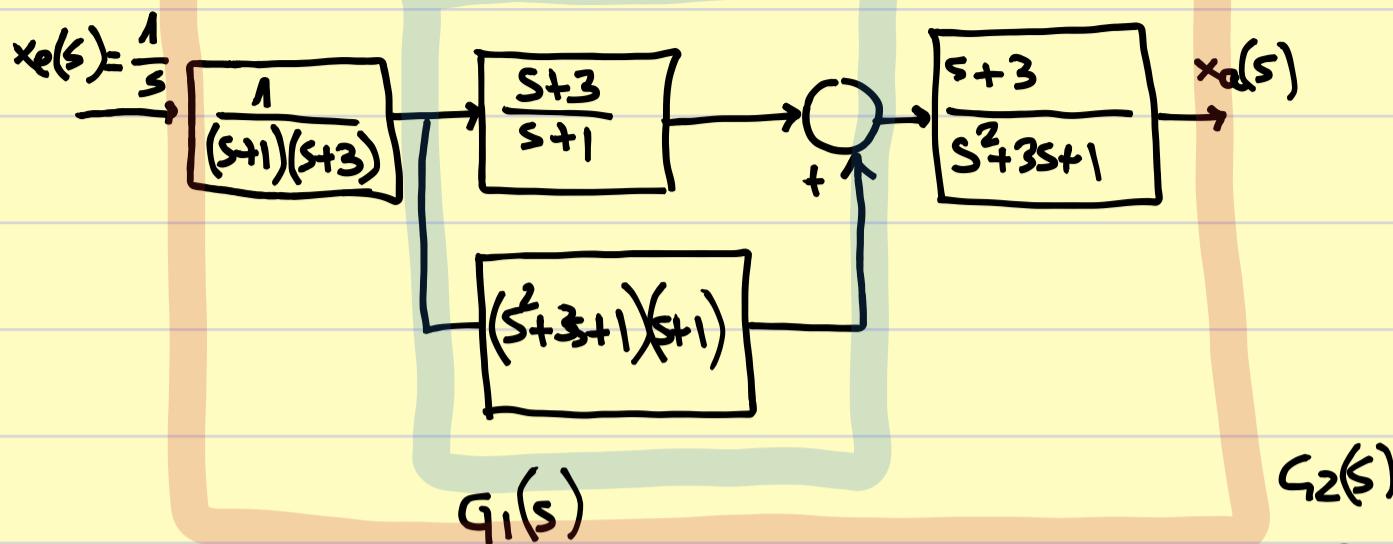


1)



$$G_1(s) = \frac{s+3}{s+1} + (s^2+3s+1)(s+1) = \frac{(s+3)+(s^2+3s+1)(s+1)}{s+1}$$

$$G_2(s) = \frac{1}{(s+1)(s+3)} \cdot G_1(s) \cdot \frac{s+3}{s^2+3s+1} = \frac{(s+3)+(s^2+3s+1)(s+1)^2}{(s+1)(s+1)(s^2+3s+1)}$$

$$\frac{x_a(s)}{x_e(s)} = \frac{s+3 + (s^2+3s+1)(s^2+2s+1)}{(s+1)^2 \left(s - \frac{-3+\sqrt{5}}{2} \right) \left(s - \frac{3-\sqrt{5}}{2} \right)}$$

$$s^2 + 3s + 1 = 0 \rightarrow s^* = \frac{-3 \pm \sqrt{9 - 4}}{2} = \begin{cases} \frac{-3 + \sqrt{5}}{2} \\ \frac{-3 - \sqrt{5}}{2} \end{cases}$$

$$x_0(s) = \frac{1}{s} \cdot \frac{s+3 + (s^2+3s+1)(s^2+2s+1)}{(s+1)^2 \left(s - \frac{-3 + \sqrt{5}}{2}\right) \left(s - \frac{-3 - \sqrt{5}}{2}\right)^2}$$

$$= \frac{A}{s} + \frac{B}{(s+1)^2} + \frac{C}{s - \frac{-3 + \sqrt{5}}{2}} + \frac{D}{s - \frac{-3 - \sqrt{5}}{2}}$$

