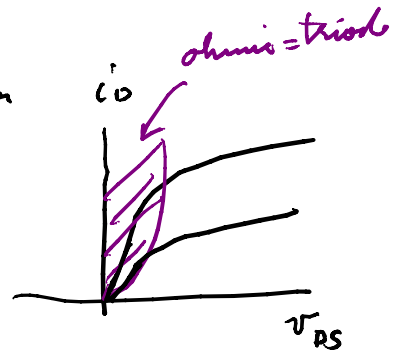


pages 550-551 = summary of models
 321 = MOS capacitors

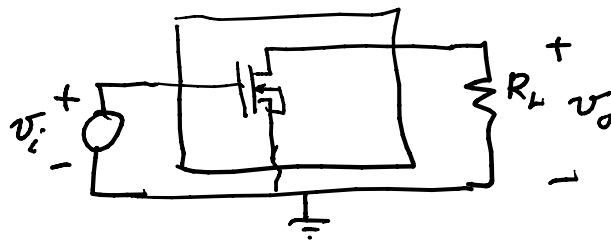
EE303
 02/21/08
 correction 02/22/08

$$C_{ga} = C_{gd} = \frac{1}{2} \frac{WL \epsilon_{ox}}{t_{ox}} = \frac{1}{2} WL C_{ox} \quad \text{in saturation}$$

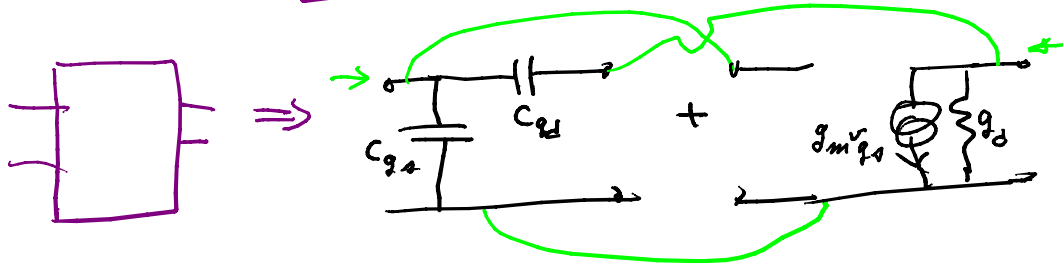
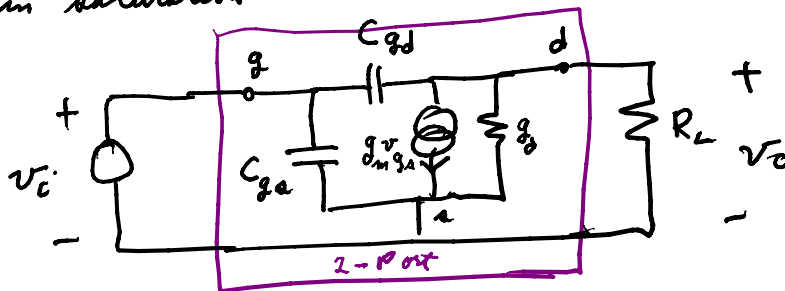
$$\left. \begin{array}{l} C_{ga} = \frac{2}{3} WL C_{ox} \\ C_{gd} = 0 \end{array} \right\} \text{in ohmic = triode region}$$



small signal



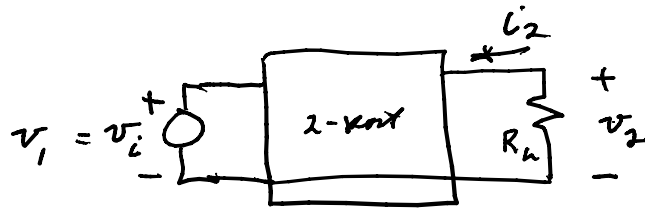
in saturation



$$C_g = C_{ga} + C_{gd}$$

$$Y_c + Y_{gm} = \begin{bmatrix} sC_g & -sC_{gd} \\ g_m - sC_{gd} & g_d + sC_{gd} \end{bmatrix}$$

$$= \begin{bmatrix} sC_g & -sC_{gd} \\ g_m - sC_{gd} & g_d + sC_{gd} \end{bmatrix}$$



$$v_2 = -R_L i_2 \Rightarrow i_2 = -G_L \cdot v_2$$

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

here $v_1 = v_i \xrightarrow{\text{2nd eq.}} i_2 = -G_L v_2 = y_{21} v_i + y_{22} v_2$

$$v_2 = \frac{1}{-(G_L + y_{22})} [y_{21} v_i] \Rightarrow \frac{v_2}{v_i} = \text{voltage gain of this amplifier} = \frac{-y_{21}}{G_L + y_{22}}$$

here

$$\frac{v_2}{v_i} = \frac{-[g_m - sC_{gd}]}{G_L + g_d + sC_{gd}}$$

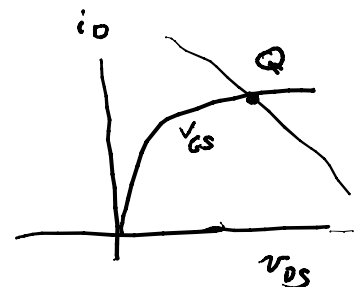
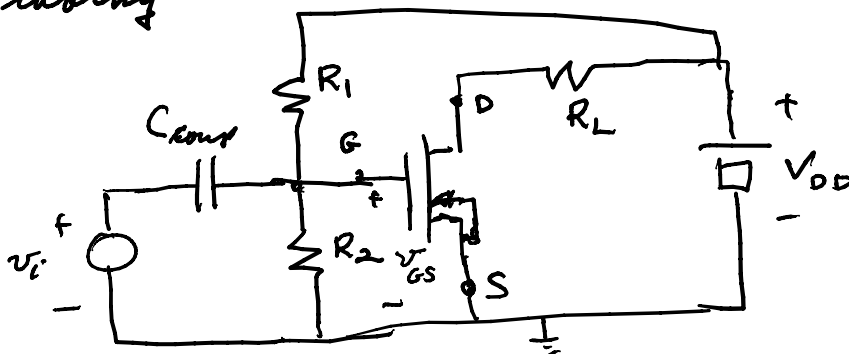
as $s \rightarrow 0$ (low frequencies)

