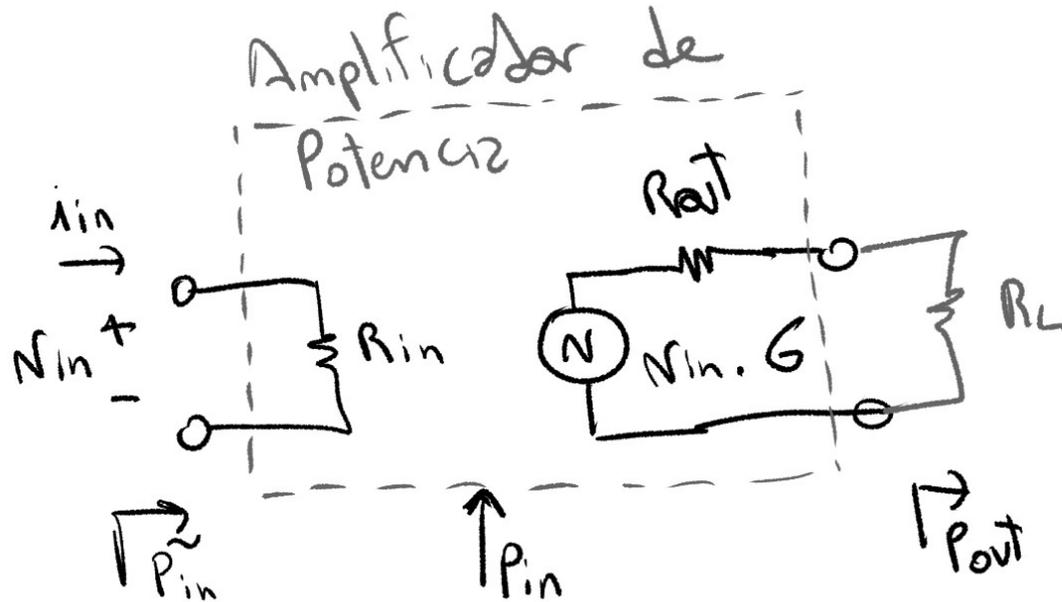


# Amplificadores de potencia

¿Que diferencia tiene una amplificador de potencia con un amplificador de señal?

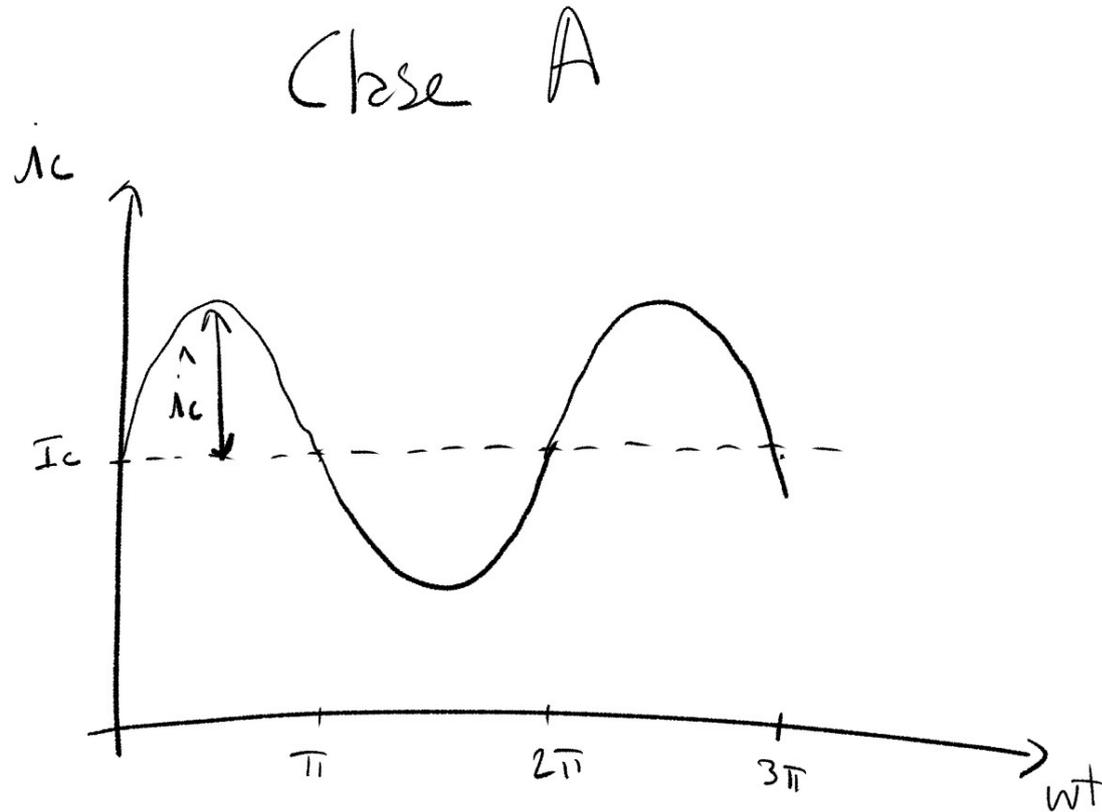
¿que busco en un amplificador de potencia?



- Baja  $R_{out}$
- Eficiencia  $\eta = P_{out}/P_{in}$
- Baja distorsión de armónicos

# Algunos tipos de amplificadores de potencia:

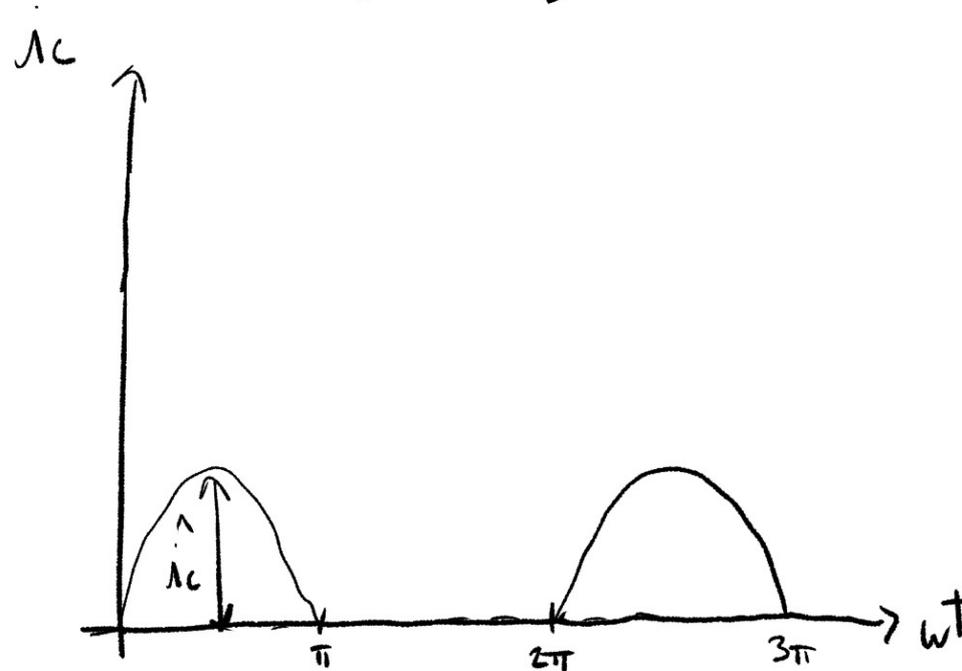
Los clasificamos según  $i_c$  (corriente de colector de transistor/es de salida)



# Algunos tipos de amplificadores de potencia:

Los clasificamos según  $i_c$  (corriente de colector de transistor/es de salida)

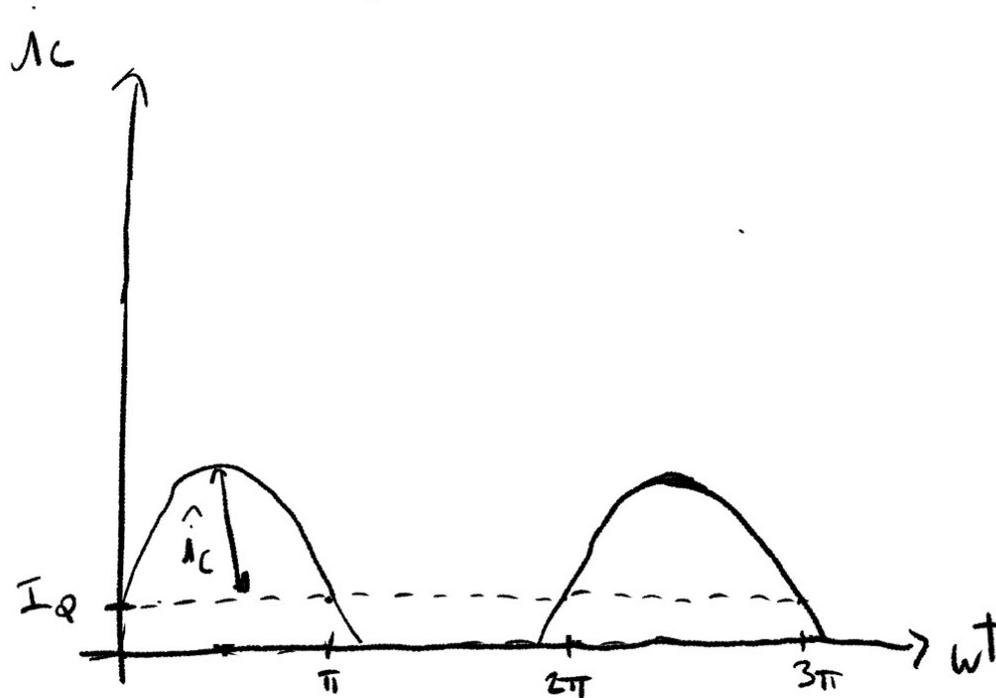
Clase B



# Algunos tipos de amplificadores de potencia:

Los clasificamos según  $i_c$  (corriente de colector de transistor/es de salida)

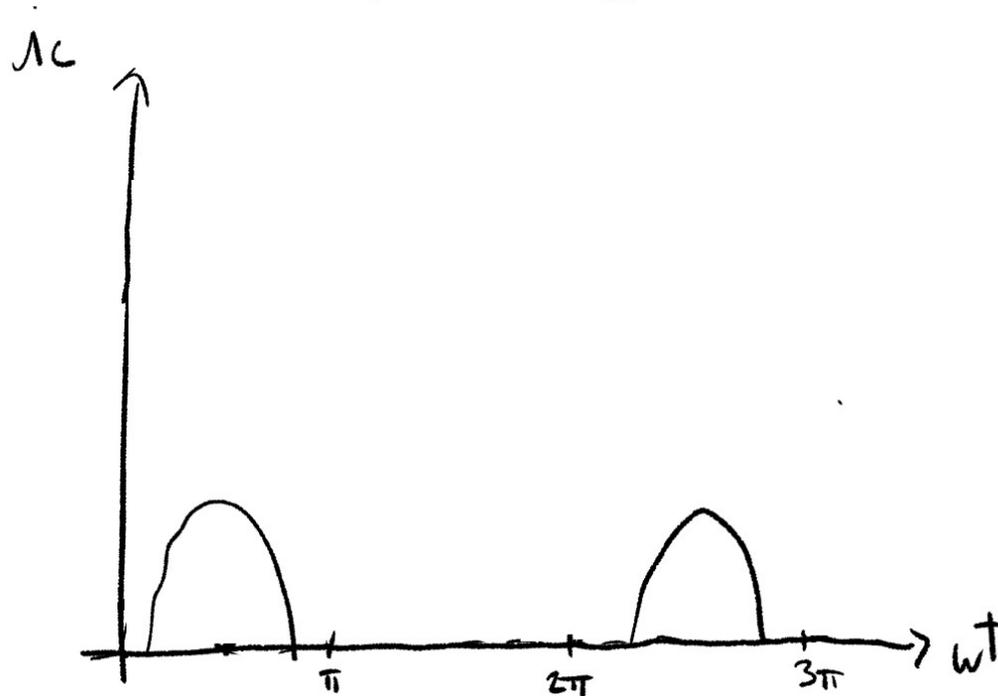
Clase AB



# Algunos tipos de amplificadores de potencia:

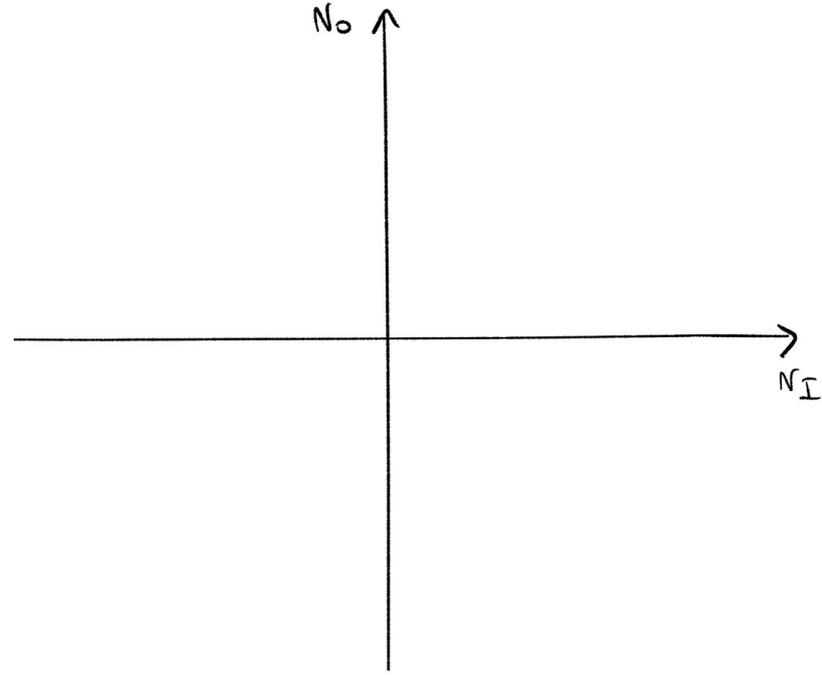
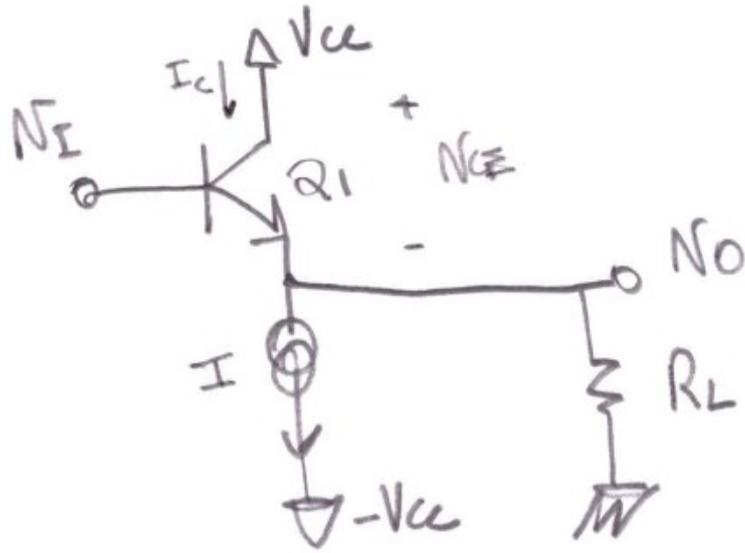
Los clasificamos según  $i_c$  (corriente de colector de transistor/es de salida)

Clase C



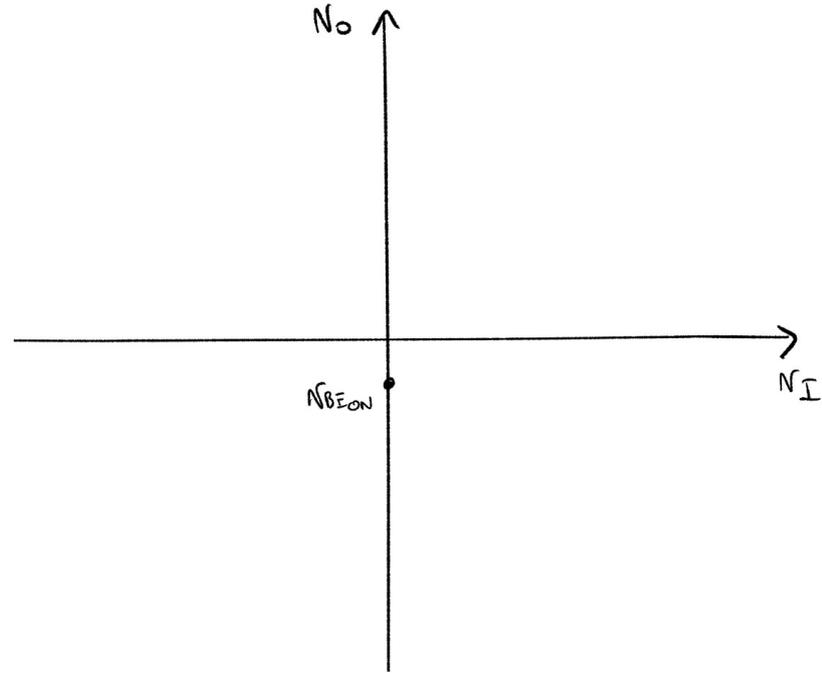
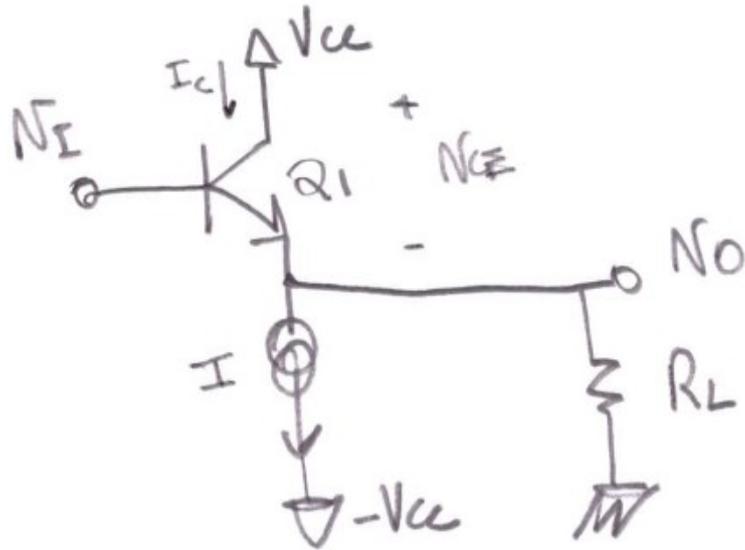
# Clase A

