THE OPEN UNIVERSITY OF SRI LANKA
DIPLOMA IN TECHNOLOGY
ECX4232 POWER SYSTEMS I
FINAL EXAMINATION 2009/2010

Duration Three Hours

Date: 13 March 2010 Time: 0930-1230

*This paper contains seven questions. Answer **any five**. All questions carry equal marks.*

Electric space constant $\varepsilon_o = 8.85 \times 10^{-12}\ Fm^{-1}$
Magnetic space constant $\mu_o = 4\pi \times 10^{-7}\ Hm^{-1}$

Question 1

A three-phase balanced load of 360 MW at 0.9 power factor lagging is connected to a supply through a double circuit 230 kV transmission line and two 200 MVA,230 kV/11 kV parallel connected transformers as shown in figure Q1. Each transformer has a leakage reactance of 0.11p.u. The length of the transmission line is 200 km. The voltage at load is 9.9 kV.

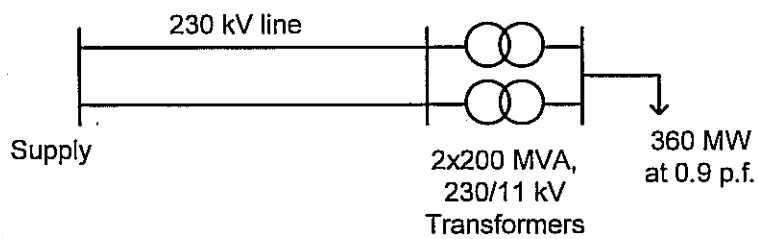


Figure Q1

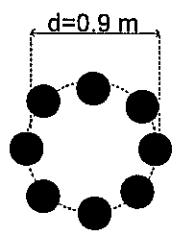
Per-phase equivalent parameters of the line are as follows :
Resistance: 0.098 Ω/km; Reactance: 0.429 Ω/km; Sucepctance : 2.64×10^{-6} S/km

a. Calculate
   I. voltage at supply.
   II. total reactive power generated by the line
   III. Power loss in the system
   IV. Sending end power and power factor

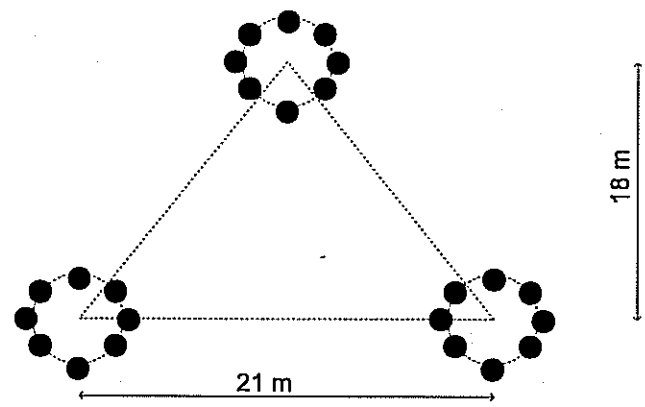
b. Sketch the phasor diagram to illustrate all voltages (voltage at load, at the HV side of the transformer, Supply voltage) and currents (line current, charging currents, current in the HV side of the transformer)

Question 2

An Extra-High voltage over -head transmission line has eight sub-conductor bundle arrangement as shown in figure Q2(a). Radius of each sub-conductor is 21 mm. Three-phases of this bundle conductors have delta arrangement as shown in figure Q2(b).



Q2 (a)



Q2(b)

a. Calculate
   I. geometric mean radius (GMR) of bundle arrangement shown in Q2(a)
   II. geometric mean distance (GMD) of circuit arrangement shown in figure Q2(b)
b. Calculate the per-phase per kilometer inductance and capacitance of the line

Answer questions 3 and question 4 based on the power system shown in figure Q and data given in table T (you may attempt two questions independently) .

