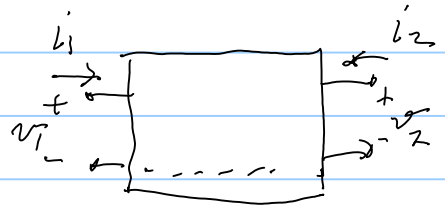
EE 303H
09/17/15

Note Title 9/17/2015

TI CC430 - Chronos Development Tool

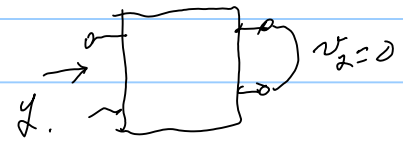
Y matrix 2-port $\Rightarrow$ linear operation



$i = Yv$

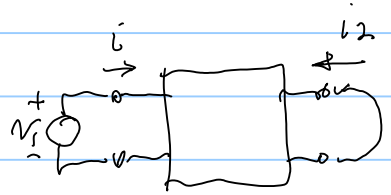
$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \cdot \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

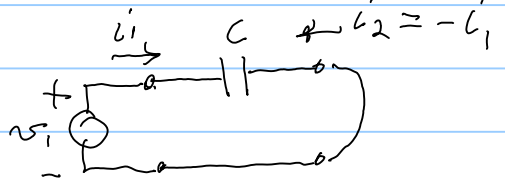
$$i_1 = y_{11} \cdot v_1 + y_{12} \cdot v_2 \Rightarrow y_{11} = \left.\frac{i_1}{v_1}\right|_{v_2=0}$$

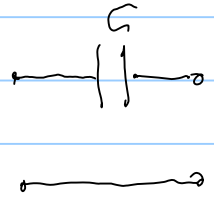


$$y_{12} = \left.\frac{i_1}{v_2}\right|_{v_1=0}$$

$$y_{21} = \left.\frac{i_2}{v_1}\right|_{v_2=0}$$

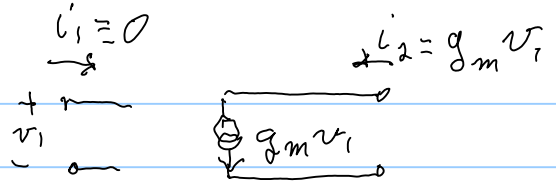




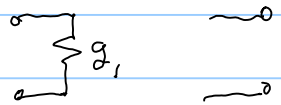


$$\frac{i_1}{v_1} = sC = -\frac{i_2}{v_1} \Rightarrow \frac{i_2}{v_1} = -sC$$

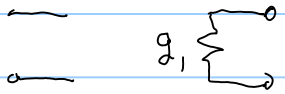
$$\Rightarrow Y = \begin{bmatrix} sC & -sC \\ -sC & sC \end{bmatrix} = sC \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$



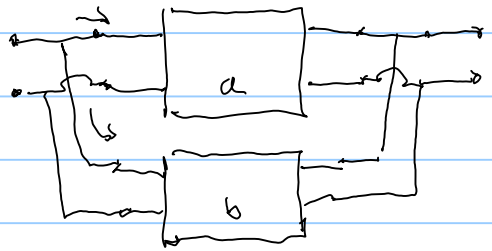
$$Y = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix}$$



$$Y = \begin{bmatrix} g_1 & 0 \\ 0 & 0 \end{bmatrix}$$



$$Y = \begin{bmatrix} 0 & 0 \\ 0 & g_1 \end{bmatrix}$$

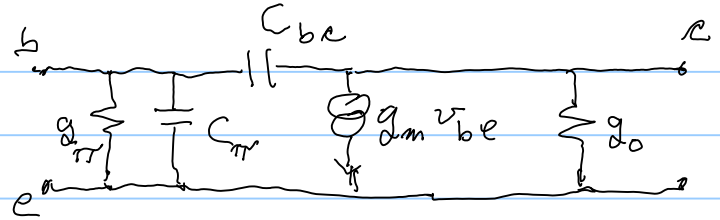


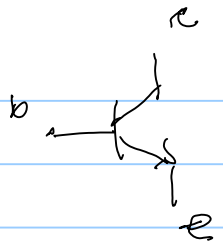
$i_a = Y_a v_a \qquad i_b = Y_b v_b \qquad v_a = v_b = v$

