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.

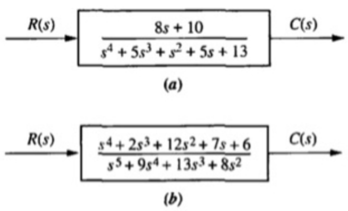

Figure 2.

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Expert Answer

Anonymous answered this
110 answers

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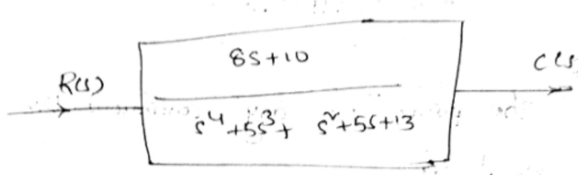
(1)

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 value of A, B, C, D.

(2)

A= [-5 -1 -5 -13
1 0 0 0
0 1 0 0 ...

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

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

$$C = \begin{bmatrix} 0 & 0 & 8 & 10 \end{bmatrix}$$

$$D = [0]$$

$$\dot{x} = AX + BU$$

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

$$Y = CX + DU$$

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

(b) Given transfer function

$$R(t) \rightarrow \boxed{\frac{s^4 + 2s^3 + 12s^2 + 7s + 6}{s^5 + 9s^4 + 13s^3 + 8s^2}} \rightarrow C(t)$$

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

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

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

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

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

(4)

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

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

$$Y = Cx + Du$$

$$Y = \begin{bmatrix} 1 & 2 & 12 & 7 & 6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_6 \end{bmatrix} + \begin{bmatrix} 0 \end{bmatrix} u$$

sss.m | sss2.m

```
n= [8 10];
d= [1 5 1 5 13];
T= tf(n,d)
[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

fx >>
```

sss.m | sss2.m

```
n= [1 2 12 7 6];
d= [1 9 13 8 0 0];
T= tf(n,d)
[A,B,C,D] = tf2ss(n,d)
```

Command Window

```
T =

  s^4 + 2 s^3 + 12 s^2 + 7 s + 6
  ------------------------------
   s^5 + 9 s^4 + 13 s^3 + 8 s^2
```

```
Continuous-time transfer function.

A =

    -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


B =

     1
     0
     0
     0
     0


C =

     1     2    12     7     6


D =

     0
```