070

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	: 2022/2023
Date	: 11th February 2024
Time	: 0930-1230hrs

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

I. Sketch block-schematic diagram of a coal-fired thermal power plant and indicate its main parts [8 marks]

II. List two factors that decide locating of a coal-fired thermal power plant. [2marks]

III. Critically analyze the feasibility of replacement of a coal power plant with a nuclear power plant of the same capacity under the following topics. Technical, environmental, socio-economic. (your answer should be limited to 250-300 words) [5 marks]

IV. New constructions of fossil fuel-based power plants are going to be stopped due to their negative effects to the environment and depletion of fossil fuel. It is planned to replace these plants with renewable energy-based power plants. Briefly describe the challenges faced by the power grids due to this change. Your answer should focus on power availability, economic issues, and technical feasibility. (your answer should be limited to 250-300 words) [5 marks]

Question 2

a. Clearly distinguish the functions of isolator, load-break switch and circuit breaker. [5 marks]

b. Describe why voltage distribution across the insulating discs of an insulator is not uniform [3 marks]

c. In a substation, four 132 kV transmission lines (L1, L2, L3 and L4) are connected to two step-down transformers 132 kV/ 33 kV (T1, T2) using a mesh scheme (shown in figure Q2).

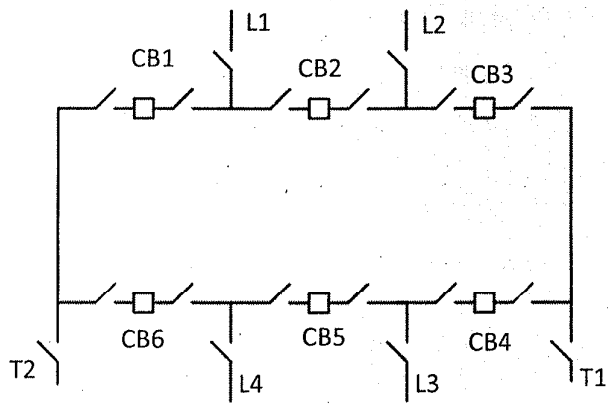


Figure Q2

State and describe the problems of the mesh scheme when each of the below listed incidents takes place.

a. a fault occurs in line L1 and CB2rejects to operate.

b. CB1 is taken for maintenance and a fault occurs in L2.

c. CB2 is taken for maintenance and a fault occurs in L3.

[6 marks]

d. If 16 feeders are connected to the 33 kV side of the substation, sketch a suitable busbar scheme. [2 marks]

e. Propose two busbar schemes that can replace the above mesh scheme and give one reason for each proposed schemes (sketching busbar schemes are not necessary)

[4 marks]

Question 3

Bundle arrangement of 500 kV, 50 Hz overhead transmission line is shown in the figure Q3. The detail of the conductor is given in table Q3.

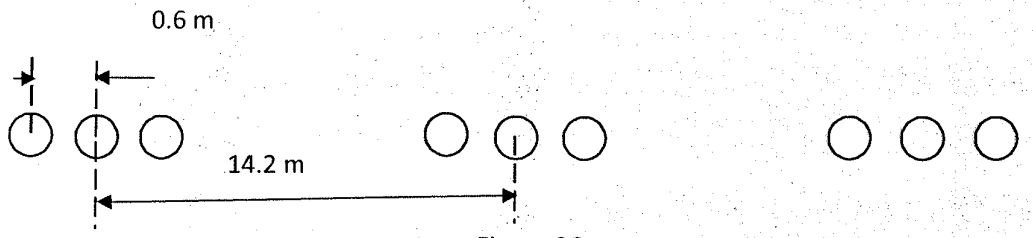


Figure Q3

Table Q3

Conductor type	Outside diameter mm	AC resistance at 20^0C Ω/km	Temperature coefficient $1/^0$C
ACSR	16.5	0.22	0.0043

I. Calculate per-phase inductance and capacitance of the line. (ε=8.85 x10^{-12} Fm^{-1})

[8 marks]

II. If the line operates at the ambient temperature of 32 ^{0}C, calculate per phase resistance of the line. [2 marks]

III. If the length of the line is 200 km, sketch the π – model of the transmission line and indicate the line-parameters in the model. [6 marks]

IV. If the above model is required to be more accurate, list down the additional data you recommend to include. [2 marks]

Question 4

I. A 11 kV, three-phase radial distribution line delivers power from point A to two loads at points B and C of the line as shown in figure Q4. Per- phase line impedance of the lines AB and BC, and three-phase loads are indicated in the figure. Shunt susceptances of the lines are negligible. Voltage at point C is to be maintained at 11 kV.

