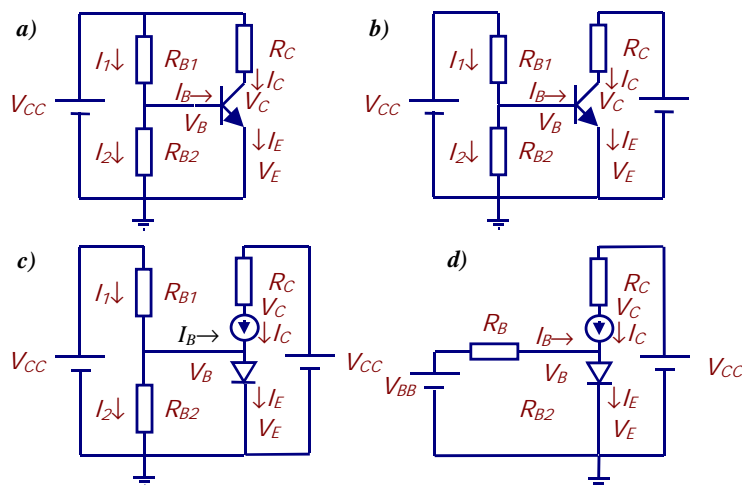




## El Transistor Bipolar: Polarización y Amplificación



## Polarización en emisor común





## Cálculo del punto de polarización

$$I_B = \frac{V_{BB} - 0,7V}{R_B}$$

$$I_C = \beta I_B$$

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

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

Resolver para  $V_{CC}=10V$ ,  $R_{B1}=80K\Omega$ ,  
 $R_{B2}=20K\Omega$ ,  $R_C=1K\Omega$  y  $\beta=100$



## Modelo de pequeña señal del TB

$$I_E = I_{Es} \left( e^{\frac{qV_{BE}}{kT}} - 1 \right)$$

$$I_E = I_B + I_C = I_B + \beta I_B = (1 + \beta) I_B$$

$$I_B = \frac{I_{Es}}{1 + \beta} \left( e^{\frac{qV_{BE}}{kT}} - 1 \right)$$



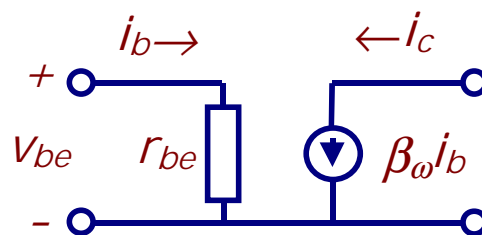
## Resistencia dinámica de base



$$\frac{i_b}{v_{be}} \approx \frac{\partial I_B}{\partial V_{BE}} = \frac{I_{Es}}{1 + \beta} \frac{q}{kT} e^{\frac{qV_{BE}}{kT}} \approx \frac{qI_B}{kT} = g_{be}$$
$$r_{be} = \frac{1}{g_{be}} = \frac{kT}{qI_B}$$

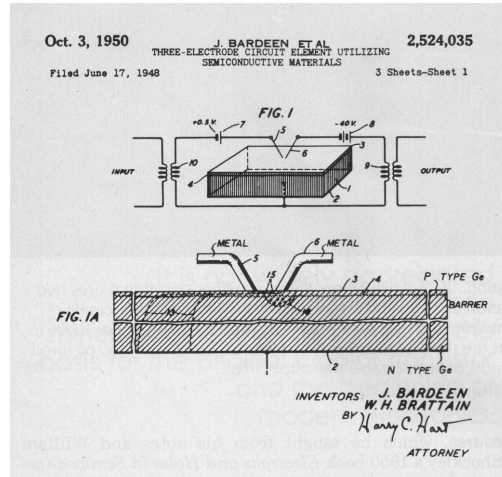


## Modelo equivalente





## El TB como amplificador



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## Evolución Tecnológica

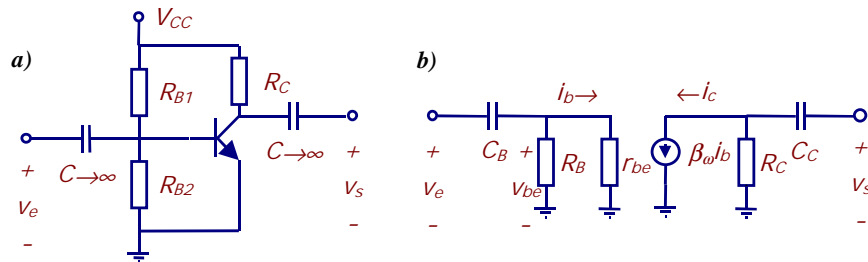


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## Equivalente de pequeña señal



