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	**: EEX5832/ECX5332 Power Systems II**
Academic Year	: 2019/20
Date	:26th July 2020
Time	: 0930-1230
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (07)** questions in **six (06)** pages.
3. Answer any **Five (05)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant charts/ codes are provided.
6. This is Closed Book Test (CBT).
7. Answers should be in clear hand writing.
8. Do not use Red colour pen.

Question 1

a) Briefly describe meaning of "loss of synchronism" [4 marks]

b) A synchronous generator delivers power of 35 MW to a large system via two transformers and a transmission line as shown in figure Q1. Maximum power of the generator that can be delivered to the system is 60 MW. The generator loses synchronism due to sudden increase of its output power. Determine possible range of the output power of the generator and corresponding power angle [hint: use equal area criterion] [16 marks]

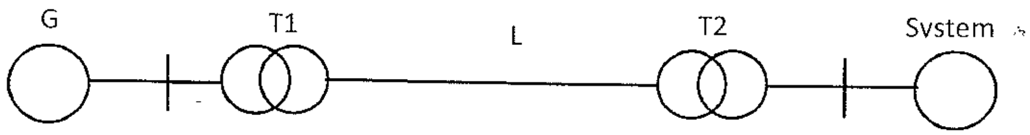

Figure Q1

Question 2

A 500 kV, 300 km transmission line delivers 1000 MW at 0.95 power factor lagging. Series impedance and shunt admittance are $z= j0.32\ \Omega/km$ and $y=j5.2 \times 10^{-6}$ S/km.

a) Calculate surge impedance and propagation constant [4 marks]

b) If the voltage at the receiving end is equal to the rated value, determine sending end voltage and current [10 marks]

c) With the clear arguments, state whether the voltage at the sending end is at the acceptable level. [2 marks]

d) Assess the feasibility of bringing down the sending end voltage to the acceptable level by reducing the voltage at the receiving end. [4 marks]

Question 3

Single line diagram of a three bus power system is shown in figure Q3. Bus data and branch data are given in table Q3.1 and Q3.2. Line parameters are given on 132 kV, 100 MVA base. Bus 1 is slack bus and bus 2 is a PV bus

Table Q3.1: Bus data

Bus No	V, p.u.	P gen MW	Q gen MVAr	P load MW	Q load MVAr
1	1.0	-	-	-	-
2	1.05	250	-	50	10
3	1.0	-	-	200	60

Table Q3.2: Branch data

From	To	R , p.u.	X,p.u
1	2	0.03	0..2
1	3	0	0.25
2	3	0	0.16

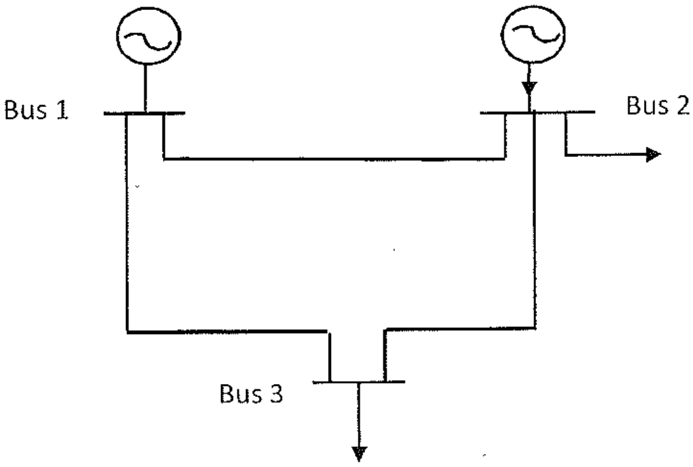

Figure Q3

a) Form the bus admittance matrix [6 marks]
b) Calculate the voltage at buses using Gauss-Seidel method. One iteration is sufficient [10 marks]
c) Calculate the slack bus power and power factor [4 marks]

Question 4

Two generating units of a plant have following incremental fuel cost characteristics in monetary units/MWh

$$\lambda_1 = 2.2\,P_1 + 800$$

$$\lambda_2 = 2.6\,P_2 + 700$$

Minimum and maximum limits of each unit are 5 MW and 60 MW respectively. These two units economically dispatch a common load which vary from 10 MW to 120 MW. Line losses are neglected and both units should operate all the time.

