Review of Chapter 3 – Diodes

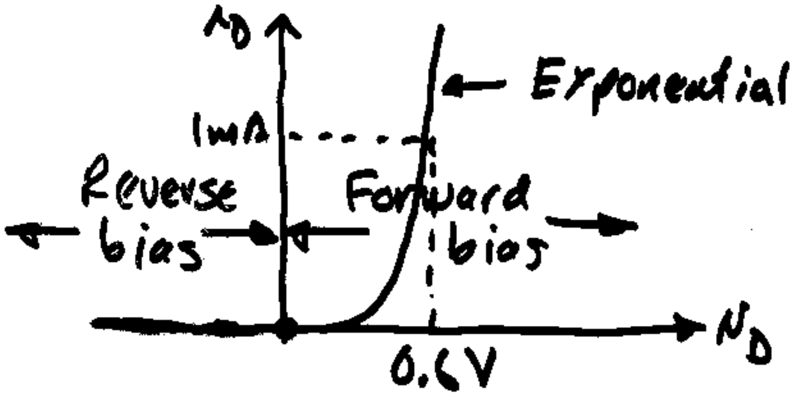
① Diode basics –

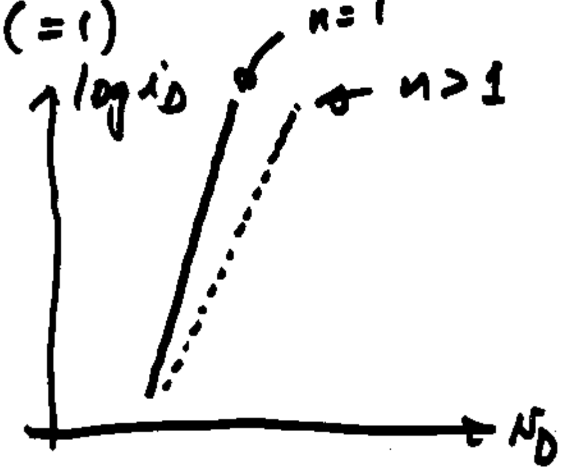
Large signal model

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

I_S = saturation current (10^{-13}A) ←

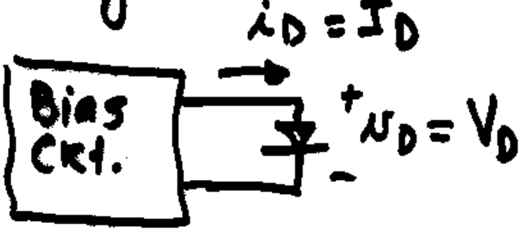
n = nonideal factor (=1)

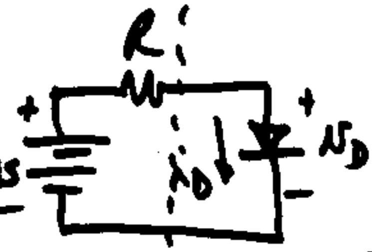




Slope ∝ transconductance → Gain in amplifiers

② Biasing

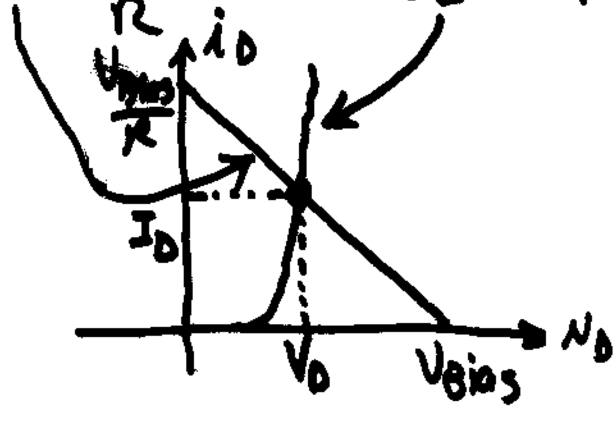




$i_D = \frac{V_{Bias} - v_D}{R}$ $i_D = I_S\left[\exp\left(\frac{v_D}{V_T}\right) - 1\right]$

