UNIVERSITY OF ESWATINI

SIT/RESIT EXAMINATION

JANUARY 2019

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER: Power System Analysis and Operation

COURSE CODE : EE552

TIME ALLOWED: Three Hours

INSTRUCTIONS:

1. There are four questions in this paper.
2. Answer all four questions. Each question carries 25 marks.
3. Useful information is attached at the end of this paper.
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 FIVE (5) PAGES INCLUDING THIS PAGE

Question 1 *(25 Marks)*

(a) Discuss the need for power flow analysis? [3]

(b) For the system show in Fig. Q.1 , state the following

(i) Number of load flow equations. [2]

(ii) Total number of variables. [2]

(iii) Based on your answers in (i) and (ii) above, Discuss how to solve the load flow problem. [3]

(c) In the power system network shown in Fig. Q.1

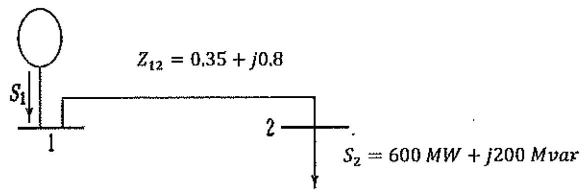


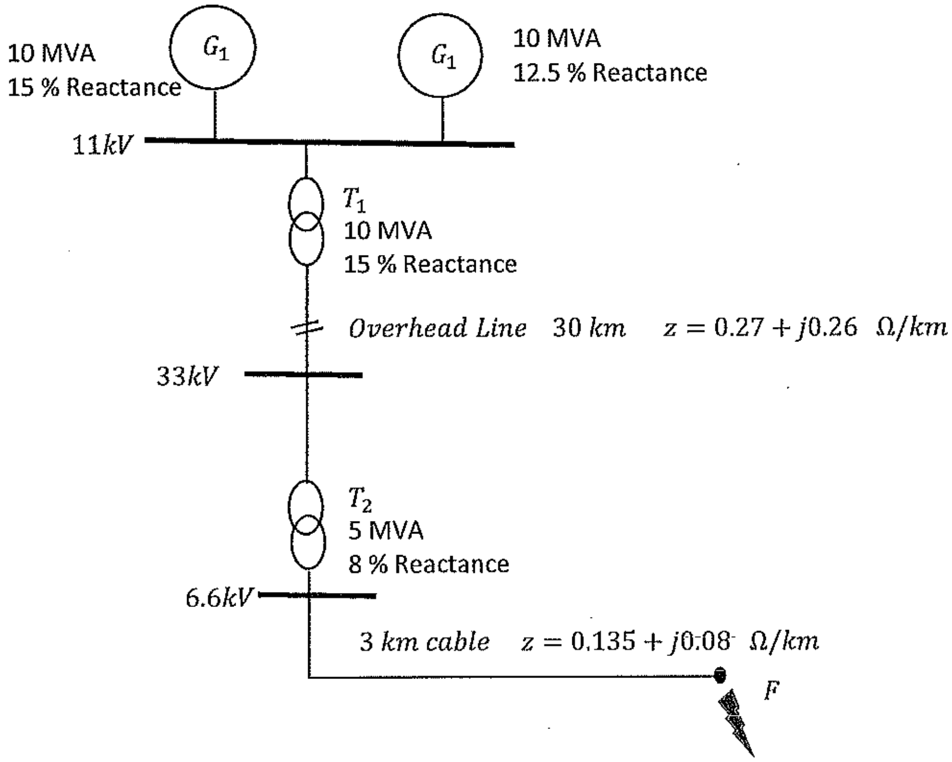
Fig. Q.1

(i) Using Gauss-Seidel method, determine V_2 after two iterations. [5]

(ii) If after several iterations voltage at bus 2 converges to $V_2 = 0.95 - j0.10$ determine S_1 and the real and reactive power loss in the line. [10]

Question 2 (25 Marks)

For the radial network shown in Fig. Q.2 below, a three-phase fault occurs at F. Determine the fault current and the line voltage at 11 kV bus under fault conditions [25]



Question 3 (25 Marks)

A power plant having two units with the following cost characteristics:

$$C_1 = 0.6P_1^2 + 200P_1 + 2000 \qquad E/hour$$

$$C_2 = 1.2P_2^2 + 150P_2 + 2500 \qquad E/hour$$

Where P_1 and P_2 are the generating powers in MW. The daily load cycle is as follows:

0600hrs - 1800hrs	150 MW
1800hrs - 0600hrs	50 MW

The cost of taking each unit offline and returning it to service after 12 hrs is E 5000.00.

