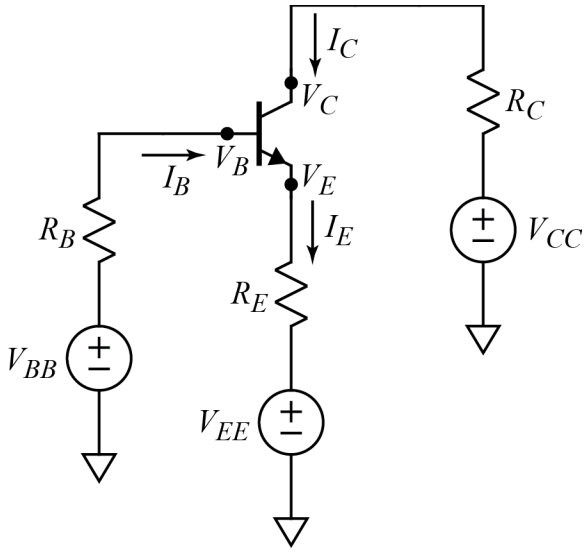
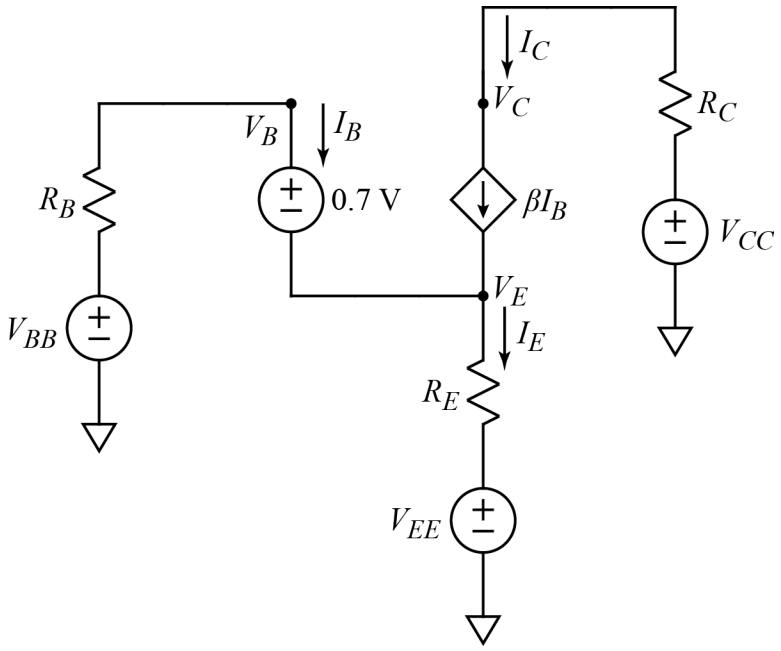
MODEL: Amplifier Circuit

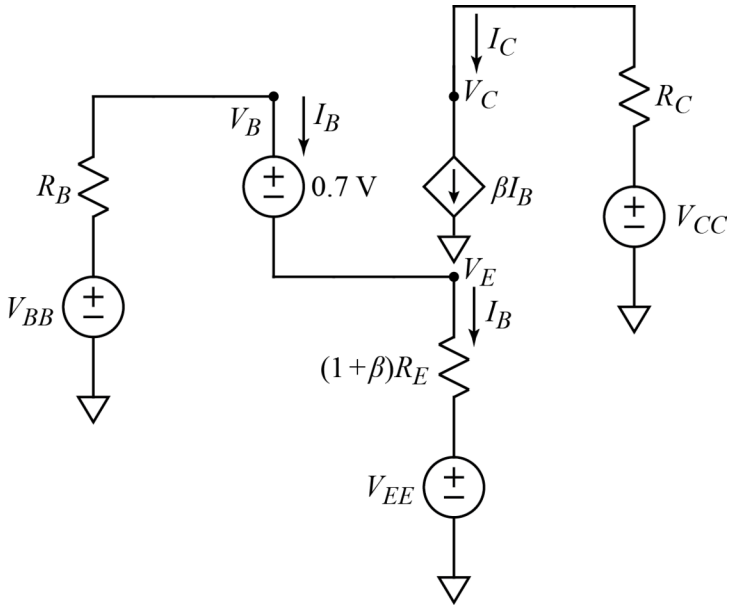


MODEL: DC Model



NOTE: 1) Circuits connected to Base, Emitter, and Collector are converted to Thévenin equivalents.

