**1** $W_0(s)$ általános alakja

$$W_0(s)=\frac{K}{s^i}\cdot\frac{\prod(1+s\tau_i)}{\prod(1+sT_i)}\cdot\frac{\prod(1+2\mu_i\tau_i s+\tau_i^2 s^2)}{\prod(1+2\xi_i T_i s+T_i^2 s^2)}=\frac{K}{s^i}\cdot W_{01}(s)$$

$$W_{01}(0)=1$$

k – felnyitott kör körerősítése $[sec^{-i}]$

i – típusszám, integrátorok száma

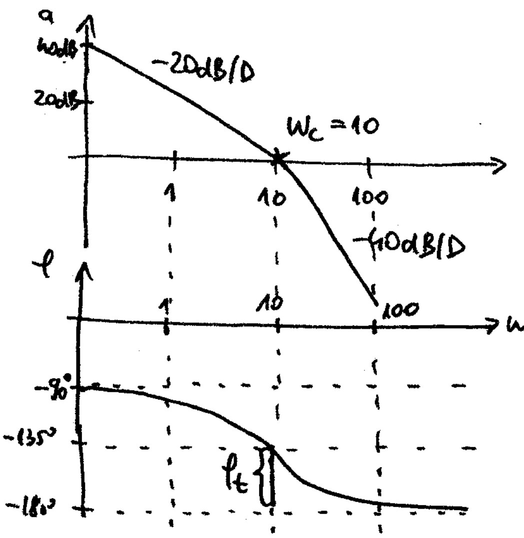
**2** $$W_0(s)=\frac{25(s+0{,}1)}{s(s+1)(s+5)}=\frac{0{,}5}{s}\cdot\frac{(1+10s)}{(1+s)(1+0{,}2s)}$$

$\underline{k=0{,}5}$

$\underline{i=1}$

**3** $$W_0(s)=\frac{10}{s(1+0{,}1s)}$$

$w_1=10$




$\underline{W_c=10}$ $\quad p_1=0$

$\underline{k=10}$ $\quad p_2=-10$

$\underline{φ_t}=180°-90°-arctg(1)\approx\underline{45°}$

$\underline{φ_t=51{,}8°}$

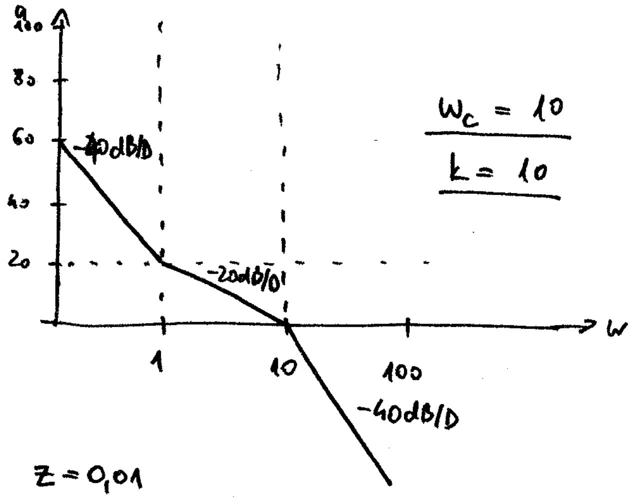
**4** $$W_0(s)=\frac{10(1+s)}{s^2(1+0{,}1s)}$$

$p_{1,2}=0 \rightarrow -40dB/D$

$z=1 \rightarrow -20dB/D$

$p_3=10 \rightarrow -40dB/D$

$a_{dB}(w=1)=20$




$\underline{W_c=10}$

$\underline{k=10}$

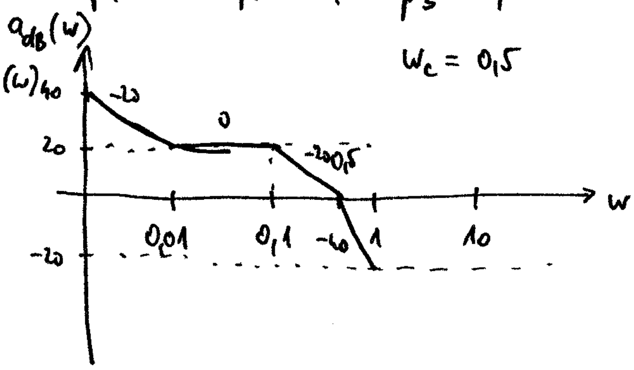
**5** $$W_0(s)=\frac{0{,}05(1+100s)}{s(1+10s)(1+2s)}$$

