Total: ____/50

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Part I. ____/8

State Space Model Representation of $H_1(s)$ ____/8

Compare the plots of y_dot and y obtained in Part 1 of the lab with the plots previously made for the prelab. Why are they identical? Attach plots – if your prelab plot was wrong, fix it and attach the corrected plot.

The one in Part 1 is the state-space model for that of prelab.

$$\begin{cases} \dot{x} = \begin{bmatrix} -6 & -25 \\ 1 & 0 \end{bmatrix} x + \begin{bmatrix} 25 \\ 0 \end{bmatrix} u \\ y = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} x \Rightarrow y_1 = x_1,\ y_2 = x_2. \end{cases}$$

$$\Rightarrow x = y,\ \dot{x} = \dot{y}$$

$$\Rightarrow \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -6x_1 - 25x_2 \\ x_1 \end{bmatrix} + \begin{bmatrix} 25u_1 \\ 0 \end{bmatrix}$$

$$\Rightarrow \dot{x}_1 = -6x_1 - 25x_2 + 25u_1,\ \dot{x}_2 = x_1$$

$$\Rightarrow \ddot{y} + 6\dot{y} + 25y = 25u.$$

/2 thus the same transfer function.

Part II. ____/22

Effects of a Zero on M_p, t_r, and t_s.

Fill the table and attach plot for part II.

Property	No Zero $H_1(s)$	$H_2(s)$ with Zero at s = -30	$H_2(s)$ with Zero at s = -3	$H_2(s)$ with Zero at s = -1.5	$H_2(s)$ with Zero at s = 1.8	$H_2(s)$ with Zero at s = 18
M_p %	9.5 %	9.6 %	41.1 %	114.9 %	19.5 %	9.78 %
t_r (s)	0.4 s	0.37 s	0.13 s	0.06 s	0.21 s	0.36 s
t_s (s)	1.04 s	1.02 s	0.85 s	1.38 s	1.34 s	1.10 s

Table 1: Effects of Zero

Discuss the Effects of a LHP Zero ____/4

Explain how M_p, t_r, and t_s are affected by the zero's location. When can the zero be ignored? when zero is far from the origin.

M_p increased ~~if~~ when the zero moves closer to the origin in LHP. & RHP.

t_r decreased when moving to origin in LHP, but remain unchanged in RHP.

t_s remains unchanged for a LHP zero but decreased when moving to origin in RHP.

Effects of a Non-minimum Phase (RHP) Zero ____/2

What is unique in this situation?

It creates an undershoot before the response overshoots.

Decomposition of $H_2(s)$ ____/14

Take $H_2(s)$, set ζ to the value found in the prelab, and separate the numerator into two terms so that $H_2(s)$ is a sum of 2 fractions. Discuss how this decomposition helps to explain the effect of the zero location. In particular, discuss what each term represents. Also discuss α's effect. Which term dominates as α approaches 0? As α approaches ∞? What happens when α is negative?

Output regarded as $y_2(t) = y_1(t) + \frac{m}{\alpha\zeta}\dot{y}_1(t)$.

$$H_2 = \frac{25 + \frac{25s}{\alpha\zeta}}{s^2 + 10\zeta s + 25} = \frac{25\cdot\left(\frac{s}{\alpha\zeta}\right)}{s^2 + 10\zeta s + 25} + \frac{25}{s^2 + 10\zeta s + 25}.$$

This is the sum of two responses; one is the original, another has a zero at the origin. The additional Term is the first-order derivative of the original output with a coefficient $\frac{1}{\alpha\zeta}$.

For α: it controls the amount of contribution by $\dot{y}(t)$ to $y_2(t)$, the new output. When $\alpha \to 0$, the 1-st order derivative original output dominates; $\alpha \to \infty$, the original Term dominates. When α is negative, it creates undershoot, as $\alpha \to -\infty$, the output looks similar to the original.

Part III. ____/20

Effects of an Extra Pole on M_p, t_r, and t_s. ____/2

Fill the table and attach plot for part III. Attach Plots.

Property	No Pole $H_1(s)$	$H_3(s)$ with Pole at s = -30	$H_3(s)$ with Pole at s = -3	$H_3(s)$ with Pole at s = -1.5
M_p %	9.5 %	9.3 %	8.5 %	1.5 %
t_r (s)	0.4 s	0.4	0.7	1.4
t_s (s)	1.04 s	1.01	1.05	2.21

Table 2: Effects of Extra Pole

Discuss the Effects of an Extra Pole ____/4

Explain how M_p, t_r, and t_s are affected by the location of the additional pole. When can the extra pole be ignored? The closer the poles are to the origin, the ~~longer~~ smaller the overshooting percentage and rising time.

The extra pole can be ignored when the pole is far away in LHP.

Decomposition of $H_3(s)$ ____/14

Take $H_3(s)$, set ζ to the value found in the prelab, and perform a partial fraction expansion to make three terms in the form of the expansion on page 18 in the lab manual. Determine the values of k_1, k_2, and k_3. Discuss how this decomposition helps to explain the effect of the location of an additional pole. In particular, discuss what each term represents. Also discuss α's effect. Which term dominates as α approaches 0? As α approaches ∞?

By partial fraction:

$$H_3 = \frac{\frac{-25}{\alpha\zeta(10\zeta-\alpha\zeta)}}{1+\frac{s}{\alpha\zeta}} + \frac{\frac{25}{10\zeta-\alpha\zeta}s}{s^2+10\zeta s+25} + \frac{25}{s^2+10\zeta s+25}. \Rightarrow k_1 = \frac{625}{9\alpha^2-90\alpha+625}, \quad k_2 = \frac{375\alpha}{90\alpha^2-90\alpha+675}.$$

This shows a composition by the original output, its first-order derivative, and the extra pole.

$$k_3 = \frac{225\alpha^2-2250\alpha}{9\alpha^2-90\alpha+625}$$

Attachments (4)

- Plot from PreLab
- Plots for Part I, II and III.

All the plots are included in the compressed archive submitted.