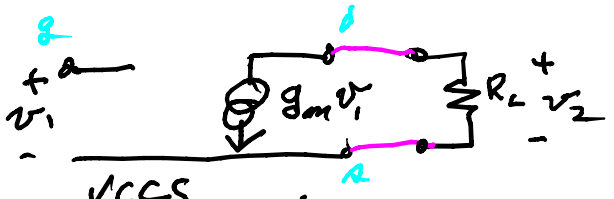
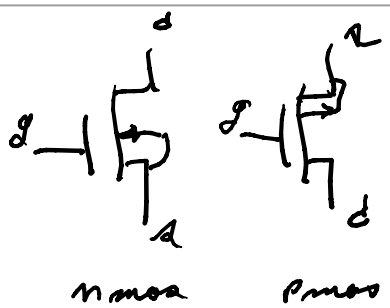
EE303
9/22/11

Note Title 9/20/2012

small signal near DC

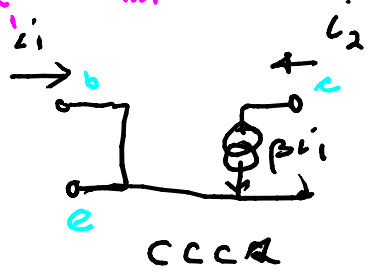


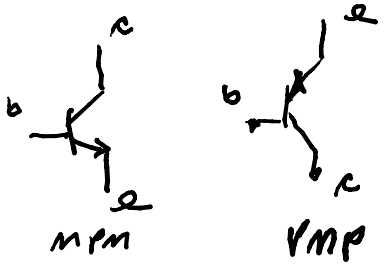
$\Rightarrow$



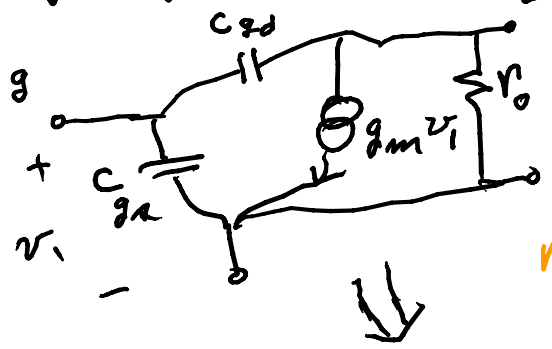
g_m mutual transconductance

$\frac{v_2}{v_1} = -g_m R_L$

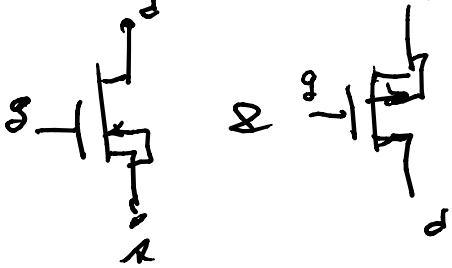




for higher frequencies & some loss



$=$



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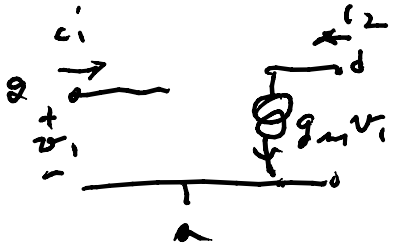
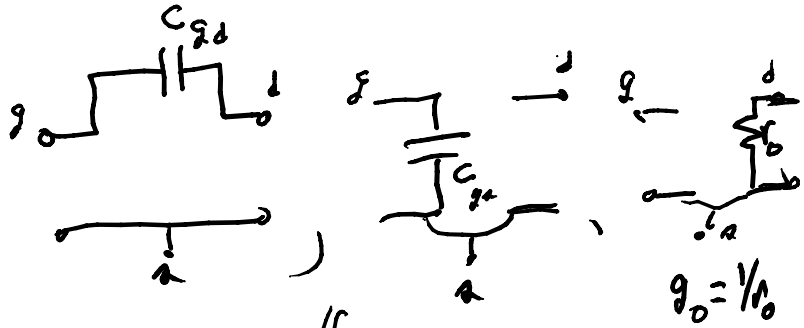
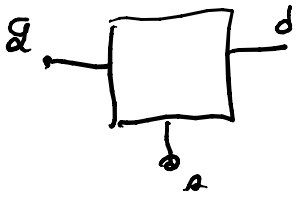
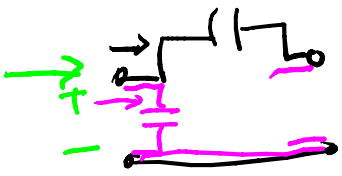
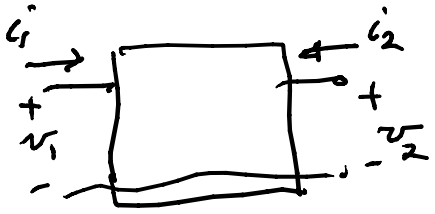




