UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, FIRST SEMESTER

DECEMBER 2017

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER: Power System Analysis and Operation

COURSE CODE : EE552

TIME ALLOWED: Three Hours

INSTRUCTIONS:

1. There are five questions in this paper.
2. Question ONE (1) is compulsory
3. Choose any other three questions. Each question carries 25 marks.
4. If you think not enough data has been given in any question you may assume any reasonable values.

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THIS PAPER CONTAINS FIVE (5) PAGES INCLUDING THIS PAGE

Question 1 *(25 Marks)*

(a) Define steady state operating condition of a power system. [2]

(b) Discuss the effect of acceleration factor in the load flow solution algorithm. [3]

(c) List the quantities specified and the quantities to be determined from load flow study for various types of buses. [6]

(d) Compare Gauss-Seidel (G-S) method and Newton-Raphson (N-R) methods of load flow solutions. [5]

(e) For the small power system shown in Figure Q.3 the line data is given on the table below.

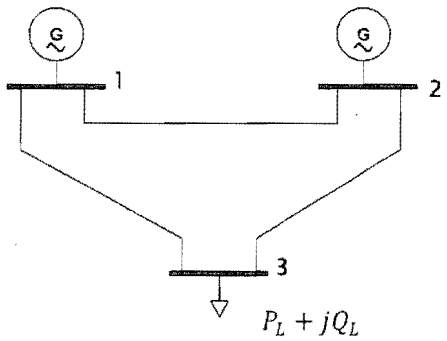

Figure Q. 1

Line data

i	j	R_{ij}	X_{ij}	B_{ij}
1	2	0.25	0.9	0.02
1	3	0.18	0.6	0.01
2	3	0.4	0.8	0.05

Determine the bus admittance matrix of this system [9]

Question 2 ***(25 Marks)***

(a) Derive the ABCD parameters of symmetrical π – *network* using the concept of cascaded networks. **[5]**

(b) Find the exact ABCD parameters for a 400 km long 900 kV bundle-conductor line with 3 sub-conductors per phase with sub-conductor resistance of 0.265Ω/km. Assume that the series inductive reactance per phase is 0.668 Ω/km and the shunt capacitive susceptance of $7.4722\ x10^{-6}$ siemens /km to neutral. Neglect shunt conductance. **[12]**

(c) Find the voltage, current and power at the sending end of the line in (b) and the transmission line efficiency given that the receiving-end load is 1500 MVA at 850 kV with 0.9 pf lagging. **[8]**

Question 3 ***(25 Marks)***

(a) Explain the advantages of the p.u form of representation? **[5]**

(b) A new dc transmission system is compared with a three phase ac system transmitting the same power and having the same losses and size of conductor. Assume that the direct voltage for breakdown of an insulator string is equal to the peak value of alternating voltage to cause break down. Show that the dc line will not only have two conductors instead of three for ac line but in addition the insulation level will be 87% of that of the ac line. **[10]**

(c) Draw an impedance diagram for the electric power system shown in Figure Q.3 , showing all impedances in per unit on a 100-MVA base. Choose 20 kV as the voltage base for generator. The three-phase power and line-line ratings are given below. **[10]**

G_1 : 90 MVA 20 kV $X = 9\%$
$T1$: 80 MVA 20/200 kV $X = 16\%$
T_2 : 80 MVA 200/20 kV $X = 20\%$
G_2 : 90 MVA 18 kV $X = 9\%$
Line: 200 kV $X = 120$
Load: 200 kV $S = 48$ MW $+j64$ Mvar

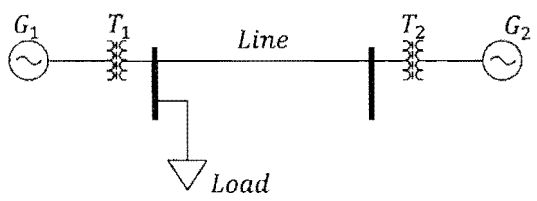

Figure Q.3

Question 4 *(25 Marks)*

(a) For a fault at a given location, rank the various faults in the order of severity. [5]

(b) The power system shown in **Figure Q.4 (b)** is working at no load when a symmetrical three phase fault is developed on bus 2.

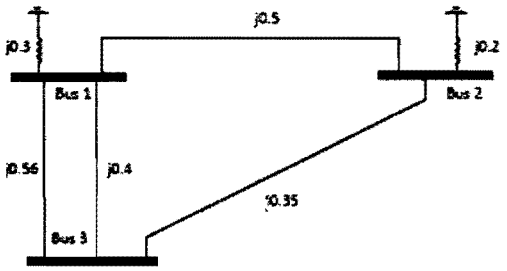

Figure Q.4(b)

Given that the per-phase per-unit impedance matrix is

$$Z_{BUS} = \begin{bmatrix} j0.183 & j0.078 & j0.141 \\ j0.078 & j0.148 & j0.106 \\ j0.141 & j0.106 & j0.267 \end{bmatrix}$$

For a solid 3-phase fault on bus 2

(i) Calculate the per-unit sub transient fault current I_f'' [3]

(ii) Calculate the per-unit voltage at every bus in the system during the sub transient period. [6]

(iii) Calculate the per-unit current I_{23} flowing in line $L_{2\text{-}3}$ during the sub transient period of the fault. [1]

(c) The following sequence impedances exist between the source and the point of fault on a radial transmission system:

$Z_+ = 0.3 + j0.6$ p.u.
$Z_- = 0.3 + j0.55$ p.u.
$Z_0 = 1 + j0.78$ p.u.

(i) The fault path to earth on a single line-to-ground fault has a resistance of 0.66 p.u. Determine the fault current and the voltage at the point of fault. [6]

(ii) Calculate the three-phase fault current. Compare with the single line-to-ground fault current assuming the fault path to ground has a negligible impedance. [4]

Question 5 *(25 Marks)*

(a) Define swing curve and state its use? **[2]**

(b) Find the Critical clearing angle for the system shown in Figure Q.5 for a three phase fault at the point P in the middle of the second transmission line. The generator is delivering 1.0 p.u. power under pre-fault conditions. **[21]**

(c) Given that the generator is 50 Hz synchronous machine with inertia constant of 5MJ/MVA, calculate the critical clearing time. **[2]**

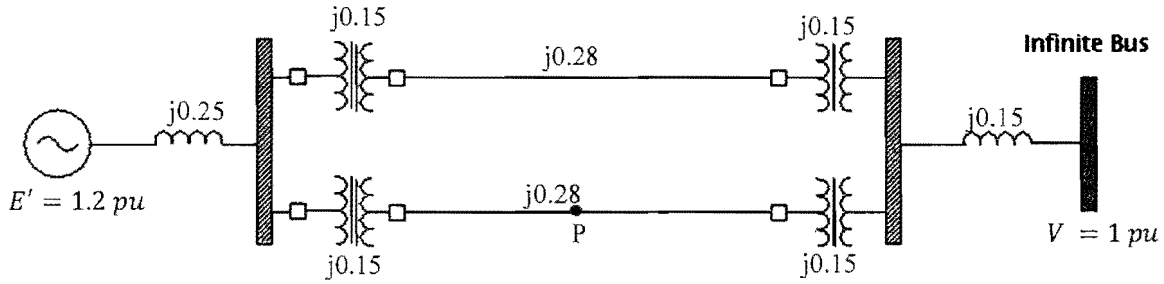

Figure Q.5