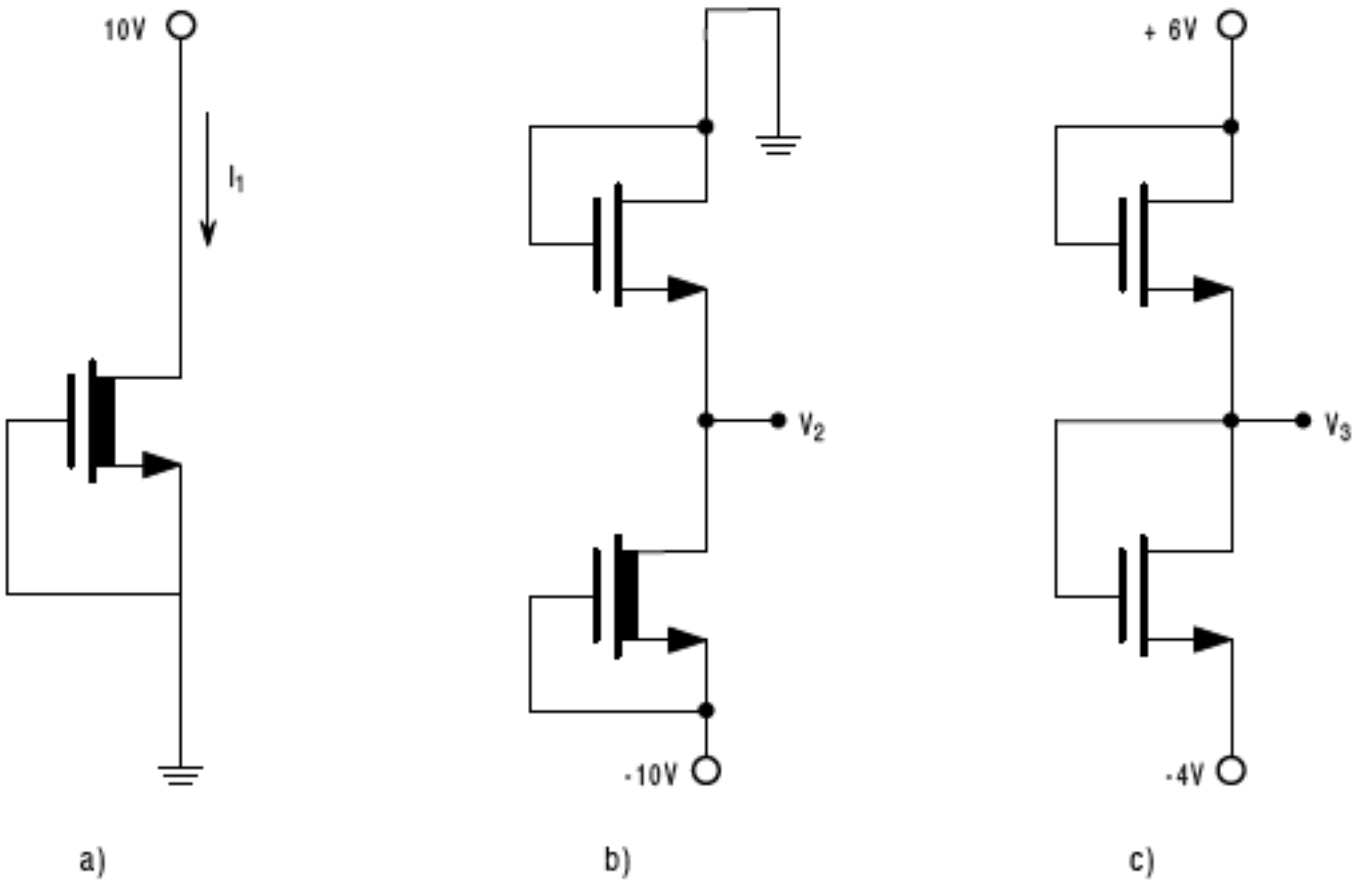
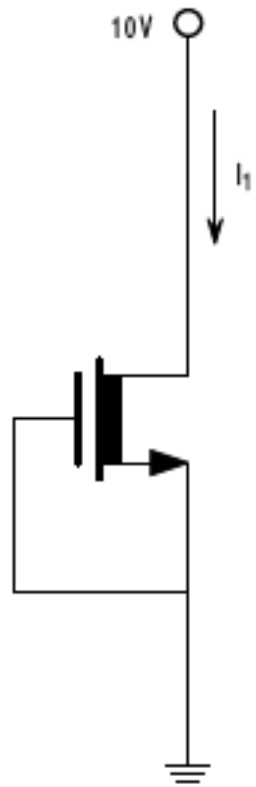
PROBLEMA 1: POLARIZACIÓN DE MOSETS

