

Equations for BJT Amplifier Configurations

Equations Based on Large-Signal Characteristics:

$$\text{Active Region: } i_E = I_{ES} \left(e^{\frac{v_{BE}}{V_T}} - 1 \right)$$

$$r_\pi = \frac{V_T}{I_{BQ}} = \frac{\beta V_T}{I_{CQ}}$$

Common Emitter:

$$A_v = \frac{v_o}{v_{in}} = - \frac{\beta R'_L}{r_\pi + (\beta + 1)R_{E1}}$$

$$A_i = A_v \frac{Z_{in}}{R_L}$$

$$Z_{in} = \frac{1}{\frac{1}{R_B} + \frac{1}{Z_{it}}} \text{ where } Z_{it} = \frac{v_{in}}{i_b} = r_\pi + (\beta + 1)R_{E1}$$

$$Z_o = R_C$$

Common Collector (Emitter Follower):

$$A_v = \frac{v_o}{v_{in}} = \frac{(1 + \beta)R'_L}{r_\pi + (1 + \beta)R'_L}$$

$$A_i = A_v \frac{Z_{in}}{R_L}$$

$$Z_{in} = \frac{1}{\frac{1}{R_B} + \frac{1}{Z_{it}}} \text{ where } Z_{it} = \frac{v_{in}}{i_b} = r_\pi + (1 + \beta)R'_L$$

$$Z_o = \frac{1}{\frac{(1 + \beta)}{(R'_S + r_\pi)} + \frac{1}{R_E}}$$

Common Base:

$$A_v = \frac{v_o}{v_{in}} = \frac{\beta R'_L}{r_\pi}$$

$$A_i = A_v \frac{Z_{in}}{R_L}$$

$$Z_{in} = \frac{R_E}{\left(\frac{r_\pi}{\beta + 1} \right)}$$

$$Z_o = R_C$$

Equations for FET Amplifier Configurations

Equations Based on Large-Signal Characteristics:

Triode Region: $i_D = K[2(v_{GS} - V_{to})v_{DS} - v_{DS}^2]$ where $K = \left(\frac{W}{L}\right)\frac{KP}{2}$

Saturation Region: $i_D = K(v_{GS} - V_{to})^2$ where $K = \left(\frac{W}{L}\right)\frac{KP}{2}$

$$g_m = 2\sqrt{KI_{DQ}}$$

Common Source:

$$A_v = \frac{v_o}{v_{in}} = -g_m R'_L$$

$$A_i = A_v \frac{Z_{in}}{R_L}$$

$$Z_{in} = R_G$$

$$Z_o = \frac{1}{\frac{1}{R_D} + \frac{1}{r_d}}$$

Common Drain (Source Follower):

$$A_v = \frac{v_o}{v_{in}} = \frac{g_m R'_L}{1 + g_m R'_L}$$

$$A_i = A_v \frac{Z_{in}}{R_L}$$

$$Z_{in} = R_G$$

$$Z_o = \frac{1}{g_m + \frac{1}{R_S} + \frac{1}{r_d}}$$

Common Gate:

$$A_v = \frac{v_o}{v_{in}} = g_m R'_L$$

$$A_i = A_v \frac{Z_{in}}{R_L}$$

$$Z_{in} = \frac{1}{g_m + \frac{1}{R_S}}$$

$$Z_o = R_D$$