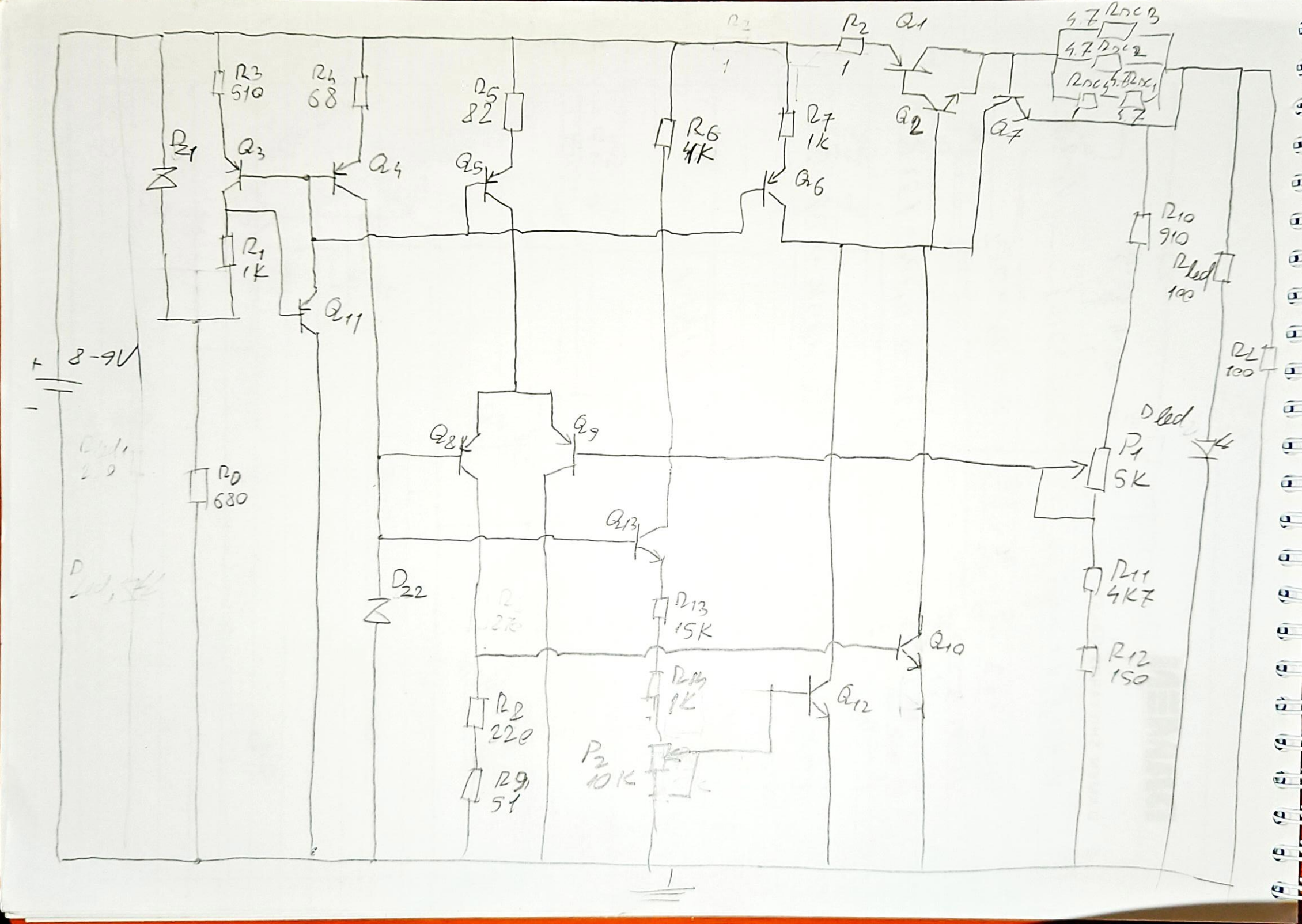

R3 510
R4 68
R5 82
R6 4K
R7 1K
R2
Q1
Q2
Q7
4.7
4.7
4.7
4.7
Q3
Q4
Q5
Q6
Z1
R1 1K
Q11
R10 910
Rled 100
RL 100
+ 8-9V -
R0 680
Q8
Q9
Dled
P1 5K
Q13
D22
R11 4K7
R12 150
D13 15K
Q10
R14 1K
Q12
R8 22e
R9 51
P2 10K

