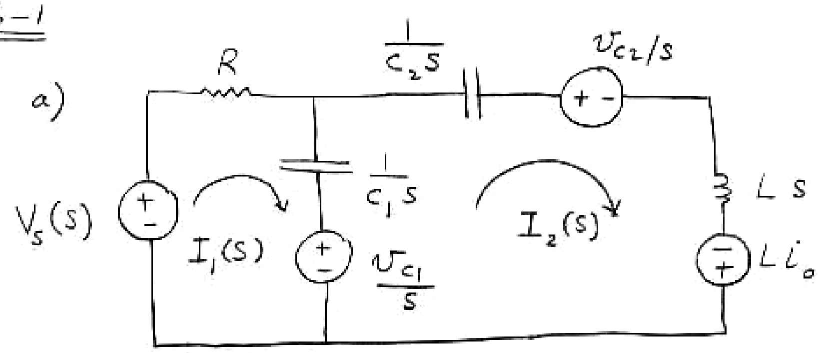
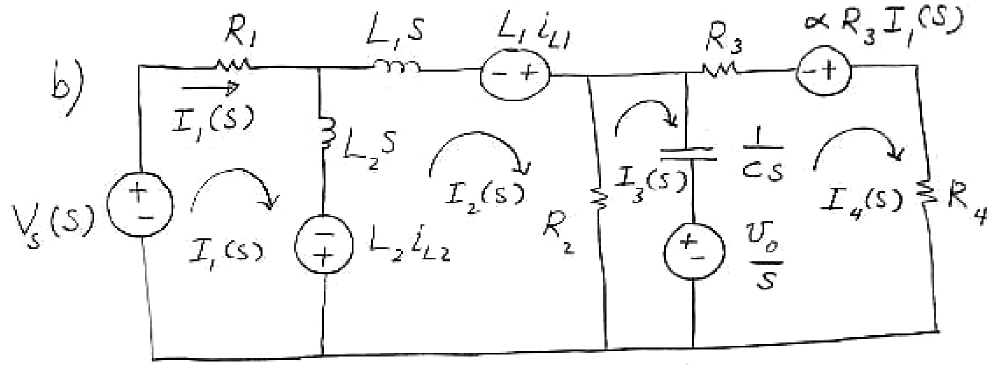
6-1

a)



b)



6-2 KVL around each loop (mesh):

a) $$-V_s(S) + R\,I_1(S) + \frac{1}{C_1 S}\left(I_1(S) - I_2(S)\right) + \frac{v_{c1}}{S} = 0 \quad (1)$$

$$-\frac{v_{c1}}{S} + \frac{1}{C_1 S}\left[I_2(S) - I_1(S)\right] + \frac{1}{C_2 S} I_2(S) + \frac{v_{c2}}{S} + LS\,I_2(S) - L i_o = 0 \quad (2)$$

Eqns. (1) & (2) can be written in matrix notation $\Rightarrow$

$$\begin{bmatrix} R + \frac{1}{C_1 s} & -\frac{1}{C_1 s} \\ -\frac{1}{C_1 s} & \frac{1}{C_1 s} + \frac{1}{C_2 s} + Ls \end{bmatrix} \begin{bmatrix} I_1(s) \\ I_2(s) \end{bmatrix} = \begin{bmatrix} V_s(s) - \frac{v_{c1}}{s} \\ \frac{v_{c1}}{s} - \frac{v_{c2}}{s} + L i_o \end{bmatrix}$$

b) In a similar fashion, the loop eqns. can be written as:

$$\begin{bmatrix} R_1 + L_2 s & -L_2 s & 0 & 0 \\ -L_2 s & L_2 s + L_1 s + R_2 & -R_2 & 0 \\ 0 & -R_2 & R_2 + \frac{1}{Cs} & -\frac{1}{Cs} \\ 0 & 0 & -\frac{1}{Cs} & \frac{1}{Cs} + R_3 + R_4 \end{bmatrix} \begin{bmatrix} I_1(s) \\ I_2(s) \\ I_3(s) \\ I_4(s) \end{bmatrix} =$$

