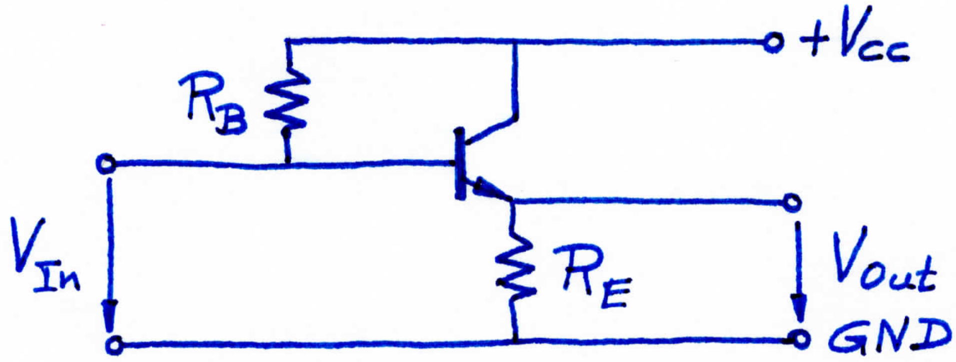
Common - collector circuit

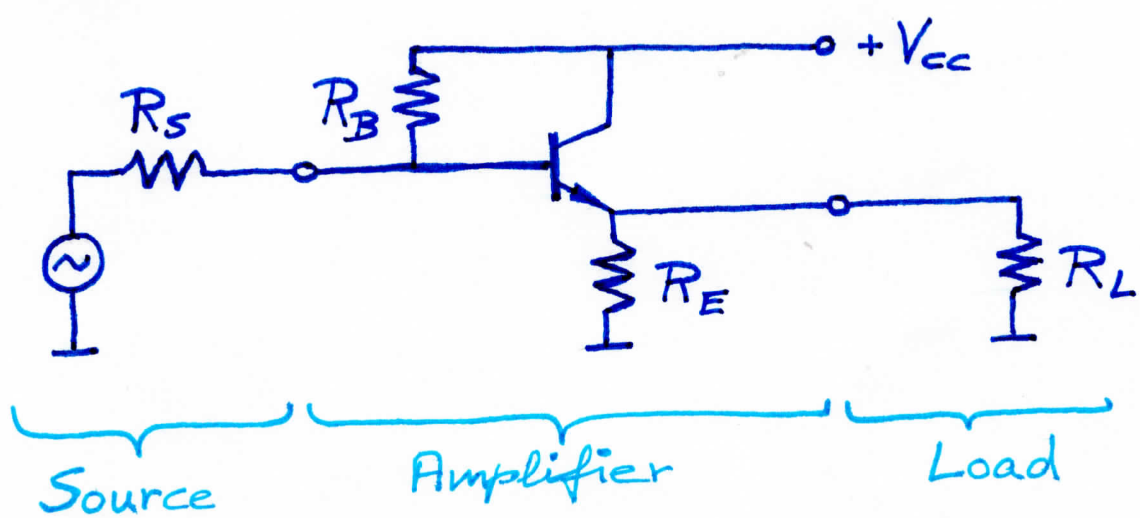
⇒ **Emitter follower**



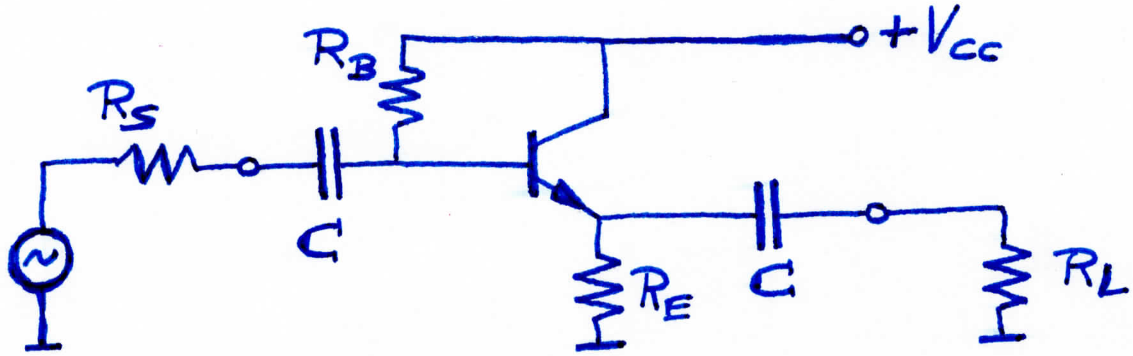
$$V_{out} = V_{In} - V_{BE} = V_{In} - 0.7\,V$$

