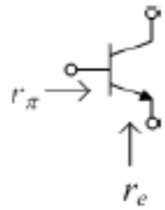
Miglioramenti del modello a T:

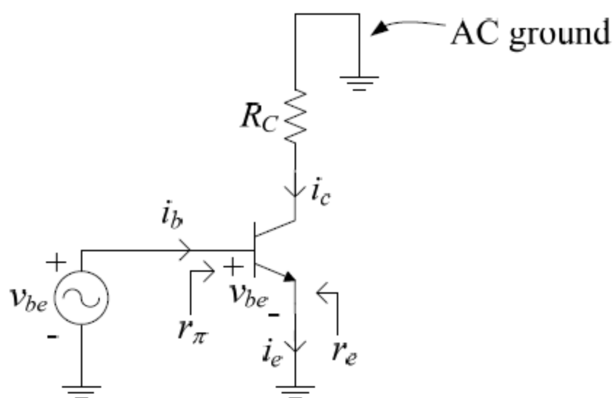
Resistenze equivalenti 'guardando' nella base e nell' emettitore



$$r_e = \frac{V_T}{I_C}$$ resistenza dinamica della giunzione BE in zona attiva

$$g_m = \frac{1}{r_e} = \frac{I_C}{V_T}$$ transconduttanza (per piccoli segnali) del transistor

$$g_m = \frac{1}{r_e} \sim \frac{dI_C}{dV_{BE}} \sim \frac{i_c}{v_{be}} \rightarrow i_c \simeq g_m v_{be} \rightarrow i_b \simeq \frac{g_m}{\beta} v_{be}$$



$$r_\pi = \frac{v_{be}}{i_b} = \frac{\beta}{g_m} = \frac{\beta V_T}{I_C}$$

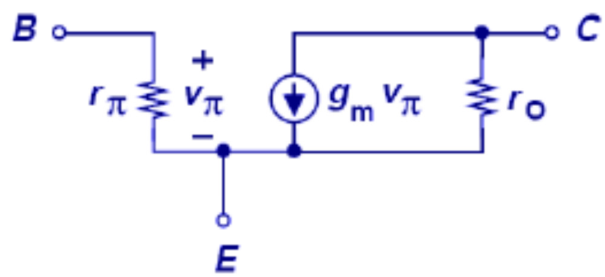
$$i_E = \frac{i_C}{\alpha} = \frac{I_C}{\alpha} + \frac{i_c}{\alpha}$$

$$i_e = \frac{i_c}{\alpha} = \frac{I_C}{\alpha}\frac{v_{be}}{V_T} = \frac{I_E v_{be}}{V_T}$$

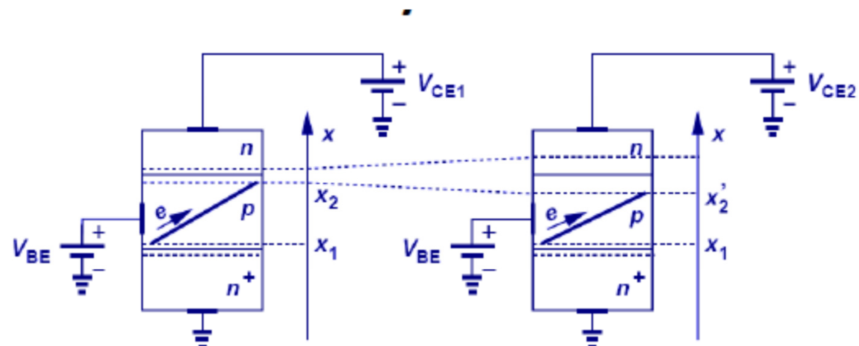
$$r_e = \frac{v_{be}}{i_e} = \frac{V_T}{I_E} = \frac{\alpha}{g_m}\left(\approx \frac{1}{g_m}\right)$$

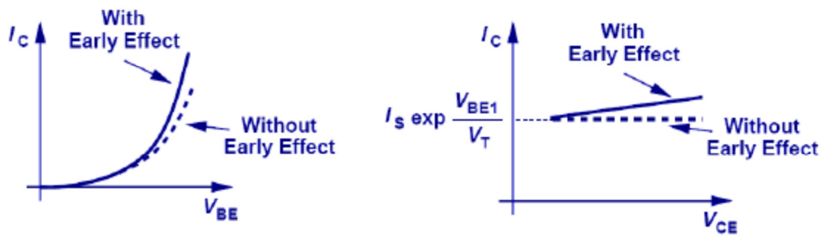
$$\rightarrow r_\pi = \frac{\beta}{g_m} = \frac{\beta}{\alpha} r_e = \frac{\beta}{\beta}(\beta+1) r_e = (\beta+1) r_e$$

