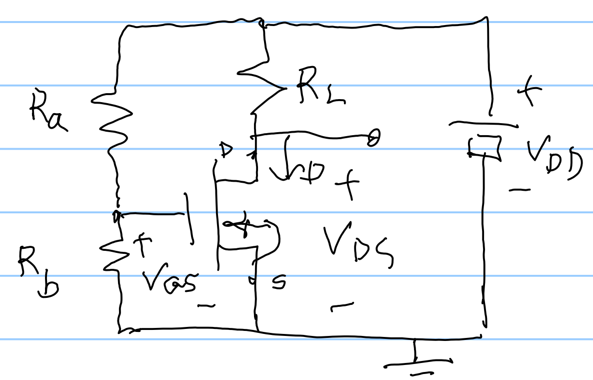
EE303H
09/29/16

Note Title 9/29/2016

Given a transistor (MOS), & I_D & A_v & V_{DD}

$I_D = \beta (V_{GS} - V_{TO})^2 (1 + \lambda V_{DS})$ $\beta = \frac{KP}{2}\frac{W}{L}$, V_{TO}, λ known

$A_v = -g_m R_L$ (actually $g_o + G_L \Rightarrow 1/R_L$)



sat try $\lambda \to 0$

$I_D = \beta (V_{GS} - V_{TO})^2 \Rightarrow V_{GS} = V_{TO} + \sqrt{I_D/\beta}$

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

choose R_b large

$g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_Q = \frac{2 I_D}{(V_{GS} - V_{TO})}$ known if $\lambda = 0$ as found V_{GS}

$\Rightarrow R_L = \frac{-A_v}{g_m} = \frac{(V_{GS} - V_{TO})}{2 I_D}$

$V_{DS} = V_{DD} - R_L I_D$. need $V_{DS} > (V_{GS} - V_{TO})$

If $\lambda \approx 0$ then $I_D \cdot R_L = \frac{(V_{GS} - V_{TO})}{2} = \beta (V_{GS} - V_{TO})^2 (1 + \lambda V_{DS}) \cdot R_L$

$(V_{GS} - V_{TO}) \approx \beta (V_{GS} - V_{TO})^2 \cdot (1 + \lambda [V_{DD} - R_L I_D]) \cdot R_L$

$\Rightarrow \quad 1 = \beta (V_{GS} - V_{TO})(1 + \lambda [V_{DD} - R_L \beta (V_{GS} - V_{TO})^2 \cdot (1 + \lambda V_{DS})]) \cdot R_L$

$\Rightarrow$ use 1st order approximation & iterate via CAD

Spice $\Rightarrow$ PARAM

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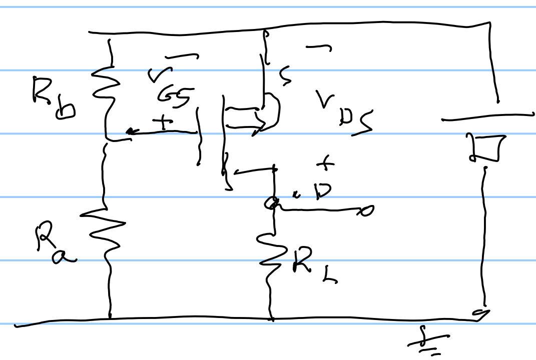
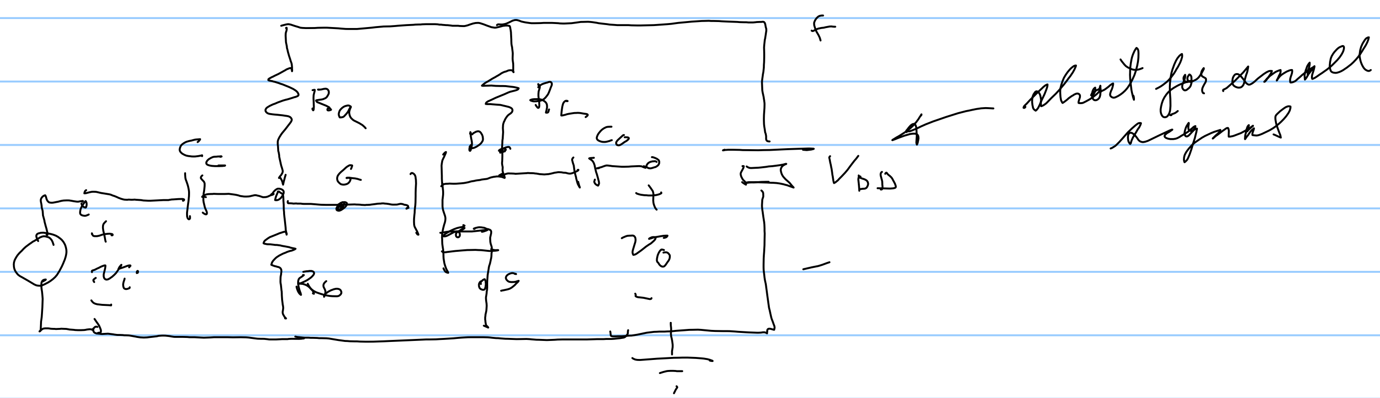
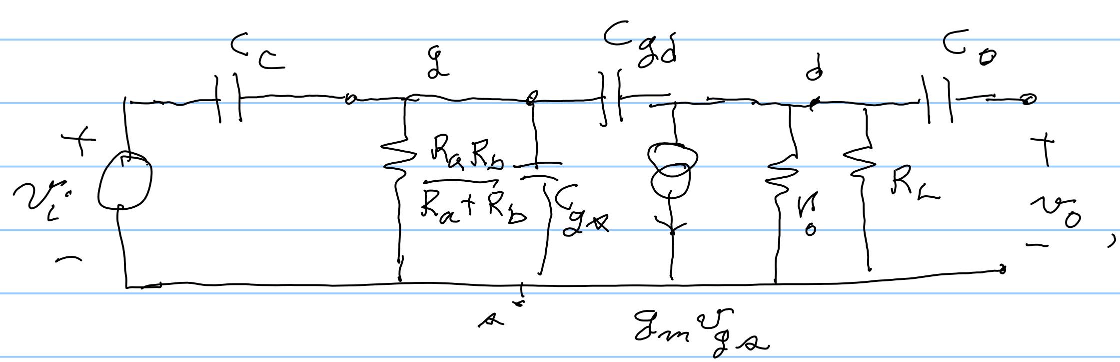
for PMOS



