



به نام خدا



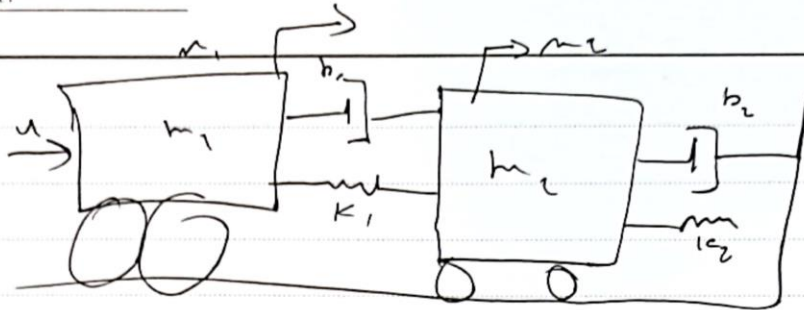
دانشگاه تهران
دانشکده برق و کامپیوتر
کنترل صنعتی

تمرین ۲ام

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شماره دانشجویی	۸۱۰۱۹۹۴۹۲
تاریخ ارسال گزارش	

۳.....	۱۱
۵.....	۱۲
۸.....	۱۳
۱۰.....	۱۴
۱۲.....	۱۵
۱۳.....	۱۶
۱۴.....	۱۷
۱۶.....	۱۸
۱۸.....	۱۹

Subject: _____
Date: _____



$$\begin{cases} m_1 \ddot{x}_1 = -b_1 \dot{x}_1 - K_1 x_1 + u \\ m_2 \ddot{x}_2 = -b_2 \dot{x}_2 - K_2 x_2 - b_1 (\dot{x}_2 - \dot{x}_1) - K_1 (x_2 - x_1) \end{cases} \quad (1) \quad (2)$$

$$\begin{aligned} \ddot{x}_1 &= \ddot{x}_1 \\ \dot{x}_1 &= \dot{x}_1 \\ \ddot{x}_2 &= \ddot{x}_2 \\ \dot{x}_2 &= \dot{x}_2 \end{aligned} \quad \Rightarrow \quad \ddot{x}_1 = \frac{-b_1 (\dot{x}_2 - \dot{x}_1) - K_1 (x_2 - x_1) + u}{m_1}$$

$$\ddot{x}_2 = \frac{-b_2 \dot{x}_2 - K_2 x_2 - b_1 (\dot{x}_2 - \dot{x}_1) - K_1 (x_2 - x_1)}{m_2}$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -\frac{K_1}{m_1} & -\frac{b_1}{m_1} & \frac{K_1}{m_1} & \frac{b_1}{m_1} \\ 0 & 0 & 0 & 1 \\ \frac{K_1}{m_2} & \frac{b_1}{m_2} & -\frac{K_2 + K_1}{m_2} & -\frac{b_1 + b_2}{m_2} \end{bmatrix} \begin{bmatrix} x_1 \\ \dot{x}_1 \\ x_2 \\ \dot{x}_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} u$$

992

Subject: _____
Date: _____

$$K_1 + b_2 = \frac{1+11}{15} = \frac{12}{15} = \frac{4}{5} \quad \left| \quad K_2 = b_2 = \frac{10+18}{100} = \frac{28}{100} \right.$$

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -\frac{4}{5} & -\frac{28}{100} & \frac{4}{5} & \frac{28}{100} \\ 0 & 0 & 0 & 1 \\ \frac{4}{5} & \frac{28}{100} & -\frac{1}{100} & -\frac{1}{100} \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \end{bmatrix} u$$

$$K_1 + K_2 = \frac{4}{5} + \frac{28}{100} = \frac{80+28}{100} = \frac{108}{100}$$

$$b_1 + b_2 = \frac{108}{100}$$

ب) تانچہ تبدیل ۱، ۲، ۳ استعمال سے

$$(m_1 s^2 + b_1 s + k) X_1(s) = (b_1 s + k_1) X_2(s) + U(s) \quad (6)$$

$$((m_2 s^2 + b_2 s + k_2 + b_1 s + k_1) X_2(s) = (b_1 s + k_1) X_1(s) \quad (3)$$

$$\Rightarrow X_1(s) = \frac{(b_1 s + k_1) X_2(s) + U(s)}{(m_1 s^2 + b_1 s + k)} \quad (4)$$

