THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY
ECX5332 – Power systems II
Final Examination 2007/2008

Duration Three Hours

Date: 28th April 2008 Time: 0930-1230

*This paper consists of seven questions. Answer ANY **FIVE** questions. All questions carry equal marks.*
Graph papers and log-log papers will be available on your request
Show your work

Q1.
A three phase 50 Hz, 400 kV transmission line has a length of 280 km. Series impedance and shunt admittance are 0.025+j0.3 Ω/km and $j4x10^{-6}$ S/km.

i. Calculate characteristic impedance, propagation constant and wave length *[04 marks]*

ii. The voltage at the sending end is maintained at its rated value while the far end of the line is opened. Calculate the voltage at far end of the line at this situation. *[06 marks]*

iii. At the full load condition this line delivers 700 MW at 0.98 power factor leading. Under this load condition the voltage at receiving end is 0.95 of the rated voltage. Calculate
(a). sending end voltage and current. *[06 marks]*
(b). reactive power at the mid point of the line *[04 marks]*

Q2.
(a). Explain briefly the reason for keeping constant system frequency in power system operation *[05 marks]*

(b). A synchronous generator operating at normal frequency of 50 Hz delivers 0.8 pu power to a system via transformer and double circuit transmission lines as shown in figure Q3. Parameters of the system are indicated in the figure Q2.

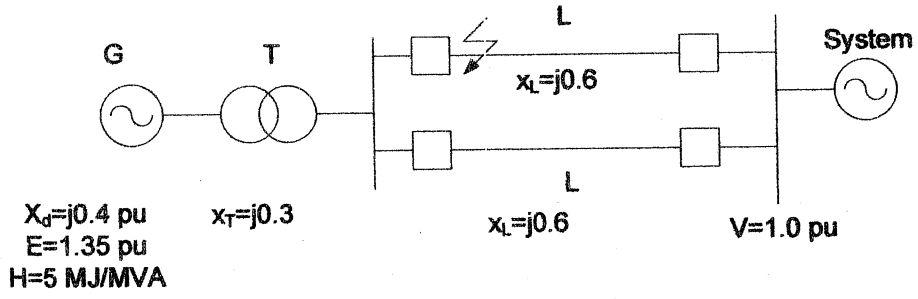

Figure Q3

i. Calculate the maximum power that can be delivered from generator to the system.

[03 marks]

ii. A three phase fault with zero fault impedance occurs at the beginning of one of the transmission line as shown in the figure. The circuit barkers at both ends are opened six cycles after the fault.

a. Calculate the critical clearing angle and critical clearing time. *[08 marks]*

b. Determine whether system is stable under this condition *[04 marks]*

Q3.

(a). For the system shown in figure Q3 line impedances are indicated in the figure. The admittances of the capacitor and reactor are j0.82 and –j0.06 respectively. Form the nodal admittance matrix.

[06 marks]

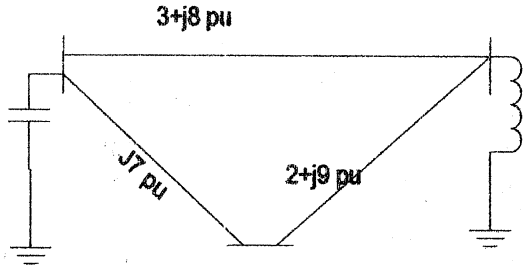

Figure Q3(a)

(b). Nodal admittance matrix of the system shown in figure Q3(b) is given below. Calculate the voltage at nodes after the first iteration using Gauss-Zeidel method. Sate any assumption made. *[14 marks]*

$$\begin{bmatrix} 3-j9 & -1+j5 & -1+j2 & -1+j2 \\ -1+j5 & 5-j11 & -4+j6 & 0 \\ -1+j2 & -4+j6 & 7-j11 & -2+j3 \\ -1+j2 & 0 & -2+j3 & 3-j5 \end{bmatrix}$$

