A, B
A, C

Electrical Engineering
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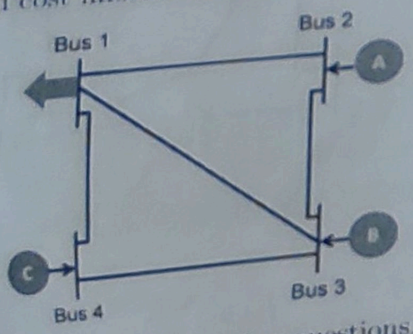
EE 722, Spring 2023
Quiz 3
***Total Marks** = 15*
Date: April 3, 2023

Instructions

- State your assumptions and new notation (if any) clearly to aid the checking.
- All answers are to be written in the space provided with equations clearly stated.
- Rough work can be done on supplements provided and should be attached here.

All questions are concerned with a four bus system shown below.

1. (Total = 9 points) Consider the four bus system shown below: generators A, B and C are located at buses 2, 3 and 4 respectively and serve the load at bus 1. The generator capacity and cost information and the line impedances and flow limits are also specified in tables below.

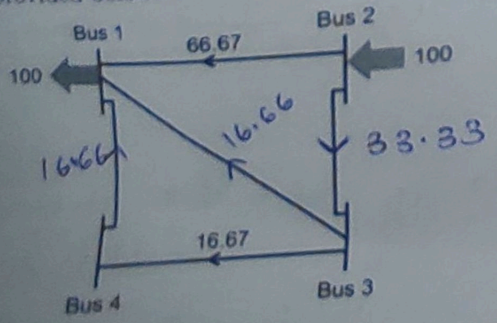


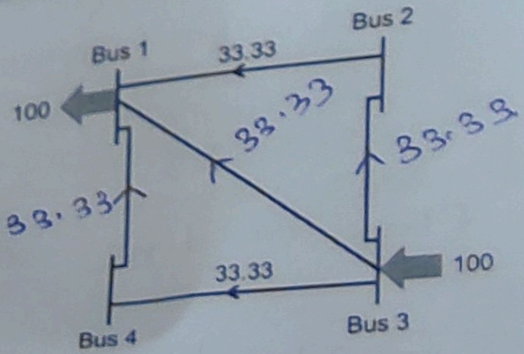
Gen	Max MW	₹ kWh
A	250	4
B	400	3
C	150	7

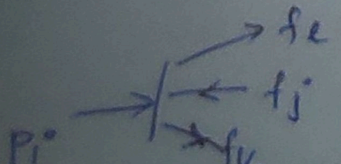
Line	Max MW	X p.u.
1–2	150	0.1
1–3	150	0.2
1–4	150	0.1
2–3	150	0.1
3–4	150	0.1

Now answer the following questions.

(a) (3 points) Two line flows (line 1–2 and line 3–4) are monitored for 100 MW transactions to the load at bus 1 from each of the generators. The MW flows and directions are as shown in the figures below (all injections/withdrawals/flows are in MW). Find the flows on the remaining lines and justify your answer. Clearly show the MW and direction on each of the below diagrams and provide a short justification for your reasoning in the space provided below.

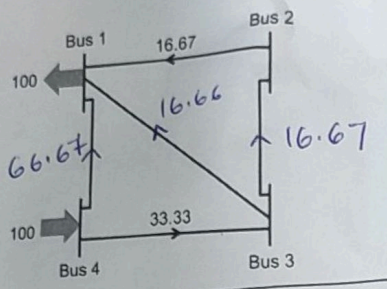




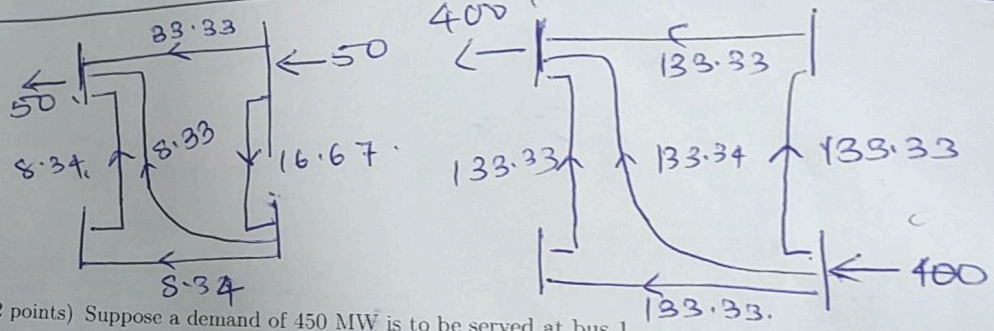


$P_i + f_j = f_k + f_e$

∴ summation of flows incident on the node
= — " — " flows moving away from it.