$$\textcircled{3} \text{ 2) } \frac{X_2(s)}{X_1(s)} = \frac{(b_1 s + k_1)}{(m_2 s^2 + b_2 s + k_2 + b_1 s + k_1)} \quad (5)$$

$$⑤ \Rightarrow X_2(s) = \frac{(b_1 s + k_1)}{(m_2 s^2 + b_2 s + k_2 + b_1 s + k_1)}$$

$$⑥, ⑤ \Rightarrow X_1(s) =$$

$$(m_1 s^2 + b_1 s + k_1) X_1(s) = \underbrace{(b_1 s + k_1)^2}_{A} X_1(s) + U(s)$$

$$\xrightarrow{\times A} A(m_1 s^2 + b_1 s + k_1) X_1(s) = A(b_1 s + k_1)^2 X_1(s) + AU(s)$$

$$(A(m_1 s^2 + b_1 s + k_1) - (b_1 s + k_1)^2) X_1(s) = AU(s)$$

$$\Rightarrow X_1(s) = \frac{(m_2 s^2 + b_2 s + k_2 + b_1 s + k_1)}{(m_2 s^2 + (b_2 + b_1) s + k_2 + k_1)(m_1 s^2 + b_1 s + k_1) - (b_1 s + k_1)^2} U(s)$$

$$⑦, ⑤ \Rightarrow \frac{X_2(s)}{U(s)} = \frac{X_2}{X_1} \cdot \frac{X_1(s)}{U(s)} \Rightarrow$$

فایل متلب حساب شود

محرم ← محرم

③

$$k1 = 0.8000$$

$$b2 = 0.8000$$

$$k2 = 0.2800$$

$$b1 = 0.2800$$

$$m1 = 1$$

$$m2 = 1$$

$$X2_to_X1 =$$

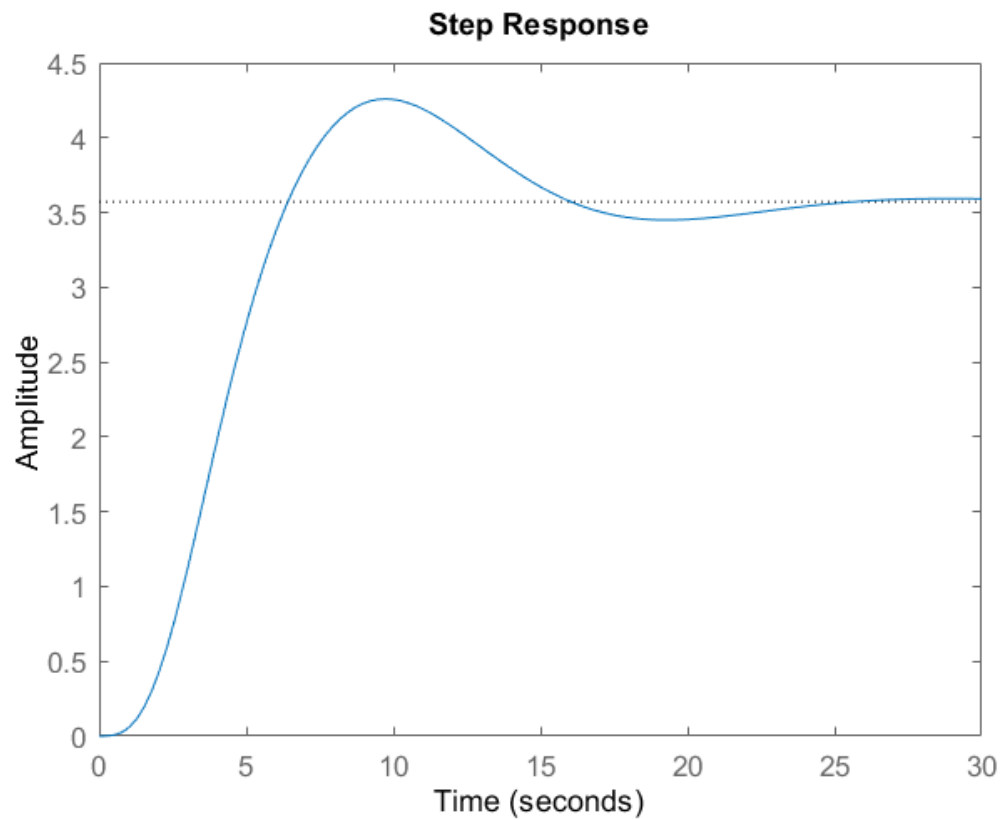
$$\frac{\frac{7s}{25} + \frac{4}{5}}{s^2 + \frac{27s}{25} + \frac{27}{25}}$$

