SISTEMI DI CONTROLLO

[Appunti Di Esercizi, Parte 2]

A CURA DI ALESSANDRO PAGHI

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LINK AL CORSO ANNO 2015/2016:
http://www3.diism.unisi.it/FAC/index.php?bodyinc=didattica/inc.insegnamento.php&id=55078&aa=2015

FREQUENTAZIONE: Consigliata.

SINTESI 1

CASO 1

$$G(s)=\frac{s+0,1}{s(s^2+s+1)}=\frac{1}{10}\cdot\frac{(1+10s)}{s(1+s+s^2)}$$

$|d_1|\leq 0,5$

$|d_2|\leq 3$

1. $\frac{Y}{R}=2 \rightarrow K_H=\frac{1}{2}$

2. $e_{ramp}\leq 0,2$

$G(s)\cdot C(s)$ TIPO 1 -> $C(s)$ TIPO $\emptyset$ con $G(s)$ TIPO 1

$$e_{ramp}=\frac{1}{\frac{1}{2}\left(\frac{1}{10}\cdot K_c\cdot\frac{1}{2}\right)}=\frac{2}{\frac{K_c}{20}}=\frac{2\cdot 20}{K_c}=\frac{40}{K_c}\leq 0,2$$

$$K_c \geq \frac{40}{0,2} \rightarrow K_c\geq 200$$

3. $e_{dist}\leq 0,1$

$G(s)\cdot C(s)$ TIPO 1 -> $C(s)$ TIPO $\emptyset$

$R\neq\emptyset,\ d_1=\emptyset,\ d_2=\emptyset \rightarrow e_{grad}=\emptyset$

$R=\emptyset,\ d_1\neq\emptyset,\ d_2=\emptyset$

$$\lim_{s\to\emptyset} \not{s}\cdot\frac{0,5}{\not{s}}\cdot\frac{\frac{1}{10\cdot s}}{1+\frac{1}{10\cdot s}\cdot K_c\cdot\frac{1}{2}}=\lim_{s\to\emptyset}\frac{\frac{0,5}{10\cdot s}}{1+\frac{K_c}{20\cdot s}}=\lim_{s\to\emptyset}\frac{0,5}{\not{10}\not{s}}\cdot\frac{\not{20}^{\,2}\cdot\not{s}}{20s+K_c}$$

$$=\lim_{s\to\emptyset}\frac{1}{20\cdot s+K_c}=\frac{1}{K_c}$$

$R=\emptyset,\ d_1=\emptyset,\ d_2\neq\emptyset$

$$\lim_{s\to\emptyset}\not{s}\cdot\frac{3}{\not{s}}\cdot\frac{1}{1+\frac{1}{2}\cdot K_c\cdot\frac{1}{10\cdot s}}=\lim_{s\to\emptyset}\frac{3}{1+\frac{K_c}{20\cdot s}}=\lim_{s\to\emptyset}\frac{3\cdot 20\cdot s}{20\cdot s+K_c}=\emptyset$$

$$e_{dist}=\frac{1}{K_c}\leq 0,1 \rightarrow K_c\geq 10$$

$K_c\geq 200$; $C(s)$ TIPO $\emptyset$

$C(s) = 200 \cdot C'(s) \quad ; \quad C'(\emptyset) = 1 .$

4.5.

$T_r \leq 0,5$ sec

$M_r \leq 3$ dB $\quad -> M_{r\,lim} = 1,4125$

$T_r \cdot B_W = 3 \quad -> B_W = \frac{3}{0,5} = 6$ rad/sec

$W_c = [0,5 \div 0,8] B_W = [3 \div 4,8]$ rad/sec

$\phi_m = \frac{2,3 - M_{r\,lim}}{1,25} = 0,71 \cdot \frac{180}{\pi} = 40,68° -> 41°$

$$\begin{cases} W_c = 4 \text{ rad/sec} \\ \phi_m = 41° \end{cases}$$

BODE di $F(s) = C(s) \cdot G(s) \cdot K_H$

$m_{lim} = 6,4436$

fase $= -166,5° = -167°$

$\measuredangle = 41 - 13 + \varepsilon = 28 + \varepsilon$

con $\varepsilon = 8 \quad -> \measuredangle = 36$

$C_A(s) = \frac{1 + \tau \cdot s}{1 + \alpha \cdot \tau \cdot s}$

$\alpha = \frac{1 - \text{sen}(\measuredangle)}{1 + \text{sen}(\measuredangle)} = 0,2569$

$= \frac{1 + 0,4906 \cdot s}{1 + 0,1260 \cdot s}$

$\tau = \frac{1}{w_c \sqrt{\alpha}} = 0,4906$

BODE di $F(s) = C(s) \cdot C_A(s) \cdot G(s) \cdot K_H$

$m_{lim} = 12,6734$

fase $= -130,2° = -130°$

$C_R(s) = \frac{1 + \alpha \cdot \tau \cdot s}{1 + \tau \cdot s}$

$\alpha = \frac{1}{m_{lim}} = 0,0789$

$\tau = \frac{100}{w_c} = 25$

$= \frac{1 + 1,9725 \cdot s}{1 + 25 \cdot s}$

$m_{lim} = 1,0079$

fase $= -136,9° = -137°$

$M_r = 3$ dB $= 3$ dB

$T_r = 0,423$ sec $< 0,5$ sec

Ma attenzione $M_r = 3\,dB$ quindi per risolvere il problema aumento $m = \frac{1}{9}$ ↑ in $C_A(s)$.

Me ne accorgo guardando l'attraversamento coi 3dB in Nychols di AA.

$$\alpha \cdot \tau = 0,1260 \Rightarrow \alpha_1 \cdot \tau = 0,12.$$

$\rightarrow M_r = 2,83\,dB$

$T_r = 0,424$ sec.

SINTESI 1

CASO 2

$$G(s) = \frac{10^6 \cdot s}{s^2 + 3\cdot 10^3 \cdot s + 10^6} = \frac{10^6 \cdot s}{10^6 \left(1 + 3 \cdot \frac{10^3}{10^6} \cdot s + \frac{s^2}{10^6}\right)} = \frac{s}{(1 + 3\cdot 10^{-3} \cdot s + 10^{-6} \cdot s^2)}$$

$|d_1| \leq 1$

$|d_2| \leq 2$

1. $\frac{Y}{R} = 1 \rightarrow K_H = 1$

2. $e_{ramp} \leq 10^{-2}$

$G(s)$ TIPO -1 $\rightarrow$ $G(s) \cdot C(s)$ TIPO 1 $\rightarrow$ $C(s)$ TIPO 2

$$e_{ramp} = \frac{1}{K_c \cdot 1 \cdot 1} = \frac{1}{K_c} \leq 10^{-2} \rightarrow K_c \geq 100$$

3. $e_{dist} \leq 0{,}1$

$G(s) \cdot C(s)$ TIPO 1 $\rightarrow$ $C(s)$ TIPO 2

$R \neq \emptyset$, $d_1 = \emptyset$, $d_2 = \emptyset$ $\qquad e_{graal} = \emptyset$

$R = \emptyset$, $d_1 \neq \emptyset$, $d_2 = \emptyset$

$$\lim_{s \to \emptyset} s \cdot \frac{1}{s} \cdot \frac{s}{1 + s \cdot 1 \cdot \frac{K_c}{s^2}} = \lim_{s \to \emptyset} \frac{s}{1 + \frac{K_c}{s}} = \lim_{s \to \emptyset} \frac{s^2}{s + K_c} = \emptyset$$

$R = \emptyset$, $d_1 = \emptyset$, $d_2 \neq \emptyset$

$$\lim_{s \to \emptyset} s \cdot \frac{2}{s} \cdot \frac{1}{1 + 1 \cdot s \cdot \frac{K_c}{s^2}} = \lim_{s \to \emptyset} \frac{2}{1 + \frac{K_c}{s}} = \lim_{s \to \emptyset} \frac{2 \cdot s}{s + K_c} = \emptyset$$

$e_{dist} = \emptyset \qquad \forall K_c$

$K_c \geq 100$

$C(s)$ TIPO 2

$C(s) = \frac{100}{s^2} \cdot C'(s)$; $C'(\emptyset) = 1$

4.5.