to signal we insert capacitors to decouple bias from signal

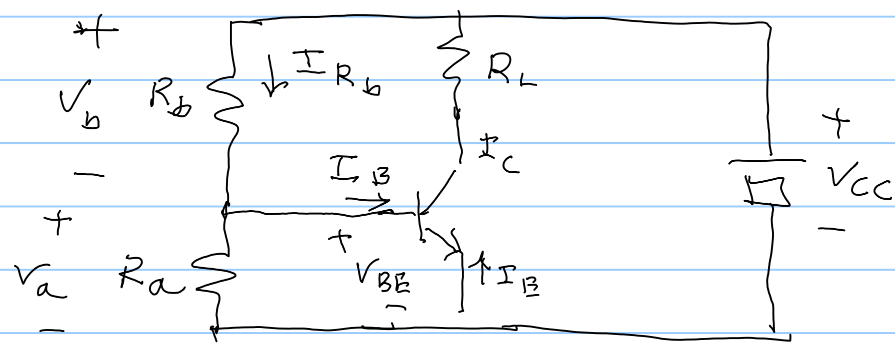




$R_L' = r_o \| R_L = \frac{1}{g_o + G_L}$

$A_v = \frac{v_o}{v_i}(s) \Big|_{@\,small} = -g_m R_L'$

choose C_c & C_o large so they are shorts @ signal frequency for npn: has $I_B \neq 0 \Rightarrow$ if know I_C, $I_B = \frac{1}{\beta} I_C$



assume $V_{BE} \approx 0.65V$

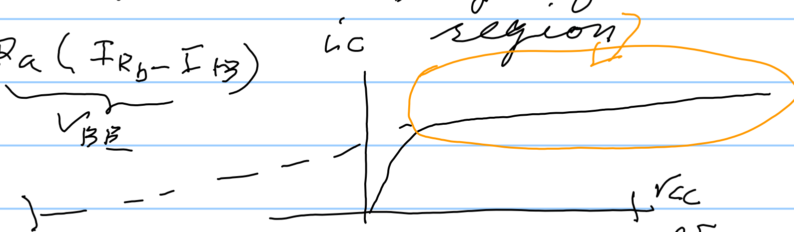
here $V_{CC} = R_b I_{R_b} + R_a(I_{R_b} - I_B)$

$V_a = 0.65 = V_{BE}$ if in forward active region

if choose $R_b \Rightarrow I_{R_b}$

then we know R_a $V_{CC} = V_b + R_a(I_{R_b} - I_B)$ (V_{BE})

