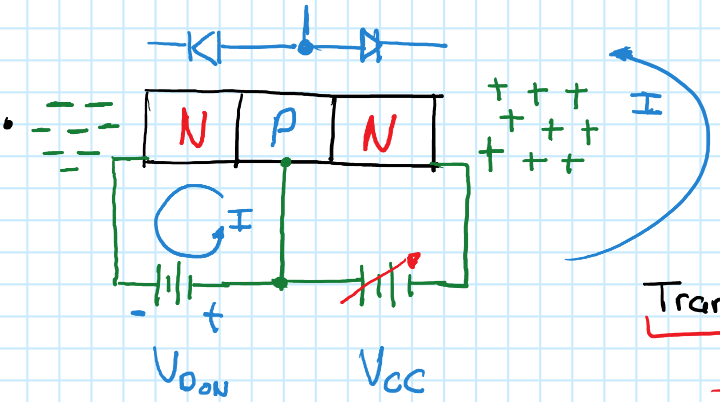
TBJ

Friday, September 13, 2019 7:26 AM

- Transistor Bipolar de Juntura (Unión) | Definición
- Bipolar Junction Transistor (BJT)

- Se inventó en 1947 → NOBEL 1956
  - John Bardeen - Walter H. Brattain
  - William Schockley

  } Bell Telephone Company ↳ AT & T

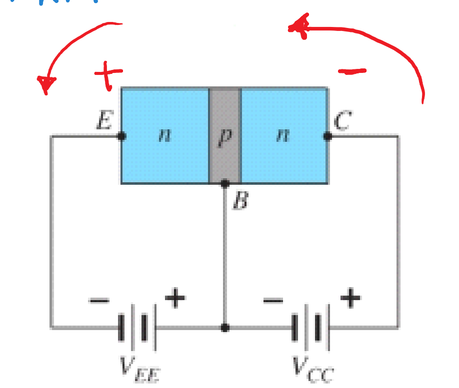
- 

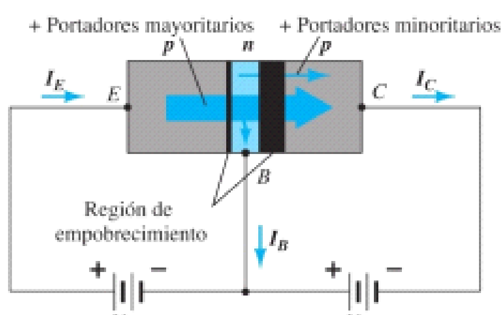
$\underbrace{\text{Transfer}}\ \underbrace{\text{Resistor}}$ → Transistor

Bipolar

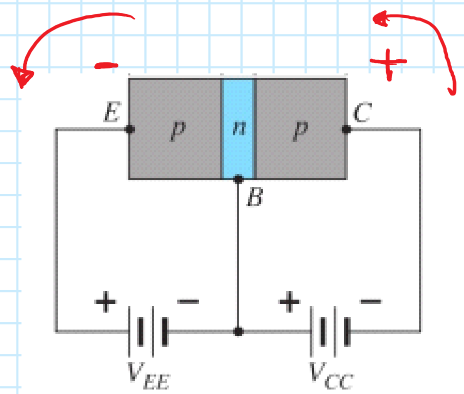
▸ Transistor Bipolar

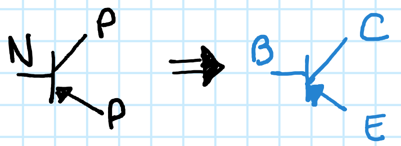
▸ NPN





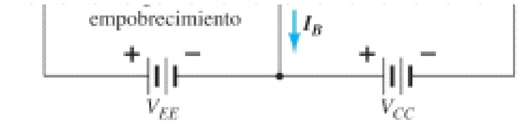
▸ PNP

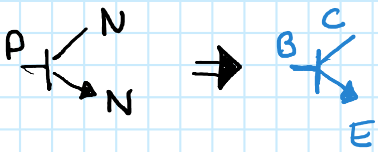




B ≙ Base C ≙ Colector

E ≙ Emisor



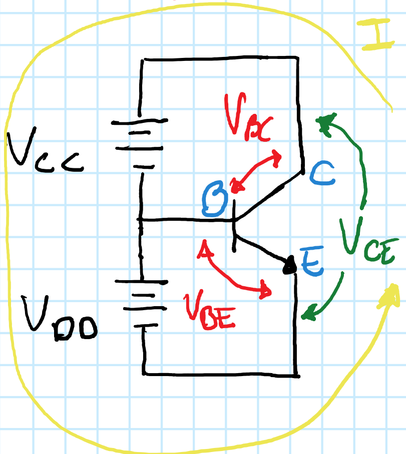


$B \triangleq$ Base $C \triangleq$ Colector

$E \triangleq$ Emisor

$E \triangleq$ Emisor

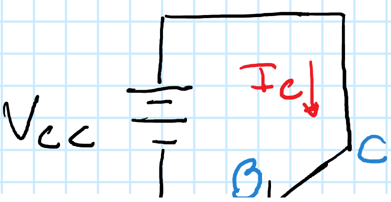
▸ Configuración NPN



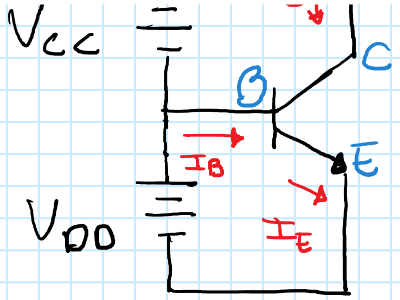
- Voltaje Base - Emisor (V_{BE})
  ↳ Voltaje de encendido Diodo
  Si es de silicio
  $\therefore V_{BE} = .7$ [V]
- Voltaje Base - Colector
  ↳ Es inverso de otro diodo
  $\therefore$ Se comporta como Zener
- Voltaje Base - Emisor
  ↳ Resultado de los voltajes anteriores

- If there's current in the BJT
  $\therefore V_{CE} \to 0$ & $I_{CE} \to \infty$
- But if there is n't current in the BJT $\therefore V_{CE} \to \infty$ & $I_{CE} \to 0$

▸ Corrientes (i)



- Normalmente I_B es pequeña
- $I_C \approx I_E$; $I_C = \alpha I_E$



- $I_C \approx I_E$; $I_C = \alpha I_E$

// $0 < \alpha < 1^*$ $\rightarrow .999$

$\therefore I_E = I_C + I_B$

$$\frac{I_C}{\alpha} = I_C + I_B ;$$

// Despejando

✓ Válido

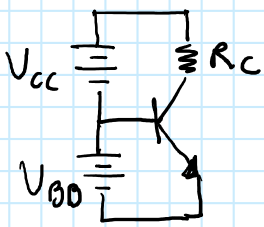
$$I_B = \frac{I_C}{\alpha} - I_C = \frac{1-\alpha}{\alpha} I_C$$

$\therefore I_C = \frac{\alpha}{1-\alpha} I_B$; $I_C = \beta I_B$; $\beta = \frac{I_C}{I_B}$

$$\beta = \frac{\alpha}{1-\alpha}$$

Factor de ganancia del TBJ

▶ BJT as Switch

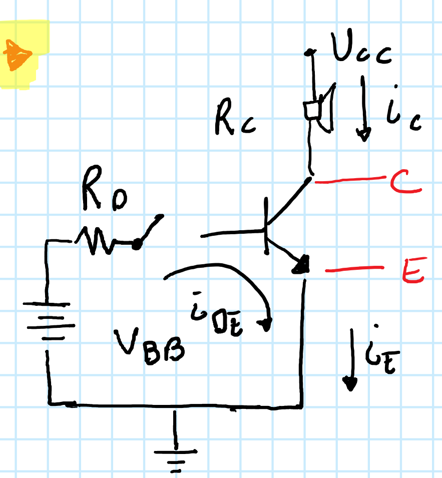


$I_{Cmax} = \frac{V_{CC}}{R_C}$; $I_B = \frac{I_{Cmax}}{\beta}$

- Determinar que valor de R_B es necesario para mantener máxima corriente.

TBJ as switch

Wednesday, September 25, 2019 7:30 AM



if $R_C = 850 [\Omega]$

Data sheet: $\beta = 100$

$V_{BE} = .7 [V]$

→ ¿Qué valor toma R_B para mantener I_{Cmax}?

