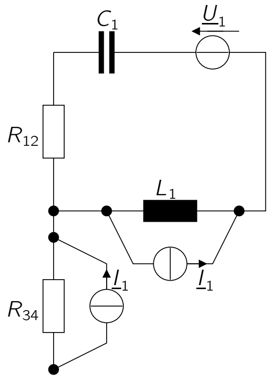
Aufgabe 1

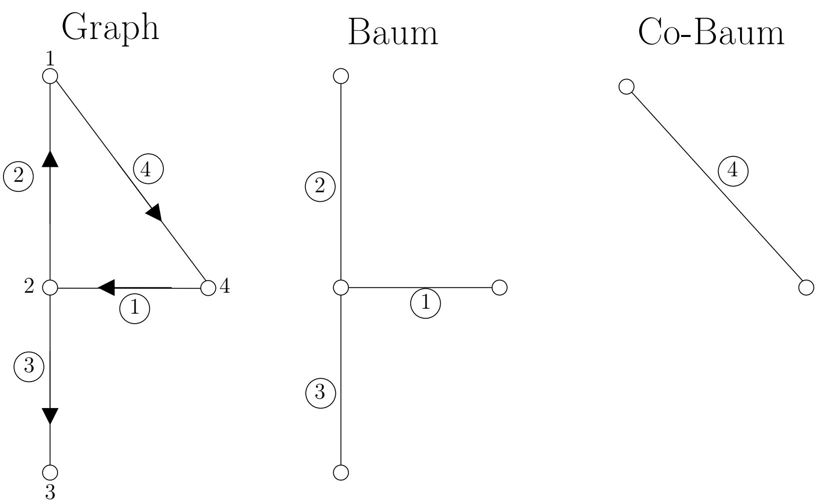
a)



$R_{12} = R_1||R_2$

$R_{34} = R_3||R_4$

b)



c)

$$Y = \begin{pmatrix} \frac{1}{sL_1} & 0 & 0 & 0 \\ 0 & \frac{1}{R_{12}} & 0 & 0 \\ 0 & 0 & \frac{1}{R_{34}} & 0 \\ 0 & 0 & 0 & sC \end{pmatrix}$$

d)

$$A = K \overset{Z}{\begin{array}{c|cccc} & 1 & 2 & 3 & 4 \\ \hline 1 & 0 & -1 & 0 & 1 \\ 2 & -1 & 1 & -1 & 0 \\ 3 & 0 & 0 & 1 & 0 \\ 4 & 1 & 0 & 0 & -1 \end{array}}$$

Knoten 2 als Bezugsknoten $\rightarrow$ Steichen 2. Zeile:

$$\Rightarrow A = \begin{pmatrix} 0 & -1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & -1 \end{pmatrix}$$

d)

$$Y_n = AYA^T = \begin{pmatrix} 0 & -1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} \frac{1}{sL_1} & 0 & 0 & 0 \\ 0 & \frac{1}{R_{12}} & 0 & 0 \\ 0 & 0 & \frac{1}{R_{34}} & 0 \\ 0 & 0 & 0 & sC \end{pmatrix} \begin{pmatrix} 0 & 0 & 1 \\ -1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & -1 \end{pmatrix}$$

$$= \begin{pmatrix} 0 & -1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} 0 & 0 & \frac{1}{sL_1} \\ -\frac{1}{R_{12}} & 0 & 0 \\ 0 & \frac{1}{R_{34}} & 0 \\ sC & 0 & -sC \end{pmatrix} = \begin{pmatrix} \frac{1}{R_{12}} + sC & 0 & -sC \\ 0 & \frac{1}{R_{34}} & 0 \\ -sC & 0 & \frac{1}{sL_1} + sC \end{pmatrix}$$

$$I_{qn} = A(I_g - YU_g) = \begin{pmatrix} 0 & -1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & -1 \end{pmatrix} \left[\begin{pmatrix} I_1 \\ 0 \\ I_1 \\ 0 \end{pmatrix} - \begin{pmatrix} \frac{1}{sL_1} & 0 & 0 & 0 \\ 0 & \frac{1}{R_{12}} & 0 & 0 \\ 0 & 0 & \frac{1}{R_{34}} & 0 \\ 0 & 0 & 0 & sC \end{pmatrix} \begin{pmatrix} 0 \\ 0 \\ 0 \\ U_1 \end{pmatrix} \right]$$

$$= \begin{pmatrix} 0 & -1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} I_1 \\ 0 \\ I_1 \\ -sC \cdot U_1 \end{pmatrix} = \begin{pmatrix} -sC \cdot U_1 \\ I_1 \\ I_1 + sC \cdot U_1 \end{pmatrix}$$

$$\underbrace{\begin{pmatrix} \frac{1}{R_{12}} + sC & 0 & -sC \\ 0 & \frac{1}{R_{34}} & 0 \\ -sC & 0 & \frac{1}{sL_1} + sC \end{pmatrix}}_{Y_n} \underbrace{\begin{pmatrix} U_{n1} \\ U_{n3} \\ U_{n4} \end{pmatrix}}_{\underline{U}_n} = \underbrace{\begin{pmatrix} -sC \cdot U_1 \\ I_1 \\ I_1 + sC \cdot U_1 \end{pmatrix}}_{\underline{I}_{qn}}$$