Seguidor de emisor



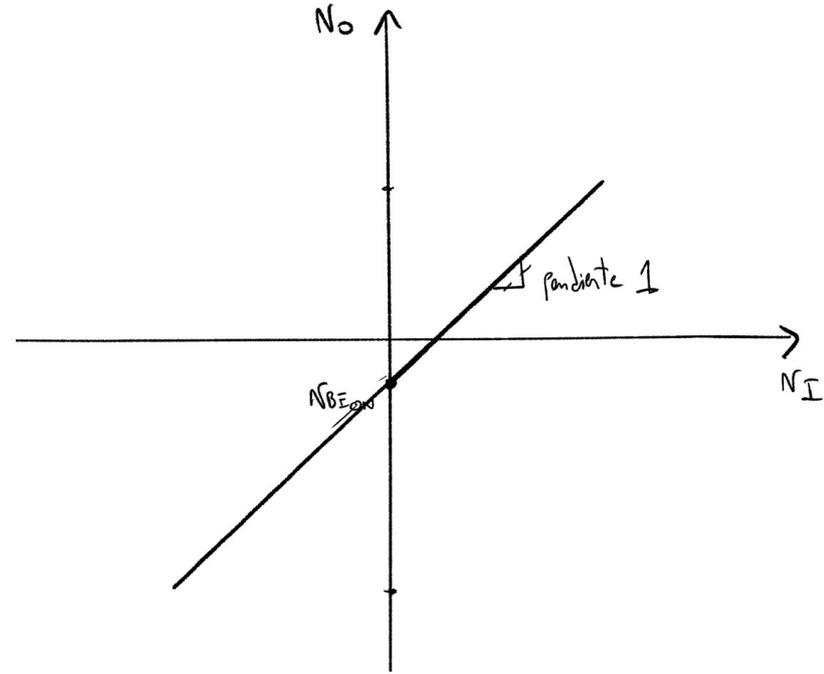
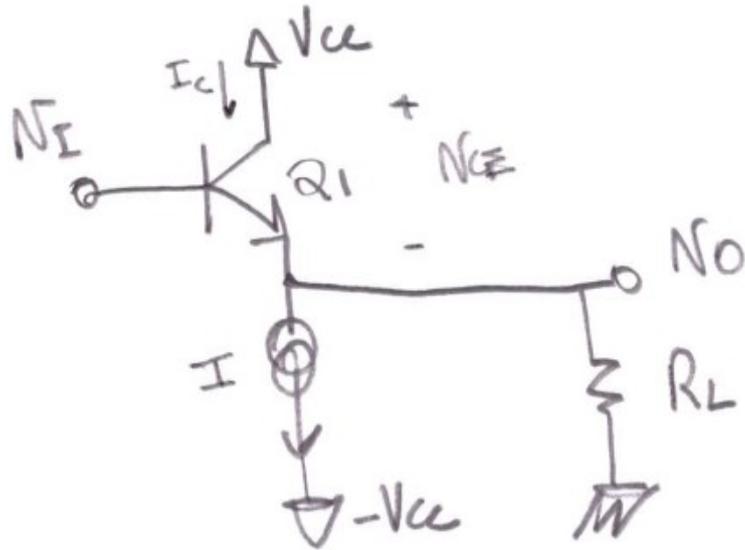
# Clase A

Seguidor de emisor



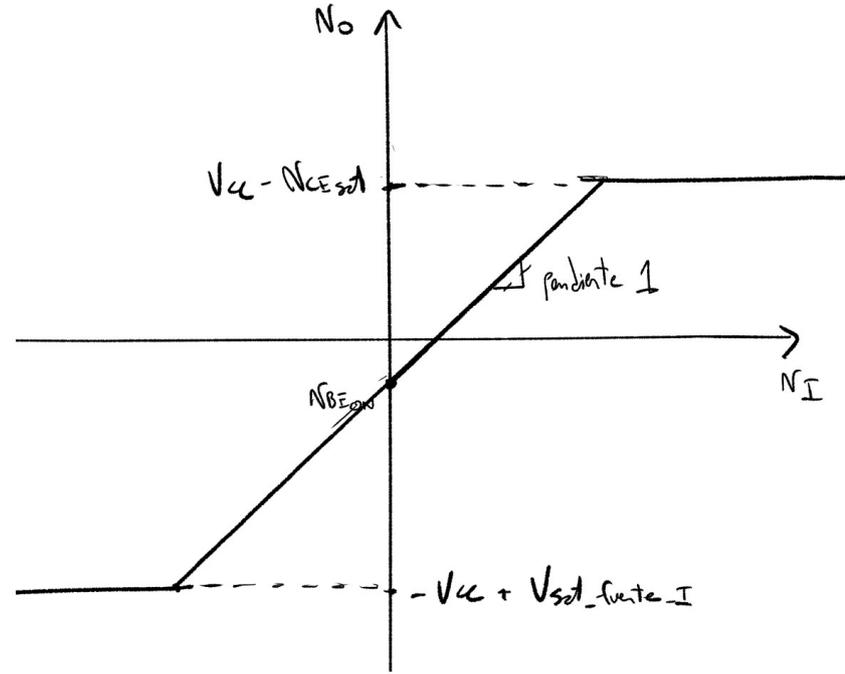
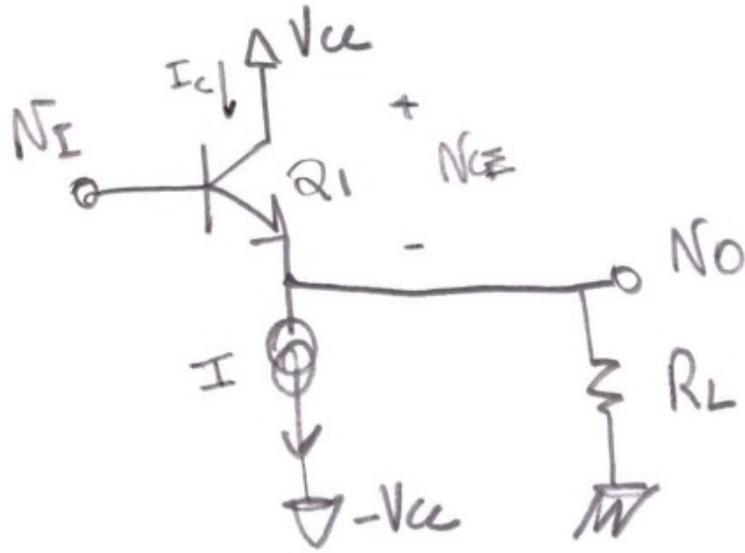
# Clase A

Seguidor de emisor



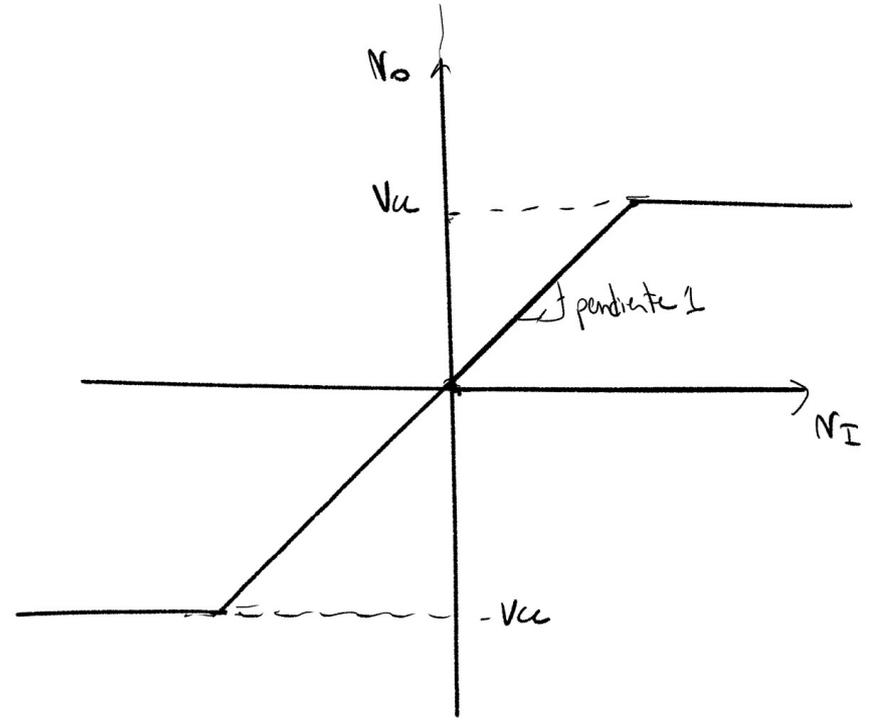
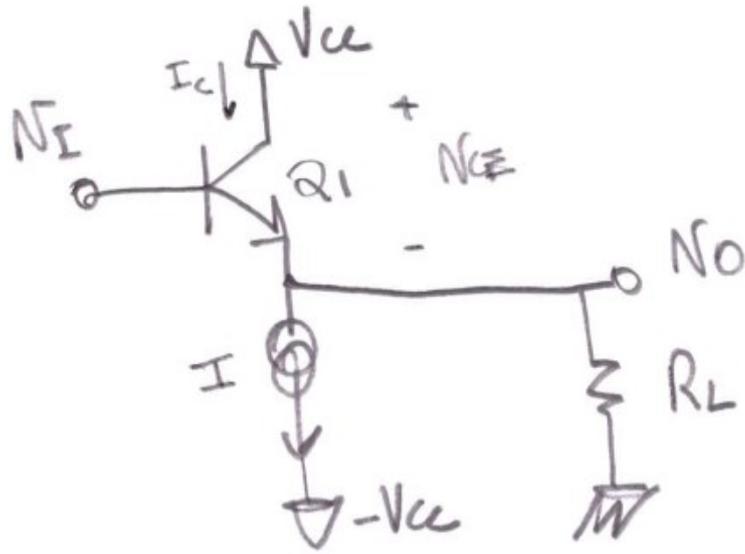
# Clase A

Seguidor de emisor



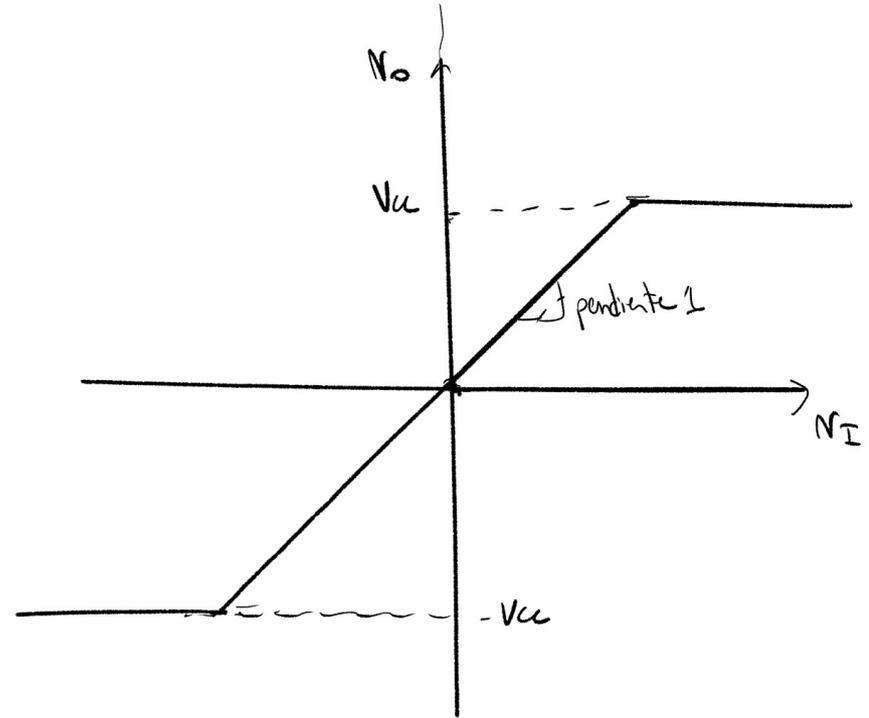
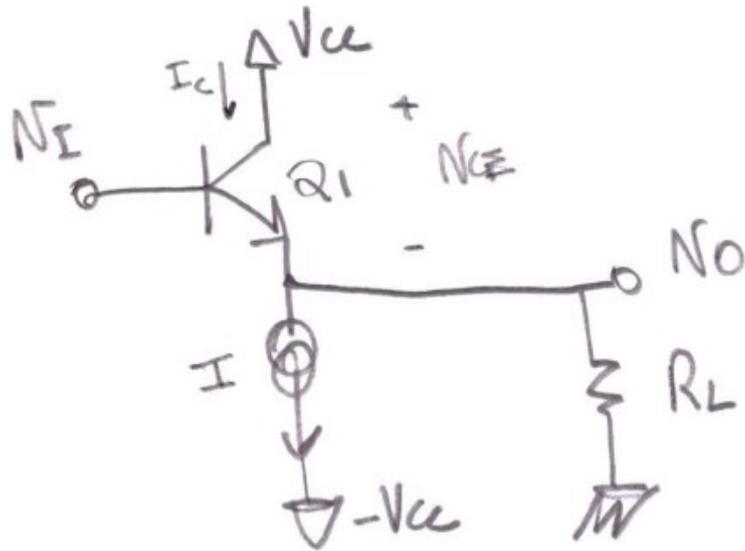
# Clase A

Seguidor de emisor



# Clase A

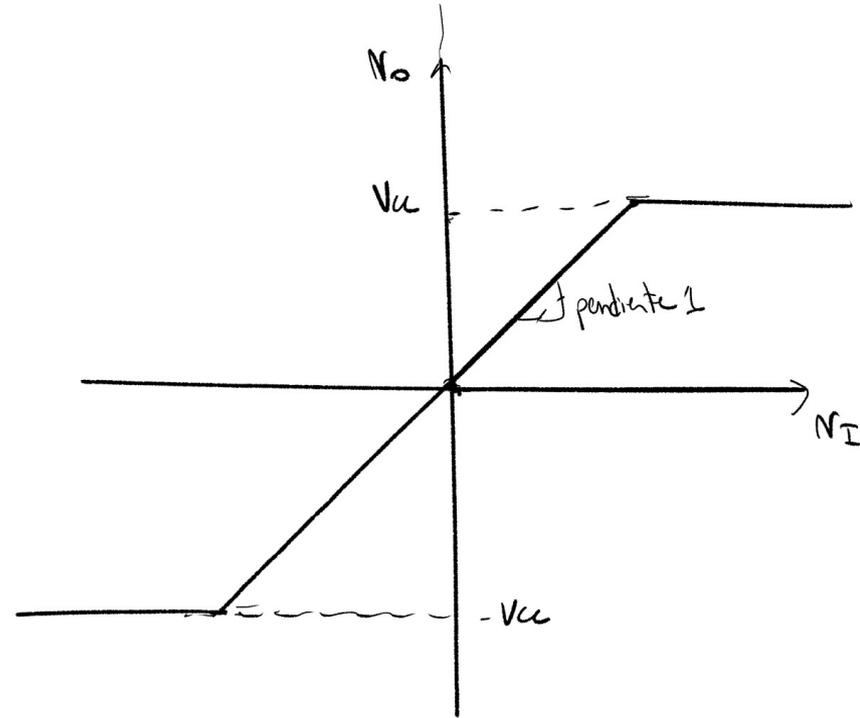
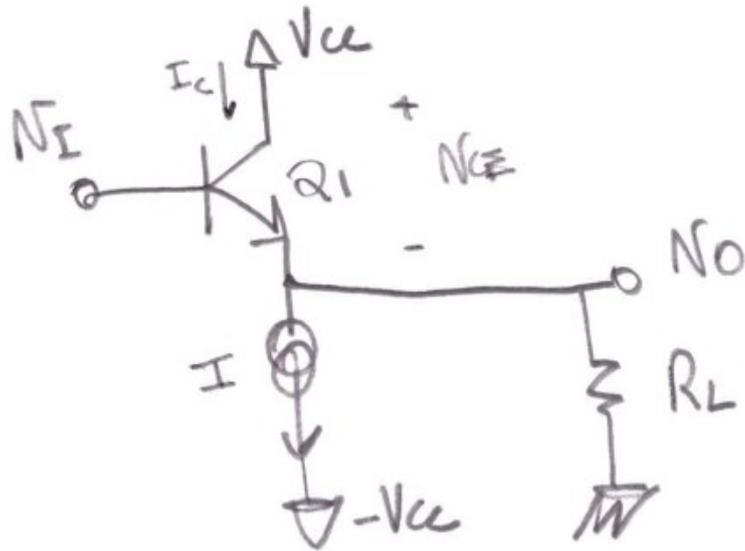
Seguidor de emisor



¿Que condición le tengo que pedir a la fuente de corriente?

