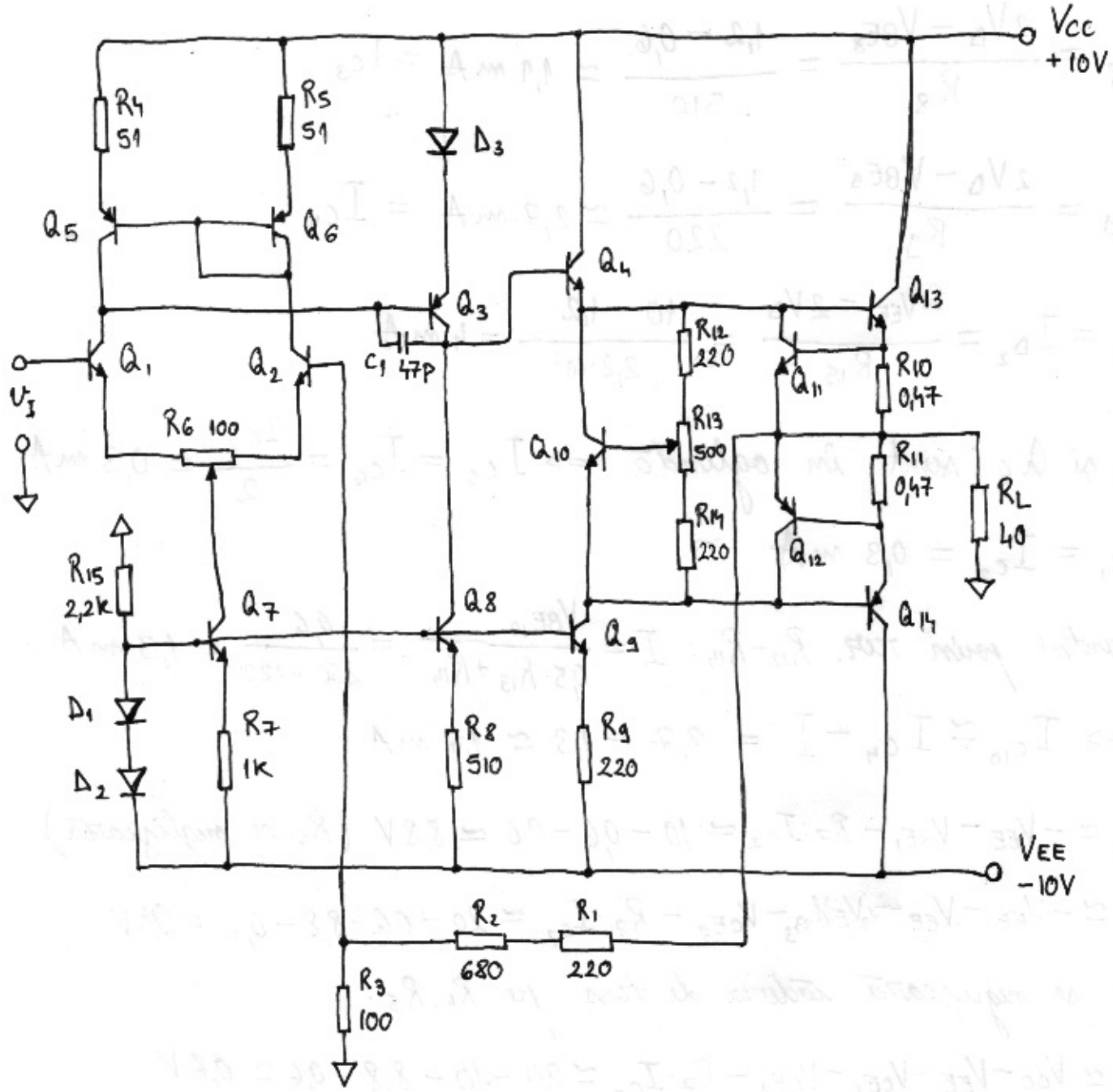
Punct static de funcționare



Q_{1-12} $\begin{cases} |V_{BE}| \simeq 0{,}6V \\ \beta = 290 \end{cases}$ Q_{13-14} $\begin{cases} |V_{BE}| \simeq 0{,}6V \\ \beta = 160 \end{cases}$ $D_{1,2}$ $\begin{cases} V_D \simeq 0{,}6V \\ r_d = 0 \end{cases}$

Tranzistoarele Q_{11} și Q_{12} au rol de protecție la scurt-circuit sau supraîncărcare și vor fi neglijate.

Pp. Q_1 - Q_{14} în RAN și D_1 - D_2 polarizate în conducție.

