EGE UNIVERSITY
ELECTRICAL AND ELECTRONICS ENGINEERING

CONTROL SYSTEMS 1

LAB-9

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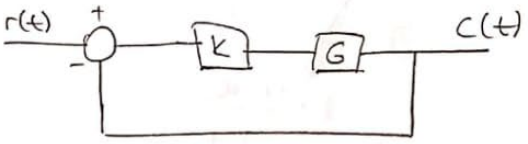
Control Lab-9

$$G(s) = \frac{1}{(s+a)(s+b)} \quad \text{where} \quad a > b > 0$$

$$K_p = \lim_{s \to 0} \frac{K}{(s+a)(s+b)}$$



$$K_p = \frac{K}{ab} \qquad ess = \frac{1}{1+K_p} = \frac{1}{1+\frac{K}{ab}} = \frac{ab}{ab+K}$$

$$G_{cl}(s) = \frac{K}{s^2 + (a+b)s + ab + K}$$

$$s^2 + 2\zeta\omega_n s + \omega_n^2$$

$$\omega_n = \sqrt{ab+K}$$

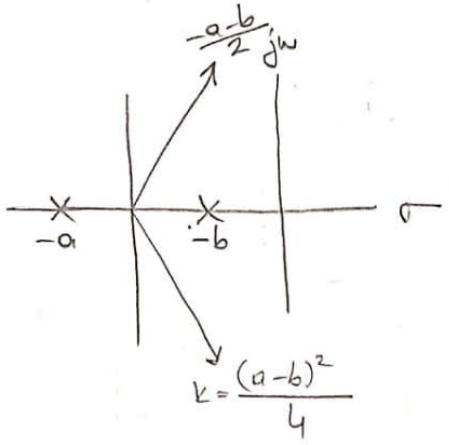
$$a+b = 2\zeta\sqrt{ab+K}$$

$$\zeta = \frac{a+b}{2\sqrt{ab+K}}$$

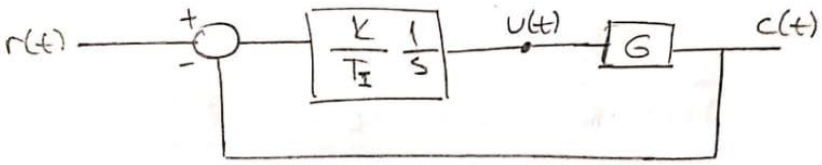
for $\zeta = 1$ $\qquad 4(ab+K) = (a+b)^2$

$$K = \frac{(a+b)^2 - 4ab}{4}$$

$$K = \frac{(a-b)^2}{4}$$



integral feedback



$$G_{cl} = \frac{\frac{K}{T_I} \cdot \frac{G}{s}}{1 + \frac{K}{T_I} \frac{G}{s}} = \frac{KG}{T_I s + KG}$$

T_I : integral time constant

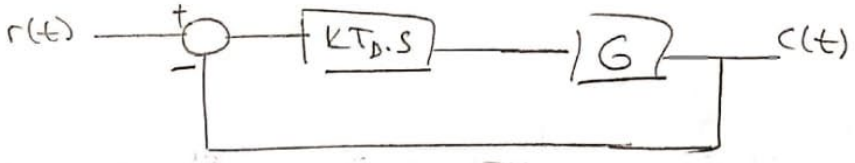
$$U(t) = \frac{K}{T_I} \int_0^t e(\tau)\, d\tau$$

$$G_{cl} = \frac{\frac{K}{(s+a)(s+b)}}{T_I s + \frac{K}{(s+a)(s+b)}} = \frac{K}{T_I s (s+a)(s+b) + K}$$

$$K_p = \lim_{s\to 0} G_{ol} = \lim_{s\to 0} \frac{K}{T_I}\cdot\frac{1}{s}\cdot\frac{1}{(s+a)(s+b)}$$

$$K_p = \frac{1}{\infty} = 0 \longrightarrow \boxed{ess = \frac{1}{1+\infty} = 0}$$