U_{n3} ist entkoppelt $\Rightarrow$ streichen 2. Zeile und 2. Spalte:

$$\begin{pmatrix} \frac{1}{R_{12}} + sC & -sC \\ -sC & \frac{1}{sL_1} + sC \end{pmatrix} \begin{pmatrix} U_{n1} \\ U_{n4} \end{pmatrix} = \begin{pmatrix} -sC \cdot U_1 \\ I_1 + sC \cdot U_1 \end{pmatrix}$$

$U_x = -U_{n1}$

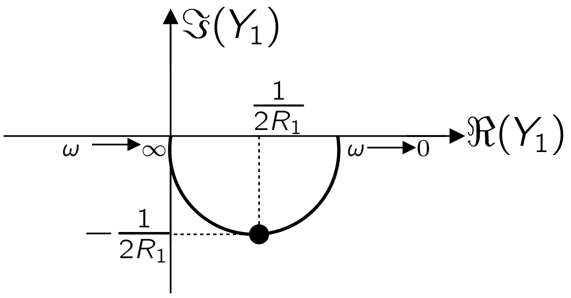
$$U_{n1} = \frac{\begin{vmatrix} -sC \cdot U & -sC \\ I_1 + sC \cdot U & \frac{1}{sL_1} + sC \end{vmatrix}}{\begin{vmatrix} \frac{1}{R_{12}} + sC & -sC \\ -sC & \frac{1}{sL_1} + sC \end{vmatrix}}$$

Aufgabe 2

a)

$$\underline{Y}_1 = \frac{1}{R_1 + j\omega L_1} \qquad \underline{Y}_2 = \frac{1}{R_2 + j\omega L_2 + \frac{1}{j\omega C_2}} = \frac{1}{R_2 + j\left(\omega L_2 - \frac{1}{\omega C_2}\right)}$$

b)



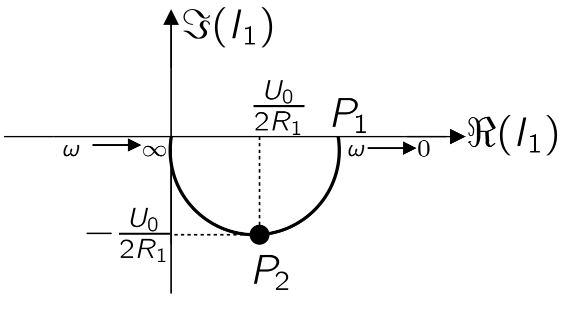
$$\max\{\Im\{\underline{Y}_1\}\} : \rightarrow \quad \Re\{\underline{Y}_1\} = \frac{1}{2R_1}$$

$$\Im\{\underline{Y}_1\} = \frac{-\omega L_1}{R_1^2 + \omega^2 L_1^2}$$

$$\Re\{\underline{Y}_1\} = \frac{R_1}{R_1^2 + \omega^2 L_1^2} \stackrel{!}{=} \frac{1}{2R_1}$$

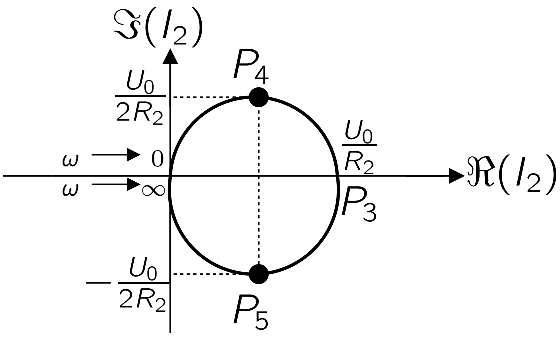
$$\Leftrightarrow \omega^2 L_1^2 = R_1^2 \Leftrightarrow \omega = \frac{R_1}{L}$$

$$\Im\left\{\underline{Y}_1\left\{\frac{R_1}{L_1}\right\}\right\} = \frac{-R_1}{R_1^2 + R_1^2} = -\frac{1}{2R_1}$$



$$P_1 : \underline{I}_1 = \frac{U_0}{R_1}$$

$$P_2 : \underline{I}_1 = \frac{U_0}{2R_1} - j\frac{U_0}{2R_1}$$

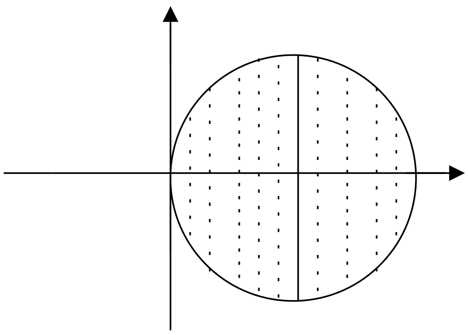


$$P_3 : \underline{I}_2 = \frac{U_0}{R_2}$$
$$P_4 : \underline{I}_2 = \frac{U_0}{2R_2} + j\frac{U_0}{2R_2}$$
$$P_5 : \underline{I}_2 = \frac{U_0}{2R_2} - j\frac{U_0}{2R_2}$$

c)

$$\frac{U_0}{R_1} \overset{!}{=} \frac{U_0}{R_2} \Leftrightarrow R_1 = R_2$$

d)



$$\underline{I}_\Delta = \underline{I}_1 - \underline{I}_2$$

$\Rightarrow$ Verbindung muss senkrecht verlaufen, damit :

$$\Re\{\underline{I}_1 - \underline{I}_2\} = 0 \Leftrightarrow \Re\{T_1\{\omega_x\}\} = \Re\{I_2\{\omega_x\}\}$$

