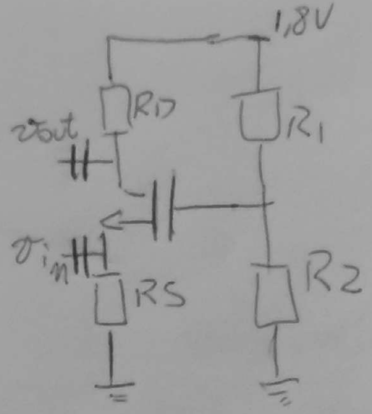
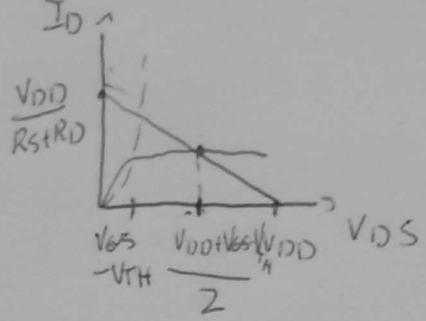


$A_v = 5$
$\mu_n C_{ox} = 100\,\mu A/V$
$V_{TH} = 0{,}5V$
$\frac{W}{L} = 244$
$Z_{in} = 45{,}5\Omega$



- $1{,}8 + R_D I_D + R_S I_D + V_{DS} = 0 \Rightarrow V_{DS} = \underset{V_{DD}}{1{,}8} - I_D.(R_D+R_S)$ (1)
- $I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2$ (2)
- $V_{DS} = \frac{V_{DD}+V_{GS}-V_{TH}}{2}$ (3)
- $\begin{cases} A_v = g_m R_D \\ g_m = \mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH}) \end{cases}$ → Ver pq nos sinais $\Rightarrow R_D = \frac{A_v}{\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})}$ (4)

~> Ver pq nos sinais

$1/g_m = r_m$

- $Z_{in} = R_S // \frac{1}{g_m} = \frac{1}{\frac{1}{R_S}+g_m} = \frac{\frac{R_S}{g_m}}{R_S+\frac{1}{g_m}} \Rightarrow = Z_{in} = \frac{R_S r_m}{R_S+r_m}$

$\Rightarrow Z_{in}R_S + Z_{in}r_m = R_S r_m \Rightarrow R_S.(r_m - Z_{in}) = Z_{in} r_m$

$R_S = \frac{Z_{in} r_m}{r_m - Z_{in}} = \frac{\frac{Z_{in}}{g_m}}{\frac{1}{g_m} - Z_{in}} = \frac{\frac{Z_{in}}{g_m}}{\frac{1-g_m Z_{in}}{g_m}}$

$$\boxed{R_S = \frac{Z_{in}}{1-g_m Z_{in}}} \quad (5)$$

- $g_m = \mu_n C_{ox}\frac{W}{L}.(V_{GS}-V_{TH})$ (6)
- (6) → (5)

$$\boxed{R_S = \frac{Z_{in}}{1-Z_{in}\mu_n C_{ox}\frac{W}{L}.(V_{GS}-V_{TH})}} \quad (7)$$

- (1) = (3)

$V_{DD} - I_D(R_D+R_S) = \frac{V_{DD}+V_{GS}-V_{TH}}{2} \Rightarrow 2.V_{DD} - 2I_D(R_D+R_S) = V_{DD}+V_{GS}-V_{TH}$

$\rightarrow \boxed{V_{DD} - V_{GS} + V_{TH} - 2I_D(R_D+R_S) = 0}$ (8)

- (2), (4) e (7) → (8)

$V_{DD} - V_{GS} + V_{TH} - \cancel{2}.\frac{1}{\cancel{2}}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2.\left[\frac{A_v}{\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})} + \frac{Z_{in}}{1-Z_{in}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})}\right] = 0$

$\underset{1{,}8}{V_{DD}} - (V_{GS} - \underset{0{,}5}{V_{TH}}) - \underbrace{(V_{GS}-V_{TH})}_{X}.\underset{5}{A_v} - \frac{Z_{in}\,\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2}{1 - \underset{45{,}5.10^3}{Z_{in}}\,\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})} = 0$

$$V_{DD} - (V_{GS}-V_{TH})(A_v+1) - \frac{Z_{in} \cdot \overbrace{K}^{\mu_n C_{ox}\frac{W}{L}} (V_{GS}-V_{TH})^2}{1 - Z_{in} K \underbrace{(V_{GS}-V_{TH})}_{X}} = \emptyset$$

