UNIVERSITY OF ESWATINI

MAIN EXAMINATION, FIRST SEMESTER

DECEMBER 2019

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 five questions in this paper.
2. Answer any FOUR (4)
3. Each question carries 25 marks.
4. If you think not enough data has been given in any question you may assume any reasonable values.

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THIS PAPER CONTAINS SIX (6) PAGES INCLUDING THIS PAGE

Question 1 *(25 Marks)*

(a) Discuss the effect of acceleration factor in the load flow solution algorithm. **[2]**

(b) For the small power system shown in Figure Q.1(b), Evaluate the elements of the Jacobian Matrix with the initial estimates. **[23]**

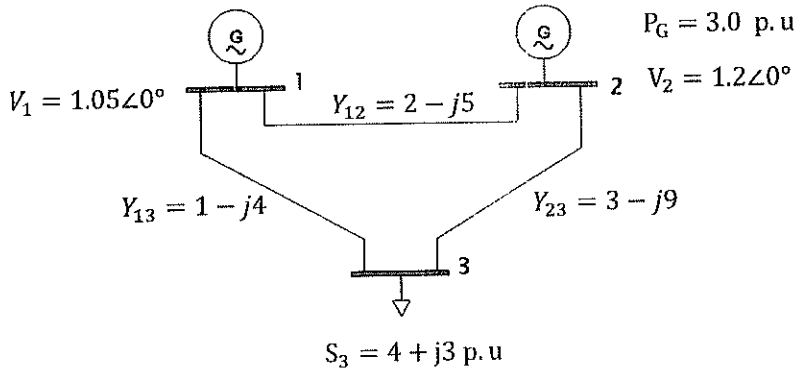

Fig. 1(b)

Question 2 *(25 Marks)*

The cost characteristic equations of three units in a plant are

$$C_1 = 0.4P_1^2 + 160P_1 + 600 \quad \text{E/h}$$

$$C_2 = 0.45P_2^2 + 120P_2 + 450 \quad \text{E/h}$$

$$C_3 = 0.6P_3^2 + 140P_3 + 500 \quad \text{E/h}$$

$$30 \leq P_1 \leq 90 \text{ MW}$$

$$30 \leq P_2 \leq 100 \text{ MW}$$

$$30 \leq P_3 \leq 90 \text{ MW}$$

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

(a) Obtain the priority list for these units based on full load average production cost **[5]**

(b) Find the optimum load allocation between the three units when the total load is 250 MW. **[14]**

(c) What will be the daily loss if the units are loaded equally? **[6]**

Question 3 (25 Marks)

(a) Define the following terms

(i) Incremental cost? [2]

(ii) Participation factor? [2]

(iii) Spinning reserve? [2]

(b) State and explain the equal area criterion? [2]

(c) Given two small power systems with H_1 and H_2 values of 4.0 and 5.0 respectively. The reactance of the tie line interconnecting the areas is 0.6 P.U. The voltage V_1 and V_2 are 1.03 P.U and 1.02 P.U respectively. The load angle is 15 degrees. Calculate the frequency of inter area oscillation. [7]

(d) Determine the critical clearing time for the system whose power angle curve is shown in Fig. Q.3(d), Given that the a 50 Hz generator having an inertia constant H=15 MJ/MVA [10]

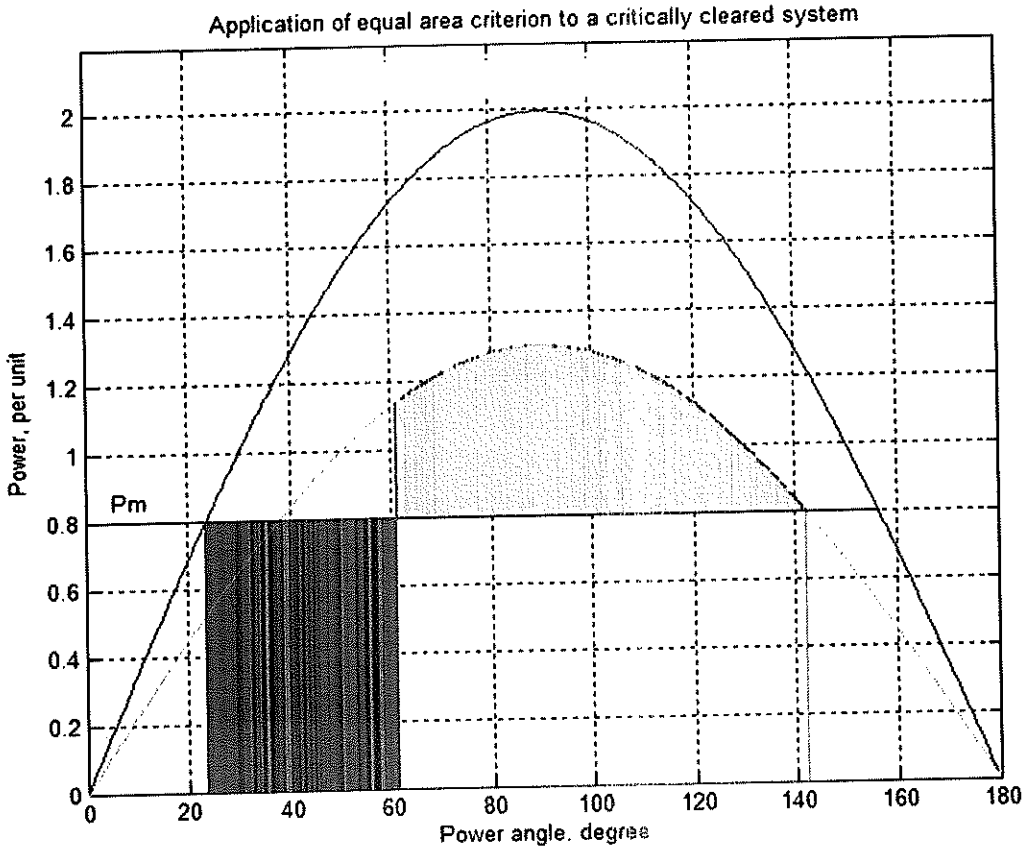

Fig. Q.3 (d)

