Problems on Nyquist and Bode Stability Criteria

1. Consider a closed-loop system whose open-loop transfer function is given by:

$$G(s)H(s) = \frac{K}{(\tau_1 s + 1)(\tau_2 s + 1)}$$

Examine the stability of the closed-loop system using Nyquist plots for different values of K, τ_1 and τ_2.

2. Consider the system with the following open-loop transfer function:

$$G(s)H(s) = \frac{K}{s(\tau_1 s + 1)(\tau_2 s + 1)}$$

Determine the stability of the closed-loop system for (1) gain K small, and (2) gain K large.

3. Consider the system with the following open-loop transfer function:

$$G(s)H(s) = \frac{K(\tau_2 s + 1)}{s^2(\tau_1 s + 1)}$$

Examine the stability of the closed-loop for the cases (1) $\tau_1 < \tau_2$, (2) $\tau_1 = \tau_2$, and (3) $\tau_1 > \tau_2$.

4. Consider the system with the following open-loop transfer function:

$$G(s)H(s) = \frac{K}{s(\tau s - 1)}$$

Determine the stability of the closed-loop system.

5. Consider the system with the following open-loop transfer function:

$$G(s)H(s) = \frac{K(s + 3)}{s(s - 1)}$$

for $K > 1$. Determine the stability of the closed-loop system.

6. Consider the open-loop transfer function

$$G(s)H(s) = \frac{K}{(s + 1)(2s + 1)(4s + 1)}$$

Determine the closed-loop stability for $K = 1$ and $K = 50$.

7. Plot the Bode diagrm of the open-loop transfer function

$$G(s)H(s) = \frac{20(s + 1)}{s(s + 5)(s^2 + 2s + 10)} \tag{1}$$

Determine the gain margin, phase margin, phase-crossover frequency, and gain-crossover frequency with Matlab.

8. Consider the three-tank system discussed in the lectures, now operating with a PID controller, a perfect measuring device, and a perfect valve. In this case, the open-loop transfer function will be given by:

$$G(s)H(s) = \frac{6K_c(1 + \tau_I s + \tau_D \tau_I s^2)}{\tau_I s(s + 2)(s + 4)(s + 6)}$$

Determine the range of stable controller gains using Nyquist stability criterion for P-only control, PI control with $1/\tau_I = 0.05$, and PID control with $\tau_D = 10, 1/\tau_I = 1.33$. Also use gain-neutral Bode plots to determine the stability limit on K_c for each controller.