PID

① Pronaći parametre P, PI i PID regulatora Ziegler Nichols metodom sistema sa prenosnom fun.

$$G(S) = \frac{1}{(S+0,1)(S+0,3)(S+0,7)}$$

i napisati razlike koje uočite između ovih regulatora

Regul.	Kp	Ti	Td
P	$0,55K_{kr}$	-	-
PI	$0,35K_{kr}$	$1,25T_{kr}$	-
PID	$0,6K_{kr}$	$0,8T_{kr}$	$0,2T_{kr}$

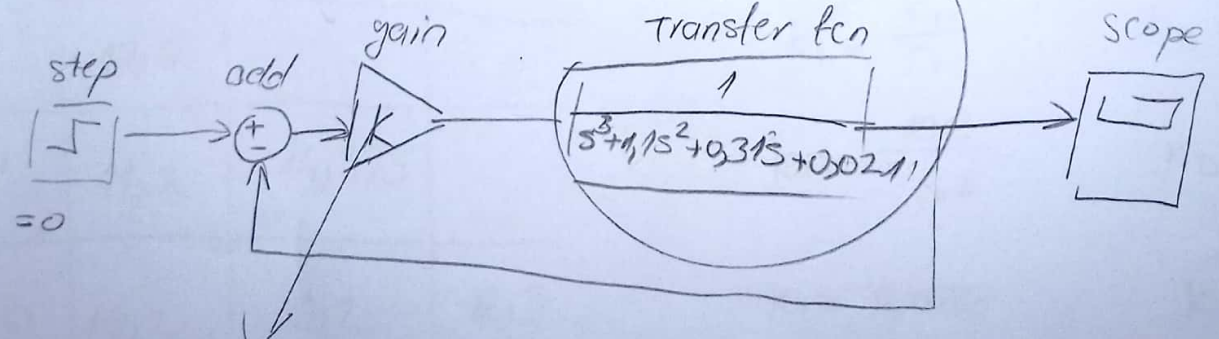
To su K_{kr} i T_{kr} ⇒ metoda rubne stabilnosti

$$G(S) = \frac{1}{(S+0,1)(S+0,3)(S+0,7)} = \frac{1}{(S^2+0,35+0,15+0,03)(S+0,7)}$$

$$= \frac{1}{(S^2+0,4S+0,03)(S+0,7)} = \frac{1}{S^3+0,7S^2+0,4S^2+0,28S+0,03S+0,021}$$

$$= \frac{1}{S^3+1,1S^2+0,31S+0,021}$$

početna fun. ide u Transfer fcn



K računamo preko Routa, kada od $G(S) \Rightarrow G_0(S) =$

$K \in (0, +\infty)$

$$G(s) = \frac{K}{s^3 + 1{,}1s^2 + 0{,}31s + 0{,}021}$$

$$G_o(s) = \frac{\frac{K}{s^3 + 1{,}1s^2 + 0{,}31s + 0{,}021}}{1 + \frac{K}{s^3 + 1{,}1s^2 + 0{,}31s + 0{,}021}} = \frac{1}{s^3 + 1{,}1s^2 + 0{,}31s + 0{,}021 + K}$$

$P(s) = s^3 + 1{,}1s^2 + 0{,}31s + 0{,}021 + K$

$a_n(s^3) = 1$

$a_{n-1}(s^2) = 1{,}1$

$a_{n-2}(s) = 0{,}31$

$a_{n-3}(s^0) = 0{,}021 + K$

s^3	1	0,31
s^2	1,1	$0{,}021 + K$
s^1	$\frac{0{,}32 - K}{1{,}1}$	
s^0	$0{,}021 + K$	

$$b_1 = \frac{1{,}1 \cdot 0{,}31 - 0{,}021 - K}{1{,}1}$$

$$b_1 = \frac{0{,}32 - K}{1{,}1}$$

$0{,}021 + K > 0$

$K > -0{,}021$

$0{,}32 - K > 0$

$-K > -0{,}32$

$K < 0{,}32$

$K \in (-0{,}021 ; 0{,}32)$

Za $K = 32$

to je rezervnost za gain!

