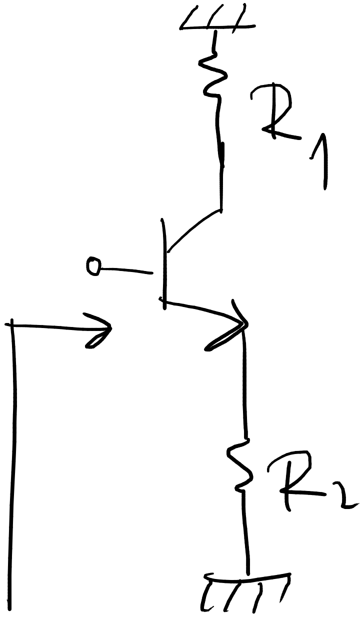
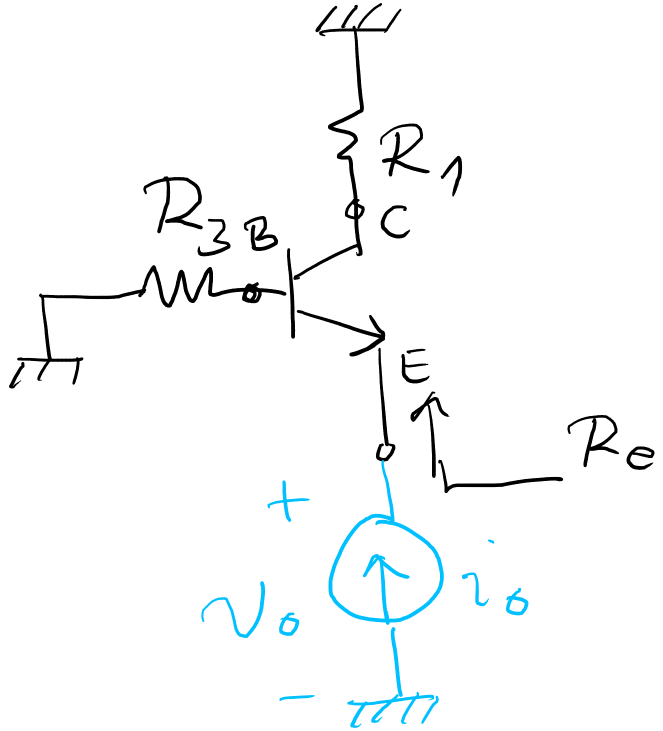
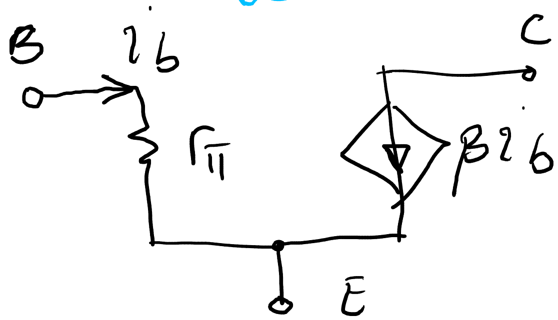
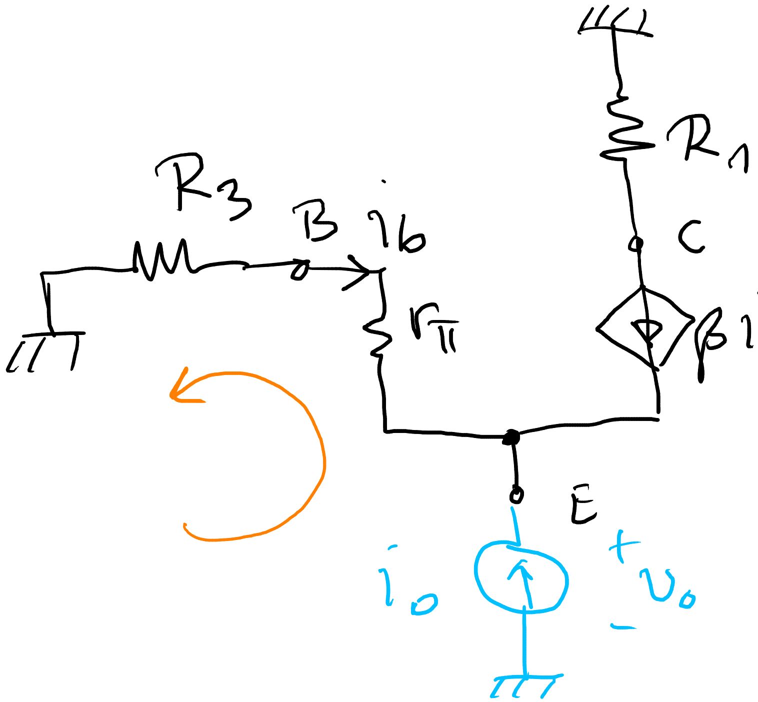


