The Open University of Sri Lanka
Bachelor of Technology
Final Examination 2011/2012

ECX5332 – Power systems II

Duration Three Hours

Date: 21st February 2012 **Time: 0930-1230**

Instructions:
This paper consists of seven questions. Answer **ANY FIVE (5)** questions. All questions carry equal marks.
Graph papers and log-log papers will be available on your request

Question 1

(a) Explain briefly how following parameters are affected to the transient stability
   i. Line impedance
   ii. Fault clearing time
   iii. Machine inertia [3 marks]

(b) A hydro generator delivers power to a system which can be considered as an infinite bus via transmission line. The infinite bus receives power of 0.85 p.u. at 0.9 power factor lagging. Voltage at the infinite bus is 1.0 p.u. Transmission line has reactance of 0.8 p.u. Sub transient reactance and inertia constant of the hydro generator are 0.25 p.u. and 5 s respectively. System frequency is 50 Hz.

   i. Calculate excitation voltage of the generator [3 marks]
   ii. What is the maximum power that can be delivered to the system? [2 marks]
   iii. A three phase fault occurs in the transmission line and the fault is cleared after 2.5 cycles. Determine whether the generator losses synchronism during faulty period [10 marks]
   iv. Sketch the graph of power angle variation versus time for the situation (iii) (qualitative only). [2 marks]

Question 2

A 230 kV, 50 Hz transmission line has length of 350 km. Distributed parameters of the line are x=j0.428 Ohm/km, y=j3.26x10^{-6} S/km. A load at the receiving end consumes 180 MW at 0.95 power factor lagging. Voltage at the receiving end is maintained at 230 kV.

   i. Calculate surge impedance, propagation constant and surge impedance loading [2 marks]
   ii. Determine ABCD parameters of the line [8 marks]
   iii. Calculate sending end voltage, current, power and power factor. [6 marks]
   iv. If the line delivers power equals to surge impedance loading, what is the voltage and reactive power at the sending end (no calculations required)? [2 marks]
   v. When the line is opened at far end, the voltage at far end is higher than that of sending end. Briefly explain the reason for this [2 marks]

Question 3

(a) List the advantages and disadvantages of Gauss-Zedel method when compare with Newton-Raphson method [5 marks]

(b) Consider the power system shown in figure Q3. Data relevant to loadflow calculation are indicated in the figure. The values given are in p.u. on common base

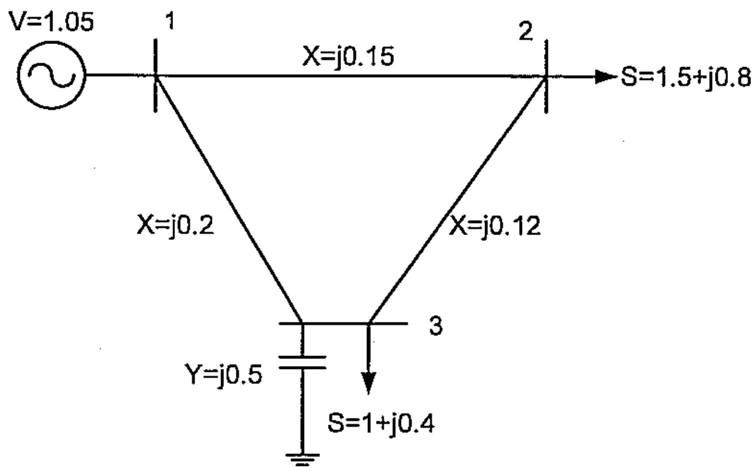

Figure Q3

i. Form the nodal admittance matrix [5 marks]

ii. Calculate voltage at nodes 2 and 3 after first iteration of Gauss-Zeidel method [8 marks]

iii. What is the accuracy of your solution? [2 marks]

