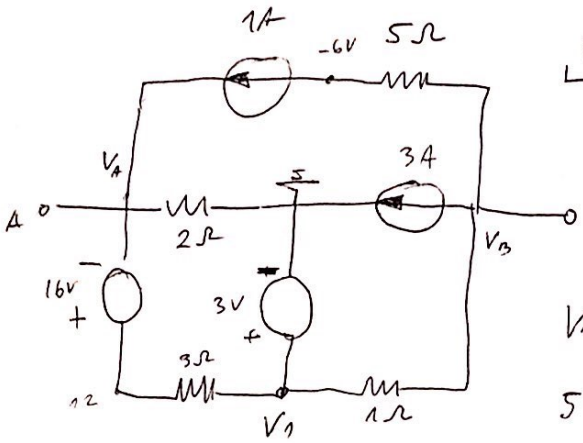
jan '19



$V_1 = 3V$ $\quad V_B - V_1 = -4$

$V_B = -1V$

$V_A\left(\frac{1}{2}+\frac{1}{3}\right) - \frac{1}{3}V_1 = -\frac{16}{3} + 1 \;/\cdot 6$

$5V_A - 2V_1 = -32 + 6$

$5V_A = -20$

$V_A = -4V$

-26

$I_A = 2A$ $\quad P_{3A} = 3W$

$I_B = 3A$ $\quad P_{3V} = 3W$

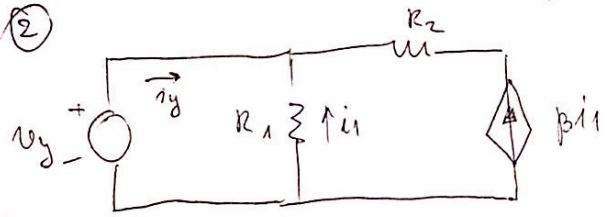
$I_C = 1A$ $\quad P_{16V} = 48W$

$I_D = 4A$ $\quad P_{1A} = 2W$

$\frac{2\cdot 3}{5} = \frac{6}{5} + 1 = \frac{11}{5}$

$V_T = -3V$ $\quad R_T = \frac{11}{5}\Omega$ $\quad R_p = \frac{11}{5}\Omega$

②

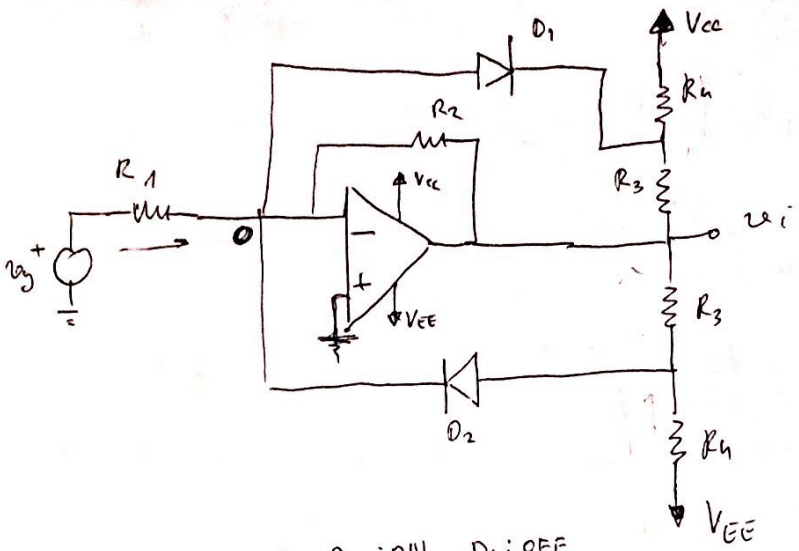


$i_g = -(1+\beta) i_1$

$i_1 R_1 + v_g = 0$

$i_1 = -\frac{v_g}{R_1}$ $\quad i_g = \frac{1+\beta}{R_1} v_g$

$R_{EKV} = \frac{R_1}{1+\beta}$



за $v_g = -3V$ имаме D_2 : ON D_1 : OFF

$$\frac{v_g}{R_1} + \frac{v_i}{R_2} + \frac{v_i}{R_3} + \frac{V_{EE}}{R_н} = 0$$

$$v_i\left(\frac{1}{R_2} + \frac{1}{R_3}\right) = -\frac{v_g}{R_1} - \frac{V_{EE}}{R_н}$$

$$v_i = -\frac{R_2 R_3}{R_1(R_2+R_3)} v_g - \frac{R_2 R_3}{(R_2+R_3)R_н} V_{EE}$$

