UNIVERSITY OF ESWATINI

SIT/RESIT EXAMINATION, FIRST SEMESTER

JANUARY 2020

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER: Power System Analysis and Operation

COURSE CODE : EEE552/EE552

TIME ALLOWED: Three Hours

INSTRUCTIONS:

1. There are FOUR questions in this paper. Answer all questions each question carries 25 marks.
2. If you think not enough data has been given in any question you may assume any reasonable values.
3. Useful information sheet is available at the end of this paper.

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THIS PAPER CONTAINS SIX (6) PAGES INCLUDING THIS PAGE

Question 1 (25 *Marks)*

(a) Discuss the need for power flow analysis? [4]

(b) Given the admittance diagram of a four bus power system as shown in *Fig. 1*(b)

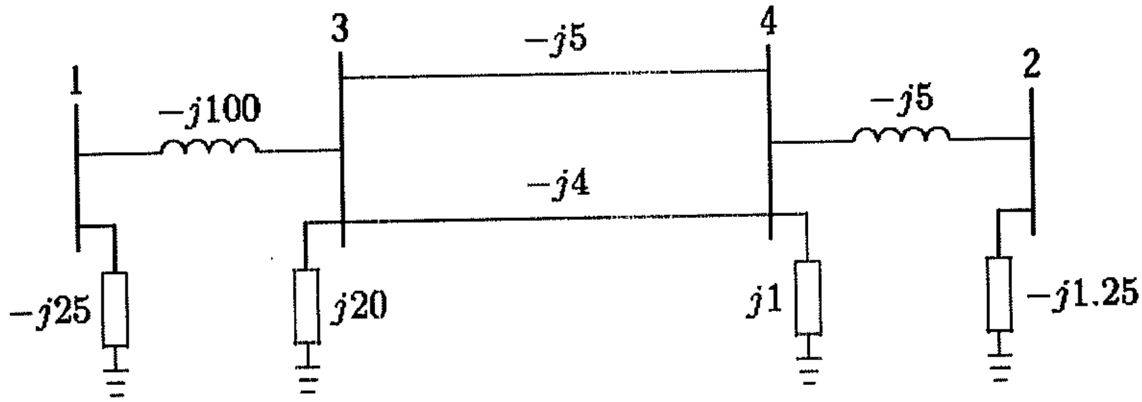

Fig. 1*(b)* Four Bus Power System

Construct the Y_{bus} Matrix [6]

(c) Using Newton-Raphson method, obtain the voltage magnitude and phase angle in bus 2 for the system shown in Fig 1(c). Start with an initial estimate of $V_2 = 1\angle 0°$ pu. Perform only one iteration. Choose base to be 100 MVA. [15]

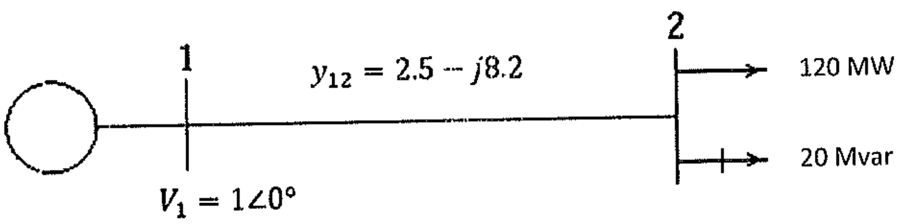

Fig. 2*(c)* Two Bus Power System

Question 2 (25 Marks)

(a) List the three types of power system stability, and give the cause of each in a typical power system. [6]

(b) Define the swing equation [2]

(c) Given the system shown Fig.Q.2(c) Where a three-phase fault is occurred at the point P. Find the critical clearing angle for the fault with simultaneous opening of the breakers 1 and 2. The reactance values of' various components are indicated on the diagram. The generator is delivering 1.2 p.u power at the instant preceding the fault. [17]

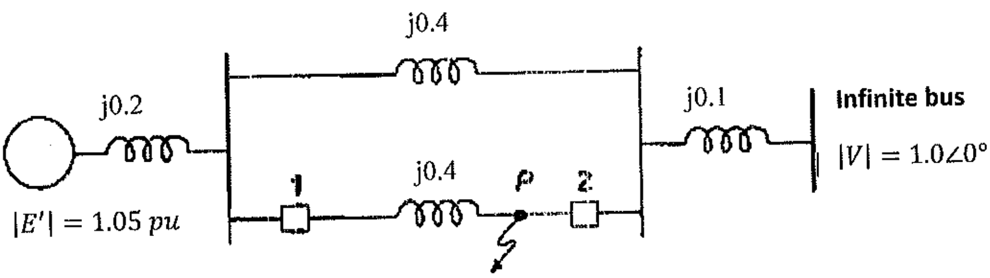

Fig. Q.2(c)