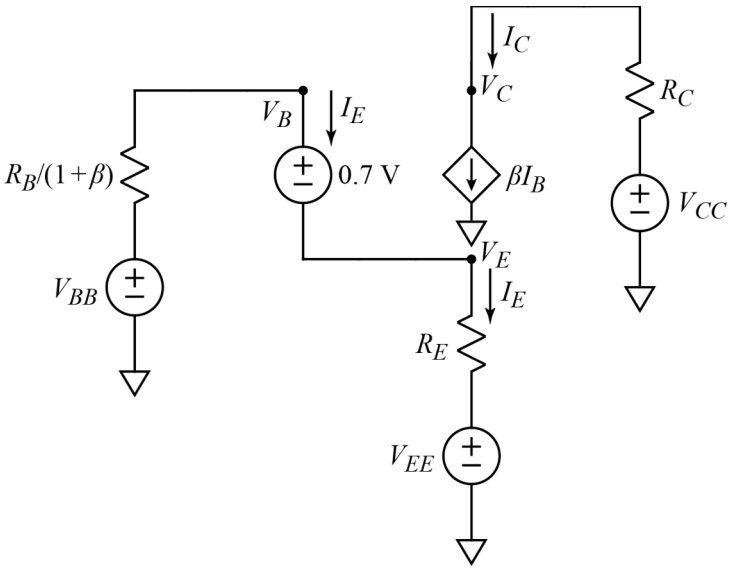
MODEL: DC model for I_B based on reflected resistance



NOTES: 1) All values in the model have the correct value except I_E.

2) The dependent source is now disconnected from emitter and is terminated at reference.

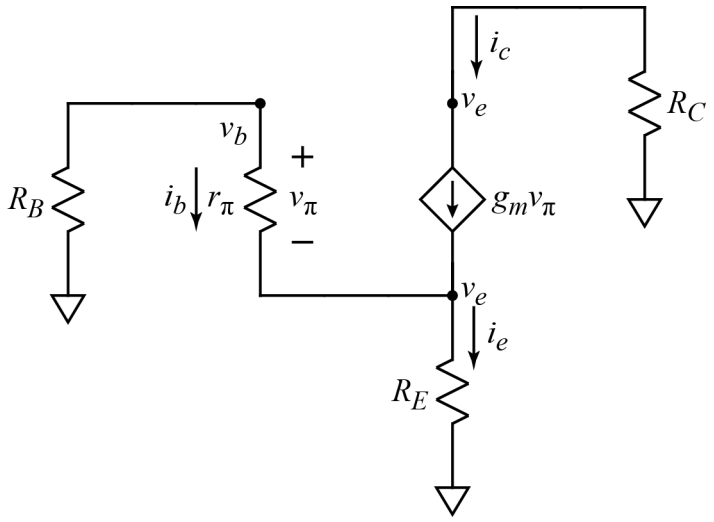
MODEL: DC model for I_E based on reflected resistance



NOTES: 1) All values in the model have the correct value except I_B.

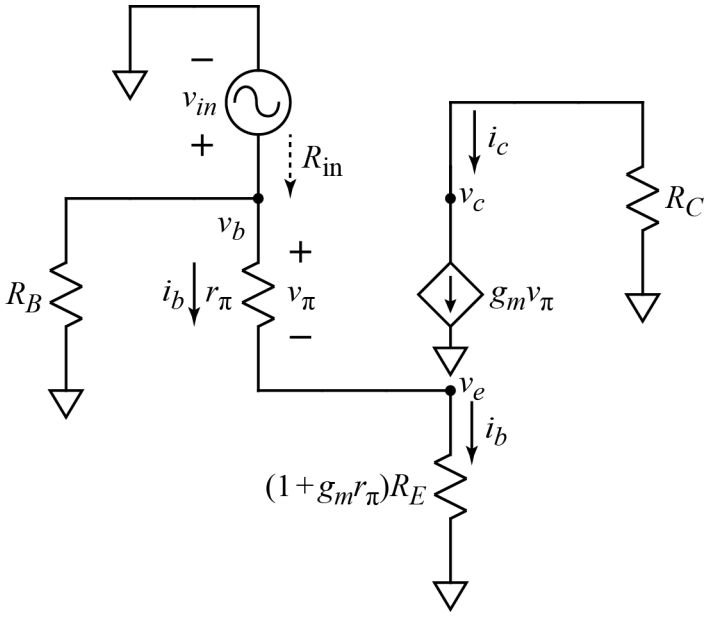
2) The dependent source is now disconnected from emitter and is terminated at reference.

MODEL: AC Model



NOTE: 1) Independent DC sources are set to zero, $r_\pi = v_T / I_B$ where $v_T = kT/q$ is the thermal voltage. $v_T \approx 26$ mV at room temperature.

MODEL: AC Model for signal into base, reflected R model



$$R_{\text{in}} = R_B || [r_\pi + (1+g_m r_\pi)R_E]$$

$$v_e = v_{in}\frac{(1+g_m r_\pi)R_E}{r_\pi + (1+g_m r_\pi)R_E}$$

$$i_c = v_{in}\frac{g_m r_\pi}{r_\pi + (1+g_m r_\pi)R_E}$$

$$A_v = \frac{v_c}{v_{in}} = -\frac{(g_m r_\pi)R_E}{r_\pi + (1+g_m r_\pi)R_E} \quad \text{(output taken from collector)}$$

$$A_v = \frac{v_e}{v_{in}} = \frac{(1+g_m r_\pi)R_E}{r_\pi + (1+g_m r_\pi)R_E} \quad \text{(output taken from emitter)}$$

