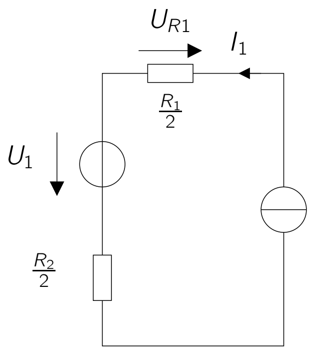
Aufgabe 1

a) (i) Spannung U_{R1} :



$$\Rightarrow U_{R1} = \frac{-R_1}{2} I_1$$

(ii) $P_{\sum}$:

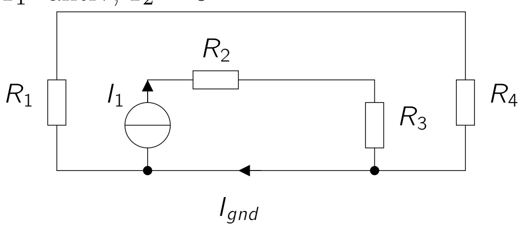
$$U_{R2} = \frac{R_2}{R_1} U_{R1} = -\frac{R_2}{2} I_1$$
$$\Rightarrow P_{\sum} = 2\frac{{U_{R1}}^2}{R_1} + 2\frac{{U_{R2}}^2}{R_2}$$
$$= \frac{1}{2} R_1 {I_1}^2 + \frac{1}{2} R_2 {I_1}^2$$

b) I_2, I_3:

$$I_1 = I_2$$
$$I_1 = -I_3$$

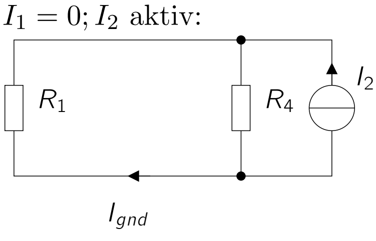
c) I_{gnd} :

I_1 aktiv; $I_2 = 0$



$\rightarrow I_{gnd} = I_1$

$I_1 = 0; I_2$ aktiv:

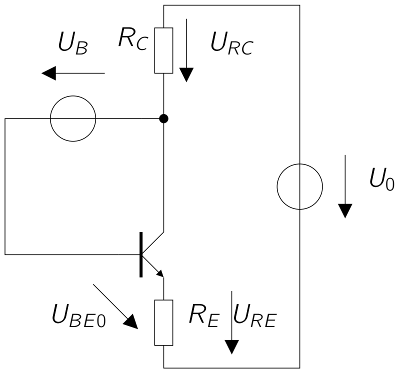


Stromteiler: $I_{gnd} = -\dfrac{\dfrac{1}{R_1}}{\dfrac{1}{R_1} + \dfrac{1}{R_4}} I_2 = -\dfrac{R_4}{R_1 + R_4} I_2$

$\Rightarrow I_{gnd} = I_1 - \frac{R_4}{R_1+R_4} I_2$

Aufgabe 2

a) Gleichstromersatzschaltbild:



b) Dimensionierungsvorschrift:

$$U_{RC} \stackrel{!}{=} \frac{U_0}{2} \qquad \Rightarrow I_C = \frac{U_{RC}}{R_C} = \frac{U_0}{2R_c}$$

$$I_E \approx I_C, \text{da } I_B \ll I_C \qquad \Rightarrow U_{RE} = R_E I_E = R_E I_C = \frac{R_E}{2R_C} U_0$$

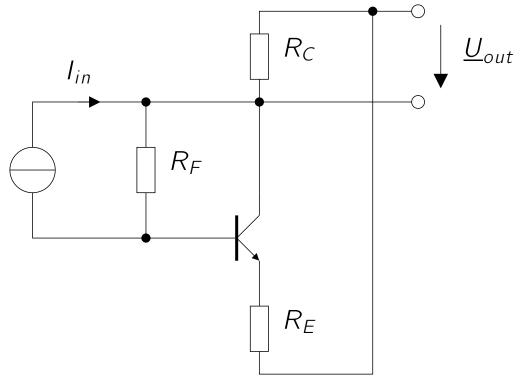
$$U_{RC} + U_B + U_{BE0} + U_{RE} - U_0 = 0 \qquad \Leftrightarrow \frac{U_0}{2} + U_B + U_{BE0} + \frac{R_E}{2R_C} U_0 - U_0 = 0$$