PSF - pag 1

$D_{Z1} = D_{Z2}$ $\begin{cases} V_Z = 2,7V \\ I_{Z,min} = 5mA \\ \Delta V_Z / \Delta T = 0mV/K \end{cases}$

Q_1 $\begin{cases} V_{EB} = 0.6V \\ \beta_1 = 100 \\ V_{EC,max} = 100V \end{cases}$

$Q_{2,7,10,12,13}$ $\begin{cases} V_{BE} = 0.66V \\ \beta = 300 \\ V_{CE,max} = 65V \\ P_{d,max} = 0,25W \end{cases}$

$Q_{3,4,5,6,8,9,11}$ $\begin{cases} V_{EB} = 0.7V \\ \beta_1 = 300 \\ V_{EC,max} = 65V \\ P_{d,max} = 0,25W \end{cases}$

Tr. transz. în RAN cu excepția Q_7, Q_{12} diodele în conducție și stabilizare

$V_{IN} = 8V$

$$i_{12_0} = \frac{V_{IN} - V_{Z1}}{R_0} = \frac{8 - 2,7}{680} = 7,8mA$$

$$i_{12_1} = \frac{V_{Z1} - 2V_{BE} \to (V_{BE_3} + V_{BE_{11}})}{R_1} = \frac{2,7 - 1.4}{1} = 1,3mA = i_{C_3}$$

Cum $Q_3 \approx Q_4 \approx Q_5 \approx Q_6$ → curentul va fi reglat cu ajutorul R_2, R_3, R_4, R_5, R_6

$$i_{C_3} R_3 + V_{BE_3} - V_{BE_4} + i_{C_4} R_4 = 0 \Rightarrow i_{C_4} = \frac{i_{C_3} R_3}{R_4} = 1.3 \cdot \frac{510}{68} = 7,5mA$$

$$i_{C_5} = i_{C_3} \frac{R_3}{R_5} = 1.3 \cdot \frac{510}{82} = 6,2mA \quad | \quad i_{C_4} = i_{Z_2} = 7,5mA > i_{Z,min}$$

$$i_{C_6} = i_{C_3} \cdot \frac{R_3}{R_6} = 1.3 \cdot \frac{510}{470} = 1.085mA \quad | \quad i_{Z_1} = i_{12_0} - i_{12_1} = 6,5mA > i_{Z,min}$$

$$i_{C_8} = \frac{V_{BE10}}{R_8 + R_9} = \frac{0.66}{280} = 2,3mA \to i_{C_9} = i_{C_5} - i_{C_8} = 3,8mA$$

$$V_{R11} + V_{R12} = V_{Z_2} + V_{BE_8} - V_{BE_9} = V_0 \cdot \frac{(R_{11} + R_{12})}{(R_{11} + R_{12}) + R_{10} + P_1}$$

PSF - pag 2

$V_o = \left(1 + \frac{R_{10} + P_1}{R_{11} + R_{12}}\right) \cdot V_z \Rightarrow$ dacă $P_1 = 0 \Rightarrow V_o = \left(1 + \frac{910}{4850}\right) \cdot 2{,}7 = 3{,}2V$

dacă $P_1 = 5K \Rightarrow V_o = \left(1 + \frac{5910}{4850}\right) \cdot 2{,}7 = 6V$

$i_o = \frac{V_o}{R_L} = 32 \div 60\ mA$ $\quad P_1 = 2{,}5 \Rightarrow V_o = \left(1 + \frac{3410}{4850}\right) \cdot 2{,}7 = 4{,}5V$

$i_o = i_{C_1} = 45\ mA$

$i_{C_2} = \frac{i_{C_1}}{\beta_1} = \frac{45}{100} = 0.45\ mA$

$i_o \cdot R_{DC} = V_{BE_7} = 0.72\ mV \Rightarrow$ Q_7 în funcț normală blocat $\Rightarrow i_{C_7} = 0$