## Amplificación (I)



$$i_e = \frac{v_e}{\frac{1}{j\omega C_B} + \frac{R_B r_{be}}{R_B + r_{be}}} =$$

$$= v_e \frac{j\omega C_B (R_B + r_{be})}{R_B + r_{be} + j\omega C_B R_B r_{be}}$$



## Amplificación (II)



$$i_b = i_e \frac{\frac{1}{R_B} + \frac{1}{r_{be}}}{\frac{1}{R_B} + \frac{1}{r_{be}}} = i_e \frac{R_B}{R_B + r_{be}} =$$
$$= v_e \frac{j\omega C_B R_B}{R_B + r_{be} + j\omega C_B R_B r_{be}}$$



## Amplificación (III)



$$i_c = \beta \omega i_b = v_e \beta \omega \frac{j\omega C_B R_B}{R_B + r_{be} + j\omega C_B R_B r_{be}}$$

$$v_s = -i_c R_C = -v_e \beta \omega \frac{j\omega C_B R_B R_C}{R_B + r_{be} + j\omega C_B R_B r_{be}}$$



## Amplificación (IV)



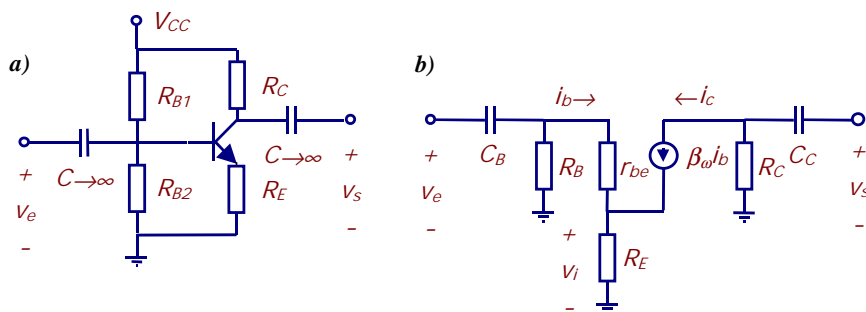
$$G = \frac{v_s}{v_e} = -\beta\omega \frac{j\omega C_B R_B R_C}{R_B + r_{be} + j\omega C_B R_B r_{be}}$$

$$R_B + r_{be} \ll j\omega C_B R_B r_{be}$$

$$G = \frac{v_s}{v_e} \cong -\beta\omega \frac{j\omega C_B R_B R_C}{j\omega C_B R_B r_{be}} = -\beta\omega \frac{R_C}{r_{be}}$$



## Autopolarizador





## Autopolarizador (II)



$$i_E = \frac{v_e - v_i}{r_{be}} + \beta i_b = + \frac{v_e - v_i}{r_{be}} + \beta \frac{v_e - v_i}{r_{be}}$$

$$i_E = (\beta + 1) \frac{v_e - v_i}{r_{be}}$$



## Autopolarizador (III)



$$v_i = i_E R_E = (\beta + 1) R_E \frac{v_e - v_i}{r_{be}}$$

$$v_i = v_e \frac{(\beta + 1) R_E}{r_{be} + (\beta + 1) R_E}$$

$$v_e - v_i = v_e \frac{r_{be}}{r_{be} + (\beta + 1) R_E}$$



## Autopolarizador (IV)



$$i_b = \frac{v_e}{r_{be} + (\beta + 1)R_E}$$

$$i_c = \beta i_b = v_e \frac{\beta}{r_{be} + (\beta + 1)R_E}$$

$$v_s = -i_c R_C = -v_e \frac{\beta R_C}{r_{be} + (\beta + 1)R_E}$$



## Autopolarizador (V)



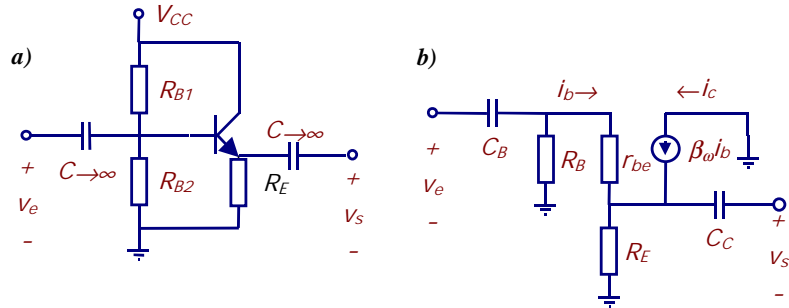
$$G = \frac{v_s}{v_e} = - \frac{\beta R_C}{r_{be} + (\beta + 1)R_E}$$

$$r_{be} \ll \beta R_E$$

$$G \cong - \frac{R_C}{R_E}$$



## Colector común



$$Z_e = \frac{v_e}{i_e} \cong \beta R_E$$