TOPIC 6: PID-regelaars = (proportionele) regelaar

$\boxed{\text{OEFENING 1}}$ ✓

1. $Y = R P_u (Y^* - MY) + P_2 Z$

$Y(1 + RP_uM) = RP_uY^* + P_2 Z$

$$Y(s) = \frac{R(s)P_u(s)}{1 + R(s)P_u(s)M(s)} Y^*(s) + \frac{P_2(s)}{1 + R(s)P_u(s)M(s)} Z(s)$$

2. $E = Y^* - YM$?

$$= Y^* - \frac{RP_uM}{1 + RP_uM} Y^* - \frac{P_2 M}{1 + RP_uM} Z$$

$$= \frac{1 + \cancel{RP_uM} - \cancel{RP_uM}}{1 + RP_uM} Y^* - \frac{P_2 M}{1 + RP_uM} Z$$

$$= \frac{1}{1 + R(s)P_u(s)M(s)} Y^*(s) - \frac{M(s)P_2(s)}{1 + R(s)P_u(s)M(s)} Z$$

V

OEFENING 2

1. $C\dfrac{dy}{dt} = u - Q_{uit}$

met $y - z = Q_{uit}\, R$

drukverschil = debiet . weerstand

$\rightarrow C\dfrac{dy}{dt} = u - \dfrac{y-z}{R}$

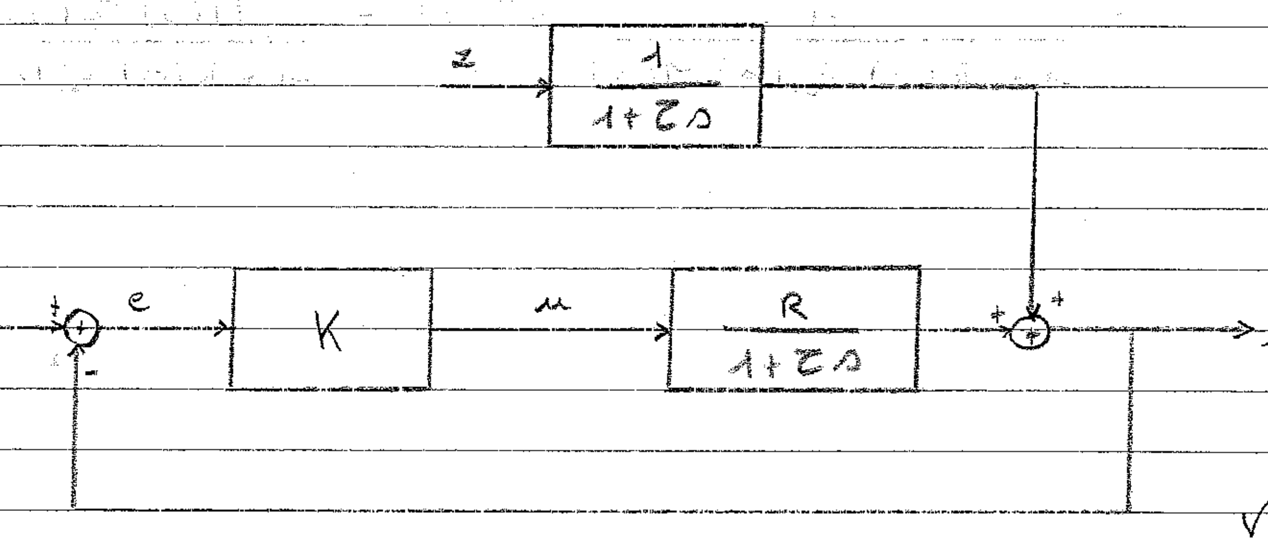
2. $RC\dfrac{dy}{dt} + y = Ru + z$

$\tau\dfrac{dy}{dt} + y = Ru + z$

$\tau\left(sY(s) - y(0)\right) + Y(s) = RU(s) + Z(s)$

$Y(s)(1+\tau s) = RU(s) + Z(s) + \tau \underbrace{y(0)}_{=0}$

$Y(s) = \dfrac{R}{1+\tau s}U(s) + \dfrac{1}{1+\tau s}Z(s)$ ✓



✓

3. Neem voor eenvoud $U(s)=0$: alles relatief tov die waarde $(z=0)$

$$\rightarrow Y(s) = \frac{1}{1+s\tau} Z(s) + \frac{R}{1+s\tau} K \left[\overset{0}{\overset{\parallel}{U(s)}} - Y(s) \right]$$

$$Y(s) = \frac{\frac{1}{1+s\tau}}{1+\frac{R}{1+s\tau}.K} Z(s)$$

$$= \frac{1}{1+s\tau+RK} Z(s) \quad \approx \text{ Oplossing ?}$$

~~4.~~ niet Regimewaarde: $\lim_{s\to 0} s.Y(s) = \frac{z_0}{1+RK} = \lim_{s\to 0} \frac{\cancel{s}.\frac{z_0}{\cancel{s}}}{1+RK}$

Stapantwoord: $Z(s) = \frac{z_0}{s}$

$$\rightarrow Y(s) = \frac{z_0}{s(1+s\tau+RK)} = \frac{z_0/\tau}{s\left(\frac{1}{\tau_1}+s\right)} \quad \text{met } \tau_1 = \frac{\tau}{1+R}$$

$$= \frac{A\left(\frac{1}{\tau_1}+s\right)+Bs}{s\left(\frac{1}{\tau_1}+s\right)}$$

