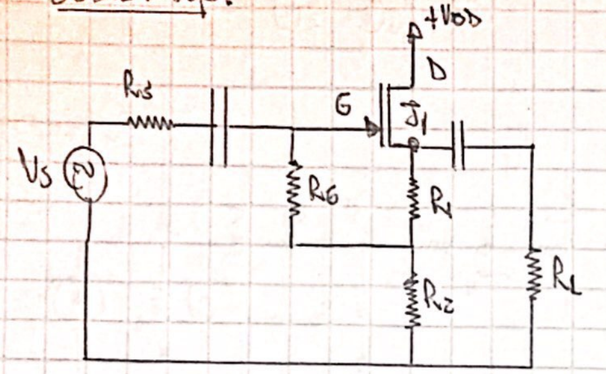
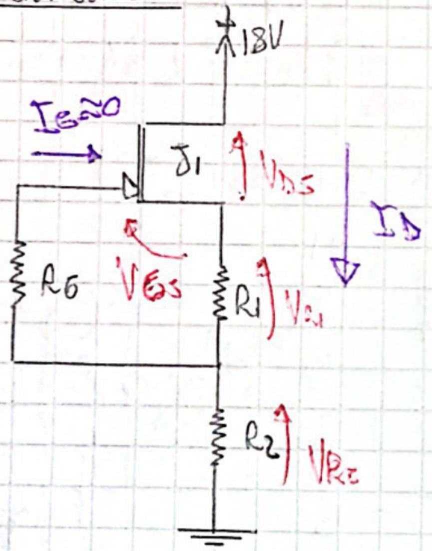
Bootstrap.



Datos: J_1 J308 ~~2N3819~~ $\begin{cases} V_p = -3{,}1V \\ I_{DSS} = 36mA \end{cases}$ $g_{fs\,min} = 8mS$, $g_{os\,max} = 250\mu S$ $\rightarrow$ $\boxed{r_{d\,min} = 4K}$

$R_S = 100k\Omega$
$R_L = 5k\Omega$
$R_G = 6{,}8M\Omega$
$R_1 = 1{,}8k\Omega$
$R_2 = 5{,}6k\Omega$
$V_{DD} = 18V$

Polarización



(1) $V_{DD} = V_{DS} + I_D \cdot (R_1 + R_2)$

(2) $V_{R1} = R_1 \cdot I_D = -V_{GS} \longrightarrow I_D = -\dfrac{V_{GS}}{R_1}$ (2')

(3) $I_D = \dfrac{I_{DSS}}{V_p^2} \cdot (V_{GS} - V_p)^2$

(2') = (3)

$$-\frac{V_{GS}}{R_1} = \frac{I_{DSS}}{V_p^2}\left(V_{GS}^2 - 2V_p \cdot V_{GS} + V_p^2\right)$$

$$0 = \frac{I_{DSS}}{V_p^2} \cdot V_{GS}^2 + \left(\frac{-2V_p \cdot I_{DSS}}{V_p^2} + \frac{1}{R_1}\right) V_{GS} + \left(I_{DSS}\right)$$