Calcular las corrientes y voltajes señaladas en los circuitos de la figura si para todos los dispositivos $|V_{th}| = 1V$ y $K = 0{,}5mA/V^2$, considerando que en saturación se cumple $I_D = K\,(V_{GS} - V_{th})^2$



a)



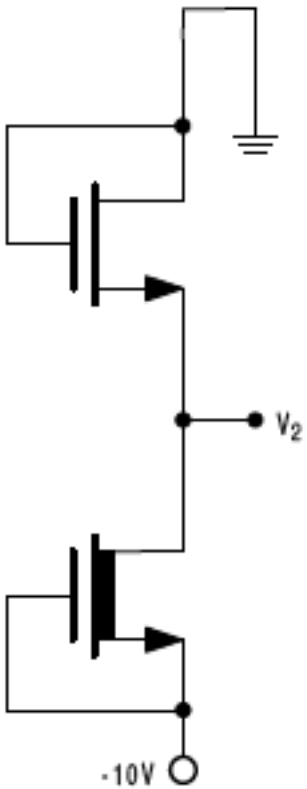
$$I_D = 0{,}5\,\frac{mA}{V^2}\left(V_{GS} - V_T\right)^2$$

$$V_{GS} = 0$$

$$V_T = -1$$

$$I_D = \frac{0{,}5\,mA}{V^2}\left(0-(-1)\,V\right)^2 = 0{,}5\,mA$$

b) Del circuito externo:



$$v_{DS_1} + v_{DS_2} = 10 \qquad v_{GS_2} = 0$$

En el MOSFET de vaciamiento Q2:

$$I_D = 0{,}5\left(0 - (-1)\right)^2 = 0{,}5\ mA$$

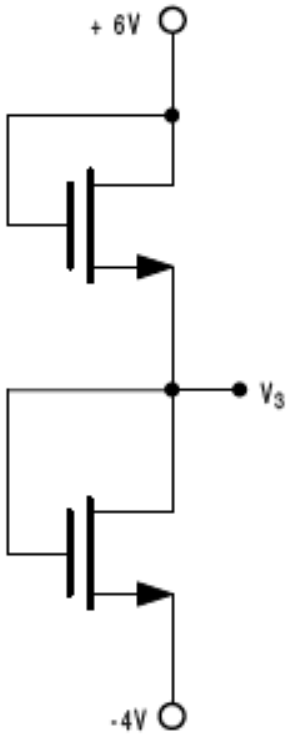
En el MOSFET de enriquecimiento Q1 la corriente es la misma, por lo tanto:

$$0{,}5\left(v_{GS_1} - 1\right)^2 = 0{,}5\ mA$$

$$v_{GS_1} - 1 = \pm 1 \qquad v_{GS_1} = 2$$

$$\mathbf{V_2 = V_{S1} = -2V}$$

c) Del circuito externo



$V_{G1} = V_{D1} = 6V \quad V_{S2} = -4V$

$V_{S1} = V_{D2} = V_3 \quad V_{G2} = V_{D2} = 1$

$I_{D1} = I_{D2}$

$0{,}5\,(V_{GS_1} - 1)^2 = 0{,}5\,(V_{GS_2} - 1)^2$

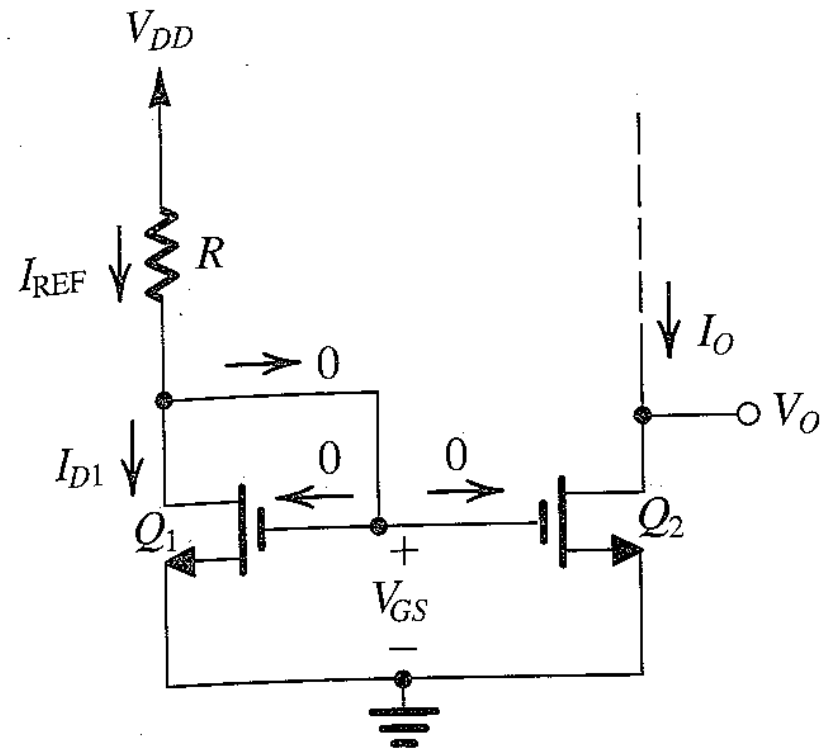
$V_{GS_1} = V_{GS_2} \quad V_{G1} - V_{S1} = V_{G2} - V_{S2}$

$6V - V_{S_1} = V_{G2} - (-4) \quad 6V - 4V = 2V = V_{G2} + V_{S1} =$

$V_3 + V_3 = 2V_3 = 2 \quad V_3 = 1$

PROBLEMA 2 ESPEJO DE CORRIENTE CON MOSFETS.

