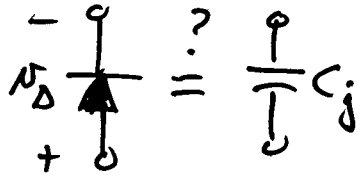
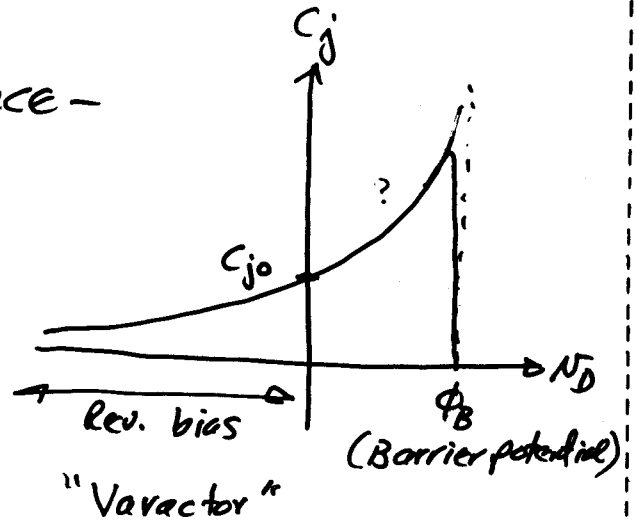
Diodes - Cont'd

Depletion Capacitance - Reverse biased

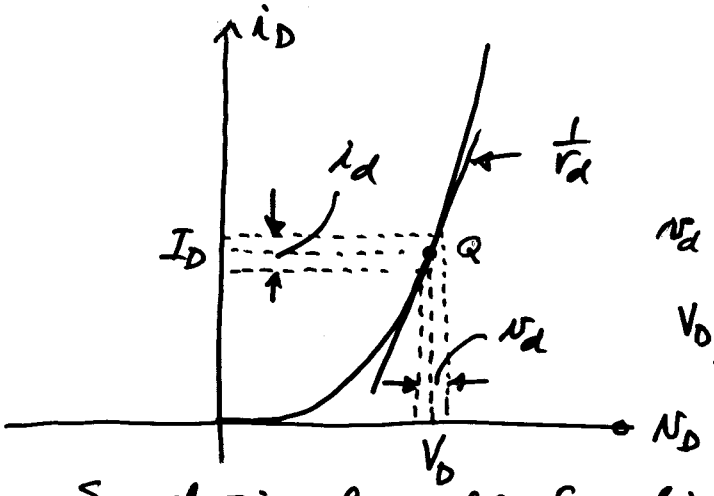


$$C_j = \frac{C_{j0}}{\sqrt{1 - \frac{v_D}{\Phi_B}}}$$

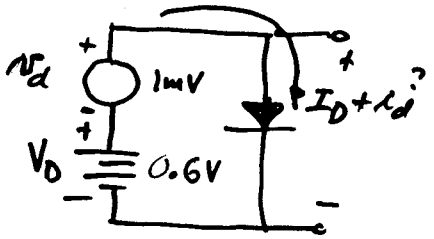


Large & Small Signal Models

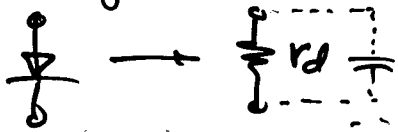
Consider the I-V Diode Plot



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



Small signal model of a diode

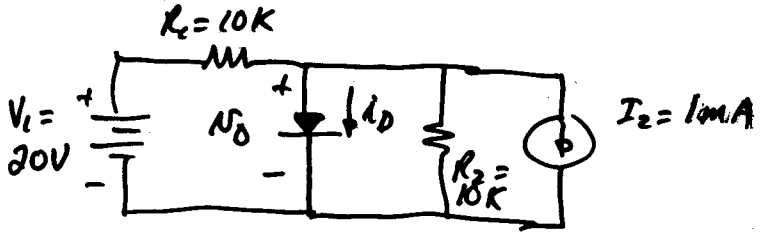


$$\frac{1}{r_d} = g_d = \left.\frac{\partial i_D}{\partial v_D}\right|_Q \cong \frac{I_S}{V_T}\exp\left(\frac{v_D}{V_T}\right) = \frac{I_D}{V_T}$$