$B_W \leq 800$ rad/sec

$M_r \leq 3$ dB $\rightarrow M_{r\,lim} = 1{,}4125$

$\omega_c = [0{,}5 \div 0{,}8] B_W = [400 \div 640]$ rad/sec

$\phi_m = \frac{2{,}3 - M_{r\,lim}}{1{,}25} \cdot \frac{180}{\pi} \approx 41°$

$$\begin{cases} \omega_c = 520 \text{ rad/sec} \\ \phi_m = 41° \end{cases}$$

BODE di $F(s) = C(s) \cdot G(s) \cdot K_H$

$m_{lim} = 0{,}1117$

fase $= -154{,}9 \approx -155°$

$\phi = 16° + \varepsilon = 25°$ con $\varepsilon = 9$

$C_A(s) = \frac{1 + \tau \cdot s}{1 + \alpha \cdot \tau \cdot s}$

$\alpha = \frac{1 - \text{sen}(\phi)}{1 + \text{sen}(\phi)} = 0{,}4059$

$= \frac{1 + 0{,}0030 \cdot s}{1 + 0{,}0012 \cdot s}$

$\tau = \frac{1}{\omega_c \sqrt{\alpha}} = 0{,}0030$

BODE di $F(s) = C(s) \cdot C_A(s) \cdot G(s) \cdot K_H$

$m_{lim} = 0{,}1755$

fase $= -125{,}6° \approx -126°$

$m_{dB} = -15{,}11$ dB

Con $K_c = 500$ $\Rightarrow$ $B_W = 821$ rad/sec > 800 rad/sec
$M_r = 0{,}78 < 3$ dB

Se non volessi aumentare K_c, allora uso un anticipatrice con guadagno in modulo grande e guadagno in fase piccolo.

In questo caso:

$m_{dB} = -15,11 \ dB$

Dalle carte normalizzate:

$m = 6 \Rightarrow \frac{1}{\alpha} = 6 \rightarrow \alpha = \frac{1}{6}$

$\omega \tau = 100$

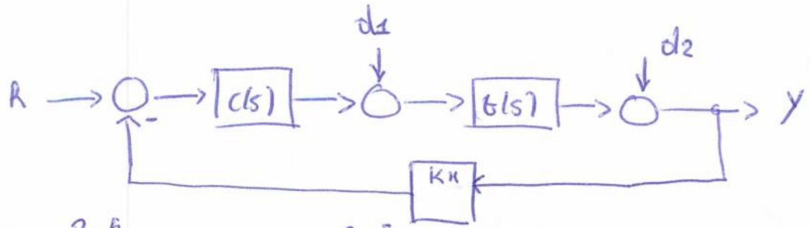
$\tau = \frac{\omega \tau}{\omega_c} = \frac{100}{520} = 0,1923$

$C_A(s) = \frac{1 + 0,1923 \cdot s}{1 + 0,0321 \cdot s}$

$\begin{cases} B_w = 939 \ rad/sec \\ M_r = 1,22 \ dB \end{cases}$

SINTESI 2

CASO 1



$$G(s) = \frac{2,5}{(s+1)(s+5)} = \frac{2,5}{(1+s)\left(1+\frac{s}{5}\right)\cdot 5} = \frac{1}{2}\cdot\frac{1}{(1+s)\left(1+\frac{s}{5}\right)}$$

$|d_1| \leq 2$

$|d_2| \leq 10$

$$C(s) = \frac{K_C}{s^h} C'(s) \quad , \; C'(\emptyset) = 1$$

1. $\frac{Y}{R} = 8 \Rightarrow K_H = \frac{1}{8}$

2. $e_{step} \leq 0,1$

$G(s)$ TIPO $\emptyset$ $\qquad$ $C(s)$ TIPO $\emptyset$

$$e_{step} = \frac{1}{K_H(1+K_G K_C K_H)} = \frac{1}{\frac{1}{8}\left(1+\frac{1}{2}\cdot K_C\cdot\frac{1}{8}\right)} = \frac{8}{1+\frac{K_C}{16}} = \frac{8\cdot 16}{16+K_C}$$

$$= \frac{128}{16+K_C} \leq 0,1 \quad \rightarrow \quad 16+K_C \geq 1280 \quad \rightarrow \quad K_C \geq 1264$$

$\forall K$ in quanto TIPO $\emptyset$

3. $e_{ramp} \leq 0,4$

$G(s)$ TIPO $\emptyset$, $C(s)$ TIPO 1

$$e_{ramp} = \frac{1}{K_G K_C K_H^2} = \frac{1}{\frac{1}{2}\cdot K_C\cdot\frac{1}{64}} = \frac{1}{\frac{K_C}{128}} = \frac{128}{K_C} \leq 0,4$$

$$K_C \geq \frac{128}{0,4} = 320$$

4. $e_{dist} \leq 0,2$

$R \neq \emptyset,\ d_1 = \emptyset,\ d_2 = \emptyset$ $\qquad$ $G(s) \cdot C(s)$ TIPO 1

$\Rightarrow e_{dist_R} = \emptyset$

$R = \emptyset,\ d_1 \neq \emptyset,\ d_2 = \emptyset$

$$\lim_{s \to \emptyset} s \cdot \frac{2}{s} \cdot \frac{\frac{1}{2}}{1 + \frac{1}{2} \cdot \frac{K_c}{s} \cdot \frac{1}{8}} = \lim_{s \to \emptyset} \frac{1}{1 + \frac{K_c}{16 \cdot s}} = \emptyset$$

$R = \emptyset \quad d_1 = \emptyset \quad d_2 \neq \emptyset$

$$\lim_{s \to \emptyset} s \cdot \frac{10}{s} \cdot \frac{1}{1 + \frac{1}{8} \cdot \frac{K_c}{s} \cdot \frac{1}{2}} = \lim_{s \to \emptyset} \frac{10}{1 + \frac{K_c}{16 \cdot s}} = \emptyset$$