CÁLCULO DE R



Parámetros: $K = 1mA/V^2$ $V_{th} = 1V$

Calcule R para $I_o = 4mA$ si $V_{DD} = 7V$

$$I_D = \frac{1mA}{V^2}(V_{GS_1} - V_{th})^2 = 4mA$$

$$(V_{GS_1} - V_{th})^2 = 4$$

$$V_{GS} - V_{th} = \pm 2$$

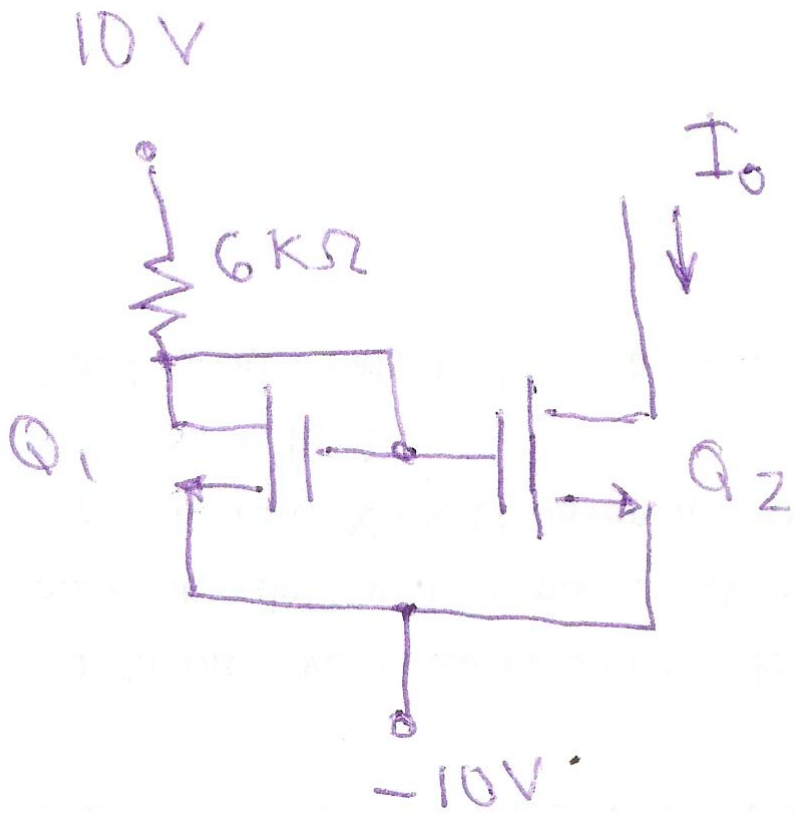
$$V_{GS} = 2 + 1 = 3V$$

$$V_G = 3V = V_D \qquad I_{REF} = I_O$$

$$R = \frac{V_{DD} - V_D}{I_D}$$

$$R = \frac{7-3}{4} = 1k\Omega$$

PROBLEMA 3 ESPEJO DE CORRIENTE CON MOSFETS.
CÁLCULO DE I_o



Parámetros: $K = 3mA/V^2$ $V_{th} = 1V$

Calcule I_o

$$10V = I_D \times 6K + V_{GS_1} - 10$$

$$20V = 6 I_D + V_{GS_1}$$

$$V_{GS_1} = 20V - 6 I_D$$

$$I_D = K (V_{GS} - V_t)^2$$

$$I_D = 3(20 - 6I_D - 1)^2 = 3(19 - 6I_D)^2$$

Resolviendo:

$$I_D = 3(361 - 228 I_D + 36 I_D^2)$$

$$0 = 1083 - 685 I_D + 108 I_D^2$$

$$I_D = \frac{685 \pm \sqrt{469.225 - 467.856}}{216}$$

$$I_D = \frac{685 \pm 37}{216} \begin{cases} \nearrow 3{,}34 \\ \searrow 3 \end{cases}$$

