The Open University of Sri Lanka
Bachelor of Technology
Final Examination 2014/2015
ECX5332 – Power systems II
Duration Three Hours

Date: 04th August 2015 ***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) Describe briefly the meaning of transient stability. [5 marks]

(b) Certain three-phase, 50 Hz generator delivers 0.5 p.u. power to an infinite bus via a transmission line (shown in figure Q1). Voltage at both ends of the lines are maintained at 1 p.u. Reactance of the line is 0.42 p.u and resistance of the line is neglected. Sub – transient reactance and inertia constant of the generator are 1.3 p.u. and 4 respectively.

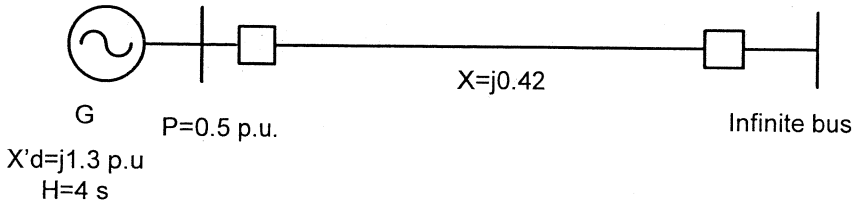

Figure Q1

i. Calculate the excitation voltage of the generator. [5 marks]

ii. The circuit breakers of the line is open at t=0 and reclose when t= T. If the generator does not lose the synchronism, what is the maximum possible value for T? [10 marks]

Question 2

(a) Define the term "surge impedance loading". [2 marks]

(b) Prove that when the loss less line delivers load equal to the surge impedance loading voltages at both ends of the line are equal in magnitude. [4 marks]

(c) A 400 kV, 50 Hz, 300 km transmission line delivers 700 MW at 0.85 power factor lagging. Parameters of the line are given below;

Series impedance : $z=(0.025+j0.3)\ \Omega/km$
Shunt admittance : $y=(j4x10^{-6})\ S/km$

i. If the voltage at the receiving end equals to the rated value determine the sending end voltage current and power factor [10 marks]

ii. State what would happen to the receiving end voltage when the load is disconnected. Explain your answer. [4 marks]

Question 3

(a) Describe following terms with respect to the over current relay;

i. Discrimination margin ,
ii. Plug setting multiplier,
iii. Time lever setting.

[6 marks]

(b) A 22 kV three-phase radial distribution line delivers power to loads S1 and S2 as shown in figure Q3. The system is protected by induction cup type over-current relays at the locations of circuit breakers X and Y. The generator G has an impedance of j0.25 p.u. and j0.01 p.u. on 100 MVA base under the minimum and maximum fault conditions. Positive sequence impedance of each line is j0.25 p.u. on the same base. The pick-up settings of the over current relays can be adjusted by taps at 2.5, 3.75, 5.0, 6.25, 7.5, 8.75 and 10.0 A and time-multiplier can be adjustable from 0.1 to 1 continuously. Current transformer ratio at both relays is 250:5. The time-current characteristic of the over current relay (time multiplier at 1.0) is as follows:

PSM	1.5	4	5	10	20
Time (s)	15	4.5	3.9	2.65	2.0

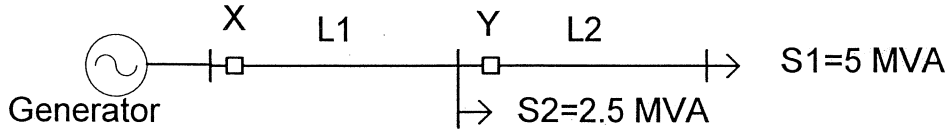

Figure Q3.

i. Select suitable pick-up values for the relays located at circuit breakers X and Y. [8 marks]

ii. If the relay at circuit breaker Y provides remote back up for the relay at X, determine suitable time leaver setting. [6 marks]

Question 4

Single line diagram of a power system is shown in figure Q4. Voltage of the slack bus is 1.05 p.u. Generator at node 2 delivers power of 400 MW and the magnitude of the voltage is fixed at 1.02 p.u. Active and reactive power of the load at bus 3 are 350 MW and 150 MVAR respectively. Reactance of the lines on 100 MVA base are shown in the figure.

a) Calculate voltage at each nodes using the Gauss Seidel method. Perform two iterations. [10 marks]

b) Determine power flows through the lines [6 marks]

c) What is the slack bus power and power factor? [4 marks]