$R_{DC} = (R_{DC_1} + R_{DC_4}) \,//\, R_{DC_2} \,//\, R_{DC_3} = 5.7 \,//\, 4.7 \,//\, 4.7 \simeq 1.6\Omega$

$i_{B_2} = i_{C_2} / \beta_2 = \frac{0.45}{300} = 1{,}5\mu A$

$i_{C_{10}} = i_{R_6} - i_{B_2} = 1.085 - 0.0015 \simeq 1.083\ mA$

$V_{Z_2} = V_{BE_3} + i_{E_{13}}\left(R_{13} + \frac{P_2 \cdot 0}{+R_{14}}\right) \Rightarrow i_{E_{13}} = \frac{V_{Z_2} - V_{BE_{13}}}{R_{15} + R_{13} + P_2 \cdot 0.5} = \frac{2{,}7 - 0.7}{\frac{20K}{21K}} = \frac{95\mu A}{105\mu A}$

$i_{E_{13}} \cdot 0.5 P_{12} = V_{BE_{12}} = 0.5V \rightarrow Q_{12}$ - în funcț. normală blocat $i_{C_{12}} = 0$

$i_{C_{13}} \simeq i_{E_{13}} = 95\mu A \simeq 0{,}1\ mA$

$V_{EC_1} = V_{iN} - V_o - R_{DC} I_o \cong V_{iN} - V_o = 8 - 4{,}5 = 3{,}5V$

$V_{CE_2} = V_{EC_1} - V_{EB_1} = 3{,}5 - 0.6 = 2{,}9V$

$V_{EC_3} = 2 V_{EB} = 1.4V$

$V_{EC_4} = V_{iN} - V_{Z_2} = 8 - 2.7 = 5.3V$

$V_{EC_5} = V_{iN} - V_{EB_8} - V_{Z_2} = 8 - 0.7 - 2.7 = 4.6V$

$V_{EC_6} = V_{EC_1} - V_{BE_2} = 3{,}5 - 0.6 = 2.9V$

PSF - pag 3

$V_{EC_{11}} = V_{iN} - V_{EB_3} = 8 - 0.7 = 7.3V$

$V_{EC_8} = V_{Z2} + V_{EB_8} = V_{EC_9} = 2.7V$

$V_{EC_9} = V_{B2} + V_{EB_8} = 3,4V$

$V_{CE_{10}} = V_o + V_{BE_2} = 4,5 + 0.7 = 5,2V$

$V_{CE_{13}} = V_{iN} - i_{C_{13}}(R_Z + 0.5P_2) = 8 - 0.1 \cdot 6K = 7,4V$

$V_{CE_7} = V_{CE_{10}} - V_o = 5,2 - 4,5 = 0.7V$

$V_{CE_{12}} = V_{CE_{10}} = 5,2V$

$V_{R_{ech_2}} = V_o \cdot \frac{R_{ech_2}}{R_{ech_2} + R_L} = 4,5 \cdot \frac{1}{2} = 2.25V$