$e_{dist} = \emptyset \quad , \forall K_c.$

$K_c \geq 320 \quad \to K_c = 320$

$C(s)$ TIPO 1

$$C(s) = \frac{320}{s} \cdot C'(s) \quad , \quad C'(\emptyset) = 1 .$$

5.6. $T_r \leq 0,7$ sec

$M_r \leq 2,8$ dB $\rightarrow M_{r\,lim} = 1,38$

$T_r \cdot B_W = 3 \rightarrow B_W = 4,29$

$\omega_c = [0,5 \div 0,8] B_W = [2,15 \div 3,43]$ rad/sec

$$\phi_m = \frac{2,3 - M_{r\,lim}}{1,25} \cdot \frac{180}{\pi} = 42,17°$$

$$\begin{cases} \omega_c = 3 \text{ rad/sec} \\ \phi_m = 42° \end{cases}$$

BODE di $F(s) = C(s) \cdot G(s) \cdot K_H$

$m_{lim} = 1,81$

fase $= -192°$ $\qquad \measuredangle = 54° + \varepsilon = 60°$ con $\varepsilon = 6°$

$$\alpha = \frac{1 - \operatorname{sen}(\measuredangle)}{1 + \operatorname{sen}(\measuredangle)} = 0,072$$

$$\tau = \frac{1}{\omega_c \sqrt{\alpha}} = 1,24$$

$$C_A(s) = \frac{1 + \tau s}{1 + \alpha \tau s} = \frac{1 + 1,24 \cdot s}{1 + 0,089 \cdot s}$$

BODE di $F(s) = C(s) \cdot C_A(s) \cdot G(s) \cdot K_H$

$m_{lim} = 6,73$

$f = -132°$

$$\tau = \frac{100}{\omega_c} = 33,33$$

$$\alpha = \frac{1}{m_{lim}} = 0,15$$

$$C_R(s) = \frac{1 + \alpha \tau s}{1 + \tau s} = \frac{1 + 5 \cdot s}{1 + 33,33 \cdot s}$$

BODE di $F(s) = C(s) \cdot C_A(s) \cdot C_R(s) \cdot G(s) \cdot K_H$

$m_{lim} = 1,01$

fase $= -136°$ $\qquad \Rightarrow M_r = 2,59$ dB, $T_r = 0,618$ sec

SINTESI 2

CASO 2

$$G(s) = \frac{1}{2} \cdot \frac{1}{(1+s)\left(1+\frac{s}{5}\right)}$$

$K_c \doteq 320$

$c(s)$ TIPO 1 $\rightarrow$ $c(s) = \frac{320}{s} \cdot c'(s)$, $c'(\emptyset) = 1$

$T_r \leq 0{,}25$ sec

$M_r \leq 1{,}5$ dB

$T_r \cdot B_W = 3 \rightarrow B_W = \frac{3}{T_r} = 12$

$W_c = [0{,}5 \div 0{,}8] B_W = [6 \div 15]$ rad/sec

$M_{r\,lim} = 10^{M_{r\,dB}/20} = 1{,}1885$

$\phi_m = \frac{2{,}3 - M_{r\,lim}}{1{,}25} \cdot \frac{180}{\pi} = 51°$

$$\begin{cases} \omega_c = 10 \text{ rad/sec} \\ \phi_m = 51° \end{cases}$$

BODE DI $c(s) \cdot G(s) \cdot K_H$

$m_{lim} = 0{,}356$

$f = -237{,}72° \simeq -238°$

$\measuredangle\ 58 + 51 + \varepsilon = 109 + \varepsilon$

$= 109 + 11 = 120$

con $\varepsilon = 11$

Uso due reti da 60°.

$$C_A(s) = \frac{1+\tau \cdot s}{1+\alpha \cdot \tau \cdot s} = \frac{1+0{,}3732 \cdot s}{1+0{,}0268 \cdot s}$$

$$\alpha = \frac{1-\text{sen}(\measuredangle)}{1+\text{sen}(\measuredangle)} = 0{,}0718$$

$$\tau = \frac{1}{\omega_c \sqrt{\alpha}} = 0{,}3732$$

BODE DI $C(s) \cdot C_A(s) \cdot C_A(s) \cdot G(s) \cdot K_H$

$m_{lim} = 4{,}9581 \rightarrow M_{dB} = 13{,}91$ dB

$f = -117{,}73° \approx -118°$

$$C_R(s) = \frac{1+\alpha\tau \cdot s}{1+\tau \cdot s} = \frac{1+2{,}017 \cdot s}{1+10 \cdot s}$$

$$\tau = \frac{100}{\omega_c} = 10$$

$$\alpha = \frac{1}{m_{lim}} = 0{,}2017$$

BODE DI $C(s) \cdot C_A(s) \cdot C_A(s) \cdot C_R(s) \cdot G(s) \cdot k_M$

$M_{lim} = 1{,}0012$

$\varphi = -119{,}9° = -120°$

$T_r = 0{,}182 < 0{,}25$ sec

$M_r = 0{,}705$ dB $< 1{,}5$ dB

SINTESI 3

CASO 1

$$G(s) = 100 \cdot \frac{s+10}{s(s+20)(s+50)} = \frac{100}{20 \cdot 50} \cdot \frac{10\left(1+\frac{s}{10}\right)}{s\left(1+\frac{s}{20}\right)\left(1+\frac{s}{50}\right)} = \frac{\left(1+\frac{s}{10}\right)}{s\left(1+\frac{s}{20}\right)\left(1+\frac{s}{50}\right)}$$

$|d_1| \leq 3$

$|d_2| \leq 5$

$$C(s) = \frac{K_c}{s^h} \cdot C'(s) \quad ; \quad C'(\phi) = 1$$

N.B: Se aggiungo 1 polo in C(s) posso non calcolare il punto 3

1. $\frac{Y}{R} = 0,2 \quad \rightarrow \quad K_H = 5$

2. $e_{ramp} \leq \frac{1}{200}$

$G(s) \cdot C(s)$ TIPO 1 $\rightarrow$ $G(s)$ TIPO 1, $C(s)$ TIPO ϕ

$$e_{ramp} = \frac{1}{K_c \cdot 1 \cdot 5^2} = \frac{1}{25 K_c} \leq \frac{1}{200} \rightarrow 25 K_c \geq 200$$

~~$K_c \geq 8$~~

3. $e_{parab} \leq \frac{1}{1500}$

$G(s) \cdot C(s)$ TIPO 2 $\rightarrow$ $C(s)$ TIPO 1

$$e_{parab} = \frac{1}{K_c \cdot 1 \cdot 5^2} = \frac{1}{25 K_c} \leq \frac{1}{1500} \rightarrow 25 K_c \geq 1500$$

$K_c \geq 60$

4. $e_{dist} \leq \frac{1}{50}$

$R \neq \phi$, $d_1 = \phi$, $d_2 = \phi$ $\rightarrow$ $e_{grad} = \phi$

$R = \phi$, $d_1 \neq \phi$, $d_2 = \phi$

$$\lim_{s \to \phi} s \cdot \frac{3}{s} \cdot \frac{\frac{1}{s}}{1 + \frac{1}{s} \cdot 5 \cdot \frac{K_c}{s}} = \lim_{s \to \phi} \frac{\frac{3}{s}}{1 + \frac{5K_c}{s^2}} = \lim_{s \to \phi} \frac{\frac{3}{s} \cdot s^2}{s^2 + 5K_c} = \phi$$

$R = \phi$, $d_1 = \phi$, $d_2 \neq \phi$

$$\lim_{s \to \phi} s \cdot \frac{5}{s} \cdot \frac{1}{1 + \frac{1}{s} \cdot 5 \cdot \frac{K_c}{s}} = \lim_{s \to \phi} \frac{5 \cdot s^2}{s^2 + 5K_c} = \phi \qquad e_{grad} = \phi$$