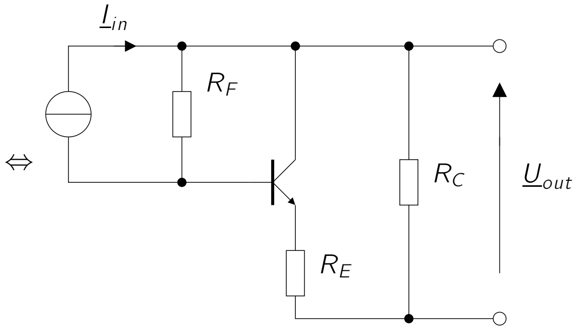
$$\Leftrightarrow U_B = U_0 \left(1 - \frac{1}{2} - \frac{R_E}{2R_C}\right) - U_{BE0} \qquad = U_0 \left(\frac{1}{2} - \frac{R_E}{2R_C}\right) - U_{BE0}$$

c) normal-aktiv:

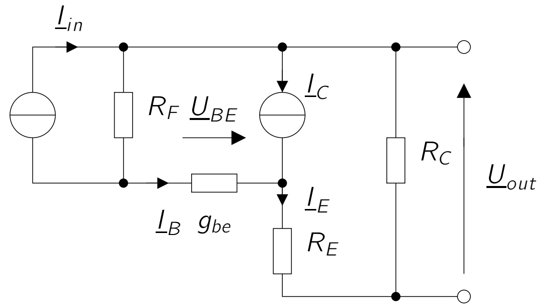
$$U_{BE} > 0 \ ; \ U_{BC} < 0 \ ; \ I_C > 0$$
$$U_B = -U_{BC} < 0 \quad \Leftrightarrow U_B > 0$$
$$U_{RC} + U_B + U_{BE} + U_{RE} - U_0 = 0 \ \Leftrightarrow U_{BE} = U_0 - U_{RC} - U_{RE} - U_B$$
$$U_{BE} = U_0 - (R_C + R_E) I_C - U_B > 0$$
$$\Leftrightarrow U_B < U_0 - (R_C + R_B) I_C$$
Grenzfall ($U_{BE} \to 0 \Rightarrow I_C \to 0$) :
$$U_B < U_0$$
$$\Rightarrow 0 < U_B < U_0$$

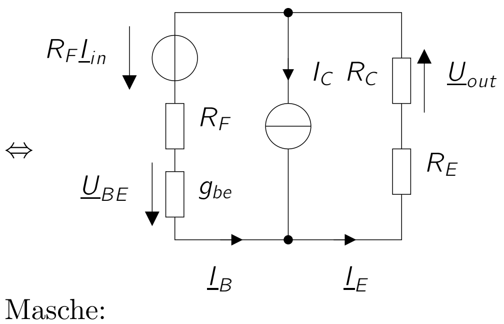
d) WS-ESB:





e) Kleinsignal-Wechselstromersatzschaltbild:





Masche:

$$R_F \underline{I}_{in} + R_F g_{be} \underline{U}_{BE} + \underline{U}_{BE} = -\underline{U}_{out} - \frac{R_E}{R_C} \underline{U}_{out}$$

$$\Leftrightarrow R_F \underline{I}_{in} + (1 + R_F g_{be}) \underline{U}_{BE} = -\underline{U}_{out} \left(1 + \frac{R_E}{R_C}\right) \tag{1}$$

$$U_{out} = R_C I_E = R_C(\underline{I}_B + \underline{I}_C) = R_C \underbrace{\left(\frac{1}{\beta_0} + 1\right)}_{\approx 1} \underline{I}_C = R_C g_m \underline{U}_{BE} \tag{2}$$

$$(1), (2) \rightarrow R_E \underline{I}_{in} + (1 + R_F g_{be}) \frac{\underline{U}_{out}}{R_C g_m} + \underline{U}_{out} \left(1 + \frac{R_E}{R_C}\right) = 0$$