⇒ V_{out} follows V_{In} but is $0.7\,V$ smaller than V_{In} ⇒ **Emitter follower**

Connect source and load



AC coupling capacitors (to decouple source and load from DC bias of transistor



DC analysis $\Rightarrow$ Quiescent point (Q-point)

KVL $\qquad I_B R_B + \underbrace{V_{BE}}_{0.7V} + \underbrace{I_E}_{(\beta+1)I_B} R_E = V_{cc}$

$\Rightarrow$ One eqn. with one unknown (I_B)

$\Rightarrow$ Solve for I_B

$$\Rightarrow \quad I_B = \frac{V_{cc} - 0.7V}{R_B + (\beta+1)R_E}$$

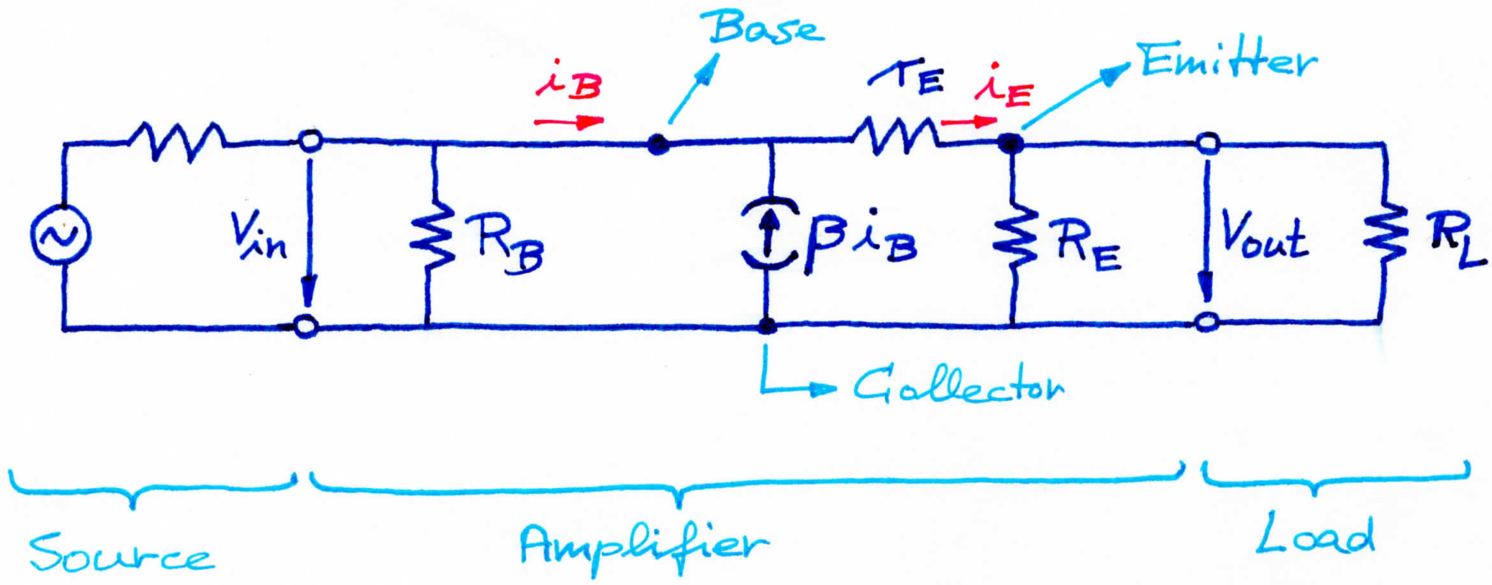
$$\Rightarrow \quad I_E = (\beta+1) I_B \qquad\qquad I_C = \beta I_B$$