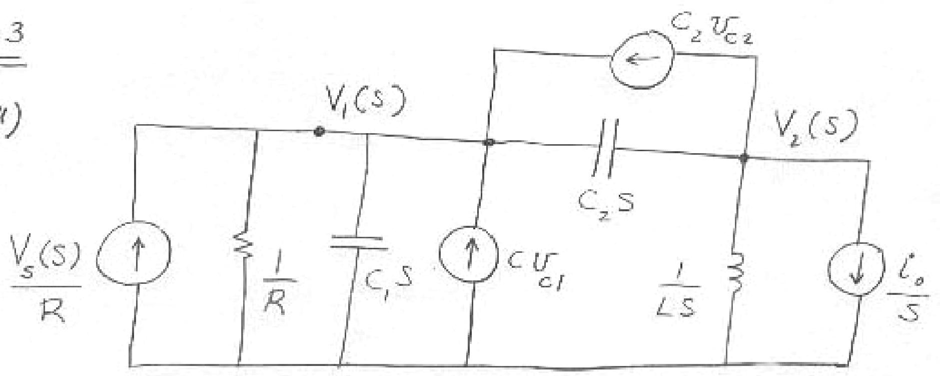
$$\begin{bmatrix} V_s(s) + L_2 i_{L2} \\ -L_2 i_{L2} + L_1 i_{L1} \\ -\frac{v_o}{s} \\ \frac{v_o}{s} + \alpha R_3 I_1(s) \end{bmatrix}$$

or

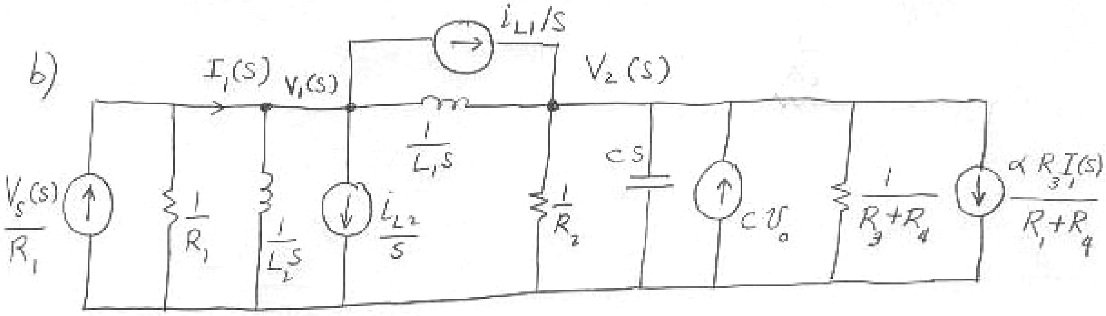
$$\begin{bmatrix} R_1+L_2 s & -L_2 s & 0 & 0 \\ -L_2 s & L_2 s+L_1 s+R_2 & -R_2 & 0 \\ 0 & -R_2 & R_2+\frac{1}{Cs} & -\frac{1}{Cs} \\ -\alpha R_3 & 0 & -\frac{1}{Cs} & \frac{1}{Cs}+R_3+R_4 \end{bmatrix} \begin{bmatrix} I_1(s) \\ I_2(s) \\ I_3(s) \\ I_4(s) \end{bmatrix} = \begin{bmatrix} V_s(s)+L_2 i_{L2} \\ -L_2 i_{L2}+L_1 i_{L1} \\ -\frac{v_0}{s} \\ \frac{v_0}{s} \end{bmatrix}$$

6-3

a)



b)



6-4

a) Apply KCL at each node $\Rightarrow$

$$-\frac{V_s(s)}{R} + \frac{V_1(s)}{R} + C_1 s V_1(s) - C v_{c1} + C_2 s\left[V_1(s) - V_2(s)\right]$$

$$- C_2 v_{c2} = 0 \qquad (1)$$

$$C_2 s\left[V_2(s) - V_1(s)\right] + C_2 v_{c2} + \frac{1}{Ls} V_2(s) + \frac{i_o}{s} = 0 \qquad (2)$$

