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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	POWER SYSTEM ANALYSIS
COURSE CODE	:	BEV 20703
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY/AUGUST 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 **SIX (6)** PAGES

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Q1 (a) Explain **TWO (2)** types of loads in power system.

(5 marks)

(b) The one-line diagram of a three-phase power system is shown in **Figure Q1(b).** Select a common base of 100MVA and 23kV on the generator side. The manufacturers data for each device is given in **Table 1.** The three-phase load at bus 4 absorbs 57MVA, 0.6 power factor lagging at 10.45kV. Line 1 and Line 2 has reactance of 50.5Ω and 65.5Ω, respectively.

(i) Determine the voltage base V_{B2}, V_{B4}, V_{B5} and V_{B6} of the system.

(2 marks)

(ii) Calculate the per-unit reactance of all the system components.

(6 marks)

(iii) Draw an impedance diagram of the system marked in per-unit.

(2 marks)

(c) A 500MVA, 230kV/ 23kV, three phase, Y-Δ transformer has an equivalent series impedance of 1.5 + j5.5 Ω per-phase referred to the high-voltage side. The transformer is supplying a three-phase load of 500MVA, 0.68 power factor lagging at a terminal voltage of 23kV (line-to-line) on its low-voltage side. The primary is supplied from a feeder with an impedance of 0.7+ j1.8 Ω per phase. Determine the line-to-line voltage, V_{LL} at the high-voltage terminal terminals of the transformer and the sending-end of the feeder.

(10 marks)

Q2 (a) List down **THREE (3)** techniques for solving the nonlinear algebraic equation.

(3 marks)

(b) Explain briefly **TWO (2)** types of system buses.

(4 marks)

(c) Figure **Q2(c)** shows the one-line diagram of a simple three-bus system with generator at bus 1. The voltage at bus 1, V_1 = 1.06 pu. The real and reactive power at bus 2 and 3 are marked in the diagram. Line resistances and line charging susceptance are neglected. Line impedances are marked in pu on a 100MVA base.

(i) Using the Gauss-Seidel method and initial estimates of $V_2^{(0)}$ = 1.0 +j0.0, and $V_3^{(0)}$ =1.03 +j0.0, determine V_2 and V_3. Perform two iterations.

(6 marks)

(ii) If after several iterations the bus voltages converge to: V_2 = 0.90 - j0.10 pu and V_3 = 0.95 - j0.05 pu, calculate the line flows, line losses and slack bus real and reactive power.

(9 marks)

(iii) Draw the power flow diagram of system based on results in **Q2(b)(ii)**.

(3 marks)

Q3 (a) Summarize the objective of the optimal dispatch of generation in power systems including the steps involved in achieving this objective.

(5 marks)

(b) Describe the factors that will give an impact on power generation at minimum cost.

(3 marks)

(c) **THREE (3)** thermal plants in a power system have varying fuel-cost function in MYR/h as follows:

$$C_1 = 1470 + 30.24P_1 + 0.0168P_1^2$$
$$C_2 = 2100 + 30.66P_2 + 0.0105P_2^2$$
$$C_3 = 2520 + 28.308P_3 + 0.0126P_3^2$$

Where P_1, P_2, and P_3 represent the power output in MW. The line losses are neglected. The power output of each generator is constrained within these specific limits:

$$122 \text{ MW} \leq P_1 \leq 400 \text{ MW}$$
$$260 \text{ MW} \leq P_1 \leq 600 \text{ MW}$$
$$50 \text{ MW} \leq P_1 \leq 445 \text{ MW}$$

(i) Determine the optimal dispatch scheduling of generation when the total load is 1335 MW by using the analytical method.

(11 marks)

(ii) Evaluate the cost-saving gained every hour between the optimal scheduling of generators with the equal load sharing of generators.

(6 marks)

Q4 (a) Identify the different types of faults in a power system, including both balanced and unbalanced faults.

(4 marks)

(b) Compare the three periods of generator behaviour, including their respective reactance and durations.

(6 marks)

(c) **Figure Q4(c)** displays a single-line diagram of a power system with four buses, showing the connections between them. An electromotive force (emf) is assigned to each generator based on their transient reactance, with all impedances given in per unit on a common MVA base. The resistances and shunt capacitances are not considered. The generators operate at their rated voltage with the emf in phase, and there is a solid three-phase fault at Bus 4.

(i) Determine the impedance to the point of fault, the fault current and current that flows via generators in per unit during fault.

(7 marks)

(ii) Calculate the bus voltages and the line currents during fault.