$$V_E = I_E R_E = (\beta+1) I_B R_E$$

$$V_{CE} = V_{cc} - V_E$$

$\Rightarrow$ This completes Q-point calculation

AC analysis $\Rightarrow$ AC equivalent circuit



OC voltage gain A_{voc}

$$A_{voc} = \frac{V_{out}}{V_{in}} = \frac{i_E R_E}{i_E r_E + i_E R_E} = \frac{R_E}{r_E + R_E}$$

$\Rightarrow A_{voc} < 1$

Recall: $r_E \ll R_E \Rightarrow A_{voc} \approx \dfrac{R_E}{R_E} \approx 1$

$\Rightarrow \boxed{A_{voc} \lessapprox 1} \Rightarrow V_{out} \approx V_{in}$

Input impedance Z_{in}

$$Z_{in} = \frac{V_{in}}{i_{in}} = \frac{V_{in}}{i_{RB} + i_B} = \left(\frac{i_{RB} + i_B}{V_{in}}\right)^{-1}$$

$$= \left(\frac{1}{R_B} + \frac{i_B}{V_{in}}\right)^{-1} = R_B \parallel \frac{V_{in}}{i_B}$$

$$= R_B \parallel \frac{i_E (r_E + R_E)}{i_B} = R_B \parallel (\beta+1)(r_E + R_E)$$

$$\approx R_B \parallel \beta (r_E + R_E)$$

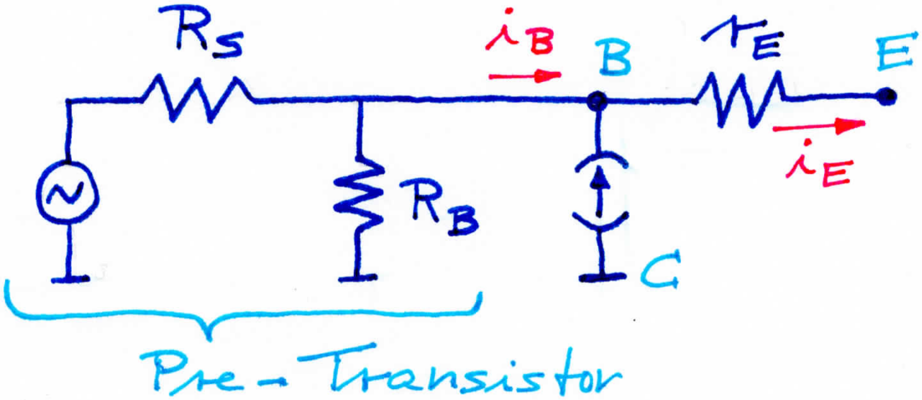
Note: Base bias network generally more resistive than R_E. Also: $r_E \ll R_E$

$\Rightarrow$ $Z_{in} \approx \beta R_E$

$\Rightarrow$ Emitter follower has high input impedance.

Output impedance z_{out}

$$z_{out} = \frac{v_{out}}{i_{out}} = R_E \parallel (r_E + \underbrace{z_{pre-T}}_{z_{\text{pre-Transistor}}})$$



$$z_{pre-T} = \frac{v_{pre-T}}{i_E} = \frac{i_B (R_S \parallel R_B)}{i_E} = \frac{i_B (R_S \parallel R_B)}{(\beta+1)\, i_B}$$

$$= \frac{R_S \parallel R_B}{\beta + 1}$$

$$\Rightarrow \quad z_{out} = R_E \parallel \left(r_E + \frac{R_S \parallel R_B}{\beta+1} \right)$$

$$\Rightarrow \quad z_{out} \leq R_E$$

⇒ z_{out} is much smaller than z_{in}

⇒ Difference is a factor of β

SC current gain A_{ISC}

$$A_{ISC} = \frac{i_{out}}{i_{in}} = \frac{(\beta+1)\, i_B}{i_B + i_{RB}} = \frac{\beta + 1}{1 + \frac{i_{RB}}{i_B}}$$

