(1)

$k_p = 4 \qquad k_I = 28$

$$R_{PI}(s) = k_p + \frac{k_I}{s} = 4 + \frac{28}{s} = \frac{4s+28}{s} =$$

$$= \frac{4(s+7)}{s}$$

$$R_{PI}(s) = \frac{V(s)}{E(s)}$$

$$v(t) = 4\,e(t) + 28\int_0^t e(\tau)\,d\tau$$

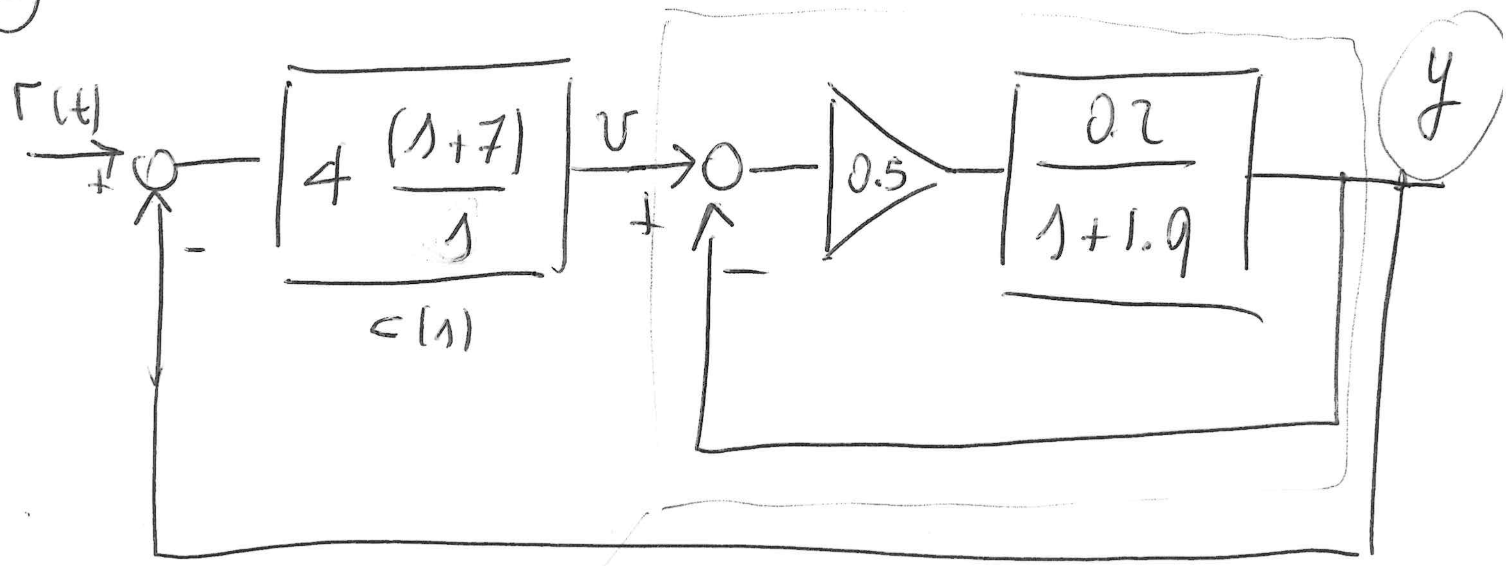
$$\downarrow$$

$$V(s) = 4E(s) + \frac{28\,E(s)}{s} =$$

$$= E(s)\left[4 + \frac{28}{s}\right]$$

$$\frac{V(s)}{E(s)} = 4 + \frac{28}{s}$$

2



$$G_v^y = \frac{\frac{0.1}{s+1.9}}{1 + \frac{0.1}{s+1.9}} = \frac{0.1}{s+2}$$

$$W_r^y = \frac{4\,\frac{(s+7)}{s}\,\frac{0.1}{s+2}}{1 + 4\,\frac{s+7}{s}\,\frac{0.1}{s+2}} = \frac{4(s+7)\,0.1}{s(s+2) + 4(s+7)\,0.1}$$

$$= \frac{0.4\,(s+7)}{s^2 + 2s + 0.4s + 2.8} = \boxed{\frac{0.4\,(s+7)}{s^2 + 2.4s + 2.8}}$$

