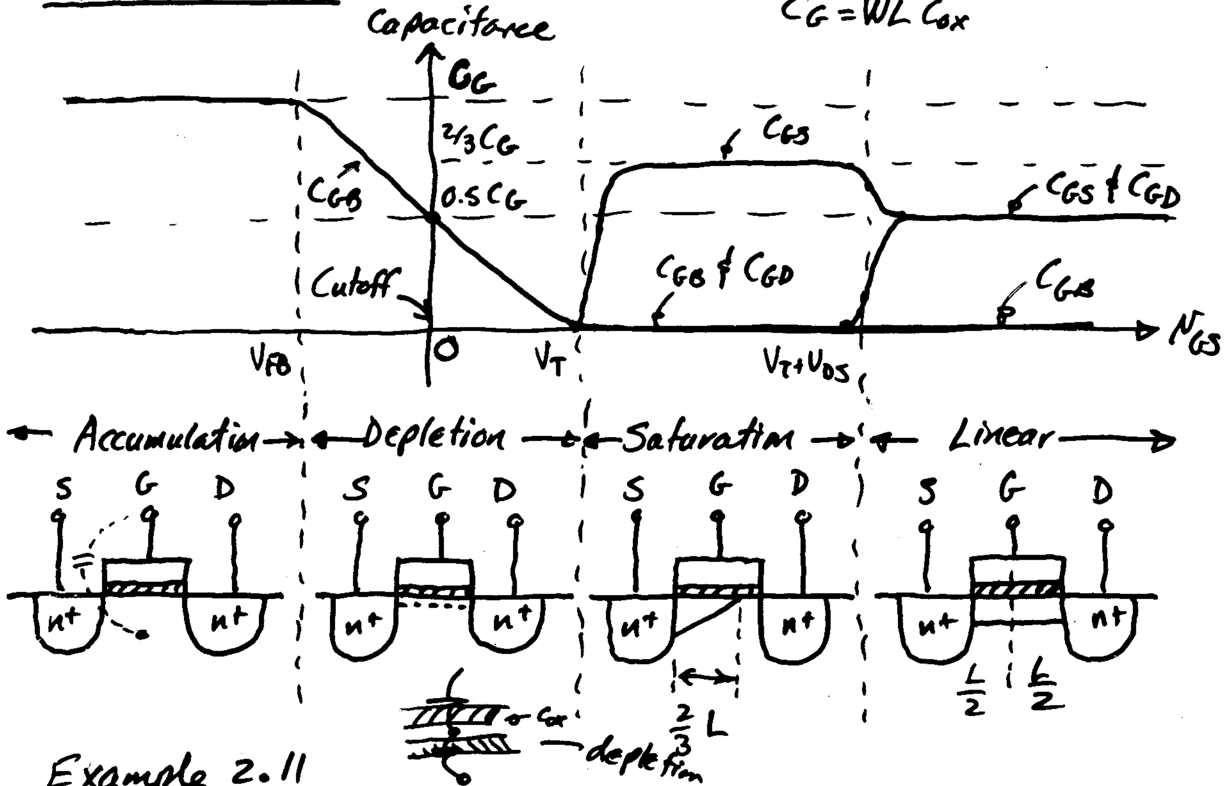
C_{GS}, C_{GD}, C_{GB}

$C_G = WL\,C_{ox}$



Example 2.11

Find the components of C_g in the cutoff, linear and saturation regions for a PMOS with $t_{ox} = 22\,Å$, $W = 400\,nm$, $L = 100\,nm$ and $V_{GS} = 0$ in the cutoff region.

$$C_G = C_g W = C_{ox} W L = \frac{\epsilon_{ox}}{t_{ox}} WL \qquad \epsilon_0 = 8.85\times10^{-14}\,\frac{F}{cm}, \quad \epsilon_{ox} = 4\epsilon_0$$

$$C_G = \frac{4\,(8.85\times10^{-14}\,F/cm)}{22\times10^{-8}\,cm}\,(400\times10^{-7}\,cm)(100\times10^{-7}\,cm) = 0.64\,fF$$