# Clase A

Seguidor de emisor

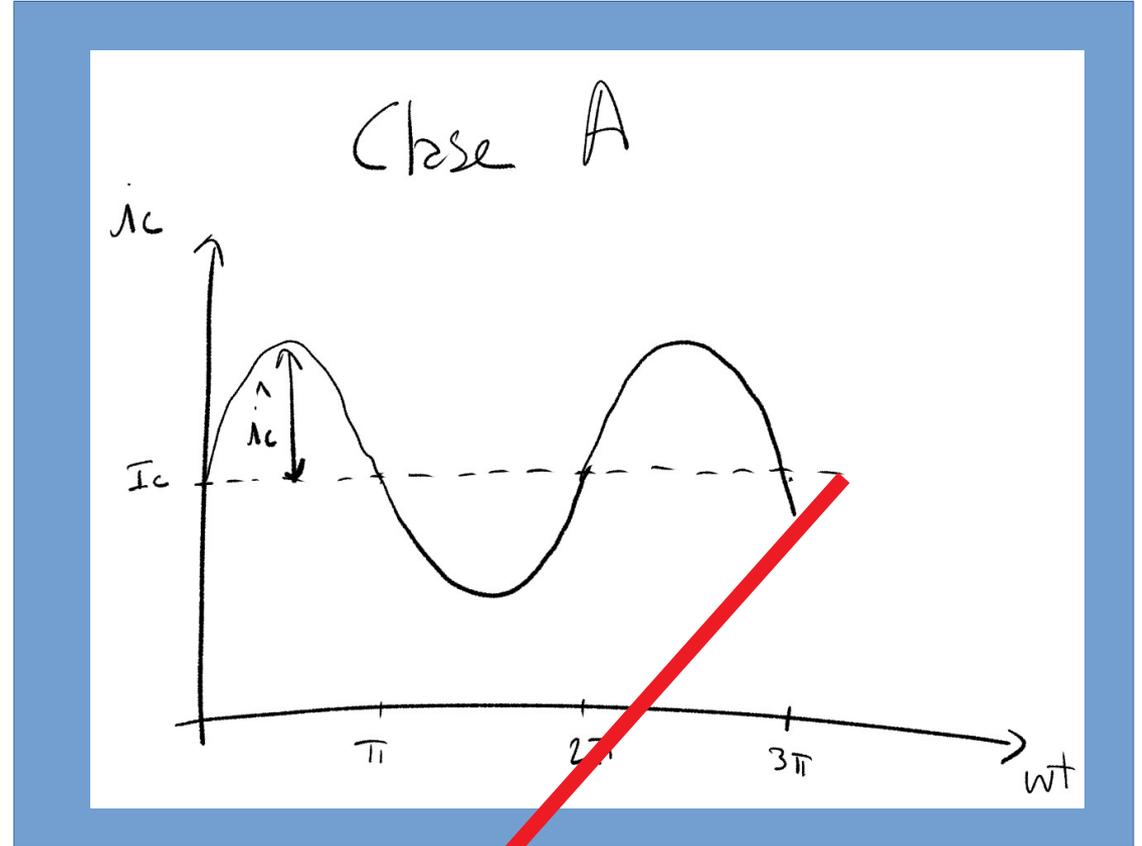
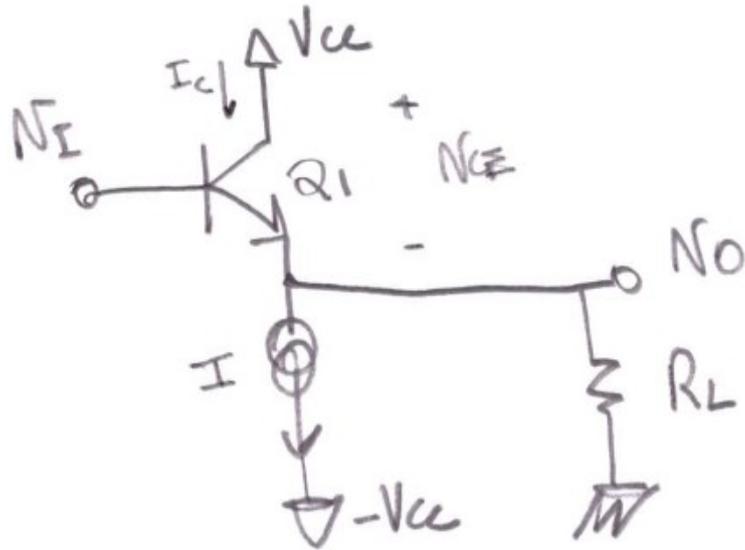


¿Que condición le tengo que pedir a la fuente de corriente?

**I mayor o igual a  $V_{CC}/R_L$**

# Clase A

Seguidor de emisor

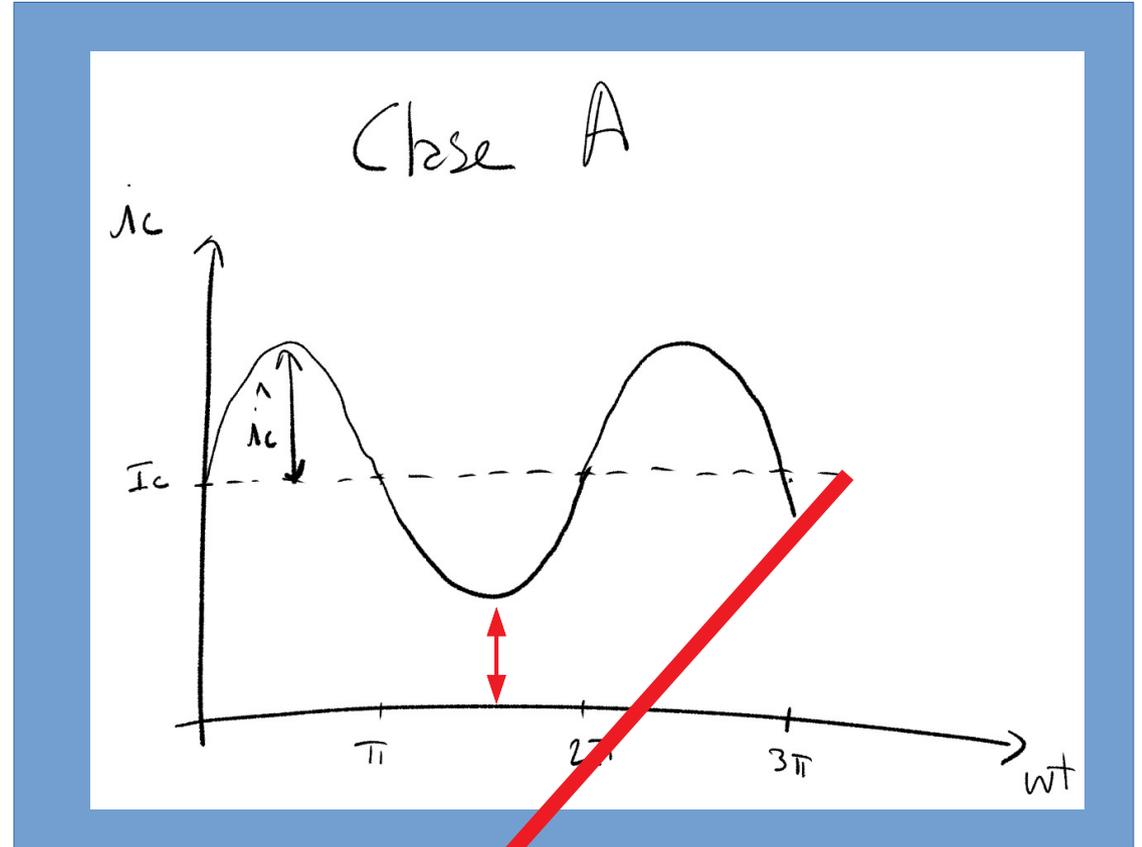
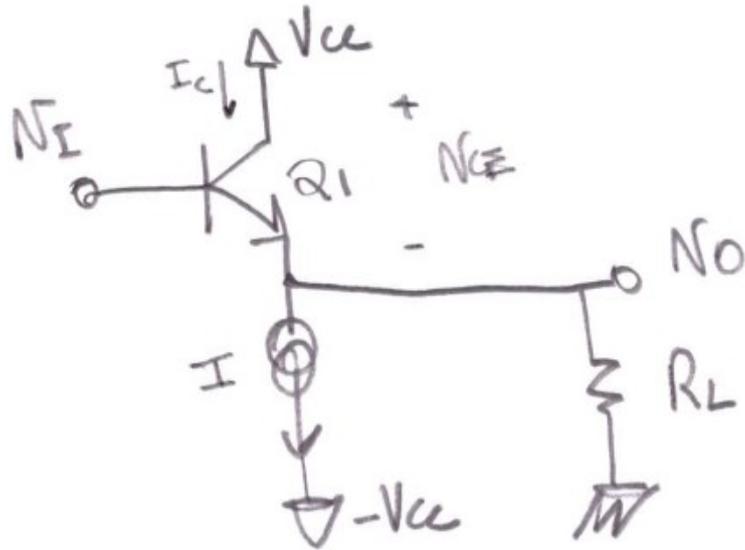


¿Que condición le tengo que pedir a la fuente de corriente?

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Seguidor de emisor

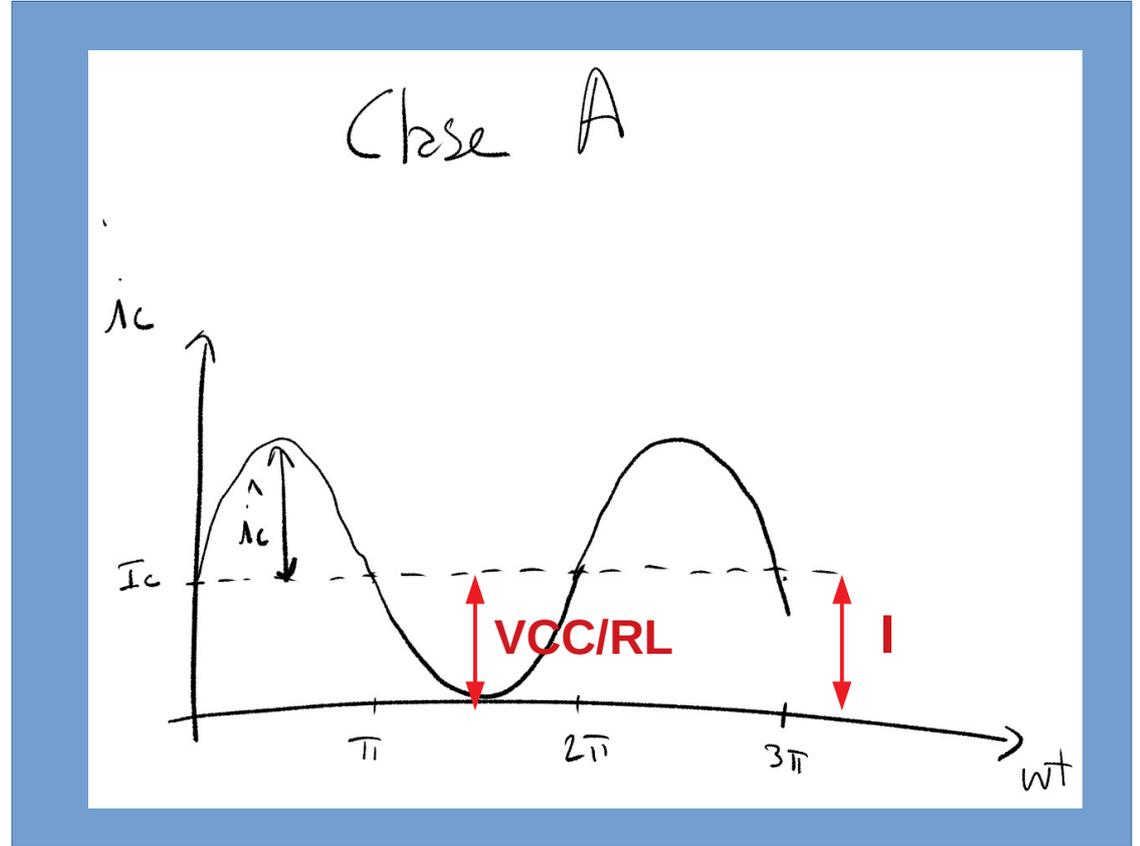
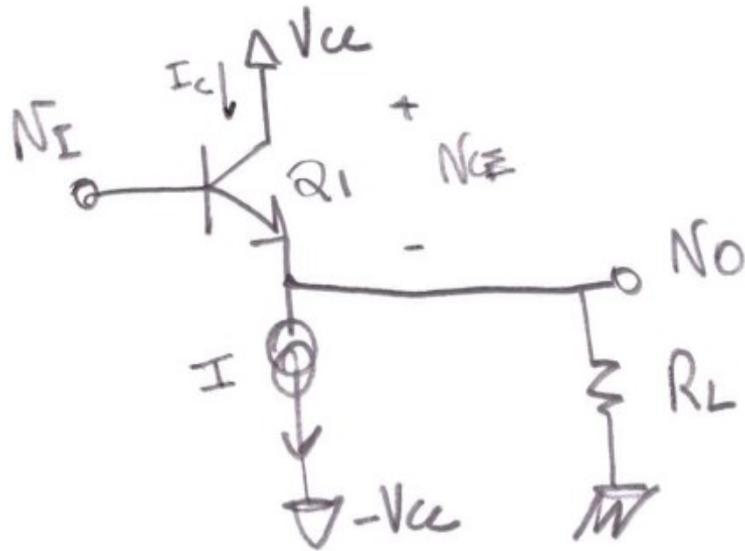


¿Que condición le tengo que pedir a la fuente de corriente?

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Seguidor de emisor

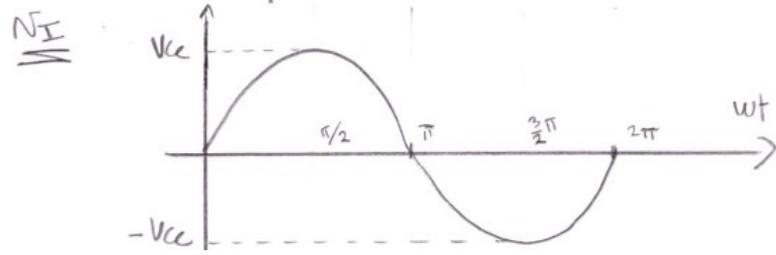
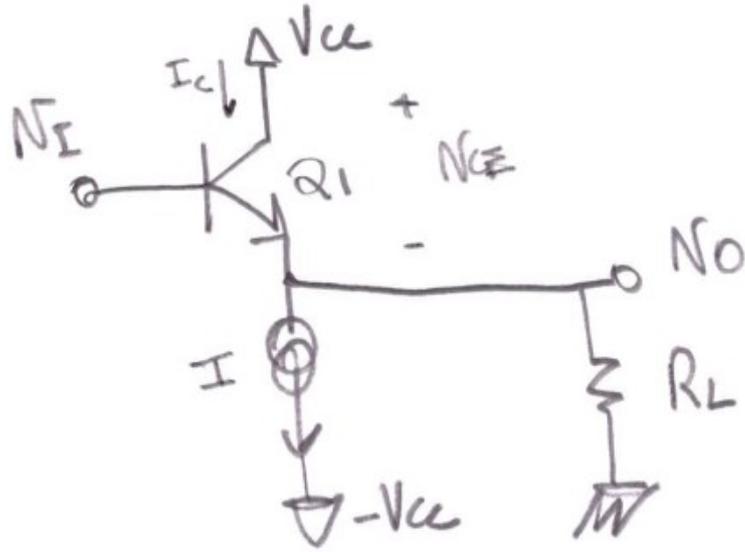


¿Que condición le tengo que pedir a la fuente de corriente?

