VALIDITY OF APPROXIMATIONS OF IDEAL DIODE

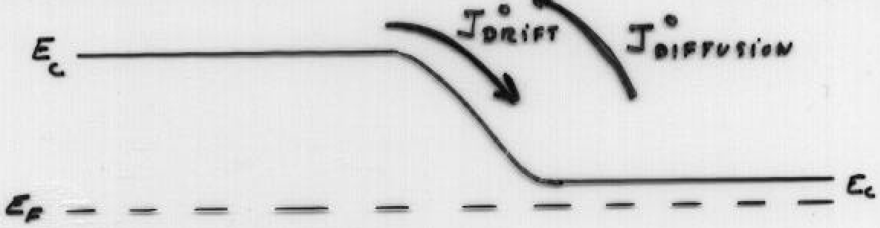
1- LOW LEVEL INJECTION : $\Rightarrow V_a \ll \phi_{bi}$: - V_a ACROSS THE JUNCTION ONLY

- NO OHMIC DROP IN Q-NEUTRAL REGION

IF $V_a \sim \phi_{bi}$: $R_{Q\text{-NEUTRAL}} I \sim V_a$

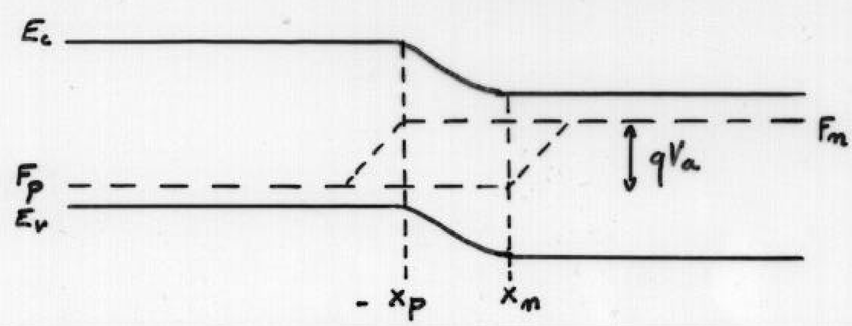
$\rightarrow$ OHMIC DROP IN Q-NEUTRAL REGION

2- QUASI-EQUILIBRIUM : $J_n^{min}, J_p^{min} \ll J^{\circ}_{DRIFT} = J^{\circ}_{DIFFUSION}$



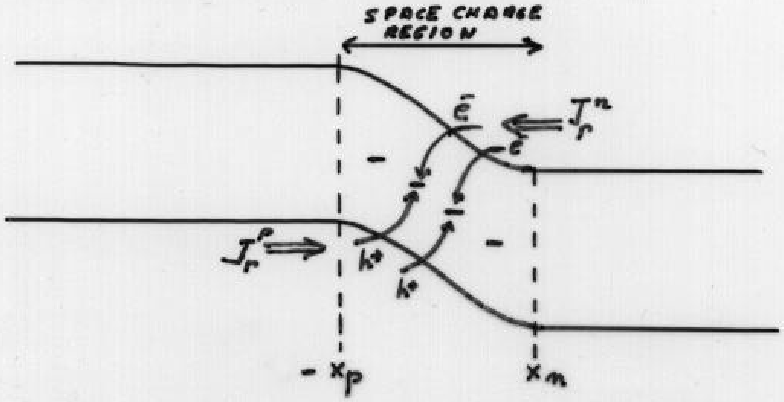
$$\Rightarrow \quad n_{no}(x_n) \simeq n_{no}(x_n^{\circ})$$
$$p_{po}(-x_p) \simeq p_{po}(-x_p^{\circ})$$

3. DEPLETION APPROXIMATION : NON EQUILIBRIUM CONDITIONS



$$p(-x_p)\,n(-x_p) = p(x_n)\,n(x_n) = n_i^2 \exp\left(\frac{F_n - F_p}{kT}\right) = n_i^2 \exp\left(\frac{qV_a}{kT}\right)$$

SPACE - CHARGE CURRENT



$$J_r = q \int_{-x_p}^{x_n} U\, dx \qquad \text{WITH} \quad U = \frac{n_i^2 \left(e^{\frac{qV_a}{kT}} - 1\right)}{\left[p + n + 2 n_i \cosh\left(\frac{E_t - E_i}{kT}\right)\right] \tau_0}$$

IF $\begin{cases} E_t \sim E_i \\ U \text{ IS MAXIMIZED} \quad \text{i.e.} \quad p = n = n_i \exp\left(\frac{qV_a}{2kT}\right) \\ \text{OVER DISTANCE } x' \end{cases}$

$$U = \frac{n_i^2 \left(e^{\frac{qV_a}{kT}} - 1\right)}{\left[2 n_i \left(e^{\frac{qV_a}{2kT}} + 1\right)\right] \tau_0}$$

$$J_r \simeq \frac{q x' n_i}{2 \tau_0} \exp\left(\frac{qV_a}{2kT}\right) \qquad \text{FOR } \frac{qV_a}{2kT} > 1$$