Maximum generation of each plant is 100 MW.

Consider a 24 hr period from 0600 hrs one morning to 0600hrs the next morning.

(a) Would it be economical to keep both units in service for this 24 hour period or remove one unit from service for 12 hour period from 6:00 P.M. one evening to 6:00 A.M. the next morning? [11]

(b) Compute the economic schedule for the peak load and off peak load conditions. [5]

(c) Calculate the optimum operating cost per day. [3]

(d) If operating one unit during off peak load is decided, up to what cost of taking one unit off and returning to service after 12 hours, this decision is acceptable? [4]

(e) If the cost of taking one unit off and returning to service after 12 hours exceeds the value calculated in (d), what must be done during off peak period? [2]

Question 4 (25 Marks)

(a) Define the following Unit Commitment constraints (UC)

(i) Spinning Reserves. [3].

(ii) Transmission line limitation: [2]

(iii) Minimum down time. [2]

(b) The equal area criterion suggests that the stability of the system is enhanced if the area A_1 is reduced or if the potential area A_2 is increased. This can be achieved in several ways, Discuss. [10]

(c) Determine the critical clearing time for the system whose power angle curve is shown in Fig. Q.4, Given that the a 60 Hz generator having an inertia constant H=10 MJ/MVA [8]

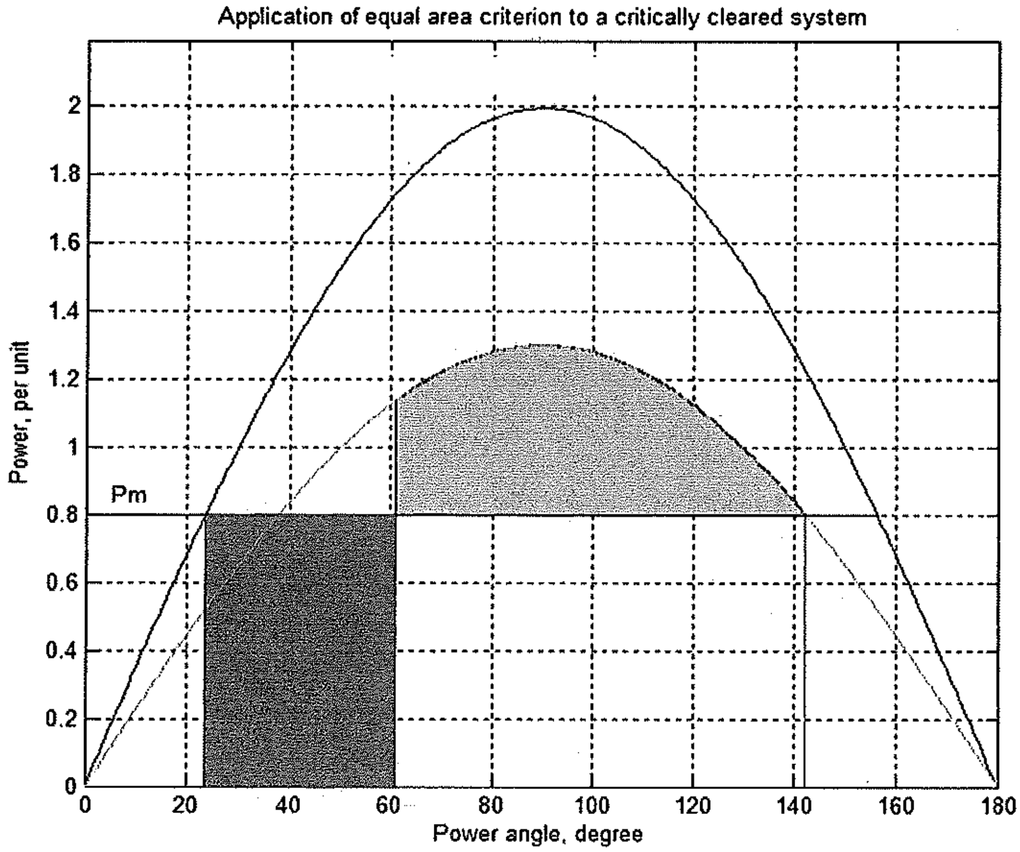


Fig. Q.4

Useful Information

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

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

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

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

$$\lambda = a_T\, P_T + b_T$$

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

$$\frac{d\delta}{dt} = \sqrt{\frac{2\pi f_0}{H}\int_{\delta_0}^{\delta} (P_m - P_e)\, d\delta}$$