Mathematical solution
Iteration

Graphical solution –



3) Temperature dependence

Forward bias – $\frac{dv_D}{dT} \approx -2\,mV/°C$

$v_D = V_T \ln\left(\frac{i_D}{I_S}\right)$

$I_S = K_1 T^3 \exp\left(\frac{V_{GO}}{V_T}\right)$

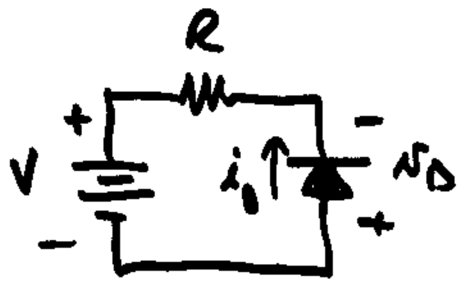
Reverse bias –

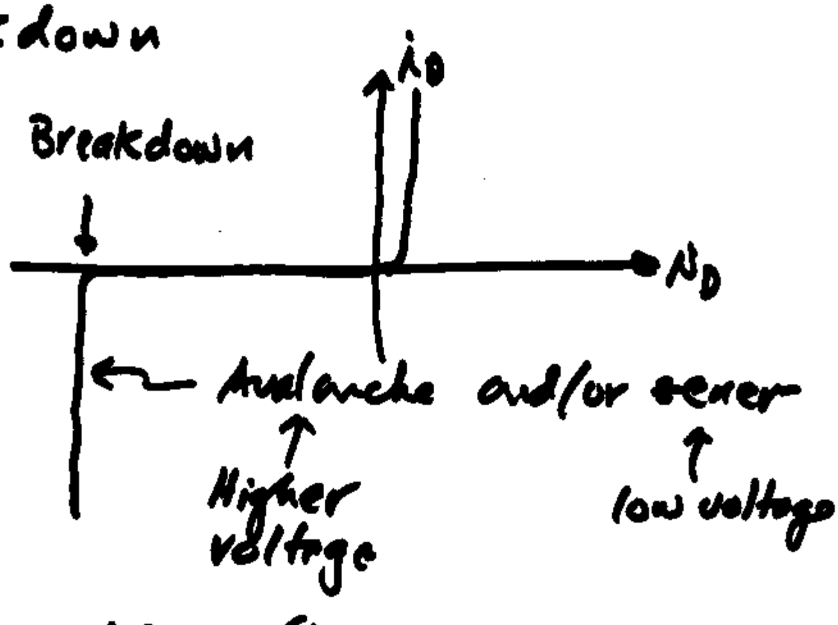
$i_D \approx -I_S \qquad \frac{di_D}{dT} \Rightarrow \frac{dI_S}{dT}$

TCF → $\frac{1}{I_S}\frac{dI_S}{dT} = \frac{3}{T} + \frac{V_{GO}}{V_T T} \approx \frac{V_{GO}}{T V_T}$

I_S approx. doubles every 5-10°C increase

4.) Diode breakdown





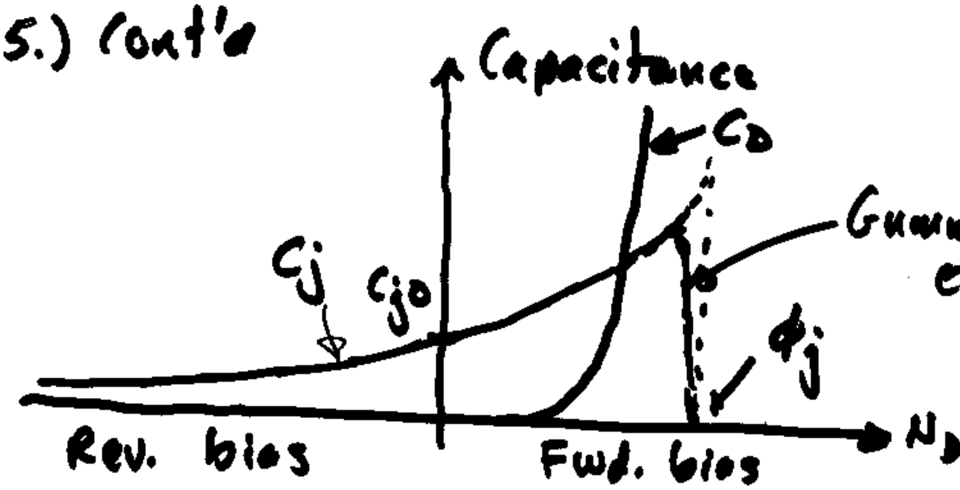
5.) Capacitance

Depletion $\quad C_j = \frac{dQ_j}{dv_D} = \frac{C_{jo}}{\sqrt{1 - \frac{v_D}{\Phi_j}}}$

Diffusion

$C_D = \frac{dQ_D}{dv_D} = \frac{i_D \tau_F}{V_T}$ ← Forward time constant

5.) Cont'd



6.) Approximate diode models

a.) Short-circuit/open-circuit model

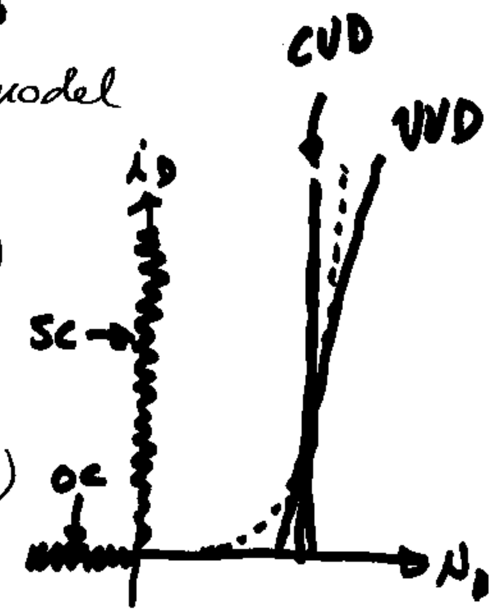
Ideal diode

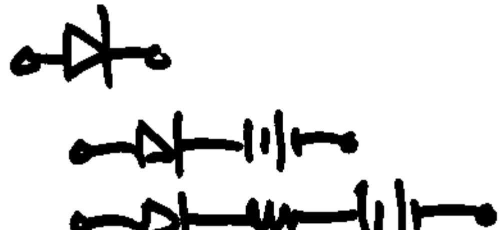
b.) Constant voltage drop (CVD)

Ideal diode in series with a battery

c.) Variable voltage drop (VVD)

Ideal diode + Battery + R





7.) Small-signal model