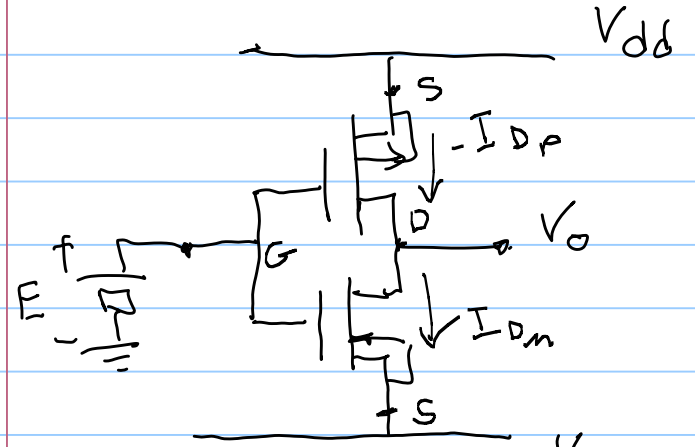
EE301

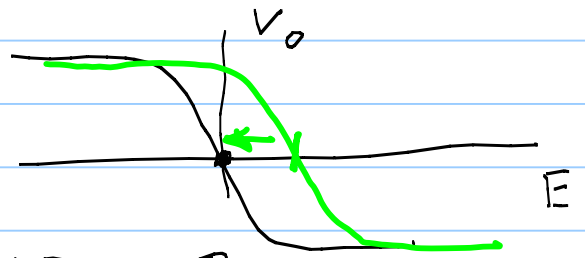
Note Title 3/16/2004



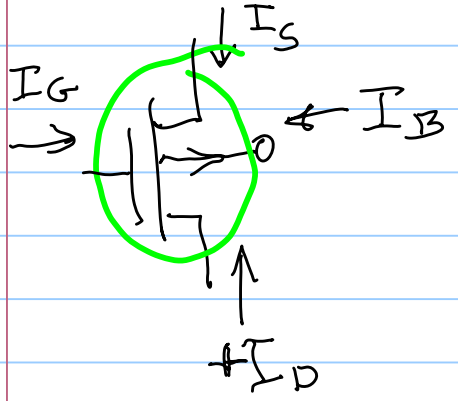
if $E = 0$ & $V_o \approx 0$ then

$V_{D_{n,p}} \approx V_{G_{n,p}}$

$|V_{DS}| \geq |V_{GS}| - |V_{TO}| \Rightarrow$ saturation



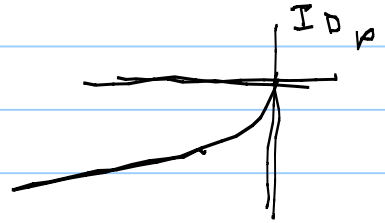
$V_{out} = -V_{dd}$

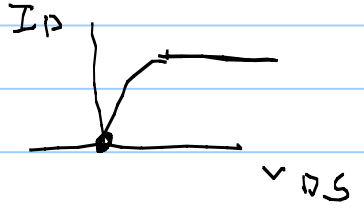


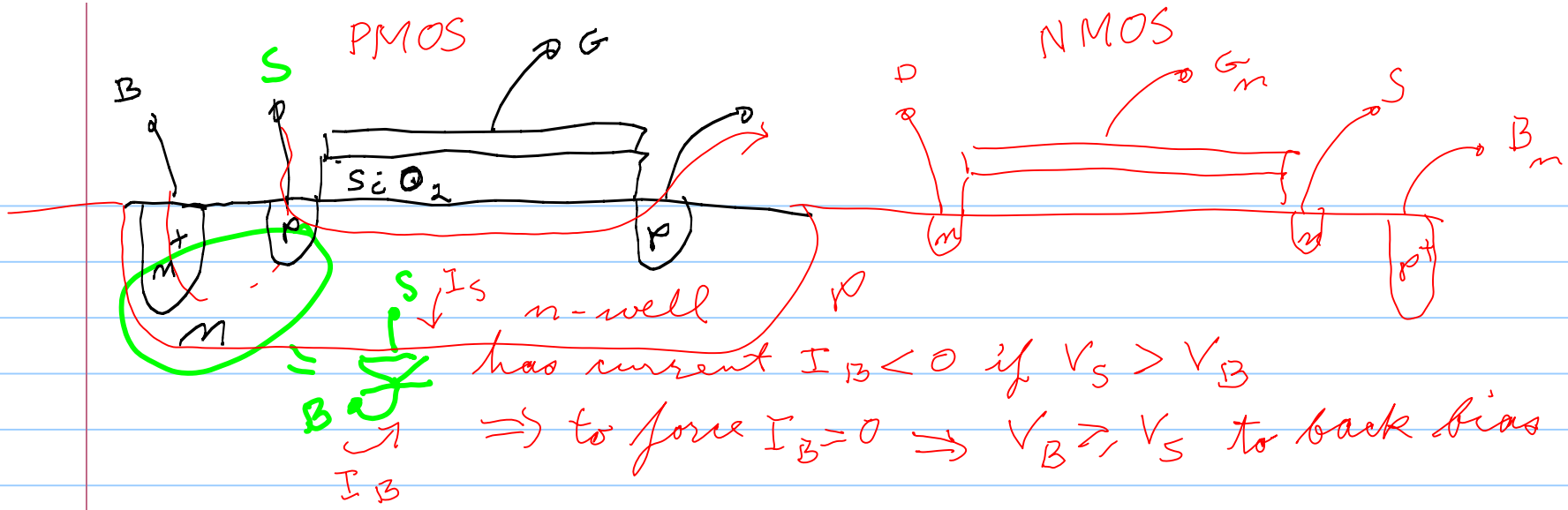
by KCL: $I_G + I_S + I_D + I_B = 0$

at DC, $I_G = 0$

we desire $I_D = -I_S \Rightarrow I_B = 0$







has current $I_B < 0$ if $V_S > V_B$

$\Rightarrow$ to force $I_B = 0 \Rightarrow V_B \geq V_S$ to back bias

$$I_{D_n} = \frac{KP}{2}\frac{W}{L}(V_{GS} - V_{th})^2 \quad ; \quad V_{th} = VTO + gamma\left(\sqrt{|V_{SB} - |2\phi_F|} - \sqrt{|2\phi_F|}\right)$$

