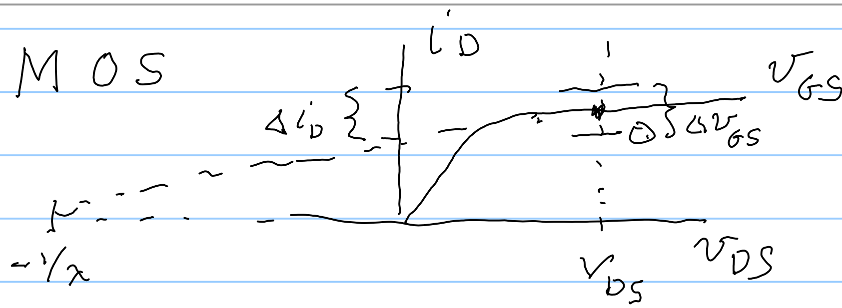
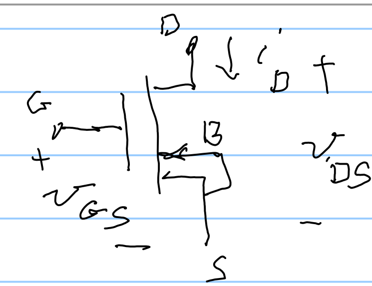
Note Title 9/22/2016

EE 303 H
09/22/16

MOS





enhancement mode NMOS

$V_{TH} > 0$

$$i_D(v_{DS}, v_{GS}) = I_D + \frac{\partial i_D}{\partial v_{DS}}\Big|_Q (v_{DS} - V_{DS}) + \frac{\partial i_D}{\partial v_{GS}} (v_{GS} - V_{GS}) + \dots$$

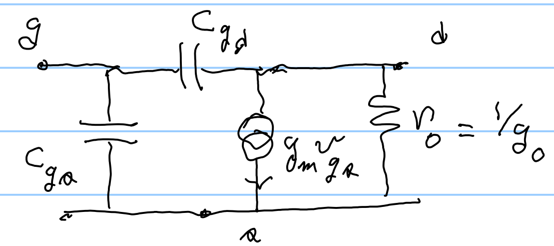
ignore for small signal

$$\Rightarrow i_D - I_D = i_d$$

$$v_{DS} - V_{DS} = v_{ds}, \quad v_{GS} - V_{GS} = v_{gs}$$

$$i_d = \frac{\partial i_D}{\partial v_{DS}}\Big|_Q v_{ds} + \frac{\partial i_D}{\partial v_{GS}}\Big|_Q \cdot v_{gs}$$

$$= g_o \cdot v_{ds} + g_m \cdot v_{gs}$$



C of channel = $W \cdot L \cdot C_{ox}$, $C_{ox} = \epsilon_{SiO_2}$ / thickness of oxide (t_{ox})

p.252 $\epsilon_{SiO_2} = 8.854 \times 10^{-12}$ F/m

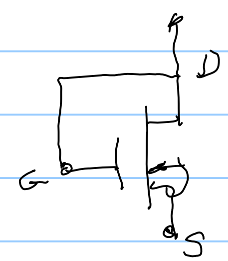
$g_o \approx \frac{I_D}{\lambda}$, g_m = hold $v_{DS} = V_{DS}$ & find $\Delta i_D / \Delta v_{GS}$ for small Δv_{GS}

