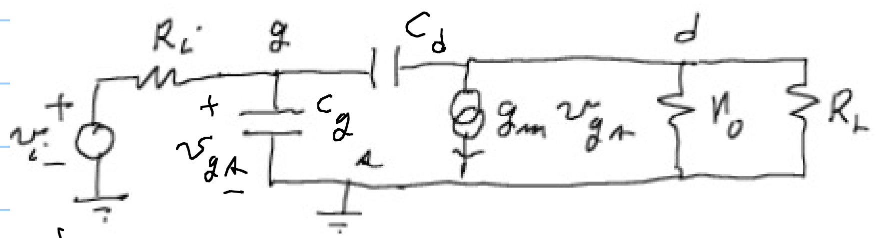
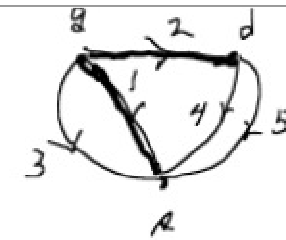
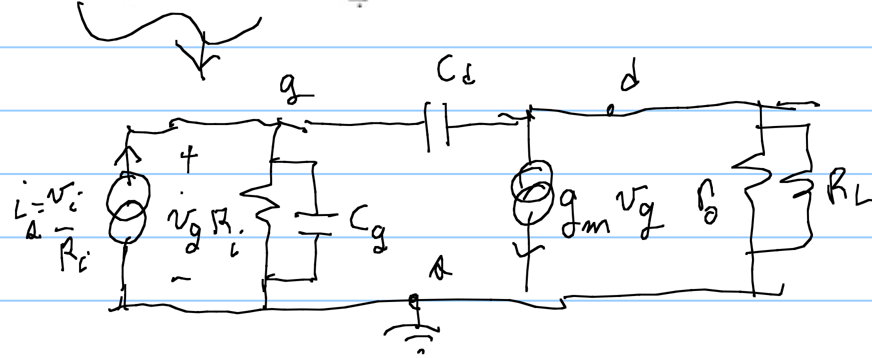
Note Title 9/1/2016

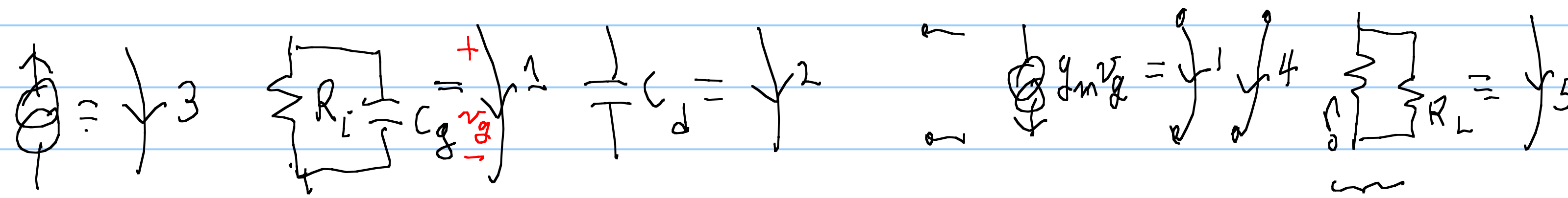
EE610
09/01/16



$\Rightarrow$







$g_i = 1/R_i$

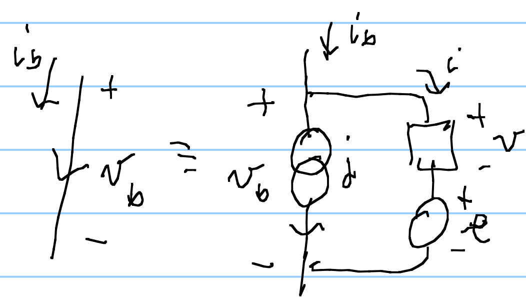
$G_o = g_o + G_L$

$= \frac{1}{r_o} + \frac{1}{R_L}$

$Y_{b\times b}$ = branch by branch admittance matrix b = # of branches $= 5$

$$\begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \end{bmatrix} = \begin{bmatrix} g_i + sC_g & 0 & 0 & 0 & 0 \\ 0 & sC_d & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ g_m & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & G_0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{bmatrix}$$

$$i = Y_{b\times b} v$$



$\Rightarrow$ $i_b = i + j$ $\Rightarrow$ $i_b = \mathcal{J}^T i_\ell$, $0 = \mathcal{C}\, i_b$

