Homework 4

Problems 1 to 6 (50 points):

12.3. A single area consists of two generating units, rated at 400 and 800 MVA, with speed regulation of 4 percent and 5 percent on their respective ratings. The units are operating in parallel, sharing 700 MW. Unit 1 supplies 200 MW and unit 2 supplies 500 MW at 1.0 per unit (60 Hz) frequency. The load is increased by 130 MW.
(a) Assume there is no frequency-dependent load, i.e., $D = 0$. Find the steady-state frequency deviation and the new generation on each unit.

(b) The load varies 0.804 percent for every 1 percent change in frequency, i.e., $D = 0.804$. Find the steady-state frequency deviation and the new generation on each unit.

12.4. An isolated power station has the LFC system as shown in Figure 12.9 with the following parameters

Turbine time constant $\tau_T = 0.5$ sec
Governor time constant $\tau_g = 0.25$ sec
Generator inertia constant $H = 8$ sec
Governor speed regulation = R per unit

The load varies by 1.6 percent for a 1 percent change in frequency, i.e., $D = 1.6$.
(a) Use the Routh-Hurwitz array (Appendix B.2.1) to find the range of R for control system stability.
(b) Use *MATLAB* **rlocus** function to obtain the root-locus plot.

12.5. The governor speed regulation of Problem 12.4 is set to $R = 0.04$ per unit. The turbine rated output is 200 MW at nominal frequency of 60 Hz. A sudden load change of 50 MW ($\Delta P_L = 0.25$ per unit) occurs.
(a) Find the steady-state frequency deviation in Hz.
(b) Obtain the closed-loop transfer function and use *MATLAB* to obtain the frequency deviation step response.
(c) Construct the *SIMULINK* block diagram and obtain the frequency deviation response.

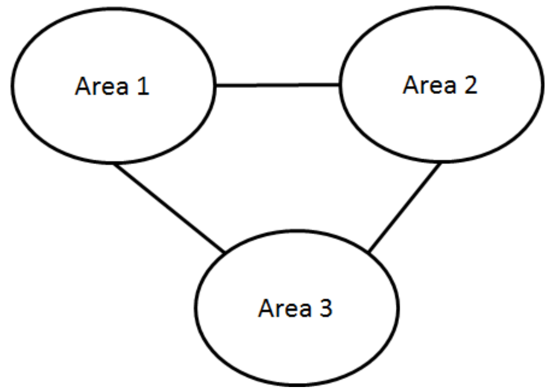
12.6. The LFC system in Problem 12.5 is equipped with the secondary integral control loop for automatic generation control as shown in Figure 12.16.
(a) Use the *MATLAB* **step** function to obtain the frequency deviation step response for a sudden load change of $\Delta P_L = 0.25$ per unit. Set the integral controller gain to $K_I = 9$.
(b) Construct the *SIMULINK* block diagram and obtain the frequency deviation response for the condition in part (a).

12.7. The load changes of 200 MW and 150 MW occur simultaneously in areas 1 and 2 of the two-area system of Example 12.4. Modify the *SIMULINK* block diagram (sim12ex4.mdl), and obtain the frequency deviation and the power responses.

12.8. Modify the *SIMULINK* model for the two-area system of Example 12.5 with the tie-line bias control (sim12ex5.mdl) to include the load changes specified in Problem 12.7. Obtain the frequency and power response deviation for each area.

Problem 7 (20 points) Consider three interconnected areas. The connected load at 60Hz is 20,000MW in Area 1, 30,000MW in Area 2, and 40,000MW in Area 3. Respectively in Area 1, Area 2 and Area 3, the load varies 1%, 1.5% and 2% for every 1% change in frequency. Area 1 is exporting 1,200MW, Area 2 is importing 1,500MW, and Area 3 is exporting 300MW. The speed regulation, R, is 4% for all units. If the load in Area 3 decreases by 1000MW, and there are no supplementary load frequency controls, determine:

a. the new steady-state system frequency
b. the new generation and load of each area
c. the new MW export or import of each area



Problem 8 (30 points) Consider two interconnected areas. The connected load at 60Hz is 19,000MW in area 1 and 32,000MW in area 2. The load in each area varies 1.2% for every 1% change in frequency. Area 1 is exporting 2,000MW to Area 2. The speed regulation, R, is 5% for all units. Area 1 is operating with a spinning reserve of 2,000MW spread uniformly over a generation of 5,000MW capacity, and Area 2 is operating with a spinning reserve of 2,000MW spread uniformly over a generation of 10,000MW. If the generation carrying spinning reserve in each area is on supplementary control with frequency bias factor settings of 800MW/0.1Hz for area 1 and 500MW/0.1Hz for area 2.

For each of the following cases, determine the new steady-state frequency, generation and load, final ACE and remaining spinning reserve of each area and the tie line power:

a. Area 1 loses 1000MW generation, which is not carrying any spinning reserve, and at the same time, Area 2 loses 2,000MW generation, which is part of the generation carrying spinning reserve
b. Tripping the tie line, assuming that there is no change to the interchange schedule of the supplementary control