26.3.2012 **2. Übungsblatt**

1.1) ① $U_R = R \cdot i$; $i = i_C$; $i_C = C \cdot \dot{U}_C$; $U_e = U_R + U_C$

$$\Rightarrow U_e = R \cdot C \cdot \dot{U}_C + U_C = R \cdot C \cdot \dot{U}_a + U_a$$

② $F_c = c \cdot x_a$; $F_d = d \cdot \dot{x}_a$; $F_e = F_c + F_d$ (Kräftegleichgewicht)

$$\Rightarrow d\dot{x}_a + c \cdot x_a = F_e$$

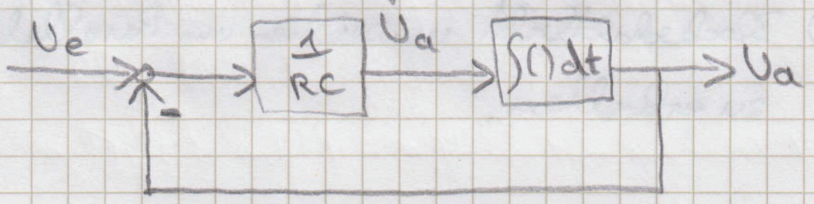
③ $F_c = c \cdot x_a$; $F_d = d \cdot \dot{x}_a$; $F_T = m \cdot \ddot{x}_a$ (Trägheitskraft)

$F_e = F_c + F_d + F_T$ (Kräftegleichgewicht)

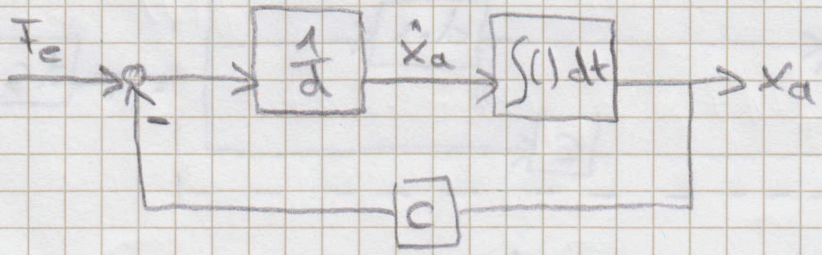
$$\Rightarrow m\ddot{x}_a + d\dot{x}_a + c \cdot x_a = F_e$$

1.2)

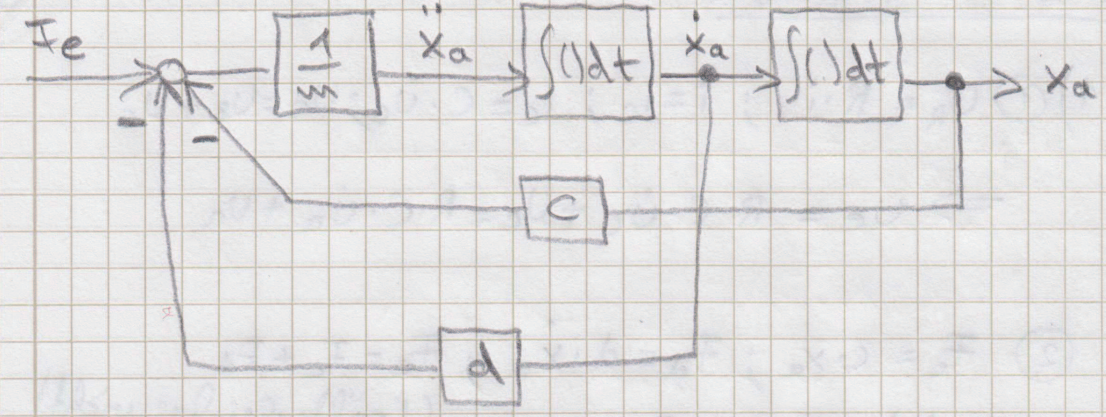
① $$\Rightarrow \dot{U}_a = -\frac{1}{RC} \cdot U_a + \frac{1}{RC} \cdot U_e$$



② $$\Rightarrow \dot{x}_a = -\frac{c}{d} \cdot x_a + \frac{1}{d} \cdot F_e$$



③ $$\Rightarrow \ddot{x}_a = -\frac{d}{m} \cdot \dot{x}_a - \frac{c}{m} \cdot x_a + \frac{1}{m} \cdot F_e$$



