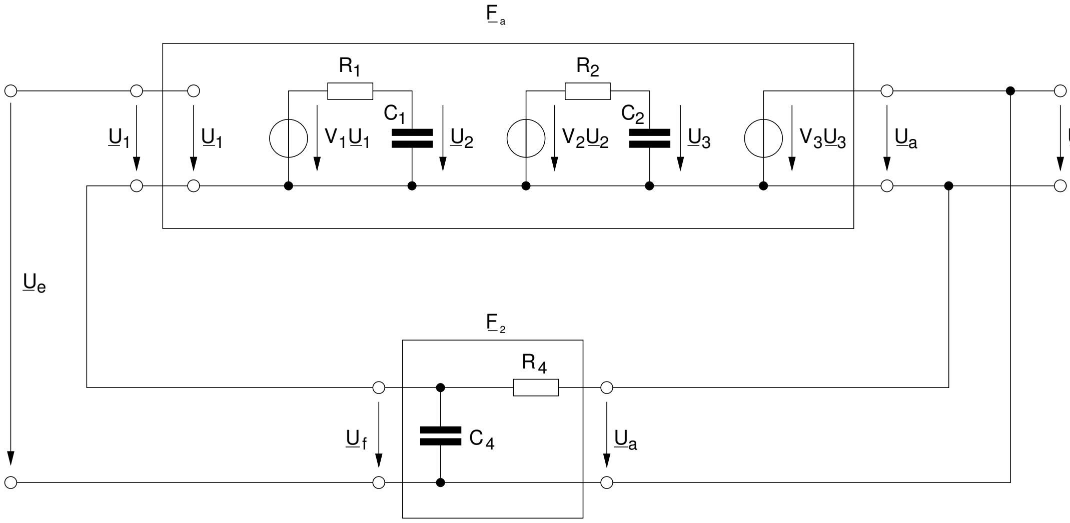
Universität des Saarlandes
Lehrstuhl für Elektronik und Schaltungstechnik
Elektronik II, SS 10 — Übung 10

Aufgabe 1) *Rückkopplung, Zweitor.*

1. Frequenzgang



$$\underline{U}_\text{e} = \underline{U}_1 + \underline{U}_\text{f} \;\Leftrightarrow\; \underline{U}_1 = \underline{U}_\text{e} - \underline{U}_\text{f}$$

$$\underline{U}_\text{a} = \underline{F}_\text{a}\underline{U}_1 = \underline{F}_\text{a}\underline{U}_\text{e} - \underline{F}_\text{a}\underline{U}_\text{f} = \underline{F}_\text{a}\underline{U}_\text{e} - \underline{F}_\text{a}\underline{F}_2\underline{U}_\text{a} \;\Leftrightarrow\; \underline{U}_\text{a}(1+\underline{F}_\text{a}\underline{F}_2) \;\Leftrightarrow\; \underline{F} = \frac{\underline{U}_\text{a}}{\underline{U}_\text{e}} = \frac{\underline{F}_\text{a}}{1+\underline{F}_\text{a}\underline{F}_2}$$

$$\begin{aligned}
\underline{U} = v_3\underline{U}_3 &= v_3 v_2 \frac{\frac{1}{\text{j}\omega C_2}}{R_2 + \frac{1}{\text{j}\omega C_2}}\underline{U}_2 = v_3 v_2 \frac{1}{1+\text{j}\omega R_2 C_2}\underline{U}_2 \\
&= v_3 v_2 v_1 \frac{1}{1+\text{j}\omega R_2 C_2}\,\frac{\frac{1}{\text{j}\omega C_1}}{R_1 + \frac{1}{\text{j}\omega C_1}}\underline{U}_1 \\
&= \frac{v_3 v_2 v_1}{(1+\text{j}\omega R_1 C_1)(1+\text{j}\omega R_2 C_2)}\underline{U}_1
\end{aligned}$$

$$\Leftrightarrow \underline{F}_a = \frac{\underline{U}_a}{\underline{U}_1} = \frac{v_0}{(1+\text{j}\frac{\omega}{\omega_1})(1+\text{j}\frac{\omega}{\omega_2})}$$

$$v_0 = v_1 v_2 v_3;\; \omega_1 = \frac{1}{R_1 C_1};\; \omega_2 = \frac{1}{R_2 C_2}$$

$$\underline{U}_\text{f} = \frac{\frac{1}{\text{j}\omega C_4}}{R_4 + \frac{1}{\text{j}\omega C_4}}\underline{U}_\text{a} \;\Leftrightarrow\; \underline{F}_2 = \frac{\underline{U}_\text{f}}{\underline{U}_\text{a}} = \frac{1}{1+\text{j}\omega R_4 C_4} = \frac{1}{1+\text{j}\frac{\omega}{\omega_4}};\; \omega_4 = \frac{1}{R_4 C_4}$$

$$\Rightarrow\; \underline{F}(\text{j}\omega) = \frac{\frac{v_0}{(1+\text{j}\frac{\omega}{\omega_1})(1+\text{j}\frac{\omega}{\omega_2})}}{1+\frac{v_0}{(1+\text{j}\frac{\omega}{\omega_1})(1+\text{j}\frac{\omega}{\omega_2})(1+\text{j}\frac{\omega}{\omega_4})}}$$

