Form No. T611

Philadelphia University
Faculty of Engineering

Student Name:
Student Number:

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

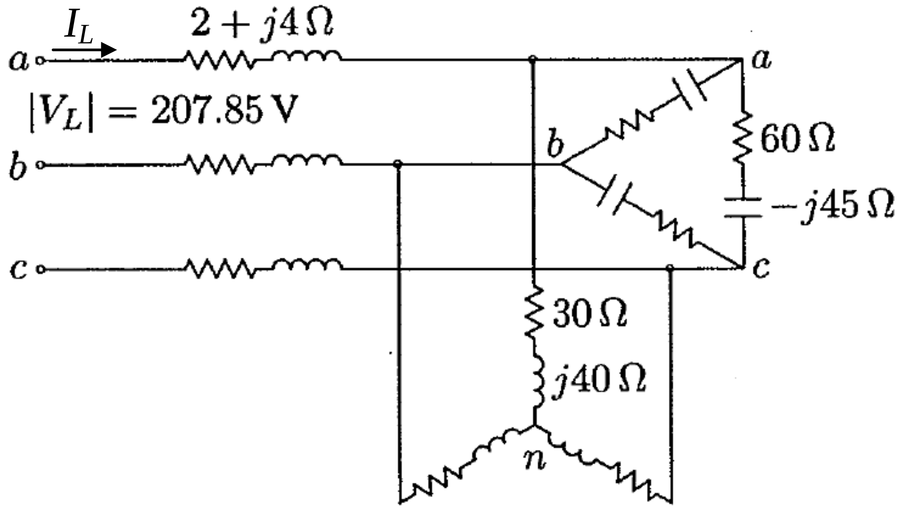
Course Title: Power Systems I	**Date: 2/4/2017**
Course No: (610411)	**Time Allowed: 50 Minutes**
Lecturer: Dr. Mohammad Abu-Naser	**No. of Pages: 2**

Question 1: ***(6Mark)***

Objectives: This question is related to per phase circuit analysis

A balanced three-phase at the sending end of a transmission line supply 207.85 V line-to-line to two three phase loads that are connected in parallel as shown in the following figure. Determine:

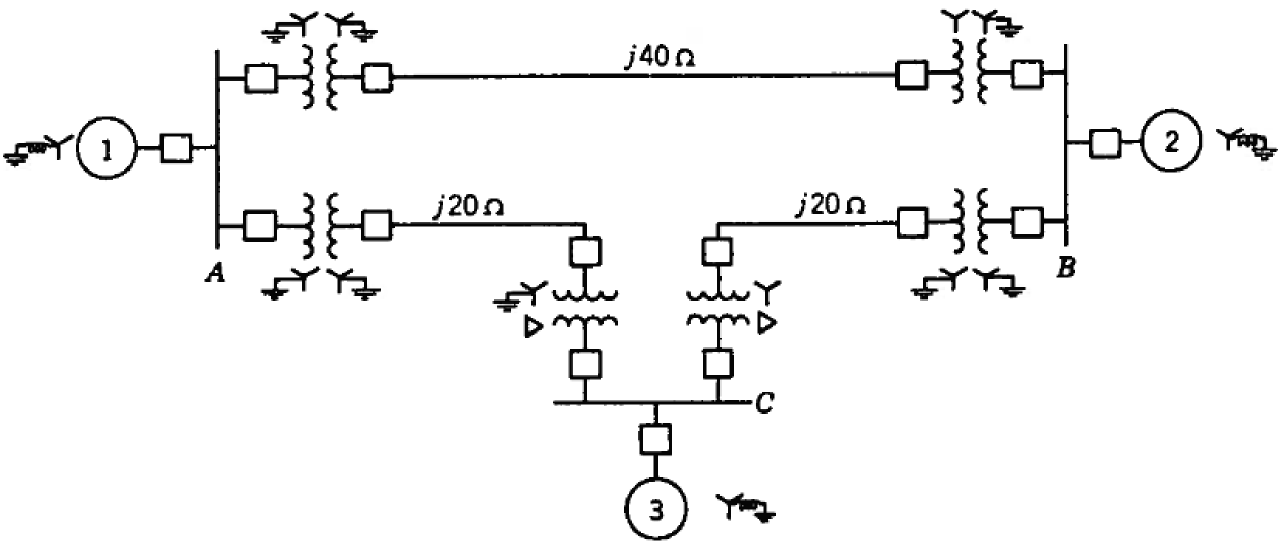
a) Supply current (I_L=?)
b) Real power and reactive power drawn from the supply.
c) The line-to-line voltage at the combined load (V_{ab}=?)