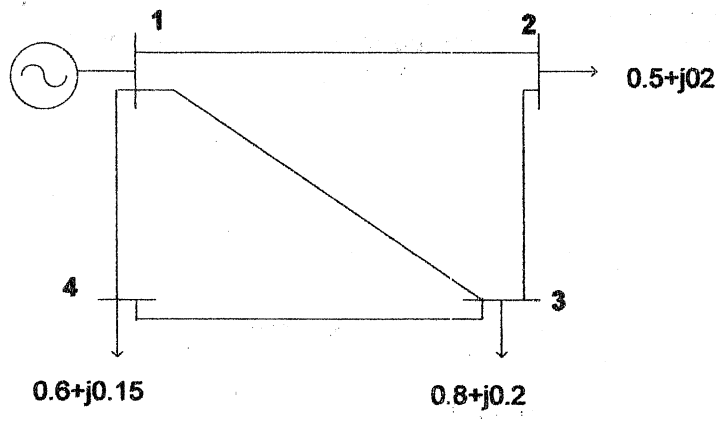

Figure Q3(b)

Q4.

The nodal matrix of a power system shown in figure Q4 is as follows:

$$\begin{bmatrix} 3-j9 & -2+j6 & -1+j3 \\ -2+j6 & 2.5-j7.5 & -0.5+j1.5 \\ -1+j3 & -.5+j1.5 & 1.5-j4.5 \end{bmatrix}$$

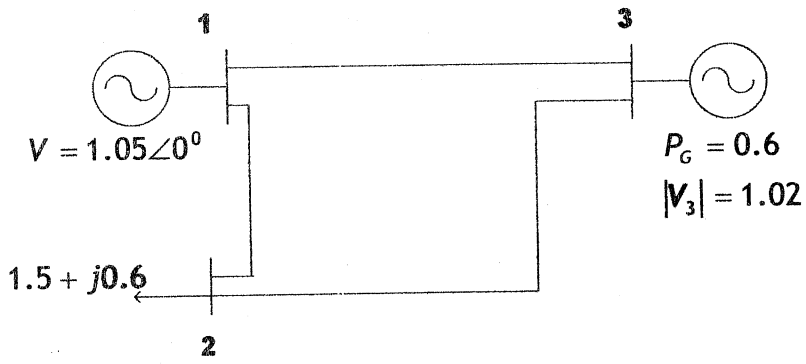

Figure Q4

i. Identify the known and unknown parameters of the system *[03 marks]*

ii. Assume that the voltage at node 2 is $1\angle 0$ calculate the power mismatches at nodes. *[10 marks]*

iii. Form the Jakobian matrix (no need any calculations) and write the lineraized equation. *[04 marks]*

iv. Suppose that the results are obtained after number of iterations. But, the reactive power that should be delivered from the generator exceeds its maximum value. What will be the next step? *[03 marks]*

Q5.

i. What is meant by "incremental fuel cost"? *[04 marks]*

ii. What is the reason for having minimum limit of fuel cost characteristic in fossil fuel? *[04 marks]*

iii. The operating cost of two units are given bellow:

$C_1 = 10P_1 + 0.008P_1^2, \$/hr$ $\quad 100 \le P_1 \le 600, MW$

$C_2 = 8P_2 + 0.009P_2^2, \$/hr$ $\quad 400 \le P_2 \le 1000, MW$

(a). Calculate the incremental operating cost for each unit. *[02 marks]*

(b). Find the contribution of each unit when the total load is 1000 MW and 1400 MW. *[10 marks]*

Q6.

(a). Explain briefly working principle of differential relay *[02 marks]*

(b). With suitable example show how D/Y three phase transformer is protected using differential relay. *[02 marks]*

(c). List the main types of distance relays (you may draw the suitable diagrams for each) . *[02 marks]*

(d). A 330 kV transmission system shown in figure Q6 is to be protected by zone distance relays adjacent to each relay location. Zone 1 and Zone 2 settings are adjustable from 0.5 Ω to 40 Ω and zone 3 setting from 1 Ω to 60 Ω in increment of 0.1 Ω. Angle setting is 85^0.

