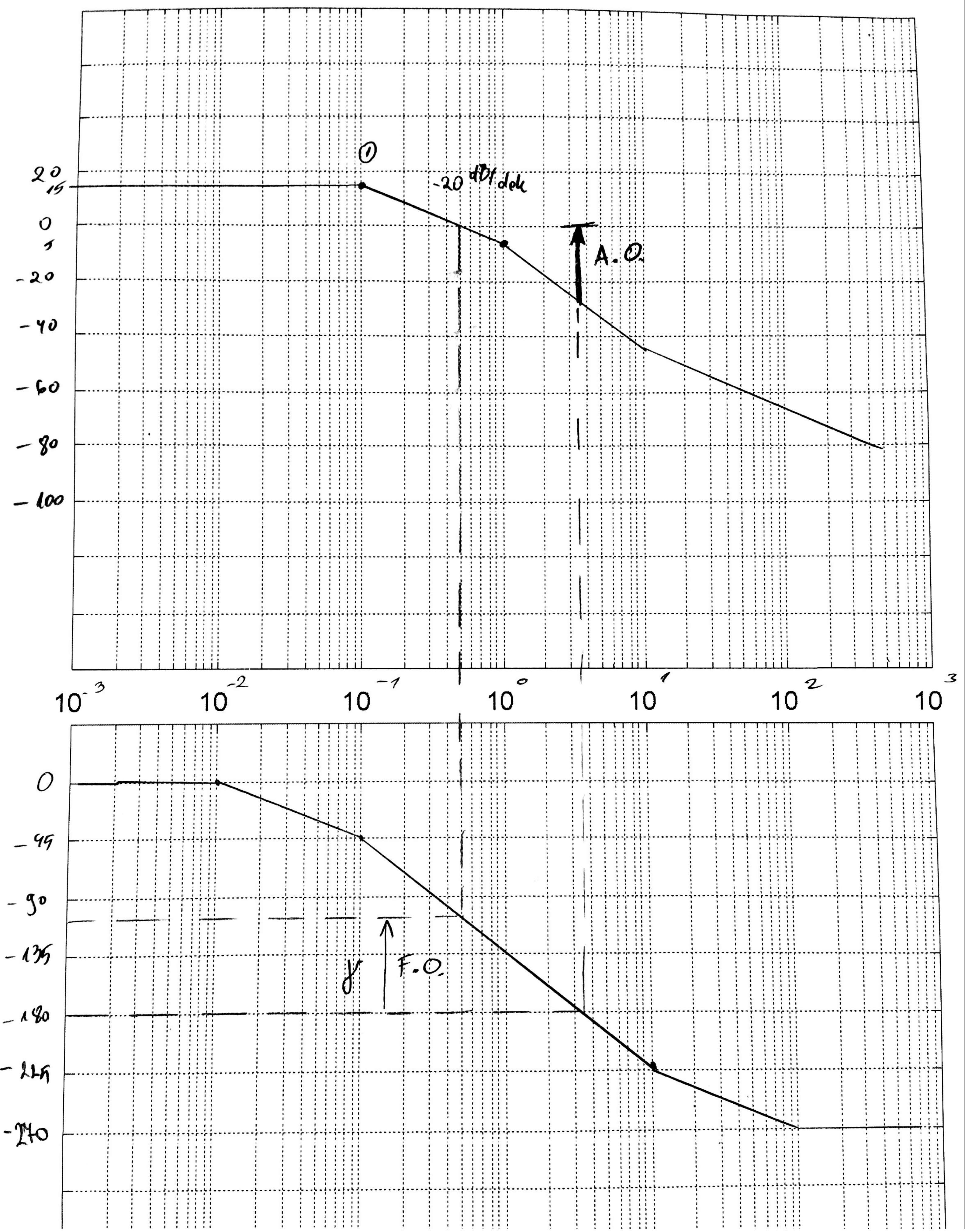
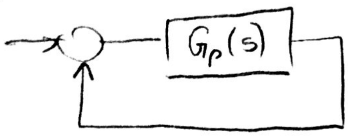


20
15
0
-5
-20
-40
-60
-80
-100
①
-20 dB/dek
A.O.
10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
0
-45
-90
-135
-180
-225
-270
γ
F.O.

(1.)



$G_o(s) = G_p(s)$

FAZNO OSIGURANJE
AMPLITUDNO ?

