THE OPEN UNIVERSITY OF SRI LANKA
Faculty of Engineering Technology
Department of Electrical & Computer Engineering
Bachelor of Technology Honours in Engineering

Final Examination (2016/2017)
ECX4252: Power Systems I

Date: 20th November2017 (Monday) **Time: 9:30 am – 12:30 pm**

This paper contains Seven (7) questions. ***Answer any five (5) questions.*** *All questions carry equal marks.*

Q1.

I. A schematic diagram of a gas turbine power plant is shown in Figure Q1(I). Identify the elements 1,2,3,4 and A, B, C, D and E. Briefly describes the operating principle of that power plant. **[5 Marks]**

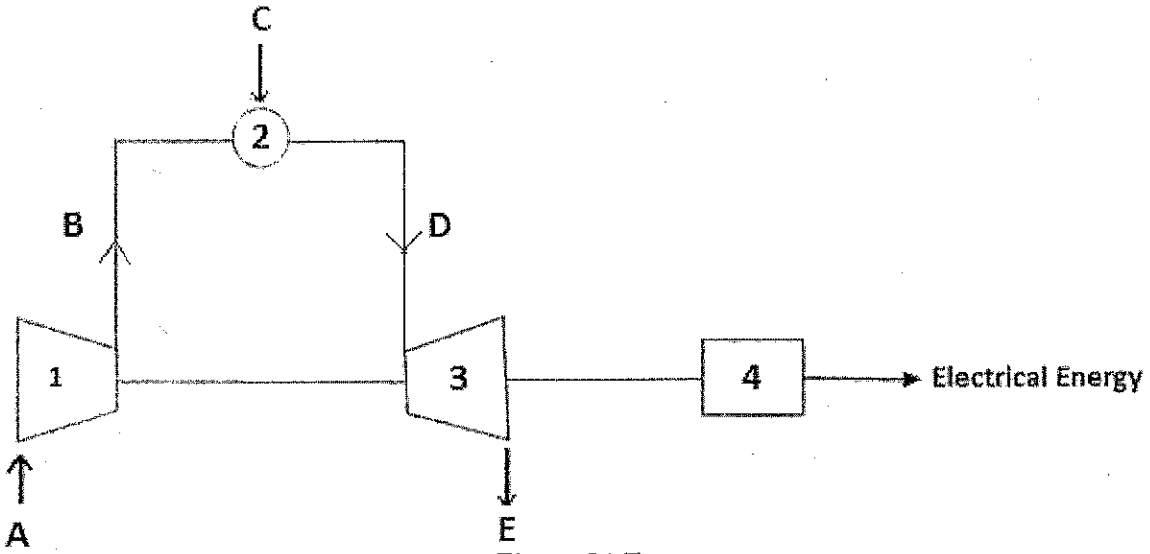

Figure Q1(I)

II. Describe how the contribution of hydro, thermal and non-conventional renewable energy source based power plants have varied through the last three decades in fulfilling the electricity demand in Sri Lanka (Maximum number of words should not be exceeded 150). **[5 Marks]**

III. The annual load duration curve for a typical heavy load being served by a steam station, a run-of-river station and a hydro-electric (reservoir) station is as shown Figure Q1(III) .The ratio of the number of units supplied of the annual total load is 7:4:1 for steam, run-of-river and reservoir respectively.

The run-of-river station is capable of generating power continuously and works as base load station.

a) Calculate the total number of generation units per annum in kWh. **[3 Marks]**
b) Calculate the number of units generated by each plant separately. **[4 Marks]**
c) Calculate the power delivered by run-of river power station. **[3 Marks]**