$z=0{,}01$

$p_1=0 \quad p_2=0{,}1 \quad p_3=0{,}5$

$W_c=0{,}5$

$\underline{k=0{,}05}\rightarrow -26dB$ len a(w)

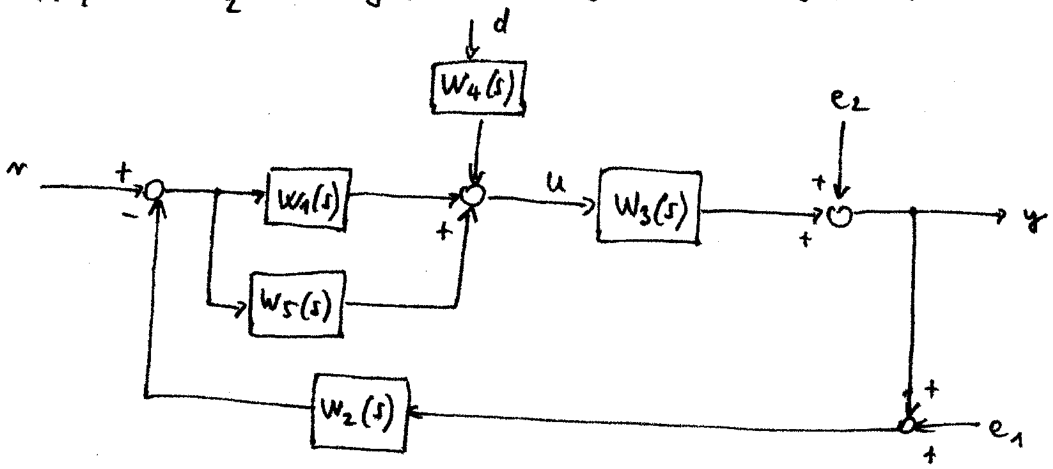


6. $$W_0(s) = \frac{0{,}05(1+100s)}{s(1+10s)(1+2s)}$$

$$\varphi(\omega) = 180^\circ - 90^\circ - \operatorname{arctg}(\omega \cdot 10) - \operatorname{arctg}(\omega \cdot 2) + \operatorname{arctg}(\omega \cdot 100)$$

$$\varphi(\omega) = \pi - \frac{\pi}{2} - \operatorname{arctg}(\omega \cdot 10) - \operatorname{arctg}(\omega \cdot 2) + \operatorname{arctg}(\omega \cdot 100)$$

7.




$$W_{yr}(s) = \frac{[W_1(s) + W_5(s)] \cdot W_3(s)}{1 + W_3(s) \cdot W_2(s) \cdot [W_1(s) + W_5(s)]}$$

$$W_0(s) = W_3(s) \cdot W_2(s) \cdot [W_1(s) + W_5(s)]$$

$$W_{yd}(s) = \frac{W_4(s) \cdot W_3(s)}{1 + W_3(s) \cdot W_2(s) \cdot [W_1(s) + W_5(s)]}$$

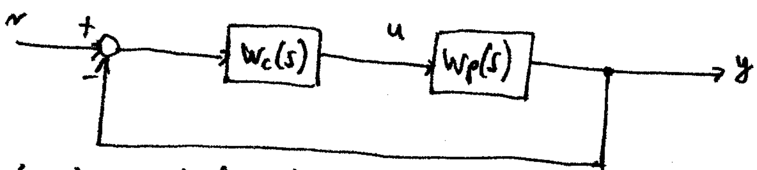
$$W_{ye_1}(s) = \frac{-W_2(s) \cdot W_3(s) \cdot [W_1(s) + W_5(s)]}{1 + W_0(s)}$$

8. $$W_p(s) = \frac{A(1+s\tau_1)}{(1+sT_1)(1+sT_2)(1+sT_3)}$$

$A = 10$ $\quad T_1 = 100s$ $\quad T_3 = 1s$

$\tau_1 = 10s$ $\quad T_2 = 10s$

$W_c(s) = 1$



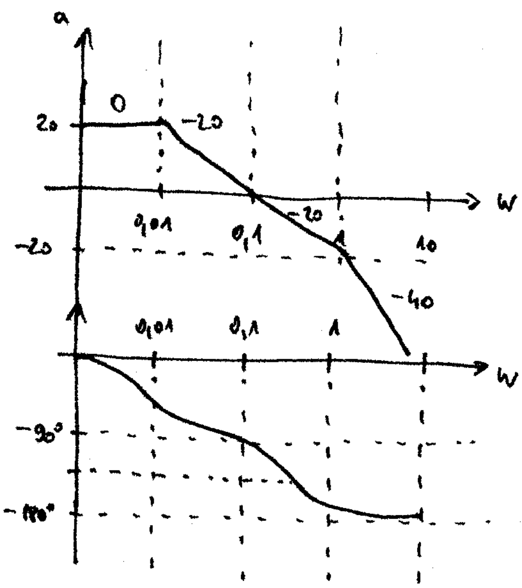

$$\varphi_t = 180^\circ - \operatorname{arctg}(\omega \cdot 1) - \operatorname{arctg}(\omega \cdot 100)$$