$I_{ech_2} = \frac{V_{ech_2}}{R_{ech_2}} = 22mA$

$i_{ech_1} = \frac{V_{iN}}{R_{ech_1}} = 36mA$

D_{Z_1} { $i_Z = 6,5mA$, $V_Z = 2,7V$ }

D_{Z_2} { $i_Z = 7,5mA$, $V_Z = 2.7V$ }

Q_1 { $i_{C_1} = 45mA$, $V_{EC} = 3,5V$, $V_{EB} = 0.6V$ }

Q_2 { $i_{C_2} = 0.45mA$, $V_{CE_2} = 2.9V$, $V_{BE_2} = 0.6V$ }

Q_3 { $i_{C_3} = 1,3mA$, $V_{EC_3} = 1.4V$, $V_{EB_3} = 0.7V$ }

Q_4 { $i_{C_4} = 7.5mA$, $V_{EC_4} = 5.3V$, $V_{EB_4} = 0.8V$ }

Q_5 { $i_{C_5} = 6.2mA$, $V_{EC_5} = 4.6V$, $V_{EB_5} = 0.7V$ }

Q_6 { $i_{C_6} = 1.085mA$, $V_{EC_6} = 2.9V$, $V_{EB_6} = 0.8V$ }

Q_7 { $i_{C_7} = 0$, $V_{CE_7} = 0.785mV$, $V_{BE_7} = 0.6V$ }

Q_8 { $i_{C_8} = 2,4mA$, $V_{EC_8} = 2.7V$, $V_{EB_8} = 0.7V$ }

Q_9 { $i_{C_9} = 3.8mA$, $V_{EC_9} = 3.4V$, $V_{EB_9} = 0.7V$ }

Q_{10} { $i_{C_{10}} = 1.07mA$, $V_{CE_{10}} = 5,2V$, $V_{BE_{10}} = 0.6V$ }

Q_{11} { $i_{C_{11}} = 0$, $V_{CE_{11}} = 7.3V$, $V_{BE_{11}} = 0.7V$ }

Q_{12} { $i_C = 0$, $V_{CE} = 5.2V$, $V_{BE} = 0.6V$ }

Q_{13} { $i_{C_{13}} = 0.1mA$, $V_{CE_{13}} = 7,4V$, $V_{BE_{13}} = 0.6V$ }

P_{ech} { $V_{ech} = 3V$ }

Q_{11} - suportă curentul de bază a oglinzii de curent $\Rightarrow i_{C_{11}} \approx 0$

Calculul puterilor - pag 4

$P_{dQ_1} = i_{C_1} V_{EC_1} = 0.15 mW$
$P_{dQ_{12}} = i_{C_2} V_{CE_2} = 0.5 mW$
$P_{dQ_3} = i_{C_3} V_{EC_3} = 1.2 mW$
$P_{dQ_4} = i_{C_4} V_{EC_4} = 35 mW$
$P_{dQ_5} = i_{C_5} V_{EC_5} = 25 mW$
$P_{dQ_6} = i_{C_6} V_{EC_6} = 2,5 mW$
$P_{dQ_7} = i_{C_7} V_{CE_7} \cong 0$
$P_{dQ_8} = i_{C_8} V_{EC_8} = 6.48 mW$
$P_{dQ_9} = i_{C_9} \cdot V_{EC_9} = 11,1 mW$
$P_{dQ_{10}} = i_{C_{10}} \cdot V_{EE_{10}} = 5,8 mW$
$P_{dQ_{11}} \cong 0$
$P_{dQ_{12}} \cong 0$
$P_{dQ_{13}} \cong 0.7 mW$

$P_{dR_1} = i_{C_3}^2 R_1 = 1 mW$
$P_{dR_2} = i_{C_1}^2 R_2 = 2 mW$
$P_{dR_3} = i_{C_3}^2 R_3 = 0,5 mW$
$P_{dR_4} = i_{C_4}^2 R_4 = 3,1 mW$
$P_{dR_5} = i_{C_5}^2 R_5 = 2.7 mW$
$P_{dR_7} = i_{C_{13}}^2 R_7 = 0,01 mW$
$P_{dR_6} = i_{C_6}^2 R_6 = 0,56 mW$
$P_{dR_8} = i_{C_8}^2 R_8 = 1,5 mW$
$P_{dR_{13}} = i_{C_{13}}^2 \cdot R_{13} = 0,17 mW$
$P_{dP_1} = i_{C_{13}}^2 \cdot P_2 \cdot 0,5 = 0.06 mW$

$P_{dR_{xc_3}} \cong P_{dR_{xc_2}} \cong P_{d(R_{xc_1} + R_{xc_4})} = \left(\frac{i_0}{3}\right)^2 R_{xc_1} = 2,2 mW$