$i = i_a + i_b$

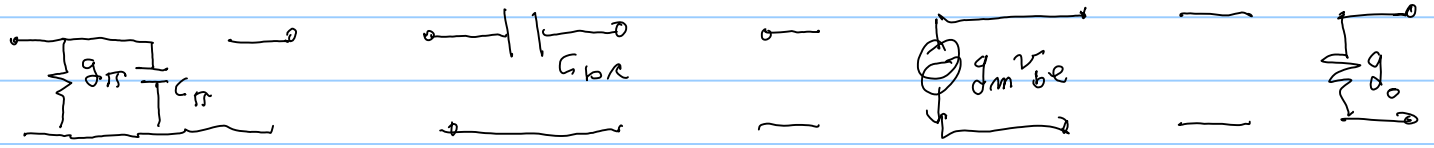
$i = Y_a v_a + Y_b v_b = (Y_a + Y_b) v \Rightarrow Y = Y_a + Y_b$

π equivalent circuit for a BJT



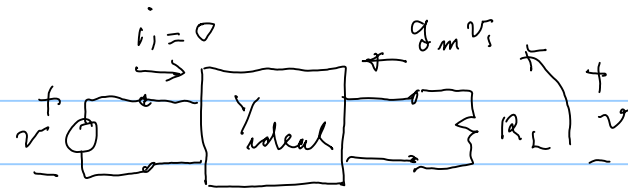


C_π = b-e capacitance



$$Y_\pi = \begin{bmatrix} g_\pi + s C_\pi + s C_{bc} & -s C_{bc} \\ -s C_{bc} + g_m & s C_{bc} + g_o \end{bmatrix}$$

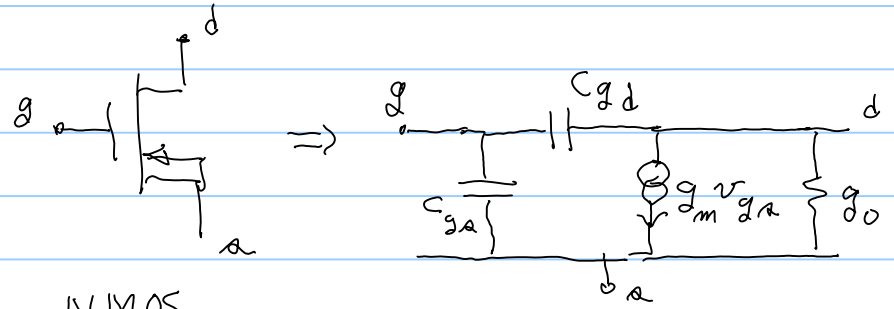
ideal Y_π for the BJT $\quad Y_{ideal} = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix}$



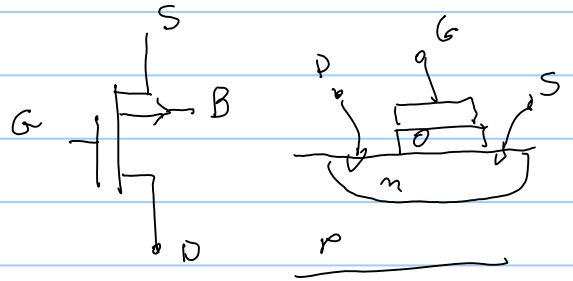
$$\Rightarrow -i_2 = G_L v_2 = -g_m v_1$$

$$\frac{v_2}{v_1} = -g_m / G_L \approx -g_m R_L \simeq A_v$$

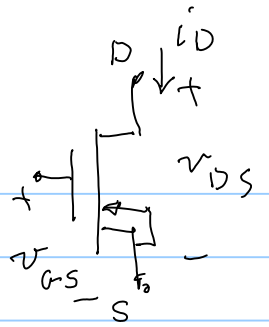
V_T = thermal voltage $= \frac{kT}{|q|}$; $i_D = I_S\left(e^{v_D/V_T} - 1\right)$

