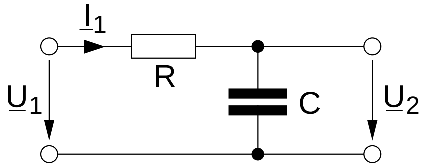
Aufgabe A)

1)



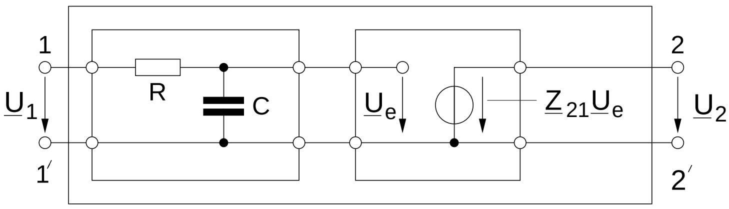
$$\underline{U}_2 = \frac{\frac{1}{sC}}{R + \frac{1}{sC}} \underline{U}_1 \Rightarrow \frac{\underline{U}_2}{\underline{U}_1} = \frac{1}{sRC + 1} = \frac{1}{1 + \frac{s}{\omega_0}} \quad \text{mit } \omega_0 = \frac{1}{RC}$$

keine Nullstellen, Pol bei $s = -\omega_0 = -\frac{1}{RC} \Rightarrow$ stabil, da in LHE

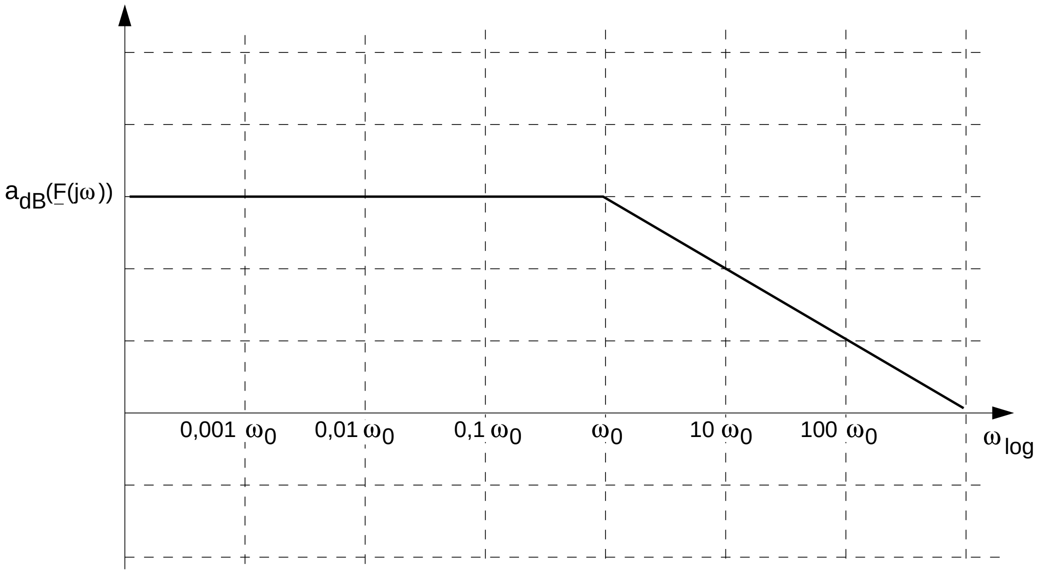
$$\frac{\underline{I}_1}{\underline{U}_1} = \frac{1}{R + \frac{1}{sC}} = \frac{sC}{sRC + 1} = \frac{sC}{1 + \frac{s}{\omega_0}}$$