in saturation

$$I_{D_n} = \frac{KP_n}{2}\left(\frac{W}{L}\right)_n \underbrace{(E - V_{ss})}^{0} - V_{th_n})^2 (1 + \lambda_n \underbrace{(V_0 - (V_{ss}))}^{0}) = k_n (V_{GS} - V_{th})^2 (1 + \lambda V_{DS})$$

$$= k_n (V_{dd} - V_{th_n})^2 (1 + \lambda_n V_{dd})$$

$$k = \frac{KP}{2} \cdot \frac{W}{L}$$

$$= -I_{D_p} = k_p \underbrace{(V_{dd} - E - |V_{th_p}|)}_{(V_{GS} - V_{th_p})}^2 (1 + |\lambda_p|(V_{dd} - V_0)) = k_p (V_{dd} - |V_{th_p}|)^2 (1 + |\lambda_p| V_{dd})$$

$$(V_{GS} - V_{th_p}) \simeq (E - V_{dd} - V_{th_p}) \quad = I_{S_p} \text{ if } I_B = 0$$

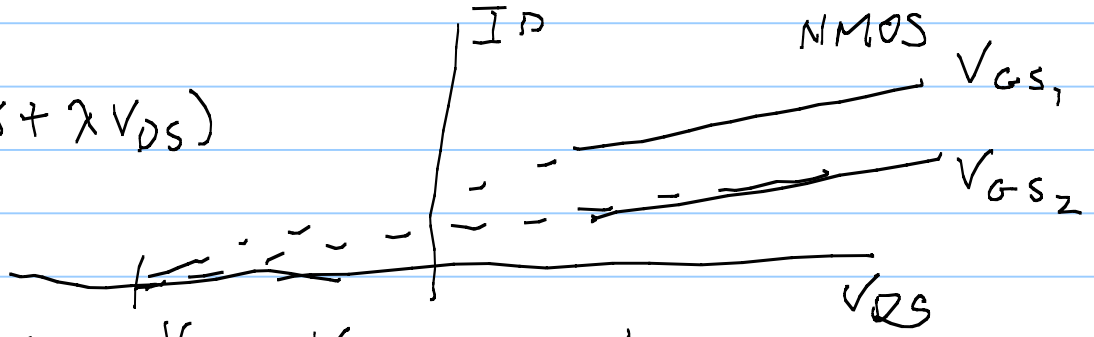
$$k_p = k_n \left(\frac{(V_{dd} - V_{thn})^2 (1 + \lambda_n V_{dd})}{(V_{dd} - |V_{thp}|)^2 (1 + |\lambda_p| V_{dd})} \right)$$

