H2

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

FIFTH YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE
OF
BACHELOR OF SCIENCE IN ELECTRICAL AND COMMUNICATION ENGINEERING

COURSE CODE: ECE 511E

COURSE TITLE: POWER SYSTEMS ANALYSIS

DATE: 20th April, 2022 **TIME:08.00 a.m-10.00 a.m.**

INSTRUCTIONS TO CANDIDATES

Question ONE (1) is compulsory
Answer Any Other TWO (2) questions

TIME: 2 Hours

Question 1 (30 Marks)

(a) A set of linear algebraic equations representing a power system in matrix format is given as **Ax=y**, the determinant det(**A**) is found to be negative. Will such a system of equations converge when performing load flow? Briefly explain. (4 marks)

(b) Explain what a slack bus (or swing bus) is, and its purpose in power system load flow calculations (5 marks)

(c) Referring to fig. 1

i Formulate the Y-bus matrix in rectangular form. (3 marks)

ii Develop the B_p matrix and it's inverse as used in the Fast Decoupled Power Flow calculation. Assume bus 1 is the swing bus. (3 marks)

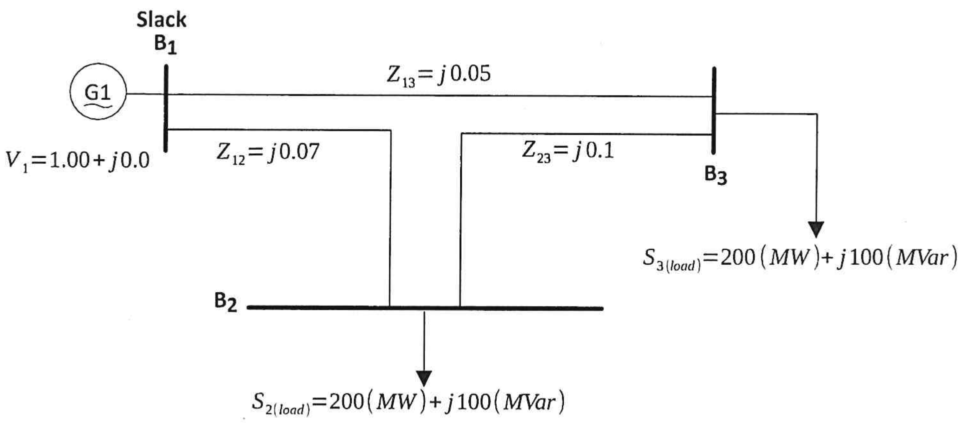

Figure 1: Three bus system FDLF

(d) Figure 2 shows the one-line diagram of a simple three-bus power system with generation at buses 1 and 2. The voltage at bus 1 is $V = 1.0\angle 0^0$ per unit. Voltage magnitude at bus 2 is fixed at 1.05 pu. Line admittances are marked in per unit on a 100 MVA base. Line resistances and line charging susceptances are neglected.

i Write out the bus admittance matrix in polar form. (2 marks)

ii Using the provided values, write out the power flow expressions for P_2, P_3, Q_3 in polar form. (3 marks)

iii Obtain the Jacobian matrix elements (4 marks)

(e) Define the Per-unit droop or speed regulation R_u of a generating unit and explain why generators must have a droop characteristic in order to allow parallel operation with other generators. (6 marks)

Question 2 (20 Marks)

(a) Two areas A and B are interconnected via a tie line. Area A has a frequency bias constant $\beta_A = 0.015$ MW/0.1 Hz while area B's frequency bias constant $\beta_B = 0.01$ MW/0.1 Hz. At a particular point in time when area A is generating 36,000 MW and area B is generating 4000 MW, a sudden increase of 400 MW load occurs in area B.

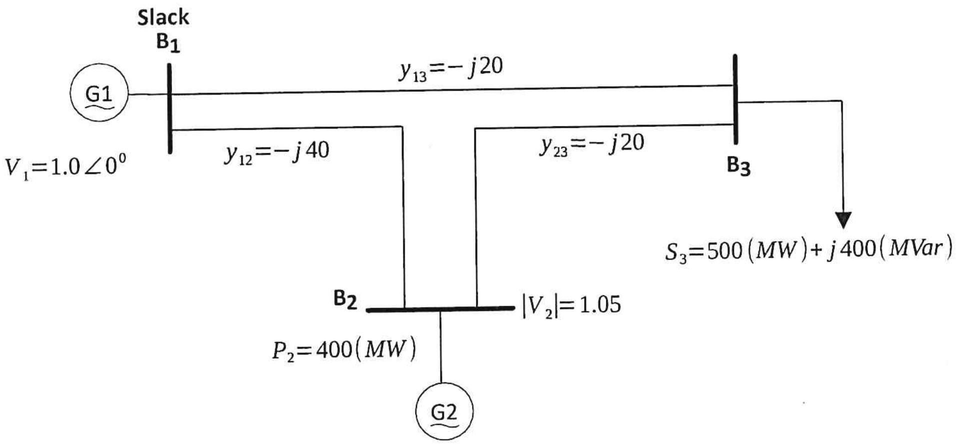

Figure 2: Three bus system

i Determine the overall frequency drop Δf. (4 marks)

ii Determine the tie line flow ΔT_L in MW. (4 marks)

iii Determine each area's share of the 400 MW load increase. (3 marks)

(b) What are the two basic Load Frequency Control objectives for an interconnected power system? (2 marks)

(c) List three (**3**)assumptions made in load flow calculations. (3 marks)

(d) Define critical clearing time and critical clearing angle. (4 marks)

Question 3 (20 Marks)

(a) With the aid of the Jacobian matrix elements and principle underlying the approach, explain the fast-decoupled load flow (FDLF). (12 marks).

