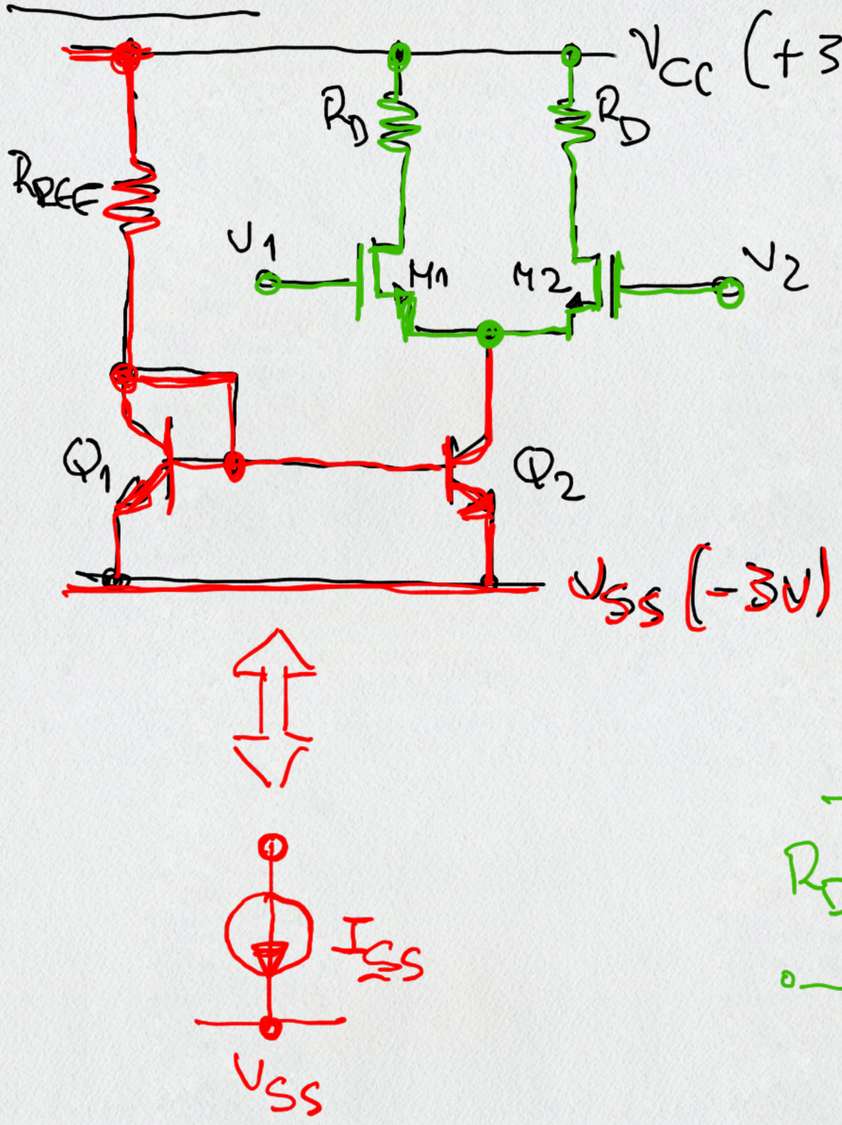
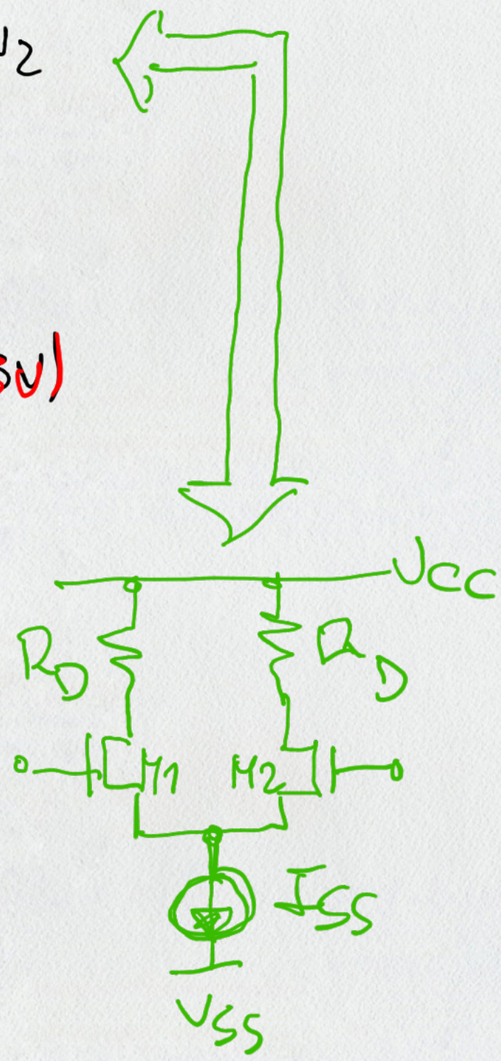
Problema 1