Deoarece $\beta > 50$, se pot neglija curenții de bază.

$$I_{C_7} = \frac{2V_D - V_{BE_7}}{R_7} = \frac{1,2 - 0,6}{1 \cdot 10^3} = 0,6 \text{ mA}$$

$$I_{C_8} = \frac{2V_D - V_{BE_8}}{R_8} = \frac{1,2 - 0,6}{510} \simeq 1,1 \text{ mA} = I_{C_3}$$

$$I_{C_9} = \frac{2V_D - V_{BE_9}}{R_9} = \frac{1,2 - 0,6}{220} \simeq 2,7 \text{ mA} = I_{C_4}$$

$$I_{D_1} = I_{D_2} = \frac{-V_{EE} - 2V_D}{R_{15}} = \frac{10 - 1,2}{2,2 \cdot 10^3} = 4 \text{ mA}$$

Q_5 și Q_6 sunt în oglindă $\Rightarrow I_{C_5} = I_{C_6} = \frac{I_{C_7}}{2} = 0,3 \text{ mA}$

$I_{C_1} = I_{C_2} = 0,3 \text{ mA}$

Curentul prin rez. R_{12}-R_{14}: $I = \frac{V_{BE_{10}}}{0,5 \cdot R_{13} + R_{14}} = \frac{0,6}{250 + 220} \simeq 1,3 \text{ mA}$

$\Rightarrow I_{C_{10}} \simeq I_{C_4} - I = 2,7 - 1,3 \simeq 1,4 \text{ mA}$

$V_{CE_7} \simeq -V_{EE} - V_{BE_1} - R_7 \cdot I_{C_7} \simeq 10 - 0,6 - 0,6 \simeq 8,8 V$ (R_6 se neglijează)

$V_{CE_1} \simeq V_{CC} - V_{EE} - V_{D_3} - V_{EB_3} - V_{CE_7} - R_7 \cdot I_{C_7} \simeq 20 - 1,2 - 8,8 - 0,6 \simeq 9,4 V$

Dacă se neglijează căderea de tens. pe R_4, R_5:

$V_{EC_5} \simeq V_{CC} - V_{EE} - V_{CE_1} - V_{CE_7} - R_7 \cdot I_{C_7} \simeq 20 - 9,4 - 8,8 - 0,6 \simeq 1,2 V$

Q_6 ref. oglindă $\Rightarrow V_{EC_6} = 0,6 V$

$V_{CE_2} \simeq V_{CC} - V_{EE} - V_{EC_6} - V_{CE_7} - R_7 \cdot I_{C_7} \simeq 20 - 0,6 - 8,8 - 0,6 \simeq 10 V$

Dacă se neglijează căderea de tens. pe R_{10}:

$V_{EC_3} \simeq V_{CC} - V_{D_3} - V_{BE_4} - V_{BE_{13}} \simeq 10 - 1,8 \simeq 8,2 V$

$V_{CE_4} \simeq V_{CC} - V_{BE_{13}} \simeq 10 - 0,6 \simeq 9,4 V$

$V_{CE_{13}} \simeq V_{CC} = 10 V$

Dacă se neglijează căderea de tens. pe R_{11}:

$V_{EC_{14}} \simeq -V_{EE} = 10\,V$

$V_{CE_9} \simeq -V_{EE} - V_{EB_{14}} - R_9 \cdot I_{C_9} \simeq 10 - 0{,}6 - 0{,}6 \simeq 8{,}8\,V$

$V_{CE_8} \simeq V_{CC} - V_{EE} - V_{D_3} - V_{EC_3} - R_8 \cdot I_{C_8} \simeq 20 - 8{,}2 - 1{,}2 \simeq 10{,}6\,V$

$V_{CE_{10}} \simeq V_{CC} - V_{EE} - V_{CE_4} - V_{CE_9} \simeq 20 - 9{,}4 - 8{,}8 \simeq 1{,}8\,V$