$$\frac{v_2}{v_i} = \frac{-g_m}{G_L + g_d}$$

If the Early effect can be ignored then $\lambda = 0$, $\Delta i_D / \Delta v_{DS} = 0 \Rightarrow g_d = 0$

$$\frac{v_2}{v_i} = -\frac{g_m}{G_L} = -R_L g_m$$

Biasing



coupling
blocks DC
allows signal
to go through.

$$V_{GS} = \frac{R_2}{R_1 + R_2} \cdot V_{DD} = \frac{1}{1 + (R_1/R_2)} \cdot V_{DD}$$

for min mos $t_{ox} = 418 \times 10^{-10}$ meters

(see p. 261) $\epsilon_{ox} = 3.45 \times 10^{-11}$ Farads/meter

$$C_{ga} = \frac{1}{2} W L \times \frac{\epsilon_{ox}}{t_{ox}} \quad \text{if } W = 10\mu = L, \quad \mu = \text{micron} = 10^{-6} \text{ meter}$$

$$= \frac{1}{2} 10 \times 10^{-6} \times 10 \times 10^{-6} \times \frac{3.45 \times 10^{-11}}{418 \times 10^{-10}} \text{ Farads}$$

$$= \frac{10^{-10}}{10^{-10}} \times \frac{3.45 \times 10^{-11}}{0.836 \times 10^{-3}} \approx 4 \times 10^{-11} \times 10^{-3} = 4 \times 10^{-14} = 4 \times 10^{-2} \times 10^{-12} = 0.04 \text{ pF}$$

$K_P = 5.05 \times 10^{-5} \text{ amp/V}^2$ Choose a Q point

$$g_m = \frac{K_P W}{2 L} (V_{GS} - V_{TO}) \cdot 2 \left(\frac{\text{amp}}{\text{volt}} = \text{Mhos} \right) ; V_{TO} = 0.86 \text{ volts from model}$$

choose $V_{GS} = 2.86 \Rightarrow g_m = K_P \cdot \frac{W}{L} (2.86 - 0.86)$

$$= 5.05 \times 10^{-5} \times 2 \text{ amp/volt} = 50.5 \times 10^{-6} \text{ amp/volt}$$

for g_d : $g_d = \frac{K_P W}{2 L} (V_{GS} - V_{TO})^2 \cdot \lambda ; \lambda = 1.84 \times 10^{-2} \text{ from model}$

$$= \frac{K_P}{2} (2)^2 \times 1.84 \times 10^{-2} = 5.05 \times 1.84 \times 2 \times 10^{-7}$$

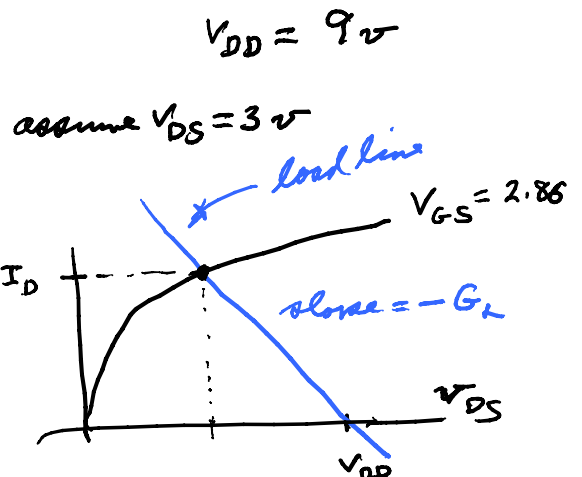
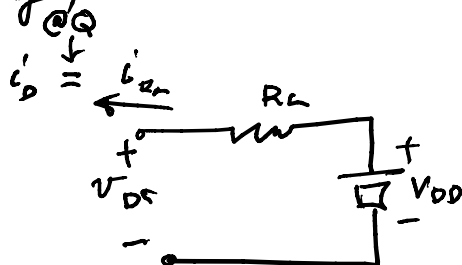
$$\approx 2 \times 10^{-6} ; \mu_D \approx \frac{1}{2} \times 10^6 = 500 \text{ k}\Omega$$

$$I_D = \frac{K_P W}{2 L} (V_{GS} - V_{TO})^2 (1 + \lambda V_{DS})$$

$$= 5.05 \times 10^{-5} \times 2 (1 + 1.84 \times 10^{-2} \times 3)$$

$$\approx 11 \times 10^{-5} = 110 \text{ nAmp}$$

This fixes the load line



$$V_{DD} = R_L I_{R_L} + V_{DS}$$

$$\Rightarrow I_{R_L} = \frac{V_{DD} - V_{DS}}{R_L} = G_L V_{DD} - G_L V_{DS}$$

assuming $V_{DS} = 3$, $G_m = \frac{I_D}{V_{DD} - V_{DS}} = \frac{110 \times 10^{-6}}{5 - 3} = 55 \mu \text{ mhos}$

$$R_L = \frac{1}{G_m} = \frac{2}{110} \times 10^6 = \frac{2}{1.10} \times 10^4 \approx 18 \text{ kOhms}$$

$$\frac{v_2}{v_1} = -g_m R_L = -50.5 \times 10^{-6} \times 18 \times 10^3 \approx -0.9 \times 2 = -1.8$$