

$$A(s) = \frac{R_2}{R_1} \frac{1}{1 + \underbrace{\omega_g C_1 (R_2 + R_3 + \frac{R_2 R_3}{R_1})}_{a_1} s + \underbrace{\omega_g^2 R_2 R_3 C_1 C_2}_{b_1} s^2}$$

$$U_{C1} + U_a = 0$$

$$U_{C1} = -U_a$$

$$b_1) R_3 =$$

$$R_1 = \frac{R_2}{A_0}$$

$$a_1) R_2 =$$

$$\frac{a_1 C_2 - \sqrt{a_1^2 C_1^2 - 4 C_1 C_2 b_1 (1 - A_0)}}{2 \omega_g C_1 C_2}$$

$$\frac{\sqrt{(\quad)}}{\geq 0} \rightarrow \frac{C_2}{C_1} \geq \frac{4 b_1 (1 - A_0)}{a_1^2}$$

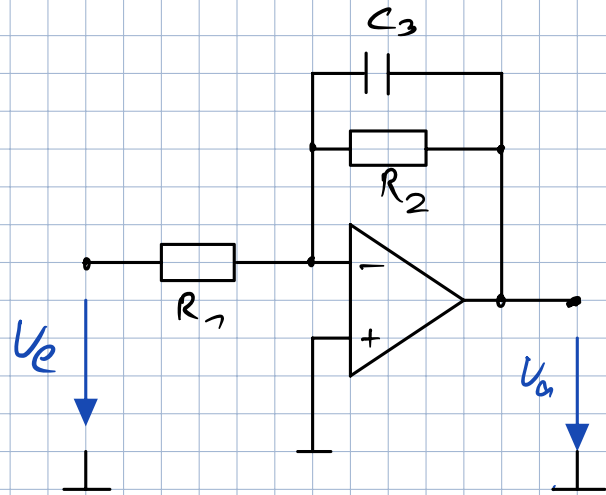
Aufgaben: Verstärkung $A = 10$, $f_g = 1 \text{ kHz}$, 3dB Welligkeit
 $C_1 = C_3 = 10 \text{ nF}$, $A_1 = -2$, $A_2 = -5$

Filter-Koeffizient:			
$n=3$	a_1	b_1	
	3,3496	0	1.0
	0,3559	1,1923	2.0

TP. 1. Ordnung:

$$G(j\omega) = \frac{U_a}{U_e}$$

$$\begin{aligned} R_{C3} &= C_3 \parallel R_2 \\ &= \frac{1}{\frac{1}{R_2} + \frac{1}{j\omega C_3}} \\ &= \frac{1}{\frac{1}{R_2} + j\omega C_3} \end{aligned}$$



$$\begin{aligned} G(j\omega) = \frac{U_a}{U_e} &= - \frac{\frac{1}{\frac{1}{R_2} + j\omega C_3}}{R_1} = - \frac{1}{R_1 \left(\frac{1}{R_2} + j\omega C_3 \right)} \cdot \frac{R_2}{R_2} = - \frac{R_2}{R_1 \left(\frac{R_1}{R_2} + j\omega R_1 R_2 C_3 \right)} \\ &= \frac{-\frac{R_2}{R_1}}{1 + j\omega R_1 R_2 C_3} = \frac{A_1}{1 + s \tau_1} \end{aligned}$$

$$\tau_1 = \omega_g R_1 R_2 C_3 \Rightarrow R_2 = \frac{\tau_1}{\omega_g C_3} = \frac{3,3496}{6,28k \cdot 10nF} = 53,53k\Omega$$

$$\omega_g = 2\pi f = 2\pi 7kHz = 6,28k$$

$$A_1 = -\frac{R_2}{R_1} \Rightarrow R_1 = -\frac{R_2}{A_1} = \frac{-53,33k\Omega}{-2} = 26,7k\Omega$$

TP 2. Ordnung:

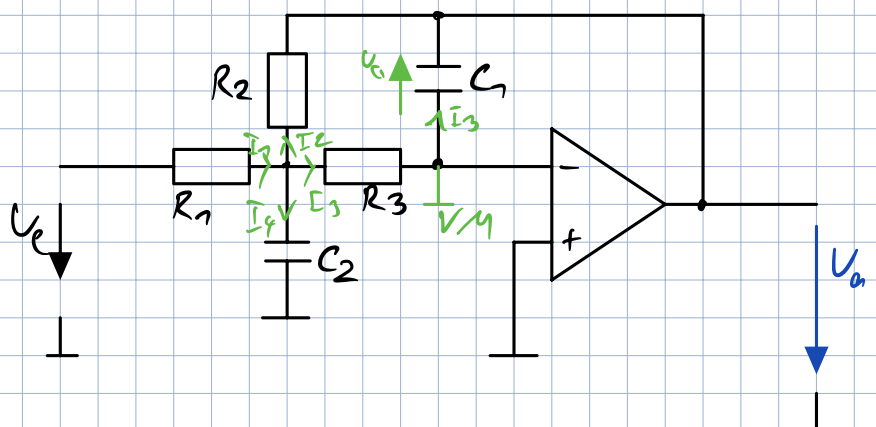
$$U_{C1} = -U_a$$

$$I_1 = \frac{U_e - U_{R3}}{R_1} \quad U_{R3} = I_3 \cdot R_3$$

$$I_2 = \frac{U_{R2}}{R_2} = \frac{U_e - R_1 - U_a}{R_2}$$

$$I_3 = \dots$$

$$I_4 = \frac{U_{R3}}{R_2}$$



$$I_1 = I_2 + I_3 + I_4$$

$$I_3 = -\frac{U_1}{j\omega C_1} = -U_1 \cdot j\omega C_1$$

$$U_{R3} = -U_1 \cdot j\omega C_1 \cdot R_3$$

$$I_1 = \frac{U_e + (U_1 \cdot j\omega C_1 \cdot R_3)}{R_1}$$

$$I_4 = \frac{-U_1 \cdot j\omega C_1 \cdot R_3}{j\omega C_2} - \frac{U_1 \cdot j^2 \omega^2 C_1 C_2 R_3}{j\omega C_2}$$

$$I_2 = \frac{U_e - U_1 - (+U_1 \cdot j\omega C_1 \cdot R_3 + U_1)}{R_2}$$

$$= \frac{-U_1 - U_1 \cdot j\omega C_1 R_3}{R_2} = -U_1 \left(\frac{1 + j\omega C_1 R_3}{R_2} \right)$$

$$\frac{U_e}{R_1} + \frac{U_1}{R_1} \cdot j\omega C_1 R_3 = -U_1 \left(\frac{1 + j\omega C_1 R_3}{R_2} \right) - U_1 \cdot j\omega C_1 - U_1 \cdot j^2 \omega^2 C_1 C_2 R_3$$

$$\frac{U_e}{R_1} = -U_1 \cdot \left(\frac{1 + j\omega C_1 R_3}{R_2} + \frac{j\omega C_1 R_3}{R_1} - j\omega C_1 - j^2 \omega^2 C_1 C_2 R_3 \right)$$

$$\frac{U_e}{U_1} = -\frac{R_1}{R_2} \cdot \frac{1}{R_1 \left(\frac{1 + j\omega C_1 R_3}{R_2} + \frac{j\omega C_1 R_3}{R_1} + j\omega C_1 + j^2 \omega^2 C_1 C_2 R_3 \right)}$$

$$= -\frac{R_1}{R_2} \left(1 + j\omega C_1 R_3 + \frac{j\omega C_1 R_3}{R_1} + j\omega C_1 R_2 + j^2 \omega^2 C_1 C_2 R_3 R_2 \right)$$

$$= -\frac{R_2}{R_1} \cdot \frac{1}{1 + j\omega C_1 (R_2 + R_3 + \frac{R_2 R_3}{R_1}) + j^2 \omega^2 C_1 C_2 R_3 R_2}$$

$$a_1 = \omega_0 C_1 \left(R_2 + R_3 + \frac{R_2 R_3}{R_1} \right)$$

$$b_1 = \omega_0^2 C_1 C_2 R_2 R_3$$

$$A_0 = -\frac{R_2}{R_1}$$

Dim:

$$A_0: R_1 = -\frac{R_2}{A_0}$$

$$a_1: R_2 = \frac{a_1 C_2 - \sqrt{a_1^2 C_2^2 - 4 C_1 C_2 b_1 (1 - A_0)}}{2 \omega_0 C_1 C_2}$$

$$R_3 = \frac{b_1}{\omega_0^2 C_1 C_2 R_2}$$

$$\frac{C_2}{C_1} \geq \frac{4 b_1 (1 - A_0)}{a_1^2}$$