

$$\frac{\partial h_{FE}}{\partial V_{CB}} = \frac{\left[ \frac{W_B}{L_{pb}} + \frac{N_{DB} D_{ne}}{D_{pb} N_{AE} L_{ne}} + \frac{W_{EB} N_{DB} \ell^{-\left(\frac{qV_E}{k_b T}\right)}}{2n_i \tau_o D_{pb}} \right] \Delta V_{CB}}{\left[ \frac{W_B}{2L_{pb}^2} + \frac{N_{DB} D_{ne}}{D_{pb} N_{AE} L_{ne}} + \frac{W_{EB} N_{DB} \ell^{-\left(\frac{qV_E}{k_b T}\right)}}{2n_i \tau_o D_{pb}} \right]^2 \left( \frac{\epsilon_s \epsilon_o}{q} \right)^{1/3} 3V_{CB}^{4/3}}$$

Equation 3-21