Form No. T611

Philadelphia University
Faculty of Engineering

Student Name:
Student Number:

Dept. of Electrical Engineering
First Exam, First Semester: 2017/2018

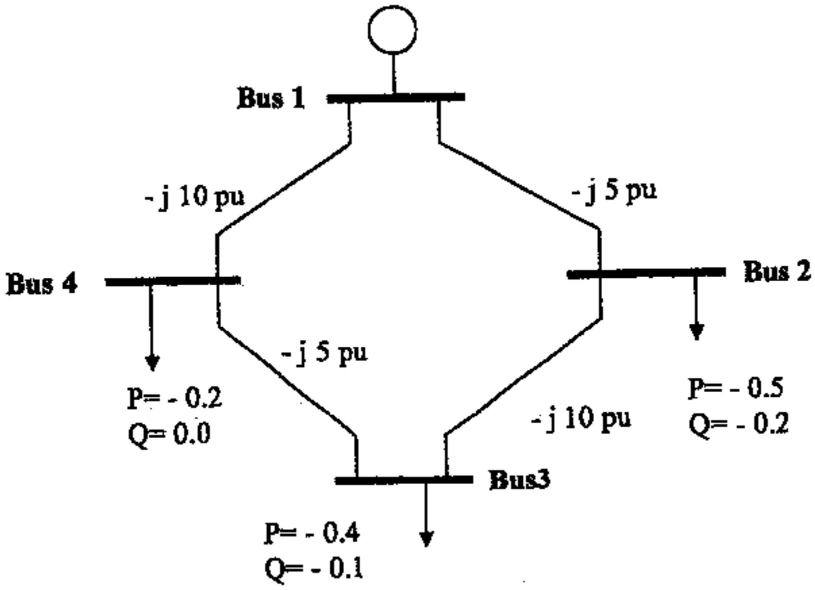
Course Title: Power Systems 2	**Date: 22/11/2017**
Course No: (610412)	**Time Allowed: 50 Minutes**
Lecturer: Dr. Mohammad Abu-Naser	**No. of Pages: 2**

Question 1: ***(10Mark)***

Objectives: This question is related to load flow analysis using GS method

In the following power system, branch admittances and bus loads are given in per unit.

a) Construct the bus admittance matrix.
b) Using Gauss-Seidel method, determine voltages at buses 2, 3, 4 for the first iteration. Bus 1 is slack with $V_1 = 1\angle 0^\circ$. Start with an initial estimate of $V_2^{(0)} = 1\angle 0^\circ, V_3^{(0)} = 1\angle 0^\circ, V_4^{(0)} = 1\angle 0^\circ$.



Question 2: ***(10Mark)***

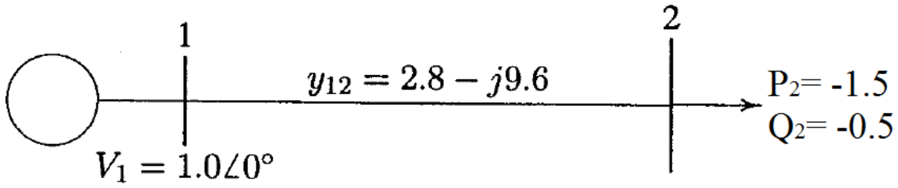
Objectives: This question is related to load flow analysis using NR method

In the following two-bus system, the expression for real and reactive power at bus 2 is

$$P_2 = 10|V_2|\cos(\delta_2 - 106.26^\circ) + 10|V_2|^2\cos(73.74^\circ)$$

$$Q_2 = 10|V_2|\sin(\delta_2 - 106.26^\circ) + 10|V_2|^2\sin(73.74^\circ)$$

Using Newton Raphson method, determine the voltage magnitude and angle of bus 2. Start with an initial estimate of $|V_2|^{(0)} = 1$ and $\delta_2^{(0)} = 0^\circ$. Perform two iterations only.