$\Rightarrow |\Im(\underline{I}_\Delta(\omega_x))|$ möglichst groß $\Rightarrow$ in der Mitte

$$\Rightarrow \underline{I}_1\{\omega_x\} = \frac{U_0}{2R_1} - j\frac{U_0}{2R_2} \quad ; \; \underline{I}_2\{\omega_x\} = \frac{U_0}{2R_1} + j\frac{U_0}{2R_2}$$

$$\Rightarrow \underline{I}_\Delta\{\omega_x\} = -j\frac{U_0}{R_2}$$

$$\Rightarrow \quad \underline{I}_1 = \underline{Y}_1 \cdot \underline{U}_0 = \frac{1}{R_0 + j\omega L_1}\underline{U}_0 = \frac{R_0 - j\omega L_1}{R_0^2 + \omega^2 L^2{}_1}\underline{U}_0$$

$$\Re \underline{I}_1(\omega_x) = -\Im \underline{I}_1(\omega_x) \;\Leftrightarrow\; R_0 = j\omega L_1 \;\Leftrightarrow\; \omega_x = \frac{R_0}{L_1}$$

$$\underline{I}_2 = \underline{Y}_2 \cdot \underline{U}_0 = \frac{1}{R_2 + j\omega - xL_2 + \frac{1}{j\omega_x C_2}} \cdot \underline{U}_0 = \frac{j\omega_x C_2}{1 - \omega_x^2 C_2 L_2 + j\omega R_0 C_2} \cdot \underline{U}_0$$

$$= \frac{j\omega_x C_2(1 - \omega_x^2 C_2 L_2 + j\omega R_0 C_2)}{(1 - \omega_x^2 C_2 L_2)^2 + (\omega R_0 C_2)}\underline{U}_0$$

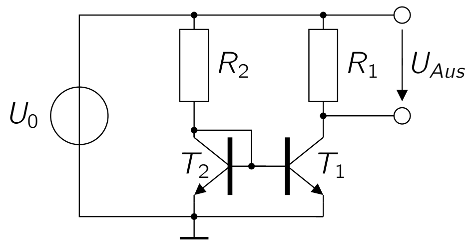
$$\Re \underline{I}_2(\omega_x) = \Im \underline{I}_2(\omega_x) \;\Leftrightarrow\; \omega_x^{\cancel{2}} R_0 C_2^{\cancel{2}} = \cancel{\omega_x C_2}(1 - \omega_x^2 C_2 L_2) \rightsquigarrow 1 - \omega_x^2 C_2 L_2 - \omega_x^2 R_0 C_2 = 0$$

$$\rightsquigarrow 1 - \frac{R_0^2}{L_1^2} C_2 L_2 - \frac{R_0^2 C_2}{L_1} = 0$$

$$\Rightarrow L_2 = \frac{1 - \frac{R_0^2\ C_2}{L_1}}{\frac{R_0^2\ C_2}{L_1^2}} = \frac{L_1^2}{R_2^2 C_2} - L_1 = L_1\left(\frac{L_1}{R_0^2 C_2} - 1\right)$$

Aufgabe 3

a)



b)

Normalaktiver Bereich für T1 :$U_{CE,1} \geq U_{BE}$

$$U_{aus,min} = 0 \;\; ; \;\; U_{aus,max} = U_0 - U_{BE,0}$$

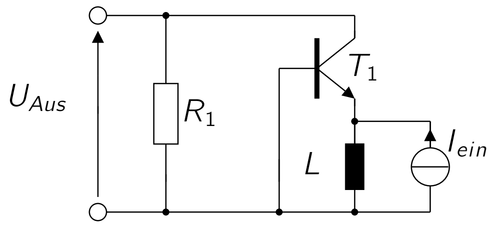
$$U_{aus,0} = \frac{1}{2}(U_{aus,max} + U_{aus,min}) = \frac{U_0 - U_{BE,0}}{2}$$

$$I_{C1,0} = \frac{U_{aus,0}}{R_1} = \frac{U_0 - U_{BE,0}}{2R_1}$$

c)

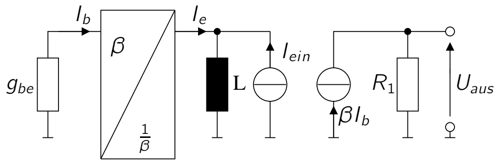
$$I_{C2,0} = I_{C1,0} \;\; ; \;\; R_2 I_{C2,0} + U_{BE,2} = U_0 \quad \Rightarrow R_2 = \frac{U_0 - U_{BE,0}}{I_{C2,0}} = 2R_1$$

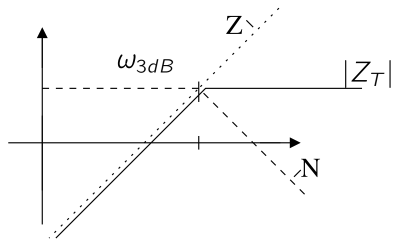
d)



