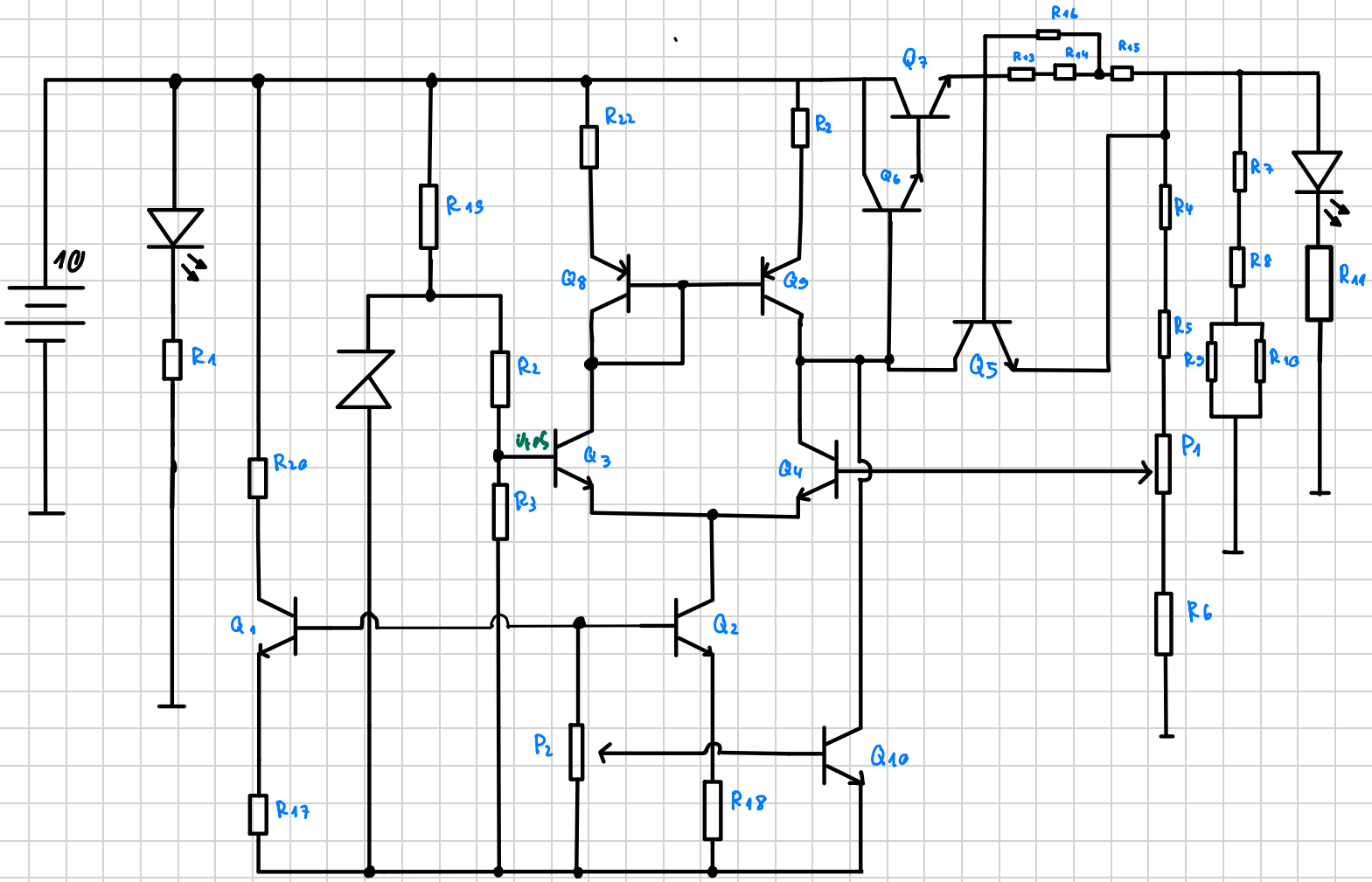
Calculatea punctului static de funcționare