1.3) ①

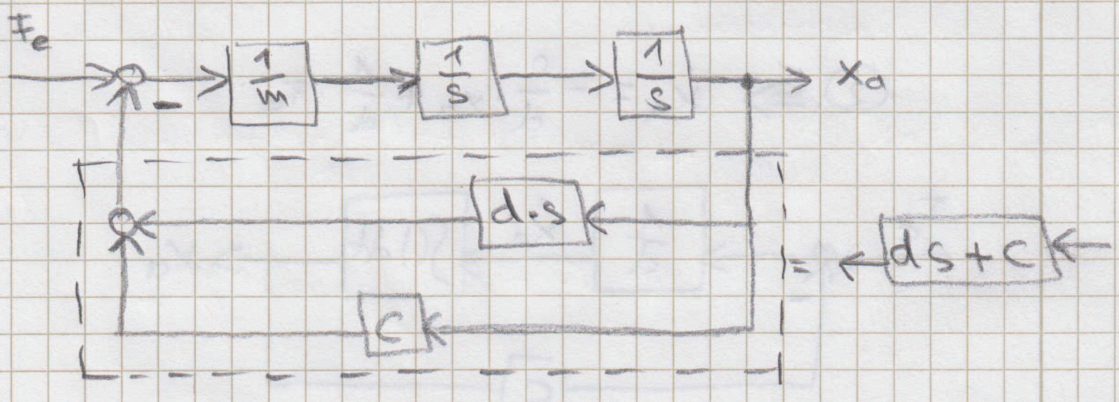
28.3.2012

Laplace ⇒ $R \cdot C \cdot (s \cdot U_a(s) - U_a(t=0)) + U_a(s) = U_e(s)$

$$F(s) = \frac{U_a(s)}{U_e(s)} = \frac{1}{RCs+1}$$

② $$F(s) = \frac{x_a}{F_e} = \frac{\frac{1}{d \cdot s}}{1 + \frac{c}{d \cdot s}} = \frac{1}{d \cdot s + c}$$

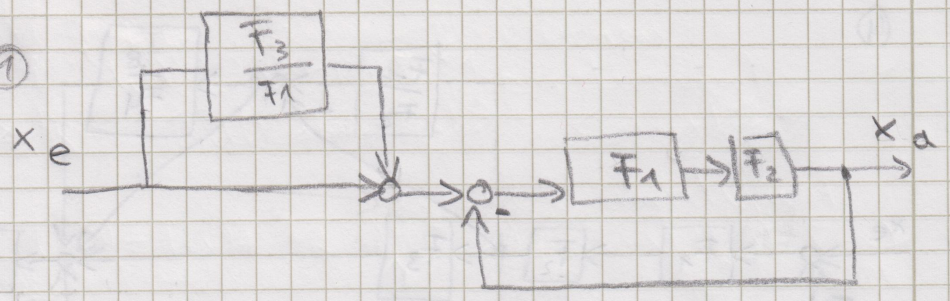
③ Blockschaltbild umzeichnen um Parallelstrukturen zu erhalten.



$$F(s) = \frac{x_a}{F_e} = \frac{\frac{1}{m \cdot s^2}}{1 + \frac{1}{m s^2}(ds + c)} = \frac{1}{ms^2 + ds + c}$$

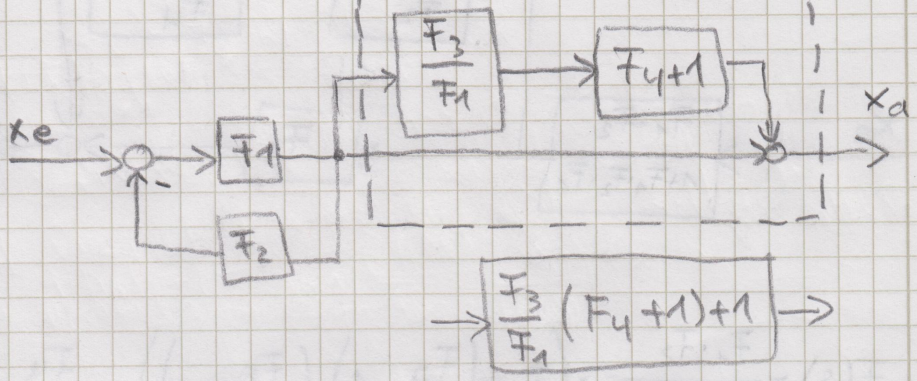
2)

