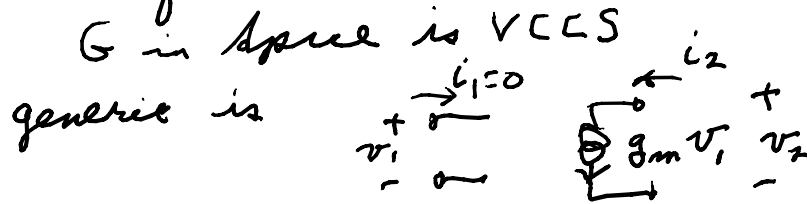


Some equivalences:



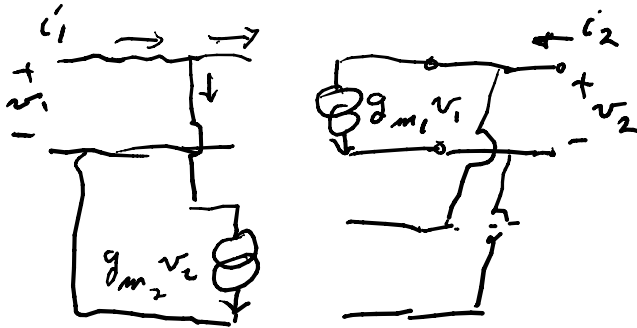
$$i_1 = 0 = 0 \cdot v_1 + 0 \cdot v_2$$

$$i_2 = g_m v_1 = g_m \cdot v_1 + 0 \cdot v_2$$

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

$$AV = Bi \Rightarrow \begin{bmatrix} 0 & 0 \\ g_m & 0 \end{bmatrix} v = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} i = \frac{1}{2} i = i$$

$$P_{in} = i_1 v_1 + i_2 v_2 = 0 + g_m v_1 v_2$$

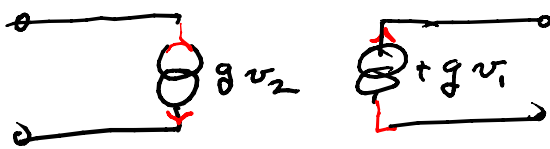


$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 0 & g_{m_2} \\ g_{m_1} & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$P_{in} = i_1 v_1 + i_2 v_2 = g_{m_2} v_2 v_1 + g_{m_1} v_1 v_2 = (g_{m_1} + g_{m_2}) v_1 v_2$$

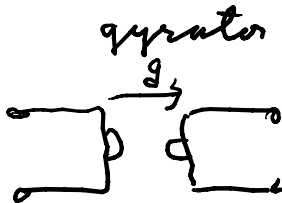
turn around one & set $|g_{m_2}| = |g_{m_1}| = g$, $g_{m_1} = -g$, $g_{m_2} = g$