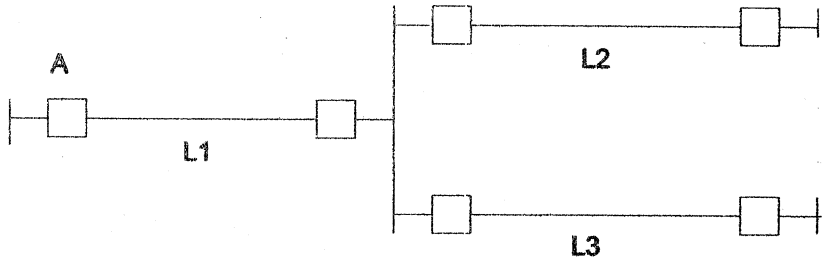

Figure Q6.

Positive sequence impedance of lines L1,L2 and L3 are $60\angle 85^0\ \Omega$, $25\angle 85^0\ \Omega$ and $90\angle 85^0\ \Omega$ respectively. CT ratio and VT ratio at each relay location are 330 kV/110 V and 2000/1 A respectively.

i. Determine the three zone settings at relay A. *[08 marks]*

ii. What is the fault resistance that relay tolerate when fault occurs at 80% of zone 1 boundary (assume that the remote lines are out of service). *[06 marks]*

Q7.

A 33 kV power system is shown in figure Q7. The relays at A and E are provided complete back up protection for the relay at C.

System data are as given bellow:

System equivalent	$Z_1=Z_2=0.35$ pu under minimum generation condition $Z_1=Z_2=0.10$ pu under maximum generator condition
Transmission lines	$Z_1=0.15$ pu each
Load	10 MVA each
CT ratio	400/5 at each location

Z_1, Z_2 Positive and negative sequence impedance

All impedances are given on system voltage and 50 MVA base.

The time current characteristic of over current relay is given bellow:

Multiples of pick up current	1.5	4.0	5	10	20
Operating time (s)	15	4.5	3.9	2.65	2.0

The pick up settings of the relays are adjustable by the taps at 2.5, 3.75, 5.00, 6.25, 7.5, 8.75 and 10.0 A. The time lever setting is adjustable from 0.1 to 1.0

The relay at C has the pick up value of 3.75 A and its time lever set at 0.2. If the relay at A has the pick up value of 5.0 determine the time lever setting of this relay. *[15 marks]*

Plot the time current characteristics of relays and show the discriminating margin. *[05 marks]*

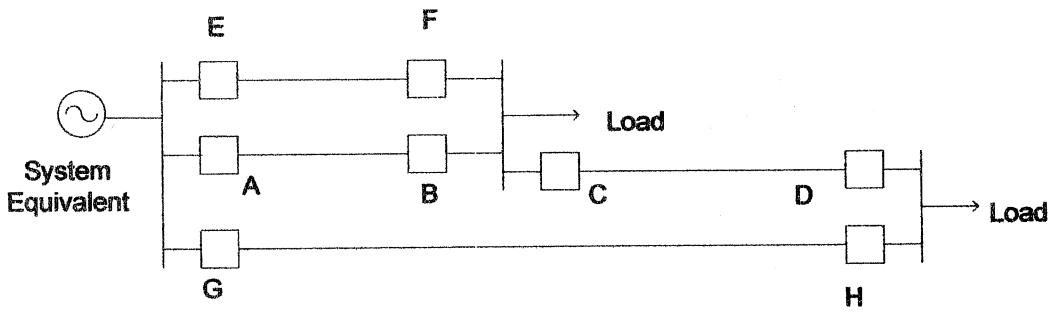

Figure Q7