Theoretical eqs. ($v_{DS} \geq 0$, $v_{GS} \geq 0$) ← = V_{TH} ($V_{TH} = V_{TO}$ if $v_{BS} = 0$

$$i_D = \begin{cases} 0 & \text{when } v_{GS} < V_{TH} \text{ cutoff} \\ \frac{KP}{2} \cdot \frac{W}{L} \times \begin{cases} (v_{GS} - V_{TH})^2 (1 + \lambda v_{DS}) & \text{saturation when } v_{GS} - V_{TH} \leq v_{DS} \\ (2(v_{GS} - V_{TH}) v_{DS} - v_{DS}^2)(1 + \lambda v_{DS}) & \text{when } v_{GS} - V_{TH} \geq v_{DS} \text{ ohmic = triode} \end{cases} \end{cases}$$

p.266

diode connected



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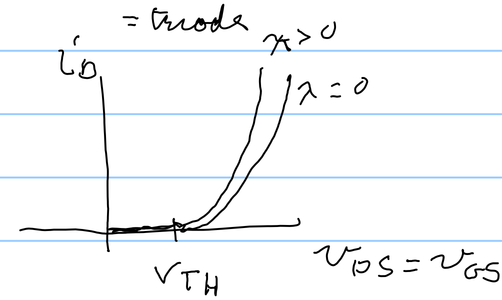
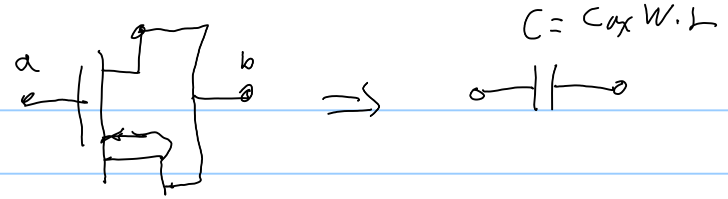
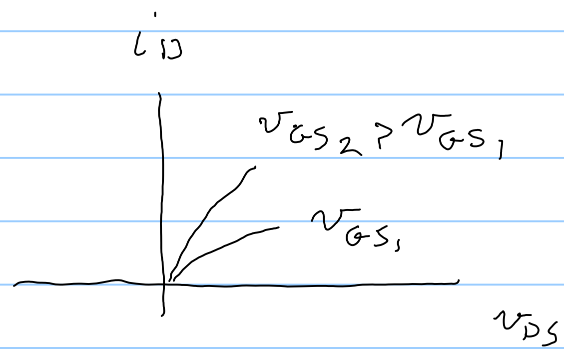


to make a capacitor

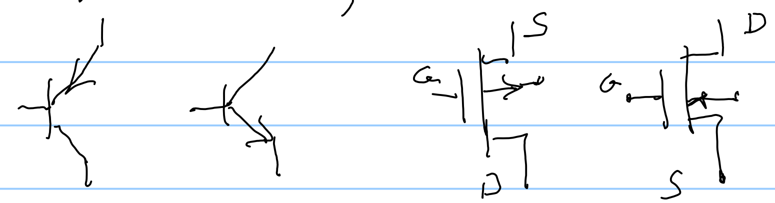


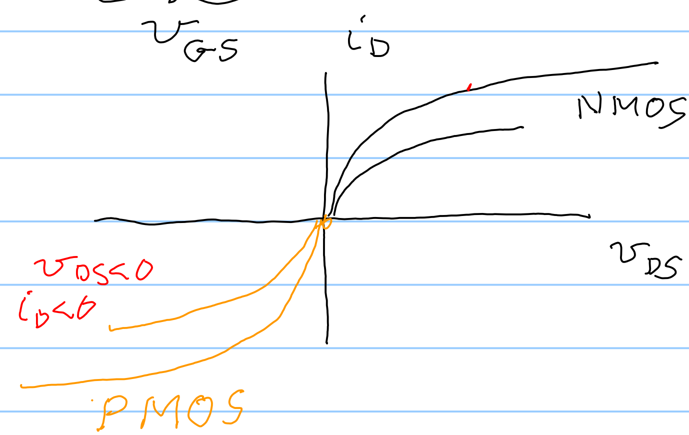


$g\Big|_{\text{near } v_{DS}=0} = 2(v_{GS} - V_{TH}) \cdot \frac{KP}{2}\frac{W}{L} = \frac{I_D}{V_{DS}}$