$$R_b = r_\pi + (1+\beta) R_2$$



$$R_e = \frac{v_o}{i_o}$$



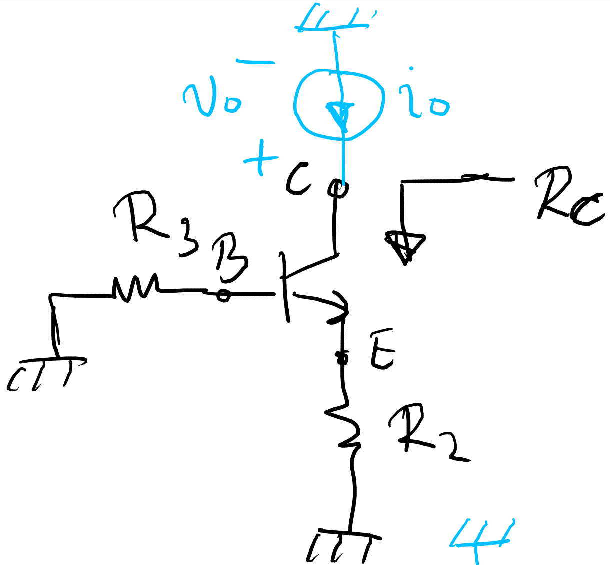


(E) $(1+\beta) i_b + i_o = 0$

(K) $v_o = -i_b (r_\pi + R_3)$

$$R_e = \frac{v_o}{i_o} = \frac{r_\pi + R_3}{1+\beta}$$

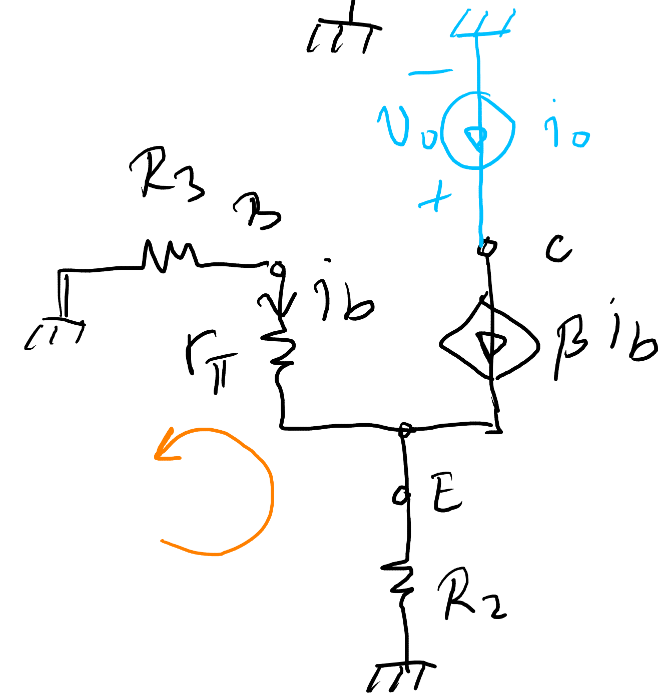
$$\beta \gg 1 \Rightarrow R_e = \frac{r_\pi + R_3}{\beta}\Bigg|_{\beta = g_m \cdot r_\pi} = \frac{1}{g_m} + \frac{R_3}{\beta}\Bigg|_{R_3 \to 0} \approx \frac{1}{g_m}$$



AKO JE $V_A \to \infty V$ KOLIKO JE R_C?