(b) Define transient stability limit of a power system. (4 marks)

(c) Define steady state stability of a power system. (4 marks)

Question 4

(a) Figure 3 shows a single line diagram of a five-bus power system. The input data are given in Tables 1, 2, and 3. As shown in Table 1, bus 1, to which a generator is connected, is the swing bus. Bus 3, to which a generator and load are connected, is a voltage-controlled bus. Buses 2, 4, and 5 are load buses.

i Determine the network admittance matrix. (5 marks)

ii Use Gauss -Seidel to calculate $V_3^{(1)}$ the phasor voltage at bus 3 after the first iteration. (11 marks)

(b) Explain the need for power (load) flow studies in power systems. (5 marks)

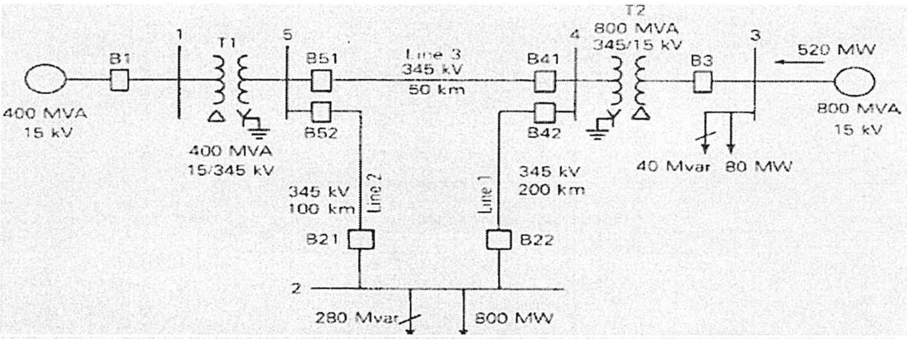

Table 1
Bus input data

Bus	Type	V per unit	δ degrees	P_G per unit	Q_G per unit	P_L per unit	Q_L per unit	Q_{Gmax} per unit	Q_{Gmin} per unit
1	Swing	1.0	0	—	—	0	0	—	—
2	Load	—	—	0	0	8.0	2.8	—	—
3	Constant voltage	1.05	—	5.2	—	0.8	0.4	4.0	−2.8
4	Load	—	—	0	0	0	0	—	—
5	Load	—	—	0	0	0	0	—	—

*S_{base} = 100 MVA, V_{base} = 15 kV at buses 1, 3, and 345 kV at buses 2, 4, 5

Table 2
Line input data

Bus-to-Bus	R′ per unit	X′ per unit	G′ per unit	B′ per unit	Maximum MVA per unit
2–4	0.0090	0.100	0	1.72	12.0
2–5	0.0045	0.050	0	0.88	12.0
4–5	0.00225	0.025	0	0.44	12.0

Table 3
Transformer input data

Bus-to-Bus	R per unit	X per unit	G_c per unit	B_m per unit	Maximum MVA per unit	Maximum TAP Setting per unit
1–5	0.00150	0.02	0	0	6.0	—
3–4	0.00075	0.01	0	0	10.0	—

Figure 3: Single line diagram

Question 5

(a) In the two-bus system shown in Fig. 4, bus 1 is a slack bus with $V_1 = 1.0\angle 0°$. A load of 100 MW and 50 MVAR is taken from bus 2. The line impedance is as indicated on a base of 100 MVA. Initial estimate of $V_2^{(0)} = 1.0$ p.u. and $\delta_2^{(0)} = 0°$.

i Express the load in per unit. (1 mark)

ii Determine Y_{bus} in polar form . (1 mark)

iii Write the power flow equations for P and Q in polar form (use the admittance values obtained in (ii) above and initial values provided in your expressions). . (2 marks)

iv Determine the Jacobian elements (partial derivatives of the expressions of (iii) above

. (4 marks)

(b) With the aid of the Jacobian matrix elements and principle underlying the approach, explain the fast-decoupled load flow (FDLF). (12 marks)

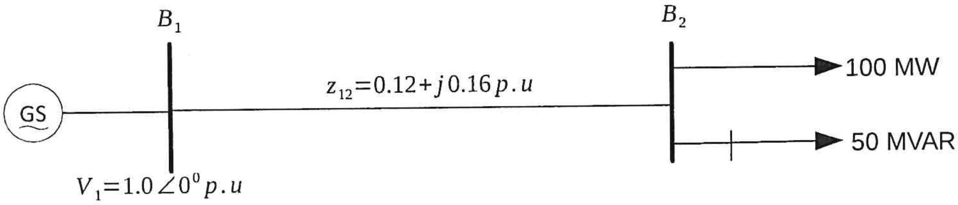

Figure 4: Single line diagram of two bus system