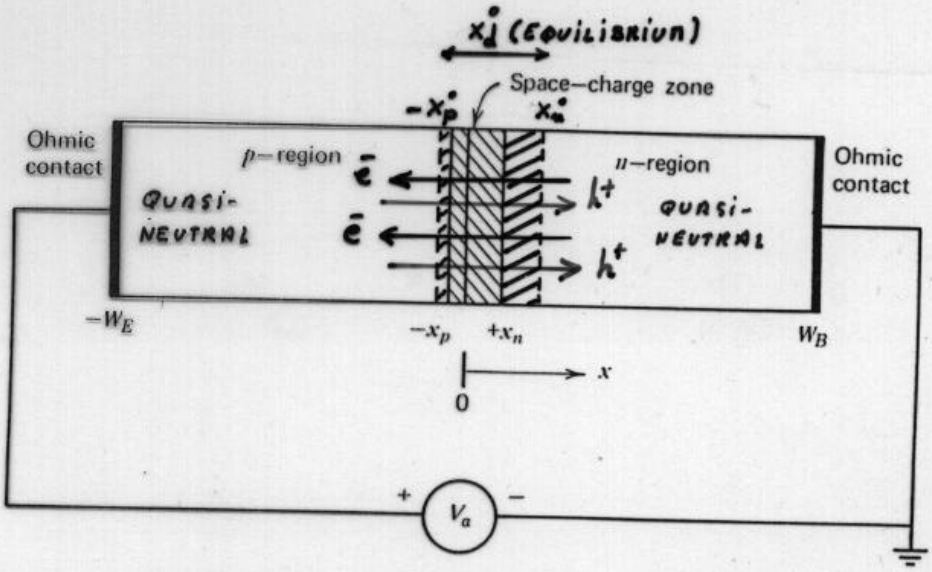
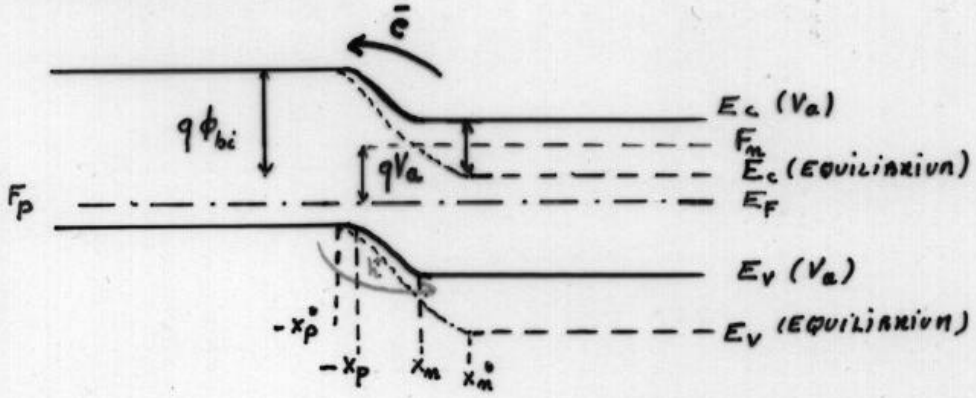
CURRENT-VOLTAGE CHARACTERISTICS OF PN JUNCTIONS