$$s+3 + (s^2 + 3s + 1)(s^2 + 2s + 1) = A(s+1)^2 \left(s - \frac{-3 + \sqrt{5}}{2}\right) \left(s - \frac{-3 - \sqrt{5}}{2}\right) + B s \left(s - \frac{-3 + \sqrt{5}}{2}\right) \left(s - \frac{-3 - \sqrt{5}}{2}\right) + C s (s+1)^2 \left(s - \frac{-3 - \sqrt{5}}{2}\right) +$$

$$s=0 \rightarrow 3+1 \cdot 1 = A \cdot 1 \cdot \left(-\frac{-3+\sqrt{5}}{2} \right) \left(-\frac{-3-\sqrt{5}}{2} \right)$$

$$4 = A \cdot 1 \rightarrow A = 4$$

$$s=-1 \rightarrow -1+3 = B \cdot (-1) \cdot \left(-1 - \frac{-3+\sqrt{5}}{2} \right) \left(-1 - \frac{-3-\sqrt{5}}{2} \right)$$

$$\rightarrow B = b_0$$

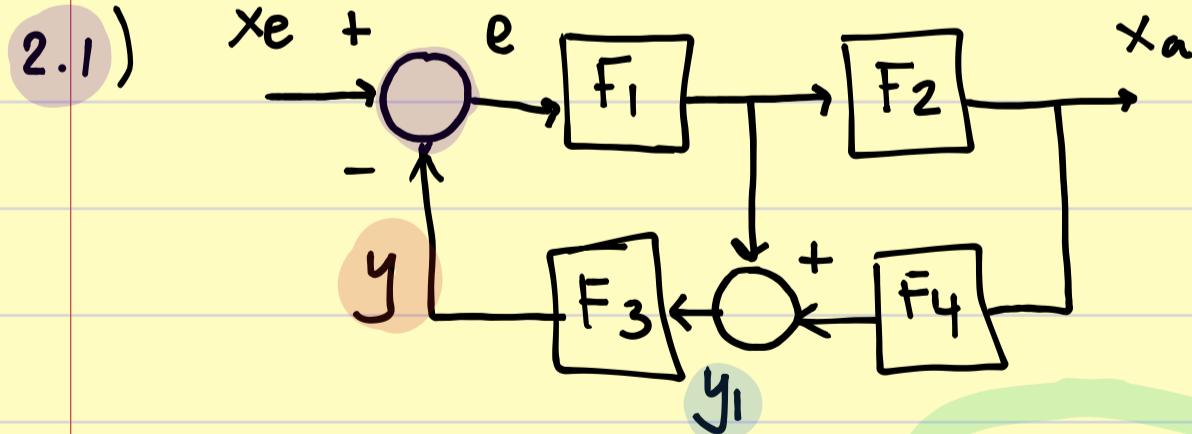
$$s = \frac{-3+\sqrt{5}}{2} \rightarrow \frac{-3+\sqrt{5}}{2} + 3 = C \cdot \frac{-3+\sqrt{5}}{2} \cdot \left(\frac{-3+\sqrt{5}}{2} + 1 \right) \cdot 1$$

$$\rightarrow C = c_0$$

$$s = \frac{-3-\sqrt{5}}{2} \rightarrow \frac{-3-\sqrt{5}}{2} + 3 = D \cdot \frac{-3-\sqrt{5}}{2} \cdot \left(\frac{-3-\sqrt{5}}{2} + 1 \right) \cdot 1$$

$$\rightarrow D = d_0$$

$$x_a(s) = \frac{4}{s} + \frac{b_0}{(s+1)^2} + \frac{c_0}{\left(s - \frac{-3+\sqrt{5}}{2}\right)} + \frac{d_0}{\left(s - \frac{-3-\sqrt{5}}{2}\right)} \rightarrow x_a(t) = \dots$$



