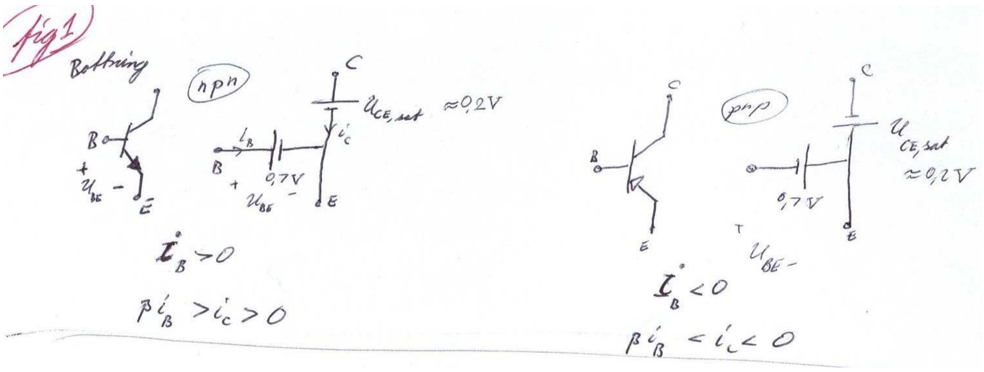
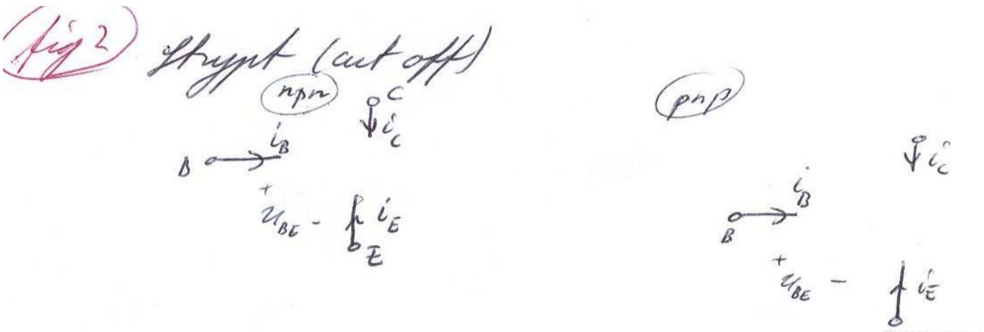
2006–11–15

Fortsättning storsignalschema, BJT. Bottning ⟨fig1⟩.



Figur 1.

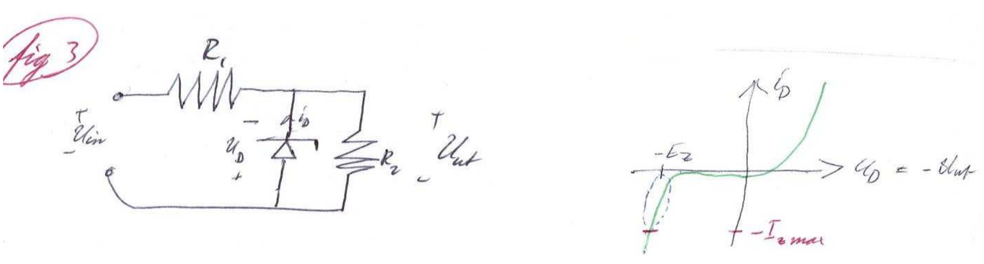
Strypt ⟨fig2⟩.



Figur 2. Strypt transistor, ekvivalenta kretsar.

Strypt: $i_B = i_C = i_E = 0$. I gränsfallet gäller $u_{BE} = 0.7\,\mathrm{V}$.

Uppgift B10 ⟨fig3⟩, $R_1 = 150\,\Omega, R_2 = 220\,\Omega, E_z = 5.1\,\mathrm{V}, r_z = 0, I_{z,\max} = 60\,\mathrm{mA}$.



Figur 3.

Inom vilka områden kan u_{in} variera, så att vi ligger inom det streckade området i ⟨fig3⟩.

Krav $u_{\mathrm{ut}} = E_z$ samt $I_z \leqslant I_{z,\max}$.