$$X1_to_U =$$

$$\frac{s^2 + \frac{27s}{25} + \frac{27}{25}}{\left(s^2 + \frac{7s}{25} + \frac{4}{5}\right) \left(s^2 + \frac{27s}{25} + \frac{27}{25}\right) - \left(\frac{7s}{25} + \frac{4}{5}\right)^2}$$

$$X2_to_U =$$

$$\frac{\frac{7s}{25} + \frac{4}{5}}{\left(s^2 + \frac{7s}{25} + \frac{4}{5}\right) \left(s^2 + \frac{27s}{25} + \frac{27}{25}\right) - \left(\frac{7s}{25} + \frac{4}{5}\right)^2}$$



stepinfo

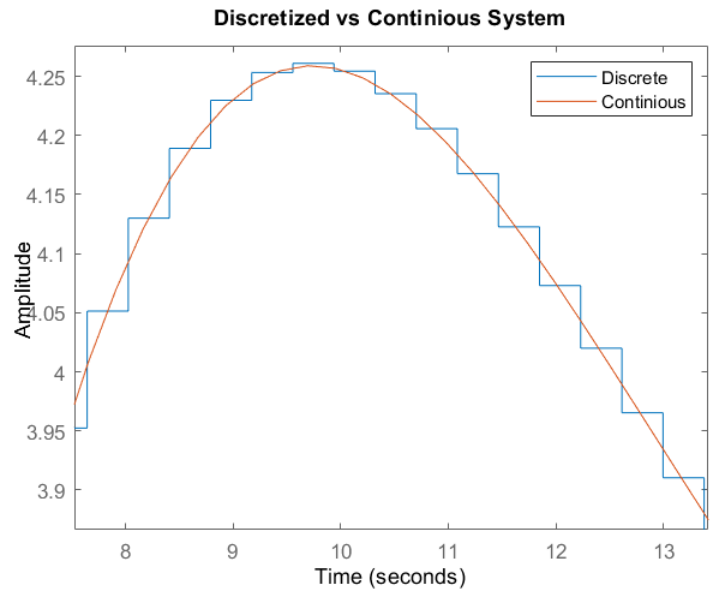
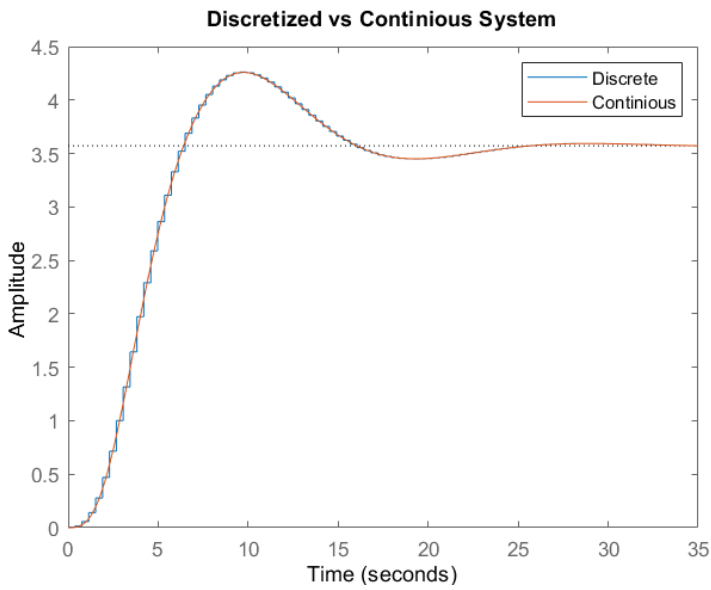
struct with fields:

```
RiseTime: 3.8222
SettlingTime: 22.3115
SettlingMin: 3.3010
SettlingMax: 4.2589
Overshoot: 19.2502
Undershoot: 0
Peak: 4.2589
PeakTime: 9.6965
```

stepinfo

T_s = 0.3822

Figure 1: Comparison of Discrete and Continuous System Responses



$G_z =$

$$\frac{0.00178 z^4 + 0.004763 z^3 + 0.00361 z^2 + 5.015e-05 z - 0.0005766}{z^4 - 3.634 z^3 + 5.052 z^2 - 3.19 z + 0.7734}$$

G_z می باشد.



