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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	POWER SYSTEM ANALYSIS
COURSE CODE	:	BEV20703
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSE BOOK** 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUTED VIA **CLOSED BOOK**

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

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Q1 (a) State **three (3)** types of sources of energy in power system operation.

(3 marks)

(b) **Figure Q1(b)** shows a single-line diagram of a typical power system model. Line 1, Line 2, and Line 3 have reactances of 56.3 Ω, 43.2 Ω, and 51.6 Ω, respectively. Calculate the per-unit (pu) impedance of all components available in the system using a common base of 100 MVA and 20 kV on the generator G_1 side.

(17 marks)

Q2 (a) Explain **five (5)** iterative conditions of stopping criteria, typically considered in load flow analysis.

(5 marks)

(b) **Figure Q2(b)** represents a single-line diagram of typical power system with the line impedances as indicated in pu on a 100 MVA base with a synchronous generator at Bus 1. The line charging susceptance is neglected. Calculate the bus voltages of V_2 and V_3 in pu using Gauss-Seidel method with the initial estimates of $V_2^{(0)} = 1 + j0$ pu and $V_3^{(0)} = 1 + j0$ pu. Perform only **three (3)** iterations.

(15 marks)

Q3 (a) List **three (3)** operating scenarios, that are typically considered in optimal dispatch of generation studies.

(3 marks)

(b) The fuel-cost function in RM/hour for **three (3)** thermal plants are given by:

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

P_1, P_2, and P_3 are in MW. The line losses are neglected. The generator outputs are subject to the following limits:

$$122 \text{ MW} \leq P_1 \leq 400 \text{ MW}$$
$$260 \text{ MW} \leq P_2 \leq 600 \text{ MW}$$
$$50 \text{ MW} \leq P_3 \leq 445 \text{ MW}$$

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

(11 marks)

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

(6 marks)

Q4 (a) Summarize the procedure to include the effects of load current in the fault analysis.

(5 marks)

(b) A single-line diagram of a four-bus power system is shown in **Figure Q4(b)**. Each generator is represented by an electromotive force (emf) behind the transient reactance. All impedances are expressed in pu on a common MVA base. All resistances and shunt capacitances are neglected. The generators operate on no-load at their rated voltage with their emf in phase. A solid three-phase fault occurs at Bus 4.

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

(7 marks)

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

(8 marks)

Q5 (a) State assumptions to represent the multimachine equations with a single machine infinite bus system.

(4 marks)

(b) A 50 Hz synchronous generator with inertia constant $H = 6.2$ MJ/MVA is connected to an infinite bus through a purely reactive circuit, as depicted in **Figure Q5(b)**. The generator is delivering real power $P_3 = 0.950$ pu and $Q_3 = 0.713$ pu to the infinite bus at a voltage of $V_3 = 1.0$ pu. A temporary 3-phase fault occurs at the receiving end of Line 1 at point F. When the fault is cleared, both lines remain following the disturbance. Calculate the critical clearing angle (δ_c) and the critical fault clearing time (t_c) for the given disturbance.

(16 marks)

-END OF QUESTIONS-

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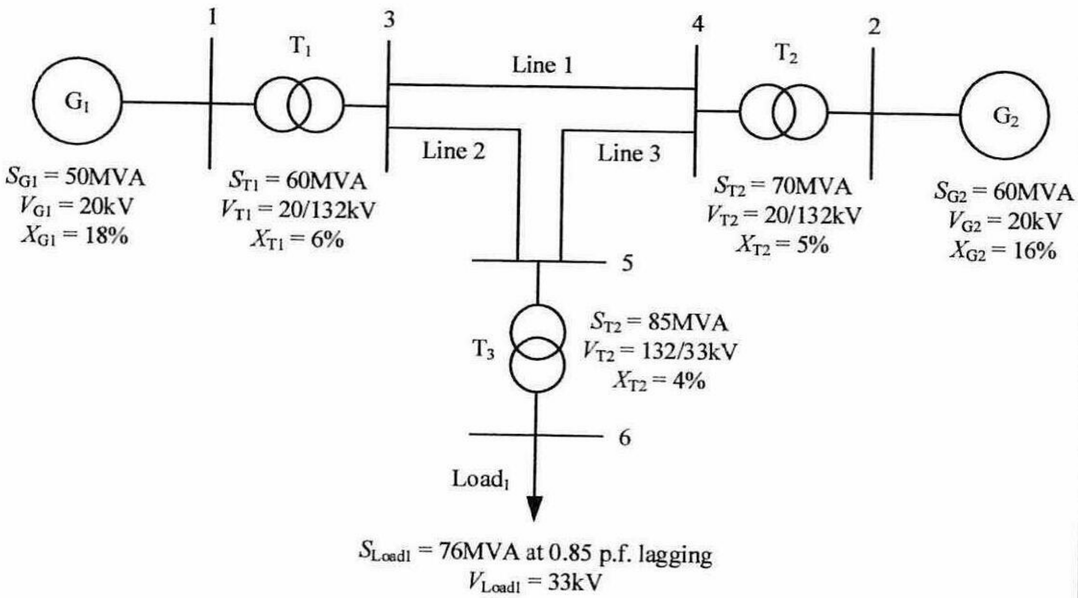

