Form No. T611

Philadelphia University
Faculty of Engineering

Student Name:
Student Number:

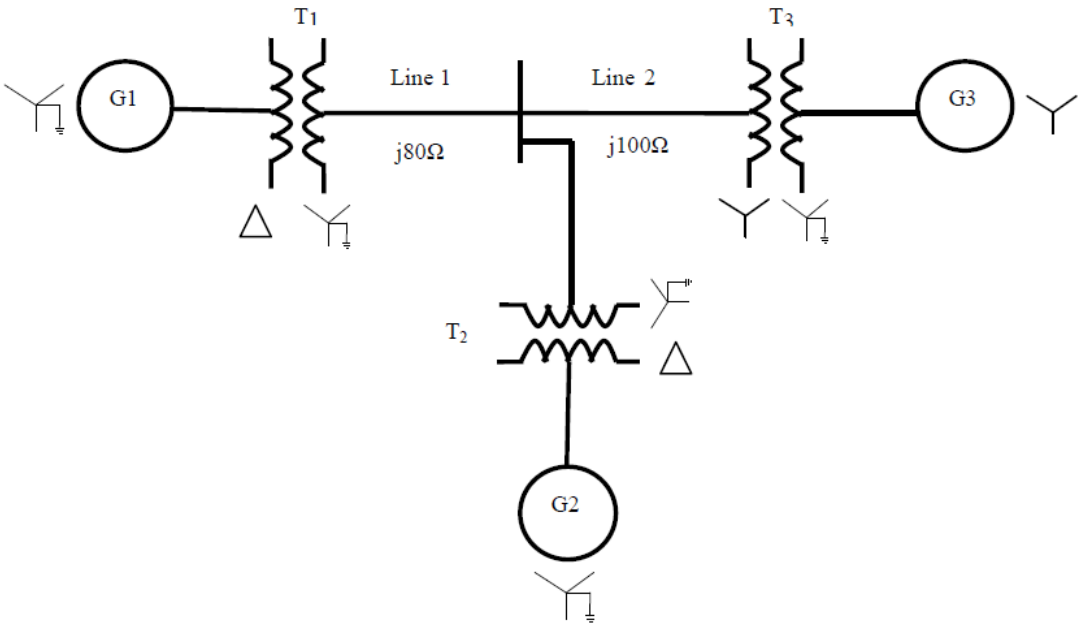
Dept. of Electrical Engineering
Final Exam, Second Semester: 2016/2017

Course Title: Power Systems I	**Date: 12/6/2017**
Course No: (610411)	**Time Allowed: 2 Hours**
Lecturer: Dr. Mohammad Abu-Naser	**No. of Pages: 2**

Question 1: ***(10 Marks)***

Objectives: This question is related to single line diagram and per unit system

Draw the reactance diagram using a base of 50MVA and 13.8KV on generator G_1



G1: 20MVA, 13.8kV, X=0.2
G2: 30MVA, 18.0kV, X=0.2
G3: 30MVA, 20.0kV, X=0.2
T1: 25MVA, 220/13.8 kV, X =0.1
T2: 3Single phase unit each rated 10MVA, 127/18 kV, X =0.1
T3: 35MVA, 220/22 kV, X =0.1

Question 2: ***(10 Marks)***

Objectives: This question is related to performance of transmission line

A 16-km three phase line has a series impedance z = 0.125 + j0.4375 Ω/km. The line delivers 120 MVA at unity power factor at 64 kV. Calculate:

1) ABCD parameters of the transmission line
2) Sending end voltage and current (V_s and I_s)
3) Sending end power
4) Transmission line efficiency
5) Percent voltage regulation

QUESTIONS 3,4,5 ARE BASED ON THE FOLLOWING SINGLE-LINE DIAGRAM

Synchronous generators:

G1: $X_1=X_2=0.2$, $X_0=0.05$ pu

G2: $X_1=X_2=0.2$, $X_0=0.05$ pu

Transformers:

T1: X=0.05 pu

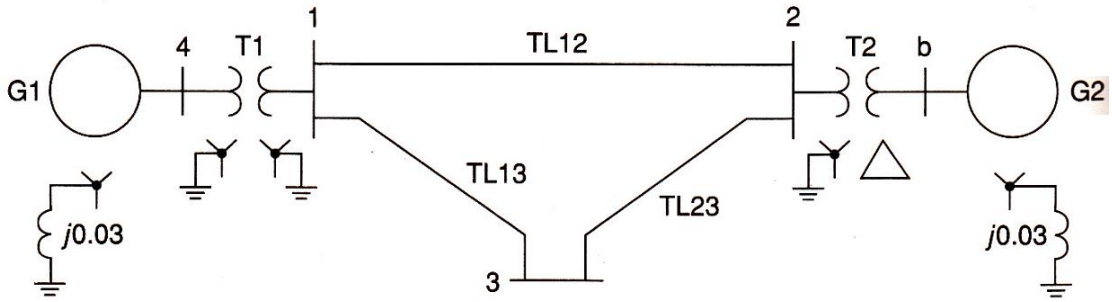
T2: X=0.05 pu

Transmission lines:

TL12: $X_1=X_2=0.1$, $X_0=0.3$

TL13: $X_1=X_2=0.1$, $X_0=0.3$

TL23: $X_1=X_2=0.1$, $X_0=0.3$



Question 3: ***(10 Marks)***

Objectives: This question is related to sequence networks

1) Draw the per-unit positive, negative, and zero sequence networks.
2) Determine the Thevenin equivalent of each sequence network as viewed from bus 3.

Question 4: ***(5 Marks)***

Objectives: This question is related to symmetrical fault analysis

1) Determine the positive sequence fault current $I_a^{(1)}$ for a bolted three phase fault at bus 3.
2) Determine the phase currents I_a, I_b, I_c.

Question 5: ***(5 Marks)***

Objectives: This question is related to unsymmetrical fault analysis

Determine the fault current for a bolted double line-to-ground fault at bus 3.

Good luck

Power Systems (1)

Final Exam, Second Semester 2016/2017

Model Answers

Question 1

G_1: $X = 0.2 \times \frac{50}{20} = .5$ (1)

G_2: $X = 0.2 \times \frac{50}{30} = .3333$ (1)

G_3: $X = 0.2 \times \frac{50}{30} \times \left(\frac{20}{22}\right)^2 = .2755$ (1)

T_1: $X = 0.1 \times \frac{50}{25} = .2$ (1)

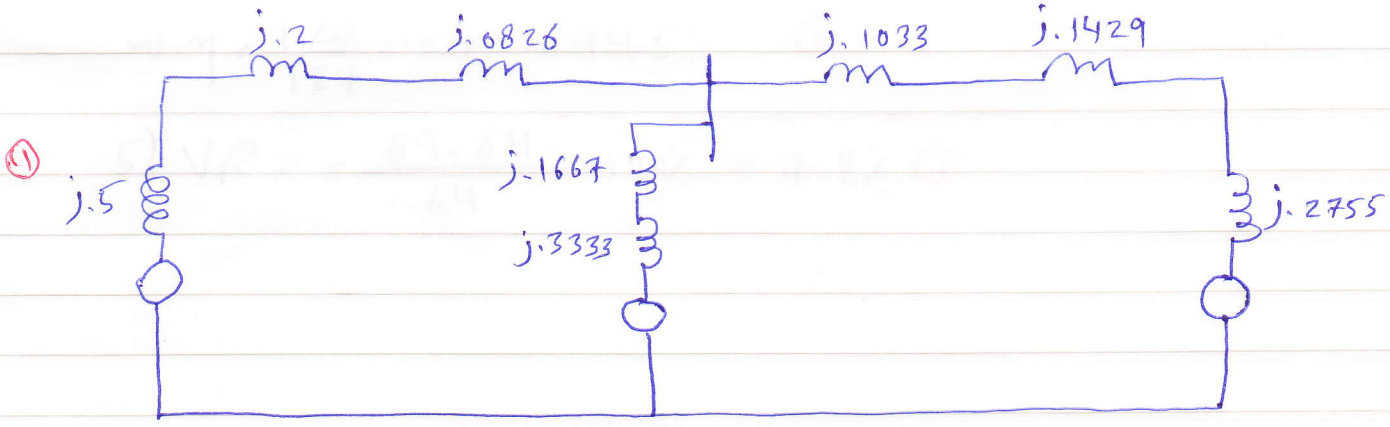
T_2: $X = 0.1 \times \frac{50}{30} = .1667$ (1)