2. Stabilität von $\underline{F}_\mathrm{a}(s)$, $\underline{F}_2(s)$

$$s = \sigma + \mathrm{j}\omega$$

$$\underline{F}_\mathrm{a}(s) = \frac{v_0}{(1+\frac{s}{\omega_1})(1+\frac{s}{\omega_2})} = \frac{v_0\omega_1\omega_2}{(s+\omega_1)(s+\omega_2)}$$

$$\Rightarrow \; s_1 = -\omega_1; \; s_2 = -\omega_2$$

mit $\omega_1, \omega_2 \in \mathbb{R}$ und $\omega_1, \omega_2 > 0 \Rightarrow$ Pole von $\underline{F}_\mathrm{a}(s)$ in der LHE $\Rightarrow$ $\underline{F}_\mathrm{a}(s)$ ist stabil.

$$\underline{F}_2(s) = \frac{1}{1+\frac{s}{\omega_4}} = \frac{\omega_4}{s+\omega_4}$$

$$\Rightarrow \; s_4 = -\omega_4$$

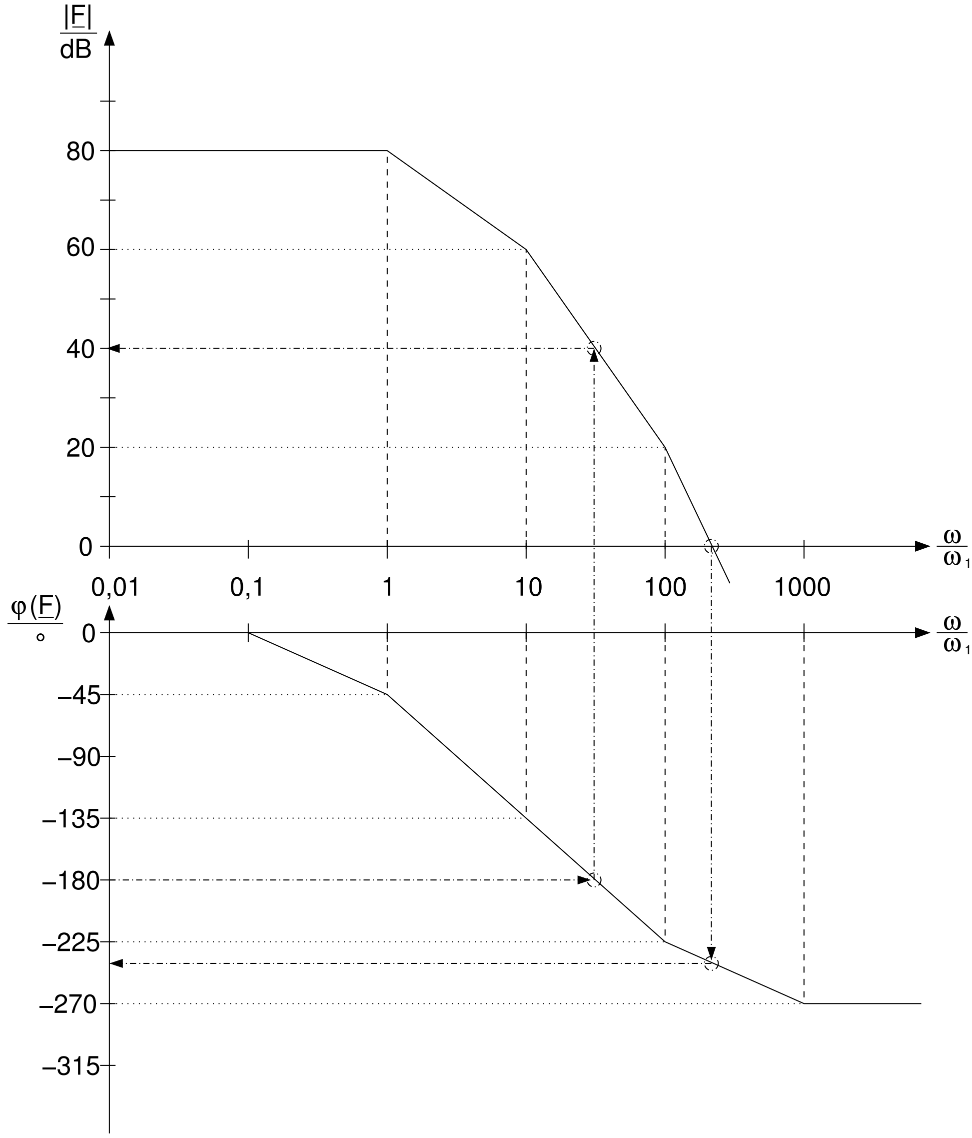
mit $\omega_4 \in \mathbb{R}$ und $\omega_4 > 0 \Rightarrow$ Pol von $\underline{F}_2(s)$ in der LHE $\Rightarrow$ $\underline{F}_2(s)$ ist stabil.

3. Bode-Diagramm

$$\underline{F}_\mathrm{a}\underline{F}_2 = \frac{v_0}{(1+\mathrm{j}\frac{\omega}{\omega_1})(1+\mathrm{j}\frac{\omega}{\omega_2})(1+\mathrm{j}\frac{\omega}{\omega_4})}$$

$$|v_0| = |v_1 v_2 v_3| = 10000 = 80 \text{ dB}$$

$$100R_4C_4 = 10R_2C_2 = R_1C_1 \;\Leftrightarrow\; \frac{1}{\omega_1} = \frac{10}{\omega_2} = \frac{100}{\omega_4} \;\Leftrightarrow\; \omega_4 = 10\omega_2 = 100\omega_1$$



$\varphi_{\text{Rand}} = 180° - 238{,}5° = -58{,}4° < 0 \Rightarrow$ instabil

$A_{\text{Rand}} = 40\text{ dB} > 0 \Rightarrow$ instabil

$\varphi_{\text{Rand}} = 0$: $|v_0|_{\text{dB}} = 80\text{ dB} - 40\text{ dB} = 40\text{ dB}$