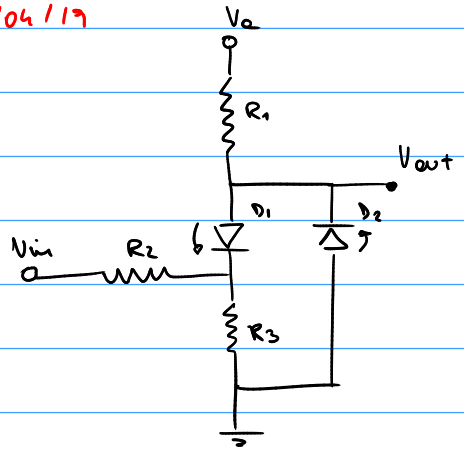
Diodi 2017/04/19



D_1 e D_2 ideali

$V_e = 5V$

$R_1 = 4k\Omega$

$R_2 = R_3 = 8k\Omega$

$V_{in} \in [-12 ; 12]$

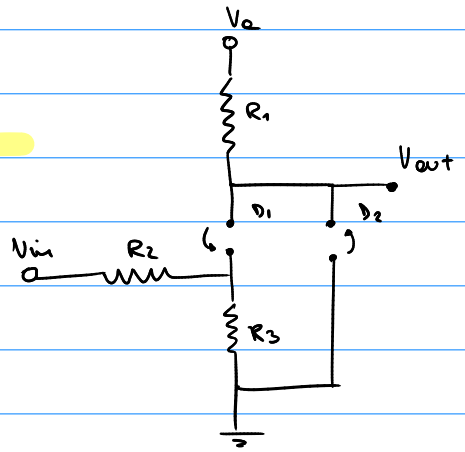
Calcolare la trasconduttanza $V_{out}(V_{in}) = ?$

Hp off off

↓

Valida per $V_{in} > 10V$

con $V_{out} = 5V$



$V_{out} = V_e$

D_1: $V_{out} - \frac{R_3}{R_2+R_3} V_{in} < 0$

$V_{in} > \frac{R_2+R_3}{R_3} V_e = 10V$

D_2: $0 - V_{out} < 0$

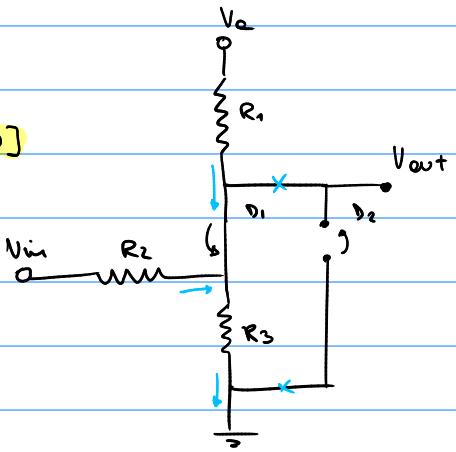
$V_e > 0$ ✓

Hp on off

↓

Valida per $V_{in} \in [-10;10]$

con $V_{out} = \frac{V_{in}}{4} + \frac{5}{2}$



$$I_1 = \frac{V_e - V_{out}}{R_1} \qquad I_2 = \frac{V_{in} - V_{out}}{R_2} \qquad I_3 = \frac{V_{out}}{R_3}$$

$I_1 + I_2 = I_3$

↳ $\frac{V_e - V_{out}}{R_1} + \frac{V_{in} - V_{out}}{R_2} = \frac{V_{out}}{R_3}$

$(V_e - V_{out}) R_2 R_3 + (V_{in} - V_{out}) R_1 R_3 = V_{out} R_1 R_2$

$$V_{out}(R_1R_2 + R_2R_3 + R_1R_3) = V_a R_2 R_3 + V_{in} R_1 R_3$$

$$V_{out} = \frac{R_1R_3}{R_1R_2 + R_2R_3 + R_1R_3} V_{in} + \frac{R_2R_3}{R_1R_2 + R_2R_3 + R_1R_3} V_a$$

$$= \frac{1}{4} V_{in} + \frac{5}{2}$$

D_1: $I_1 = \frac{V_a - V_{out}}{R_1} > 0 \rightarrow \frac{1}{4}V_{in} + \frac{5}{2} < V_a$

