THE OPEN UNIVERSITY OF SRI LANKA
DIPLOMA IN TECHNOLOGY
ECX4232 POWER SYSTEMS I

FINAL EXAMINATION 2011/2012

Duration Three Hours   **Closed book**

Date: 03 March 2012	**Time: 0930-1230**

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

Electric space constant $\varepsilon_0 = 8.85 \times 10^{-12}$ Fm^{-1}
Magnetic space constant $\mu_0 = 4\pi \times 10^{-7}$ Hm^{-1}

Question 1

Grid sub-station at A delivers power to loads at B and C as shown in figure Q1. Loads at B and C are as indicated in the figure. Leakage reactance referred to the high voltage side of the transformer T (132 kV/11 kV) is 11.7 Ohm. Nominal voltage of transmission line L is 132 kV and it's length is 55 km. Per-phase, per-unit length parameters of the line are: R= 0.098 Ohm/km; X=j0.4 Ohm/km; Y=j2.02x10^{-6} S/km.
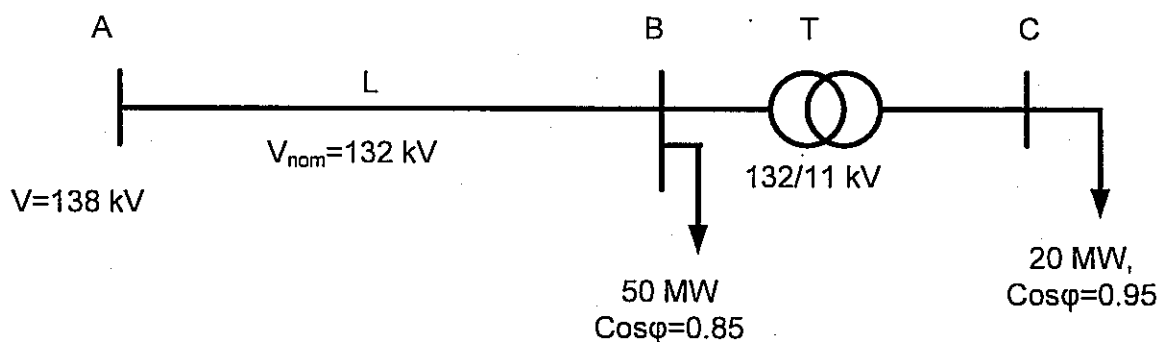Voltage at grid sub station is maintained at 138 kV.

Figure Q1

(a) Calculate parameters of equivalent π-model of the transmission line   [3 marks]
(b) Sketch per –phase circuit diagram for the system and indicate all relevant
    parameters   [2 marks]
(c) Determine approximate values of voltages at load points B and C   [10 marks]
(d) Calculate voltage regulation at load C   [2 marks]
(e) State whether the voltage at load C is acceptable. If it is beyond the permissible level
    of voltage, suggest how to improve it   [3 marks]

Question 2

(a) What are the advantages and disadvantages of AC transmission over DC
    transmission?   [4 marks]
(b) What is "skin effect" with relate to conductors and how it is taken in to account
                                                                            [3 marks]
(c) Certain conductor is named as ACSR 24/7. What ACSR is stand for? With the help of
    necessary sketches explain the structure of this conductor   [3 marks]

(d) Conductor arrangement of a 3-phase, 50 Hz single circuit overhead transmission line is shown in figure Q2. Diameter of conductor is 7.77 mm.
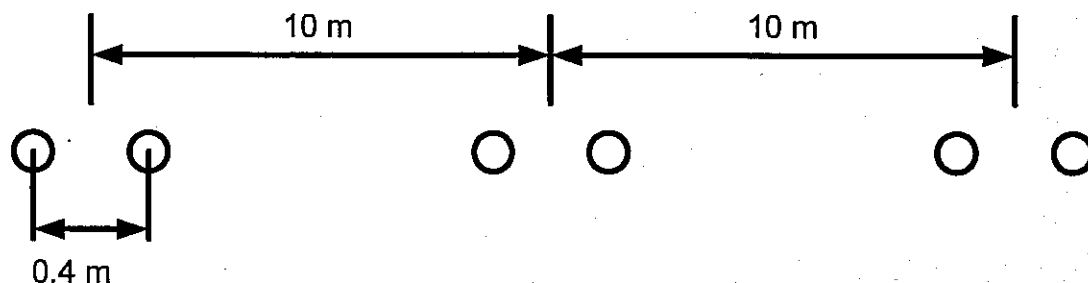

Figure Q2

I. Calculate geometric mean radius (GMR) and geometric mean distance (GMD)

[4 marks]

