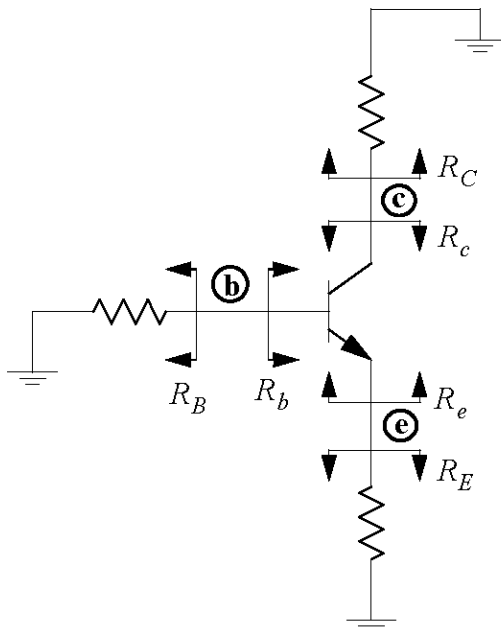


# Useful Inspection Formulas

## The General Case (Midband)



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

$$R_e = \frac{r_\pi + R_B}{\beta + 1} \cong \frac{1}{g_m} + \frac{R_B}{\beta + 1} \quad [r_o \gg R_C]$$

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

### Base-to-Collector Gain:

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

### Emitter-to-Collector Gain:

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

### Base-to-Emitter Gain:

$$\frac{v_e}{v_b} = \frac{R_E \parallel r_o}{R_E \parallel r_o + r_e} \approx \frac{R_E}{R_E + r_e} \approx \frac{g_m R_E}{1 + g_m R_E} \quad [r_o \gg R_E]$$

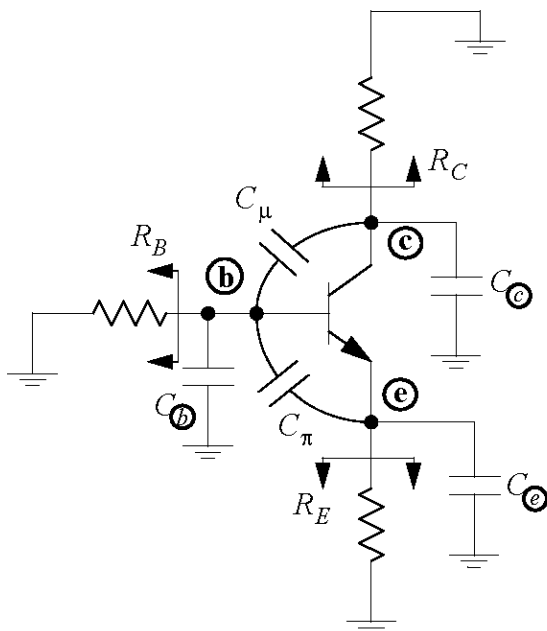
### Node Resistances:

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

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

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

## High Frequency Analysis



$$\omega_H = \frac{1}{\tau_b + \tau_c + \tau_e + \tau_{\mu o} + \tau_{\pi o}}$$

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

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

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

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

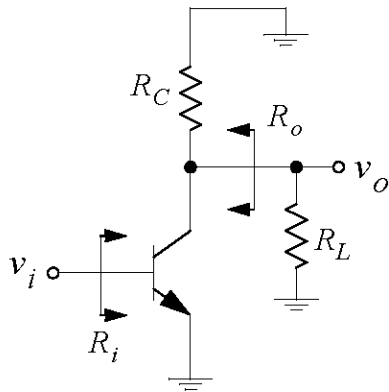
$$\tau_e = C_{e\textcircled{e}} R_{e\textcircled{e}}$$

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

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

## Frequent Cases (Midband)

### Common Emitter

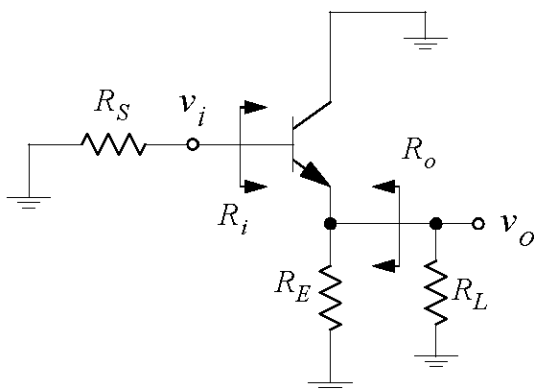


$$R_i = r_\pi$$

$$R_o = r_o \parallel R_C \approx R_C$$

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

### Common Collector (Emitter Follower)



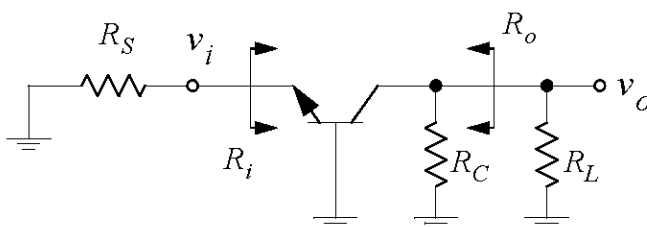
$$R_i = r_\pi + (\beta + 1)(r_o \parallel R_E \parallel R_L)$$

$$\approx r_\pi + (\beta + 1)(R_E \parallel R_L)$$

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

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

### Common Base



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

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

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