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UTM
UNIVERSITI TEKNOLOGI MALAYSIA

FINAL EXAMINATION SEMESTER I
SESSION 2016/2017

COURSE CODE	:	**MEP / MKEP 1623**
COURSE NAME	:	**Power Transmission & Security**
LECTURER	:	**Dr. Md Pauzi bin Abdullah**
PROGRAMME	:	**MEP / MKEP**
SECTION	:	
TIME	:	**2 HOURS 30 MINUTES**
DATE	:	

INSTRUCTION TO CANDIDATES : Instruction: Answer **ALL** questions in PART A and **ALL** questions in PART B

THIS EXAMINATION BOOKLET CONSISTS OF **8** PAGES INCLUDING THE FRONT COVER

PART A

Q1. A 275 kV transmission line has the following constant:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 0.94 \angle 2^\circ & 131 \angle 73^\circ \\ 0.001 \angle 90^\circ & 0.94 \angle 2^\circ \end{bmatrix}$$

a) The sending end voltage is 275 kV. If load at the receiving end is 300 MW at 0.8 power factor lagging, what type and rating of compensation equipment required to keep the receiving end voltage at 275 kV?

(8 marks)

b) If the compensation equipment in Q1(a) is not available, determine the maximum power at unity power factor that can be delivered to the load to keep the voltage at the receiving end at the rated voltage.

(7 marks)

Q2.

An engineer is designing a 133 kV overhead sub-transmission line between two towers crossing above railroad. The design requirements and constraints are as follows:

- Minimum clearance of conductors above ground is 50ft.
- Outside diameter of the conductor is 1.05 in. and weight of 5300 lb/mi.
- The ultimate strength of the conductor is 20,000 lb.
- The two towers are at the same level
- The height of tower 1 is 60 ft. and the height of tower 2 is 80 ft.
- The span between the two towers is 620 ft
- Assumption: The tension is uniform along the conductor.
  (note: 1 mile = 5280 ft.)

a) Considering the effect of ice and wind, calculate the minimum allowable tension of the conductor in order to meet the minimum clearance above ground. Assuming radial thickness of the ice is 0.7 in. and a wind that exerts a pressure of 4 lb/ft^2.

(10 marks)

b) If the engineer decided to reduce the height of tower 2 to 60 ft. and to fix the tension as calculated in question Q2(a), discuss the modification that can be made on the sub-transmission design. Include related calculations in your answer.

(5 marks)

Q3.

(a) Discuss briefly the purpose of contingency ranking and contingency assessment in power system security analysis.

(4 marks)

(b) Figure Q3(b) shows a 3-bus system consisting of 3 generators, 3 loads and 5 transmission lines. The generation cost of each generator is given as follows:

G1= RM 30/MW, G2= RM 36/MW and G3=RM40/MW.

The impedances of the lines are the same and their power flow limit are given as follows; Line A= 500 MW , Line B= 400 MW , Line C= 450 MW, Line D= 500 MW, Line E= 500 MW.

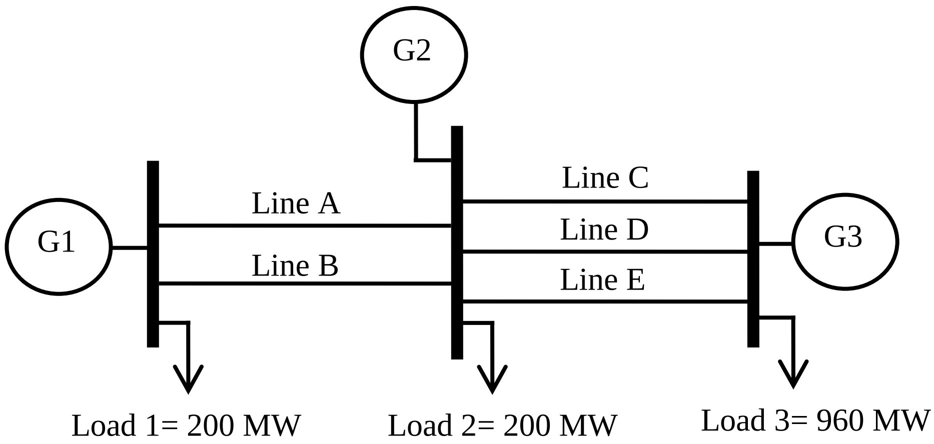

Figure Q3(b)

(i) The system of Figure Q3(b) is operated as follows: G1 generates 600 MW G2 generates 760 MW and G3 generates 0 MW. Identify the operation state of the system and justify your answer.

