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

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4542 – Power Systems I**
Academic Year	: 2023/2024
Date	: 11th March 2025
Time	: 13:30-16:30 hrs

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of five **(5)** questions in four **(4)** 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.

Question 1

(a) A significant part of electric vehicles (EV) is charged connecting them to 230 V socket outlets at homes. Usually, this EV charging happens at home after 23:00 h. Briefly describe the main positive to the load curve due to EV charging happening during the above time. [4 marks]

(b) It is proposed to allocate battery energy storage devices (BESD) in electrical systems that consist of a higher number of solar PVs. Briefly explain what problem(s) is going to solve by integrating BESD into the electrical systems with solar PVs. [5 marks]

(c) Consider a hypothetical power system which has a daily load curve as shown in Fig. Q1. The load of the power system is met by one or a combination of the following power plants.

- Run-off river plant
- Hydropower plant with limited reservoir capacity
- Coal power plant
- Gas Turbine power plant

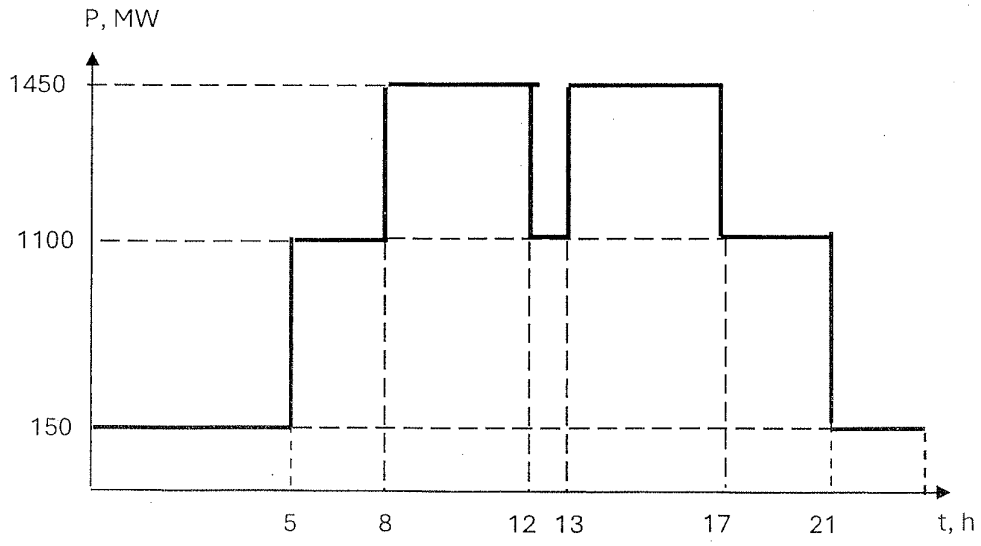


Fig.Q1

Answer the following questions with techno-economic justification.

(i). What is the most appropriate capacity of run-off river plant? [3 marks]

(ii). What is the possible maximum power that can be delivered by the coal power plant? [3 marks]

(iii). If the gas turbine power plant has 150 MW, what can be the capacity of hydro power plant with limited reservoir capacity? [3 marks]

(iv). the dry season, the hydropower plants in the system cannot run at their full capacity. What are the options available to the system operator to keep the system balanced during the dry season? [2 marks]

Question 2

(a) Distinguish the functions of each of the following electrical equipment.

(i). Circuit Breaker

(ii). Isolator

(iii). Load Break switch

[6 marks]

(b) Explain briefly the importance of "making current" and "breaking current" of a circuit breaker in selecting a circuit breaker for a given location in the power system. [3 marks]

(c) Generally, insulators are designed so that flashover takes place before the puncture. Explain the reason. [3 marks]

(d) High voltage (HV) side of a grid substation has six 220 kV incoming lines and two parallel operating 220 kV/ 33 kV transformers (Fig. Q2)