$$\left(\frac{W}{L}\right)_p = \left(\frac{W}{L}\right)_n \frac{KP_n}{KP_p} \left(\frac{(V_{dd} - V_{thn})^2 (1 + \lambda_n V_{dd})}{(V_{dd} - |V_{thp}|)^2 (1 + \lambda_p V_{dd})} \right)$$

gives transitions at 0

$$I_D = k(V_{GS} - V_{TO})^2 (1 + \lambda V_{DS})$$

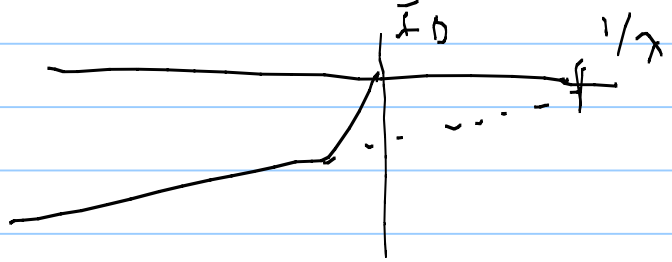
$$\text{slope} = k(V_{GS} - V_{TO})^2 \cdot \lambda$$



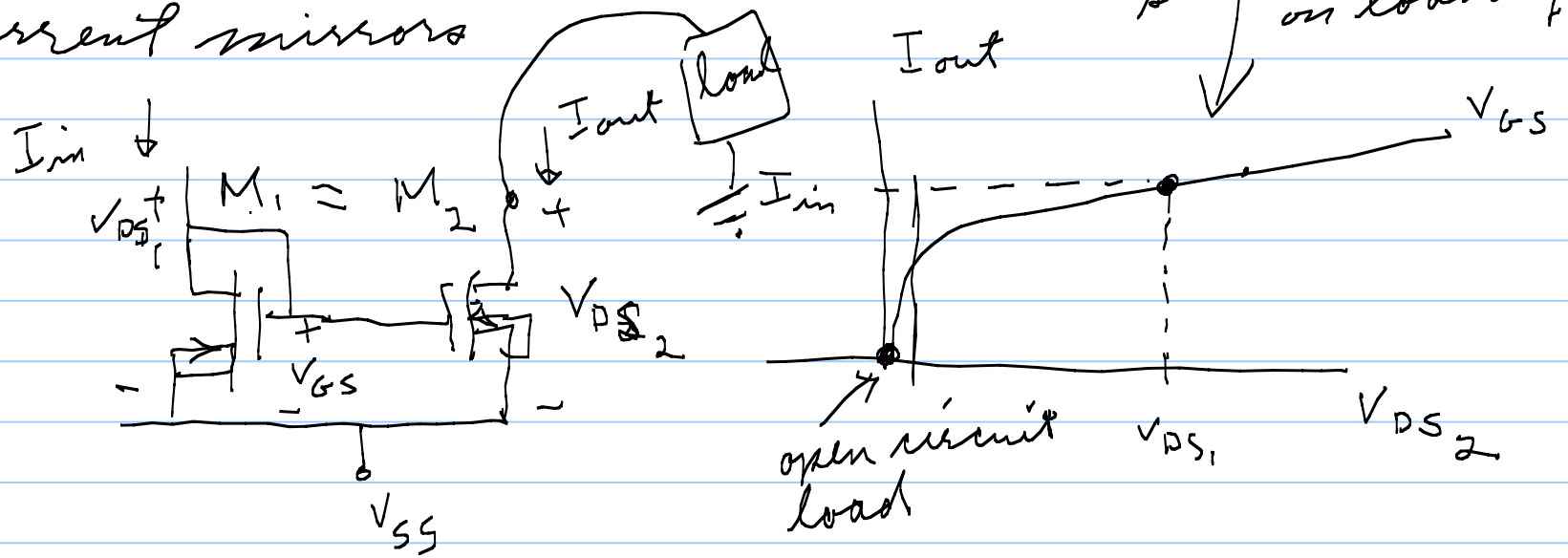
$$V_{DS} = -1/\lambda \simeq -V_A$$

λ = 1/Early voltage

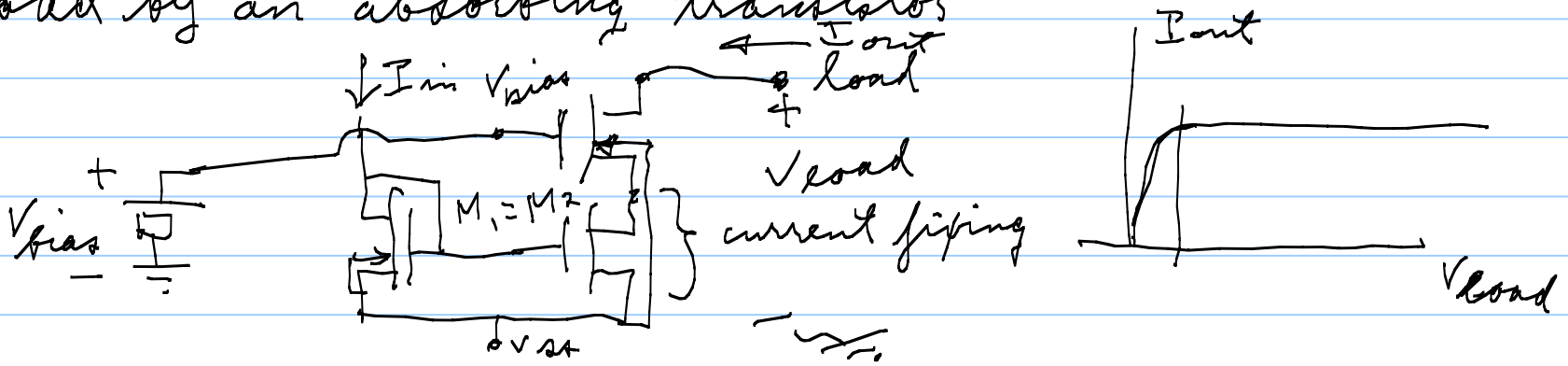
if $V_A = 100$, $\lambda = 0.01$



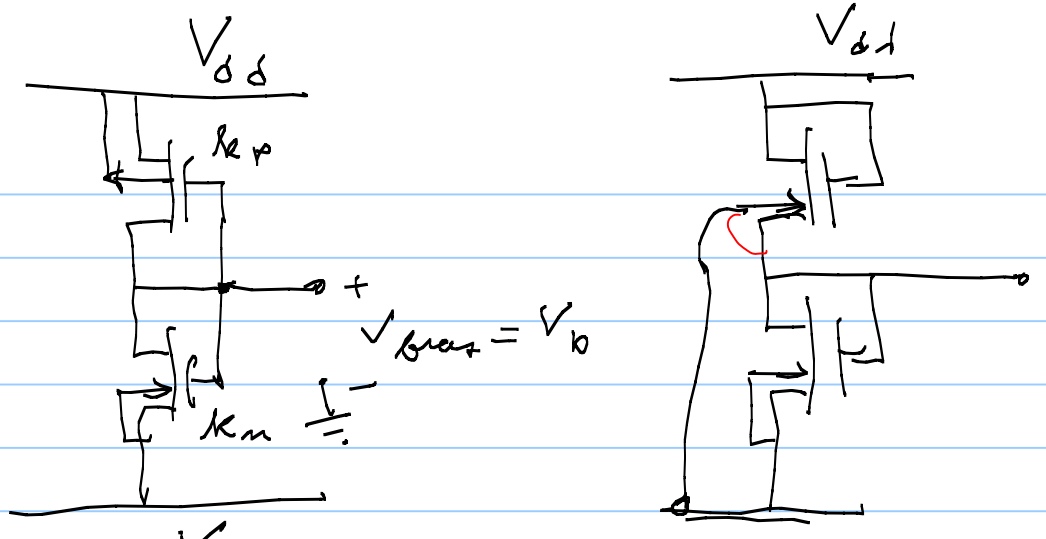
Current mirrors



desire Iout independent of loading; so isolate the load by an "absorbing" transistor



to get V_{bias}



$$I_{D_n} = k_n (V_b - V_{ss} - V_{th_n})^2 = k_p (V_{dd} - V_b - |V_{th_p}|)^2 = -I_{D_p}$$

$$(V_{SG} - |V_{th_p}|)^2$$

$$V_b - V_{ss} - V_{th_n} = \sqrt{\frac{k_p}{k_n}} (V_{dd} - V_b - |V_{th_p}|)$$

$$\text{or } \left(1 + \sqrt{\frac{k_p}{k_n}}\right) V_b = V_{ss} + V_{th_n} + \sqrt{\frac{k_p}{k_n}} (V_{dd} - |V_{th_p}|)$$

$$\text{also } \frac{k_p}{k_n} = \left(\frac{(V_b - V_{ss} - V_{th_n})}{(V_{dd} - V_b - |V_{th_p}|)} \right)^2$$

for transistor sizing given V_b

$$V_{ss} + V_{th_n} \leq V_b \leq V_{dd} - |V_{th_p}|$$