- $I_C \approx I_E$

$$V_{CC} = I_C R_C + \cancel{V_{CE}}^{0} \quad ; \quad I_{Cmax} = \frac{V_{CC}}{R_C}$$

- if $V_{CC} = 15 [V]$

$$\rightarrow I_{Cmax} = \frac{15}{850} = 17 [mA]$$

// Calculando I_B

$$I_C = \beta I_B \quad ; \quad I_B = \frac{I_C}{\beta} = \frac{.017}{\beta} = \frac{.017}{100} = 170 [\mu A]$$

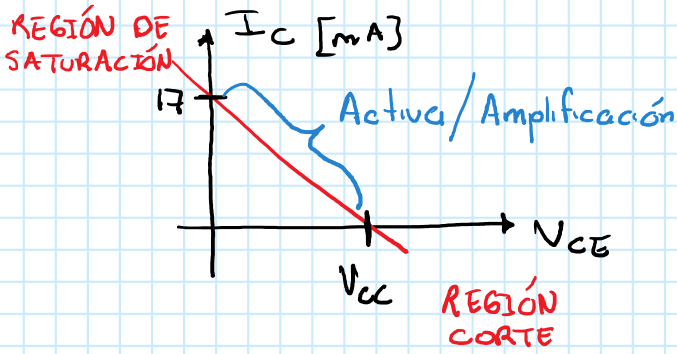
$$V_{BB} = I_B R_B + V_{BE}$$ //El switch está cerrado

$$\therefore R_B = \frac{V_{BB} - V_{BE}}{I_B}$$

- if $V_{BB} = 3 v$

$$R_B = \frac{3 - .7}{170 \times 10^{-6}} = 13529.41 [\Omega]$$

// Modelado Gráfico | V_{CE} vs I_C



$$I_C = -\underbrace{\frac{V_{CE}}{RC}}_{x\,m} + \underbrace{\frac{V_{CE}}{R_C}}_{b}$$

$$\therefore\; m = -\frac{1}{RC}$$

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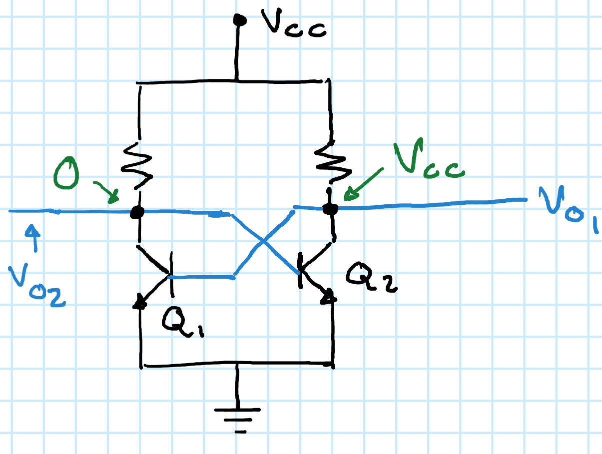
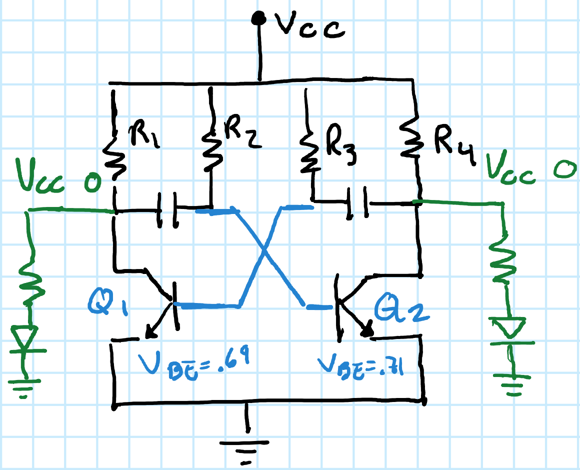
① Ejercicio



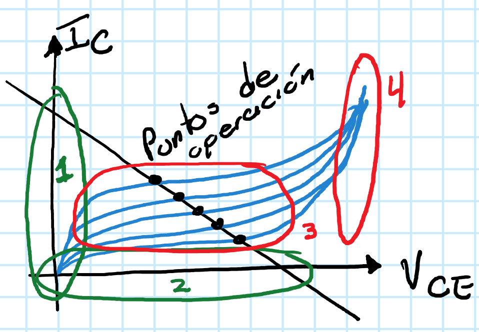
$Q_1 = Q_2$; $V_{BE} = .69$ $V_{BE} = .71$

// Agregan 2 elementos



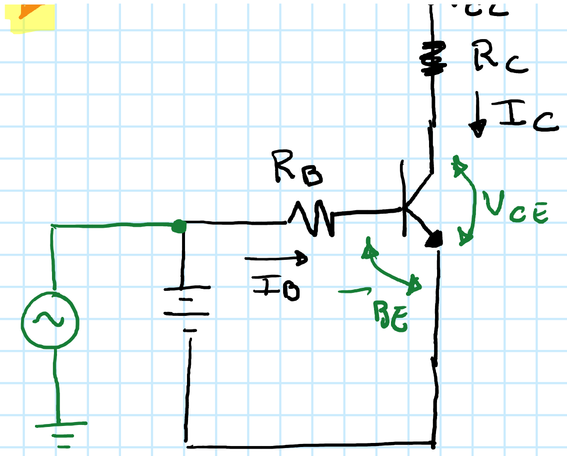
// Circuito de reloj

NOTA



① Región de saturación
② Región de corte (Abierto)
③ Región de amplificación o activa directa
④ Región de ruptura

• $V_{CC} = I_C R_C + V_{CE}$



- $V_{CC} = I_C R_C + V_{CE}$

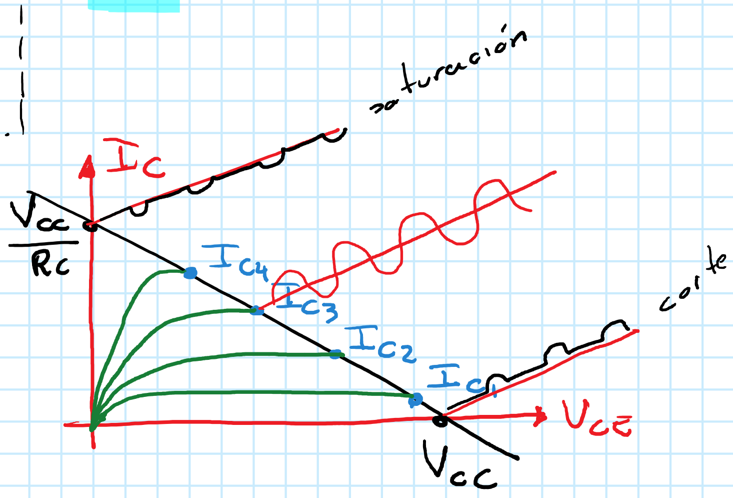
$$I_C = \frac{V_{CC}}{R_C} - \frac{V_{CE}}{R_C}$$

- Recordemos

$$I_C = \beta I_B$$

- $V_{BB} = I_B R_B + V_{BE}$

$$I_B = \frac{V_{BB}}{R_B} - \frac{V_{BE}}{R_B}$$



// Físicamente sólo trabajamos en el rango de la gráfica (función)

→ Valores

- $V_{BB} = 3\,[V]$
- $V_{CC} = 10\,[V]$
- $V_{BE} = 0.7$
- $R_C = 1\,[k\Omega]$
- $\beta = 100$

TABLA

Físicamente (no)

R_B	I_C	V_{CE}
0	∞	∞
5	46 A	-45990
10	23 A	-22990
50	4.6 A	-4590
100	2.3 A	-2290
500	.46 A	-450
1,000	.23 A	-220
5,000	.046 A	-36
10,000	.023 A	-13
50,000	.0046 A	5.4
100,000	.0023 A	7.7

← Obteniendo valor

$$I_{C_{sat}} = \frac{V_{CC}}{R_C} = \frac{10}{1000}$$

$$= 10\,[mA]$$

$$I_B = \frac{I_C}{\beta} = \frac{10\,[mA]}{100} =$$

$$I_B = 100\,[\mu A]$$

- $R_B = 3 - .7$

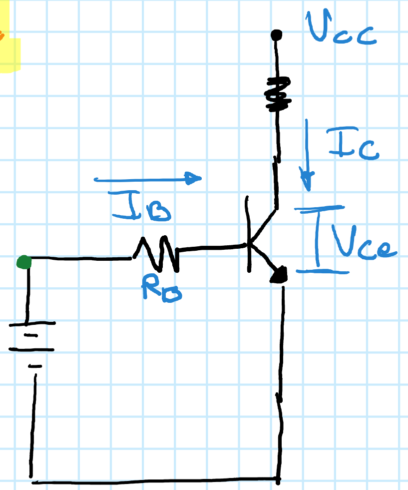
50,000	.0046 A	5.4
100,000	.0023 A	7.7
500,000	.00046 A	9.54
1,000,000	.00023 A	9.77

$$V_{CE} = V_{CC} - I_C R_C$$

$$\therefore R_B = \frac{3 - .7}{100 \times 10^{-6}} = 23 [k\Omega]$$

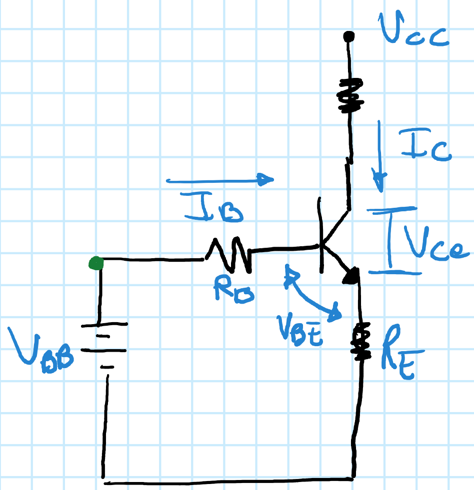
TBJ estable

Monday, September 30, 2019 7:22 AM



// Para mantener la estabilidad en el circuito TBJ

Agregamos R_E



//Ecuaciones

$$V_{BB} = I_B R_B + V_{BE} + I_E R_E$$

// Condiciones propuestas

$$I_E \cong I_C \qquad I_B = \frac{I_C}{\beta}$$

$$\therefore V_{BB} = \frac{I_C}{\beta} + V_{BE} + I_C R_E$$

$$I_C = \frac{\beta (V_{BB} - V_{BE})}{R_B + \beta R_E}$$

Nota

- Se cumple si $R_B < \beta R_E$

$R_B \triangleq$ ¿Cualquier Valor?

if $R_E = 400\,[\Omega]$ $V_{CC} = 10\,[V]$ $R_C = 1\,[k\Omega]$

$V_{BB} = 3\,[V]$ $\beta = 100$ $V_{BE} = .7$

→ Calcular I_C and V_{CE}

R_B	I_C	V_{CE}
[illegible]	[illegible]	[illegible]

