0105

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

Study Programme	:	Bachelor of Science Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**EEX5352 Power Systems II**
Academic Year	:	2024/2025
Date	:	28th January 2026
Time	:	0930-1230h
Duration	:	3 hours

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. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. This is a Closed Book Test (CBT).
7. Log-log papers are available on request.
8. Scientific calculators are allowed.
9. Formula sheet is attached

Question 1

a) Briefly describe why long length transmission lines are not modeled using lumped parameters? [3 marks]

b) A 500 kV, 50 Hz, 275 km long transmission line delivers power of 700 MW at 0.85 power factor lagging. Voltage at the receiving end of the line is 500 kV. Per unit length parameters are given below

$X = j0.323\ \Omega\ km^{-1}$, $Y = j4.75 \times 10^{-6}\ S\ km^{-1}$

Calculate

i. Surge impedance and propagation constant. [4 marks]
ii. Current at the receiving end. [3 marks]

iii. Voltage and current at the sending end. [8 marks]
iv. Express the voltage at the sending end as a percentage of the rated voltage and state whether the sending end voltage is within the acceptable range. [2 marks]

Question2

Figure Q2 shows a sample power system. Bus 1 is slack bus having voltage magnitude of 1.1 p.u. with zero phase angle. A load of 1.5 +j0.7 p.u. is connected to the bus 2. A generator connects to bus 3 and delivers power of 0.8 p.u. Voltage magnitude of generator is 1.02 p.u. Reactance of the lines are given in the figure.

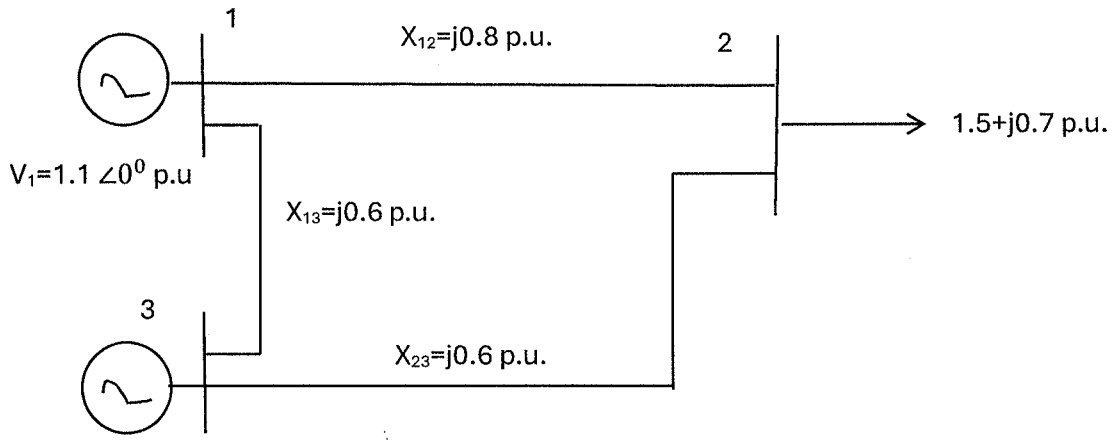


Figure Q2

i. Form the bus admittance matrix. [06 marks]
ii. Calculate unknown voltages and phase angles using Gauss-Seidel method (one iteration is sufficient). [12 marks]
iii. Determine the accuracy of the results. [02 marks]

Question 3

A generator (G) delivers power of 0.9 p.u. to a system (S) via transformer (T) and double circuit lines (L1 and L2) as shown in Figure Q3. Reactance of generator is 0.15 p.u., transformer reactance is 0.1 and each line has reactance of 0.6 p.u. Voltage at the system bus is 1.0 p.u. and excitation voltage is 1.4 p.u.

i. Sketch the power angle curve and indicate mechanical power, initial power angle, and maximum possible power that can be delivered by the generator [08 marks]

ii. A three-phase fault occurred at point F. If a=0.25, determine whether the system remain stable under sustained fault condition. Assume that the excitation voltage remains unchanged. [12 marks]

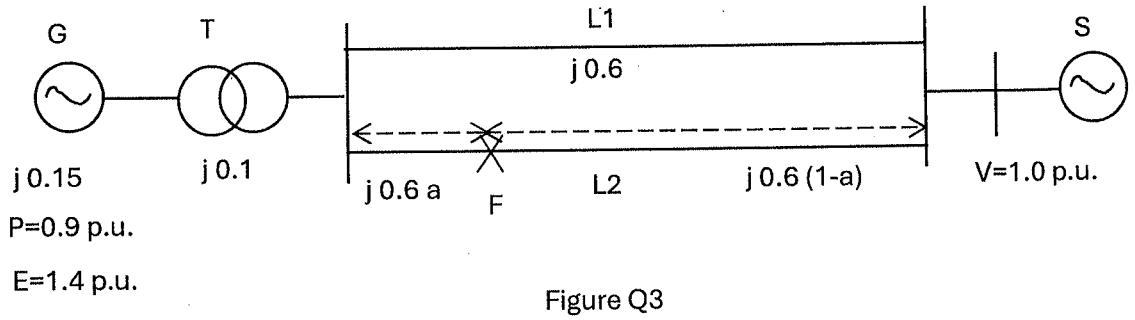


Figure Q3

Question 4

a) A 33 kV distribution line shown in figure Q4 (a) is protected by overcurrent relays at circuit breaker's locations A and B. Relay at A provides back-up protection for the relay at B. The current transformer ratios at A and B are 500:1 and 600:1 respectively. Pick-up values of relays at A and B are 0.75 A and 0.5 A respectively, Three-phase fault current at maximum generating condition at location B is 3000 A.

