Ideal BJT Summary (no base recombination)

$$I_E = qn_i^2 A\left(\frac{D_E}{L_E N_E} + \frac{D_B}{W N_B}\right)\left(e^{\frac{qV_{EB}}{kT}} - 1\right)$$

$$- qn_i^2 A\left(\frac{D_B}{W N_B}\right)\left(e^{\frac{qV_{CB}}{kT}} - 1\right)$$

$$I_C = -qn_i^2 A\left(\frac{D_C}{L_C N_C} + \frac{D_B}{W N_B}\right)\left(e^{qV_{CB}/kT} - 1\right)$$

$$+ qn_i^2 A\left(\frac{D_B}{W N_B}\right)\left(e^{\frac{qV_{EB}}{kT}} - 1\right)$$

$$I_B = I_E - I_C = qn_i^2 A\left(\frac{D_E}{N_E L_E}\right)\left(e^{\frac{qV_{EB}}{kT}} - 1\right)$$

$$+ qn_i^2 A\left(\frac{D_C}{L_C N_C}\right)\left(e^{\frac{qV_{CB}}{kT}} - 1\right)$$

$\alpha_T = 1$ no base recombination in ideal case

$$\gamma = \frac{\frac{D_B}{W N_B}}{\frac{D_E}{L_E N_E} + \frac{D_B}{W N_B}}$$

$$\alpha_{dc} = \gamma \alpha_T = (\gamma)(1) = \gamma$$

$$\beta = \frac{\alpha_{dc}}{1-\alpha_{dc}} = \frac{D_B L_E N_E}{D_E W N_B}$$

Including Base Recombination

$$I_B = I_{B,ideal} + I_{B recomb.}$$

$$I_B = q n_i^2 A \left(\frac{D_E}{L_E N_E} + \frac{W}{2\tau_B} \frac{1}{N_B} \right) \left(e^{\frac{qV_{EB}}{kT}} - 1 \right)$$

$$+ q n_i^2 A \left(\frac{D_C}{L_C N_C} + \frac{W}{2\tau_B} \frac{1}{N_B} \right) \left(e^{\frac{qV_{CB}}{kT}} - 1 \right)$$

$$I_C = I_{C,ideal} - I_{B recomb.} \left(\approx I_{C,ideal} \right)$$

$$I_E = I_{E,ideal}$$

$$\alpha_T = \frac{I_{Cp}}{I_{Ep}} = \frac{\frac{D_B}{W N_B} - \frac{W}{2\tau_B} \frac{1}{N_B}}{\frac{D_B}{W N_B}} = 1 - \frac{W^2}{2L_B^2}$$