Question 4

Certain power system is shown in figure Q4

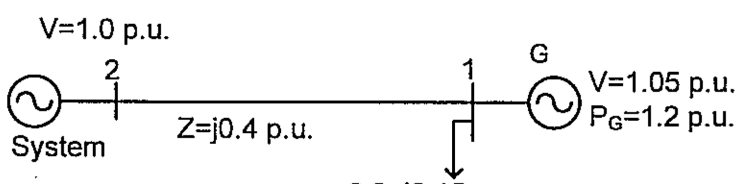

Figure Q4

i. Calculate phase angle between nodes 1 and 2 after two iterations of Newton-Raphson method [8 marks]

ii. What is the power mismatch after two iterations? [2 marks]

iii. Determine reactive power generated by the generator G [3 marks]

iv. Suppose the reactive power that is calculated in above exceeds the reactive power limit of the generator G. How you would calculate the actual voltage that can exist at generator terminal? [3 marks]

v. Explain briefly how the voltage is kept constant at the output terminals of the generator [4 marks]

Question 5

Certain radial distribution line is protected by two identical over current relays set at circuit breaker locations A and B. The relay at B provides remote back-up for the relay at A. Current transformer ratio at both relay locations are 500:5 A. The operating time-current characteristic of the relay at A is given below

Fault current (A)	562.5	1500	1875	3750	7500
Operating time (s)	1.5	0.45	0.39	0.265	0.2

Relay has plug settings at 2.5, 3.75, 5.00, 6.25, 7.5, 8.75 and 10 A. The time multiplier can be adjusted from 0. 1 to1.0
Pick-up value of A is set at 3.75 A and time lever is set at 0.1 s. Maximum load current at B and maximum fault current at A are 300 A and 6500 A respectively.

i. What is the minimum fault current? [2 marks]
ii. Determine suitable pick-up value for the relay at B [5 marks]
iii. Sketch the time-current characteristic of relay at A on the log-log paper provided [3 marks]
iv. What is the suitable time lever setting for the relay at B? [5 marks]
v. Sketch the time-current characteristic of relay at B on the same graph (in (iii)) [3 marks]
vi. The relay at A fails to operate a fault current of 4000 A. Determine the time required to isolate fault by the back-up relay at B [2 marks]

Question 6

(a) Explain the importance of optimally allocation of generation levels to various units in power systems [4 marks]

(b) Certain thermal power station has two generating units. The two units share a load of 1600 MW during 16 hours and 850 MW during the rest of period of the day. 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 [4 marks]
ii. Determine optimal power shearing between two units [8 marks]
iii. Calculate the total cost of operation per day [4 marks]

Question 7

(a) For the power system shown in figure Q7 mark the zones of protection (redraw the system and mark) [4 marks]

(b) The system shown in the figure is protected by impedance relay. Impedance of lines and sub-transient reactance of generators are indicated in the figure. The impedance relay at circuit breaker A is set to protect whole length of line L1 and fifty percent of line L2 ($Z_A = Z_{L1} + 0.5Z_{L2}$).

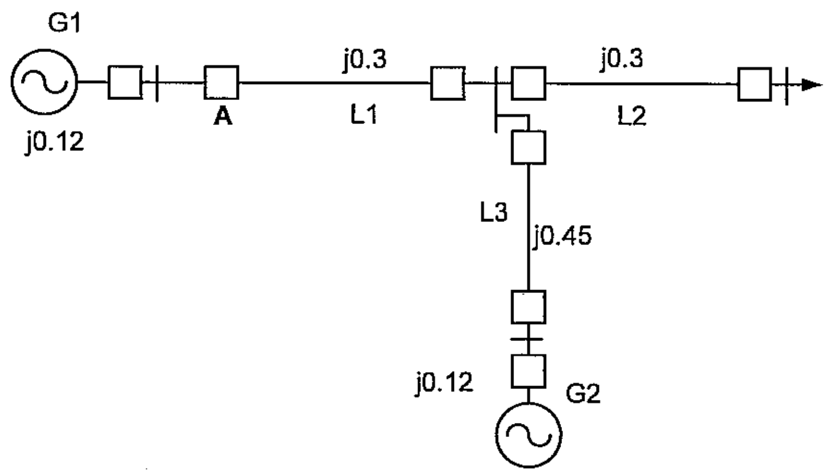

Figure Q7

i. Calculate the actual impedance seen be the relay at A when three phase fault occurs at the mid point of the line L2 [8 marks]

ii. State whether the relay at A detect the fault in (i) [2 marks]

iii. Determine the actual length of line L2 (as a percentage) protect by the line relay at A [6 marks]