The Open University of Sri Lanka
Bachelor of Technology Honours in Engineering
Final Examination 2015/2016
ECX5332 – Power systems II
Duration Three Hours

Date: 17th November 2016 ***Time: 0930-1230***

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*This paper consists of Six questions. Answer **ANY FIVE** questions. All questions carry equal marks.*
Graph papers will be available on your request.
Show your work.

Question 1

a) Define transient stability. [2 marks]

b) A 200 MVA, 50 Hz synchronous generator has inertia constant of 8 MJ/MVA.

i. Calculate Kinetic Energy of the generator when the machine is operating at the synchronous speed, [2 marks]

ii. Calculate M constant of the machine, [2 marks]

iii. When the generator is operating at the steady sate condition the electrical load is suddenly increased. If the excess of electrical power over the mechanical power at the rotor is 80 MW calculate the acceleration/ deceleration of the rotor at the moment of the increase of the load. [3 marks]

c) A three-phase, 50 Hz synchronous generator (G) delivers power to a system through a double circuit line as shown in the figure Q1. The system receives power of 1.2 p.u at 0.9 power factor lagging. Sub-transient reactance of the generator and reactance of the lines are 0.2 p.u. and 0.4 p.u. respectively. Voltages at the both ends of the lines are maintained at 1.0 p.u. H constant of the machine is 5 s.

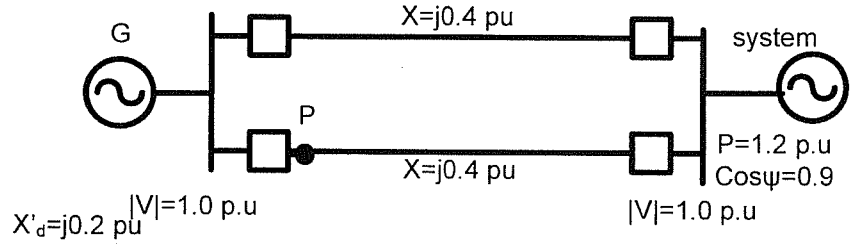

Figure Q1

i. Calculate the generator's excitation voltage (Eq) [4 marks]

ii. Determine the maximum power that can be delivered from generator to the system [2 marks]

iii. A three-phase short circuit occurs just behind the circuit breaker of the one of the line (point P) and after a while the fault is self extinguished. How long the fault can exist without losing synchronism. [5 marks]

Question 2

a) Explain why the voltage drop through the long length transmission line is not lenient [4 marks]

b) A power plant is connected with a grid sub-station via 750 kV, 50 Hz, 285 km overhead transmission line. Series impedance and shunt susceptance of the line (per unit length) are 0.025+j0.3 Ωkm^{-1} and j6.8x10^{-6} Skm^{-1} respectively

I. Calculate surge impedance and propagation constant [4 marks]

II. When the grid substation receives 1000 MW at 0.8 power factor lagging the voltage at the grid sub-station is 95% of the rated voltage. Calculate voltage, current and power factor at the sending end of the line. [12 marks]

Question 3

a) Computation time per iteration required in Gauss –Seidel method is less than that of Newton-Raphson method. Explain why. [3 marks]

b) Which are the two partial derivatives of the Jacobian matrix that are made zero in Decoupled load flow calculation? Explain briefly justification for this [5 marks]

c) In a certain power system number of load buses (PQ buses) is *n1* and number of voltage controlled buses (PV buses) is *n2*. Determine order of sub matrices of Jacobian matrix. [4 marks]

d) In a power system certain bus (bus ***a***) is connected with two buses (buses ***b*** and ***c***). The active and reactive power of the load at bus ***a*** is 0.225+j0.08 p.u. The impedance of the branches are

Zab=0.03+j0.68 p.u; Zac=0.07+j0,82 p.u.

After *k* number of iterations of the Newton-Raphson method the voltages at nodes are found as

$V_a = 0.98\angle -3.42\ pu; V_b = 0.95\angle -4\ pu;\quad V_c = 0.92\angle -2\ pu$

Calculate the active and reactive power mismatch at node ***a*** [8 marks]

Question 4

Branch and bus data of a power system are given in the tables T4.1 and T4.2 respectively. Line reactance of the lines is given on 100 MVA base. Some of the voltages and their phase angles given in table T4.2 are initial estimates and others are fixed values.

Table 4.1

Bus number	Bus number	Series impedance p.u.
1	2	j0.025
1	3	j0.04
2	3	j0.06

Table 4.2

Bus number	P MW	Q MVar	V p.u.	Voltage angle
1	-	-	1.05	0^0
2	400	-	1.02	0^0
3	500	200	1.0	0^0

I. Draw the single line diagram of the power system [2 marks]

II. With the help of the information given in table 4.2 identify the types of buses. [3 marks]

III. Form the nodal admittance matrix [5 marks]

IV. Calculate voltage of the buses using Gauss-Seidel method. One iteration is sufficient. [8 marks]

V. Determine the accuracy of the results obtained in (IV) [2 marks]

Question 5

a) Define the term "incremental fuel cost". [4 marks]

b) Explain briefly the reasons for having minimum and maximum output limits for the generating units of a thermal power plant. [6 marks]

c) Certain thermal power plant consists of two units. The minimum and maximum power output of each unit are 100 MW and 500 MW respectively. The load to the plant varies from 200 MW to 1000 MW. Incremental fuel cost characteristic (in $/MWh) of each unit are given bellow (Pg1, Pg2 are output power of each unit respectively);

$C1=0.0012\ Pg1+8$

$C2=0.008Pg2+9.6$

Plot the variation of plant C versus plant output for economical dispatch [10 marks]

Question 6

a) A 132 kV overhead transmission line having series impedance of 15+j85 Ω is protected with the help of Mho relay. The Mho relay has the maximum reach of 4 Ω with the angle of 75^0. Voltage and current transformer ratio at the circuit breaker location are 132 kV:120 V and 400 A: 5 A respectively.