Basisgrundschaltung

e)





$$\omega_{3dB} = \frac{1}{Lg_m} = \frac{r_e}{L} = \frac{U_T}{I_c L}$$

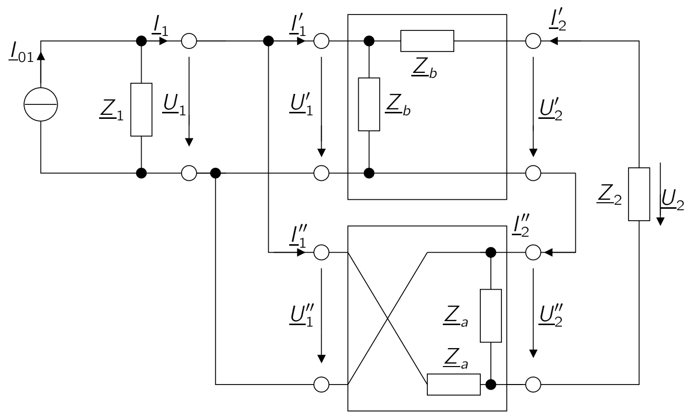
$$\begin{aligned} U_{aus} &= \beta \cdot I_b \cdot R_1 = \frac{\beta}{\beta+1} \cdot I_e \cdot R_1 \\ &= \frac{\beta}{\beta+1} \cdot (-I_{ein}) \cdot \frac{j\omega L}{\frac{1}{\beta}\frac{1}{g_{be}} + j\omega L} \cdot R_1 \\ &= -\frac{\beta}{\beta+1} \cdot R_1 \cdot \frac{j\omega L g_m}{1 + j\omega L g_m} \cdot I_{ein} \\ \Rightarrow |Z_T| &= \frac{\beta}{\beta+1} \cdot R_1 \cdot \left| \frac{j\omega L g_m}{1 + j\omega L g_m} \right| \end{aligned}$$

$Z = j\omega L g_m$ (Zähler)

$N = 1 + j\omega L g_m$ (Nenner)

Aufgabe 4

a)



b)

i)PSK
ii)$\underline{G}$-Parameter , weil:

$$\underline{U}_1' = \underline{U}_1'' = \underline{U}_1; \quad \underline{I}_2 = \underline{I}_2' + \underline{I}_2'';$$

$$\underline{I}_1 = \underline{G}_{11}'\underline{U}_1' + \underline{G}_{12}'\underline{I}_2' + \underline{G}_{11}''\underline{U}_1'' + \underline{G}_{12}''\underline{I}_2'' = (\underline{G}_{11}' + \underline{G}_{11}'')\underline{U}_1 + (\underline{G}_{12}' + \underline{G}_{12}'')\underline{I}_2$$

$$\underline{U}_2 = \underline{G}_{21}'\underline{U}_1' + \underline{G}_{22}'\underline{I}_2' + \underline{G}_{21}''\underline{U}_1'' + \underline{G}_{22}''\underline{I}_2'' = (\underline{G}_{21}' + \underline{G}_{21}'')\underline{U}_1 + (\underline{G}_{22}' + \underline{G}_{22}'')\underline{I}_2$$

$$\Rightarrow \underline{G} = \underline{G}' + \underline{G}''$$

c)

$$\underline{G}_{11}' = \left.\frac{\underline{I}_1'}{\underline{U}_1'}\right|_{\underline{I}_2'=0} = \frac{1}{\underline{Z}_b} \qquad \underline{G}_{12}' = \left.\frac{\underline{I}_1'}{\underline{I}_2'}\right|_{\underline{U}_1'=0} = -1$$

$$\underline{G}_{21}' = \left.\frac{\underline{U}_2'}{\underline{U}_1'}\right|_{\underline{I}_2'=0} = 1 \qquad \underline{G}_{22}' = \left.\frac{\underline{U}_2'}{\underline{I}_2'}\right|_{\underline{U}_1'=0} = \underline{Z}_b$$

$$\Rightarrow \underline{G}' = \begin{pmatrix} \frac{1}{\underline{Z}_b} & -1 \\ 1 & \underline{Z}_b \end{pmatrix}$$

$$\underline{G}_{11}'' = \left.\frac{\underline{I}_1''}{\underline{U}_1''}\right|_{\underline{I}_2''=0} = \frac{1}{2\underline{Z}_a} \qquad \underline{G}_{12}'' = \left.\frac{\underline{I}_1''}{\underline{I}_2''}\right|_{\underline{U}_1''=0} = \frac{1}{2}$$

$$\underline{G}_{21}'' = \left.\frac{\underline{U}_2''}{\underline{U}_1''}\right|_{\underline{I}_2''=0} = -\frac{1}{2} \qquad \underline{G}_{22}'' = \left.\frac{\underline{U}_2''}{\underline{I}_2''}\right|_{\underline{U}_1''=0} = \frac{\underline{Z}_a}{2}$$

$$\Rightarrow \underline{G}'' = \begin{pmatrix} \frac{1}{2\underline{Z}_a} & \frac{1}{2} \\ -\frac{1}{2} & \frac{\underline{Z}_a}{2} \end{pmatrix}$$

$$\Rightarrow \underline{G} = \underline{G}' + \underline{G}'' = \begin{pmatrix} \frac{1}{\underline{Z}_b} + \frac{1}{2\underline{Z}_a} & -\frac{1}{2} \\ \frac{1}{2} & \underline{Z}_b + \frac{\underline{Z}_a}{2} \end{pmatrix}$$

d)

$$\underline{U}_2 = -\underline{Z}_2 \underline{I}_2 \quad \Leftrightarrow \quad \underline{I}_2 = -\frac{\underline{U}_2}{\underline{Z}_2}$$