Question 3 (25 Marks)

(a) What is symmetrical and unsymmetrical fault, give examples in each? [4]

(b) Assuming that the Z_{BUS} for the system shown in fig. Q3 (b). is given as

$$Z_{bus} = j\begin{bmatrix} 0.45 & 0.24 & 0.18 \\ 0.24 & 0.48 & 0.25 \\ 0.18 & 0.25 & 0.65 \end{bmatrix}$$

(i) A three-phase fault occurs at bus 3 through a fault impedance of $Z_f = 0.012$ p.u. Using the bus impedance matrix calculate the *fault current, bus voltages,* and *line currents* during fault. [14]

(ii) If there is a line outage and the line from bus 1 to bus 3 is removed by opening breakers, if the branch impedance to be removed is $Z_{13} = j0.2$. Determine the new Z_{bus}. [7]

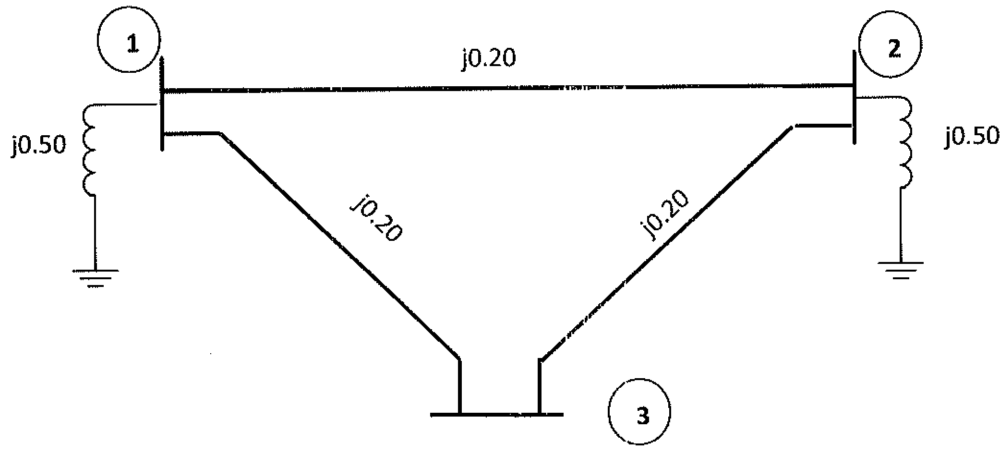

Fig. Q5 (b)

Question 4

(a) Define economic dispatch problem? [2]

(b) Define the following Unit Commitment constraints

(i) Minimum up time? [2]

(ii) Crew constraints? [2]

(c) What is meant by scheduled reserve? [3]

(d) The fuel-cost functions in E/h for three thermal plants are given by

$$C_1 = 0.004P_1^2 + 7.2P_1 + 350 \quad \text{E/h}$$
$$C_2 = 0.0025P_2^2 + 7.3P_2 + 500 \quad \text{E/h}$$
$$C_3 = 0.003P_3^2 + 6.74P_3 + 600 \quad \text{E/h}$$

Where P_1 and P_2 and P_3 are power outputs in MW.

The governors are set such that generators share the load equally. Neglecting line losses and generator limits, find the total loss in E/h due to this decision when the total load is $P_T = 500$ MW. [16]

Useful information

$$\overline{V}_i = \frac{1}{\overline{Y}_{ii}}\left[\frac{P_i - jQ_i}{\overline{V}_i^{\,*}} - \sum_{\substack{j=1\\ \neq i}}^{n} \overline{Y}_{ij}\overline{V}_j\right]$$

$$\overline{S}_i = P_i + jQ_i = \overline{V}_i\overline{I}_i^{\,*}$$

$$P_i = \sum_{j=1}^{n} |V_i|\,|V_j||Y_{ij}|\cos(\theta_{ij} - \delta_i + \delta_j)$$

$$Q_i = -\sum_{j=1}^{n} |V_i|\,|V_j||Y_{ij}|\sin(\theta_{ij} - \delta_i + \delta_j)$$

$$\lambda = a_T P_T + b_T$$

$$a_T = \left(\sum_{i=1}^{n}\frac{1}{a_i}\right)^{-1} \qquad b_T = a_T\left(\sum_{i=1}^{n}\frac{b_i}{a_i}\right)$$