$v_b = v + e$ $\Rightarrow$ $v_b = \mathcal{C}^T v_t$ $0 = \mathcal{J}\, v_b$

$$j = \begin{bmatrix} 0 \\ 0 \\ -i_a \\ 0 \\ 0 \end{bmatrix} \quad e = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$i_b = i + j = Y_{b\times b} v + j$$
$$= Y_{b\times b} \times (v_b - e) + j$$

$$0 = e\, i_b = e\, Y_{b\times b} \cdot v_b + 0 + e_j$$

$$= e\, Y_{b\times b}\, e^T \cdot v_t + e_j \Rightarrow -e_j = \left[e\, Y_{b\times b}\, e^T \right] v_t$$

$$\underset{t\times t}{Y} = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & -1 & -1 \end{bmatrix} \begin{bmatrix} g_i + \alpha C_d & 0 & 0 & 0 & 0 \\ 0 & \alpha C_d & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ g_m & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & G_o \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \\ 1 & -1 \\ 1 & -1 \end{bmatrix}$$

$$-e_j = -\begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & -1 & -1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ -i_a \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} +i_a \\ 0 \end{bmatrix} = Y_{t\times t} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$\text{desire} = v_t = Y_{t\times t}^{-1} \cdot (-e_j)$$

$$= \begin{bmatrix} 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & -1 & -1 \end{bmatrix} \begin{bmatrix} g_i + sC_g & 0 & 0 & 0 & 0 \\ 0 & sC_d & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ g_m & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & G_o \end{bmatrix} = \begin{bmatrix} g_i + sC_g + g_m & 0 & 0 & 0 & G_o \\ -g_m & sC_d & 0 & 0 & -G_o \end{bmatrix}$$

$$= \mathcal{C} Y_{b \times b}$$

$$\begin{bmatrix} g_i + sC_g + g_m & 0 & 0 & 0 & G_o \\ -g_m & sC_d & 0 & 0 & -G_o \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \\ 1 & -1 \\ 1 & -1 \end{bmatrix} = \begin{bmatrix} g_i + g_m + sC_g + G_o & -G_o \\ -g_m - G_o & sC_d + G_o \end{bmatrix} = \mathcal{C} Y_{b \times b} \mathcal{C}^T$$

$$\begin{bmatrix} +i_A \\ 0 \end{bmatrix} = \begin{bmatrix} g_i + g_m + sC_g + G_o & -G_o \\ -g_m - G_o & sC_d + G_o \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix} sC_d + G_0 & G_0 \\ g_m + G_0 & g_i + g_m + G_0 + sC_g \end{bmatrix} \begin{bmatrix} i_s \\ 0 \end{bmatrix}; \quad \Delta = \text{determinant}$$

$$= (sC_d + G_0)(g_i + g_m + G_0 + sC_g) - G_0(g_m + G_0)$$

special components with no Y: nullator $v = 0, i = 0$ $\quad \begin{bmatrix} 1 \\ 0 \end{bmatrix} v = \begin{bmatrix} 0 \\ 1 \end{bmatrix} i$

norator, v = arbitrary

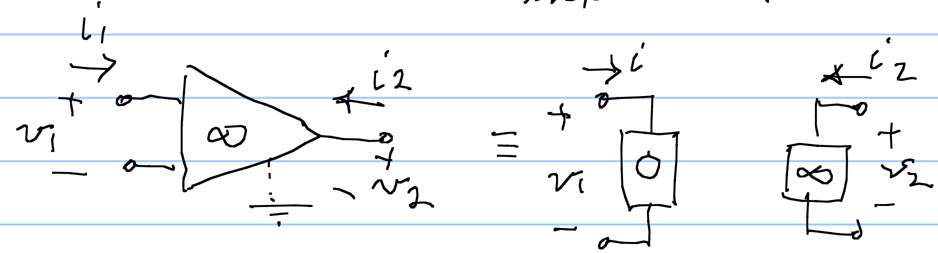
i = arbitrary independent of v

$$\begin{bmatrix} 0 \end{bmatrix}[v] = \begin{bmatrix} 0 \end{bmatrix}[i] \Rightarrow$$

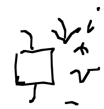
(op amp output)

nullator

input to op amp



$$\begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

If linear components, for the  parts of branches:

$A v = B i$ $\qquad$ $i = Y v$ if Y = admittance matrix

for any non-singular C $\qquad$ $Y = B^{-1} A$, $\quad$ for $C = B^{-1}$

this is equivalent to $\qquad$ $Z = Y^{-1} = A^{-1} B$ for $C = A^{-1}$

$C A v = C B i$