Fall 1: U_{in}:s nedre gräns. Ingen ström genom zenerdioden ($I_z = 0$) men spänningen $u_{\text{ut}} = E_z$. Samma ström genom R_1 och R_2. Spänningsdelning ger:

$$u_{\text{ut}} = E_z = u_{\text{in}} \cdot \frac{R_2}{R_1 + R_2} \quad \Longrightarrow \quad u_{\text{in}} = E_z \cdot \frac{R_1 + R_2}{R_2} = \ldots = 8.58\,\text{V}$$

Fall 2: $I_z = I_{z,\max}$, $u_{\text{ut}} = E_z$.

$$I_2 = \frac{u_{\text{ut}}}{R_2} = \frac{E_z}{R_2} = \text{konstant}$$

$$I_1 = I_z + I_2$$

Vid maximal ström:

$$I_{1,\max} = I_{2,\max} + I_z$$

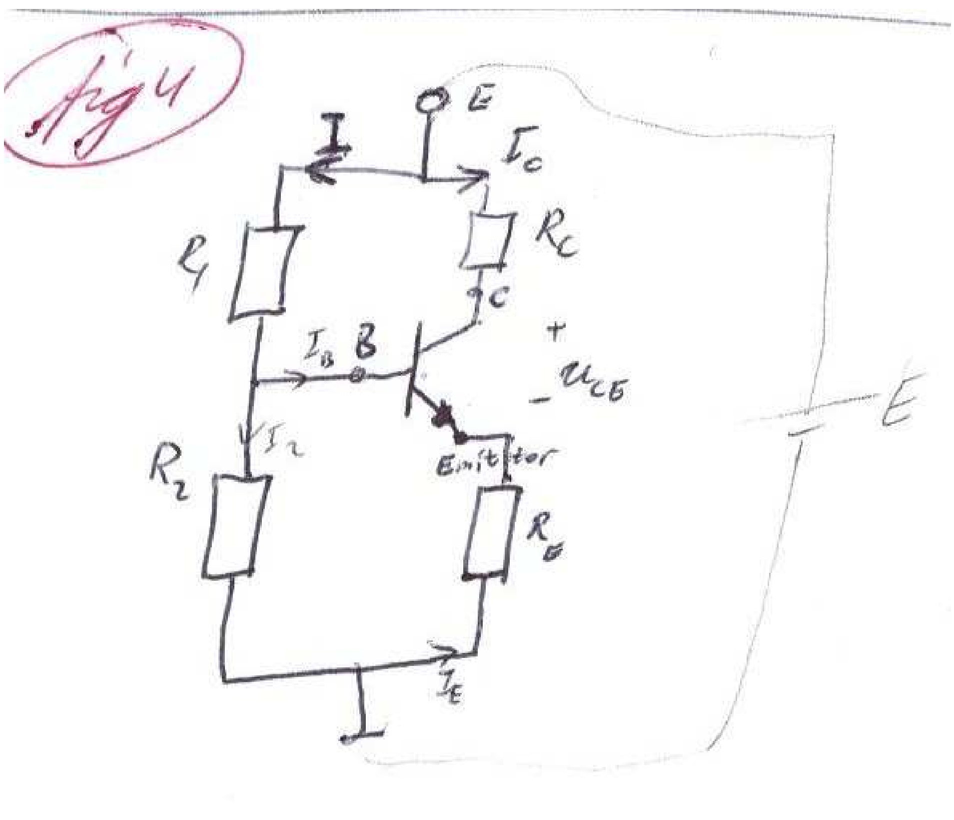
Maximal inspänning u_{in} för $I_1 = I_{1,\max}$.

$$U_{\text{in},\max} = R_1 \cdot I_{1,\max} + E_z =$$

$$= R_1 \left(I_{z,\max} + \frac{E_z}{R_2} \right) + E_z = \ldots = 17.58\,\text{V}$$

Svar: $8.6 \leqslant u_{\text{in}} \leqslant 17.5$.

Uppgift C2 ⟨fig4⟩. Beräkna R_1, R_2 och R_C.



Figur 4.

Givet: Arbetspunkt. $I_C = 2.5$ mA, $U_{\mathrm{CE}} = 3$ V. $U_{\mathrm{BE}} = 0.7$V, $\beta = 300$, $E = 6$V, $R_E = 200\Omega$.

Låt $I \approx 0.3$ mA. ($I_{\mathrm{CO}} = 0$) $I_C = \beta I_B$.

$$U_{R2} = U_{BE} - I_E R_E$$

$$-I_E = I_B + I_C = \frac{I_C}{\beta} + I_C = I_C\left(\frac{1}{\beta} + 1\right)$$

$$U_{R2} = U_{\mathrm{BE}} + R_E I_C\left(\frac{1}{\beta} + 1\right) = \ldots = 1.2\,\mathrm{V}$$

