The Open University of Sri Lanka
Diploma in Technology
ECD 2205- Power System Studies
Final Examination 2005/2006

Duration Three Hours

Date: 06th April 2006 **Time: 0930-1230**

This paper contains seven questions. Answer any four. All questions carry equal marks.

Graph papers are available on your request

Q1. ABCD parameters of a certain 230 kV transmission line are given bellow:

$\underline{A} = 0.818\angle 2^0 = \underline{D}$, $\underline{B} = 173\angle 85^0\ \Omega$, $\underline{C} = 0.002\angle 90^0$ S

Sending end voltage of above transmission line is maintained at 242 kV.

(i). Determine the sending end voltage and current when the load is disconnected.

(ii). A shunt reactor with admittance of j0.0021 S is connected at the receiving end of the line. Calculate the new **ABCD** parameters of the system.

(iii). Determine the no-load voltage at the receiving end and the current at the sending end after connecting reactor described in (ii).

Q2. A small power system shown in figure Q2 consists of three nodes. Parameters of the transmission lines are given in table Q2. Voltage at bus 1 is equal to $1\angle 0^0$ pu. A capacitive and an inductive load are connected to the nodes 2 and 3 respectively. Admittance of inductor and capacitor are j0.25 pu and –j0.50 pu respectively.

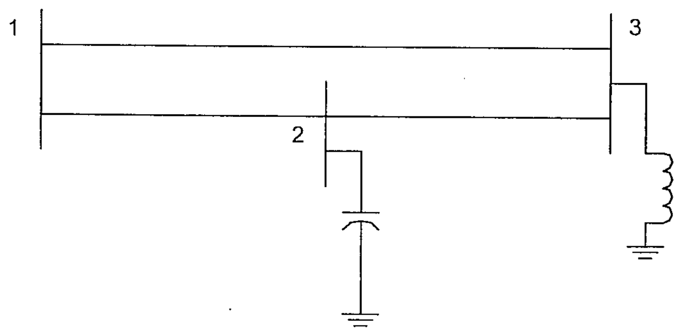

Figure Q2.

Table Q2

Branch	Series reactance pu	Shunt admittance pu
1-2	j0.2	j0.24
2-3	j0.1	j0.16
1-3	j0.25	j0.40

(i). Calculate the elements of nodal admittance matrix.

(ii). Use Gauss-Zeidel method to calculate voltages at nodes 2 and 3 (one iteration is sufficient).

Q3. Figure Q3 shows a simple radial transmission system. Parameters of the system are indicated as shown.

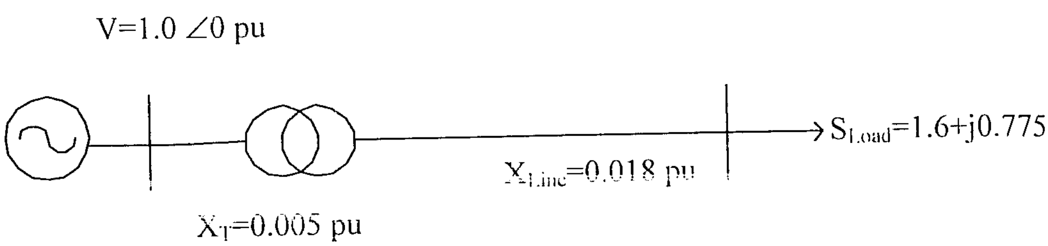

Figure Q3.

By considering "Transformer + Transmission line" as one branch

(i). Determine the order of the Jakobian matrix.

(ii). Calculate the elements of Jakobian matrix.

(iii). Calculate the voltage at load using Newton-Raphson method (one iteration is sufficient).

