THE OPEN UNIVERSITY OF SRI LANKA
DIPLOMA IN TECHNOLOGY
ECX4232 POWER SYSTEMS I
FINAL EXAMINATION 2008/2009

061

Duration Three Hours

Date: 20 March 2009 **Time: 1400-1700**

*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) Explain why more than one conductor per phase are used in transmission line [3 marks]

b) Explain the effects of transmission line transposition on electrical performances of the transmission line. [3 marks]

c) Figure Q1 shows bundle arrangement of three-phase 400 kV, 50 Hz, 220 km transmission line. Outside diameter of a conductor is 16 mm and AC resistance at 20^0 C is 0.9 Ω/km. Temperature coefficient is 0.0044. The line is being operated at the ambient temperature of 40^0 C.

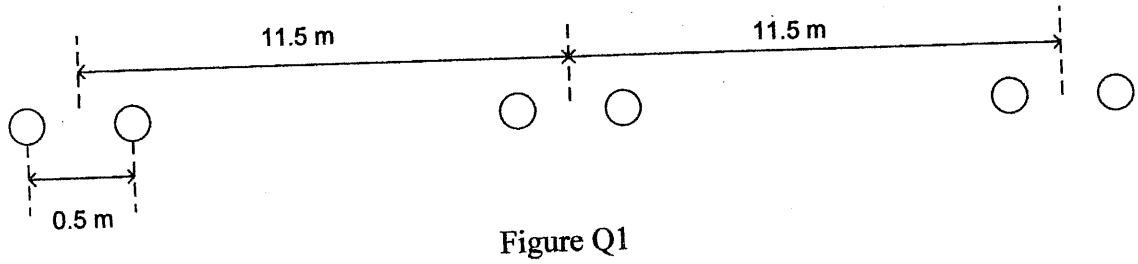

Figure Q1

I. Calculate:
   1. Geometric mean radius (GMR) an geometric mean distance (GMD) [4 marks]
   2. Inductance and capacitance per-phase per kilometre (clearly state any assumption that you make) [7 marks]

II. Draw and calculate equivalent π – model of the transmission line. [3 marks]

Question 2

A three-phase, 400 kV (line-line), 50 Hz transmission line delivers power to a load of 200 MW at 0.75 power factor lag. The length of the line is 200 km. Parameters of the equivalent π- model (per-phase per kilometre) of the line are:

resistance = 0.08 Ω/km, reactance = 0.3 Ω/km, sucepctance = 4×10^{-9} S/km

a) If voltage at the receiving end of the line is maintained at 400 kV determine
   I. Sending end voltage
   II. Sending end power and power factor
   III. Transmission efficiency
[10 marks]

b) Find the required reactive power compensation to maintained 400 kV voltage at the both ends of the line. [6 marks]

c) When the voltage at the sending end is maintained as in (a) the line is open circuited at the receiving end. What voltage would you expect at the receiving end? [4 marks]

Question 3

a) For the power system shown in figure Q3, pu values are given on equipment basis. Draw the pu impedance diagram of the system using 132 kV, 100 MVA on the transmission line.
[8 marks]

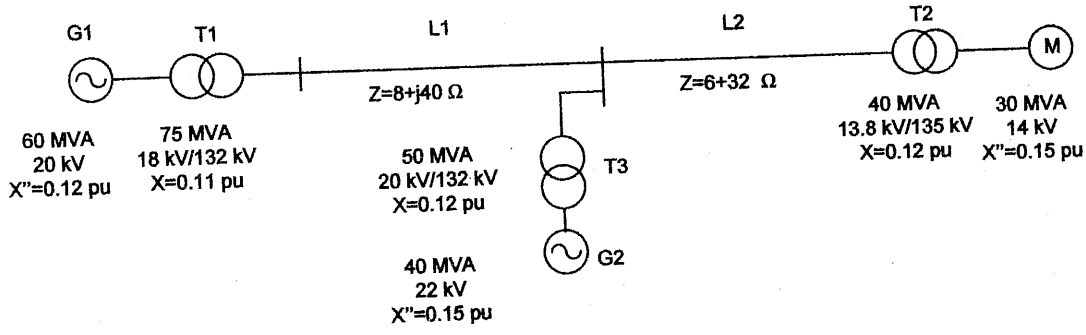

Figure Q3

b) A single-phase to ground fault occurs at the output terminals of a three phase generator while it is being operated under open circuited condition. Phase voltages are as given below:

$\underline{V}_a = 0.0\ pu;\ \ \underline{V}_b = 1.2\angle -100^0\ pu;\ \ \underline{V}_c = 1.2\angle 100^0$ pu

The neutral of the generator is solidly earthed. Positive, negative and zero sequence reactance of the generator are 0.22 pu, 0.3pu and 0.11 pu.

Calculate the currents in each phases of the generator during the fault.
[12 marks]

Question 4

a) Explain term "fault" with related to power system. Give examples. [3 marks]
b) What are the consequences of short circuit current? [2 marks]
c) In short circuit calculations the synchronous generator is represented by an emf and reactance connected in series. Identify this reactance? [3 marks]
d) A three-phase fault with zero fault impedance occurs at point P of the system shown in figure Q4. pu values are given on equipment basis.