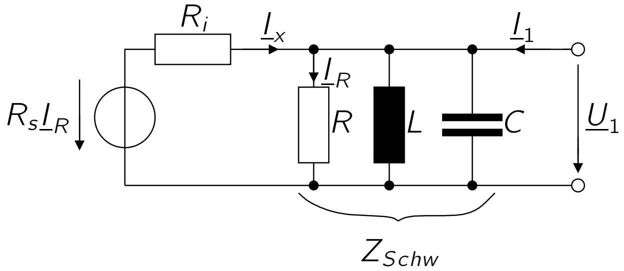
$$\underline{U}_2 = \underline{G}_{21}\underline{U}_1 + \underline{G}_{22}\underline{I}_2 = \underline{U}_1\underline{G}_{21} - \frac{\underline{G}_{22}}{\underline{Z}_2}\underline{U}_2$$

$$\Leftrightarrow \quad \underline{U}_2\left(1 + \frac{\underline{G}_{22}}{\underline{Z}_2}\right) = \underline{G}_{21}\underline{U}_1$$

$$\Rightarrow \underline{F}_U = \frac{\underline{U}_2}{\underline{U}_1} = \frac{\underline{G}_{21}}{1 + \frac{\underline{G}_{22}}{\underline{Z}_2}} = \frac{\frac{1}{2}}{1 + \frac{\underline{Z}_b + \frac{\underline{Z}_a}{2}}{\underline{Z}_2}} = \frac{\underline{Z}_2}{2\underline{Z}_2 + 2\underline{Z}_b + \underline{Z}_a}$$

$$\underline{F}_U = 0 \text{ für } |\underline{Z}_a|, |\underline{Z}_a| \longrightarrow \infty$$

Aufgabe 5



a)

$$\underline{Z}(s) = \frac{\underline{U}_1}{\underline{I}_1}$$

$$\underline{U}_1 = (\underline{I}_1 + \underline{I}_x) \cdot \underline{Z}_{Schw} \qquad \underline{I}_R = \frac{\underline{U}_1}{R} \qquad \underline{I}_x = \frac{R_s\underline{I}_R - \underline{U}_1}{R_i} = \frac{R_s\frac{\underline{U}_1}{R} - \underline{U}_1}{R_i} = \frac{\underline{U}_1}{R_i}\left(\frac{R_s}{R} - 1\right)$$

$$\underline{U}_1 = \left(\underline{I}_1 + \frac{\underline{U}_1}{R_i}\left(\frac{R_s}{R} - 1\right)\right)\underline{Z}_{Schw} \quad \Leftrightarrow \quad \underline{U}_1 \cdot \left(1 - \frac{\left(\frac{R_s}{R} - 1\right)\underline{Z}_{Schw}}{R_i}\right) = \underline{I}_1 \cdot \underline{Z}_{Schw}$$

$$\underline{Z}(s) = \frac{\underline{U}_1}{\underline{I}_1} = \frac{\underline{I}_1 \cdot \underline{Z}_{Schw}}{1 - \frac{\left(\frac{R_s}{R} - 1\right)\underline{Z}_{Schw}}{R_i}} = \frac{\frac{1}{\frac{1}{R} + \frac{1}{sL} + sC}}{1 - \left(\frac{R_s}{R} - 1\right) \cdot \frac{1}{R_i} \cdot \frac{1}{\left(\frac{1}{R} + \frac{1}{sL} + sC\right)}}$$

$$= \frac{1}{\frac{1}{R} + \frac{1}{sL} + sC - \left(\frac{R_s}{R} - 1\right) \cdot \frac{1}{R_i}} = \frac{sL \cdot R_i R}{sL \cdot R_i + R_i R + s^2 \cdot CL \cdot R_i R - (R_s - R)sL}$$

b)

Spannung soll oszillieren $\Rightarrow$ schließe hochomige Last an Oszillator an
$\Rightarrow \; \underline{I} \mapsto 0 \;\; \underline{U} = \underline{I} \cdot \underline{Z} \;\; \neq \; 0$ für Pole von $\underline{Z}$

c)

$$s^2 \cdot R_i R \cdot CL + sL \cdot (R_i - R_s + R) + R_i R \overset{!}{=} 0 \;\Leftrightarrow\; s^2 + s \cdot \frac{R_i - R_s + R}{R_i R \cdot C} + \frac{1}{CL} = 0$$

$$s_{1,2} = -\frac{R_i - R_s + R}{2R_i RC} \pm \sqrt{\left(\frac{R_i - R_s + R}{2R_i RC}\right)^2 - \frac{1}{LC}}$$