$$\Leftrightarrow \underline{H} = \frac{\underline{U}_{out}}{\underline{I}_{in}} = -\frac{R_F}{\frac{1 + R_F g_{be}}{R_C g_m} + 1 + \frac{R_E}{R_C}}$$

$$= -\frac{R_F R_C}{R_E + R_C + \frac{1}{g_m} + R_F \frac{1}{\beta_0}}$$

Aufgabe 3

a) $u_{CE}(t) = 0\,\mathrm{V} \;\Rightarrow I_{C,max} = \frac{U_0}{R_C} = \frac{10\,\mathrm{V}}{500\,\Omega} = 20\,\mathrm{mV}$

b) $I_B \approx 100\,\mathrm{\mu A}$

c) Dimensionierung:

$$I_{in}(t) = I_B(t) + \frac{U_{BE}}{R_B}$$
$$\Leftrightarrow R_B = \frac{U_{BE}}{I_{in}(t) - i_B(t)} = \frac{0{,}7\,\mathrm{V}}{1\,\mathrm{mA} - 100\,\mathrm{\mu A}} = 778\,\Omega$$

d) $I_{C,max}$:

$$I_{C,max} = \frac{U_0 - 0{,}3\,\mathrm{V}}{R_C} = \frac{10\,\mathrm{V} - 0{,}3\,\mathrm{V}}{500\,\Omega} = 19{,}4\,\mathrm{mA}$$
$$\frac{19{,}4\,\mathrm{mA}}{20\,\mathrm{mA}} 100\,\% = 97\,\% \Rightarrow 3\,\%\text{Abweichung}$$

Klein.Außerdem ist der "neue" Strom $I_{C,mge}$, kleiner als der zuvor berechnet, sodass der Transistor definitiv durchschaltet.

Aufgabe 4

a) Differentialgleichung:

$0 \leq t < DT$:

$$L\frac{di_{in}}{dt} + U_{out}(t) = U_{in}(t)$$

$$\Leftrightarrow \frac{L}{R}\frac{du_{out}}{dt} + u_{out}(t) = U_0$$

$DT \leq t < T$:

$$\frac{L}{R}\frac{du_{out}}{dt} + u_{out}(t) = 0$$

b) $U_{out}(t) \approx U_{out}$

$$\Rightarrow \frac{L}{R}\frac{du_{out}}{dt} + U_{out} = U_0 \qquad \frac{L}{R}\frac{du_{out}}{dt} + U_{out} = 0$$

c) Mittelwert:

$$\frac{L}{R}\int_0^{DT} \frac{du_{out}}{dt} dt + U_{out} = U_0 \qquad \frac{L}{R}\int_{DT}^{T} \frac{du_{out}}{dt} dt + U_{out} = 0$$

$$\Leftrightarrow \frac{L}{R}(\underbrace{u_{out}(DT)}_{=U_{out,max}} - \underbrace{u_{out}(0)}_{=U_{out,min}}) = (U_0 - U_{out})\,DT \qquad \frac{L}{R}(\underbrace{u_{out}(T)}_{=U_{out,min}} - \underbrace{u_{out}(DT)}_{=U_{out,max}}) = -U_{out}(T - DT)$$

$$\Leftrightarrow \frac{L}{R}(U_{out,max} - U_{out,min}) = (U_0 - U_{out})DT \qquad \frac{L}{R}(U_{out,min} - U_{out,max}) = -U_{out}(T - DT)$$

$$\Leftrightarrow (U_0 - U_{out})DT - U_{out}(T - DT) = 0 \Leftrightarrow U_0 DT = U_{out} T \Leftrightarrow U_{out} = U_0 D$$

d) Dimensionierungsvorschrift:

$$\frac{L}{R}\Delta U_{out} = (U_0 - U_{out})DT = U_0(1 - D)DT$$

$$\Leftrightarrow L = R\frac{U_0}{\Delta U_{out}}(1 - D)DT \quad \text{oder} \quad L = R\frac{U_{out}}{\Delta U_{out}}(1 - D)T$$