THE OPEN UNIVERSITY OF SRI LANKA
ECX4232 POWER SYSTEMS I
FINAL EXAMINATION 2012/2013
Bachelor of Technology (Engineering)

Duration; Three Hours

Date: 03rd August 2013 **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 $\mu_o = 4\pi \times 10^{-7}\ Hm^{-1}$

Q1.

A three-phase, 50 Hz over head transmission line arranged in horizontal configuration consisting of four conductors per-phase is shown in figure Q1. Outside diameter of each conductor is equal to 29.64 mm. Per-unit length resistance at 20 ^{0}C equals to 0.062 Ω/km. Temperature coefficient of copper is 0.0068 $^0C^{-1}$

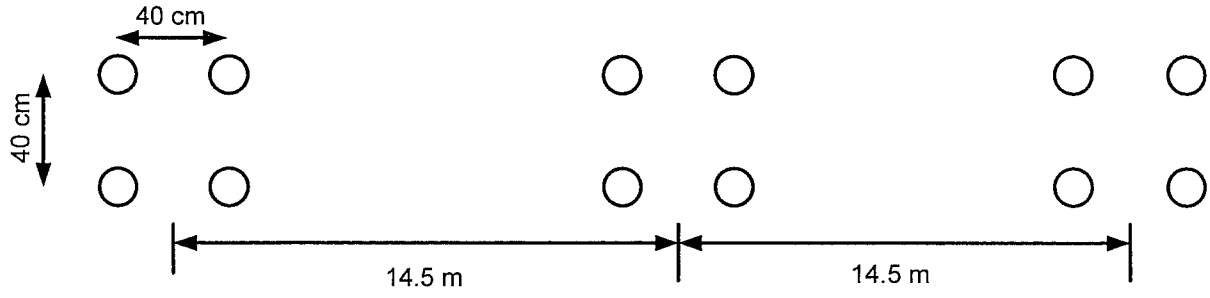

Figure Q1

I. Calculate GMD of the line and GMR of the bundle condcutor [6]
II. Determine per unit length inductance and capacitance of the line [6]
III. If the length of the transmission line is 200 km and ambient temperature is 42 ^{0}C, calculate per-phase parameters (R, X_L and X_c) of the equivalent pi model of the line [8]
(State any assumptions you made)

Q2.

A 132 kV, three-phase 120 km long double circuit overhead transmission line delivers power to a load of 80 MW at 0.85 power factor lagging. Per-phase equivalent parameters of the line are: R=0.12 Ω/km; X_L=0.40 Ω/km; b=1.5x10^{-6} S/km; Voltage at the load to be maintained at 135 kV

I. Calculate voltage, current, power and power factor at the sending end of the line [7]
II. Determine voltage regulation and transmission efficiency [4]
III. Draw the phasor diagram to show all the voltages and currents [4]
IV. State whether the sending end voltage is acceptable. Give reason [2]
V. If the voltage is not acceptable, what measures would you take to bring the voltage level to the acceptable limit [3]

Q3.

I. Explain briefly the importance of short circuit calculation in electrical power systems [5]
II. Certain star connected 125 MVA, 12.5 kV synchronous generator is subjected to a single-line to ground fault while operating at open circuit condition. Positive, negative and zero sequence reactances of the generator are $X_1=X_2=j0.15$ pu and $X_0=j0.05$ pu respectively. Neutral point of the generator is grounded via j0.05 p.u reactance.
   a. Calculate short circuit current (in kA) [7]
   b. Determine voltage at phases A, B and C during the fault (in kV) [5]
   c. What is the power developed during the short circuit [3]

Q4.

Consider the power system shown in figure Q4. ,Per-unit values are given on equipment base.