$$e \cdot F_1 F_2 = x_a \rightarrow e = \frac{x_a}{F_1 F_2}$$

$$e = x_e - y = x_e - y_1 F_3 = x_e - [e F_1 + x_a F_4] F_3$$

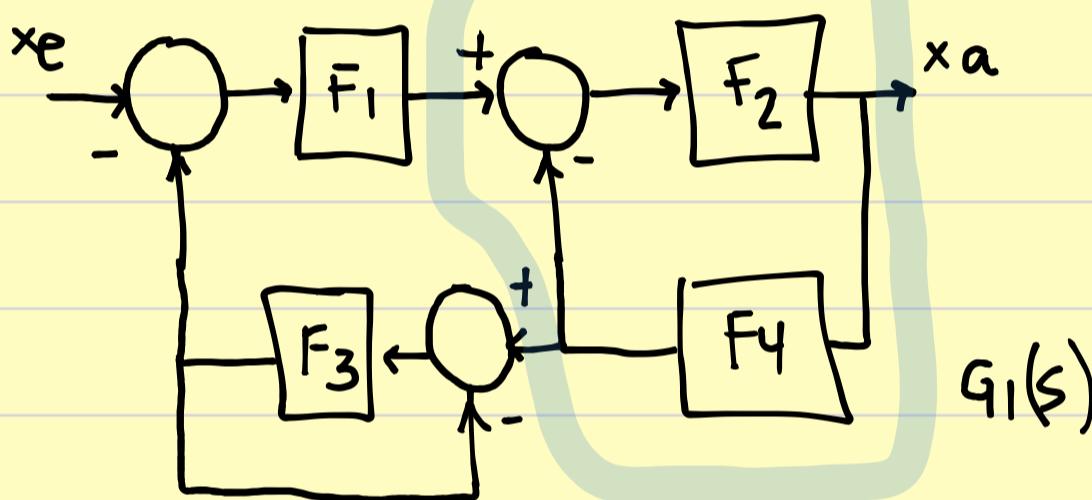
$$\frac{x_a}{F_1 F_2} = x_e - \left[\frac{x_a}{F_1 F_2} \cdot F_1 + x_a F_4 \right] F_3$$

$$\frac{x_a}{F_1 F_2} + \frac{x_a F_3}{F_2} + x_a F_4 F_3 = x_e$$

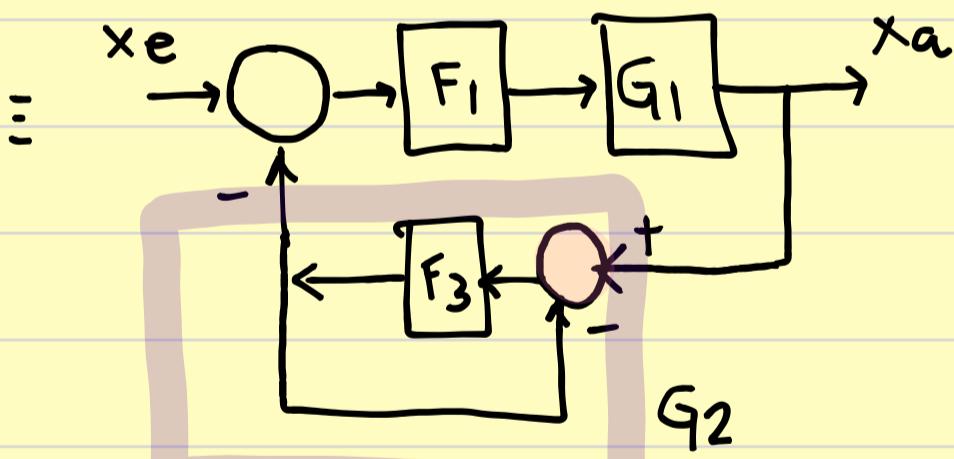
$$x_a \left[\frac{1}{F_1 F_2} + \frac{F_3}{F_2} + F_4 F_3 \right] = x_e \rightarrow$$