$\underline{\omega_c = 0{,}1}$

$\underline{\varphi_t(\omega_c) = 90^\circ}$

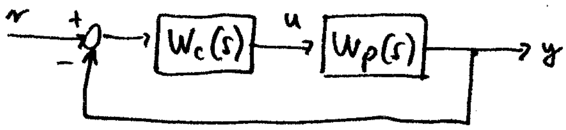
$\underline{GM = \infty}$

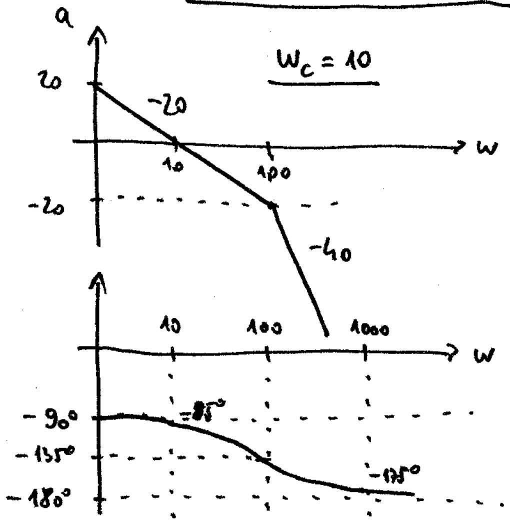
↳ mert végtelenben −180°-hoz tart



**9** $W_p(s) = \frac{A}{s(1+sT_1)}$  $A=10$  $T_1 = 0{,}01s$

$W_c(s) = 1$




$\varphi_t = 180° - 90° - \operatorname{arctg}(0{,}01 \omega_c)$

$\underline{\varphi_t \approx 88°}$

$\underline{GM = \infty}$

**10** $W_p(s) = \frac{A}{(1+sT_1)(1+sT_2)}$  $A=10$  $T_1 = 1s$  $T_2 = 10s$

$W_p(s) = \frac{10}{(1+s)(1+10s)}$

$p_1 = -1$

$p_2 = -\frac{1}{10}$

zérus nincs

$$\lim_{t\to\infty} v_p(t) = \lim_{s\to 0} W_p(s) = \underline{A = 10}$$

$$\lim_{t\to 0} v_p(t) = \lim_{s\to\infty} W_p(s) = \underline{0}$$

$$W(s) = \frac{W_p(s)}{1+W_p(s)} = \frac{10}{10+(1+s)(1+10s)} = \underline{\frac{1}{s^2+1{,}1s+1{,}1}}$$

$$\lim_{t\to\infty} v(t) = \frac{k}{k+1} = \underline{0{,}91}$$

**11** $W_p(s) = \frac{A}{(1+sT_1)(1+sT_2)(1+sT_3)}$  $A=10$  $T = 100, 10, 1$

a) $W_c(s) = 1$

b) $W_c(s) = \frac{1+s\tau_1}{1+sT_4}$  $\tau_1 = 100s$  $T_4 = 10s$

1. nagy fázistartalék: ⓐ esetben sokkal nagyobb lesz
2. állandósult hiba minimalizálása: mindegy, mert egyikben sincs integrátor → körerősítést nem befolyásolja
3. t=0-nál beavatkozójel minimalizálása: ⓐ esetben, másiknál D miatt lesz nagyobb

a) $W(s) = \frac{10}{(1+100s)(1+10s)(1+s)}$

b) $W(s) = \frac{10}{(1+s)(1+10s)^2}$

**12** bal ábra: strukturálisan labilis, felnyitott körben kis körerősítés mellett sem tudunk pozitív fázistartalékot biztosítani

jobb ábra: ezen tervezhető stabilis zárt kört adó szabályozás

$\boxed{13}$ a) $\omega_c \approx 0{,}3$ b) $\omega_c \approx 3$

$\varphi_t \approx 5°$ $\varphi_t \approx 24°$

$GM \approx -20dB$ $GM \approx -17dB$

fázistartalék (b) esetben nagyobb

erősítéstartalék (b) esetben nagyobb

$\boxed{14}$ $W_{01}(s) = \frac{10}{s(s+10)}$ $W_{02}(s) = \frac{10}{(s+1)(s+10)}$ $\longrightarrow$ állandósult hiba : $\frac{K}{1+K} \approx \cancel{0{,}5}$ $0{,}52$

