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The Open University of Sri Lanka
Bachelor of Technology
Final Examination 2010/2011

ECX5332 – Power systems II

Duration Three Hours

Date: 01st March 2011 **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

I. What are the methods of improving transient stability limit?

II. A 50 Hz, 200 MVA turbogenerator G is connected to a large system via transformer and double circuit transmission line as shown in figure Q1. The inertia constant of the generator is 8 MJ/MVA. The parameters of elements of the system on common base are indicated in the figure. Power delivered to the system is 1.2 p.u. The excitation voltage of the generator and voltage at the system bus are 1.14 p.u and 1.05 p.u respectively.

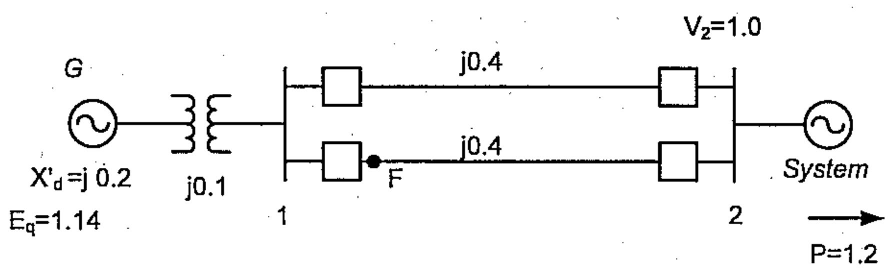

Figure Q1

(a) Determine:

i. Energy stored in rotor at synchronous speed
ii. Initial power angle
iii. Maximum power that can be delivered from generator to the system

(b) A three-phase fault occurs at point F (indicated in the figure) and it is cleared by opening the circuit breakers at both ands of the faulty line. Calculate:

i. acceleration of the rotor just after the fault
ii. critical clearing angle

(c) The fault is self extinguished after de-energizing the faulty line and the line is energized using auto-reclosure. Sketch the power angle diagram (qualitatively).

Question 2

I. Explain briefly term "surge impedance loading"

I. Explain the reason for maintaining higher voltages (at the ends of line) than its nominal value at the peak load and maintaining nominal voltage during the off-peak load

II. A 50 Hz, 500 kV transmission line has following parameters:

Length of the line : 320 km

Inductive reactance : 0.33 Ω/km

Capacitive suscepcatnce : 4.8×10^{-6} S/km

(a) Calculate

i. surge impedance, propagation constant, and wave length

ii. ABCD parameters of the line

iii. Surge impedance loading

(b) When the sending end voltage is 500 kV determine the receiving end voltage, sending end current and reactive power for the following conditions:

i. The line is opened at the receiving end

ii. Load at the receiving end is equal to the surge impedance

iii. Load at the receiving end is equal to the two times of surge impedance

Question 3

I. Certain generator G delivers power to a large system S which can be considered as infinite bus. A load centre is connected between generator and system (shown in figure Q4). Parameters of the elements of the system in p.u. on common base are indicated in the figure.

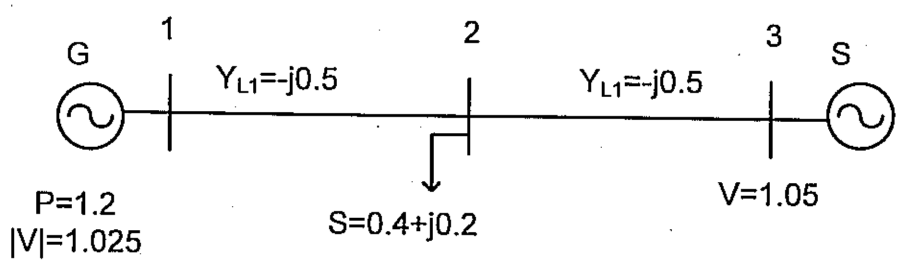

Figure Q3

(a) Identify the types of buses in the system

(b) Form the bus admittance matrix

(c) The power flow calculation of above method is to be performed by using Newton Raphson method at flat start initials guesses. Compute

i. power mismatch at nodes .