**$I$  mayor o igual a  $V_{CC}/R_L$**

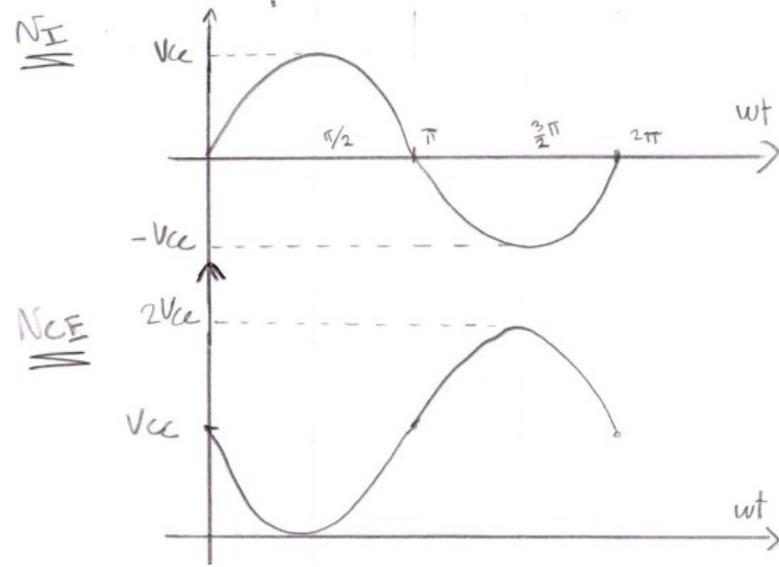
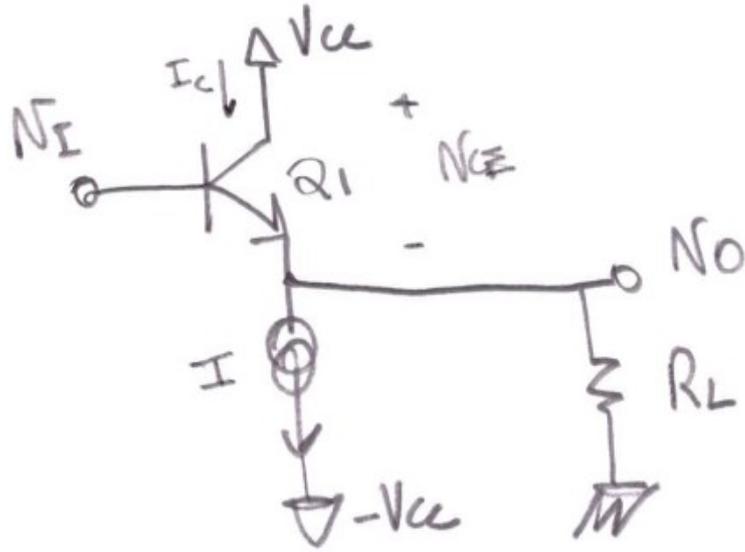
# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



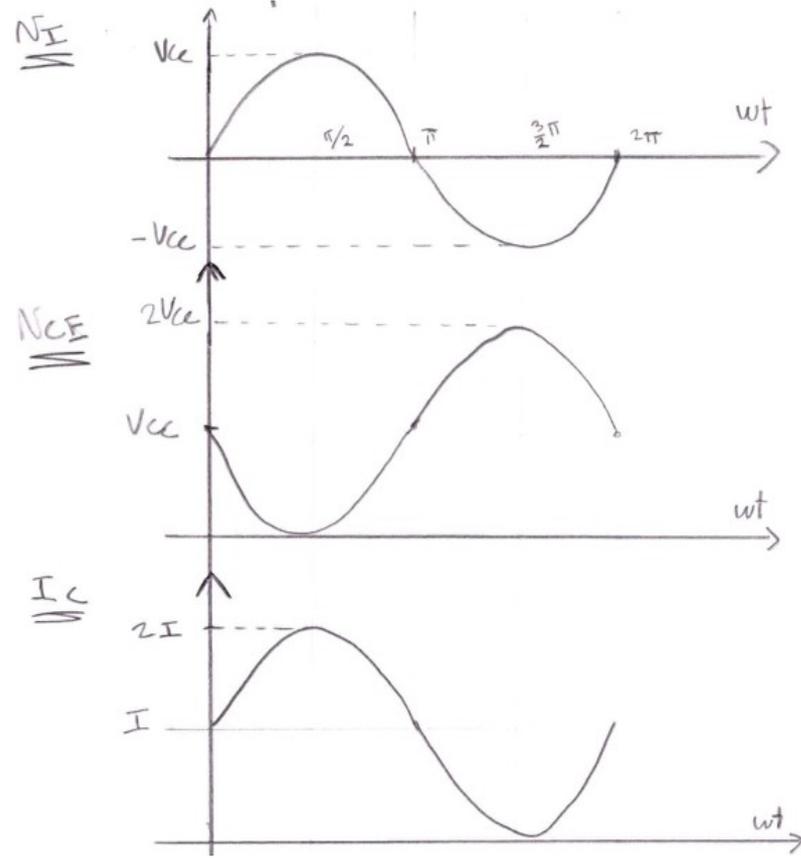
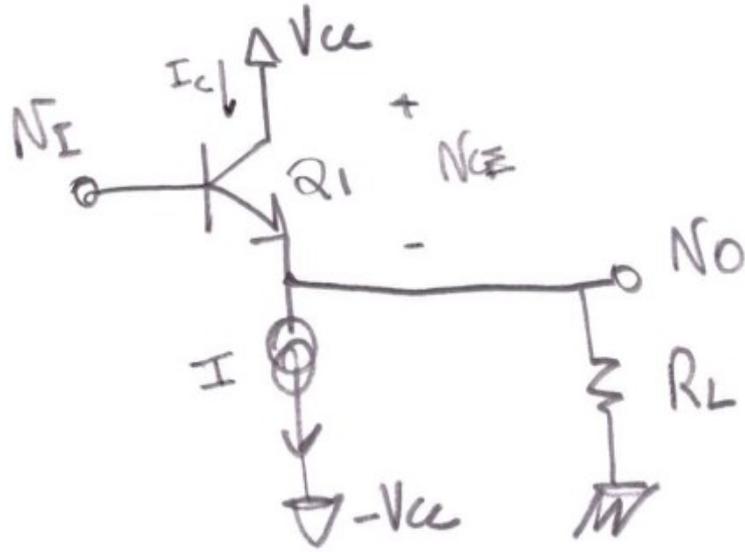
# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



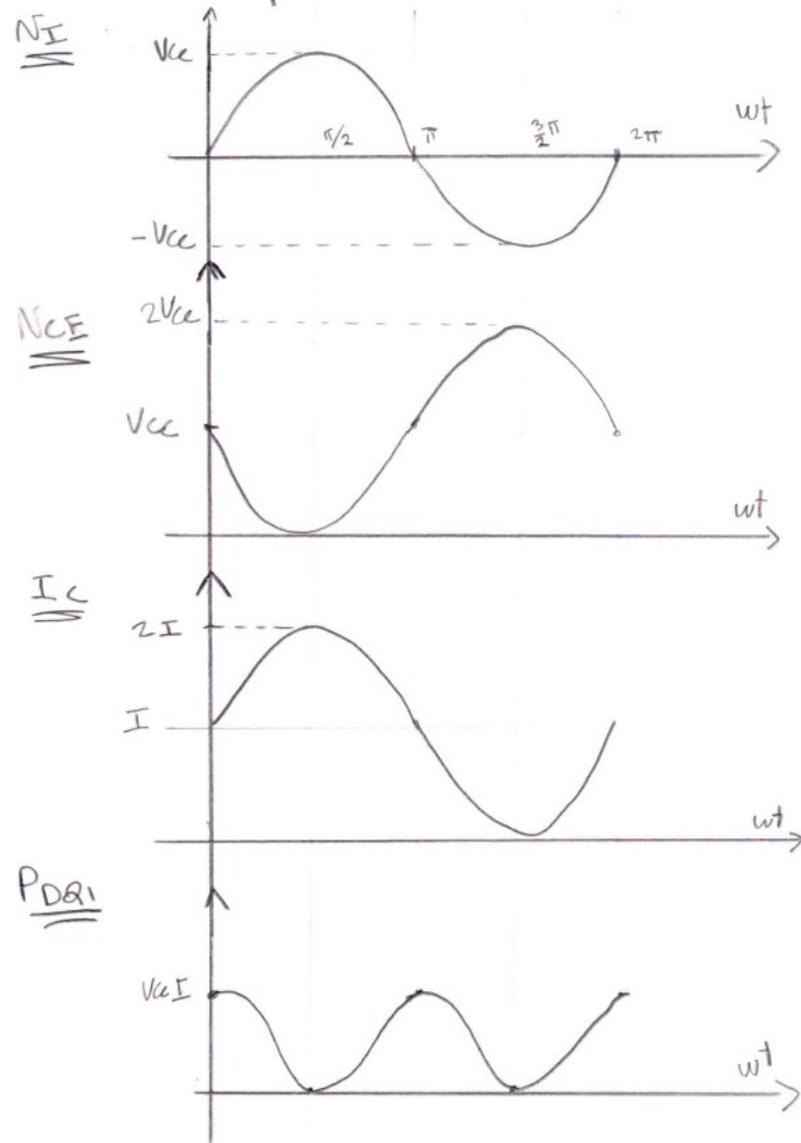
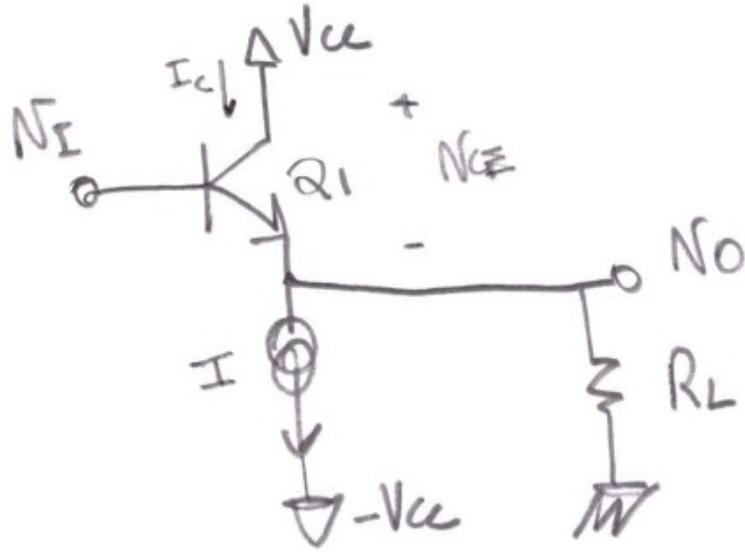
# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



# Clase A

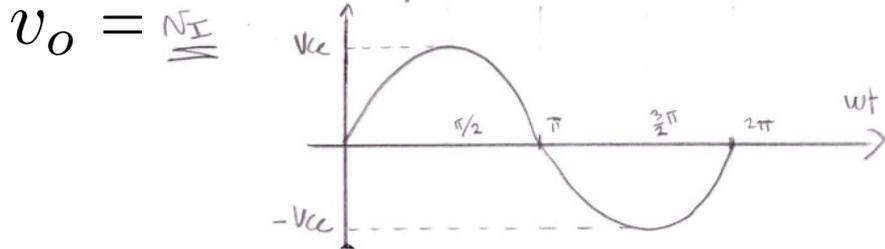
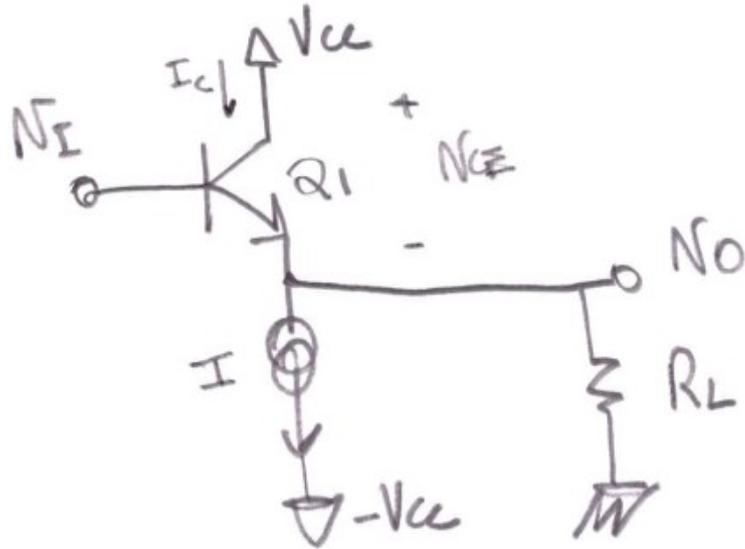
Seguidor de emisor  
Con  $V_{CC}/R_L=I$



# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$

$$\bar{P}_L = \frac{1}{T} \int_0^T v_o(t) \times i_o(t) dt$$

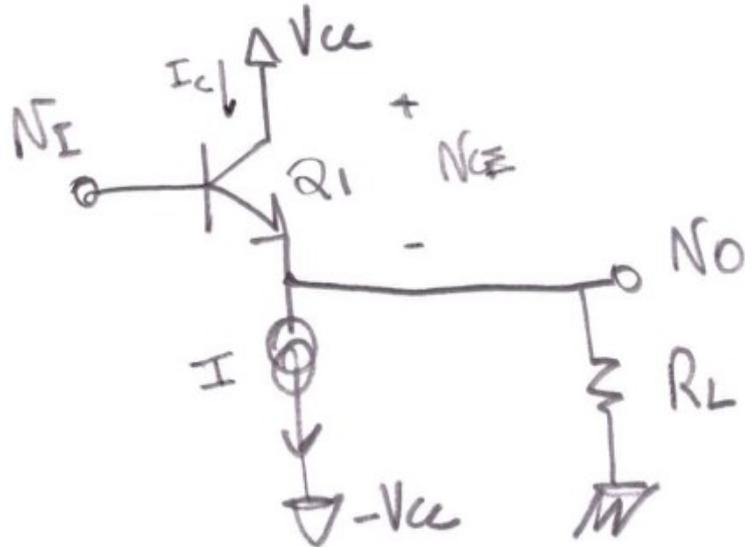


# Clase A

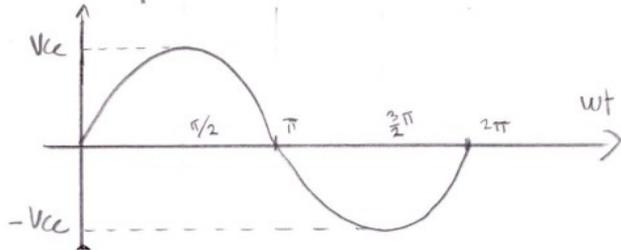
Seguidor de emisor  
Con  $V_{CC}/R_L=I$

$$\bar{P}_L = \frac{1}{T} \int_0^T v_o(t) \times i_o(t) dt$$

$$\bar{P}_L = \frac{1}{2\pi} \int_0^{2\pi} v_o(\theta) \times i_o(\theta) d\theta$$

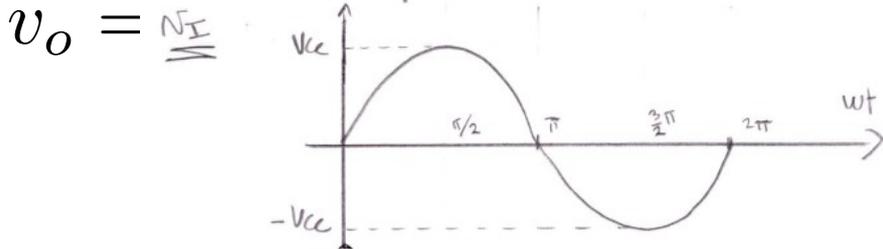
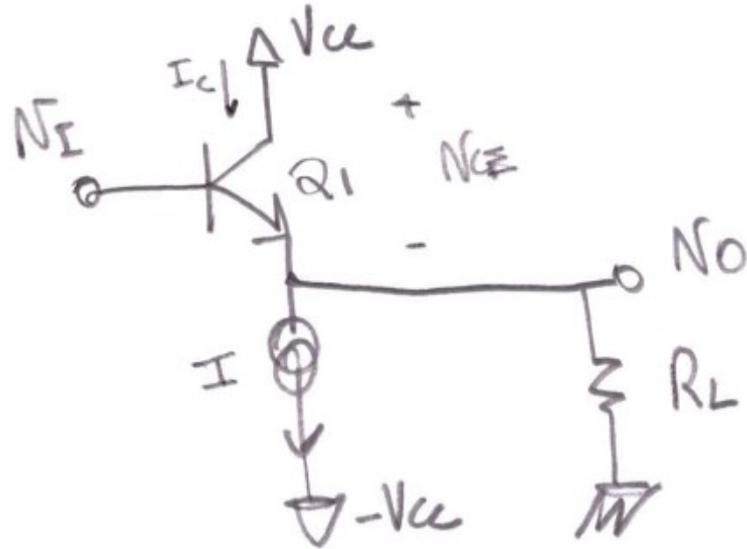


$$v_o = \underline{\underline{N_I}}$$



# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



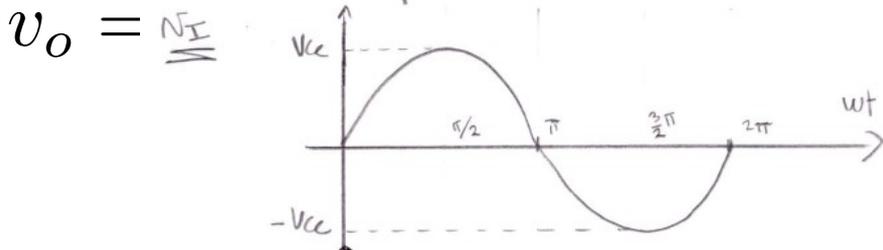
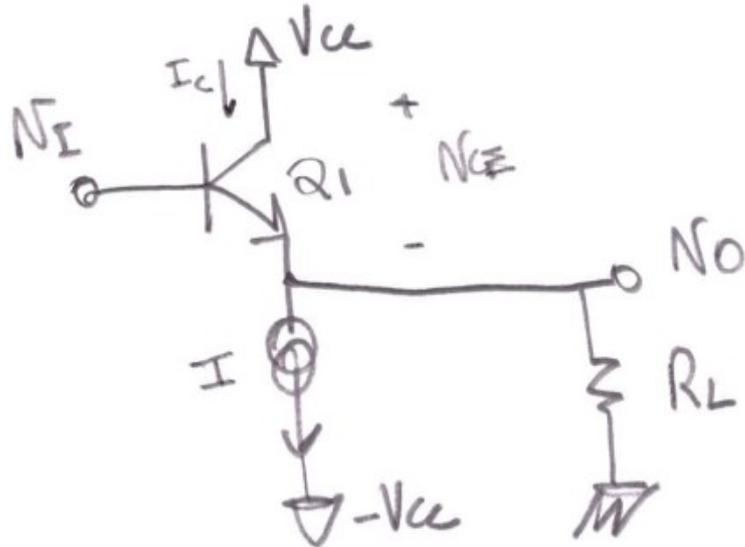
$$\bar{P}_L = \frac{1}{T} \int_0^T v_o(t) \times i_o(t) dt$$