$$\frac{x_a}{x_e} = \frac{1}{\frac{1}{F_1 F_2} + \frac{F_3}{F_2} + F_4 F_3}$$

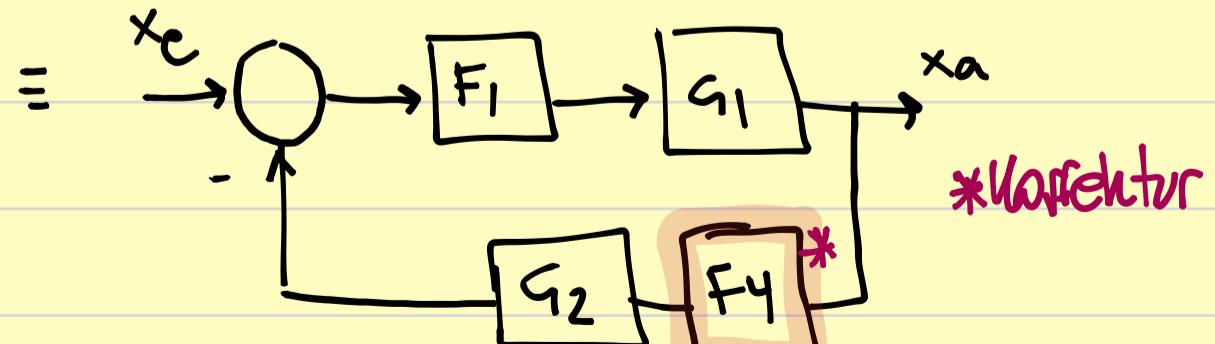
2.2.



$$G_1(s) = \frac{F_2}{1 + F_2 F_4}$$

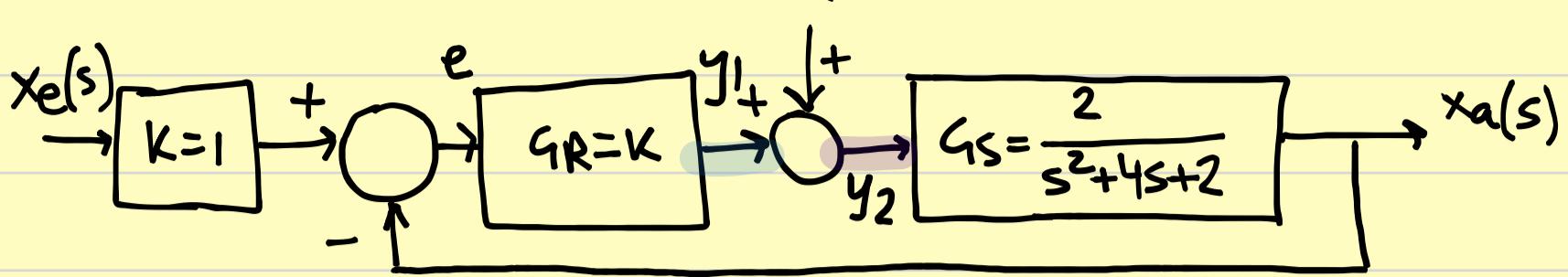


$$G_2(s) = \frac{F_3}{1 + F_3}$$



$$G(s) = \frac{F_1 G_1}{1 + F_1 G_1 G_2} = \frac{F_1 \cdot \frac{F_2}{1 + F_2 F_4}}{1 + F_1 \cdot \frac{F_2}{1 + F_2 F_4} \cdot \frac{F_3}{1 + F_3}} F_4$$

3.



a) Annahme: $x_e(s) = \frac{1}{s}$; $D(s) = \frac{1}{s}$

$$e = x_e \cdot K - x_a \rightarrow x_a = x_e - e$$

$$x_a = \left(e \cdot G_R + D(s) \right) \cdot G_S = \left[(x_e - x_a) \cdot K + \frac{1}{s} \right] \cdot \frac{2}{(s^2 + 4s + 2)}$$

$$\underbrace{y_1}_{\text{---}} \quad \underbrace{y_2}_{\text{---}}$$

$$x_a = \left[x_e \cdot K \cdot \frac{2}{(s^2 + 4s + 2)} - x_a \cdot K \cdot \frac{2}{(s^2 + 4s + 2)} + \frac{2}{s(s^2 + 4s + 2)} \right]$$

$$x_a + x_a \cdot K \cdot \frac{2}{(s^2 + 4s + 2)} = x_e \cdot K \cdot \frac{2}{s^2 + 4s + 2} + \frac{2}{s(s^2 + 4s + 2)}$$

$$x_a \left(1 + \frac{2K}{(s^2 + 4s + 2)} \right) = x_e \cdot \frac{2K}{s^2 + 4s + 2} + \frac{2}{(s^2 + 4s + 2)} \cdot D(s)$$

$D(s) = \varepsilon \rightarrow 0 \equiv D(s)$ ist zu vernachlässigen.

