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Question: 2. For each system shown in Figure 2, write the state equations ...

2. For each system shown in Figure 2, write the state equations and the output equation for the phase-variable representation.

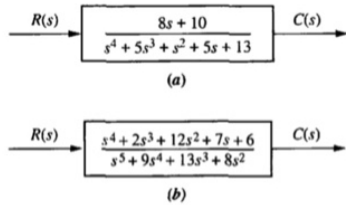


Figure 2.

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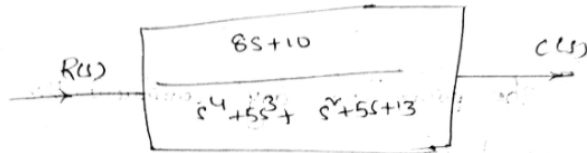
Expert Answer

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Solution:

(a) Given phase variable representation of a transfer function



this can be solved simply by using MATLAB commands
write the following code in MATLAB script:

```

n = [8 10]; numerator
d = [1 5 1 5 13]; denominator
T = tf(n,d); transfer function
[A,B,C,D] = tf2ss(n,d)
    
```

Now we can see the values of A, B, C, D.

$$A = \begin{bmatrix} -5 & -1 & -5 & -13 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

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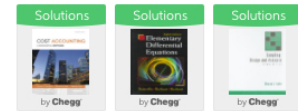
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$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$C = [0 \ 0 \ 8 \ 10]$$

$$D = [0]$$

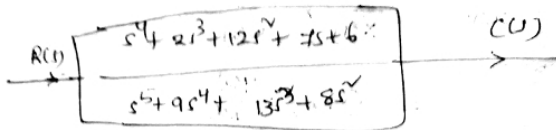
$$\dot{x} = Ax + Bu$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \end{bmatrix} = \begin{bmatrix} -5 & 1 & -5 & -13 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} u$$

$$y = Cx + Du$$

$$y = [0 \ 0 \ 8 \ 10] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} + [0]u$$

(b) Given transfer function



MATLAB script code:

$$n = [1 \ 2 \ 12 \ 7 \ 6];$$

$$d = [1 \ 9 \ 13 \ 8 \ 0 \ 0];$$

$$T = tf(n,d);$$

$$[A, B, C, D] = tf2ss(n,d);$$

we get

$$A = \begin{bmatrix} -9 & -13 & -8 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

$$B = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$C = [1 \ 2 \ 12 \ 7 \ 6] \cdot x$$

$$D = [0]$$

$$\dot{x} = Ax + Bu$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \\ \dot{x}_5 \end{bmatrix} = \begin{bmatrix} -9 & -13 & -8 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} + \begin{bmatrix} -1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} u$$

$$Y = CX + DU$$

$$Y = [1 \ 2 \ 12 \ 7 \ 6] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} + [0] u$$

```

sss.m x sss2.m x +
1 - n = [8 10];
2 - d = [1 5 1 5 13];
3 - T = tf(n,d)
4 - [A,B,C,D] = tf2ss(n,d)

Command Window
-----
      8 s + 10
-----
s^4 + 5 s^3 + s^2 + 5 s + 13

Continuous-time transfer function.

A =
   -5   -1   -5   -13
    1    0    0    0
    0    1    0    0
    0    0    1    0

B =
    1
    0
    0
    0

C =
    0    0    8    10

D =
    0

fs >>

sss.m x sss2.m x +
1 - n = [1 2 12 7 6];
2 - d = [1 9 13 8 0 0];
3 - T = tf(n,d)
4 - [A,B,C,D] = tf2ss(n,d)

Command Window
-----
      a^4 + 2 a^3 + 12 a^2 + 7 a + 6
-----
a^5 + 9 a^4 + 13 a^3 + 8 a^2

```

Continuous-time transfer function.

A =

$$\begin{bmatrix} -9 & -13 & -8 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

B =

$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

C =

$$\begin{bmatrix} 1 & 2 & 12 & 7 & 6 \end{bmatrix}$$

D =

$$\begin{bmatrix} 0 \end{bmatrix}$$

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Up next for you in Electrical Engineering

Question 3: Second-order system design (8 marks). Consider the following system with velocity feedback control.

a. Determine the velocity gain k such that the system has a damping ratio $\zeta = 0.5$.

b. With the values obtained in (a), how long does it take for the system response $c(t)$ to reach its maximum value (be not stop signal)? what is the maximum value of the response $c(t)$?

c. Briefly discuss the effect of the velocity feedback gain k to the closed-loop system (damping and an-damped natural frequency).

See answer

design the PI controller with three parameters Software to Use is MatLab.

The final project involves the design of a PI controller to control the speed of a DC motor. The block diagram of the closed-loop control system is shown in the figure below. Assume $J_m = 0.01$, $r = 0.002$ ohms, and $K = 1$. Choose appropriate values for K_p and K_i so that the system meets the following requirements:

- The 2% settling time must be less than 0.05 seconds.
- The maximum overshoot allowed is 5%.
- The closed-loop system must be stable.

See answer

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Q: Figure 1.2. For each system shown in Figure 2, write the state equations and the output equation for the phase-variable representation $R(s) C(s) 8s 10 45s^3 +s +5s +1:3$

A: See answer 100% (1 rating)

Q: For the system shown in Figure P2, write the state equations and the output equation for the phase-variable representation. 2. (s 24) 69+ 10

A: See answer

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