Derivative Feedback

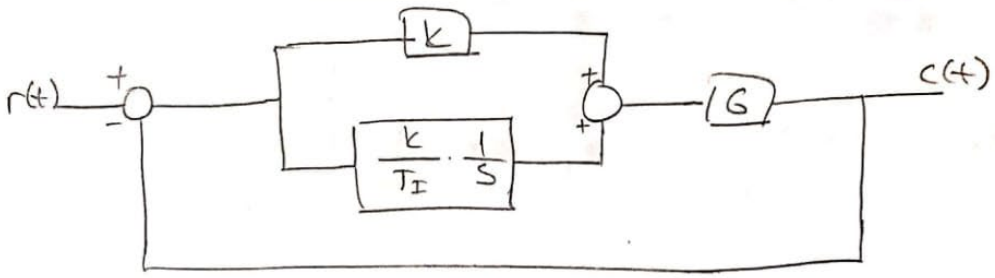


$u(t) = KT_D\dot{e}$ $\quad T_D$: derivative time constant

$$K_p = \lim_{s\to 0} KT_D.S\ \frac{1}{(s+a)(s+b)} = 0 \qquad ess = \frac{1}{1+0} = 1$$

$$G_{cl} = \frac{KT_D s}{(s+a)(s+b)+KT_D s} = \frac{KT_D s}{s^2+(a+b+KT_D)s+ab}$$

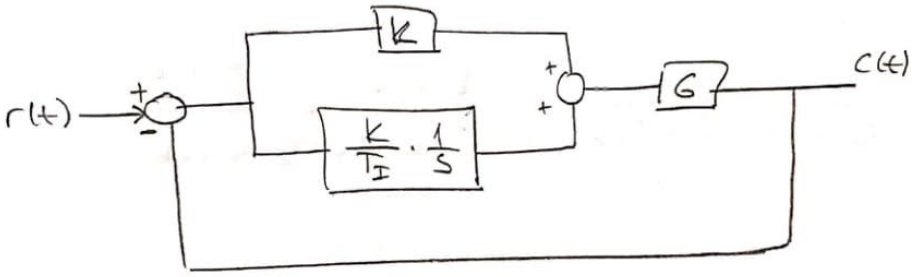
PI Controller



$$\text{Controller} = K\left(1+\frac{1}{T_I S}\right) = K\,\frac{S+\frac{1}{T_I}}{S}$$

$$K_p = \lim_{S\to 0} K\,\frac{S+\frac{1}{T_I}}{S}\cdot\frac{1}{(S+a)(S+b)} = \infty \qquad ess = \frac{1}{1+\infty} = 0$$

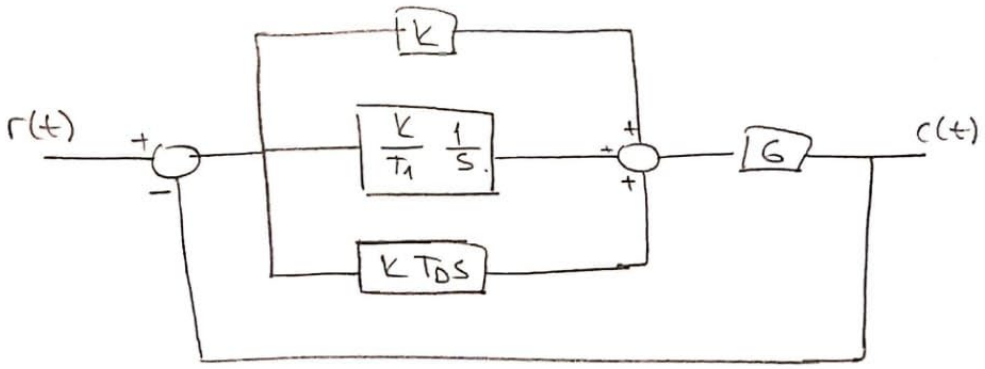
PD Controller



$$K_p = \lim_{S\to 0} K(1+T_D S)\,\frac{1}{(S+a)(S+b)} = \frac{K}{ab}$$

$$ess = \frac{1}{1+\frac{K}{ab}} = \frac{ab}{ab+K}$$

PID Controller



$$\text{Controller} = K\left(1 + \frac{1}{T_I}\frac{1}{S} + T_D S\right)$$

$$K_p = \lim_{S\to 0} K\left(1 + \frac{1}{T_I}\frac{1}{S} + T_D S\right)\frac{1}{(S+a)(S+b)}$$