(4 marks)

(ii) Determine security actions that can be performed for the system to operate at N-1 security criterion (considering transmission line contingencies) by using i) Generation Redispatch ii) Load Curtailment

(4 marks)

(iii) If the limit of the transmission lines can be exceeded up to 30% for short term period, briefly discuss how corrective action approach can reduce generation cost

(3 marks)

Q4.

(a) Briefly discuss the difference between pool market model and single buyer market model.

(2 marks)

(b) Figure Q4(a) shows a 2-bus system consisting of 3 generators (each belong to different company) and a load operating in a pool market. The system operator has received bids from 3 generation companies as shown in Table Q4(b) for the supply of electrical energy during a given period.

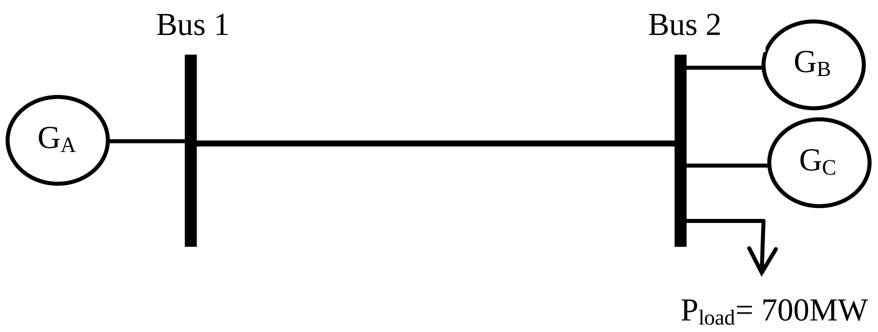

Figure Q4(a)

Table Q4(b)

Generation Company	Energy Bid (MWh)	Price Bid (RM/MWh)
G_A	300	10.5
G_A	200	13
G_B	150	12
G_B	50	14
G_C	100	13.5
G_C	100	14.5

i) Find the unconstrained dispatch of the generators and the System Marginal Price (SMP)

(3 marks)

ii) If the line limit is 380 MW, determine the Security-constrained dispatch of the generators and the security cost.

(5 marks)

iii) Determine the payment that the ISO has to pay to the '*Constrained-ON*' generators (including compensation if any)

(5 marks)

PART B: Answer **ALL** Questions.

Q5.

Figure Q5(a) shows a four-bus system with three generators and three loads. The Power Transfer Distribution Factor (PTDF) and Line Outage Distribution Factor (LODF) of the system is given in Table Q5(a) and Table Q5(b) respectively. The total fuel-cost function for the thermal plants in RM/h are given by;

$$C_{Total} = 900 + 4P_1 + 5.7P_2 + 4.3P_4 + 0.003P_1^2 + 0.006P_2^2 + 0.005P_4^2$$

with the following generator limits:

$$0 \leq P_1 \leq 480 \text{ MW}$$

$$0 \leq P_2 \leq 400 \text{ MW}$$

$$0 \leq P_4 \leq 500 \text{ MW}$$

Where P_1, P_2 and P_4 are the generation output of G1, G2 and G4 respectively.

Transmission line limit for each line is given by:

Line 1-2: 500 MW
Line 1-4: 500 MW
Line 2-3: 500 MW
Line 3-4: 500 MW
Line 2-4: 120 MW

From contingency analysis, the Performance Index (PI) of each contingency (transmission line) is given by Figure Q5(b).

Transmission losses is neglected. The demand of each load during off-peak and peak hour is given in Table Q5(c).

(a) Analyze the system in Figure Q5(a) and design the optimum output of each generator during peak hour such that the system is operated with the following conditions:

- Total generation cost is minimized
- Generation limits and transmission line limits are satisfied
- N-1 security criterion (Transmission line only) is satisfied

(30 marks)

(b) Assume that G1 becomes a private generator and has signed a bilateral contract to supply 200 MW to Load 2 and 300 MW to Load 4. Generators G2 and G4 are remained regulated.