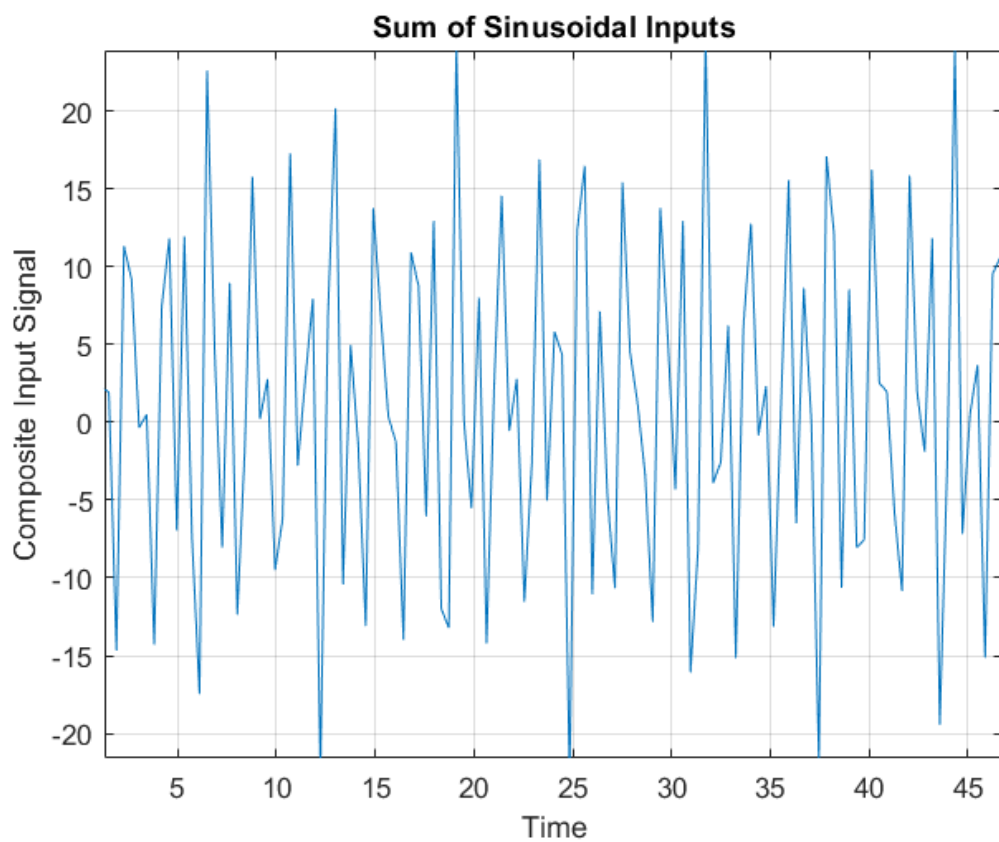
oct 9, 2019 10:00 AM

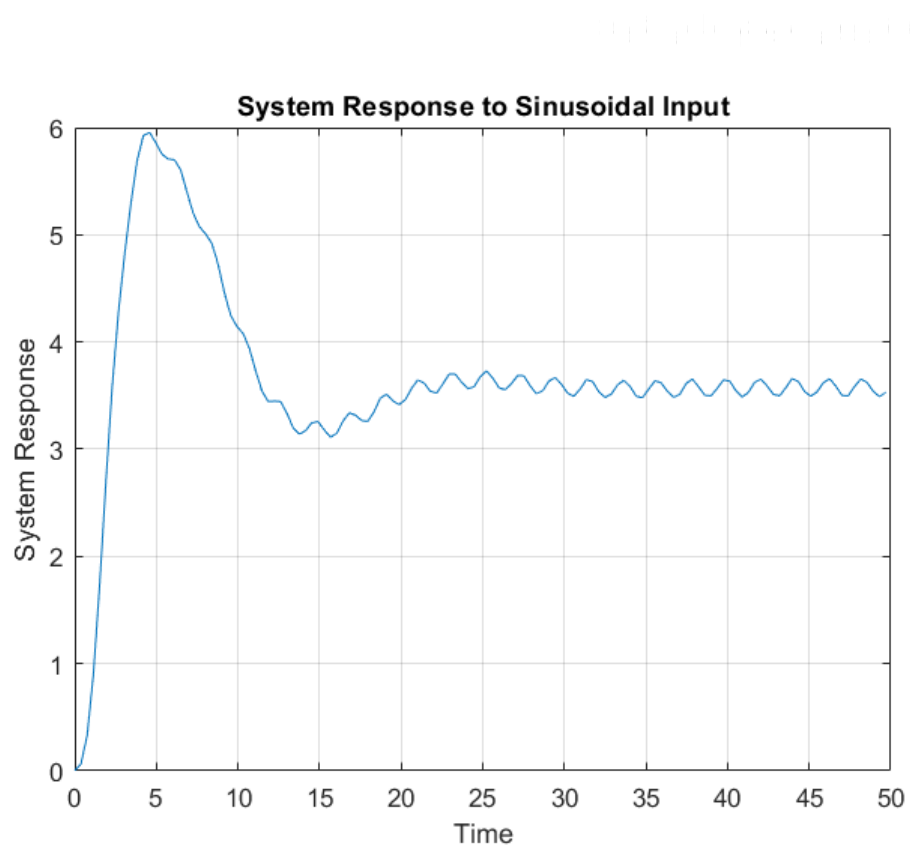
```
% Define the number of sinusoidal components
num_components = 6;
G_i = randi([1, 7], 1, 6); % Random amplitudes between 0 and 7
display(G_i)
omega_i = randi([1, 7], 1, 6); % Random angular frequencies between 0 and 7
display(omega_i)
```

```
G_i = 1x6
     6     2     1     6     5     6