$$U_{R2} = I_2 \cdot R_2$$

$$I_2 = I - I_B = I - \frac{I_C}{\beta}$$

$$U_{R2} = R_2\left(I - \frac{I_C}{\beta}\right)$$

$$R_2 = \frac{U_{R2}}{I - \frac{I_C}{\beta}} = \ldots = 4.1\,\mathrm{k}\Omega$$

$$U_{R1} = E - U_{R2} = I \cdot R_1$$

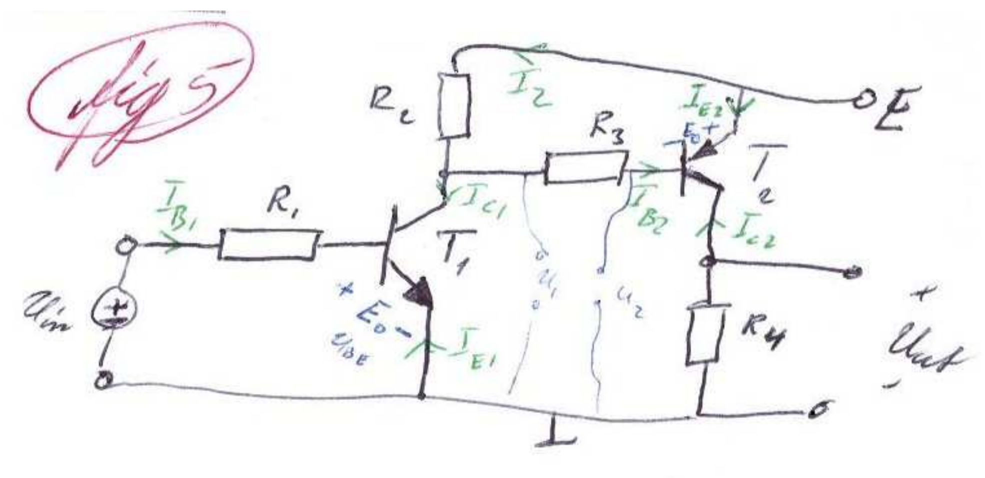
$$R_1 = \frac{E - U_{R2}}{I} = \ldots = 16\,\mathrm{k}\Omega$$

$$E = U_{R_C} + U_{CE} + U_{R_E}$$

$$U_{R_2} = U_{BE} + U_{R_E} \Longrightarrow U_{R_E} = U_{R_2} - U_{BE}$$

$$R_C = \frac{U_{R_C}}{I_C} = \frac{E - U_{\mathrm{CE}} - U_{R_E}}{I_C} = \ldots = 1.0\,\mathrm{k}\Omega$$

Uppgift C4 ⟨fig5⟩. $R_1 = R_3 = 20\,R$. $R_2 = R_4 = R$. $\beta = 50$ för både T_1 och T_2.



Figur 5.

$E_0 = |U_{\mathrm{BE}}| = \frac{1}{10}E$ (både T_1 och T_2).

∘ T_2 strypt:

Gränsfall då T_2 precis slutar leda ström.

$$U_{\mathrm{EB}_2} = \frac{E}{10} \quad (= E_0)$$

$$I_{B2} = 0$$

$$U_2 = E - E_0$$

$$U_1 = U_2, \quad \text{ty } I_{B2} = 0$$

$$I_2 = \frac{E - U_1}{R_2}$$

$$I_{C1} = I_2, \quad \text{ty } I_{B2} = 0$$

$$I_{C1} = \beta \cdot I_{B1}$$

Alltså slutligen:

$$U_{\mathrm{in}} = I_{B1}\, R_1 + E_0$$

$$I_{B2} = \frac{I_{C1}}{\beta} = \frac{I_2}{\beta} = \frac{E - U_1}{\beta\, R_2} = \frac{E - (E - E_0)}{\beta\, R_2} = \frac{E_0}{\beta\, R_2} = \frac{E}{10}\left(1 + \frac{20}{50}\right) = 0.14\, E$$

∘ T_2 bottnad:

Då gäller $U_{\mathrm{CE}_2} = 0$.

$$I_{C2} = \frac{-E}{R_4}, \quad \text{ty } U_{\mathrm{ut}} = E$$

$$I_{C2} = \beta\, I_{B2}$$

$$I_{B2} = \frac{I_{C2}}{\beta} = -\frac{E}{\beta R_4}$$

$$U_2 = E - E_0$$

$$U_1 - U_2 = R_3 \cdot I_{B2}$$

$$I_2 = \frac{E - U_1}{R_2}$$

$$I_{C1} = I_2 - I_{B2}$$

$$I_{B1} = \frac{I_{C1}}{\beta}$$

Teckna I_{B1}:

$$I_{B1} = \frac{I_2 - I_{B2}}{\beta} = \frac{\frac{E - U_1}{R_2} - I_{B2}}{\beta} = \frac{\frac{1}{R_2}\left(E + \frac{E\, R_3}{\beta} - E + E_0\right) + \frac{E}{\beta\, R_4}}{\beta}$$

Slutligen:

$$U_{\mathrm{in}} = R_1\, I_{B1} + U_{\mathrm{BE}}$$

Insättning av I_{B1} enligt ovan ger

$$U_{\mathrm{in}} = 0.308E$$

Kontrollera! Stryps eller bottnar transistorn T_1 “före” transistor T_2.