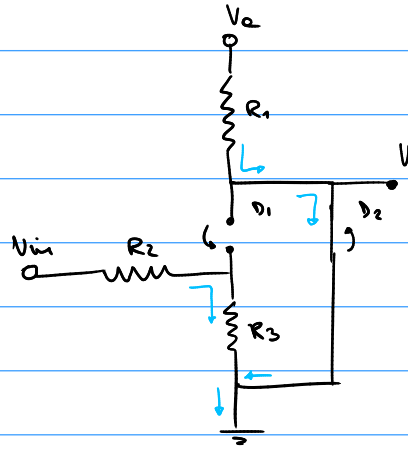
$V_{in} < 4V_a - 10V = 10V$

D_2: $0 - V_{out} < 0 \rightarrow \frac{1}{4}V_{in} + \frac{5}{2} > 0 \rightarrow V_{in} > -10V$

Hp off on

↓

Impossibile



$V_{out} = 0$

D_1: $V_{out} - \frac{R_3}{R_2+R_3} V_{in} < 0$

$V_{in} > 0$

D_2: $I_2 = -\frac{V_a}{R_1} > 0$

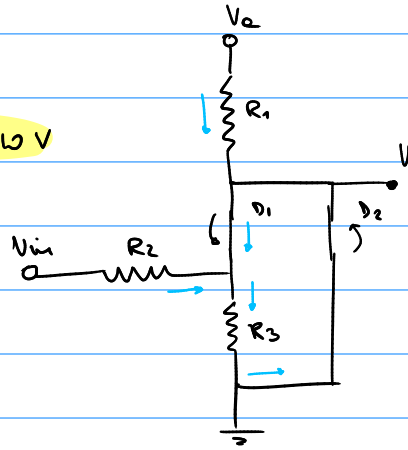
$V_a < 0 \rightarrow$ Impossibile

Hp on on

↓

Verificata per $V_{in} < -10$ V

con $V_{out} = 0$



$V_{out} = 0$ $\quad \frac{V_{out} - V_{out}}{R_3} = 0$

D_1: $I_1 = \cancel{I_{R3}} - I_{R1} > 0$

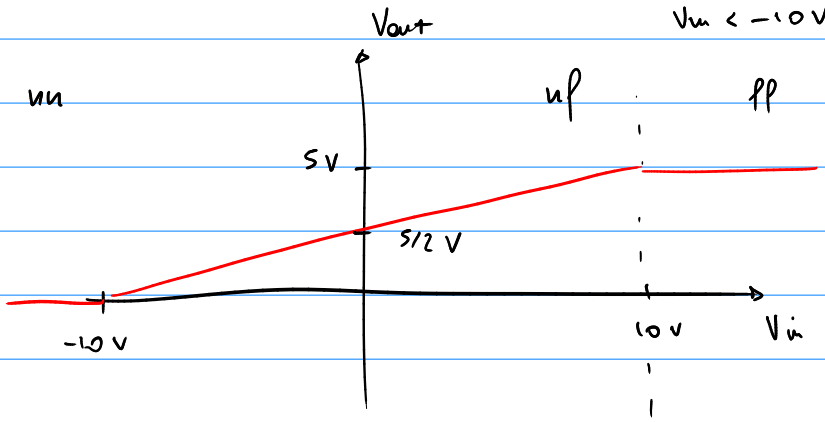
$= -\frac{V_{in}}{R_2} > 0$

$V_{in} < 0$

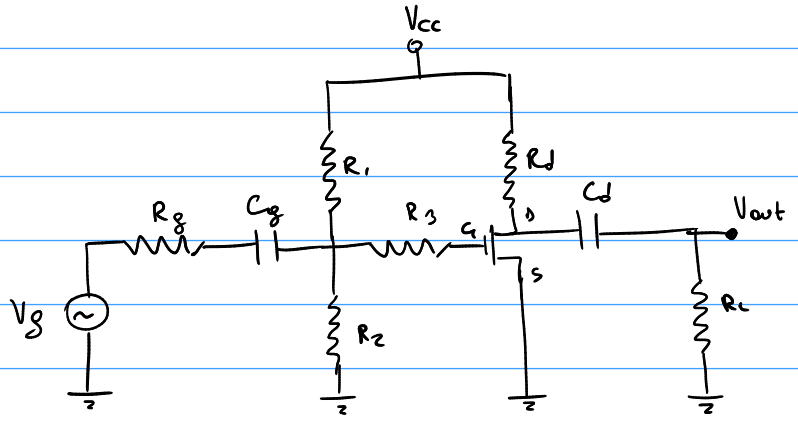
D_2: $I_2 = I_1 - I_{R1} > 0$

$= -\frac{V_{in}}{R_2} - \frac{V_a}{R_1} > 0$

$V_{in} < -10V$



Mosfet 2017/06/15



$V_{cc} = 16V$ $V_{th} = 1V$

$R_1 = 900k\Omega$ $k_n = 25 \cdot 10^{-6} A/V^2$

$R_2 = 300k\Omega$

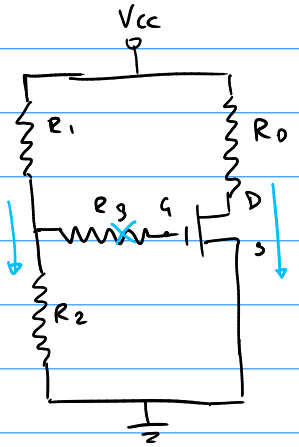
$R_3 = 300k\Omega$

$R_d = 80k\Omega$

$R_L = 60k\Omega$

$R_g = 1k\Omega$

1) P. to di riposo



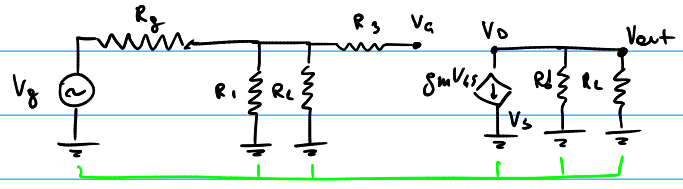
Ipotizzo transistor in fase di saturazione: $V_{DS} > V_{GS} - V_{th}$

