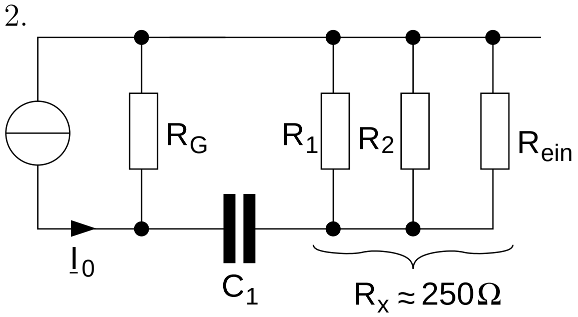
Aufgabe A)

1. $I_C = 10\ mA \rightarrow I_B = \frac{I_C}{\beta_0} = 0,1\ mA$
Daumenregel: $I_{ST} = 10 I_B = 1\ mA \quad \rightarrow \frac{U_{CC}}{I_{ST}} = R_{ges} = \frac{5\ V}{1\ mA} = 5000\ \Omega$
$U_E = R_E I_C = 100\ \Omega \cdot 0,01\ A = 1\ V$
Aus Maschenumlauf folgt:

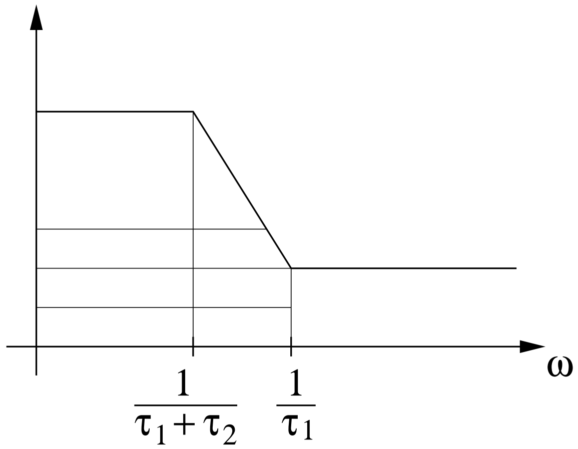
$$U_2 = U_{BE} + U_E = 1,7\ V$$
$$\rightarrow R_2 = \frac{U_2}{I_{ST}} = \frac{1,7V}{1mA} = 1700\ \Omega$$
$$\rightarrow R_1 = R_{ges} - R_2 = 3300\ \Omega$$

2.



$$U_1 = I_0 \left[R_G || \left(\frac{1}{j\omega C_1} + R \right) \right] = I_0 \frac{R_G \frac{1+j\omega\tau_1}{j\omega C_1}}{R_G + \frac{1+j\omega\tau_1}{j\omega C_1}} \quad (1)$$
$$U_1 = R_G I_0 \frac{1 + j\omega\tau_1}{1 + j\omega(\tau_1 + \tau_2)} \quad (2)$$

$\tau_1 = C_1 R_x \quad \tau_2 = C_1 R_G$



$$U_1 = R_G I_0 \frac{\sqrt{1+(\omega\tau_1)^2}}{\sqrt{1+\omega^2(\tau_1+\tau_2)^2}} e^{j(arctan(\frac{\omega\tau_1}{1})-arctan(\omega(\tau_1+\tau_2)))}$$

$\sqrt{1+(\omega\tau_1)^2} = x \qquad \omega \to 0: \; x = 1$

für x=$\sqrt{2}: \omega = \frac{1}{\tau_1} \;\to\; 2\pi 100Hz = \frac{1}{C_1 R_x} \quad \to C_1 = \frac{1}{2\pi 100Hz\, R_x}$

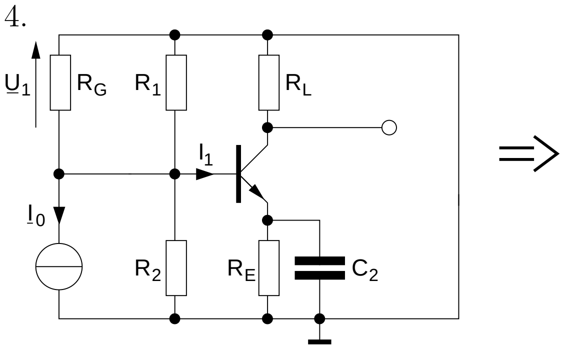
3.

