

Spannungsgegenkopplung

Driftverstärkung: $V_D = \frac{\Delta U_{CE}}{\Delta U_{BE}}$

$$U_{CE} = \frac{R_N + R_1}{R_1} \cdot U_{BE}$$

$$\frac{U_{CE}}{U_{BE}} = \frac{R_N + R_1}{R_1} \Rightarrow \frac{\bar{U}_{CE} + \Delta U_{CE}}{\bar{U}_{BE} + \Delta U_{BE}} = \frac{R_N + R_1}{R_1}$$

$$\Rightarrow \frac{\Delta U_{CE}}{\Delta U_{BE}} = \frac{R_N + R_1}{R_1} = V_D = 1 + \frac{R_N}{R_1}$$

Bsp.)

$U_{Batt} = 12V$; $I_C = 10mA$; $|V_{ol}| = 2$; $B = 100$; $U_{RC} = \frac{U_{Batt}}{2}$
ohne diese Angabe $\rightarrow$ next page

1) $U_{Batt} = U_{RC} + U_{CE} \Rightarrow U_{CE} = U_{Batt} - U_{RC} = \frac{U_{Batt}}{2} = 6V$

$U_{BE} = 0,7V$

$$\Rightarrow I_C = I_{RN} + I_{CV1}$$

$$I_{RN} = I_b + I_{R1}$$

$$I_{RN} > 10 \cdot I_b > \frac{10}{B} I_C$$

$$\frac{10}{B} I_{CV1} = \frac{I_{CV1}}{B} + I_{R1}$$

$$I_C = \frac{10}{B} I_{CV1} + I_{CV1} \Rightarrow I_{CV1} = \frac{I_C}{(1 + \frac{10}{B})} = \frac{10mA}{1,1} = 9,1mA$$

$$I_{R1} = I_{RN} - I_b = \frac{10}{B} I_{CV1} - \frac{1}{B} I_{CV1} = 0,1 \cdot I_{CV1} - 0,01 \cdot I_{CV1} = I_{CV1} \cdot 0,09 = 0,82mA$$

$$R_1 = \frac{U_{R1}}{I_{R1}} = \frac{U_{BE}}{I_{R1}} = \frac{0,7V}{0,82mA} = 850\Omega$$

2) $U_{Batt} = U_{RC} + U_{RN} + U_{R1}$

$$= I_C R_C + U_{RN} + U_{BE}$$

$$U_{RN} = U_{Batt} - I_C R_C - U_{BE} = 12V - 6V - 0,7V = 5,3V$$

$$R_N = \frac{U_{RN}}{I_{RN}} = \frac{5,3V}{I_C - I_{CV1}} = \frac{5,3V}{10mA - 9,1mA} = 58k\Omega$$

Beispiel ist überstimmt da

$$|V_{ol}| = 1 + \frac{R_N}{R_1} = 1 + \frac{58k\Omega}{850\Omega} = 7,8 \neq 2 \text{ weil zu viele Angaben}$$

ohne zu viel Angaben:

$$V_{CE} = V_{be} - \frac{R_N + R_1}{R_2} \cdot V_{D1} = 0,7V \cdot 2 = \underline{\underline{1,4V}}$$

$$I_C = 10mA$$

$$R_C = \frac{V_{R_{alt}} - V_{CE}}{I_C} = \frac{70,6V}{10mA} \approx 7k\Omega$$

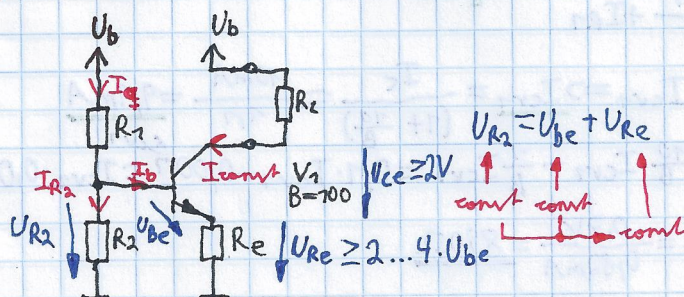
$$I_C = I_{R_N} + I_{C_{V1}}$$

danach selbe Formeln wie vorher

Beispiel: Transistorsromquelle

$$I_{const} = 20mA$$

$$V_b = 12V$$



Wenn V_{R2} & V_{be} konstant sind

→ V_{Re} konstant

$$V_{R2} = V_{Re} + V_{be} = 2,8V + 0,7V = 3,5V$$

$$I_b = \frac{I_C}{\beta} = \frac{20mA}{100} = 200\mu A$$

$$I_q = 11 \cdot I_b = 2,2mA$$

$$I_{R2} = I_q - I_b = 10I_b = 2mA$$

$$R_2 = \frac{V_{R2}}{I_{R2}} = \frac{3,5V}{2mA} = \underline{\underline{1,75k\Omega}}$$

$$V_{R1} = V_b - V_{R2} = 12V - 3,5V = 8,5V$$

$$R_1 = \frac{V_{R1}}{I_q} = \frac{8,5V}{2,2mA} \approx \underline{\underline{4k\Omega}}$$

$$R_e = \frac{V_{Re}}{I_C + I_b} = \frac{V_{Re}}{I_C \cdot (1 + \frac{1}{\beta})} = \frac{2,8V}{20,2mA} \approx \underline{\underline{140\Omega}}$$