Briefly discuss the challenge to ensure secure operation of the above system. Also suggest the appropriate security action needed to ensure N-1 security criterion is met.

(10 marks)

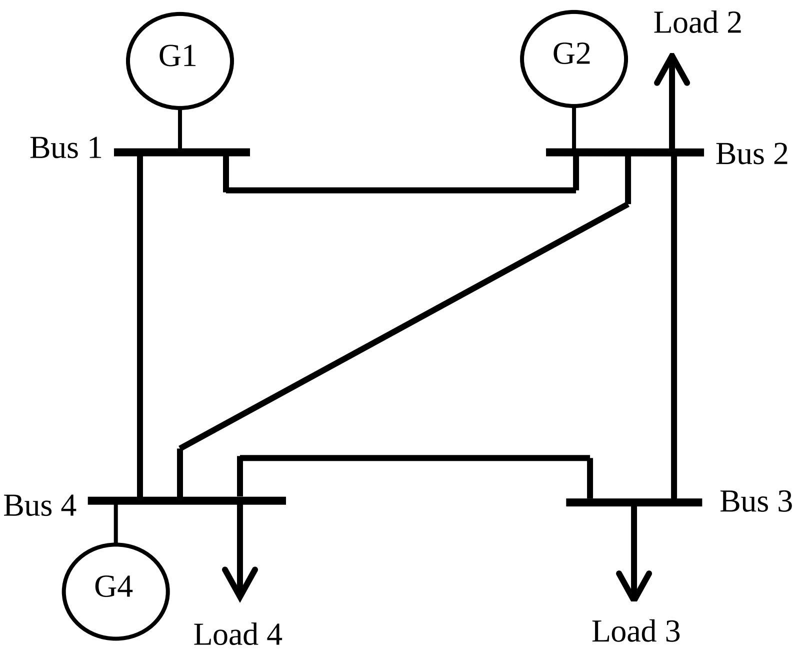

Figure Q5(a): Four-bus system

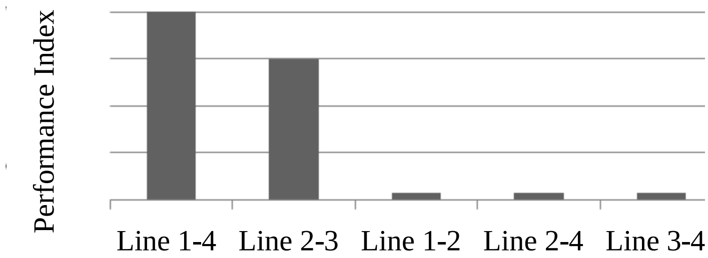

Figure Q5(b): Performance Index of each contingency in the system

Table Q5(a): Power Transfer Distribution Factor (PTDF) of the four- bus system

PTDF	Bus 1	Bus 2	Bus 3	Bus 4
Line 1-2	0.00	-0.5493	-0.4789	-0.3380
Line 1-4	0.00	-0.4507	-0.5211	-0.6620
Line 2-3	0.00	0.2817	-0.5493	-0.2113
Line 2-4	0.00	0.1690	0.0704	-0.1268
Line 3-4	0.00	0.2817	0.4507	-0.2113

Table Q5(b): Line Outage Distribution Factor (LODF) of the four- bus system

LODF		Outage on Line				
		Line 1-2	Line 1-4	Line 2-3	Line 2-4	Line 3-4
Flow on Line	Line 1-2	0	1.0000	-0.4167	-0.3000	-0.4167
	Line 1-4	1.0000	0	0.4167	0.3000	0.4167
	Line 2-3	-0.6250	0.6250	0	0.7000	-1.0000
	Line 2-4	-0.3750	0.3750	0.5833	0	0.5833
	Line 3-4	-0.6250	0.6250	-1.0000	0.7000	0

Table Q5(c) Load demand during off-peak hour and peak hour

Time	Load 2 (MW)	Load 3 (MW)	Load 4 (MW)
Off-peak Hour	40	65	300
Peak Hour	80	120	600