$K_c \geq 60$

$c(s)$ TIPO 1

$$c(s) = \frac{60}{s} \cdot c'(s) \quad , \quad c'(\emptyset) = 1$$

5.6. $B_W \geq 90$ rad/sec

$\hat{S} \leq 20\%$

$$\omega_c = [0{,}5 \div 0{,}8]\, B_W = [45 \div 72] \text{ rad/sec}$$

$$M_r = \frac{1+\hat{S}}{[0{,}85 \div 1]} \quad ; \quad \phi_m = \frac{2{,}3 - M_r}{1{,}25}$$

$$M_r = [1{,}2 \div 1{,}4118] = 1{,}3$$

$$\phi_m = 0{,}8 \cdot \frac{180}{\pi} = 45{,}84° \approx 46°$$

$$\begin{cases} \omega_c = 60 \text{ rad/sec} \\ \phi_m = 46° \end{cases}$$

BODE di $c(s) \cdot G(s) \cdot K_H$

$m_{lin} = 0{,}1026$

$f = -221{,}2° = -221°$

$\measuredangle\ 41 + 46 + \varepsilon = 87 + \varepsilon = 94$

con $\varepsilon = 7$

$\frac{94}{2} = 47°$ $\quad \measuredangle = 47° * 2$

$$C_A(s) = \frac{1 + \tau \cdot s}{1 + \alpha \cdot \tau \cdot s} \qquad \alpha = \frac{1 - \text{sen}(\measuredangle)}{1 + \text{sen}(\measuredangle)} = 0{,}1552$$

$$= \frac{1 + 0{,}0423 \cdot s}{1 + 0{,}0066 \cdot s} \qquad \tau = \frac{1}{\omega_c \sqrt{\alpha}} = 0{,}0423$$

BODE di $c(s) \cdot C_A(s) \cdot C_A(s) \cdot G(s) \cdot K_H$ $\quad$ con $K_c = 80$

$m_{lin} = 0{,}6601$ $\quad \rightarrow \hat{S} = 17\%$

fase $= -127{,}44 \approx -127°$ $\quad B_W = 102$ rad/sec

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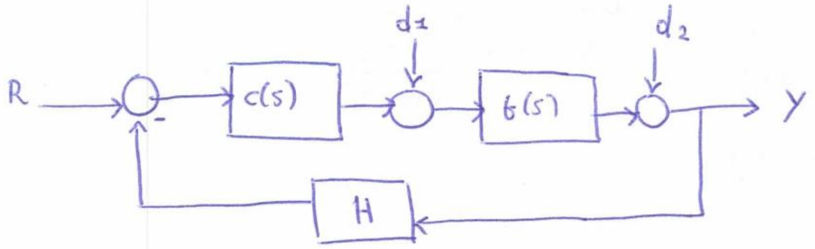
17/12/2014

ES. 1



$$G(s) = \frac{800\,(s+7)^2}{s\,(s+20)^2\,(s^2+s+1)} \qquad \begin{cases} d_1 = 0,5 \\ d_2 = 3 \end{cases}$$

1. $\frac{Y}{R} = 100 \Rightarrow H = \frac{1}{100}$.

2. $|e_{ramp}| \leq 5$

$$G(s) = \frac{800 \cdot 49}{400} \cdot \frac{\left(1+\frac{s}{7}\right)^2}{s\left(1+\frac{s}{20}\right)^2\left(1+s+s^2\right)} = \frac{98}{s} \cdot \frac{\left(1+\frac{s}{7}\right)^2}{\left(1+\frac{s}{20}\right)^2\left(1+s+s^2\right)}$$

G(s) TIPO 1

C(s) TIPO $\emptyset$

$$e_{ramp} = \frac{1}{K_c \cdot 98 \cdot \frac{1}{100^2}} = \frac{1}{\frac{98\,K_c}{100^2}} = \frac{100^2}{98 \cdot K_c} \leq 5$$

$$98\,K_c \geq \frac{100^2}{5} \rightarrow K_c \geq \frac{100^2}{98 \cdot 5} = 20,41$$

3. $|e_{dist}| \leq 2$

$R \neq \emptyset$, $d_1 = \emptyset$, $d_2 = \emptyset$

$G(s) \cdot C(s)$ TIPO 1 $\quad e_{grad} = \emptyset$

$R = \emptyset$, $d_1 \neq \emptyset$, $d_2 = \emptyset$

$$\lim_{s \to \emptyset} s \cdot \frac{0,5}{s} \cdot \frac{\frac{98}{s}}{1 + K_c \cdot \frac{98}{s} \cdot \frac{1}{100}} = \lim_{s \to \emptyset} \frac{\frac{49}{s}}{1 + \frac{98\,K_c}{100 \cdot s}} = \lim_{s \to \emptyset} \frac{49 \cdot 100}{100\,s + 98\,K_c}$$

$$= \frac{4900}{98\,K_c}$$

$R=0,\ d_1=0,\ d_2\neq 0$

$$\lim_{s\to 0} s\cdot\frac{3}{s}\cdot\frac{1}{1+\frac{98}{s}\cdot K_c\cdot\frac{1}{100}} = \lim_{s\to 0}\frac{3}{1+\frac{98 K_c}{100\cdot s}}$$

$$= \lim_{s\to 0}\frac{3\cdot 100\cdot s}{100\cdot s+98\cdot K_c} = 0$$

$$\frac{4900}{98\cdot K_c}\leq 2 \quad\rightarrow\quad 98\cdot K_c\cdot 2\geq 4900$$

$$K_c \geq \frac{4900}{196} = 25$$

$K_c \geq 25$

$C(s)$ TIPO 0

$C(s) = 25\cdot C'(s)\quad ;\quad C'(0)=1$

4.5. $M_r \leq 3\ dB \rightarrow M_{r\,lim} = 1{,}4125$

$T_s \leq 0{,}4$ sec

$$\phi_m = \frac{2{,}3 - M_{r\,lim}}{1{,}25}\cdot\frac{180}{\pi} = 40{,}68^\circ \approx 41^\circ$$

$$T_s\cdot B_w = 3 \rightarrow B_w = \frac{3}{T_s} = 7{,}50\ rad/sec$$

$$\omega_c = [0{,}5 \div 0{,}8]\,B_w = [3{,}75\div 6]\ rad/sec = 5\ rad/sec$$

$$\begin{cases}\omega_c = 5\ rad/sec\\ \phi_m = 41^\circ\end{cases}$$

BODE di $C(s)\cdot G(s)\cdot H$

$M_{lim} = 0{,}2841$

fase $= -215{,}23^\circ \approx -215^\circ$

$\measuredangle = 35+41+\varepsilon = 76+\varepsilon = 84$ con $\varepsilon = 8$

$\measuredangle = 42 * 2$

$$C_A(s) = \frac{1+\tau\cdot s}{1+\alpha\cdot\tau\cdot s} \qquad \alpha = \frac{1-\mathrm{sen}(\measuredangle)}{1+\mathrm{sen}(\measuredangle)} = 0{,}1982$$

$$= \frac{1+0{,}4492\cdot s}{1+0{,}0890\cdot s} \qquad \tau = \frac{1}{\omega_c\sqrt{\alpha}} = 0{,}4492$$