a) Determine which unit should be loaded first while other unit operating at its minimum output [4 marks]
b) Calculate the minimum total power of the plant when both units start to load simultaneously [3 marks]
c) Which unit reaches its maximum power first? [3 marks]
d) Write functions $\lambda = f(P_{plant})$ when load varies from 10 MW to 120 MW [10 marks]

Question 5

a) Distinguish between Newton-Raphson load flow and Decoupled load flow methods. Indicate the nature of Jacobian matrix in these two methods [4 marks]

b) Explain briefly the relation between generator bus voltage magnitude and its reactive power limits (Q_{max}, Q_{min}) in load flow calculation [4 marks]

c) Load flow calculation of a power system shown in figure Q5 has been carried out by using Newton-Raphson method. Bus voltages after number of iterations are indicated in the figure. Convergence tolerance was set as 1 MVA. Line reactance are given on 220 kV, 100 MVA base.

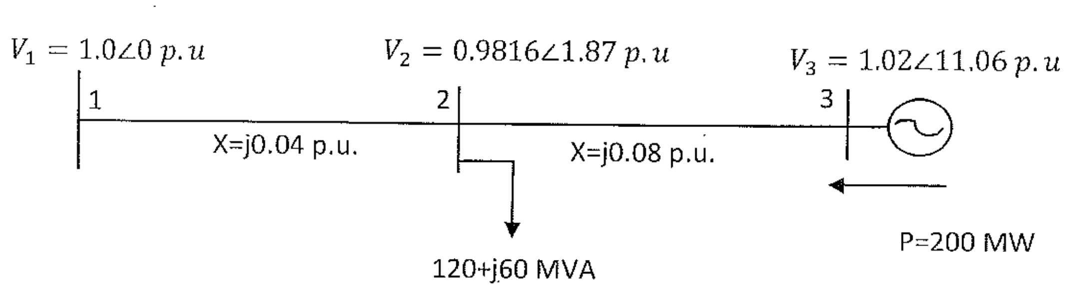

Figure Q5

i. Prove that the iteration process has not been converged to the solution [10 marks]

ii. Calculate active and reactive power flow to the bus 2 from bus 3 [2 marks]

Question 6

A radial distribution system having two lines L1 and L2 are serving two loads is shown in figure Q6. Maximum load current at bus 2 and 3 are 100 A and 300 A respectively. Three phase short circuit current at the beginning and end of the line L2 are 3000 A and 1500 A respectively. The lines are protected by IDMT (Inverse Definite Minimum Time) over current relays installed at circuit breakers X and Y. Pick-up values of the relay are adjustable by taps 1, 1.2, 1.5, 2.0,2.5,3.0, 3.5,4.0, 5.0, 6.0, 7.0, 8.0,10,12 A. Relay's characteristic curve is shown in figure A1 (appendix A, page 6). Current transformer ratio at circuit breaker locations X and Y are 400:5 and 200:5 respectively.

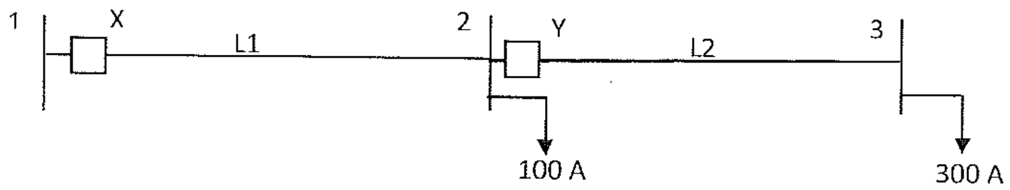

Figure Q6

a) Determine pick-up values of the relays at X and Y [8 marks]
b) What should be the time dial setting of the relay at Y? Explain why? [2 marks]
c) If the relay at X serves as the remote back-up for the relay at Y, determine time dial setting of the relay at X [7 marks]
d) A three phase 2000 A short circuit occurred in line L2 and the relay at X did not operate. How long did it take to isolate the fault by the remote back up relay? [3 marks]

Question 7

Consider 132 kV transmission system shown in figure Q7. Line impedance are indicated in the figure. Maximum load through the circuit breaker A is 120 MVA. The lines are protected by the Mho relay installed at circuit breaker locations. Available distance relay has zone 1 and zone 2 settings from 0.2 Ω to 10 Ω in increment of 0.1 Ω and Zone 3 settings from 0.5 Ω to 40 Ω in increment of 0.1 Ω. The angle of maximum torque can be either 75^0 or 90^0. VT ratio at relay location is 132000:120.

