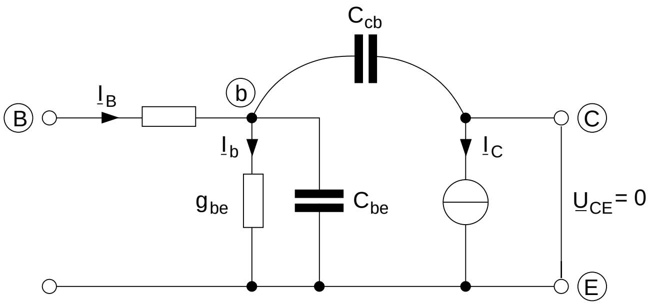
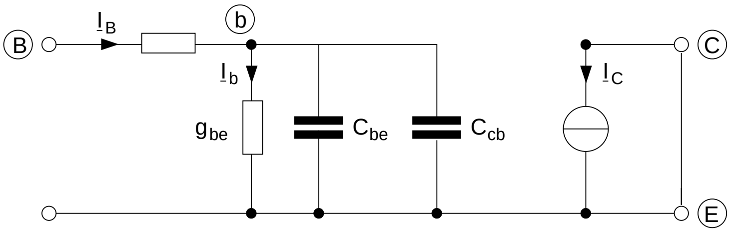
Aufgabe A)

1) ges.: $\beta\,|_{U_{CE}=0} = \frac{\underline{I}_C}{\underline{I}_B}$




$$C_{cb} \ll C_{be} \Rightarrow C = C_{cb} + C_{be} \approx C_{be}$$

$$\underline{I}_C = \beta_0 \underline{I}_b$$

$$\underline{I}_b = \frac{g_{be}}{g_{be} + j\omega C_{be}} \underline{I}_B \Rightarrow \underline{I}_C = \frac{\beta_0 g_{be}}{g_{be} + j\omega C_{be}} \underline{I}_B$$

$$\Leftrightarrow \underline{\beta} = \frac{\underline{I}_C}{\underline{I}_B} = \frac{\beta_0 g_{be}}{g_{be} + j\omega C_{be}} = \frac{\beta_0}{1 + j\omega \frac{C_{be}}{g_{be}}}$$

2) ges.: 3dB Grenzfrequenz

$$|\underline{\beta}| \stackrel{!}{=} \frac{|\beta_0|}{\sqrt{2}}$$

$$\Leftrightarrow \frac{|\beta_0|}{|1 + j\omega \frac{C_{be}}{g_{be}}|} = \frac{|\beta_0|}{\sqrt{2}}$$

$$\Leftrightarrow \sqrt{2} = |1 + j\omega \frac{C_{be}}{g_{be}}| = \sqrt{1 + \omega^2 \frac{C_{be}^2}{g_{be}^2}}$$

$$\Rightarrow 2 = 1 + \omega^2 \frac{C_{be}^2}{g_{be}^2}$$

$$\Leftrightarrow \omega^2 = \frac{C_{be}^2}{g_{be}^2} \Rightarrow \omega = \frac{C_{be}}{g_{be}} =: \omega_\beta$$

3) Näherung für $\underline{\beta}$

$$T \ll \frac{C_{be}\beta_0}{g_m}, \qquad T = \frac{1}{f}; \frac{\beta_0}{g_m} = \frac{1}{g_{be}} \Rightarrow \frac{C_{be}\beta_0}{g_m} = \frac{1}{\omega_\beta}$$