$$V_A \to \infty V \Rightarrow r_0 \approx \frac{V_A}{I_C} \to \infty \Omega$$

$$\boxed{R_C \to \infty \Omega}$$



(C) $i_o = \beta i_b \Rightarrow i_b = \frac{i_o}{\beta}$

(E) $(1+\beta) i_b = \frac{V_e}{R_2}$

(K) $V_e = -i_b(r_\pi + R_3)$

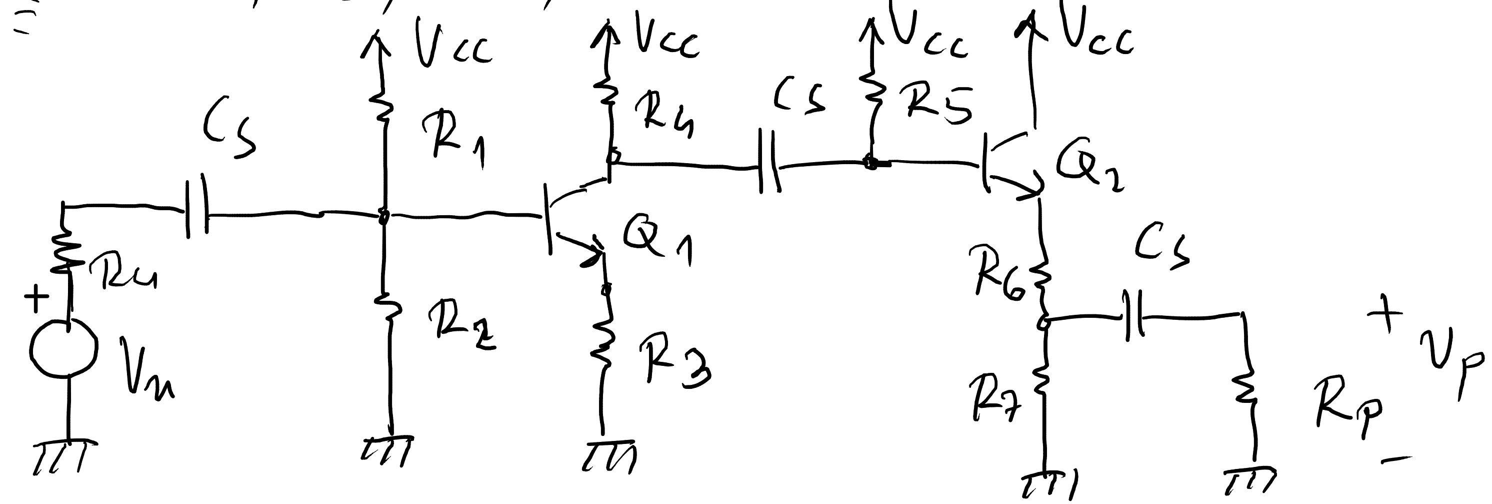
$\Rightarrow i_b = 0\,A$

$\Downarrow$

$i_o = \beta i_b = 0\,A$

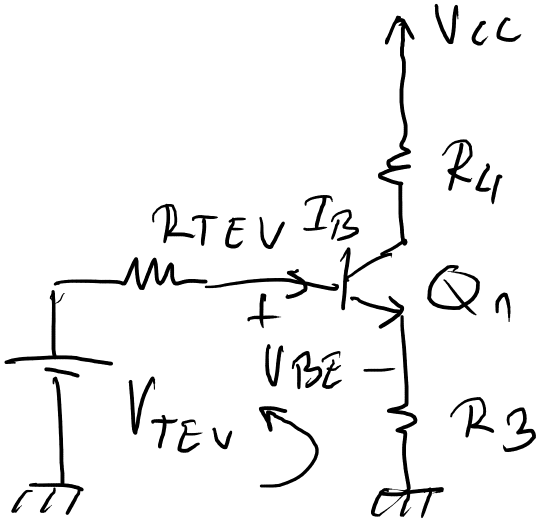
$$R_C = \frac{V_o}{i_o} \to \infty \Omega$$

P1 A_u, A_s, R_{ul}, R_{iz}



DC

$X_{C_S} = \frac{1}{\omega C_S} = \frac{1}{2\pi f \cdot C_S}\Big|_{ZA\ DC,\ f \to 0\,Hz} \to \infty\,\Omega$; $V_T = \frac{kT}{q}\Big|_{T=300K} \approx 26\,mA$



$I_{B_1} = \frac{V_{TEV} - V_{BE}}{R_{TEV} + (1+\beta)R_3} \Rightarrow I_{C_1} = \beta_1 I_{B_1} \Rightarrow g_{m_1} = \frac{I_{C_1}}{V_T}$

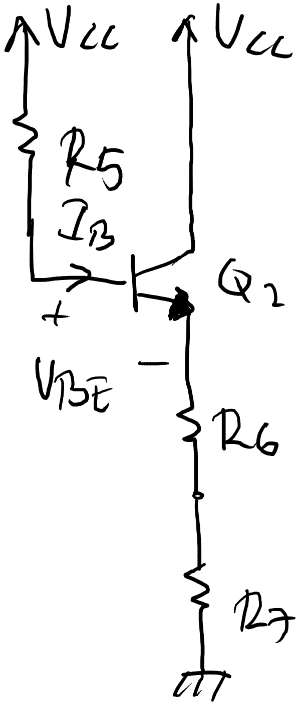
$\Downarrow$

$r_{\pi_1} = \frac{V_T}{I_{B_1}} = \frac{\beta_1}{g_{m_1}}$

$R_{TEV} = R_1 \| R_2$

$V_{TEV} = \frac{R_2}{R_2 + R_1} \cdot V_{CC}$

$r_{o_1} \approx \frac{V_{A1}}{I_{C_1}}\Big|_{V_A \to \infty V} \to \infty\,\Omega$



$$I_{B_2} = \frac{V_{CC} - V_{BE}}{R_5 + (1+\beta_2)(R_6 + R_7)} \Rightarrow I_{C_2} = \beta_2 I_B \Rightarrow g_{m_2} = \frac{I_{C_2}}{V_T}$$