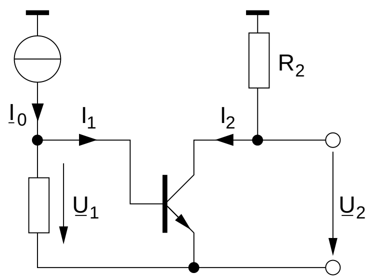
$|R_E \parallel C_2| = \frac{1}{100}\, R_E$

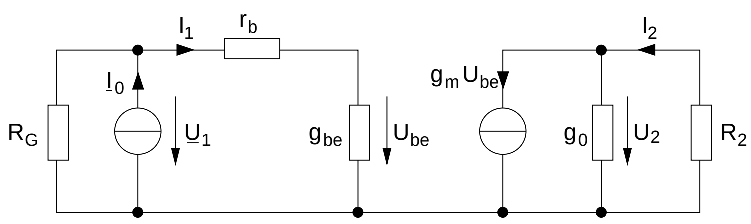
$$\frac{R_E}{j\omega R_E C_2 + 1} = \frac{1}{100} R_E$$

$\Rightarrow \sqrt{1+(\omega R_E C_2)^2} = 100 \qquad C_2 = \sqrt{\frac{100^2-1}{\omega^2 R_E^2}} \approx \sqrt{\frac{1}{\omega^2}}$ =1,6 mF

4.







$$g_m = \frac{\partial I_C}{\partial U_{BE}} = \frac{\partial I_S(1+\frac{U_{CE}}{U_A})e^{\left(\frac{U_{BE}}{U_T}\right)}}{\partial U_{BE}} = \frac{I_C}{U_T} = \frac{10mA}{27mV} \approx 1/3\ S$$

$$\frac{\partial U_{BE}}{\partial I_B} = \frac{\partial U_{BE}}{\partial I_C}\frac{\partial I_C}{\partial I_B} = \frac{1}{g_m}\beta_0 = \frac{1}{g_{be}} \quad \Rightarrow g_{be} = \frac{g_m}{\beta_0} = 3{,}7 \text{ mS}$$

$$g_0 = \frac{\partial I_C}{\partial U_{CE}} = \frac{\partial I_S(1+\frac{U_{CE}}{U_A})e^{\left(\frac{U_{BE}}{U_T}\right)}}{\partial U_{CE}} = \frac{I_S}{U_a}e^{(\frac{U_{BE}}{U_T})} = \frac{10mA}{100V} = 100\ \mu S$$

5. $ges: \underline{V}_U = \frac{\underline{U}_2}{\underline{U}_1}, \quad \underline{V}_I = \frac{\underline{I}_2}{\underline{I}_1}, \quad \underline{R}_{ein} = \frac{\underline{U}_1}{\underline{I}_1}, \quad \underline{R}_{aus} = \frac{\underline{U}_2}{\underline{I}_2}$

$$\begin{pmatrix} G_y+g_b & -g_b & 0 \\ -g_b & g_b+g_{be} & 0 \\ 0 & 0 & g_0+G_L \end{pmatrix} \begin{pmatrix} U_1' \\ U_2' \\ U_3' \end{pmatrix} = \begin{pmatrix} I_0 \\ 0 \\ -g_m U_2' \end{pmatrix}$$

$$U_3' = \frac{\begin{vmatrix} G_y+g_b & -g_b & I_0 \\ -g_b & g_b+g_{be} & 0 \\ 0 & 0 & -g_m U_2' \end{vmatrix}}{\begin{vmatrix} G_y+g_b & -g_b & 0 \\ -g_b & g_b+g_{be} & 0 \\ 0 & 0 & g_0+G_L \end{vmatrix}} = \frac{-g_m U_2'((G_y+g_b)(g_b+g_{be})-g_b^2)}{(g_0+G_L)((G_y+g_b)(g_b+g_{be})-g_b^2)}$$

