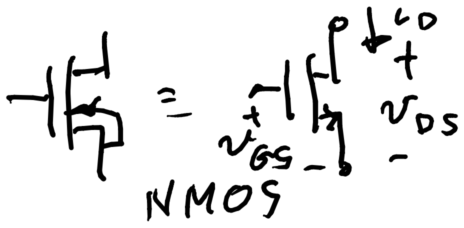
EE303
09/11/12

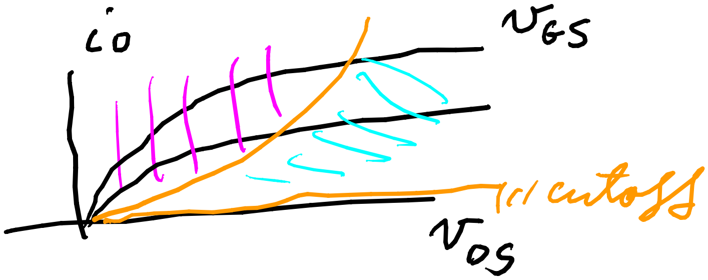
Load lines, diode, p. 180, Fig 4.11 (& Q point)

Biasing BJT (npn, p. 447, Fig 6.60)
MOS (NMOS, p. 308, Fig. 5.52)

Current mirrors BJT (npn, p. 452, Fig. 6.63(b))
MOS (NMOS, p. 313, Fig. 5.55(b))

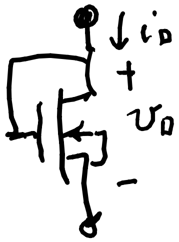
MOS characteristics





$$i_D = \frac{KP}{2}\cdot\frac{W}{L}\cdot\begin{cases} 0 & v_{GS}-VTO \le 0 \le v_{DS} \quad \text{cutoff}\\ (v_{GS}-VTO)^2(1+\lambda v_{DS}) & 0 \le v_{GS}-VTO \le v_{DS} \quad \text{saturation}\\ \left[2(v_{GS}-VTO)v_{DS}-v_{DS}^2\right](1+\lambda v_{DS}) & 0 \le v_{DS} \le v_{GS}-VTO \quad \text{triode, ohmic}\end{cases}$$

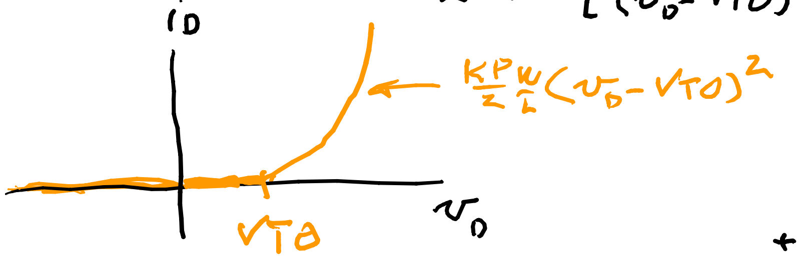
Can make a diode

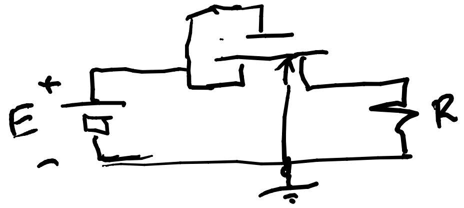


if VTO > 0 (enhancement device)

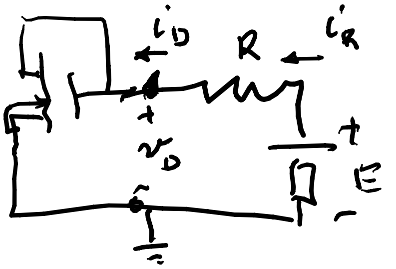
$v_D = v_{GS} = v_{DS} \Rightarrow v_{GS} - V_{TO} \le v_{GS} = v_{DS}$ in saturation if $v_D > VTO$

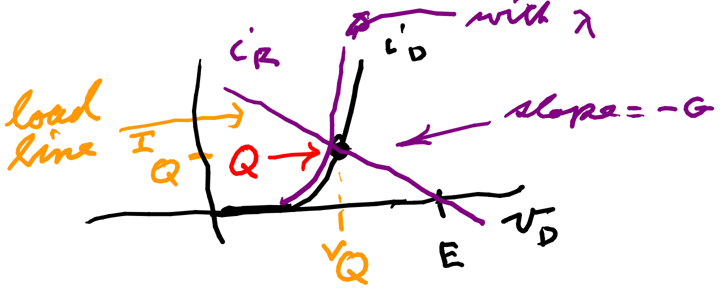
$$i_D = \frac{KP}{2}\frac{W}{L}\cdot\begin{cases} 0 & \text{if } v_{GS}-VTO = v_D - VTO < 0\\ (v_D-VTO)^2 \end{cases}$$





or





$$v_D = -R i_R + E$$

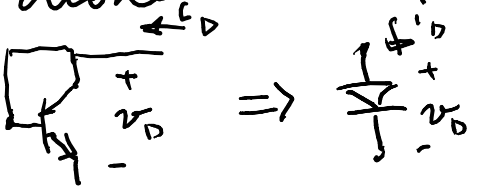
$$i_R = \frac{1}{R}(E - v_D) = G(E - v_D)$$

