

Bi-Junction Transistor Equation Sheet

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Revision 0.2

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Revision History

Revision 0.2

- Added additional equations
- Adjusted formatting of document

General Equations

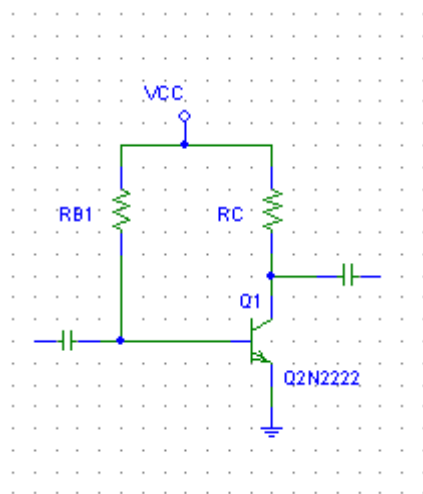
$$r_o = \frac{V_A}{I_C} \quad r_\pi = \frac{V_T}{I_B} \quad V_T = \frac{kT}{q} \approx 25.8\text{mV @ } 300\text{ K}$$

Constants

$$k = 1.602 \times 10^{-19} \text{ C} \quad q = 1.381 \times 10^{-23} \text{ J/K}$$

Common Emitter (Grounded Emitter)

DC Analysis



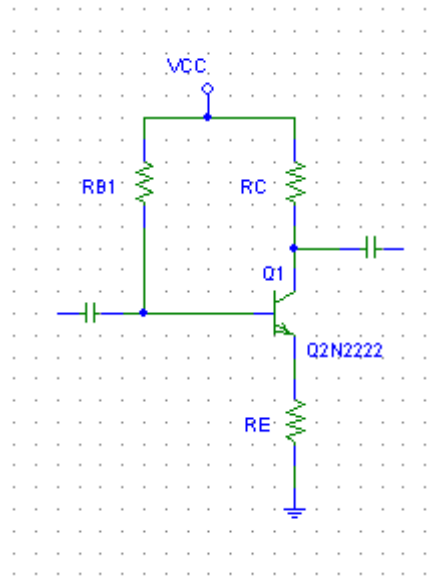
$$I_B = \frac{V_{CC} - 0.7}{R_B} \quad I_E = (\beta + 1)I_B \quad I_C = \beta I_B$$
$$V_B = V_{CC} - (R_B I_B) = 0.7\text{V} \quad V_C = V_{CC} - (R_C I_C) \quad V_E = 0\text{V}$$

AC Analysis

$$A_V = \frac{\beta R_C}{r_\pi} \quad A_I = -\beta \frac{R_B}{R_B + r_\pi}$$
$$r_{in} = R_B || r_\pi \quad r_{out} = R_C || r_O$$

Common Emitter

DC Analysis



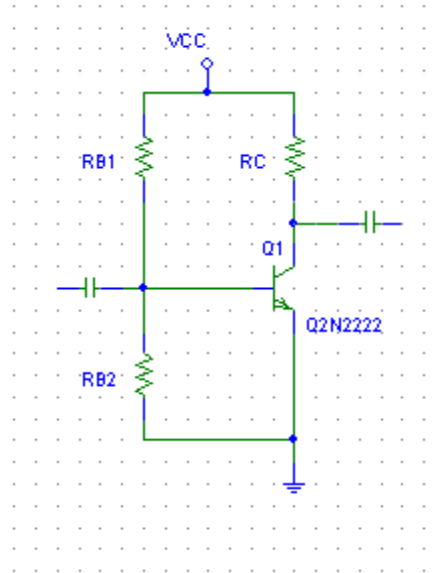
$$I_B = \frac{V_{CC} - 0.7}{R_B + (\beta + 1) R_E} \quad I_C = \beta I_B \quad I_E = (\beta + 1) I_B$$
$$V_B = V_{CC} - I_B R_B \quad V_C = V_{CC} - I_C R_C \quad V_E = I_E R_E$$

AC Analysis

$$A_V = \frac{\beta R_C}{r_\pi + (\beta + 1) R_E} \quad A_I = -\beta?$$
$$R_{in} = R_B \parallel [r_\pi + (\beta + 1) R_E] \quad R_{out} = ?$$