①



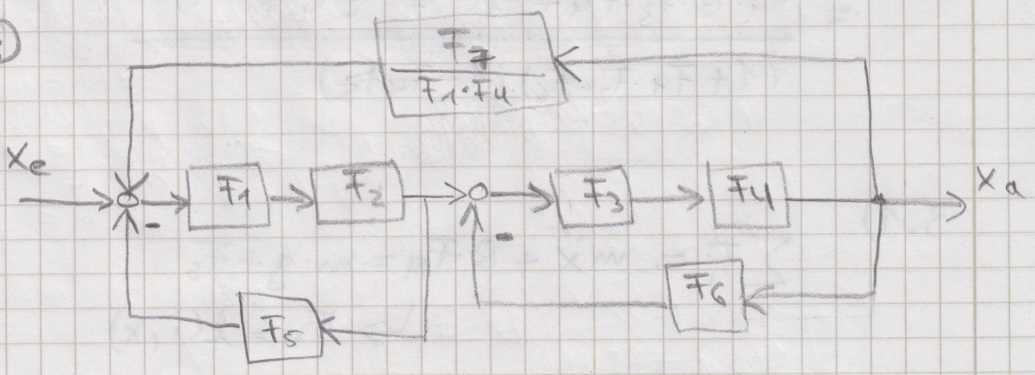
$$F_1 = \left(1 + \frac{F_3}{F_1}\right) \cdot \frac{F_1 \cdot F_2}{1 + F_1 F_2} = \frac{(F_1 + F_3) \cdot F_2}{1 + F_1 \cdot F_2}$$

②



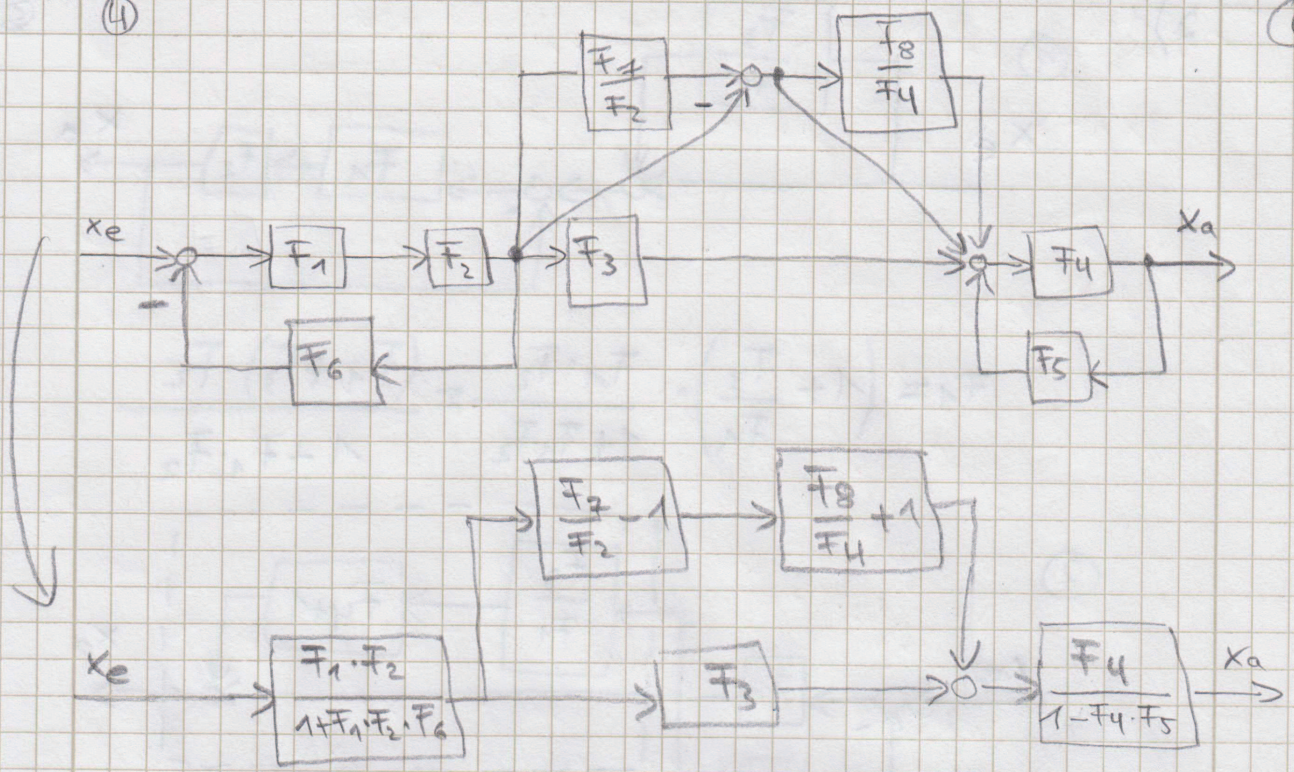
$$F(s) = \frac{F_1}{1 + F_1 F_2} \cdot \left(\frac{F_3}{F_1}(F_4 + 1) + 1 \right) = \frac{F_3(F_4+1) + F_1}{1 + F_1 \cdot F_2}$$

