

B.E. ELECTRICAL ENGINEERING
FOURTH YEAR FIRST SEMESTER EXAMINATION 2025

ADVANCED POWER SYSTEM ANALYSIS

Time: Three hours

Full Marks: 100

(50 marks for each part)

Use separate answer script for each part.

PART I

Figures in the margin indicate full marks

1. Answer either question (A) or (B)
 - (A) Derive expression for the power flow equation in terms of bus voltage and admittance matrix. From this expression develop the load flow equations for the Newton-Raphson and Gauss-Seidel load flow. Explain how PV and PQ buses are treated in Load Flow solution. (4+7+5=16)
 - Or,
 - (B) State and justify the assumptions made in the formulation of Fast Decoupled load flow. Show the solution algorithm for ensuring simultaneous convergence of the active and reactive power equations in Fast Decoupled load flow. (8+8=16)
2. Answer either question (A) or (B)
 - (A) (I) Explain the physical significance of the Lagrange multiplier when the Economic Dispatch problem is solved with and without consideration of transmission loss. (8+8=16)

(II) In a power station there are three generating units having incremental fuel costs as $F_1=0.1 + 0.1 P_1$, $F_2= 0.2 + 0.06 P_2$, $F_3=0.12 + 0.14 P_3$, where P_1, P_2, P_3 are power outputs in MW and F_1, F_2, F_3 are in thousand rupees per hour. At a certain loading condition, the Economic dispatch solution gives the P_1 value as 100 MW. Determine the generation schedule if the capacity limits are given by $100 \leq P_1 \leq 300$, $50 \leq P_2 \leq 200$, $50 \leq P_3 \leq 150$.

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Or,

- (B) (I) Explain the necessity of solving the Unit Commitment problem. (3+5+5+3=16)
(II) Discuss the constraints to be considered in the Unit Commitment problem.
(III) How start up and shut down costs are represented?
(IV) Differentiate between the Economic Dispatch and the Unit Commitment problems.
- 3 (i) Why area control error (ACE) is formed including both the deviation in tie line power flow and frequency error while solving the frequency control problem of two area power system? (8 +5 +5 =18)
(ii) State and justify the assumptions needed to represent the transmission loss in terms of active power output of the generators.
(iii) A 32 bus Power system has 5 generating stations of which two are operated at their limiting values of field excitations. One of the substations has a tap changing transformer and another substation is having a shunt capacitor bank. A Static var compensator installed at another substation is operated for voltage control. Determine the number of bus voltage and phase angle variables of the load flow problem. Also write justification for your answer.

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PART-II

Answer any two questions.

1 (a). Discuss how the loads and the synchronous machines need to be modeled in classical transient stability and also explain why such models are necessary. Also discuss the modifications required in GS load flow equations to accommodate the above models. 10

(b). Explain why flux-decay model of synchronous machine is necessary in transient stability study for longer duration. Write down the differential equations corresponding to the above mentioned model and draw the relevant phasor diagram showing the different armature voltages and currents. 7

(c). With the help of a neat sketch show the transfer function block diagram of the IEEE-Type 1 model of synchronous machine excitation system. Mention the significance of all the blocks and derive the relevant differential equation model. 8

2 (a). Write down the steps required to compute the initial values of all the dynamic variables involved in transient stability study when the effect of synchronous machine excitation system is to be considered with the excitation system represented by IEEE-Type 1 model? 8

(b). Establish the relation between the sequence impedance matrix and the phase impedance matrix of a 3-phase power system element and hence explain why sequence component quantities are preferred over phase quantities for analysis of power system with unbalanced loading. 7

(c). Derive the general equation for fault current in a 3-phase power system in sequence component quantities when fault impedance matrix is available and there from derive the expression in phase quantities for fault current for a 3-phase to ground fault. 10

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3 (a). Derive the fault impedance or admittance matrix (whichever is applicable) in phase for the following faults:

- i) SLG
- ii) LLG

8

(b). The elements of the partial Z_{bus} of a power system are given as follows

$$Z_{11} = j0.15, Z_{22} = j0.25, Z_{12} = Z_{21} = 0.0$$

With necessary derivation obtain the new Z_{bus} when bus 1 is connected to a new bus 3 through a branch having an impedance $j0.10$, then bus 3 and bus 2 are connected by an impedance $j0.20$, after which, bus 3 is connected to the reference bus by a branch having impedance $j0.12$. All impedance values are in p.u.

17