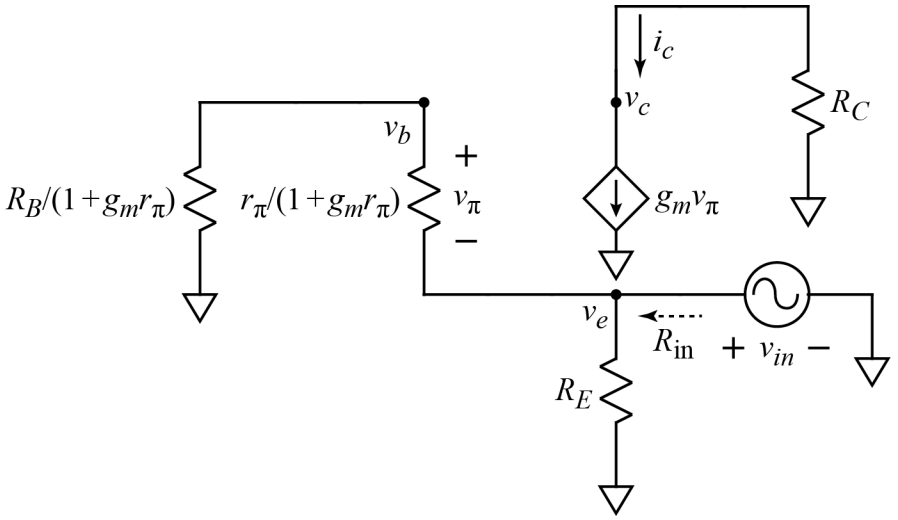
$$R_{\text{out}} = R_E || \frac{R_B + r_\pi}{1+g_m r_\pi} \quad \text{(see Note 3)}$$

NOTES: 1) All values in the model have the correct value except i_e.

2) The dependent source is now disconnected from emitter and is terminated at reference.

3) See next model circuit where R_{in} becomes R_{out} if output is taken from emitter.

MODEL: AC Model for signal into emitter, reflected R model



$$R_{\text{in}} = R_E || \frac{R_B + r_\pi}{1 + g_m r_\pi}$$

$$i_c = g_m v_\pi = -v_{in} g_m \frac{r_\pi}{r_\pi + R_B}$$

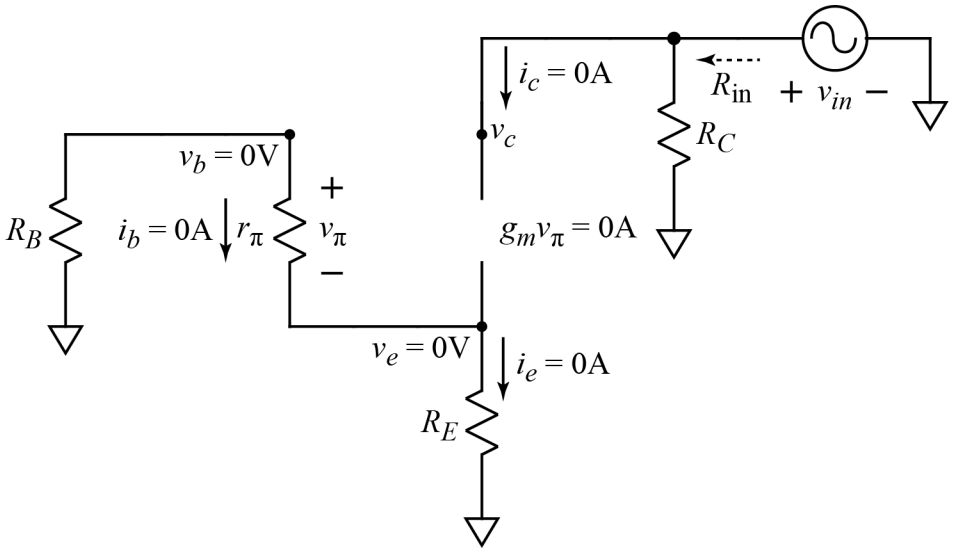
$$v_c = -i_c R_C = v_{in} g_m \frac{r_\pi R_C}{r_\pi + R_B}$$

$$A_v = \frac{v_c}{v_{in}} = \frac{g_m r_\pi R_C}{r_\pi + R_B} \quad \text{(output taken from collector)}$$

NOTE: 1) All values in the model have the correct value except i_b.

2) R_{in} becomes R_{out} and gives correct value if output is taken from emitter, as in previous model circuit.

MODEL: AC Model for signal into collector, reflected *R* model



$$R_{in} = R_C$$

$$i_b = 0\text{ A} \qquad i_e = 0\text{ A} \qquad v_b = 0\text{ V} \qquad v_e = 0\text{ V}$$

NOTE: 1) All values in the model have the correct value.

2) R_{in} becomes R_{out} and gives correct value if output is taken from collector.

REF: Adel S. Sedra and Kenneth C. Smith, *Microelectronic Circuits, 5th Ed.,* New York, NY: Oxford University Press, 2004.