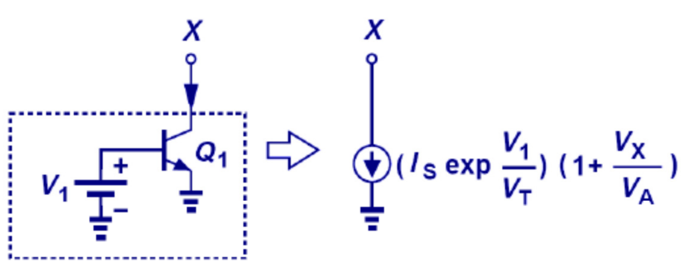
Modello a π ibrido: Versione a bassa frequenza



r_0 legata all'effetto Early: I_C non indipendente da V_{CE}

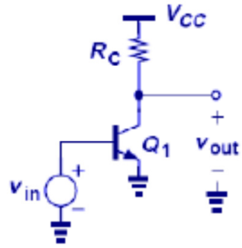


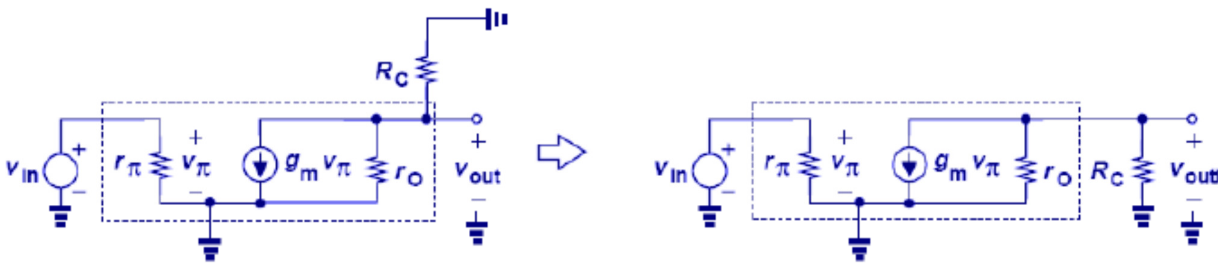




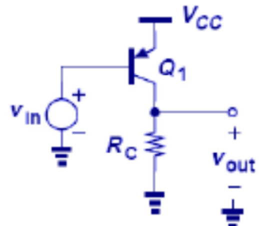
C generatore non ideale di corrente $\rightarrow r_0 < \infty$ in parallelo al generatore di corrente

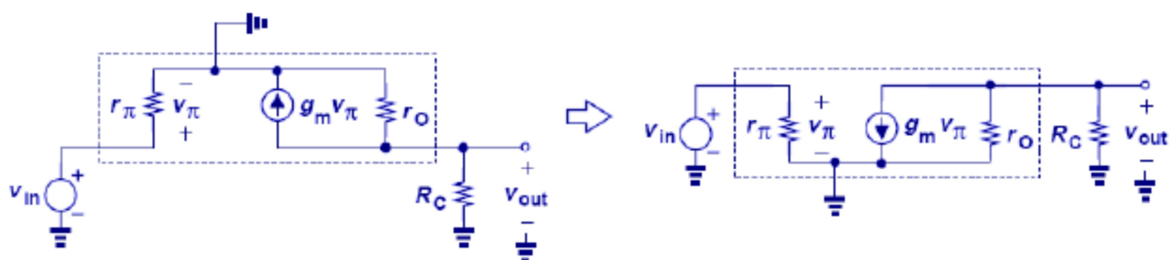
Esempio: Applicazione a stadio semplice CE





Identico per PNP:





Impedenze intrinseche del BJT (in zona attiva!):

Base: Si 'guarda' dentro B

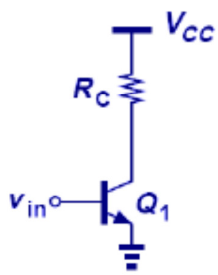
$R_b = r_\pi$; stato uscita irrilevante perche' r_π a ground

