00087

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

Study Programme	: Bachelor of Science in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX5352 Power Systems II**
Academic Year	: 2023/24
Date	: 06th March 2025 (13:30-16:30)

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **five (05)** questions on **four (04)** pages.
3. Answer **all** the **questions**
4. Answer to each question should commence from a new page.
5. Graph papers are available on request.
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) Prove that when a long length transmission line is terminated by the surge impedance, magnitude of voltages at both ends of the line are equal. [4 marks]

(b) A 500 kV, 50 Hz, 300 km transmission line connects a large capacity power plant that delivers power to a grid substation. The parameters of the line are given below. Resistance of the line is neglected.

$X = j0.38\ \Omega km^{-1}$; $Y = j\,5.2 \times 10^{-6}\ Skm^{-1}$

Calculate:

(i). Surge impedance and propagation constant of the line. [2 marks]

(ii). ABCD constants for the line (hint: ABCD constants should be expressed using hyperbolic functions) [8 marks]

(iii). If the plant delivered 750 MW of power at 0.85 power factor lagging and the voltage at the gird substation is 500 kV, determine the voltage at the sending end of the line. [4marks]

(iv). State whether the voltage at the sending end of the line is at the acceptable level. What measures would you suggest if the voltage is beyond the acceptable level? [2 marks]

Question 2

Consider the power system shown in Fig.Q2. Voltage of bus 1 is given as $1.05\angle 0^0$ p.u. Magnitude of the voltage at generator bus 4 is 1.02 p.u. Power delivered by the generator at bus 4 is 0.75 p.u. Load at bus 3 is 1.4+j 1.05 p.u. A reactor having shunt susceptance (Y_R) of -j1.25 p.u. is connected to the bus 2. Line reactance of the branches in p.u. are indicated in the figure. All the per unit values are given on a common base.

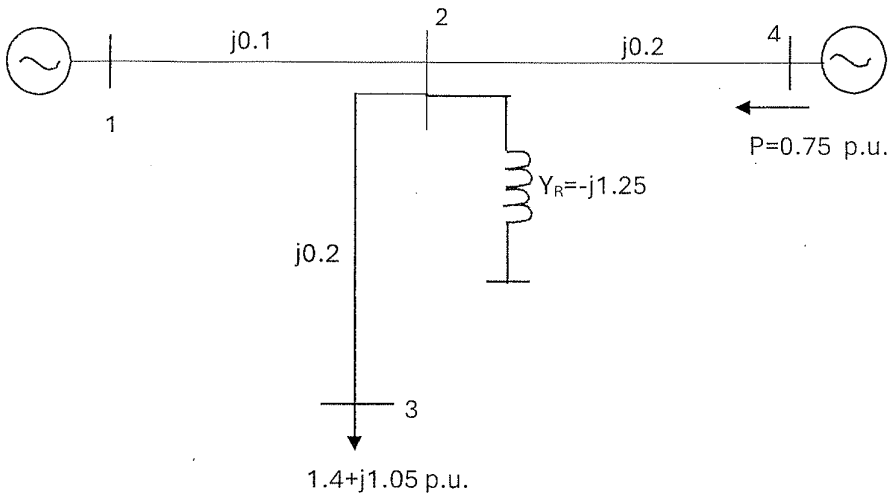


Fig. Q2

(i). Determine the bus admittance matrix. [5 marks]
(ii). Calculate unknown voltages of the buses after first iteration of Gauss- Seidel method. [10 marks]
(iii). Determine slack bus power and power factor. [2 marks]
(iv). If the generator at bus 4 has reactive power limits from 0 p.u. (Qmin) to 1 p.u. (Qmax), state whether the generator can serve as the PV bus. Explain your answer [3 marks]

Question 3

(a) With the help of the power angle curve, describe how fast excitation control can prevent loss of synchronism due to a large disturbance. [5 marks]

(b) A three-phase, 50 Hz synchronous generator (G) delivers a power of 0.4 p.u. to a system through a transmission line (L) as shown in Fig.Q3. Direct axis reactance (Xd) of the generator and reactance of the transmission line are 1.2 p.u. and 0.32 p.u. respectively. Excitation voltage (Eq) of the generator is 2 p.u. and system bus voltage is 1.0 p.u. H constant of the generator is 0.4 p.u. The circuit breakers (CB1, CB2) at both ends of the line are open and reclose after T seconds.