$$\bar{P}_L = \frac{1}{2\pi} \int_0^{2\pi} v_o(\theta) \times i_o(\theta) d\theta$$

$$\bar{P}_L = \frac{1}{2\pi} \int_0^{2\pi} \hat{v}_o \sin(\theta) \times \frac{\hat{v}_o}{R_L} \sin(\theta) d\theta$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



$$\bar{P}_L = \frac{1}{T} \int_0^T v_o(t) \times i_o(t) dt$$

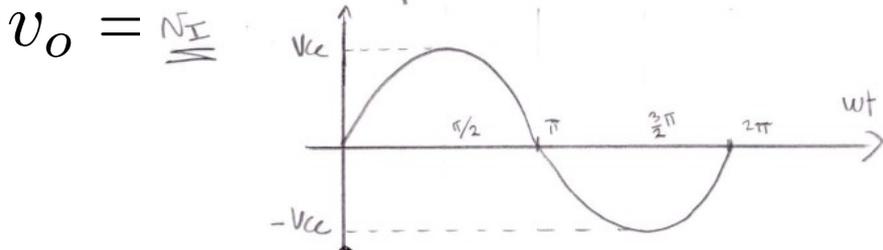
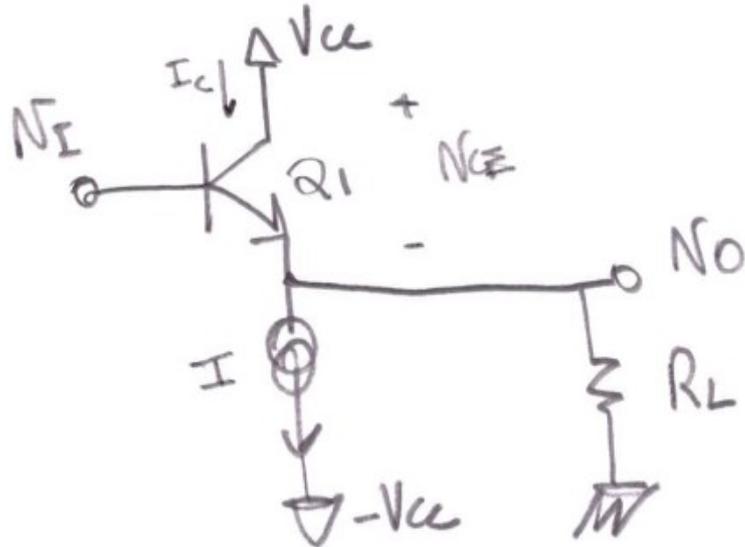
$$\bar{P}_L = \frac{1}{2\pi} \int_0^{2\pi} v_o(\theta) \times i_o(\theta) d\theta$$

$$\bar{P}_L = \frac{1}{2\pi} \int_0^{2\pi} \hat{v}_o \sin(\theta) \times \frac{\hat{v}_o}{R_L} \sin(\theta) d\theta$$

$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \int_0^{2\pi} \sin^2(\theta) d\theta$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



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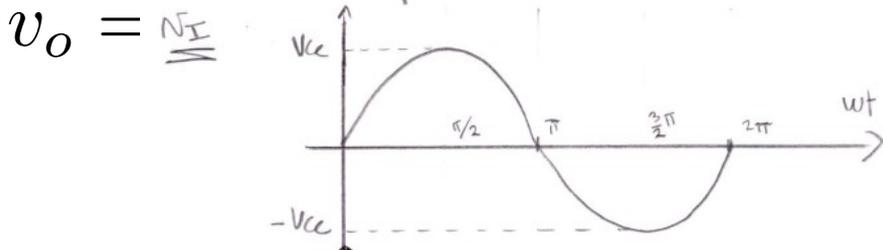
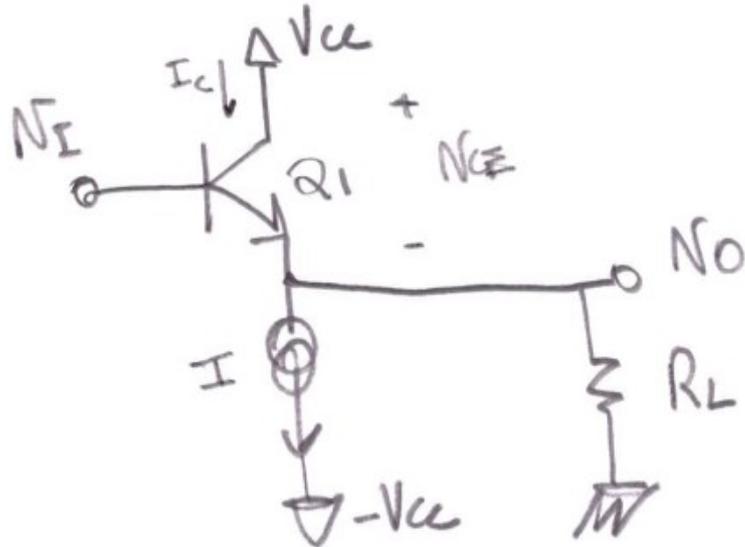
$$\bar{P}_L = \frac{1}{2\pi} \int_0^{2\pi} \hat{v}_o \sin(\theta) \times \frac{\hat{v}_o}{R_L} \sin(\theta) d\theta$$

$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \int_0^{2\pi} \sin^2(\theta) d\theta$$

$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \int_0^{2\pi} \left( \frac{1}{2} - \frac{1}{2} \cos(2\theta) \right) d\theta$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



$$\bar{P}_L = \frac{1}{T} \int_0^T v_o(t) \times i_o(t) dt$$

$$\bar{P}_L = \frac{1}{2\pi} \int_0^{2\pi} v_o(\theta) \times i_o(\theta) d\theta$$

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$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \int_0^{2\pi} \sin^2(\theta) d\theta$$

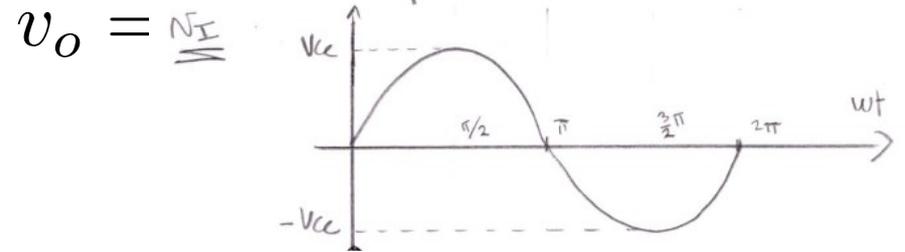
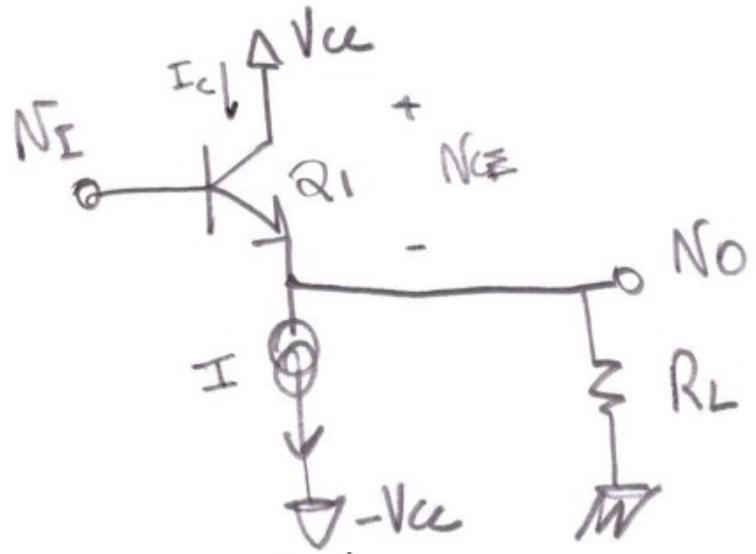
$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \int_0^{2\pi} \left( \frac{1}{2} - \frac{1}{2} \cos(2\theta) \right) d\theta$$

$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \left( \frac{1}{2} \theta - \frac{\sin(2\theta)}{4} \right) \Big|_0^{2\pi}$$

# Clase A

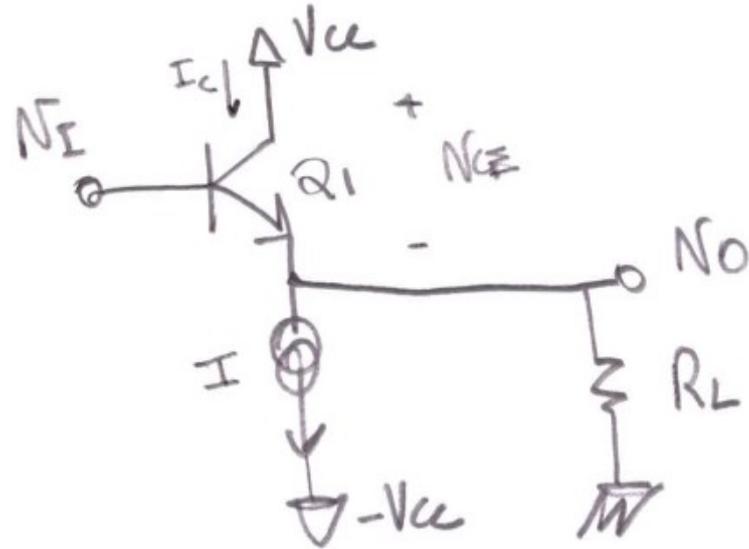
Seguidor de emisor  
Con  $V_{CC}/R_L=I$

$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \left( \frac{1}{2}\theta - \frac{\sin(2\theta)}{4} \right) \Big|_0^{2\pi}$$

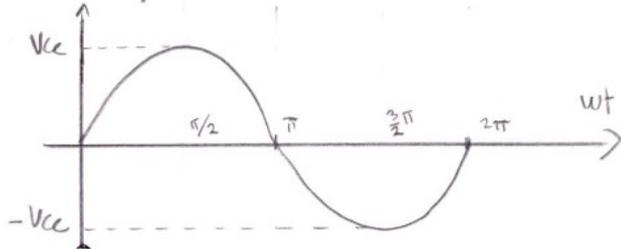


# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



$$v_o = \underline{\underline{N_I}}$$



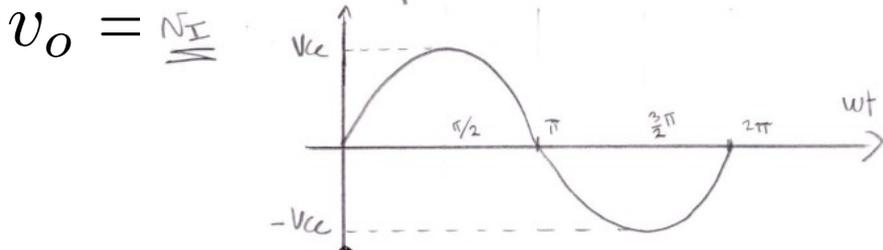
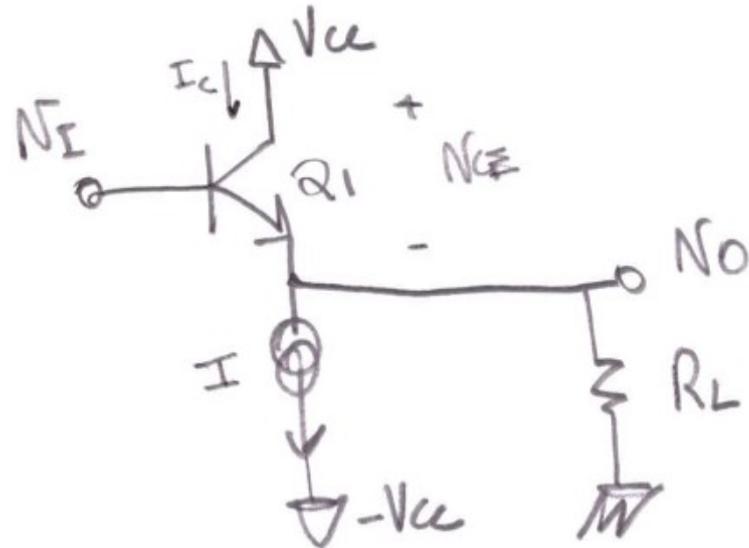
$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \left( \frac{1}{2}\theta - \frac{\sin(2\theta)}{4} \right) \Big|_0^{2\pi}$$

$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \pi$$

# Clase A

Seguidor de emisor

Con  $V_{CC}/R_L=I$



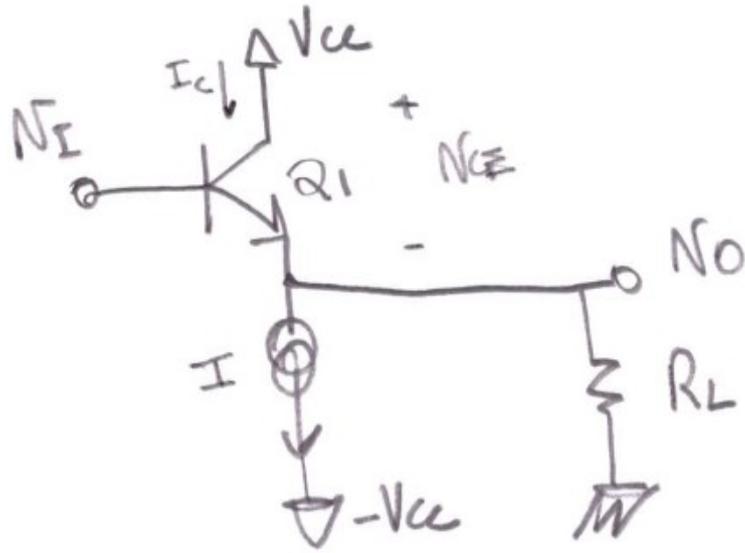
$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \left( \frac{1}{2}\theta - \frac{\sin(2\theta)}{4} \right) \Big|_0^{2\pi}$$

$$\bar{P}_L = \frac{\hat{v}_o^2}{R_L} \frac{1}{2\pi} \pi$$

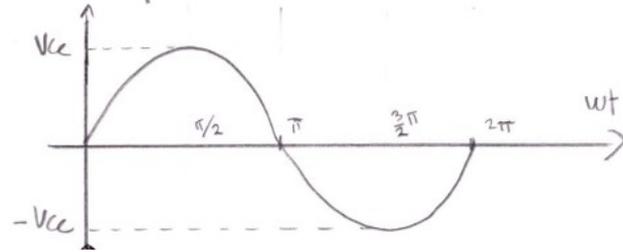
$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



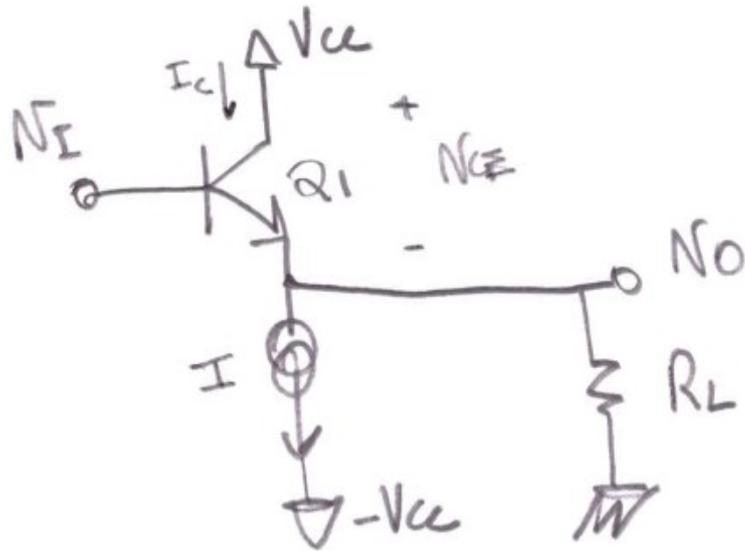
$$v_o = \underline{N_I}$$



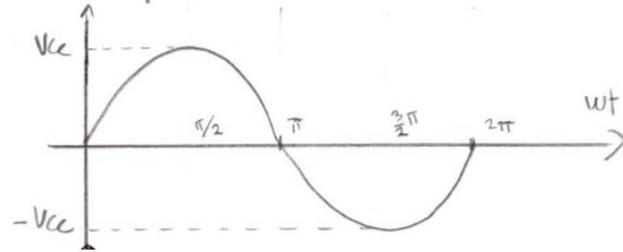
$$\bar{P}_S =$$

# Clase A

Seguidor de emisor  
**Con  $V_{CC}/R_L=I$**



$$v_o = \frac{N_I}{I}$$

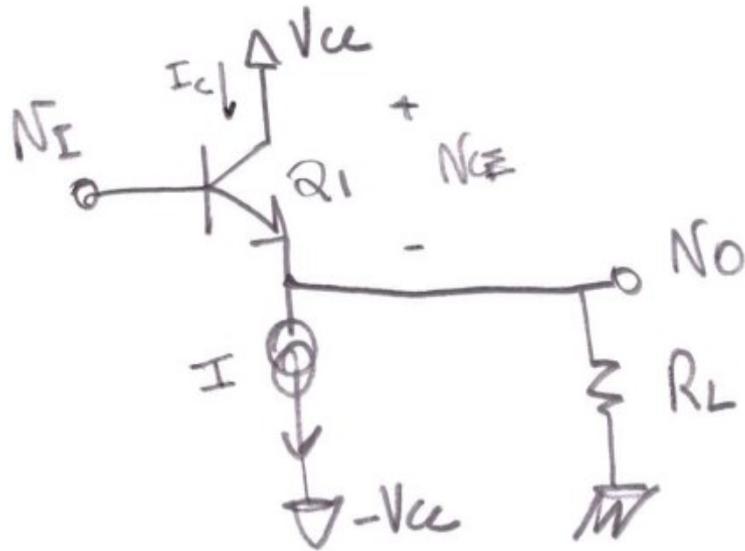


$$\bar{P}_S = V_{CC}I + \frac{1}{2\pi} \int_0^{2\pi} V_{CC} \left( I + \frac{\hat{v}_o}{R_L} \sin(\theta) \right) d\theta =$$

