PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Final Examination : Semester 2 **Academic Year : 2011**

Date : 1 March 2012 **Time : 13.30-16.30**

Subject : 210-471 Power Systems I **Room : ROBOT**

คำแนะนำ

1. ข้อสอบชุดนี้มี **5** ข้อ จำนวน **8** หน้า (ไม่รวมปก) ควรตรวจสอบก่อนลงมือทำ
2. ทำข้อสอบด้วยความสุจริต ไม่ตื่นเต้นหรือประมาทจนเกินไป
3. อนุญาตให้นำเครื่องคำนวณเข้าห้องสอบได้ แต่ไม่อนุญาตให้นำหนังสือหรือเอกสารอื่นๆเข้าห้องสอบ
4. สามารถใช้ดินสอหรือปากกาก็ได้ในการเขียนคำตอบ
5. หากพื้นที่สำหรับแสดงวิธีทำไม่เพียงพอ สามารถเขียนต่อหน้าหลังของข้อสอบได้
6. **การแสดงวิธีทำ ควรจะดูดี สร้างสรรค์ เป็นตัวของตัวเอง เพื่อแสดงศักยภาพที่มีของตัวนักศึกษา**

ชื่อ ______________________________ **รหัส** _____________

	ข้อที่ 1	ข้อที่ 2	ข้อที่ 3	ข้อที่ 4	ข้อที่ 5	รวม
คะแนนเต็ม	8	12	8	12	10	50
คะแนนที่ได้						

ผู้ออกข้อสอบ ธวัชชัย ทางรัตนสุวรรณ

นักศึกษารับทราบ ลงชื่อ ....

1. A bundled 400-kV , 50-Hz , three-phase completely transposed overhead line has three conductors per phase as shown in Figure 1A and 1B. The conductors have a diameter of 16.5 mm.

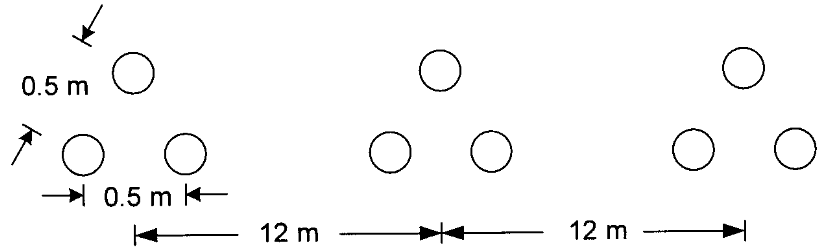

Figure 1A

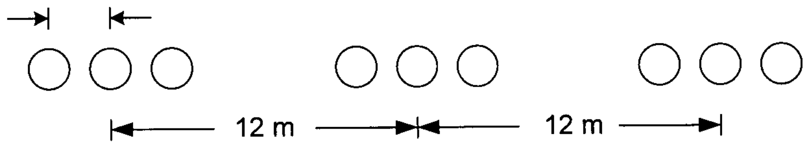

Figure 1B

$$C = \frac{2\pi\varepsilon_0}{\ln\left(\frac{GMD}{r^b}\right)} \quad \text{[F/m]}$$

$(\varepsilon_0 = 8.85 \times 10^{-12}$ F/m)

(a) Calculate the shunt admittance for the line in Figure 1A. [5 points]

Answer : ______________________

(b) Calculate the shunt admittance for the line in Figure 1B. [3 points]

Answer : ______________________

2. A 230-kV , 200 km long , three-phase transmission line has a per phase series impedance of $z = 0.20 + j0.80\ \Omega/\text{km}$ and a per phase shunt admittance of $y = j6\times10^{-6}$ S/km.

(a) Determine the transmission line ABCD constants. [3 points]

Answer : ____

(b) Determine the voltage and current at the sending end when the line supplies a load of 300 MVA , 0.8 power factor lagging at 230 kV. [3 points]

Answer : ____

(c) Determine the transmission-line efficiency and percent voltage regulation when the line supplies the load in part (b). [3 points]

Answer : ____

(d) Calculate the receiving end voltage when line is terminated in an open circuit and is energized with 230 kV at the sending end. [3 points]

Answer : ____________________________

3. A three-phase 420-kV , 60 Hz transmission line is 463 km long and may be assumed lossless. The line is energized with 420 kV at the sending end. When the load at the receiving end is removed , the voltage at the receiving end is 700 kV , and the per phase sending end current is $646.6\angle 90^\circ$ A.

(a) Find the phase constant β in radians per km and the serge impedance Z_C in Ω. [4 points]

Answer : ______________________________

(b) Ideal reactors are to be installed at the receiving end to keep $|V_S| = |V_R| = 420\,\text{kV}$ when load is removed. Determine the required three-phase kVAR and the reactance per phase. [4 points]

Answer : ______________________________

4. Consider the four-bus power system of Figure 2.

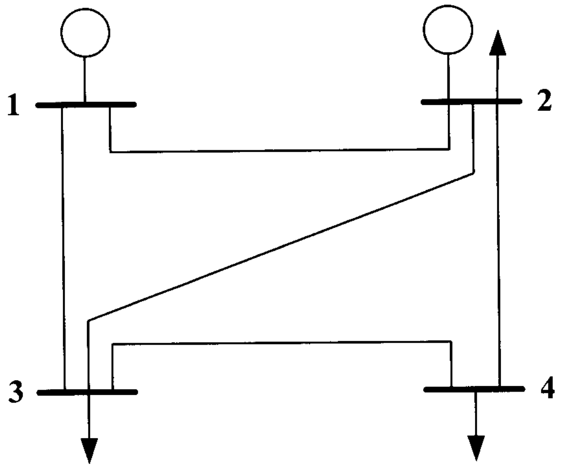

Figure 2

Line Data

Line No.	From	To	R (pu)	X (pu)
1	1	2	0.05	0.15
2	1	3	0.10	0.30
3	2	3	0.10	0.30
4	2	4	0.10	0.30
5	3	4	0.05	0.15