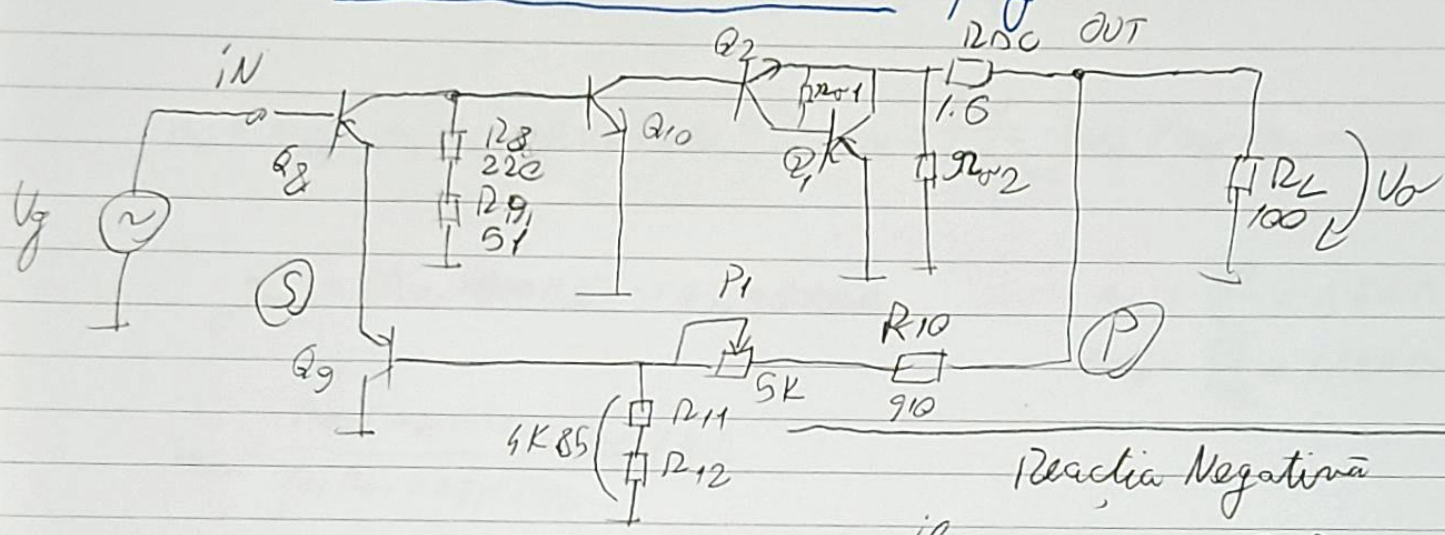
$U_{R_{10}} = V_0 \cdot \frac{R_{10}}{R_{10} + R_L} = 4,5 \cdot 0,9 = 4,05 V \rightarrow i_{R_{10}} = \frac{4,05}{910} = 4,5 mA$

$P_{dR_{10}} = i_{R_{10}}^2 R_{10} = 0,3 mW$
$P_{dP_1} = i_{R_{10}}^2 \cdot P_1 \cdot 0,5 = 2,7 mW$

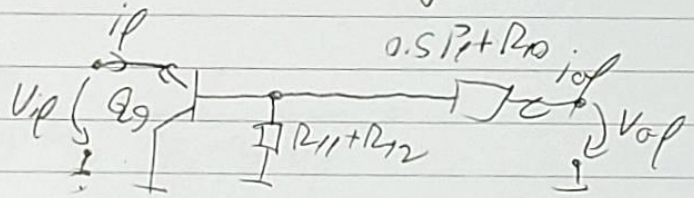
$P_{dR_{11}} = i_{R_{10}}^2 R_{11} = 1,5 mW$
$P_{dR_{12}} = i_{R_{10}}^2 \cdot R_{12} = 0.05 mW$

$P_{dR_{bcd}} = I_{bcd}^2 \cdot R_{bcd} = 23 mW$
$P_{dbcd} = I_{bcd}^2 \cdot V_{bcd} = 46 mW$

Calcul curent alternativ - pag 5



Reactia Negativa



$\beta_{et} = 0.5 \Rightarrow P_1 = 2K\Omega$

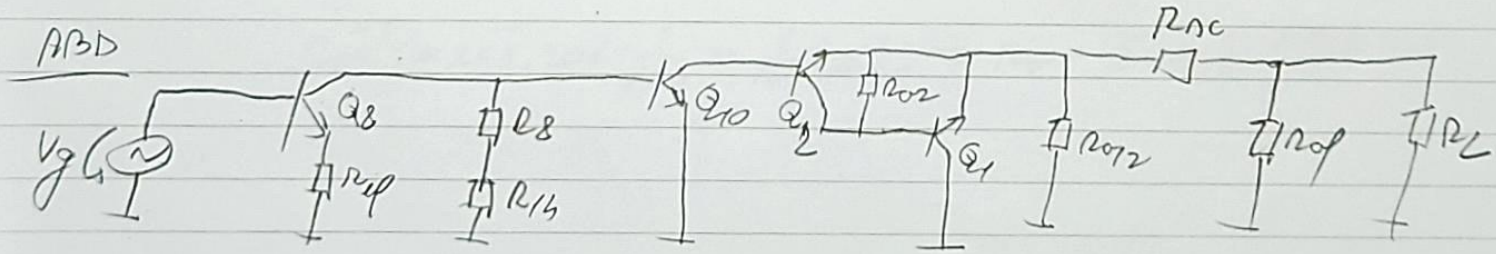
$$f_N = \frac{R_{11}+R_{12}}{R_{11}+R_{12}+0.5+R_{10}} = \frac{4850}{8260} = 0.58$$