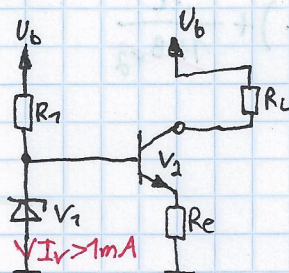
$$U_{sat} = 0,2V$$

$$U_{RL,max} = U_b - U_{sat} - U_{Re}$$

$$= 12V - 0,2V - 2,8V = 9V$$

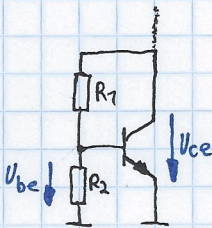
$$R_{L,max} \leq \frac{U_{RL,max}}{I_{cont}} = \frac{9V}{20mA} = \underline{\underline{450\Omega}}$$

Durch Ersetzen von R_2 durch eine Zenerdiode wird der Konstantstrom nahezu unabhängig von der Betriebsspannung.



I_V muss größer 1mA sein $\rightarrow$ Im Durchlassbereich besitzen Zenerdioden schlechte Eigenschaften (Noise)

Beispiel: einstellbare Spannungsquelle

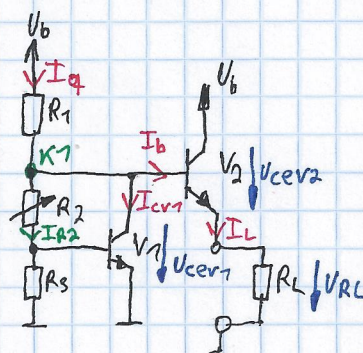
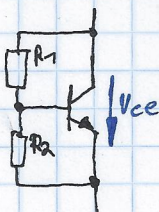


$$|V_o| = 1 + \frac{R_1}{R_2} = \frac{U_{ce}}{U_{be}}$$

U_{be} ist für den linearen Betrieb des Transistors nahezu konstant $= 0,7V$

$$U_{ce} = U_{be} \cdot \left(1 + \frac{R_1}{R_2}\right) = 0,7V \left(1 + \frac{R_1}{R_2}\right) \text{ für}$$

$B r_1 \gg$



$$U_{ceV1} = U_{beV2} + U_{RL}$$

$$0,7V \left(1 + \frac{R_2}{R_1}\right) = U_{beV2} + U_{RL}$$

$$\frac{R_2}{R_1} = \frac{U_{beV2} - 0,7V + U_{RL}}{0,7V} = \frac{U_{RL}}{0,7V}$$

Wie bei AP-Einstellung wird der Strom $I_q = 11 \cdot I_{br2}$ angenommen.

$$I_L = I_{ev2} = I_{cv2} + I_{br2} = I_{br2}(1 + B_{v2})$$

$$I_{br2} = \frac{I_L}{1 + B_{v2}} \Rightarrow I_q = 11 \frac{I_L}{1 + B_{v2}}$$

$$I_{cv1} = \frac{10 \frac{I_L}{1 + B_{v2}}}{11 \left(1 + \frac{1}{B_{v1}} \right)}$$

K1) $I_q = I_{R2} + I_{cv1} + I_{br2}$

$$I_q = 11 I_{br2} + I_{cv1} + I_{br2}$$

$$= 11 \cdot \frac{I_{cv1}}{B_{v1}} + I_{cv1} + I_{br2}$$

$$\overset{10}{11} \cdot \frac{I_L}{1 + B_{v2}} = 11 \cdot I_{cv1} \left(1 + \frac{1}{B_{v1}} \right) + \frac{I_L}{1 + B_{v2}}$$

$$I_{R2} = 11 \cdot \frac{I_{cv1}}{B_{v1}} = \frac{11}{B_{v1}} \cdot \frac{10 \frac{I_L}{1 + B_{v2}}}{11 \left(1 + \frac{1}{B_{v1}} \right)} =$$

$$\boxed{B_{v1} > 1} \rightarrow \frac{10 I_L}{B_{v1} (1 + B_{v2})}$$