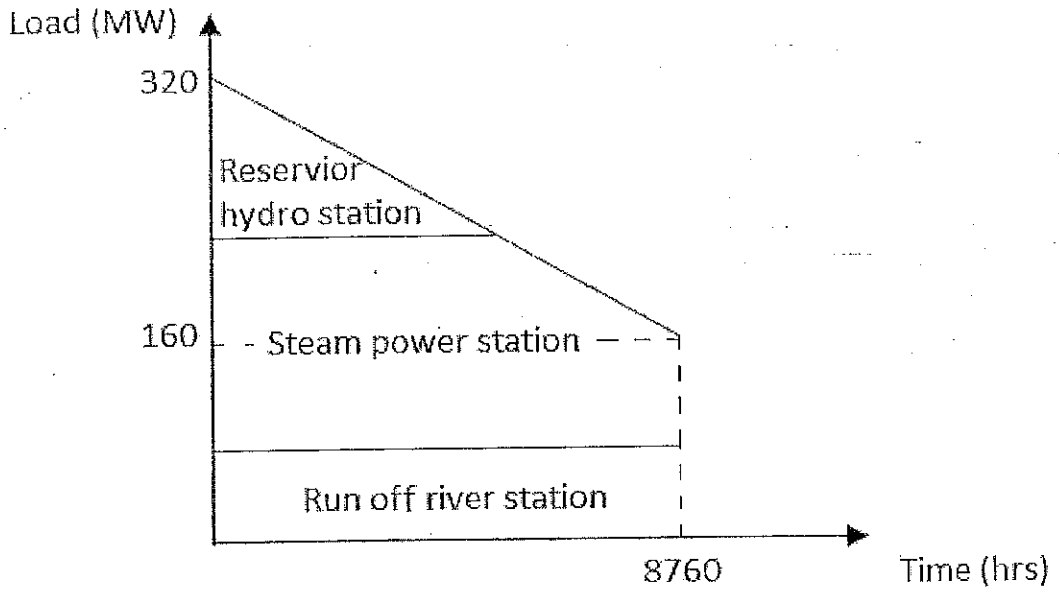

Figure Q1 (III)

Q2.

I. A diesel power station supplies the loads to various consumers in accordance to table Q2. If the maximum demand is 2500 kW and the number of kWh generated per year is 4×10^5. Calculate,

a) diversity factor **[3 Marks]**

b) annual load factor **[3 Marks]**

Table Q2

Consumers	Power (kW)
Industrial Consumer	1500
Commercial Establishment	750
Domestic Power	100
Domestic Light	450

II.

a) Saving on energy is a basic objective of energy management. Briefly describe the methods of energy saving due consideration to the industrial and domestic sector. **[6 Marks]**

b) A single line diagram of a domestic consumer is shown in Figure Q2. The main incoming power factor of the system is 0.85 lag. Calculate the required capacitance of capacitor bank to improve power factor to 0.9 lag.

[8 Marks]

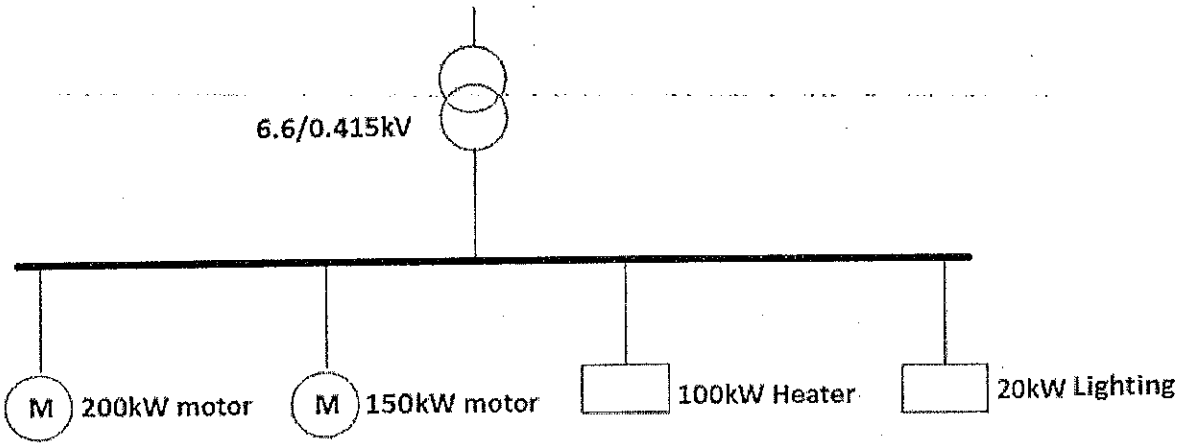

Figure Q2

Q3.