$$= \frac{K}{ab} + \frac{K}{T_I S (S+a)(S+b)} + \frac{T_D S}{(S+a)(S+b)}$$

$$= \underbrace{\frac{K}{ab}}_{P} + \underbrace{\infty}_{I} + \underbrace{0}_{D} = \infty$$

$$ess = \frac{1}{1+\infty} = 0$$

SİMULİNK

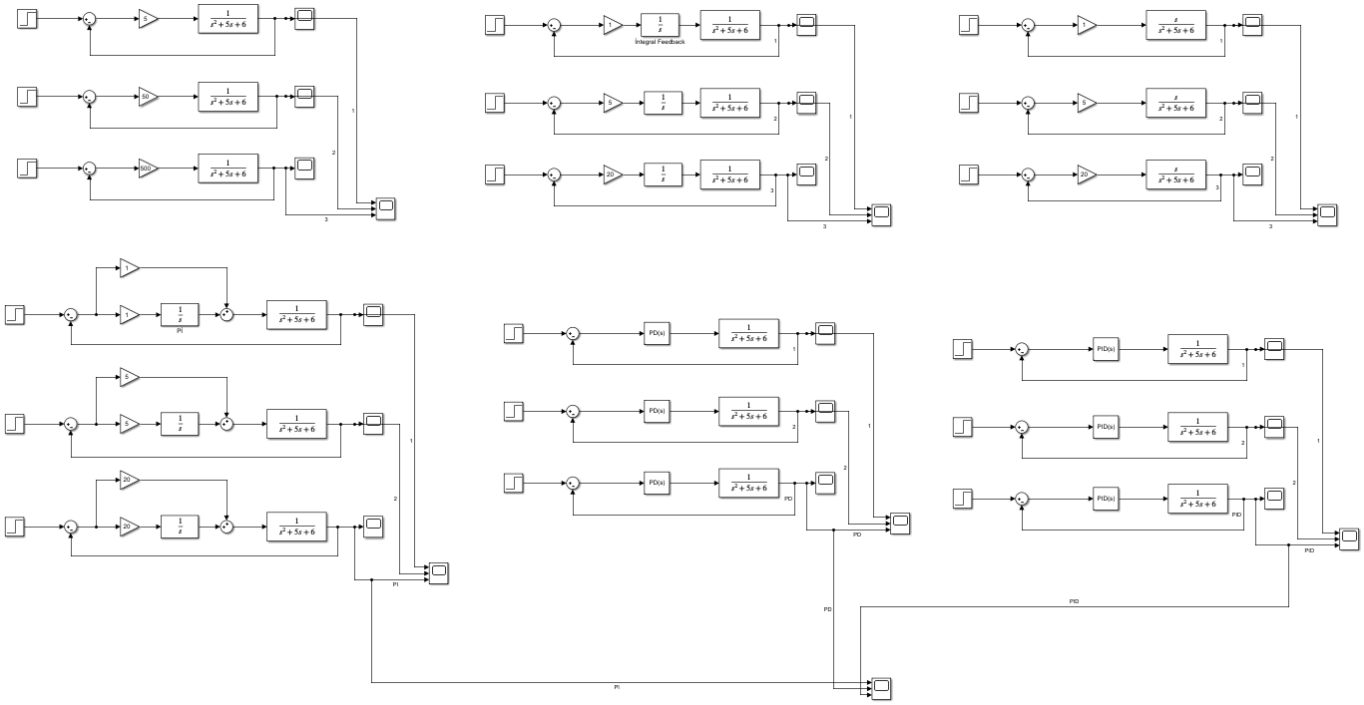


Figure 1 SİMULİNK SİMÜLASYON DEVRESİ

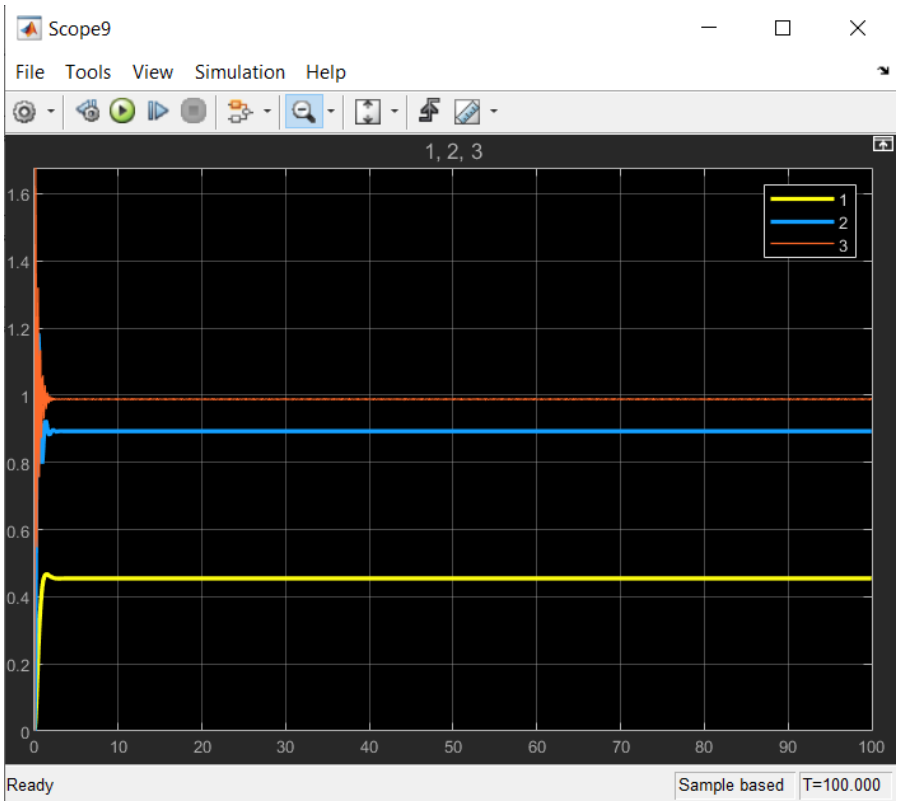


Figure 2 K=5, K=50 ve K=500 değerlerini kullanarak oransal kontrol için birim basamak cevabı