$$V_{GS_1} = 20V - 6 \times 3{,}34 = 0$$

$$V_{GS_1} = 20V - 6.3 = 2V$$

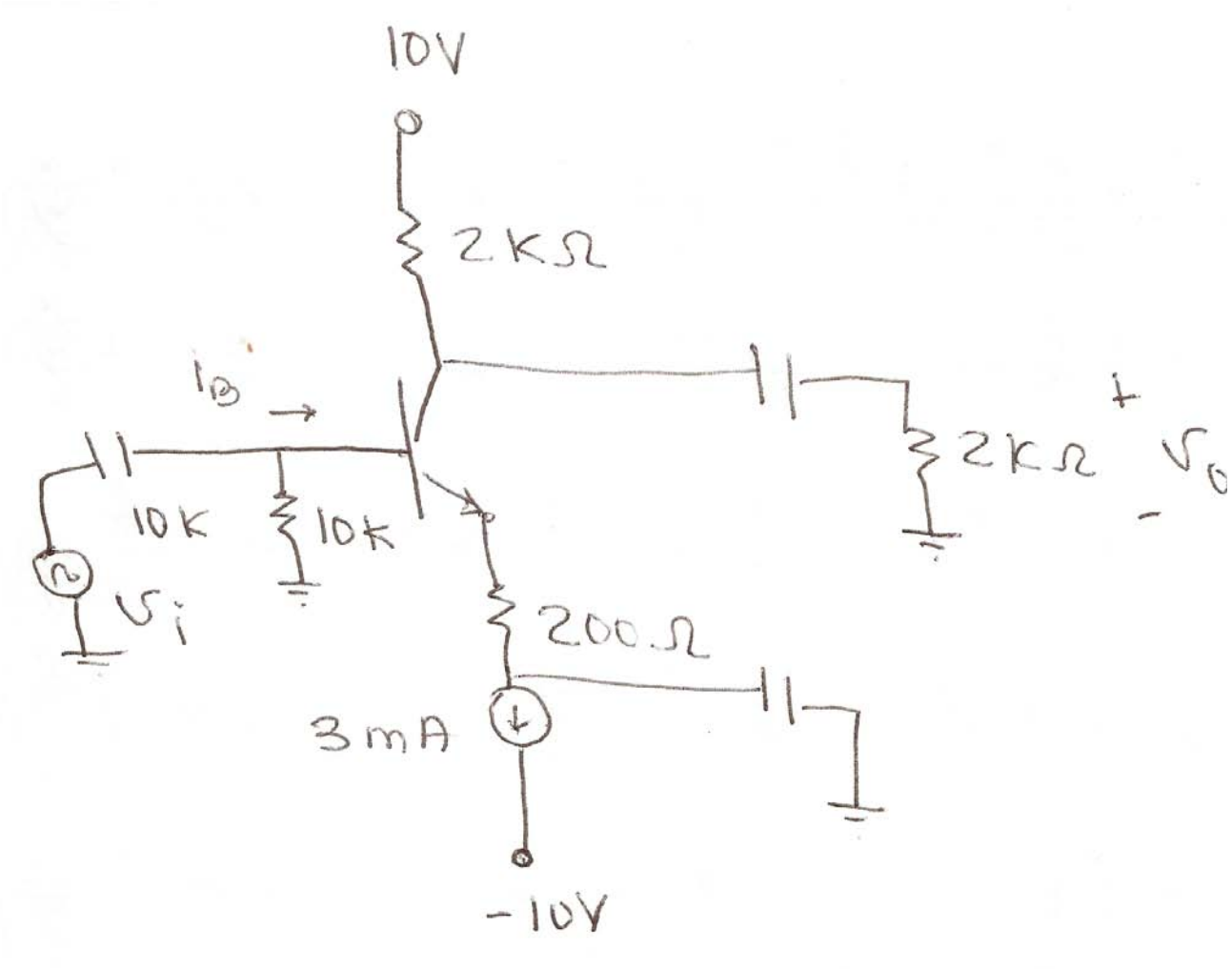
$$\boxed{I_D = 3\ mA}$$

PROBLEMA 4: AMPLIFICADOR EMISOR COMÚN CON RESISTENCIA DE EMISOR, POLARIZADO CON FUENTE DE CORRIENTE

Para el circuito mostrado calcular el punto de operación, la ganancia de voltaje, la ganancia de corriente, la resistencia de entrada y la resistencia de salida.