F.O. ⇒ iznos faze koliko još možemo spustiti fazu do $-180°$ u ω_c koju odredimo u amp. karakt. (pravac koji sijeće 0)

nagib → iznos ampl. u dB

1) $(-1, 15)$

$$y - y_1 = a(x - x_1)$$
$$y - 15 = -20(x+1)$$
$$y = -20x - 5$$

$$y = 0 \Rightarrow x = -0{,}25$$
$$\omega_c = 10^{-0.25} = 0{,}56$$

nagib → iznos faze

2) $(-1, -45)$ → u faznom

$$y = -90x - 135$$
$$x = -0{,}25 \Rightarrow y = -112{,}5°$$

$$\gamma = 180° - 112{,}5 = \underline{67{,}5°} //$$

A.O. ⇒ koliko još možemo promijeniti amplitudu do nam faza bude $-180°$ u ω_π koju odredimo u faznoj karakt. (pravac koji se nalazi na $-180°$

3) $y = -90x - 135$

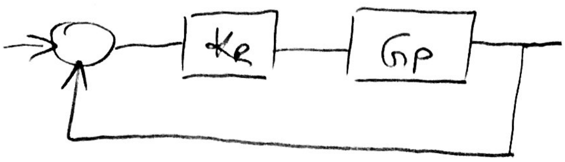
$$y = 180° \Rightarrow x = +0{,}5$$
$$\omega_\pi = 10^{+0{,}5} = 3.16$$

4) $(0, -5)$

$$y = -40x - 5$$

za $x = 0{,}5 \Rightarrow y = -25 \Rightarrow \underline{A_r = 25\ dB} //$

b)



$K_R = ?$ $\rightarrow \gamma = 90°$

$y = -90x - 135$

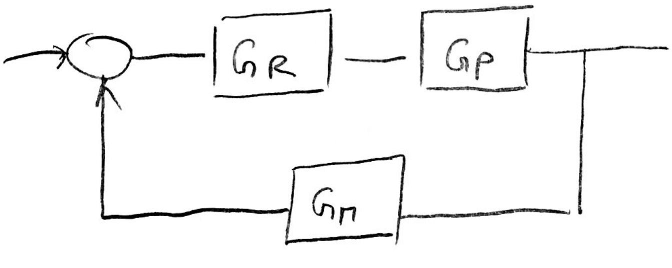
$y = -60° \Rightarrow x = -0{,}5$

$\omega_c^* = 10^{-0{,}5} = 0{,}316$

$y = -20x - 5 \Rightarrow y = 5$

$K_R = 10^{-\frac{5}{20}} = 0{,}56$

c)



$G_o = G_R \cdot G_P \cdot G_M$

$G_R(s) = 1$

$G_M(s) = e^{-sT}$, $T = 1s$

$\omega = 10^{-2}$

$|G_M(s)| = 1$

$\arg(e^{-sT}) = -\omega T$

$\varphi(\omega) = -10^{-2} \cdot 1 \text{ rad} = -0{,}57°$

(2)

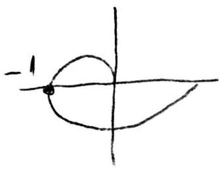
$$G_P(s) = \frac{1}{s^2+2s+2}$$

a) Koristeći ZN metodu rub stabilnosti

$$G_R(s) = K_R \cdot \frac{1+T_1 s}{T_1 s}$$

$$G_M(s) = \frac{1}{s+2}$$

rub stabilnosti



$\boxed{\begin{matrix} A=1 \\ \varphi=-180 \end{matrix}}$ ili $\boxed{\begin{matrix} Re=-1 \\ Im=0 \end{matrix}}$

↳ iz $G_0(s)$

$$G_0(s) = K_{kr} \cdot \frac{1}{s^2+2s+2} \cdot \frac{1}{s+2}$$

$$G_0(j\omega) = \frac{K_{kr}}{(j\omega+2)(2-\omega^2+j2\omega)} = \frac{K_{kr}}{-j\omega^3-4\omega^2+6j\omega+4} = \frac{K_{kr}}{j(-\omega^3+6\omega)-4\omega^2+4}$$

*Ne moram racionalizirati.

$$I_m = 0 \Rightarrow -\omega^3+6\omega = 0$$

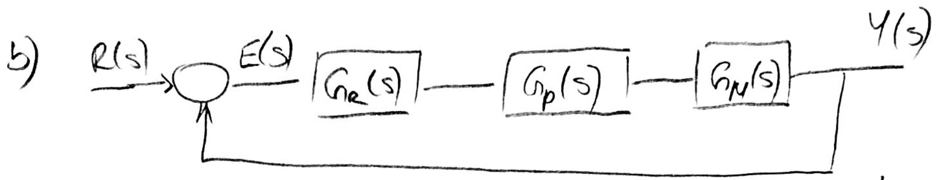
$$\underline{\omega_{kr} = \sqrt{6}}$$

$$Re = -1 \qquad \frac{K_{kr}}{-4\omega^2+4} = -1 \Rightarrow \underline{K_{kr} = 20}$$