$$r_{if} = \frac{r_{\pi 9} + (R_{11}+R_{12}) \,||\, (0.5P_1 + R_{10})}{\beta_9 + 1} = 0.013K\Omega$$

$r_{of} = P_{11} + R_{12} + 0.5P_1 + R_{10} = 8,26K$

$g_{m9} = 40 I_{C9} = 152 K\Omega^{-1}$
$g_{m8} = 40 I_{C8} = 98 K\Omega^{-1}$
$g_{m10} = 40 I_{C10} = 43 K\Omega^{-1}$
$r_{\pi 10} \cong 7K\Omega$
$r_{\pi 9} \cong 1,97K\Omega$
$r_{\pi 8} \cong 3,125K\Omega$

ABD



$$a_{Vg} = \frac{V_o}{V_g} = \frac{V_o}{i_{C12}} \cdot \frac{i_{C12}}{i_{b12}} \cdot \frac{i_{b12}}{i_{C10}} \cdot \frac{i_{C10}}{i_{b10}} \cdot \frac{i_{b10}}{i_{C8}} \cdot \frac{i_{C8}}{i_{b8}} \cdot \frac{i_{b8}}{V_g} \cong$$

$$\cong (-R_{01} \,||\, R_{of} \,||\, R_L)(-\beta_1\beta_2)(-1)\beta_{10} \cdot \frac{R_8 + R_9}{R_8 + R_9 + r_{\pi 10}} \cdot (-\beta_8) \cdot \frac{1}{r_{\pi 8} + (\beta_8 + 1) R_{if}}$$

Calcul curent alternativ - pag 6

$r_i = r_{\pi 8} + \beta_8 R_{if} = 7.025 k\Omega$ $\quad r_o = \left.\frac{v_o}{i_o}\right|_{v_g=0} = r_{o2} \| r_{of} \| R_L \simeq 100\Omega$

$g_{m1} = 40 I_{C1} = 1800 k\Omega^{-1} \rightarrow r_{\pi 1} = 600 k\Omega$ $\quad r_{o1} = \frac{80}{I_{C1}} = 1,78 k\Omega$

$r_{o2} = \frac{80}{I_{C2}} = 178 k\Omega$

$r_{o12} = \frac{r_{o1}(r_{\pi 1} + r_{o2})}{\beta_1 r_{o1} + r_{\pi 1} + r_{o2}} \simeq 1 k\Omega$

$a_{vg} = R_L \beta_1 \beta_2 \beta_{10} \beta_8 \cdot \frac{R_8 + R_9}{R_8 + R_9 + r_{\pi 10}} \cdot \frac{1}{r_{\pi 2} + \beta_8 \cdot R_{sf}} =$

$= 0,1 \cdot 300^4 \cdot \frac{0,270}{7} \cdot \frac{1}{3 + 300 \cdot 0,01} = 0,1 \cdot 300^4 \cdot 0,03 \cdot 0,11$

$= 360.000$

$T = a_{vg} \cdot f_v = 360.000 \cdot 0,58 = 208.200 > 0$

Cum $T >> 1 \Rightarrow A_{vg} = \frac{1}{f} = 1,72$

$R_o^{-1} = (1 + T) r_o^{-1} - R_L^{-1}$

$R_o^{-1} = 208.201 \cdot \frac{1}{100} - \frac{1}{100} (\Omega^{-1}) \rightarrow R_o = \frac{1}{208,2} = 4,8 m\Omega$