Question: 32. For each of the three unit step responses shown in Figure P4...

32. For each of the three unit step responses shown in Figure P4.10, find the transfer function of the system. [Sections: 4.3, 4.6]

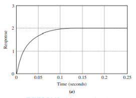

FIGURE P4.10 (*figure continues*)

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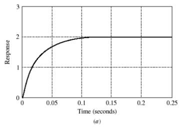
Expert Answer

Anonymous answered this
524 answers

Answer:-

Given that:-

The step response shown in Fig (a) is typical of a first order system. We need to find the transfer function of the unit



step response shown in Fig

1 From the graph we can determine the constant T_c that is the time for the amplitude to reach 63% of its final value. SInce the final value is 2. the time constant is evaluated where the curve reaches 0.63*2:

$$y(T_c) = 0.63, y(\infty) = 0.63, z = 1.26$$

$$\Rightarrow T_c = 0.025$$

2 The genral form of a transfer function of a first - order system is:

$$G(s) = \frac{K}{s+a}$$

3. From the defintion of the time constant , $\alpha = \frac{1}{T_c}, or$

$$\alpha = \frac{1}{0.025} = 40$$

4To find the static gain K, we employ the final value theorem (the system is stable):

$$y(\infty) = lim_{s\to 0} sY_{(s)} = lim_{s\to 0} sG(s).\frac{1}{s} = \frac{K}{a} = 2$$

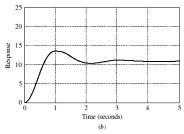
$$\Rightarrow K = 2a = 80$$

5 Substituting all of the values in the general expression (3) gives

$$G(s) = \frac{80}{s+40}$$

6 Part b:

We need to find transfer function of the system from its unit step response shown in Fig (b)



This is response is typical of an underdamped second order system, which has a transfer function of the form.

$$G(s) = \frac{Kw_n^2}{s^2 + 2\xi w_n s + w_n^2}$$

7 bFrom the graph and form the definition of the overshoot , we have:

$$OS = \frac{y_{max} - y_{(\infty)}}{y(\infty)} = \frac{13.8 - 11}{11} = 0.25$$

8. Now we can calculate ξ, From the relationship between the overshoot and the damping ratio

$$OS = e^{\frac{\xi\pi}{\sqrt{1-\xi^2}}}$$

$$-\frac{\xi\pi}{\sqrt{1-\xi^2}} = ln(0.25)$$

$$\xi^2(\pi^2 + 1.92) = 1.92$$

$$\Rightarrow \xi^2 = 0.40$$

9 The natural frequency w_n is calculated from the relationship between the peak time and the natural frequency:

$$T_p = \frac{\pi}{w_n\sqrt{1-\xi^2}}$$

10 According to the graph , the peak time is 0.9 second , and thus:

$$\Rightarrow 0.9 = \frac{\pi}{w_n\sqrt{1-\xi^2}}$$

$$w_n = 3.81$$

11 Substituting ζ and w_n into the transfer function of a second order system , we obtain:

$$G(s) = \frac{Kw_n^2}{s^2 + 2\zeta w_n s + 145} = \frac{14.5K}{s^2 + 3.05s + 14.5}$$

12 To find the static gain K, we use the final value theorem

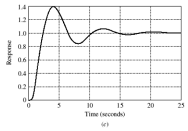
$$y(\infty) = lim_{s\to 0} sY(s) = lim_{s\to 0} sG(s).\frac{1}{s} = K = 11$$

13 Finally , substituing the value of K into (12) yields

$$G(s) = \frac{159.5}{s^2 + 3.05s + 14.5}$$

14 Part c:

we need to find the transfer function of the system for the unit step response shown in Fig(c)



This step response is typical of an underdamped second order system, which has a transfer function of the form

$$G(s) = \frac{Kw_n^2}{s^2 2\xi w_n s + w_n^2}$$

15 From the graph, we determine the overshoot and the peak time:

$$OS = \frac{y_{max} - y_{(\infty)}}{y_{(\infty)}} = \frac{1.4 - 1}{1} = 0.4$$

$$y(T_p) = y_{max} \Rightarrow T_p = 4$$

16 Using the relation between %os and ζ, we get:

$$OS = e^{\frac{-\xi\pi}{1-\xi^2}} \Rightarrow \xi = 0.28$$

17 From the equation for the peak time T_p,we find the natural frequency w_n :

$$T_p = \frac{\pi}{w_n\sqrt{1-\xi^2}} \Rightarrow w_n = 0.818$$

18 SInce the final value of Y(t) is equal to one, the static gain , K, is also 1.

19 Substituting all values into the general expression yields:

$$G(s) = \frac{Kw_n^2}{s^2 + 2\xi w_n s + w_n^2} = \frac{0.67}{s^2 + 0.46 + 0.67}$$

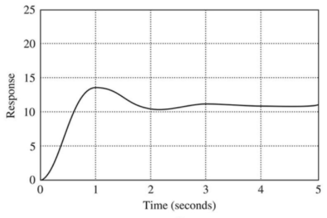
Comment >

Question: For each of the three unit step responses shown in Figure P4.7, ...