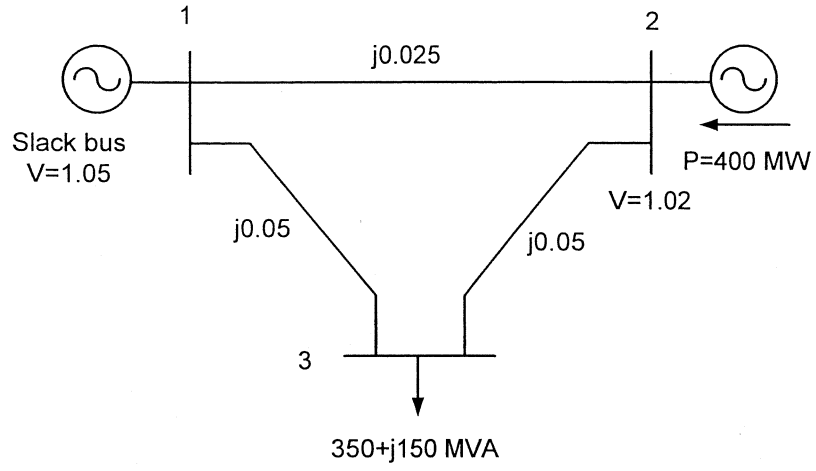

Figure Q4

Question 5

(a) Certain computer program for load flow calculation is done by combining both Newton-Raphson and Gauss-Seidel methods. Explain how this program overcomes disadvantage of each of methods [2 marks]

(b) What do you understand by "flat start" in load flow calculations? [2 marks]

(c) Certain power system consists of n1 number of PV busses and n2 number of PQ busses. State order of sub-matrices of Jakobian matrix: $\frac{\partial P}{\partial \delta}, \frac{\partial P}{\partial V}, \frac{\partial Q}{\partial \delta}, \frac{\partial Q}{\partial V}$. [4 marks]

(d) Consider power system shown in figure Q5. This system is to be solved using Newton-Raphson method.

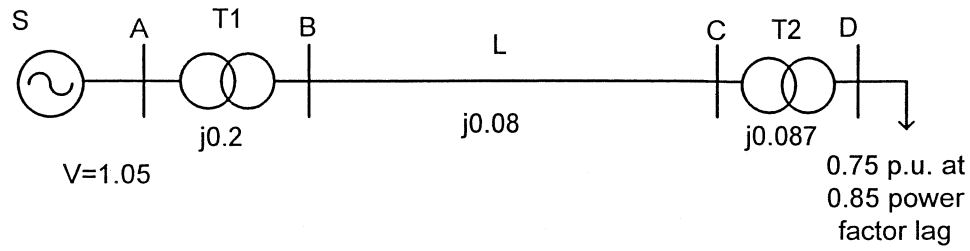

Figure Q5

i. Calculate power mismatch at load bus. [4 marks]

ii. Determine the voltage at load after 1st iteration [8 marks]

Question 6

(a) Define the term "incremental fuel cost" [5 marks]

(b) Incremental fuel cost of two generating units of a power plant are given below:

$$\lambda_1 = 0.01P_{G1} + 7, \quad \$/MWh$$

$$\lambda_2 = 0.08P_{G2} + 10, \quad \$/MWh$$

Minimum and maximum output of both generators are 100 MW and 600 MW respectively. Load of the plant varies from 200 MW to 1200 MW. Sketch the variation of incremental fuel cost of the plant versus total output of the plant.

[15 marks]

Question 7

(a) With suitable sketches, discuss the use of differential relays for the protection of

i. Generators,

ii. Power Transformers,

iii. Bus-Bars.

[6 marks]

(b) A 132 kV transmission line has series impedance of (25+j100) Ω. The line is protected by Mho relay having maximum reach of 5 Ω at angle of 60^0. Voltage and current transformer ratio at the circuit breaker location are 132 kV: 120 V and 400:5 respectively.

i. Sketch the operating diagram of the relay and clearly indicate the operating and non-operating regions. [4 marks]

ii. Determine the fraction of the line that is protected by this rely. [8 marks]

iii. A fault with the fault resistance of R occurs at the midpoint of the line. If the fault is detected by the relay, show the maximum value of R in R-X diagram (further calculation of Rmax is not required). [2 marks]