Question 2: ***(7Mark)***

Objectives: This question is related to reactance diagrams

Draw the reactance diagram for the following power system showing all reactances in per unit on a 50 MVA, 138 kV in the 40 Ω line.



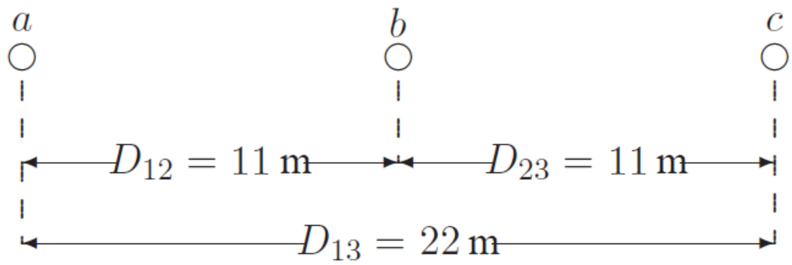
G1: 20 MVA, 13.8 kV, X=0.2p.u.
G2: 20 MVA, 18 kV, X=0.2p.u.
M3: 30 MVA, 13.8 kV, X=0.2p.u.
Three-phase Y-Y transformers: 20 MVA, 138Y/20Y kV, X=0.1p.u.
Three-phase Y-Δ transformers: 15 MVA, 138Y/13.8Δ kV, X=0.1p.u.

Question 3: ***(7Mark)***

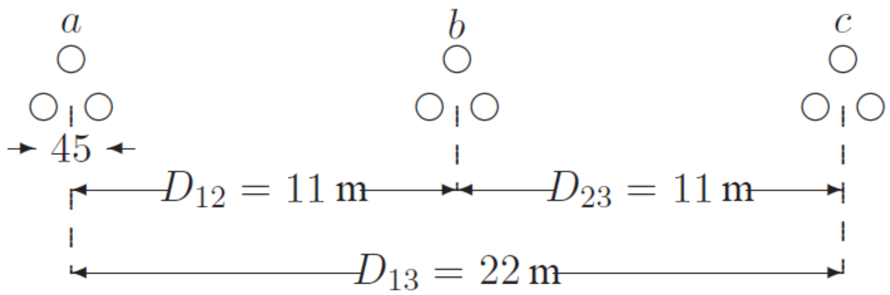
Objectives: This question is related to inductance of transmission line

A three-phase transposed line is composed of one conductor per phase with flat horizontal spacing of 11 m as shown in the figure. The conductors have a diameter of 3.625 cm.

a) Determine the inductance per phase per kilometer of the line



b) The line is to be replaced by three conductor bundle having the same diameter and horizontal spacing. The spacing between conductors in the bundle is 45 cm, what would be the inductance per phase per kilometer of the line?



c) What is the percentage reduction in the inductance?