$$V_{GS} = V_G - V_S = \frac{R_2}{R_1+R_2} V_{cc} - 0 = 4V$$

$$I_{DS} = \frac{1}{2} k_n (V_{GS} - V_{th})^2 \simeq 0.1125\ mA$$

$$V_{DS} = V_{cc} - I_{DS} R_D \simeq 10V$$

2) $g_m = k_n (V_{GS} - V_{th}) \simeq 7.5 \cdot 10^{-3}\ S$



3) $R_{in} = R_1 \parallel R_2 \approx 215\ k\Omega$ $\qquad R_{out} = R_d = 80 k\Omega$

4) $V_G = V_{in}$

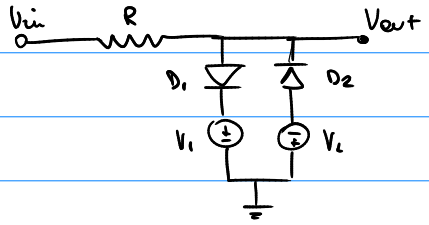
$V_{out} = -g_m V_{GS} R_D$

$= -g_m (V_G - V_S) R_D$

$= -g_m R_D V_{in}$

$= -6\, V_{in} \qquad A_V = -6$

Diodi 2017/06/15

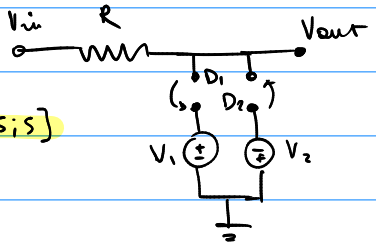


$V_1 = V_2 = 5V$

$R = 1k\Omega$

$V_{in} \in [-10; 10]$

Hp off off



Valida per $V_{in} \in [-5;5]$

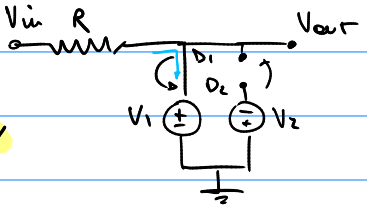
con $V_{out} = V_{in}$

$V_{out} = V_{in}$

D_1: $V_{out} - V_1 < 0 \rightarrow V_{in} > 5V$

D_2: $-V_2 - V_{out} < 0 \rightarrow V_{in} > -5V$

Hp on off



Verificata per $V_{in} > 5V$

con $V_{out} = 5V$

$I_1 = \frac{V_{in} - V_1}{R}$

$V_{out} = V_{in} - I_1 R$

$= V_{in} - V_{in} + V_1$

$= V_1$

D_1: $I_1 = \frac{V_{in} - V_1}{R} > 0 \rightarrow V_{in} > 5V$

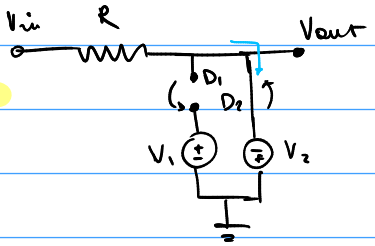
D_2: $-V_2 - V_{out} < 0 \rightarrow V_{out} > -5V$