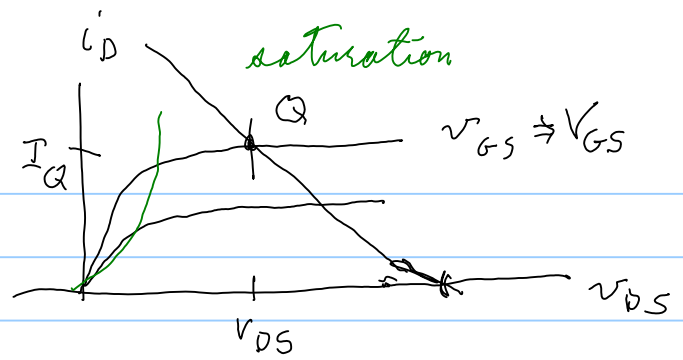


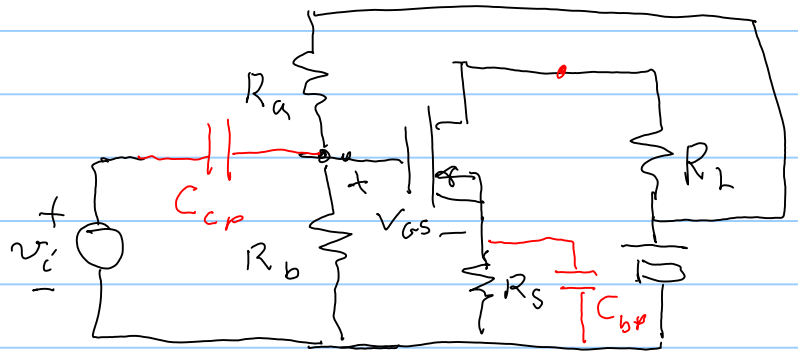
NMOS



Biasing







$$V_G = \frac{R_b}{R_a + R_b} \cdot V_{DD}$$

$$v_o \approx -g_m R_L$$

$$V_G = R_S I_D \simeq -R_S I_S$$

$$V_{GS} = \frac{R_b}{R_a + R_b} V_{DD} - R_S I_D \simeq \frac{1}{1 + \frac{R_b}{R_a}} V_{DD} - R_S I_D$$

Ex: $V_{DD} = 3\,V$, $I_D = 1\,mA$, $V_{GS} - VTO \Rightarrow VTO \simeq 1\,v$

$V_{GS} = 3\,V$ from curve

let (choose) $R_S \simeq 100\,\Omega \Rightarrow R_S I_D = 10^{-1} \simeq 0.1\,v$

$\frac{R_b}{R_a+R_b} \cdot 3 - 0.1\,v = V_{GS}$ can't find R_b & R_a if $V_{GS} = 3\,V$

$\therefore$ try $R_S I_D \simeq 1\,V \Rightarrow R_S = 1/10^{-3} = 1\,K\Omega$

$\frac{R_b}{R_a+R_b} \cdot 3 - 1 = 3 = V_{GS} \Rightarrow \frac{1}{1+\frac{R_a}{R_b}} = 4/3 \Rightarrow$ need a bigger battery

Try $V_{DD} = 6\,V \Rightarrow \frac{6}{1+\frac{R_a}{R_b}} - 1 = 3 \Rightarrow$ $R_S = 1K$

$4/6 = \frac{1}{1+\frac{R_a}{R_b}} \Rightarrow 1 + \frac{R_a}{R_b} = \frac{6}{4} = 3/2$

$\frac{R_a}{R_b} = \frac{1}{2} \Rightarrow$ choose large

if $R_b = 10\,Meg$

$R_a = 5\,Meg$

Need g_m (in saturation)

$$i_D = \frac{KP}{2} \cdot \frac{W}{L} (V_{GS} - VTO)^2 \quad ; \quad g_m = \left.\frac{\partial i_D}{\partial v_{GS}}\right|_Q = 2 \cdot \frac{\left(\frac{KP}{2}\frac{W}{L}\right)(V_{GS}-V_{TO})^2}{(V_{GS}-V_{TO})}$$

$$= 2\frac{I_D}{(V_{GS}-V_{TO})}$$

$$\Rightarrow q_m = \frac{2 \times 10^{-3}}{(3-1)} = 10^{-3} \text{ V}.$$