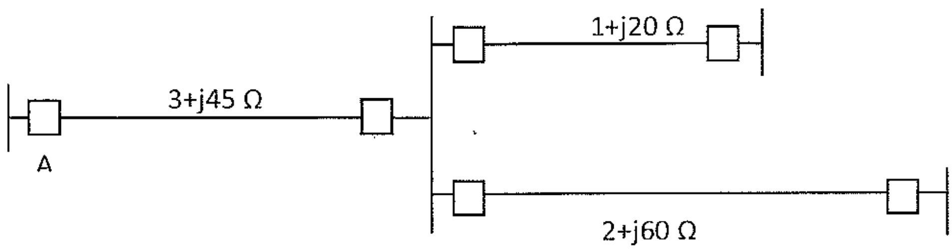

Figure Q7

a) Select suitable CT ratio for the relay at circuit breaker A. Available CT ratio are 200:5, 400:5, 600:1, 600:5 [3 marks]
b) Determine three zone settings for the relay at the circuit breaker A [9 marks]
c) Plot the zone settings in R-X diagram [3 marks]
d) Show the transmission line in the L1 in the R-X diagram drown above and determine actual percentage of the line protected by the relay at A. [5 marks]

Appendix A

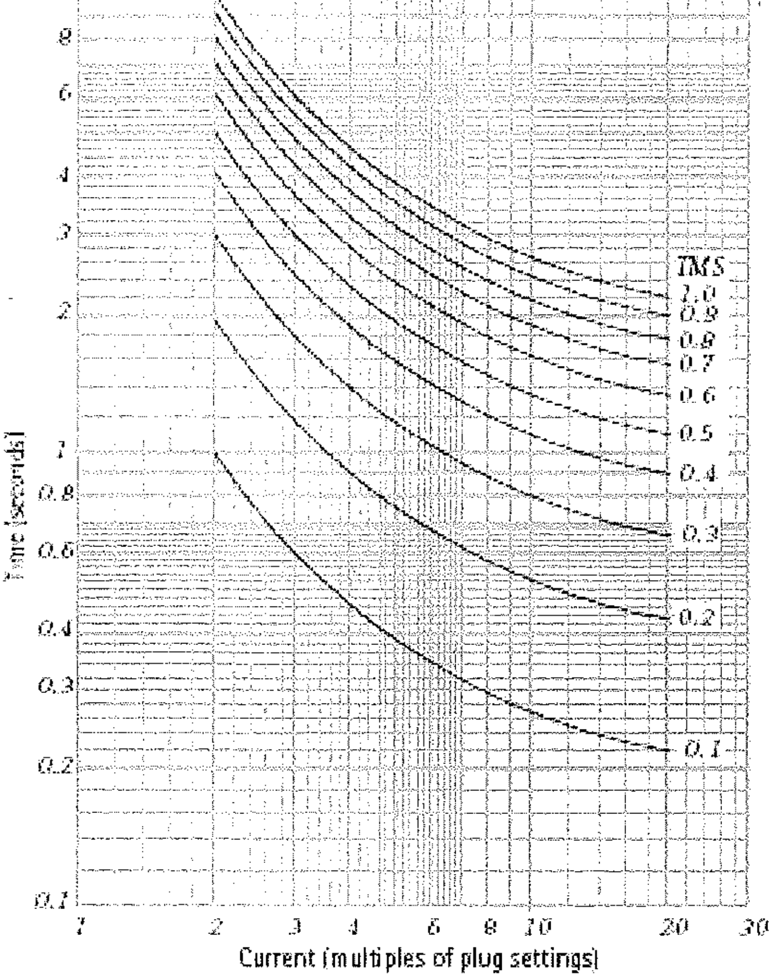

Figure A1. Characteristic curves of IDMT relay