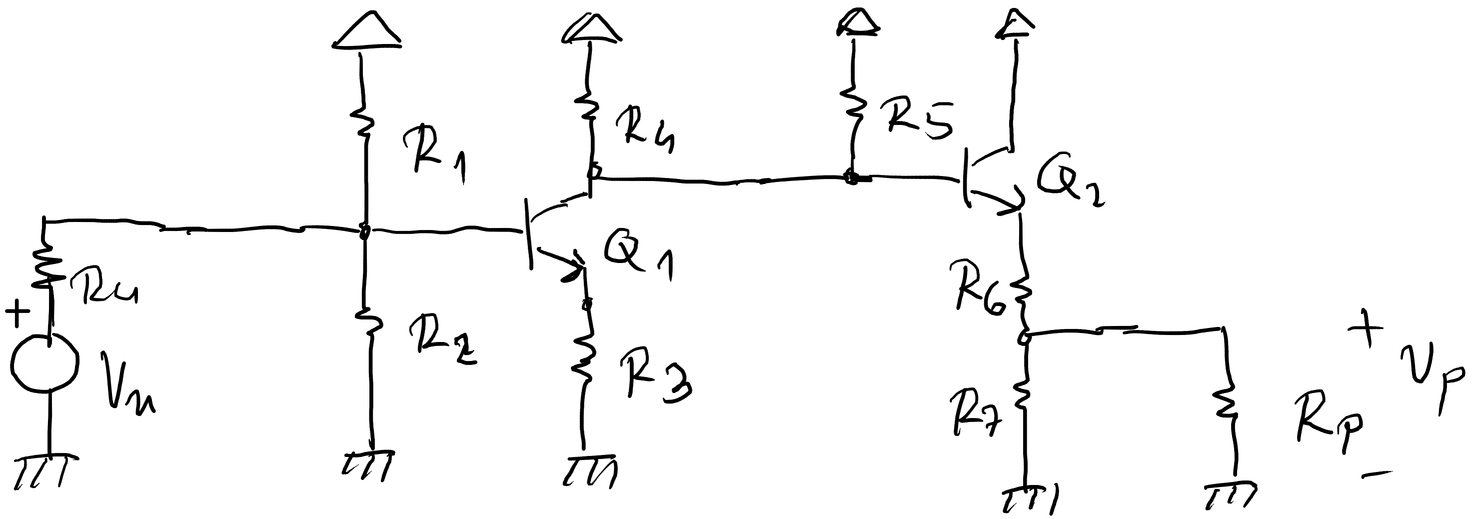
$$\Downarrow$$

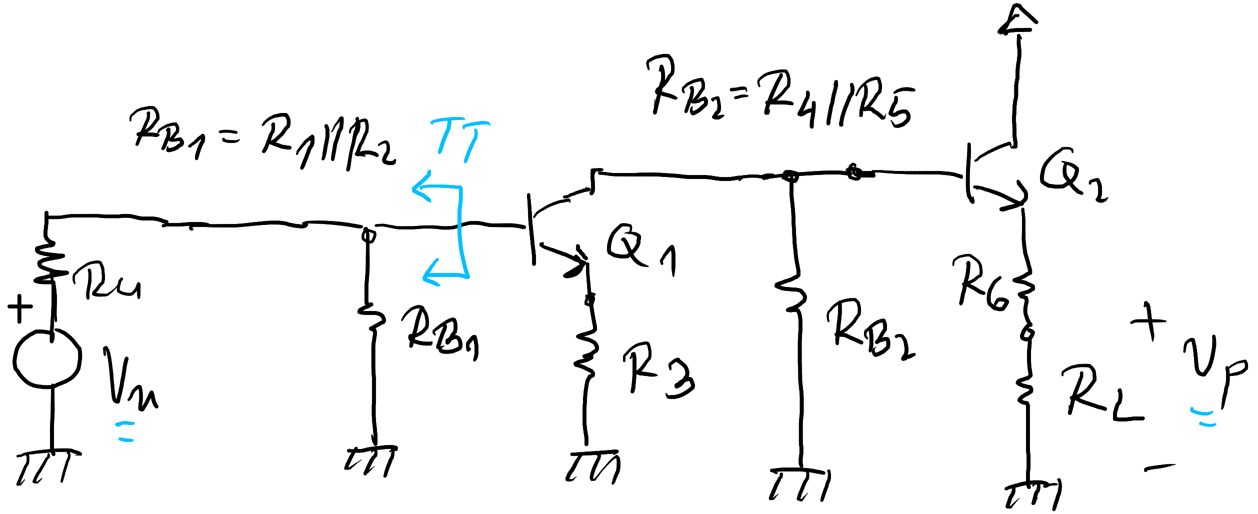
$$r_{\pi_2} = \frac{V_T}{I_{B_2}} = \frac{\beta_2}{g_{m_2}}$$

$$r_{o_2} \approx \frac{V_{A_2}}{I_{C_2}} \quad \Bigg| \quad \to \infty\,\Omega, \quad V_{A_2} \to \infty\,V$$

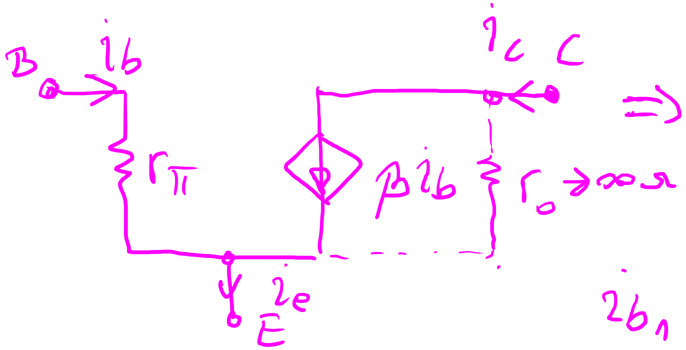
SS (AC) ; $C_S \to \infty\,F \Rightarrow X_{C_S} = \frac{1}{2\pi f \cdot C_S} \to 0\,\Omega$ (MF, ZF)