```

```
omega_i = 1x6
     5     3     3     6     3     6
```

oct 9, 2019 10:00 AM







parameter = 9×1

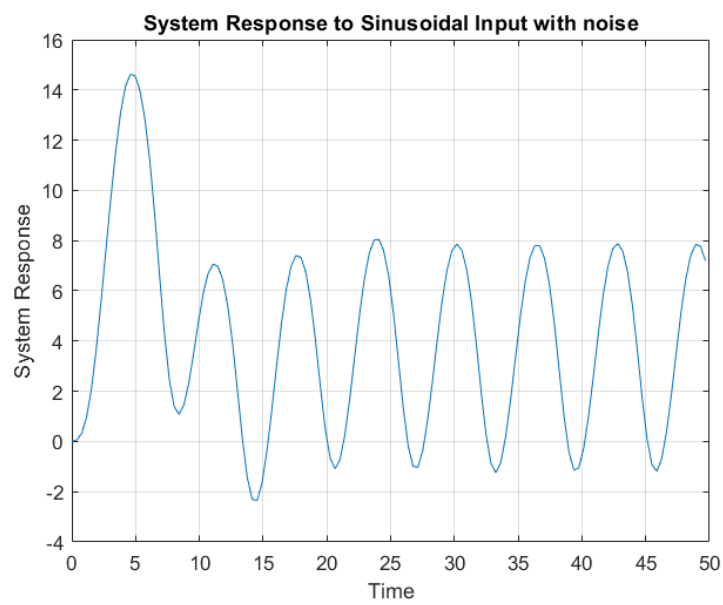
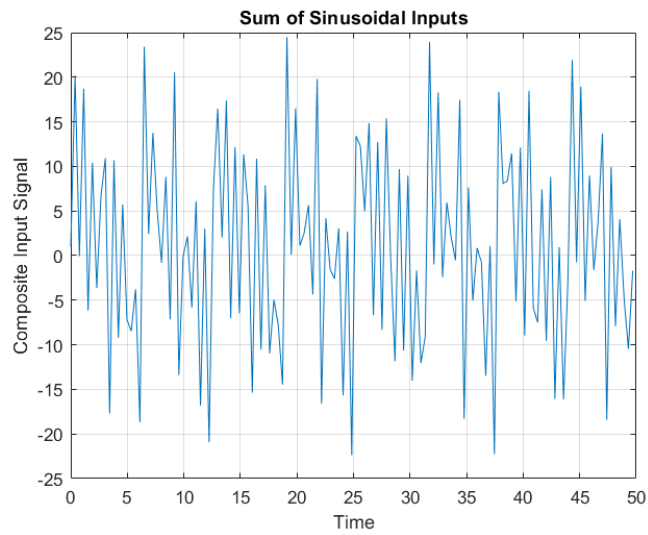
-3.3594
4.3576
-2.5997
0.6052
0.0023
0.0061
0.0048
0.0003
-0.0007

$$\frac{0.00178 z^4 + 0.004763 z^3 + 0.00361 z^2 + 5.015e-05 z - 0.0005766}{z^4 - 3.634 z^3 + 5.052 z^2 - 3.19 z + 0.7734}$$