$$\Leftrightarrow \frac{1}{f} \ll \frac{1}{\omega_\beta}$$

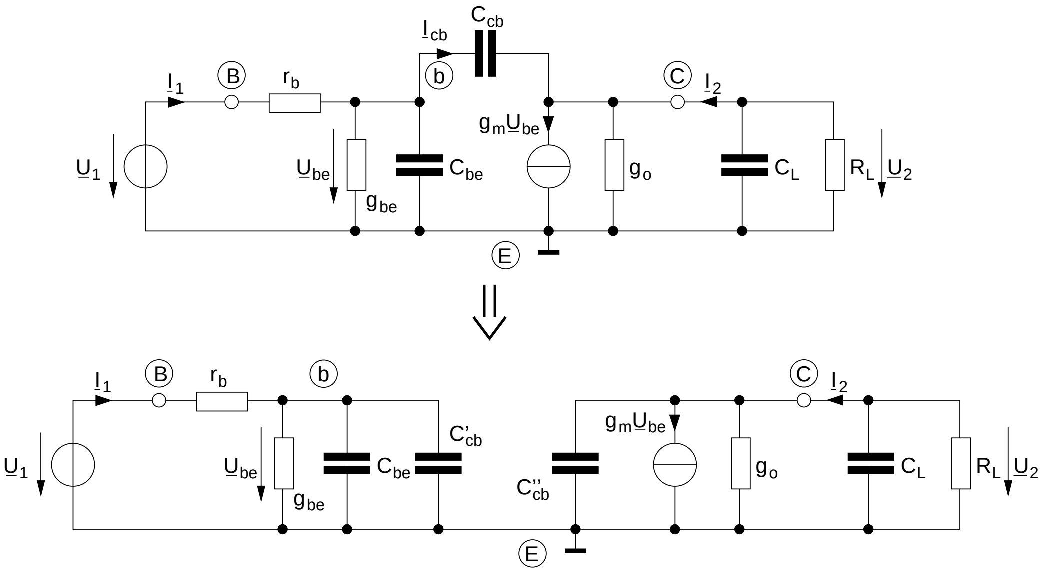
$$\Leftrightarrow f \gg \omega_\beta$$

$$\Rightarrow \omega = 2\pi f \gg \omega_\beta$$

$$\Rightarrow \underline{\beta} = \frac{\beta_0}{1 + j \underbrace{\frac{\omega}{\omega_\beta}}_{\gg 1}} \approx \frac{\beta\omega_\beta}{j\omega}$$

Aufgabe B)

1) ges.: komplexe Spannungsverstärkung $\underline{V}_U = \frac{\underline{U}_2}{\underline{U}_1}$
Ansatz: Zerlegung der Kollektor-Basis-Kapazität mittels Miller-Theorem in $C'_{cb} \| C_{be}$ und $C''_{cb} \| C_L$




Transformation mit Miller-Theorem

$$\underline{I}_{cb} = j\omega C_{cb}(\underline{U}_{be} - \underline{U}_2)$$

$$= j\omega C_{cb}(1 - \frac{\underline{U}_2}{\underline{U}_{be}})\underline{U}_{be}; \quad \underline{V}'_U := \frac{\underline{U}_2}{\underline{U}_{be}}$$

$$\Rightarrow \underline{Z}'_{cb} = \frac{\underline{U}_{be}}{\underline{I}_{cb}} = \frac{1}{j\omega C_{cb}(1 - \underline{V}'_U)} = \frac{1}{j\omega C'_{cb}}$$

$$\Rightarrow C'_{cb} = C_{cb}(1 - \underline{V}'_U)$$

$$\underline{I}_{cb} = j\omega C_{cb}(\underline{U}_{be} - \underline{U}_2)$$

$$= j\omega C_{cb}(\frac{\underline{U}_{be}}{\underline{U}_2} - 1)\underline{U}_2$$

$$= j\omega C_{cb}(\frac{1}{\underline{V}'_U} - 1)\underline{U}_2$$

$$\Rightarrow \underline{Z}''_{cb} = -\frac{\underline{U}_2}{\underline{I}_{cb}} = \frac{1}{j\omega C_{cb}(1 - \frac{1}{\underline{V}'_U})} = \frac{1}{j\omega C'_{cb}}$$

$$\Rightarrow C''_{cb} = C_{cb}(1 - \frac{1}{\underline{V}'_U})$$

$$\underline{I}_{cb} = j\omega C_{cb}(\underline{U}_{be} - \underline{U}_2) = g_m\underline{U}_{be} + (g_0 + G_L + j\omega C_L)\underline{U}_2$$

$$\Leftrightarrow -(g_0 + G_L + j\omega(C_{cb} + C_L))\underline{U}_2 = (g_m - j\omega C_{cb})\underline{U}_{be}$$

$$\Leftrightarrow \underline{V}'_U = \frac{\underline{U}_2}{\underline{U}_{be}} = -\frac{g_m - j\omega C_{cb}}{g_0 + G_L + j\omega(C_{cb} + C_L)}$$

$$\underline{U}_{be} = \frac{Z_b}{r_b + Z_b}\underline{U}_1 = \frac{1}{r_b Y_b + 1}\underline{U}_1$$

mit $Y_b = g_{be} + j\omega(C_{be} + C'_{cb})$

$$\underline{U}_{be} = \frac{1}{1 + r_b g_{be} + j\omega r_b(C_{be} + C'_{cb})}\underline{U}_1$$

$$\underline{I}_2 = g_m \underline{U}_{be} + (g_0 + j\omega C''_{cb})\underline{U}_2 = -(G_L + j\omega C_L)\underline{U}_2$$

$$\Leftrightarrow \underline{U}_2 = -g_m \underline{U}_{be} \frac{1}{g_0 + G_L + j\omega(C''_{cb} + C_L)}$$

$$\Rightarrow \underline{V}_u = \frac{\underline{U}_2}{\underline{U}_1} = \frac{-g_m}{g_0 + G_L + j\omega(C''_{cb} + C_L)} \frac{1}{1 + r_b g_{be} + j\omega r_b (C_{be} + C'_{cb})}$$

2) ges.: $\underline{Z}_{ein}$ und $\underline{Z}_{aus}$

$$\underline{Z}_{ein} = \frac{\underline{U}_1}{\underline{I}_1} = r_b + g_{be}||C_{be}||C'_{cb} = r_b + \frac{1}{g_{be} + j\omega(C_{be} + C'_{cb})}$$

$$\underline{Z}_{aus} = \frac{\underline{U}_2}{\underline{I}_2} = g_0||G_L||C_L||C''_{cb} = \frac{1}{g_0 + G_L + j\omega(C_{be} + C''_{cb})}$$