Example 12.1 (chp12ex1)

An isolated power station has the following parameters

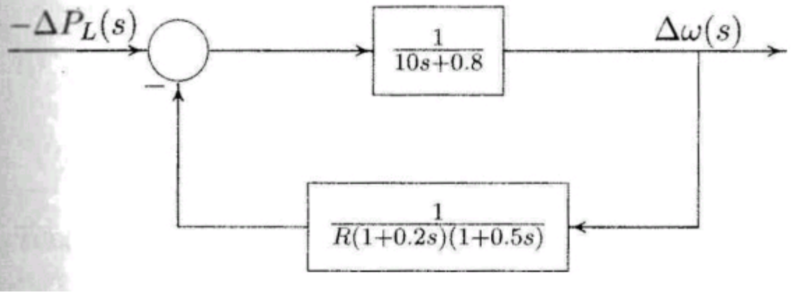
Turbine time constant $\tau_T = 0.5$ sec
Governor time constant $\tau_g = 0.2$ sec
Generator inertia constant $H = 5$ sec
Governor speed regulation = R per unit

The load varies by 0.8 percent for a 1 percent change in frequency, i.e., $D = 0.8$
(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.
(c) The governor speed regulation of Example 12.1 is set to $R = 0.05$ per unit. The turbine rated output is 250 MW at nominal frequency of 60 Hz. A sudden load change of 50 MW ($\Delta P_L = 0.2$ per unit) occurs.

(i) Find the steady-state frequency deviation in Hz.

(ii) Use *MATLAB* to obtain the time-domain performance specifications and the frequency deviation step response.

(d) Construct the *SIMULINK* block diagram (see Appendix A.17) and obtain the frequency deviation response for the condition in part (c).
Substituting the system parameters in the LFC block diagram of Figure 12.10 results in the block diagram shown in Figure 12.11. The open-loop transfer function



(c) The closed-loop transfer function of the system shown in Figure 12.11 is

$$\frac{\Delta\Omega(s)}{-\Delta P_L(s)} = T(s) = \frac{(1+0.2s)(1+0.5s)}{(10s+0.8)(1+0.2s)(1+0.5s)+1/.05}$$
$$= \frac{0.1s^2+0.7s+1}{s^3+7.08s^2+10.56s+20.8}$$

(i) The steady-state frequency deviation due to a step input is

$$\Delta\omega_{ss} = \lim_{s\to 0} s\Delta\Omega(s) = \frac{1}{20.8}(-0.2) = -0.0096 \text{ pu}$$

Thus, the steady-state frequency deviation in hertz due to the sudden application of a 50-MW load is $\Delta f = (-0.0096)(60) = 0.576$ Hz.

(ii) To obtain the step response and the time-domain performance specifications, we use the following commands

```
PL = 0.2; numc = [0.1  0.7  1];
denc = [1    7.08   10.56   20.8];
t = 0:.02:10; c = -PL*step(num, den, t);
figure(2), plot(t, c), xlabel('t,  sec'), ylabel('pu')
title('Frequency deviation step response'), grid
  timespec(num, den)
```

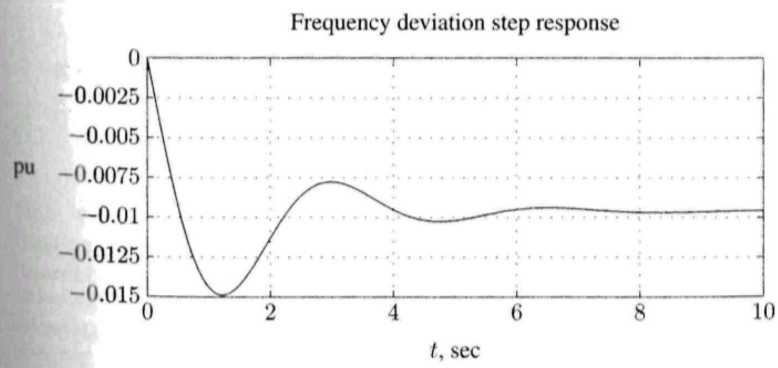


FIGURE 12.13
Frequency deviation step response for Example 12.1.

The frequency deviation step response is shown in Figure 12.13, and the time-domain performance specifications are

```
Peak time = 1.223     Percent overshoot = 54.80
Rise time = 0.418
Settling time = 6.8
```

(d) A *SIMULINK* model named **sim12ex1.mdl** is constructed as shown in Figure 12.14. The file is opened and is run in the *SIMULINK* window. The simulation results in the same response as shown in Figure 12.13.