[This question paper contains 4 printed pages.]

Your Roll No. .....

3213A **J**

MEE

Paper—EE.559

(Dynamics of Power Apparatus and System)

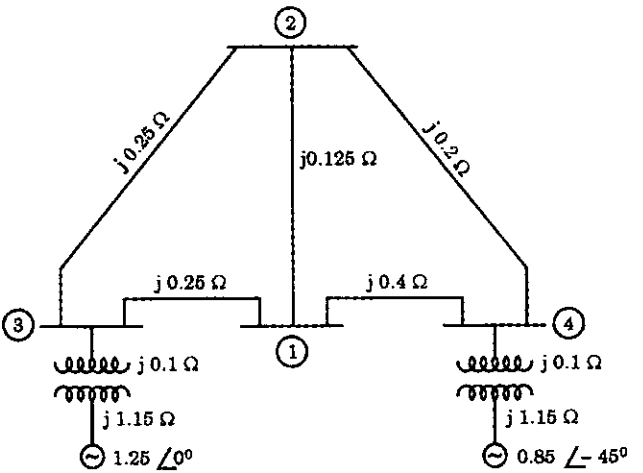
Time : 3 *Hours* *Maximum Marks* : 100

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any ***five*** *questions.*

All *questions carry equal marks.*

1. The single-line diagram of a four bus system is shown in the following Fig. The p. u. reactances are shown in the diagram.



Single-line diagram

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(i) Draw the linear graph, tree and co-tree of the above circuit.

(ii) Obtain the bus incidence matrix A and the primitive admittance matrix for the system.

(iii) Find the bus admittance matrix. 20

2. (a) What are the various types of loads in a Power System ? Discuss the voltage and frequency characteristics of these loads. 10

(b) Why we need modelling of loads ? Develop a model for composite loads. 10

3. (a) Develop the equations for stator self and mutual inductances in case of synchronous machine and hence show their variation with rotor position. 10

(b) What is the significance of Park's transformation ? Develop the stator voltage equations in d–q–o frame of reference for synchronous machine. 10

4. (a) Develop the *d*-axis and *q*-axis equivalent circuits of a synchronous machine. 10

(b) The following are the parameters in p.u. on machine rating of a 500 MVA, 20 kV, 0·9 pf, 50 Hz, 3600 rpm turbine-generator :

$L_{ad} = 1{\cdot}66$ $L_{aq} = 1{\cdot}61$

$L_{fd} = 0{\cdot}165$ $R_{fd} = 0{\cdot}0006$

$L_{1q} = 0{\cdot}75$ $R_{1q} = 0{\cdot}00619$

$L_e = 0.15$ $R_a = 0{\cdot}003$

$L_{1d} = 0{\cdot}1713$ $R_{1d} = 0{\cdot}0284$

$L_{2q} = 0{\cdot}125$ $R_{2q} = 0{\cdot}02368.$

L_{fkd} is assumed to be equal to L_{ad}.

When the generator is delivering rated MVA at 0·9 pf (lag) and rated terminal voltage, calculate :

(i) Internal angle δ_i in electrical degrees.

(ii) Per unit values of e_d, e_q, i_d, i_q, i_{1q}, i_{1d}, i_{fd}, i_{2q}, Ψ_{fd}, Ψ_{1d}, Ψ_{1q}, Ψ_{2q}, e_{fd}.

(iii) Air-gap torque in pu and Nm.

5. A 160 MVA, 15 kV, 0·8 pf, ·50 Hz, 3-phase, 2-pole synchronous generator has the following inductances and resistances associated with the stator and field windings :

$l_{aa} = 3{\cdot}2758 + 0{\cdot}0458 \cos(2\theta)$ mH

$l_{ab} = -\ 1{\cdot}6379 - 0.0458 \cos\left(2\theta + \frac{\pi}{3}\right)$ mH

$l_{afd} = 40{\cdot}0 \cos\theta$ mH

$L_{ffd} = 576.92$ mH

$R_a = 0{\cdot}0031\ \Omega$

$R_{fd} = 0{\cdot}0715\ \Omega$

(i) Find L_d and L_q in henrys.

(ii) If the stator leakage inductance L_l is 0·4129 mH, determine L_{ad} and L_{aq} in henrys.

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(iii) Using the machine rated values as base values for the stator quantities, determine the p.u. values of the following in L_{ad}-base reciprocal per unit system : L_l, L_{ad}, L_{aq}, L_d, L_q, L_{afd}. 20

6. (a) How is the modelling of Induction Motor different from that of synchronous machine. Express the stator and rotor currents in terms of d-q variables. Develop the model in d-q-o frame. 10

(b) Develop the transient equivalent circuit of Induction machine needed for stability studies. 10

7. (a) What are the functions of an excitation system ? Draw the block diagram of IEEE-type-1 excitation system showing the transfer function of each block. 10

(b) Develop the model of speed-governor system for steam turbines. 10

8. (a) Differentiate between steady-state stability and transient stability of a system. Discuss the factors that affect (i) steady-state stability and (ii) transient state stability of the system. 10

(b) Derive the swing equation and discuss its application in the study of power system stability. 10

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