$R_D = 2k\Omega$

Circuito

$V_{BE_{ON}} = 0.7V$

$V_{CE_{sat}} = 0.3V$

$V_A = 50V$

TJB

$k_n = 1mA.V^{-2}$

$V_{th} = 1V$

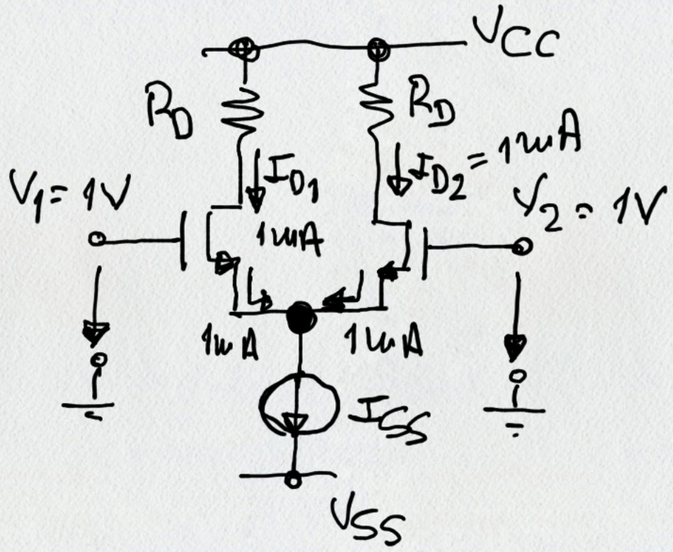
$V_A = \infty$

NMOS

a) $R_{REF} = ?$

$I_{D_1} = I_{D_2} = 1mA$

$V_1 = V_2 = 1V$

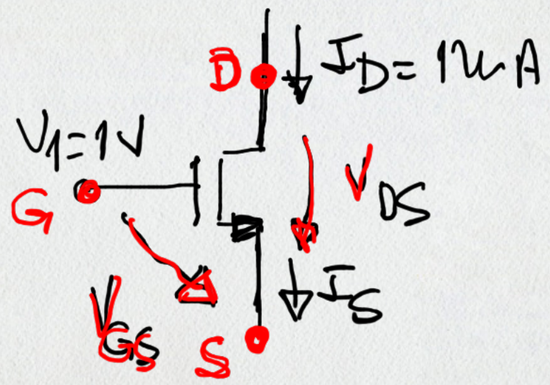


Temos que definir zona de condução de M_1 e M_2

Estão a conduzir com $I_D = 1mA$

- Sat. $\Rightarrow V_{DS} > V_{GS} - V_{th}$
- Tríodo $\Rightarrow V_{DS} < V_{GS} - V_{th}$

$\Rightarrow \boxed{I_{SS} = 2mA}$

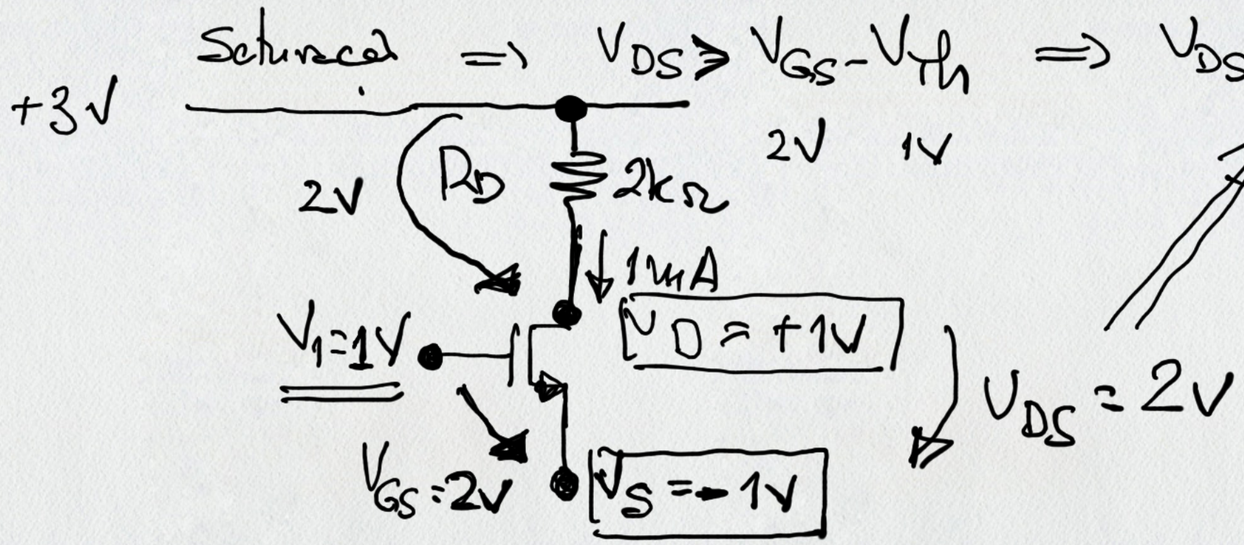


Saturação: $I_D = k_n (V_{GS} - V_{Th})^2$ (fornecidos)