I. Schematic diagram of the Main and Transfer bus bar scheme is shown in figure Q3.

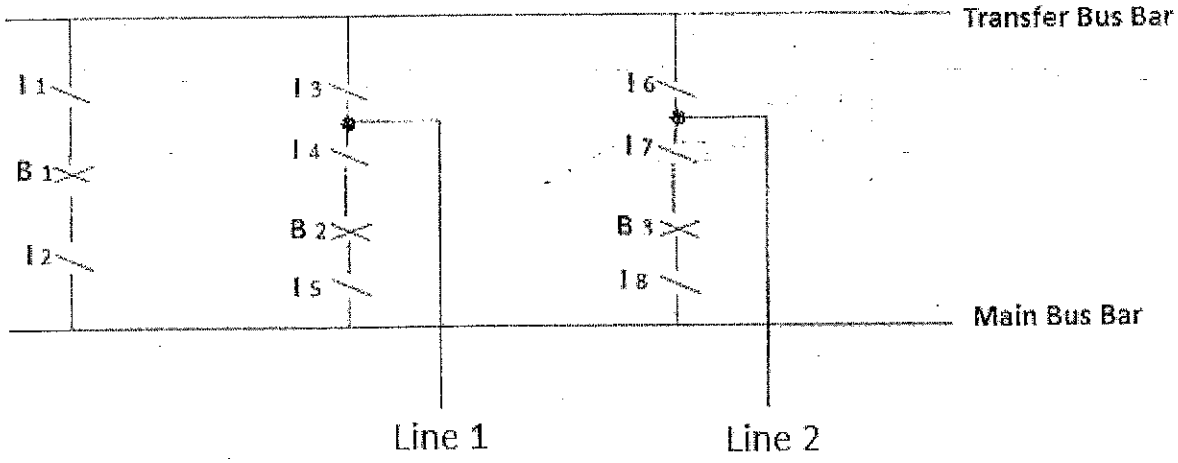

Figure Q3

a) State three technical considerations in deciding on the bus bar arrangement to be used. **[3 Marks]**

b) Explain briefly the advantages of main and transfer bus bar scheme. **[2 Marks]**

c) State the conditions (ON/OFF) of circuit breakers and isolators at normal operation condition in line 1. **[3 Marks]**

d) Write the sequence of steps to be taken in order to switch off the circuit breaker B_2 but give the uninterrupted supply to the line. **[4 Marks]**

II. A three phase 20 km distribution line connected to a 1000 kW at 0.8 power factor lag load. Per unit resistance and reactance of each conductor are 0.25 Ω/km and 0.28 Ω/km respectively. The voltage at the load is required to be kept at 11 kV. Calculate,

a) Sending end voltage(line-to line) **[3 Marks]**

b) Voltage regulation (%) **[2 Marks]**

c) Transmission efficiency **[3 Marks]**

Q4.

I. A three phase, 138 kV, 50 Hz and 100 km long transmission line has the following characteristics.

resistance = 0.103 Ω/km
inductance = 1.6 mH/km
capacitance= 0.1 nF/km

a) Calculate per phase series impedance and shunt admittance of the transmission line **[4 Marks]**

b) Calculate the ABCD constants of the transmission line using **nominal π method.** **[5 Marks]**

c) Calculate the sending end voltage if the line is supplying rated voltage and apparent power of 200 MVA at 0.9 power factor lag. **[2 Marks]**

d) Sketch the phasor diagram of the transmission line at rated voltage. **[2 Marks]**

e) What is the voltage drop of the transmission line for the conditions in (d) **[2 Marks]**

II. Describe briefly the special considerations to be made when a power line is in the vicinity of a telephone line. **[5 Marks]**

Q5.

I.

a) Define term "string efficiency" reference to insulators **[1 Marks]**
b) Explain, why it is necessary to have high string efficiency? **[2 Marks]**
c) Describe briefly three(3) methods of improving string efficiency **[3 Marks]**

II. A concentric cable has core diameter and inner sheath diameter are 32 mm and 80 mm respectively. The core potential is 40 kV and the relative permittivity of the dielectric is 3.5.

a) Calculate the capacitance per km length of the cable **[3 Marks]**
(Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$)
b) Calculate maximum and minimum values of dielectric stress **[4 Marks]**
c) The cable is capacitance graded with three dielectric materials and their relative permittivities are 5, 4 and 3 respectively. Maximum working voltage of the cable is same as 40 kV. Calculate maximum permissible stress in each dielectric. **[4 Marks]**
d) Draw a graph for the stress pattern in capacitance graded cable compared to an ungraded cable for the same applied voltage considering your obtained results. **[3 Marks]**

Q6.

I. State two assumptions made in symmetrical fault analysis and briefly explain why they are generally acceptable **[2 Marks]**

II. Figure Q6 shows how the equivalent of a large power system at A, and the generator of a local supply authority at B, feeds a load centre at D.

