Homework #5


12.9. A generating unit has a simplified linearized AVR system as shown in Figure 12.52.
   (a) Use the Routh-Hurwitz array (Appendix B.2.1) to find the range of $K_A$ for control system stability.
   (b) Use MATLAB rlocus function to obtain the root-locus plot.
   (c) The amplifier gain is set to $K_A = 40$. Find the system closed-loop transfer function, and use MATLAB to obtain the step response.
   (d) Construct the SIMULINK block diagram and obtain the step response.

![Block diagram](image)

FIGURE 12.52
AVR system of Problem 12.9.

12.10. A rate feedback stabilizer is added to the AVR system of Problem 12.9 as shown in Figure 12.53. The stabilizer time constant is $\tau_F = 0.04$ second, and the derivative gain is adjusted to $K_F = 0.1$.
   (a) Find the system closed-loop transfer function, and use MATLAB to obtain the step response.
   (b) Construct the SIMULINK model, and obtain the step response.

![Block diagram](image)

FIGURE 12.53
AVR system with rate feedback for Problem 12.10.

12.11. A PID controller is added in the forward path of the AVR system of Problem 12.9 as shown in Figure 12.54. Construct the SIMULINK model. Set the proportional gain $K_P$ to 2.0, and adjust $K_I$ and $K_D$ until a step response with a minimum overshoot and a very small settling time is obtained (suggested values $K_P = 1$, $K_I = 0.15$, and $K_D = 0.17$).

![Block diagram](image)

FIGURE 12.54
AVR system with PID controller for Problem 12.11.
**Question 4:** Assume the following parameters:

\[ K_1 = 2.0 \quad K_2 = 1.0 \quad K_3 = 1.0 \quad K_4 = 2.0 \quad T_3 = 1.0 \text{ (s)} \]
\[ K_5 = -0.1 \quad K_6 = 0.3 \quad T_R = 0.02 \text{ (s)} \quad K_A = 100 \quad H = 5.0 \text{ (s)} \quad K_D = 0.0 \]
\[ T_W = 10.0 \text{ (s)} \quad K_{STAB} = 5 \]

1) Calculate \( K_{S(\Delta \phi fd)} \) and \( K_{D(\Delta \phi fd)} \) without PSS.

2) Design \( T_1 \) and \( T_2 \) for the PSS to satisfy both conditions below and prove your design by Bode plots about, e.g., \( G_{PSS}(s) \) and \( G_{PSS}(s) \times K_A K_2 K_3 (1 + s T_3) \):
   - At least +30° phase-lead compensation for the frequency range of 0.1Hz (0.63 rad/s) to 2.0Hz (6.3 rad/s)
   - Enabling a complete phase compensation for oscillation at the frequency of 0.4Hz.