Note Title 8/31/2020

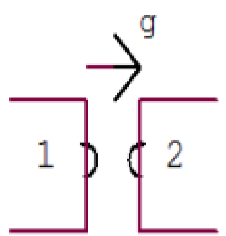
ENEE 610
09/08/20

Homework #1 new due date: Tu 09/15/20
choose base papers soon; you can change later

KVL & KCL: $\underline{0}_t = \mathscr{C} i_b$ $\underline{0}_\ell = \mathscr{T} v_b$ $v_b = \mathscr{C}^T v_t$ $I_b = \mathscr{T}^T i_\ell$

$\mathscr{C} = [1_t\ K]$ $\mathscr{T} = [-K^T\ 1_\ell]$ if tree is # first; branches for

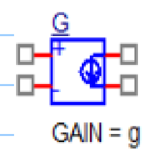
admittance matrix Y, i=Yv




gyrator: $i_1 = -gv_2$; $i_2 = gv_1$

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

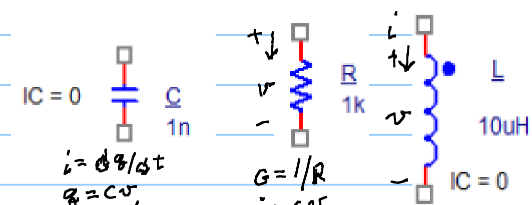
$$Y = \begin{bmatrix} 0 & -g \\ g & 0 \end{bmatrix}$$




VCCS=OTA=G of Spice $i_1=0$, $i_2=Gv_1$

Generic branch, $v_b = v_s + v$ and $i_b = i_s + i$

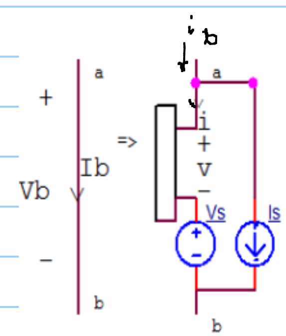
device laws: linear Av = Bi

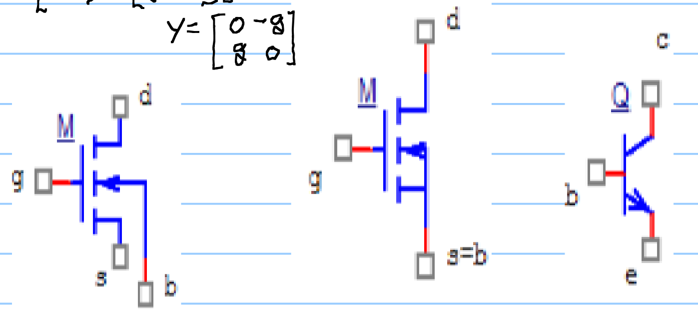



$i = dq/dt$
$q = Cv$
$i = C\frac{dv}{dt}$
$= C s v$
$s = d/dt$

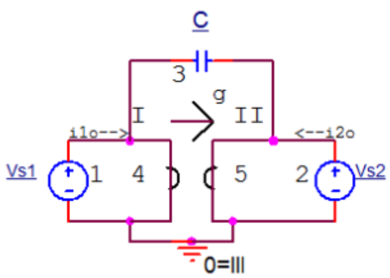
$G = 1/R$
$i = Gv$
$v = Ri$

$v = L\, di/dt$
$= s L i$

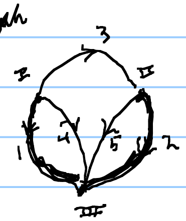


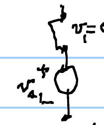

Ideal linearized transistors:
MOS: Id=gmVgs & Ig=0; BJT=>G, Ic=(beta)Ib & Vbe=0=>F
nonlinear both use models




graph




$v_1 = 0$ ; $i \neq f(v)$




branch 1

$i_3 = sC v_3$

Richards' section
(2-port)

$i_4 = -g v_5$
$i_5 = g v_4$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & sC & 0 & 0 \\ 0 & 0 & 0 & 0 & -g \\ 0 & 0 & 0 & g & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \end{bmatrix}$$

$$Av \qquad\qquad Bi$$

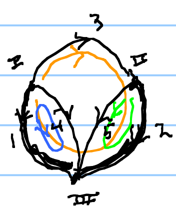
$v = v_b - v_a$
$i = i_b - i_a$

here $i_a = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$, $v_a = \begin{bmatrix} v_{s1} \\ v_{s2} \\ 0 \\ 0 \\ 0 \end{bmatrix}$

$$A(v_b - v_a) = B(i_b - i_a)$$
$$A(C^T v_t) - Av_a = B(\mathcal{G}^T) i_l - B i_a$$
$$AC^T v_t - B\mathcal{G}^T i_l = Av_a - Bi_a$$

$$b \text{ eqs} \left\{ \begin{bmatrix} AC^T & \vdots & -B\mathcal{G}^T \\ & \vdots & \end{bmatrix} \underbrace{\begin{bmatrix} v_t \\ i_l \end{bmatrix}}_{b\text{-vector}} = \underbrace{Av_a - Bi_a}_{\text{forcing functions}} \right.$$

have b eqs & b unknowns




$$C: \begin{bmatrix} 0 \\ 0 \end{bmatrix} = \left[\begin{array}{cc|ccc} 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & -1 & 0 & 1 \end{array}\right] i_b$$

$$\mathcal{G}: \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} = \left[\begin{array}{cc|ccc} -1 & +1 & 1 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 0 & 1 \end{array}\right] v_b$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & sC & 0 & 0 \\ 0 & 0 & 0 & 0 & -g \\ 0 & 0 & 0 & g & 0 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & -1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ sC & -sC \\ 0 & -g \\ g & 0 \end{bmatrix} = AC^T$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \underbrace{\begin{bmatrix} -1 & -1 & 0 \\ 1 & 0 & -1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}}_{B\mathcal{G}^T} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = B\mathcal{G}^T$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & sC & 0 & 0 \\ 0 & 0 & 0 & 0 & -g \\ 0 & 0 & 0 & g & 0 \end{bmatrix} \begin{bmatrix} v_{s1} \\ v_{s2} \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

circuit equations

desire $x$ ; inputs $= \begin{bmatrix} v_{s1} \\ v_{s2} \end{bmatrix}$

outputs $= -\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & -1 & 0 & 1 \end{bmatrix} x$

$$x = \begin{bmatrix} v_1 \\ v_2 \\ i_3 \\ i_4 \\ i_5 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ sC & -sC & -1 & 0 & 0 \\ 0 & -g & 0 & -1 & 0 \\ g & 0 & 0 & 0 & -1 \end{bmatrix} x = \begin{bmatrix} v_{s1} \\ v_{s2} \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ sC & -sC & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} x = \begin{bmatrix} -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & g & 0 & 1 & 0 \\ -g & 0 & 0 & 0 & 1 \end{bmatrix} x + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} v_{s1} \\ v_{s2} \end{bmatrix}, \quad \begin{bmatrix} -i_1 \\ -i_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & -1 & 0 & 1 \end{bmatrix} x = i_o$$

$$\boxed{\begin{aligned} E\dot{x} &= \mathcal{A}x + \mathcal{B}u \\ y &= \mathcal{C}x \end{aligned} \quad \begin{aligned} &u = \text{input} \\ &x = \text{semi-state} \\ &y = \text{output} \end{aligned}}$$