(3)

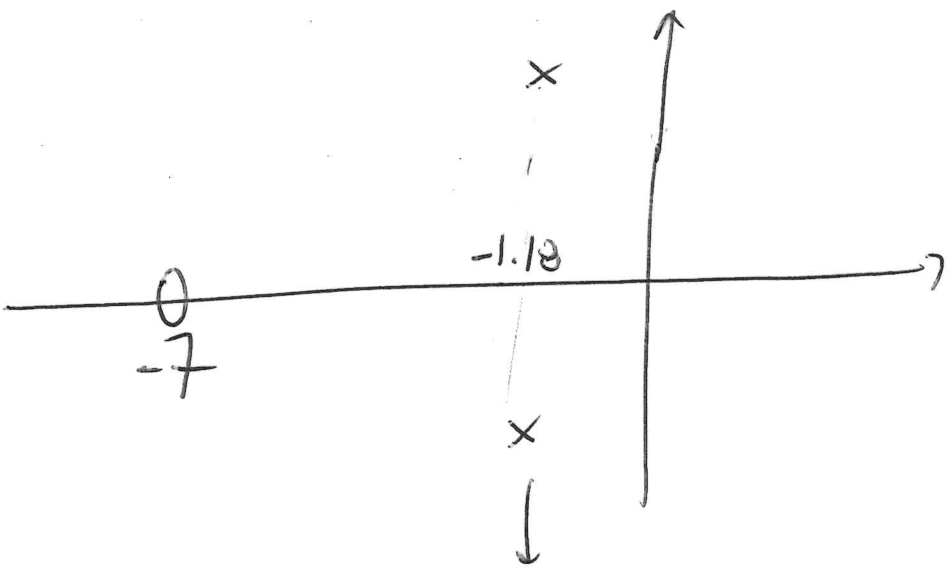
$$p_{1,2} = \frac{-2.4 \pm \sqrt{(2.4)^2 - 4 \cdot 2.8}}{2}$$

$$\sqrt{5.76 - 11.2} = \sqrt{-5.44} = 2.33j$$

$$s^2 + 2.4s + 2.8 = s^2 + 2\zeta\omega_n s + \omega_n^2$$

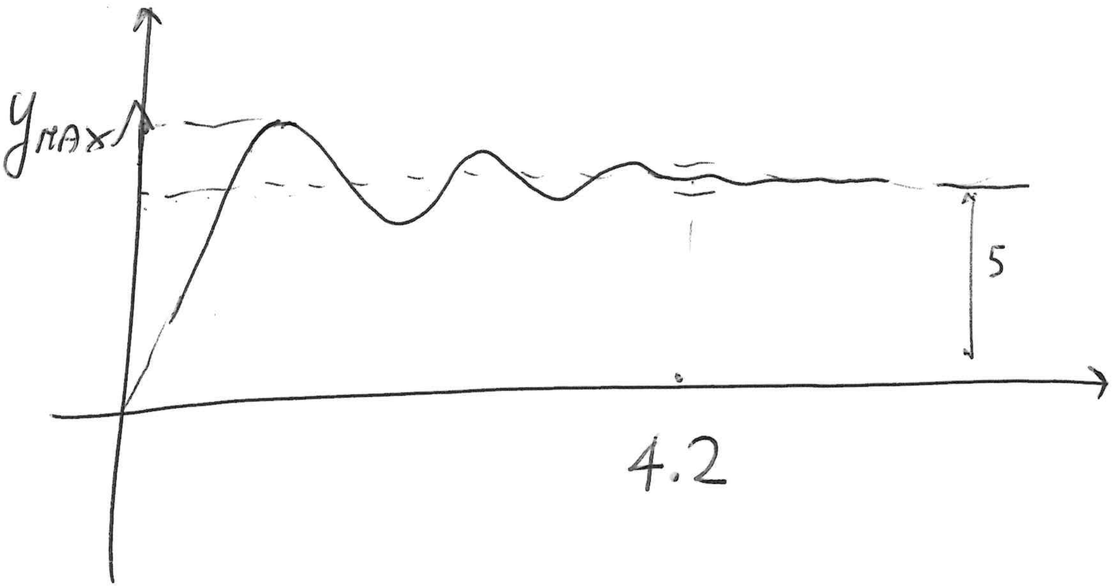
$$\omega_n = \sqrt{2.8} = 1.67 \qquad Re = -\zeta\omega_n =$$

