THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY
ECX5332 – Power systems II
Final Examination 2008/2009

Duration Three Hours

Date: 08th March 2009 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

QUESTION (1)

A three-phase 50 Hz synchronous generator delivers 0.9 pu of power to a system, via transformer and double circuit transmission line as shown in the figure Q1. The parameters of system elements as indicated in the figure (all the values are given in pu on common base). The system can be considered as infinite bus. The voltages at both ends of the transmission line are 1.05 pu (at bus 1) and 1.0 pu (at bus 2)

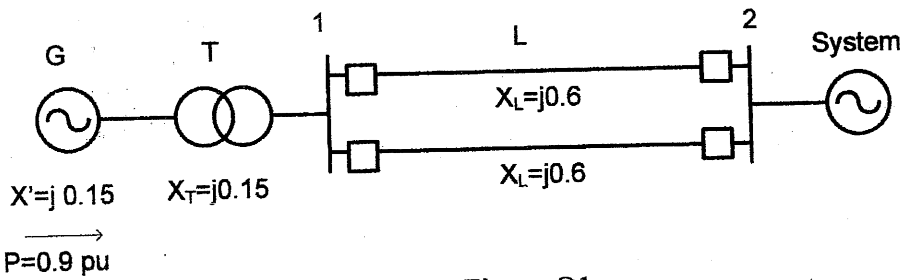

Figure Q1

a) Determine the excitation voltage of the generator. *[06 marks]*

b) A three-phase to ground fault with zero fault impedance occurs at the mid point of one of the transmission line and cleared by opening the circuit breakers at both ends of the effected line when the power angle is 112^0.

   (i). Determine whether the generator remains in stable condition under these circumstances. *[12 marks]*

   (ii) Sketch expected power angle variation. *[02 marks]*

QUESTION (2)

a) Define Surge Impedance Loading (SIL) with respect to the long length transmission line. Sketch the variation of voltage and reactive power throughout the long length transmission line when the power delivered through the line P is

   (i). $P > P_{SIL}$ (ii) $P < P_{SIL}$

   (voltage at the both ends of the line is same) *[06 marks]*

b) A three-phase load of 1200 MVA at 0.90 power factor lagging receives through 750 kV, 310 km long transmission line. The voltages at the receiving and sending ends are 700 $\angle 0^0$ kV and 760 $\angle 18^0$ kV respectively. This transmission line is modelled using ABCD parameters:

$$V_s = AV_r + BI_r$$
$$I_s = CV_r + AI_r$$
$$A^2 - BC = 1;$$
$$B = 120\angle 85^0$$

I. Calculate A and C parameters *[06 marks]*

II. Determine sending end current, power factor and transmission efficiency of the line *[08 marks]*

QUESTION (3)

For the power system shown in figure Q3

a) Calculate the nodal admittance matrix *[06 marks]*

b) Voltages at nodes after 1st iteration of Gauss-Zeidel method. *[12 marks]*

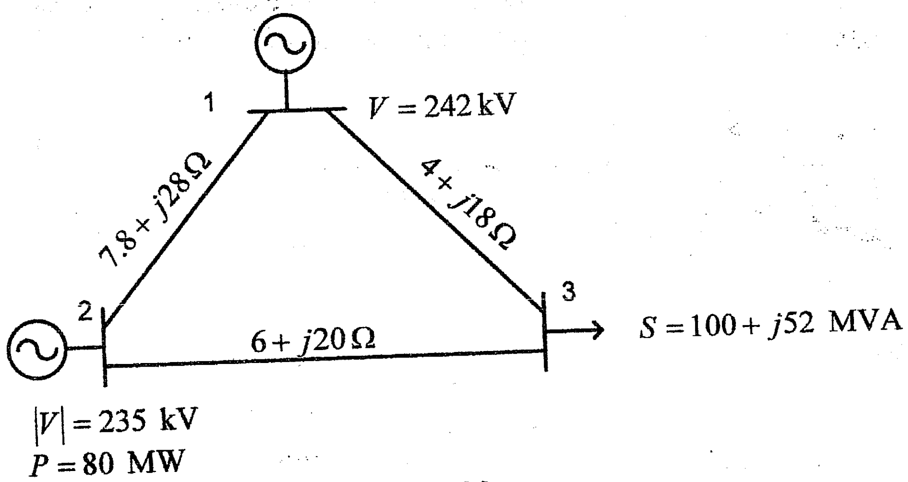

Figure Q3

QUESTION (4)

a) Certain power system consists of 200 nodes and 8 nodes out of them are PV buses. Determine the order of following blocks of Jacobian matrix.

$$\left[\frac{\partial P}{\partial V}\right], \left[\frac{\partial P}{\partial \delta}\right], \left[\frac{\partial Q}{\partial V}\right], \left[\frac{\partial Q}{\partial \delta}\right]$$ *[03 marks]*

b) The power system shown in figure Q4 is to be solved by using Newton-Raphson method.