Question 4 (*25 Marks*)

(a) List the various types of shunt and series faults. [7]

(b) Discuss the need for short circuit studies or fault analysis? [2]

(c) A radial power system network is shown in fig. a three phase balanced fault occurs at F. Determine the fault current and the line voltage at 11.8 KV bus under fault condition. [16]

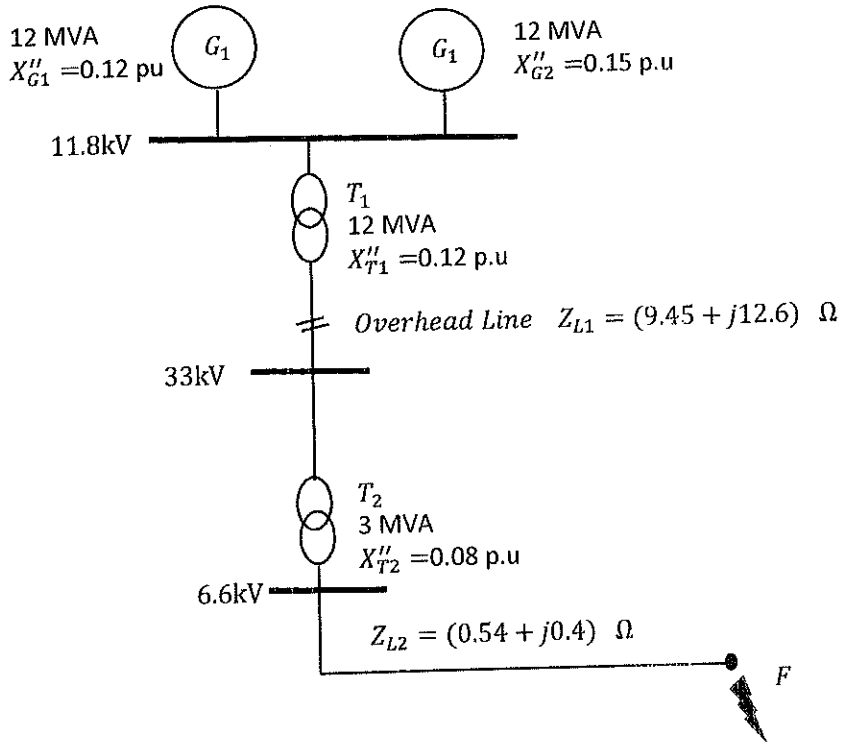

Fig Q.4 (c)

Question 5 (25 Marks)

(a) Describe the common causes of faults in a power system? [4]

(b) Obtain impedance matrix Z_{BUS} for the system shown in fig. Q5 (b). [11]

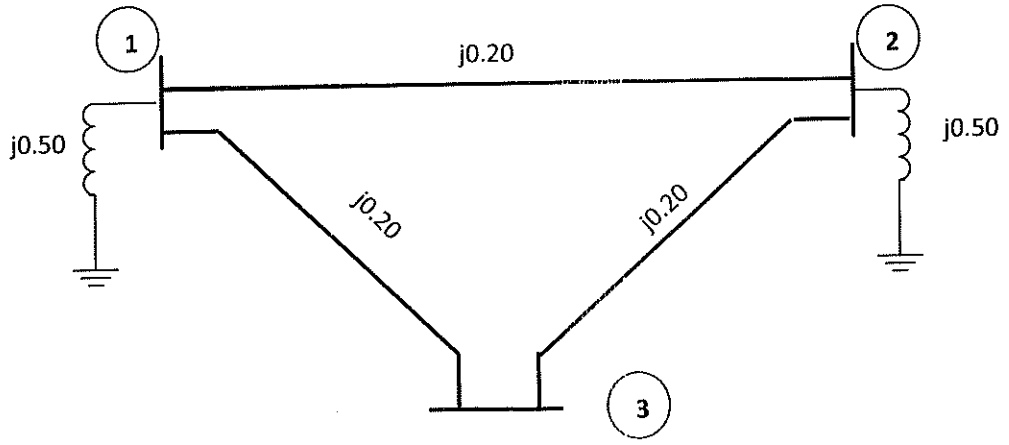

Fig. Q5(b)

(c) The following sequence impedances exist between the source and the point of fault on a radial transmission system:

$Z_+ = 0.2 + j0.4$ p.u.
$Z_- = 0.2 + j0.5$ p.u.
$Z_0 = 0.8 + j1.02$ p.u.

(i) The fault path to earth on a single line-to-ground fault has a resistance of 0.66 p.u. determine the fault current and the voltage at the point of fault. [6]

(ii) Calculate the three-phase fault current. Compare with the single line-to-ground fault current assuming the fault path to ground has a negligible impedance. [4]

Useful Information

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

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

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

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

$$\lambda = a_T P_T + b_T$$

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