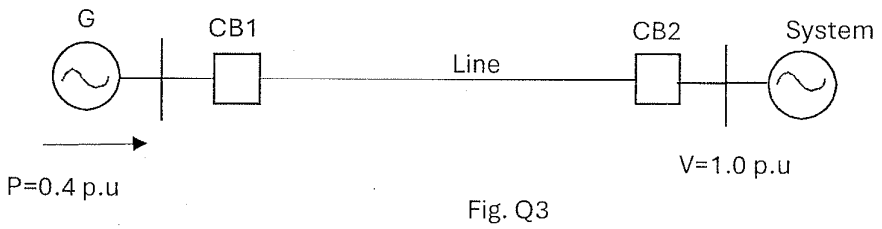


Fig. Q3

(i). Determine critical clearing angle (δ_c) [9 marks]
(ii). Find corresponding critical clearing time (T_C) [3 marks]
(iii). Find the maximum swing angle (δmax) when the breakers are closed after $T=0.9\ T_C$ [3 marks]

Question 4

A 50 Hz, 33 kV radial distribution system is protected by the over-current relays installed at circuit breaker locations A and B as shown in Fig.Q4. The relay at A provides back-up protection for the relay at B.

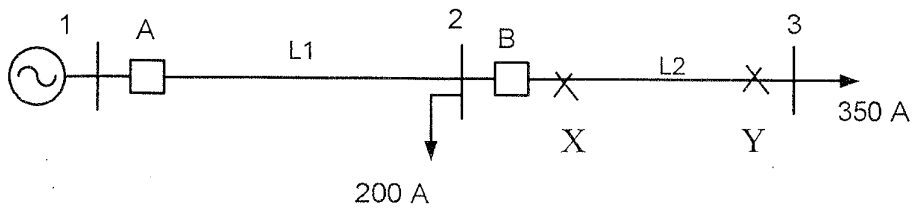


Fig.Q4

Pick-up settings of the over current relays at both the locations can be adjustable by taps at 2.5, 3.75, 5.0, 6.25, 7.5, 8.75 and 10.0 A while time-multiplier can be adjustable from 0.1 to 1 continuously. Time- current characteristic of the relay is given in Appendix A1

Consider the following data given in tables 1,2 and 3,

Table 1

Parameter	Bus 2	Bus 3
Maximum load current (A)	200	350

Table 2

Parameter	A	B
Current Transformer ratio	600:5	400:5

Table 3

Parameter	at point X	at point Y
Three phase fault current (A)	4000	2500

(i). Select suitable pick-up values for the relays at A and B [8 marks]

(ii). If the circuit breaker at B operates in 6 cycles and the current transformer operating time is 0.25 s, determine the time-dial setting of the relay at A [8 marks]

(iii). A three-phase fault of 3000 A occurred in line L2 and the relay at B did not respond. How long does it take to isolate the fault by the relay at A [4 marks]

Question 5

(a) A transmission line is fully protected by a Mho relay having the maximum reach of 10 Ω. CT and VT ratios at the relay location are 500 A: 5 A and 20000 V : 66 V. Line impedance angle and maximum torque angle of the Mho relay are same and equal to 80^0. A three-phase fault with the fault resistance of R occurs at the 80% of the line.