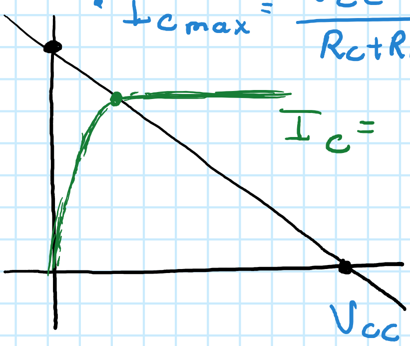
R_B	I_C	V_{CE}
0	.00575	1.95
5	.0057	1.95
10	.0057	1.95
50	.0056	1.95
100	.0056	1.97
500	.0051	2.06
1000	.0046	2.16
5000	.0025	2.86
10 000	.00164	3.56
50 000	.00042	6.43
100 000	.00022	7.7

$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$

$$I_C = \frac{\beta(V_{BB} - V_{BE})}{(R_B + \beta(R_E))}$$

→ Análisis

• $I_{C\,max} = \frac{V_{CC}}{R_C + R_E}$ $\qquad I_{C\,max}$



$I_C = 5.75\ [mA]$

$V_{CC} = 10$

$\beta R_E = 40\ [k\Omega]$

if $R_B < 0.01\ \beta R_E$

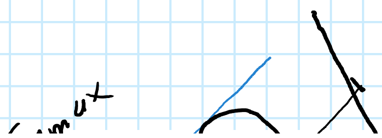
1 %

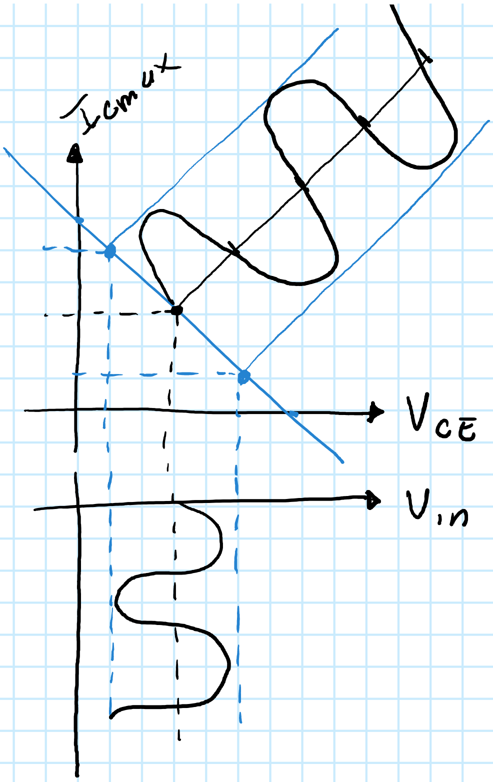
∴ I_C es independiente de la β

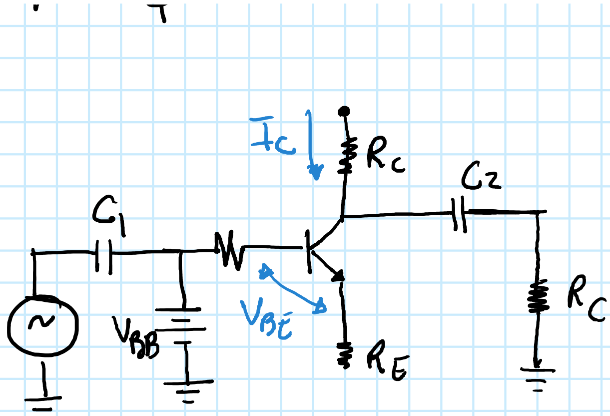
$$I_C = \frac{\beta(V_{BB} - V_{BE})}{\cancel{R_B} + \beta R_E} = \frac{\cancel{\beta}\,(V_{BB} - V_{BE})}{\cancel{\beta}\,(R_E)}$$

$$\therefore \boxed{I_C = \frac{V_{BB} - V_{BE}}{R_E}}$$

• La resistencia en la base debe ser pequeña para que sea estable







- El efecto en la corriente alterna es una modificación a la i_c

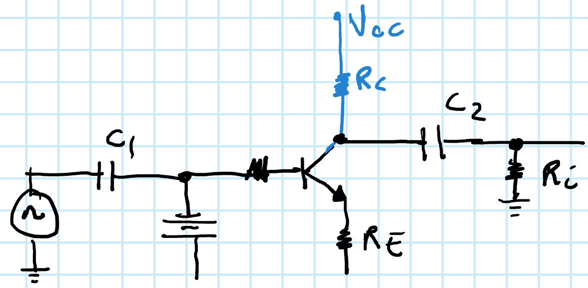
→ Calculamos la i_c a través de la ecuación de un punto al origen

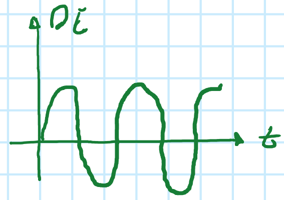
$$(i_c' - I_c) = m(V_{cc}' - V_{CE})$$

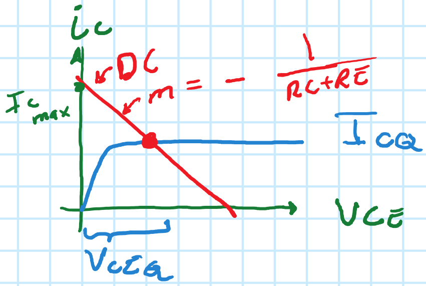
Ejercicio

Friday, October 4, 2019 7:35 AM

▸ TBJ





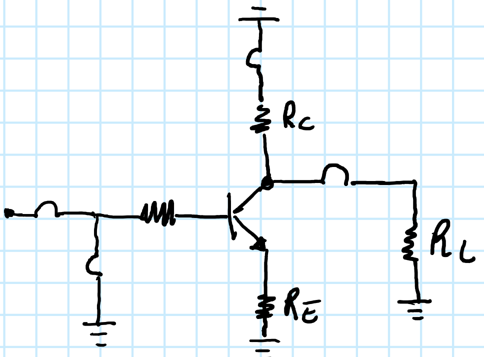


$\rightarrow V_{cc} = I_C R_C + V_{CE} + I_E R_E \qquad I_C \cong I_E$

$\therefore I_C = \dfrac{V_{cc}}{R_C + R_E} - \dfrac{V_{CE}}{R_C + R_E} \qquad m = -\dfrac{1}{R_C + R_E}$

- En un análisis de AC las fuentes de directa se suponen en C.C así como la capacitancia.

// En el diagrama



$R_{AC} = (R_C \| R_L) + R_E$

- Esto da como resultado una nueva recta de carga que calculamos de un punto conocido (V_{CEQ}, I_{CQ}) a los ejes (V_{cc}', i_c')

$\therefore (i_c' - I_{CQ}) = m\,(V_{cc}' - V_{CEQ}) \qquad m = -\dfrac{1}{R_{AC}}$

// Calculando i_{c}' y V_{cc}'

- if $i_c' \neq 0$

$- I_{CQ} = -\dfrac{1}{R_{AC}}(V_{cc}' - V_{CEQ})$

$$-I_{CQ} = -\frac{1}{R_{AC}}\left(V_{CC}' - V_{CEQ}\right)$$

$$R_{AC}\, I_{CQ} = \left(V_{CC}' - V_{CEQ}\right)$$

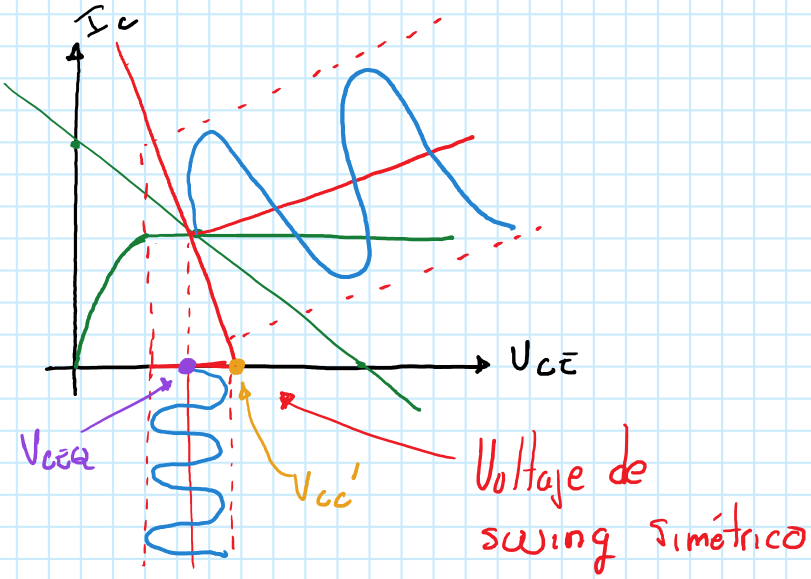
$$V_{CC}' = R_{AC}\, I_{CQ} + V_{CEQ}$$

- if $V_{CC}' = \emptyset$

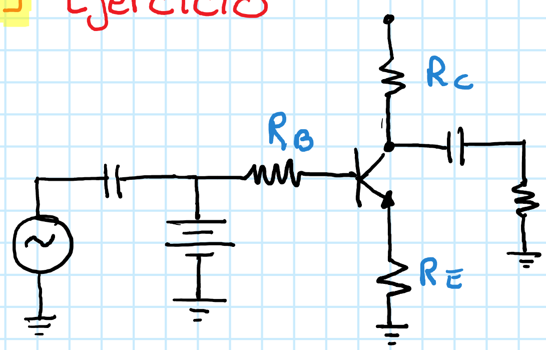
$$i_c' - I_{CQ} = (0 - V_{CEQ}) - \frac{1}{R_{AC}} \;;$$

$$i_c' = \frac{V_{CEQ}}{R_{AC}} + I_{CQ}$$

// Apartado gráfico



1] Ejercicio



DATOS

$V_{CC} = 25$ [V]
$R_C = 950$ [Ω]
$R_E = 200$ [Ω]
$R_B = 2$ [kΩ]
$V_{BB} = 3$ [V]