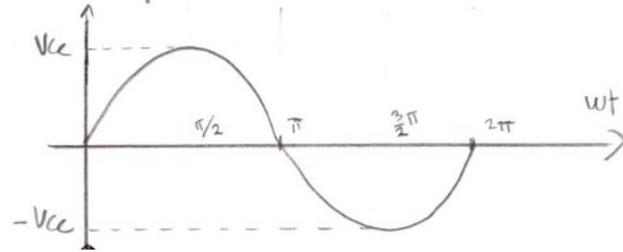
# Clase A

Seguidor de emisor

Con  $V_{CC}/R_L = I$



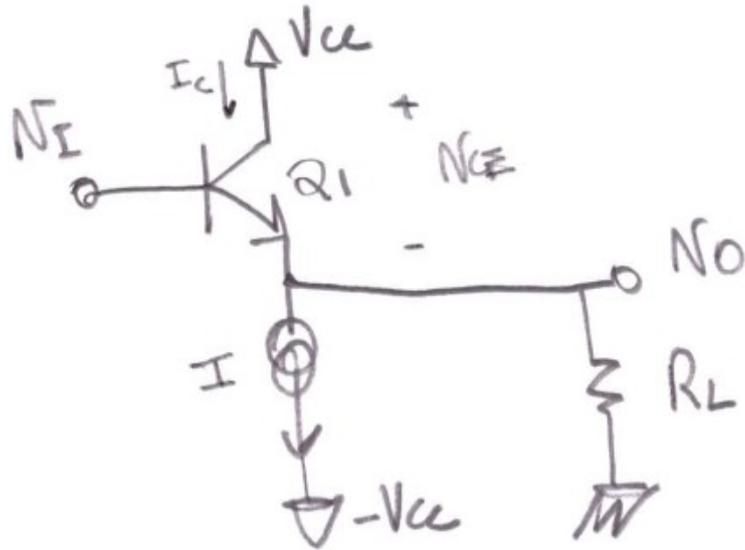
$$v_o = \frac{N_I}{R_L}$$



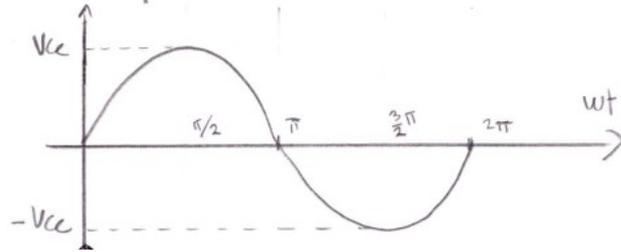
$$\bar{P}_S = V_{CC}I + \frac{1}{2\pi} \int_0^{2\pi} V_{CC} \left( I + \frac{\hat{v}_o}{R_L} \sin(\theta) \right) d\theta = 2V_{CC}I$$

# Clase A

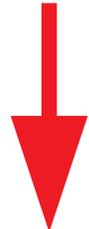
Seguidor de emisor  
Con  $V_{CC}/R_L = I$



$$v_o = \frac{N_I}{R_L}$$



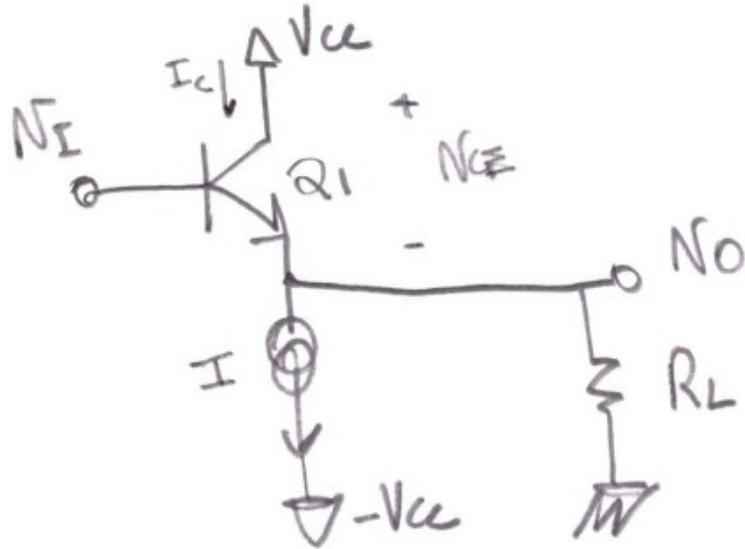
No depende de  $R_L$



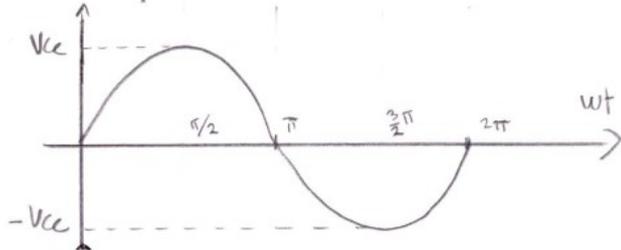
$$\bar{P}_S = V_{CC}I + \frac{1}{2\pi} \int_0^{2\pi} V_{CC} \left( I + \frac{\hat{v}_o}{R_L} \sin(\theta) \right) d\theta = 2V_{CC}I$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



$$v_o = \underline{\underline{N_I}}$$



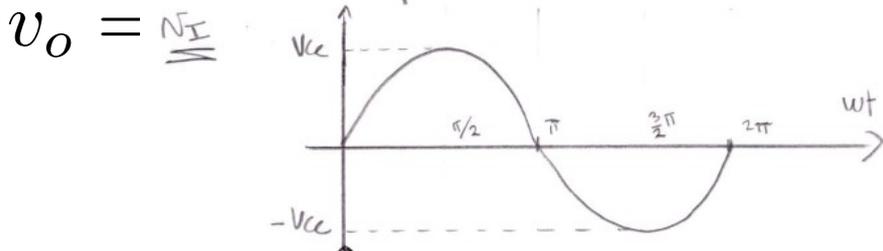
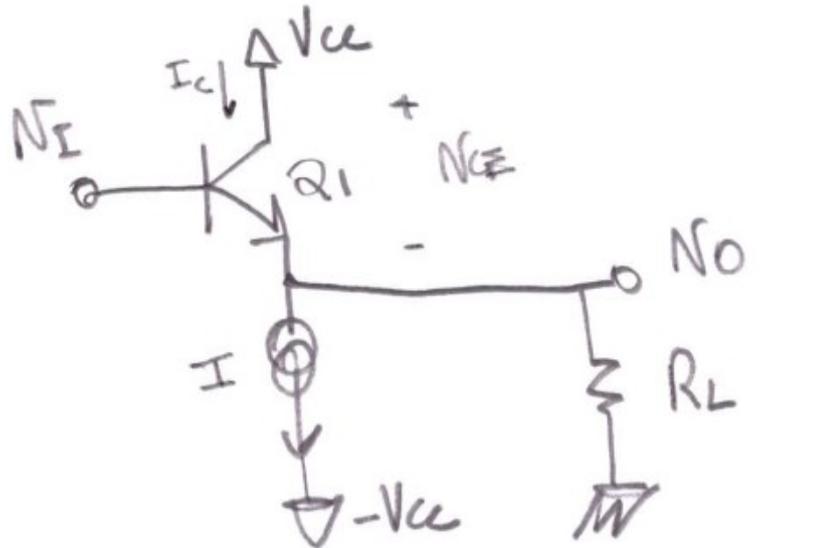
$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

$$\bar{P}_S = 2V_{CC}I$$

$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{\hat{v}_o^2}{4R_L V_{CC} I}$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

$$\bar{P}_S = 2V_{CC}I$$

A mayor  $R_L$  o  
mayor  $I$   
menor  
eficiencia

$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{\hat{v}_o^2}{4R_L V_{CC} I}$$

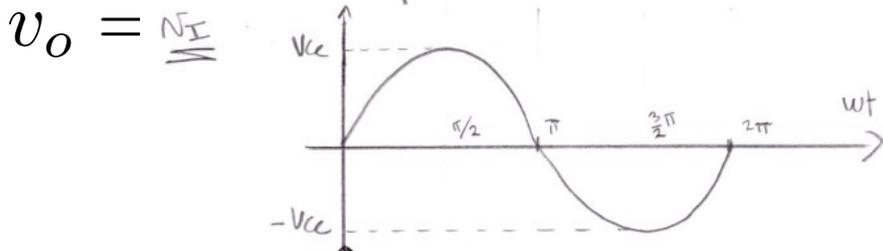
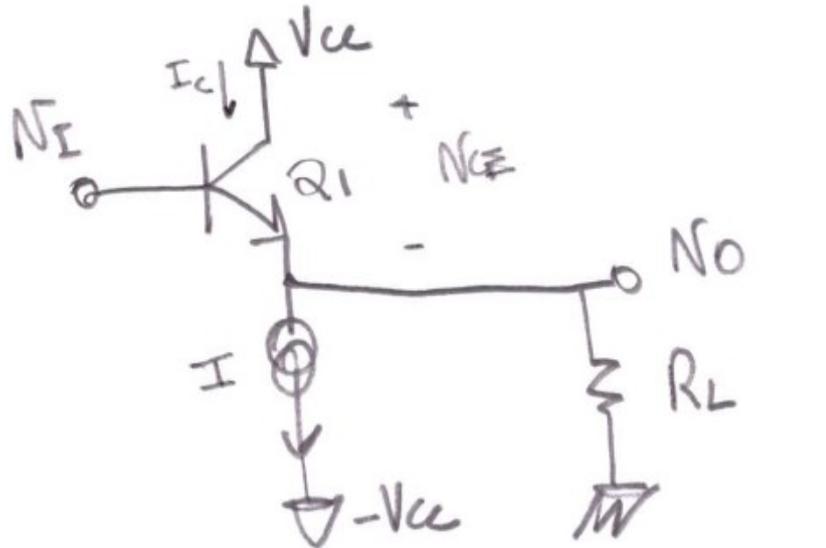
Máxima eficiencia:

$$\hat{v}_o = V_{CC} = R_L I$$

$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{1}{4} = 25\%$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

$$\bar{P}_S = 2V_{CC}I$$

A menor  
amplitud,  
menos  
eficiencia

$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{\hat{v}_o^2}{4R_L V_{CC} I}$$

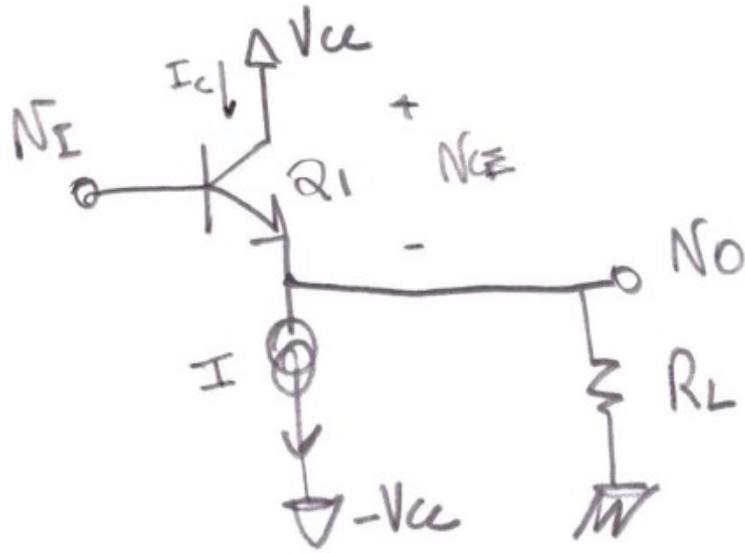
Máxima eficiencia:

$$\hat{v}_o = V_{CC} = R_L I$$

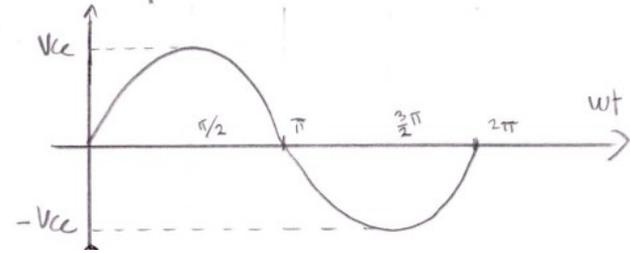
$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{1}{4} = 25\%$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



$$v_o = \underline{\underline{V_I}}$$

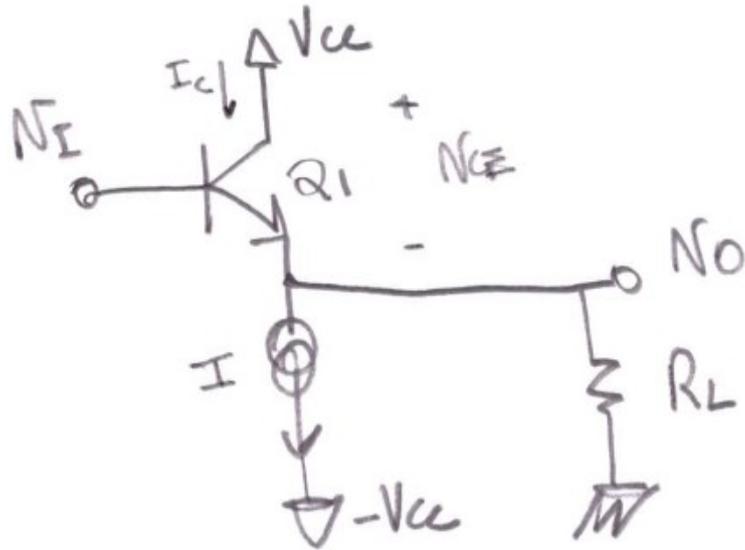


$$P_{DQ_1} =$$

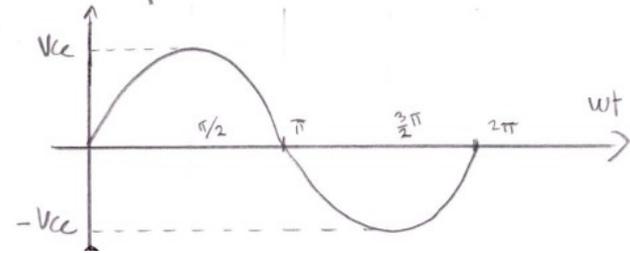
# Clase A

Seguidor de emisor

Con  $V_{CC}/R_L=I$



$$v_o = \frac{N_I}{I}$$

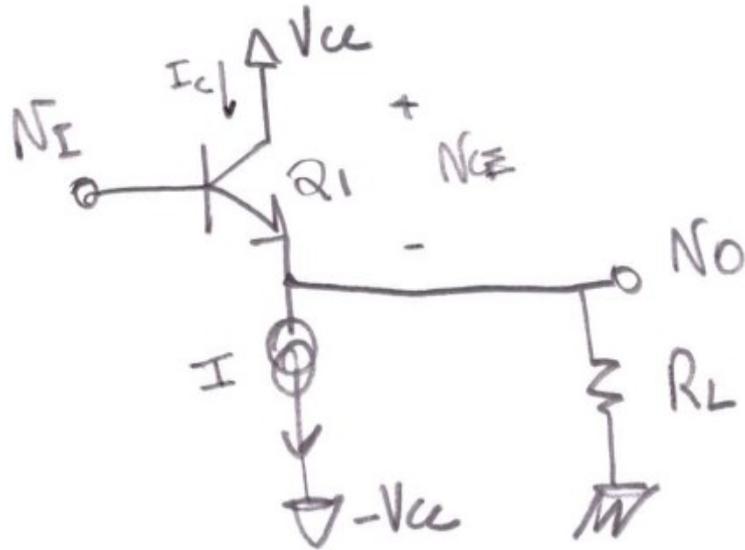


$$P_{DQ_1}^- = \frac{1}{2\pi} \int_0^{2\pi} [V_{CC} - \hat{v}_o \sin(\theta)] \left( I + \frac{\hat{v}_o}{R_L} \sin(\theta) \right) d\theta =$$