(1)(b)(ii)



(b) (2 points) Suppose a demand of 450 MW is to be served at bus 1.

i. Find the merit order dispatch in terms of generation at A, B and C in MW.

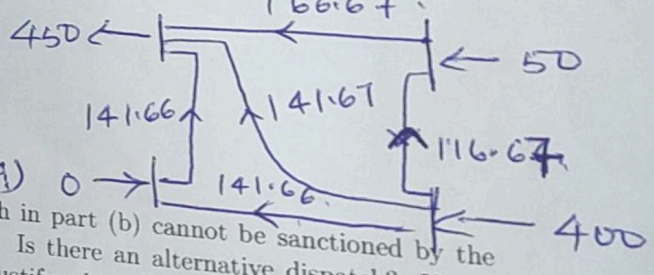
cost of B < cost of A < cost C

max 400 250 150 MW

dispatch $P_B = 400$ MW $P_A = 50$ MW

ii. Find the flows on all the lines.

We find flows by superposition and scaling of solns for (1)(a)



(c) (2 points) Verify that the merit order dispatch in part (b) cannot be sanctioned by the system operator due to a line limit violation. Is there an alternative dispatch? If yes, clearly mention the alternative. If no, clearly justify why no alternative exists.

Flow on line (1, 2) is 166.67 from 2 to 1

> 150 MW.

→ Therefore, this dispatch cannot be sanctioned by the system operator.

There is no alternative dispatch because all generators contribute to the flow on (1,2) in the same direction and hence cannot provide counter flow!

(1)(d). loss of generator: either A/B/C ~~are~~ are out. ~~If any is out~~, or any line could be outage. If any one gen is out. If line is out.

(d) (2 points) If the system adheres to a $N-1$ security criterion (single line or generator outages), then what is the maximum demand that can be served at bus 1? Justify your answer with analytical reasoning in a concise manner in the space provided below.

gen out	D^{max}
A	400+150 = 550
B	150+250 = 400
C	250+400 = 650

line out,	D_{max}
~~(1,2)~~	300
(1,3)	300
(1,4)	300
(2,3)	450
(3,4)	450

The lowest demand is the safest bet. ∴ N-1. D^{max} = 300 MW

2. (Total = 6 points) Choose all the alternative(s) that are correct and justify your answer.

(a) (2 points) As more and more transactions between different source/sink nodes are executed on the system, the available transfer capacity from some node m to some node n may
A. increase B. decrease C. increase or decrease

Justification: (people may select A+B also)
The effect of transactions can lead to flows or counter flows effectively ↑ or ↓ ATC

(b) (2 points) The energy prices at different locations in the power grid may vary if
A. some lines being congested → M^+, M^- lead to LMPs.
B. impact of losses is considered → sensitivity $\frac{\partial P_{loss}}{\partial P_G}$ leads to LMPs.
C. some generators dispatched at their limit

Justification:
generators dispatched @ limits ⇒ next unit is dispatched. This sets marginal price. But can be same @ all locations.

(c) (2 points) Consider a system of two buses connected via two transmission lines and operated according to the $N-1$ security criterion. The operation is constrained only by thermal limits on the transmission lines: the lines have a continuous thermal rating of 300 MW and during emergencies, they can sustain a 10% overload for 20 minutes. If both lines are in service and the generating units on the downstream bus can increase their output at the rate of 4 MW per minute, the maximum demand that can be served at the downstream bus is
A. 380 MW B. 360 MW C. 660 MW

Justification:
Each line can carry 330 MW upto 20 min
downstream generator can ↑ o/p ~~by~~ upto 80 MW in 20 min.
∴ 330 MW is the correct answer.