$$\boxed{v_i = -2v_g + 2{,}4}$$

$$i_{D2} = \frac{v_i}{R_3} + \frac{V_{EE}}{R_н} = -\frac{2v_g}{R_3} - \frac{14{,}4}{R_н} > 0$$

$$\frac{V_{cc} - V_x}{R_н} = \frac{V_x - v_i}{R_3}$$

V_x | D_2 ie ON

$$-\frac{2v_g}{R_3} - \frac{14{,}4}{R_н}$$

за $v_g = -2{,}38V$ OFF

D_2

$$\frac{R_3}{R_н} V_{cc} - \frac{R_3}{R_н} V_x = V_x - v_i$$

$$\frac{R_3}{R_н} V_{cc} + v_i = \left(\frac{R_н + R_3}{R_н}\right) v_x$$

$$v_x = \frac{R_3}{R_н + R_3} V_{cc} + \frac{R_н}{R_н + R_3}(-2v_g + 2{,}4) > 0$$

D_1 je OFF

$$i_{D2} = -\frac{v_g}{R_1} - \frac{v_i}{R_2} = -\frac{v_g}{R_1} + \frac{2v_g}{R_2} - \frac{2{,}4}{R_2} = \text{около } 90\mu A$$

$$-\frac{v_g}{R_2}$$

за $v_g = -1{,}2V$ $D_2 \rightarrow$ OFF

$$\frac{v_g}{R_1} = -\frac{v_i}{R_2} \qquad \boxed{v_i = -4v_g}$$

$$\frac{V_{cc} - v_x}{R_4} = \frac{v_x - v_i}{R_3} \qquad v_x = \frac{R_3}{R_3+R_4} V_{cc} + \frac{R_4}{R_3+R_4} \cdot (-4v_g) \searrow$$

za $v_x = 0$ mj. $\quad v_g = \frac{R_3}{4R_4} V_{cc} = 1{,}2 \quad D_1 \nearrow ON$

$$\frac{v_g}{R_1} + \frac{V_{cc}}{R_4} + \frac{-v_i}{R_2} + V_{EE} -$$

$$\frac{v_g}{R_1} + \frac{v_i}{R_2} + \frac{V_{cc}}{R_4} = -\frac{v_i}{R_3}$$

$$\frac{2v_i}{R_2} = -\frac{v_g}{R_1} - \frac{V_{cc}}{R_4} \qquad \boxed{v_i = -2v_g - 2{,}4}$$

$$\frac{v_g}{R_1} + \frac{v_i}{R_2} = i_D = \frac{4v_g - 2v_g - 2{,}4}{R_2} = \frac{2v_g - 2{,}4}{R_2} \nearrow D_1 \text{ ostaje } ON$$

$$\frac{v_i - V_y}{R_3} = \frac{v_x - V_{EE}}{R_4} \qquad \frac{R_4}{R_3} v_i + V_{EE} = v_x \left(\frac{R_3 + R_4}{R_3}\right)$$

$$v_x = \frac{R_4}{R_3+R_4} v_i + \frac{R_3}{R_3+R_4} V_{EE} \quad < 0$$

4. a) Vz/R8=10mA→Vz=5V.

