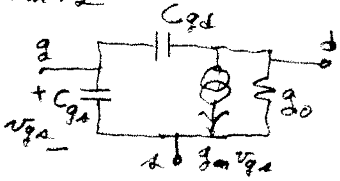
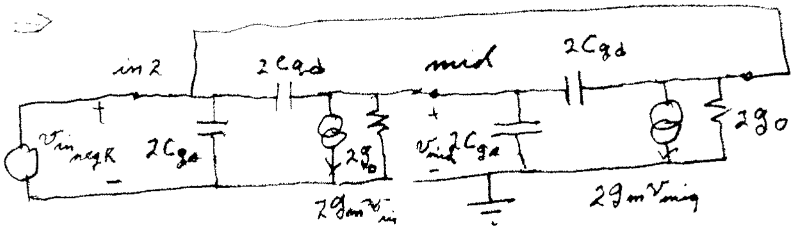
Homework set #1, problem #2 RWN 12/01/09

#2. $Y_{mos} = \begin{bmatrix} s(C_{gs}+C_{gd}) & -sC_{gd} \\ -sC_{gd}+g_m & sC_{gd}+g_o \end{bmatrix} \Rightarrow$

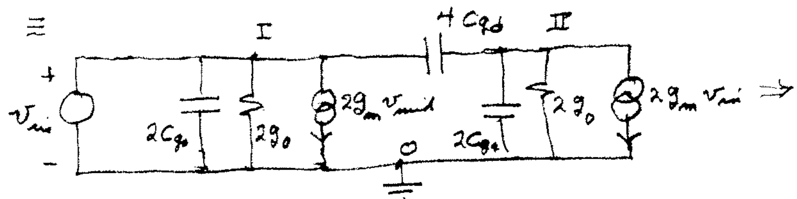


$\Rightarrow$

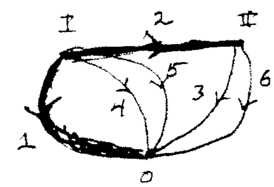


a)

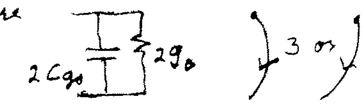
$\equiv$



$\Rightarrow$



here



with $y_{3,4} = 2(g_o + sC_{gs})$; branches 1, 2 as tree

Cut set: $0_t = C i_b \Rightarrow \begin{bmatrix} 0 \\ 0 \end{bmatrix} = \left[\begin{array}{cc|cccc} 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & -1 & 0 & 0 & -1 \end{array}\right] \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \\ i_6 \end{bmatrix}_b$

Tie set: $0_\ell = T v_b \Rightarrow \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \left[\begin{array}{cc|cccc} -1 & 1 & 1 & 0 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 & 1 & 0 \\ -1 & 1 & 0 & 0 & 0 & 1 \end{array}\right] \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \end{bmatrix}_b$

as a check the non-identity parts of C & T are $-$transposes.

b) Remove v_{in} & consider nodes I & II fed by current sources i_I, i_{II}

$\begin{bmatrix} i_I \\ i_{II} \end{bmatrix} = Y_{nodal} \begin{bmatrix} v_I \\ v_{II} \end{bmatrix}$ v_I & v_{II} = node voltages referenced to ground, $v_I = v_1$, $v_{II} = v_3$

$$Y_{nodal} = \begin{bmatrix} y_2+y_4 & -y_2+2g_m \\ -y_2+2g_m & y_2+y_3 \end{bmatrix} = \begin{bmatrix} s(4C_{gd}+2C_{gs})+2g_o & 2g_m - 4C_{gd}s \\ 2g_m - 4C_{gd}s & s(4C_{gd}+2C_{gs})+2g_o \end{bmatrix}$$

Eliminate v_{II} by setting $i_{II}=0 \Rightarrow v_{II} = -(2g_m - 4C_{gd}s)v_1/[2g_o + s(4C_{gd}+2C_{gs})]$

$\therefore$

$$y_{in} = y_{11} - y_{12}y_{22}^{-1}y_{21} = 2g_o + s(4C_{gd}+2C_{gs}) - (2g_m - 4C_{gd}s)^2/[2g_o + s(4C_{gd}+2C_{gs})]$$

$$= \left\{[2(g_o + s(2C_{gd}+C_{gs}))]^2 - (2(g_m - 2C_{gd}s))^2\right\} / [2(g_o + s(2C_{gd}+C_{gs}))]$$

2nd order in s even though 3 C's due to Δ of C's

@ $s=0$

$$y_{in}\Big|_{s=0} = \frac{(4g_o^2) - 4(g_m)^2}{2g_o} = 2g_o - 2\frac{g_m^2}{g_o}$$

as usually $g_m > g_o$, $y_{in}(0) \approx -2\dfrac{g_m^2}{g_o} < 0$

giving a negative resistance at low frequencies