Beta Independent Common Emitter (Emitter Grounded)

DC Analysis



$$I_B = ? \quad I_C = ? \quad I_E = ?$$

$$V_B = V_{CC} \frac{R_{B2}}{R_{B1} + R_{B2}} = 0.7 \quad V_C = ? \quad V_E = 0$$

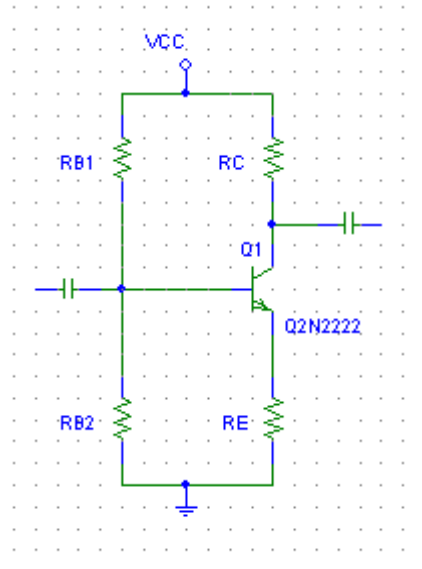
AC Analysis

$$A_V = ? \quad A_I = ?$$

$$R_{in} = R_{B1} \parallel R_{B2} \parallel r_{\pi} \quad R_{out} = ?$$

Beta Independent Common Emitter

DC Analysis



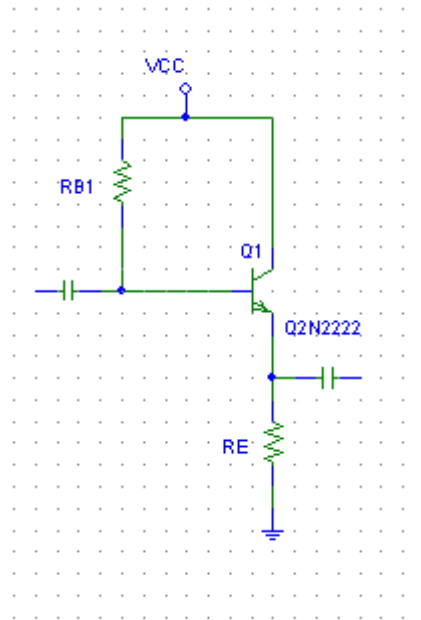
$$I_B = \frac{I_E}{\beta + 1} \quad I_C = \beta I_B \quad I_E = \frac{V_B - 0.7}{R_E}$$
$$V_B = V_{CC} \frac{R_{B2}}{R_{B1} + R_{B2}} \quad V_C = V_{CC} - I_C R_C \quad V_E = V_B - 0.7$$

AC Analysis

$$A_V = \frac{-\beta R_C}{r_\pi + (\beta + 1) R_E} \quad A_I = ?$$
$$R_{in} = R_{B1} \parallel R_{B2} \parallel [r_\pi + (\beta + 1) R_E] \quad R_{out} = ?$$

Common Collector (Grounded Collector)

DC Analysis



$$I_B = \frac{V_{CC} - 0.7}{R_B + (\beta + 1)R_E} \quad I_C = \beta I_B \quad I_E = (\beta + 1)I_B$$

$$V_B = V_{CC} - I_B R_B \quad V_C = V_{CC} \quad V_E = I_E R_E$$

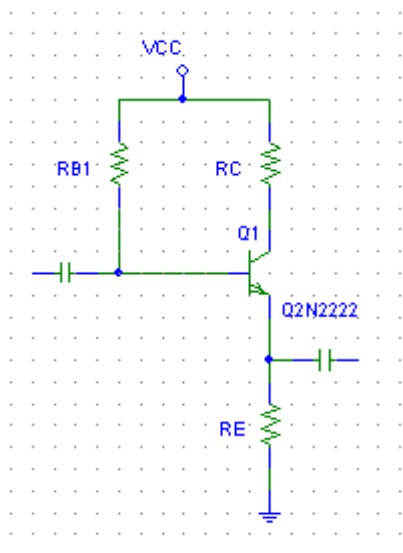
AC Analysis

$$A_V = \frac{(\beta + 1)R_E}{(\beta + 1)R_E + r_\pi} \leq 1 \quad A_I = \frac{(\beta + 1)R_B}{R_B + r_\pi + (\beta + 1)R_E} \leq \beta + 1$$

$$R_{in} = R_B \parallel [r_\pi + (\beta + 1)R_E] \quad R_{out} = R_E \parallel r_o \parallel \frac{r_\pi + R_B}{\beta + 1}$$