Q_1 { $V_{BE_1} = 0{,}6\,V > 0$; $V_{CE_1} = 9{,}4\,V \geq V_{BE_1}$; $I_{C_1} = 0{,}3\,mA$ } ‖ RAN

Q_2 { $V_{BE_2} = 0{,}6\,V > 0$; $V_{CE_2} = 10\,V \geq V_{BE_2}$; $I_{C_2} = 0{,}3\,mA$ } ‖ RAN

Q_3 { $V_{EB_3} = 0{,}6\,V > 0$; $V_{EC_3} = 8{,}2\,V \geq V_{EB_3}$; $I_{C_3} = 1{,}1\,mA$ } ‖ RAN

Q_4 { $V_{BE_4} = 0{,}6\,V > 0$; $V_{CE_4} = 9{,}4\,V \geq V_{BE_4}$; $I_{C_4} = 2{,}7\,mA$ } ‖ RAN

Q_5 { $V_{EB_5} = 0{,}6\,V > 0$; $V_{EC_5} = 1{,}2\,V \geq V_{EB_5}$; $I_{C_5} = 0{,}3\,mA$ } ‖ RAN

Q_6 { $V_{EB_6} = 0{,}6\,V > 0$; $V_{EC_6} = 0{,}6\,V \geq V_{EB_6}$; $I_{C_6} = 0{,}3\,mA$ } ‖ RAN

Q_7 { $V_{BE_7} = 0{,}6\,V > 0$; $V_{CE_7} = 8{,}8\,V \geq V_{BE_7}$; $I_{C_7} = 0{,}6\,mA$ } ‖ RAN

Q_8 { $V_{BE_8} = 0{,}6\,V > 0$; $V_{CE_8} = 10{,}6\,V \geq V_{BE_8}$; $I_{C_8} = 1{,}1\,mA$ } ‖ RAN

Q_9 { $V_{BE_9} = 0{,}6\,V > 0$; $V_{CE_9} = 8{,}8\,V \geq V_{BE_9}$; $I_{C_9} = 2{,}7\,mA$ } ‖ RAN

Q_{10} { $V_{BE_{10}} = 0{,}6\,V > 0$; $V_{CE_{10}} = 1{,}8\,V \geq V_{BE_{10}}$; $I_{C_{10}} = 1{,}4\,mA$ } ‖ RAN

Q_{13} { $Q_{BE_{13}} = 0{,}6\,V > 0$; $V_{CE_{13}} = 10\,V \geq V_{BE_{13}}$ } ‖ RAN

Q_{14} { $V_{EB_{14}} = 0{,}6\,V > 0$; $V_{EC_{14}} = 10\,V \geq V_{EB_{14}}$ } ‖ RAN

$D_{1,2}$ { $I_D = 4\,mA$; $V_D = 0{,}6\,V$ } ‖ Polarizare directă

D_3 { $I_{D_3} = 1{,}1\,mA$; $V_{D_3} = 0{,}6\,V$

Putori

Q_1: $V_{CE_1} \cdot I_{C_1} = 3\,mW$ ($< 0{,}25\,W$)

Q_2: $V_{CE_2} \cdot I_{C_2} = 3\,mW$ ($< 0{,}25\,W$)

Q_3: $V_{EC_3} \cdot I_{C_3} = 9{,}4\,mW$ ($< 0{,}25\,W$)

Q_4: $V_{CE_4} \cdot I_{C_4} = 25{,}4\,mW$ ($< 0{,}25\,W$)

Q_5: $V_{EC_5} \cdot I_{C_4} = 360\,\mu W$ ($< 0{,}25\,W$)

Q_6: $V_{EC_6} \cdot I_{C_6} = 180\,\mu W$ ($< 0{,}25\,W$)

Q_7: $V_{CE_7} \cdot I_{C_7} = 5{,}3\,mW$ ($< 0{,}25\,W$)

Q_8: $V_{CE_8} \cdot I_{C_8} = 11{,}6\,mW$ ($< 0{,}25\,W$)

Q_9: $V_{CE_9} \cdot I_{C_9} = 23{,}8\,mW$ ($< 0{,}25\,W$)

Q_{10}: $V_{CE_{10}} \cdot I_{C_{10}} = 2{,}5\,mW$ ($< 0{,}25\,W$)

Q_{13}: $63\,mW$ ($< 0{,}25\,W$)

Q_{14}: $63\,mW$ ($< 0{,}25\,W$)

Δ_1, Δ_2: $V_\Delta \cdot I_\Delta = 2{,}4\,mW$; Δ_3: $0{,}66\,mW$

R_4, R_5: $I_{C_1}^2 \cdot R = 4{,}6\,\mu W$ ($< 0{,}125\,W$)

R_6: $9\,\mu W$ ($< 0{,}125\,W$)

R_7: $I_{C_7}^2 \cdot R_7 = 360\,\mu W$ ($< 0{,}125\,W$)

R_8: $I_{C_8}^2 \cdot R_8 = 617\,\mu W$ ($< 0{,}125\,W$)

R_9: $I_{C_9}^2 \cdot R_9 = 1{,}6\,mW$ ($< 0{,}125\,W$)