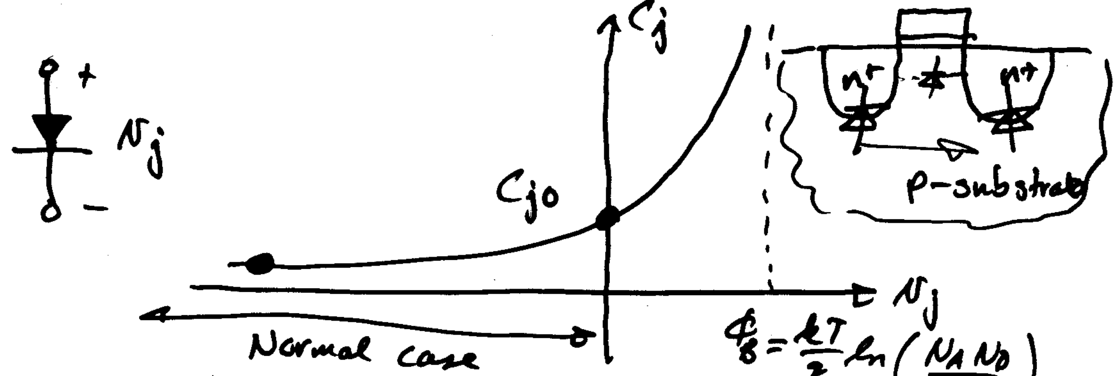
Cutoff: $C_{GS} = C_{GD} = 0$, $C_{GB} = 0.5\,C_G = \underline{0.32\,fF}$

Linear: $C_{GS} = C_{GD} = 0.5\,C_G = 0.32\,fF$, $C_{GB} = 0$

Saturation: $C_{GS} = \frac{2}{3} C_G = 0.43\,fF$, $C_{GD} = 0$, $C_{GB} = 0$

(Ignored the overlap capacitances, $C_{OL} = (LD)\cdot W \cdot C_{ox} \approx \frac{1}{10} C_G$)

pn-Junction Capacitances (Depletion Caps)



$$\phi_B = \frac{kT}{q} \ln\left(\frac{N_A N_D}{n_i^2}\right)$$

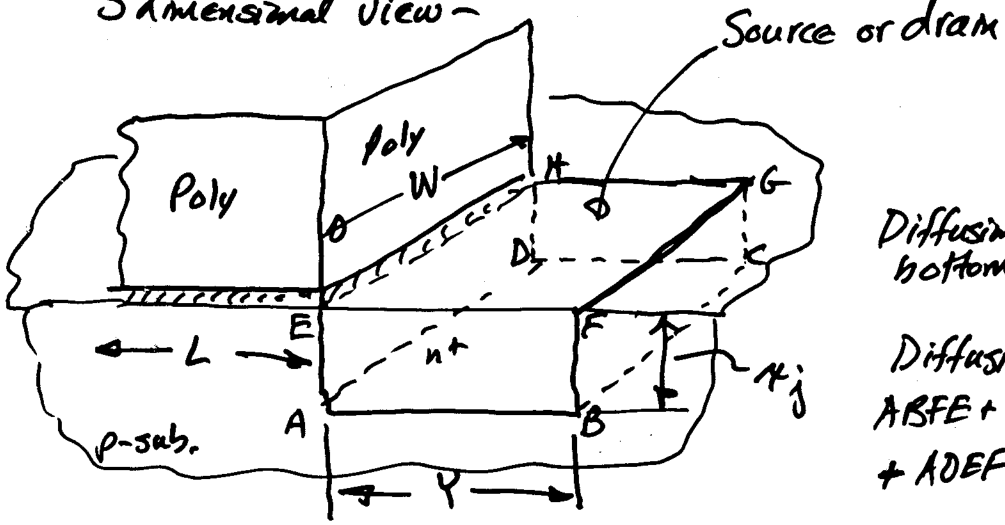
Theory –

$$C_j = \frac{C_{jo}}{\left(1 - \frac{v_j}{\phi_B}\right)^m}$$

$m = \frac{1}{2}$ for a step junct.
$m = \frac{1}{3}$ for a graded "