$$2\zeta\omega_n = 2.4 \qquad \zeta = \frac{2.4}{2 \cdot \omega_n} = 0.71$$



DOMINANTI

4B

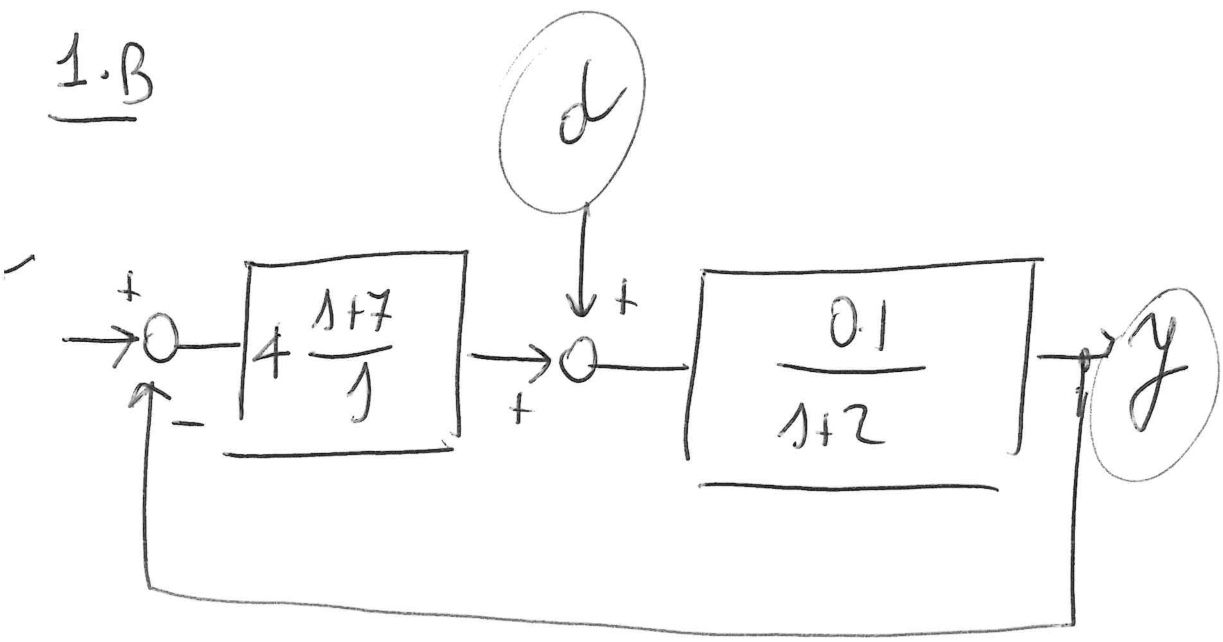


$$y_{MAX} = 5 + \underbrace{0.05 \cdot 5} = 5.25$$

$$t_{a\,1\%} = 5\,\tau_{ep} = 5 \cdot 0.84 \simeq 4.2$$

$$= \frac{1}{\xi \omega_n}$$

1.B

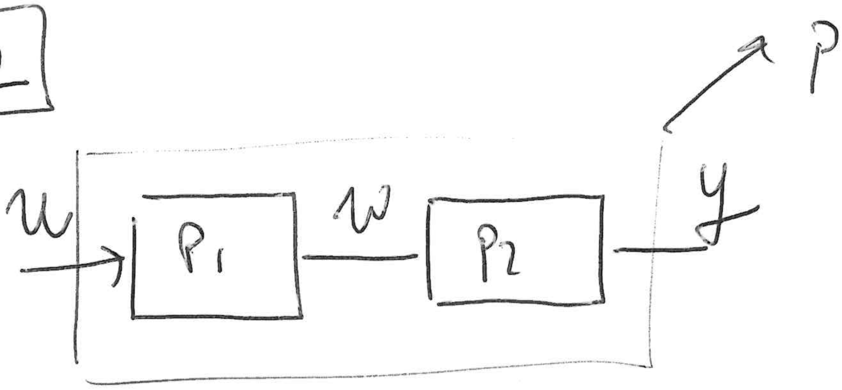


$$W_d^y = \frac{\frac{0.1}{s+2}}{1+4\,\frac{s+7}{s}\,\frac{0.1}{s+2}} = \frac{(0.1)\,s}{s(s+2)+0.4\,(s+7)}$$

