1.) Physical aspects of the BJT – Continued

c.) Gummel-Poon Large-Signal Model:

Add the forward and reverse currents for the collector, base and emitter to get,

$$i_C = I_S\left[\exp\left(\frac{v_{BE}}{V_T}\right) - \exp\left(\frac{v_{BC}}{V_T}\right)\right] - \frac{I_S}{\beta_R}\left[\exp\left(\frac{v_{BC}}{V_T}\right) - 1\right] = i_T - \frac{I_S}{\beta_R}\left[\exp\left(\frac{v_{BC}}{V_T}\right) - 1\right]$$

$$i_E = I_S\left[\exp\left(\frac{v_{BE}}{V_T}\right) - \exp\left(\frac{v_{BC}}{V_T}\right)\right] - \frac{I_S}{\beta_F}\left[\exp\left(\frac{v_{BE}}{V_T}\right) - 1\right] = i_T - \frac{I_S}{\beta_F}\left[\exp\left(\frac{v_{BE}}{V_T}\right) - 1\right]$$

$$i_B = \frac{I_S}{\beta_F}\left[\exp\left(\frac{v_{BE}}{V_T}\right) - 1\right] + \frac{I_S}{\beta_R}\left[\exp\left(\frac{v_{BC}}{V_T}\right) - 1\right]$$

Example not done in lecture

d.) Example 3.1

Find the voltage at the emitter to ground, V_E, for the transistor shown if $\beta_F = 100$ at room temperature.

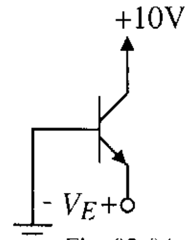

Fig. 03-04

Solution

All we know is that $i_E = 0$ and the base-collector is strongly reverse-biased. Thus,

$$i_E = 0 = I_S \exp\left(\frac{v_{BE}}{V_T}\right) - \frac{I_S}{\beta_F}\exp\left(\frac{v_{BE}}{V_T}\right) + \frac{I_S}{\beta_F} \rightarrow \left(1 - \frac{1}{\beta_F}\right)\exp\left(\frac{v_{BE}}{V_T}\right) = -\frac{1}{\beta_F}$$

$$\exp\left(\frac{v_{BE}}{V_T}\right) = \frac{1}{1-\beta_F} \qquad \rightarrow \qquad v_{BE} = -V_T\, ln(1-\beta_F) =$$

$0.025 ln(99) = 0.115$V

$\therefore\ V_E = -v_{BE} = \underline{0.115\text{V}}$

2.) The pnp transistor.

Reverse the current and voltage directions and all equations for the npn hold for the pnp BJT.

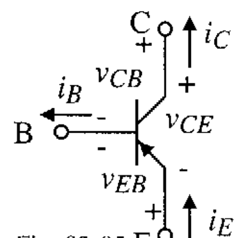

Fig. 03-05

3.) The BJT Transport Models

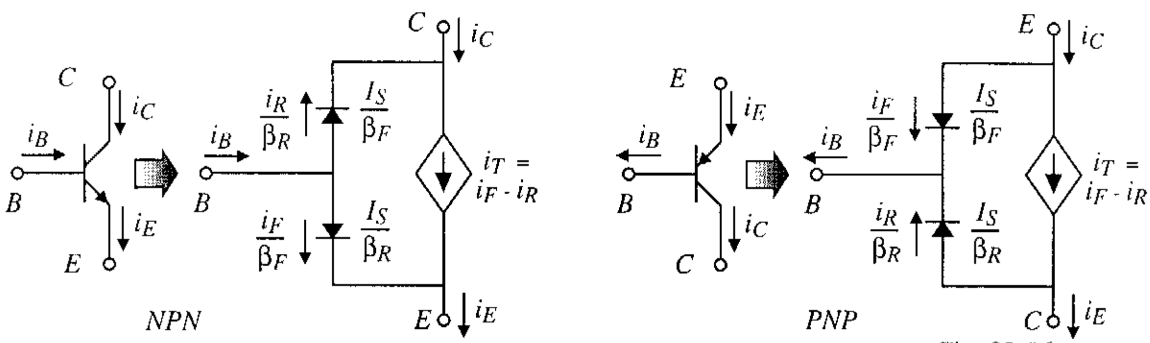

Fig. 03-06

$$i_T = I_S\left[\exp\left(\frac{v_{BE}}{V_T}\right) - \exp\left(\frac{v_{BC}}{V_T}\right)\right] \qquad i_T = I_S\left[\exp\left(\frac{v_{EB}}{V_T}\right) - \exp\left(\frac{v_{CB}}{V_T}\right)\right]$$