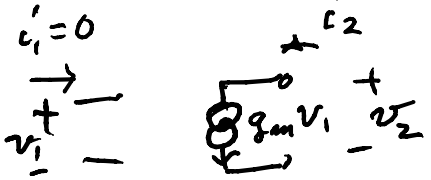




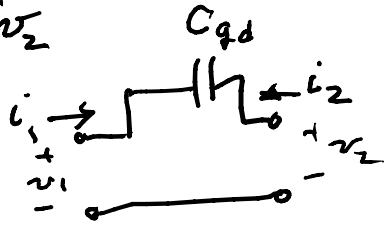
$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$



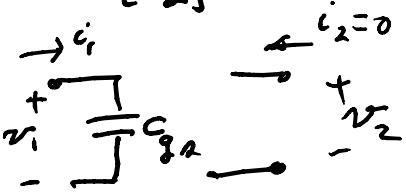
$i = \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$ $v = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$; $i = Y v$



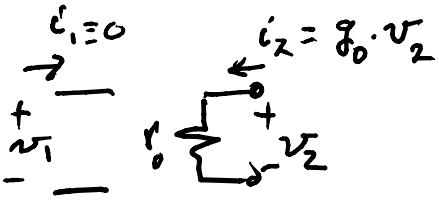
$$Y_{g_m} = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix}$$



$$Y_{C_{gd}} = \begin{bmatrix} sC_{gd} & -sC_{gd} \\ -sC_{gd} & sC_{gd} \end{bmatrix}$$



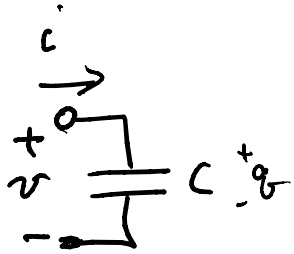
$$Y_{C_{gs}} = \begin{bmatrix} sC_{gs} & 0 \\ 0 & 0 \end{bmatrix}$$



$$Y_{r_0} = \begin{bmatrix} 0 & 0 \\ 0 & g_0 \end{bmatrix}$$

$$Y_{FET}(s) = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix} + \begin{bmatrix} sC_{gd} & -sC_{gd} \\ -sC_{gd} & sC_{gd} \end{bmatrix} + \begin{bmatrix} sC_{gs} & 0 \\ 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & g_0 \end{bmatrix}$$

$$= \begin{bmatrix} s(C_{gd}+C_{gs}) & -sC_{gd} \\ g_m - sC_{gd} & sC_{gd} + g_0 \end{bmatrix}$$

