MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293
Website: www.must.ac.ke Email: info@mucst.ac.ke

UNIVERSITY EXAMINATIONS 2024/2025

FOURTH YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF TECHNOLOGY IN ELECTRICAL AND ELECTRONIC ENGINEERING

EET 3410: POWER SYSTEMS ANALYSIS

DATE: JANUARY 2025 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.
All workings must be clearly shown.

QUESTION ONE (30 MARKS)

a) Briefly explain what you understand by a swing bus (1 Mark)

b) Highlight any four methods of voltage control in power system (4 Marks)

c) The Figure Q1 (c) shows a 3-bus system. Obtain the voltage magnitude and angles at buses 2 and 3 using Gauss-Seidel method. Perform two iterations only. Impedances are given on 100 MVA base. Assume $V_2^{(0)} = 1.00\angle 0^0$ and $V_3^{(0)} = 1.03\angle 0^0$ (9 Marks)

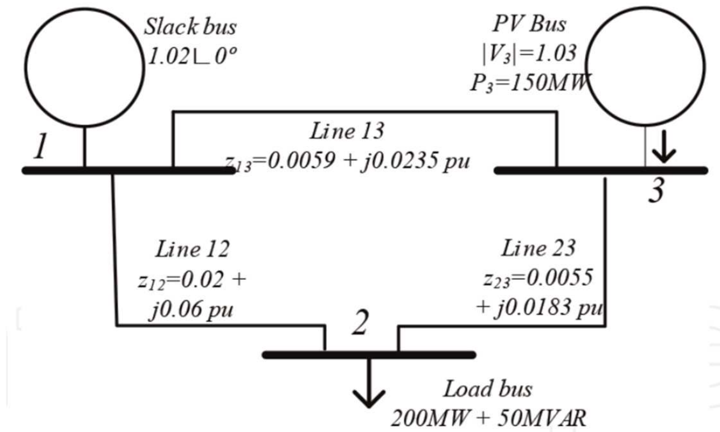

Figure Q1(c)

d) The Figure Q1 (d) shows a three-bus power system. Bus 1 is a slack bus with V= 1.05/00 p.u, bus 2 is a PV bus with V = 1.0 p.u. Pg = 3 p.u. and bus 3 is a PQ bus with PL = 4 p.u., QL = 2 p.u. Obtain the bus admittance matrix by inspection. Neglect limits on reactive power generation. (7 Marks)

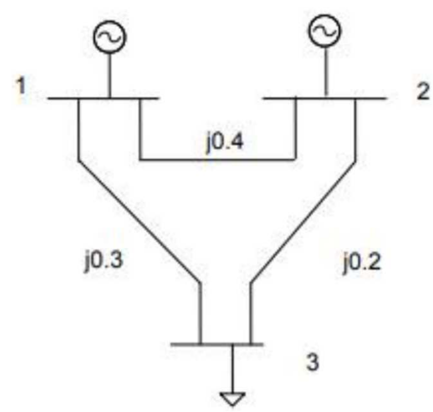

Figure Q1 (d)

e) The fuel-cost functions for three thermal plants in Sh/hr are given by

$$C_1 = 500 + 5.3P_1 + 0.004P_2^2$$
$$C_2 = 400 + 5.5P_1 + 0.006P_2^2$$
$$C_3 = 200 + 5.8P_1 + 0.009P_2^2$$

where P_1, P_2 and P_3 are in MW. The total load, Pd, is 800 MW. Neglecting line losses and generator limits, find the optimal dispatch and the total cost in Sh/hr by iterative technique using the gradient method (9 Marks)

QUESTION TWO (15 MARKS)

a) Give the span and the applications of short-term load forecasting (2 Marks)

b) Discuss any three reasons as to why load flow analysis is important (3 Marks)

c) Highlight the three main advantages of Newton-Raphson method over Gauss-Seidel method in power flow analysis (3 Marks)

d) Obtain the power flow solution for the three-bus network shown in figure Q2(d) using fast decoupled power flow method. Perform one iteration only (7 Marks)

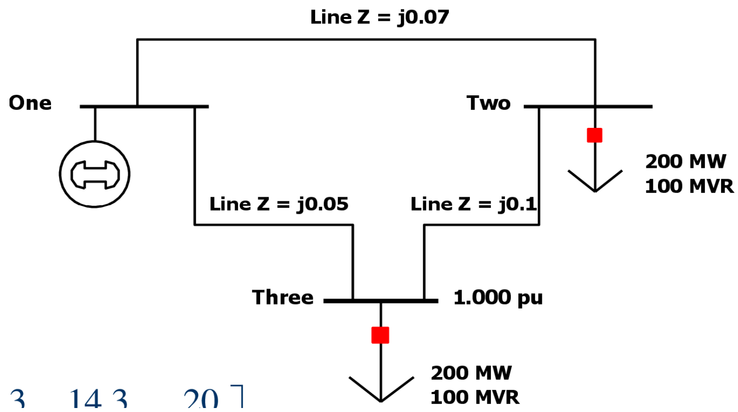

Figure Q 2(d)

