B.Sc. in EEE, 8th Semester

Date: May 08, 2023
Time: 10:00AM – 1:00 PM

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

Semester Final Examination
Course No.: EEE 4835
Course Title: Power System Operation and Control

Summer Semester, A. Y. 2021-2022
Time: 3 Hours
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. a) Explain in short, the necessity of unit commitment and de-commitment in economic power system operation. How is it different than economic load dispatch? **05 (CO1, PO1)**

   b) For a four-unit thermal power plant the following data are given: **20 (CO3, PO3)**

Unit No.	$P_{g,min}$ (MW)	$P_{g,max}$ (MW)	Cost function ($/h)	Priority Order
1	200	500	$510+7.2P_{g1}+0.00142P_{g1}^2$	1
2	80	350	$600+7.85P_{g2}+0.00121P_{g2}^2$	3
3	100	420	$320+8.0P_{g3}+0.00185P_{g3}^2$	2
4	60	200	$80+7.55P_{g4}+0.00158P_{g4}^2$	4

   Consider a demand of 950 MW.
   i) Find out all infeasible unit combinations for the given demand.
   ii) Using the given priority ordering, identify the units which should be running to ensure the most economic operation.

2. a) Discuss with appropriate equations, the concepts of hot start-up and cold start-up costs. **05 (CO1, PO1)**

   b) Consider a two-generator power system with the following quadratic cost functions **20 (CO3, PO3)**

$$C_1(P_{G1}) = 900 + 10P_{G1} + 0.05P_{G1}^2 \ \$/hr$$
$$C_2(P_{G2}) = 500 + 18P_{G2} + 0.04P_{G2}^2 \ \$/hr$$

   The demand to be supplied is given as 850 MW. A simplified real power loss expression is provided as $P_{loss} = 0.00005P_{G1}^2 + 0.00012P_{G2}^2$ Using loss formula method, find out the output of each unit, actual loss, and the value of λ after three iterations. Assume, equal values of P_{G1} and P_{G2} as their initial estimates.

3. A three-unit power system data is given below: **25 (CO3, PO3)**

Unit No.	Max. (MW)	Min. (MW)	Inc. Heat Rate (BTU/kWh)	No load cost ($/h)	Initial Status	Cold start Cost ($)
1	80	25	10500	670	OFF	350
2	250	60	9080	580	OFF	420
3	300	75	8700	210	ON	800

   The load demand is given as 280 MW and 540 MW for hour 1 and hour 2, respectively. Let the fuel cost be 2.1 $/MBTU and a simplified unit cost

characteristic as $F(P) = No\ load\ cost + Incremental\ cost \times P$. Applying dynamic programming method, solve the unit commitment schedule for this power system. Neglect minimum up time and down time constraints, hot start costs, shut down costs, and follow strict priority ordering. Use unit incremental cost values for setting priority among the units.

4. Consider a 3-unit power generating station supplying a demand of 300 MW. The detail of the units is presented below. **25 (CO2, CO3, PO2, PO3)**

Gen no.	g_i^{min}	g_i^{max}	C_i ($/MWh)
1	20	100	25
2	15	270	22
3	18	120	23

i) Formulate the objective function for the aforementioned station for minimizing the cost of generation.
ii) List the associated equality and inequality constraints.
iii) Ignoring network and security related constraints, show the feasible solution space in a 2-D plane.
iv) Calculate the Economic Load Dispatch (ELD) solution for the given scenario.
v) If an additional constraint $2g_1 + g_3 \geq 100$ is imposed, determine the updated ELD solution. (g_1 and g_3 are the real power outputs of generator 1 and 3, respectively)

5. a) Discuss the difference between binding and non-binding constraints related to a constrained optimization problem. **05 (CO1, PO1)**

b) Consider the following system data for an optimal power flow problem. **20 (CO3, PO3)**

Bus data:

Bus No.	Type	P_{Load}	Q_{Load}
1	Swing	0	0
2	PV	0	0
3	PQ	80	15
4	PV	90	10

Line data:

From bus	To bus	x
1	2	0.1
1	3	0.2
2	3	0.1
2	4	0.2
3	4	0.3

i) Calculate the B′ matrix for the given data.
ii) Calculate the generation shift distribution factors (GSDF).

6. a) Discuss the consequences of uncontrolled frequency and voltage on the operation of an industrial manufacturing plant. Also, explain how the generator output voltage and frequency variation beyond the prescribed limit would incur losses in the power system components and transmission lines. **05 (CO1, PO1)**

b) Formulate the block diagram representation of the frequency control loop of a single area power system. **05 (CO2, PO2)**

c) Explain with neat diagram the working principle of Watt speed governor mechanism. **15 (CO1, PO1)**