$$C_{jo} \hat{=} \sqrt{\frac{\epsilon_{si} q N_A}{2\phi_B}}$$

3 dimensional view –



Diffusion bottom = ABCD

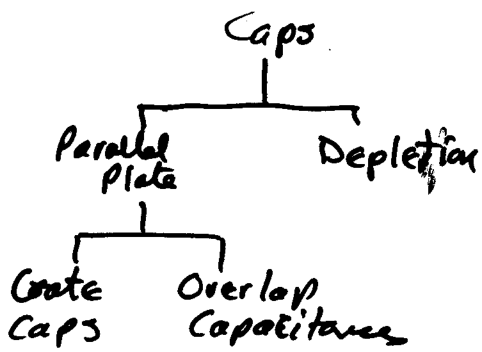
Diffusion sidewall = ABFE + BCFG + DCGH + ADEH

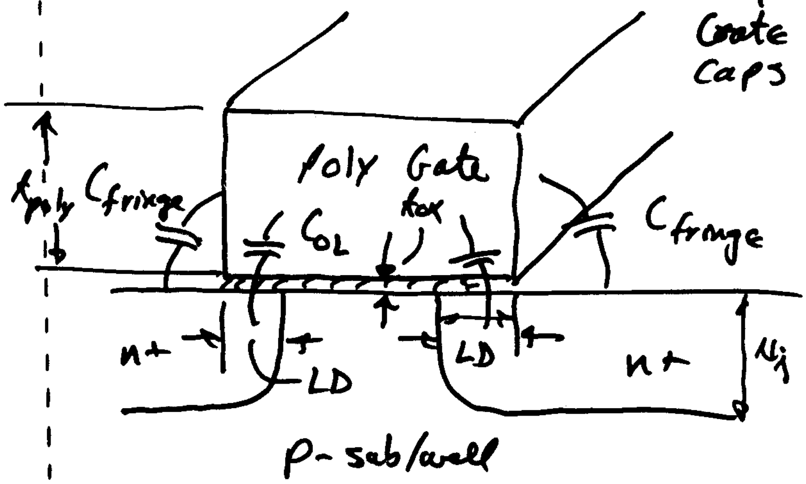
$$C_j = \frac{C_{jb} Y W}{\left(1 + \frac{v_j}{\phi_{Bb}}\right)^{m_j}} + \frac{C_{jsw} W \times x_j}{\left(1 + \frac{v_j}{\phi_{Bsw}}\right)^{m_{jsw}}} \approx \frac{C_{jb}(A_b + A_{sw})}{\left(1 - \frac{v_j}{\phi_B}\right)^m}$$

For digital applications, there are only two states.

$$C_J = K_{eq} C_{jb} (Y + x_j) W \text{ where } K_{eq} = \frac{-2\sqrt{\phi_B}}{V_{Hi} - V_{Lo}} \left[\sqrt{\phi_B - V_{Hi}} - \sqrt{\phi_B - V_{Lo}}\right]$$

Overlap Capacitances





$$C_{OL} = C_{ov} + C_f = C_{ox} L_D + \frac{2\epsilon_{ox}}{\pi} \ln\left(1 - \frac{T_{poly}}{t_{ox}}\right)$$

Ex. 2.13

Find C_{OL} for a $T_{poly}/t_{ox} = 100$ and $L_D = LD = 10\,nm$

$$C_f = \frac{2(4)(8.85\times10^{-14}\,F/cm)}{3.14} \ln(1+100) = 0.11\,fF/\mu m$$

$$C_{ov} = \frac{4 \cdot 8.85\times10^{-14}\,F/cm}{22\times10^{-8}\,cm} \times 10\times10^{-7}\,cm = 0.16\,fF/\mu m$$

$$C_{OL} = 0.27\,fF/\mu m$$