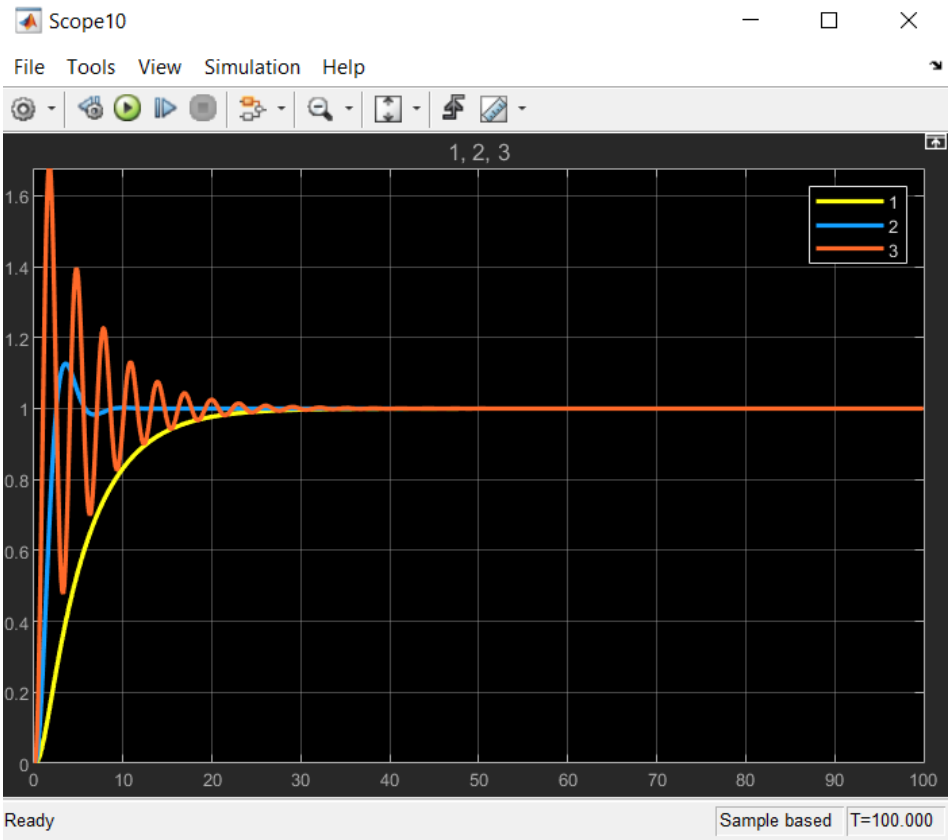


Figure 3 K=1, K=5 ve K=20 değerlerini kullanarak integral feedback için birim basamak cevabı

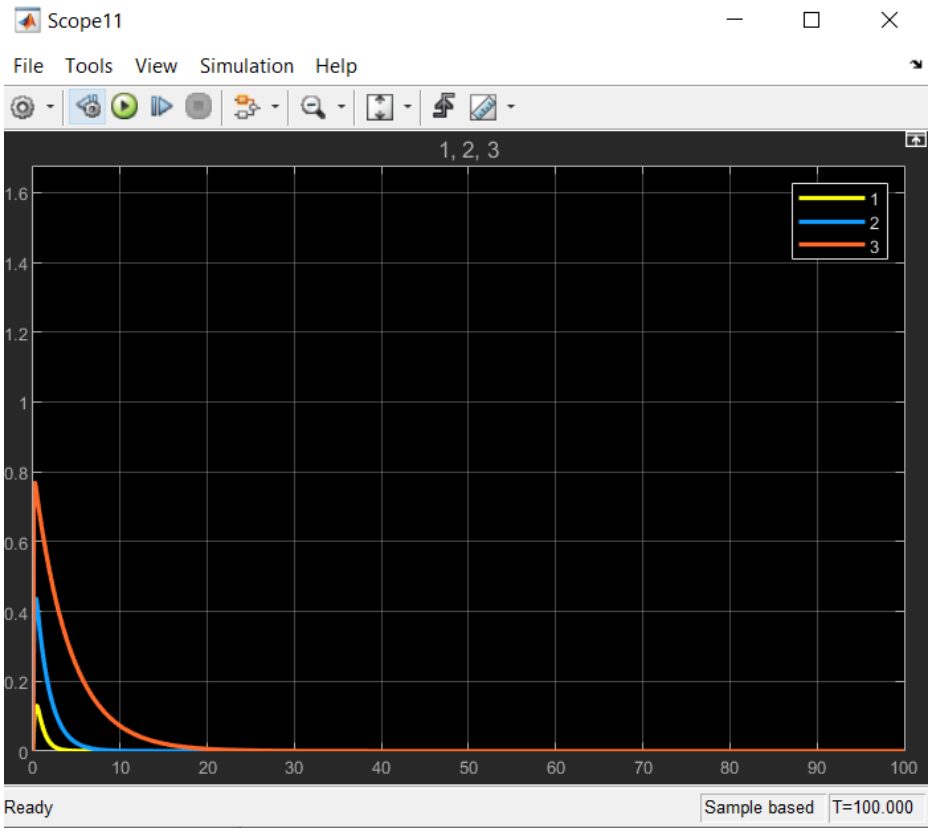


Figure 4 K=1, K=5 ve K=20 değerlerini kullanarak türev feedback için birim basamak cevabı

