



$$\left\{ \begin{array}{l} i_E = I_{ES} \left[\exp \left(\frac{v_{BE}}{n_C V_T} \right) - 1 \right] \\ I_{ES} = I_{ES}^0 \left(1 + \frac{v_{CE}}{V_A} \right) \\ i_B + \alpha_F i_E - i_E = 0 \\ i_C = \alpha_F i_E \end{array} \right.$$