BODE di $C(s) \cdot C_A(s) \cdot C_A(s) \cdot G(s) \cdot H$

$m_{lim} = 1{,}4334 \rightarrow M_{dB} = 7{,}2 \text{ dB}$

fase $= -131{,}2° \approx -131°$

$$C_R(s) = \frac{1 + \alpha \cdot \tau \cdot s}{1 + \tau \cdot s} \qquad \alpha = \frac{1}{m_{lim}} = 0{,}6972$$

$$= \frac{1 + 13{,}9440 \cdot s}{1 + 20 \cdot s} \qquad \tau = \frac{100}{\omega_c} = 20$$

BODE di $C(s) \cdot C_A(s) \cdot C_A(s) \cdot C_R(s) \cdot G(s) \cdot H$

$m_{lim} = 0{,}9994$

fase $= -131{,}5° \approx -132°$

Risposta $M_r = 3{,}49 \text{ dB} > 3 \text{ dB}$

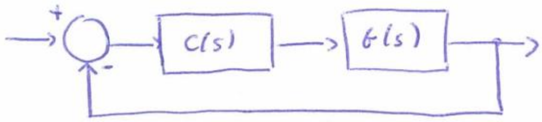
modifico $\alpha \downarrow$ in $C_A(s)$

$$\rightarrow C_A(s) = \frac{1 + 0{,}4492 \cdot s}{1 + 0{,}06 \cdot s}$$

Risposta adesso $M_r = 2{,}39 \text{ dB}$; $T_s = 0{,}287$ sec.

17/12/2014

ES. 2



$$G(s) = \frac{(s+100)^2}{(s^2+s+1)(s+1)} = 100 \cdot 100 \cdot \frac{\left(1+\frac{s}{100}\right)^2}{(1+s)(1+s+s^2)} \qquad K_G = 100.00$$

1. $e_{grad} = \varnothing$

$G(s)$ TIPO $\varnothing$

$C(s)$ TIPO 1 $\quad \rightarrow G(s) \cdot C(s)$ TIPO 1

2.3. $M_r \leq 1\,dB$

$B_W \doteq 100$ rad/sec

$$C(s) = \frac{K_C}{s} \cdot C'(s) \quad ; \quad C'(\varnothing) = 1 \qquad K_C = 1$$

$M_{r\,lim} = 1,1220$

$$\phi_m = \frac{2,3 - M_{r\,lim}}{1,25} \cdot \frac{180}{\pi} = 53,99 \approx 54°$$

$$W_c = [0,5 \div 0,8]\,B_W = [50 \div 80] \text{ rad/sec}$$

$$\begin{cases} \phi_m = 54° \\ W_c = 65 \text{ rad/sec} \end{cases}$$

BODE di $C(s) \cdot G(s)$

$m_{lim} = 7,9689 \cdot 10^{-4} \rightarrow m_{dB} = -61,97\ dB$

fase $= -292,1892° \approx -292°$

$\measuredangle = 112 + 54 + \varepsilon = 166 + \varepsilon = 180$ con $\varepsilon = 14$ $\qquad \frac{\measuredangle}{3} = 60$

$$C_r(s) = \frac{1 + \tau \cdot s}{1 + \alpha \cdot \tau \cdot s} \qquad \alpha = \frac{1 - \text{sen}(\measuredangle)}{1 + \text{sen}(\measuredangle)} = 0,0718$$

$$= \frac{1 + 0,0691 \cdot s}{1 + 0,0050 \cdot s} \qquad \tau = \frac{1}{w_c \sqrt{\alpha}} = 0,0691$$

BODE di $C(s) \cdot C_A(s)^3 \cdot G(s)$

$m_{lim} = 0,0668 \quad \rightarrow \quad M_{dB} = -23,51 \text{ dB}$

fase $= -113,8570$

$\rightarrow K_c = 15$

$m_{lim} = 1,0018$

fase $= -113,86° \simeq -114°$

Ma non soddisfo le specifiche.

Quindi tramite Nychols in AA.

$\alpha \cdot \tau$ di $C_A(s) = 0,0040$

$$\rightarrow C_A(s) = \frac{1+0,0691 \cdot s}{1+0,0040 \cdot s} \quad \text{e} \quad K_c = 55$$

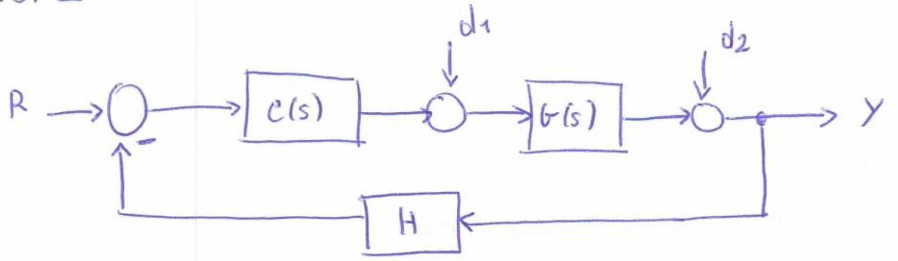
$\rightarrow M_{r\,dB} = 0,927 \text{ dB}$

$B_W = 700 \text{ rad/sec}$

17/12/2014

ES. 1

$d_1 = 10$
$d_2 = 5$



$$G(s) = \frac{7500(s+40)(s+80)}{s(s+10)^2(s+200)(s+300)} = \frac{75\not{0}\not{0}\cdot 4\not{0}\cdot 8\not{0}}{1\not{0}\not{0}\cdot 2\not{0}\not{0}\cdot 300} \cdot \frac{\left(1+\frac{s}{40}\right)\left(1+\frac{s}{80}\right)}{s\left(1+\frac{s}{10}\right)^2\left(1+\frac{s}{200}\right)\left(1+\frac{s}{300}\right)}$$

$$= \frac{4}{s} \cdot \frac{\left(1+\frac{s}{40}\right)\left(1+\frac{s}{80}\right)}{\left(1+\frac{s}{10}\right)^2\left(1+\frac{s}{200}\right)\left(1+\frac{s}{300}\right)}$$

1. $\frac{Y}{R} = 20 \Rightarrow H = 1/20$.

2. $|e_{ramp}| \leq 2$

$C(s) \cdot G(s)$ TIPO 1 $\rightarrow$ $C(s)$ TIPO $\emptyset$

$$e_{ramp} = \frac{1}{K_c \cdot 4 \cdot \left(\frac{1}{20}\right)^2} = \frac{1}{\frac{4K_c}{400}} = \frac{100}{K_c} \leq 2 \Rightarrow K_c \doteq 50$$

3. $|e_{dist}| \leq 2,5$

$R \neq \emptyset$, $d_1 = \emptyset$, $d_2 = \emptyset$

$e_{grad} = \emptyset$ $\qquad$ $G(s) \cdot C(s)$ TIPO 1

$R = \emptyset$, $d_1 \neq \emptyset$, $d_2 = \emptyset$

$$\lim_{s \to \emptyset} \not{s} \cdot \frac{10}{\not{s}} \cdot \frac{\frac{4}{s}}{1 + K_c \cdot \frac{4}{s} \cdot \frac{1}{20}} = \lim_{s \to \emptyset} \frac{\frac{40}{s}}{1 + \frac{4K_c}{20 \cdot s}} = \lim_{s \to \emptyset} \frac{\frac{800 \cdot \not{s}}{\not{s}}}{20 \cdot s + 4K_c}$$

$$= \frac{800}{4K_c} = \frac{200}{K_c}$$

$R = \emptyset$, $d_1 = \emptyset$, $d_2 = \emptyset$

$e_{grad} = \emptyset$ $\qquad \Rightarrow \frac{200}{K_c} \leq 2,5 \rightarrow K_c \doteq 80$

$K_c \doteq 80$; $C(s)$ TIPO $\emptyset$.