I. Sketch the operating diagram of the relay and clearly identified the operating and non operating region of the rely. [4 marks]
II. Calculate the impedance of the line as seen by the relay [2 marks]
III. Determine the fraction of the line that is protected by the relay [4 marks]

b) A distribution line having a circuit breaker installed at the sending end delivers 350 A to a load. A current transformer is to be installed at the circuit breaker location of the line. The available CT ratios are: 100:5; 200:5; 400:5;

i. Select suitable CT ratio. [2 marks]
ii. If the three-phase short circuit current at the far end of the line is 3500 A. determine suitable pick-up value for the relay. The available tap setting are : 1.0,1.5, 2.0, 2.5,3.0,3.5, 4.0, 5.0, 6.0, 7.0, 8.0, 10 A. [4 marks]
iii. If the short circuit occurs in the line is 1550 A, determine the relay operating time. You may use the time current characteristic of the relay given in figure Q6 [4 marks]

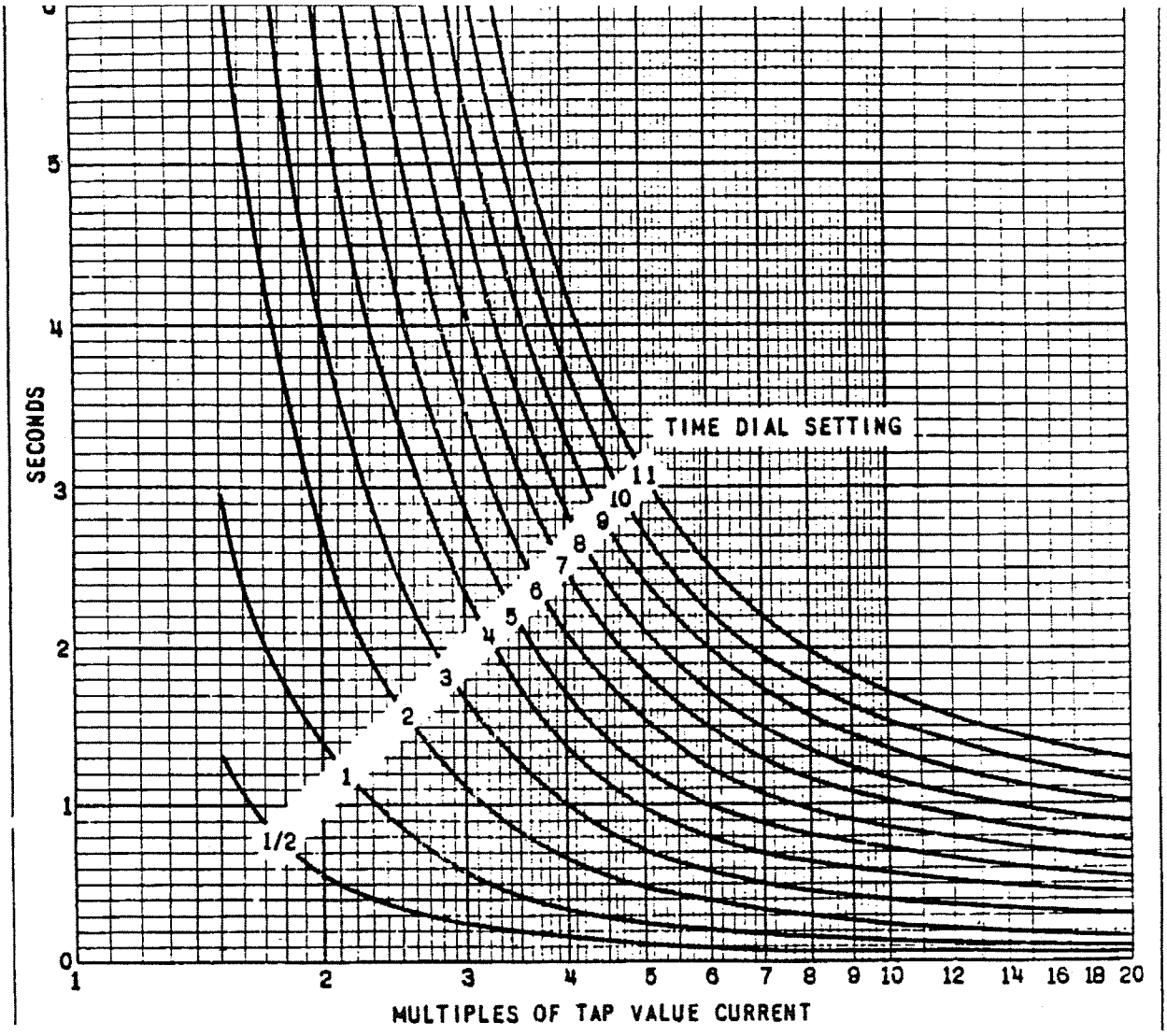
SECONDS
TIME DIAL SETTING
11
10
9
8
7
6
5
4
3
2
1
1/2
0
1
2
3
4
5
6
7
8
9
10
12
14
16
18
20
MULTIPLES OF TAP VALUE CURRENT

Figure Q6