Good luck

Power System (1)
First Exam
Second Semester 2016/2017

Model Answers

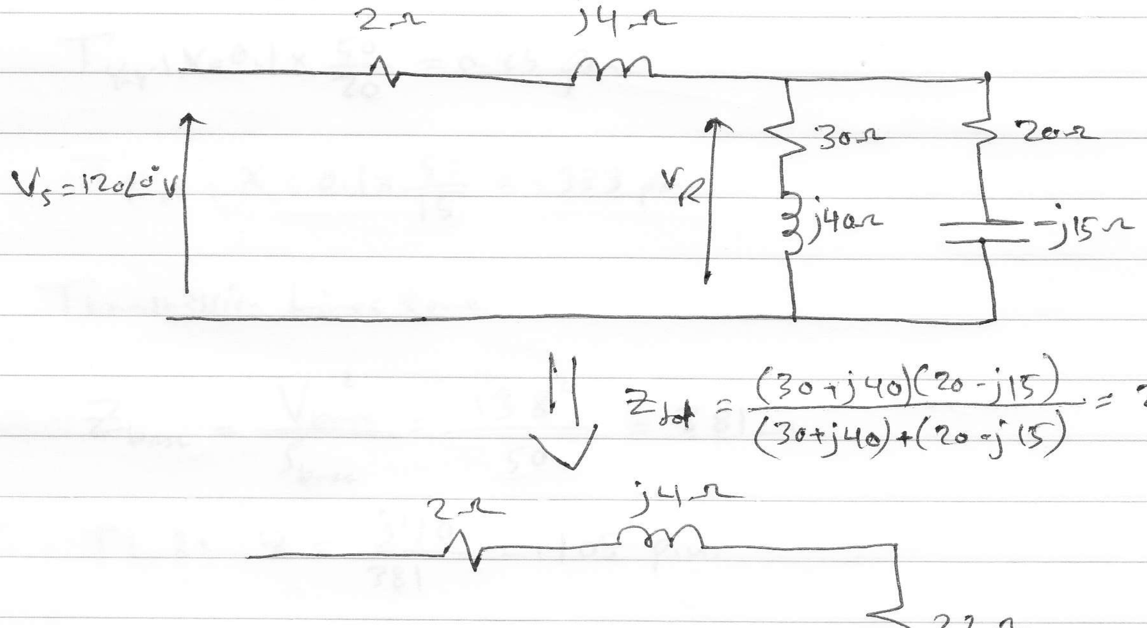
Q1 The Δ-connected load is transformed into an equivalent Y.

$$Z_Y = \frac{60-j45}{3} = 20-j15\ \Omega$$

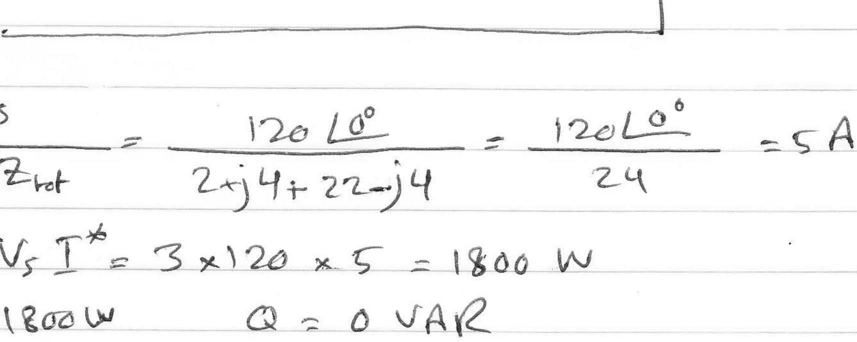
The phase voltage is

$$V_s = \frac{207.85}{\sqrt{3}} = 120V$$

The per phase equivalent circuit is



$$Z_{tot} = \frac{(30+j40)(20-j15)}{(30+j40)+(20-j15)} = 22-j4\ \Omega$$



a) $I = \dfrac{V_s}{2+j4+Z_{tot}} = \dfrac{120\angle 0°}{2+j4+22-j4} = \dfrac{120\angle 0°}{24} = 5A$

b) $(S)_{3\phi} = 3\, V_s I^* = 3 \times 120 \times 5 = 1800\ W$

$P = 1800W \qquad Q = 0\ VAR$

c) $V_R = V_S - Z_L I$

$= 120\angle 0^\circ - (2+j4)(5\angle 0^\circ) = 110 - j20 = 111.8\angle -10.3^\circ \text{ V}$

$V_{ab} = \sqrt{3}\, V_R \angle 30^\circ = \sqrt{3} \times 111.8 \angle -10.3+20$

$= 193.64 \angle 19.7^\circ \text{ V}$

Q2

G1: $X = 0.2 \times \frac{50}{20} \times \left(\frac{13.8}{20}\right)^2 = .238$ p.u.

G2: $X = .2 \times \frac{50}{20} \times \left(\frac{18}{20}\right)^2 = .405$ p.u.