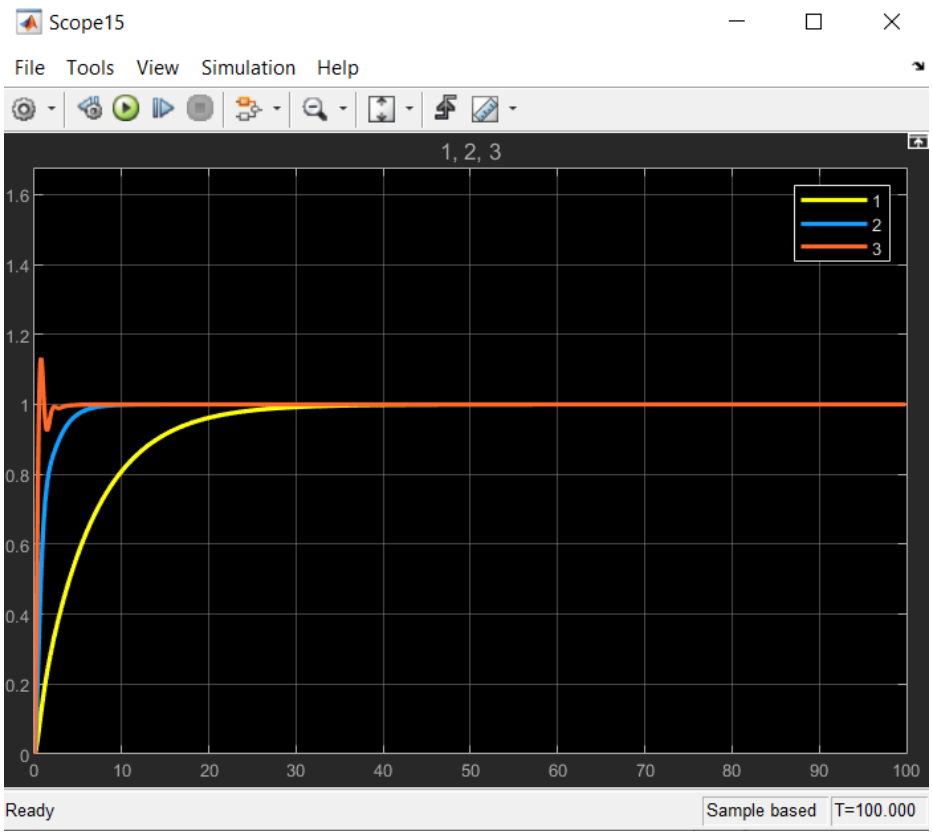


Figure 5 K=1, K=5 ve K=20 değerlerini kullanarak PI kontrolör için birim basamak cevabı