③



$$F(s) = \frac{\frac{F_1 \cdot F_2}{1 + F_1 \cdot F_2 \cdot F_5} \cdot \frac{F_3 \cdot F_4}{1 + F_3 \cdot F_4 \cdot F_6}}{1 - \frac{F_1 \cdot F_2}{1 + F_1 \cdot F_2 \cdot F_5} \cdot \frac{F_3 \cdot F_4}{1 + F_3 \cdot F_4 \cdot F_6} \cdot \frac{F_7}{F_1 \cdot F_4}}$$

$$= \frac{F_1 \cdot F_2 \cdot F_3 \cdot F_4}{(1 + F_1 \cdot F_2 \cdot F_5) \cdot (1 + F_3 \cdot F_4 \cdot F_6) - F_2 \cdot F_3 \cdot F_7}$$



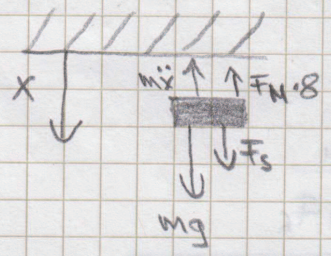
$$F(s) = \frac{F_1 \cdot F_2}{1+F_1 \cdot F_2 \cdot F_6} \cdot \left(F_3 + \left(\left(\frac{F_7}{F_2} - 1 \right) \cdot \left(\frac{F_8}{F_4} + 1 \right) \right) \right) \cdot \frac{F_4}{1-F_4 \cdot F_5}$$

$$= \frac{F_1 \cdot F_2 \cdot F_3 \cdot F_4 + F_1 (F_7 - F_2)(F_8 + F_4)}{(1 + F_1 \cdot F_2 \cdot F_6)(1 - F_4 F_5)}$$

3.1)

$$\sum F_i = m\ddot{x} + 8 \cdot F_M = m \cdot g + F_S$$

$$\hookrightarrow F_M = f(i, x)$$

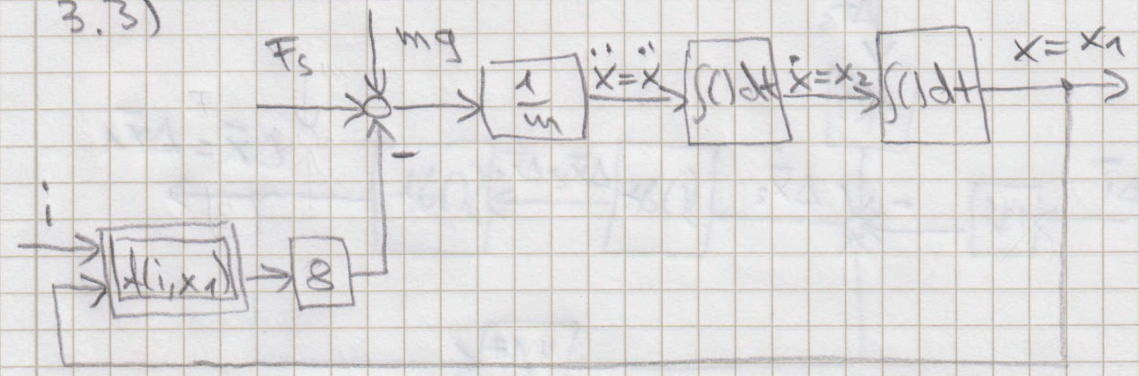


3.2) $x = x_1, \; x_2 = \dot{x}$

$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = \frac{1}{m} \cdot (-8 f(i, x_1) + m \cdot g + F_S)$$

3.3)



