Recommended Assessment

PD Position Control

Understanding System Gains

1. When setting $k_d = 0$ V/(rad/s) and varying the proportional gain k_p between 1 and 4, describe how varying k_p affects the response of the system.

2. When setting $k_p = 2.5$ V/rad and varying the derivative gain k_d between 0 and 0.15, describe how varying k_d affects the response of the system.

Calculating System Response

3. Compare the standard second order transfer function and the transfer function of the Qube-Servo 3 with a PD controller to find k_p and k_d in terms of ω_n and ζ.

$$\frac{Y(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2} \qquad \frac{Y(s)}{R(s)} = \frac{K \cdot k_p}{\tau s^2 + (1 + K \cdot k_d)s + K \cdot k_p}$$

4. For the response to have a peak time of 0.15s and a percent overshoot of 2.5%, calculate the natural frequence and damping ratio needed. Use the equations for peak time and percent overshoot.
   Hint: You can use MATLAB's symbolic solve to calculate the values
   https://www.mathworks.com/help/symbolic/sym.solve.html#:~:text=Solve%20Polynomial%20and%20Return%20Real%20Solutions

$$PO = 100\, e^{\left(-\frac{\pi\zeta}{\sqrt{1-\zeta^2}}\right)} \qquad t_p = \frac{\pi}{\omega_m \sqrt{1-\zeta^2}}$$

5. Use the Qube-Servo 3 model parameters K and τ, found in any of the Modeling Labs to calculate the k_p and k_d control gains needed to satisfy the requirements of a peak time of 0.15s and a percent overshoot of 2.5%.
   NOTE: If no modeling lab has been done, for Qube-Servo 3, $K = 24$ and $\tau = 0.1$ are good defaults if this equation needs to be used.

Measuring System Response

6. Attach the system response for the k_p and k_d calculated in the previous question. What were the peak time and overshoot for your response? Do the results match the theoretical peak time and percent overshoot?

7. Give one reason why the calculated and actual responses don't match.

8. If the responses did not match, attach the response that more closely matches the desired peak time and percent overshoot after tuning k_p and k_d. Write down the k_p and k_d used to obtain the response.

9. Write down your thought process for tuning the control gains in the previous question.