Schwingkreis entdämpft für $\sigma > 0$

$$\sigma = -\frac{R_i - R_s + R}{2R_i RC} \;,\; R > 0, R_i > 0, C > 0 \;\Rightarrow\; \sigma > 0 \quad \text{für} \quad R_s > R_i + R$$

d)

$$j\omega = \sqrt{\underbrace{\left(\frac{R_i - R_s + R}{2R_i RC}\right)^2 - \frac{1}{LC}}_{<0}} = \sqrt{\left(\frac{R - 4R + R}{2R^2 C}\right)^2 - \frac{1}{LC}} = \sqrt{\left(\frac{-\cancel{2R}}{\cancel{2}R^{\cancel{2}}C}\right)^2 - \frac{1}{LC}}$$

$$= \sqrt{\left(\frac{R - 4R + R}{2R^2 C}\right)^2 - \frac{1}{LC}} = \sqrt{\underbrace{\frac{1}{R^2C^2} - \frac{1}{LC}}_{<0}} \;\Rightarrow\; \omega = \sqrt{\frac{1}{LC} - \frac{1}{R^2C^2}}$$

$$\Rightarrow \frac{1}{L\cancel{C}} > \frac{1}{R^2 C^{\cancel{2}}} \;\rightarrow\; L < R^2 C \;\rightarrow\; \frac{L}{C} < R^2$$

e)

$\delta(t) \circ\!\!-\!\!\bullet \, 1$

$$\Rightarrow \underline{U}_1(s) = 1 \cdot \underline{Z}(s) = 1 \cdot \frac{sL \cdot R^2}{sL \cdot R + R^2 + s^2 \cdot CL \cdot R^2 - (4R - R)sL}$$

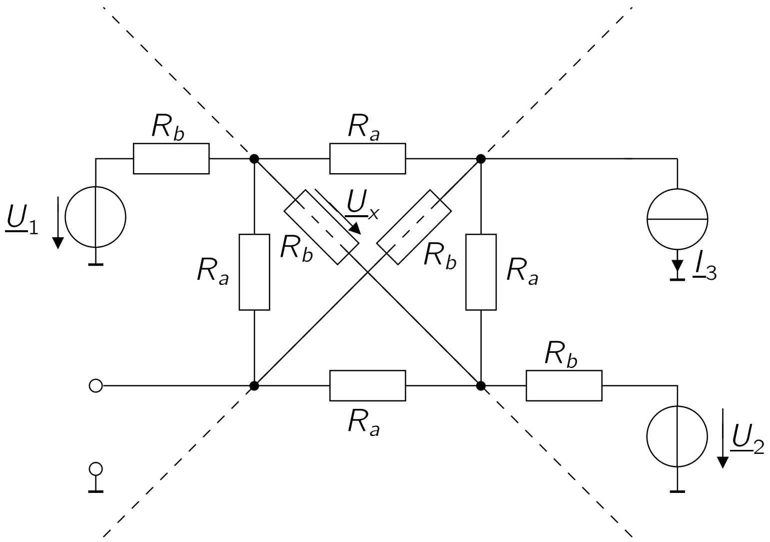
$$= 1 \cdot \frac{s\, \cancel{L \cdot R^2}}{C\cancel{L \cdot R^2} \cdot (s^2 - 2\frac{s}{CR} + \frac{1}{CL})} = \frac{1}{C} \cdot \frac{s}{(s - s_1)(s - s_2)}$$

Heavisidscher Entwicklungssatz : $u_1(t) = \sum_{s_1, s_2} \frac{\underline{Z}(s)}{\underline{N}'(s)} \cdot e^{st} \Big|_{s=s_i} = \frac{1}{C}\left(\frac{s_1}{s_1 - s_2} \cdot e^{s_1 t} \frac{s_2}{s_2 - s_1} \cdot e^{s_2 t}\right)$

mit s_1, s_2 aus Aufgabenteil c)

Aufgabe 6

a)

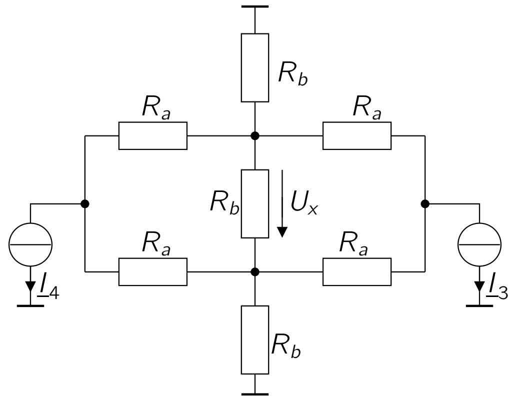


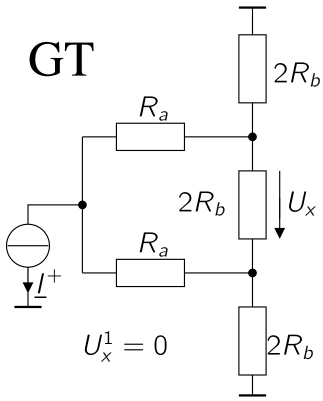
1)

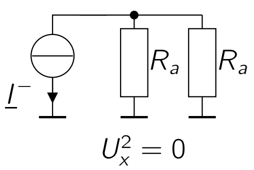
$$U_1 = U_2 = 0$$

$$\underline{I}_4 = \underline{I}^+ + \underline{I}^- = 0 \quad , \quad \underline{I}_3 = \underline{I}^+ - \underline{I}^-$$