za $T_{kr} = 11{,}5$

$K_{kr} = 32$ računamo parametre regulatora

	K_P	T_I	T_D
P	17,6		
PI	11,2	14,375	
PID	19,2	9,2	2,3

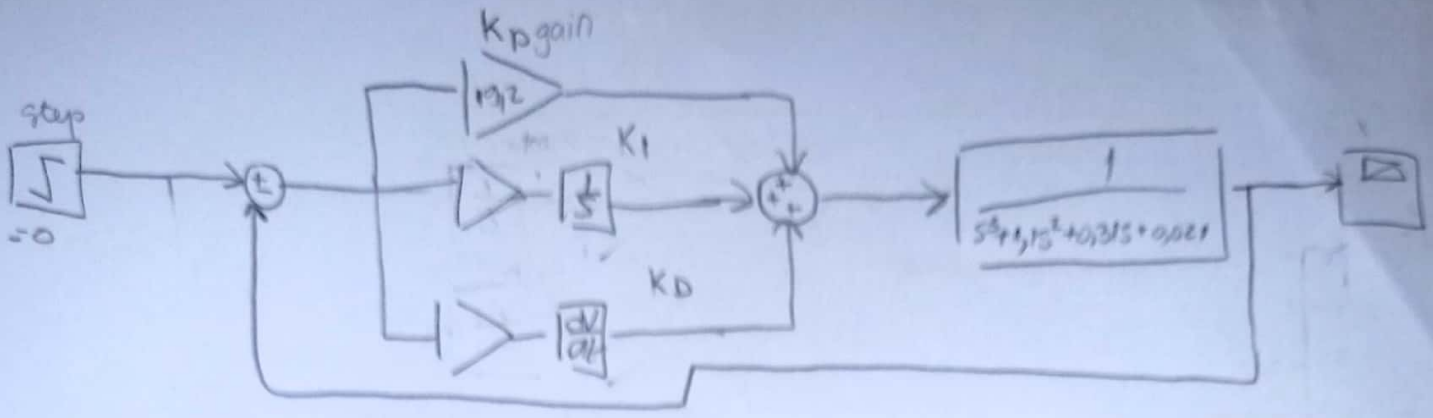
PID:

$$k_I = \frac{K_P}{T_I} \qquad k_D = \frac{T_D}{K_P}$$

$$k_I = \frac{19{,}2}{9{,}2} \qquad k_D = \frac{2{,}3}{19{,}2}$$

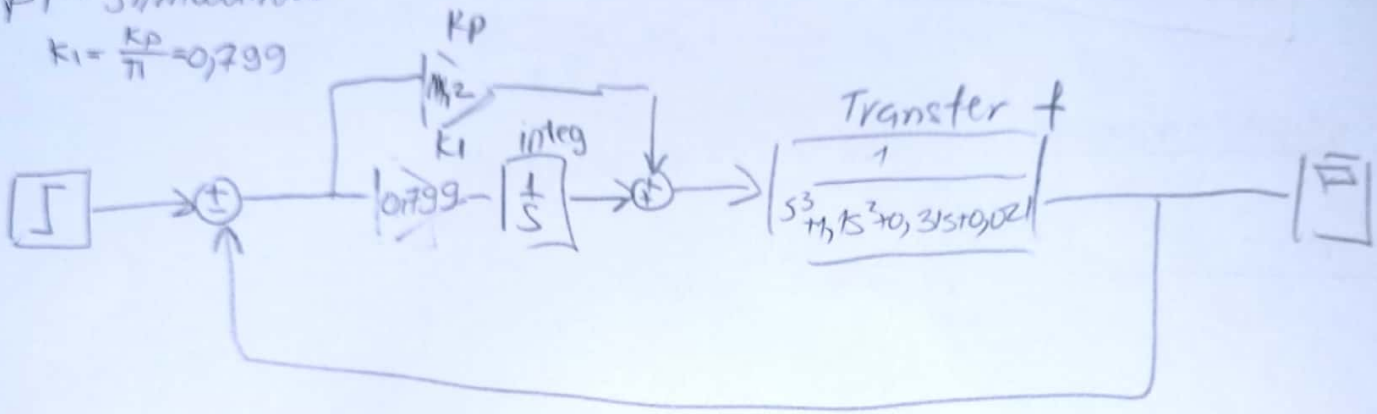
$k_I = 2{,}086$ $\qquad$ $k_D = 0{,}119$

PID - SIMULINK:

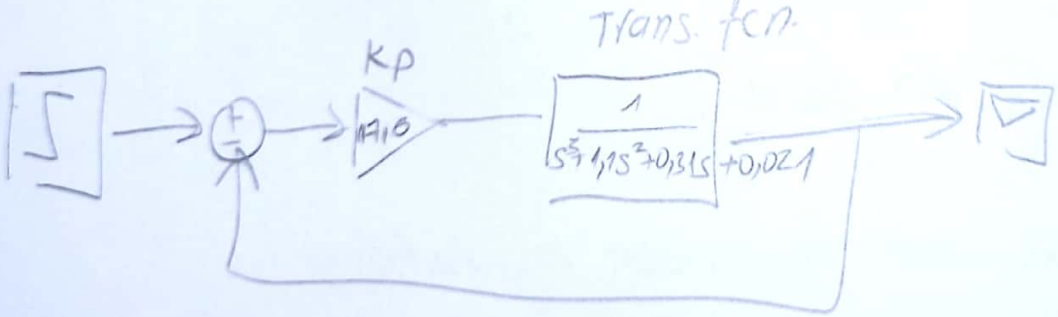


PI - simulink:

$K_I = \frac{K_P}{T_I} = 0{,}799$



P - simulink



PID

② $G(S) = \frac{Km}{S(Tm \cdot S+1)}$ $\quad Tm = 0{,}25$ $\quad Km = 10$

$G(S) = \frac{10}{0{,}25S^2 + S} \cdot Kp$ $\quad Kp = \frac{1}{10}$ $\quad (Kp \cdot 10 = 1)$

$G(S) = \frac{10Kp}{0{,}25S^2 + S}$

$G(S) = \frac{\frac{10Kp}{0{,}25S^2+S}}{1 + \frac{10Kp}{0{,}25S^2+S}} = \frac{10Kp}{0{,}25S^2 + S + 10Kp} = \frac{1}{0{,}25S^2 + S + 1}$

↓ simulink.

Tools ⇒ style ⇒ ....

File ⇒ print to figure

$T = 0{,}28 \Rightarrow$ po x osi

$a = 0{,}16 \Rightarrow$ po y osi

	K_p	T_I	T_D
PID	$\frac{1{,}2}{a}$	$\frac{0{,}6}{aT}$	$\frac{0{,}6T}{a}$

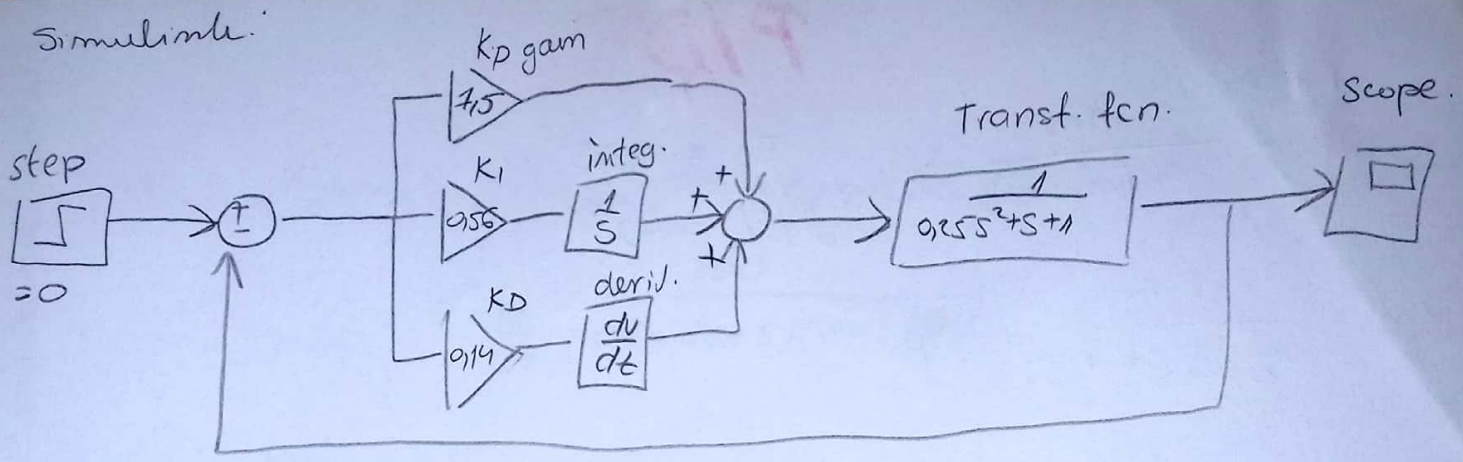
$K_p = \frac{1{,}2}{0{,}28} \Rightarrow Kp = 7{,}5$

$T_I = \frac{0{,}6}{0{,}28} \Rightarrow T_I = 13{,}39$ $\quad K_I = \frac{K_P}{T_I} \Rightarrow K_I = 0{,}56$

$T_D = 1{,}05$ $\quad K_D = \frac{T_D}{K_P} = 0{,}14$

...n-grana; n → broj polova prenosne fun. otvore-
nog sistema $G_o(s)$. Svaka grana čini zaseban GMK za
svoje vrijednosti: $k \in [0, +\infty)$

(2) grane RM..