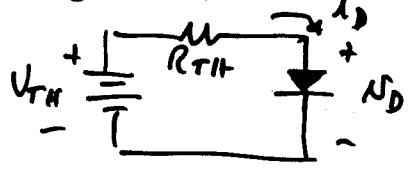
Assumed fwd. bias

$$V_T = \frac{kT}{q} \cong 25\text{mV}$$

Diode Example



a.) Find the dc operating point if $V_T = 25mV$, $n = 1$ and $I_S = 100fA$.



$$V_{TH} = 20V \frac{R_1}{R_1+R_2} - (10K \| 10K)\,1mA$$

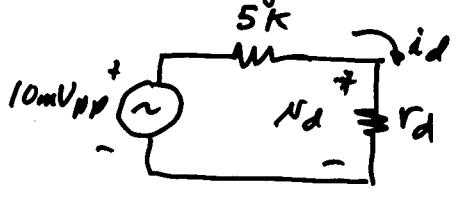
$$V_{TH} = 10V - 5V = 5V$$

$$R_{TH} = 5K$$

Solution – Guess at v_D	$i_D = \frac{5V - v_D}{5K}$	$i_D = I_S \exp\left(\frac{v_D}{V_T}\right)$
0.6	0.88mA	2.331 mA
0.57	0.886mA	0.798mA
⋮	⋮	⋮
0.5726	0.88548mA	0.88528mA

b.) If the 20V voltage source has a peak-to-peak sinusoidal signal of 10mV p-p placed in series with it, find the p-p value of v_d and i_d of the diode

Small signal model:

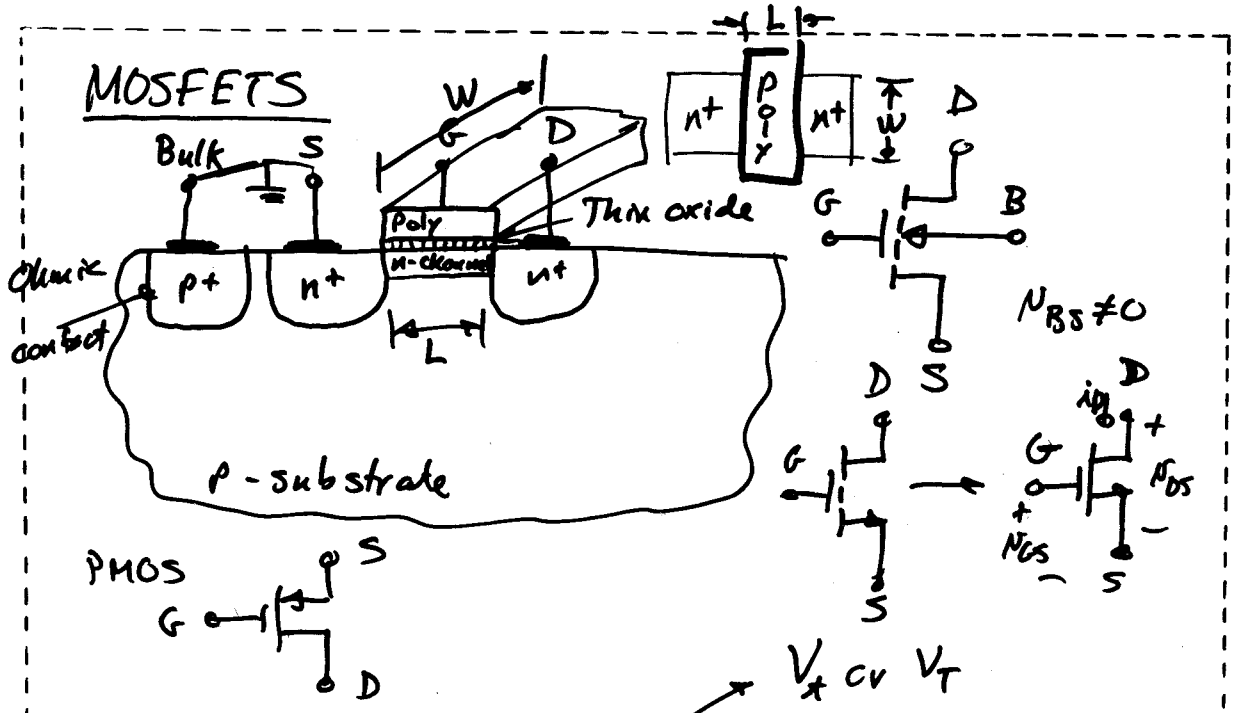


$$r_d = \frac{V_T}{I_D} = \frac{25mV}{0.885mA} \approx 28.5\Omega$$

$$i_d = \frac{10mV}{5028.5\Omega} \approx 2\mu A\ p\text{-}p$$

$$v_d = i_d r_d \simeq 57\mu V\ p\text{-}p$$

MOSFETS



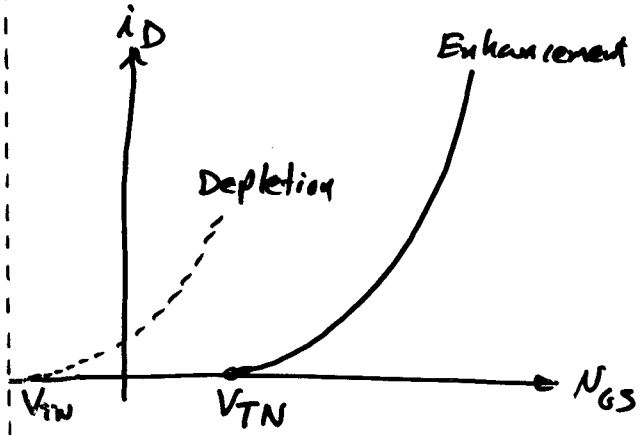
V_t or V_T

Enhancement – Threshold > 0 for NMOS

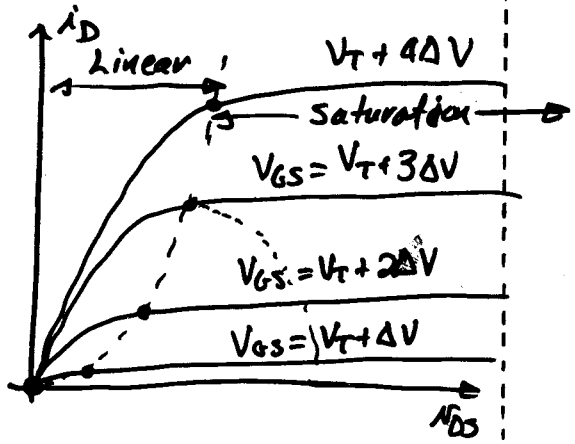
Depletion – Threshold for NMOS < 0

Graphical Model for NMOS

Transconductance Char.:



Output Characteristic:



Math Model

1.) Linear region – $i_D = K_n' \frac{W}{L}\left(N_{GS} - V_{TN} - \frac{N_{DS}}{2}\right) N_{DS}\left(1 + \lambda N_{DS}\right)$

where $N_{GS} - V_{TN} < N_{DS}$

2.) Saturation region – $i_D = \frac{K_n'}{2} \frac{W}{L}\left(N_{GS} - V_{TN}\right)^2 \left(1 + \lambda N_{DS}\right)$