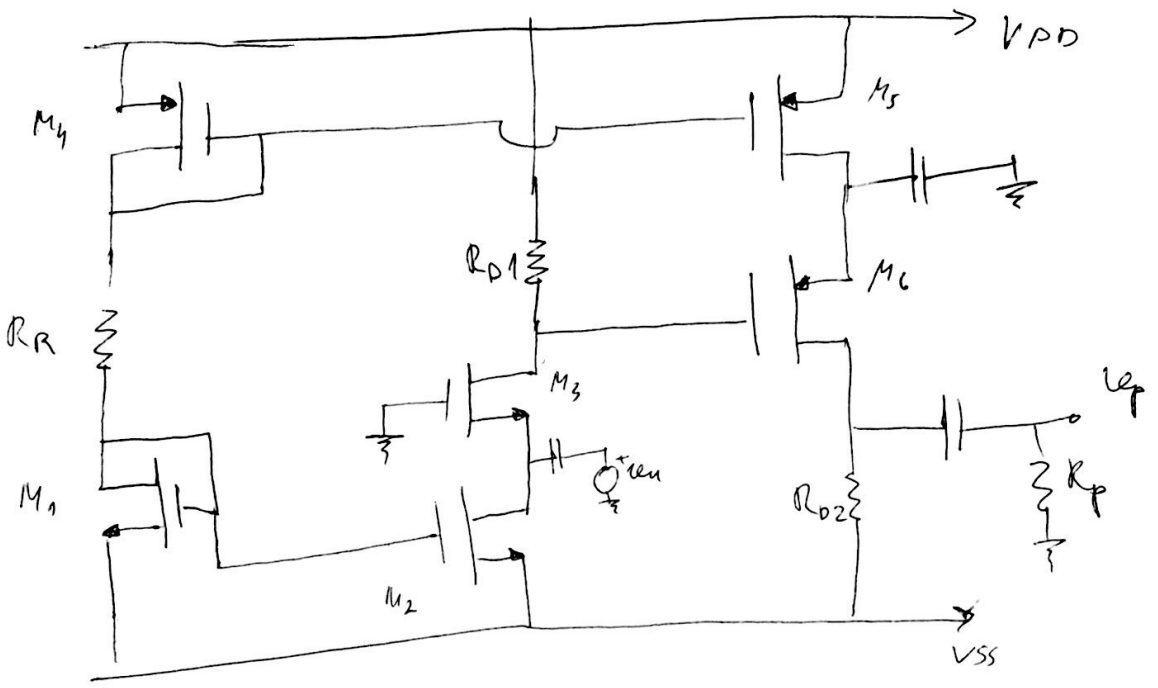
b) Vout=$-105\Omega \cdot 10\text{mA} \cdot 10 = -10.5\text{V}$.

c) Kada je temperatura nula na izlazu treba da bude nula, prema tome Vref treba da bude jednako 10V.

d) Minimalni mogući napon na izlazu je –12V.

$$-12\text{V} = -100\text{mV} \cdot T_{max} / {}^{\circ}\text{C} \rightarrow T_{max} = 12\text{V} \cdot {}^{\circ}\text{C} / 100\text{mV} = 120\,{}^{\circ}\text{C}$$

e) $$I = 10\text{mA} - \frac{10\text{mA}}{(1+\beta)^2} = 10\text{mA}\left(1 - \frac{1}{(1+\beta)^2}\right)$$



