15

(University of Choice)
MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY SPECIAL/SUPPLEMENTARY EXAMINATIONS 2021/2022 ACADEMIC YEAR

FIFTH YEAR EXAMINATIONS

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

COURSE CODE: ECE 511E

COURSE TITLE: POWER SYSTEM ANALYSIS

DATE: 5th October, 2022 **TIME:09.00 a.m-11.00 a.m.**

INSTRUCTIONS TO CANDIDATES

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

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over.

Question 1 (30 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) Explain what a slack bus (or swing bus) is, and its purpose in power system load flow calculations (5 marks)

(c) Write the power flow equations in polar form for buses $i = 1, 2, ...n$; and explain why they cannot be solved using direct methods. (4 marks)

(d) 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)

(e) Briefly outline the following two components of Load frequency control

i Primary control. (1.5 marks)

ii Secondary control. (1.5 marks)

Question 2 (20 Marks)

(a) Define a *voltage controlled bus* as used in a power flow study and explain what quantity is allowed to change in such a bus during computations and in what manner. (4 marks)

(b) Consider the four-bus, five-line power system shown below. All indicated values are admittances given in per-unit.

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

ii Develop the B_p matrix used in the Fast Decoupled Power Flow calculation. Assume bus 1 is the swing bus. (3 marks)

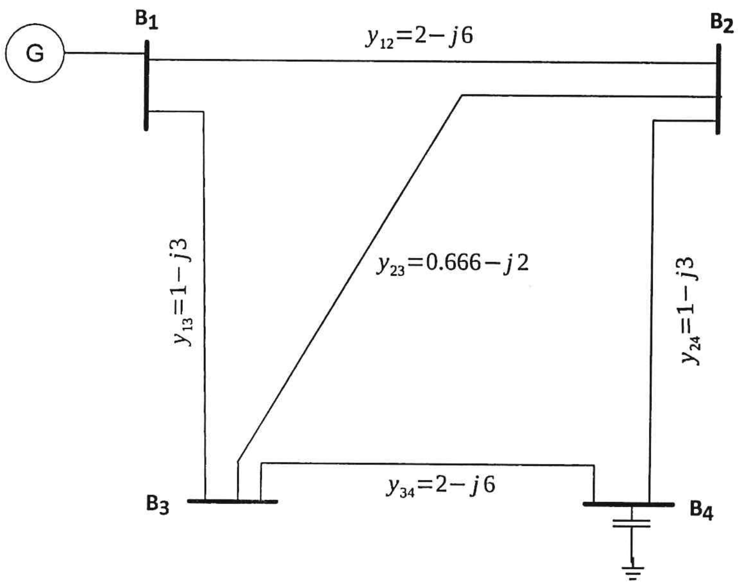

Figure 1: Four bus system

(c) A 6000 bus system has 900 generators, all of which are modeled in a power flow program with specified terminal voltage and reactive limits, i.e., they are voltage-controlled buses, and there are no other voltage-controlled buses besides these 900 generator buses. At the beginning of the Newton Raphson solution procedure (initialization of iteration 1), answer the following:

i How many type PV buses are there in the power flow model?. (2 marks)

ii How many type PQ buses are there in the power flow model?. (2 marks)

iii How many bus voltage magnitudes are unknown? (2 marks)

iv How many bus voltage angles are unknown? (2 marks)

v What is the number of power flow equations used? (2 marks)

Question 3 (20 Marks)

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

(b) Define critical clearing time and critical clearing angle. (3 marks)

(c) A 50Hz, 4 pole turbo alternator rated 150 MVA, 11 kV has an inertia constant of 9 MJ / MVA. Find

i the stored energy at synchronous speed . (1 mark)

ii the rotor acceleration if the input mechanical power is raised to 100 MW when the electrical load is 75 MW, (13 marks)

iii the speed at the end of 10 cycles if acceleration is assumed constant at the initial value. (1 mark)

Question 4

(a) The power-angle relationship for the network of Fig. 2 is given as $P_{max} = 2.087\text{pu}$: $P_e = \frac{V_g V_b}{X} \sin\delta = 2.087 \sin\delta$. A short circuit occurs in the middle of the line L_2

i draw the equivalent circuit indicating the reactances during the short circuit. (3 marks)

ii determine the power-angle relationship during the short circuit in the middle of the line . (6 marks).

iii Determine the power-angle relationship after the fault is cleared by outage of line L_2 (4 marks)

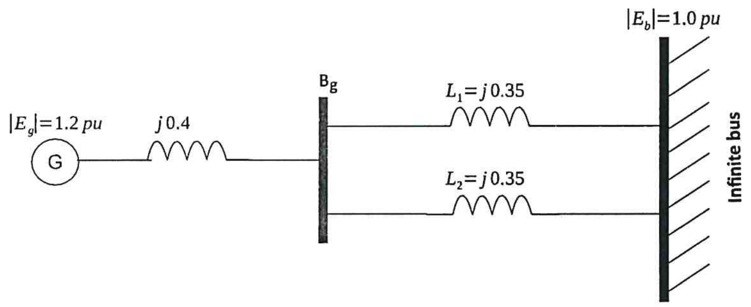

Figure 2: Single machine infinite bus system

(b) Briefly describe the following studies as applied to power systems

i Steady-state stability (2 marks)

ii Transient stability

(c) Explain why the swing bus is necessary in power flow calculations. (3 marks)

Question 5

(a) Derive the swing equation as used in power system stability studies,and state what class of stability studies it is used for. (9 marks)

(b) A 50 Hz interconnected power system has two areas denoted area 1 and area 2, where the area frequency response characteristics are given by $\beta_1 = 100$ MW/Hz and $\beta_2 = 100$ MW/Hz. The total power generated in each of these areas is 500 and 250 MW, respectively. Each area is initially generating power in steady state with $\Delta P_{tie1} = \Delta P_{tie2} = 0$ when the load in area 1 suddenly increases by 60 MW. Compute the resulting steady state change in frequency Δf as well as the steady state changes in tie–line flows ΔP_{tie1} and ΔP_{tie2} with Load frequency control (LFC). (8 marks)

(c) Briefly describe what is meant by the transient state of a power system, and when a power system is said to be the transiently stable. (3 marks)