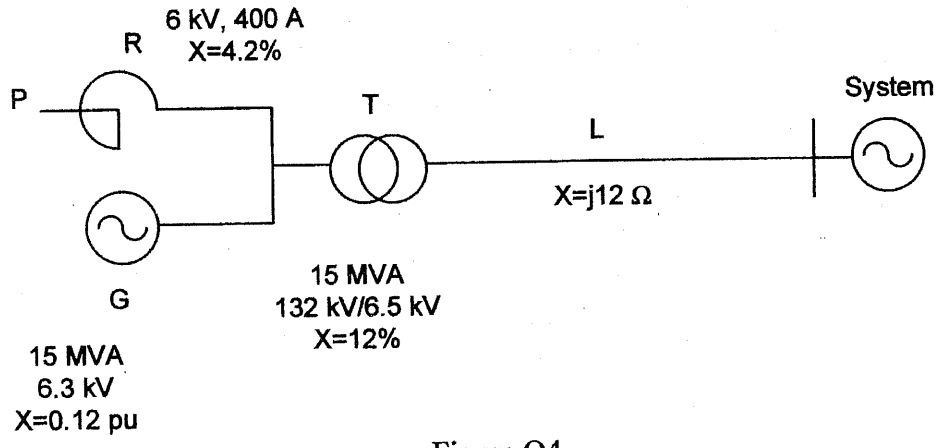

Figure Q4

I. Determine fault current in amperes [8 marks]
II. Current through the generator during the fault [4 marks]

Question 5

For the system shown in figure Q5 parameters of the system elements in pu on common base given in table Q5

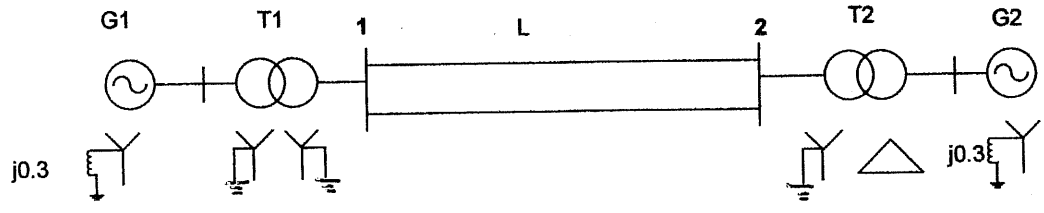

Figure Q5

table Q5

Element	X_1	X_2	X_0
G1	0.2	0.2	0.05
G2	0.2	0.2	0.05
T1	0.11	0.11	0.11
T2	0.12	0.12	0.12
L (each)	0.12	0.12	0.38

I. Draw the positive negative and zero sequence network [08 marks]
II. If a single line to ground fault occurs at bus 1 calculate fault current in pu. [12 marks]

Question 6

a) Derive an expression for capacitance of a single-core underground cable. [5 marks]

b) Explain briefly methods of improving "string efficiency" [5 marks]

c) Figure Q6 shows an insulator string consisting four discs. Conductor voltage is 66 kV. If C1=C2=12 C and C3=C4=7C, calculate

I. Voltage distribution [8 marks]

II. String efficiency [2 marks]

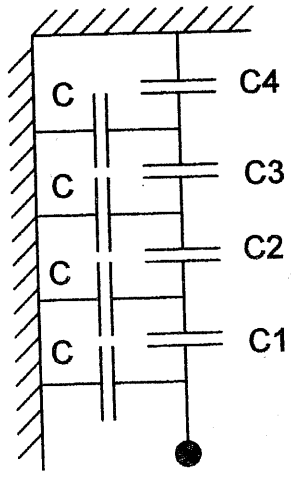

Figure Q6

Question 7

a) With the help of a suitable diagram explain the function of bus coupler and bus sectionalizer. [4 marks]

b) Certain substation consists of two 132 kV transmission lines, two 132 kV/11kV transformers and twelve 11 kV cables as shown in figure Q7. What would be a possible bus bar for the substation justify your selection. [5 marks]

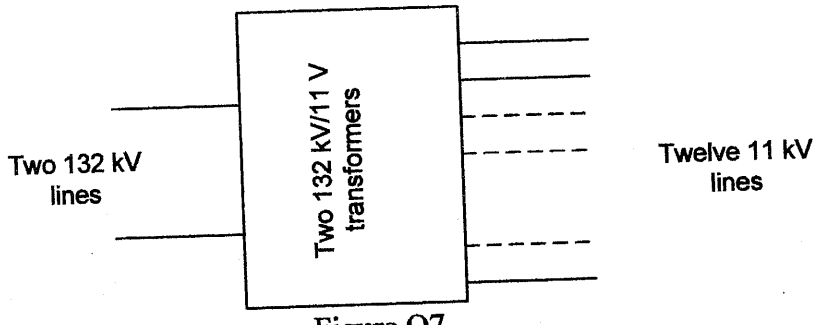

Figure Q7

c) Explain two methods used to extinguish an electric arc. [4 marks]

d) Explain why SF_6 circuit breakers (sulphur hexafluoride) are more superior to oil circuit breakers [3 marks]

e) Sketch the block schematic diagram of a thermal power station and explain function of each element [4 marks]