$1mA = 1mA.V^{-2} (V_{GS} - 1)^2$

$1V^2 = (V_{GS} - 1V)^2$

$\Rightarrow \boxed{V_{GS} = 1 + 1 = 2V}$



Saturação $\Rightarrow V_{DS} \geq V_{GS} - V_{Th} \Rightarrow V_{DS} > 1V$

2V 1V

$\Rightarrow$ NMOS está em saturação

M1

$I_{D_1} = 1mA$

$V_{GS_1} = 2V$

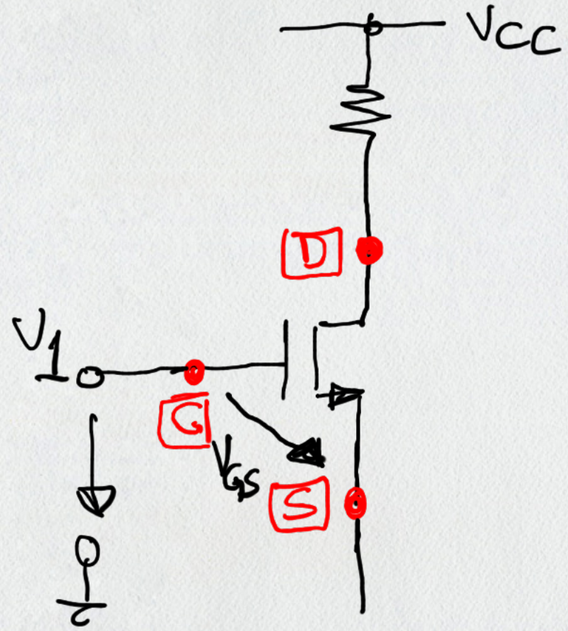
$V_{DS_1} = 2V$

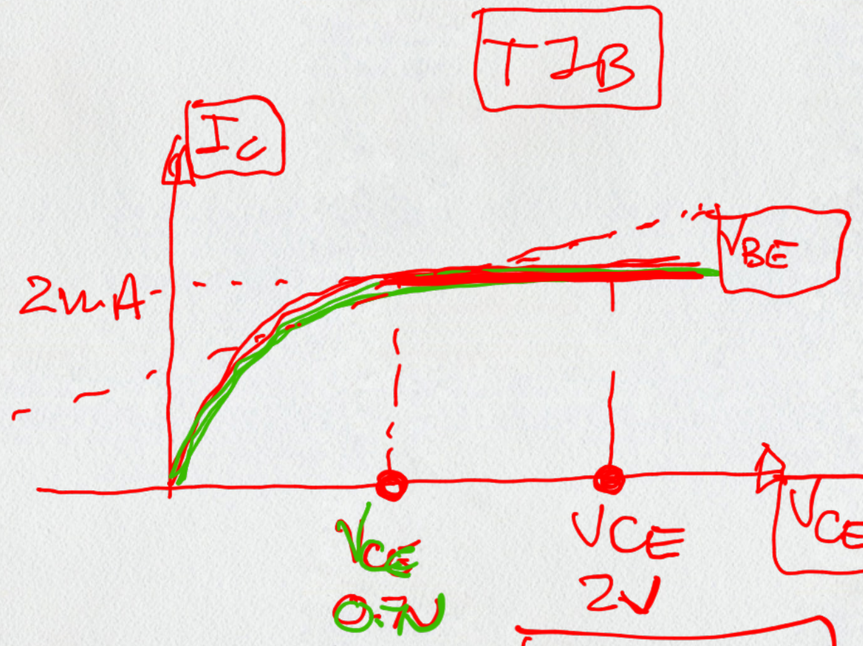
M2

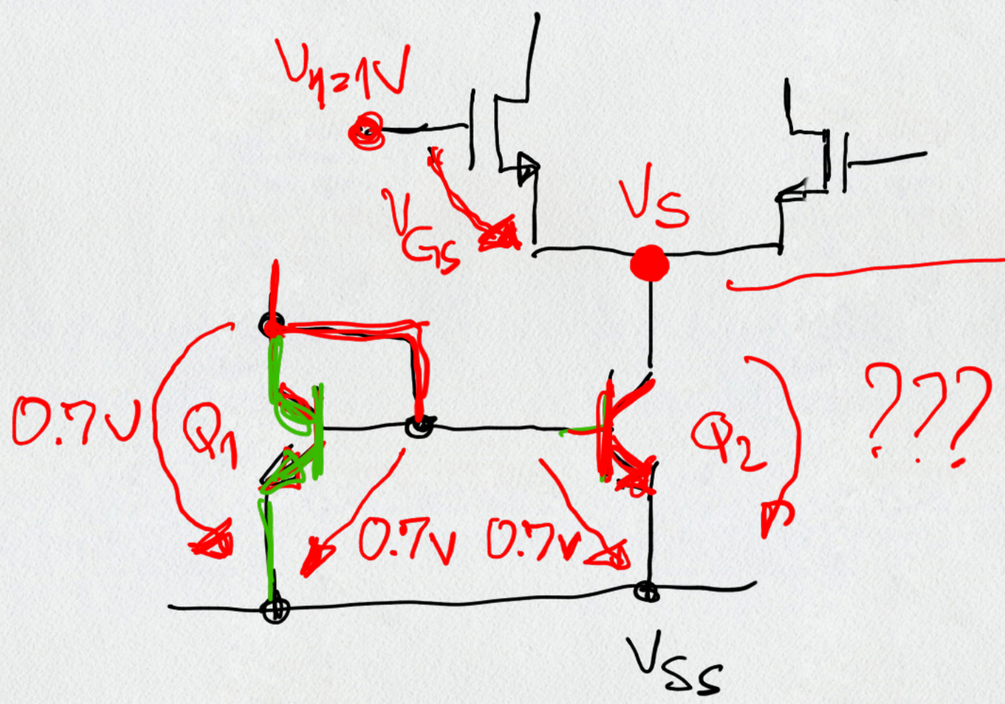
$I_{D_2} = 1mA$

$V_{GS_2} = 2V$

$V_{DS_2} = 2V$

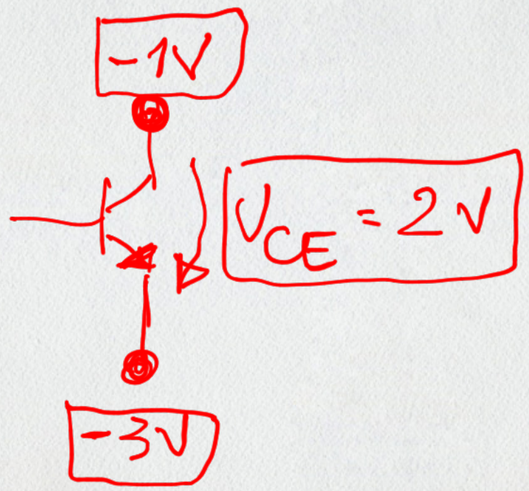


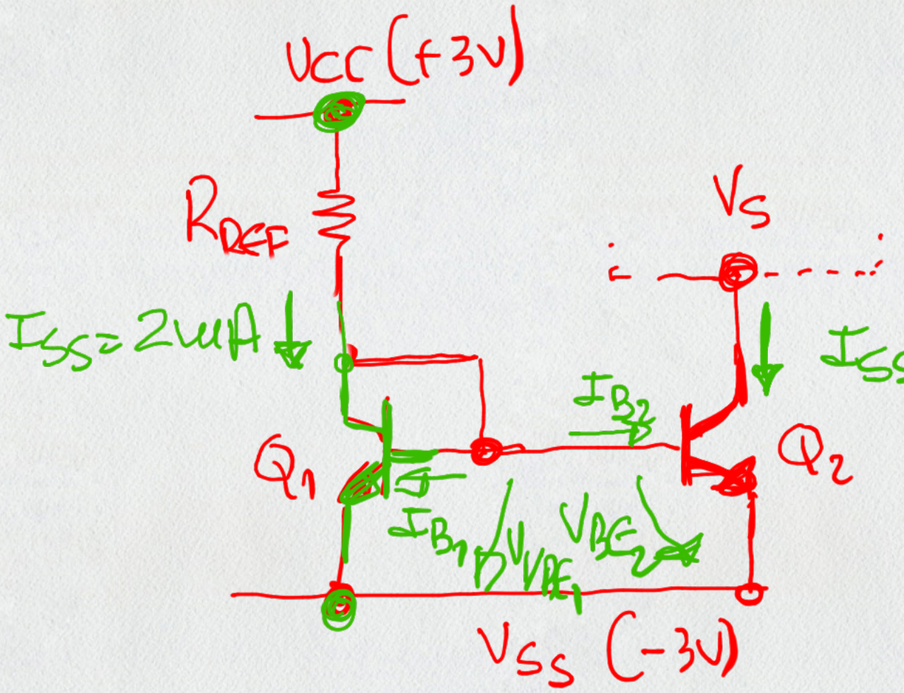


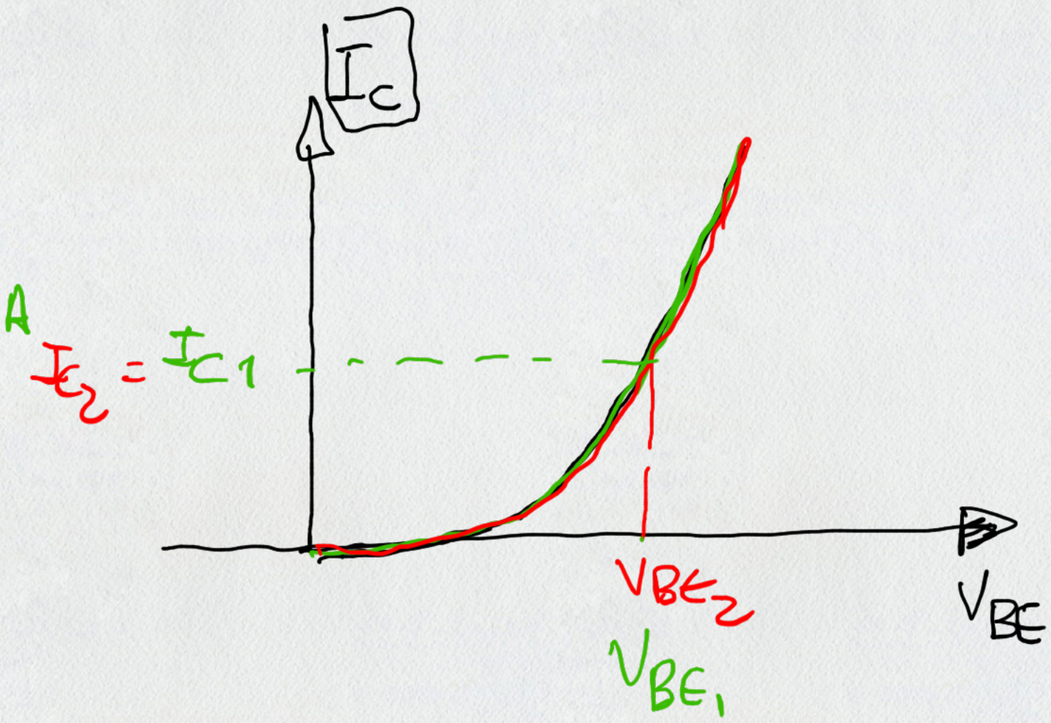


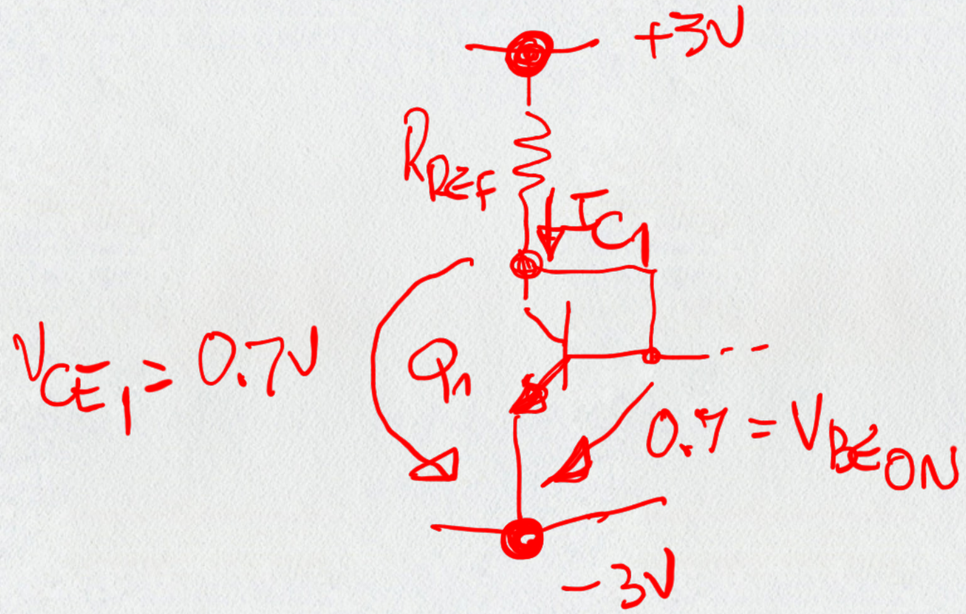