$I_1 = I_2 = I_3$

$$V_{SG4} = \sqrt{\frac{2I}{B_4}} + V_t$$

$$V_{G4} = V_{DD} - \sqrt{\frac{2I}{B_4}} - V_t = 10V$$

$$V_{G1} = \sqrt{\frac{2I}{B_1}} + V_t + V_{SS} = -10V$$

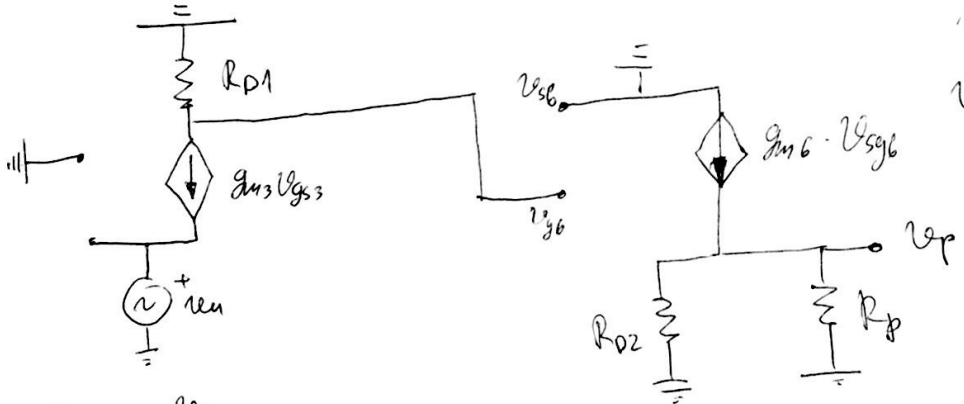
$R_R = 20\,k\Omega$

$I_5 = 2\mu A$

$g_{m3} = 2m\,S$

$g_{m6} = 4m\,S$

$v_{in} + g_{m3} v_{gs3} R_g = v_{s3}$



$v_{s3} = g_{m3} v_{gs3} R_g + v_{in}$

$v_s (1 + g_{m3} R_g) = + v_{in}$

$$v_s = + \frac{v_{in}}{1 + g_{m3} R_g}$$

$$v_{gs3} = - \frac{v_{in}}{1 + g_{m3} R_g}$$

$v_{gs3} = - v_{in}$

$v_{g6} = - g_{m3} \cdot v_{gs3} \cdot R_{D1} = g_{m3} R_{D1} \cdot v_{in}$

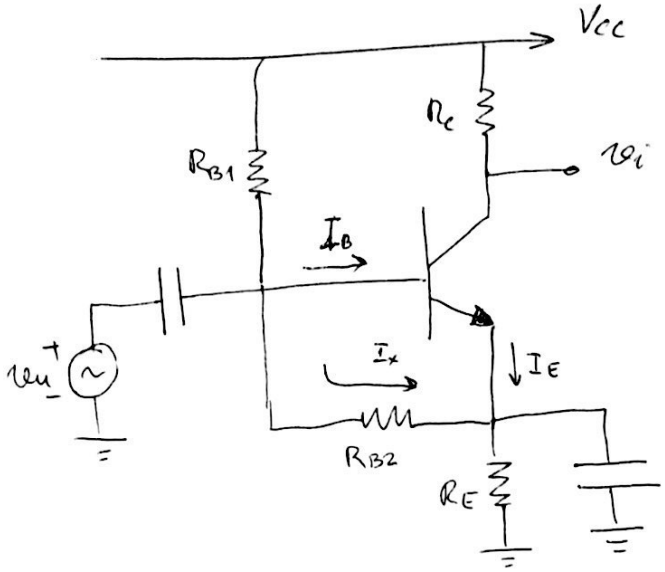
$$v_p = \underbrace{- g_{m3} g_{m6} \cdot R_{D1} \cdot R_{D2} \| R_p}_{a = -150} \cdot v_{in}$$

$-a_2 = -75$

$R_i = R_{D2}$

$v_s = g_{m3} v_{gs3} \cdot R_g$

$v_s (1 + g_{m3} R_g) = 0$



$I_C = 1{,}5\,mA$

$I_B = 30\,\mu A$

$I_E = 1{,}53\,mA$

$(I_x + I_E) R_E = V_E$

$V_B = (I_x + I_E) R_E + 0{,}7$

V_{BE}

$V_{cc} - R_{B1}(I_B + I_x) = V_B$

$V_{cc} - R_{B1}(I_B + I_x) - R_E(I_x + I_E) = 0{,}7\,V$

$V_{cc} - 0{,}7V = R_{B1} I_B + R_{B1} I_x + R_E I_x + R_E I_E$

$I_x (R_E + R_{B1})$

$I_x = \frac{1{,}47}{R_E + R_{B1}} \Rightarrow R_{B2} = \frac{0{,}7}{I_x} \approx 1031\,\Omega$

KVL

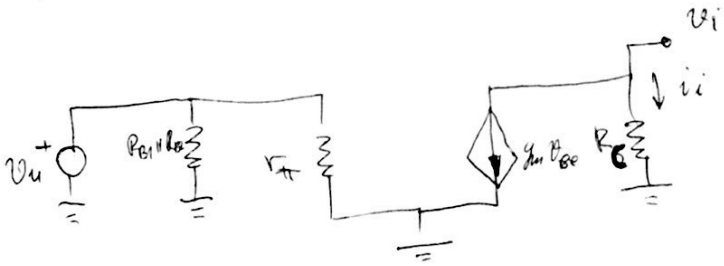
$I_x R_{B2} = 0{,}7$

$R_{B2} = \frac{0{,}7}{I_x}$

$r_\pi = 833{,}33\,\Omega$

$g_m = 60\,mS$

$R_{B1} // R_{B2} =$



$i_i = \frac{v_u}{r_\pi}$

$i_i = -\beta i_b = -\frac{\beta}{r_\pi} \cdot v_u$

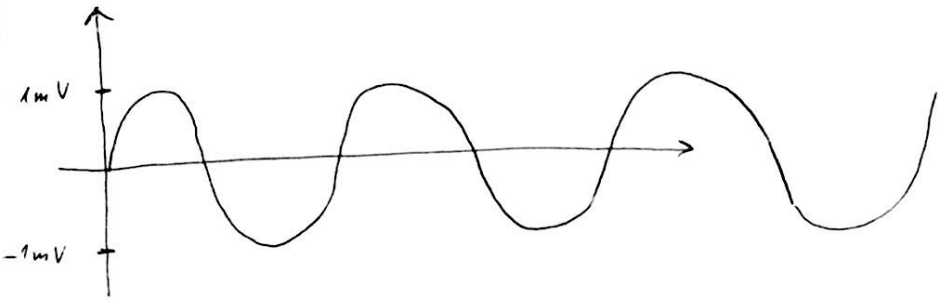
$i_u = \frac{v_u}{r_\pi // R_{B1} // R_{B2}}$