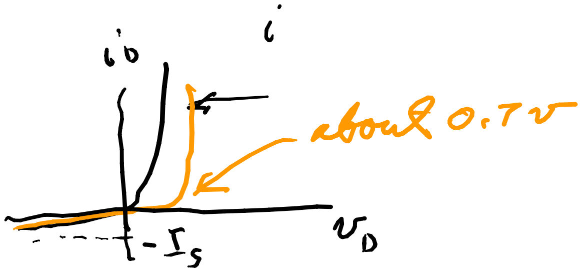
$G = 1/R$ = conductance works, by KCL, where $i_R = i_D$

To find I_Q, V_Q have a quadratic eq.

$$G(E - V_Q) = \frac{KP}{2}\frac{W}{L}(V_Q - VTO)^2$$

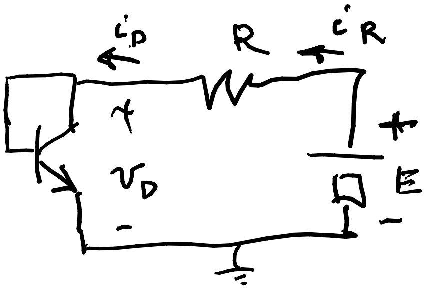
a BJT diode

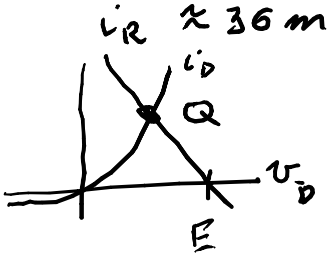




$i_D = I_S(e^{v_D/V_T} - 1)$, $-\infty < v_D < \infty$ $V_T = \frac{kT}{|Q_{electron}|}$, k = Boltzmann const, T in °Kelvin

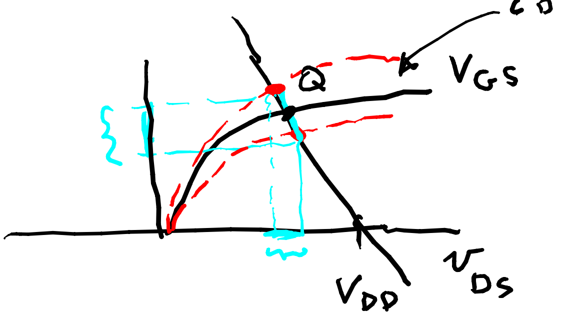
≈ 36 mV @ room T

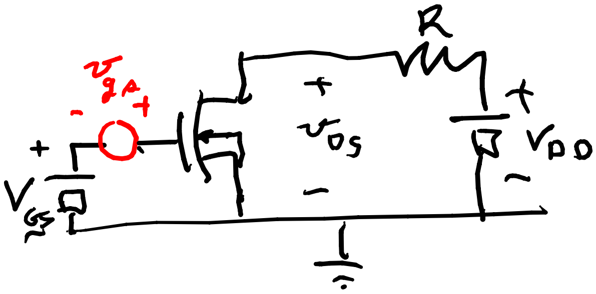




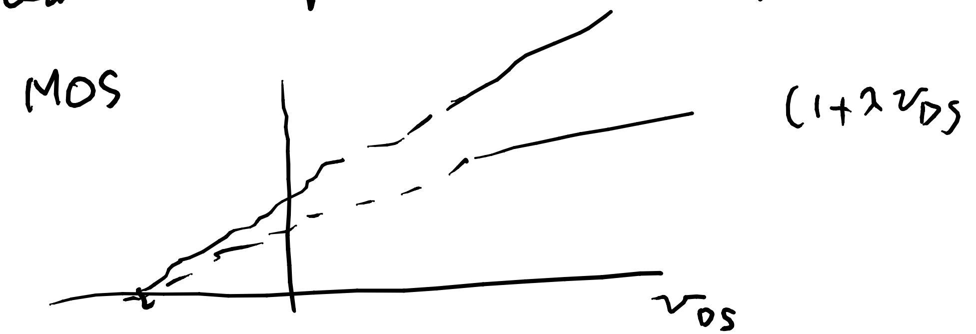
$$i_R = G(E - V_Q) = i_D = I_S(e^{V_Q/V_T} - 1)$$

Bias a transistor



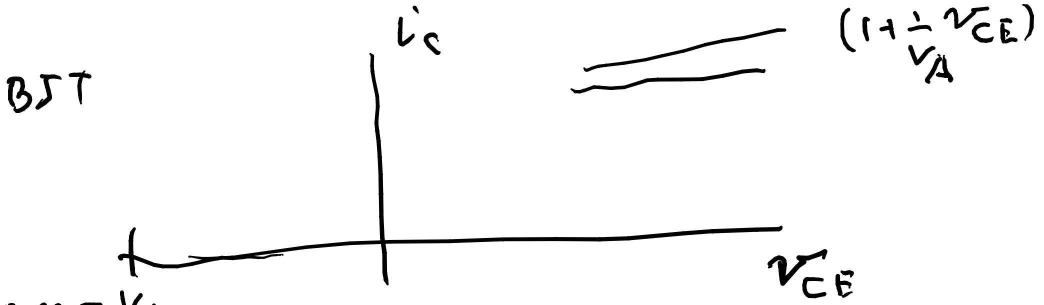


interested in changes in i_D vs changes in v_{GS}



$-10v \approx -1/\lambda$

$= -$ Early voltage $= -V_A$



$-100 \approx -V_A$