???

$V_{GS} = 2V \Rightarrow V_S = -1V$









$$V_{cc} - (V_{ss}) = R_{REF} \cdot I_{C_1} + V_{CE_1}$$

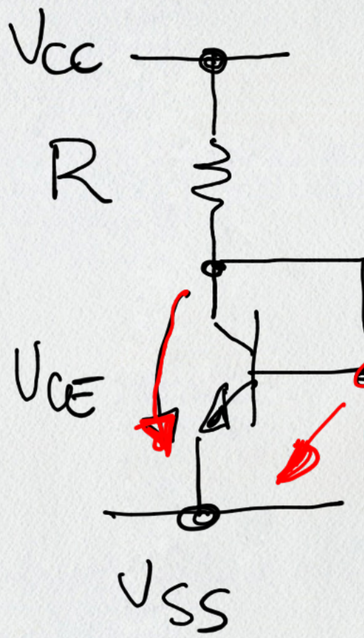
$$+3V - (-3V) = R_{REF} \cdot 2\mu A + 0.7V$$

$$R_{REF} = \frac{+6V - 0.7V}{2\mu A} = \frac{5.3}{2} k\Omega$$

$$\boxed{R_{REF} = 2.65\, k\Omega}$$

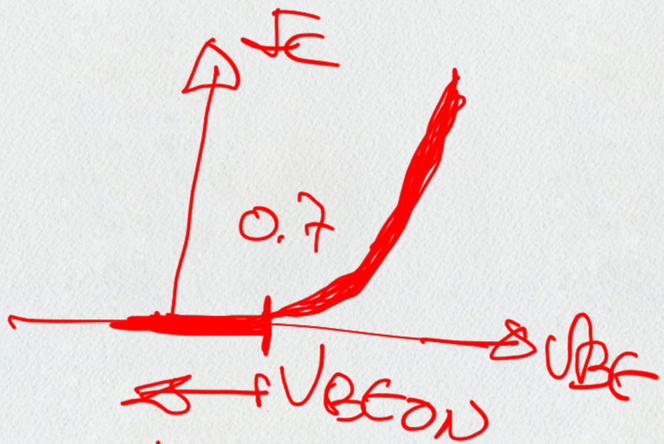
b)

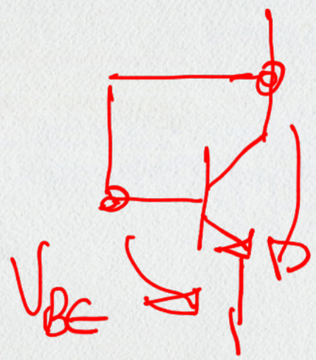
M1	M2	Q1	Q2
$I_{D_1} = 1mA$	$I_{D_2} = 1mA$	$V_{BE_1} = 0.7V$	$V_{BE_2} = 0,7V$
$V_{GS_1} = +2V$	$V_{GS_2} = +2V$	$V_{CE_1} = 0.7V$	$V_{CE_2} = 2V$
$V_{DS_1} = +2V$	$V_{DS_2} = +2V$	$I_{C_1} = 2mA$	$I_{C_2} = 2mA$