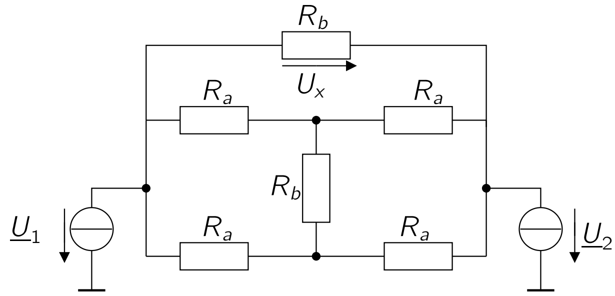
$$\underline{I}^+ = \frac{\underline{I}_3 + \underline{I}_4}{2} = \frac{\underline{I}_3}{2} \quad , \quad \underline{I}^- = \frac{\underline{I}_4 - \underline{I}_3}{2} = -\frac{\underline{I}_3}{2}$$







2)

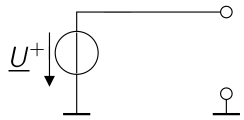


$$I_3 = 0$$

$$\underline{U}_1 = \underline{U}^+ + \underline{U}^- \quad , \quad \underline{U}_2 = \underline{U}^+ - \underline{U}^-$$

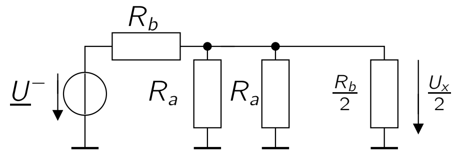
$$\underline{U}^+ = \frac{\underline{U}_2 + \underline{U}_1}{2} \quad , \quad \underline{U}^- = \frac{\underline{U}_1 - \underline{U}_2}{2}$$

GT



$$U_x^3 = 0$$

GGT



b)

$$\frac{\underline{U}_x}{2} = \underline{U}^- \cdot \frac{R_a||R_a||\frac{R_b}{2}}{R_b + (R_a||R_a||\frac{R_b}{2})} \overset{(*)}{=} \frac{\frac{1}{2}R_aR_b}{R_b(R_a+R_b) + \frac{1}{2}R_aR - b}\underline{U}^-$$

$$\Rightarrow \underline{U}_x = \frac{R_a}{\frac{3}{2}R_a + R_b} \cdot (\underline{U}_1 - \underline{U}_2)$$

$$(*) \qquad R_a||R_a||\frac{R_b}{2} = \frac{\frac{R_a}{2}\frac{R_a}{2}}{\frac{R_a}{2} + \frac{R_a}{2}} = \frac{1}{2}\frac{R_aR_b}{R_a + R_b}$$

Aufgabe 7

a)

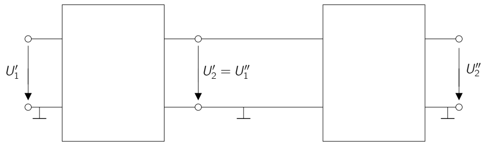
$$F = \frac{\underline{U}_2}{\underline{U}_1} \qquad \underline{U}_2 = v_u \underline{U}_d$$

$$\underline{U}_d = k_F \underline{U}_1 - k_R \underline{U}_2 \qquad \frac{\underline{U}_2}{\underline{U}_1} = \frac{v_u k_F}{1 + v_u k_R}$$

$$k_F = \left.\frac{\underline{U}_d}{\underline{U}_1}\right|_{\underline{U}_2=0} = \frac{\underline{z}_2}{\underline{z}_1 + \underline{z}_2} \qquad k_R = -\left.\frac{\underline{U}_d}{\underline{U}_2}\right|_{\underline{U}_1=0} = -\frac{\underline{z}_1}{\underline{z}_1 + \underline{z}_2}$$

$$\Rightarrow \quad \frac{\underline{U}_2}{\underline{U}_1} = \frac{v_u \frac{\underline{z}_2}{\underline{z}_1 + \underline{z}_2}}{1 - v_u \frac{\underline{z}_1}{\underline{z}_1 + \underline{z}_2}}$$

b)



$$\frac{U_2''}{U_1'} = \frac{U_2'}{U_1'}\frac{U_2''}{U_2'} = \frac{\alpha\frac{\underline{Z}_2'}{\underline{Z}_1'+\underline{Z}_2'}}{1-\alpha\frac{\underline{Z}_1'}{\underline{Z}_1'+\underline{Z}_2'}} \cdot \frac{\alpha\frac{\underline{Z}_2''}{\underline{Z}_1''+\underline{Z}_2''}}{1-\alpha\frac{\underline{Z}_1''}{\underline{Z}_1''+\underline{Z}_2''}} = \frac{\alpha\frac{R_1}{R_1+\frac{1}{j\omega C_1}}}{1-\alpha\frac{\frac{1}{j\omega C_1}}{R_1+\frac{1}{j\omega C_1}}} \cdot \frac{\alpha\frac{R_2+\frac{1}{j\omega C_2}}{R_2+R_2+\frac{1}{j\omega C_2}}}{1-\alpha\frac{R_2}{R_2+R_2+\frac{1}{j\omega C_2}}}$$

