00063

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	: 2020/2021
Date	: 30th January 2022
Time	: 0930-1230hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Six (6)** questions in **Five (5)** pages.
3. Answer **ALL** the questions
4. Answer for each question should commence from a new page.
5. No 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.

Q1

a) List three advantages of having mixture of different types of power plants in an electrical power system [3 marks]

b) Compare pumped storage power plants with the battery energy storage systems under following headings:
   i. Capital investment
   ii. Construction time
   iii. Lifetime
   iv. Locations in the system

[4 marks]

c) Briefly describe the following statements:
   i. Nuclear power plants produce clean energy. However, these plants can also bring huge damage to the environment. [4 marks]
   ii. Factors that are to be considered in locating gas turbine power plants is much less than that of coal power plants. [4 marks]

[total: 15 marks]

Q2

a) A grid substation receives power from two 220 kV transmission lines and this power is distributed to eight 33 kV feeders using two parallel operating 220 kV/33 kV transformers. Busbar arrangement used in the substation is double bus bar with a bus coupler.
   i. Sketch the busbar arrangement clearly indicating all the incoming, outgoing feeders, circuit breakers, and isolators [7 marks]
   ii. Write the steps to be followed to transfer power from one of the busbars to the other (you can use any of the connection drawn in (i)). [2 marks]

b) Briefly explain the operation of following elements of Air Brake Circuit Breaker in interrupting an electric arc.
   i. Arc hone
   ii. Arc chutes

[4 marks]

c) State whether the circuit breaker given in (b) can be used for high voltage applications. Give reason(s) if any [2 marks]

[total: 15 marks]

Q3

A small community consisting of number of houses does not have access to the electricity from the gird. They have decided to build a solar power plant to meet their electricity demand. Total area of the solar panels is 100 m^2. Daily load curve of these houses is given in figure Q3.1. Solar panel efficiency is 18%. Solar irradiation of the location in W/m^2 is given in figure Q3.2.

