THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
BACHELOR OF TECHNOLOGY
ECX5332– Power systems II

Final Examination 2009/2010 **CLOSED BOOK**

Date: 2nd March 2010 Time: 0930-1230

This paper contains seven questions and answer only four questions. Each question carries equal marks. Show your work

Log-Log papers and graph papers are available on your request

Question 1

A 50 Hz, three-phase generator s connected to an infinite bus via double circuit transmission line as shown in figure Q1. Parameters of the elements of the systems in p.u. on common base are indicated in the figure. At the steady-state condition mechanical power developed by the generator is 1.5 pu and Emf of the generator is 1.2 pu. Voltage at infinite bus is maintained at 1.0 pu.

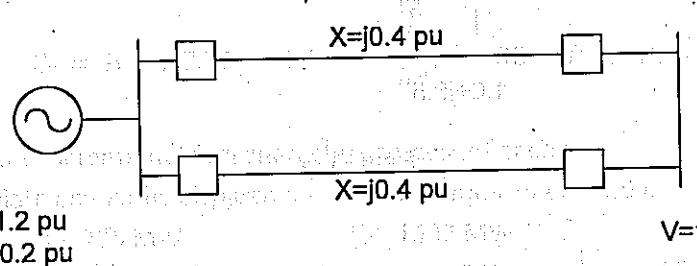

Figure Q1

a. Determine the power angle at the normal working condition
b. If one of the line is disconnected from the supply by opening circuit breakers at the both ends of the line determine new power angle at which the system become stable
c. When a single line is at operation a three-phase fault occurs at the generator bas-bar. If the fault is not cleared how long the system can remain in stable condition (H=1.4 s)?
d. Sketch the power angle curves for the situations (a), (b) and (c).

Question 2

Certain generator delivers power to a large system via 275 km, 400 kV three phase transmission line. Per–phase inductance and sucepctance of the line are j0.36 Ω/ km and j4.2 μS/km respectively.

a. Calculate the propagation constant and surge impedance
b. What should be the maximum sending end voltage in order to maintain the far-end voltage below 445 kV when the line is opened?

c. During the off-peak load the above line delivered 30% of surge impedance loading while the voltage at both ends of the line are maintained at its rated value.
   i. Calculate the voltage at the midpoint of the line
   ii. If the generator has reactive power limit of -25 <Q< 50 MVAr determine whether it is required any additional device to install at the sending-end of the line. If required identify the type and capacity

Question 3

For the system shown in figure Q3 (all parameters are given in pu on common base)

a. Form the nodal admittance matrix
b. Calculate voltages at nodes 2 and 3 after 1st iteration using Gauss- Zeidel method
c. What is the power delivered by slack bus?

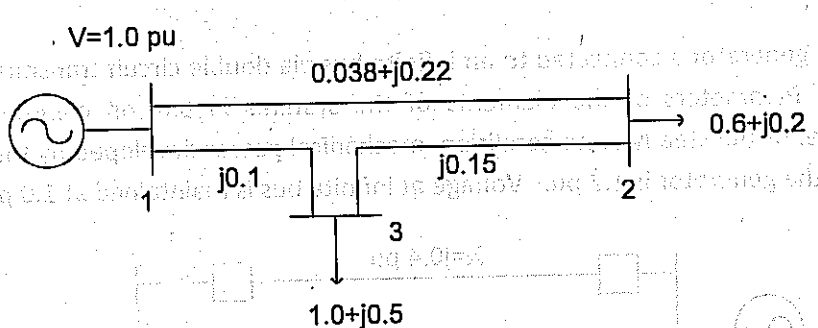

Figure Q3

Question 4

a. Explain why Newton-Raphson method and it's modifications are widely used for load – flow calculation when compare with the Gauss- Zeidel method.
b. What are the disadvantages of use of Newton-Raphson method for load flow calculations?
c. Nodal admittance matrix of the power system shown in figure Q4 is given below

$$\begin{bmatrix} 3-j9 & -2+j6 & -1+j3 \\ -2+j6 & 3-j8 & -1+j2 \\ -1+j3 & -1+j2 & 2-j5 \end{bmatrix}$$

   i. Write the equations for the real power at bus 2 and real and reactive power at bus 3
   ii. Calculate maximum power mismatch
   iii. Write the elements of the matrices given:

$$[\mathbf{J}]\begin{bmatrix}\Delta\boldsymbol{\delta}\\ \Delta\mathbf{V}\end{bmatrix}=\begin{bmatrix}\Delta\mathbf{P}\\ \Delta\mathbf{Q}\end{bmatrix}$$