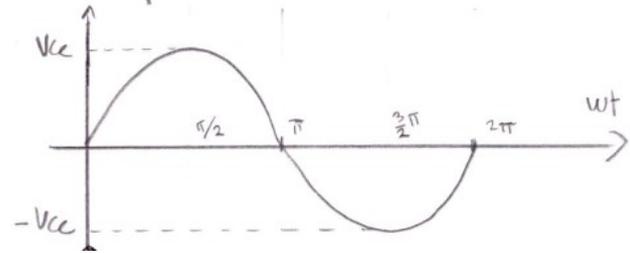
# Clase A

Seguidor de emisor

Con  $V_{CC}/R_L=I$



$$v_o = \frac{N_I}{N_O}$$

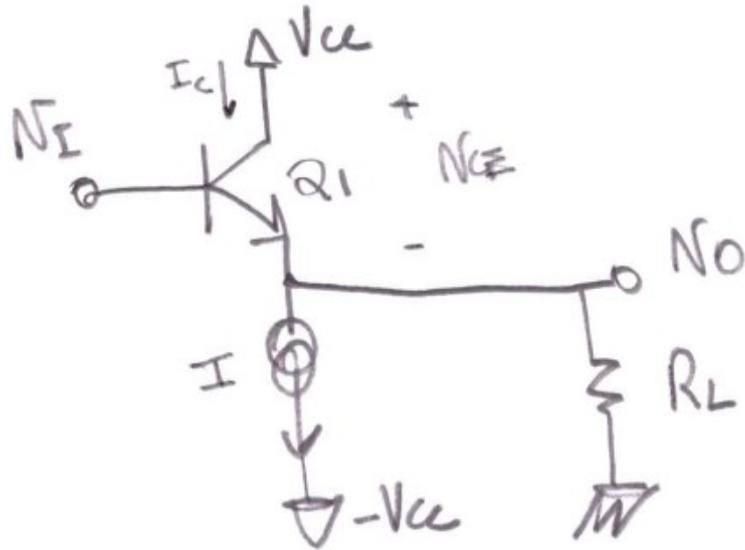


$$P_{DQ_1}^- = \frac{1}{2\pi} \int_0^{2\pi} [V_{CC} - \hat{v}_o \sin(\theta)] \left( I + \frac{\hat{v}_o}{R_L} \sin(\theta) \right) d\theta = V_{CC} I - \frac{\hat{v}_o^2}{2R_L}$$

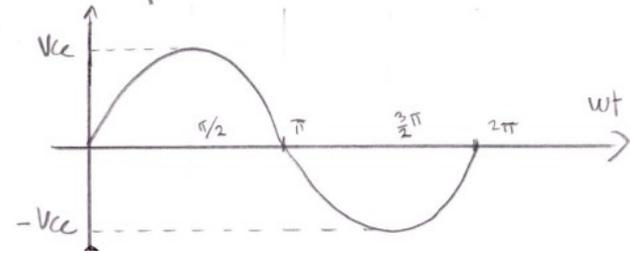
# Clase A

Seguidor de emisor

Con  $V_{CC}/R_L=I$



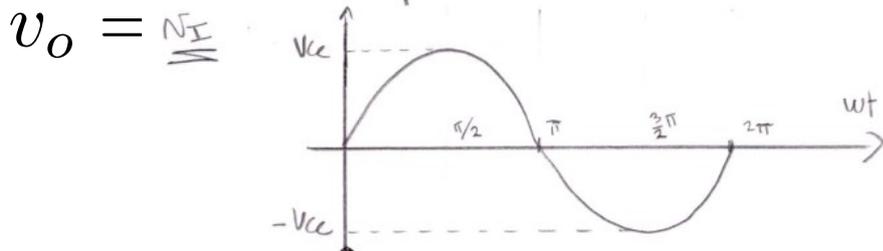
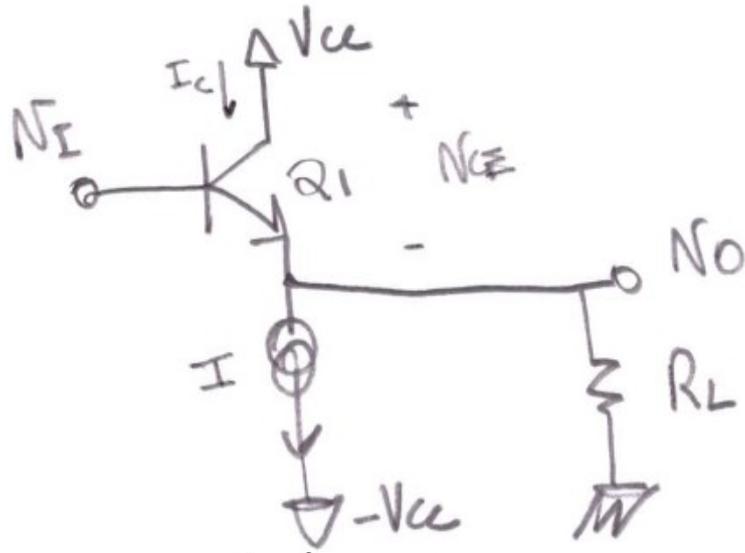
$$v_o = \underline{\underline{N_I}}$$



$$P_{DI}^- = \frac{1}{2\pi} \int_0^{2\pi} I(\hat{v}_o \sin(\theta) + V_{CC}) d\theta = V_{CC} I$$

# Clase A

Seguidor de emisor  
Con  $V_{CC}/R_L=I$



$$\bar{P}_S = 2V_{CC}I$$

$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

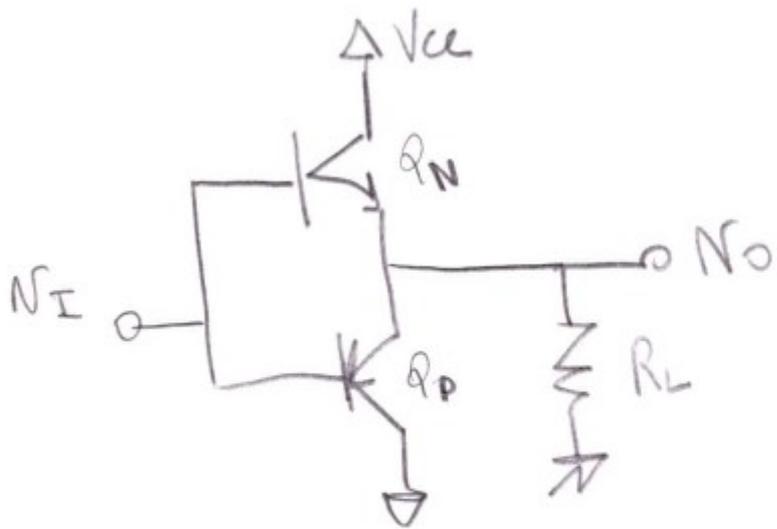
$$P_{DQ_1}^- = V_{CC}I - \frac{\hat{v}_o^2}{2R_L}$$

$$P_{DI}^- = V_{CC}I$$

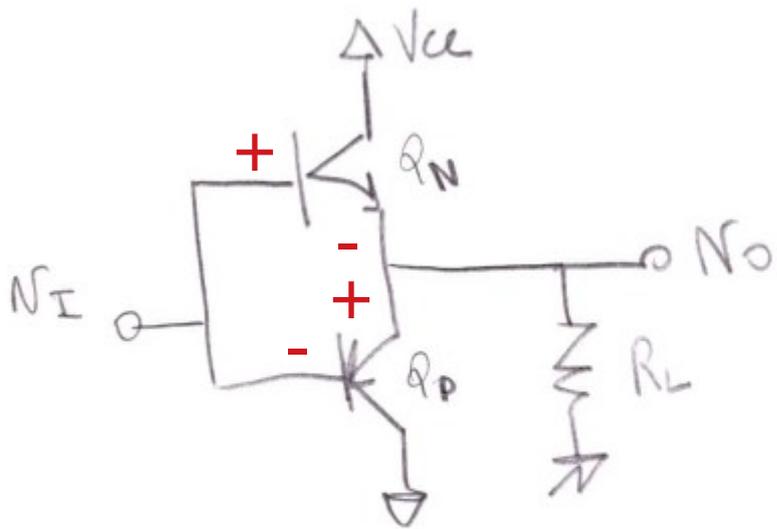
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$$\bar{P}_S = \bar{P}_L + P_{DQ_1}^- + P_{DI}^-$$

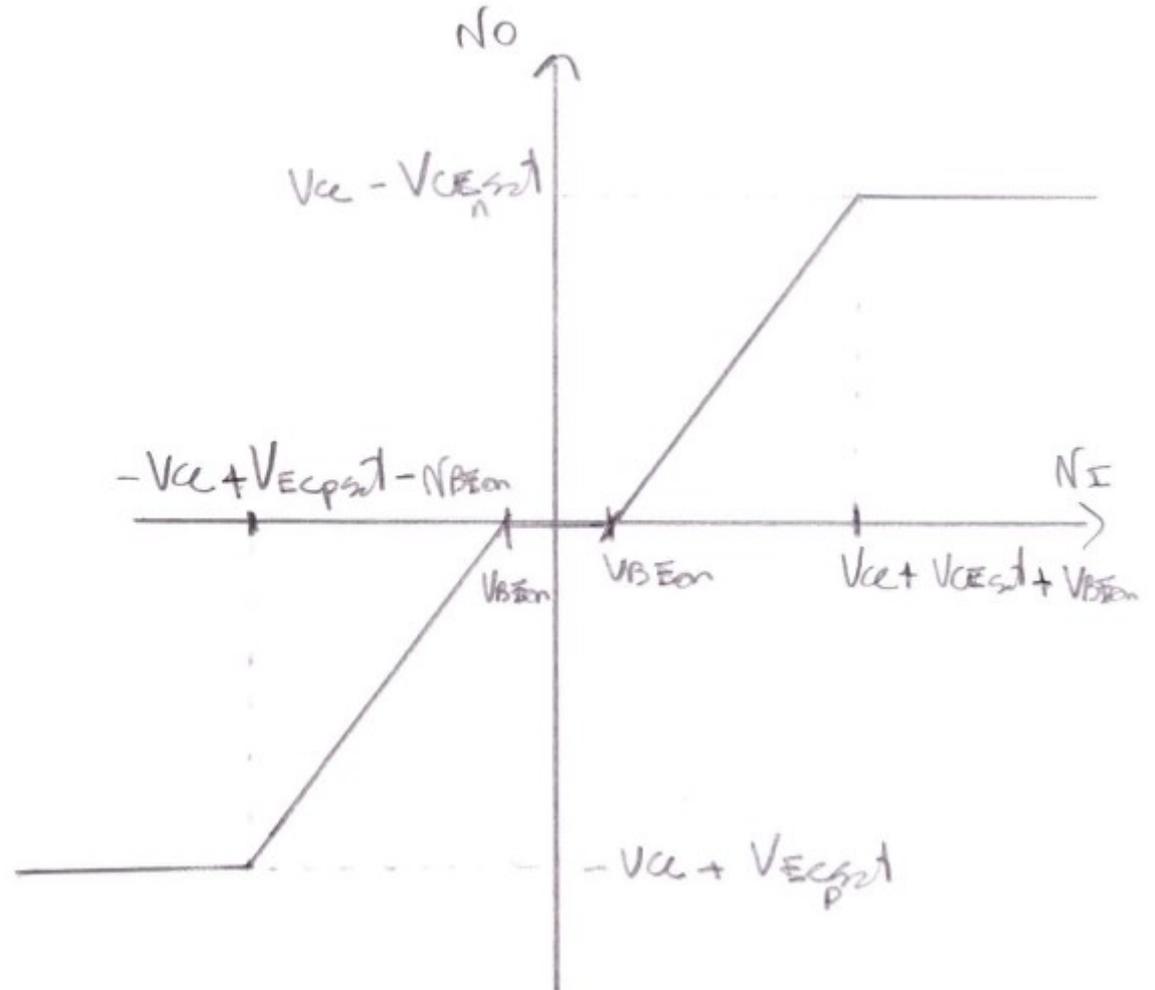
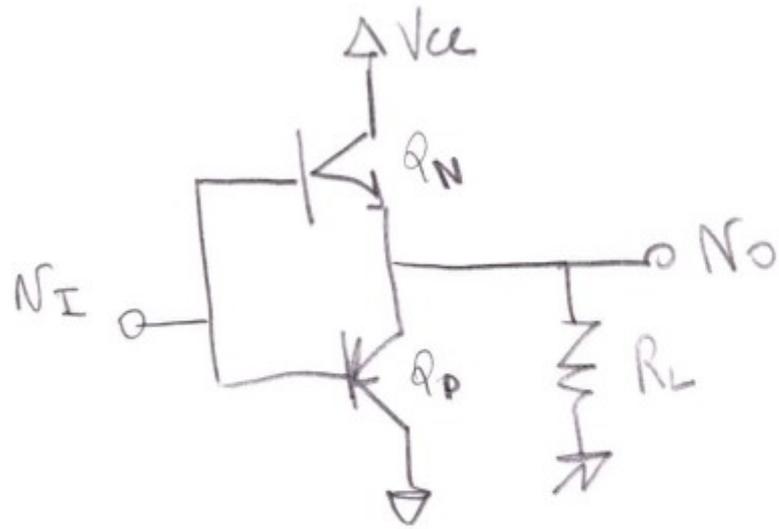
# Class B



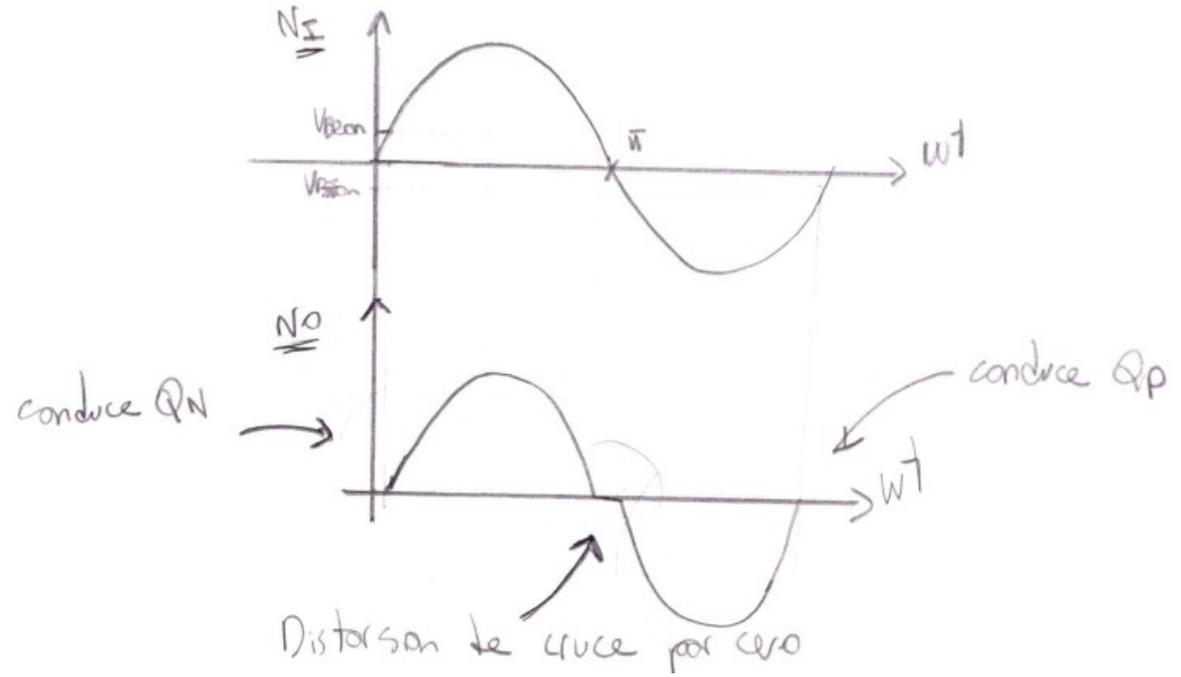
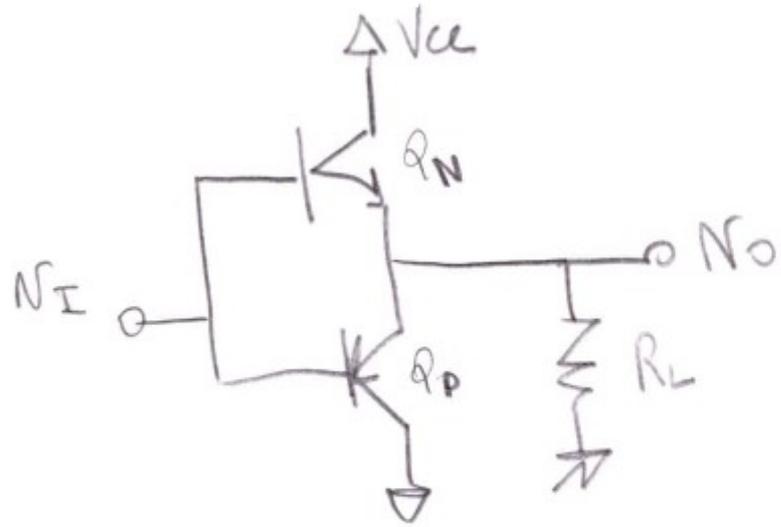
# Class B



