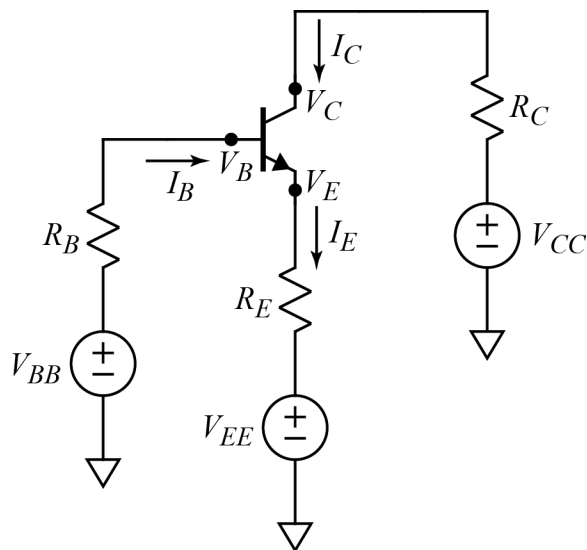
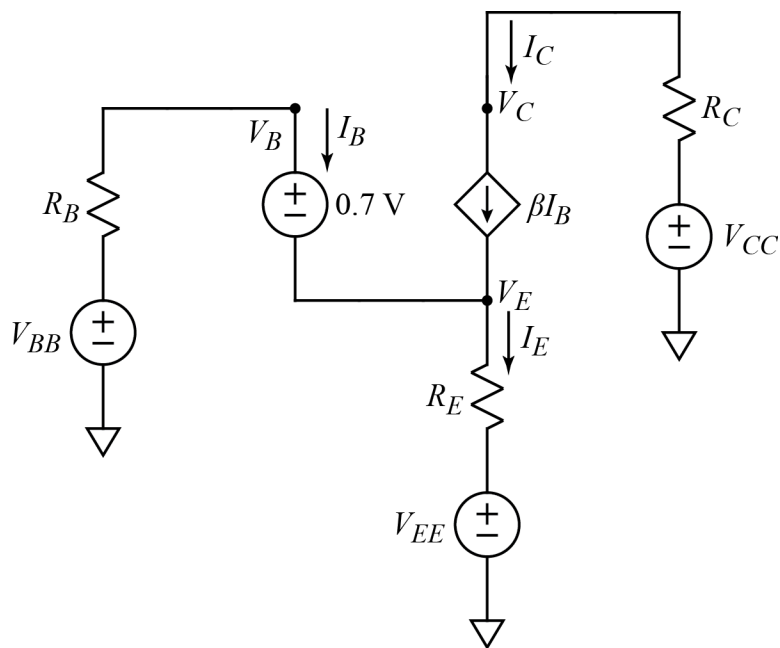