I. For each bus, determine the bus type and their known and unknown parameters. *[02 marks]*

II. Write the linearized system of equations that are solved at each iteration using usual notations (no need any calculation). *[05 marks]*

III. Calculate power mismatches at nodes before 1st iteration *[08 marks]*

IV. Calculate $\frac{\partial P_2}{\partial V_3}$ and $\frac{\partial Q_3}{\partial \delta_3}$ of the Jacobian matrix *[02 marks]*

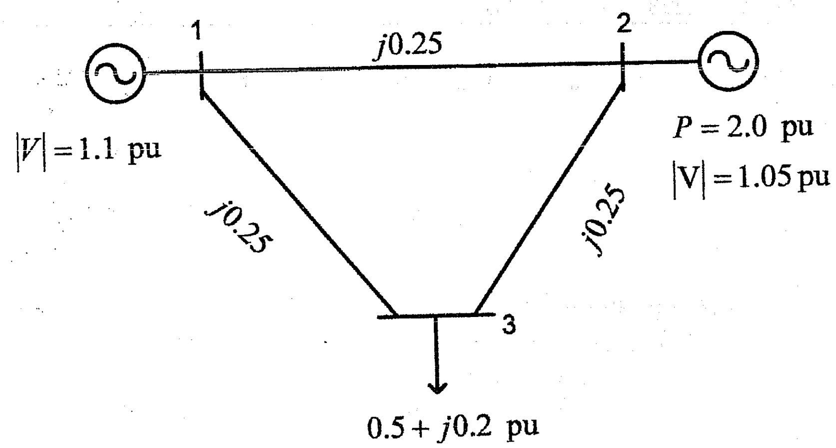

Figure Q4

QUESTION (5)

Relays at points A and E of the system shown in figure Q5 provides complete back up protection for the relay at C.

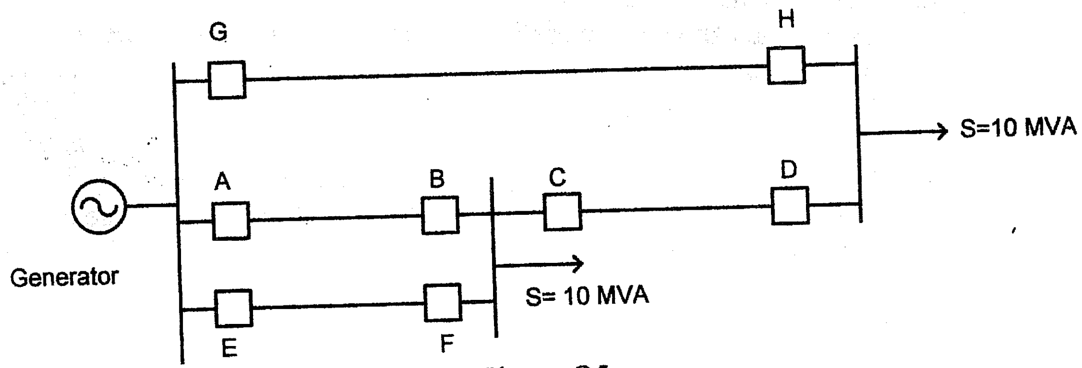

Figure Q5

Impedances of the system elements are given in table Q5

Table Q5

Element	Impedance (pu) on 50 MVA base	Condition
Generator	0.35	Min. generator condition
	0.10	Max. generator condition
All distribution lines	0.15 each	

The time- current characteristic of the over-current relay at any location with the time lever set at 1.0 pu is given as 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 are adjustable by tap 2.5, 3.75, 5.0, 6.25, 7.5, 8.75, 10 A and the time multiplier is adjustable from 0.1 to 1.0.
Current transformer used at relay location has ratio of 400/5 A.
The relay at C has a pick up 3.75 A and time lever set at 0.2. The relay at A has its pick-up set at 5.0 A.

I. Determine the time lever setting of relay at A. *[12 marks]*
II. Plot the time current characteristics of relay A and C *[08 marks]*

QUESTION (6)

a) With suitable diagram explain the zones of distance relay *[02 marks]*
b) Explain briefly applications of differential relay. *[04 marks]*
c) Certain transmission line is protected by a Mho relay. The relay has the maximum reach of 70 Ω making an angle of 60^0 with R- axis. The transmission line impedance is given as $20 + j100\ \Omega$.
   I. Sketch the Mho characteristic and draw the transmission line on same R-X coordinate plane *[04 marks]*
   II. Calculate the fraction of the transmission line that is protected by the relay. *[06 marks]*
   III. Show the minimum fault resistance on the characteristic in (I), if the phase – phase fault that is occurred at the mid point of the line and is not detected by the Mho relay. *[04 marks]*

QUESTION (7)

Daily load curve of a certain system is shown in figure Q7.

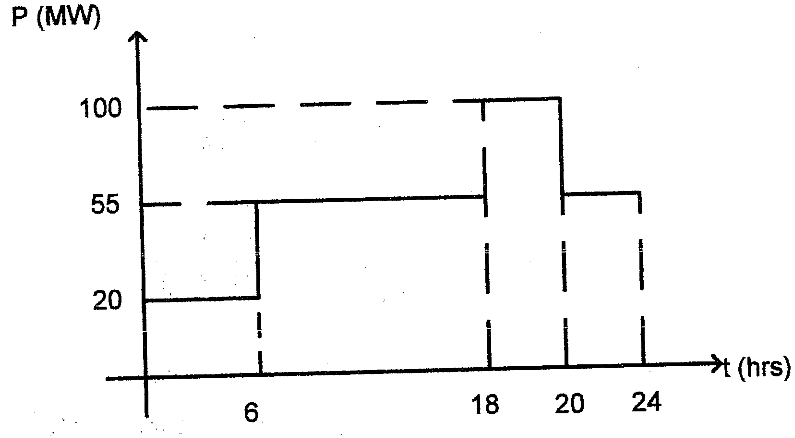

Figure Q7

This load is shared by two units while operating all the time. The losses can be neglected. The cost functions of each unit are given as

Unit 1: $C_1 = 1.2P^2 + 800P + 1200$ Rs/hr. $10 \le P \le 75$ MW

Unit 2: $C_2 = 1.4P^2 + 700P + 1600$ Rs/hr. $10 \le P \le 60$ MW

I. Calculate the incremental operating cost for each unit *[04 marks]*

II. Find the optimum allocation of power between the units throughout the day. *[12 marks]*

III. Find the loss in rupees if the two units share the load equally throughout the day. *[04 marks]*