$$0 = 3{,}74\,\frac{mA}{V^2}\, V_{GS}^2 + 23{,}7\,m\mho\; V_{GS} + 36mA$$

$V_{GS1} = -2{,}56V$ ✓

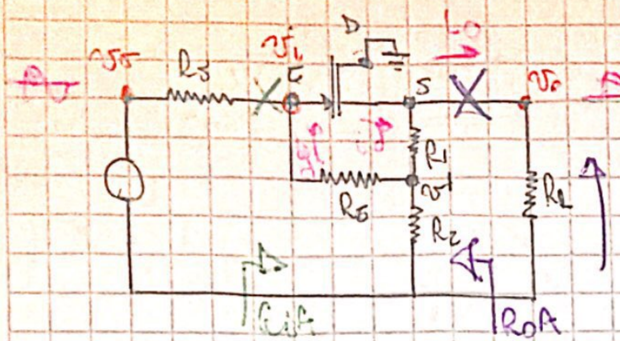
$V_{GS2} = -3{,}81V$ ✗

En (2') $\boxed{I_D = \dfrac{2{,}56V}{1{,}8k\Omega} = 1{,}42mA}$

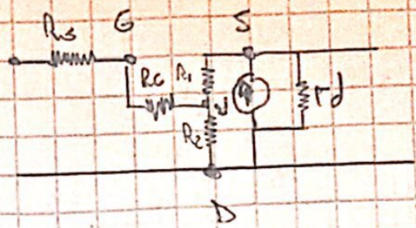
En (1) $V_{DS} = V_{DD} - I_D \cdot (R_1 + R_2)$

$\boxed{V_{DS} = 18V - 1{,}42mA\,(1{,}8k\Omega + 5{,}6k\Omega) = 7{,}492V}$

Análisis de Señal

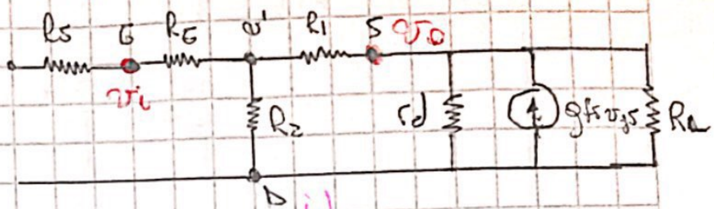


Modelo →

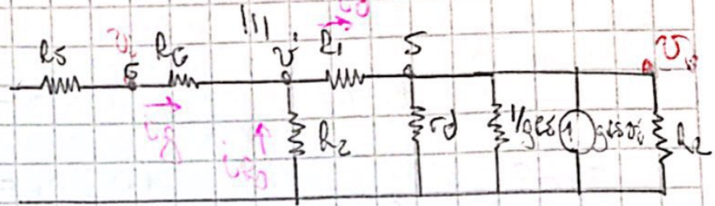


$v_{gs} = v_i - v_o$

⇓

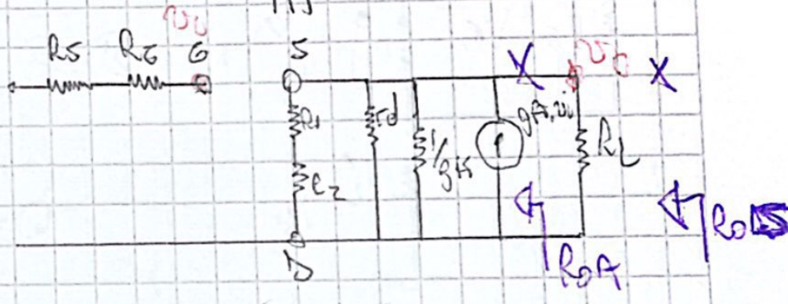


⇓



Si tomamos $i_g \approx 0 \Rightarrow i_{R_2} \approx i_d$

⇓



$$A_{vs} = \frac{R_{iA}}{R_S + R_{iA}} \cdot A_v$$

$$A_v = \frac{v_o}{v_i} = \frac{g_{fs} \cdot v_i \cdot R_{oA}}{v_i}$$

$$\boxed{R_{oA}} = \frac{1}{\frac{1}{R_1+R_2} + \frac{1}{rd_{máx}} + g_{fs_{mín}}} = \boxed{120\,\Omega}$$

