Equations for BJT Amplifier Configurations

Equations Based on Large-Signal Characteristics:

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

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

Common Emitter:

\[ A_v = \frac{v_o}{v_{in}} = -\frac{\beta R'_L}{r_\pi + (\beta + 1)R_E} \]

\[ A_i = A_v \frac{Z_{in}}{R_L} \]

\[ Z_{in} = \frac{1}{\frac{1}{R_B} + \frac{1}{Z_{it}}} \]

where \( Z_{it} = \frac{v_{in}}{i_b} = r_\pi + (\beta + 1)R_E \)

\[ Z_o = R_C \]

Common Collector (Emitter Follower):

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

\[ A_i = A_v \frac{Z_{in}}{R_L} \]

\[ Z_{in} = \frac{1}{\frac{1}{R_B} + \frac{1}{Z_{it}}} \]

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

\[ Z_o = \frac{1}{\frac{(1 + \beta)}{(R'_L + r_\pi)} + \frac{R_E}{R_E}} \]

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 \( K = \left( \frac{W}{L} \right) \frac{KP}{2} \)

\( g_m = 2\sqrt{K T_{DQ}} \)

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:

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

\( A_i = A_v \frac{Z_{in}}{R_L} \)

\( Z_{in} = \frac{1}{g_m + \frac{1}{R_S}} \)

\( Z_o = R_D \)