ZN1, PI $\rightarrow K_R = 0.45 K_{kr}$

$T = 0.85 T_{kr}$

$$T_{kr} = \frac{2\pi}{\omega_{kr}}$$

b) 

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

$G_M(s) = 1 \qquad G_R(s) = \frac{1}{T_1 s}$

Odrediti T_1 koji minimizira kvadr. pogrešku regulacijskog odstupanja pri odzivu na skokovitu pobudu $R(s) = \frac{1}{s}$

ISE kriterij : $\int e^2(t)\,dt$

$$E(s) = \frac{1}{1+G_0(s)} \cdot R(s)$$

$$\frac{E(s)}{R(s)} = \frac{1}{1+G_0(s)}$$

$$E(s) = \frac{1}{1+\frac{1}{T_1 s}\cdot\frac{1}{s^2+2s+2}} \cdot \frac{1}{s} = \frac{\overset{c_2}{T_1} s^2 + \overset{c_1}{2T_1} s + \overset{c_0}{2T_1}}{\underset{d_3}{T_1} s^3 + \underset{d_2}{2T_1} s^2 + \underset{d_1}{2T_1} s + \underset{d_0}{1}}$$

* prijenosna f-ja 3. reda $\rightarrow$ $I_{3,3} = \frac{c_2^2 d_0 d_1 + (c_1^2 - 2c_0c_2)d_0d_3 + c_0^2 d_2 d_3}{2d_0d_3(-d_0d_3 + d_1d_2)}$

$$I_{3,3} = \frac{T_1 + 4T_1^2}{4T_1 - 1}$$

$$\frac{\partial I_{3,3}}{\partial T_1} = \frac{(1+8T_1)(4T_1-1)(T_1-4T_1^2)\cdot 4}{(4T_1-1)^2}$$

$16T_1^2 - 8T_1 - 1 = 0$ $\quad$ $\left\langle \begin{array}{l} \underset{\sim\sim\sim}{T_{1,1} > 0} \\ T_{1,2} < 0 \end{array} \right.$ $\rightarrow$ ij. je veće od nule

3. $G_d(z) = \dfrac{1}{a_2 z^2 + a_1 z + 0{,}1}$ Odredi stabilnost korištenjem Hurwitza!

$z = \dfrac{1+w}{1-w}$ → bilinearna transf.

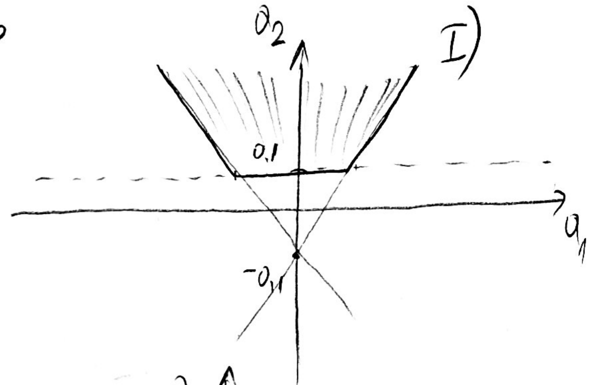
$$G_{ce}(w) = \frac{(1-w^2)}{w^2\underbrace{(a_2-a_1+0{,}1)}_{g_2} + w\underbrace{(2a_2-0{,}2)}_{g_1} + \underbrace{(a_2+a_1+0{,}1)}_{g_0}}$$

I)

$g_2 > 0 \quad a_2 - a_1 + 0{,}1 > 0 \Rightarrow a_2 > a_1 - 0{,}1$

$g_1 > 0 \quad 2a_2 - 0{,}2 > 0 \Rightarrow a_2 > 0{,}1$

$g_0 > 0 \quad a_1 + a_1 + 0{,}1 > 0 \Rightarrow a_2 > -a_1 - 0{,}1$

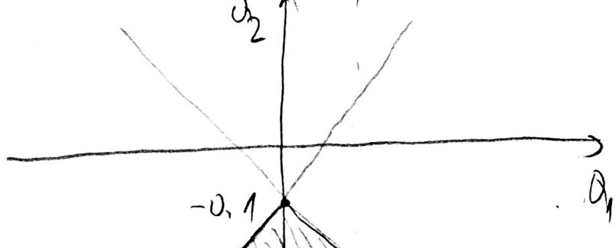


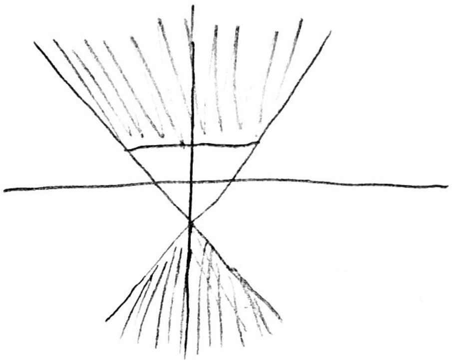
II)