Hp off on

↓

Verificare per $V_{in} < -5V$

con $V_{out} = -5V$



$$I_2 = -\frac{V_{in} + V_2}{R}$$

$$V_{out} = V_{in} - (-I_2)R$$

$$= V_{in} - V_{in} - V_2$$

$$= -5V$$

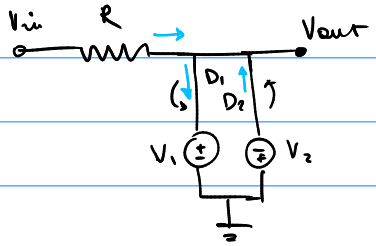
D_1: $V_{out} - V_1 < 0 \rightarrow -10V < 0$

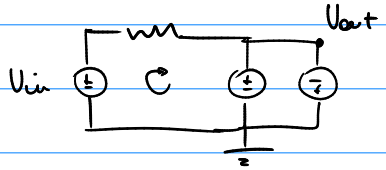
D_2: $I_2 = -\frac{V_{in} + V_2}{R} > 0 \quad V_{in} < -5V$

Hp on on

↓

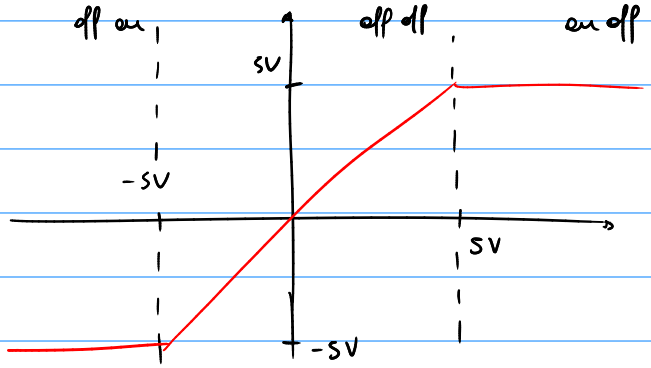
Impossibile



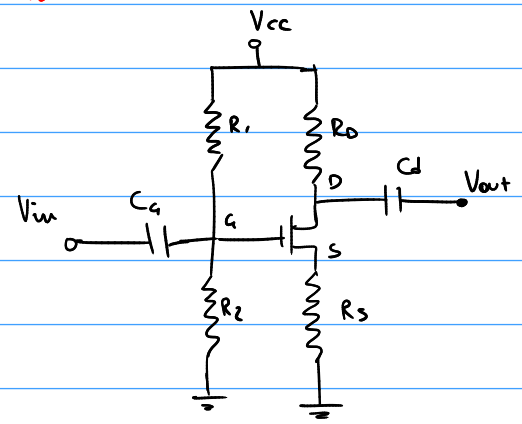


$V_{in} - V_1 = I_{e1} R$

$V_1 + V_2 = 0 \rightarrow$ Impossibile



Mosfet 2017/02/13



$V_{cc} = 10V$ $\quad V_{th} = 1.5V$

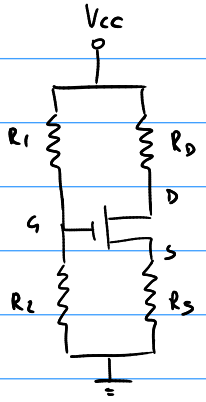
$R_1 = 1M\Omega$ $\quad k_n = 25\mu A/V^2$