$C(s) = \frac{80}{s\not{}} \cdot C'(s) \quad ; \quad C'(\not{0}) = 1$

4.5.

$$\begin{cases} \hat{S} \leq 5\% \\ B_W \doteq 40 \text{ rad/sec} \end{cases}$$

$\omega_c = [0,5 \div 0,8]\, B_W = [20 \div 32]$ rad/sec

$M_r = \frac{1+\hat{S}}{[0,85 \div 1]} = [1,05 \div 1,24] = 1,15$

$\phi_m = \frac{2,3 - M_r}{1,25} = 0,92 \cdot \frac{180}{\pi} = 52,71° \approx 52°$

$$\begin{cases} \omega_c = 26 \text{ rad/sec} \\ \phi_m = 52° \end{cases}$$

BODE di $C(s) \cdot G(s) \cdot H$

$m_{lim} = 0,0983 \approx -20,15\,dB$

fase $= -189,26° \approx -189°$

$\measuredangle = 9 + 52 + \varepsilon = 61 + \varepsilon = 70°$ con $\varepsilon = 9$

$\frac{\measuredangle}{2} = 35°$

$C_A(s) = \frac{1 + \tau \cdot s}{1 + \alpha \cdot \tau \cdot s}$

$\alpha = \frac{1 - \text{sen}(\measuredangle)}{1 + \text{sen}(\measuredangle)} = 0,27010$

$\tau = \frac{1}{\omega_c \sqrt{\alpha}} = 0,0739$

$= \frac{1 + 0,0739 \cdot s}{1 + 0,0200 \cdot s}$

BODE di $C(s) \cdot C_A(s)^2 \cdot G(s) \cdot H$

$m_{lim} = 0,3629 \rightarrow -8,80\,dB = M_{dB}$

fase $= -119,20° \approx -119°$

$C_R(s) = \frac{1 + \alpha\tau \cdot s}{1 + \tau \cdot s}$

$\alpha = \frac{1}{m_{lim}} = 2,7556$

$\tau = \frac{100}{\omega_c} = 3,8462$

$= \frac{1 + 10,5986 \cdot s}{1 + 3,8462 \cdot s}$

BODE di $C(s) \cdot (C_A(s))^2 \cdot C_R(s) \cdot G(s) \cdot H \rightarrow$ $m_{lim} = 0,9999$

fase $= -118,83° \approx -119°$

Soddisfo Bw ma non soddisfo $\hat{S}$.
Vado a modificare $\alpha \cdot \tau$ in $C_A(s)$.

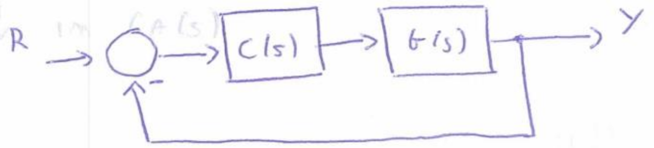
$$\alpha \cdot \tau = 0,1000$$

$$C_A(s) = \frac{1+0,0739 \cdot s}{1+0,0100 \cdot s}$$

-> $B_W = 51,1$ rad/sec

-> $\hat{S}\% = 3,56$

17/12/2014
ES. 2



$$G(s) = \frac{(s+1)^2}{(10s+1)(s^2+0,02\cdot s+0,01)} = \frac{100\cdot(s+1)^2}{(1+10\cdot s)(1+2\cdot s+100\cdot s^2)}$$

1. $E_{grad} = \emptyset$

$G(s)$ TIPO $\emptyset$ -> $C(s)$ TIPO 1 $\forall K_c$

$$C(s) = \frac{1}{s}\cdot C'(s) \quad , \quad C'(\emptyset) = 1$$

2.3. $\begin{cases} M_r \leq 0,5\ dB & \rightarrow M_{r\,lim} = 1,0593 \\ B_W \doteq 10\ rad/sec \end{cases}$

$$\phi_m = \frac{2,3 - M_{r\,lim}}{1,25} = 0,9926\cdot\frac{180}{\pi} = 56,87^\circ \approx 57^\circ$$

$$\omega_c = [0,5 \div 0,8]\ B_W = [5 \div 8]\ rad/sec = 6,5\ rad/sec$$

$$\begin{cases} \phi_m = 57^\circ \\ \omega_c = 6,5\ rad/sec \end{cases}$$

BODE di $C(s)\cdot G(s)$

$m\ lim = 0,0024$

fase $= -196,45^\circ \approx -196^\circ$

$\measuredangle\ 16 + 57 + \varepsilon = 73 + \varepsilon = 80$ con $\varepsilon = 7$ -> $\frac{\measuredangle}{2} = 40^\circ$

$$C_A(s) = \frac{1+\tau\cdot s}{1+\alpha\cdot\tau\cdot s} \qquad \alpha = \frac{1-\mathrm{sen}(\measuredangle)}{1+\mathrm{sen}(\measuredangle)} = 0,2174$$

$$\tau = \frac{1}{\omega_c\sqrt{\alpha}} = 0,3296$$

$$= \frac{1+0,3296\cdot s}{1+0,0717\cdot s}$$

BODE di $C(s) \cdot C_A(s)^? \cdot G(s)$

$m_{lim} = 0{,}0111$

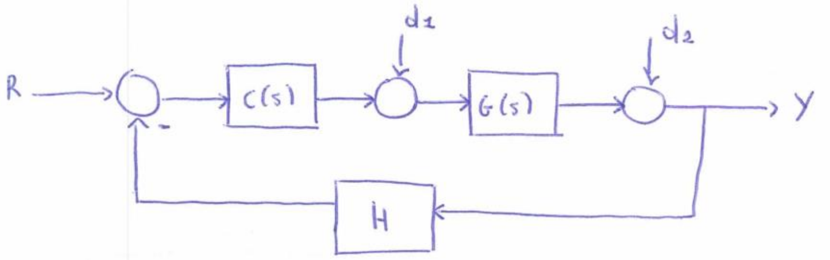
fase $= -116{,}65° \approx -116°$

Modifica $K_c \rightarrow K_c = 150$

$$\begin{cases} B_W = 16{,}5 \text{ rad/sec} \\ M_{dB} = 2{,}32 \text{ dB} \end{cases}$$