Nullstelle bei $s = 0$, Pol bei $s = -\omega_0 \Rightarrow$ stabil

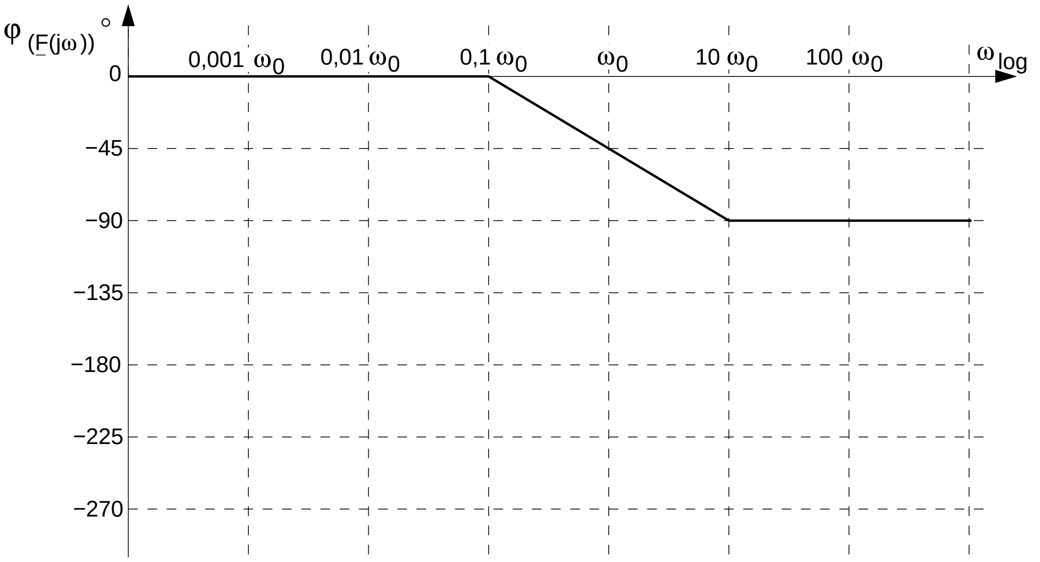
2)



$$\underline{U}_2 = \frac{1}{1 + \frac{s}{\omega_0}} \underline{U}_1 \underline{Z}_{21} \Rightarrow \frac{\underline{U}_2}{\underline{U}_1} = \frac{\underline{Z}_{21}}{1 + \frac{s}{\omega_0}} = \frac{v_u}{1 + \frac{s}{\omega_0}}$$

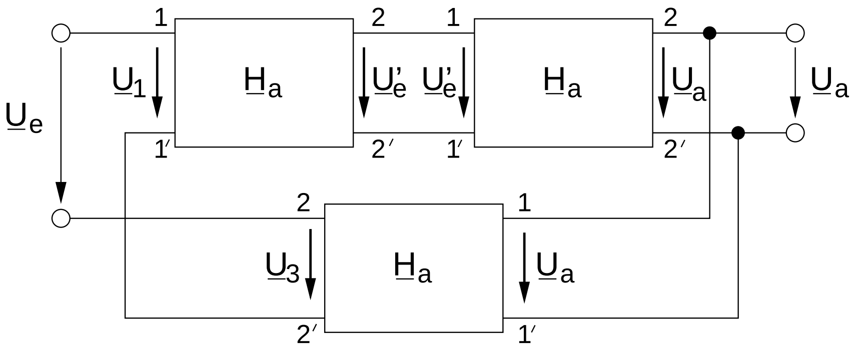


a_dB(F(jω))
0,001 ω0
0,01 ω0
0,1 ω0
ω0
10 ω0
100 ω0
ω log



φ (F(jω)) °
0
−45
−90
−135
−180
−225
−270
0,001 ω0
0,01 ω0
0,1 ω0
ω0
10 ω0
100 ω0
ω log

