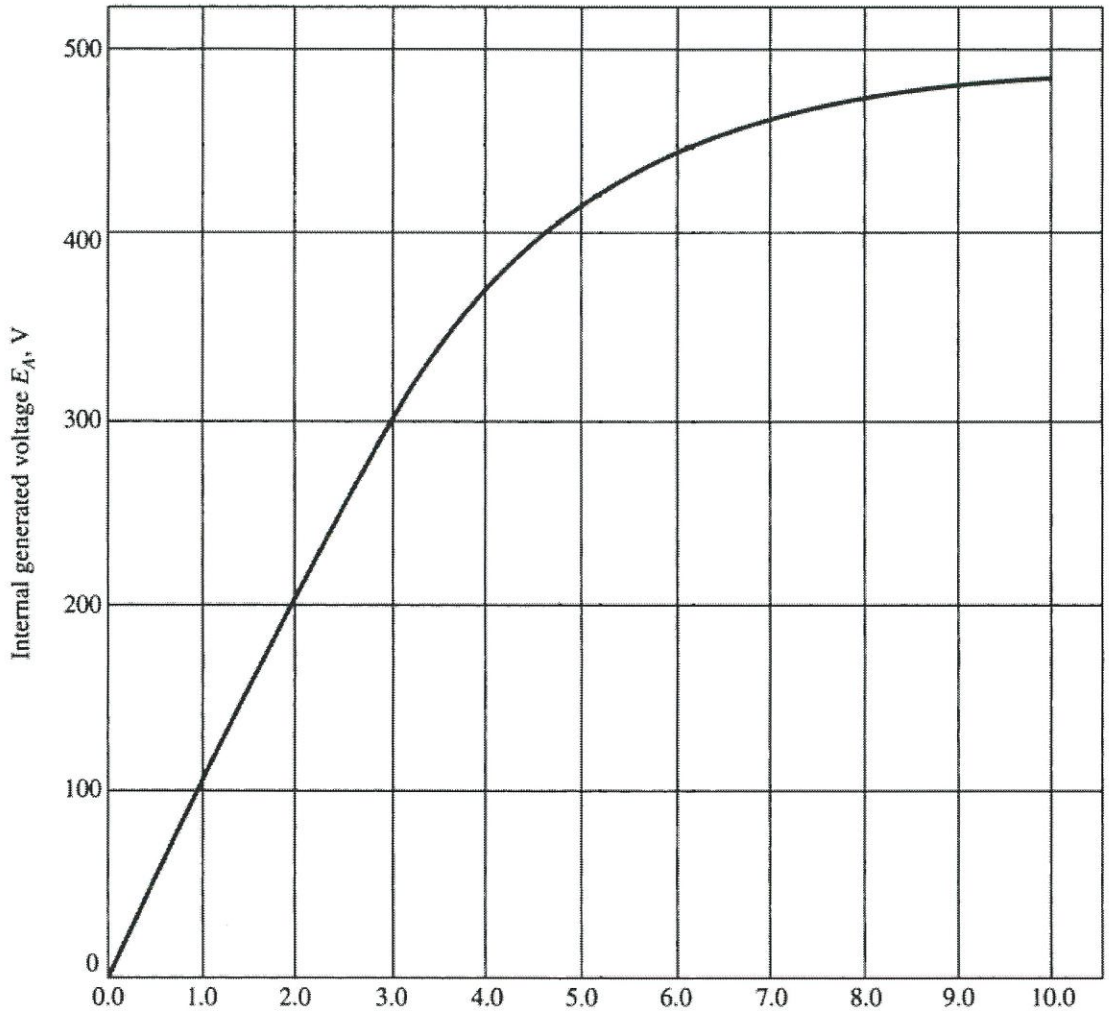

Note: When the field current is zero, E_A is about 3 V.

Magnetization curve for the DC generator, made at a constant speed of 1800rpm

Figure Q4(c)