Universidade Federal de Uberlândia

Faculdade de Engenharia Elétrica

Sistemas de Controle

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Uberlândia

data
fecha

2.a) $C(s) = \frac{5}{s(s+5)} = \frac{1}{s} - \frac{1}{s+5} \Rightarrow c(t) = 1 - e^{-5t}$

$T = \frac{1}{5}$, $T_r = \frac{2,2}{a} = \frac{2,2}{5} = 0,44$ $\quad T_s = \frac{4}{5} = 0,8$

b) $C(s) = \frac{20}{s(s+20)} = \frac{1}{s} - \frac{1}{s+20} \Rightarrow c(t) = 1 - e^{-20t}$

$T = \frac{1}{20}$ $\quad T_r = \frac{2,2}{20} = 0,11$ $\quad T_s = \frac{4}{20} = 0,2$

8.

	Polos	Zeros	c(t)
a)	-2		$A + Be^{-2t}$
b)	$-3, -6$		$A + Be^{-3t} + Ce^{-6t}$
c)	$-10, -20$	-7	$A + Be^{-10t} + Ce^{-20t}$
d)	$(-3 + j3\sqrt{15}), (-3 - j3\sqrt{15})$		$A + Be^{-3t}\cos(3\sqrt{15}t + \phi)$
e)	$j3, -j3$	-2	$A + B\cos(3t + \phi)$
f)	$-10, -10$	-5	$A + Be^{-10t} + Cte^{-10t}$

→

Continuação do 8

a) primeira ordem
b) superamortecido
c) superamortecido
d) subamortecido
e) não amortecio
f) criticamente amortecido

10. $G(s) = C(sI - A)^{-1} B$

$$A = \begin{bmatrix} 8 & -4 & 1 \\ -3 & 2 & 0 \\ 5 & 7 & 9 \end{bmatrix} \quad B = \begin{bmatrix} -4 \\ -3 \\ 4 \end{bmatrix} \quad C = [2 \ 8 \ -3]$$

$$(sI - A)^{-1} = \frac{1}{s^3 - s^2 - 31s + 67} \begin{bmatrix} (s-2)(s+9) & -(4s+29) & (s-2) \\ -(3s+27) & s^2+s-77 & -3 \\ 5s-31 & 7s-76 & (s^2-10s+4) \end{bmatrix}$$

$$G(s) = \frac{-44s^2 + 291s + 1814}{s^3 - s^2 - 31s + 67}$$

Polos: 9,683
0,7347
-9,4179

12. $V_c(s)\left(\frac{1}{R_2} + \frac{1}{Ls} + Cs\right) + \frac{V_c(s) - V(s)}{R_1} = 0$

$$\frac{V_c(s)}{V(s)} = \frac{\frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{Ls} + Cs} = \frac{10s}{s^2 + 20s + 500}$$

Polos: $-10 \pm j20$ $\quad V_c(t) = Ae^{-10t}\cos(20t + \phi)$

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14. $F(s) = (Ms^2 + fvs + ks)X(s)$

$$\frac{X(s)}{F(s)} = \frac{1}{Ms^2 + fvs + ks} = \frac{1}{s^2+s+5}$$

$$X(s) = \frac{1}{s(s^2+s+5)} = \frac{1/5}{s} - \frac{1/5s + 1/5}{(s+1/2)^2 + 19/4}$$

$$= \frac{\frac{1}{5}(s+\frac{1}{2}) + \frac{1}{5}\frac{\sqrt{19}}{2}}{(s+\frac{1}{2})^2 + \frac{19}{4}}$$

$$x(t) = \frac{1}{5} - \frac{1}{5}e^{-0,5t}\left(\cos\frac{\sqrt{19}}{2}t + \frac{1}{\sqrt{19}}\operatorname{sen}\frac{\sqrt{19}}{2}t\right)$$

26. $T(s) = (1,07s^2 + 1,53s)\Theta_1(s) - 1,53\Theta_2(s)$

$0 = 1,53\Theta_1(s) + (1,53s + 1,92)\Theta_2(s)$

$$\Theta_2(s) = \frac{\begin{vmatrix} 1,07s^2+1,53s & T(s) \\ -1,53s & 0 \end{vmatrix}}{\Delta} = \frac{0,935T(s)}{s^2+1,25s+1,79}$$

$$\frac{\Theta_2(s)}{T(s)} = \frac{0,935}{s^2+1,25s+1,79}$$

$\omega_m = 1,34$; $2\xi\omega_m = 1,25$; $\xi = 0,467$; $\%OS = 19\%$

$T_s = 6,40$; $T_p = 2,66$

20.

	ω_n^2	ξ	ω_n	T_s	T_p	%OS
a)	$16\pi/s$	0,375	4	$\frac{4}{\xi\omega_n} = 2,667s$	0,8472s	28,06%
b)	$0,04\pi/s$	0,05	0,2	400s	15,732	85,45%
c)	$1,05 \cdot 10^7 \pi/s$	0,247	3240	0,005s	0,001s	44,92%

T_r

a) 0,356s

b) 5,26s

c) $3,88 \cdot 10^{-4}s$

23. a) $\xi = \frac{-\ln\left(\frac{\%OS}{100}\right)}{\sqrt{\pi^2 + \ln^2\left(\frac{\%OS}{100}\right)}} = 0,56$; $\omega_n = \frac{4}{\xi T_s} = 11,92$

Polos: $-\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2} = -6,67 \pm j9,88$

b) $\xi = 0,591$; $\omega_n = \frac{\pi}{T_p\sqrt{1-\xi^2}} = 0,779$

Polos: $-0,4605 \pm j0,6283$

c) $\xi\omega_n = \frac{4}{T_s} = 0,571$; $\omega_n\sqrt{1-\xi^2} = \frac{\pi}{T_p} = 1,047$

Polos: $0,571 \pm j1,047$

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25. a) $F(s) = (5s^2 + 5s + 28)X(s)$

$$\frac{X(s)}{F(s)} = \frac{1/5}{s^2 + s + 28/5}$$

b) $\omega_n^2 = 28/5$; $2\zeta\omega_n = 1$ $\zeta = 0,211$; $\omega_n = 2,37$

$T_s = \frac{4}{\zeta\omega_n} = 8,01s$; $T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = 1,36s$

$\%OS = e^{-\zeta\pi/\sqrt{1-\zeta^2}} \cdot 100 = 50,1\%$; $\omega_n T_r = (1,76\zeta^3 - 0,417\zeta^2 + 1,039\zeta + 1)$

$T_r = 0,514s$