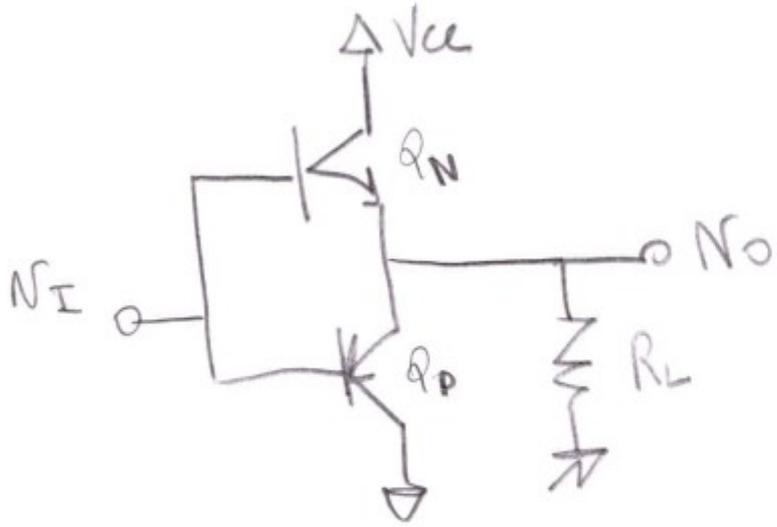
# Class B



# Clase B

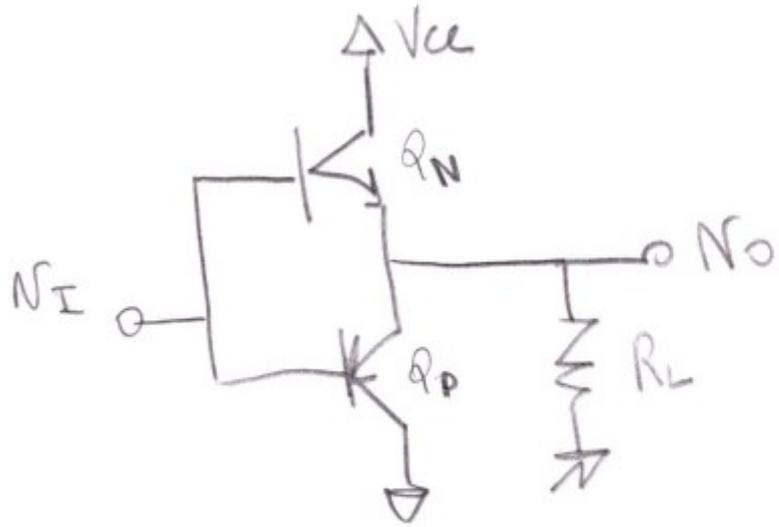


# Class B



$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

# Class B

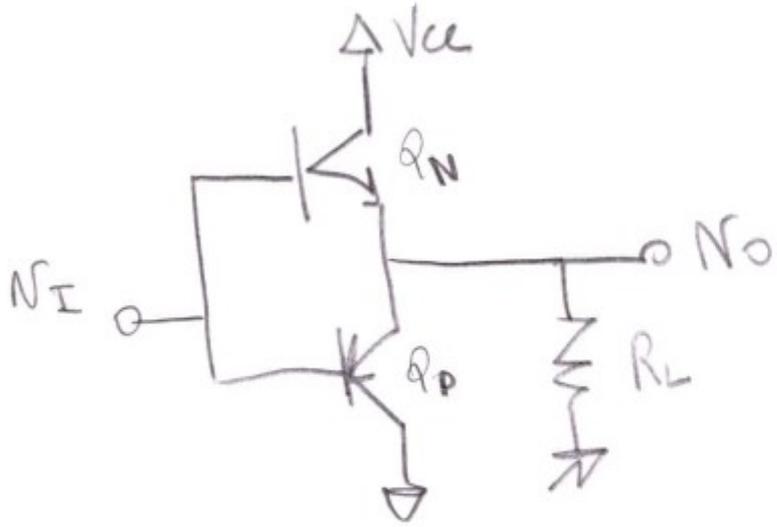


$$P_{S+}^- = P_{S-}^- = \frac{1}{2\pi} \int_0^\pi V_{CC} \frac{\hat{v}_o}{R_L} \sin(\theta) d\theta$$

$$= \frac{V_{CC} \hat{v}_o}{R_L} \frac{1}{2\pi} \left( -\cos(\theta) \Big|_0^{2\pi} \right)$$

$$= \frac{V_{CC} \hat{v}_o}{R_L \pi}$$

# Class B

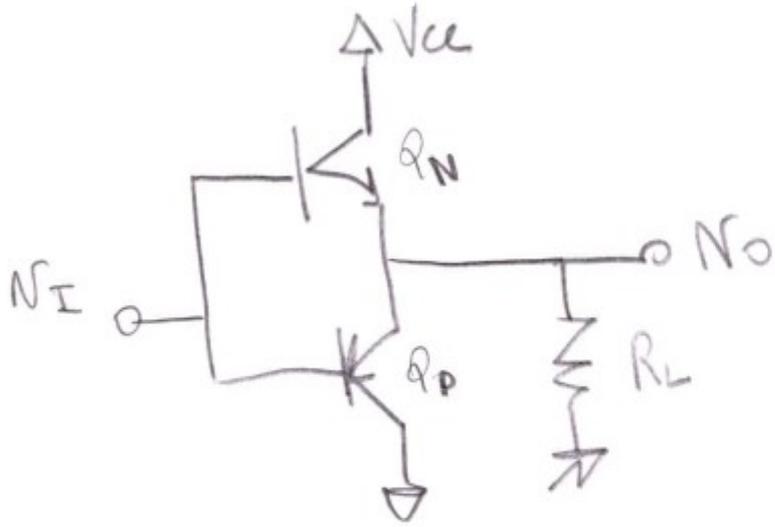


$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

$$\bar{P}_S = \frac{2V_{CC}\hat{v}_o}{R_L\pi}$$

$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{\pi}{4} \frac{\hat{v}_o}{V_{CC}}$$

# Clase B



$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

$$\bar{P}_S = \frac{2V_{CC}\hat{v}_o}{R_L\pi}$$

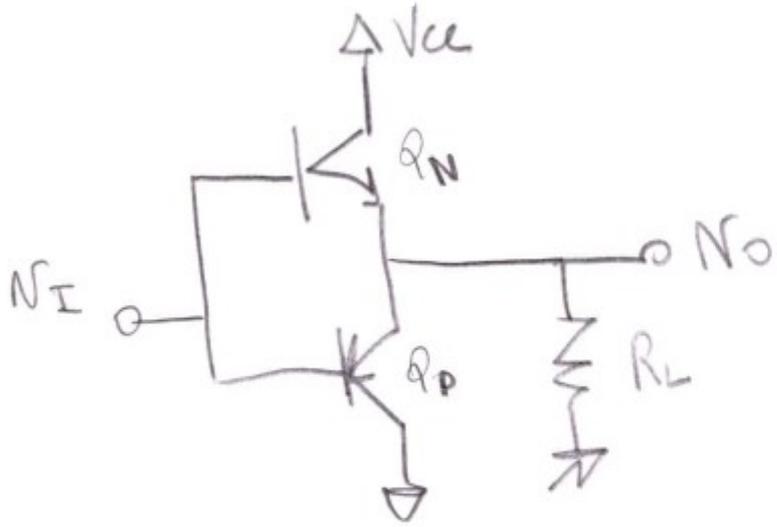
$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{\pi}{4} \frac{\hat{v}_o}{V_{CC}}$$

Máxima eficiencia:

$$\hat{v}_o = V_{CC}$$

$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{\pi}{4} = 78.5\%$$

# Class B

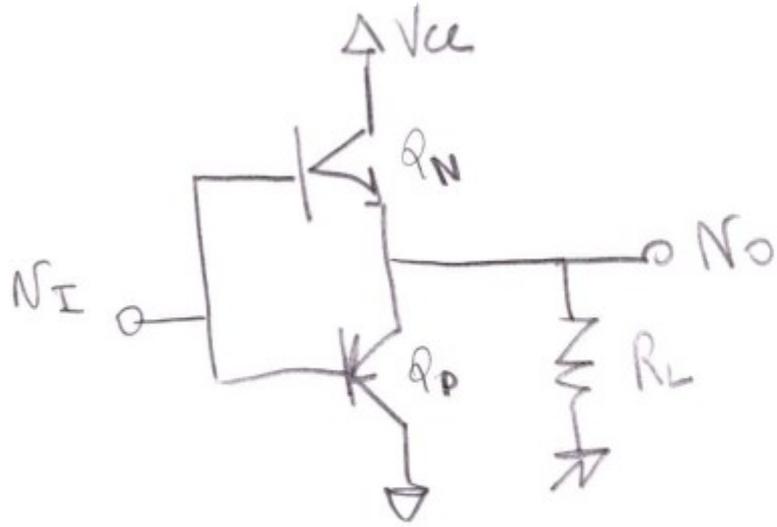


$$\bar{P}_L = \frac{\hat{v}_o^2}{2R_L}$$

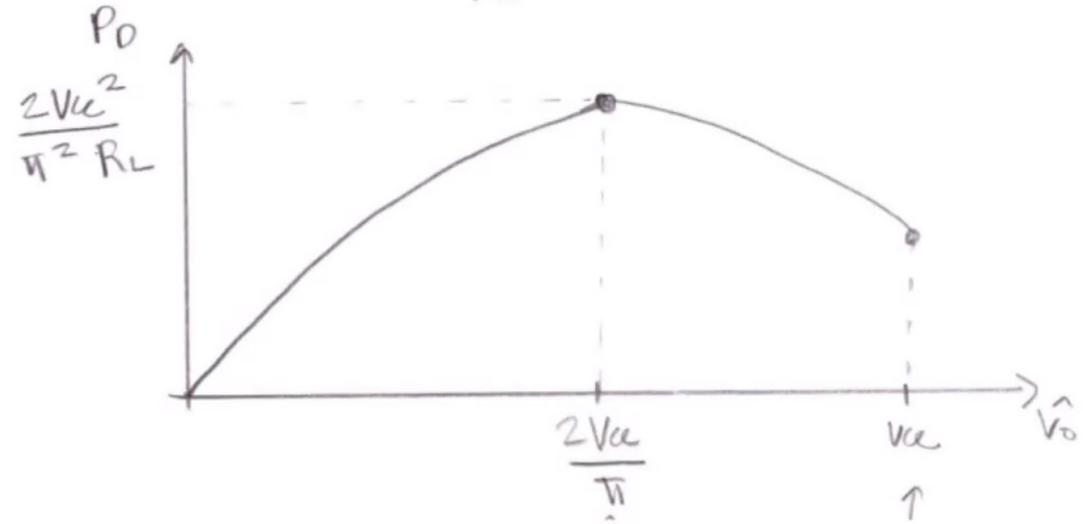
$$\bar{P}_S = \frac{2V_{CC}\hat{v}_o}{R_L\pi}$$

$$\bar{P}_D = \bar{P}_S - \bar{P}_L = \frac{2V_{CC}\hat{v}_o}{R_L\pi} - \frac{\hat{v}_o^2}{2R_L}$$

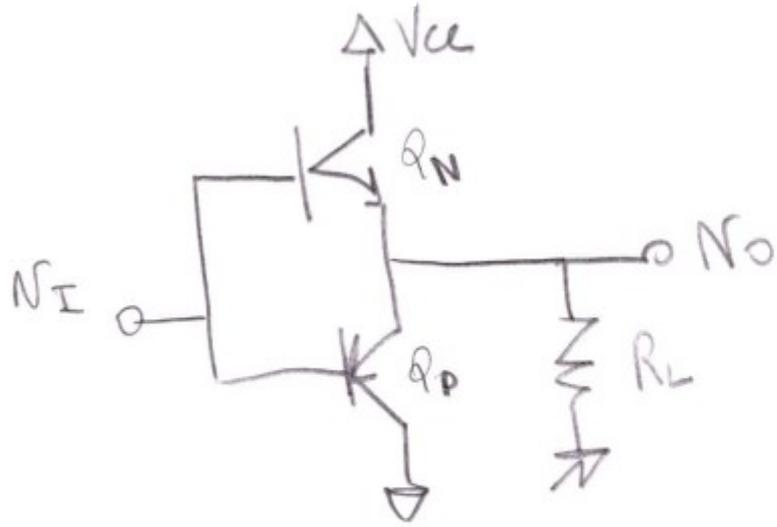
# Class B



$$P_D = P_S - P_L = \frac{2V_{CC}\hat{v}_o}{R_L\pi} - \frac{\hat{v}_o^2}{2R_L}$$

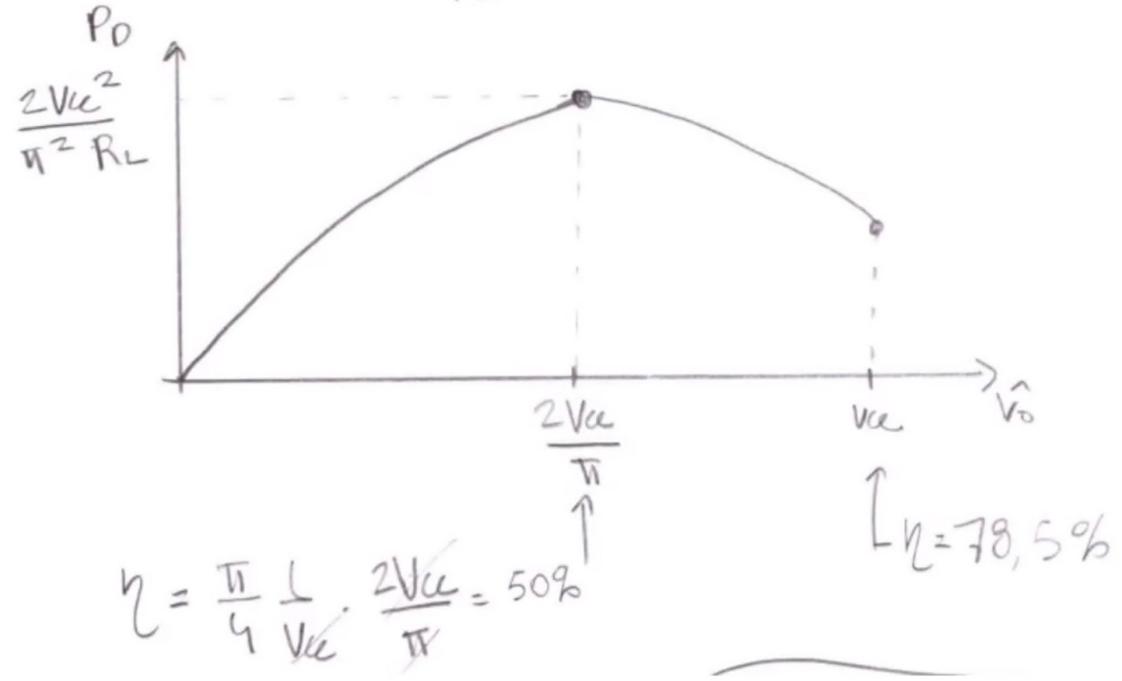


# Clase B



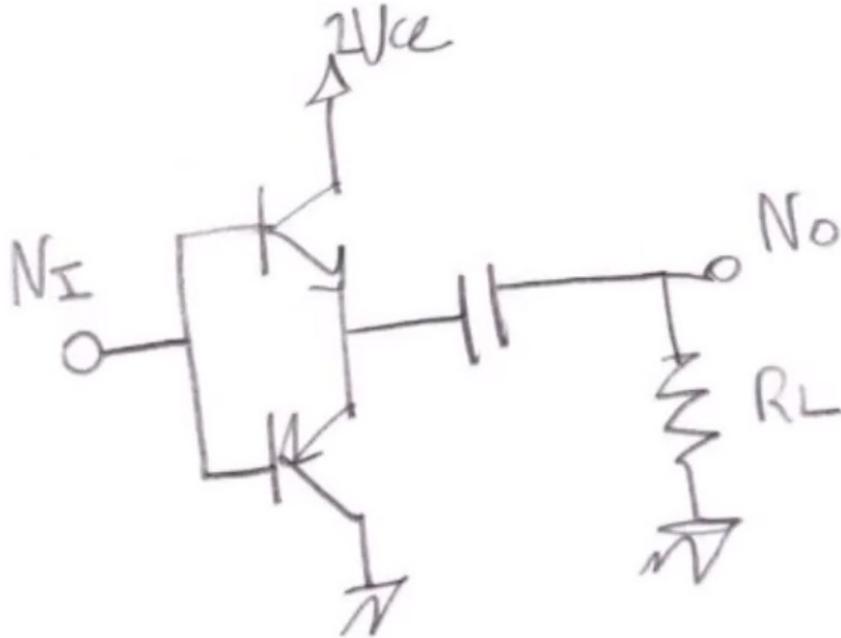
$$\eta = \frac{\bar{P}_L}{\bar{P}_S} = \frac{\pi}{4} \frac{\hat{v}_o}{V_{CC}}$$

$$P_D = P_S - P_L = \frac{2V_{CC}\hat{v}_o}{R_L\pi} - \frac{\hat{v}_o^2}{2R_L}$$



# Clase B

Operación con fuente única



# Clase B

Reducción de distorsión por cruce (de  $V_{BEon}$  a  $V_{BEon}/A_0$ )

