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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination — Summer Semester, A. Y. 2022-2023
Course No.: EEE 4635/ EEE 4699 — Time: 3 Hours
Course Title: Power System Operation and Control — Full Marks: 150

There are **6 (six)** questions. Answer all **6 (six)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets.

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1. For a three-unit thermal power plant the following data are given: **25 (CO3, PO2)**

Unit No.	$P_{g,max}$ (MW)	$P_{g,min}$ (MW)	Cost function (\$/h)
1	500	200	$510+7.2P_{g1}+0.00142P_{g1}^2$
2	350	80	$600+7.85P_{g2}+0.00121P_{g2}^2$
3	420	100	$320+8.0P_{g3}+0.00185P_{g3}^2$

The total demand for a certain hour is given as 900 MW, and it is mentioned that unit 3 should not be turned off during this hour as it should supply heat energy to a nearby fertilizer industry.

i) Calculate the full load average production cost for each unit.
ii) Identify the units which should be running to ensure the most economic operation.

2. A three-unit power system data is given below: **25 (CO3, PO2)**

Unit No.	Max. (MW)	Min. (MW)	Min up time (h)	Min down time (h)	No-load cost (\$/h)	Marginal Cost (\$/MWh)	Start-up cost (\$)
1	80	25	2	2	670	10	0
2	250	60	2	1	580	8	0
3	300	75	1	1	210	12	0

Initially, Unit 2 and Unit 3 are turned on. The load demand is given as 450 MW, 540 MW, and 370 MW for three consecutive hours. Find out the feasible unit transitions between consecutive hours and calculate the operating cost for each feasible state.

3. a) Consider a 3-unit power generating station supplying a demand of 300 MW. The details of the units are presented below. **15 (CO3, PO2)**

Gen no.	g_i^{min}	g_i^{max}	C_i (\$/MWh)
1	30	100	25
2	15	240	22
3	40	120	23

i) Calculate the most economic combination for the given scenario and plot that combination on a 2-D plane.
ii) If an additional constraint $g_1 + g_3 \geq 80$ is imposed, determine the up-dated ELD solution. (g_1 and g_3 are the real power outputs of generator 1 and 3, respectively)

b) List down the states associated with the five-state power system security. Discuss any three state transitions in detail. **10 (CO1, PO1)**

4. Consider the following system data. **25 (CO3, PO2)**

Bus data:

Bus No.	Type	P_{Load} (MW)	P_{gen} (MW)
1	Swing	0	---
2	PV	0	50
3	PV	80	40
4	PQ	90	---

Line data:

Line no.	From bus	To bus	*x (p.u.)*
1	1	2	0.1
2	1	3	0.2
3	2	3	0.1
4	2	4	0.2
5	3	4	0.3

i) Illustrate the one-line diagram of the system.
ii) Using DC load flow equations, calculate the line flows and output of the generator at Bus 1.
iii) Determine the power transfer distribution factors (PTDF) for Bus 2 injection and Bus 1 reception.

5. The schematic diagram of Watt speed governor is shown in figure 5. Explain its' operation in detail if the load gets increased or decreased while the reference setting remains unchanged. **25 (CO2, PO2)**

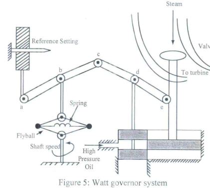

Figure 5: Watt governor system

6. a) A single area power system consists of three generating units with the following characteristics. **15 (CO2, PO2)**

Unit	Rating	Speed Regulation, R (pu on unit MVA base)
1	650 MVA	5%
2	450 MVA	3%
3	350 MVA	1.5%

The units are running in parallel, sharing 1000 MW at the nominal frequency of 50 Hz. The unit outputs are 500 MW, 300 MW, and 200 MW, respectively at 50 Hz. The load is increased by 110 MW. If the load varies 2% for every 1% change in frequency, find the steady-state frequency deviation and the new generation on each unit. Also, find out any difference between the change in load demand and the total change in generation. Select 1000 MVA as the apparent power base.

b) Formulate the block diagram representation of the automatic generation control of a single area power system and compute its' open loop and close loop transfer functions. **10 (CO2, PO2)**