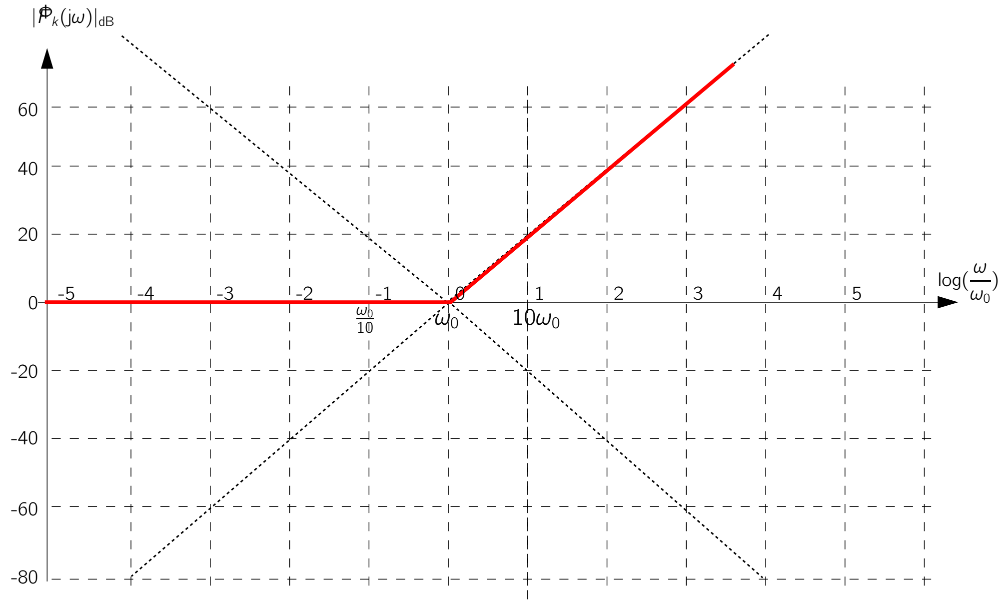
$$= \frac{\alpha R_1}{(1-\alpha)\frac{1}{j\omega C_1}+R_1} \cdot \frac{\alpha(R_2+\frac{1}{j\omega C_2})}{(1-\alpha)R_2+R_2+\frac{1}{j\omega C_2}} = \frac{j\omega R_1 C_1}{(\frac{1}{\alpha}-1)+\frac{j\omega R_1 C_1}{\alpha}} \cdot \frac{1+j\omega R_2 C_2}{(\frac{1}{\alpha}-1)j\omega R_2 C_2+\frac{1+j\omega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

$$\overset{\alpha\to\infty}{=} -j\omega R_1 C_1 \cdot \frac{1+j\omega R_2 C_2}{-j\omega R_2 C_2} \qquad \Rightarrow \underline{F}_k = j\frac{\omega}{\omega_1} \cdot \frac{1+j\frac{\omega}{\omega_2}}{j\frac{\omega}{\omega_2}}$$

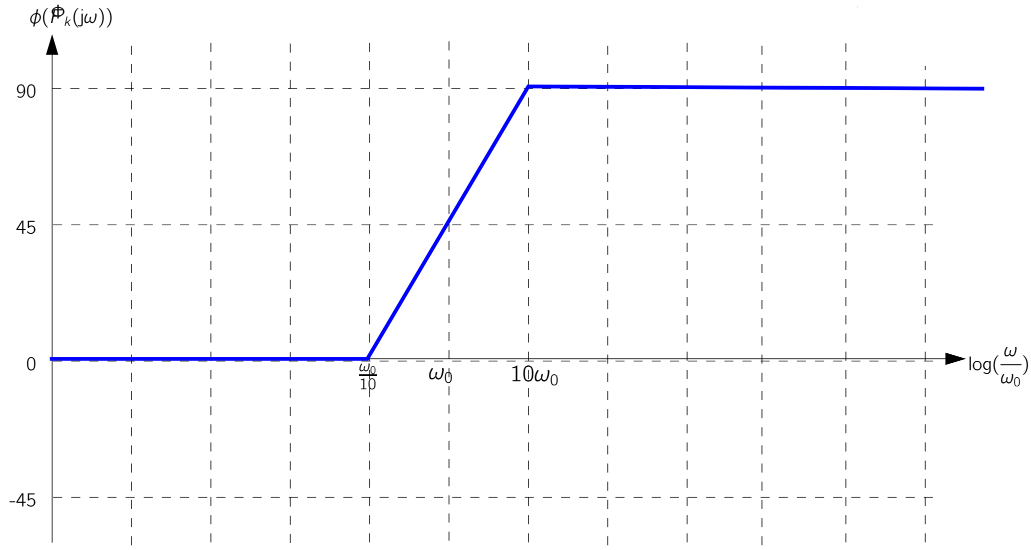
c)

$$\omega_1 = \omega_2 = \omega_0 \qquad \Rightarrow R_1 C_1 = R_2 C_2 \qquad \Rightarrow \underline{F}_k = 1 + j\frac{\omega}{\omega_0}$$

d)



|Φ_k(jω)|_dB
60
40
20
0
-20
-40
-60
-80
-5
-4
-3
-2
-1
0
1
2
3
4
5
log(ω/ω_0)
ω_0/10
ω_0
10ω_0



ϕ(Φ_k(jω))
90
45
0
-45
ω_0/10
ω_0
10ω_0
log(ω/ω_0)