The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4542 – Power Systems I**
Academic Year	: 2019/2020
Date	: 10th August 2020
Time	: 13.30-16.30hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Six (6)** questions in **Six (6)** pages.
3. Answer **ALL** the questions
4. Answer for each question should commence from a new page.
5. No Relevant charts / codes are required.
6. This is a Closed Book Test **(CBT).**
7. Answers should be in clear handwriting.
8. Do not use red color pen.

Question 1

a) In the recent time electrical energy generated by solar and wind has been significantly increasing in Sri Lanka. At the same time, construction of large-scale power plants has been delayed due to various reasons. From the demand side, domestic loads share the larger portion of the daily energy consumption.
Considering the above facts, explain the significance of introducing energy storage devices for grid application in Sri Lanka.

[6 marks]

b) Certain power system consists of following types of power plants:
- Hydro power plants with ample storage capacity
- Run-off river hydro power plants
- Gas turbine power plants
- Diesel power plants
- Coal power plants
- Nuclear power plants
- Hydro power plants with limited storage capacity

Daily load curve of the system is shown in figure Q1. List the power plants that are more suitable for the areas of A, B and C of the curve. Give reasons for your answer.

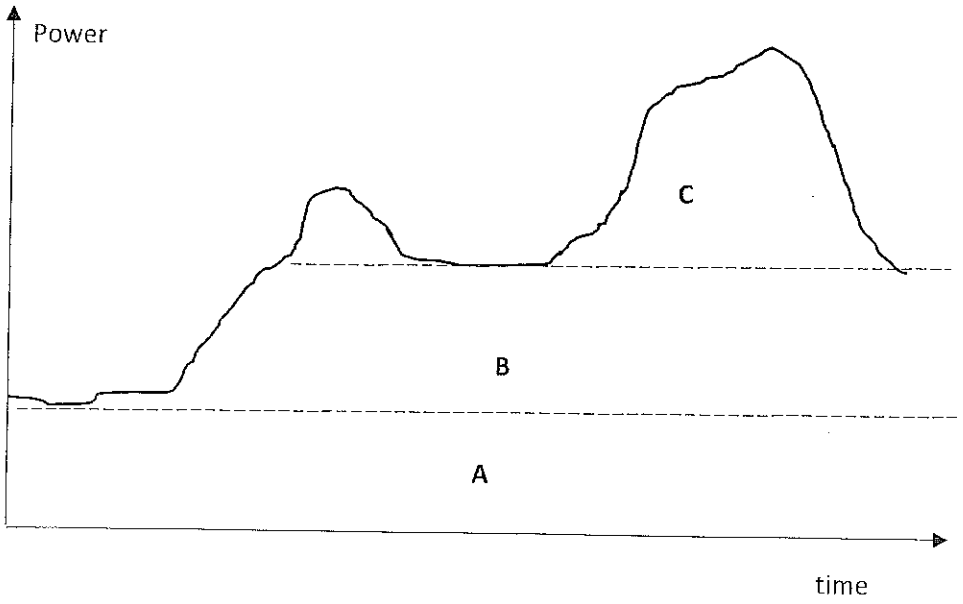


Figure Q1

[9 marks]

[Total marks 15]

Question 2

Table Q2 shows the details of electrical appliances and their usage in a private residence

Table Q2

Electrical Appliance	Power rating W	Power factor*	Number of appliances	Average Usage
LED bulbs	8	0.9	7	6 hrs/per day
Desktop computer	250	0.85	1	3 hrs/per day
Ceiling fan	30	0.9	2	6 hrs/per day
Television	91.5	0.96	1	3 hrs/ per day
Microwave oven	425	0.9	1	0.5 hrs/ per day
Washing machine	300	0.85	1	2 hrs/per week
Air Conditioners	1400	0.95	2	2 hours per day

*(*all the appliances have lagging power factor)*

a) Maximum demand of the house occurs between 7 pm-8 pm when all the appliances except washing machine and air conditioners are in operation

i. Calculate the maximum power consumed by the house between 7 pm -8 pm

ii. What is the power factor during the maximum demand?

iii. Calculate the energy consumed by the house per month

[12 marks]

b) Calculate the expected electricity bill of the consumer under domestic tariff structure. Domestic tariff structures are given in tables Q2.2 (a) and Q2.2(b) [3 marks]

Monthly energy consumption between 0- 60 kWh

Table Q2.2(a)

Monthly consumption kWh	Unit charge Rs/kWh	Fixed charge Rs.
0-30	2.50	30.00
31-60	4.85	60.00

Monthly energy consumption greater than 60 kWh

Table Q2.2(b)

Monthly consumption kWh	Unit charge Rs/kWh	Fixed charge Rs.
0-60	7.85	N/A
61-90	10.00	90.00
91-120	27.75	480.00
121-180	32.00	480.00
>180	45.00	540.00

[Total marks: 15]

