The Open University of Sri Lanka
Bachelor of Technology
Final Examination 2012/2013

ECX5332 – Power systems II
Duration Three Hours

Date: 23rd ~~August~~ July 2013 ***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

Q1 A 1200 MVA, 50 Hz synchronous generator delivers power of 0.45 p.u through a transmission line to a system which can be considered as an infinite bus as shown in figure Q1. The reactance of the transmission line is 0.4 p.u. and that of the generator is 1.12 p.u. Voltage at the infinite bus is 1.0 p.u. and emf of the generator is 1.8 p.u.
Circuit breakers A and B at the ends of the transmission line were opened at time t=0 and reclosed after certain time T. Inertia constant (M) of the machine is 34.39 MJ/mech.rad

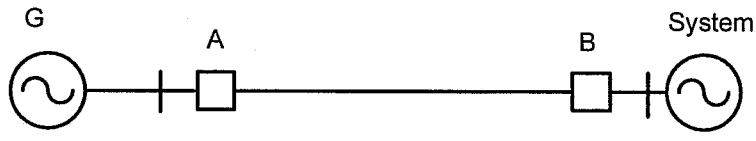

Figure Q1.

i. What is the initial power angle? [03]
ii. Calculate H constant [03]
iii. Determine acceleration of the rotor just after opening the breaker [04]
iv. Calculate the critical clearing angle [07]
v. If the machine did not lose the synchronism after reclosing what is the maximum allowable time? [03]

Q2 a Explain the model used for a long length transmission line [03]
b A 400 kV, 300 km long transmission line delivers 0.7 times of surge impedance loading to a load. Power factor of the load is 0.85 lag. Voltage at load is equal to 400 kV. Resistance of the line is neglected and reactance and suscepctance per-phase per-unit length are j0.348 Ω/km and j 4.6×10^{-6} S.
i. Calculate the characteristic impedance and propagation constant [02]
ii. Determine the ABCD parameters for the line [06]
iii. Calculate the sending end voltage, current and power factor [06]
iv. If the load is disconnected while the voltage end at the sending end equals to the value calculated in (iii), what is the voltage at load end? [03]

Q3 Consider the power system shown in figure Q3. Reactance of the lines are indicated in the figure. Bus 1 is considered as slack bus and its voltage is 1.05 p.u. Bus 2 is a voltage controlled bus and magnitude of the voltage is 1.02 . Generation and load of the busses 2 and 3 are as indicated in the figure

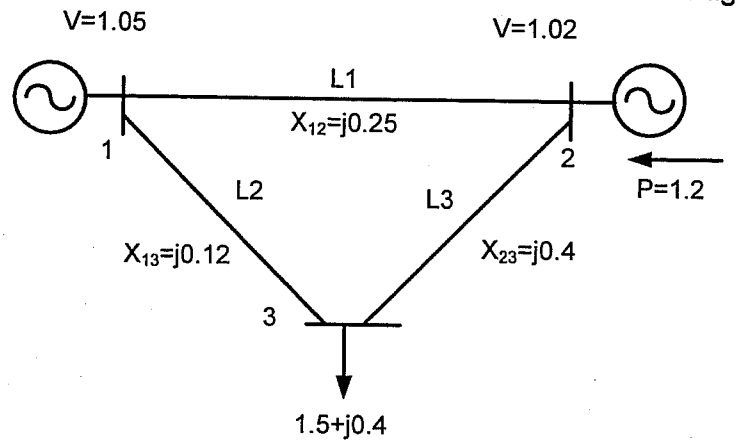

Figure Q3

i. Form the nodal admittance matrix [05]
ii. Use Gauss-Zeidel method to calculate voltages at buses 2 and 3 after first iteration [08]
iii. Determine current through line L1 and L2 [04]
iv. Calculate the slack bus power [03]

Q4 Explain why power plants have their minimum and maximum power limits. [04]
A certain coal fired steam power plant consists of two generating units. Fuel cost, minimum and maximum output of each unit are given below:

Unit 1 : $f(P_1) = 560 + 7.92P_1 + 0.00156P_1^2$ \$ $150 \leq P_1 \leq 600\ MW$
Unit 2 : $f(P_2) = 310 + 7.6\,P_2 + 0/0018P_2^2$ \$ $100 \leq P_2 \leq 400\ MW$

i. Determine the incremental fuel cost of each unit [02]
ii. If the total output of the plant is 850 MW determine the optimum power output of each unit [06]
iii. Calculate the total cost for the generation of 850 MW [02]
iv. If the output power varies from 300 MW to 1000 MW sketch incremental fuel cost versus plant output for each plant. (graph papers will be available on request) [06]