$$\frac{x_a}{x_e} = \frac{\frac{2K}{s^2 + 4s + 2}}{1 + \frac{2K}{s^2 + 4s + 2}} = \frac{2K}{s^2 + 4s + 2 + 2K} \quad (*)$$

$$s^* = \frac{-4 \pm \sqrt{16 - 4(2+2k)}}{2} = -2 \pm \sqrt{4 - 2 - 2k} = -2 \pm \sqrt{2 - 2k}$$

$$2 - 2k < 4 \rightarrow -2k < 2 \rightarrow -k < 1 \rightarrow k > -1$$

b) Vorlesung 2023/130

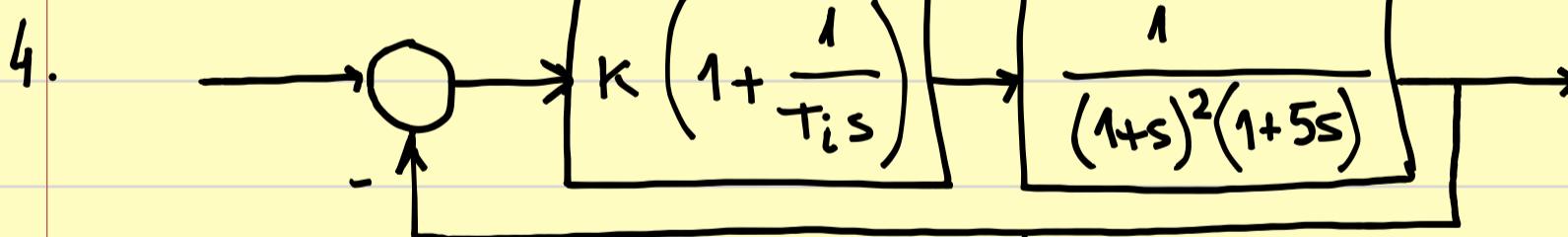


$$\text{Überschwingung} = |G(j\omega)| \Big|_{\omega=\omega_E} = \frac{K_P \cdot T_2}{T_1}$$

$$(*) \quad \frac{x_a}{x_e} = \frac{(*) \quad 2k}{s^2 + 4s + 2 + 2k} = \frac{2k}{2 + 2k} \cdot \frac{\frac{1}{1}}{1 + \frac{4s}{2 + 2k} + \frac{1 \cdot s^2}{2 + 2k}}$$

$$\text{Überschwingung} = \frac{2k \cdot \sqrt{\frac{1}{2 + 2k}}}{\frac{4}{2 + 2k}} \leq 1 \rightarrow 2k \cdot \sqrt{\frac{1}{2 + 2k}} \leq \frac{4}{2 + 2k}$$

$$2k \sqrt{2 + 2k} \leq 4 \rightarrow k \sqrt{2 + 2k} \leq 2 \rightarrow k \leq 1 \quad (*) \text{ korrigiert ab dem Punkt}$$



$$G(s) = \frac{K \left(1 + \frac{1}{T_i s}\right) \left(\frac{1}{(1+s^2)(1+5s)}\right)}{1 + K \left(1 + \frac{1}{T_i s}\right) \left(\frac{1}{(1+s^2)(1+5s)}\right)} =$$

$$= \frac{K \left(\frac{1+T_i s}{T_i s}\right) \left(\frac{1}{(1+s^2)(1+5s)}\right)}{1 + \left(\frac{1+T_i s}{T_i s}\right) \left(\frac{1}{(1+s^2)(1+5s)}\right)}$$

$$= \frac{K \left(\frac{1+T_i s}{T_i s}\right) \left(\frac{1}{(1+s^2)(1+5s)}\right)}{1 + \left(\frac{1+T_i s}{T_i s}\right) \left(\frac{1}{(1+s^2)(1+5s)}\right)} = K$$

