EE 434
02/27/06

$$C \frac{dn}{dt} = W a - G n + I_b \; ; \quad n(0) \text{ given}$$

$$a = f(n)$$

Choose n's such that they are equilibria

$$\Rightarrow \frac{dn}{dt} = 0 \Rightarrow W f(n) - G n + I_b = \underline{0} = \text{zero vector}$$

assume desire n_1 & n_2 equilibria, also choose a third, n_3.

assume W is 2×2 to illustrate; i.e. n's are 2-vectors

1) $W f(n_1) - G n_1 + I_b = \underline{0}_2$

2) $W f(n_2) - G n_2 + I_b = \underline{0}_2$

3) $W f(n_3) - G n_3 + I_b = \underline{0}_2$

∴ form [subtract 3) from 1) & from 2)]

4) $W(f(n_1) - f(n_3)) - G(n_1 - n_3) = \underline{0}_2$

5) $W(f(n_2) - f(n_3)) - G(n_2 - n_3) = \underline{0}_2$

$$W\left[(f(n_1) - f(n_3)) \,\vdots\, (f(n_2) - f(n_3))\right] = G\left[(n_1 - n_3) \,\vdots\, (n_2 - n_3)\right]$$

$$W = G\left[(m_1 - m_3) \,\vdots\, (m_2 - m_3)\right]\left[(f(m_1) - f(m_3)) \,\vdots\, (f(m_2) - f(m_3))\right]^{-1}$$

we want $W = W^T$; choose m_1 & m_2 as desired to store data in them

choose m_3 to for $W = W^T \Rightarrow$ requires solving some nonlinear algebraic equations.

If we make in VLSI $\quad m \to$ voltages on capacitors

$\quad v$

$\alpha \to$ voltage controlled current sources

$\quad y$

$W \to$ current controlled current sources = current mirrors

det of right f matrix

$$W = G\begin{bmatrix} m_{1_1} - m_{3_1} & m_{2_1} - m_{3_1} \\ m_{1_2} - m_{3_2} & m_{2_2} - m_{3_2} \end{bmatrix}\begin{bmatrix} (2,2) & -(1,2) \\ -(2,1) & (1,1) \end{bmatrix}$$

$(2,2) = f(m_{2_2}) - f(m_{3_2}) \qquad -(1,2) = -\left[f(m_{2_1}) - f(m_{3_1})\right]$

$-(2,1) = -\left[f(m_{1_2}) - f(m_{3_2})\right] \qquad (1,1) = \left[f(m_{1_1}) - f(m_{3_1})\right]$

m_{j_k} = jth vector, kth component

after multiplying right side, set $(1,2) = (2,1)$ to get a symmetric W.

From mathcad example

$$W = \begin{bmatrix} 2.15568 & -0.035206 \\ -0.035213 & 2.1522 \end{bmatrix} \qquad v1 := \begin{bmatrix} 0.5 \\ 0.25 \end{bmatrix} \qquad v2 := \begin{bmatrix} -0.5 \\ 0.5 \end{bmatrix}$$

$$G := \begin{bmatrix} G1 & 0 \\ 0 & G2 \end{bmatrix} \qquad C := \begin{bmatrix} C1 & 0 \\ 0 & C2 \end{bmatrix} \qquad v3 = \begin{bmatrix} 0.494563 \\ 0.3 \end{bmatrix} \qquad I = \begin{bmatrix} 0.012446 \\ -0.010841 \end{bmatrix}$$

$$y(v) := \begin{bmatrix} \tanh(v_1) \\ \tanh(v_2) \end{bmatrix}$$