An





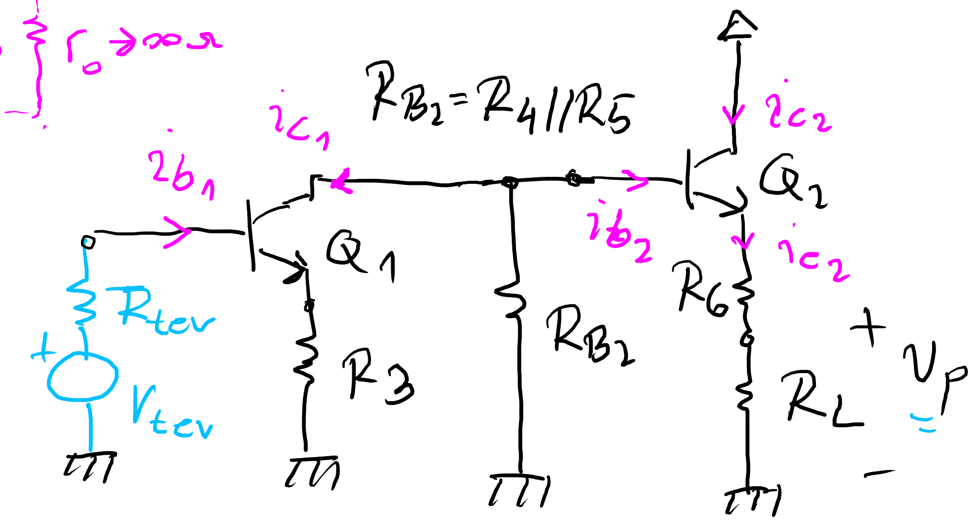
$R_L = R_7 || R_p$



$\Rightarrow i_c \approx \beta i_b \,, \quad i_e = (1+\beta) i_b$

$R_{tev} = R_{B_1} || R_u$

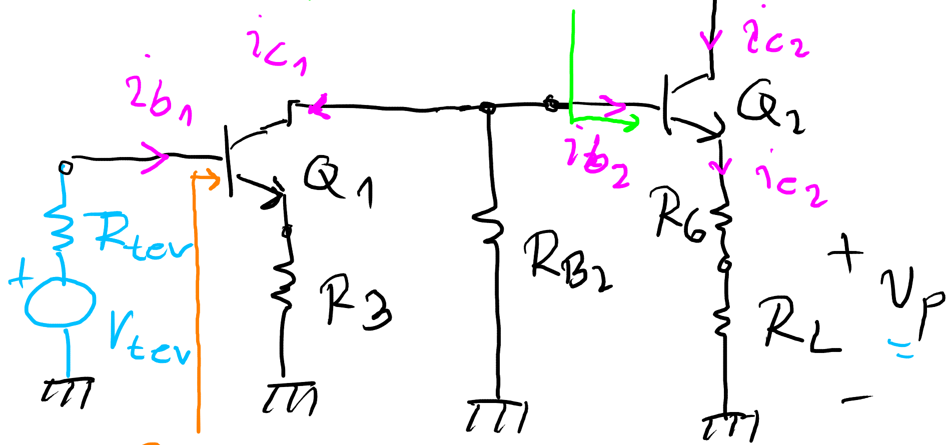
$v_{tev} = \frac{R_{B_1}}{R_{B_1} + R_u} \cdot v_u$



$R_L = R_7 || R_p$

$$A_n = \frac{v_p}{v_u} = \frac{v_p}{i_{e_2}} \cdot \frac{i_{e_2}}{i_{b_2}} \cdot \frac{i_{b_2}}{i_{c_1}} \cdot \frac{i_{c_1}}{i_{b_1}} \cdot \frac{i_{b_1}}{v_{tev}} \cdot \frac{v_{tev}}{v_u}$$

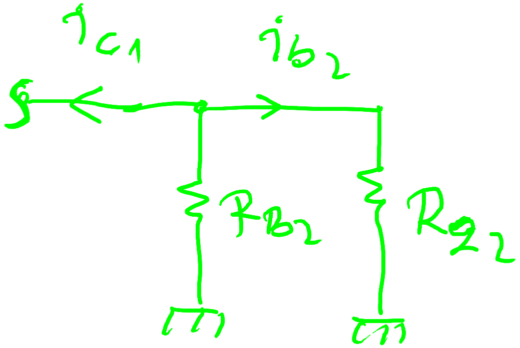
$$R_{g2} = r_{\pi 2} + (1+\beta_2)\cdot(R_6 + R_L)$$