↳ van benne integrátor → állandósult hiba $\varnothing$

$W_2(s) = \frac{W_{02}(s)}{1+W_{02}(s)} =$

$\boxed{15}$

$W_c(s) = k$

$W_p(s) = \frac{10}{(1+s)(1+10s)}$

$W(s) = \frac{W_c(s)\cdot W_p(s)}{1+W_c(s)\cdot W_p(s)} = \frac{10k}{10s^2+11s+(1+10k)}$

$p_{1,2} = \frac{-11 \pm \sqrt{121-40(1+10k)}}{20}$ zérus nincs

$W(s) = \frac{10k}{(s-p_1)(s-p_2)} = \frac{10k}{p_1 \cdot p_2}\cdot\frac{1}{\left(1-\frac{s}{p_1}\right)\left(1-\frac{s}{p_2}\right)}$ $A = \frac{10k}{p_1\cdot p_2}$ – stat erősítés

$\boxed{16}$ $T_{1\%}$, $\Delta v\%$ max túllövés

$W(s) = \frac{1}{1+2\xi T s + T^2 s^2}$

$s_{1,2} = -\xi\omega_0 \pm j\omega_0\sqrt{1-\xi^2}$

$T_{1\%} = \frac{\ln\frac{100}{1}}{\omega_0\cdot\xi}$ $\Delta v = e^{-\frac{\pi\cdot\xi}{\sqrt{1-\xi^2}}}$

↳ $\omega_0$ kiszámolható ↳ $\xi$ kiszámolható

$\boxed{17}$ `Wp = tf(1, conv([1 1], [0.1 1]));` $\longrightarrow$ $W_p(s) = \frac{1}{(s+1)(0{,}1s+1)}$

`Wc = series(tf(10,1), parallel(tf(1,1), tf(1,[1 0])))` $\longrightarrow$ $W_c(s) = 10\left(1+\frac{1}{s}\right) = \frac{10s+10}{s} = \frac{s+1}{0{,}1s}$

`Wo = series(Wp, Wc)` $W_o(s) = W_p(s)\cdot W_c(s) = \frac{1}{0{,}1s(1+0{,}1s)}$

`Wc1 = feedback(Wo, tf(1,1), -1)` $W_{c1}(s) =$

?

$\boxed{18}$ $W_p(s) = \dfrac{1}{(s+1)(0{,}1s+1)}$ $W_c(s) = \dfrac{10(s+1)}{s}$ $W_0(s) = W_p(s) \cdot W_c(s)$

$W_{c1}(s) =$

wc1 = feedback(wo, tf(1,1), -1)

↳ ?

ltiview (wc1)

$\boxed{19}$ $W_p(s) = \dfrac{1}{(s+1)(0{,}1s+1)}$ $W_c(s) = \dfrac{10(s+1)}{s}$ $W_0(s) = W_c(s) \cdot W_p(s) = \dfrac{100}{S(s+10)}$

$W_{c1}(s) = \dfrac{100}{s^2+10s+100}$

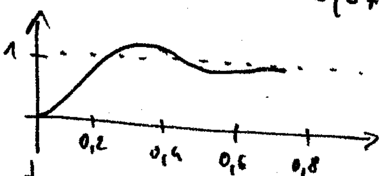
damp: pólusai Wc1-nek
sajátérték, természetes frekvencia, damping faktor megjelenítése

$\boxed{20}$ $W_p(s) = \dfrac{1}{(s+1)(0{,}1s+1)}$ $W_c(s) = \dfrac{10(s+1)}{s}$ $W_0(s) = W_p(s) \cdot W_c(s) = \dfrac{100}{s(s+100)}$

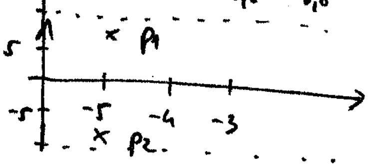
$W_{c1}(s) = \dfrac{100}{s^2+10s+100}$

damp: ugyanaz

$\underline{p_{1,2} = -5 \pm j\,8{,}66}$




step response




pzmap