

# EC 470 POWER SYSTEMS I

Test # 2 - 1998

NAME \_\_\_\_\_

BOX # \_\_\_\_\_

Attempt all four questions.

**NO PARTIAL CREDIT** will be given for incorrect answers without a full explanation of the solution procedure followed.

Textbooks permitted.  
Time allowed - 3 periods.

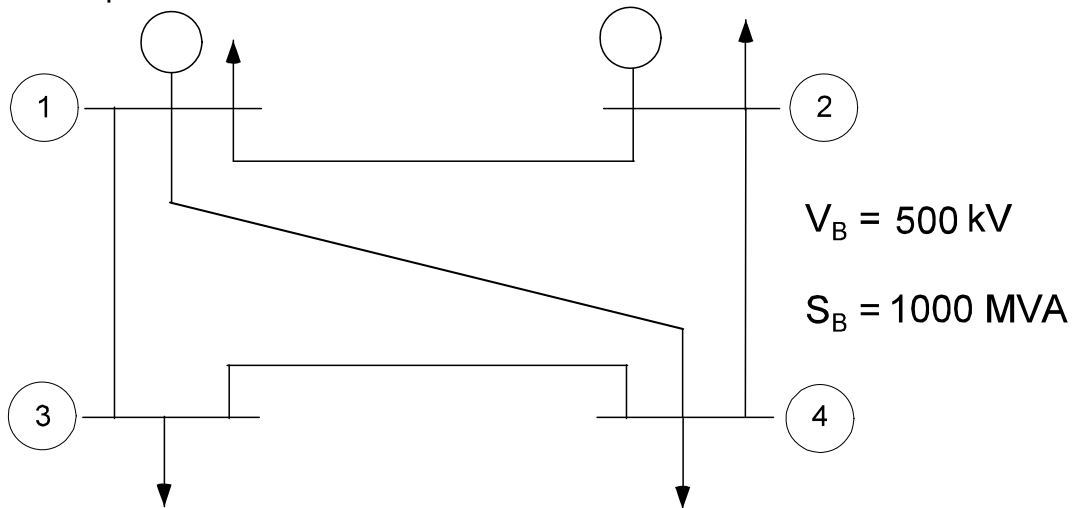
Question #	Possible Points	Awarded Points
1	25	
2	20	
3	25	
4	25	
<b>Total</b>	<b>100</b>	

1. A 14kV, 60 Hz, 5 MVA, Y-connected, 16-pole, **salient-pole** generator supplies rated load at 0.9 lag pf and rated terminal voltage. Neglect armature resistance,  $X_d = 60 \Omega$ ,  $X_q = 45 \Omega$ . Determine:
- (a) Excitation Voltage  $E_f$  and Load Angle  $\delta$ ,
  - (b) Active and Reactive Power developed, and
  - (c) Driving Torque if the rotational losses are 300 kW.

$$\delta = 34.6^\circ, \quad T = 101.9 \text{ kNm}$$

2.

- a) Load Flow analysis was performed on the system shown below and the results are presented in tables 1 & 2. Determine:
- the current (A or kA) flowing from bus 1 to bus 3,
  - the current (A or kA) received at bus 3 from bus 1, and
  - the current (A or kA) flowing out of generator 2.
- b) Another load flow was run with one line removed for maintenance; the results are shown in table 3. If losses cost \$35/MWh and the outage lasts for eight weeks, how much is the increase in losses costing the utility. (Assume the loads are constant).
- c) It was decided to install capacitors at bus 4 during the outage. The results of a load flow are shown in table 4. Determine:
- The MVAR rating of the capacitor bank.
  - The capacitance/phase for wye-connected capacitors.
  - The saving in losses achieved by installing the capacitors for the outage period.



$$I_{13} = 1244 \text{ A}$$

$$I_{G2} = 1757 \text{ A}$$

BUS#	MAGNITUDE pu	ANGLE degrees	PG pu	QG pu	PL pu	QL pu
1	1.050	0.000	2.046	1.953	0.400	0.300
2	1.050	2.040	1.500	0.550	1.200	0.800
3	0.985	-2.213	0.000	0.000	1.000	0.600
4	0.975	-3.141	0.000	0.000	0.800	0.500
TOTAL			3.546	2.503	3.400	2.200

LINE #	BUS TO BUS	P	Q	S
1	1 2	0.797	1.047	1.316
	2 1	-0.705	-0.636	0.950
2	1 3	0.695	0.892	1.131
	3 1	-0.601	-0.219	0.640
3	1 4	0.554	0.014	0.554
	4 1	-0.334	0.080	0.343
4	2 4	1.005	0.386	1.077
	4 2	-0.761	-0.865	1.152
5	3 4	-0.399	-0.381	0.552
	4 3	0.295	0.285	0.410