3)



$$\underline{U}_a = \underline{H}_a^2 \underline{U}_1$$

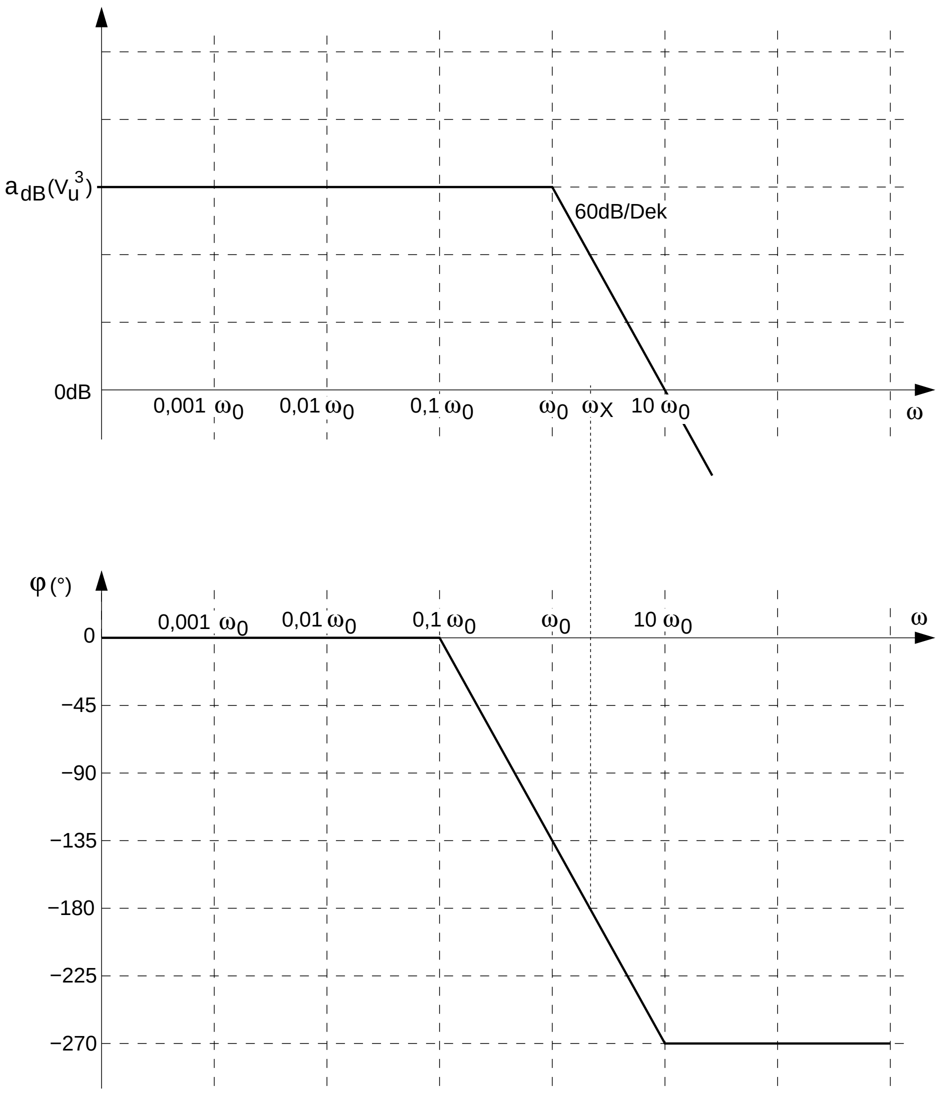
$$\underline{U}_3 = \underline{H}_a \underline{U}_a = \underline{H}_a^3 \underline{U}_1$$

$$\underline{U}_e = \underline{U}_1 - \underline{U}_3 = (1 - \underline{H}_a^3)\underline{U}_1$$

$$\Rightarrow \frac{\underline{U}_a}{\underline{U}_e} = \frac{\underline{H}_a^2 \underline{U}_1}{(1 - \underline{H}_a^3)\underline{U}_1} = \frac{\underline{H}_a^2}{1 - \underline{H}_a^3} \leftarrow \text{(-) bedeutet Mitkopplung, instabil}$$

