THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY
ECX5332 – Power systems II
Final Examination 2005/2006

C35

Duration Three Hours

Date: 24th April 2006 Time: 0930-1230

*This paper consists of seven questions. Answer ANY **FOUR** questions. All questions carry equal marks.*
Graph papers and log-log papers will be available on your request

Q1. A certain power station is connected to a power system via 500 kV, 50 Hz three phase single circuit over head transmission line. The length of the line is 300 km. The parameters of the line are given bellow:

r=0.089 Ω/km; $x=\omega L$=0.308 Ω/km; $b=\omega C=3.6\times10^{-6}$ S/km

Power losses due to corona can be neglected.

(a). Calculate characteristic impedance, prorogation constant and surge impedance loading (SIL).

(b). If the voltage at the receiving end is 500 kV and power received by the system is 1.2 times of SIL at 0.85 power factor lagging, calculate voltage, current, active and reactive powers at the mid point of the transmission line.

Q2. (a). For the system shown in figure Q2 determine the power angle δ_0 and maximum power transfer (P_{max}) from generator G. Reactances of transmission lines are as follows:

x_{12}=j0.25 pu, x_{13}=j0.15 pu, x_{23}=j0.2 pu

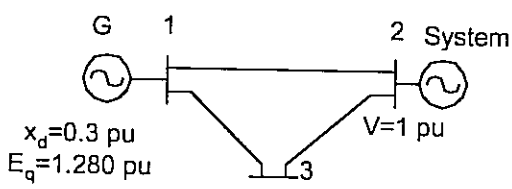

Figure Q2.

(b). A three-phase fault occurs at bus bar 3 and the fault self extinguishes after a while, but power angle has been increased. Determine the critical clearing angle.

Q3. A simple power system is shown in figure Q3. Voltage at bus 1 which can be considered as slack bus is $1\angle 0^0$ pu. Resistance and shunt admittance of the lines are neglected. Rest of parameters are shown in figure Q3 (all parameters are given in pu on a common base).

(a). Calculate the elements of the nodal admittance matrix.
(b). Use Gauss-Zeidel method to calculate voltages at nodes 2 and 3.
(c). Calculate the power mismatch after first iteration.

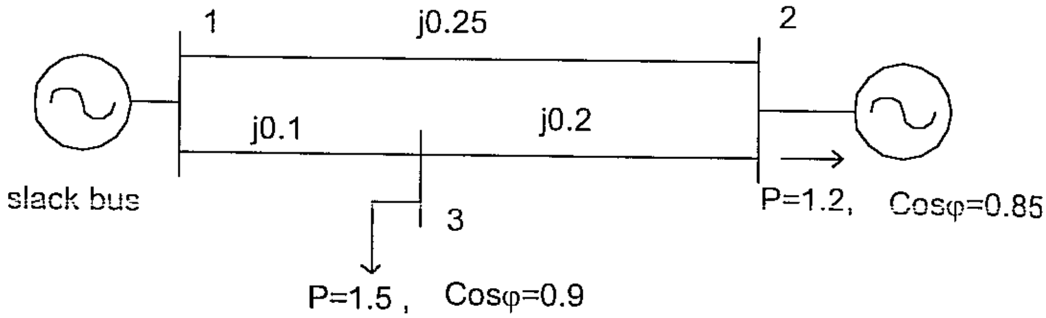

Figure Q3.

Q4. Two coal fired steam units have following incremental fuel costs:

Unit 1: $\dfrac{dc_1}{dP_1} = 510 + 7.2P_1$ Rs./MW $150 \le P_1 \le 600$ MW

Unit 2: $\dfrac{dc_2}{dP_2} = 310 + 7.85P_2$ Rs./MW $100 \le P_2 \le 400$ MW

These two units share a common load, which varies from 250 MW to 950 MW. Losses of the system can be neglected. If both units are working at all the time, plot the incremental fuel cost and allocation of loads between two units for minimum fuel cost for various total loads. What are the contributions of each unit when the total load is 750 W?

Q5. Three loads S1,S2 and S3 are connected to a 33 kV radial line as shown in figure Q5.

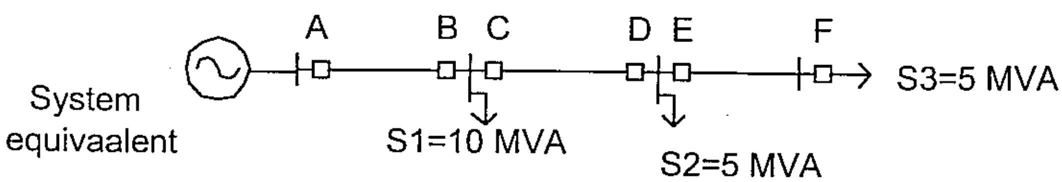

Figure Q5.

Each transmission line has positive sequence reactance of 0.1 pu on 100 MVA base. System equivalent has impedance of 0.3 pu under minimum generator condition and 0.1 pu under maximum generator conditions on the same base. At each location of circuit breaker 750/5 current transformers are used.
The relays have adjustable pick up values at 2.4, 3.75, 5.0, 6.25, 7.5, 8.75 and 10.0 A and time multiplier adjustable from 0.1 to 1.
With the time multiplier set at 1.0 the time-current characteristic of the relay on any pick up setting is given bellow:

Pick-up setting multiplier	1.5	4	5	10	20
Operating time	15	4.5	3.9	2.65	2.0

If the time lever at C is set at 0.25 and its pick up value is set at 5.0 A what should be the time lever setting for relay at A in order to provide back up protection for relay C.

Q6. (a). What is meant by phase angle comparator?

(b). A certain distance relay has operating region which is common to following two relays:

(i). An off-set Mho relay with its centre on the x axis at point (0,5) with a radius of 6 Ω.

(ii). a Mho relay of 6 Ω having maximum reach direction 45^0 with the R-axis.

Clearly sketch the operating region of the relay on R-X region.
A transmission line whose impedance is $14 \angle 80^0$ Ω is protected by this relay. What is the percentage of line protected by this relay.

Q7. (a). Compare the Newton –Raphson and Gauss –Zeidel methods that are used for load flow calculations. What are the advantages and disadvantages of them? What is the benefit that you will have if you combine these two methods for load flow calculations?

(b). List examples for small and large disturbances of a power system. Briefly explain the transient and steady state stability of a power system.

(c). Is it possible to have more voltage along the long length line than the voltages at the sending and receiving ends? Explain your answer.

(d). Distinguish between local and remote back-up protection.