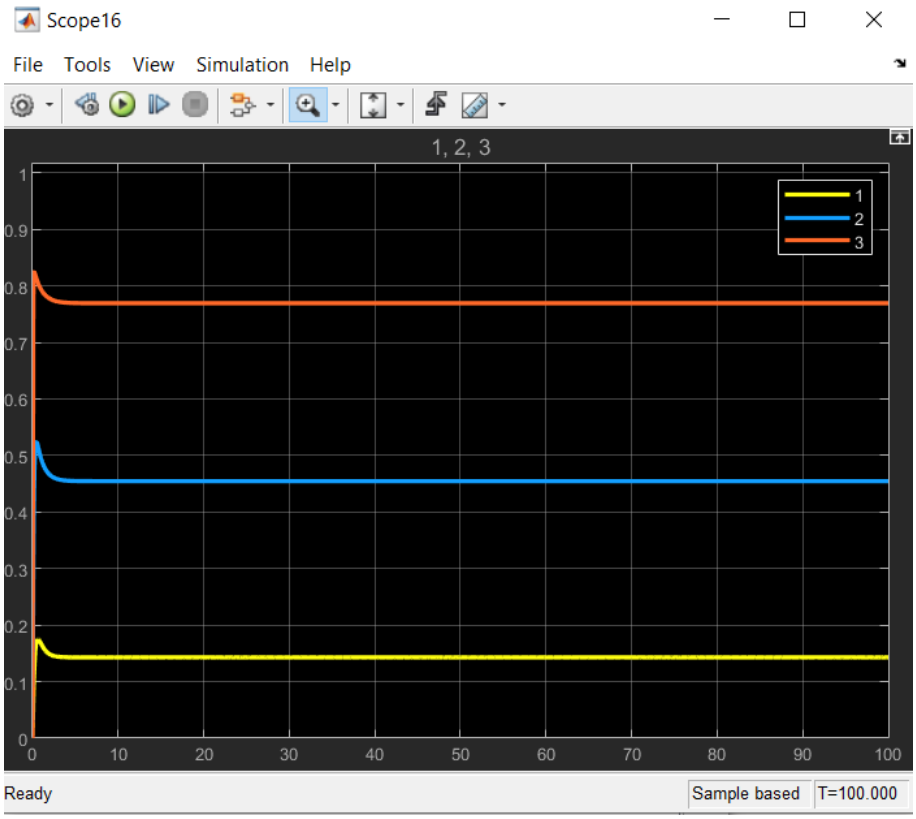


Figure 6 K=1, K=5 ve K=20 değerlerini kullanarak PD kontrolör için birim basamak cevabı

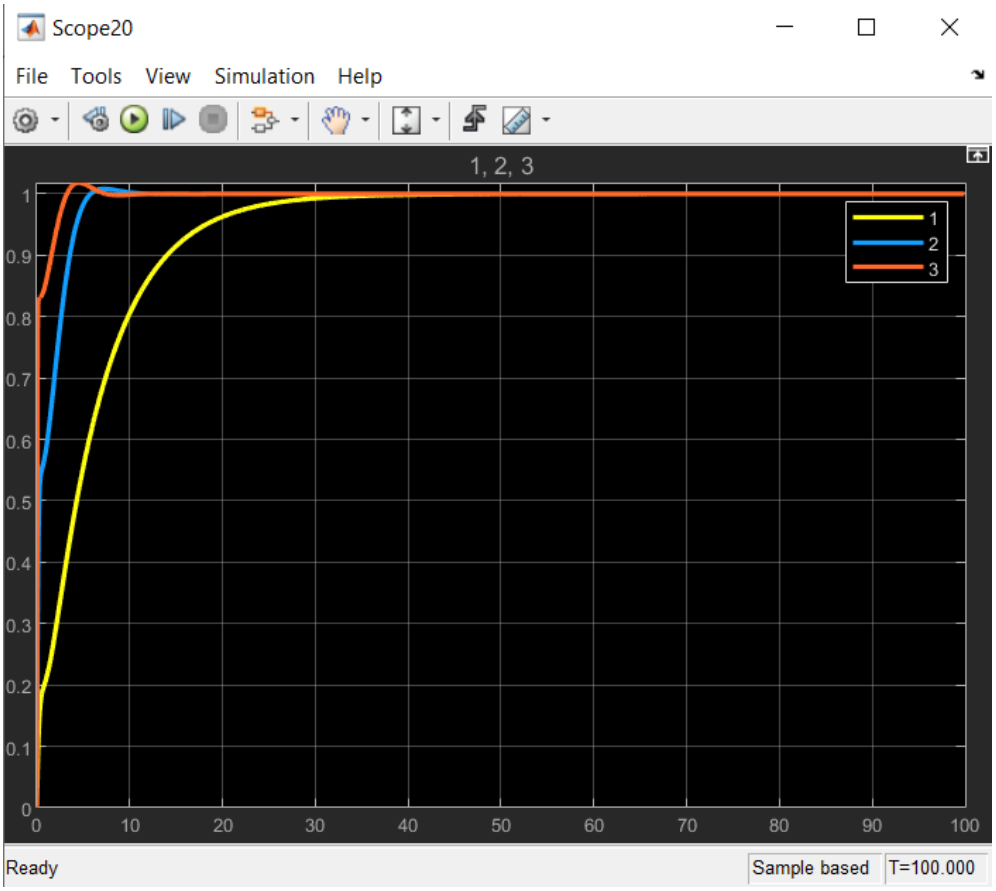


Figure 7 K=1, K=5 ve K=20 değerlerini kullanarak PID kontrolör için birim basamak cevabı

