EC571 CONTROL OF POWER SYSTEMS

Third Test, Winter 2002 - 2003

Name_____

Box #_____

Attempt all five questions.
No partial credit unless you explain your solution procedure.

Open Book Open Notes. Time Allowed - 2½ hours.

Question #	Possible Points	Awarded Points
1	20	
2	20	
3	20	
4	20	
5	20	
Total	100	

1.

A hydroelectric unit is rated at 200 MW and has the following dimensions: Penstock outside diameter = 5 ft, penstock wall thickness = 3”, penstock length = 300 ft, forebay elevation = 450 ft, tailrace elevation = 230 ft, flow through penstock for rated output = 12000 cfs.

Determine the rated efficiency and the water starting time under these conditions.

89.6% 31.9 sec

2.

a) The parameters of a standard voltage regulator are shown below. The $|V|_{ref}$ setting has been turned off for a long time; apply the final value theorem to determine the % error if $|V|_{ref}$ is suddenly increased to 1.1 pu.

b) Use the Simulink file **Volt.mdl** to obtain the step response for the conditions in part (a). Assume that the response is second-order dominated and determine: damping ratio (ζ), undamped natural frequency (ω_o), and damped natural frequency (ω_d).

c) Repeat part (b) with the stabilizer turned off.
(Print out your responses for b) and c) and attach them.)

$K_A = 15$,	$K_E = 4$,	$K_r = 1.5$,	$K_{st} = 0.1$
$T_A = 0.2$,	$T_E = 2.0$,	$T_r = 15$,	$T_{st} = 0$

a) 1.1%

b) 0.085 0.86 rad/s 0.857 rad/s

c) 0.0076 1.655 rad/s

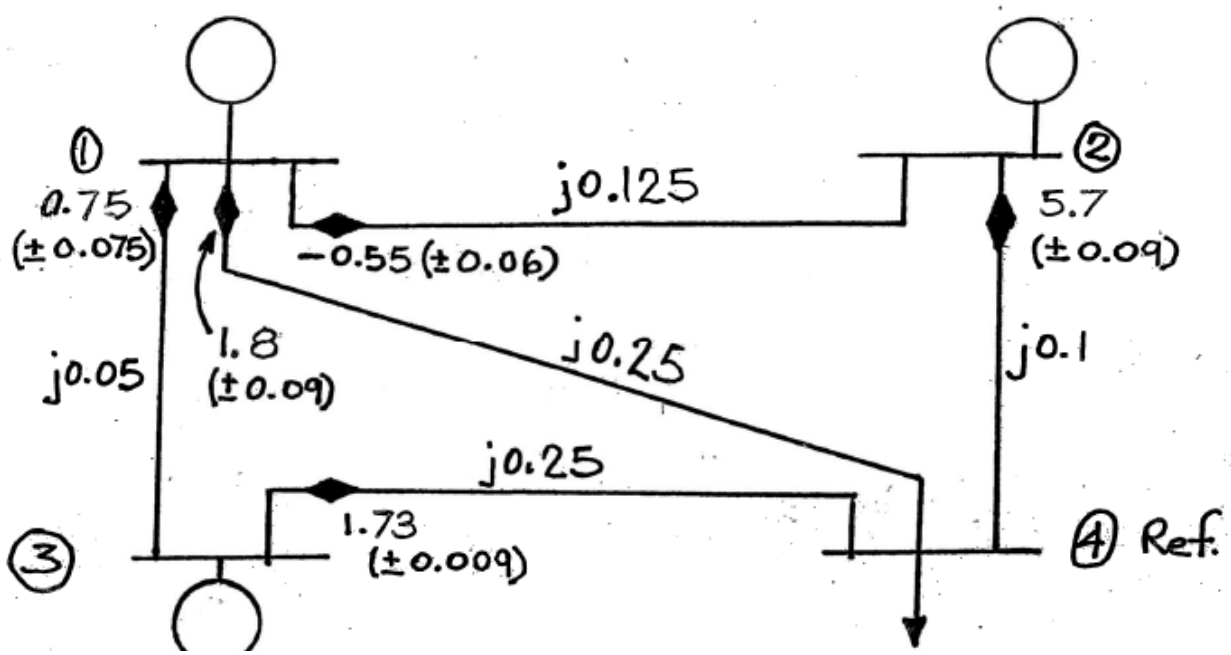
3.

The meters in the system shown below register the values indicated beside them with the associated accuracy in parentheses. The reactances of the lines are indicated. All values are in pu on a common 100 MVA base. Use state estimation to determine:

a) the power flowing in each line,

b) the generated (load) power at each bus, and

c) the residual error.



a) $P_{12} = -0.642$

b) $P_2 = 6.176$

c) 65.97

4.

A control area which has a peak demand of 25 GW and is part of an interconnection with a peak demand of 250 GW. The control area may be modeled as a single unit of 25 GW and the rest of the interconnection may be modeled as a single 225 GW unit.

The control area loses the output of an entire generating station, amounting to 5 GW at the time of peak demand while it is exporting a total of 2 GW to utilities in the rest of the interconnection.

The utility has a load damping factor of 1.3333 pu and overall regulation of 30%, while the rest of the interconnection has a load damping factor of 1.5 pu and overall regulation of 22½%, all quantities are based on individual peak demand.