$V_{BE} = 0,3V$

$V_{CE} = V_{CE_{sat.}}$

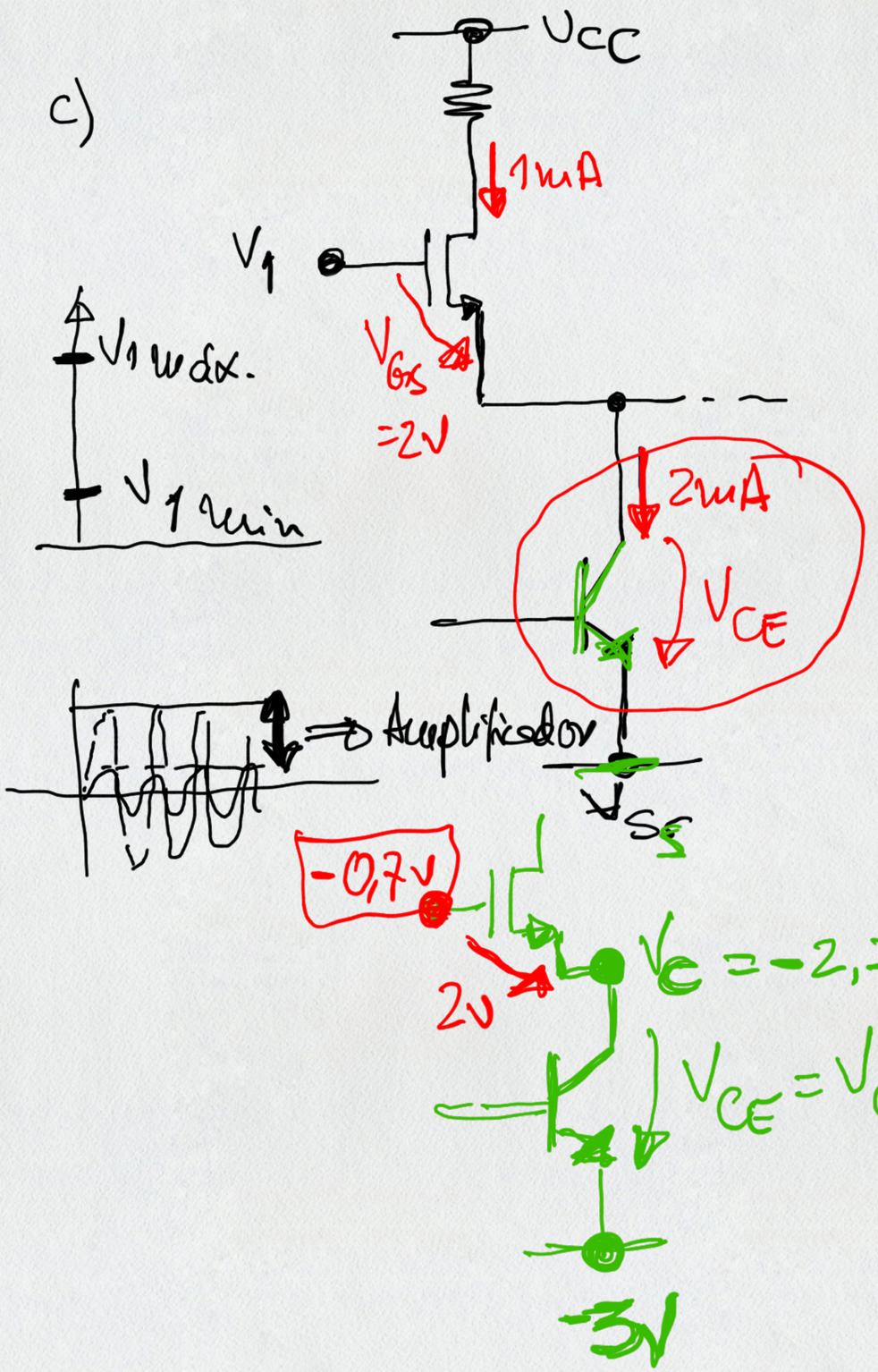


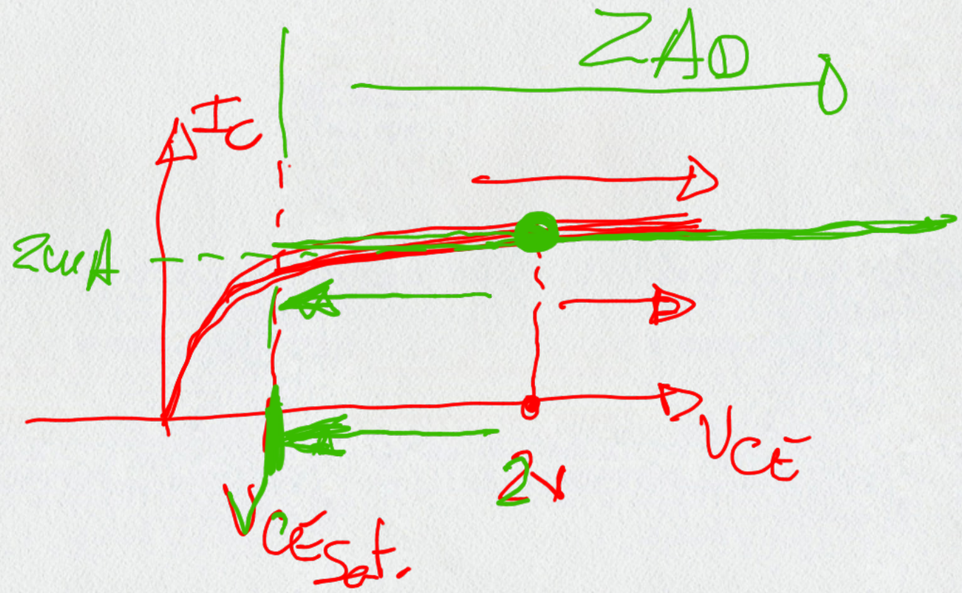


$V_{CE} = V_{BE} \Rightarrow$ TJB está en ZAD

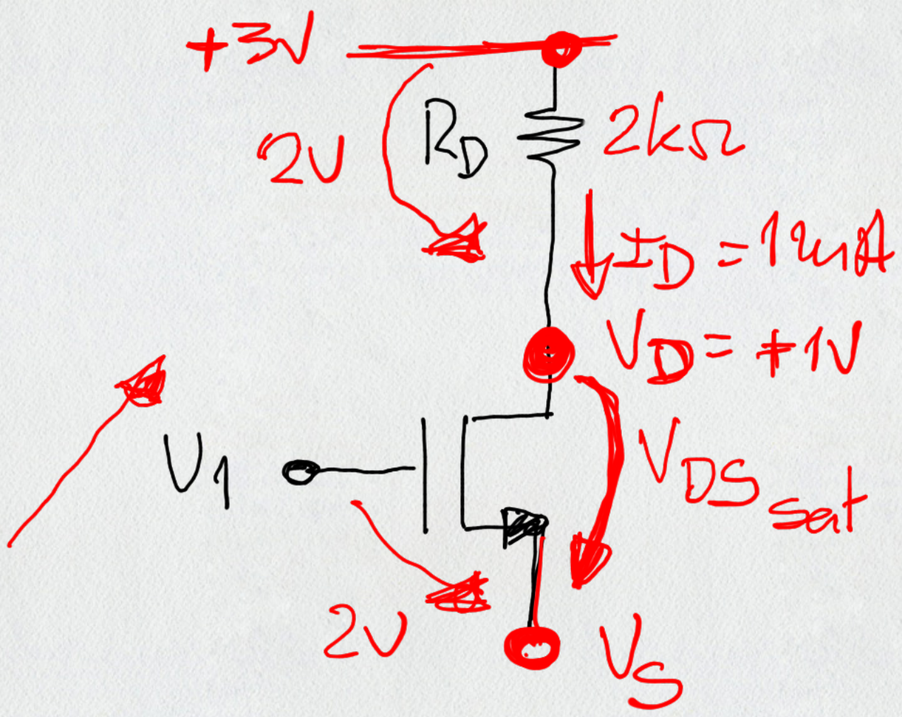