Q5 a What are the types of buses used in load flow calculations? Clearly state known and unknown parameters of each bus type. [04]
b A certain power system consists of 200 buses of which 8 buses are voltage control busses. Determine the order of its Jacobian matrix. [02]
c Consider the power system shown in figure Q5. Voltages at buses are calculated using Newton-Raphson method. Voltage, power and line impedance are as indicated in the figure

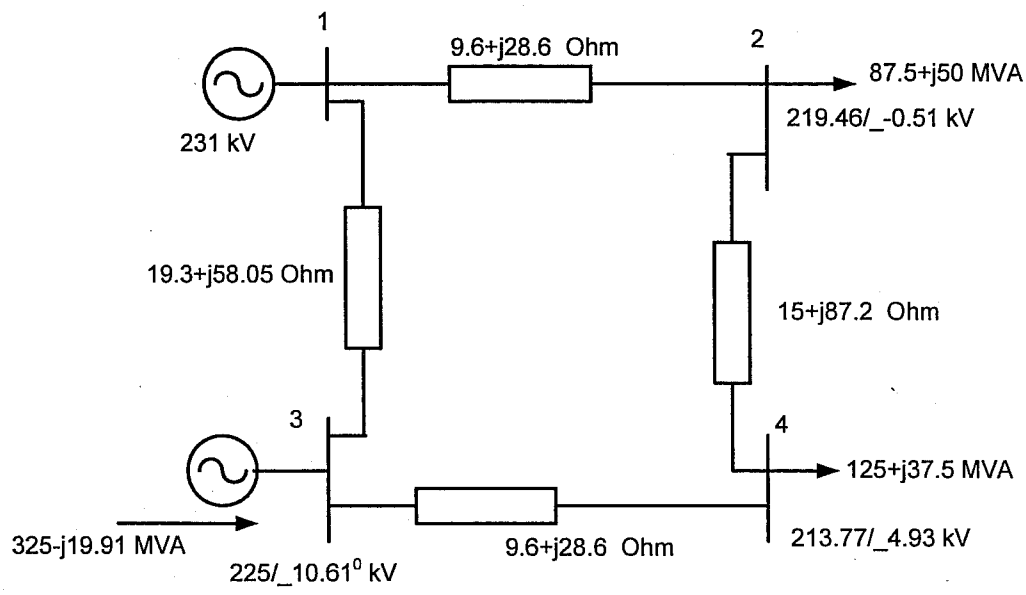

Figure Q5

I. Calculate the active and reactive power mismatches and hence determine the accuracy of the result. [06]

II. Calculate the power flows through the lines [08]

Q6 a What do you understand by " zone" of protection? What is the importance of zones? [04]

b Explain briefly the operating mechanism of induction cup type over current relay. How are pick-up and time dial settings adjusted in this type of relay? [06]

c Define the following terms : [04]
   i. Plug Setting Multiplier (PSM)
   ii. Time Multiplier Setting (TMS)

d Distance relays are more suitable than over current relays in transmission line protection. What is the reason for this? [04]

e Explain the basis on which current and voltage transformer ratios at relay locations are selected. [02]

Q7 a Explain what is meant by the discrimination margin in power system protection [02]

B A radial distribution system is shown in figure Q7. The pick-up value of the over current relay at D is set at 2.5 A and time lever is set at 0.1 s. Maximum and minimum fault currents at the relay location D are 3000 A and 1000 A respectively. Current transformer ratio at D is 500/5

The relays at A and B provide the remote back-up for the relay at D.

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

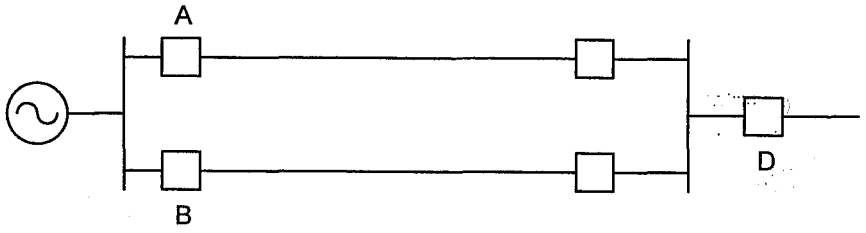

Figure Q7

i. What is the maximum possible load current that can flow through D without tripping [04]

ii. Select suitable current transformer ratios for the relay A and B (CT available are 50:5, 100:5 and 250:5) [02]

iii. Determine the pick-up value for relays A and B [06]

iv. What is the time dial setting for the relays A and B [06]