$$\boxed{R_{oS}} = R_{oA} \parallel R_L = \boxed{117\,\Omega}$$

$$\boxed{A_{v_{mín}}} = g_{fs_{mín}} \cdot R_{oS} = \boxed{0{,}935}$$

$$g_{fs} = \frac{2 I_{DSS}}{V_p} \cdot \sqrt{\frac{I_D}{I_{DSS}}}$$

$$g_{fs} = 4{,}6\,mS$$

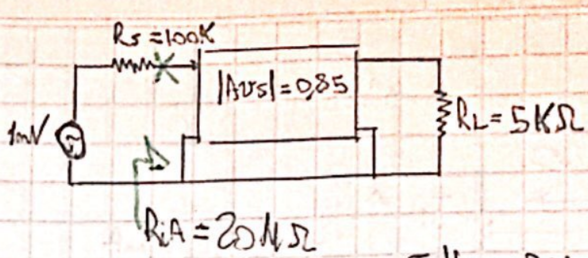
$$R_{iA} = \frac{v_i}{i_g} = \frac{v_i}{\frac{v_i - v'}{R_G}} = \frac{v_i \cdot R_G}{v_i - v_o \cdot \frac{R_2}{R_1+R_2}} = \frac{R_G}{1 - A_v \cdot \frac{R_2}{R_1+R_2}}$$

$$\boxed{R_{iA}} = \frac{R_G}{1 - A_v \cdot \frac{R_2}{R_1+R_2}} = \boxed{23{,}31\,M\Omega}$$

$$\boxed{A_{vs} = 0{,}932}$$

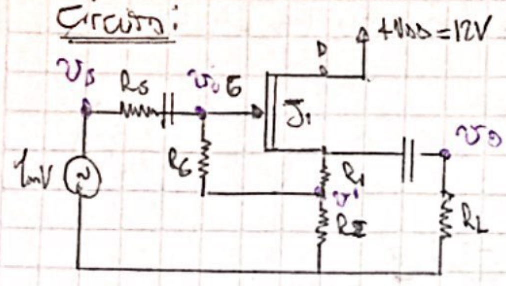
Grupo 10 — Trabajo de Laboratorio Aplicada 1

Diseñamos Un Bootstrap con:



- Admitimos Una Tolerancia del 5%
- Suponemos Una $V_{DD} = 12V$

Circuito:



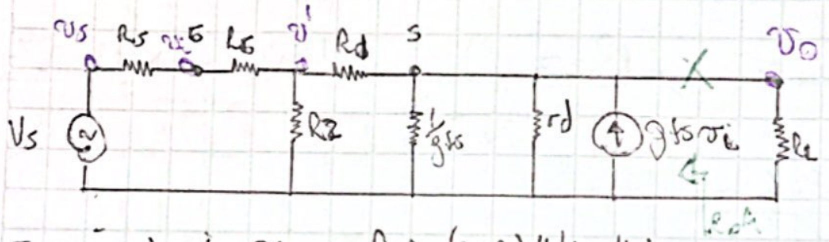
J_1: J109 de ON semiconductors / FNT

$$\begin{cases} V_P = -3V \\ I_{DSS_{min}} = 40mA \end{cases}$$

Suponemos $I_D = 1mA$ para sacar gfs y gos de las Tablas $\Big\} \rightarrow$ $gfs = 9mS$

$gos = 20\mu S \rightarrow r_d \approx 50K\Omega$

Señal: con Modelo equivalente



$$\approx 0{,}995$$

$$A_{vs} = \frac{R_{iA}}{R_S + R_{iA}} \cdot A_v$$

$$A_v = \frac{gfs \cdot v_i \cdot R_{os}}{v_i}$$

Suponiendo $i_g \approx 0 \Rightarrow R_{oA} = (R_1 + R_2) \,//\, 1/gfs \,//\, r_d$

$$R_{oA} = \overset{110{,}8\Omega}{\cancel{50K}} \,//\, (R_1 + R_2)$$

Si $(R_1 + R_2) \geq 1K\Omega \Rightarrow R_{oA} \approx 100\Omega$

$\boxed{\text{Si } R_{oA} \approx 100\Omega \Rightarrow A_v \approx 0{,}9 \text{ y } A_{vs} \approx 0{,}9}$

$$R_{iA} = \frac{v_i}{i_g} = \frac{v_i}{\frac{(v_i - v')}{R_G}} = \frac{v_i \cdot R_G}{v_i - v_O \frac{R_2}{R_1 + R_2}} = \frac{R_G}{1 - A_v \cdot \frac{R_2}{R_1 + R_2}}$$