Single line diagram of a certain power system is shown in figure Q. Parameters of the elements of the system in p.u. on equipment basis are given in table T

Table T

Element and its rating	Positive and negative sequence p.u. (on equipment basis)	Zero sequence p.u. (on equipment basis)
G1: 500 MVA, 16 kV	j0.15	j0.05
G2: 500 MVA, 16 kV	j0.15	j0.05
T1 : 500 MVA, 20/ 230 kV	J0.11	j0.11
T2: 500 MVA, 20/ 230 kV	j0.11	j0.11
L1 : 230 kV	j0.05	j0.15
L2: 230 kV	j0.022	j0.066
L3 : 230 kV	j0.022	j0.066

Generator G1 is solidly grounded and G2 grounded via j0.03 pu reactance.

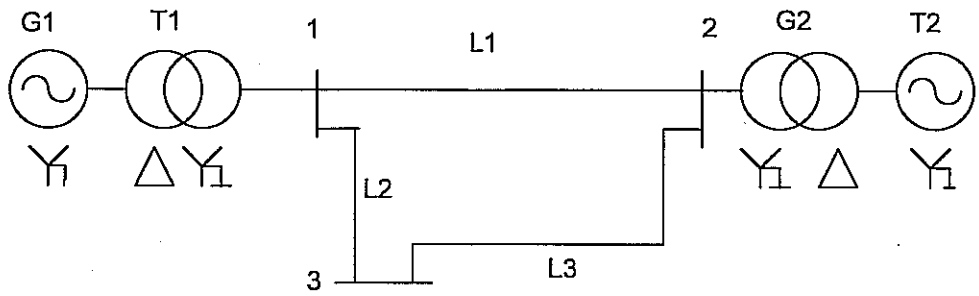


Figure Q3-4

Question 3

For the power system shown in figure Q (relevant data are given in table T)

a. Calculate the pu values on common base 100 MVA on 230 kV transmission line for the positive sequence network.
b. A three-phase fault occurs at bus No 3. Calculate :
    I. Fault current
    II. Current flows through the lines
    III. Voltage at generators G1 and G2

Question 4

For the power system shown in figure Q (relevant data are given in table T)

a. Draw the positive, negative and zero sequence circuits and calculate the pu values on common base of 100 MVA on 230 kV line.
b. A single-line to ground fault occurs at bus 3. Calculate:
    I. Fault current
    II. Voltage at generator G1

Question 5

a. Explain briefly the arc interruption methods in ac and dc circuits
b. List the main types of insulators that are used in over-head transmission lines
c. Explain how grading of insulators improve the string efficiency and list the other methods that are used to improve string efficiency
d. Certain string insulator is made consisting of 6 similar units. The capacitance between each interlink and earth is one tenth of the capacitance between the metal interlinks. The flashover voltage of one unit is 75 kV. Calculate the voltage at which this whole assemble will flashover.

Question 6

a. What are the important factors that should be considered when a bus bar arrangement is to be selected?
b. Compare (advantages/disadvantages, area of use) following two bus bar arrangements with necessary sketches.
   I. Single bus bar with bus sectionalizer
   II. Main bus bar with transfer bus scheme
c. Sketch the symbols and explain the function of following elements in electrical power system
   I. Current transformer
   II. surge arrester
   III. reactor
   IV. capacitor bank
d. "Coal power plants are not used as peak-load plants, whereas combined cycle plants are used as peak load plants" give reasons for this.
e. What is the importance of having pumped storage plants in Sri Lankan power system?

Question 7

a. Unbalanced voltages of a three-phase system are given as below

$$\underline{V_A} = 230\angle 30^0\ V, \quad \underline{V_B} = 192\angle -70^0\ V, \quad \underline{V_C} = 120\angle 165^0\ V$$

Calculate the sequence components $\underline{V_{A0}}, \underline{V_{B1}}$, and $\underline{V_{C2}}$.

b. A 33 kV/11 kV , Δ/Y, 100 MVA three-phase transformer with star point on the 11 kV side is solidly earthed, has following current distribution on the 11 kV winding.

$$\underline{I_A} = 100\angle 85^0\ A, \quad \underline{I_B} = 100\angle -25^0\ A, \quad \underline{I_C} = 150\angle 210^0 A$$

Determine

I. sequence components of the currents on 11 kV side
II. current distribution in the Δ connected windings