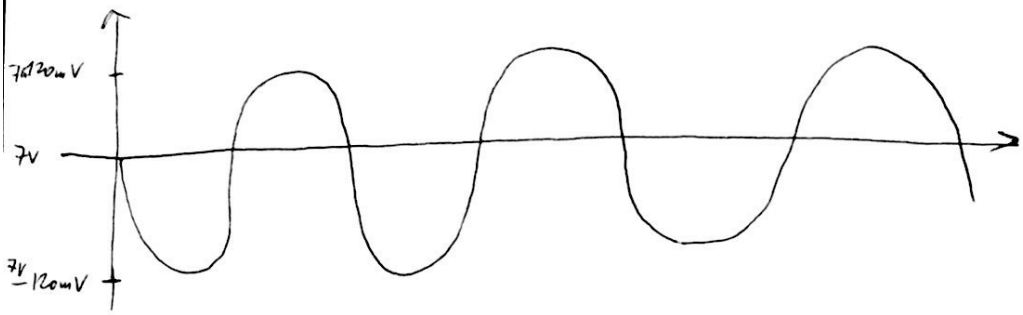
$v_i = i_i \cdot R_C = -\frac{\beta R_C}{r_\pi} \cdot v_u =$

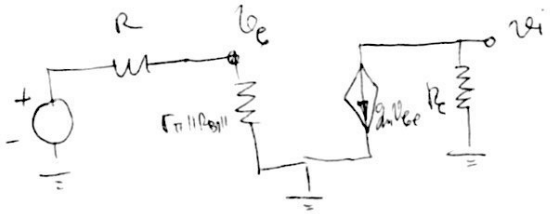
$A_V = -120$

$A_V = -510$

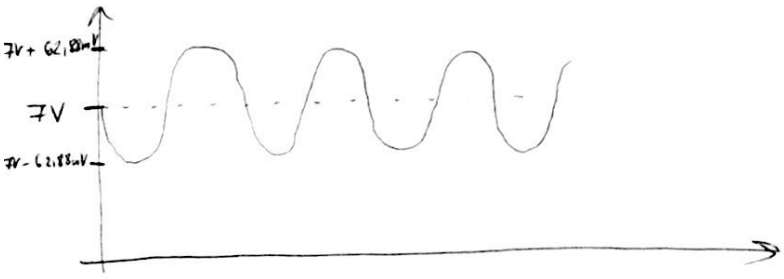
$A_i = \frac{-\beta \cdot r_\pi // R_{B1} // R_{B2}}{r_\pi} = -26{,}42$