MODEL: Amplifier Circuit

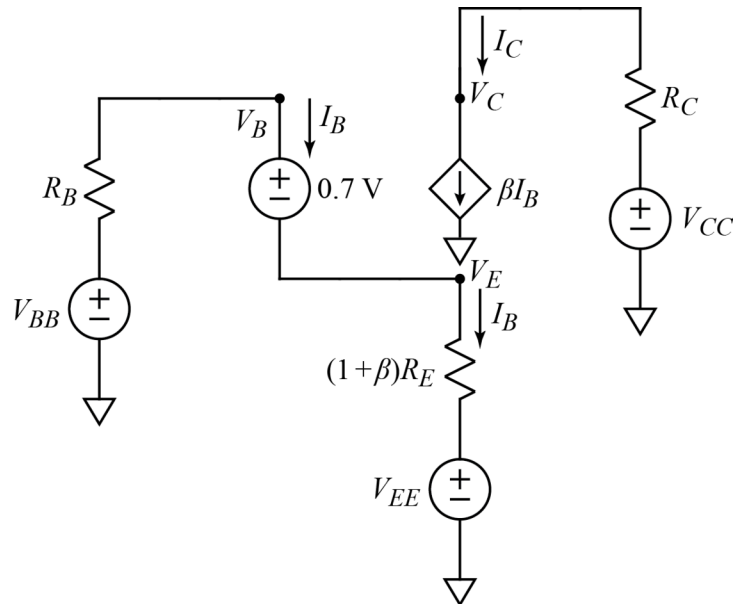


MODEL: DC Model



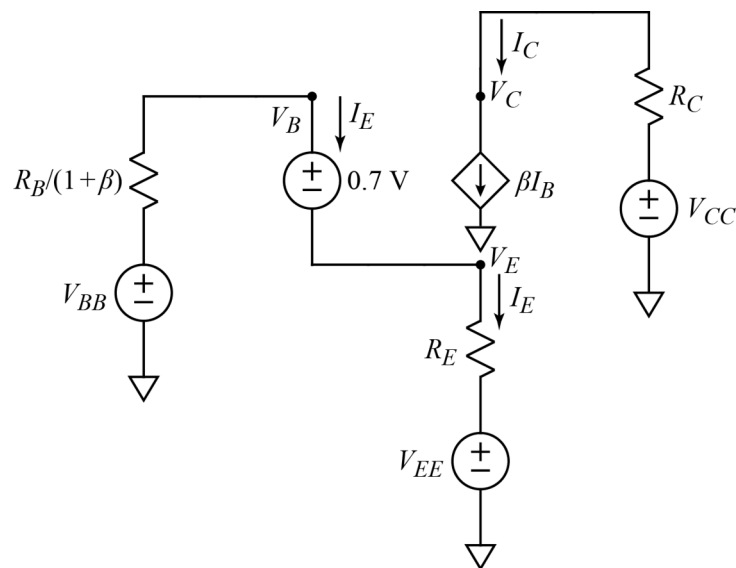
NOTE: 1) Circuits connected to Base, Emitter, and Collector are converted to Thévenin equivalents.

MODEL: DC model for I_B based on reflected resistance



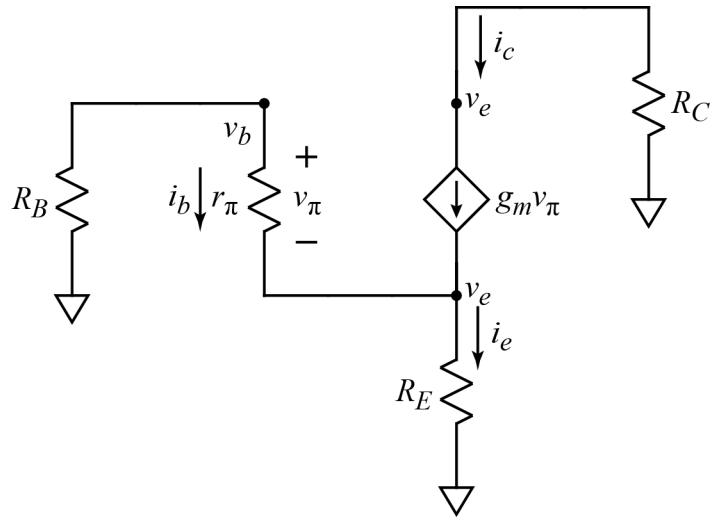
- NOTES:** 1) All values in the model have the correct value except I_E .
2) The dependent source is now disconnected from emitter and is terminated at reference.

MODEL: DC model for I_E based on reflected resistance



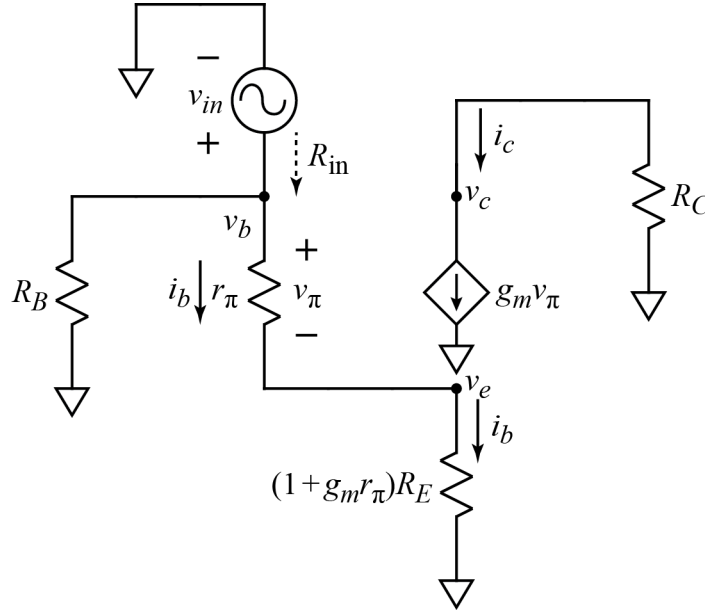
- NOTES:** 1) All values in the model have the correct value except I_B .
2) The dependent source is now disconnected from emitter and is terminated at reference.