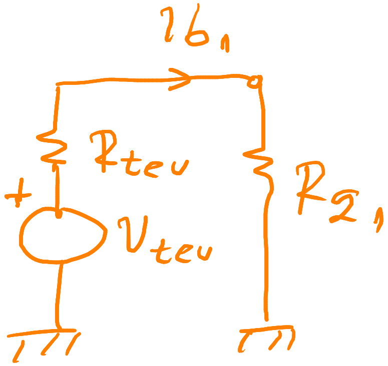


$$R_{g1} = r_{\pi 1} + (1+\beta_1)\cdot R_3$$

$$A_v = R_L \cdot (1+\beta_2)\cdot\left(-\frac{R_{B2}}{R_{B2}+R_{g2}}\right)\cdot\beta_1\cdot\frac{1}{R_{tev}+R_{g1}}\cdot\frac{R_{B1}}{R_{B1}+R_u}$$

$$\frac{i_{b2}}{i_{c1}} = ?$$



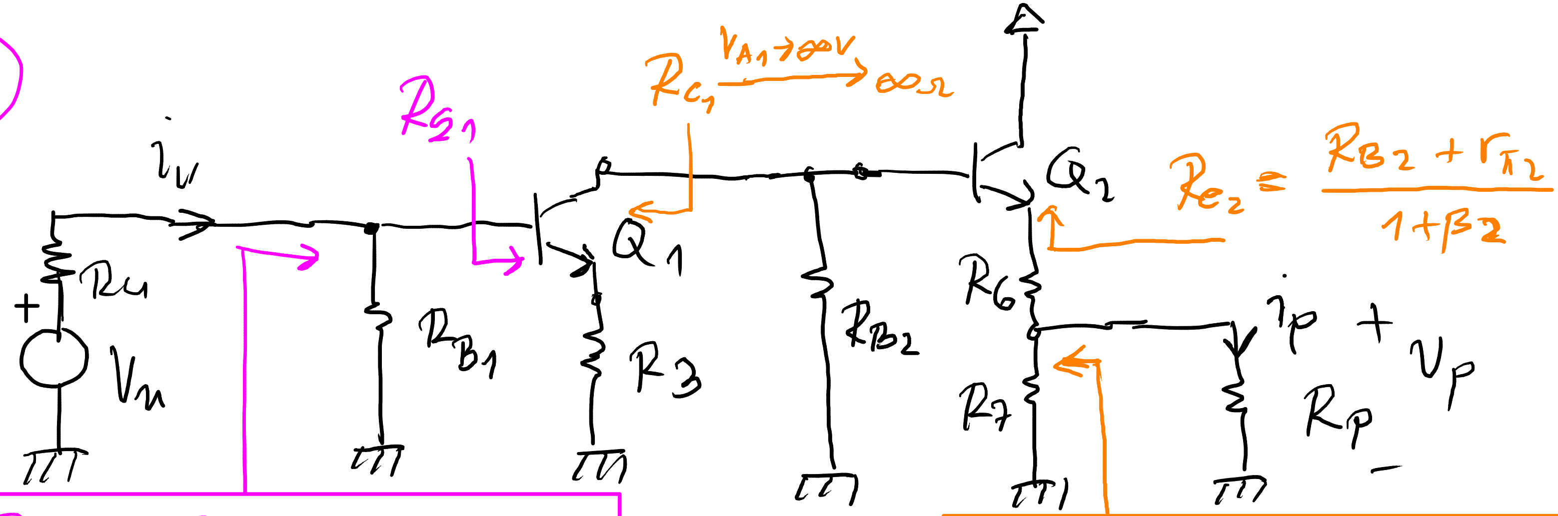


$$\frac{i_{b1}}{V_{tev}} = ?$$

$$\frac{i_{b1}}{V_{tev}} = \frac{1}{R_{tev}+R_{g1}}$$

$$\frac{i_{b2}}{i_{c1}} = \frac{-R_{B2}}{R_{B2}+R_{g2}}$$

A_s R_{ul} R_{iz}

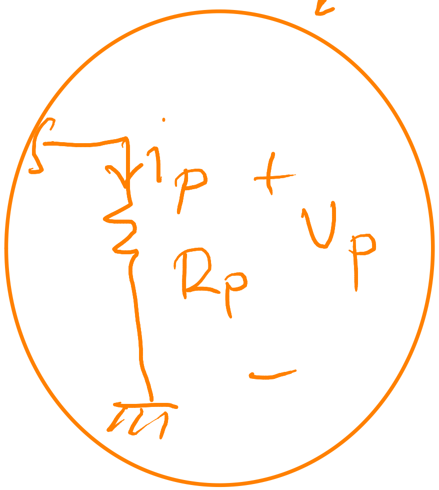


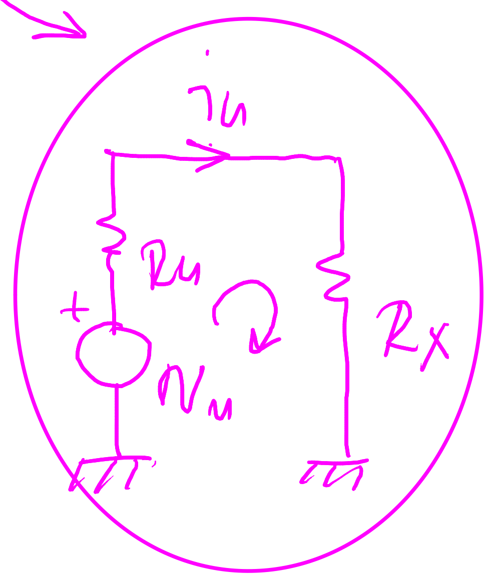
$$R_{e_2} = \frac{R_{B2} + r_{\pi 2}}{1+\beta_2}$$

$$R_{ul} = R_X = R_{B1} \parallel R_{g1}$$

$$R_{iz} = R_{p2} = R_7 \parallel (R_6 + R_{e2})$$

$$A_s = \frac{i_p}{i_u} = \frac{i_p}{v_p} \cdot \frac{v_p}{v_u} \cdot \frac{v_u}{i_u} = \frac{1}{R_p} \cdot A_u \cdot (R_u + R_X) = \frac{R_u + R_X}{R_p} \cdot A_u$$