M3: $X = .2 \times \frac{50}{30} = .333$ p.u.

T_{Y-Y}: $X = 0.1 \times \frac{50}{20} = 0.25$ p.u.

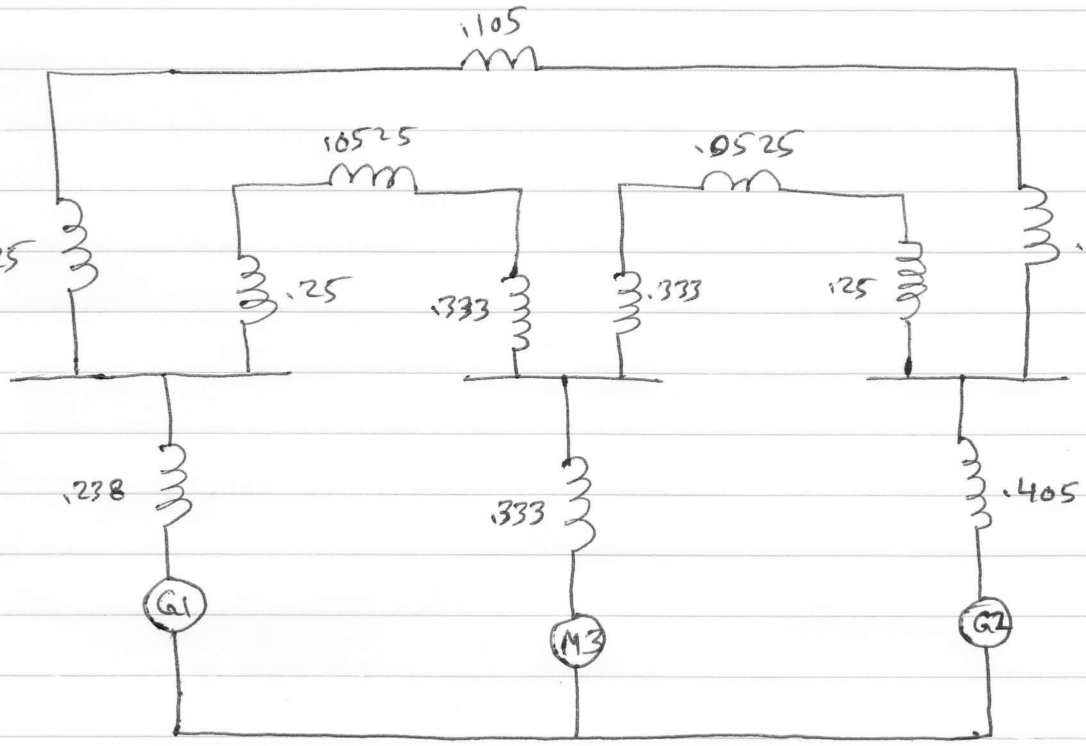
$T_{Y-\Delta}$: $X = 0.1 \times \frac{50}{15} = .333$ p.u.

Transmission Lines Zone

$Z_{base} = \frac{V_{base}^2}{S_{base}} = \frac{138^2}{50} = 381\,\Omega$

TL1: $Z = \frac{j40}{381} = .105$ p.u.

TL23: $Z = \frac{j20}{381} = .0525$ p.u.



Q3

a) $r' = .7788 \times \frac{d}{2}$

$= .7788 \times \frac{3.625 \times 10^{-2}}{2} = .0141 \text{ m}$

$D_{eq} = \sqrt[3]{11 \times 11 \times 22} = 13.86 \text{ m}$

$L = 2 \times 10^{-7} \ln \frac{D_{eq}}{r'} = 2 \times 10^{-7} \ln \frac{13.86}{.0141} = 1.378 \times 10^{-6} \text{ H/m}$

b) $D_s = \sqrt[3]{.0141 \times .45^2} = 0.142 \text{ m}$

$L = 2 \times 10^{-7} \ln \frac{13.86}{.142} = 9.16 \times 10^{-7} \text{ H/m}$

c) $\Delta L = \frac{1.378 \times 10^{-6} - 9.16 \times 10^{-7}}{1.378 \times 10^{-6}} \times 100\%$

$= 33.5\%$