$\beta = 100$
$V_{BE} = .7$
$R_L = 300$ [Ω]

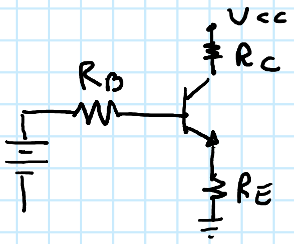
// Preguntas

a) Calcular V_{CEQ}, I_{CQ}

b) Rectas de Carga | b.1) DC | b.2) AC

c) V_{SS}

a) En DC



• $I_{CQ} = \dfrac{\beta(V_{BB} - V_{BE})}{R_B + \beta R_E}$

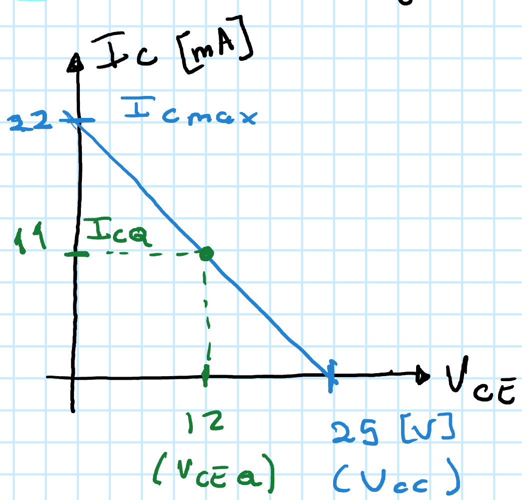
$= \dfrac{(100)(3 - .7)}{2\,000 + (100)(200)} = 11\ [mA]$

• $V_{CEQ} = V_{CC} - I_{CQ}(R_C + R_E)$

$= 25 - (11 \times 10^{-3})(1150)$

$= 11.91\ [V]$

b) Rectas de carga



$I_C = -\dfrac{V_{CE}}{R_C + R_E} + \dfrac{V_{CC}}{R_C + R_E}$

$I_{Cmax} = -\cancel{\dfrac{V_{CE}}{R_C + R_E}} + \dfrac{V_{CC}}{R_C + R_E}$ 0

$\therefore I_{C\,max} = \dfrac{V_{CC}}{R_C + R_E}$

$= \dfrac{25}{1150} = 22\ [mA]$

c) Obtener V_{SS}

$R_{AC} = (R_C \parallel R_L) + R_E$

$= \dfrac{(950)(300)}{950 + 300} + 200 = 428\ [\Omega]$

$$V_{cc}' = R_{AC} I_{CQ} + V_{CEQ}$$

* Graficar para AC

$$= (11 \times 10^{-3})(428) + 11.91 = \underline{16.78\ [V]}$$

$$i_c' = \frac{V_{CEQ}}{R_{AC}} + I_{CQ}$$

$$= \frac{11.9}{428} + (11 \times 10^{-3}) = \underline{39\ [mA]}$$

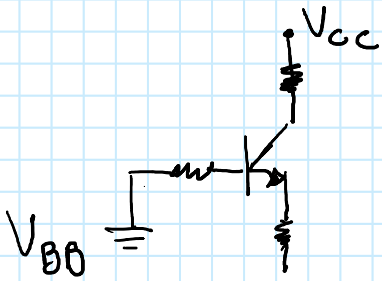
$$V_{SS} = V_{cc}' - V_{CEQ}$$

$$= 16.78 - 11.91 = \underline{4.87}$$

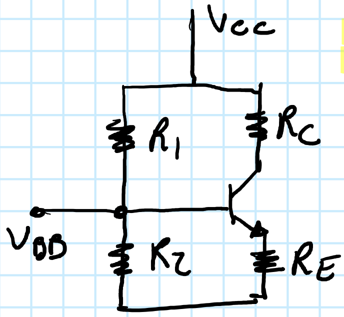
Circuito Autopolarizado

miércoles, 9 de octubre de 2019 07:34 a. m.

// Uso de 2 fuentes para que opere



// Circuito Auto-polarizado



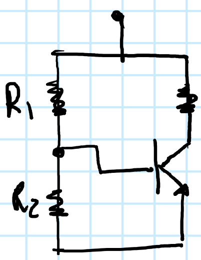
- $V_{BB} = \dfrac{R_2 V_{cc}}{R_B + R_2}$
- $R_B = \dfrac{R_1 R_2}{R_1 + R_2}$

① Ejercicio

Datos

$V_{CC} = 25\ V$ $R_1 = 20\ k\Omega$ $R_2 = 5\ k\Omega$

$R_C = 950\ \Omega$ $R_2 = 300\ \Omega$

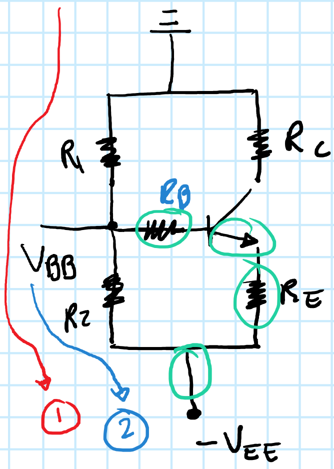


$$R_B = \frac{(20 \times 10^3)(5 \times 10^3)}{(20 \times 10^3) + (5 \times 10^3)} = 4[k\Omega]$$

$$V_{BB} = \frac{(25)(5 \times 10^3)}{25 \times 10^3} = 5\ [V]$$

$$I_{CEQ} = \frac{\beta(5 - .7)}{(4 \times 10^3) + (100)(300)} = 12.6\ [mA]$$

$$V_{CEQ} = 25 - (12.6 \times 10^{-3})(1250 = 9.25[V]$$



① $0 = IR_1 + IR_2 + (-V_{EE})$

② $V_{BB} = IR_2 + (-V_{EE})$

$$I = \frac{V_{EE}}{R_1 + R_2}$$

$$\therefore V_{BB} = \left(\frac{V_{EE}}{R_1 + R_2}\right) R_2 - V_{EE}$$

// Del otro lado

$$V_{BB} = I_B R_B + V_{BE} + I_E R_E + (-V_{EE})$$

* $I_C = \beta I_B$ * $I_E \cong I_C$

$$\therefore V_{BB} = \frac{I_C}{\beta} R_B + V_{BE} + I_C R_E - V_{EE}$$

$$I_{CQ} = \beta \left(\frac{V_{BB} - V_{BE} + V_{EE}}{\beta R_E + R_B} \right)$$

// Respecto a Q

$$V_{CEQ} = V_{EE} - I_{CQ}(R_C + R_E)$$

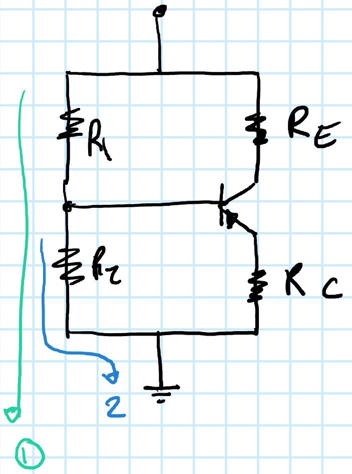
// Valores (Sustitución)

$$V_{BB} = \left(\frac{25}{20000}\right)(5000) - 25 = -20\ [V]$$

$$I_{CQ} = \frac{100(-20 - 250.7^{*} + 25)}{(100(300) + 4000)} = .0126\ [A]$$

$$\therefore V_{CEQ} = 25 - (.0126)(1250) = 9.25\ [V]$$

// Ahora PNP



① $V_{CC} = I_{R_1} + I_{R_2}$; $I = \frac{V_{CC}}{R_1+R_2}$

② $V_{BB} = I R_2$; $I = \frac{V_{BB}}{R_2}$

$$\therefore V_{BB} = \left(\frac{-V_{CC}}{R_1+R_2}\right)(R_2)$$

$$V_{BB} = I_B R_B + (-V_{BE}) + I_I R_E$$

$$I_{CQ} = \frac{\beta(V_{BB} - (-V_{BE}))}{\beta R_E + R_B}$$

$$-V_{CC} = I_C R_C + V_{CE} + I_E R_E$$

$$-V_{CC} = V_{CE} + I_C (R_C + R_E)$$

$$\therefore V_{CE} = -V_{CC} - I_C (R_C + R_E)$$

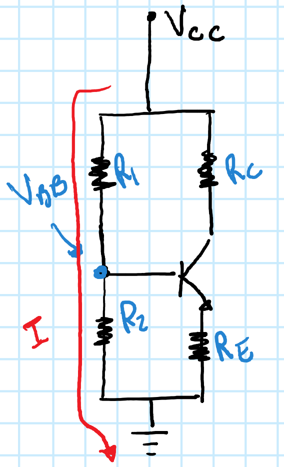
// Sustituyendo valores

$$I_{CQ} = \frac{\beta(-.5 - (-.07))}{(4000) + (100)(500)} = .0126\ [A]$$

$$V_{CEQ} = -25 - (.0126)(1250) = -9.25\ [V]$$

Tipos de Circuitos

miércoles, 9 de octubre de 2019 07:55 a. m.