Good luck

Power Systems 2
First Exam
First Semester 2017/2018
Model Answers

Question 1

a)

$$Y_{bus} = \begin{bmatrix} -j15 & j5 & 0 & j10 \\ j5 & -j15 & j10 & 0 \\ 0 & j10 & -j15 & j5 \\ j10 & 0 & j5 & -j15 \end{bmatrix}$$

b)

$$V_K^{i+1} = \frac{1}{Y_{KK}}\left[\frac{P_K - jQ_K}{V_K^{i*}} - \sum_{n=1}^{K-1} Y_{Kn}V_n^{i+1} - \sum_{n=K+1}^{N} Y_{Kn}V_n^{i}\right]$$

$$V_2^{(1)} = \frac{1}{Y_{22}}\left[\frac{P_2 - jQ_2}{V_2^{(0)*}} - Y_{21}V_1 - Y_{23}V_3^{(0)} - Y_{24}V_4^{(0)}\right]$$

$$= \frac{1}{-j15}\left[\frac{-.5+j.2}{1\angle 0^\circ} - j5\times 1 - j10\times 1 - 0\right]$$

$$= .9872\angle -1.93^\circ \ V$$

$$V_3^{(1)} = \frac{1}{Y_{33}}\left[\frac{P_3 - jQ_3}{V_3^{(0)*}} - Y_{31}V_1 - Y_{32}V_2^{(1)} - Y_{34}V_4^{(0)}\right]$$

$$= \frac{1}{-j15}\left[\frac{-.4+j.1}{1\angle 0^\circ} - 0 - j10\times .9872\angle -1.193^\circ - j5\times 1\right]$$

$$= .9857\angle -2.84^\circ \ V$$

$$V_4^{(1)} = \frac{1}{Y_{44}}\left[\frac{P_4 - jQ_4}{V_4^{(0)*}} - Y_{41}V_1 - Y_{42}V_2^{(1)} - Y_{43}V_3^{(1)}\right]$$

$$= \frac{1}{-j15}\left[\frac{-.2+j0}{1\angle 0^\circ} - j10\times 1 - 0 - j5\times .9857\angle -2.84^\circ\right]$$

$$= .9953\angle -1.7^\circ \ V$$

$\boxed{\text{Question 2}}$

$$\frac{\partial P_2}{\partial \delta_2} = -10|V_2| \sin(\delta_2 - 106.26^\circ)$$

$$\frac{\partial P_2}{\partial |V_2|} = 10 \cos(\delta_2 - 106.26^\circ) + 20|V_2| \cos(73.74^\circ)$$

$$\frac{\partial Q_2}{\partial \delta_2} = 10|V_2| \cos(\delta_2 - 106.26^\circ)$$

$$\frac{\partial Q_2}{\partial |V_2|} = 10 \sin(\delta_2 - 106.26^\circ) + 20|V_2| \sin(73.74^\circ)$$

1st Iteration

$$\begin{bmatrix} P_2 \\ Q_2 \end{bmatrix}^{(0)} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \quad J^{(0)} = \begin{bmatrix} 9.6 & 2.8 \\ -2.8 & 9.6 \end{bmatrix}$$

$$J^{(0)^{-1}} = \begin{bmatrix} .096 & -.028 \\ .028 & .096 \end{bmatrix}$$

$$\begin{bmatrix} \delta_2 \\ |V_2| \end{bmatrix}^{(1)} = \begin{bmatrix} \delta_2 \\ |V_2| \end{bmatrix}^{(0)} + J^{(0)^{-1}} \left(\begin{bmatrix} P_2 \\ Q_2 \end{bmatrix}_{\text{actual}} - \begin{bmatrix} P_2 \\ Q_2 \end{bmatrix}^{(0)} \right) = \begin{bmatrix} 0 \\ 1 \end{bmatrix} + \begin{bmatrix} .096 & -.028 \\ .028 & .096 \end{bmatrix} \begin{bmatrix} -1.5 \\ -.5 \end{bmatrix}$$

$$= \begin{bmatrix} -.13 \\ .91 \end{bmatrix}$$

2nd iteration

$$\begin{bmatrix} P_2 \\ Q_2 \end{bmatrix}^{(1)} = \begin{bmatrix} -1.34 \\ -.38 \end{bmatrix}, \quad J^{(1)} = \begin{bmatrix} 8.33 & 1.07 \\ -3.66 & 8.32 \end{bmatrix}$$

$$J^{(1)^{-1}} = \begin{bmatrix} .1136 & -.0147 \\ .05 & .1138 \end{bmatrix}$$

$$\begin{bmatrix} \delta_2 \\ |V_2| \end{bmatrix}^{(2)} = \begin{bmatrix} -.13 \\ .91 \end{bmatrix} + \begin{bmatrix} .1136 & -.0147 \\ .05 & .1138 \end{bmatrix} \left(\begin{bmatrix} -1.5 \\ -.5 \end{bmatrix} - \begin{bmatrix} -1.34 \\ -.38 \end{bmatrix} \right) = \begin{bmatrix} -.146 \\ .889 \end{bmatrix}$$