note
change
09/15/11

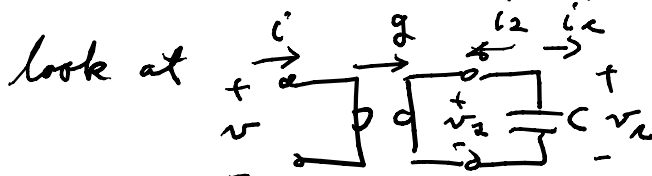


$$\Rightarrow Y = \begin{bmatrix} 0 & g \\ -g & 0 \end{bmatrix}, P_{in} = 0$$

$$= -Y^T, \Rightarrow Y + Y^T = 0_{2 \times 2}$$



basic lossless ($P_{in} = 0$)
2-port

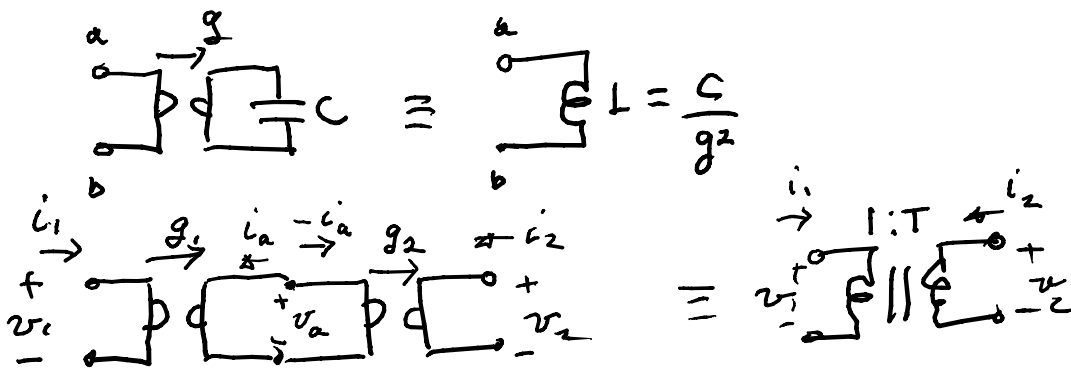


$$i_2 = -C \frac{dv_2}{dt}$$

$$i_1 = i = g v_2 = g \left(-\frac{1}{sC} \right) i_2$$

$$i_2 = -g v_1 \Rightarrow i_1 = \frac{-g}{sC} \cdot (-g) v_1$$

$$i = \frac{g^2}{sC} v \Rightarrow v = s C i = s \frac{C}{g^2} i$$

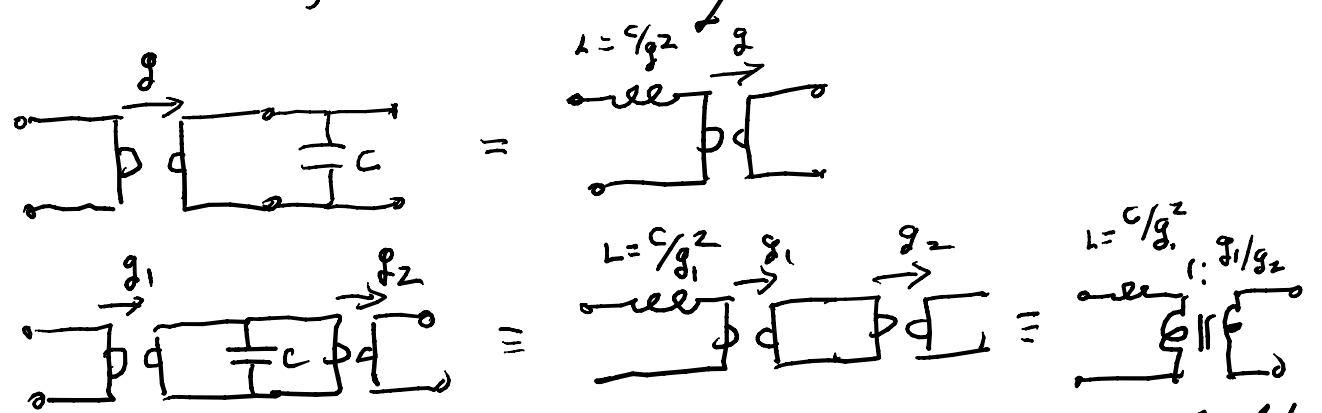


$$\begin{aligned}
 i_1 &= g_1 v_a & v_a &= i_1/g_1 = \frac{i_2}{-g_2} \Rightarrow i_2 = -\frac{g_2}{g_1} i_1 \\
 i_2 &= -g_2 v_a \\
 i_a &= -g_1 v_1 & -g_1 v_1 &= -g_2 v_2 \Rightarrow v_2 = \frac{g_1}{g_2} v_1 = T v_1 \\
 -i_a &= g_2 v_2 & T &= \frac{g_1}{g_2} = \text{turns ratio}
 \end{aligned}$$

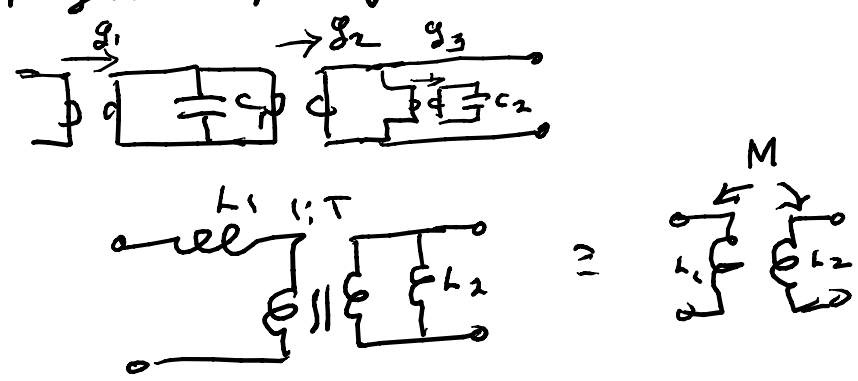
$$g_1 i_2 + g_2 i_1 = 0 \Rightarrow \Sigma \text{ of amp turns} = 0$$

$$g_2 v_2 - g_1 v_1 = 0 \Rightarrow \text{ratio of turns}$$

$$\begin{aligned}
 P_{in} &= i_1 v_1 + i_2 v_2 = i_1 v_1 + \left(-\frac{g_2}{g_1} i_1\right) \left(\frac{g_1}{g_2} v_1\right) = i_1 v_1 - i_1 v_1 = 0 \\
 &= \text{lossless, instantaneous}
 \end{aligned}$$



non-perfect coupling



equivalent for coupled coils with perfect coupling