	1	2	3	4	5	6	
2	-3.3594	-3.3594	-3.3594	-3.3594	-3.3594	-3.3594	
3	4.3576	4.3576	4.3576	4.3576	4.3576	4.3576	
4	-2.5997	-2.5997	-2.5997	-2.5997	-2.5997	-2.5997	
5	0.6052	0.6052	0.6052	0.6052	0.6052	0.6052	
6	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	
7	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	
8	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	
9	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	
0	4.58E-13	1.29E-16	6.84E-16	1.17E-17	1.19E-17	1.19E-17	loss

الخطوة الأولى هي تحديد المتغيرات المستقلة والمتبعية في النموذج. في هذه الحالة، المتغيرات المستقلة هي LTI و LTI² و LTI³ و LTI⁴ و LTI⁵ و LTI⁶ و LTI⁷ و LTI⁸ و LTI⁹ و LTI¹⁰. المتبعية هي loss.



ans = 81.7473

-1.1026
 -0.1129
 0.0092
 0.2780
 0.0197
 0.0003
 0.0142
 0.0423
 0.0510

$$\frac{0.00178 z^4 + 0.004763 z^3 + 0.00361 z^2 + 5.015e-05 z - 0.0005766}{z^4 - 3.634 z^3 + 5.052 z^2 - 3.19 z + 0.7734}$$



Recursive Least Squares

Initialize: (\mathbf{b}_0 appears)

$$\mathbf{P}_0 = (\mathbf{A}_0^T \mathbf{A}_0)^{-1}$$

$$\hat{\mathbf{x}}_0 = \mathbf{P}_0 (\mathbf{A}_0^T \mathbf{b}_0)$$

for $k = 1, 2, 3, \dots$ do

(\mathbf{b}_k appears)

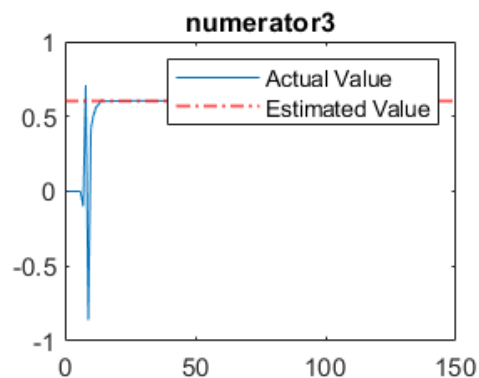
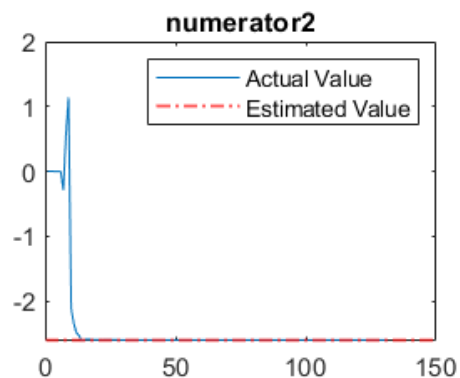
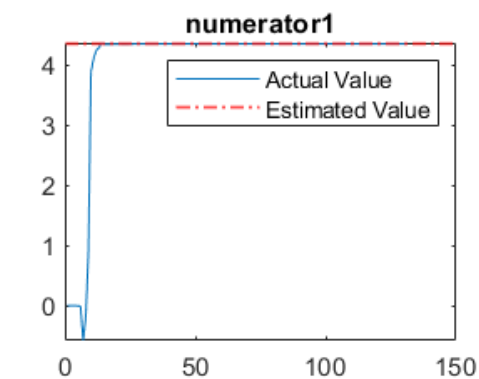
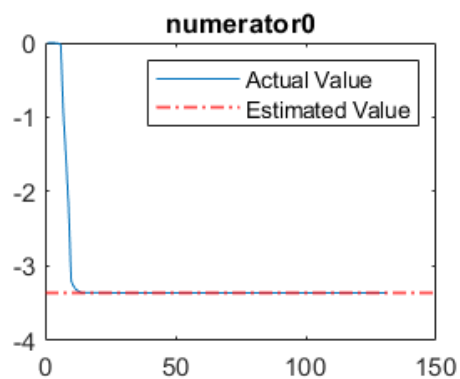
$$\mathbf{P}_k = \mathbf{P}_{k-1} - \mathbf{P}_{k-1} \mathbf{A}_k^T (\mathbf{I} + \mathbf{A}_k \mathbf{P}_{k-1} \mathbf{A}_k^T)^{-1} \mathbf{A}_k \mathbf{P}_{k-1}$$