T_3: $X = 0.1 \times \frac{50}{35} = .1429$ (1)

$Z_{base} = \frac{220^2}{50} = 968\ \Omega$ (1)

Line 1: $X = \frac{80}{968} = .0826$ (1)

Line 2: $X = \frac{100}{968} = .1033$ (1)



(1)

Question 2

1) $Z = 16(.125 + j.4375) = 2 + j7$ (1)

$A = 1$ (.5)

$B = Z = 2 + j7$ (.5)

$C = 0$ (.5)

$D = 1$ (.5)

2) $V_R = \frac{64}{\sqrt{3}} = 36.9504 \angle 0^\circ \text{ kV}$ (.5)

$I_R = \frac{S_R^*}{3V_R^*} = \frac{120 \text{ MVA}}{3 \times 36.9504} = 1082.5 \angle 0^\circ \text{ A}$ (1)

$V_S = V_R + ZI_R$

$= 36.9504 \angle 0^\circ + (2 + j7) \times 1082.5 \times 10^{-3}$

$= 39.84 \angle 10.96^\circ \text{ kV}$ (1)

$V_{S_{LL}} = 39.84 \times \sqrt{3} = 69 \text{ kV}$ (.5)

$I_S = I_R = 1082.5 \angle 0^\circ \text{ A}$ (1)

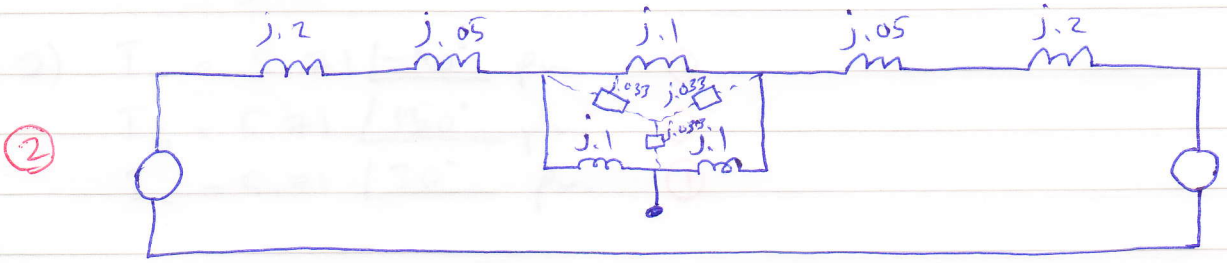
3) $S_S = 3V_S I_S^* = 127 + j24.6 \text{ MVA}$ (1)

4) $\eta = \frac{120}{127} \times 100\% = 94.5\%$ (1)

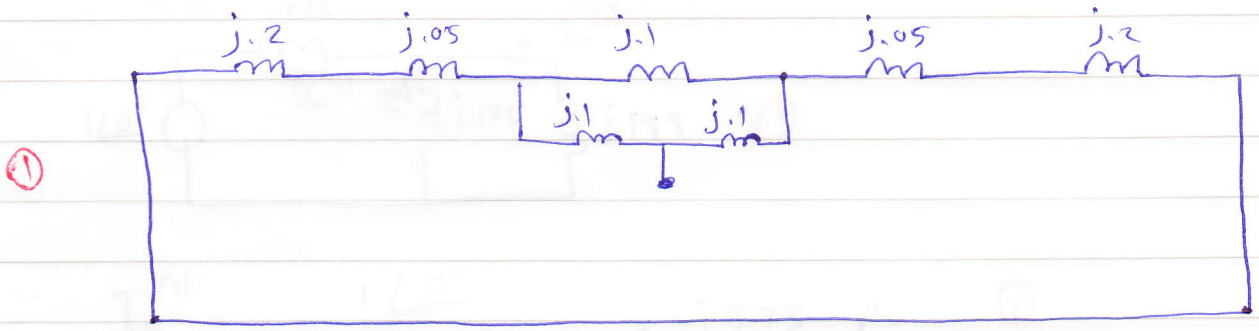
5) $VR\% = \frac{69 - 64}{64} \times 100\% = 7.8\%$ (1)