(8 marks)

– END OF QUESTIONS –

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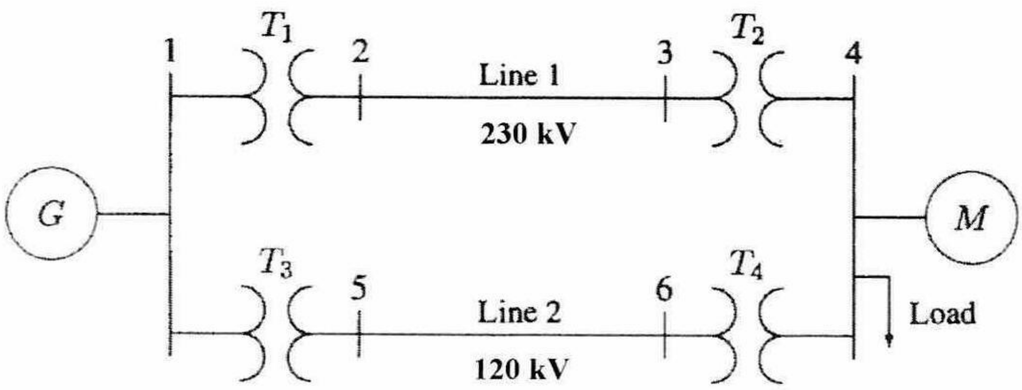

Figure Q1(b)

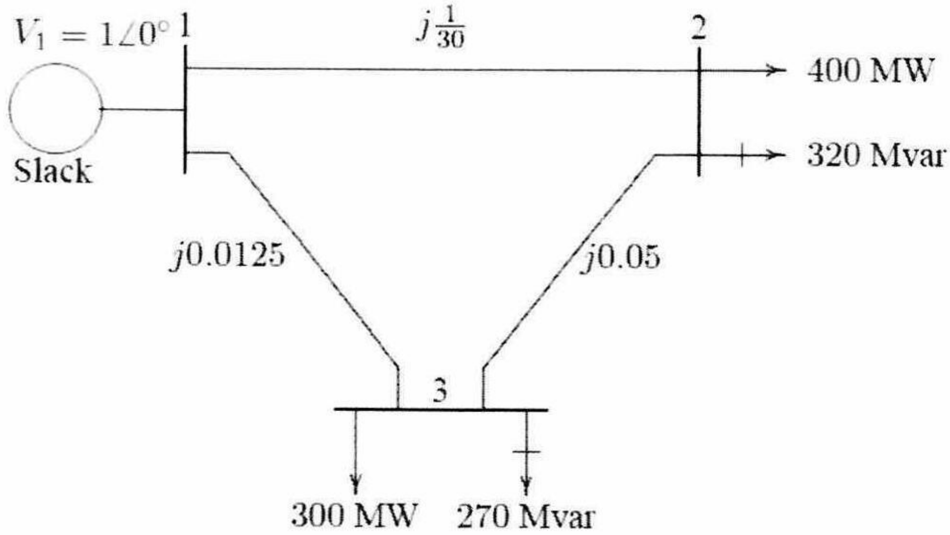

Figure Q2(c)

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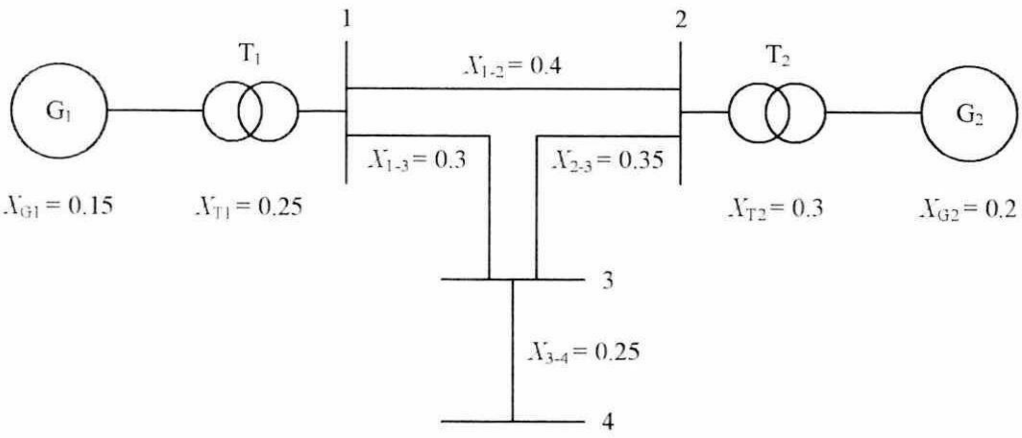

Figure Q4(c)

Table 1: Three-phase power and line-line ratings

Components	Apparent Power (MVA)	Phase Voltage (kV)	Percentage Impedance (%)
G	90	23	18
T1	50	23/230	11
T2	40	23/12	05
T3	40	12/120	05
T4	40	120/12	05
M	65	11	19