$R_a = \frac{V_{BE}}{I_{R_b} - I_B}$



$-74V = -V_{AF} = -$ Early voltage

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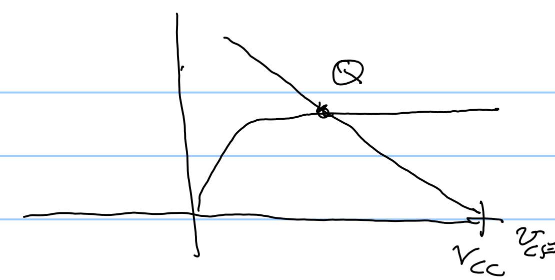
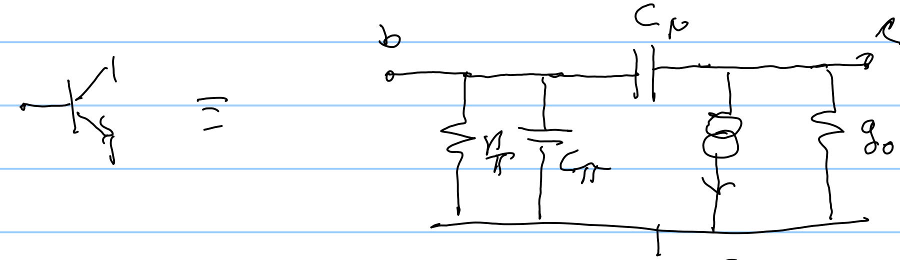
$$A_v = -g_m R_L = -\frac{I_C}{V_T} \cdot R_L \Longrightarrow R_L = -\frac{A_v}{g_m}$$



so some difficulties



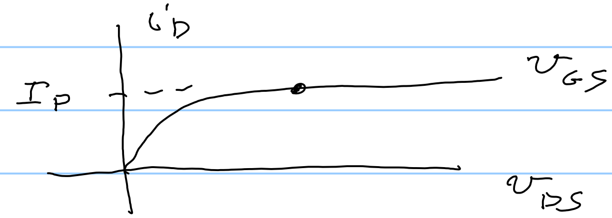
$g_m v_{be}$, $g_m = \frac{I_C}{V_T}$

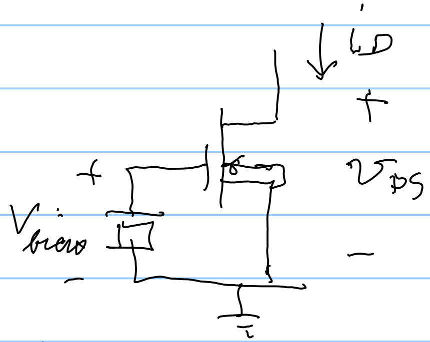
$$g_\pi = 1/r_\pi = \frac{g_m}{\beta} \simeq$$

data sheet gives $h_{FE} = \left.\frac{i_C}{i_B}\right|_{Q \Rightarrow \text{constant } v_{CE} = \text{a short}} \equiv \beta$

comes from H parameters $\begin{bmatrix} v_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{FE} & h_{21} \end{bmatrix} \begin{bmatrix} i_1 \\ v_2 \end{bmatrix}$

Current mirrors & sources





v_{DS} constant $\Longrightarrow$ looks like current source

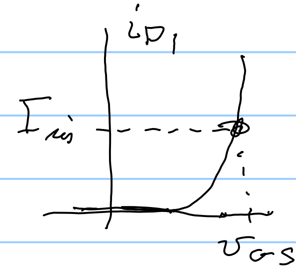
$I_D = I_{bias}$

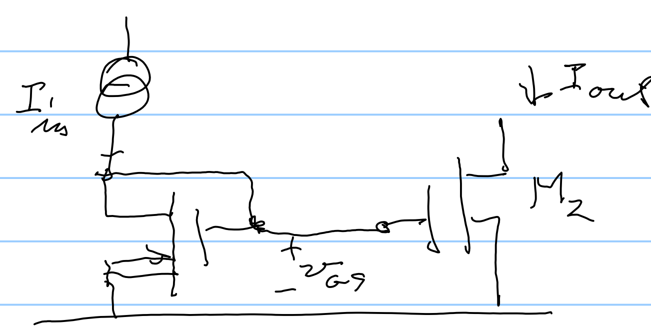
needs

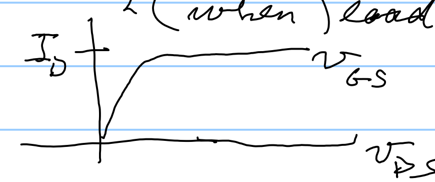
$v_{DS} \geq (V_{bias} - V_{TO})$

a current source

To mirror







operation
keep M_2 in saturation
(when) load