Assume $i_{RB} \approx i_B \Rightarrow A_{ISC} = \beta/2$

Assume $i_{RB} \ll i_B \Rightarrow A_{ISC} = \beta$

$\Rightarrow$ $A_{ISC} \leq \beta$

Summary of emitter follower

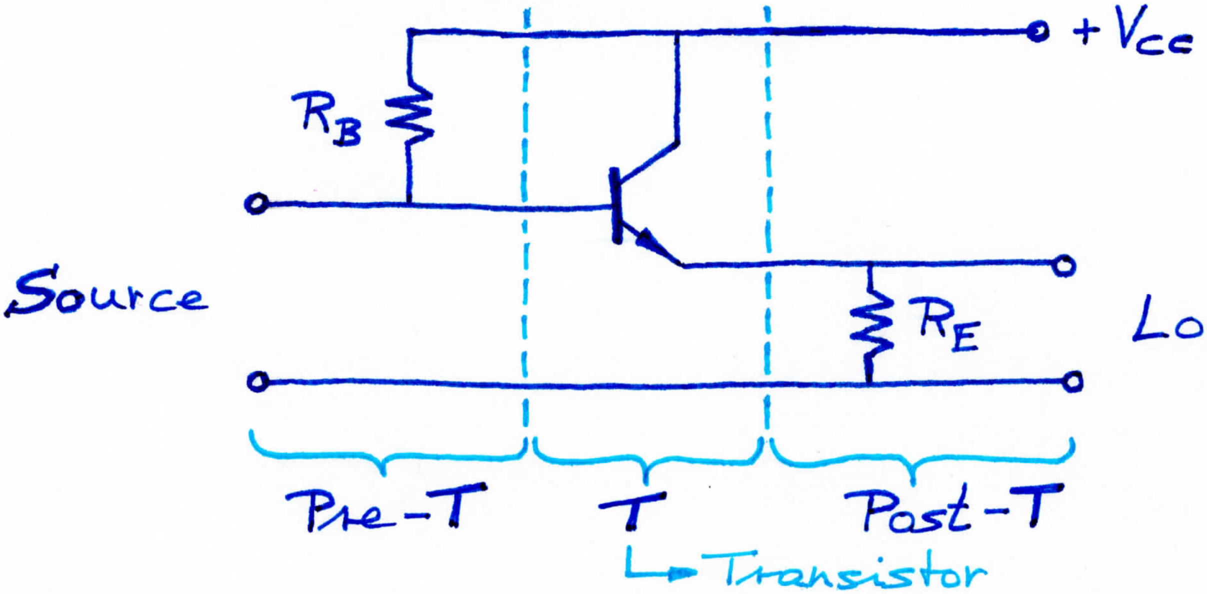
$Z_{in} \approx \beta R_E$ (high)

$Z_{out} \approx R_E$ (low)

$A_{VOC} \approx 1$ (low)

$A_{ISC} \leq \beta$ (high)

Note on resistance transformation



Note: When applying a signal i_B to the input side, the current through R_E is $(\beta+1)\, i_B$. Accordingly, the voltage drop across R_E is $i_B(\beta+1)R_E$, so that the resistance appears to be $(\beta+1)\, R_E$

Note: When applying a signal i_E to the output side, the current through R_B is $\frac{i_E}{\beta+1}$. Accordingly, the voltage drop across R_B is $i_E \frac{1}{\beta+1} R_B$, so that the resistance appears to be $R_B/(\beta+1)$.