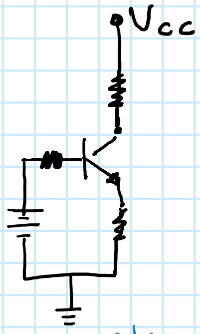


$V_{CC} = IR_1 + IR_2; \; I = \frac{V_{CC}}{R_1+R_2}$

$R_B = \frac{R_1 R_2}{R_1+R_2}$ $\quad R_B = R_1 \,||\, R_2$

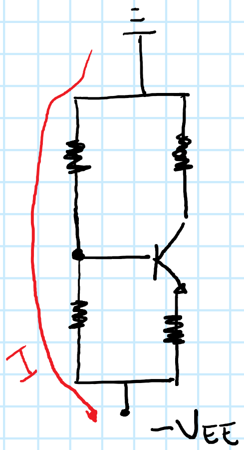
$V_{BB} = \left(\frac{V_{CC}}{R_1+R_2}\right) R_2$

$\Rightarrow$



$I_{CQ} = \beta\left(\frac{V_{BB} - V_{BE}}{R_B + \beta R_E}\right)$

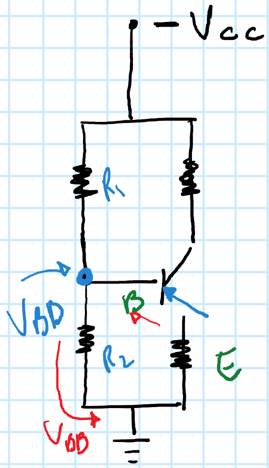
$V_{CE} = V_{CC} - I_C(R_C + R_E)$



- $V_{EE} = IR_2 + IR_1$; $I = -\frac{V_{EE}}{R_1+R_2}$
- $V_{EE} = IR_2 + V_{BB}$

$V_{EE} = \left(-\frac{V_{EE}}{R_1+R_2}\right) R_2 + V_{BB}$;

$V_{BB} = \left(\frac{V_{EE}}{R_1+R_2}\right) R_2 - V_{EE}$



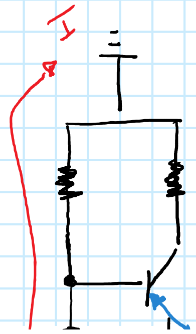
- $-V_{CC} = IR_2 + IR_1$; $I = -\frac{V_{CC}}{R_1+R_2}$

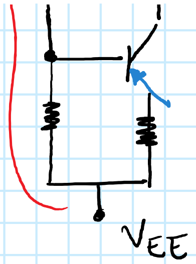
$V_{BB} = IR_2$ $\quad \therefore V_{BB} = \left(-\frac{V_{CC}}{R_1+R_2}\right) R_2$

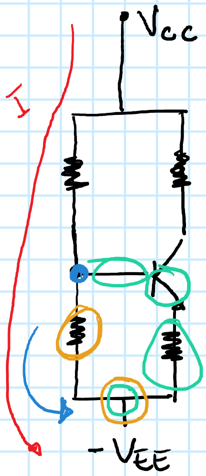
//Calculando I_C

- $V_{BB} = I_B R_B + (-V_{BE}) + I_E R_E$ $\qquad I_C = \beta I_B$

$\therefore V_{BB} = \frac{I_C}{\beta} R_B + (-V_{BE}) + I_C R_E$ //Despeja I_{CQ}



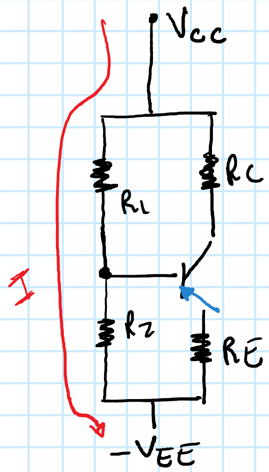




- $V_{cc} = IR_1 + IR_2 + (-V_{EE})$
- $V_{BB} = IR_2 + (-V_{EE})$

$V_{BB} = I_B R_B + V_{BE} + I_E R_E + (-V_{EE})$

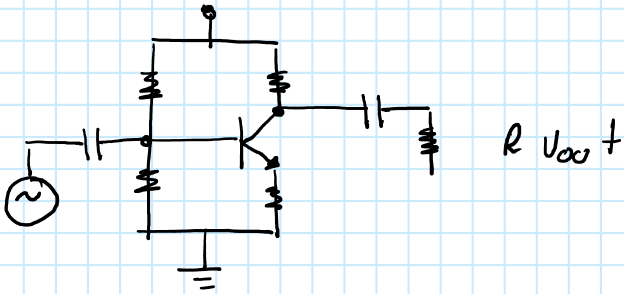
$V_{cc} = IR_c + V_{CE} + I_E R_E + (-V_{EE})$



Análisis AC

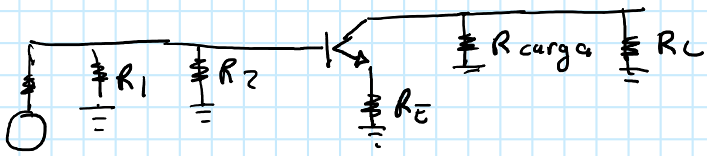
lunes, 14 de octubre de 2019 07:28 a. m.

V_m [mV]



// Ganancia | $\dfrac{V_{in}}{V_{out}} = \dfrac{I_{in}}{I_{out}} = \dfrac{P_{in}}{P_{out}}$

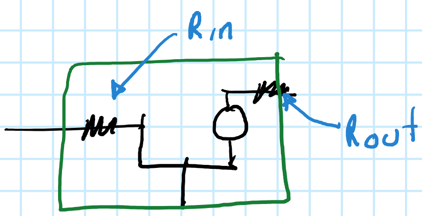
// El análisis en AC, las fuentes, capacitores se manejan como corto circuito

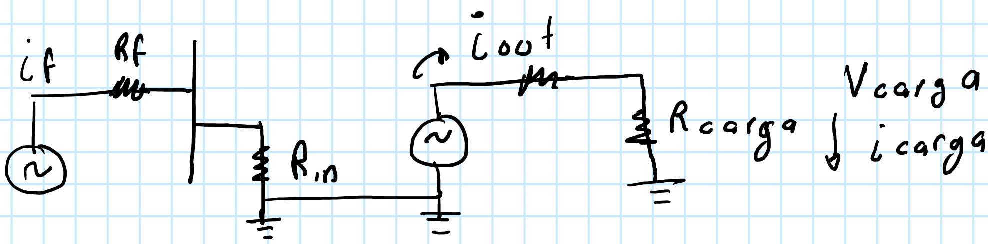


- En un principio todo amplificador se constituye por una resistencia.

$R_{in} \triangleq$ grupo de elementos resistivo

$R_{out} \triangleq$ Elementos resistivos que se encuentran en serie con el elemento amplificador





- $V_c = i_c R_c \qquad i_c = i_{carga} \quad \therefore \quad i_{carga} = \dfrac{V_{carga}}{i_{carga}}$

- $V_c = i_c R_c \qquad i_c = i_{carga} \quad \therefore \quad i_{carga} = \dfrac{V_{carga}}{i_{carga}}$

$$V_{out} = i_{carga} R_{out} + i_{carga} R_{carga}$$

$$i_{carga} = \frac{V_{out}}{R_{out} + R_{carga}}$$

$$\therefore V_{carga} = \left(\frac{V_{out}}{R_{out} + R_{carga}}\right) R_{carga}$$

- $V_{in} = i_f R_{in}$; $V_f = i_f R_f + i_f R_{in}$

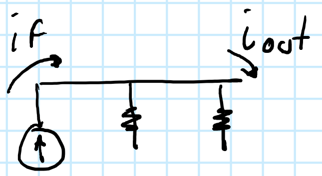
$$i_f = \left(\frac{V_f}{R_f + R_{in}}\right)$$

$$\therefore V_{in} = \left(\frac{V_f}{R_f + R_{in}}\right) R_{in} = V_f \left(\frac{R_{in}}{R_f + R_{in}}\right)$$

$$V_{carga} = \left(\frac{V_f R_{in}}{R_f + R_{in}}\right) A_v \left(\frac{R_{carga}}{R_{out} + R_{carga}}\right)$$

$$\frac{V_{carga}}{V_{fn}} = \left(\frac{R_{in}}{R_f + R_{in}}\right) A_v \left(\frac{R_{carga}}{R_{out} + R_{carga}}\right)$$

Ganancia en voltaje de cualquier amplificador



$$i_{out} = i_{R_c} + i_{carga}$$

$$= \frac{i_{carga} R_{carga}}{R_{out}} + \frac{i_{carga} R_{out}}{R_{out}}$$

$$= \frac{i_{carga}(R_{carga} + R_{out})}{R_{out}}$$

$$i_{carga} = \frac{i_{out} R_{out}}{R_{carga} + R_{out}}$$

$$i = i_{in} R_{in}$$

$$i_{Rf} R_f = i_{in} R_{in}$$

$$i_{Rf} = \frac{i_{in} R_{in}}{R_f}$$

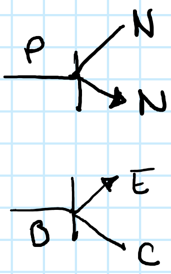
$$i_f = i_{Rf} + i_{in} = \frac{i_{in} R_{in}}{R_f} + i_{in} = i_{in}\left(\frac{R_{in} + R_f}{R_f}\right)$$

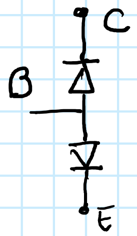
$$\therefore \frac{i_f}{i_{in}} = \left(\frac{R_f}{R_{in} + R_f}\right) A_i \left(\frac{R_{out}}{R_{carga} + R_{out}}\right)$$

Ganancia corriente

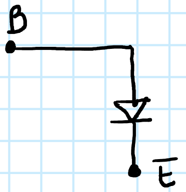
Modelo TB| Señal pequeña

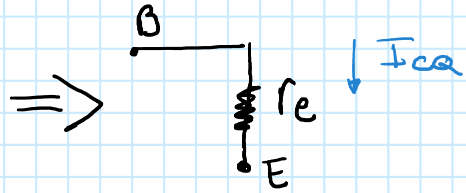
lunes, 14 de octubre de 2019 07:28 a. m.