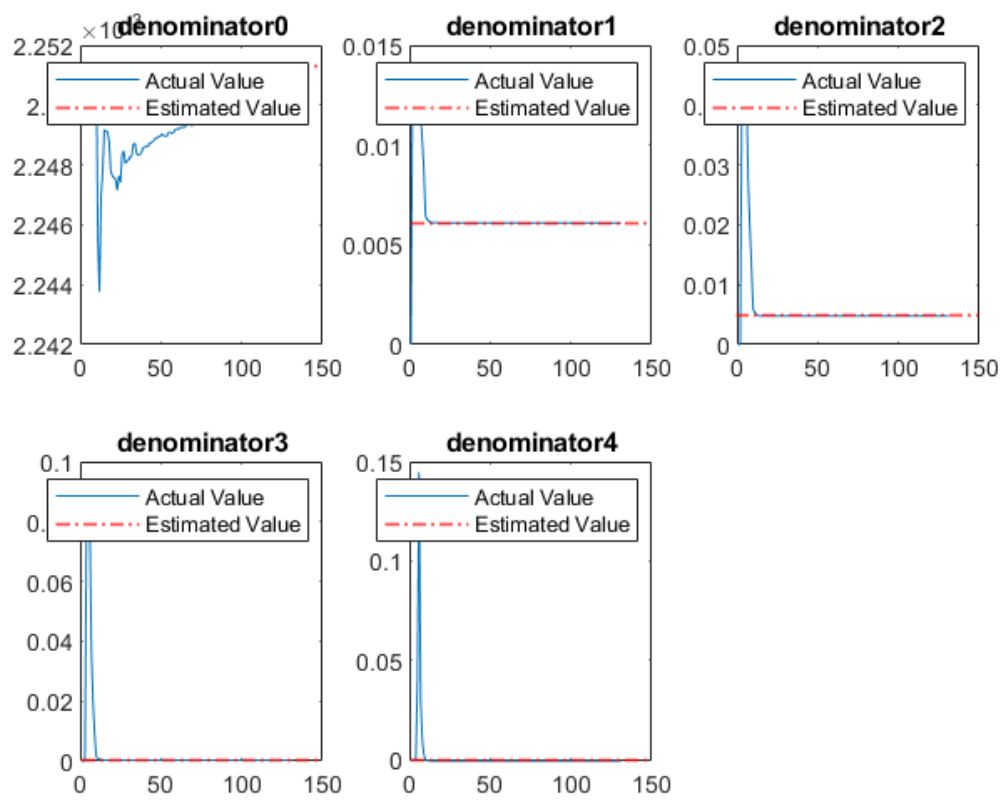
$$\mathbf{K}_k = \mathbf{P}_k \mathbf{A}_k^T$$

$$\hat{\mathbf{x}}_k = \hat{\mathbf{x}}_{k-1} + \mathbf{K}_k (\mathbf{b}_k - \mathbf{A}_k \hat{\mathbf{x}}_{k-1})$$