$$= \frac{-g_m U_2'}{g_0+G_L}$$

$$U_2' = \frac{\frac{1}{g_{be}}}{\frac{1}{g_{be}}+r_b}U_1' \Rightarrow \frac{U_2'}{U_1'} = \frac{\frac{1}{g_{be}}}{\frac{1+r_b g_{be}}{g_{be}}} = \frac{1}{1+r_b g_{be}}$$

$$\Rightarrow \underline{V}_U = \frac{U_3'}{U_1'} = \frac{\frac{-g_m}{g_b e r_b+1}}{g_0+G_L} = -g_m R_L$$

$\underline{V}_I$:

$$\begin{aligned}
I_{out} &= g_m U_{be} = \beta I_1 \\
\frac{I_{out}}{I_2} &= \frac{R_L}{R_{ges}} = \frac{R_L}{(g_0 + R_L)^{(-1)}} = g_0 R_L + 1 \\
\beta I_1 &= (g_0 R_L + 1) I_2 \\
\Rightarrow V_I &= \frac{I_2}{I_1} = \frac{\beta}{g_0 R_L + 1}
\end{aligned}$$

$\underline{R}_{ein}$:

$$\begin{aligned}
U &= RI \\
&= r_b + \frac{1}{g_{be}} I_1 = \frac{r_b g_{be} + 1}{g_{be}} I_1 \quad \leftarrow g_{be} = \frac{g_m}{\beta} \\
&= \frac{\frac{r_b g_m + \beta}{\beta}}{\frac{g_m}{\beta}} = \frac{r_b g_m + \beta}{g_m} = r_b + \frac{\beta}{g_m} = r_b + \beta r_e
\end{aligned}$$

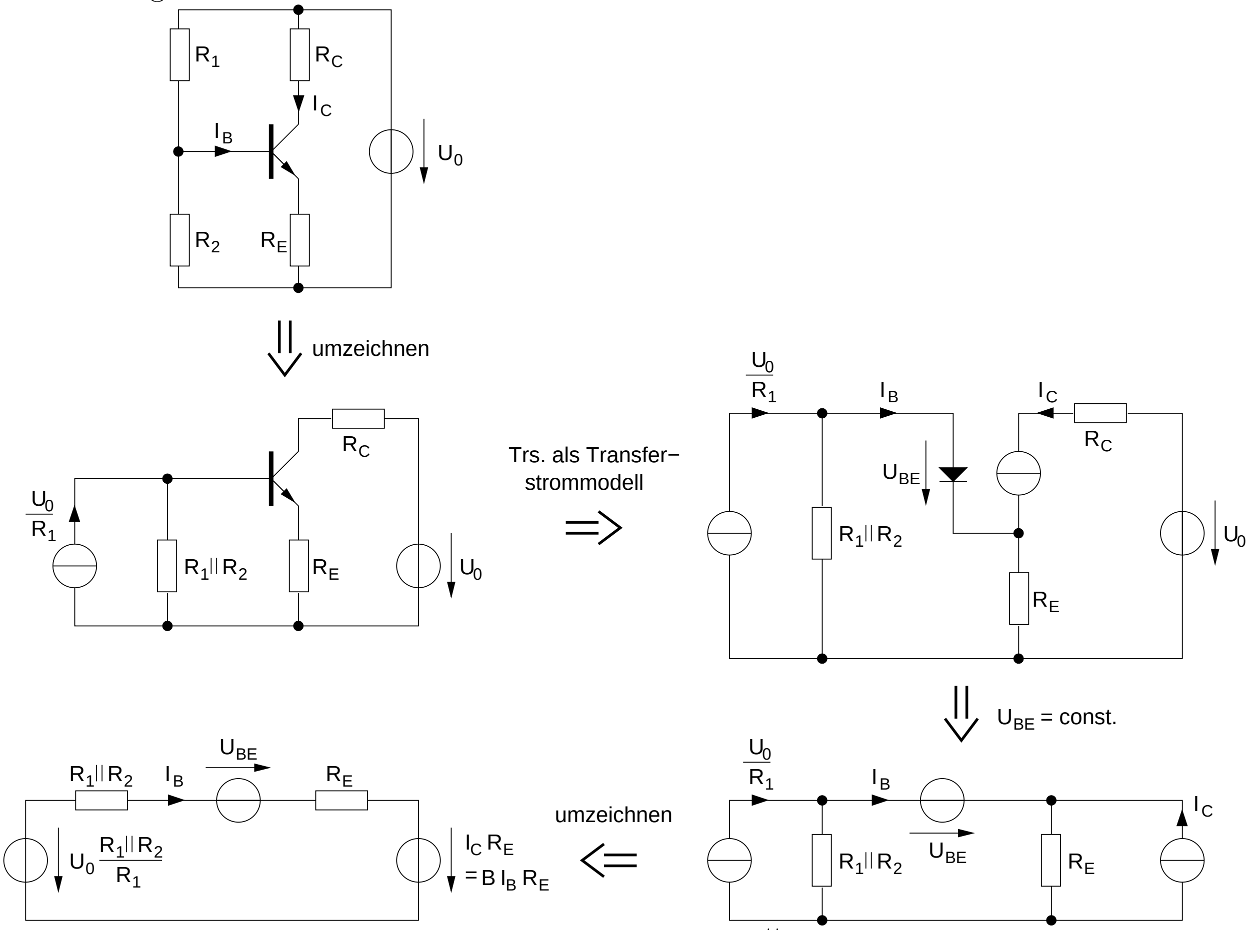
$\underline{R}_{aus}$:

$$\underline{R}_{aus} = \frac{\underline{U}_2}{\underline{I}_2}\Big|_{\underline{I}_1 = 0} = \frac{1}{g_0}$$

Aufgabe B)

Berechnen von I_C unter der Annahme, dass U_{BE} = const.

Umformungen:



$$\Rightarrow I_B = (U_0 \tfrac{R_1||R_2}{R_1} - U_{BE} - \beta I_B R_E)\frac{1}{R_1||R_2 + R_E} \qquad \frac{R_1||R_2}{R_1} = \frac{R_2}{R_1 + R_2}$$

$$I_B \left(1 + \tfrac{\beta R_E}{R_1||R_2 + R_E}\right) = \left(U_0 \tfrac{R_2}{R_1 + R_2} - U_{BE}\right) \frac{1}{R_1||R_2 + R_E}$$

$$I_B = \frac{U_0 \frac{R_2}{R_1+R_2} - U_{BE}}{R_1||R_2 + \beta R_E} \overset{\beta \gg 1}{\approx} \frac{U_0 \frac{R_2}{R_1+R_2} - U_{BE}}{R_1||R_2 + \beta R_E} \overset{\mathrm{R_1||R_2 \ll \beta R_E}}{\approx} \frac{U_0 \frac{R_2}{R_1+R_2} - U_{BE}}{\beta R_E}$$

$$I_C = \beta I_B = \frac{U_0 \frac{R_2}{R_1+R_2} - U_{BE}}{R_E}$$

Aufgabe C)

Aus Maschenumlauf:

$$U_D + U_{aus}\frac{R_2}{R_2+R_1} - U_{ein} = 0 \qquad U_{aus} = V_u U_d \Rightarrow\ U_d = \frac{U_{aus}}{V_u}$$

$$U_{ein} = \frac{U_{aus}}{V_u} + U_{aus}\frac{R_2}{R_2+R_1}$$

$$\frac{U_{ein}}{U_a} = \frac{1}{V_u} + \frac{R_2}{R_2+R_1} = \frac{R_1+R_2+R_2V_u}{V_u(R_1+R_2)}$$

$$\Rightarrow \frac{U_a}{U_e} = \frac{V_u(R_1+R_2)}{(R_1+R_2)+R_2V_u} = \frac{V_u}{1+\frac{R_2}{(R_1+R_2)}V_u}$$

Vergleich: $F_a = V_u \quad F_2 = \frac{R_2}{R_1+R_2}$