$g_2 < 0 \quad a_2 - a_1 + 0{,}1 > 0 \Rightarrow a_2 < a_1 - 0{,}1$

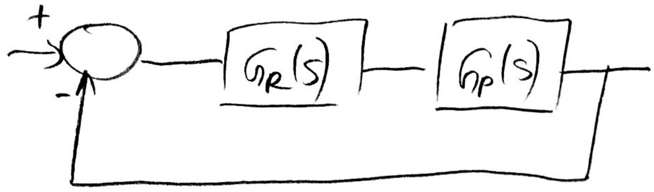
$g_1 < 0 \quad a_2 < 0{,}1$

$g_0 < 0 \quad a_2 < -a_1 - 0{,}1$

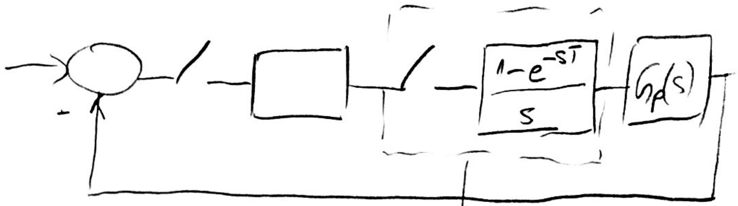




5. Kont. sustav

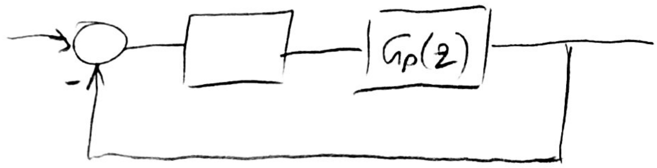


diskr. sustav u kont. domeni



DA pretvorba
ZOH

diskr. sustav. u diskr. domeni



$$G_R(z) = \mathcal{Z}\{G_R(s)\}$$

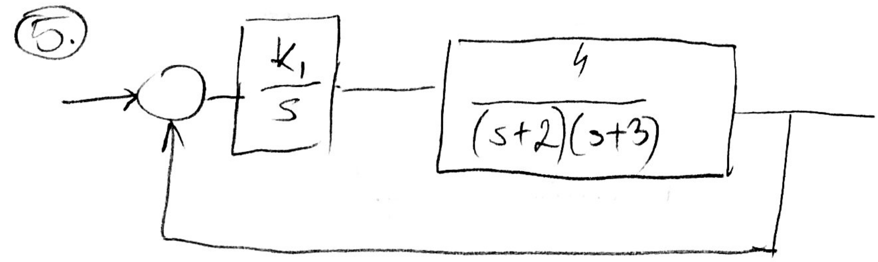
$$G_P(z) = ZOH = (1-z^{-1})\,\mathcal{Z}\left\{\frac{1}{s}G_P(s)\right\}$$

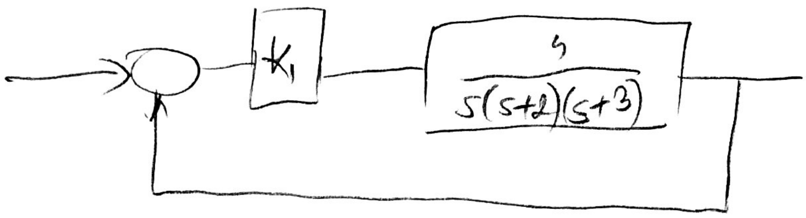
APROKSIMACIJA

$$\frac{1-e^{-sT}}{s} \approx e^{-\frac{T}{2}s}$$

unosi kašnjenje $-\omega\frac{T}{2}$

(5.)





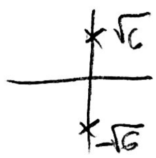
$$G_{ce}(s) = \frac{4K_{kr}}{s^3+5s^2+6s+4K_{kr}} \qquad K_{kr} > 0$$

$$D = \begin{vmatrix} 6 & 4K_{kr} \\ 1 & 5 \end{vmatrix} > 0 \Rightarrow 30 - 4K_{kr} > 0$$

$$K_{kr} < \frac{30}{4}$$

$$K_{st} \in \left\langle 0, \frac{30}{4} \right\rangle$$

$$K_{kr} \begin{cases} 0 \\ \frac{30}{4} \end{cases}$$



I) $K_{kr} = 0$

$G_{ce}(s) = 0$

II) $K_{kr} = \frac{30}{4}$

$$G_{ce}(s) = \frac{30}{s^3+5s^2+6s+30} = \frac{30}{(s+5)(s^2+6)}$$

$$\omega_{kr} = \sqrt{6}$$

$$T_{kr} = \frac{2\pi}{\sqrt{6}}$$

$$K_R = 0{,}5K_{kr}$$