$$= \frac{0.1\,s}{s^2+2.4s+2.8} = \frac{N(s)}{D(s)}$$

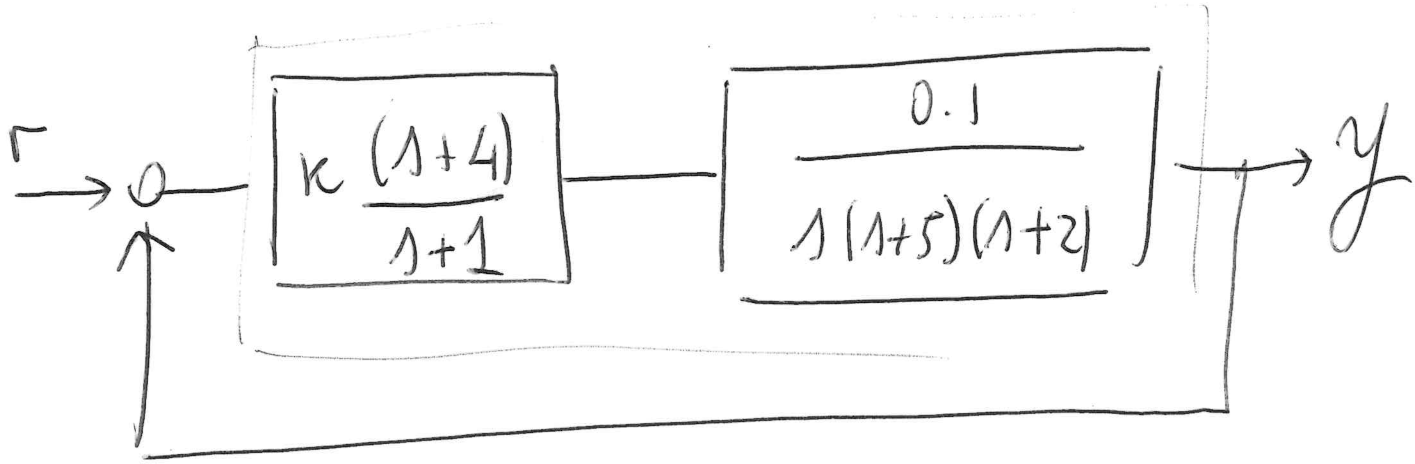
$$\ddot{y} + 2.4\dot{y} + 28 = 0.1\,\dot{d}(t)$$

Es 2



$$P_1 : \frac{1}{s+2} \qquad P_2 : \frac{0.1}{s^2+5s} = \frac{0.1}{s(s+5)}$$

$$P = \frac{0.1}{s(s+5)(s+2)}$$



$$F = C \cdot P = \frac{0.1\,k\,(s+4)}{s(s+1)(s+5)(s+2)}$$

$$P_{CAR}(s) = s(s+1)(s+5)(s+2) + 0.1K(s+4)$$

$$= (s^2+s)(s^2+7s+10) + 0.1Ks + 0.4K$$

$$= s^4 + 7s^3 + 10s^2 + s^3 + 7s^2 + 10s$$

$$+ 0.1Ks + 0.4K$$

$$= s^4 + 8s^3 + 17s^2 + (10+0.1K)s + 0.4K$$

1	17	0.4K
8	10+0.1k	
A	B	
C		

(2.3)

$$A = -\begin{vmatrix} 1 & 17 \\ 8 & 10+0.1k \end{vmatrix} \qquad B = -\begin{vmatrix} 1 & 0.4k \\ 8 & 0 \end{vmatrix}$$

$$= 17 \times 8 - (10 + 0.1k)$$

$$= 136 - 10 - 0.1k = 126 - 0.1k$$

$$B = 3.2\,K$$

$$\begin{matrix} 1 & 17 & 0.4k \\ 8 & 10+0.1k & \\ 126-0.1k & 3.2K & \end{matrix}$$