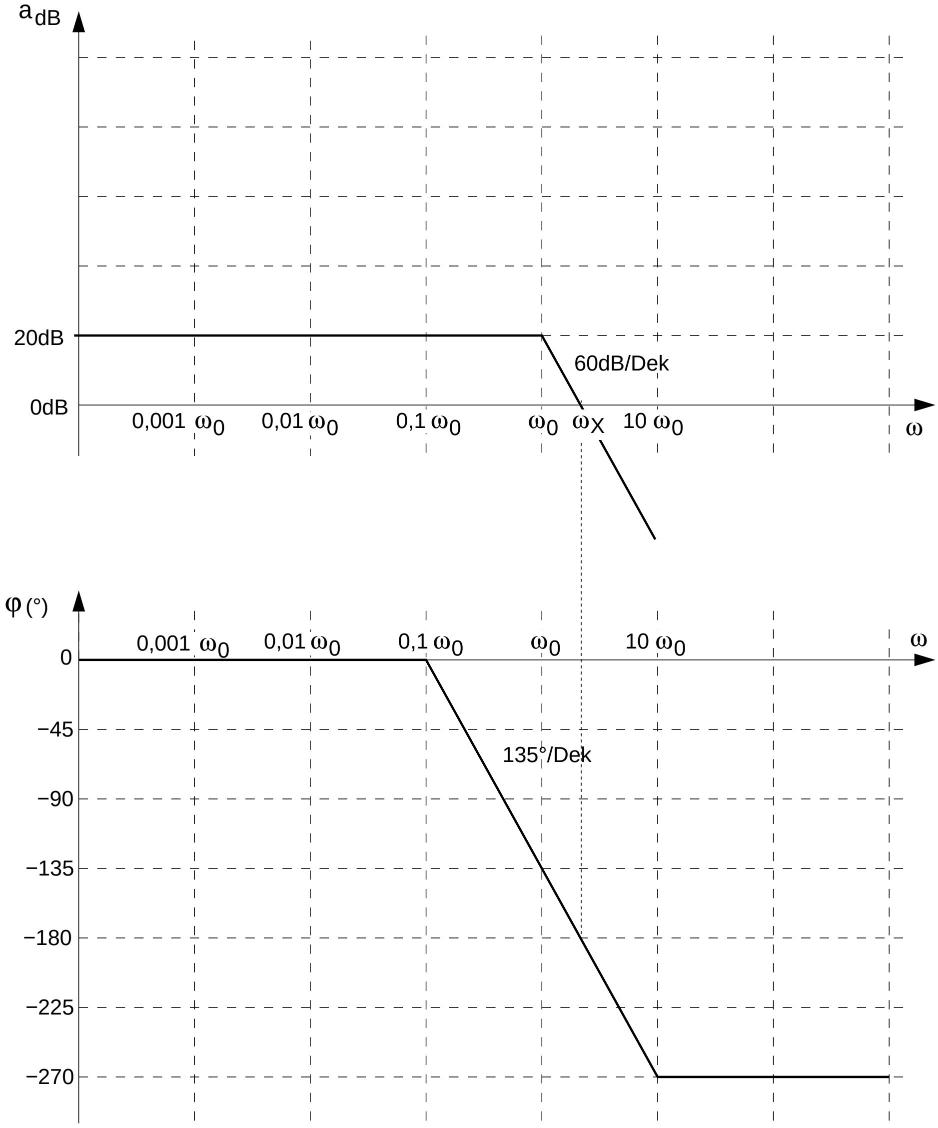
$\Rightarrow v_u < 0$, damit Gegenkopplung eintritt

Die Schleifenverstärkung ergibt sich zu: $\underline{H}_a^3 = \dfrac{v_u^3}{\left(1 + \dfrac{s}{\omega_0}\right)^3}$



Aus dem Bodediagramm ist ersichtlich, dass die Verstärkung v_u so verändert werden muss, dass die Durchtrittsfrequenz bei $-180°$ (Phasenreserve $= 0°$) liegt.