$R_1 = 1\,k\Omega$

$R_2 = 3{,}3\,k\Omega$

$R_3 = 3{,}3\,k\Omega$

$R_4 = 5.6\,k\Omega$

$R_5 = 680\,\Omega$

$R_{21} = 100\,\Omega$

$R_6 = 3{,}9\,k\Omega$

$R_7 = 100\,\Omega$

$R_8 = 100\,\Omega$

$R_9 = 100\,\Omega$

$R_{22} = 100\,\Omega$

$R_{11} = 220\,\Omega$

$R_{13} = 1\,\Omega$

$R_{14} = 1\,\Omega$

$R_{15} = 1\,\Omega$

$R_{16} = 1\,\Omega$

$R_{17} = 220\,\Omega$

$R_{18} = 220\,\Omega$

$R_{19} = 1\,k\Omega$

$R_{20} = 5{,}6\,k\Omega$

$P_1 = 5\,k\Omega$

$P_2 = 5\,k\Omega$

$Q_3 + Q_4$ - etaj diferential $\Rightarrow V_{inm} = V_{inp}$

$V_{inm} = V_{res} = V_{D1} \cdot \frac{R_3}{R_2+R_3} = 2,7 \cdot \frac{1}{2} = 1,35\,V$

$I_{C8} = I_{C9} = I_{C3} = I_{C4} = \frac{I_{C5}}{2} = \frac{I_{C1}}{2}$

$I_{C9} = \frac{V_1 - V_{BE8}}{R_{20}+R_{17}} = \frac{10 - 0,7}{5,820 \cdot 10^3} \approx 1,6\,mA$

$\Rightarrow I_{C8} = 1,6\,mA$

$I_{C5} = 1,6\,mA$

$I_{C3} = 1,6\,mA$

$I_{C4} = 1,6\,mA$

$I_{C5} = 3,2\,mA$

$I_{C1} = 3,2\,mA$

$V_{CE\,gmax} = V_{omin} + V_{BE7} + V_{BE6} - V_{R21} - V_{CE4} - V_{CE2} - V_{R18}$

$V_{CE5} = V_{res} - V_{BE3} - V_{R18} \cdot I_{C2} = 1,35 - 0,7 - 0,3 = 0,35\,V$

$V_{CE1} = V_{1max} - I_{C8} \cdot R_{22} - I_{C2} \cdot R_{18} = 10 - 0,08 - 0,7 - 0,45 - 0,3 = 8,47\,V$

$V_{CE2\,max} = V_{omax} + V_{BE7} + V_{BE8} - V_{CE2} - V_{R18} = 5 + 1,2 - 0,45 - 0,3 = 5,45\,V$

$V_{CE2\,min} = V_{CE2\,max}\Big|_{V_{omin}=2,5V}$

$V_{CE5\,max} = 2,5 + 1,4 - 0,08 - 0,55 - 0,45 - 0,3 = 2,32\,V$

$V_{LED} = 2,8\,V$

$I_{LED\,max} = 15\,mA$

$R_{LED\,out} = \frac{V_{omax} - V_{LED}}{I_{LED}} = \frac{5 - 2,8}{15 \cdot 10^{-3}} = 147\,\Omega$ (2,2)

$R_{LED\,IN} = \frac{V_{1max} - V_{LED}}{I_{LED}} = \frac{10 - 2,8}{15 \cdot 10^{-3}} = 480\,\Omega$ (7,2)

Puteri pe rezistențe

$P_{R1} = I_{R1}^2 \cdot R_1 = 10^3 \cdot (7 \cdot 10^{-3})^2 = 49 \cdot 10^{-3} = 49\ mW$

$P_{R2} = I_{R2}^2 \cdot R_2 = 3{,}3 \cdot 10^3 \cdot (450 \cdot 10^{-6})^2 = 0{,}33 \cdot 10^{-3} \cdot 202500 \cdot 10^{-12} = 600\ \mu W$