// La unión BE podemos modelar r_e



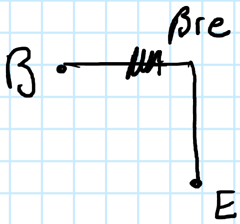


$$\therefore \quad r_e = \frac{V_T}{I_{CQ}}$$

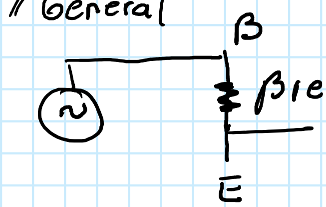
// La r_e se puede trasladar a la base

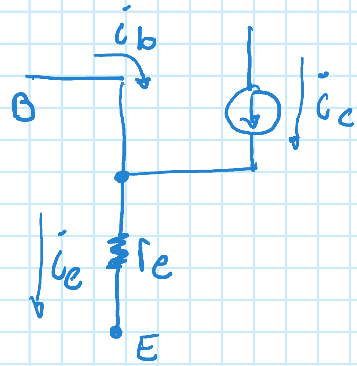
$$V_{be} = I_{CQ} r_e \quad y \quad V_{be} = \beta I_B r_e$$

$$\therefore \quad \frac{V_{be}}{I_B} = \beta r_e \quad ; \quad r_\pi = \beta r_e$$



// General





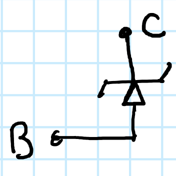
$$i_c = \beta i_b$$

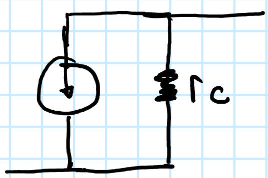
$$\beta = \frac{i_c}{i_b} \quad ; \quad h_{fe} = \frac{i_c}{i_b}$$

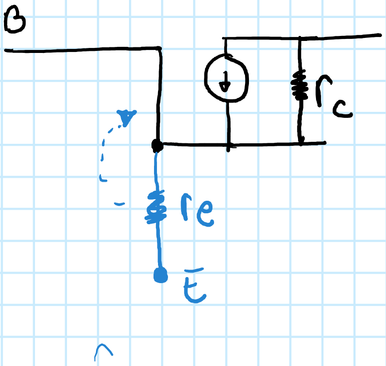
NOTA: $h_{fe} \rightarrow AC$

$\beta \rightarrow DC$

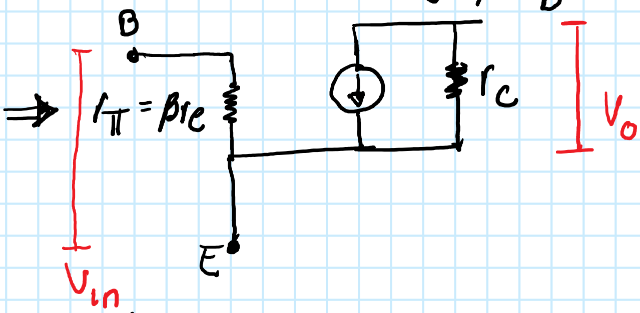
// Finalmente podemos modelarlo as



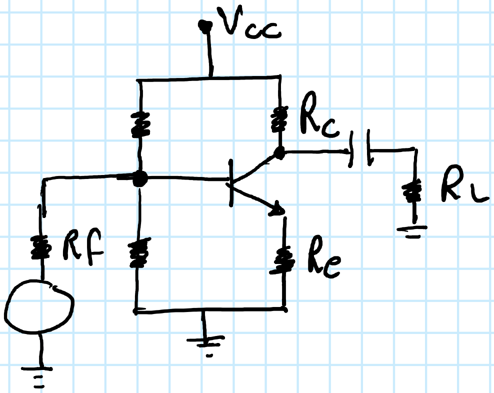


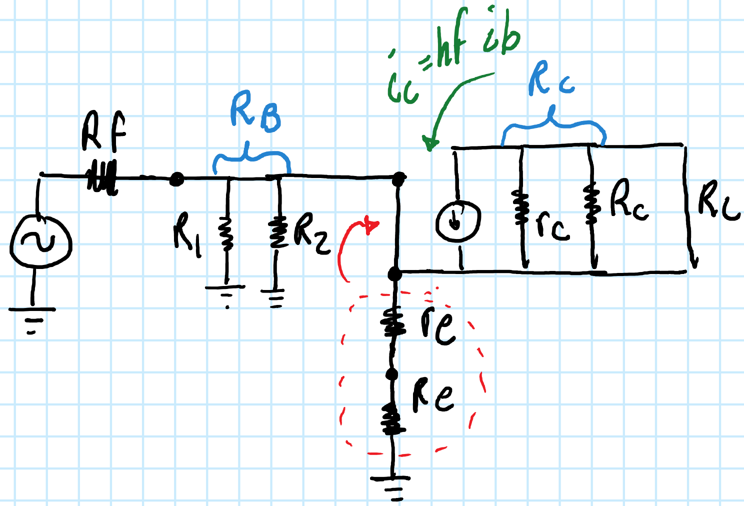


$$i_c = \beta i_b$$

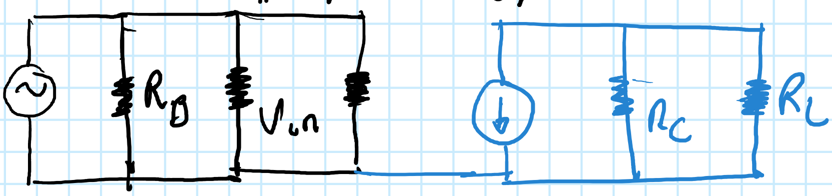


// Pasando a AC





$$R_\pi = \beta(r_e + R_E)$$



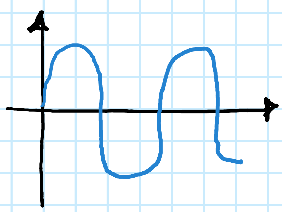
- $V_{in} = i_b r_\pi$
- $V_o = i_c R_c$

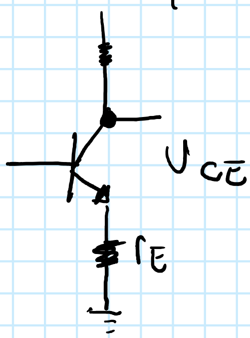
$$\frac{V_o}{V_{in}} = \frac{i_c R_c}{i_b \beta(r_e + R_E)} = \frac{\cancel{\beta i_b}(R_c)}{\cancel{\beta i_b}(r_e + \cancel{R_E})}$$

$$\frac{V_o}{V_{in}} = \frac{R_c}{r_e + R_E}$$

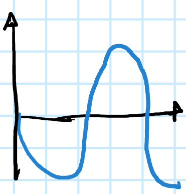
$$A_v = -\frac{R_c}{r_e}$$

// Implica señal invertida





$\Rightarrow \cancel{V_{CE}} = V_{CC} - I_C(R_C +$



$$\frac{V_L}{V_f} = -\frac{R_i}{R_f + R_L} \cdot (A_v)\left(\frac{R_L}{R_c + R_L}\right)$$

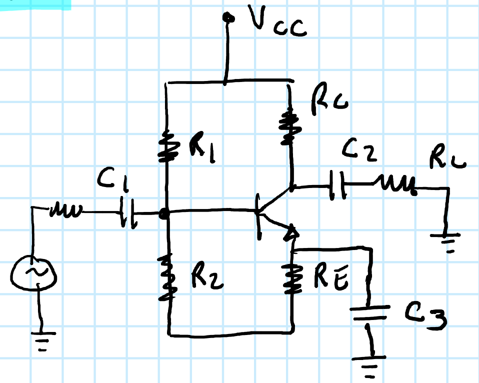
$$= -\frac{(R_B \parallel r_\pi)}{R_f + (R_B \parallel r_\pi)} \cdot \frac{R_C}{R_e} \cdot \frac{R_L}{R_C + R_L} \triangleq R_L$$

// $r_\pi = \beta(r_e + R_E)$

Ejercicio

Wednesday, October 16, 2019 7:37 AM

Ejercicio



$V_{CEQ} \to 0 \triangleq$ Corte

$C_{CEQ} \to V_{cc} \triangleq$

Valor intermedio

↳ Estado activo

- $V_{cc} = 25\ V$
- $R_1 = 20\ K$
- $R_2 = 5\ K$
- $R_E = 300\ \Omega$
- $R_C = 1\ K$
- $V_{BE} = .7$
- $\beta = 100$
- $R_L = 1\ K$
- $R_f = 150\ \Omega$

// Calcular ganancia con R_E y sin R_E

a) $$I_{CQ} = \beta \left(\frac{V_{BB} - V_{BE}}{R_B + \beta R_E} \right) = (100)\left(\frac{5 - .7}{4000 + (100)(300)} \right) = $$

$$= 12.64\ [mA]$$

$$V_{CEQ} = 25 - (12.64 \times 10^{-3})(1300) = 8.57$$

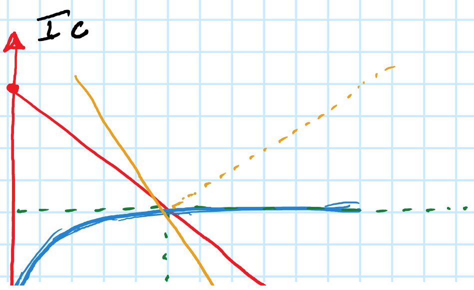
Da el estado del transistor

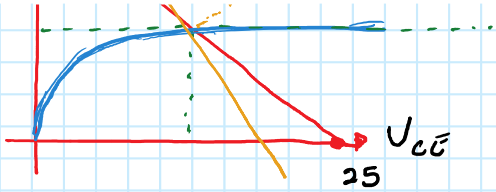
b) $$r_e = \frac{.026}{I_{CQ}} = \frac{.026}{(12.64) \times 10^{-3}} = 2.056\ [\Omega]$$ ← Voltaje térmico

b.1) $$A_v = -\frac{R_C}{r_e + R_E} \triangleq \text{Sin capacitor} = -\frac{1000}{2.056 + 1000} = -3.31$$

b.2) $$A_v = -\frac{R_C}{r_e} \triangleq \text{Con capacitor} = -\frac{1000}{2.056} = -486.36$$

$$\frac{V_{cc}}{R_C + R_E} = 19.03$$





// Calculo de swing

$$m = -\frac{1}{R_{ac}}$$

// Con capacitor

$$R_{ac} = (R_C \parallel R_L) + R_E = \left(\frac{(1000)(1000)}{2000}\right) + 300 =$$

