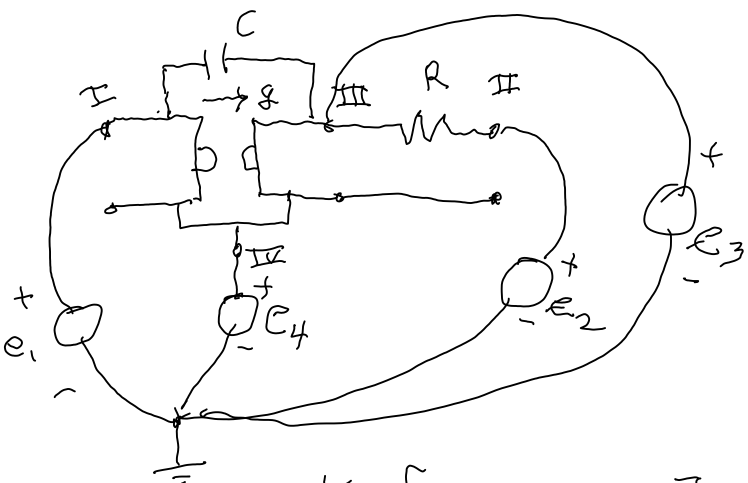
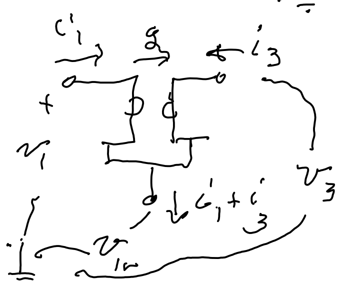




$$Y_{gy} = \begin{bmatrix} 0 & 0 & g & -g \\ 0 & 0 & 0 & 0 \\ -g & 0 & 0 & +g \\ g & 0 & -g & 0 \end{bmatrix}$$

$= -(-g)-g$

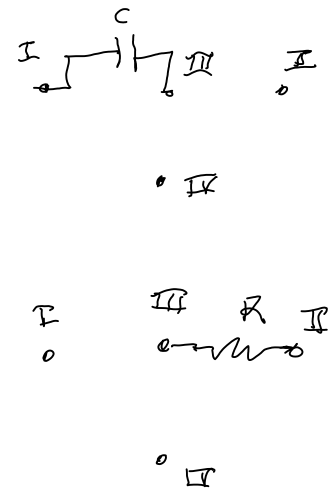
$Y_{ind} \Rightarrow$ sum of rows $= 0$

" " columns $= 0$

For the capacitor

$$Y_C = \begin{bmatrix} C\alpha & 0 & -C\alpha & 0 \\ 0 & 0 & 0 & 0 \\ -C\alpha & 0 & C\alpha & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$Y_R = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & G & -G & G \\ 0 & -G & G & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$



$$Y_{ind} = \begin{bmatrix} Cs & G & g-Cs & -g \\ 0 & G & -G & 0 \\ -g-Cs & -G & G+Cs & g \\ g & 0 & -g & 0 \end{bmatrix}$$

can ignore

multiplies by 0

move ground to node IV

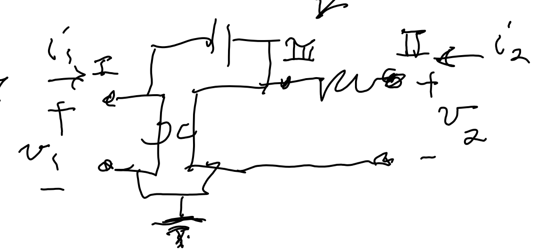
$v_4 = 0$ (also current into gnd is the sum of all others so can ignore

$$Y_{nodal} = \begin{bmatrix} Cs & 0 & g-Cs \\ 0 & G & -G \\ -g-Cs & -G & G+Cs \end{bmatrix}$$

$$\begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} Cs & 0 & g-Cs \\ 0 & G & -G \\ -g-Cs & -G & G+Cs \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$$

external current $i_3 = 0$

if desire 2-port Y for



allows v_3 as a function of v_1 & v_2

$$\begin{bmatrix} i_1 \\ i_2 \\ \hline 0 \end{bmatrix} = \left[\begin{array}{cc|c} \underset{Y_{11}}{CR} & 0 & g-CR \\ 0 & G & -G \; Y_{12} \\ \hline -g-CR & -G & G+CR \\ Y_{21} & & Y_{22} \end{array}\right] \begin{bmatrix} v_1 \\ v_2 \\ \hline v_3 \end{bmatrix}$$

$$\Rightarrow 0 = \begin{bmatrix} -g-CR & -G \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + \begin{bmatrix} G+CR \end{bmatrix} \cdot v_3$$