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



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

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

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

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

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

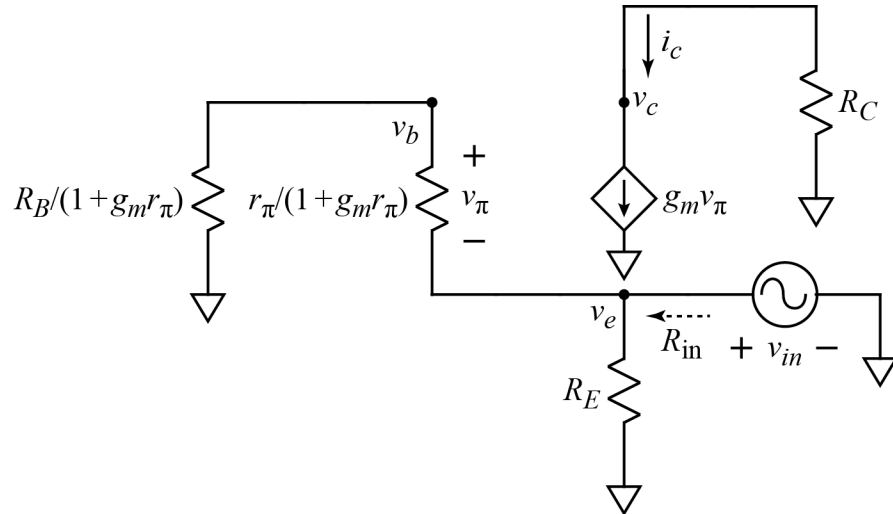
$$R_{out} = R_E || \frac{R_B + r_{\pi}}{1 + g_m r_{\pi}} \quad (\text{see Note 3})$$

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



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

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

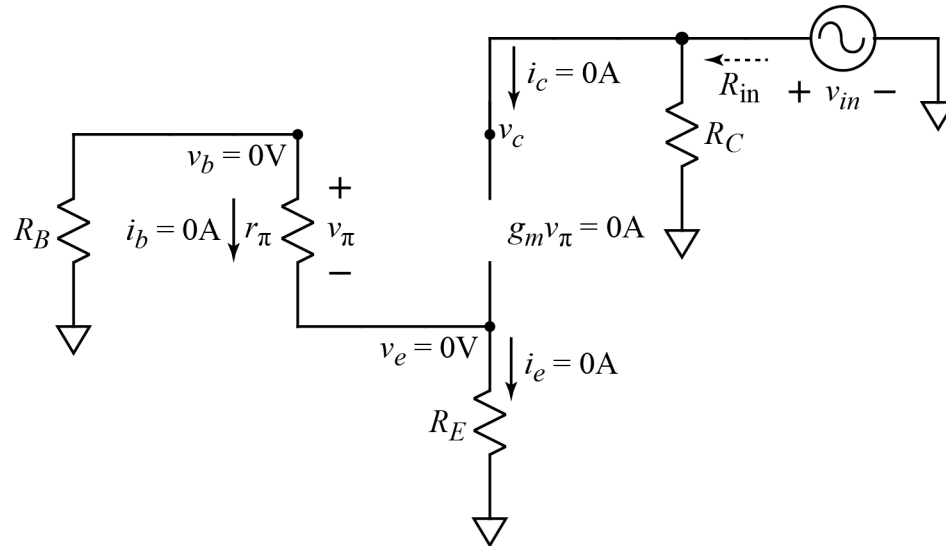
$$v_c = -i_c R_C = v_{in} g_m \frac{r_\pi R_C}{r_\pi + R_B}$$

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

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



$$R_{in} = R_C$$

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

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.