$V_{CE} = V_{BE} = 0,7 > 0,3$ (Sat.)

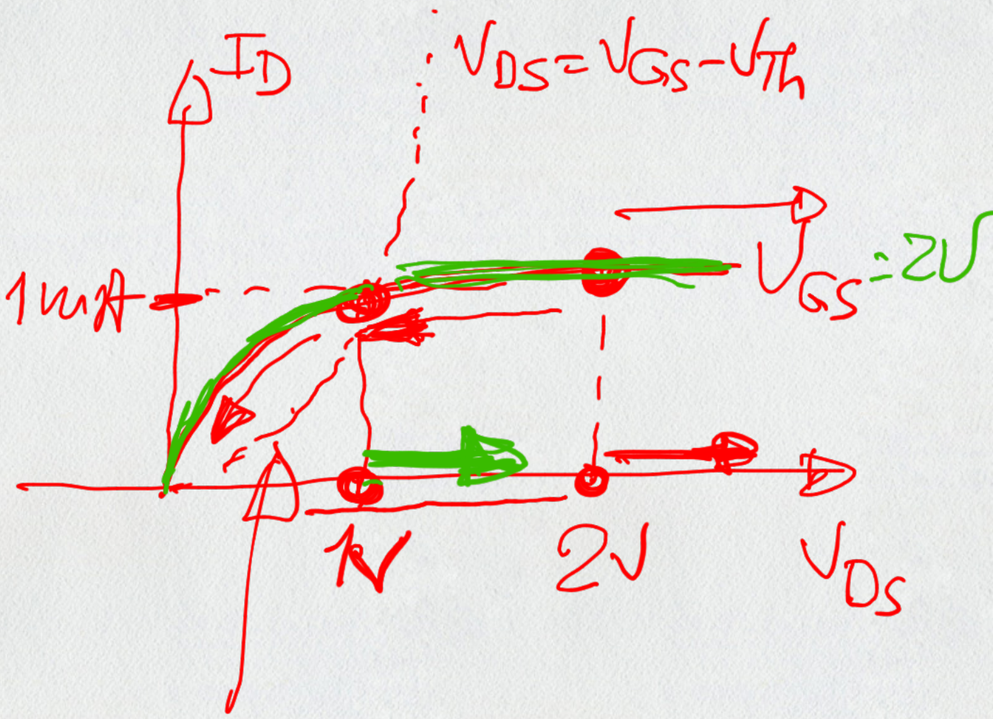
c)


V_{CC}
1mA
V_1
$V_{1\,max.}$
$V_{1\,min}$
V_{GS}
=2V
2mA
V_{CE}
Amplificador
V_S
-0,7V
2V
$V_E = -2,7V$
$V_{CE} = V_{CE\,sat.} = +0,3V$
-3V