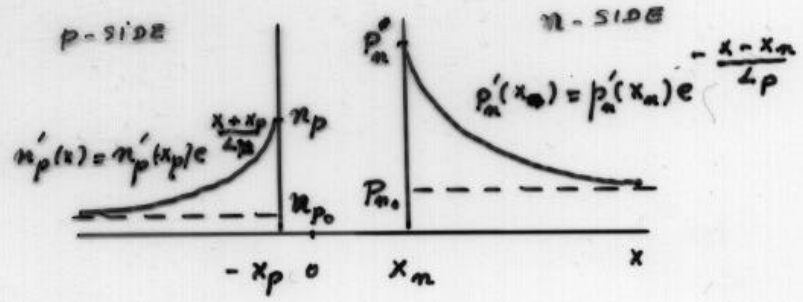
ENERGY BAND DIAGRAM



EXCESS CHARGE CARRIERS & ASSUMPTIONS { - LOW LEVEL INJECTION; - DETAILED BALANCE min-max

$$\begin{cases} n' \equiv n - n_o \longrightarrow n'_p(-x_p) = n^*_{p_o}(-x_p)\left[\exp\left(\frac{qV_a}{kT}\right) - 1\right] & \text{IN p-SIDE} \\ p' \equiv p - p_o \longrightarrow p'_n(+x_n) = p^*_{n_o}(x_n)\left[\exp\left(\frac{qV_a}{kT}\right) - 1\right] & \text{IN n-SIDE} \end{cases}$$

IDEAL DIODE ANALYSIS : DIFFUSION OF MINORITY CARRIERS



CONTINUITY EQUATION

$$\begin{cases} D_p \dfrac{d^2}{dx^2} p_n = \dfrac{p_n - p_{n_0}}{\tau_p} & \text{IN n-SIDE} \\ D_n \dfrac{d^2}{dx^2} n_p = \dfrac{n_p - n_{p_0}}{\tau_n} & \text{IN p-SIDE} \end{cases}$$

SOLUTION:

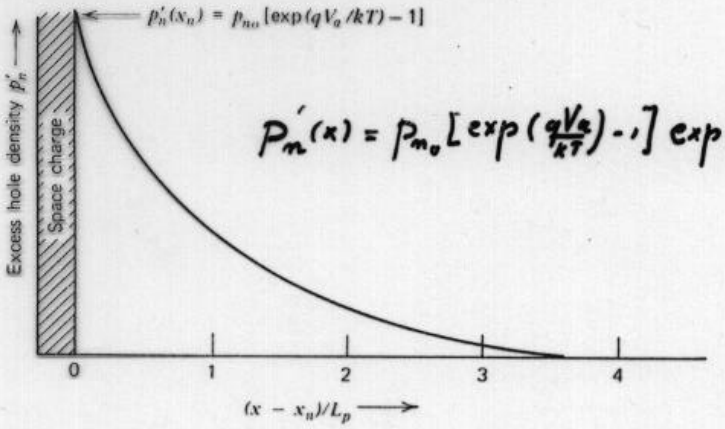
$$\begin{cases} p'_n = p_n - p_{n_0} = \overbrace{[p_n(x_n) - p_{n_0}(x_n)]}^{p'_n(x_n)} e^{-\frac{x-x_n}{L_p}} & \text{IN n-SIDE} \\ n'_p = n_p - n_{p_0} = \underbrace{[n_p(-x_p) - n_{p_0}(-x_p)]}_{n'_p(-x_p)} e^{\frac{x+x_p}{L_n}} & \text{IN p-SIDE} \end{cases}$$

BUT: $p'_n(x_n) = p_{n_0}(x_n)\left[\exp\left(\frac{qV_a}{kT}\right) - 1\right]$

$$n'_p(-x_p) = n_{p_0}(-x_p)\left[\exp\left(\frac{qV_a}{kT}\right) - 1\right]$$

LONG-BASE DIODE ($\because L_p \ll W_B$)