(1 bookmark)

For each of the three unit step responses shown in Figure P4.7, find the transfer function of the system.
[Sections: 4.3, 4.6]

SS 21. for each of the three unit step responses shown in Figure P4.7, find the transfer function of the system. [Sections: 4.3, 4.6]



(b)

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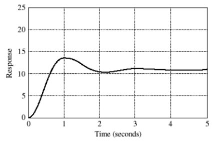
Expert Answer

Tanuja Navudu answered this
3,600 answers

Was this answer helpful? 1 0

6. Part b:
We need to find the transfer function of the system from its unit step response shown in Fig. (b)



(b)

This step response is typical of an underdamped second order system, which has a transfer function of the form:

$$G(s) = \frac{K\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$$

7. From the graph and from the definition of the overshoot, we have:

$$OS = \frac{y_{max}-y(\infty)}{y(\infty)} = \frac{13.8-11}{11} = 0.25$$

(peak overshoot)

8. Now we can calculate ξ. From the relationship between the overshoot and the damping ratio :

$$OS = e^{-\frac{\xi\pi}{\sqrt{1-\xi^2}}}$$

$$-\frac{\xi\pi}{\sqrt{1-\xi^2}} = \ln(0.25)$$

$$\xi^2\left(\pi^2+1.92\right) = 1.92$$

$$\Rightarrow \quad \xi = 0.40$$

9. The natural frequency ω_n is calculated from the relationship between the peak time and the natural frequency :

$$T_p = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$$

10. According to the graph, the peak time is 0.9 second, and thus:

$$\Rightarrow 0.9 = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$$

$$\Rightarrow \omega_n = 3.81$$

11. Substituting ζ and ω_n into the transfer function of a second order system, we obtain:

$$G(s) = \frac{K\omega_n^2}{s^2+2\zeta\omega_n s+14.5} = \frac{14.5K}{s^2+3.05s+14.5}$$

12. To find the static gain K , we use the final value theorem:

$$y(\infty) = \lim_{s\to 0} sY(s) = \lim_{s\to 0} sG(s)\cdot\frac{1}{s} = K = 11$$

$$\Rightarrow \quad K = 11$$

13. Finally, substituting the value of K into (12) yields:

$$G(s) = \frac{159.5}{s^2+3.05s+14.5}$$

hope you like it..

Comment >

Practice with similar questions

Q: For each of the unit step responses shown in Figure P4.9, find the transfer function of the system [sections; 4.3, 4.6]

A: See answer

Q: 32. For each of the three unit step responses shown in Figure P4.10, find the transfer function of the system. [Sections: 4.3, 4.6] 0 0 0.05 0.15 Time (seconds) 0.2 0.25 FIGURE P4.10 (figure continues)

A: See answer 94% (17 ratings)

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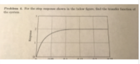
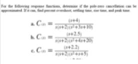
Up next for you in Mechanical Engineering

Problem 4. For the step response shown in the below figure, find the transfer function of the system 0.1 T...



See answer

For the following response functions, determine if the pole-zero cancellation can be approximated. If it can, find...



See answer

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Q: for each of the three unit step responses shown in Figure P4.7, find the transfer function of the system. [Sections: 4:3, 4.6] Response 3 Time (seconds) (b)

A: See answer

Q: 32. For each of the three unit step responses shown in Figure P4.10, find the transfer function of the system. [Sections: 4.3, 4.6] 0 0 0.05 0.15 Time (seconds) 0.2 0.25 FIGURE P4.10 (figure continues)

A: See answer 94% (17 ratings)

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Question: Find the percent overshoot, settling time, rise time, and peak ti...

(1 bookmark)

Find the percent overshoot, settling time, rise time, and peak time for the following system:

Find the percent overshoot, settling time, rise time, and peak time for the following system:

$$T(s) = \frac{14.145}{(s^2 + 0.842s + 2.829)(s+5)}$$

Hint: note, this is a 3rd order system, so think about the influence of the poles and how you can approximate the behavior of the 3rd order system based on the proximity of the poles.

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Expert Answer

shahansari answered this
1,472 answers

Was this answer helpful? 0 0

$$T(s) = \frac{14.145}{(s^2+0.842s+2.829)(s+5)}$$

from above Transfer function

$\omega_n^2 = 2.829$

$\omega_n = 1.68$

$2\xi\omega_n = 0.842$

$2\xi = 0.5$

$\xi = 0.25$

$\xi = 0.25, \ \omega_n = 1.68$

$M_p = \text{Peak overshoot} = e^{-\pi\xi/\sqrt{1-\xi^2}}$

$= \exp\left[\frac{-\pi\xi}{\sqrt{1-\xi^2}}\right]$

$= \exp\left[\frac{-\pi \times 0.25}{\sqrt{1-(0.25)^2}}\right]$

$= 0.4$

$t_s = \text{settling time} = 4\tau = \frac{4}{\xi\omega_n} = \frac{4}{0.25 \times 1.68}$

$= 9.52 \text{ sec}$

Peak time $(t_p) = \frac{\pi}{\omega_d}$

$\omega_d = \omega_n \cdot \sqrt{1-\xi^2} = 1.68\sqrt{1-(0.25)^2}$

$= 1.62 \text{ sec}$

Rise time $= t_r = \frac{\pi - \theta}{\omega_d}$

$\theta = \cos^{-1}(\xi)$

$= \cos^{-1}(0.25) = 75.5^\circ \times \frac{\pi}{180}$

$= 0.41\pi$

$t_r = \frac{\pi - 0.41\pi}{1.68\sqrt{1-(0.25)^2}} = \frac{0.58\pi}{1.62}$

$= 1.11 \text{ sec}$

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Q: Find the percent overshoot, settling time, rise time, and peak time for H(s)=14.145/(s^2+0.842s+2.829)(s+5)

A: See answer 100% (1 rating)

Q: find the percent overshoot , settling time, rise time , and peak time for h(s)

A: See answer 100% (1 rating)

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