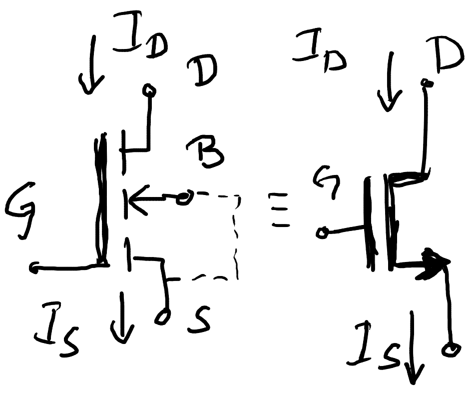




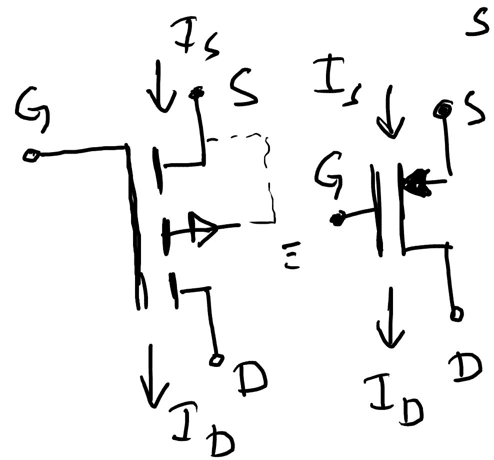
MOS-FET POLARIZACIJA (DC REŽIM)

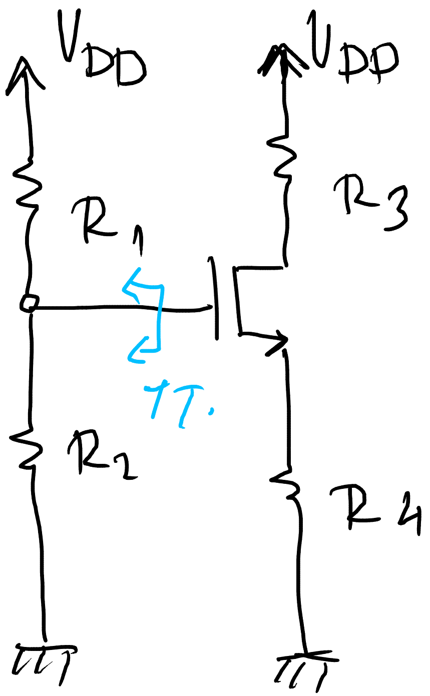
$$I_D = A\,(V_{GS} - V_{TH})^2 \rightarrow N\,MOS\,(V_{TH} > 0V)$$