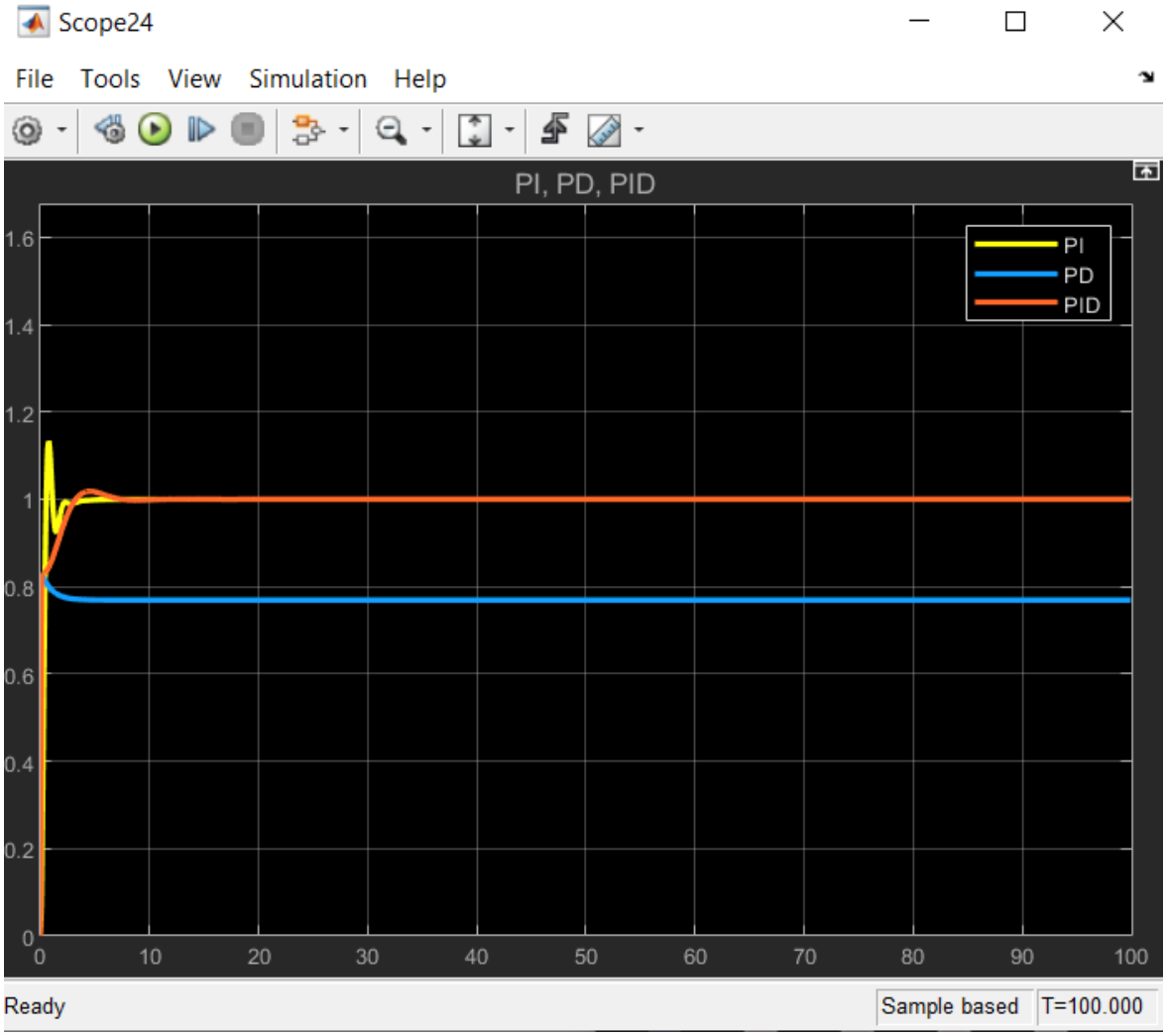


Figure 8 PI PD PID kontrolörlerinin birim basamak cevaplarının tek bir scopedeki görüntüsü