$P_{R3} = I_{R3}^2 \cdot R_3 = 3{,}3 \cdot 10^3 \cdot (439 \cdot 10^{-6})^2 = 613\ \mu A$

$P_{R4} = I_{R4}^2 \cdot R_4 = 5{,}6 \cdot 10^3 \cdot (165 \cdot 10^{-6})^2 = 5{,}6 \cdot 10^3 \cdot 165^2 \cdot 10^{-12} = 1{,}52 \cdot 10^{-4} = 0{,}152\ mW = 152\ \mu W$

$P_{R5} = I_{R5}^2 \cdot R_5 = 680 \cdot (165 \cdot 10^{-9})^2 = 680 \cdot 10^{-12} \cdot 165^2 = 1{,}85 \cdot 10^{-5} = 18{,}5 \cdot 10^{-6} = 18{,}5\ \mu W$

$P_{R6} = I_{R6}^2 \cdot R_6 = 3{,}3 \cdot 10^3 \cdot (165 \cdot 10^{-9})^2 = 3{,}3 \cdot 10^{-9} \cdot 165^2 = 0{,}1056 \cdot 10^{-6} = 106\ \mu W$

$P_{R7} = I_{R7}^2 \cdot R_7 = 100 \cdot (10 \cdot 10^{-3})^2 = 100 \cdot 10^2 \cdot 10^{-6} = 10\ mW$

$P_{R8} = I_{R8}^2 \cdot R_8 = 100 \cdot (10 \cdot 10^{-3})^2 = 100 \cdot 10^2 \cdot 10^{-6} = 10\ mW$

$P_{R9} = I_{R9}^2 \cdot R_9 = 100 \cdot (5 \cdot 10^{-3})^2 = 100 \cdot 25 \cdot 10^{-6} = 2{,}5\ mW$

$P_{R10} = I_{R10}^2 \cdot R_{10} = 100 \cdot (5 \cdot 10^{-3})^2 = 100 \cdot 25 \cdot 10^{-6} = 2{,}5\ mW$

$P_{R11} = I_{R11}^2 \cdot R_{11} = 220 \cdot (20 \cdot 10^{-3})^2 = 220 \cdot 400 \cdot 10^{-6} = 88\ mW$

$P_{R13} = I_{R13}^2 \cdot R_{13} = 1 \cdot (10 \cdot 10^{-3})^2 = 10\ \mu W$

$P_{R14} = I_{R14}^2 \cdot R_{14} = 1 \cdot (10 \cdot 10^{-3})^2 = 10\ \mu W$

$P_{R15} = I_{R15}^2 \cdot R_{15} = 1 \cdot (10 \cdot 10^{-3})^2 = 10\ \mu W$

$P_{R16} = I_{R16}^2 \cdot R_{16} = 1 \cdot (7 \cdot 10^{-3})^2 = 49\ \mu W$

$P_{R17} = I_{R17}^2 \cdot R_{17} = 22 \cdot (1{,}5 \cdot 10^{-3})^2 = 220 \cdot 1{,}5 \cdot 1{,}5 \cdot 10^{-6} = 450\ \mu W$

$P_{R18} = I_{R18}^2 \cdot R_{18} = 220 \cdot (1{,}5 \cdot 10^{-3})^2 = 220 \cdot 1{,}5 \cdot 1{,}5 \cdot 10^{-6} = 450\ \mu W$

$P_{R19} = I_{R19}^2 \cdot R_{19} = 1 \cdot 10^3 \cdot (7{,}5 \cdot 10^{-3})^2 = 10^3 \cdot 10^{-6} \cdot 7{,}5 \cdot 7{,}5 = 56{,}25\ mW$ (56,25)

$P_{R20} = I_{R20}^2 \cdot R_{20} = 5{,}6 \cdot 10^3 \cdot (12 \cdot 10^{-3})^2 = 5{,}6 \cdot 10^3 \cdot 4 \cdot 10^{-6} = 22{,}4\ mW$ (22,4)