Si R_{iA} Tiene que ser $20M\Omega$, Adopto $R_G = 8{,}2M\Omega$

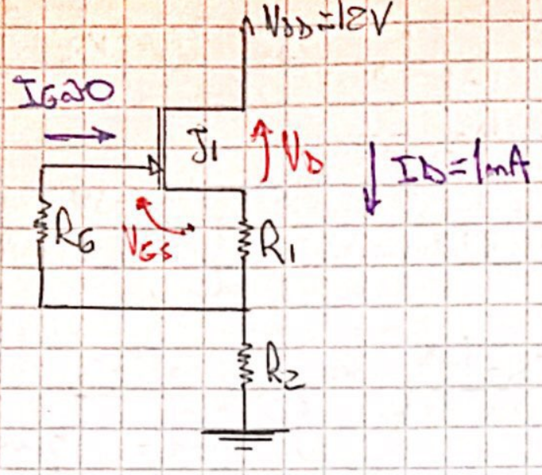
Defino $R_P = R_1 // R_2$

$$1 - A_v \cdot \frac{R_2}{R_1 + R_2} = \frac{8{,}2M\Omega}{20M\Omega}$$

$$\frac{R_2}{R_1 + R_2} = \frac{1}{A_v}\left(1 - 0{,}41\right) = \frac{1}{A_v} \cdot 0{,}59 = 0{,}655$$

$$\frac{R_2}{R_1 + R_2} = 0{,}655 \Longrightarrow \boxed{R_P = 0{,}655 \cdot R_1}$$

Polarización



$$I_D = \frac{I_{DSS}}{V_P^2}\left(V_{GS}-V_P\right)^2$$

$$\frac{1mA\,(9V)}{40mA} = V_{GS}^2 + 6V\,V_{GS} + 9V^2$$

$$0 = V_{GS}^2 + 6V \cdot V_{GS} + \left(9V^2 - \frac{9}{40}V^2\right)$$

$$V_{GS_1} = -2{,}52V$$

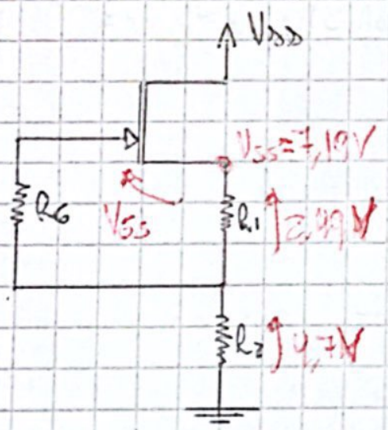
$$\cancel{V_{GS_2} = -3{,}4V}$$

$$R_1 = \frac{-V_{GS1}}{I_D} = 2{,}52\,K\Omega$$

$$\boxed{R_1 = 2{,}49K\Omega \rightarrow +/-5\%}$$

$$R_P = 0{,}655 \cdot R_1 \Rightarrow R_P = 1{,}63K\Omega$$

$$R_2 = \frac{1}{\frac{1}{R_P} - \frac{1}{R_1}} = 4{,}71K\Omega \longrightarrow 4{,}7K\Omega\ +/-10\%$$



