Review of ECE 3040

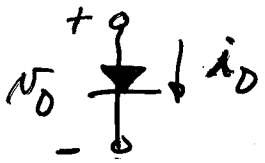
Two-terminal devices – Diode

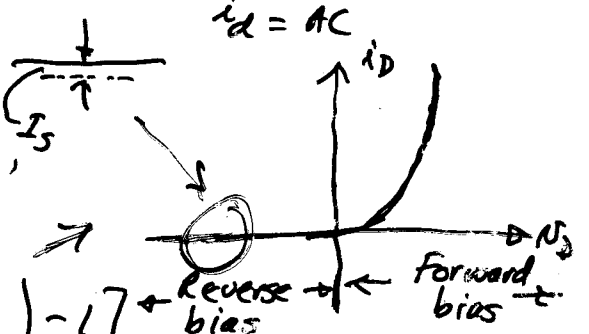
i_D = ac + dc (complete)

I_D = DC

i_d = AC

Symbol –





Model – (Large signal)

$$i_D = I_S\left[\exp\left(\frac{v_D}{n V_T}\right) - 1\right]$$

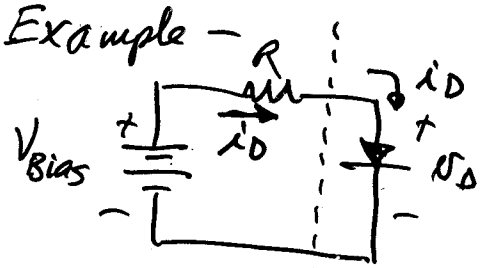
I_S = saturation current = $KT^3 \exp\left(-\frac{V_{GO}}{V_T}\right) \approx 10^{-15}$ A

$V_T = \frac{kT}{q} \cong 26$ mV at 300°K

n = linearity (slope of exponential) ≈ 1

Application of the diode model

Example –



Find i_D & v_D

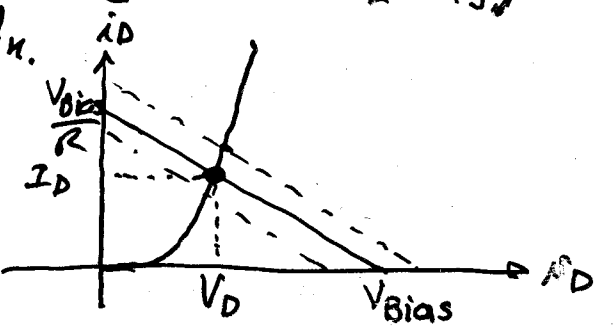
Given V_{Bias} & R & I_S & n.

a.) Mathematical solution

$$V_{Bias} = i_D R + v_D$$

$$\begin{cases} i_D = \dfrac{V_{Bias} - v_D}{R} \\ i_D \cong I_S \exp\left[\dfrac{v_D}{n V_T}\right], \; V_{Bias} > 0 \end{cases}$$

b.) Graphical



Influence of Temperature

Forward biased diode –

$$i_D \cong I_S \exp\left(\frac{v_D}{n V_T}\right) \rightarrow v_D = n V_T \ln\left(\frac{i_D}{I_S}\right)$$

$$\frac{dv_D}{dT} = ? = \frac{V_D + 3V_T + V_{GO}}{T} \approx -2\,mV/^\circ C \quad (I_D \text{ is fixed})$$

Reverse biased diode – $(i_D \cong -I_S)$

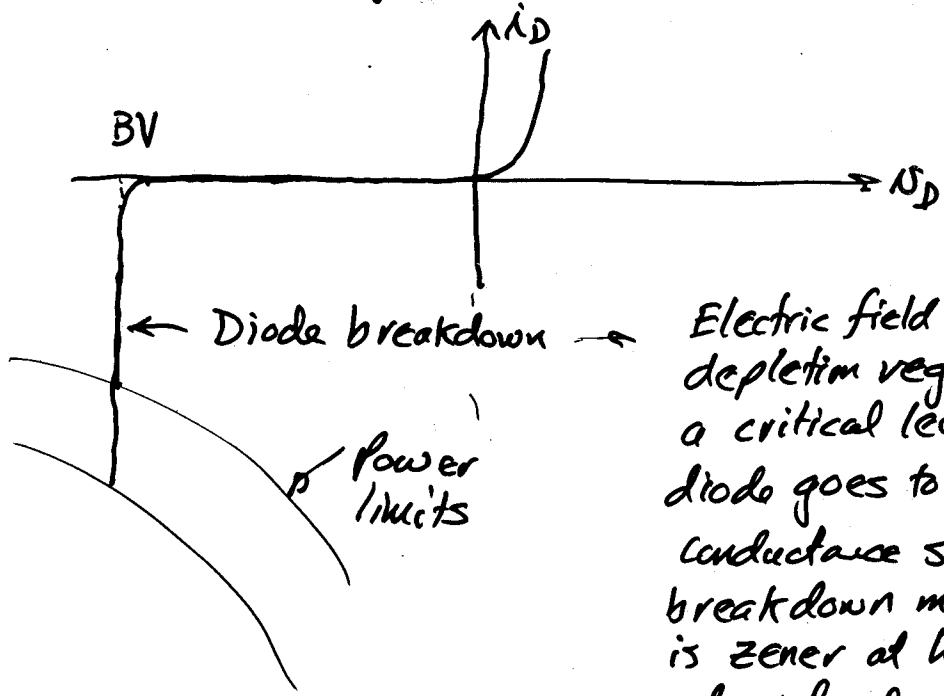
Temp. coefficient of I_S (i_D)

$$I_S = KT^3 \exp\left(\frac{-V_{GO}}{n V_T}\right)$$

$$\frac{1}{i_D}\frac{di_D}{dT} \rightarrow \frac{1}{I_S}\frac{dI_S}{dT} = \frac{3}{T} + \frac{V_{GO}}{T V_T} \quad (n=1)$$

$\rightarrow$ I_S doubles every 10°C increase

Breakdown Voltage of Diode

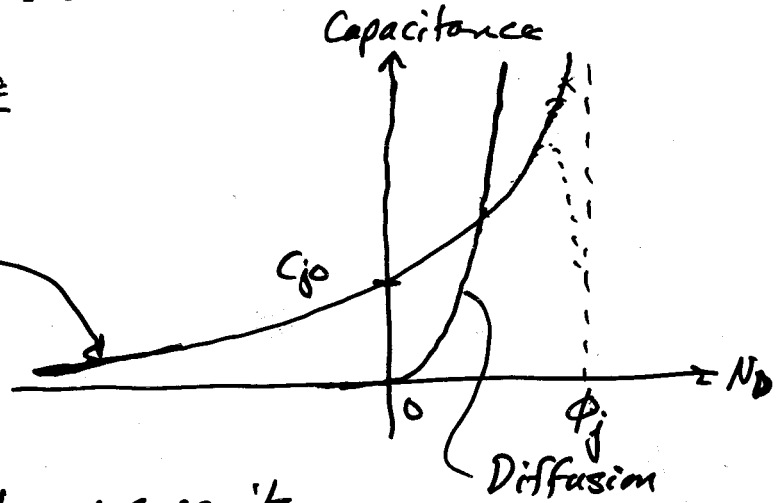


Electric field in the depletion region reaches a critical level and diode goes to a high conductance state. The breakdown mechanism is zener at high doping and avalanche a lower doping.

Diode Capacitance

a.) Depletion

$$C_j = \frac{C_{j0}}{\sqrt{1 - \frac{V_D}{\Phi_j}}}$$



b.) Diffusion

Current flow & capacitance

Diode Models