Start with the following initial voltage guess

$$\begin{bmatrix} \theta_2 \\ \theta_3 \end{bmatrix}^{(0)} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \qquad \begin{bmatrix} |V|_2 \\ |V|_3 \end{bmatrix}^{(0)} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

QUESTION THREE (15 MARKS)

a) Highlight three weaknesses of Gauss-seidel method of power flow (3 Marks)

b) List any three advantages of Fast Decoupled method of load flow solution over other iterative methods (3 Marks)

c) Enumerate any four reasons for load forecasting in power systems (4 Marks)

d) A power system network is shown in Figure Q3(d). The generators at buses 1 and 2 are represented by their equivalent current sources with their reactances in per unit on a 100-MVA base. The lines are represented by π model where series reactances and shunt reactances are also expressed in per unit on a 100 MVA base. The loads at buses 3 and 4 are expressed in MW and Mvar. Assuming a voltage magnitude of 1.0 per unit at buses 3 and 4, convert the loads to per unit impedances. Obtain the bus admittance matrix by inspection. (5 Marks)

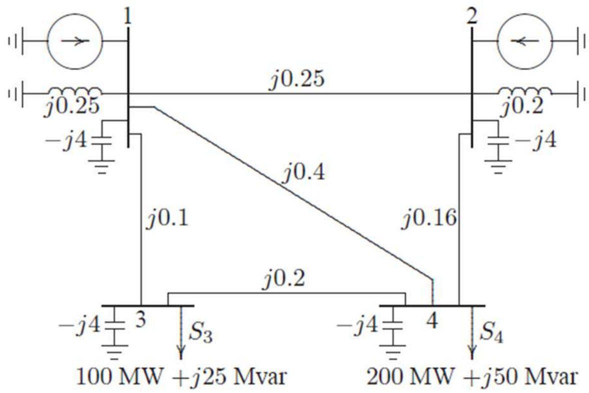

Figure Q3(d)

QUESTION FOUR (15 MARKS)

a) List six short term load forecasting methods (6 Marks)

b) Assuming a flat start, determine the voltage at the end of the first iteration using Newton-Raphson method for the network in Figure Q4(b). The line and bus data are given in Table Q4 (b1) and Table Q4 (b2). Take $0.2 \leq Q_2 \leq 2$

(9 Marks)

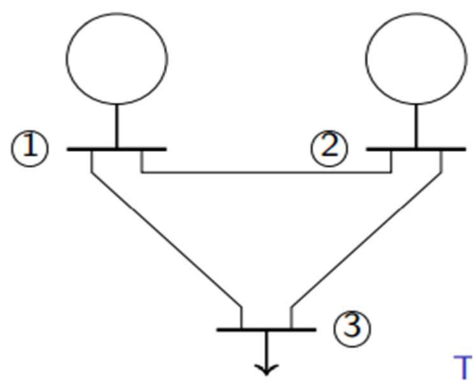

Figure Q4(b)

Table Q4(b1) Line data

Bus Code	R (p.u.)	X (p.u.)	$\frac{Y}{2}$ (p.u.)
1-2	0	j 0.1	j 0.01
1-3	0	j 0.1	j 0.01
2-3	0	j 0.1	j 0.01

Table Q4(b2) Bus data

Bus	P_g	Q_g	P_d	Q_d	$\|V\|$	δ	Type
1	—	—	—	—	1	0	Slack
2	0.6661	—	—	—	1.05	—	PV
3	—	—	2.8653	1.2244	—	—	PQ

QUESTION FIVE (15 MARKS)

a) Define the term "Load Forecasting" and give its application in electrical power system (2 Marks)

b) Discuss the effect of acceleration factor in the load flow solution algorithm (2 Marks)

c) Briefly discuss what you understand by merit order as used in energy industry (2 Marks)

d) Highlight two advantages of Gauss-Seidel method of power flow solution (2 Marks)

e) Obtain the load flow solution at the end of first iteration of the system shown in Figure Q5 (e) with data as given in Tables Q5 (e) using Gauss-Seidel method. All buses except bus 1 are PQ Buses. (7 Marks)

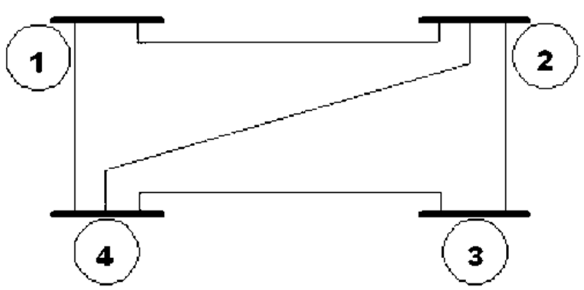

Figure Q5 (e)

Table Q5 (e1)

SB	EB	R (pu)	X (pu)
1	2	0.05	0.15
1	3	0.10	0.30
2	3	0.15	0.45
2	4	0.10	0.30
3	4	0.05	0.15

Table Q5 (e2)

Bus No.	P_i (pu)	Q_i (pu)	V_i
1	–	–	$1.04 \angle 0^0$
2	0.5	– 0.2	–
3	– 1.0	0.5	–
4	– 0.3	– 0.1	–