// Sin capacitor

$$R_{ac} = (R_C \parallel R_L) = \left(\frac{(1000)(1000)}{2000}\right) =$$

$$V_{CC}'\Big|_{\text{sin cap}} = (800)(12.64 \times 10^{-3}) + 8.57 = 18.68$$

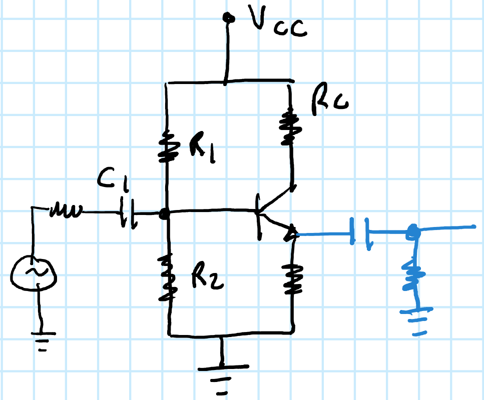
$$\therefore V_{SS} = 18.68 \underbrace{-8.57}_{\text{swing simétrico}} = 10.11 < V_{CEQ}$$

$$V_{CC}'\Big|_{\text{Con cap}} = (500)(12.64 \times 10^{-3}) + 8.57 = 14.89$$

$$\therefore V_{SS} = 14.89 - 8.57$$

Colector común

Wednesday, October 16, 2019 8:12 AM

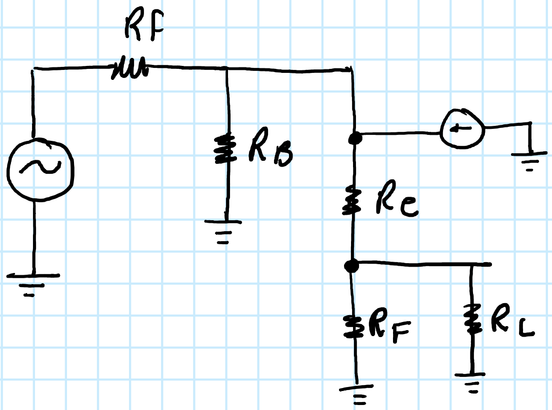


- $I_{CQ} = \beta\left(\dfrac{V_{BB} - V_{BE}}{R_B + \beta R_E}\right)$

- $V_E = I_{CQ} R_E$

// Con una señal pequeña

a) Salida

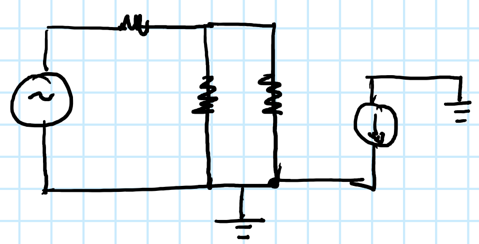


- $R_L = \dfrac{R_E R_L}{R_E + R_L}$
- $V_L = i_L r_L$

Aux $\rightarrow$ $i_L = i_C$

- $\therefore V_L = i_C r_L$

b) Entrada



- $r_\pi = \beta(r_e + r_L)$

$V_{in} = i_b(r_e + r_L)$

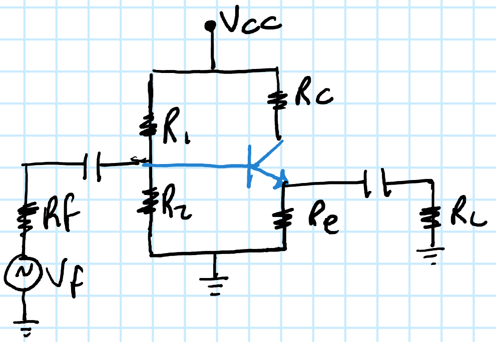
$$\therefore \frac{V_L}{V_{in}} = \frac{\cancel{i_C} r_L}{\cancel{(i_b)(\beta)}(r_e + r_L)} = \frac{r_L}{r_e + r_L} \quad \therefore \frac{V_L}{V_{in}} = 1 \#$$

// No tenemos ganancia en Voltaje sino en Corriente

Colector común

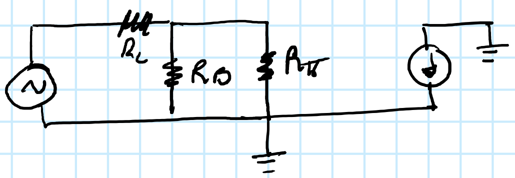
Friday, October 18, 2019 7:25 AM

// Colector Común



$$\frac{V_L}{V_{in}} = \frac{R_L}{R_e + R_L} \simeq 1$$

// Modelo en señal pequeño



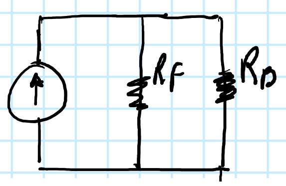
$$R_{in} = R_B \parallel R_\pi$$

$$\therefore \frac{V_L}{V_f} = \left[\frac{\left(\frac{R_B * \beta(R_e + R_E)}{R_B + \beta(R_e + R_E)} \right)}{R_f + \left(\frac{R_B * \beta(R_e + R_E)}{R_B + \beta(R_e + R_E)} \right)} \right] \left(\frac{r_1}{r_e + r_L} \right)$$

$$\frac{V_L}{V_f} = \left(\frac{R_{in}}{R_f + R_{in}} \right) \left(\frac{r_1}{r_e + r_L} \right)$$

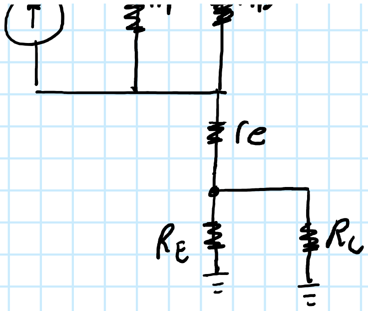
// Ganancia en corriente de un Circuito Colector Común

1) Salida



$$i_c = i_{RE} + i_L$$

$$i_{RE} R_E = i_L R_L \; ; \; i_{RE} = \frac{i_L R_L}{R_E}$$



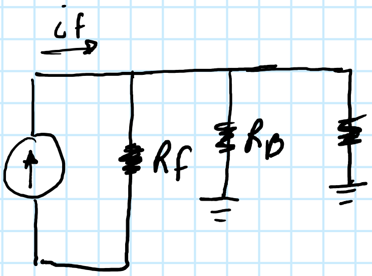
$$i_{R_E} R_E = i_L R_L \; ; \; i_{R_E} = \frac{i_L R_L}{R_E}$$

$$\therefore i_c = \frac{i_L R_L}{R_E} + i_L = \frac{i_L R_L + i_L R_E}{R_E}$$

$$\rightarrow i_L = \frac{i_c R_E}{R_L + R_E} \; ; \; i_L = (i_b \beta)\left(\frac{R_E}{R_L + R_E}\right)$$

$$\boxed{\frac{i_L}{i_f} = \left(\frac{R_B}{R_B + r_\pi}\right)(\beta)\left(\frac{R_E}{R_L + R_E}\right)}$$

2) Entrada



$$r_\pi = \beta(r_e + r_L)$$

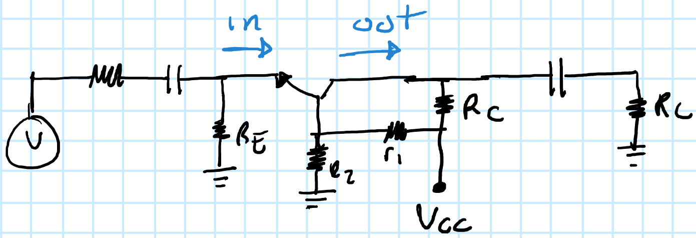
$$r_L = \left(\frac{R_E R_L}{R_C + R_L}\right)$$

- $i_f = i_{R_B} + i_{r_\pi}$
- $i_{R_B} R_B = i_{r_\pi}$ ($i_{r_\pi} \updownarrow i_b$) ; $i_{R_B} R_B = i_b r_\pi$; $i_{R_B} = \dfrac{i_b r_\pi}{R_B}$
- $i_f = \dfrac{i_b r_\pi}{R_B} + i_b = \dfrac{i_b r_\pi + R_B i_b}{R_B}$; $i_b = \dfrac{i_f R_B}{r_\pi + R_B}$

$$\boxed{\frac{i_L}{i_f} = \frac{R_B \, \beta R_E}{[R_B + \beta(r_e + r_L)](R_L + R_E)}}$$