3.4) a) Variablen: $\dot{x}_1, \dot{x}_2, x_1, x_2, i, F_s$

b) Arbeitspunkt $\Leftarrow \dot{x}_1 = 0,\ \dot{x}_2 = 0$

c) $\Delta\dot{x}_1 = \Delta x_2$

$$\Delta\dot{x}_2 = -\frac{g}{m}\cdot\left.\frac{\partial f}{\partial i}\right|_{AP}\cdot\Delta i - \frac{g}{m}\cdot\left.\frac{\partial f}{\partial x_1}\right|_{AP}\cdot\Delta x_1 + \frac{1}{m}\cdot\Delta F_s$$

$$\left.\frac{\partial f}{\partial i}\right|_{AP} = c_i = \frac{20\,kN}{2\,A} = 4\,\frac{kN}{A}$$

$$\left.\frac{\partial f}{\partial x_1}\right|_{AP} = c_x = \frac{-17\,kN}{1\,cm} = -\frac{17\,kN}{cm}$$

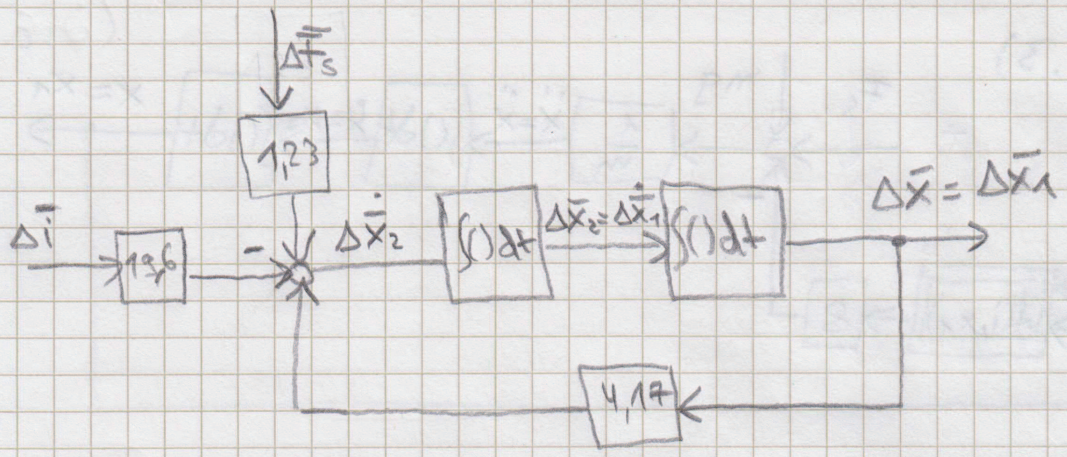
3.5)

$$\Delta\bar{x}_2 = \frac{\Delta x_2}{\left(\frac{x_0}{t_0}\right)};\quad \Delta\bar{x}_1 = \frac{\Delta x_1}{x_0};\quad \Delta\bar{i} = \frac{\Delta i}{i_0};\quad \bar{t} = \frac{t}{t_0};\quad \Delta\bar{F}_s = \frac{\Delta F_s}{F_{H_0}};\quad \Delta\dot{\bar{x}}_2 = \frac{\Delta\dot{x}_2}{\left(\frac{x_0}{t_0^2}\right)}$$

$$\Delta\dot{\bar{x}}_1 = \Delta\bar{x}_2;\quad \frac{x_0}{t_0^2}\Delta\dot{\bar{x}}_2 = \frac{1}{m}\left(-g\cdot c_i\cdot i_0\cdot\Delta\bar{i} - g\cdot c_x\cdot x_0\cdot\Delta\bar{x}_1 + \bar{F}_{H_0}\cdot\Delta\bar{F}_s\right)$$

$$\Delta\dot{\bar{x}}_1 = \Delta\bar{x}_2$$

$$\Delta\dot{\bar{x}}_2 = 4{,}17\cdot\Delta\bar{x}_1 - 19{,}6\cdot\Delta\bar{i} + 1{,}23\cdot\Delta\bar{F}_s$$



3. 6) $$F_1(s) = \frac{\Delta\bar{x}}{\Delta\bar{i}} = -19{,}6 \cdot \frac{\frac{1}{s^2}}{1 - \frac{1}{s^2} \cdot 4{,}17} = \frac{-19{,}6}{s^2 - 4{,}17}$$

$$F_2(s) = \frac{\Delta\bar{x}}{\Delta\bar{F}_s} = \frac{1{,}23}{s^2 - 4{,}17}$$