Question 3

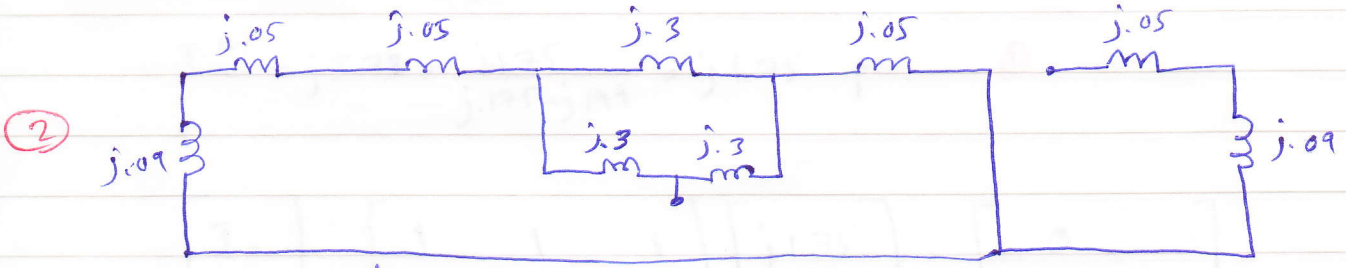
1) +ve seq. net.



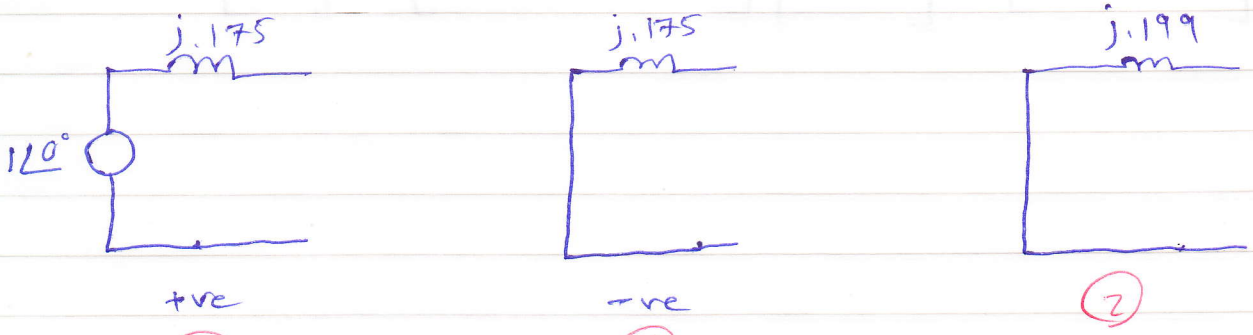
-ve seq. net.



Zero seq. net.



2) Using Δ-Y transformation and series-parallel combinations, Thevenin equivalents looking into bus 3 are:



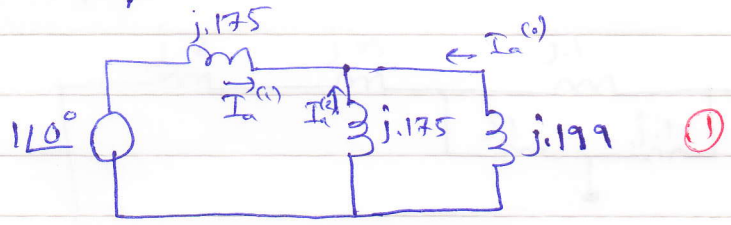
Question 4

1) $I_a^{(1)} = \dfrac{1\angle 0^\circ}{j.175} = -j5.71$ pu. (2)

2) $I_a = 5.71\angle -90^\circ$ pu (1)
$I_b = 5.71\angle 150^\circ$ pu (1)
$I_c = 5.71\angle 30^\circ$ pu (1)

Question 5

The sequence network interconnection is shown below



(1)

$$I_a^{(1)} = \frac{1\angle 0^\circ}{j.175 + j.175 \,//\, j.199} = -j3.73 \text{ pu.}$$ (1)

$$I_a^{(2)} = j3.73 \times \frac{j.199}{j.175 + j.199} = j1.99 \text{ pu.}$$ (1)

$$I_a^{(0)} = j3.73 \times \frac{j.175}{j.175 + j.199} = j1.75 \text{ pu.}$$ (1)

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} j1.75 \\ -j3.73 \\ j1.99 \end{bmatrix} = \begin{bmatrix} 0 \\ 5.6\angle 152.1^\circ \\ 5.6\angle 27.9^\circ \end{bmatrix}$$ (1)