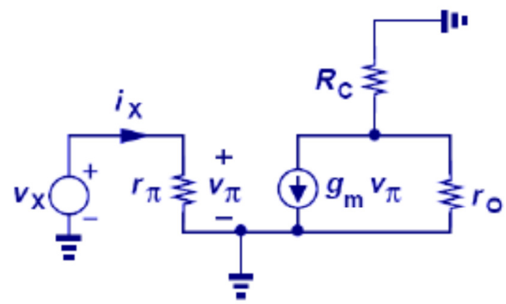
Collettore: Si 'guarda' dentro C

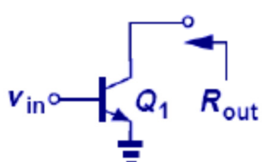
$R_c = r_0 \simeq \infty,\ r_0 \to \infty;$ B (ed E) a ground $\to v_\pi = 0 \to g_m v_\pi = 0$

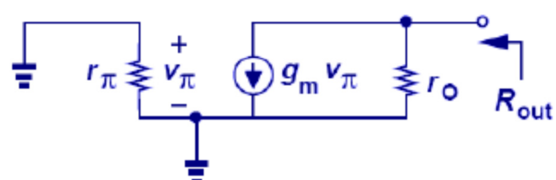
Emettitore: Si 'guarda' dentro E

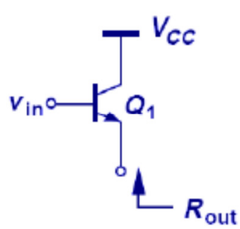
$$R_e = \frac{v_x}{i_x} = \frac{1}{g_m + \frac{1}{r_\pi}} \simeq \frac{1}{g_m},\ r_0 \to \infty;\ \text{B e C a ground} \to i_x = \frac{v_\pi}{r_\pi} + g_m v_\pi$$

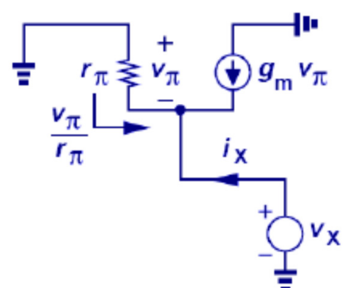








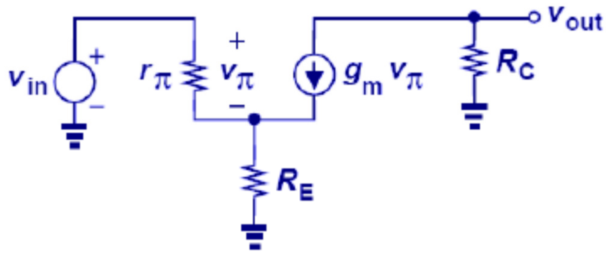




Applicazione: Stadio *CE* con resistenza su emettitore

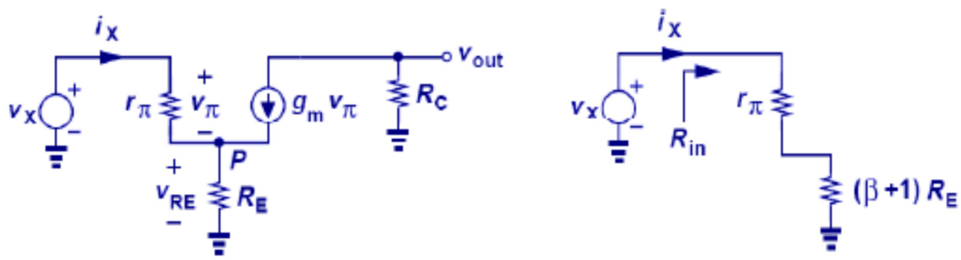
NB: Non considerate resistenze del partitore di bias

Non considerato effetto Early



$$A_v = -\frac{g_m R_C}{1 + g_m R_E} = -\frac{R_C}{\frac{1}{g_m} + R_E}$$

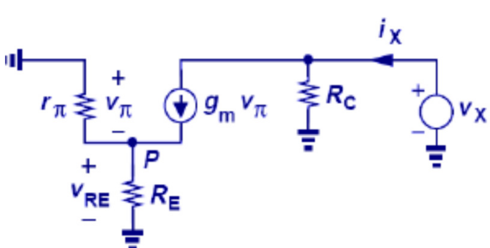
Impedenza di ingresso:



$$v_x = \left[r_\pi + R_E (1+\beta) \right] i_x$$

$$\rightarrow R_{in} = \frac{v_x}{i_x} = r_\pi + R_E (1+\beta)$$

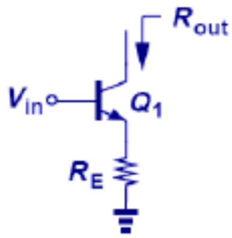
Impedenza di uscita:

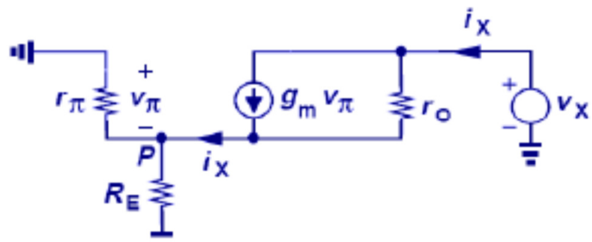


$$v_{in} = v_\pi + \left(\frac{v_\pi}{r_\pi} + g_m v_\pi \right) R_E = 0 \rightarrow v_\pi = 0$$

$$\rightarrow R_{out} = \frac{v_x}{i_x} = R_C$$

Tenendo conto dell'effetto Early:

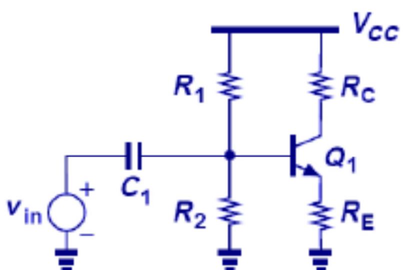


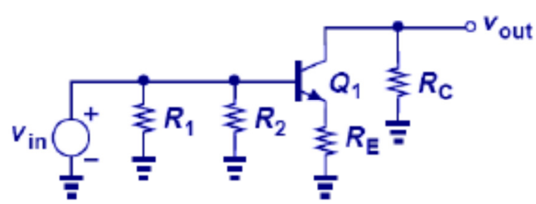


$$R_{out} = \left[1 + g_m (R_E \parallel r_\pi)\right] r_O + R_E \parallel r_\pi$$
$$R_{out} = r_O + (g_m r_O + 1)(R_E \parallel r_\pi)$$
$$R_{out} \approx r_O \left[1 + g_m (R_E \parallel r_\pi)\right]$$

R_{out} aumentata → Migliorato generatore di corrente

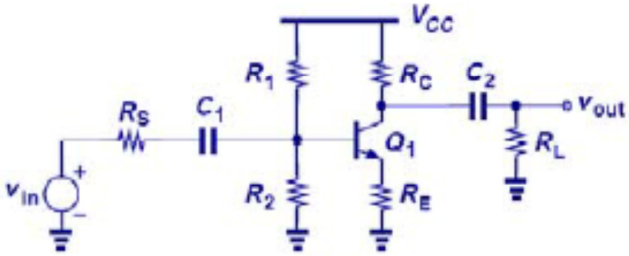
Tenendo conto del partitore di bias:



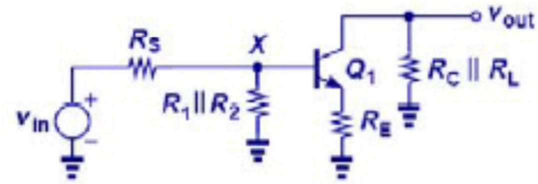


$$A_v = \frac{-R_C}{\dfrac{1}{g_m} + R_E}$$
$$R_{in} = \left[r_\pi + (\beta + 1) R_E\right] \parallel R_1 \parallel R_2$$
$$R_{out} = R_C$$

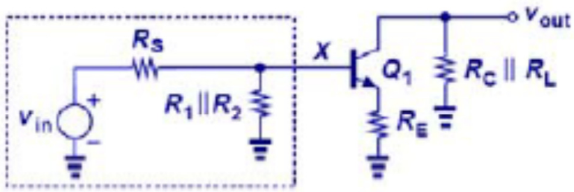
Al gran completo:



(a)



(b)



(b)

$$A_v = \frac{-R_C \parallel R_L}{\frac{1}{g_m} + R_E + \frac{R_s \parallel R_1 \parallel R_2}{\beta + 1}}$$