$\beta = 100$

Vbe = 0,7V



Punto de operación, sabiendo que I_E = 3mA

$$I_E \simeq I_C$$

$$i_B = \frac{I_C}{\beta} = 0{,}03\ mA$$

$$V_B = i_B \times 10k = -0{,}3\ mA$$

$$V_B - V_E = 0{,}7\ V$$

$$V_E = V_B - 0{,}7V = -0{,}3V - 0{,}7\ V = -1V$$

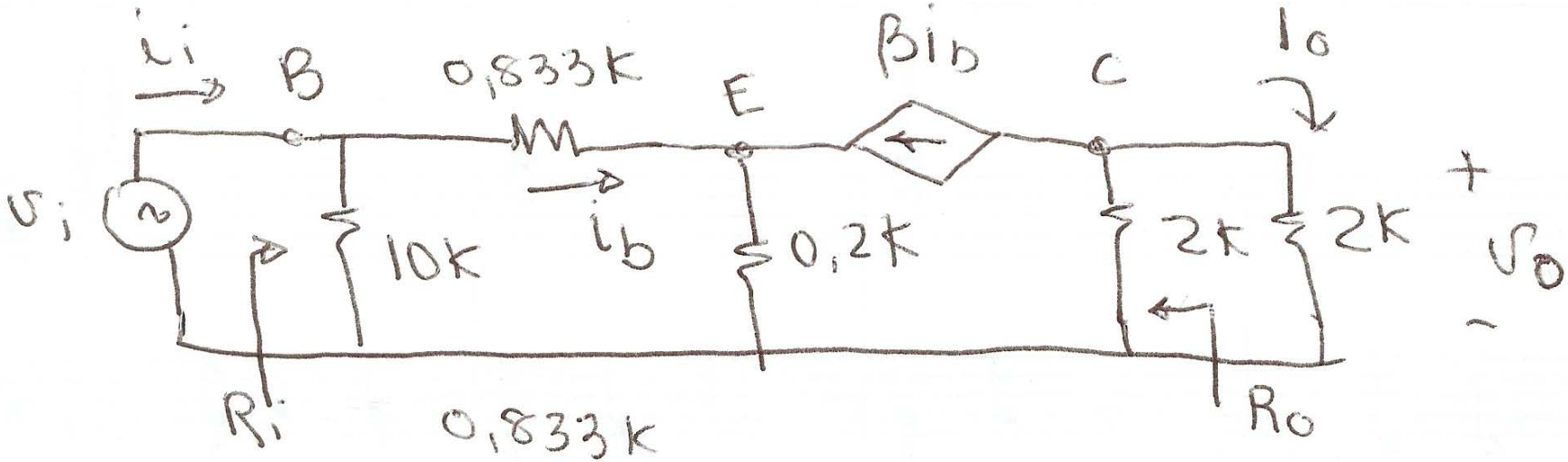
$$V_C = 10V - 2k\,I_C = 10V - 6V = 4V$$

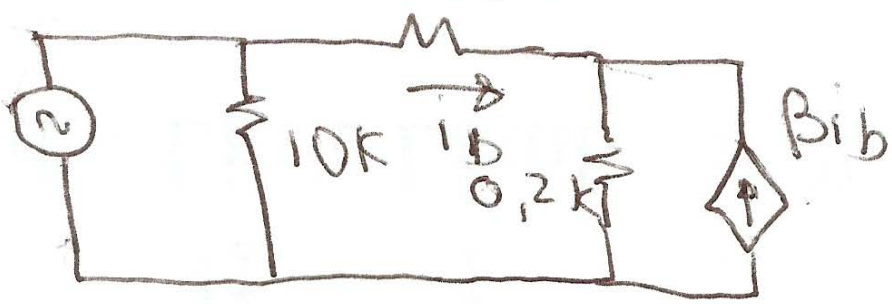
$$V_{CE} = V_C - V_E = 4V - (-1V) = 5V$$

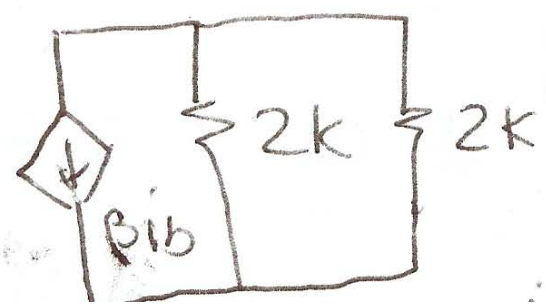
I_C = 3mA **I_B = 0,03mA** **V_{CE} = 5V**

Análisis AC

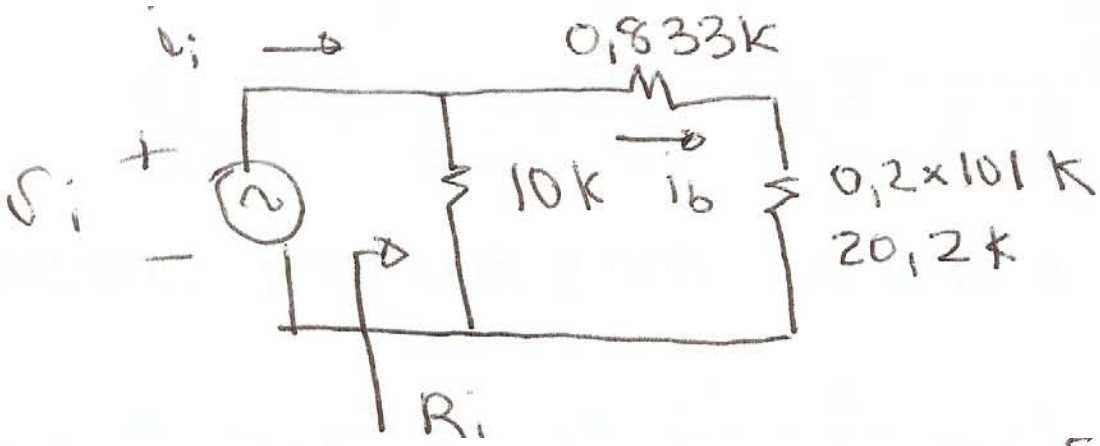
$$g_m = \frac{3\,mA}{0{,}025\,V} = 120\,\frac{mA}{V} \qquad r_\pi = \frac{\beta}{g_m} = 0{,}833\,k\Omega$$