(i). Sketch the relay characteristic and indicate transmission line and maximum fault resistance (Rmax) on the same graph. [4 marks]

(ii). Determine analytically maximum allowable fault resistance (Rmax) [8 marks]

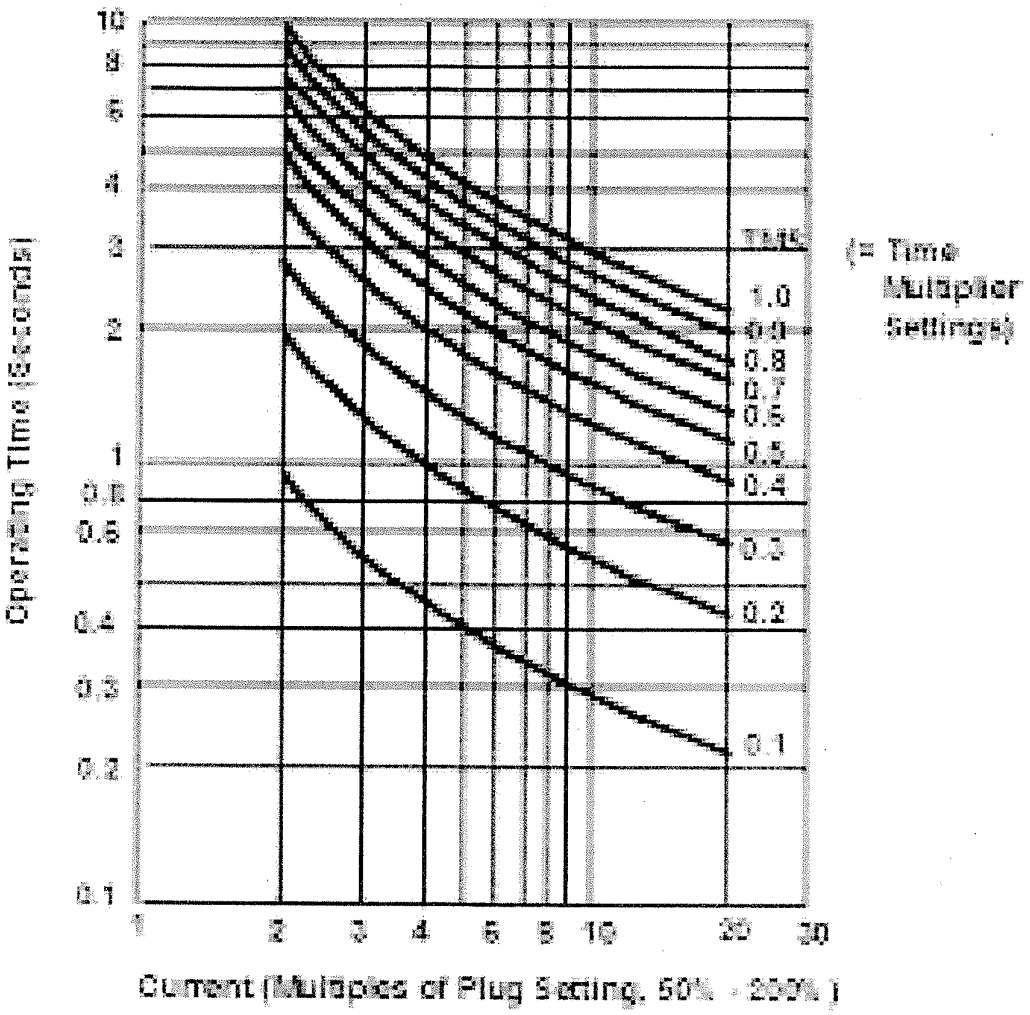
(b) Two generators of a thermal power plant have fuel-cost characteristics as given below

$C1=10P_1+0.008P_1^2$ \$/h $\quad 100 \leq P_1 \leq 600$ MW

$C2=8P_2+0.00P_2^2$, \$/h $\quad 400 \leq P_2 \leq 1000$ MW

Calculate the economic power dispatch between the generating units for the total load of 1000 MW and 1400 MW. Losses are neglected [8 marks]

APPENDIX A1


Operating Time (Seconds)
10
8
6
4
3
2
1
0.8
0.6
0.4
0.3
0.2
0.1
1
2
3
4
5
6
8
10
20
30
TMS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
(= Time Multiplier Settings)
Current (Multiples of Plug Setting, 50% - 200%)