Question 3

a) Define recovery voltage and re-striking voltage with reference to the electric arc extinction in a circuit breaker [4 marks]

b) Insulators of the distribution lines in the coastal areas fails more frequently than the other regions of the country. What might be the reason? [3 marks]

c) Four 220 kV transmission lines have to be connected to 33 kV feeders with the help of two 220 kV/33 kV transformers in a grid substation. Two types of bus bar schemes are proposed for the HV side of the grid substation:

- Main and transfer bus bar
- Mesh scheme

Compare the above bus bar schemes with respect to the following requirements and recommend a suitable bus bar arrangement for the grid substation

- Continuity of supply during the outages of breakers/ bus bar
- Future expansion
- Cost effectiveness

[8 marks]

[Total marks: 15]

Question 4

A 132 kV, 100 km long transmission line delivers a load of 50 MW operating at 0.9 power factor lagging. Series impedance of the line is $(0.12 + j\,0.45)\ \Omega\ km^{-1}$ and shunt susceptance is $0.4 \times 10^{-6}\ Skm^{-1}$. Voltage at the load is equal to the rated voltage

a) Compute:
   I. sending end voltage and current
   II. sending end power and power factor
   III. transmission efficiency

[13 marks]

b) With the help of necessary calculations, show that the effect of line capacitance is negligible [3 marks]

c) In order to reduce the sending end voltage to 138 kV (while keeping receiving end voltage at rated value), capacitors have been connected to the line in series. If the per-phase capacitance is Xc, derive an expression to determine Xc. Solving the equation is not required. [4 marks]

[Total: 20 marks]

Question 5

Consider a power system shown in figure Q5. Ratings of the generators (G1,G2), transformers (T1,T2) and line impedance (L1,L2) are indicated in the figure. Per unit values given are on equipment base.

a) Calculate the per unit values of the system on common base of 10 MVA at 11 kV generator G1 [8 marks]

b) A three-phase fault occurs at the end of distribution line L2. Calculate
   - Short circuit current in kA
   - Fault level in MVA

[10 marks]

c) How does the location of the fault in line L2 and the fault impedance affect the short circuit current?

[2 marks]

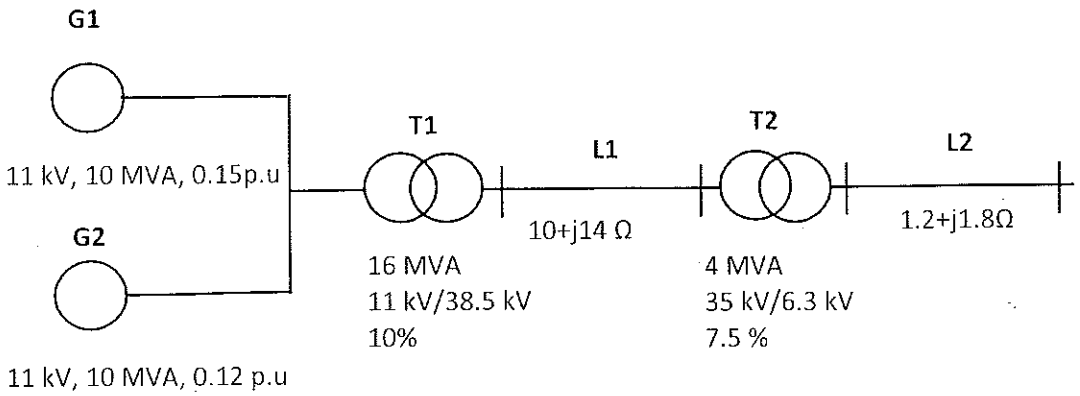
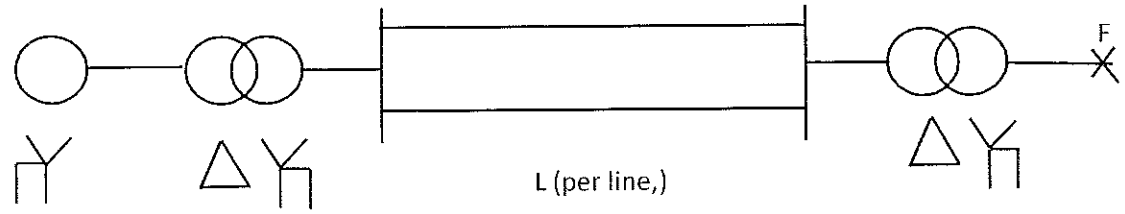


Figure Q5

[Total: 20 marks]

Question 6

The single line diagram of a three-phase power system is shown in figure Q6. Positive, negative and zero sequence reactances of the system elements in p.u. on common base are indicated in the figure. A single line to ground fault (in phase A) occurs at point F.



G1

X1=0.14;

X2=X0=0.08;

T1

X1=X2=X0=0.109

X1=X2=0.124

X0=0.31

T2

X1=X2=X0=0.18

Figure Q6

a) Sketch positive, negative and zero sequence networks and calculate equivalent positive, negative and zero sequence reactance with respect to the fault point [10 marks]

b) Calculate fault current in p.u. [4 marks]

c) What would be the current in phase B [1 mark]

[Total: 15 marks]