C

2.4

$$C = -\begin{vmatrix} 8 & 10+0.1k \\ 126-0.1k & 3.2k \end{vmatrix}$$

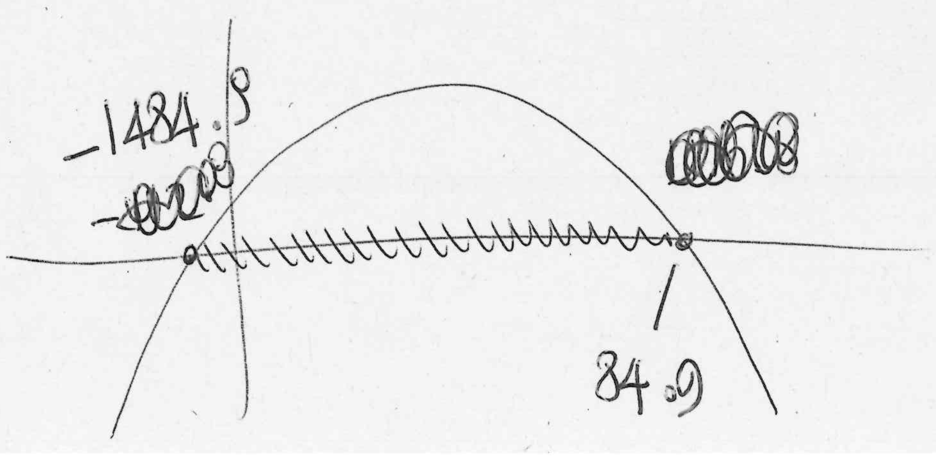
$$= (126-0.1k)(10+0.1k) - 8 \cdot 3.2k$$