Base común

Friday, October 18, 2019 8:13 AM



- $V_{BB} = \dfrac{R_2 V_{cc}}{R_1 + R_2}$

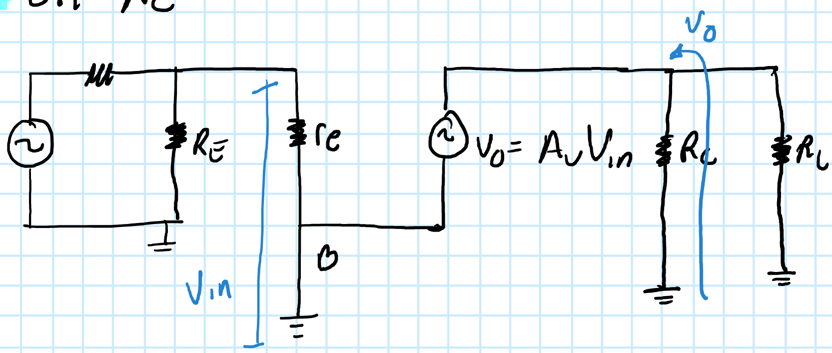
  $V_{BB} = I_B R_B + V_{BE} + I_E R_E$

  $R_B = R_1 // R_2$

  $I_{CQ} = \beta \left(\dfrac{V_{BB} - V_{BE}}{R_B + \beta R_E} \right)$

- $V_{cc} = I_c R_c + V_{CB} + V_{BE} + I_E R_E$

// En AC



$$\left. \begin{array}{l} V_o = i_c R_c \\ V_{in} = i_e R_e \end{array} \right\} \frac{V_o}{V_{in}} = \frac{\cancel{i_c} R_c}{\cancel{i_e} R_e} \longrightarrow A_v = \frac{R_c}{r_e}$$

$A_i = \dfrac{i_c}{i_e} \approx 1$

$A_{in} = i_e$

$i_o = i_c$

// Ganancia en voltaje (Ganancia unitaria en corriente)

- Base → Corriente y Voltaje
- Colector → Corriente
- Emisor → Voltaje

Ganancia

Emisor común

Monday, October 21, 2019 7:27 AM

Diseño de un Circuito Emisor Común

//Aspectos necesarios

- Datos del transistor (β, V_{BE})
- Elegir punto operación
- A_v , A_i (Ganancia)
- R_{carga} o R_L
- V_{cc}
- Tipo de circuito
- Impedancia de salida (Generador) Z_{out}

1) $R_L \longrightarrow R_C = x R_L$

if $R_L = 0$

$R_C = x R_L \mid x > 1$

$R_L \longrightarrow R_L = x R_L$

if $R_L \to \infty$

$R_C = x R_L \mid x < 1$

$\therefore R_C = R_L$

2) $A_v = \dfrac{(R_C \| R_L)}{r_e + R_E}$

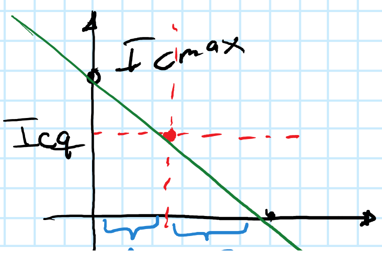
//Despejamos

$r_e + R_E = R_E'$

$R_E' = \dfrac{(R_L \| R_C)}{A_v}$

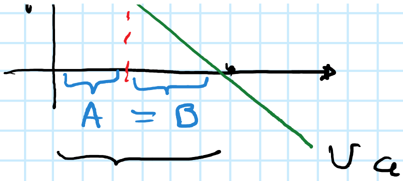
Nota: La ganancia en V no puede ser mayor a 4

3) Buscamos a I_Q y V_{CEQ} para máximo swing simétrico



- $I_{CQ} = \dfrac{V_{cc}}{R_{DC} + R_{AC}}$

- $V_{CEQ} = V_{CC} - I_Q (R_C + R_E')$



$\cdot V_{CEQ} = V_{CC} - I_Q(R_C + R_E')$

$-(R_C + R_E') + (R_C \| R_L) + R_E' =$

4) $r_e = \dfrac{V_T}{I_{CQ}}$; $R_E = R_E' - r_e$

$\therefore V_{CEQ} = V_{CC} - I_{CQ}$

5) // Independencia de β

$R_B = .01\beta R_E \Rightarrow R_B = 1\% \beta$

6) Calculamos V_{BB}

$V_{BB} = .01\beta R_E I_B + V_{BE} + I_{CQ}R_E$

$= .01\cancel{\beta} R_E\left(\dfrac{I_C}{\cancel{\beta}}\right) + V_{BE} + I_{CQ}R_E$

$= 1.01\, R_E I_{CQ} + V_{BE}$

$$V_{BB} = \frac{V_{CC}R_2}{R_1 + R_2}$$

// Multiplicamos $R_1 \Rightarrow R_1 V_{BB} = (V_{CC})\boxed{\dfrac{R_1 R_2}{R_1 + R_2}} \leftarrow R_B$

$V_{BB}\left(\dfrac{V_{CC}R_B}{V_{BB}} + R_2\right) = V_{CC}R_2 \quad V_{CC}R_B \quad R_2(V_{CC} - V_{BB})$

$V_{CC}R_B + V_{BB}R_2 = V_{CC}R_2$; $V_{CC}R_B = V_{CC}R_2 - V_{BB}R_2$

$$\therefore R_2 = \frac{V_{CC} R_B}{V_{CC} - V_{BB}} = \frac{R_B}{1 - \frac{V_{BB}}{V_{CC}}}$$

$$\therefore R_1 = \frac{V_{CC} R_B}{V_{BB}}$$

Ejercicio

Datos

Diseñar circuito emisor común que transmite la señal a una carga de 1 $K\Omega$ si tenemos un TBJ cuyos valores:

$V_{BE} = .7 \quad \beta = 100$

y queremos generar voltaje de 3, utilizando una fuente de 20 V_{DC}.

// Realizando

1) $R_C = R_L \qquad R_C = 1\,[K\Omega]$

2) $R_E' = \frac{(R_C \| R_L)}{A_V} = \frac{500}{3} = 166.66\,[\Omega]$

3) $I_{CQ} = \frac{V_{CC}}{R_{DC} + R_{AC}} = \frac{20}{1166.66 + 666.66} = 10.9\,[mA]$

$R_{DC} = 1000 + 166.66 \qquad R_{AC} = 500 + 166.66$

4) // Calculando r_e

4) // Calculando r_e

$$r_e = \frac{.026}{10.9\ mA} = 2.386\ [\Omega]$$

$$R_E = 166.66 - 2.386 = 164.26\ [\Omega]$$

5) $R_B = (.01)\,\beta\, R_E = 164.26\ [\Omega]$

$$\therefore V_{BB} = (1.01)(164.26)(10.9 \times 10^{-3}) + .7 = 2.508\ [V]$$

// Obteniendo "R_1" y "R_2"

$$R_1 = \frac{(20)(164.26)}{2.508} = 1309.8$$

$$R_2 = \frac{(164.26)}{1 - \frac{2.508}{20}} = 187.81$$

// Verificando valores

- $R_B = \dfrac{(1304.8)(187.8)}{1304.8 + 187.8} = 164.24$

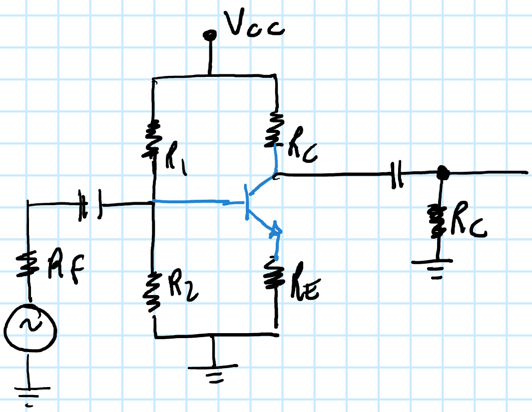
- $V_{BB} = \dfrac{(20)(187.81)}{(1304) + 187.81} = 2.5$

- $I_{CQ} = \left(\dfrac{(2.5 - .7)}{(164.24 + (100)(164.26))}\right)(100) = 10.84\ [mA]$ ✓

Ejercicio

Wednesday, October 23, 2019 7:41 AM

// Ejercicio



// Datos

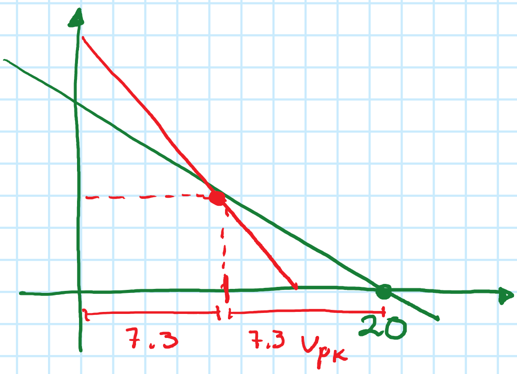
$R_C = 1K \quad R_L = 1K \quad R_E = 164.26\ \Omega$

$R_1 = 1309.8\ \Omega \quad R_2 = 187.81$

$\beta = 100 \quad V_{BE} = .7$

$V_{CC} = 20$

- $R_B = \dfrac{(1309.8)(187.81)}{1309.8 + 187.81} = 164.26$
- $V_{BB} = \dfrac{(20)(187.81)}{1309.8 + 187.81} = 2.5$
- $I_{CQ} = 10.9\,[mA]$
- $V_{CEQ} = 20 - (10.9 \times 10^{-3})(1164.26) = 7.3$
- $R_{AC} = (R_C \parallel R_L) + R_E = 664.26$



$i_c = \beta i_B$

$V'_{cc} = (664.26)(10.9 \times 10^{-3}) + 7.3 = 14.54$

$V_{ss} = 14.54 - 7.3 = 7.24$

$r_e = \dfrac{.026}{10.9 \times 10^{-3}} = 2.38$

$$A_v = -\frac{500}{2.38 + 164.26} = -3$$