$R_2 = 800k\Omega$

$R_S = 10k\Omega$

$R_D = 100k\Omega$

1)



$$V_{GS} = V_G - V_S$$
$$= \frac{R_2}{R_1+R_2} V_{cc} - R_S I_{DS}$$
$$= \frac{R_2}{R_1+R_2} V_{cc} - \frac{1}{2} k_n (V_{GS} - V_{th})^2 R_S$$

$$\frac{1}{2} k_n R_S V_{GS}^2 + (1 - k_n R_S V_{th}) V_{GS} - \frac{R_2}{R_1+R_2} V_{cc} + \frac{1}{2} k_n R_S V_{th}^2 = 0$$

$$0.125\, V_{GS}^2 + 0.625\, V_{GS} - 3.05 = 0$$

$$V_{GS} = \begin{cases} 3.04\,V \\ -8.04\,V \end{cases}$$

Perché il transistor sia acceso $V_{GS} > V_{th}$, scelgo $V_{GS} = 3.04V$

$$I_{DS} = \frac{1}{2} k_n (V_{GS} - V_{th})^2$$
$$= 0.03\,mA$$

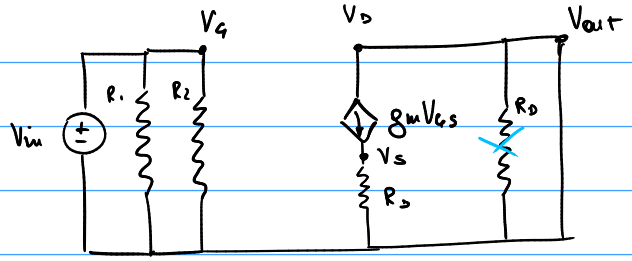
$$V_{DS} = V_{cc} - I_{DS}(R_D + R_S)$$
$$= 6.7\,V$$

Perché il transistor sia in fase di saturazione $V_{DS} > V_{GS} - V_{th}$ → Verificato

2) $g_m = k_n (V_{GS} - V_{th})$

$= 3.85 \cdot 10^{-5} S$

3)



$R_{in} = R_1 // R_2 = 333.\bar{3}\ k\Omega$

$R_{out} = R_D = 100\ k\Omega$

4) $V_G = V_{in}$

$V_S = R_S g_m V_{GS}$

$= R_S g_m (V_G - V_S)$

$V_S = \frac{R_S g_m}{1 + R_S g_m} V_{in}$

$V_{GS} = V_G - V_S$

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

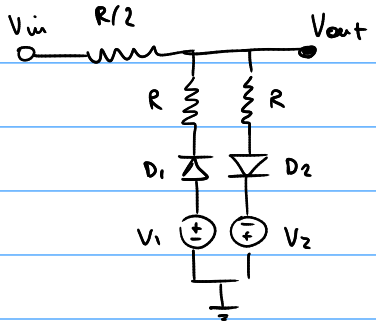
$= \frac{1}{1 + R_S g_m} V_{in}$

$V_{out} = - g_m V_{GS} R_S$

$= - \frac{g_m R_S}{1 + g_m R_S} V_{in}$

$A_V = - \frac{g_m R_S}{1 + g_m R_S}$

Diodi 2017/02/13



$V_1 = V_2 = 5V$

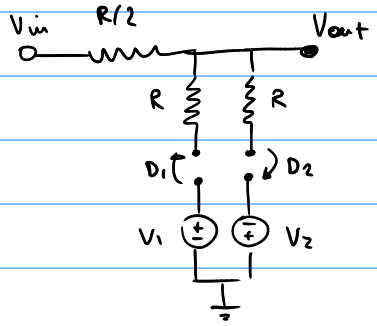
$R = 5k\Omega$

$V_{in} \in [-15 ; 15]$

Hp off off

↓

Impossibile

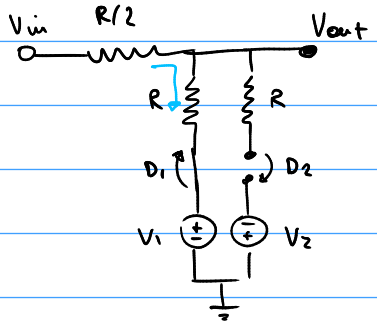


$V_{out} = V_{in}$

D_1: $V_1 - V_{out} < 0 \rightarrow V_{in} > 5V$

D_2: $V_{out} + V_2 < 0 \rightarrow V_{in} < -5V$

Hp on off



↓

Verificato per $V_{in} < -10V$

con $V_{out} = \frac{2}{3}V_{in} + \frac{5}{3}V$

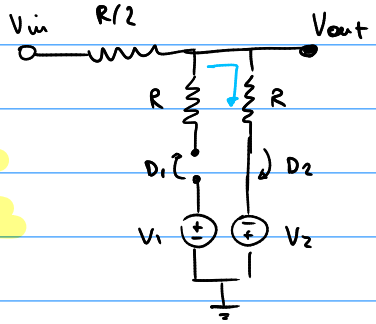
$$I_1 = -\frac{V_{in} - V_1}{R + \frac{R}{2}}$$

$$V_{out} = V_{in} - (-I_1)\frac{R}{2}$$
$$= V_{in} - \frac{V_{in}}{3} + \frac{V_1}{3}$$
$$= \frac{2}{3}V_{in} + \frac{5}{3}V$$

