EE 610
09/15/15

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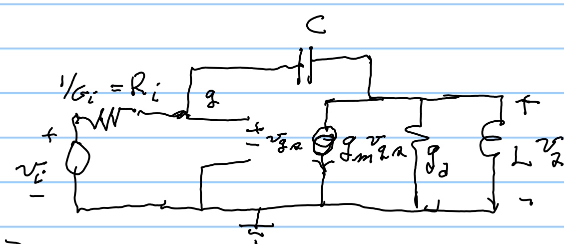
$$\left[\begin{array}{cc|cccc} G_i & 0 & -1 & 1 & 0 & 0 \\ 0 & 1 & -sL & 0 & sL & sL \\ sC & -sC & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & g_m & 0 & 0 & -1 & 0 \\ 0 & g_d & 0 & 0 & 0 & -1 \end{array}\right] \begin{bmatrix} v_1 \\ v_2 \\ \hline i_3 \\ i_4 \\ i_5 \\ i_6 \end{bmatrix} = \begin{bmatrix} G_i v_i \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$




$$y = v_2 = [\,0\ 1\ 0\ 0\ 0\,] \begin{bmatrix} v_1 \\ v_2 \\ i_3 \\ i_4 \\ i_5 \end{bmatrix}$$

$\Rightarrow$ let $x = [\,v_1\ v_2 \mid i_3\ i_4\ i_5\,]^T$
$= [\,v_t^T \mid i_\ell^T\,]^T$ = semi-state

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -L & 0 & L & L \\ C & -C & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} sx = \begin{bmatrix} -G_i & 0 & 1 & -1 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & -g_m & 0 & 0 & 1 & 0 \\ 0 & -g_d & 0 & 0 & 0 & 1 \end{bmatrix} x + \begin{bmatrix} G_i \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} v_i$$

$$E\dot{x} = Ax + Bu$$
$$y = Cx$$

$x$ = b-vector here $= \begin{bmatrix} v_t \\ i_\ell \end{bmatrix}$

semi-state equations

$\Rightarrow$ $(\alpha E - A)\, x = Bu \Rightarrow x = (\alpha E - A)^{-1} B u$

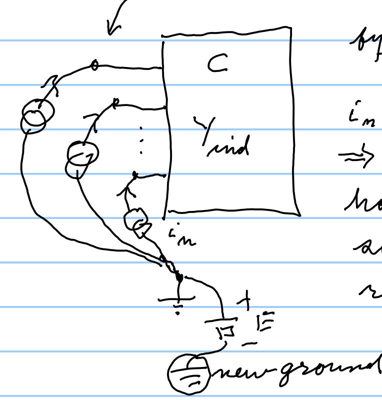
$y = C(\alpha E - A)^{-1} B \cdot u$ $\quad T(\alpha) = C(\alpha E - A)^{-1} B$ = transfer function

$\Rightarrow$ often can obtain

$$\alpha x_s = A_s x_s + B_s u$$
$$y = C_s x_s + D_s u$$

$\Rightarrow x_s$ = state

all nodes in circuit




by KCL, $\Sigma$ currents into C = 0

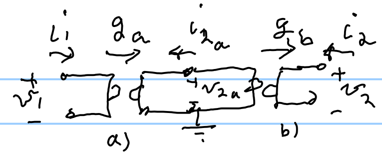
$i_n = -\Sigma$ all others

$\Rightarrow$ nth row of $Y_{ind}$ has it as the sum of all other rows.

return to indefinite $Y_{ind}$

$$i = Y_{ind}\, v$$
$$= Y_{ind}(v + E\underline{\underline{1}})$$
$$= Y_{ind}\, v + \underbrace{E\, Y_{ind} \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix}}_{\text{forces this to } 0}$$

$\Rightarrow$ $\Sigma$ of entries in each colum = 0 gyrator

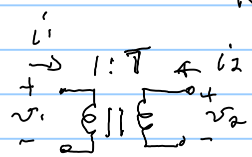



$i_1 = -g_a v_{2a}$ $\quad$ $i_2 = g_b v_{2a} \Rightarrow v_{2a} = i_2 / g_b$

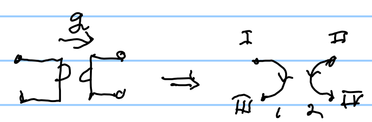
$= -\frac{g_a}{g_b} \cdot i_2 \Rightarrow$ no Y matrix

$i_{2a} = g_a v_1 = -i_b = -[-g_b v_2]$

KCL $\Rightarrow v_2 = \frac{g_a}{g_b} v_1$ ; $\quad i_1 = -\frac{g_a}{g_b} i_2$




$\Rightarrow v_2 = T v_1$ ; $\quad i_1 + T i_2 = 0 \Rightarrow i_1 = -T i_2 \quad \Rightarrow T = \frac{g_a}{g_b}$

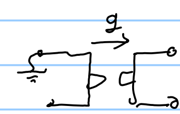



$Av = Bi$ $\quad$ $\begin{bmatrix} 0 & -g \\ g & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$

Y ind gy.

$$\begin{bmatrix} 0 & -g & 0 & g \\ g & 0 & -g & 0 \\ 0 & g & 0 & -g \\ -g & 0 & g & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix} = \begin{bmatrix} i_I \\ i_{II} \\ i_{III} \\ i_{IV} \end{bmatrix}$$

for $\underline{1}$ @ node 1




remove 1st & 1st column $Y = \begin{bmatrix} 0 & -g & 0 \\ g & 0 & -g \\ 0 & g & 0 \end{bmatrix}$

as $v_I = v_1 = 0$ & $i_I = -(I_{II} + I_{III} + I_{IV})$