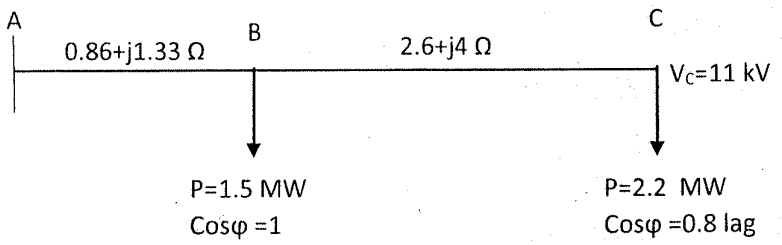


Figure Q4

Calculate the following.

a. currents in each segment of the line. [5 marks]
b. Voltage at load B and at the supply-end A. [5 marks]
c. Determine active and reactive power flow at the supply end [4 marks]
d. Indicate the losses as percentages of the total power delivered from the supply [2 marks]

II. Without any calculation assess how the voltage at point C would change compared to its value obtained in part I under each of the following scenarios
[hint: use the analytical expression of the voltage drop across the line]

a. A capacitor bank is connected to the load point at C (reactive power generated by the capacitor bank is less than the reactive power absorbed by the load at C) [2 marks]
b. A solar PV plant is connected to load point at C (solar PV power generation at the instance is greater than the load power consumption) [2 marks]

(important: throughout the calculation voltage at C should be taken as reference)

Question 5

I. Unbalanced voltages of a three-phase system are given below
$\underline{V_A} = 230\angle 30^0\ V, \quad \underline{V_B} = 192\angle -70^0\ V, \quad \underline{V_C} = 120\angle 165^0\ V$
Calculate the sequence components V_{A0}, V_{A1}, and V_{A2} [5 marks]

II. Draw the zero-sequence network of the network given in figure Q5.1 [3 marks]

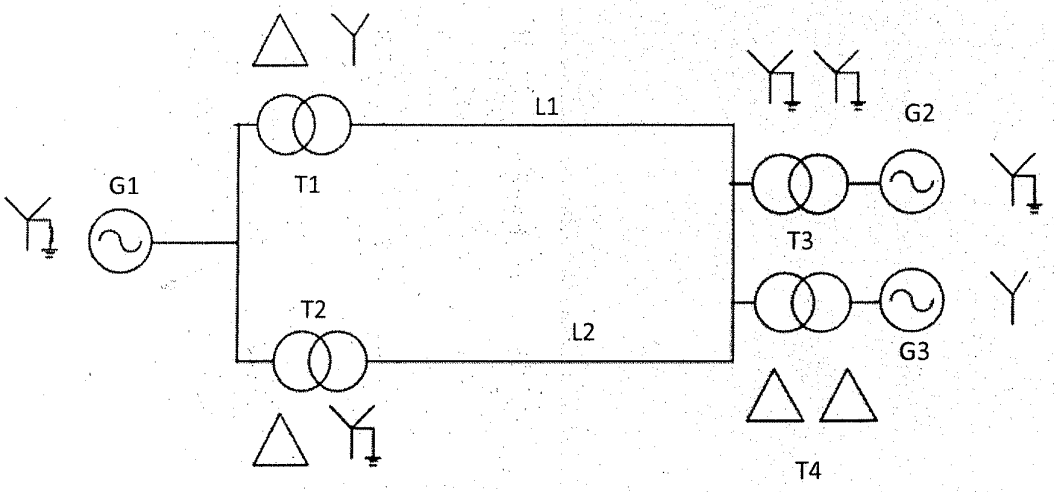


Figure Q5.1

III. Consider the 132 kV power system shown in figure Q5.2. Line reactances are given per unit on common base of 100 MVA. A three-phase short circuit occurs at the midpoint of line L4. Prior to this fault the system was in no-load condition

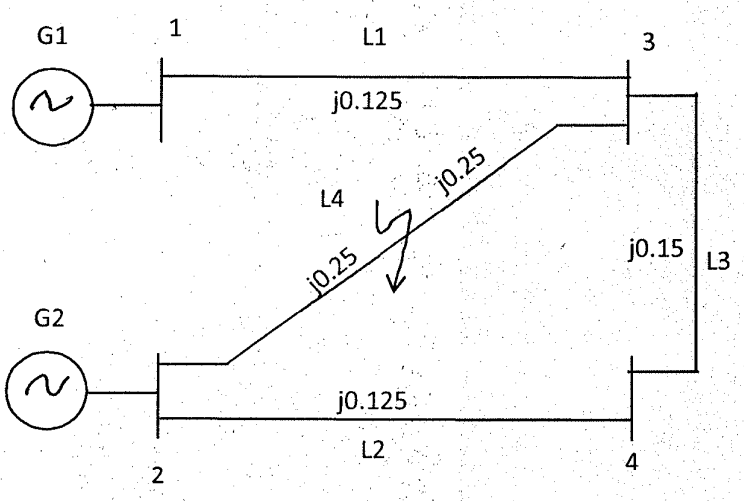


Figure Q5.2

a. Calculate the short circuit current and indicate it in kA [8 marks]
b. Determine the fault level at the fault point [2 marks]
c. Calculate voltage at bus 3 during the fault. [4 marks]