Note:

The active and reactive power at any node i of the system can be expressed as

$$P_i = g_{ii}V_i^2 + V_i\sum_{\substack{j=1\\ j\neq i}}^{n} V_j(g_{ij}Cos\delta_{ij} - b_{ij}Sin\delta_{ij})$$

$$Q_i = b_{ii}V_i^2 + V_i\sum_{\substack{j=1\\ j\neq i}}^{n} V_j(b_{ij}Cos\delta_{ij} + g_{ij}Sin\delta_{ij})$$

Where:

$g_{ij} - jb_{ij} = Y_{ij}$ *- admittance of the branch i-j*

Q4. A steam power plant consists of two generators are operating in parallel to share a common load. The load varies from 50 MW to 200 MW. The incremental costs are given bellow:

G1 : $\dfrac{\partial F_1}{\partial P_1} = 0.01P_1 + 2.0$ $/MWh

G2: $\frac{\partial F_2}{\partial P_2} = 0.012P_2 + 1.6$ \$/MWh

Minimum and maximum loads of generators G1 and G2 are 20 MW and 125 MW each.

(i). Find the incremental fuel cost and allocation of loads between two generators for the minimum cost for various loads.
(ii). Plot the graph of generator output versus plant output.

Q5. A steam generator is connected to a system through a large reactor as shown in figure Q5. The system can be represented by V=1∠0⁰ pu. voltage and series connected reactance of 0.01 pu. Power delivered from the generator to system is 0.75 pu. Power angle of the generator is 16 ⁰. Parameters of the steam generator are indicated in the figure.

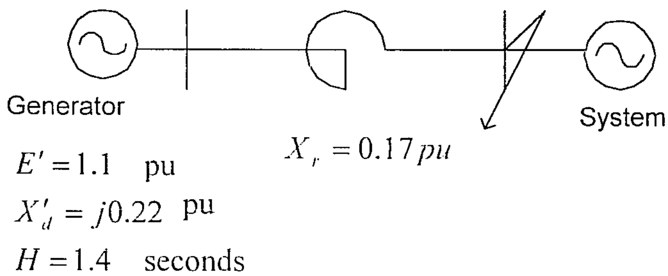

Figure Q5

(i). Determine the maximum power delivered by the generator.
(ii). Determine the critical clearing angle if a three phase fault occurs at the system bus bar. Sketch the load curves and show the accelerating and decelerating area.
(iii). Calculate the critical clearing time.

Q6.(a). A salient pole synchronous generator is connected to an infinite bus with voltage V. Draw the phasor diagram and prove that P-δ characteristic is

$$P = \frac{E_q V}{X_d} Sin\delta + 0.5V^2 \left[\frac{1}{X_q} - \frac{1}{X_d} \right] Sin2\delta$$

(b). A cylindrical rotor synchronous generator connected to an infinite bus delivers maximum power via transmission line. Infinite bus voltage is 1.0 pu and emf of the generator is 1.15 pu. Synchronous reactance and transmission line reactance are 0.85 pu and 0.12 pu respectively.

(i). Calculate the maximum power delivered by the generator.

(ii). Compute the terminal voltage of the generator at this situation?
(iii). Determine the magnitude and direction of the reactive power at both generator terminal and infinite bus.

Q7. (a). Briefly explain the methods of voltage regulation in a power system.
(b). Power angle curve of the generator is shown in figure Q7. Input and output power balance (P_{mech} = $P_{electrical}$) reach at point X and Y. With help of swing equation explain that the gnerator is stable only at point X.

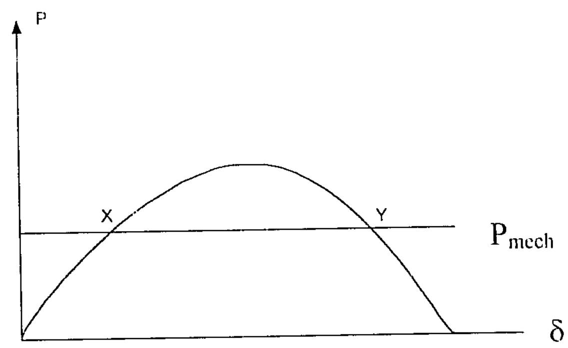

Figure Q7.

(c). In load flow analysis buses are classified as (i).Slack bus; (ii). PV bus (iii). PQ bus. Explain the difference between them reason for such classification.
(d). Why iteration methods are used for load flow calculations?