Die zeichnerische Lösung ergibt sich zu:



$$\varphi(\omega_x) - \varphi(\omega_0) = 45^\circ = \tfrac{1}{3}\ \text{Dek}$$

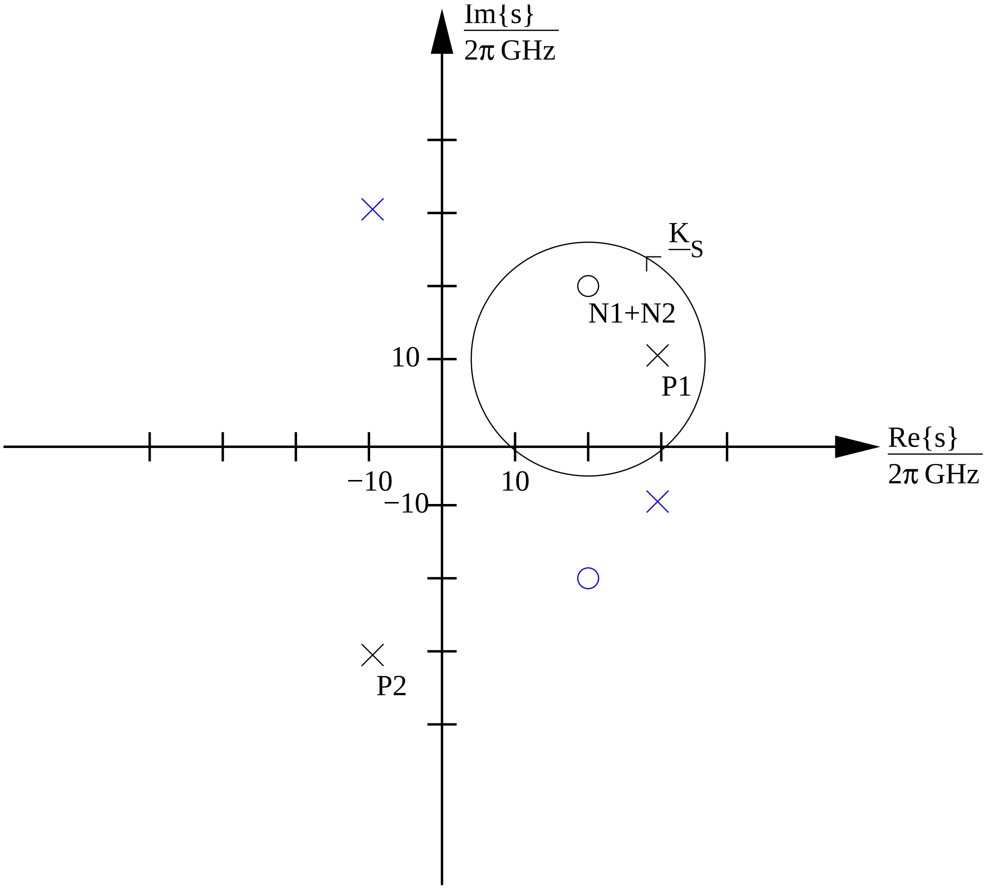
$$\tfrac{1}{3}\ \text{Dek}\,\tfrac{60\ \text{dB}}{Dek} = 20\ \text{dB}$$

$$max(a_{dB}(|v_u^3|)) = 20\ \text{dB}$$

$$20\log(|v_u^3|) = 20\ \text{dB}$$

$$\Rightarrow |v_u| = \sqrt[3]{10} \approx 2,1$$

Aufgabe B)



