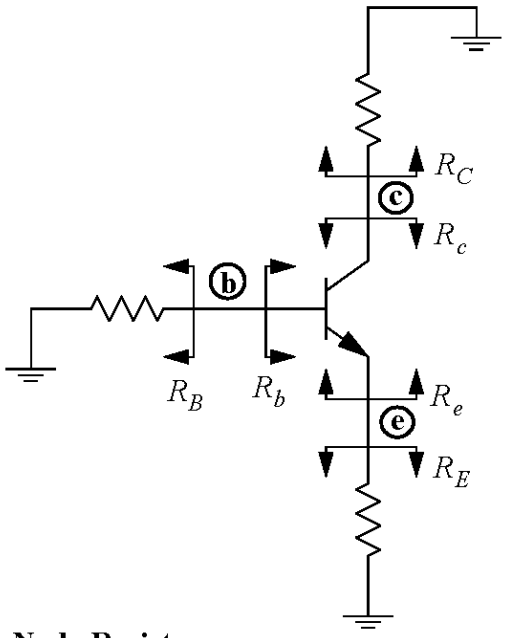
Useful Inspection Formulas

The General Case (Midband)



$$R_b = (r_e + R_E)(\beta + 1) = r_\pi + (\beta + 1)R_E$$

$$R_e = \frac{r_\pi + R_B}{\beta + 1} \cong \frac{1}{g_m} + \frac{R_B}{\beta + 1}$$

$$R_c = r_o\left[1 + \frac{g_m R_E}{1 + (R_E / r_\pi)}\right]$$

Base-to-Collector Gain:

$$\frac{v_c}{v_b} = -G_m R_{\textcircled{c}} \qquad G_m = \frac{g_m}{1 + g_m R_E}$$

Emitter-to-Collector Gain:

$$\frac{v_c}{v_e} = -G_m R_{\textcircled{c}} \qquad G_m = -\left(\frac{r_\pi}{r_\pi + R_B}\right) g_m$$

Base-to-Emitter Gain:

$$\frac{v_e}{v_b} = \frac{R_E \| r_o}{R_E \| r_o + r_e}$$

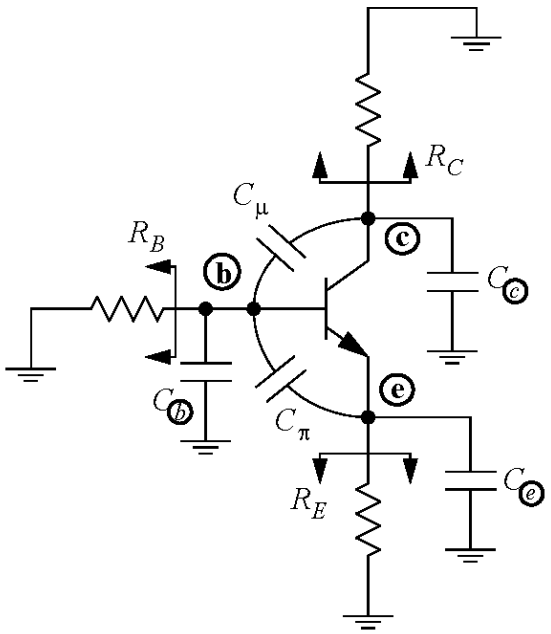
Node Resistances:

$$R_{\textcircled{c}} = R_C \| R_c$$

$$R_{\textcircled{e}} = R_E \| R_e$$

$$R_{\textcircled{b}} = R_B \| R_b$$

High Frequency Analysis



$$\omega_H = \frac{1}{\tau_{\textcircled{b}} + \tau_{\textcircled{c}} + \tau_{\textcircled{e}} + \tau_{\mu o} + \tau_{\pi o}}$$

$$\tau_b = C_{\textcircled{b}} R_{\textcircled{b}}$$

$$\tau_c = C_{\textcircled{c}} R_{\textcircled{c}}$$

$$\tau_e = C_{\textcircled{e}} R_{\textcircled{e}}$$

$$\tau_{\pi o} = C_\pi R_{\pi o}$$

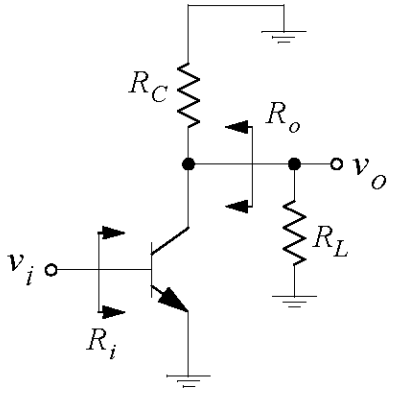
$$\tau_{\mu o} = C_\mu R_{\mu o}$$

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

$$R_{\mu o} = R_{\textcircled{b}} + R_{\textcircled{c}} + G_m R_{\textcircled{c}} R_{\textcircled{b}}$$

Frequent Cases (Midband)

Common Emitter

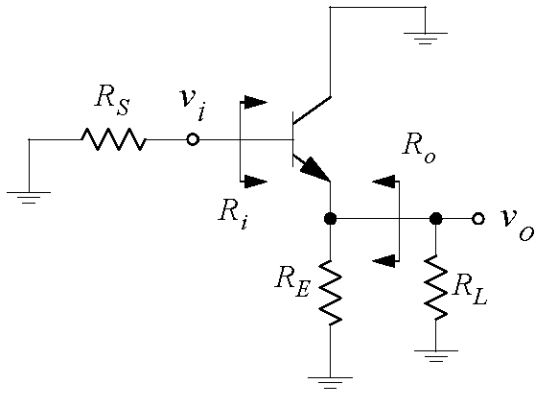


$$R_i = r_\pi$$

$$R_o = r_o \| R_C \approx R_C$$

$$\frac{v_o}{v_i} = -g_m(r_o \| R_C \| R_L) \approx -g_m(R_C \| R_L)$$

Common Collector (Emitter Follower)

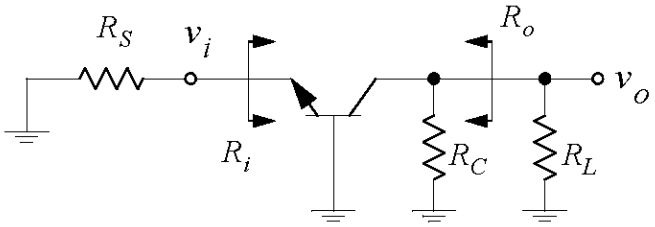


$$R_i = r_\pi + (\beta + 1)(r_o \| R_E \| R_L)$$
$$\approx r_\pi + (\beta + 1)(R_E \| R_L)$$

$$R_o \cong \left(\frac{1}{g_m} + \frac{R_S}{\beta + 1}\right) \| R_E$$

$$\frac{v_o}{v_i} = \frac{(r_o \| R_E \| R_L)}{(r_o \| R_E \| R_L) + r_e} = \frac{(\beta + 1)(r_o \| R_E \| R_L)}{(\beta + 1)(r_o \| R_E \| R_L) + r_\pi} \approx \frac{(\beta + 1)(R_E \| R_L)}{(\beta + 1)(R_E \| R_L) + r_\pi}$$

Common Base



$$R_i = r_e \cong \frac{1}{g_m}$$

$$R_o = r_o(1 + g_m R_S) \| R_C \approx R_C$$

$$\frac{v_o}{v_i} \cong g_m(R_C \| R_L)$$