Si queremos que se cumpla

$$V_{DS} > V_{GS} - V_P > 0$$

$$V_{DS} > 0{,}48V > 0$$

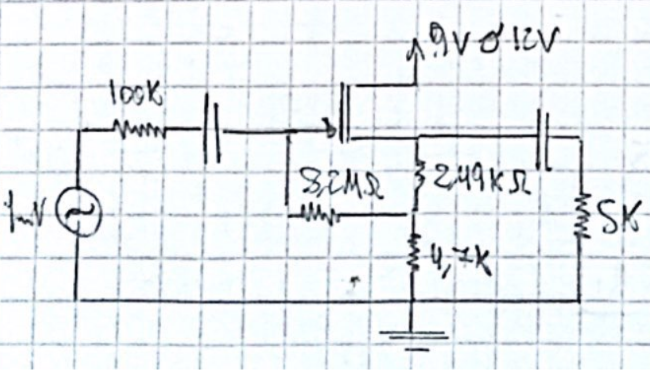
$$\Downarrow$$

$$V_{DD} - V_{SS} > 0{,}48V$$

$$V_{DD} > 7{,}67V$$

↳ podríamos poner $V_{DD} = 9V$.

Resultado Final:



Otro diseño pero con el MMBFU310LT1 $\begin{cases} V_p \approx -4{,}25V \\ I_{DSS} \approx 42mA \\ g_{fs}\big|_{2mA} \cong 3mS \end{cases}$

$g_{os}\big|_{2mA} \cong 30\mu S \Rightarrow r_d \cong 33K\Omega$

Vamos a suponer $I_D = 2mA$

$R_{oA} = (R_1+R_2) \,//\, 1/g_{fs} \,//\, r_d$

$R_{oA} = (R_1+R_2) \,//\, 330\Omega$

$Si\ (R_1+R_2) \geq 3{,}3k\Omega \Rightarrow R_{oA} \approx 330\Omega$

$A_v = g_{fs} \cdot R_S = g_{fs} \cdot (R_{oA}//R_L) \cong 0{,}92$

$A_{vs} \approx 0{,}924$

$R_{iA} = \dfrac{R_G}{1 - A_v \cdot \frac{R_2}{R_1+R_2}} \rightarrow$ Adopto $R_G = 8{,}2M\Omega$

$1 - A_v \cdot \dfrac{R_2}{R_1+R_2} = \dfrac{8{,}2M\Omega}{20M\Omega} \longrightarrow \dfrac{R_2}{R_1+R_2} = \dfrac{\left(1 - \frac{8{,}2}{20}\right)}{A_v}$

$R_p = 0{,}641 \cdot R_1$

Polarización

$0 = V_{GS}^2 + 8{,}5V\,V_{GS} + \left(18{,}06V^2 - \dfrac{18{,}06 \cdot V^2 \cdot 2mA}{42mA}\right)$

$V_{GS1} = -3{,}32V$ ✓ $\qquad R_1 = \dfrac{-V_{GS}}{I_D} = 1{,}66K\Omega \rightarrow 1{,}5K\Omega$ 10%

$V_{GS2} = -5{,}17V$ ✗ $\qquad R_p = R_1 \cdot 0{,}641 = 961\Omega \rightarrow R_2 = 585{,}7\Omega \rightarrow R_2 = 560\Omega$ 10%

$(R_1+R_2) < 3{,}3K\Omega \Rightarrow R_{oA} = (R_1+R_2)//330\Omega = 284\Omega \longrightarrow R_{os} = R_{oA}//R_L = 269\Omega$

$A_v = 3mS \cdot 269\Omega = 0{,}807$

$R_{iA} = \dfrac{8{,}2M\Omega}{1 - 0{,}8 \cdot \frac{560\Omega}{2{,}06K}} = 10{,}5M\Omega \rightarrow$ Muy CHICO!