$$= 1260 + 12.6K - K - 0.01K^2$$

$$- 2.56K$$

$$-14K$$

$$= -0.01K^2 \qquad + 1260$$



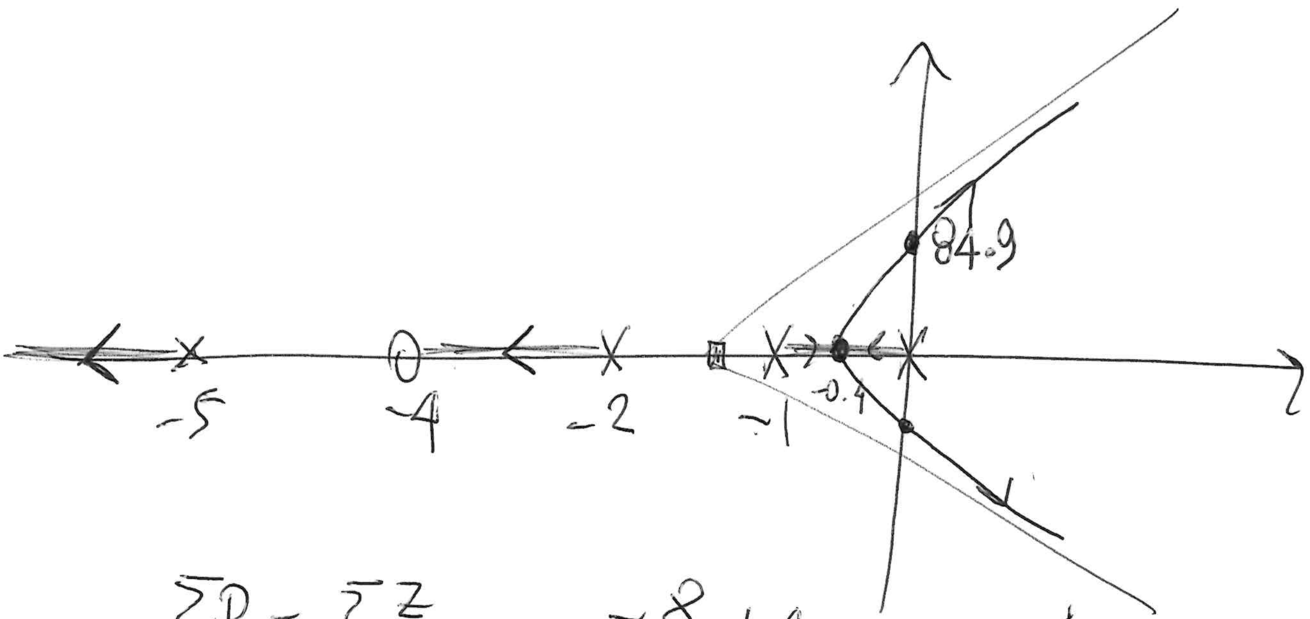
2.5

$A > 0 \implies K < 1260$

$C > 0 \implies 0 < K < 84.9$

$\boxed{K_{limite} = 84.9}$

$\boxed{2.B}$ LdR $\quad L(s) = \dfrac{0.1\,(s+4)}{s\,(s+1)\,(s+2)\,(s+5)}$



$$x_s = \frac{\Sigma p - \Sigma z}{n-m} = \frac{-8+4}{3} = -\frac{4}{3}$$

2.6

$$0 < k \leq k^{PD}$$

$$k^{PD} = \frac{1}{\bar{K}} \frac{p_1 p_2 p_3 p_4}{r_1} =$$

$\bar{K} = 0.1$

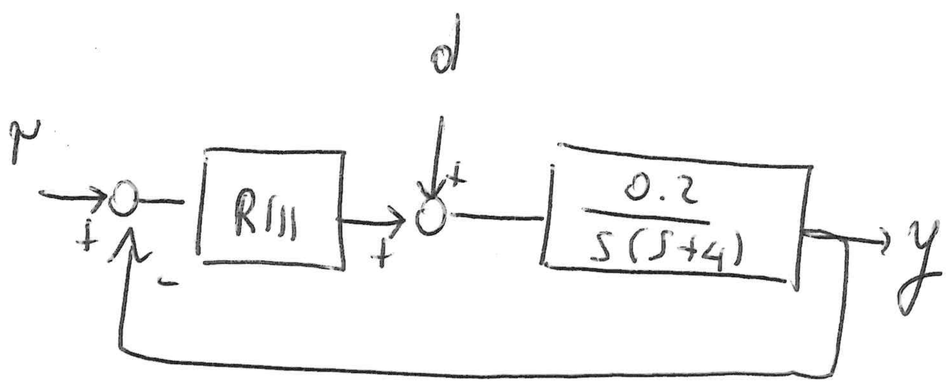
$p_1 = 0.4$ $\quad p_2 = 0.6$ $\quad p_3 = 1.6$ $\quad p_4 = 4.6$

$r_1 = 3.6$

Es 3

3.1

3



3A

S1 prec. statica

S2 $d = \text{cost} \rightarrow Att \geq 99\%$

S3 $t_{a\,2\%} \leq 3\ s$

S4 $S_\% \leq 10$

S1 $\rightarrow$ OK

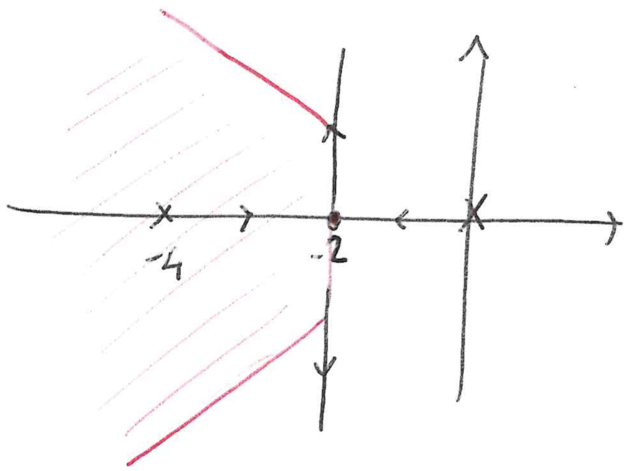
S2 $\rightarrow R(0) \geq 100$ $\rightarrow R(s) = K_R R'(s)$ $\quad R'(0) = 1$