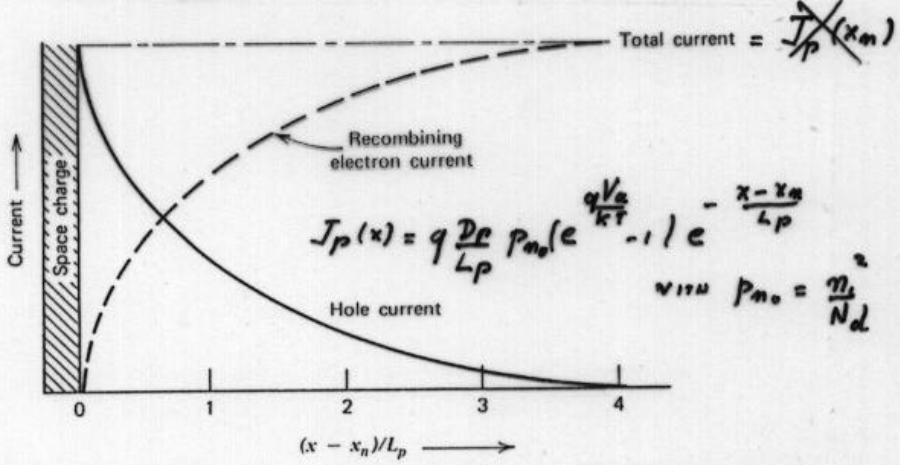
a) EXCESS CARRIER PROFILE



$$p_n'(x) = p_{no}\left[\exp\left(\frac{qV_a}{kT}\right) - 1\right]\exp\left[-\frac{x - x_n}{L_p}\right]$$

b) MINORITY CARRIER CURRENT PROFILE

$$J_p(x) = -qD_p\frac{dp_n'}{dx} \qquad \text{(DIFFUSION ONLY)}$$



$$J_p(x) = q\frac{D_p}{L_p}p_{no}\left(e^{\frac{qV_a}{kT}} - 1\right)e^{-\frac{x - x_n}{L_p}}$$

WITH $p_{no} = \frac{n_i^2}{N_d}$

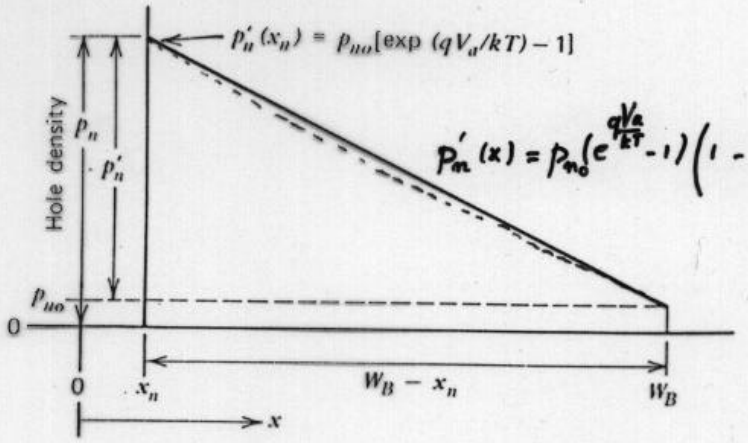
c) TOTAL CURRENT

$$J_t = J_p(x_n) + J_n(-x_p) = qn_i^2\left(\frac{D_p}{N_d L_p} + \frac{D_n}{N_a L_n}\right)\left(e^{\frac{qV_a}{kT}} - 1\right)$$

$$= J_0\left(e^{\frac{qV_a}{kT}} - 1\right)$$

SHORT-BASE DIODE ($L_p \gg W_B$)

a) CARRIER CONCENTRATION PROFILE



$$p'_n(x) = p_{no}\left(e^{\frac{qV_a}{kT}} - 1\right)\left(1 - \frac{x - x_n}{W'_B}\right)$$

b) CURRENT.

$$J_p = -qD_p \frac{d}{dx} p'_n(x)$$

$$= qD_p \frac{n_i^2}{N_d W'_B}\left(e^{\frac{qV_a}{kT}} - 1\right) : \text{CONSTANT}$$

↖ REPLACE L_p IN LONG BASE DIODES

c) TOTAL CURRENT IF SHORT-EMITTER DIODE TOO

$$J_t = qn_i^2\left(\frac{D_p}{N_d W'_B} + \frac{D_n}{N_a W_E}\right)\left(e^{\frac{qV_a}{kT}} - 1\right)$$