ii. elements of Jacobean matrix after the first iteration

iii. Form the linearaized equations that is to be solved at the first iteration (solving of equations are not necessary)

II. In Newton Raphson techniques the mismatch vector is simplified by replacing each Sin(θi-θj) with small angle approximation (θi-θj) and each Cos(θi-θj) is replaced with 1-0.5$(\theta i-\theta j)^2$. Explain how this speeds up the calculation. If the resulting iteration converge to a solution will this power flow is converged to the correct solution? Explain your answer

Question 4

I. List the properties of bus admittance matrix

II. Figure Q4 shows single line diagram of a radial distribution system. Parameters of the system elements are given in p.u. on common base. Voltage at System S is maintained at 1.05 p.u. and power of the load is 0.75 p.u. at 0.85 power factor lagging.

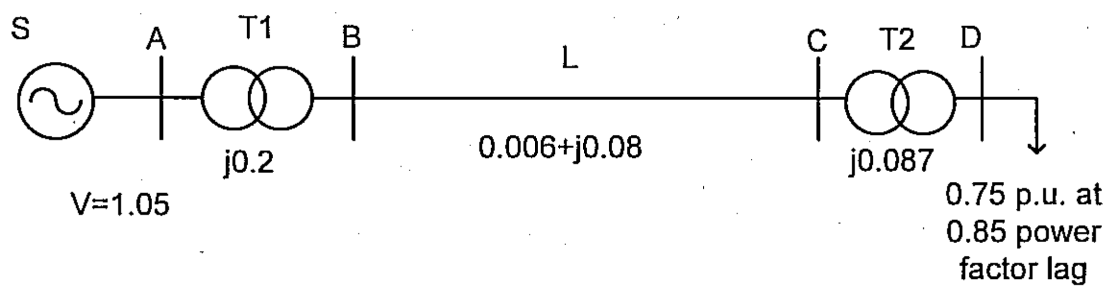

Figure Q4

(a) Use Gauss-Zeidel method to calculate voltage at load bus (calculation of voltages at other buses is not required) with the accuracy of 0.01 p.u

(b) State the number of iteration required

(c) Calculate the power and power factor at the supply end

(d) What is the power loss of the system?

(e) Assume that a generator is connected to the load bus (bus D). The voltage at this bus is now maintained at 1.00 p.u. and generator delivers power of 0.8 p.u. Calculate the voltage and reactive power after the first iteration of Gauss Zeidel method.