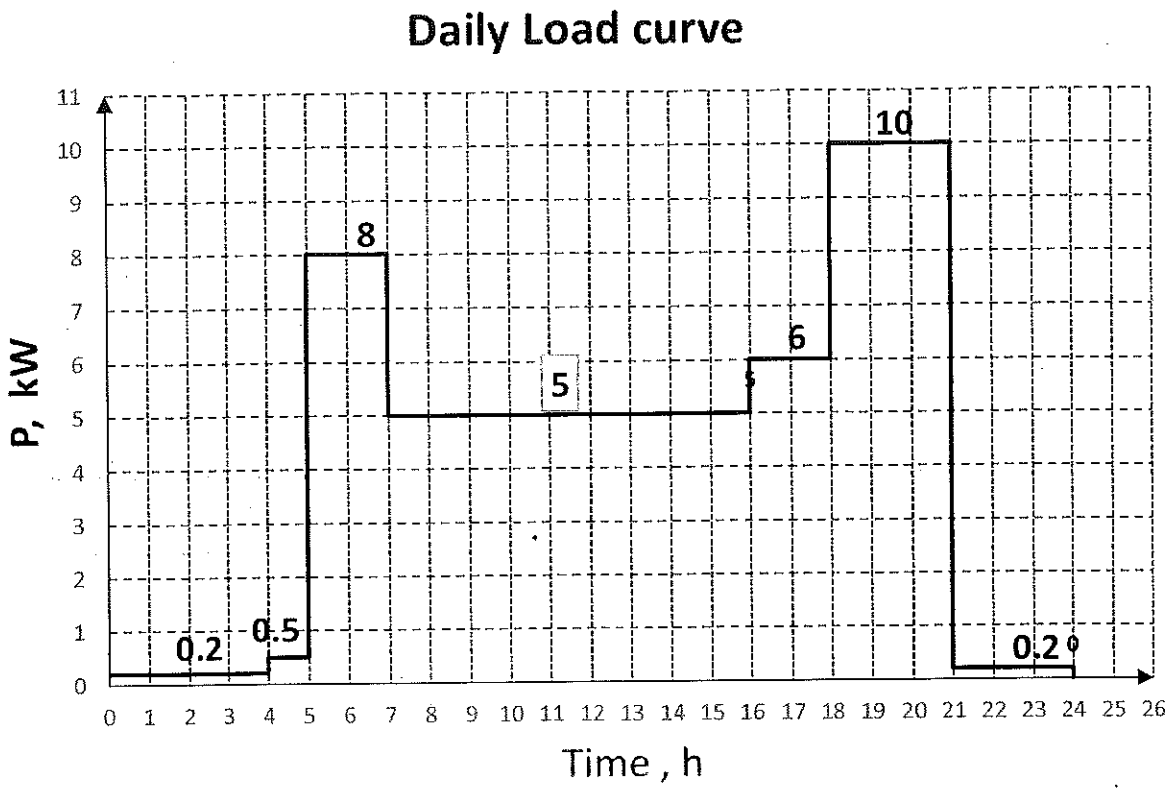


Figure Q3.1

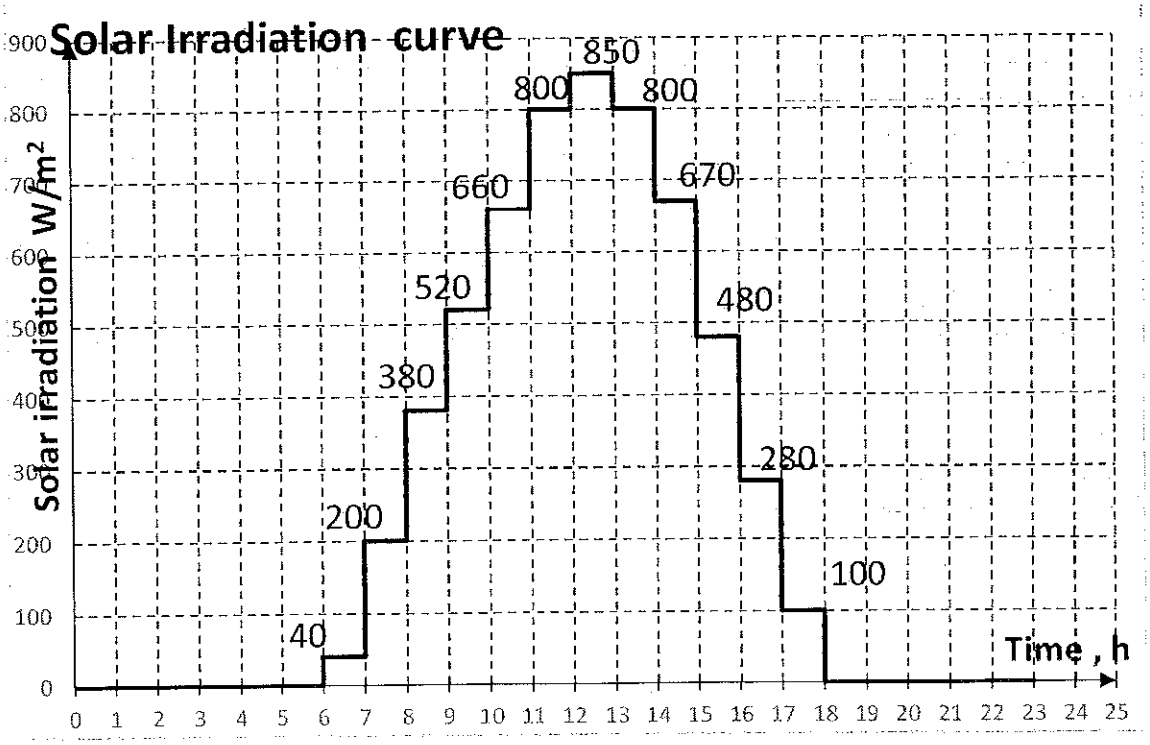


Figure Q3.2

a) Calculate:
   i. energy requirement by the community during daytime (0600-1800 h) and nighttime (1800-0600 h) separately.
   ii. Hourly power delivery by the solar power plant (from 0600-1800 h) [8 marks]

b) State whether the solar power plant can deliver the required amount of power to the houses during daytime. Explain your answer [4 marks]

c) It is proposed to install a battery energy storage system to meet the energy requirement during nighttime. These batteries are charged using excess amount of energy produced by the solar power plant during daytime and the stored energy is discharged to the loads during nighttime.
   i. Determine the amount of energy that is available for charging the batteries
   ii. State whether, the batteries can fulfil the nighttime energy requirement of the community. Give reasons