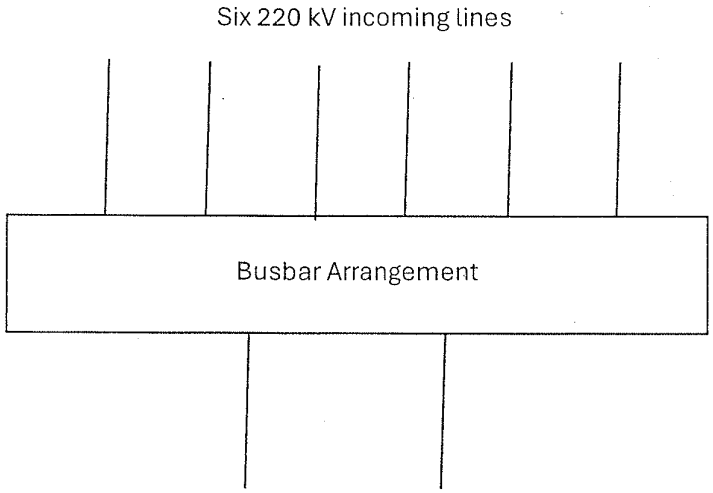


Fig.Q2

The following possible bus-bar arrangements are proposed.

- Main and Transfer busbar scheme
- Double busbar scheme
- Double busbar with bypass isolator

Propose the most suitable bus-bar arrangement for the HV side of the substation. Evaluate your answer based on the three criteria: reliability, economically, and complexity. [08 marks]

Question 3

A generator (G) delivers power to a load of 4.2-j0.8 p.u. through a transmission line (L) as shown in Fig.Q3. Impedance of the transmission line is Z = (0.008+j0.1) p.u. Voltage at the generator is $V_1 = 1\angle 0^0$ p.u. Initially, the capacitor is not connected to the load bus (switch SW is open). The voltage at the load bus ($V_2\angle\delta$) is unknown.

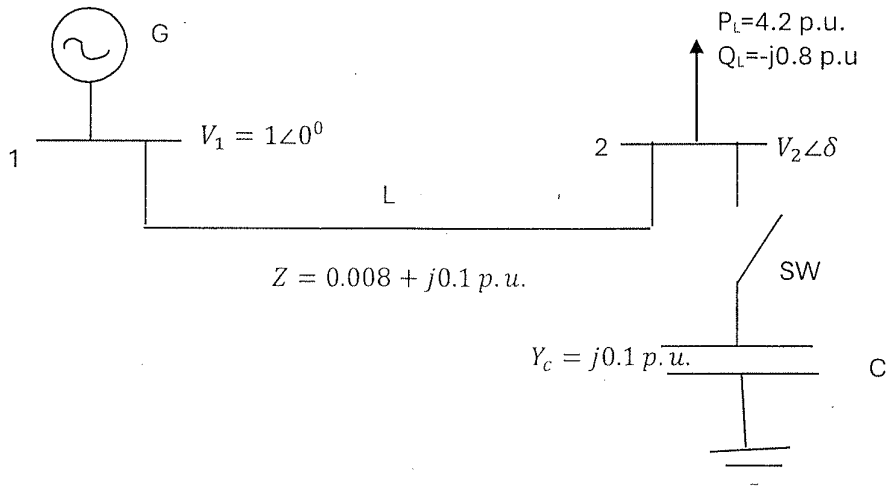


Fig.Q3.

(a) Write an expression for the current though the line (I_{12}) in terms of V_1, V_2, δ and $\underline{Z}$ [4 marks]

(b) Write an expression for the load current (I_L) in terms of $P_L, Q_L, V_2,$ *and* δ [4 marks]

(c) If the magnitude of the voltage at bus 2 is 0.8860 p.u, Using the expressions obtained in (a) and (b), determine the phase angle δ. [8 marks]

(d) Now, the capacitor C ($Y_C = j0.1\ p.u.$)is connected to the load bus to improve the voltage at load up-to 0.95 p.u. Write an equation to determine the new phase angle δ (solving the equation is not required) [4 marks]

Question 4

Consider the power system shown in Fig.Q4. Reactances of all the elements (generators, lines, and the transformer) are indicated in Fig. Q4. A three-phase short circuit occurs at point F which is 30% distance from the bus 1.