PID

Odziv otvorenog sistema → odrediti parametre PID regulatora

$$G(S) = \frac{100}{(S+1)(S+5)(S+10)(S+20)}$$

$$Kp = \frac{1}{100}$$

$$G(S) = \frac{100}{(S+1)(S+5)(S+10)(S+20)} \cdot Kp$$

$$G(S) = \frac{100\,Kp}{(S+1)(S+5)(S+10)(S+20)}$$

$$G_0(S) = \frac{\frac{100Kp}{(S+1)(S+5)(S+10)(S+20)}}{1 + \frac{100Kp}{(S+1)(S+5)(S+10)(S+20)}} = \frac{100\,Kp}{(S+1)(S+2)(S+10)(S+20) + 100Kp}$$

$$G_0(S) = \frac{1}{(S+1)(S+2)(S+10)(S+20)} = \frac{1}{(S^2+3S+2)(S^2+30S+200)}$$

$$G_0(S) = \frac{1}{S^4+30S^3+200S^2+3S^3+90S^2+600S+2S^2+60S+400}$$

$$G_0(S) = \frac{1}{S^4+33S^3+292S^2+660S+400}$$

	Kp	T_I	T_D
$\tau = 0,46$			
$a = 0,0003$			
PID	$\frac{1,2}{a}$	$\frac{0,6}{a\tau}$	$\frac{0,6\tau}{a}$
$Kp = 400$	⇓		⇓
$K_I = \frac{Kp}{T_I} = 0,09$	400	4347	92
$K_D = \frac{T_D}{Kp} = 0,23$			
simulink			

PID

2 $G(S) = \dfrac{K}{(JS+B)(LS+R)+K^2}$

$J = 0{,}07 \qquad B = 0{,}1 \qquad K = 0{,}1$

$La = 0{,}5\ mH \qquad Ra = 1$

$$G(S) = \frac{K}{(0{,}01S+0{,}1)(0{,}5\cdot 10^{-3}S+1)+(0{,}1)^2}$$

$$G(S) = \frac{K}{0{,}000005S^2+0{,}01S+0{,}00005S+0{,}1+0{,}01}$$

$$G(S) = \frac{K}{0{,}000005S^2+0{,}01005S+0{,}11}$$

$Kp = 1 \qquad K = Kp$

$\tau = 0{,}03$

$a = 0{,}2$

$Kp = 6$

$TI = 100$

$TD = 0{,}09$

	Kp	TI	TD
P	$\frac{1}{\frac{0{,}1}{9}}$		
PI	$\frac{0{,}9}{9}$	$\frac{0{,}3}{a\tau}$	
PID	$\frac{1{,}2}{9}$	$\frac{0{,}6}{a\tau}$	$\frac{0{,}6\tau}{9}$

P	$0{,}5\ K_{cr}$	
PI	$0{,}6\ K_{cr}$	$0{,}8\ T_{cr}$
PID	$0{,}4\ K_{cr}$	$0{,}5\ T_{cr}$ $0{,}125\ T_{cr}$

$(k \to \infty)$ u nulama

PID

Zatvoren sistem

$$G(S) = \frac{1}{S^3+6S^2+11S+6}$$

$$G(S) = \frac{Kp}{S^3+6S^2+11S+6}$$

$$G_0(S) = \frac{\frac{Kp}{S^3+6S^2+11S+6}}{1+\frac{Kp}{S^3+6S^2+11S+6}} = \frac{Kp}{S^3+6S^2+11S+6+Kp}$$

$S^3 / a_n = 1$

$a_{n-1} = 6$

$a_{n-2} = 11$

$a_{n-3} = 6+Kp$

$$b_1 = \frac{66-6-Kp}{6}$$

$$b_1 = \frac{60-Kp}{6}$$

S^3	1	11
S^2	6	$6+Kp$
S^1	$\frac{60-Kp}{6}$	
S^0	$6+Kp$	

$6+Kp > 0$

$Kp > -6$

$60-Kp > 0$

$-Kp > -60$

$Kp < 60$

$Kp \in (-6, 60)$

$K_{kr} = 60$

$T_{kr} = 1,8$

	Kp	Ti	Td
P	$0,5K_{kr}$		
PI	$0,6K_{kr}$	$0,8T_{kr}$	
PID	$0,4K_{kr}$	$0,5T_{kr}$	$0,125T_{kr}$

PID

$Kp = 24$

$T_I = 0,9 \Rightarrow K_I = \frac{Kp}{T_I} \Rightarrow K_I = 26,66$

$T_D = 0,225 \quad K_D = \frac{T_D}{Kp} \Rightarrow K_D = 0,00375 \Rightarrow 10$