$P_{R21} = I_{R21}^2 \cdot R_{21} = 100 \cdot (0{,}93 \cdot 10^{-3})^2 = 0{,}93 \cdot 0{,}93 \cdot 10^{-6} \cdot 10^2 = 0{,}86 \cdot 10^{-4} = 86\ \mu W$ (10^{-4})

$P_{R22} = I_{R22}^2 \cdot R_{22} = 100 \cdot (0{,}96 \cdot 10^{-3})^2 = 0{,}98 \cdot 0{,}96 \cdot 10^{-6} \cdot 10^2 = 0{,}92 \cdot 10^{-4} = 92\ \mu W$ (10^{-4})

Puteriile pe tranzistori

$P_{Q1} = I_{c1} \cdot V_{CE1} = 1{,}5 \cdot 10^{-3} \cdot 8{,}47 = 12{,}7\ mW$

$P_{Q2} = I_{c2} \cdot V_{CE2} = 1{,}5 \cdot 10^{-3} \cdot 5{,}45 = 8{,}175\ mW$

$P_{Q3} = I_{c3} \cdot V_{CE3} = 10^{-3} \cdot 8 = 8\ mW$

$P_{Q4} = I_{c4} \cdot V_{CE4} = 0{,}5 \cdot 10^{-3} \cdot 9 = 1{,}5\ mW$

$P_{Q5} = I_{c5} \cdot V_{CE5} = 1{,}5 \cdot 10^{-3} \cdot 0{,}5 = 750\ \mu W$

$P_{Q6} = I_{c6} \cdot V_{CE6} = 1{,}5 \cdot 10^{-6} \cdot 0{,}6 = 900\ \mu W$

$P_{Q7} = I_{c7} \cdot V_{CE7} = 10 \cdot 10^{-3} \cdot 8 = 80\ mW$

$P_{Q8} = I_{c8} \cdot V_{CE8} = 10^{-3} \cdot 30 \cdot 10^{-3} = 30\ \mu W$

$P_{Q9} = I_{c9} \cdot V_{CE9} = 10^{-3} \cdot 34 \cdot 10^{-3} = 34\ \mu W$

$P_{Q10} = I_{c10} \cdot V_{CE10} = 5 \cdot 10^{-6} \cdot 4 = 20\ \mu W$

Puteile pe diode

$P_{D1} = V_{D1} \cdot I_{D1} = 2{,}7 \cdot 7{,}4 \cdot 10^{-3} \approx 20\ mW$

$P_{D2} = V_{D2} \cdot I_{D2} = 2{,}8 \cdot 10^{-3} \cdot 15 \approx 42\ mW$

$P_{D3} = V_{D3} \cdot I_{D3} = 2{,}8 \cdot 15 \cdot 10^{-3} \approx 42\ mW$

Derivă termică

$V_{BE7} \rightarrow V_{BE4}$

$R_{sus} \rightarrow R_1 + R_7$ (R7-pot)

$R_{jos} \rightarrow R_{42} + R_2$

$$\frac{\Delta V_o}{\Delta T} = \frac{\Delta \left[(P_1 + R_4 + R_5) \cdot (V_{BE4} + V_{D1}) \cdot \frac{1}{R_6} \right]}{\Delta T}$$

$$\frac{\Delta V_o}{\Delta T} = \frac{P_1 + R_4 + R_5}{R_4} \cdot \left(\frac{\Delta V_{BE4}}{\Delta T} + \frac{\Delta V_{D1}}{\Delta T} \right)$$

($\frac{\Delta V_{BE4}}{\Delta T} = -2$, $\frac{\Delta V_{D1}}{\Delta T} = 2{,}3$)

$$\Rightarrow \frac{\Delta V_o}{\Delta T} = \frac{5 \cdot 10^3 + 5{,}6 \cdot 10^3 + 680}{3{,}5 \cdot 10^3} \cdot (0{,}3)$$

$$\Rightarrow \frac{\Delta V_o}{\Delta T} = 0{,}86\ \frac{mV}{^\circ C}$$