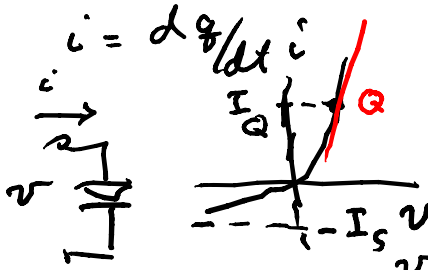


$q = Cv$

$$i = \frac{dq}{dt} = \frac{dCv}{dt} = C\frac{dv}{dt} = sC \cdot v = y(s)\, v$$

↑ C independent of time & v

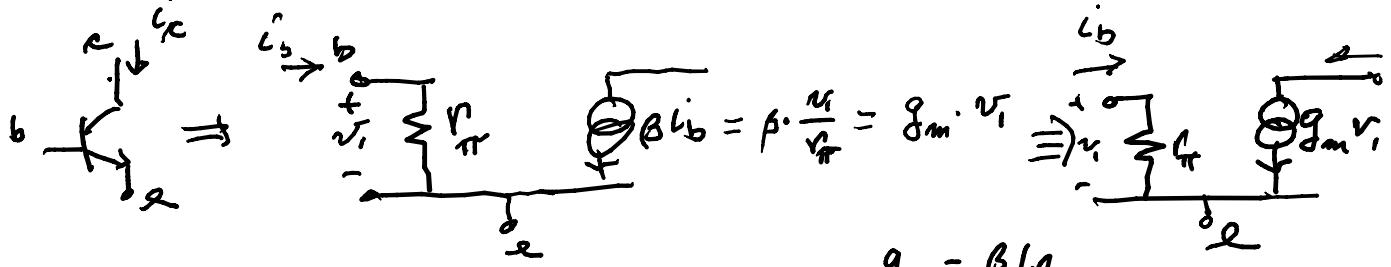
$i = dq/dt$



$$\text{slope} = \left.\frac{di}{dv}\right|_Q \approx I_S \cdot \frac{1}{V_T} e^{v/V_T}\Big|_Q = \frac{I_Q}{V_T} = g_{diode}$$

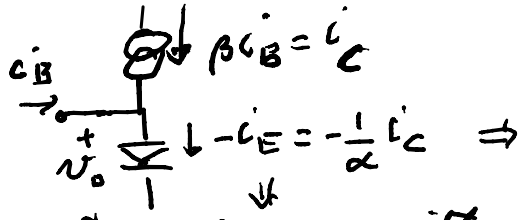
$$i = I_S(e^{v/V_T} - 1)$$

$\approx I_S e^{v/V_T}$ in forward bias



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

as back bias base to collector

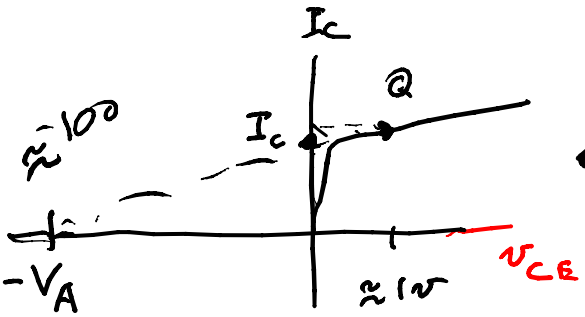


$\Rightarrow g_d = \frac{I_C}{\alpha V_T} = \frac{I_C = \beta I_B}{\alpha V_T} = g_d = \frac{\beta}{\alpha} \cdot \frac{I_B}{V_T} = \frac{I_C}{\alpha V_T}$

$g_d = \left. \frac{-i_E}{v_D} \right|_Q = -\frac{I_C / \alpha}{V_{BE}}$; $-i_e = g_d v_{be}$

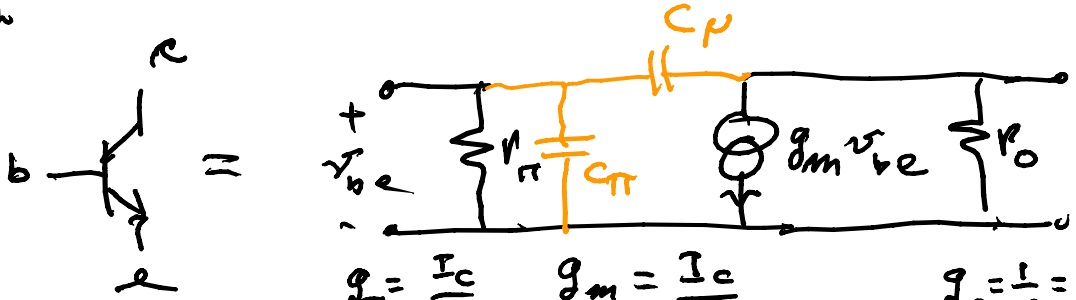
for $g_\pi = \frac{1}{r_\pi} = \frac{i_b}{v_{be}} = \frac{\frac{1}{\beta} i_c}{v_{be}} = \frac{-\alpha i_e \cdot \frac{1}{\beta}}{v_{be}} = \frac{\alpha}{\beta} \cdot \frac{i_e}{v_{be}}$

$= \frac{1}{\beta} \cdot \frac{I_C}{V_T} = \frac{g_m}{\beta} \Rightarrow$ $g_m = \frac{I_C}{V_T}$; $g_\pi = \frac{1}{\beta} \frac{I_C}{V_T}$



slope $\approx \frac{I_C}{V_A} \approx g_o$ = output conductance

Early voltage



$g_\pi = \frac{I_C}{\beta V_T}$ $g_m = \frac{I_C}{V_T}$ $g_o = \frac{1}{r_o} = \frac{I_C}{V_A}$

$\Rightarrow$ importance of I_C = Q pt. collector current

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