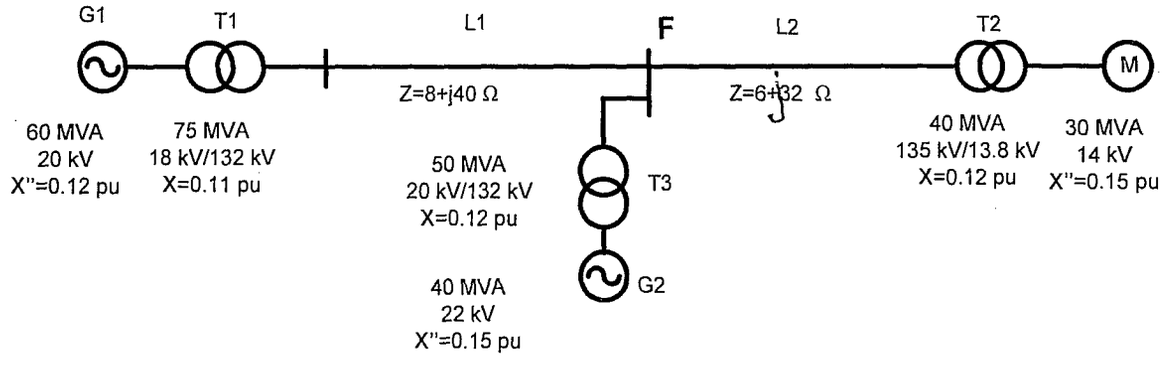

Figure Q4

I. Calculate the parameters of the system elements on common base of 100 MVA and 132 kV on transmission line. [8]
II. Sketch the per-phase impedance diagram [2]
III. If a three-phase fault occurs at the point F, determine short circuit current in kA [6]
IV. Calculate current through the generator G2 during the fault [4]

Q5.

I. Explain briefly the importance of "symmetrical components" in power system calculations [4]

II. A synchronous machine having positive, negative and zero sequence reactances of 0.22, 0.22 and 0.04, p.u. respectively, is subjected to an unsymmetrical fault at its output terminals. The currents during the fault in each phase are

$I_a = 0.0$ p.u.; $I_b = 3.23\angle 150^o$ p.u.; $I_c = 3.23\angle 30^o$ p.u.

If the neutral point of the generator is grounded through j0.04 p.u. reactance, determine the terminal voltages in each phase and voltage at the neutral point with respect to the ground. [10]

III. Sketch the zero sequence network of the circuit shown in figure Q5 [6]

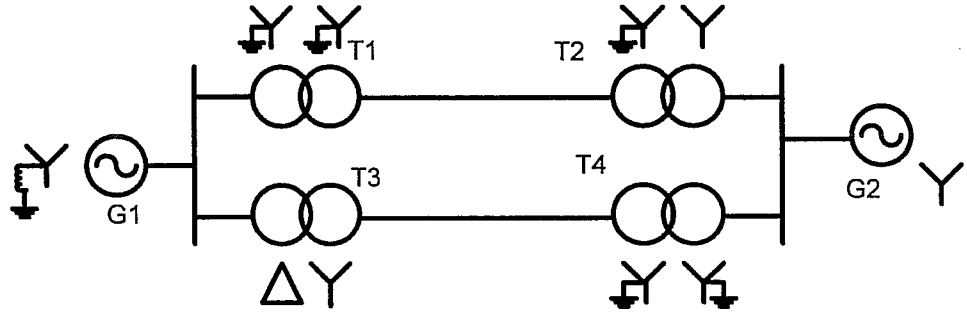

Figure Q5

Q6.

I. Explain briefly two methods of arc interruption [6]

II. Describe how the electric arc is extinguished in following types of circuit breakers
   a. Air Blast circuit Breaker
   b. Oil circuit Breaker [8]

III. Layout of the main and transfer busbar scheme is shown in figure Q6.

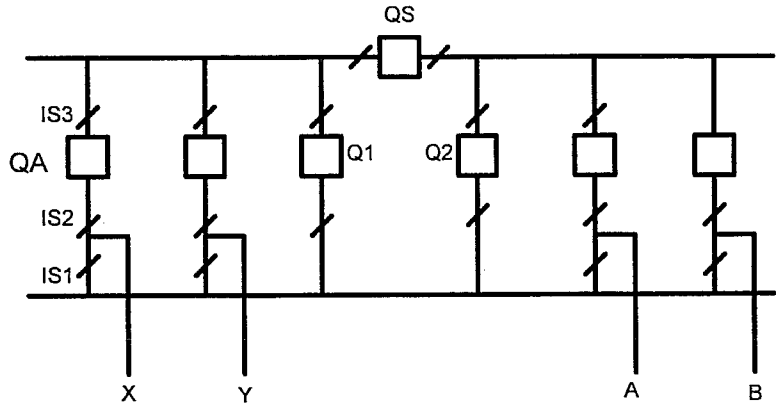

Figure Q6.

a. If two generators (G1, G2) are to be connected to two outgoing lines (L1,L2) through the above bus bar scheme, what would be the most reliable way of connecting them. Explain your answer.

b. State the conditions (ON/OFF) of circuit breakers QS, Q1, Q2, QA and isolators IS1, IS2, IS3 at normal operating condition.

c. What are the steps that have to be taken to isolate circuit breaker QA and transfer the power from X to main bus bar through transfer busbar?

[6]

Q7.

I. What is the purpose of having a cooling tower in a thermal power plant? Briefly explain its function [4]

II. With the help of block-schematic diagram, explain briefly the operating principle of a combined cycle power plant [5]

III. Explain the main factors to be considered, if a nuclear power plant is to be introduced in Sri Lankan power system [5]

IV. Explain the possibilities of renewable energy usage sources in Sri Lanka to meet the electricity demand. [6]