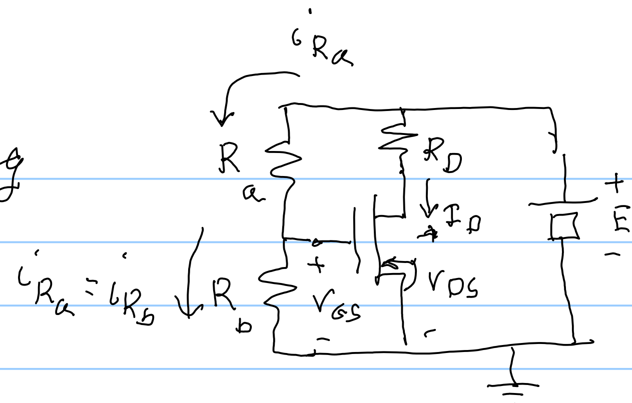
gives a voltage variable resistor (v_{GS})

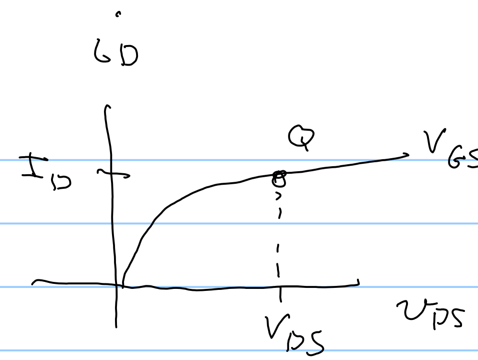
pnp vs npn, PMOS vs NMOS





Biasing



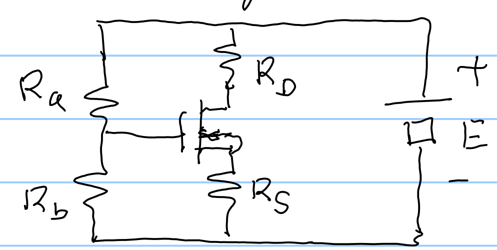


$V_{GS} = \frac{R_b}{R_a + R_b} \cdot E$; $I_D = (E - V_{DS})/R_D \Rightarrow R_D = \frac{E - V_{DS}}{I_D}$

$(R_a + R_b) V_{GS} = R_b E \Rightarrow R_a V_{GS} = R_b (E - V_{GS})$, $\frac{R_a}{R_b} = \left(\frac{E}{V_{GS}} - 1\right)$

normally choose R_b large Then $R_a = \left(\frac{E - V_{GS}}{V_{GS}}\right) R_b$

To prevent temperature run away we add R_S

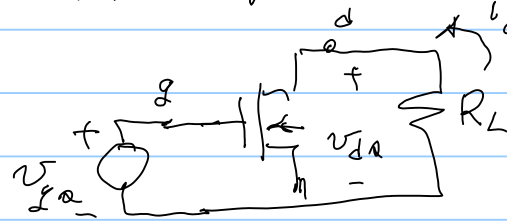


$V_{DS} = E - (R_D + R_S) I_D$

$V_{GS} = \frac{R_b}{R_a + R_b} \cdot E - R_S I_D$

Have $\frac{v_o}{v_{in}} = \frac{v_{ds}}{v_{gs}} \approx -g_m R_L = A_v$ = voltage gain

$i_d = g_m v_{gs}$ if $g_o = 0$



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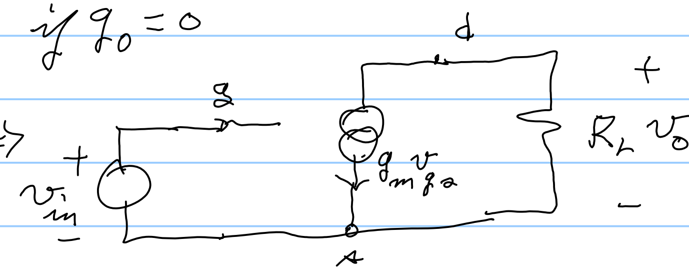

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