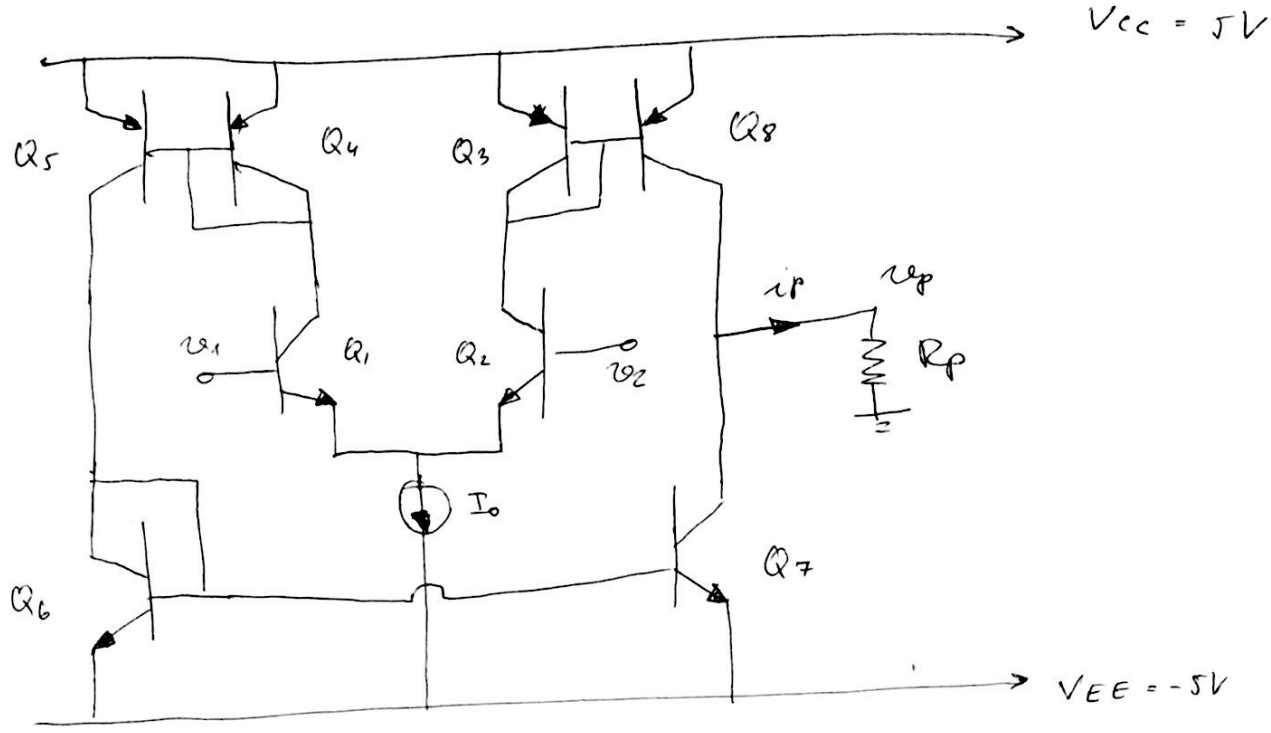






$$v_g = \frac{r_\pi \| R_{B1} \| R_{B2}}{R + r_\pi \| R_{B1} \| R_{B2}} v_g \Rightarrow v_i = -g_m v_g \cdot R_c = \underbrace{-62,88}_{a} v_g$$