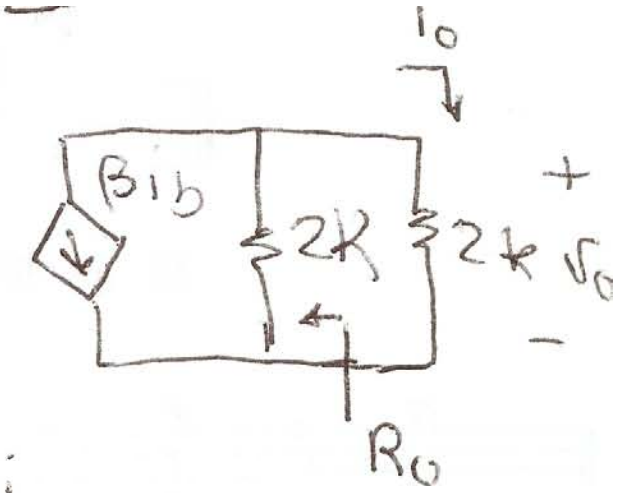






Ganancia de voltaje





$$i_b = \frac{v_i}{20{,}2\,K + 0{,}833\,K} = \frac{v_i}{21\,k}$$

$$v_o = -\beta i_b (R_L \| R_C) = -100 \times 1k \times \frac{v_i}{21\,k}$$

$$A_v = \frac{v_o}{v_i} = -\frac{100}{21} = -4{,}76$$

Ganancia de corriente, resistencia de entrada y de salida

$$R_o = 2K\Omega$$

$$R_i = 10K\Omega \parallel 21K\Omega = 6{,}77\,K\Omega$$

$$i_i = \frac{v_i}{R_i} \qquad v_o = 2K\, i_o \qquad A_i = \frac{i_o}{i_i}$$

$$A_i = \frac{v_o}{2K} \cdot \frac{R_i}{v_i} = A_v \frac{6{,}77K}{2K} = -16{,}11$$

PROBLEMA 5: ESPEJO DE CORRIENTE CON BJTs

Para el circuito mostrado calcule R para que la corriente i_o sea de 0,5mA, con V_o = 2V. Considere β = 100 y V_{BE} = 0,7V

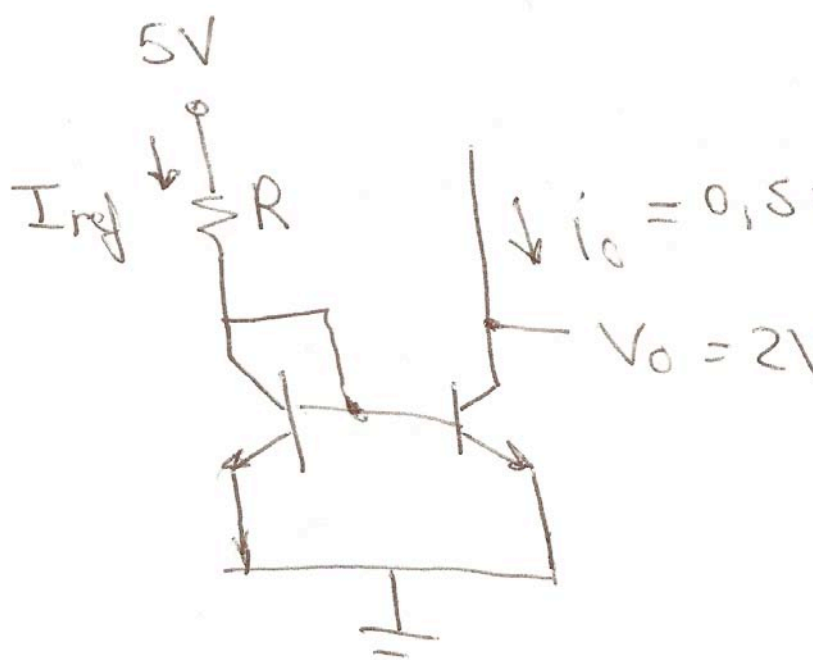
$$5V = I_{ref} R + V_{BE} \qquad I_{ref} = i_o$$