21/01/2015

ES. 3



$d_1 = 2$

$d_2 = 5$

$$G(s) = \frac{(s+10)}{(s^4+60\cdot s^3+600\cdot s^2+5000\cdot s)} = \frac{(s+10)}{s(s^3+60\cdot s^2+600\cdot s+5000)}$$

$$= \frac{(s+10)}{s(s+50)(s+5-8,66j)(s+5+8,66j)}$$

1. $\frac{Y}{R} = 0,1 \quad \rightarrow \quad H = 10$

2. $|K_c| \leq 210$

3. $|e_{\text{ramp}}| \leq 0,1 \qquad C(s)\cdot G(s) \text{ TIPO } 1 \rightarrow C(s) \text{ TIPO } \emptyset$

$$E_y = \frac{E_r}{H} \rightarrow \frac{E_r}{\cancel{R}} = \frac{1}{1+CGH}\cdot R \qquad \text{con } R = \frac{1}{s^2}$$

$$\lim_{s\to\emptyset} s\cdot E_r(s) = \lim_{s\to\emptyset} \cancel{s}\cdot\frac{1}{\cancel{s^2}}\cdot\frac{1}{s+K_c\cdot\frac{\cancel{s}+10}{\cancel{s}(\cancel{s^3}+60\cancel{s^2}+600\cancel{s}+5000)}\cdot 10}$$

$$= \frac{1}{K_c\cdot\frac{100}{5000}} = \frac{1}{\frac{K_c}{50}} = \frac{50}{K_c}$$

$$\frac{50}{K_c}\cdot\frac{1}{H} = E_y \rightarrow \frac{50}{10K_c} = E_y \rightarrow \frac{5}{K_c} \leq \frac{1}{10} \rightarrow K_c \geq 50.$$

4. $|e_{ass}| \leq 10^{-3}$

$R \neq 0$, $d_1 = 0$, $d_2 = 0$

$e_{grad} = 0$

$R = 0$, $d_1 \neq 0$, $d_2 = 0$

$$T(s) = \frac{G}{1 + CGH}$$

$$\lim_{s \to 0} s \cdot Y(s) = \lim_{s \to 0} s \cdot T(s) \cdot R(s) = \lim_{s \to 0} \cancel{s} \cdot \frac{2}{\cancel{s}} \cdot \frac{\frac{(s+10)}{(s^4 + 60s^3 + 600s^2 + 5000 \cdot s)}}{1 + K_c \cdot 10 \cdot \frac{(s+10)}{(s^4 + 60s^3 + 600 \cdot s^2 + 5000 \cdot s)}}$$

$$= \lim_{s \to 0} \frac{2 \cdot \frac{(\cancel{s}+10)}{(s^4 + 60s^3 + \cancel{600s^2} + 5000s)}}{10K_c \cdot \frac{(\cancel{s}+10)}{s(s^3 + 60s^2 + \cancel{600 s + 5000})} + s(\cancel{s^3 + 60s^2 + 600 \cdot s} + 5000)} = \frac{2 \cdot 10}{100 K_c} = \frac{2 \cdot 1}{10 \cdot K_c}$$

$R = 0$, $d_1 = 0$, $d_2 \neq 0$

$$T(s) = \frac{1}{1 + CGH}$$

$$\lim_{s \to 0} s \cdot Y(s) = \lim_{s \to 0} \cancel{s} \cdot \frac{5}{\cancel{s}} \cdot T(s) = \cancel{0}$$

$$\frac{2 \cdot 1}{10 K_c} \leq 10^{-3} \rightarrow 2 \cdot 10 K_c \geq 10^{3} \rightarrow K_c \geq 200$$

$200 \leq K_c \leq 210$

$C(s)$ TIPO 0

5.6. $M_r \leq 3\,dB$ -> $M_{r\,lim} = 1,4125$

$B_W \geq 20$ rad/sec

$$C(s) = \frac{200}{s^{\not 0}} \cdot C'(s) = 200 \cdot C'(s)$$

$$\phi_m = \frac{2,3 - M_{r\,lim}}{1,25} \cdot \frac{180}{\pi} = 40,68^\circ \approx 41^\circ$$

$\omega_c = [0,5 \div 0,8]\ B_W = [10 \div 16]$ rad/sec

$$\begin{cases} \phi_m = 41^\circ \\ \omega_c = 13 \text{ rad/sec} \end{cases}$$

BODE di $C(s) \cdot G(s) \cdot K_H$

$m_{lin} = 0,3319$

fase $= -170,10 \approx -170^\circ$

$\measuredangle = 41 - 10 + \varepsilon = 31 + \varepsilon = 38^\circ$ con $\varepsilon = 7$

$$C_A(s) = \frac{1 + \tau \cdot s}{1 + \alpha \cdot \tau \cdot s} \qquad \alpha = \frac{1 - \text{sen}(\measuredangle)}{1 + \text{sen}(\measuredangle)} = 0,2379$$

$$= \frac{1 + 0,1577 \cdot s}{1 + 0,0375 \cdot s} \qquad \tau = \frac{1}{\omega_c \sqrt{\alpha}} = 0,1577$$

$m_{lin} = 0,6804$ -> $m_{dB} = -3,35\,dB$

fase $= -132,09 \approx -132^\circ$

Uso una nuova rete anticipatrice con poco guadagno di fase e molto di modulo:

$m = 2$ $\quad \omega\tau = 100$ -> $m = \frac{1}{\alpha}$ => $\alpha = \not\frac{1}{2}$ 0,67

$$\tau = \frac{\omega\tau}{\omega_c} = 7,6923$$

$$C_A(s) = \frac{1 + 7,6923 \cdot s}{1 + \not{3,8462} \cdot s} \quad 5,1538$$

-> fase $= -132^\circ$

$M_{dB} = 0,13\,dB$

$M_r = 2,23\,dB$

$B_W = 20,5$ rad/sec

19/11/2015

ES. 2

$$G(s) = \frac{0,05\,(1+0,2\cdot s)}{s\,(1+s)\,(1+0,1\cdot s+0,01\cdot s^2)}$$

$|d_1| = 2$

$|d_2| = 0,3$

1. $\frac{Y}{R} = 10 \rightarrow H = \frac{1}{10}$

2. inutile procedere

3. $C(s)$ TIPO ϕ

$e_r \le 0,8$

$$e_r = \frac{1}{0,05\cdot K_c\cdot\frac{1}{100}} = \frac{100}{K_c\cdot 0,05} = \frac{2000}{K_c} \le 0,8 \rightarrow K_c \ge 2500.$$

4. $e_d \le 0,01$

$R \ne \phi,\ d_1 = \phi,\ d_2 = \phi$

$e_{grad} = \phi$

$R = \phi,\ d_1 \ne \phi,\ d_2 = \phi$

$$\lim_{s\to\phi} s\cdot Y(s) = \lim_{s\to\phi} \cancel{s}\cdot\frac{2}{\cancel{s}}\cdot\frac{\frac{0,05}{s}}{1+\frac{0,05}{s}\cdot\frac{1}{10}\cdot K_c} = \lim_{s\to\phi}\frac{\frac{2\cdot 0,05}{s}}{1+\frac{K_c\cdot 0,05}{10\cdot s}}$$

$$= \lim_{s\to\phi}\frac{\frac{2\cdot 0,05}{\cancel{s}}\cdot\cancel{s}}{\cancel{10}s + K_c\cdot 0,05} = \frac{0,05}{K_c\cdot 0,05} = \frac{20}{K_c}$$

$R = \phi,\ d_1 = \phi,\ d_2 \ne \phi$

$e_{grad} = \phi$

$\rightarrow \frac{20}{K_c} \le 0,01 \rightarrow K_c \ge 2000$

$\Rightarrow C(s) = 2500\cdot C'(s)\quad ;\quad C'(\phi) = 1$

5.6.