$I_{E1} = I_{E2} = \frac{I_0}{2} = 100\,\mu A$

$I_{C1} = I_{C2} = 99,01\,\mu A$

$I_{C4} + 2I_{B4} = I_{C1}$

$I_{B4} = \frac{I_{C1}}{2+\beta} = 0,9706\,\mu A$

$I_{C4} = 97,06\,\mu A = I_{C5} = I_{C8}$

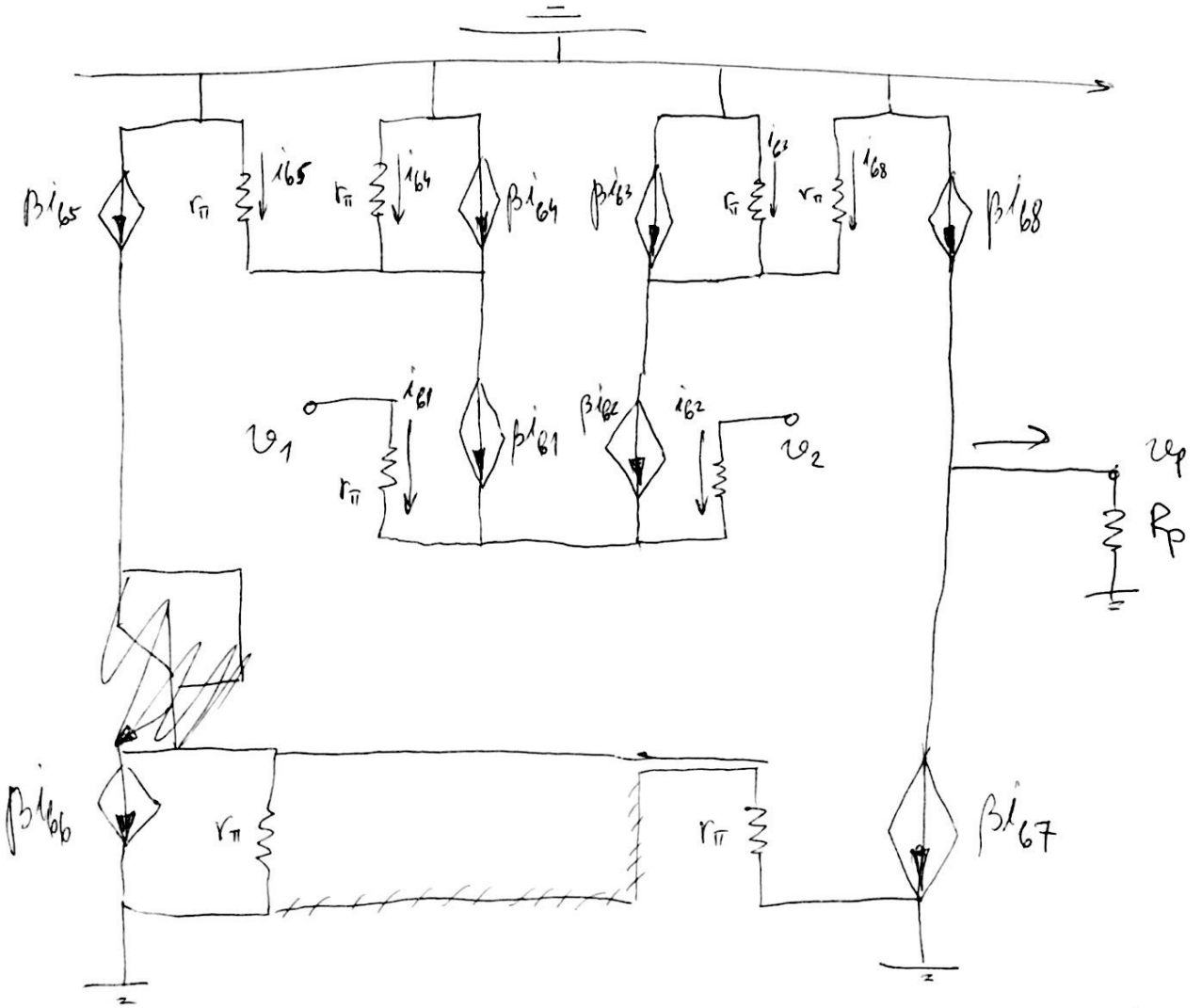
$I_{C6} + 2I_{B6} = I_{C5}$

$I_{B6} = \frac{I_{C5}}{\beta+2} = 0,952\,\mu A$

$I_{C6} = 95,2\,\mu A$

$V_p = 18,6\,\mu V$

$g_m = 4\,mS \quad r_\pi = 25\,k\Omega$



$$i_{b1} = \frac{v_1 - v_2}{2r_\pi} \qquad i_{b2} = \frac{v_2 - v_1}{2r_\pi}$$

$i_{b7} = i_{b1}$ $\quad i_{b8} = i_{b2}$

$v_{g1} = 1\text{m}V\cos\omega t$

$\underline{v_{g1}} = \frac{\sqrt{2}}{2}$ $\quad v_{g2} = -2\text{m}V\cos(\omega t + \frac{\pi}{6})$