D_1: $I_1 = -\frac{V_{in} - V_1}{\frac{3}{2}R} > 0 \rightarrow V_{in} < 5V$

D_2: $V_{out} + V_2 < 0 \rightarrow \frac{2}{3}V_{in} + \frac{5}{3} + 5 < 0 \rightarrow V_{in} < -10V$

Hp off on



↓

Verificato per $V_{in} > 10V$

con $V_{out} = \frac{2}{3}V_{in} - \frac{5}{3}V$

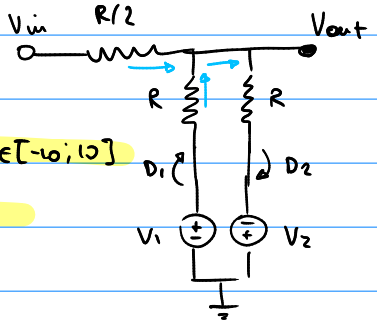
$$I_2 = \frac{V_{in} + V_1}{\frac{3}{2}R}$$

$$V_{out} = V_{in} - I_2\frac{R}{2}$$
$$= V_{in} - \frac{V_{in}}{3} - \frac{V_2}{3}$$
$$= \frac{2}{3}V_{in} - \frac{5}{3}V$$

D_1: $V_1 - V_{out} < 0 \rightarrow V_1 - \frac{2}{3}V_{in} + \frac{5}{3} < 0 \rightarrow V_{in} > 10V$

D_2: $I_2 = \frac{V_{in} + V_2}{\frac{3}{2}R} > 0 \rightarrow V_{in} > -5V$

Hp on on



↓

Verificato per $V_{in} \in [-10; 10]$

con $V_{out} = \frac{V_{in}}{2}$

$$I = \frac{V_{in} - V_{out}}{R/2}$$

$$I_1 = \frac{V_1 - V_{out}}{R}$$

$$I_2 = \frac{V_{out} + V_2}{R}$$

$I + I_1 = I_2 \qquad \frac{V_{in} - V_{out}}{R/2} + \frac{V_x - V_{out}}{R} = \frac{V_{out} + V_2}{R}$

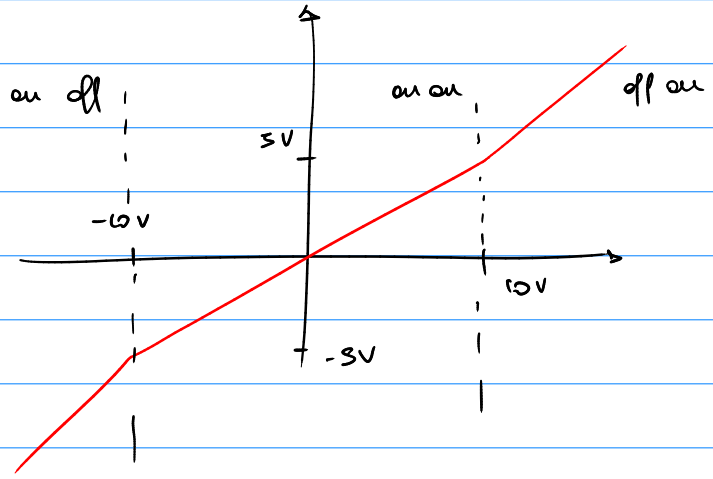
$2V_{in} - 2V_{out} + V_x - V_{out} = V_{out} + V_2$