II. Determine per-phase per unit length inductance and capacitance (effect of the earth is neglected) [6 marks]

Question 3

Consider the power system shown in figure Q3. The load S has resistance of 1 p.u..
Reactance of transmission line, transformers and generator are indicated in the figure.
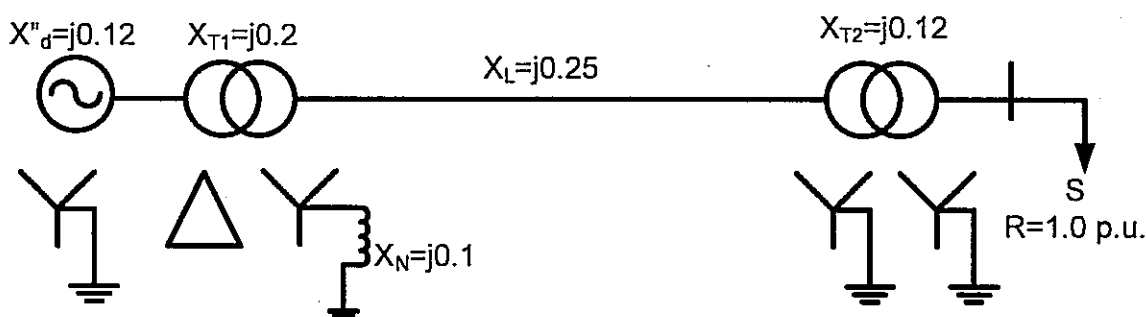All the p.u.values are given on common base. A short circuit fault occurs at load S

Figure Q3

(a) If the fault is three-phase symmetrical short circuit determine the short circuit current for following two events:
   I. Fault resistance is zero [4 marks]
   II. Fault resistance is 0.2 p.u. [6 marks]

(b) If the fault is single line to ground determine short circuit current (consider the fault resistance is 0.2 p.u). [10 marks]

Question 4

(a) Explain briefly the necessity of busbar arrangements in power systems [2 marks]
(b) List at least three factors that should be considered for the selection of bus bar arrangement [3 marks]
(c) What is "interlock"? What is it meant for? [3marks]
(d) In a sub-station two generators(G1,G2) are connected with four 230 kV outgoing lines via two step-up transformers. Following two bus-bar arrangements are suggested:

   Single bus bar with bus sectionalizer
   Single bus bar with transfer bus

I.   Sketch the suggested bus bar arrangements for the above situation   [6 marks]
II. Write merits and demerits of the use of each of arrangement. What is the most
     suitable arrangement for the substation given? Justify your answer   [6 marks]

Question 5

(a) Sketch block- schematic diagram of steam power plant and explain briefly the
    function of each block   . [6 marks]
(b) Explain briefly the working principle of gas turbine power plant   [5 marks]
(c) Explain why the safety factor is one of a very important aspects in nuclear power
    stations   [3 marks]
(d) Explain the necessity of dispatching different types of power plants in an electric
    power system   [3 marks]
(e) List renewable sources used for the generation of electrical energy (at least four) and
    explain one of them briefly.   [3 marks]

Question 6

(a) What are the various methods of voltage control?   [4 marks]
(b) With the help of necessary equations, show that "Power factor improvement reduces
    power losses of the system"   [4 marks]
(c) List main types of insulators used in overhead lines.   [2 marks]
(d) 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]
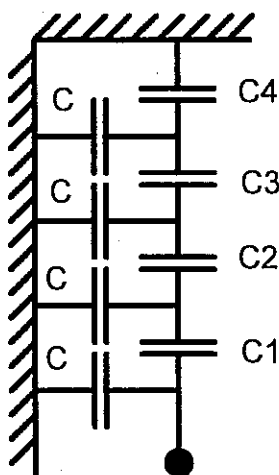

Figure Q6

Question 7

(a) Explain briefly the advantage of use of symmetrical component over phase
    component in short circuit calculations   [4 marks]
(b) Voltages of phases **a, b** and **c** (in volts) at a certain point in a system is given below
$$V_a = 250\angle 0; \qquad V_b = 305\angle -100^0; \quad V_c = 275\angle 160^0$$
    Calculate symmetrical components of voltages   [4 marks]

(c) A single-line to ground fault occurs in phase **a** at point P of the systems shown in
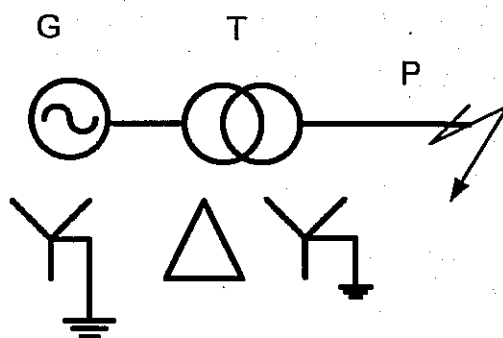   figure Q7. The short circuit current is equal to –j6.0 p.u.

Figure Q7

I. Determine positive, negative and zero sequence currents of the phase **a** at P

[2 marks]

II. Find symmetrical component of the phase **a** at generator side [4 marks]

III. Calculate generator currents in phase **a, b** and **c** [6 marks]