Work on a base of 100 GVA and determine:

a) Steady-state frequency before any secondary ALFC.
b) Steady-state tie-line flow before any secondary ALFC.
c) Frequency Bias Factor (MW/Hz) of the control area.
d) Frequency Bias Factor (MW/Hz) of the rest of the interconnection.
e) Frequency Bias Factor (MW/Hz) of the overall interconnection.
f) Percentage of generating capacity under governor control in the control area if its individual governors are set at 5% droop.
g) How long it will take for the time error to accumulate to 3 sec. if it was zero at the start of the event? (Ignore the transient component.)

a) 59.79 Hz
b) 1599 MW
f) 16⅔%
g) 872.5 sec.

5.

Five utilities are interconnected as shown below. Actual exchanges are indicated, scheduled exchanges are in parentheses. The frequency has been measured at 60.12 Hz.

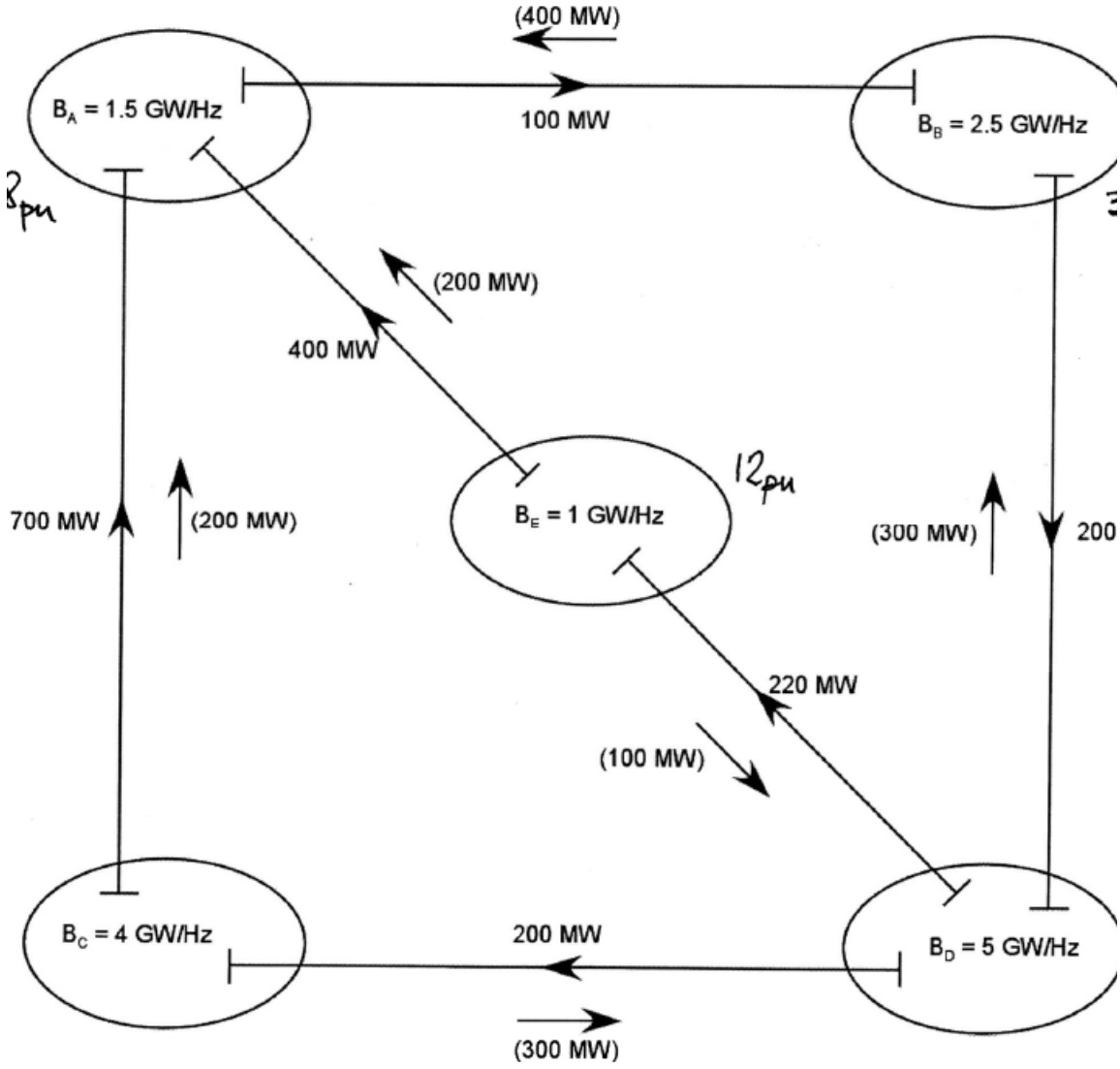
a) Work on a system base of 5 GVA and standard frequency of 60 Hz to calculate the Area Control Error (ACE) for each of the utilities.

b) State what control action is necessary at each utility to bring the frequency back to 60 Hz and put each interchange back on schedule.

c) What is the Frequency Bias Factor (GW/Hz) of the overall interconnection?

d) If a 20 mHz frequency off-set is required to correct the accumulated time error, what would be the new control action. (i.e., re-work part (a) with a standard frequency of 59.98 Hz.)

e) How long will the off-set in part (d) be required if the accumulated time error was 2 sec when the off-set was enacted?



a&b) ACE_A = 20 MW raise, ACE_B = 300 MW lower e) 6000 sec.