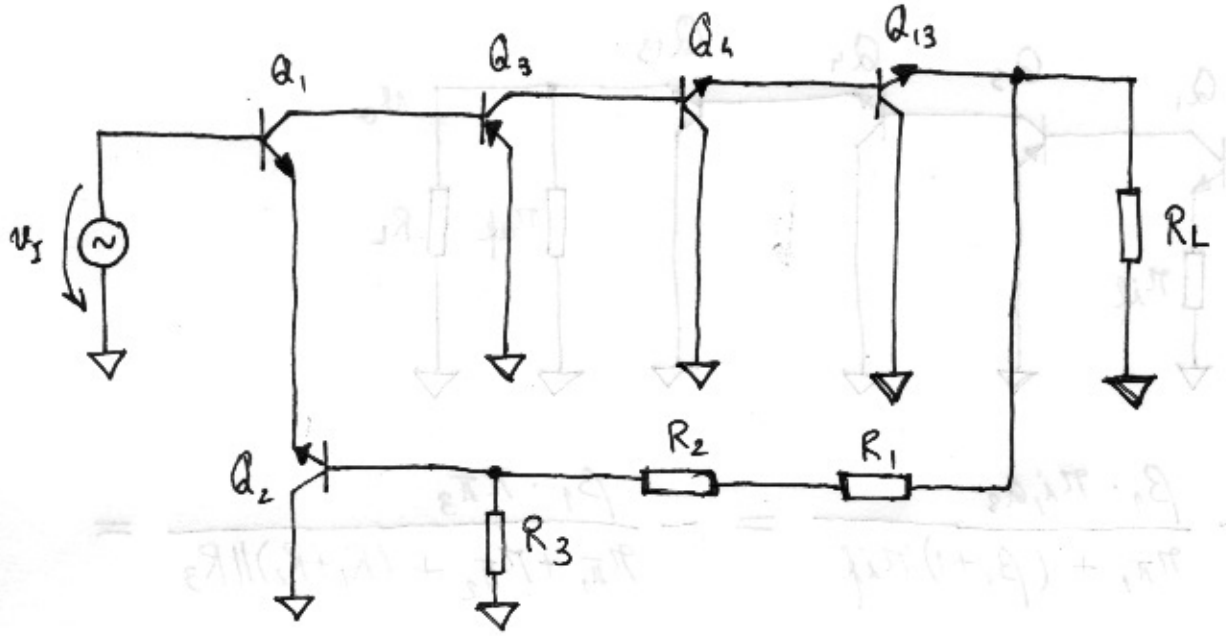
R_{12}: $I^2 \cdot R_{12} = 372\,\mu W$ ($< 0{,}125\,W$)

R_{13}: $I^2 \cdot R_{13} = 845\,\mu W$ ($< 0{,}125\,W$

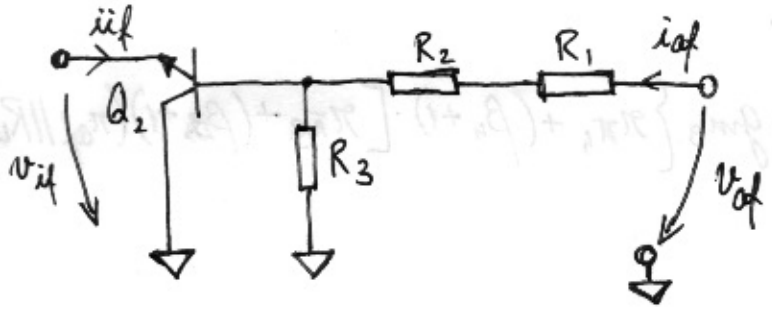
R_{14}: $I^2 \cdot R_{14} = 372\,\mu W$ ($< 0{,}125\,W$)

R_{15}: $I_\Delta^2 \cdot R_{15} = 35\,mW$ ($< 0{,}125\,W$)