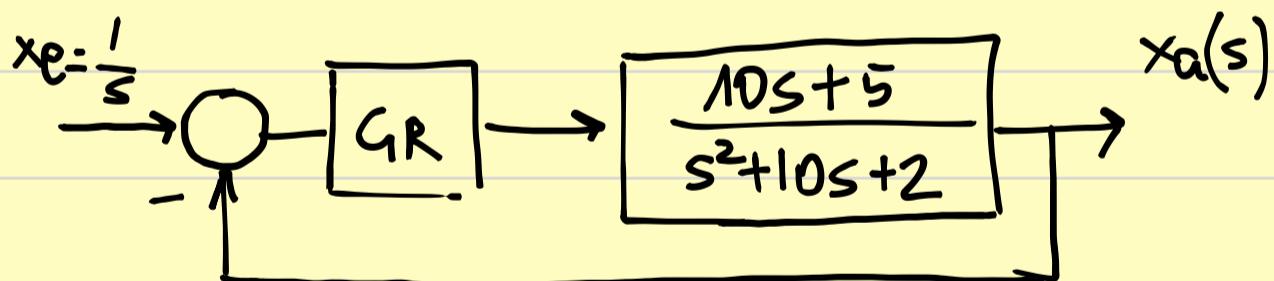
$$\begin{aligned}
 &= \frac{\kappa (1+T_i s)}{T_i s (1+s^2)(1+5s) + (1+T_i s)\kappa} = \\
 &= \frac{\kappa (1+T_i s)}{T_i s (1+5s + s^2 + 5s^3) + (1+T_i s)\kappa} = \\
 &= \frac{\kappa (1+T_i s)}{5T_i s^4 + T_i s^3 + 5T_i s^2 + (\kappa+1)T_i s + \kappa}
 \end{aligned}$$

$$\kappa = T_i = 1$$

$$= \frac{(1+s)}{5s^4 + s^3 + 5s^2 + 2s + 1}$$

$$s^* = -0.15 \pm 0.86j ; \quad s^* = 0.05 \pm 0.5j \quad \text{NICHT STABIL}$$

5.



$$G(s) = \frac{\frac{G_R \cdot (10s+5)}{s^2+10s+2}}{1 + \frac{G_R(10s+5)}{s^2+10s+2}} = \frac{G_R(10s+5)}{s^2+10s+2 + G_R(10s+5)}$$

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$$\begin{aligned}
 &\rightarrow \frac{\frac{K_P}{1+sT_1+s^2T_2^2}}{1+sT_1+s^2T_2^2} \rightarrow \\
 &w_E = \frac{1}{T_2} \\
 &\bar{u}_b = \frac{K_P T_2}{T_1}
 \end{aligned}$$

$$G(s) = \frac{GR(10s+5)}{\left[GR(10s+5)+2\right] \left[1 + \frac{10s}{2+GR(10s+5)} + \frac{1 \cdot s^2}{2+GR(10s+5)}\right]}$$

$$T_2 = \sqrt{\frac{1}{2+GR(10s+5)}}$$

$$T_1 = \frac{10}{2+GR(10s+5)}$$

$$K_P = \frac{GR(10s+5)}{2+GR(10s+5)}$$

$$\omega_E = \frac{1}{T_2} = \sqrt{2+GR(10s+5)}$$

$$\boxed{\frac{1}{2+GR(10s+5)}}$$

GR ?

$$\text{Überschw.} = \frac{K_P \sqrt{2+GR(10s+5)}}{\frac{10}{2+GR(10s+5)}} = 1'1$$

$$GR = \frac{K}{10s+5}$$

$$\text{Überschw.} = \frac{K}{2+K} \cdot \frac{\frac{1}{2+K}}{\frac{10}{2+K}} = \frac{K}{10\sqrt{2+K}} = 1'1$$