$4V_{out} = 2V_{in} + V_x - V_2$

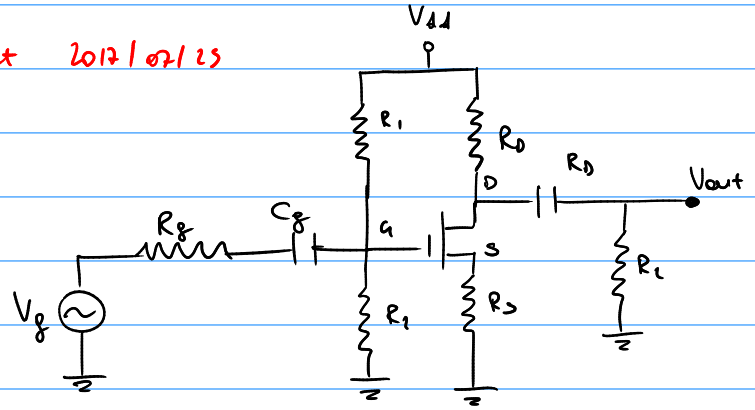
$V_{out} = \frac{V_{in}}{2}$

$D_1: \quad I_1 = \frac{V_x - V_{out}}{R} > 0 \rightarrow V_x - \frac{V_{in}}{2} > 0 \qquad V_{in} < 10V$

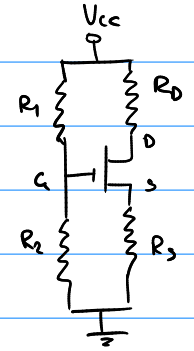
$D_2: \quad I_2 = \frac{V_{out} + V_2}{R} > 0 \rightarrow \frac{V_{in}}{2} + V_2 > 0 \qquad V_{in} > -10V$



Mosfet 2017/07/25



1) P.to di lavoro



$V_G = \frac{R_2}{R_1 + R_2} V_{dd}$

$V_S = R_S I_{ds}$

$V_{GS} = \frac{R_2}{R_1 + R_2} V_{dd} - \frac{1}{2} k_n (V_{GS} - V_{th})^2 R_S$

$\frac{1}{2} k_n R_S V_{GS}^2 + (1 - k_n V_{th} R_S) V_{GS} - \frac{R_2}{R_1 + R_2} V_{dd} + \frac{1}{2} k_n R_S V_{th}^2 = 0$

$$0.125\, V_{GS}^2 + 0.75\, V_{GS} - 2.56 = 0 \qquad V_{GS} = \begin{cases} 2.41 \\ -8.41 \end{cases}$$

Perché Q_1 sia acceso $V_{GS} > V_{th}$ → scelgo $V_{GS} = 2.41$

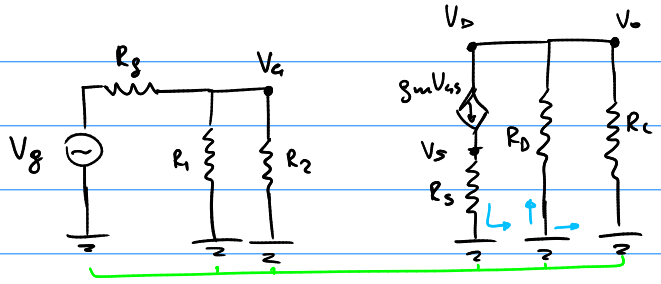
$$I_{DS} = \frac{1}{2} k_n (V_{GS} - V_{th})^2$$
$$= 0.025\ mA$$

Q_1 è in fase di sat. se $V_{DS} > V_{GN} - V_{th}$ ↳ verificato ✓

$$V_{DS} = V_{dd} - I_{ds}(R_D + R_S)$$
$$= 14.25\ V$$

2) $$g_m = k_n (V_{GS} - V_{th})$$
$$= 3.53 \cdot 10^{-5}$$

3)



$$R_{in} = R_g \,||\, R_2$$
$$= 80\ k\Omega$$

$$R_{out} = R_D = 60\ k\Omega$$

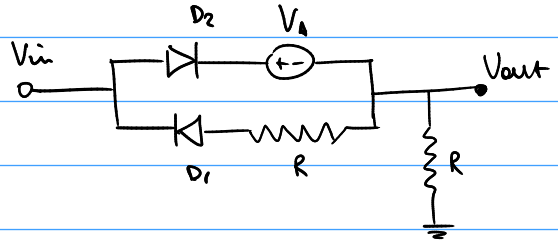
4) $$P_D = R_D I_D^2$$
$$= R_D \left(\frac{R_L}{R_D + R_L} g_m V_{GS} \right)^2$$
$$= 2.57 \cdot 10^{-4}\ W$$