$$A = \left[\frac{A}{V^2}\right] = \mu_{eff}\, C_{ox}' \,\frac{W}{2L} = A$$



$$I_S = A\,(V_{SG} - |V_{TH}|)^2 \rightarrow PMOS\,(V_{TH} < 0V)$$

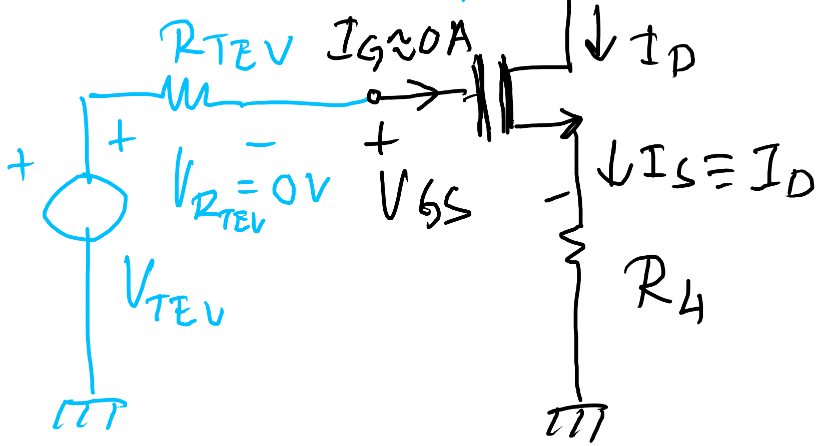


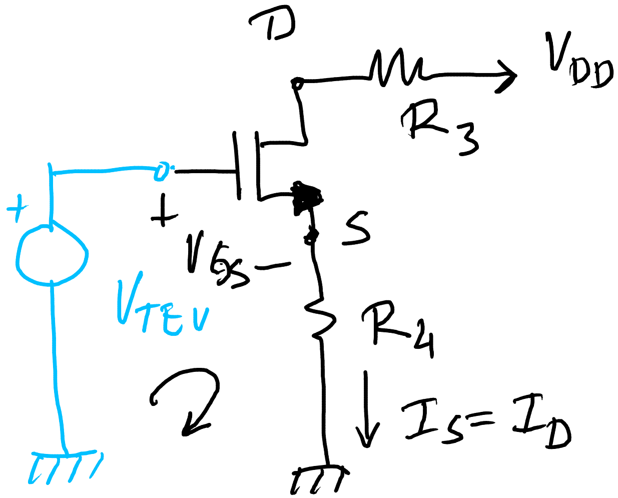


$\Rightarrow$

$R_{TEV} = R_1 \| R_2$

$V_{TEV} = V_{DD} \cdot \frac{R_2}{R_2 + R_1}$





$$V_{TEV} = V_{GS} + I_D \cdot R_4 = V_{GS} + A \cdot (\underbrace{V_{GS} - V_{TH}}) ^2 \cdot R_4$$

$V_{OV} = V_{GS} - V_{TH}$ → "OVERDRIVE" НАПОН

$$V_{TEV} - V_{TH} = V_{GS} - V_{TH} + A \cdot R_4 \, (V_{GS} - V_{TH})^2$$

$$V_{TEV} - V_{TH} = V_{OV} + A R_4 \cdot V_{OV}^2$$

$$V_{OV}^2 (A \cdot R_4) + V_{OV} - (V_{TEV} - V_{TH}) = 0$$

$$V_{OV_{1/2}} = \frac{-1 \pm \sqrt{1 + 4 A R_4 \cdot (V_{TEV} - V_{TH})}}{2 \cdot (A \cdot R_4)}$$

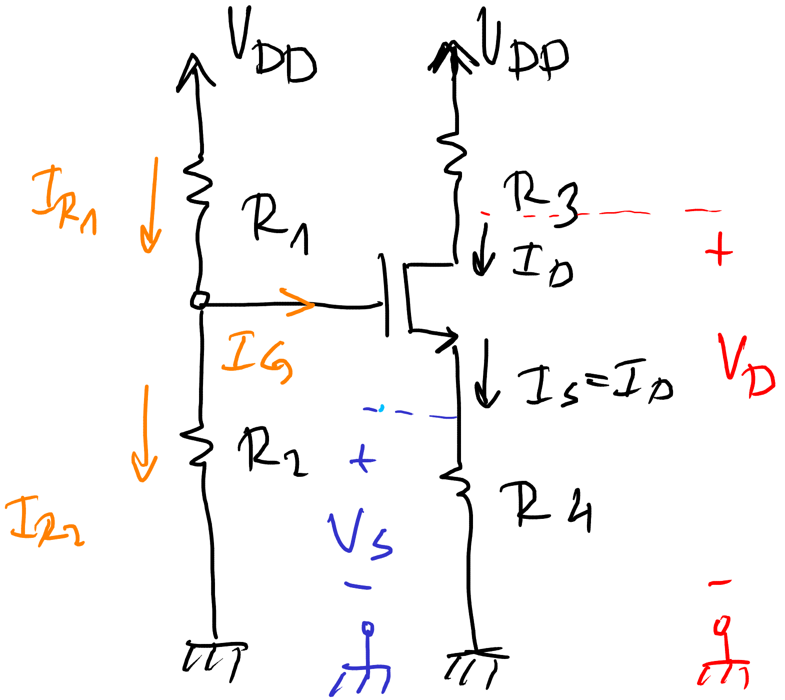
$$V_{OV} > 0 \Rightarrow \boxed{V_{OV} = \frac{-1 + \sqrt{1 + 4 A R_4 (V_{TEV} - V_{TH})}}{2 A R_4}}$$

$$I_D = A \cdot V_{OV}^2 \; ; \quad g_m = \frac{\partial I_D}{\partial V_{GS}} = 2 A V_{OV} = \frac{2 I_D}{V_{OV}} = 2 \sqrt{A \cdot I_D} \;\Big|\; I_D = A \cdot V_{OV}^2$$

• MODULACIJA DUŽINE KANALA ≡ ERLIJEV EFEKAT KOD BJT

$$I_D = A(V_{GS} - V_{TH})^2 (1 + \lambda V_{DS}) \; ; \quad \lambda \propto \frac{\Delta L}{L} \; ; \quad \lambda = \frac{1}{V_A}$$

$$r_o = \left.\frac{\partial I_D}{\partial V_{DS}}\right|_{\lambda \to 0\, V^{-1}} \approx \frac{1}{\lambda I_D} \equiv \frac{V_A}{I_D}$$



$$V_G = V_{TEV} = \frac{R_2}{R_2 + R_1} V_{DD}$$

$I_G \to 0\,A \Rightarrow I_{R_1} = I_{R_2}$

$$I_{R_1} = I_{R_2} = \frac{V_{DD}}{R_1 + R_2}$$

$$V_D = V_{DD} - R_3 I_D$$

$$V_S = R_4 \cdot I_D$$

ZA $R_4 \to 0\,\Omega \Rightarrow V_G = V_{TEV} = V_{GS} \Rightarrow$

$V_{OV} = V_{TEV} - V_{TH} \Rightarrow \quad I_D = A \cdot V_{OV}^2$