Calculate:

(a) Short circuit current [12 marks]

(b) Voltage at buses 1 and 4 during the fault [8 marks]

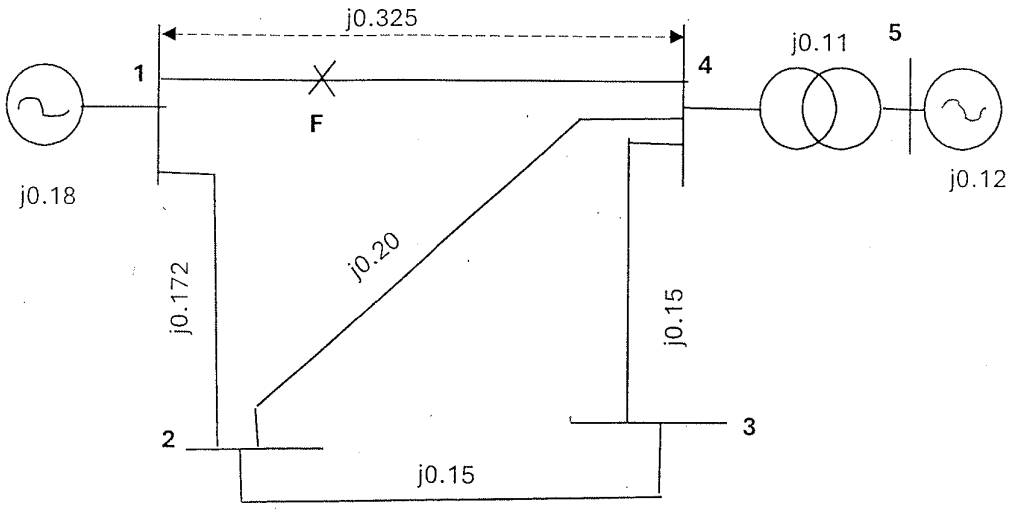


Fig.Q4

Question 5

A 100 MVA, 18 kV synchronous generator (G) is connected to a 100 MVA, 18 kV/33 kV transformer (T) (Fig.Q5). The generator is Y-connected, and the neutral point is solidly earthed. LV side of the transformer is delta connected and the HV side is Y connected with the neutral point is grounded. Positive, negative and zero sequence reactance of the generator are 0.19 p.u., 0.16 p.u. and 0.05 p.u. respectively. The transformer reactance is 0.11 p.u.

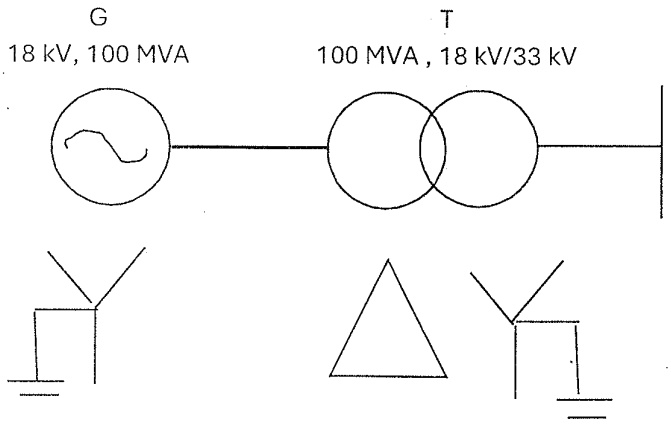


Fig.Q5

A single line-to-ground fault occurs at the HV side of the transformer.

(a) Calculate
  (i). Fault current in in kA [8 marks]
  (ii). Phase voltages (kV) at the generator terminal during the fault [8 marks]

(b) Determine inductive reactance to be inserted at the neutral point of the Y-connected windings of the transformer, to limit the single line to ground short circuit up-to 3.333 p.u. [4 marks]