sist. 2° ordine

S3 $\rightarrow A^* = -\dfrac{6}{T^*} = -2$

S4 $\rightarrow \xi \geq 0.6$

$R(s) = K_R$



$K_{\text{punto doppio}} = \frac{1}{\bar{K}} p_1 p_2$

$\bar{K} = 0.2$

$p_1 = p_2 = 2$

$K_{PD} = \frac{4}{0.2} = 20$

$K_R = 100$

$P_{CAR} = s^2 + 4s + 20 = s^2 + 2\zeta\omega_n s + \omega_n^2$

$\omega_n = \sqrt{20}$

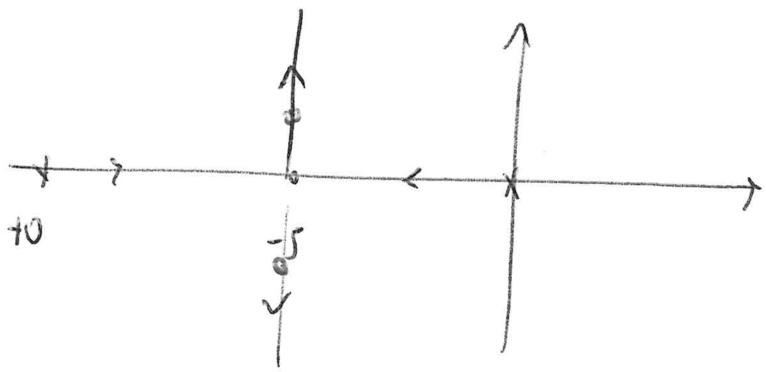
$2\zeta\omega_n = 4$

$\zeta = \frac{4}{2\omega_n} = \frac{4}{2 \cdot \sqrt{20}} = 0.44$ $\boxed{\text{NON VA BENE}}$

Proviamo ad aggiungere una coppia polo zero per "spostare a sx il polo in -4" (3.3)

$$R(s) = K_R \frac{s+4}{s+10} \cdot \frac{10}{4} \qquad \cdot \; K_R \geq 100$$

$$L(s) = \frac{10}{4} \frac{\cancel{(s+4)}}{s+10} \cdot \frac{0.2}{s\cancel{(s+4)}} = \frac{0.5}{s(s+10)}$$



vediamo che succede ai poli con $K_R = 100$

P_{CAR}: $s(s+10) + 0.5 K_R =$

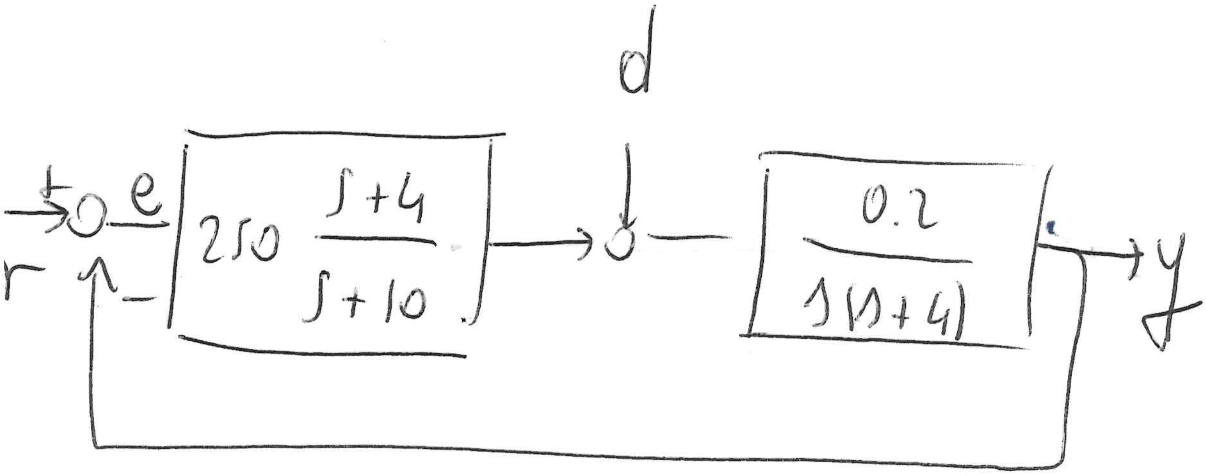
$$s^2 + 10s + 50 \qquad \Delta = 100 - 200 < 0$$

$$= s^2 + 10s + 50 = s^2 + 2\zeta\omega_n s + \omega_n^2 \qquad \downarrow \text{ poli cc con } Re = -5$$