$$\Rightarrow v_3 = -\begin{bmatrix} G+CR \end{bmatrix}^{-1} \begin{bmatrix} -g-CR & -G \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = Y_{11} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} - Y_{12} Y_{22}^{-1} Y_{21} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$= \left\{ Y_{11} - Y_{12} Y_{22}^{-1} Y_{21} \right\} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = Y_{2\text{-port}} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$0 = Y_{21} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + Y_{22} v_3$$

$$\Rightarrow v_3 = -Y_{22}^{-1} \cdot Y_{21} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$Y_{2\text{-port}} = \begin{bmatrix} CR & 0 \\ 0 & G \end{bmatrix} - \begin{bmatrix} g-CR \\ -G \end{bmatrix} \frac{1}{G+CR} \begin{bmatrix} -g-CR & -G \end{bmatrix}$$

$$Y_{2port} = \begin{bmatrix} C\alpha & 0 \\ 0 & G \end{bmatrix} - \frac{1}{G + C\alpha} \begin{bmatrix} -(g^2 - C^2\alpha^2) & -Gg + GC\alpha \\ Gg + GC\alpha & G^2 \end{bmatrix} = \frac{1}{\alpha C + G} \begin{bmatrix} GC\alpha + g^2 & Gg - GC\alpha \\ -Gg - GC\alpha & GC\alpha \end{bmatrix}$$

$$= \frac{1/C}{\alpha + G/C} \begin{bmatrix} GC(\alpha + g^2/GC) & -GC(\alpha - g/C) \\ -GC(\alpha + g/C) & GC\alpha \end{bmatrix}$$

Now set up state eqn.

$$Y_{2port} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} \Rightarrow \begin{bmatrix} GC\alpha + g^2 & -GC\alpha + Gg \\ -GC\alpha - Gg & GC\alpha \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = (\alpha + G) \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

$$d\begin{bmatrix} GC & -GC \\ -GC & GC \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} -g^2 & -Gg \\ Gg & 0 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + (CR+G)\begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

Before $d E x = \mathcal{A} x + \mathcal{B} u$ $\qquad u =$ input, $x = \begin{bmatrix} v_t \\ i_R \end{bmatrix}$

can transform $x = T_n \hat{x}$, T_R^{-1} existing

$$d E T_n \hat{x} = \mathcal{A} T_n \hat{x} + \mathcal{B} u$$

& multiply on left by T_ℓ, T_ℓ^{-1} existing

$$d T_\ell E T_n \cdot \hat{x} = T_\ell \mathcal{A} T_n \cdot \hat{x} + T_\ell \mathcal{B} u \implies d \hat{E} \hat{x} = \hat{\mathcal{A}} \hat{x} + \hat{\mathcal{B}} u$$

(identical circuit but new description

on this example choose T_r to add 1st column to column

$$\begin{bmatrix} GC & -GC \\ -GC & GC \end{bmatrix}\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} GC & 0 \\ -GC & 0 \end{bmatrix} \Rightarrow T_r = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

$$\tilde{x} = T_r^{-1} x = \begin{bmatrix} 1 & -1 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} v_1 - v_2 \\ v_2 \end{bmatrix}$$

$$T_\ell \Rightarrow \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} GC & 0 \\ -GC & 0 \end{bmatrix} = \begin{bmatrix} GC & 0 \\ 0 & 0 \end{bmatrix}$$

$$s T_\ell E T_r \tilde{v} = s\begin{bmatrix} GC & 0 \\ 0 & 0 \end{bmatrix},$$

$$T_\ell \begin{bmatrix} -g^2 & -GC \\ GC & 0 \end{bmatrix} T_r = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} -g^2 & -GC \\ GC & 0 \end{bmatrix}\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} -g^2 & -g^2 - GC \\ -g^2 + GC & -g^2 \end{bmatrix} = \begin{bmatrix} -g^2 & -GC \\ -g^2 + GC & -GC \end{bmatrix}\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

$$a\begin{bmatrix} GC & 0 \\ 0 & 0 \end{bmatrix}\begin{bmatrix} v_1 - v_2 \\ v_2 \end{bmatrix} = \begin{bmatrix} -g^2 & -GC \\ -g^2+GC & -GC \end{bmatrix}\begin{bmatrix} v_1 - v_2 \\ v_2 \end{bmatrix} + (Ca+G)\begin{bmatrix} i_1' \\ i_1+i_2 \end{bmatrix}$$

can eliminate 2nd row $\quad 0 = (-g^2+GC \quad -GC)\begin{bmatrix} v_1 - v_2 \\ v_2 \end{bmatrix} + (Ca+G)(i_1'+i_2')$