[4 marks]

d) It was also proposed to build a mini hydro power plant instead of this solar power plant. Write two advantages and disadvantages of having mini hydro plant instead of solar power plant in this situation. [4 marks]

[total: 20 marks]

Q4

A 22 kV generator (G) delivers power to a load of 80 MW at 0.9 power factor lagging through a 160 MVA, 22 kV/138 kV transformer (T) and 132 kV transmission line (L) shown in figure Q4. Per-phase reactance of the line is j45 Ω (resistance and shunt susceptance are neglected). Transformer leakage reactance is j0.11 p.u. The voltage at the load end (point A) is 133.32 kV

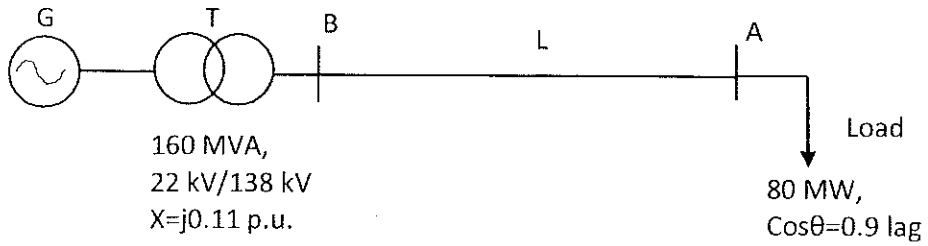


Figure Q4

i. Calculate per- unit parameters of the elements in the system shown considering generator voltage as base voltage and 100 MVA as base power. [5 marks]
ii. Sketch the per-phase equivalent circuit of the system and indicate all parameters in p.u. [2 marks]

iii. Calculate:
- line current in kA and in p.u [4 marks]
- voltage at the HV side of the transformer (point B) in p.u and kV [5 marks]
- generated power and power factor of the generator [4 marks]

[total 20 marks]

Q5

A generator (G) supplies power to a motor (M) via a transformer (T) as shown in figure Q5. During normal operating condition, current delivered by the generator is (0.8-j0.6) p.u. and the generator terminal voltage (point A) is 1.0 p.u. Reactances of the generator and motor are j0.12 p.u. and j0.2 p.u. respectively. Suddenly, a single line to ground fault occurs at the motor terminal (point B). Parameters of the elements of the system are given below:

Generator (G) : $X^{(1)}$=j0.12 p.u.; $X^{(2)}$=j0.15 p.u.; $X^{(0)}$=j0.08 p.u.

Motor (M) : $X^{(1)}$=j0.2 p.u.; $X^{(2)}$=j0.25 p.u.; $X^{(0)}$=j0.07 p.u.

Transformer (T) : X=j0.11 p.u.

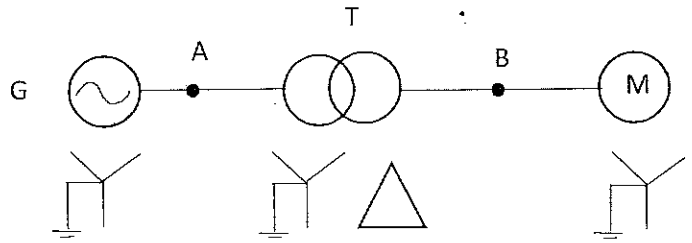


Figure Q5

i. Calculate emf of the generator (E_G) and the motor (E_M) prior to the fault [4 marks]
ii. Sketch positive, negative and zero sequence networks diagrams [5 marks]
iii. Calculate fault current at point B [6 marks]

[total: 15 marks]

Q6

a) Define string effciency and its significant in a power system
b) Explain transposition of conductors and its use in power transmission
c) What is ACSR and its advantages?
d) Describe advantages of the usage of underground cables over the usage of overhead lines in power distribution

[total: 15 marks]