Common Collector

DC Analysis



$$I_B = \frac{V_{CC} - 0.7}{R_B + R_E} \quad I_C = \beta I_B \quad I_E = (\beta + 1) I_B$$

$$V_B = V_{CC} - I_B R_B \quad V_C = V_{CC} - \beta I_B R_C \quad V_E = (\beta + 1) I_B R_E$$

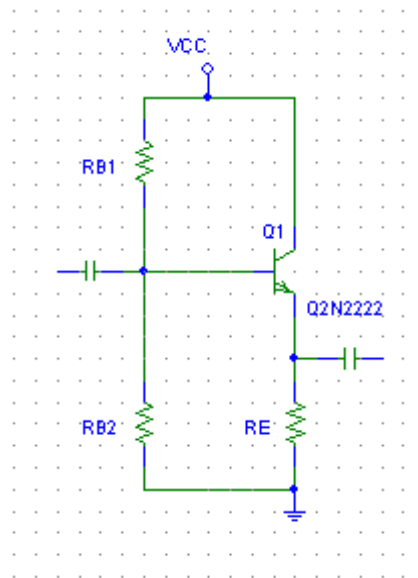
AC Analysis

$$A_V = \frac{(\beta + 1) R_E}{r_\pi + (\beta + 1) R_E} \quad A_I = ?$$

$$R_{in} = R_B \parallel [r_\pi + (\beta + 1) R_E] \quad R_{out} = R_E \parallel \frac{r_\pi + R_B}{\beta + 1}$$

Beta Independent Common Collector (Grounded Collector)

DC Analysis



$$I_B = \frac{I_E}{\beta + 1} \quad I_E = \frac{V_B - 0.7}{R_E} \quad I_C = (\beta + 1)I_B$$

$$V_B = V_{CC} \frac{R_{B2}}{R_{B1} + R_{B2}} \quad V_E = V_B - 0.7\text{V} \quad V_C = V_{CC}$$

AC Analysis

$$A_V = \frac{r_E}{r_\pi + r_E} \quad A_I = \beta \frac{Z_{in} r_E}{Z_{in(\text{base})} R_L}$$

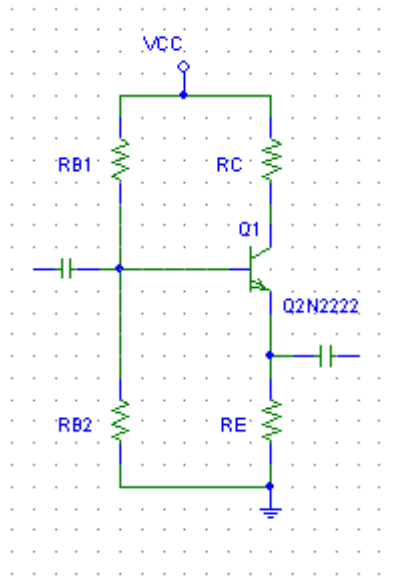
$$r_E = R_E \parallel R_L \quad A_V \approx 1 \text{ when } r_E \gg r_\pi$$

$$A_P = A_V A_I \quad Z_{in} = R_{B1} \parallel R_{B2} \parallel Z_{in(\text{base})} \quad Z_{in(\text{base})} = (\beta + 1)(r_\pi + r_E)$$

$$Z_{out} = R_E \parallel \left(r_\pi + \frac{R_{B1} \parallel R_{B2}}{\beta} \right)$$

Beta Independent Common Collector

DC Analysis



$$I_B = ? \quad I_C = ? \quad I_E = ?$$
$$V_B = ? \quad V_C = ? \quad V_E = ?$$

AC Analysis

$$A_V = ? \quad A_I = ?$$
$$R_{in} = ? \quad R_{out} = ?$$