BSc. Engg. in EEE (7th Semester) **Date: 08 December 2023 (Afternoon)**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Semester Final Examination **Winter Semester: 2022 – 2023**
Course Number: EEE 4731 **Full Marks: 150**
Course Title: Power System III **Time: 3 Hours**

There are **6 (six)** questions. Answer **all** questions. The symbols have their usual meanings. Marks of each question and the corresponding CO and PO are written in the brackets. Do not write anything on this question paper. Assume any reasonable value in case of missing data.

1. a) The fuel cost curve of a thermal power plant is usually nonlinear in nature and can be expressed with the help of different coefficients like a_i, b_i, and c_i. Explain how one can extract these coefficients from a set of measured data. **(05) (CO3) (PO2)**

b) A two-generator power system is supplying power to a local utility having a demand of 550 MW. The quadratic fuel cost expressions for the two generators are expressed as $C_1(P_{G1}) = 900 + 25P_{G1} + 0.02P_{G1}^2$ and $C_2(P_{G2}) = 850 + 20P_{G2} + 0.03P_{G2}^2$. Using the Lagrange multiplier method, calculate the most economic combination of generation dispatch for the power system. **(20) (CO3) (PO2)**

2. a) Explain in short, the significance of complementary slackness condition in solving an optimization problem with inequality constraints. Also, differentiate between binding and non-binding constraints. **(07) (CO3) (PO2)**

b) The fuel cost functions of a two-generator power system are expressed as **(18) (CO3) (PO2)**

$$C_1(P_{G1}) = 550 + 5.1P_{G1} + 0.002P_{G1}^2 \text{ and}$$
$$C_2(P_{G2}) = 450 + 5.5P_{G2} + 0.003P_{G2}^2$$

The load demand is 800 MW and the corresponding generation limits are given as $250 \le P_{G1} \le 500\ MW$ and $200 \le P_{G2} \le 450\ MW$, respectively. Apply the Karush-Kuhn-Tucker condition of optimality to determine the generation outputs considering the generation limits.

3. Consider a synchronous generator connected to an infinite bus through a transformer and a double circuit transmission line as shown in Figure 3. The generator is delivering 0.85 per unit real power at 0.95 power factor lagging to the infinite bus at steady state. Using Newton-Rapshon method of iterative solution, calculate the maximum rotor swing (δ_{max}) after three iterations. Also, evaluate the transient stability limit. Assume $\delta_{max} = 105^\circ$ as the initial estimate of the iterative solution. **(25) (CO4) (PO2)**

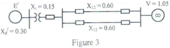

Figure 3

4. a) Consider the rotor angle response of Figure 4 (a) for a single machine infinite bus power system which is obtained through numerical integration of the swing equation. **(12) (CO4) (PO2)**

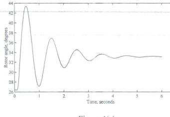

Figure 4(a)

i) Identify whether the response is stable or not. Justify your claim.

ii) Sketch the approximate rotor angle response if the fault clearing process is delayed.

iii) Demonstrate the rotor angle response if there were no damping present in the system.

iv) Explain the nature of the applied disturbance considering the final rotor angle settles to a new equilibrium.

b) Illustrate the equivalent circuit representations for the network shown in figure 4(b) for the following scenarios: **(13) (CO4) (PO2)**

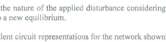

Figure 4(b)

Scenario 1: i) there is no fault, ii) there is a sustained three-phase bolted fault at the middle of Line 2, iii) the faulted line is isolated by tripping the circuit breakers at both ends of the faulted line, and iv) the faulted line is restored after some time.

Scenario 2: i) there is no fault, ii) there is a temporary three-phase bolted fault at one end of Line 1, and iii) the fault is cleared without tripping the circuit breakers.
Also, find out the expressions of equivalent transfer reactances for each of the above-mentioned scenarios.

5. a) A synchronous generator is operating at point 'a' with an electrical output power P_{e0} and a mechanical input power P_{m0} as shown in Figure 5(a). If the mechanical input power is suddenly decreased to P_{m1}, explain the trajectory of rotor movement and identify the resulting accelerating and decelerating areas. **(15) (CO4) (PO2)**

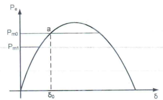

Figure 5(a)

b) A single machine infinite bus (SMIB) system was operating at steady-state equilibrium condition. Suddenly, a three-phase bolted fault occurs in such a manner that the electrical power transfer during the fault is zero and the pre-fault and post-fault equivalent transfer reactances are the same. The following set of data in per unit (unless otherwise stated) are available for the system: **(10) (CO4) (PO2)**

$$|E'| = 1.58, |V| = 1.15, P_{m0} = 0.85, X_{eq,bf} = 0.7, \text{and H} = 5.0 \text{ sec.}$$

Calculate the critical clearing angle and critical clearing time for ensuring transient stability of the SMIB system. Also, find the value of the maximum power that can be transferred after fault.

6\. a) Define zero-state response associated with the small disturbance stability of a power system. Explain how it is different than the zero-input response. **(05) (CO2) (PO2)**

b) Discuss the effects of the polarity and magnitude of damping power coefficient (D) on the small disturbance stability of a power system. Show the nature of time-domain response and s-domain plots for each case. **(10) (CO2) (PO2)**

c) Explain the merits and demerits of series compensation of power transmission system. **(10) (CO2) (PO2)**