00150

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	**: EEX5352 Power Systems II**
Academic Year	: 2021/22
Date	: 02nd February 2023
Time	: 13.30-16.30hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **six (06)** questions in **three (03)** pages.
3. Answer **all** the **questions**
4. Answer for each question should commence from a new page.
5. Relevant charts/ codes are provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear handwriting.
8. Do not use Red color pen.

Question 1 [15 marks]

A synchronous generator delivers power to an infinite bus via double circuit line. The generator operates at the steady state condition at the power angle of 40^0 and its maximum possible power is 3 p.u. Later, one of the lines was switched-off using the circuit breakers at both ends of the line and the maximum possible power of the generator was dropped to 2 p.u.

a) Sketch the power angle curves in a same graph and indicate followig parameters.
   - Pmax before and after switch off the line
   - Pmech mechanical power developed by the rotor
   - Power angles (δ) at the equlibarium points after switching off the line

   [5 marks]

b) Determine whether the generator remains at a transient stable condition with a single line in operation. [10 marks]

Question 2 [15 marks]

A Large capacity power plant connects to a grid substation via a 500 kV, 50 Hz long length transmission line (line length is greater than 240 km). During peak hours, the power delivered by the plant is 120% of the surge impedance loading. The line can be considered as a pure reactive line. The line's characteristic impedance (Z_C) is equal to 292.5 Ω while the multiplication of phase constant with the line length (βl) is equal to 42^0. Voltages at both ends of the line are kept at 500 kV

a) Determine the current and reactive power at the receiving end of the line [10 marks]
b) Calculate the voltage at the midpoint of the line. [5 marks]

Question 3 [20 marks]

Consider a power system shown in figure Q3. Mutual admittances of the bus admittance matrix are as given below. The values are given in p.u on the common base of 100 MVA

$$Y_{14} = j13.5;\ Y_{12} = j6.753;\ Y_{13} = j6.267;\ Y_{24} = j5.065;\ Y_{34} = j5.8$$

The voltage at bus 1 is $1.05\angle 0^0$ p.u. The buses 2 and 3 are load buses while bus 4 is a generator bus without an automatic voltage regulator. Active and reactive power of these three buses are as indicated in the figure.

a) Calculate voltage at buses 2,3 and 4 after the first iteration of Gauss-Seidel method [12 marks]
b) Determine the accuracy of the results obtained in (a) [3 marks]
c) Calculate power flow from bus 4 to bus 1 [5 marks]

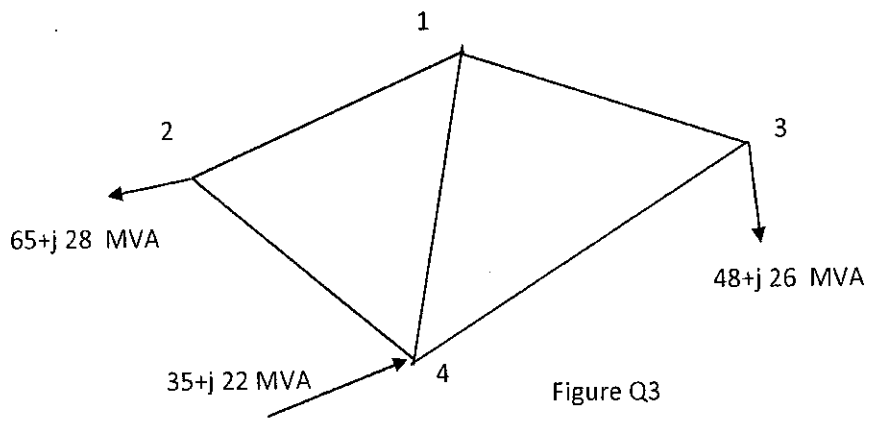


Figure Q3

Question 4 [20 marks]

A three-bus power system shown in figure Q4 is to be solved using decoupled loadflow method. Bus data are given in table Q4. Mutual admittances of bus admittance matrix are given below. The system is to be solved using decoupled loadflow method.

$$Y_{12} = j2.5\ p.u.;\ Y_{23} = j5.0\ p.u.$$

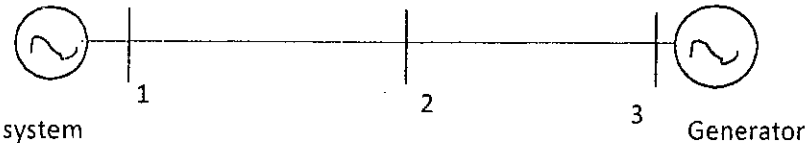


Figure Q4

Table Q4

Bus No	V, p.u.	δ , degrees	P p.u.	Q p.u.
1	1.05	0	--	--
2	--	--	1.5	1
3	1.02	--	0.6	--

a) Calculate active and reactive power mismatches to be used in the first iteration [8 marks]

b) Set up the linearized system of equations that are solved in the first iteration (solving equations is not required) [12 marks]

Question 5 [15 marks]

A Mho relay has a maximum reach of 60 Ω, at angle making 60^0 with the R- axis, on the R-X plane. A transmission line having an impedance of (25+j96) Ω is protected by the Mho relay with the relay at the beginning of the line.

a) Sketch the operating diagram of the Mho relay and the transmission line in the same graph, and mark the operating and non-operating region of the relay and the fraction of the transmission line protected by the relay. [4 marks]

b) Calculate the fraction of the transmission line protected by the relay. [8 marks]

c) A resistive fault occurs at the mid-point of the transmission line and the relay detects the fault successfully. Show the maximum fault resistance (R max) in the operating diagram. Calculation of Rmax is not required. [3 marks]

Question 6 [15 marks]

A 33 kV radial distribution system shown in figure Q6 is protected by two identical over current relays installed at circuit breakers' locations A and B. Maximum load currents at buses 2 and 3 are 150 A and 300 A. Three phase short circuit currents at starting and ending points of the line L2 are 6500 A and 4200 A respectively. The plug settings of the relay are at 2.5, 3.75, 5.00, 6.25, 7.5, 8.75, and 10 A and the time lever setting is continuously adjustable from 0.1 to 1.0. The CT ratio at relay locations A and B is 600:5. TMS of the relay at A is set at 0.2 to provide back-up protection for the relay at B. The typical time curves for standard BS and IEC standard over the current relay for TMS from 0.1 to 1 is given in appendix I.

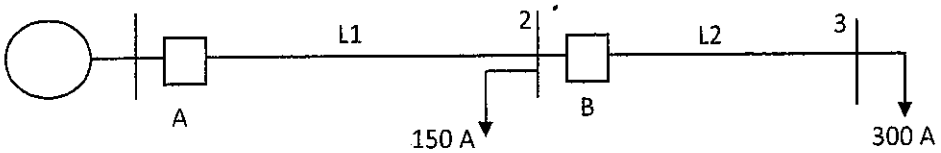


Figure Q6

a) Assess whether the current transformers with a CT ratio of 400:5 is suitable for both relay locations. [4 marks]

b) Determine the suitable pick-up values for the relays at A and B. [6 marks]

c) A short circuit occurs in line L2 and the relay at B failed to operate. If the short circuit current is 5000 A, how long does it take to isolate the fault using the relay at A? [5 marks]

Appendix I

Time curves of the over current relay