$$V_{DD} - (A_v+1)X - \frac{Z_{in} K X^2}{1 - Z_{in} K X} = \emptyset$$

$$\frac{V_{DD}(1 - Z_{in}KX) - (A_v+1)X(1 - Z_{in}KX) - Z_{in}KX^2}{1 - Z_{in}KX} = \emptyset$$

$$V_{DD} - V_{DD}Z_{in}KX - (A_v+1)X + (A_v+1)Z_{in}KX^2 - Z_{in}KX^2 = \emptyset$$

$$\underset{45,5}{Z_{in}}\,\underset{0,0244}{K}\,(\underset{5}{A_v} + \cancel{1} - \cancel{1})X^2 - (\underset{1,8}{V_{DD}}\,\underset{45,5}{Z_{in}}\,\overset{0,0244}{K} + \underset{5}{A_v} + 1)X + \underset{1,8}{V_{DD}} = \emptyset$$

$$5,5510\,X^2 - 7,9984X + 1,8 = \emptyset$$

$$X = \begin{cases} 1,1618\,V \\ \boxed{0,2791\,V} \end{cases} \quad V_{GS} = X + \overset{0,5}{V_{TH}} \Rightarrow \quad V_{GS} = \begin{cases} 1,6618\,V \\ 0,7791\,V \end{cases}$$

(2) $\Rightarrow \left\{ \begin{array}{l} 16,4660\,mA \\ \boxed{0,9504\,mA} \end{array} \right\} I_D$

(3) $\Rightarrow \left\{ \begin{array}{l} 28,3473\,mS \\ \boxed{6,8104\,mS} \end{array} \right\} g_m$

(4) $\Rightarrow R_D \begin{cases} 176,3838\,\Omega \\ \boxed{734,1763\,\Omega} \end{cases}$

(5) $\Rightarrow R_S \begin{cases} -1570043\,\Omega \Rightarrow \text{não OK} \\ \boxed{65,9247\,\Omega} \end{cases}$

• $V_{GS} = V_G - V_S \Rightarrow 0,7791 = V_G - \underset{63,92}{R_S} \cdot \underset{0,4504mA}{I_D}$

$\Rightarrow \boxed{V_G = 0,8418V}$

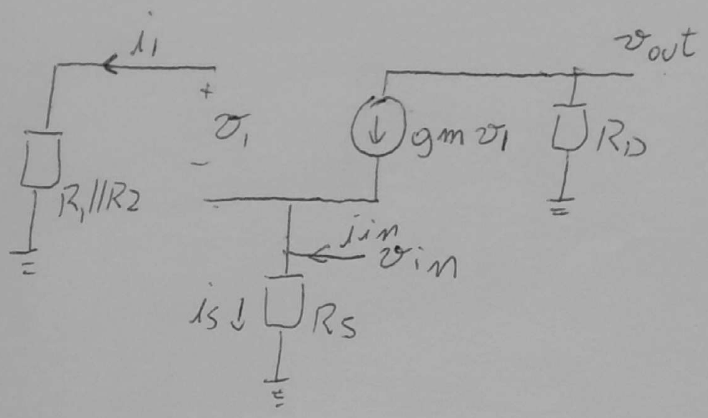
• $V_G = \frac{R_2}{R_1+R_2} \cdot V_{DD} \Rightarrow 0,8418 = \frac{R_2}{R_1+R_2} \cdot 1,8$

$\Rightarrow 0,8418(R_1+R_2) = R_2 \cdot 1,8$

$\Rightarrow R_1 = 1,383 \cdot R_2$

• Fazendo $\boxed{R_2 = 10k\Omega} \Rightarrow \boxed{R_1 = 11,383k\Omega}$

- Modelo de pequenos sinais



- $v_{out} = -g_{m1} v_1 R_D \Rightarrow \boxed{A_v = +g_{m1} R_D}$
- $v_{in} = -v_1$, pois $i_1 = \emptyset$
- $i_S = i_{in} + g_{m1} v_1 \Rightarrow \frac{\overset{-v_1}{v_{in}}}{R_S} = i_{in} + g_m v_1 \Rightarrow i_{in} = -v_1 \cdot \left(\frac{1}{R_S} + g_m\right)$

$$Z_{in} = \left(\frac{1}{R_S} + g_m\right)^{-1} = R_S // 1/g_m$$

- $Z_{out} \Rightarrow v_{in} = \emptyset \Rightarrow V_1 = \emptyset \Rightarrow \boxed{R_{out} = R_D}$