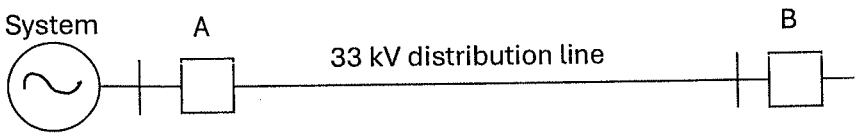


Figure Q4(a)

With the time multiplier set at 1.0 the operating time versus plug setting multiplier (PSM) characteristic of the relays on any plug setting is given in the table Q4.1. The operating time on any time multiplier setting is proportional to the operating time on time multiplier 1.0.

Table Q4.1

Operating time (s)	10	6.8	5	4.3	3.9	3.6	3.4	3.0	2.2
PSM	2	3	4	5	6	7	8	10	20

If the time multiplier setting of the relay at B set at 0.3, determine the time multiplier setting of the relay at A. Consider discriminating margin as 0.4 s [08 marks]

b) A 13.8 kV line delivers maximum load of 10 MVA at 0.8 power factor lagging as shown in Figure Q4 (b). The line is to be protected using distance protection. Current transformer ratio and voltage transformer ratio at the circuit breaker location are 500:5 and 13.8 kV: 120 V respectively. The line impedance is 4+j40 Ω.

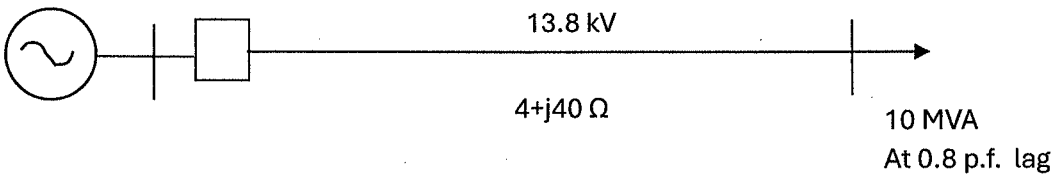


Figure Q4 (b)

i. If the type of the distance relay is Mho, determine Zone 1 and Zone 2 settings (consider angle setting is same as the impedance angle). [04 marks]
ii. Calculate load impedance seen by the relay. [03 marks]
iii. Sketch relay characteristic, transmission line and the load impedance in a same graph. [03 marks]
iv. State whether the line can serve the load without tripping under the setting determined in i. [02 marks]

Question 5

a) Two generating units of a power plant are operating in parallel and share a common load. The load varies from 400 MW to 1800 MW. Both the units are operating all the time. Fuel cost functions of the units are given below.

$C_1=400+6.0\ P_1+0.004P_1^2$ \$/ h $200\leq P_1\leq 900$ MW

$C_2=500+6.8P_2+0.002\ P_2^2$ \$/h $200\leq P_2\leq 900$ MW

If the units are to share the load optimally

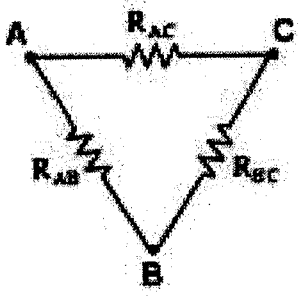
i. Determine incremental fuel cost characteristics of the units [02 marks]
ii. Determine whether both the units start to load from the beginning or only one is loaded while other unit is operating at its minimum power. [04 marks]
iii. Calculate the power delivered by each unit when the load is 1300 MW. [08 marks]

b) Briefly explain Fast-Decoupled method of load flow calculation using appropriate equations. What is the advantage of this method when compared with the Newton-Raphson method [06 marks]

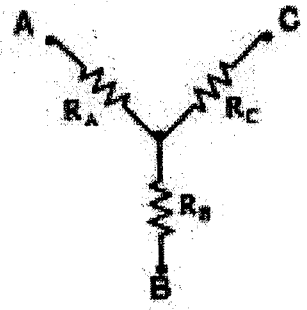
Formula Sheet

$$P_i - Q_i = \sum_{j=1}^{n} \widehat{V}_i Y_{ij} V_j$$

Delta (Δ) network



Wye (Y) network



To convert a Delta (Δ) to a Wye (Y)

$$R_A = \frac{R_{AB} R_{AC}}{R_{AB} + R_{AC} + R_{BC}}$$

$$R_B = \frac{R_{AB} R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

$$R_C = \frac{R_{AC} R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

To convert a Wye (Y) to a Delta (Δ)

$$R_{AB} = \frac{R_A R_B + R_A R_C + R_B R_C}{R_C}$$

$$R_{BC} = \frac{R_A R_B + R_A R_C + R_B R_C}{R_A}$$

$$R_{AC} = \frac{R_A R_B + R_A R_C + R_B R_C}{R_B}$$