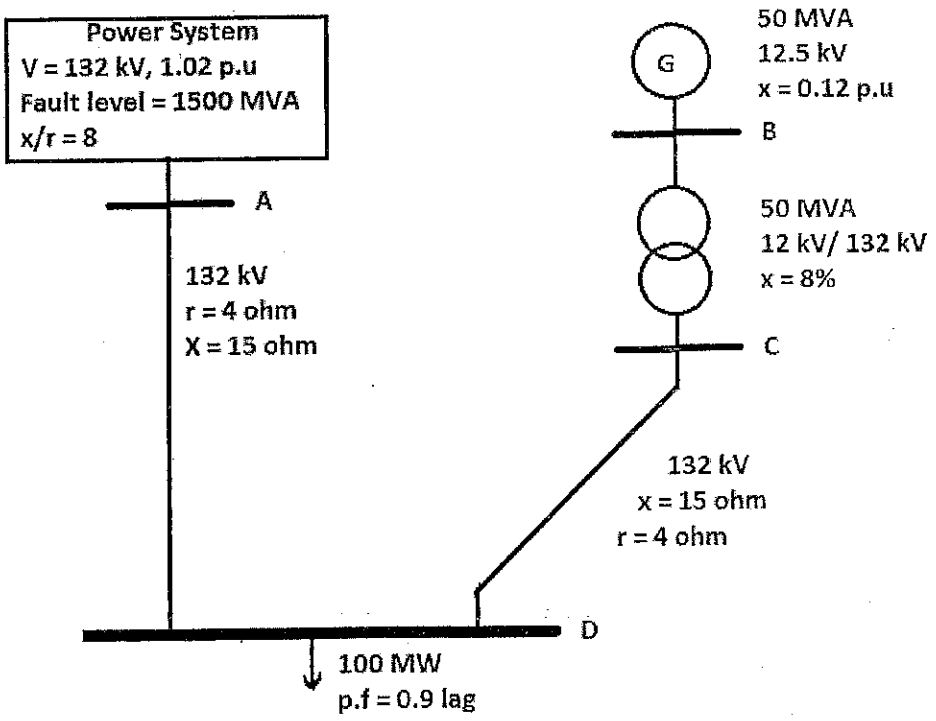

Figure Q6

Select S_{base} as 100 MVA and voltage base as 132 kV as the common base at transmission line.

a) Calculate equivalent per unit resistance and reactance of the power system connected at A **[3 Marks]**
b) Calculate per unit impedances of the system **[10 Marks]**
c) Draw the equivalent circuit, indicating all values on it in per unit to the common base **[3 Marks]**
d) Calculate the three phase symmetrical fault level at D in MVA. **[5 Marks]**

Q7.

Consider a power system is shown in Figure Q7.

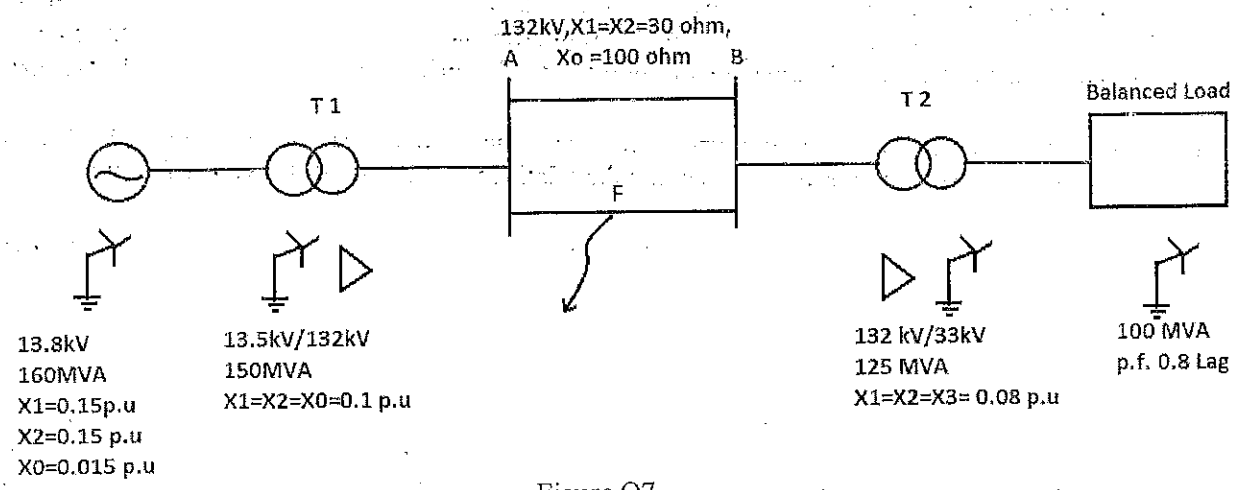

Figure Q7

a) Calculate all per unit values using a common base of 100 MVA, 132 kV at the transmission line **[3 Marks]**

b) Sketch sequence diagrams for the system shown, with significant values indicated on the diagrams **[7 Marks]**

c) Calculate the magnitude and phase angle of the voltage at the mid-point F of the circuit, in the absence of a fault. **[3 Marks]**

d) Starting from first principles,develop a sequence network for line to line fault **[2 Marks]**

e) If a line to line fault occurs at point F, determine the line to line fault current **[5 Marks]**