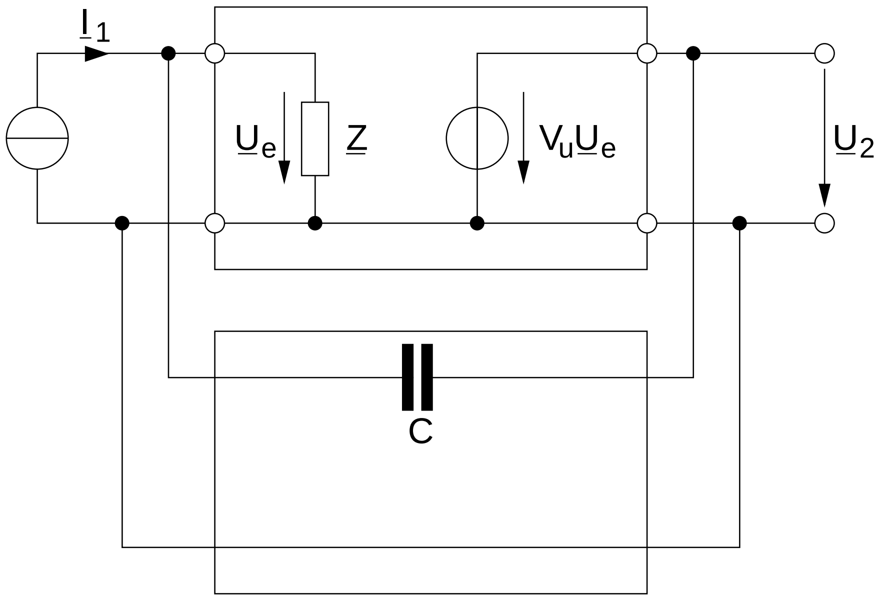
1) Ergänzungen in blau

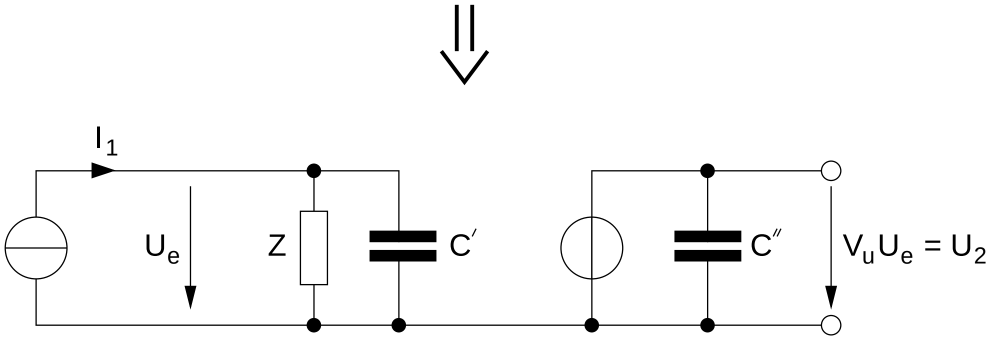
2) $Q = P - N = 1 - 2 = -1 \Rightarrow 1$ Drehung im Uhrzeigersinn

3) Das Netzwerk ist instabil, da Pole in der RHE existieren

Aufgabe C)

1)





$$\underline{U}_e = (\underline{Z}||C')\underline{I}_1 = \frac{\underline{Z}\frac{1}{sC'}}{\underline{Z}+\frac{1}{sC'}}\underline{I}_1 = \frac{1}{sC'+\frac{1}{\underline{Z}}}\underline{I}_1$$

$$\underline{U}_2 = v_u\underline{U}_e = \frac{v_u}{sC'+\frac{1}{\underline{Z}}}\underline{I}_1,\ C' = 1-v_u$$

$$\Rightarrow \frac{\underline{U}_2}{\underline{I}_1} = \frac{v_u}{s(1-v_u)C+\frac{1}{\underline{Z}}}$$

2)

$$
\begin{aligned}
&s(1-v_u)C + \frac{1}{\underline{Z}} = 0 \\
\Leftrightarrow\, &s = -\frac{1}{\underline{Z}C(1-v_u)} \quad \text{mit } \underline{Z} = R + jx \\
\Rightarrow\, &s = -\frac{1}{(R+jx)C(1-v_u)} = -\frac{R-jx}{(R^2+x^2)C(1-v_u)}
\end{aligned}
$$

stabil: $\mathrm{Re}\{s\} < 0$

$$
\mathrm{Re}\{s\} = -\frac{R}{(R^2+x^2)C(1-v_u)} < 0
$$

$$
\Rightarrow v_u \in (-\infty, 1)
$$