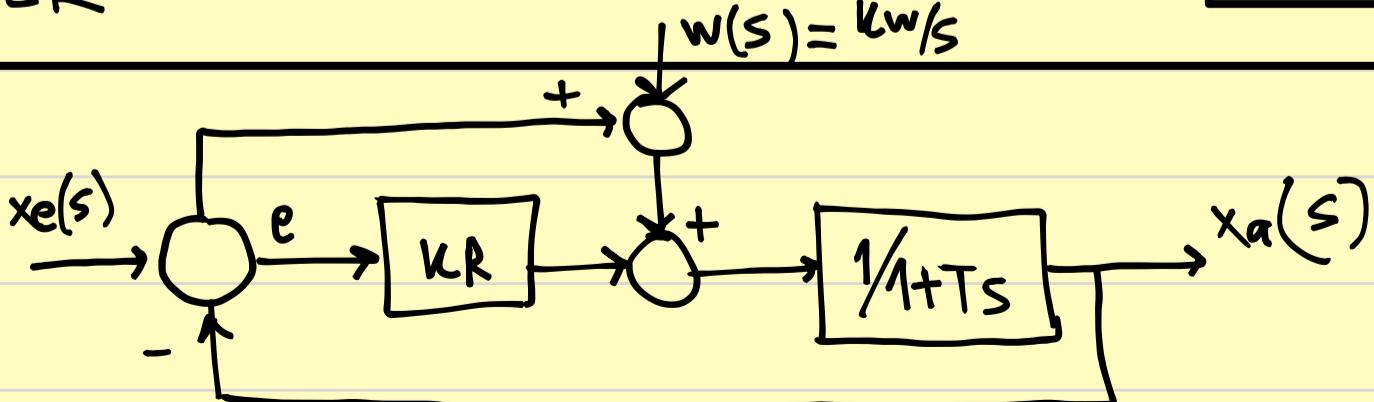
$$\rightarrow \dots \rightarrow K \approx 122$$

WOLFRAM
SOLVER

$$K = 122$$

$$GR = \frac{122}{10s+5}$$

6.



$$e = x_e - x_a$$

$$x_a = \left[e^{K_R} + e + w(s) \right] \cdot \frac{1}{1+Ts} \rightarrow$$

$$\rightarrow e = \left[x_a \cdot (1+Ts) - w(s) \right] \frac{1}{1+K_R}$$

$$\left[x_a (1+Ts) - w(s) \right] \frac{1}{1+K_R} = x_e - x_a$$

$$x_a (1+Ts) + x_a - w(s) = x_e (1+K_R)$$

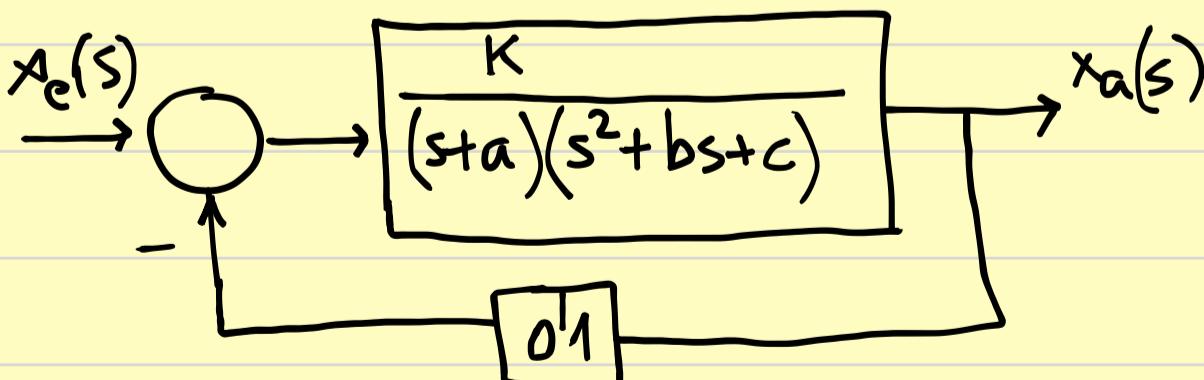
$$x_a (2+Ts) - \frac{K_W}{s} = x_e (1+K_R)$$

$$K_W = 0$$

$$FV : \frac{x_a}{x_e} = \frac{1+K_R}{2+Ts} = \frac{1+K_R}{2} \cdot \frac{1}{1+\frac{T}{2}s}$$

7.

$$G(t) = 1'8 e^{-2t} - 2 e^{-0.9t} [0.9 \cos t - \sin t]$$



$$G(s) = \frac{\frac{K}{(s+a)(s^2+bs+c)}}{1 + \frac{0.1K}{(s+a)(s^2+bs+c)}} =$$

$$= \frac{K}{(s+a)(s^2+bs+c) + D_1 K} = \frac{K}{s^3 + (a+b)s^2 + (ab+c)s + ac + D_1 K}$$

$$G(s) = \frac{\sim}{s^3 + 3^{18}s^2 + 5^{41}s + 3^{62}}$$