Question 5

Certain power system is shown in figure Q5

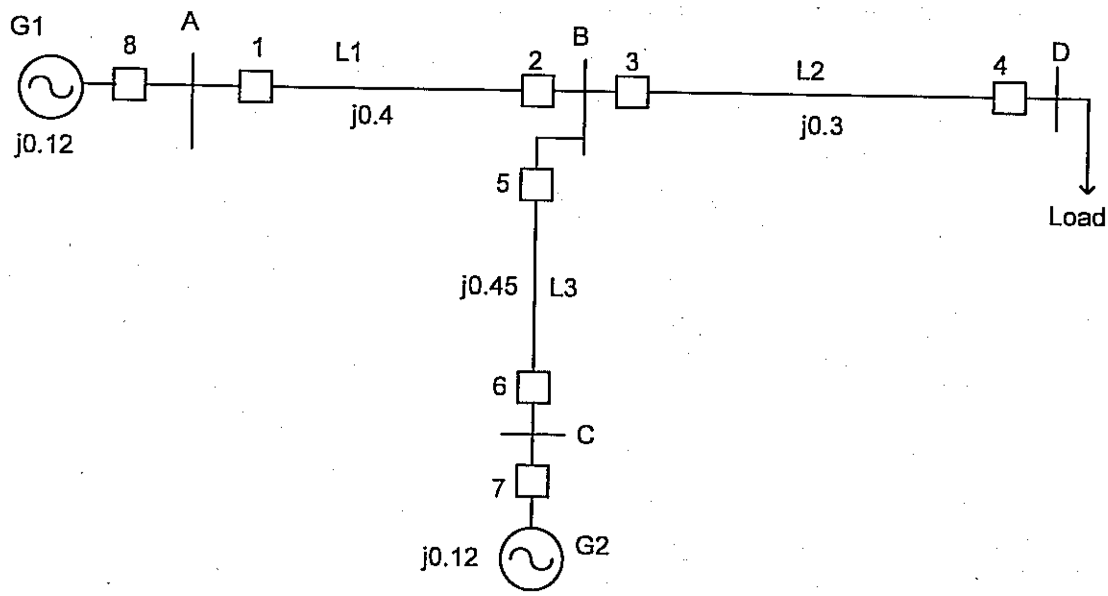

Figure Q5

(a) Mark the zones of protection (redraw the system in the answer script and mark)

(b) What are the circuit breakers that should be tripped for the following faults?

  i. Line L1

  ii. Bus B

  iii. Generator G2

  iv. Bus C

(c) If for the fault at bus A, CB1 reject to operate which breaker should act as backup?

(d) If the CB2, CB6 and CB7 operate where can be the fault?

(e) An impedance relay set at CB1 monitors the impedance of the line L1. Positive sequence reactance of the lines and generators are indicated in the figure. If three-phase fault occurs at mid point of the line L2 determine the actual impedance seen by the relay at CB1.

(f) What percentage of the line L2 is protected by this relay?

(pre-fault emf of the generators G1 and G2 are 1.0 p.u.)

Question 6

The radial distribution system shown in figure Q6 is protected by two identical over current relays installed at circuit breakers locations A and B. The CT ratio at relay locations A and B are 600:5 and 400:5 respectively. Maximum load currents at buses 2 and 3 are 150 A and 300 A. The maximum short circuit currents at starting and ending points (P and Q) of line L2 are 6500 A and 4200 A respectively. Each relay has pick-up values at 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 5.0, 7.0, 8.0, 10, 12.0 A. The multiples of relay tap setting vs. time of the relay for each time dial setting is attached is given in appendix I.

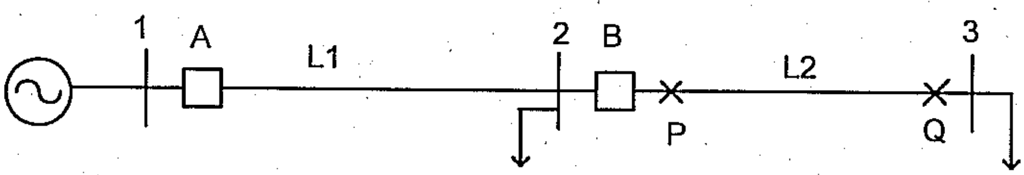

Figure Q6

(a) Select the suitable pick up values for relay at A and B

(b) What should be the time dial setting of relay at B? Explain your answer

(c) Find the suitable Time Dial Setting for the relay at A

Question 7

I. Explain why fossil-fuel characteristics have maximum and minimum limits

II. Briefly explain the importance of optimum allocation of generation levels to various units

III. Certain thermal power station has two generating units. The operating costs of each unit as a function of output power are given below

Unit 1: $C_1 = 612 + 8.64P_1 + 0.00174P_1^2$ \$/hr $\quad 150 \le P_1 \le 500$ **MW**

Unit 2: $C_2 = 310 + 7.85P_2 + 0.00142P_2^2$ \$/hr $\quad 200 \le P_1 \le 600$ **MW**

(a) Calculate incremental operating cost of each unit

(b) If the output power of the station is 950 MW, determine the output of each unit to operate at minimum cost (losses are neglected).