$\therefore$

$$\begin{bmatrix} \frac{1}{R} + C_1 s + C_2 s & -C_2 s \\ -C_2 s & C_2 s + \frac{1}{Ls} \end{bmatrix} \begin{bmatrix} V_1(s) \\ V_2(s) \end{bmatrix} = \begin{bmatrix} \frac{V_s(s)}{R} + C v_{c1} + C_2 v_{c2} \\ -C_2 v_{c2} - \frac{i_o}{s} \end{bmatrix}$$

b) Using a similar procedure $\Rightarrow$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{L_2 s} + \frac{1}{L_1 s} & -\frac{1}{L_1 s} \\ -\frac{1}{L_1 s} & \frac{1}{L_1 s} + \frac{1}{R_2} + Cs + \frac{1}{R_3 + R_4} \end{bmatrix} \begin{bmatrix} V_1(s) \\ V_2(s) \end{bmatrix} = \begin{bmatrix} \frac{V_s(s)}{R} - \frac{i_{L2}}{s} - \frac{i_{L1}}{s} \\ \frac{i_{L1}}{s} + C v_o - \frac{\alpha R_3 I_1(s)}{R_3 + R_4} \end{bmatrix}$$

$$I_1(s) = \frac{V_s(s)}{R_1} - \frac{1}{R_1} V_1(s)$$, then the factor

$$\frac{\alpha R_3 I_1(s)}{R_3 + R_4} = \frac{\alpha R_3 V_s(s)}{R_1(R_3+R_4)} - \frac{\alpha R_3}{R_1(R_3+R_4)} V_1(s)$$, which

is in the matrix eqn. to eliminate $I_1(s)$.

$\therefore$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{L_2 s} + \frac{1}{L_1 s} & -\frac{1}{L_1 s} \\ -\frac{1}{L_1 s} - \frac{\alpha R_3}{R_1(R_3+R_4)} & \frac{1}{L_1 s} + \frac{1}{R_2} + cs + \frac{1}{R_3+R_4} \end{bmatrix} \begin{bmatrix} V_1(s) \\ V_2(s) \end{bmatrix}$$

$$= \begin{bmatrix} \frac{V_s(s)}{R} - \frac{i_{L2}}{s} - \frac{i_{L1}}{s} \\ \frac{i_{L1}}{s} + cv_0 - \frac{\alpha R_3 V_s(s)}{R_1(R_3+R_4)} \end{bmatrix}$$

6-9

Use eqn. 6-60 and replace $V_c(s)$ by $\alpha R_3 I_1(s)$. $I_1(s)$ is unknown and has to be written in terms of nodal voltages.

From fig 6-12, $v_1(t) - v_2(t) = L \dfrac{di_1(t)}{dt} \Rightarrow$

$$V_1(s) - V_2(s) = L\, s I_1(s) - L i_0$$

$$\therefore\ I_1(s) = \frac{V_1(s) - V_2(s) + L i_0}{Ls}$$

$\therefore$ Replace $V_c(s)$ by $\alpha R_3 I_1(s) = \dfrac{\alpha R_3}{Ls}\left[V_1(s) - V_2(s) + L i_0\right]$

in eqn. 6-60 $\Rightarrow$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{1}{sL} & -\frac{1}{sL} & 0 \\ -\frac{1}{sL} + \frac{\alpha}{Ls} & \frac{1}{R_2} + \frac{1}{R_3} + sC + \frac{1}{sL} - \frac{\alpha}{Ls} & -\frac{1}{R_3} \\ -\frac{\alpha}{Ls} & -\frac{1}{R_3} + \frac{\alpha}{Ls} & \frac{1}{R_3} + \frac{1}{R_4} \end{bmatrix} \begin{bmatrix} V_1(s) \\ V_2(s) \\ V_3(s) \end{bmatrix} = \begin{bmatrix} \frac{V_s(s)}{R_1} - \frac{i_0}{s} \\ \frac{i_0}{s} + Cv_0 - \frac{\alpha i_0}{s} \\ \frac{\alpha i_0}{s} \end{bmatrix}$$