Bus Data

Bus No.	Type	P_G (pu)	Q_G (pu)	P_D (pu)	Q_D (pu)	$\|V\|$ (pu)
1	Slack Bus	-	-	0	0	1.05
2	Voltage-controlled Bus	1.5	-	1.0	0.8	1.04
3	Load Bus	0	0	1.0	0.75	-
4	Load Bus	0	0	0.8	0.6	-

(a) Determine the bus admittance matrix $\mathbf{Y}_{BUS}$. [4 points]

Answer : ________________________________

(b) Determine the voltages at all buses after the end of the first iteration of Gauss-Seidel procedure. Take the acceleration factor $\alpha = 1.5$ and choose the initial guess $V_3^{(0)} = V_4^{(0)} = 1.0\angle 0^\circ$ pu. [8 points]

Answer : ____________________

5. For the three-bus power system of Figure 3. Using the fast decoupled method to determine the phasor values of V_2 and V_3. Perform <u>one</u> iteration. [10 points]

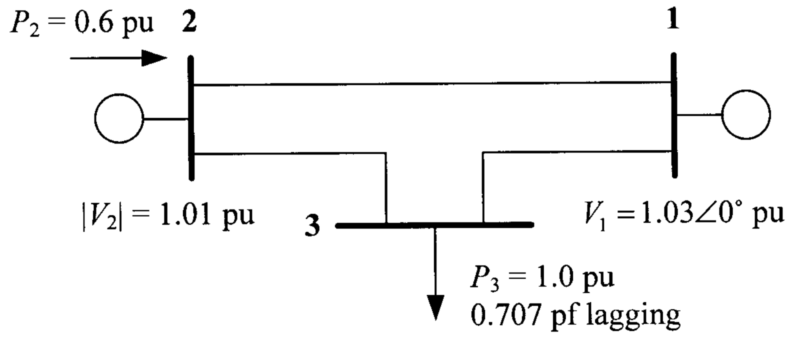

Figure 3

$$\mathbf{Y}_{BUS} = \begin{bmatrix} 3-j9 & -2+j6 & -1+j3 \\ -2+j6 & 4-j12 & -2+j6 \\ -1+j3 & -2+j6 & 3-j9 \end{bmatrix} \text{ pu}$$

Answer : ______________________________

Some useful equations

Transmission-line *ABCD* parameters :

Type	$A=D$	B	C
Short line	1	Z	0
Medium-length line	$1+\frac{YZ}{2}$	Z	$Y\left(1+\frac{YZ}{4}\right)$
Long line	$\cosh(\gamma l)$	$Z_c\sinh(\gamma l)$	$\frac{1}{Z_c}\sinh(\gamma l)$
Lossless line	$\cos(\beta l)$	$jZ_c\sin(\beta l)$	$\frac{j\sin(\beta l)}{Z_c}$

Power Flow through Transmission Lines :

$$P_{R(3\phi)} = \frac{|V_{S(L-L)}||V_{R(L-L)}|}{|B|}\cos(\theta_B-\delta) - \frac{|A||V_{R(L-L)}|^2}{|B|}\cos(\theta_B-\theta_A)$$

$$Q_{R(3\phi)} = \frac{|V_{S(L-L)}||V_{R(L-L)}|}{|B|}\sin(\theta_B-\delta) - \frac{|A||V_{R(L-L)}|^2}{|B|}\sin(\theta_B-\theta_A)$$

Power Flow Equation :

$$P_i = \mathrm{Re}\left[V_i^*\sum_{j=1}^{n}Y_{ij}V_j\right] = \sum_{j=1}^{n}|V_i||V_j||Y_{ij}|\cos(\theta_{ij}-\delta_i+\delta_j)$$

$$Q_i = -\mathrm{Im}\left[V_i^*\sum_{j=1}^{n}Y_{ij}V_j\right] = -\sum_{j=1}^{n}|V_i||V_j||Y_{ij}|\sin(\theta_{ij}-\delta_i+\delta_j)$$

Gauss-Seidel Power Flow :

For a load bus :

$$V_i^{(k+1)} = \frac{1}{Y_{ii}}\left[\frac{P_i^{sch}-jQ_i^{sch}}{V_i^{*(k)}} - \sum_{j=1}^{i-1}Y_{ij}V_j^{(k+1)} - \sum_{j=i+1}^{n}Y_{ij}V_j^{(k)}\right]$$

For a voltage-controlled bus :

$$Q_i^{(k+1)} = -\mathrm{Im}\left\{V_i^{*(k)}\left[\sum_{j=1}^{i-1}Y_{ij}V_j^{(k+1)} + \sum_{j=i}^{n}Y_{ij}V_j^{(k)}\right]\right\} \quad \text{and} \quad Q_{i(gen)} = Q_i + Q_{i(demand)}$$

Use of acceleration factor :

$$V_{i,acc}^{(k+1)} = V_i^{(k)} + \alpha(V_{i,cal}^{(k+1)} - V_i^{(k)})$$

Fast Decoupled Power Flow :

$$\frac{\Delta \mathbf{P}}{|\mathbf{V}_i|} = -\mathbf{B}'\Delta\boldsymbol{\delta} \quad \text{and} \quad \frac{\Delta \mathbf{Q}}{|\mathbf{V}_i|} = -\mathbf{B}''\Delta|\mathbf{V}|$$