$A_{vs} = 0{,}803$

Asumimos una $I_D = 3mA \Rightarrow g_{fs}|_{3mA} = 3{,}5mS$

$g_{os}|_{3mA} = 35\mu S \Rightarrow \boxed{r_d = 28{,}5K\Omega}$

Planteamos la Ecuación de polarización

$$0 = V_{GS}^2 + 8{,}5V\, V_{GS} + \left(18{,}06V^2 - \frac{18{,}06V^2 \cdot 3mA}{42mA}\right)$$

$$\boxed{V_{GS} = -3{,}11V}$$

$$\boxed{R_1 = \frac{-V_{GS}}{I_D} = 1{,}03K \to 1K\Omega}$$

$$R_{iA} = \frac{R_G}{1 - A_v \cdot \frac{R_2}{R_1+R_2}}$$

$\boxed{Si\ R_1+R_2 \geq 15K \Rightarrow (R_1+R_2)//267{,}7\Omega = 227\Omega}$

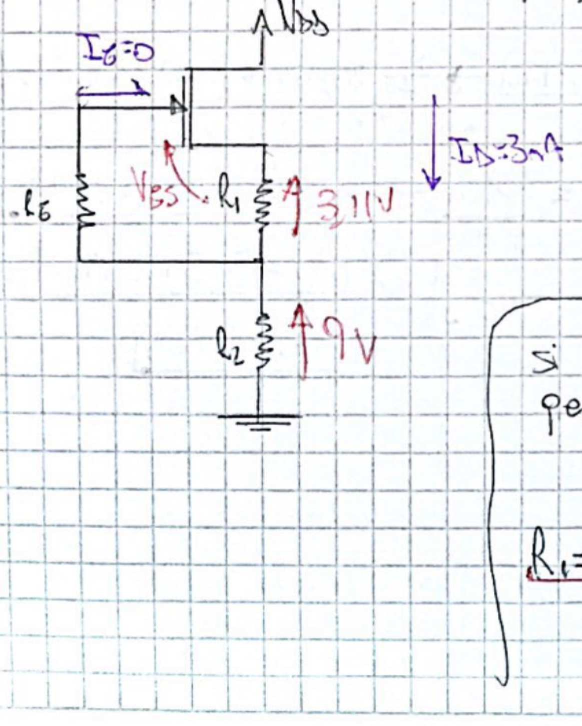
$$\boxed{A_v = g_{fs} \cdot R_{os} = g_{fs}\left[\underbrace{(R_1+R_2)//r_d}_{}//\underbrace{1/g_{fs}}_{285{,}7\Omega}//\underbrace{R_L}_{5K}\right] = g_{fs} \cdot \left((R_1+R_2)//267{,}7\Omega\right) = 0{,}795}$$

Si Asumo $R_2 = 3K\Omega$ $\Rightarrow (R_1+R_2)//267{,}7\Omega = 250{,}9\Omega \Rightarrow A_v = 0{,}87$

$$R_{iA} \cdot \left(1 - A_v \cdot \frac{R_2}{R_1+R_2}\right) = R_G$$

$$20M\Omega\left(1 - 0{,}87 \cdot \frac{3K}{4K}\right) = 6{,}95M\Omega = R_G \longrightarrow \boxed{Tomo\ R_G = 8{,}2M\Omega}$$

$$\boxed{R_{iA} = \frac{8{,}2M\Omega}{1 - 0{,}87 \cdot \frac{3}{4}} \simeq 23{,}6M\Omega}$$



$V_{DD} > 12{,}11V + 1{,}14V \Rightarrow V_{DD} > 13{,}25V$

Si $V_{DD} = 15V \Rightarrow \boxed{V_{DS} = 2{,}89V}$

Si Mantenemos los Componentes salvo R_1 y pedimos $I_D = 2mA \Rightarrow 1/g_{fs} = 333\Omega$, $r_d = 33K$ $\}$ $V_{GS} = -3{,}32V$

$\boxed{R_1 = 1{,}5K\Omega} \longrightarrow \boxed{A_v = 3mS \cdot (4{,}5K//33K//330\Omega//5K) = 0{,}868}$

$\boxed{R_{iA} \simeq 19{,}46M\Omega}$ y $V_{DD} \simeq 12V \Rightarrow V_{DS} \simeq 2{,}68V$