$\omega_n = \sqrt{50}$ $\quad 2\zeta\omega_n = 10 \quad \zeta = \frac{5}{\omega_n} = 0.70$ OK

Quindi

$$R(s) = 100\,\frac{s+4}{s+10}\cdot(2.5) = 250\,\frac{s+4}{s+10}$$



$r(t) = 3 + 0.5t + 5\,\text{sen}(20t)$

$d = 0.4 + \underbrace{e^{-2t}\,\text{sen}(t)}_{\to\, 0}$

$r(t) = 3 \rightarrow$ PMI $\quad y \rightarrow 3$

$r(t) = 0.5t \quad$ PMI non può essere utilizzato

Calcoliamo il valore di regime dell'errore (se $\exists$ finito)

3.5

La formula è

$$e(t) \rightarrow E_\infty = \frac{\Sigma}{\mu_c \mu_p}$$

Σ = pendenza rampa

μ_c = GUAD STAT CONTROLLORE

μ_p = " " processo

$\Sigma = 0.5$ $\quad \mu_c = 100$ $\quad \mu_p = \frac{0.2}{4} = 0.05$

$$E_\infty = \frac{0.5}{100 \times 0.05} = \frac{0.5}{5} = 0.1$$

a regime: $r(t) - y(t) \rightarrow 0.1$

$$y_{regime} = r(t) - 0.1 = (0.5t - 0.1)$$

calcolo il 0.1 x altra via

$$W_r^e = \frac{1}{1 + R \cdot P} = \frac{1}{1 + \frac{50}{s(s+10)}} = \frac{s(s+10)}{s(s+10) + 50}$$

$$RP = \frac{50}{s(s+10)}$$

3.6

$$E(s) = \frac{\cancel{s}(s+10)}{s(s+10)+50} \cdot \frac{0.5}{s^{\cancel{2}}} = \frac{0.5(s+10)}{s[s(s+10)+50]}$$

polo semplice all'origine

2 poli a Re < 0

OK

$$\lim_{t\to\infty} e(t) = \lim_{s\to 0} sE(s) = \left.\frac{0.5(s+10)}{s(s+10)+50}\right|_{s=0}$$

$$= \frac{5}{50} = 0.1$$

CVD

$r = 5 \sin(20t)$ serve la $W_r^y = \frac{RP}{1+RP}$

$$\hookrightarrow RP = 250\frac{\cancel{(s+4)}}{s+10} \; \frac{0.2}{s\cancel{(s+4)}} = \frac{50}{s(s+10)}$$

$$W_r^y = \frac{\frac{50}{s(s+10)}}{1+\frac{50}{s(s+10)}} = \frac{50}{s(s+10)+50} = \frac{50}{s^2+10s+50}$$

$$y_{regime} = 5 \cdot M \sin(20t + \phi)$$

(3.7)

$\omega = 20 \qquad M_{db} \cong -20\ db \qquad \phi \cong -160°$

$$M = 10^{M_{db}/20} = 10^{-1} = 0.1$$

$$\phi^{rad} = -160° \cdot \frac{2\pi}{360} = -2.79$$

$$y^{regime} = \underline{0.5 \sin(20t - 2.79)}$$

$$d = 0.4 \longrightarrow y_\infty = \frac{0.4}{\mu_c} = \frac{0.4}{100} = 0.004$$

Con il TFRG :

$$d = 0.4 \rightarrow \boxed{W_d^y(s)} \rightarrow y \rightarrow 0.4 \times W_d^y(0) \rightarrow \text{SARÀ } \frac{1}{100} = 0.01$$

$$W_d^Y(s) = \frac{P}{1+RP} = \frac{\frac{0.2}{s(s+4)}}{1 + \frac{50}{s(s+10)}} = \frac{0.2(s+10)}{s(s+4)(s+10) + 50(s+4)}$$

$$W_d^y(0) = \frac{0.2 \times 10}{50 \times 4} = \frac{2}{200} = 0.01$$