Note Title 9/5/2017

EE610
09/05/17

$v_b = \mathcal{C}^T v_t$, $i_b = \mathcal{J}^T i_\ell$, $\mathcal{C}^T = \begin{bmatrix} 1_t \\ K^T \end{bmatrix}$, $\mathcal{J}^T = \begin{bmatrix} -K \\ 1_\ell \end{bmatrix}$ $\quad i_b \downarrow \left\{ \begin{matrix} + \\ v_b \\ - \end{matrix} \right.$

$v_b^T \cdot i_b = \sum_{k=1}^{b} v_{b_k} \cdot i_{b_k}$ $\qquad v_{b_k} \cdot i_{b_k}$ = power into component branch

= total power into all branches

$= v_t^T \cdot \mathcal{C} \cdot \mathcal{J}^T \cdot i_\ell$, $\qquad \mathcal{C} \cdot \mathcal{J}^T = \begin{bmatrix} 1_t & K \end{bmatrix} \begin{bmatrix} -K \\ 1_\ell \end{bmatrix} = 1_t \cdot (-K) + K \cdot 1_\ell$

this is zero $\qquad = 0_{t \times \ell}$

$A \cdot v = B \cdot i$, $\quad v = v_b - e$, $i = i_b - j$

$$\left[A\mathcal{C}^T \;\vdots\; -B\mathcal{J}^T \right] \begin{bmatrix} v_t \\ i_\ell \end{bmatrix} = Ae - Bj$$

If. $A = Y$, $B = 1_b$ $\quad Av = Bi \Rightarrow i = \underset{b\times b}{Y} v$

$$\Rightarrow \left[\underset{b\times b}{Y} \mathcal{C}^T \;\vdots\; -1_{b\times} \mathcal{J}^T \right] x = Ae - Bj \quad \}\text{ Norton's equivalent current sources}$$

$\times \mathcal{C}$

t rows

$$\mathcal{C}\left[\underset{b\times b}{Y} \mathcal{C}^T \;\vdots\; -\mathcal{J}^T \right] x = \left[\mathcal{C}\underset{b\times b}{Y} \mathcal{C}^T - \mathcal{C}\mathcal{J}^T \right] x = \mathcal{C}Ae - \mathcal{C}Bj$$

$$= \underbrace{\mathcal{C} Y_{b\times b} \mathcal{C}^T}_{t\times t} v_t + (\underbrace{-\mathcal{C}\mathcal{J}^T}_{0_{t\times l}} i_l) = \underbrace{\mathcal{C}Ae - \mathcal{C}Bj}_{\substack{t \text{ forcing terms} \\ \text{Norton equivalents}}}$$

$\therefore$ get t eqs in t unknowns, v_t.

if branch by branch gives $\underset{b\times b}{Y} v = 1_b \cdot i$ Then can reduce the number of eqs. from b to t. $\quad$; $t + l = b$; $\quad t = n-1$ (for 1 separate part)

seems like could use the $t = n-1$ voltages with reference to ground

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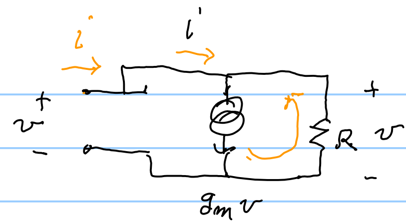
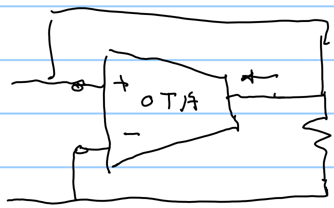
Some interesting components



$i' = g_m v + G v$, $G = 1/R$

$= (g_m + G) v$



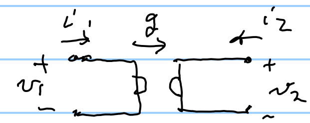
input we see $y = g_m + G$

as g_m can be < 0 then y can be negative

if use an OTA

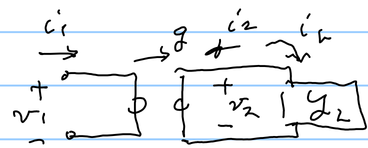
(= operational transconductance amplifies ⇒ differential pair)

The gyrator



$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 0 & g \\ -g & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$; g = real

look at



$i_L = y_L v_2$; $i_1 = g v_2$

$= y_L \cdot \frac{1}{g} i_1$

$v_1 = \frac{1}{g} \cdot \frac{1}{g} y_L \cdot i_1$

$i_2 = -i_L = -g v_1 \Rightarrow v_1 = \frac{1}{g} i_L$

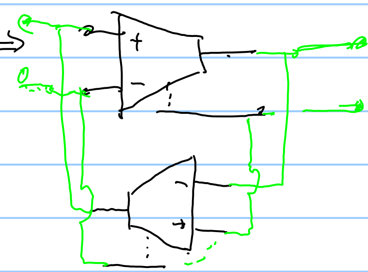
$\Downarrow$

$i_1 = y_{in} v_1 = \frac{1}{y_L} \times g^2 v_1 \Rightarrow y_{in} = \frac{1}{y_L} \cdot g^2$ if the load is a capacitor

then $y_L(s) = sC$, $y_{in} = \frac{1}{sC} \cdot g^2 = \frac{1}{s L_{eq}} \Rightarrow z_{in} = \frac{C}{g^2} s = L_{eq} s$

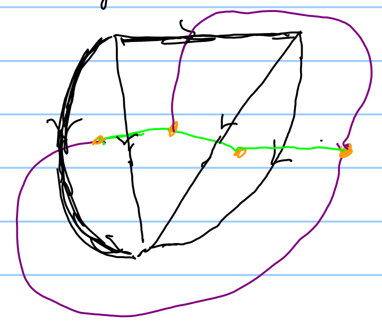
$C \rightarrow C/g^2 = L_{eq}$. if g = gyration conductance = 10^{-3}

$L_{eq} = 10^6 \cdot C$ or $C = 1\mu Fd \Rightarrow L = 1$ Henry

OTA $\Rightarrow$ $Y_1 = \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix} \Rightarrow$  $Y = Y_1 + Y_2 = \begin{bmatrix} 0 & -g_m \\ g_m & 0 \end{bmatrix}$

$Y_2 = \begin{bmatrix} 0 & -g_m \\ 0 & 0 \end{bmatrix}$

Dual of planar graph (can draw with no crossing branches)



● = nodes in dual graph

—— ⇒ tree branches in the dual graph

—— ⇒ links in dual graph