2006–12–13

Uppgift C6 ⟨fig1⟩

I aktiva området $u_{\mathrm{BE}_1} = u_{\mathrm{BE}_2} = u_{\mathrm{BE}} = 0.7\,\mathrm{V}$.

T_1: $\beta_1 = 100$, $\quad T_2$: $\beta_2 = 50$.

$$I_C = \beta\, I_B$$

Teckna kretsekvationer:

$$R_2\, I_2 = I_{B2}\, R_3 + u_{\mathrm{BE}} + u_{\mathrm{BE}} - I_E\, R_E$$

$$-\, I_{E1} = I_{C1} + I_{B1} = I_{B1}(1+\beta_1) = (I_{B2} + I_{C2})(1+\beta_1) = I_{B2}(1+\beta_2)(1+\beta_1)$$

$$R_2\, I_2 = I_{B2}(R_3 + R_E(1+\beta_2)(1+\beta_1)) + 2\,u_{\mathrm{BE}}$$

$$E = R_1\, I_1 + R_2\, I_2 = \left[I_1 = I_{B2} + I_2\right] = I_2(R_1 + R_2) + I_{B2} \cdot R_1$$

$$\Rightarrow I_2 = \frac{E - I_{B2}\, R_1}{R_1\, R_2}$$

ger

$$\frac{R_2 E}{R_1 + R_2} = I_{B2}\left(R_3 + R_E(1+\beta_1)(1+\beta_2) + \frac{R_1\, R_2}{R_1 + R_2}\right) + 2\,u_{\mathrm{BE}}$$

$$I_{B2} = \frac{\frac{R_2 E}{R_1 + R_2} - 2\,u_{\mathrm{BE}}}{R_3 + R_E(1+\beta_1)(1+\beta_2) + \frac{R_1\, R_2}{R_1 + R_2}} = \ldots = 1.94\,\mu\mathrm{A}$$

Resten av strömmarna:

$$I_{C2} = \beta_2 \cdot I_{B2} = \ldots = 96.8\,\mu\mathrm{A}$$

$$I_{B1} = I_{B2} + I_{C_2} = \ldots = 98.8\,\mu\mathrm{A}$$

$$I_{C1} = \beta_1 \cdot I_{B1} = \ldots = 9.88\,\mathrm{mA}$$

$$I_{E1} = -\, I_{B1} - I_{C1} = -\, 9.98\,\mathrm{mA}$$

$$I_2 = \ldots = 0.259\,\mathrm{mA}$$

$$I_1 = I_2 + I_{B2} = \ldots = 0.261\,\mathrm{mA}$$

$$u_1 = E - I_{C1} \cdot R_C = \ldots = 14.1\,\mathrm{V}$$

$$u_2 = -\, I_{E1} \cdot R_E = \ldots = 1.0\,\mathrm{V}$$

Uppgift D3 ⟨fig2⟩

Transistor BC167B, arbetspunkt $I_C = 1\,\mathrm{mA}, u_{\mathrm{CE}} = 10\,\mathrm{V}$. Ur datablad fås:

Vid $I_C = 2\,\mathrm{mA}, u_{\mathrm{CE}} = 5\,\mathrm{V}$	Korrektion, $I_C = 1\,\mathrm{mA}$	Korrektion $u_{\mathrm{CE}} = 10\,\mathrm{V}$
$h'_{11} = 4.5\,\mathrm{k\Omega}$	1.8	1.1
$h'_{12} = 2 \cdot 10^{-4}$	1.4	0.92
$h'_{21} = 330$	0.93	1.1
$h'_{22} = 30\,\mu\mathrm{S}$	0.63	0.72

Multiplicera nominella värden med korrektionsfaktorer.

$$\begin{cases} h_{11} = 8.9\,\mathrm{k\Omega} \\ h_{12} = 2.6 \cdot 10^{-4} \\ h_{21} = 338 \\ h_{22} = 14\,\mu\mathrm{S} \end{cases}$$

Småsignalschema ⟨fig3⟩.

Inresistans:

$$R_{\mathrm{in}} = \frac{u}{i_{\mathrm{in}}} = \frac{u}{i_b}$$

$$u = i_b \cdot h_{11} + h_{12}\, u_{\mathrm{ce}} + i_1\, R_E \tag{1}$$

$$i_1\, R_E + i_2 \cdot \frac{1}{h_{22}} = 0 \Longrightarrow i_2 = -\, i_1\, R_E\, h_{22} \tag{2}$$

$$i_1 = i_b(1 + h_{21}) + i_2 = i_b(1 + h_{21}) - i_1\, R_E\, h_{22} \quad \Rightarrow \quad i_1 = \frac{i_b(1 + h_{21})}{1 + R_E\, h_{22}} \tag{3}$$

$$u_{\mathrm{ce}} + u_{\mathrm{ut}} = 0, \quad u_{\mathrm{ut}} = R_E\, i_1$$

$$u_{\mathrm{ce}} = -\, u_{\mathrm{ut}} = -\, i_1\, R_E$$

Ur (1):

$$u = i_b\, h_{11} - i_1\, h_{12}\, R_E + i_1\, R_E = i_b\, h_{11} + i_1\, R_E\,(1 - h_{12})$$

$$u = i_b\, h_{11} + i_b \frac{R_E(1 - h_{12})(1 + h_{21})}{1 + R_E\, h_{22}}$$

$$R_{\mathrm{in}} = \frac{u}{i_b} = h_{11} + \frac{R_E(1 - h_{12})(1 + h_{21})}{1 + R_E\, h_{22}} = \ldots = 409\,\mathrm{k\Omega}$$

Utresistans:

Nollställ oberoende källor ($u_{\mathrm{in}} = 0$). Applicera spänning på utgången, u_{ut}. Beräkna resulterande ström, i_{ut}. $R_{\mathrm{ut}} = u_{\mathrm{ut}}/i_{\mathrm{ut}}$.

⟨fig4⟩

KCL:

$$i_{\mathrm{ut}} = i_1 - i_b(1 + h_{21}) - i_2$$

KVL:

$$i_b(R_g + h_{11}) + u_{\mathrm{ce}}\, h_{12} + i_1 R_E = 0$$

$$u_{\mathrm{ce}} = -\, i_1\, R_E$$

$$\Rightarrow i_b = -\, i_1 \frac{1 - h_{12}}{h_{11} + R_g}$$

$$i_2 \cdot \frac{1}{h_{22}} + i_1\, R_E = 0$$

$$i_2 = -\, i_1\, R_E\, h_{22}$$

$$i_{\mathrm{ut}} = i_1 \left(1 + \frac{R_E}{h_{11} + R_g}(1 + h_{21})(1 - h_{12}) + R_E\, h_{22}\right)$$

$$u_{\mathrm{ut}} = i_1 \cdot R_E$$

$$R_{\mathrm{ut}} = \frac{u_{\mathrm{ut}}}{i_{\mathrm{ut}}} = \frac{R_E}{1 + R_E\, h_{22} + \frac{R_E}{h_{11} + R_g}(1 + h_{21})(1 - h_{12})} = \ldots = 29\,\Omega$$