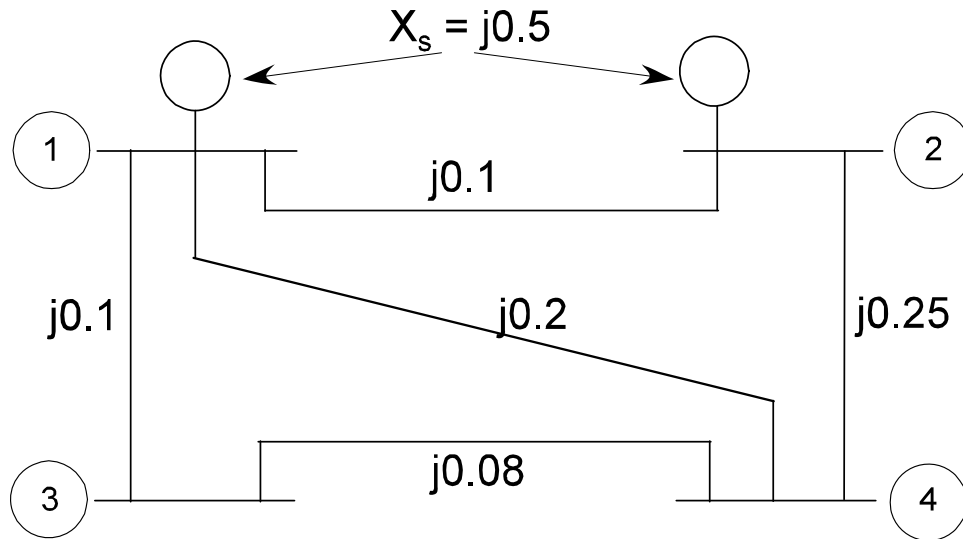
BUS#	MAGNITUDE pu	ANGLE degrees	PG pu	QG pu	PL pu	QL pu
1	1.050	0.000	2.179	1.823	0.400	0.300
2	1.050	-4.797	1.500	0.880	1.200	0.800
3	0.933	-8.945	0.000	0.000	1.000	0.600
4	0.953	-6.193	0.000	0.000	0.800	0.500
TOTAL			3.679	2.703	3.400	2.200

BUS#	MAGNITUDE pu	ANGLE degrees	PG pu	QG pu	PL pu	QL pu
1	1.050	0.000	2.114	1.770	0.400	0.300
2	1.050	-3.775	1.500	0.670	1.200	0.800
3	0.964	-13.073	0.000	0.000	1.000	0.600
4	0.970	-16.862	0.000	0.171	0.800	0.500
TOTAL			3.614	2.611	3.400	2.200

3. In the system shown below, the impedances are in pu on a base of 200 MVA, 115 kV. Both generators have 0.5 pu synchronous reactance. Ignore the effect of any loads.

Derive the  $[Y_{bus}]$  matrix of the system.

b) Determine the balanced 3 $\phi$  fault level (kA) at each bus.



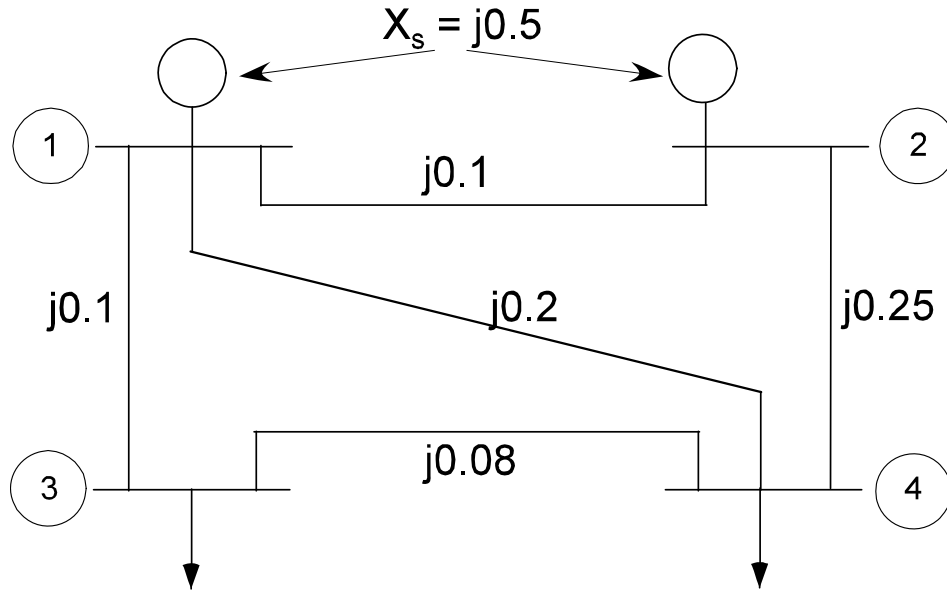
$$I_{f1} = 3.75 \text{ kA}$$

$$I_{f2} = 3.75 \text{ kA}$$

$$I_{f3} = 3.10 \text{ kA}$$

$$I_{f4} = 3.12 \text{ kA}$$

4. In the system shown below, the impedances are in pu on a base of 200 MVA, 115 kV. The excitation voltage at generator 1 is 138 kV and at generator 2 it is 153 kV. Both generators have 0.5 pu synchronous reactance. The loads at buses 3 & 4 each draw 120 MVA at 0.85 lag when they have rated voltage.
- Convert the generators to their Norton equivalents.
  - Determine the load currents in pu.
  - Derive the  $[Y_{bus}]$  matrix of the system.
  - Derive the current matrix  $[I]$  of the system including the loads.
  - Determine the bus voltages (kV).



$[Y_{bus}]$  is the same as question 3

$$[I_{bus}] = \begin{bmatrix} 2.4 \angle -90 \\ 2.66 \angle -90 \\ -0.6 \angle -31.8 \\ -0.6 \angle -31.8 \end{bmatrix}$$