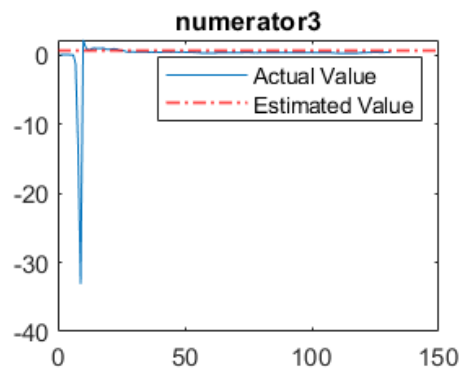
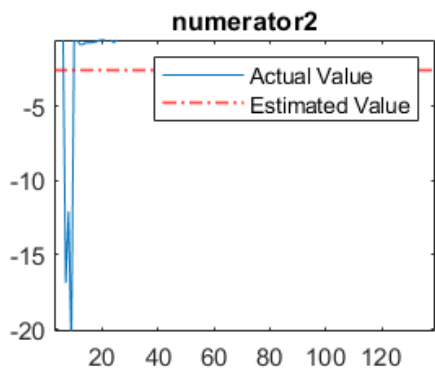
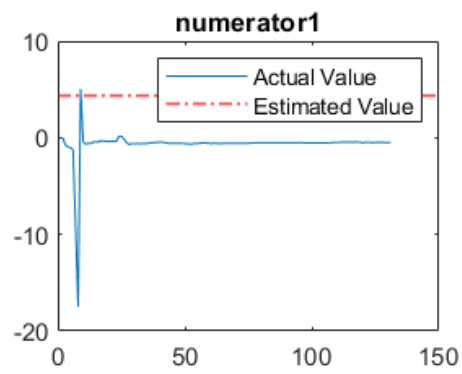
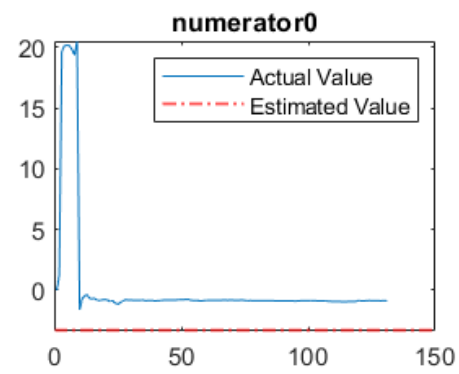
end for

Figure 10.10: Recursive Least Squares





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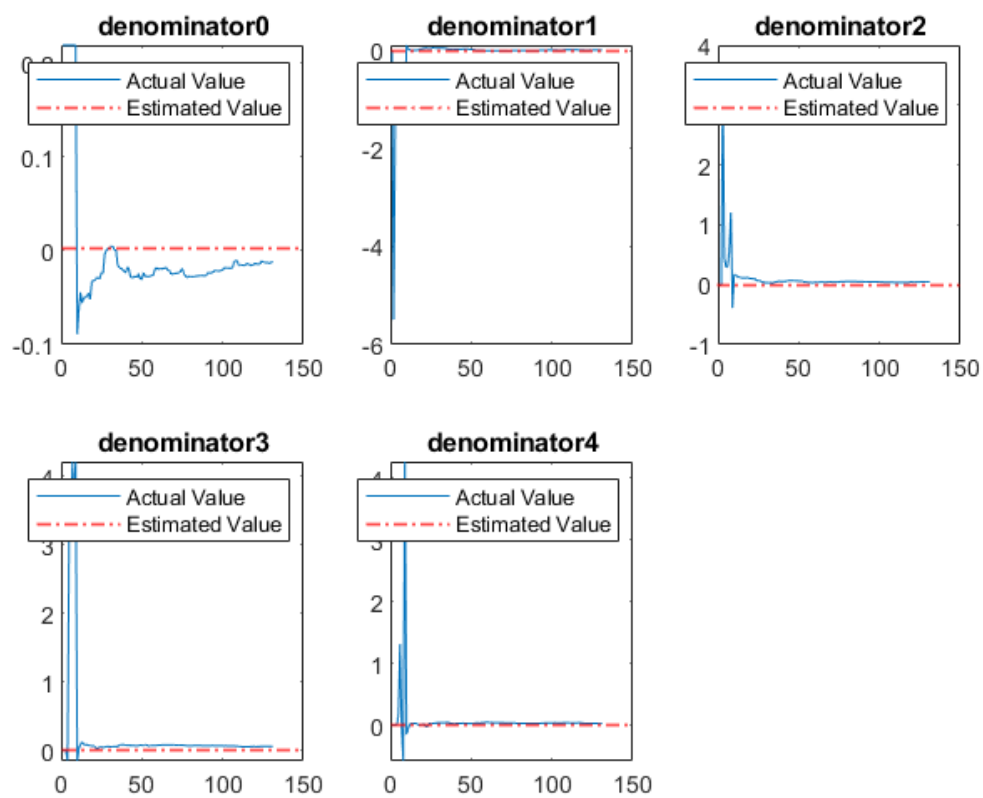


Figure 10: Comparison of the actual and estimated values of the denominators.

Figure 10