$s=0 \rightarrow \frac{A}{\tau_1} = \frac{z_0}{\tau}$

$\rightarrow A = \frac{z_0}{1+RK}$

$s=-\frac{1}{\tau_1} \rightarrow -\frac{1}{\tau_1} B = \frac{z_0}{\tau}$

$\rightarrow B = -\frac{z_0}{1+RK}$

$$\rightarrow Y(s) = \frac{z_0}{1+RK}\frac{1}{s} - \frac{z_0}{1+RK}\frac{1}{\left(\frac{1}{\tau_1}+s\right)}$$

$$\rightarrow y(t) = \frac{z_0}{1+RK}\left(1-e^{-\frac{1}{\tau_1}.t}\right) \quad ; t \geq 0 \checkmark$$

TOPIC 7: Regelaars

OEFENING 1

niet

te moeilijk

OEFENING 2

$$Y = \frac{1}{s+a} \frac{K}{s^n} (Y^* - 1.Y)$$

$$Y\left(1 + \frac{K}{(s+a)s^n}\right) = \frac{K}{(s+a)s^n} Y^*$$

$$Y = \frac{\frac{K}{(s+a)s^n}}{1 + \frac{K}{(s+a)s^n}} Y^* = \frac{K}{(s+a)s^n + K} Y^* \checkmark$$

$$\rightarrow H(s) = \frac{K}{(s+a)s^n + K} \checkmark$$

* $n=0$: $H(s) = \dfrac{K}{s+a+K}$

  - I/O stabiliteit: polen negatief
    $\rightarrow a+K > 0$ of $K > -a$

  - Regimewaarde
    $y(t \to \infty) = \lim_{s \to 0} \left(s \frac{K}{s+a+K} \frac{1}{s} \right) = \frac{K}{a+K}$

    ↳ van stapantwoord

gelopen want

→ Regimewaarde kan slechts gehaald worden met oneindig grote versterking K (fysisch onmogelijk)

* **n = 1:** $H(s) = \dfrac{K}{s^2 + as + K}$ $\qquad s^2 + as + K = 0$

- polen negatief : 2 reële polen of 2 complex toegevoegde polen
  - Som v/d polen $= -a$ → negatief → $a > 0$
  - Product v/d polen $= K$ → positief → $K > 0$

2 reele polen indien $a^2 - 4K > 0 \leadsto K < a^2/4$

2 complex toegevoegde polen: $a^2 - 4K < 0 \leadsto K > a^2/4$

- $y(t \to \infty) = \lim_{s \to 0} s \dfrac{K}{s^2 + as + K} \dfrac{1}{s} = 1$

  → verbeterde performantie bij integrerende regeling

$$\lim_{t \to \infty} y(t) = \lim_{s \to 0} s . Y(s)$$

OEFENING 3

$$P(s) = \frac{0,1}{(1+10s)^3} \qquad R(s) = K\left(1 + \frac{1}{10s}\right)(1+10s)$$

$$Y = P\,R\,(Y_{ref} - Y)$$

$$Y = \frac{PR}{1+PR}\,Y_{ref}$$

$$H = \frac{\dfrac{0,1\,K\,(1 + 1/10s)\,\cancel{(1+10s)}}{(1+10s)^{\cancel{3}4}}}{1 + \dfrac{0,5K\,(1+1/10s)\,\cancel{(1+10s)}}{(1+10s)^{\cancel{3}4}}}$$

$$\text{met } 1 + \frac{1}{10s} = \frac{10s+1}{10s}$$

$$H = \frac{0,1K\,(1/10s)}{(1+10s)^3 + 0,1K\,(1/10s)} = \frac{0,1K}{10s\,(1+10s)^3 + 0,1K} \checkmark$$

Uitgang blijven oscilleren: zuiver imaginaire polen
(1 paar) : $s = \pm j\omega$

$$10s\,(1+10s)^3 + 0,1K \qquad \text{met } s = j\omega$$

$$10j\omega\,(1+10j\omega)^3 + 0,1K = 0$$

$$10j\omega\,(1 + 30j\omega - 300\omega^2 - 1000j\omega^3) + 0,1K = 0$$

$$10j\omega - 300\omega^2 - 3000j\omega^3 + 10.000\,\omega^4 + 0,1K = 0$$

$$\underbrace{(10\omega - 3000\omega^3)}_{\text{im deel}}\,j + \underbrace{(-300\omega^2 + 10.000\,\omega^4 + 0,1K)}_{\text{reëel deel}} = 0$$

$$10\omega - 3000\omega^3 = 0$$

$$\omega(10 - 3000\omega^2) = 0$$

$$\omega^2 = \frac{10}{3000}$$

$$\omega = \frac{\pm 1}{10\sqrt{3}} \checkmark$$

Invullen in $-300\omega^2 + 10\,000\omega^4 + 0{,}1K = 0$

$$-300\,\frac{1}{300} + 10\,000\left(\frac{1}{300}\right)^2 + 0{,}1K = 0$$

$$-1 + \frac{1}{9} + 0{,}1K = 0$$

$$K = \frac{+8}{9 \cdot 0{,}1} = \frac{80}{9} \checkmark$$

Andere polen hoe vinden?