$\underline{v_{g2}} = -\sqrt{2}\left(\frac{\sqrt{3}}{2} + \frac{1}{2}j\right)$

$i_p = 2\beta i_{b2} = -\frac{\sqrt{2}}{2}(\sqrt{3}+j)$

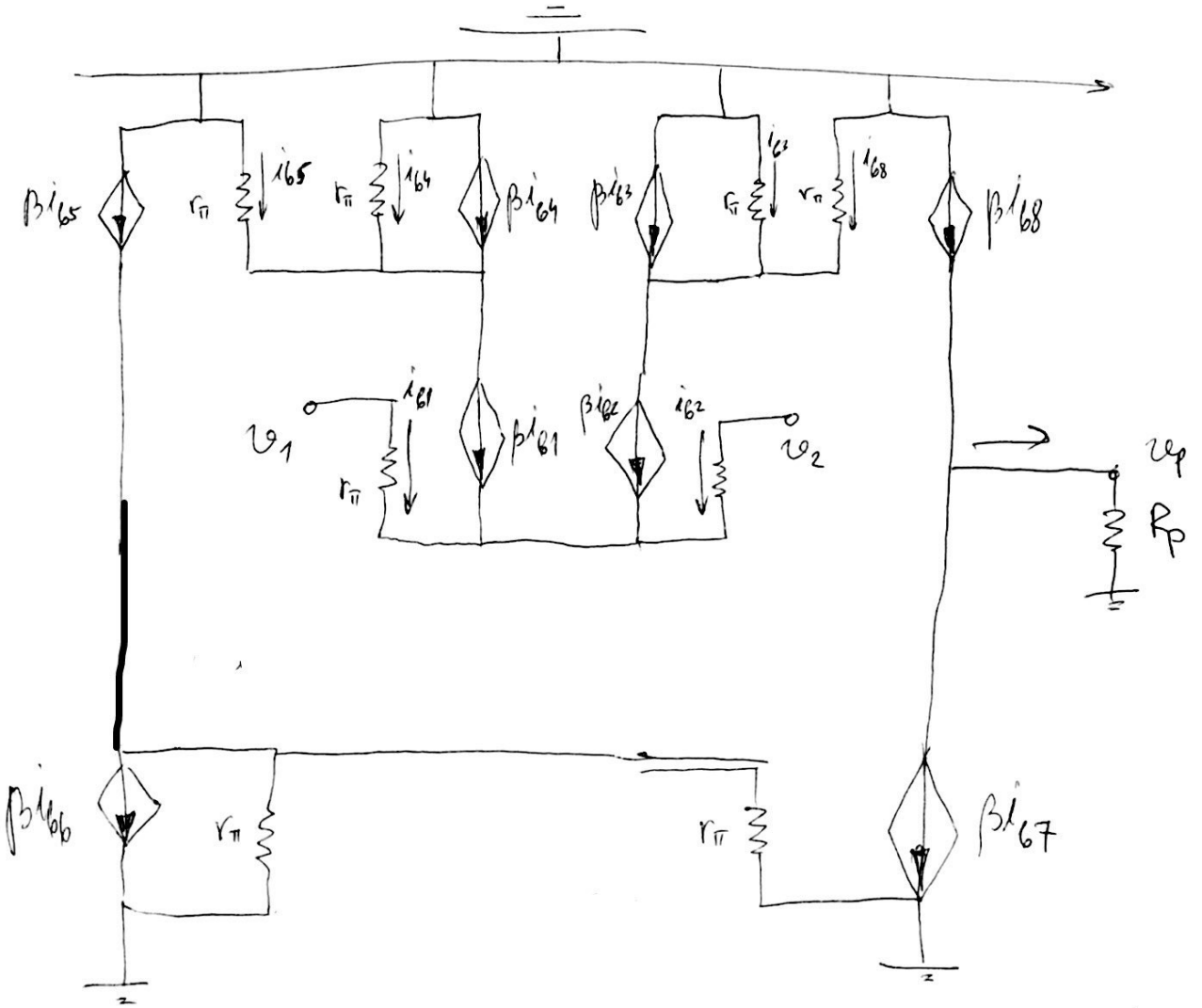
$$v_p = -\frac{\beta R_p}{r_\pi} \cdot v_d \Rightarrow \boxed{n = -0{,}04}$$

$\sqrt{2}\left(\frac{\sqrt{3}}{2} + \frac{1}{2}j\right)$

$v_p = -0{,}04\left(1\text{m}V\cos\omega t + 2\text{m}V\cos(\omega t + \frac{\pi}{6})\right)$

$\underline{v_{g1}} = \frac{\sqrt{2}}{2}\text{m}V$ $\quad \underline{v_{g2}} = -\left(\frac{\sqrt{6}}{4} + \frac{\sqrt{2}}{4}j\right) = -\frac{\sqrt{2}}{2}(\sqrt{3}+j)$

$$\underline{v_{g1}} - \underline{v_{g2}} = \frac{\sqrt{2}}{2}\left((1+\sqrt{3}) + j\right)$$



$$i_{b1} = \frac{v_1 - v_2}{2r_\pi} \qquad i_{b2} = \frac{v_2 - v_1}{2r_\pi}$$

$v_{g1} = 1\text{mV}\cos\omega t$

$\underline{v_{g1}} = \frac{\sqrt{2}}{2}$ $\quad v_{g2} = -2\text{mV}\cos(\omega t + \frac{\pi}{6})$

$\underline{v_{g2}} = -\sqrt{2}\left(\frac{\sqrt{3}}{2} + \frac{1}{2}j\right)$

$i_{b7} = i_{b1} \qquad i_{b8} = i_{b2}$

$i_p = 2\beta i_{b2} = -\frac{\sqrt{2}}{2}(\sqrt{3}+j)$

$$v_p = -\frac{\beta R_p}{r_\pi} \cdot v_d \Rightarrow \boxed{n = -0{,}04}$$

$\sqrt{2}\left(\frac{\sqrt{3}}{2} + \frac{1}{2}j\right)$

$v_p = -0{,}04\left(1\text{mV}\cos\omega t + 2\text{mV}\cos(\omega t + \frac{\pi}{6})\right)$

$\underline{v_{g1}} = \frac{\sqrt{2}}{2}\text{mV} \qquad \underline{v_{g2}} = -\left(\frac{\sqrt{6}}{4} + \frac{\sqrt{2}}{4}j\right) = -\frac{\sqrt{2}}{2}(\sqrt{3}+j)$

$$\underline{v_{g1}} - \underline{v_{g2}} = \frac{\sqrt{2}}{2}\left((1+\sqrt{3}) + j\right)$$