ZAO
I_C
2mA
V_{CE}
2V
$V_{CE\,sat.}$

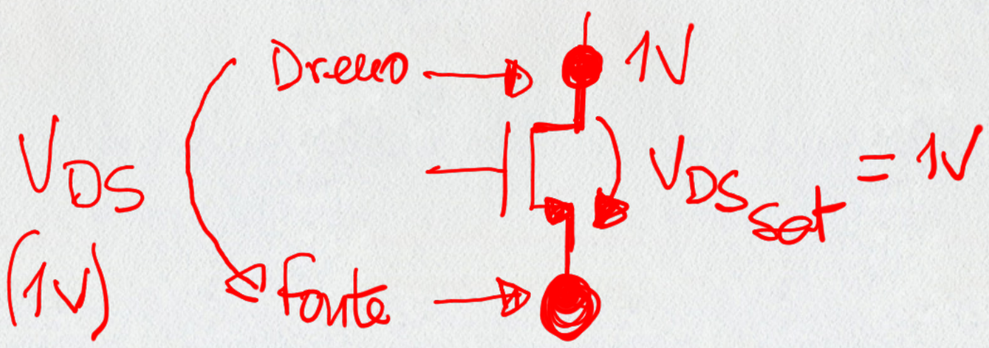
$$V_{C\,min} = -0,7\,V$$

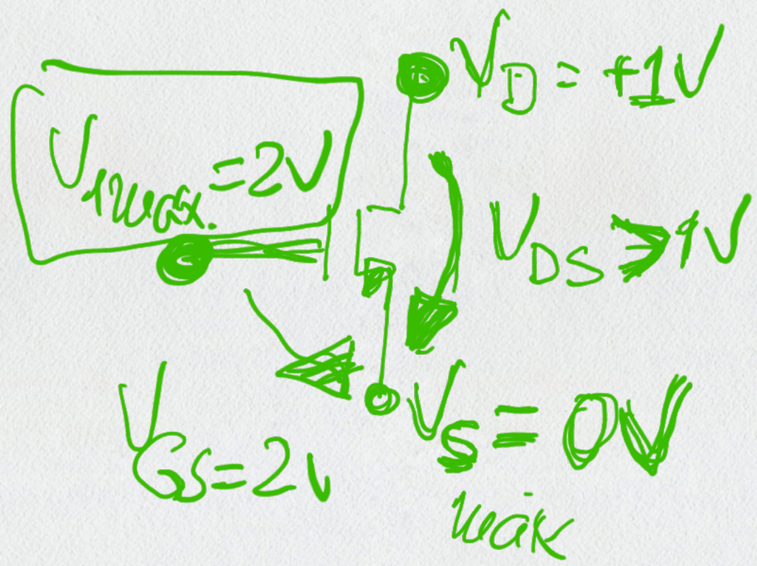




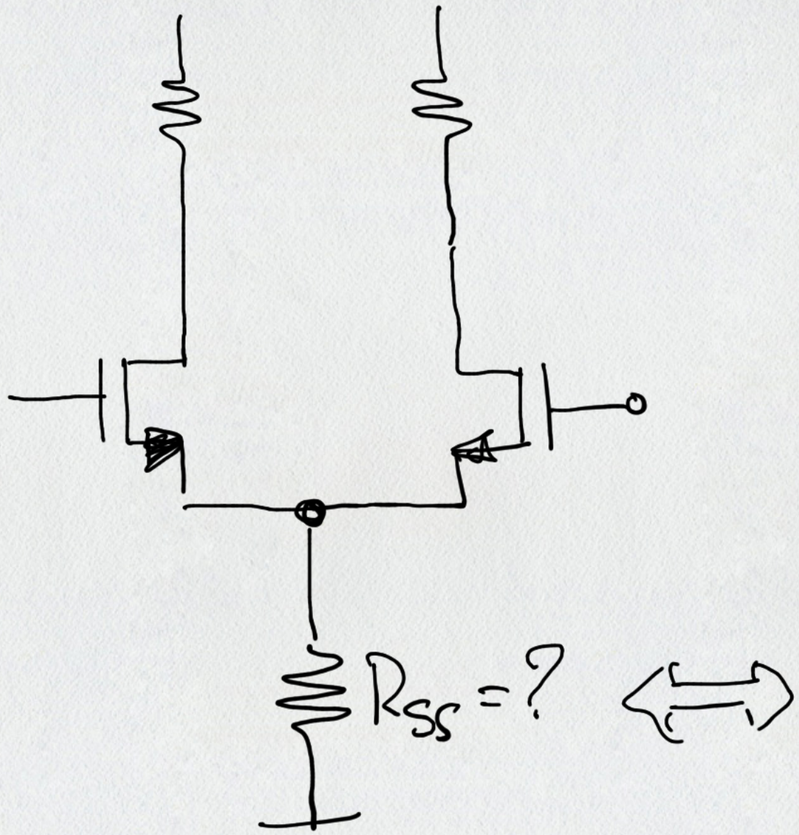
$$V_{DS\,sat} = 2V - 1V = 1V$$

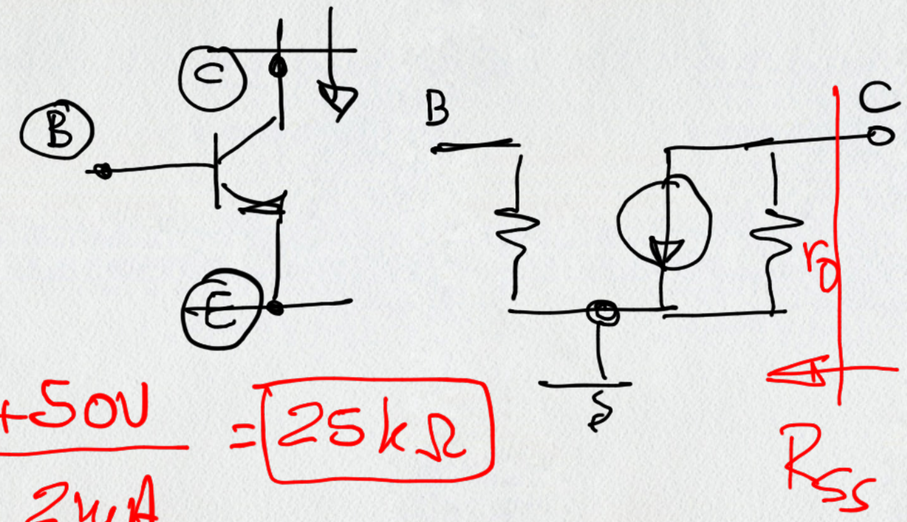
$$V_{DS} = V_{GS} - V_{th}$$



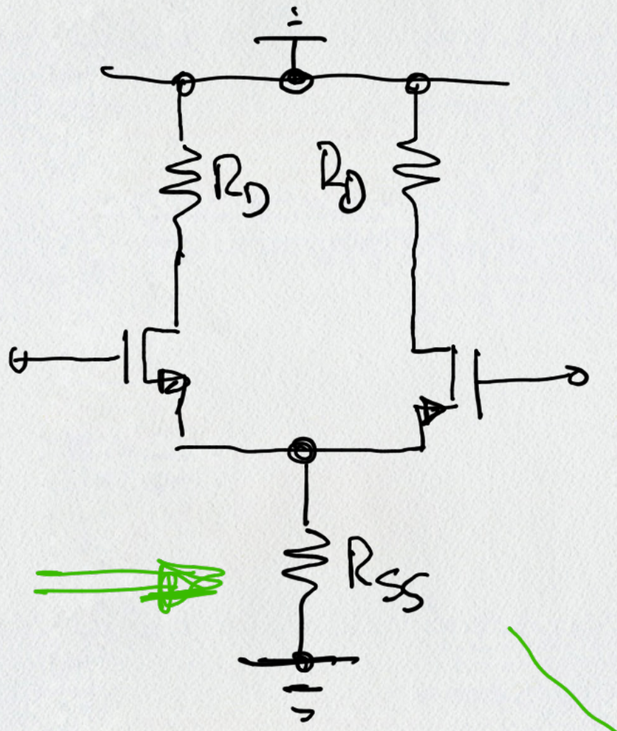


d)