$$V_{CEQ} = 5V - R I_{ref}$$

$$V_{CEQ} = V_{BE}$$

$$I_{ref} = \frac{5V - 0{,}7V}{R} = 0{,}5mA$$

$$R = \frac{5 - 0{,}7}{0{,}5} = 8{,}6\,k\Omega$$



PROBLEMA 6: AMPLIFICADOR COMBINADO CON MOSFET Y BJT

En el siguiente circuito determinar el punto de operación de ambos transistores

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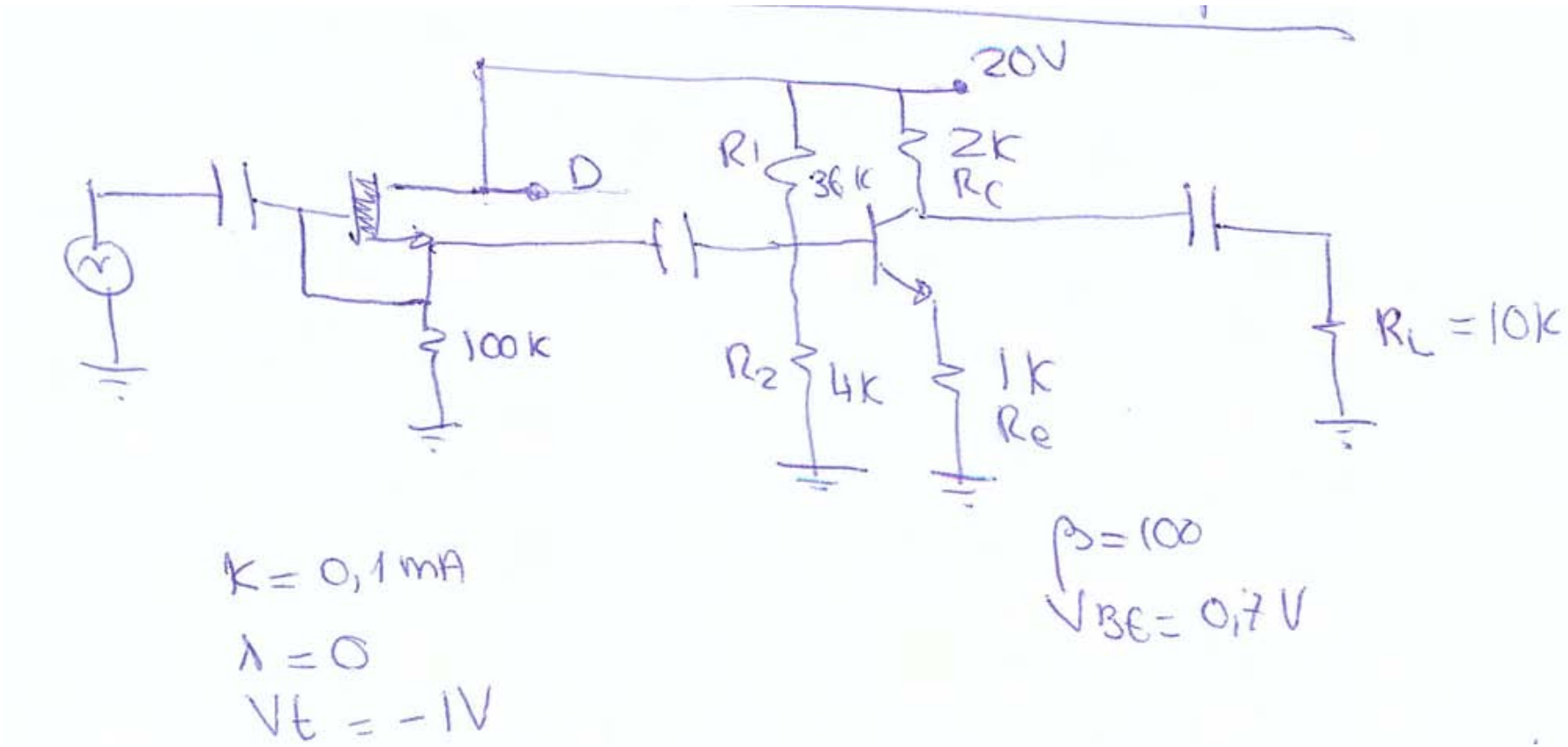

Punto de operación del MOSFET de vaciamiento

$V_{GS} = 0$

$i_d = k(v_{gs} - V_t)^2$

$I_d = 0{,}1(0-(-1))^2 = 0{,}1\,mA$

$V_{DS} = 20V - 100\,i_d = 20 - 100 \times 0{,}1 = 20 - 10 = 10V$

$V_{GS} = 0$

$I_D = 0{,}1\,mA$

$V_{DS} = 10V$

Punto de operación del BJT

Bipolar

$$R_B = 4k \parallel 36k = 3{,}6k$$

$$V_{BB} = \frac{4}{40} \times 20 = 2V$$

$$i_B = \frac{V_{BB} - V_{BE}}{R_B + R_e(\beta+1)} = \frac{2 - 0{,}7}{3{,}6 + 101} = 0{,}01243\,mA$$

$$i_C = \beta i_B = 1{,}24\,mA$$

$$i_E = (\beta+1)\, i_B = 1{,}25\,mA.$$

$$V_{CE} = 20 - 2i_C - 1\,i_E = 20 - 2{,}48 - 1{,}25 = 16{,}26V$$

$$i_B = 0{,}01243\,mA$$

$$i_C = 1{,}24\,mA$$

$$i_E = 1{,}25\,mA$$

$$V_{CE} = 16{,}26V$$