(c) If instead the both units share the load equally determine the additional cost per hour

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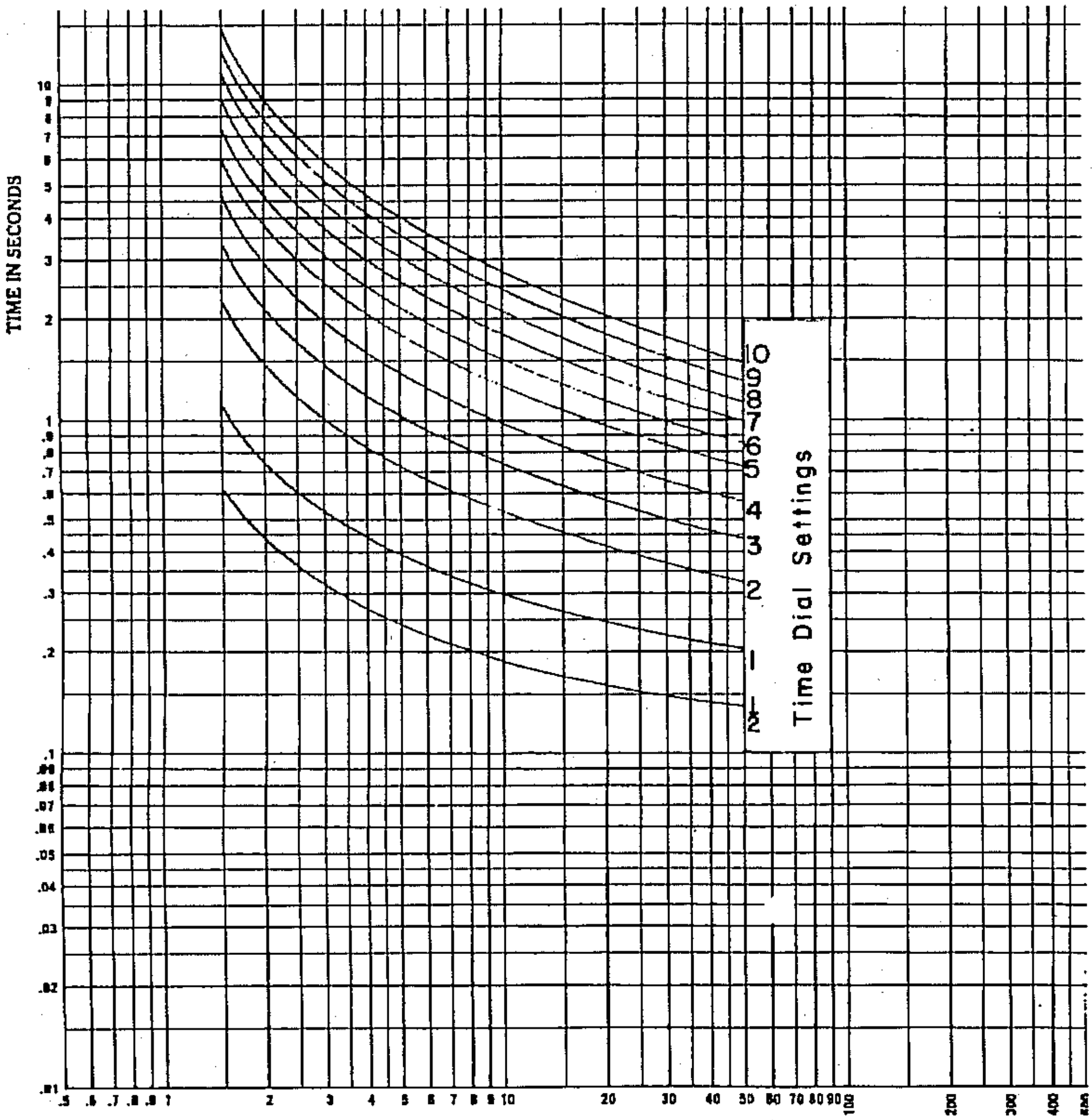
Appendix I



Multiples of tap setting