$$\begin{cases} T_s \le 0,1 \text{ sec} \\ M_r \le 2 \text{ dB} \quad \rightarrow \phi_m = 48° \end{cases}$$

$T_s \cdot B_W = 3 \rightarrow B_W = \frac{3}{0,1} = 30$

$\omega_c = [0,5 \div 0,8] B_W = [15 \div 24]$ rad/sec.

$$\begin{cases} \omega_c = 20 \text{ rad/sec} \\ \phi_m = 48° \end{cases}$$

BODE di $C(s) \cdot G(s)$

$m_{lim} = 0,3569$

fase $= -247,48° = -248°$

$\measuredangle = 68 + 48 + \varepsilon = 116 + \varepsilon = 120$ con $\varepsilon = 54$

$C_A(s) = \frac{1 + \tau \cdot s}{1 + \alpha \cdot \tau \cdot s}$ $\qquad \alpha = \frac{1 - \text{sen}(\measuredangle/2)}{1 + \text{sen}(\measuredangle/2)} = 0,0718$

$= \frac{1 + 0,1866 \cdot s}{1 + 0,0134 \cdot s}$ $\qquad \tau = \frac{1}{\omega_c \sqrt{\alpha}} = 0,1866$

BODE di $C(s) \cdot C_A(s)^2 \cdot G(s)$

fase $= -128°$

$m_{lim} = 0,4971 \rightarrow -6,07$ dB

Uso un'altra $C_A(s)$

$m = 2,5 \rightarrow \alpha = \frac{1}{2,5} = 0,4$ $\qquad C_A(s) = \frac{1 + 5 \cdot s}{1 + 2 \cdot s}$

$\omega_\tau = 100$ $\qquad \tau = \frac{\omega_\tau}{\omega_c} = 5$

$\rightarrow T_s = 0,0843$ sec

$M_r = 1,74$ dB

17/12/2014

ES. 2

$$G(s) = \frac{(s+100)^2}{(s^2+s+1)(s+1)}$$

$G(s) \cdot C(s)$ TIPO 1

$$\begin{cases} M_r \le 1 \text{ dB} \\ B_W \ge 100 \text{ rad/s} \end{cases} \Rightarrow \begin{cases} \phi_m = 54° \\ \omega_c = 65 \text{ rad/s} \end{cases}$$

$$C(s) = \frac{1}{s}$$

BODE di $C(s) \cdot G(s)$

-> zero in -1 : ↑ fase

$$C(s) = K_P + \frac{K_I}{s} = \frac{K_I\left(1 + \frac{K_P}{K_I} \cdot s\right)}{s}$$

$$-\frac{K_I}{K_P} = -1$$

ϕ_m viene soddisfatto in $\omega_c = 300$

↑ Lo vedo da Bode di $\frac{1+s}{s} \cdot G(s)$

Quindi adesso aumento K_I.

$K_I = 350$ -> $C(s) = \frac{350(1+s)}{s}$

Soddisfo AA ma non AC.

Da Micheo vedo che devo ancora aumentare K_I

-> $K_I = 1500$

$$\Rightarrow C(s) = 1500 \cdot \frac{(1+s)}{s}$$

17/12/2014

ES. 2

$$G(s) = \frac{(s+1)^2}{(10 \cdot s+1)(s^2+0,02 \cdot s+0,01)}$$

$C(s)$ TIPO 1

$$\begin{cases} M_r \leq 0,5 \text{ dB} \\ BW \geq 10 \text{ rad/sec} \end{cases} \Rightarrow \begin{cases} \phi_m = 57° \\ \omega_c = 6,5 \text{ rad/sec} \end{cases}$$

$$C(s) = K_P + \frac{K_I}{S} = \frac{K_I\left(1+\frac{K_P}{K_I} \cdot s\right)}{s}$$

Pongo uno zero $= -10^{-1}$ => così aumento la fase

$$-\frac{K_I}{K_P} = -\frac{1}{10} \rightarrow \frac{K_P}{K_I} = 10.$$

Soddisfo ϕ_m in $\omega_c = 3,5$ rad/sec

↳ lo vedo da Bode di $\frac{1+10 \cdot s}{s} \cdot G(s)$

$\rightarrow K_I = 3,5$

$$\Rightarrow C(s) = \frac{3,5\,(1+10 \cdot s)}{s}$$

Non soddisfo M_r tramite Nichols di (AA)

$$\rightarrow C(s) = \frac{30\,(1+10 \cdot s)}{s}$$

19/11/2015 ES. 2

$$G(s) = \frac{0,05(1+0,2\cdot s)}{s(1+s)(1+0,1\cdot s+0,01\cdot s^2)}$$

1. $V/R = 10$
2. $e_g \leq 0,3$
3. $e_r \leq 0,8$
4. $e_d \leq 0,01$
5. $T_s \leq 0,1$ sec
6. $M_r \leq 2\,dB$

$H = \frac{1}{10}$.

7. $C(s)$ di tipo I per soddisfare 1-4?

$G(s) \cdot \frac{1}{s}$

Non va bene perchè $\phi_m < 0 \ \forall \omega$

-> A.C. è instabile.

8. $C(s)$ di tipo PI per soddisfare 1-4?

$$C(s) = K_P + \frac{K_I}{s} = \frac{K_I(1+\frac{K_P}{K_I}\cdot s)}{s}$$

$-\frac{K_I}{K_P} = -10^{-1}$ -> $\frac{K_P}{K_I} = \frac{1}{10}\, 10$

$$C(s) = \frac{K_I(1+10\cdot s)}{s}$$ con $K_I = 1$ Soddisfa.

10/07/2015 ES. 3

$$G(s) = \frac{s+5}{s^4+11s^3+110s^2+100\cdot s} = \frac{s+5}{s(s^3+11s^2+110s+100)}$$

1. $Y/R = 10$
2. $e_g \leq 0{,}3$
3. $e_r \leq 1$
4. $e_d \leq 0{,}05$
5. $M_r \leq 2\,dB$
6. $T_s \leq 0{,}1$ sec $\qquad H = \frac{1}{10}$

7. Possibile stabilizzare il sistema con un PI ?

$C(s) = \frac{1}{s}$. $\qquad C(s) = K_P + \frac{K_I}{s} = \frac{K_I(1+\frac{K_P}{K_I}\cdot s)}{s}$

zero in $-10^{-1} = -\frac{1}{10} \quad \to \quad -\frac{K_I}{K_P} = -\frac{1}{10} \quad \to \quad \frac{K_P}{K_I} = 10$.

$C(s) = \frac{K_I(1+10\cdot s)}{s}$, $K_I = 1$

$\to C(s) = \frac{1+10\cdot s}{s} \Rightarrow$ OK : $\phi_m = 34{,}5°$

8. È possibile soddisfare 1-6 con un PI ?

$$\begin{cases} M_r \leq 2\,dB \\ T_s \leq 0{,}1 \text{ sec} \end{cases}$$

$\phi_m = \frac{2{,}3 - M_{r\,lim}}{1{,}25} = 47{,}72° \approx 48°$

$\omega_c = [0{,}5 \div 0{,}8]\,B_W = [15 \div 24]$ rad/sec

$T_s \cdot B_W = 3$

$$\begin{cases} \phi_m = 48° \\ \omega_c = 20 \text{ rad/sec} \end{cases}$$

Non riesco a trovare C(s) adatto a soddisfare le specifiche.