Analiza de curent alternativ



- Analiză RRN



$$f_v = \left.\frac{v_{if}}{v_{of}}\right|_{i_{if}=0} = \frac{R_3}{R_1+R_2+R_3} = \frac{100}{1000} = 0{,}1$$

$$r_{if} = \left.\frac{v_{if}}{i_{if}}\right|_{v_{of}=0} = \frac{r_{\pi_2} + (R_1+R_2)\parallel R_3}{\beta_2+1}$$

$$r_{of} = R_1 + R_2 + R_3 = 1\,k\Omega$$

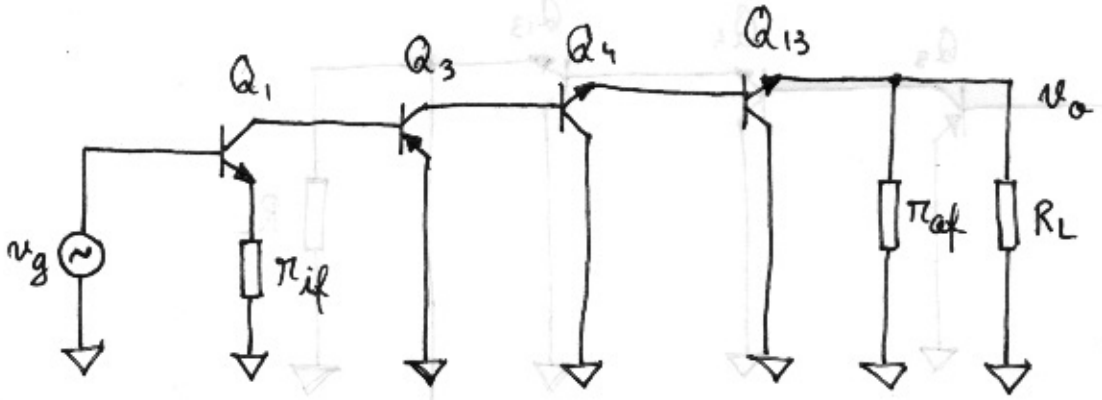
$$g_{m_1} = g_{m_2} = 40 \cdot I_{C_{1,2}} = 40 \cdot 0{,}3 = 12\ mS$$

$$r_{\pi_1} = r_{\pi_2} = \frac{\beta_{1,2}}{g_{m_{1,2}}} = \frac{290}{12} \simeq 24\,k\Omega$$

$$g_{m_3} = 40\, I_{C_3} = 40 \cdot 1{,}1 = 44\ mS$$

$$r_{\pi_3} = \frac{\beta_3}{g_{m_3}} = \frac{290}{44} \simeq 6{,}6\,k\Omega$$

• Schema ABD



$$a_{V,1} = -\frac{\beta_1 \cdot r_{i,a_3}}{r_{\pi_1} + (\beta_1+1) r_{if}} = -\frac{\beta_1 \cdot r_{\pi_3}}{r_{\pi_1} + r_{\pi_2} + (R_1+R_2) \| R_3} =$$

$$= -\frac{290 \cdot 6{,}6 \cdot 10^3}{48 \cdot 10^3 + 90} = -\frac{1914}{48{,}09} \simeq -39{,}8$$

$$a_{V,3} = -\frac{\beta_3 \cdot R_C}{r_{\pi_3} + (\beta_3+1) \underbrace{R_E}_{\omega}} = -g_{m3} \left\{ r_{\pi_4} + (\beta_4+1) \cdot \left[r_{\pi_{13}} + (\beta_{13}+1)(r_{of} \| R_L \right.\right.$$

$a_{V,1} \simeq 1$

$a_{V,13} \simeq 1$

$$a_{V,g} = a_{V,1} \cdot a_{V,3} \cdot a_{V,4} \cdot a_{V,13} = 39{,}8 \cdot g_{m3} \cdot \beta_4 \cdot \beta_{13} \cdot (r_{of} \| R_L) =$$

$$= 39{,}8 \cdot 44 \cdot 10^{-3} \cdot 290 \cdot 160 \cdot 40 \simeq 3{,}25\ M$$

$$r_i = r_{\pi_1} + (\beta_1+1) r_{if} = r_{\pi_1} + r_{\pi_2} + (R_1+R_2) \| R_3 = 48{,}09\ k\Omega$$

$$r_o = r_{of} \| R_L \simeq 40\ \Omega$$

$$T = a_{V,g} \cdot f_V \simeq 325$$

$$A_v \simeq \frac{1}{f_V} = \frac{R_1+R_2+R_3}{R_3} = 1 + \frac{R_1+R_2}{R_3} = 1 + \frac{900}{100} = 10$$

$$R_i = (1+T) r_i \simeq 325 \cdot 10^3 \cdot 48{,}09 \cdot 10^3 \simeq 15{,}63\ G\Omega$$

$$R_o = \frac{r_o}{1+T} = \frac{40}{325k} \simeq 123\mu\Omega$$

$A_v = 10$

$R_i = 15{,}63\,G\Omega > 0{,}1\,M\Omega$

$R_o = 123\mu\Omega < 0{,}8\,\Omega$

Valorile obținute îndeplinesc cerințele de proiectare.