(No-need to write full expressions and do not perform calculations)

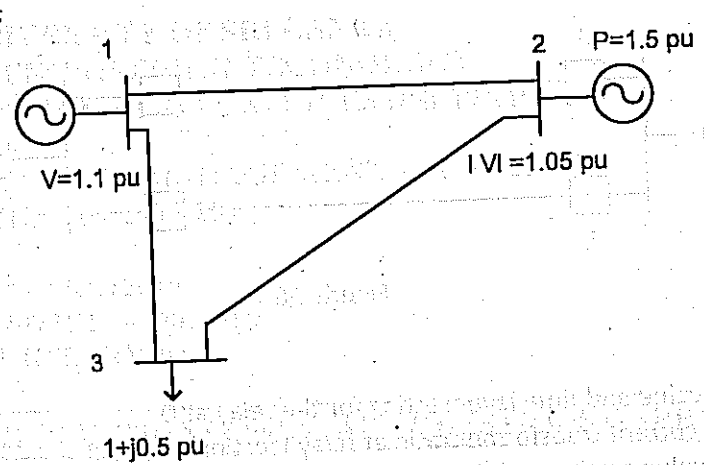

Figure Q4

Question 5

a. Explain the importance of optimally allocation of generation levels to various units in power systems

b. Certain thermal power station has two generating units. The operating costs of these units are given below:

$$C_1 = 350 + 8.8P_1 + 0.006P_1^2 \frac{\$}{hr}; \quad 300 \le P_1 \le 1200\ MW$$

$$C_2 = 400 + 7.8P_2 + 0.005P_2^2 \frac{\$}{hr}; \quad 400 \le P_2 \le 1000\ MW$$

i. Find the incremental fuel characteristic cost of each unit

ii. Calculate economic dispatch between the units when load is
(a). 725 MW (b). 1500 MW

iii. If 1500 MW consumes during 16 hours and 725 MW during 8 hours per day calculate the total cost of operation per day? *(Neglect the losses)*

Question 6

In a radial distribution system is shown in figure Q6 relays at A and B provides back-up protection for the relay at D. At relay location D following currents have been calculated:

Maximum load current	: 150 A
Minimum fault current	: 1000 A
Maximum fault current	: 5000 A

Current transformer ratio at D is 500/5.

The time- current characteristic of over-current relay at any location on any plug setting with the time lever set at 1.0 is as given below:

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

The plug settings are at 2.5, 3.75, 5.00, 6.25, 7.5, 8.75 and 10.0 A and the time lever is continuously adjustable from 0.1 to 1.0

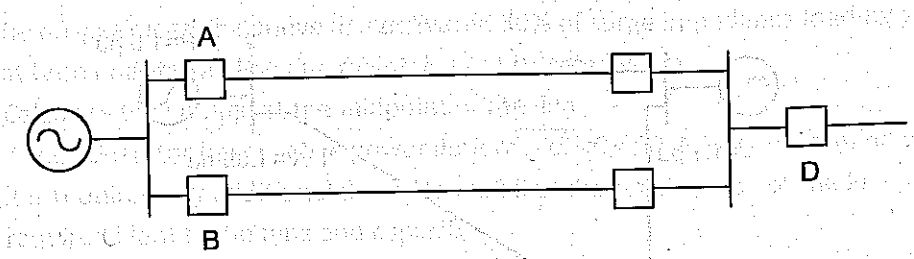

Figure Q6

a. Select
   i. pick-up value and time lever setting for the relay at D
   ii. suitable current transformer ratio at relay locations A and B
   iii. pick-up value setting and the time lever setting for the relay at A

b. Sketch the time –current characteristics for the relays at D, A and B.

Question 7

a. With suitable sketches discuss the use of differential relays for the protection of
   i. Generators
   ii. Power Transformers
   iii. Bus-Bars

b. Sketch the operating region of following types of distance relay and discuss their use:
   i. Impedance relay
   ii. Mho relay
   iii. Off-set mho relay
   iv. Directional relay

c. An off-set Mho relay characteristic has the centre of its operating region at (19.2, 14.4) on the R-X plane and its radius is 40 Ω. Determine the maximum leakage reactance of a transformer in p.u.that can be fully protected by the relay when the relay is located at the transformer on its 33 kV side. The transformer is rated at 1000 kVA, 33 kV/11kV