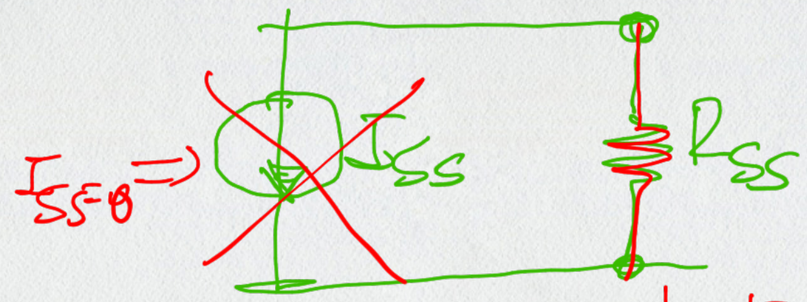
$R_{SS} = r_o \rightarrow \frac{V_A}{I_C} = \frac{+50V}{2mA} = 25k\Omega$



Esquema incremental de ficis fraco, anulam-se as fontes DC

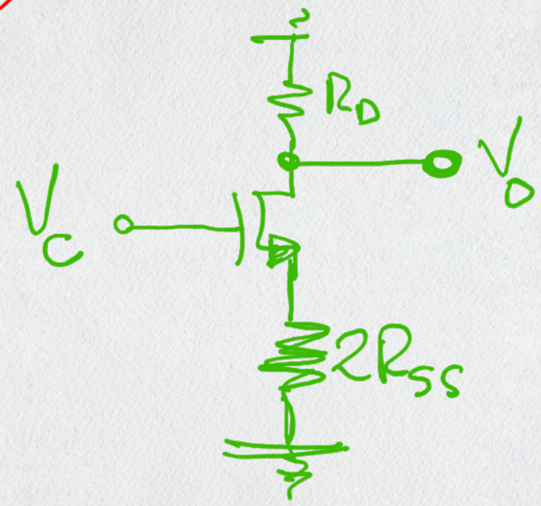
$V_{CC} = 0$

$V_{SS} = 0$



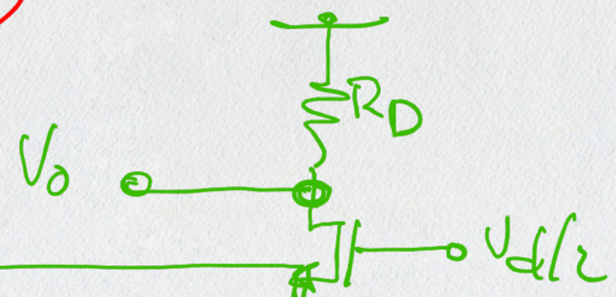
Se a fonte for ideal, R_{SS} existe

(d) Modo Comum



$$\frac{V_O}{V_C} = -\frac{R_D}{2R_{SS}}$$

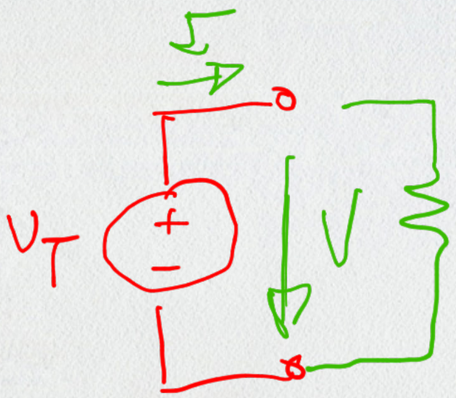
(e) Modo Diferencial



$$\frac{V_O}{(V_{d/2})} = -g_m R_D$$

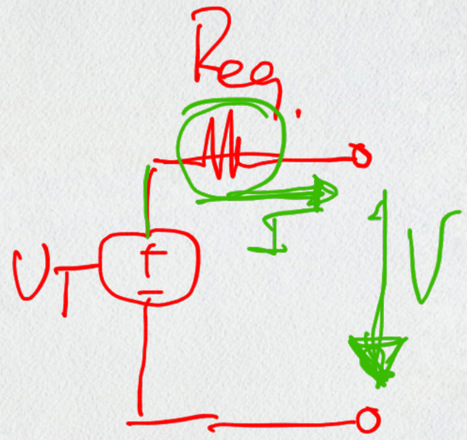
$$g_m(MOS) = 2\sqrt{k_n I_D}$$

$g_m = 2mS$



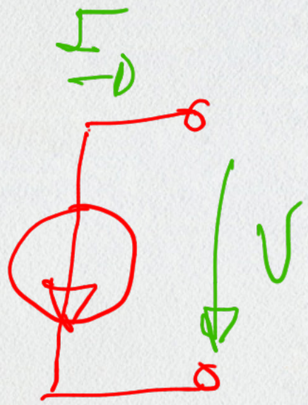
Modelo ideal

fonte tensão



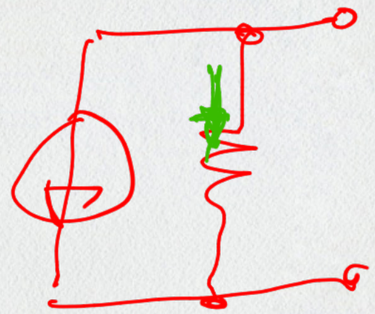
Modelo Real

fonte de tensão



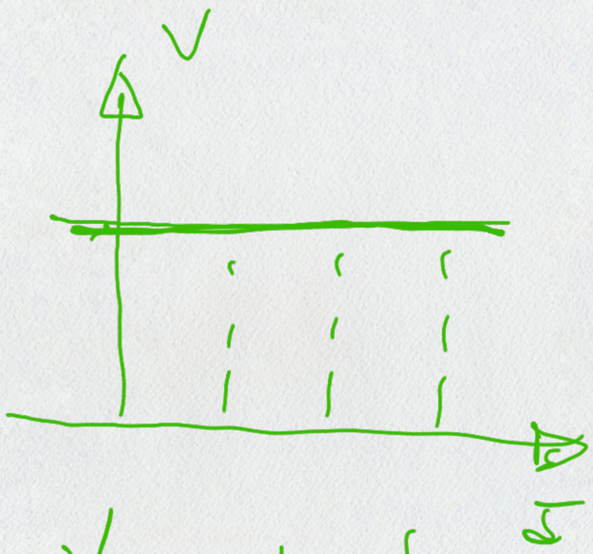
Modelo ideal

fonte de corrente



Modelo real

fonte de corrente



V constante

p/ qq. I