5) $$V_{out} = -R_D g_m V_{GS}$$
$$= -R_D \frac{g_m}{1 + g_m R_S} V_{in}$$

$$V_{GS} = V_G - V_S$$
$$= V_{in} - g_m V_{GS} R_S$$
$$V_{GS} = \frac{1}{1 + g_m R_S} V_{in}$$

$$A_v = -\frac{g_m R_D}{1 + g_m R_S}$$

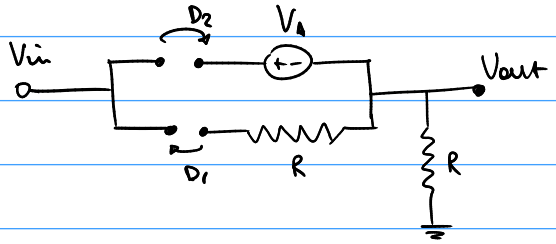
Diod: 2017/07/25



Hp off off :

↓

Verifichiamo per $V_{in} \in [-0.7; 5.7]$ con $V_{out} = 0$



$V_{out} = 0$

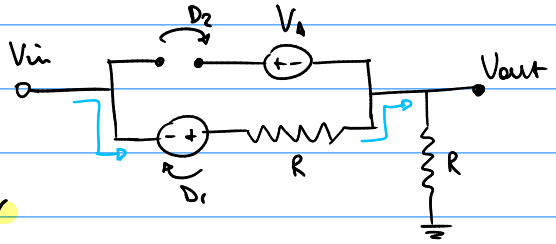
D_1: $0 - V_{in} < V_\gamma \rightarrow V_{in} > -0.7\,V$

D_2: $V_{in} - V_\alpha < V_\gamma \rightarrow V_{in} < 5.7\,V$

Hp on off

↓

Verificato per $V_{in} < -0.7V$ con $V_{out} = \frac{V_{in}}{2} + 0.35V$



$$I_1 = -\frac{V_{in} + V_\gamma}{2R}$$

$$V_{out} = V_{in} + V_\gamma - (-I_1)R$$
$$= V_{in} + V_\gamma - \frac{V_{in}}{2} - \frac{V_\gamma}{2}$$
$$= \frac{V_{in}}{2} + 0.35\,V$$

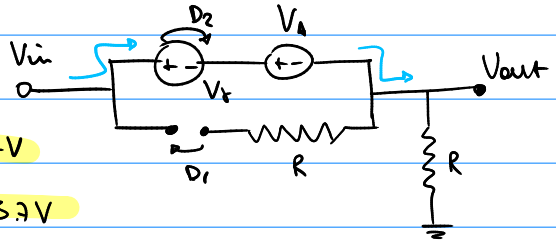
D_1: $I_1 = -\frac{V_{in} + V_\gamma}{2R} > 0 \rightarrow V_{in} < -0.7$

D_2: $V_{in} - V_\alpha < V_\gamma \rightarrow V_{in} < 5.7$

Hp off on

↓

Verificato per $V_{in} > 5.7V$ con $V_{out} = V_{in} - 5.7V$



$$I_z = \frac{V_{in} - V_\gamma - V_A}{R} \qquad V_{out} = V_{in} - V_\gamma - V_A = V_{in} - 5.7\,V$$

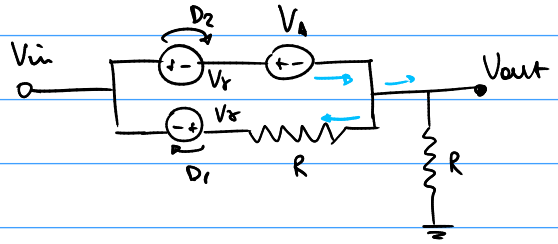
D_1: $V_{out} - V_{in} < V_\gamma \rightarrow -5.7 < V_\gamma$ ok

D_2: $I_z = \frac{V_{in} - V_\gamma - V_A}{R} > 0 \rightarrow V_{in} > 5.7\,V$

Hp on on

↓

Impossibile



$$V_{out} = V_{in} - V_\gamma - V_A$$

$$I_1 = \frac{V_{out} - V_\gamma - V_{in}}{R} = \frac{V_{in} - V_\gamma - V_A - V_\gamma - V_{in}}{R} = -\frac{2V_\gamma + V_A}{R}$$

D_1: $I_1 = -\frac{2V_\gamma + V_A}{R} > 0 \rightarrow$ impossibile