WITH $\frac{1}{\tau_0} = N_t v_{th} \sigma_0$

$$J_r \propto e^{\frac{qV_a}{2kT}}$$

SIGNATURE OF **RECOMBINATION IN SPACE CHARGE REGION**

IMPORTANCE OF SPACE CHARGE CURRENT

1. FORWARD BIAS: BECAUSE τ_0 NOT VERY WELL KNOWN

$\Rightarrow x' \sim x_d$ (DEPLETION LAYER WIDTH)

$$\frac{J_t}{J_r} = \frac{2n_i}{x_d}\left[\frac{L_n}{N_a} + \frac{L_p}{N_d}\right]\exp\left(\frac{qV_a}{2kT}\right)$$

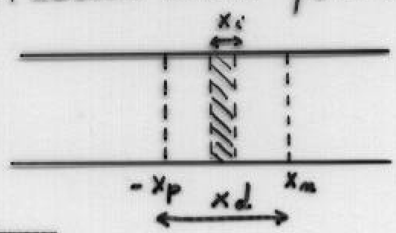
J_r IMPORTANCE DECREASES WITH APPLIED BIAS i.e. $\frac{J_r}{J_t} \downarrow$ FOR $V_a \uparrow$

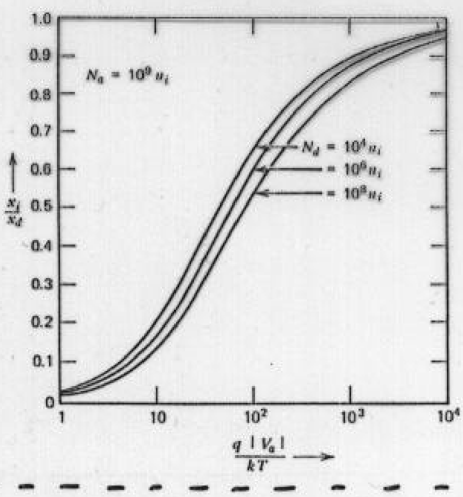
2. REVERSE BIAS: GENERATION CURRENT

$$J_g = \frac{q n_i x_i}{2\tau_0}$$

$(E_t \sim E_i)$

x_i : REGION WHERE $p, n \ll n_i$



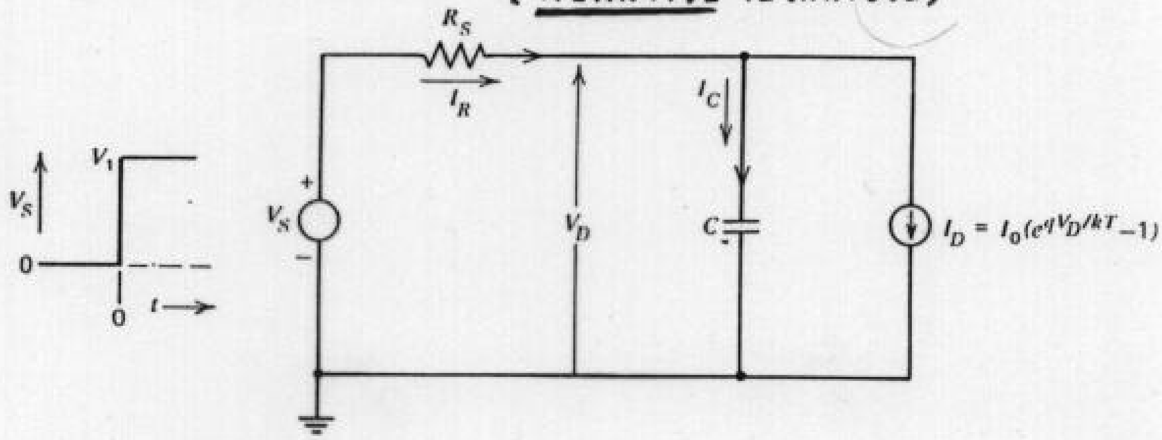


$$\frac{J_t}{J_g} = \frac{2n_i}{x_i}\left[\frac{L_n}{N_a} + \frac{L_p}{N_d}\right] < 1$$

IN PRACTICAL DIODES

$\Rightarrow$ GENERATION CURRENT DOMINATES IN REVERSE BIAS

LARGE SIGNAL ANALYSIS: MODELING DIODE SWITCHING (ITERATIVE TECHNIQUE)



Computer Operation	*Parameter Values*
Initialize I_D, C, and V_D, for steady state with $V_S = 0$.	$V_D = 0, I_D = 0, C = C_0$
Set time $t = 0$.	$t = 0$
Set V_S to new value.	$V_S = V_1$
→ Increment time.	$t = t + \Delta t$
Compute currents I_R and I_C.	$I_R = \dfrac{V_S - V_D}{R_S}$
	$I_C = I_R - I_D$
Compute change in voltage V_D during Δt.	$\Delta V_D = \dfrac{I_C \Delta t}{C} = \dfrac{(I_R - I_D)}{C}\Delta t$
Calculate new voltage.	$V_D = V_D + \Delta V_D = V_D + \dfrac{I_R - I_D}{C}\Delta t$
Calculate new diode current.	$I_D = I_0(e^{qV_D/kT} - 1)$
Test whether I_D has reached its steady-state value.	
No. Continue.	
Yes. Exit from loop.	
Calculate new capacitance. (An abrupt junction is assumed).	$C = \dfrac{C_0}{\sqrt{1 - V_D/\phi_i}} + \dfrac{q}{kT}\tau I_D$
Go to beginning of loop for next time increment.	
→ STOP	