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MODULE 12 — Practice Assignment

Problem 1

Solve the following 9th Edition textbook problems:

- **9-49 (a)**
- **9-50 (c,d)**

(9-49) Consider that the controller in the liquid-level control system shown in Fig. 9P-10 is a single-stage phase-lag controller:

$$\mathbf{G_c(s) = \frac{1 + aTs}{1 + Ts}, \quad a < 1}$$

$$\mathbf{G_p(s) = \frac{10N}{s(s+1)(s+10)}}$$

(a) For $\mathbf{N = 20}$, select the values of a and T so that the two complex roots of the characteristic equation correspond to a relative damping ratio of approximately 0.707. Plot the unit-step response of the output $\mathbf{y(t)}$. Find the attributes of the unit-step response. Plot the Bode plot of $\mathbf{G_c(s)G_p(s)}$ and determine the phase margin of the designed system.

This makes the process:

$$G_p(s) = \frac{200}{s(s+1)(s+10)}$$

The compensated system is:

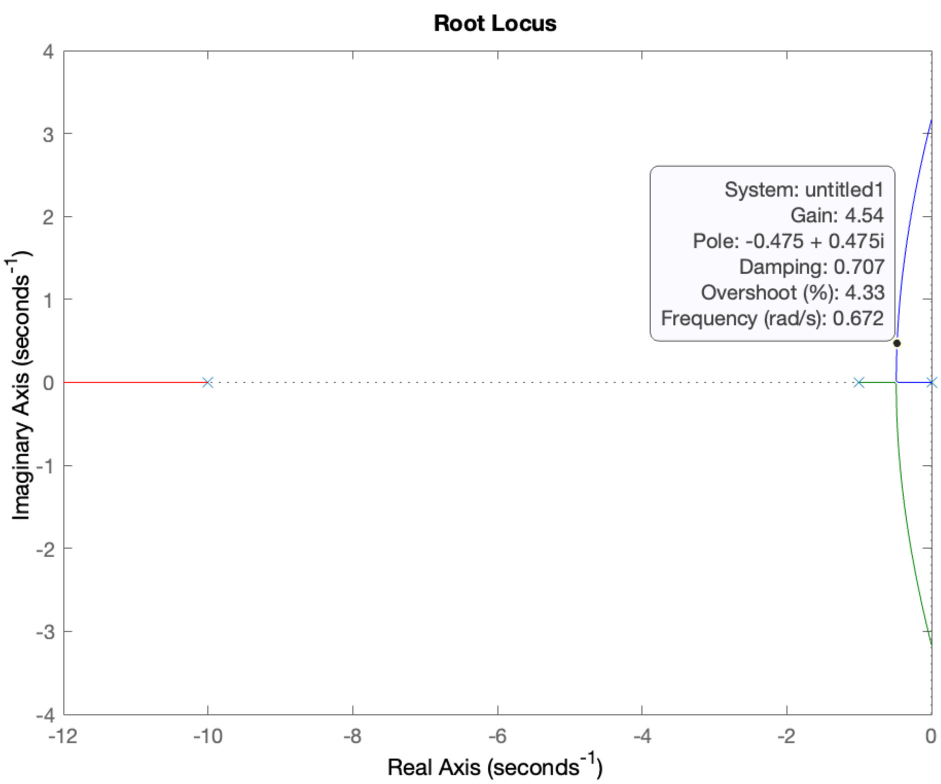
$$G_c(s)G_p(s) = \frac{200(1 + aTs)}{s(s+1)(s+10)(1+Ts)}$$

Rewriting the uncompensated process as:

$$G_p(s) = \frac{K}{s(s+1)(s+10)}$$

K_{SSE} to satisfy the SSE requirement is $K_{\text{SSE}} = 200$.

Looking at the root locus of the uncompensated system where $K = 1$, we can that $K_{\%\text{OS}}$ for a damping ratio of 0.707 is $K_{\%\text{OS}} = 4.54$:



We can calculate a for the compensated system as:

$$a = \frac{K_{\%\text{OS}}}{K_{\text{SSE}}} = \frac{4.54}{200} = 0.0227$$

If the value of T is sufficiently large, when K =1, the dominant roots of the characteristic equation will correspond to a damping ratio of approximately 0.707. Let us arbitrarily select T = 10,000.

Submitted by Austin Barrilleaux on November 30, 2023.