Figure Q1(b)

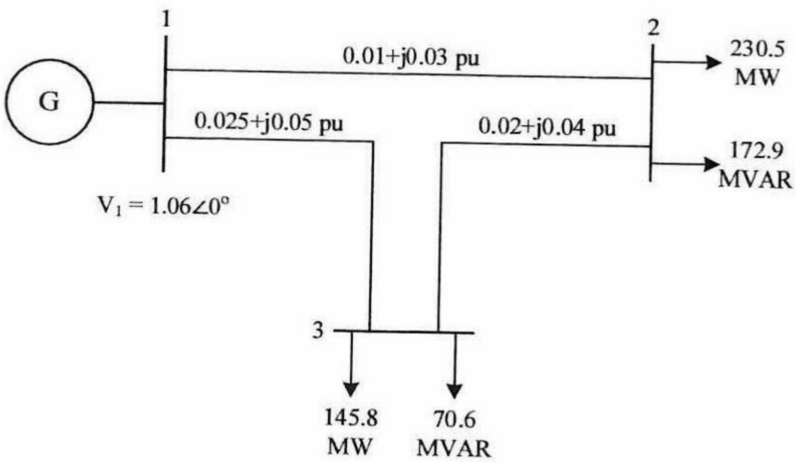

Figure Q2(b)

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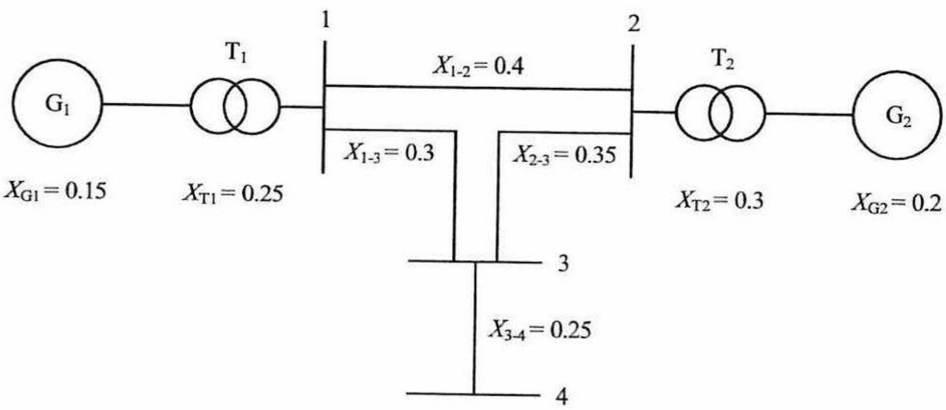

Figure Q4(b)

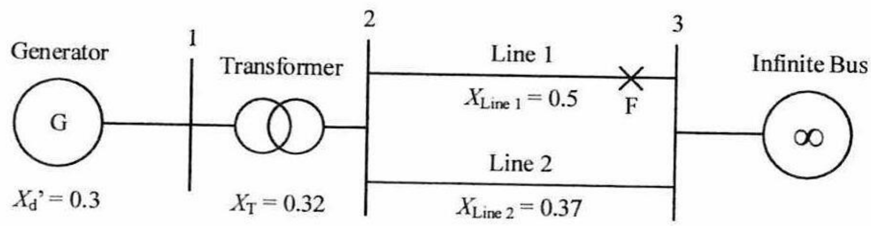

Figure Q5(b)