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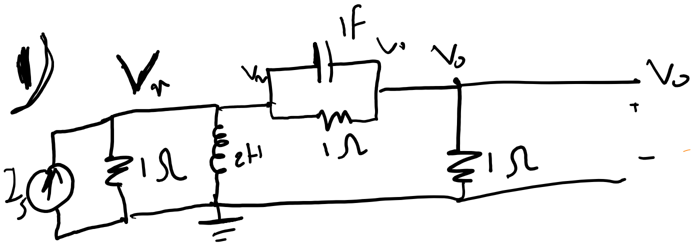
1)



$$Y_n = \begin{bmatrix} 1+\frac{1}{2D}+1+D & -1-D \\ -1-D & 1+1+D \end{bmatrix}_{2\times2} \begin{bmatrix} V_n \\ V_o \end{bmatrix}_{2\times1} = \begin{bmatrix} I_s \\ 0 \end{bmatrix}_{2\times1}$$

درسیناه

$$|Y_n| = \frac{1}{(D+2)\left(1+\frac{1}{2D}+1+D\right)-(1+D)^2} = \frac{1}{D+\frac{1}{2}+D+D^2+2+\frac{1}{D}+2+2D-(1+D^2)} =$$

$$\frac{1}{\underset{2D}{\cancel{4D}}+\underset{3.5}{\cancel{4.5}}+\cancel{D^2}+\frac{1}{D}-(\cancel{1}+\cancel{D^2}+\cancel{2D})} = \frac{1}{2D+3.5+\frac{1}{D}} = \frac{D}{2D^2+3.5D+1} = \boxed{\frac{2D}{4D^2+7D+2}}$$

$$\Downarrow$$

$$Y_n^{-1} = \frac{2D}{4D^2+7D+2}\begin{bmatrix} 2+D & 1+D \\ 1+D & D+2+\frac{1}{2D} \end{bmatrix}$$

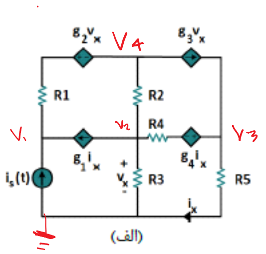
$$\Rightarrow V_o = \frac{2D}{4D^2+7D-2}\left((1+D)\times I. + \overset{0}{\cancel{\left(D+2+\frac{1}{2D}\right)\times 0}}\right)$$

$$V_o = \frac{(2D^2+2D)I_s}{4D^2+7D-2} \Rightarrow \boxed{(4D^2+7D-2)V_o = (2D^2+2D)I_s}$$

$$\boxed{4\frac{d^2V_o}{dt^2}+7\frac{dV_o}{dt}-2V_o = 2\frac{d^2I_s}{dt^2}+2\frac{dI}{dt}}$$

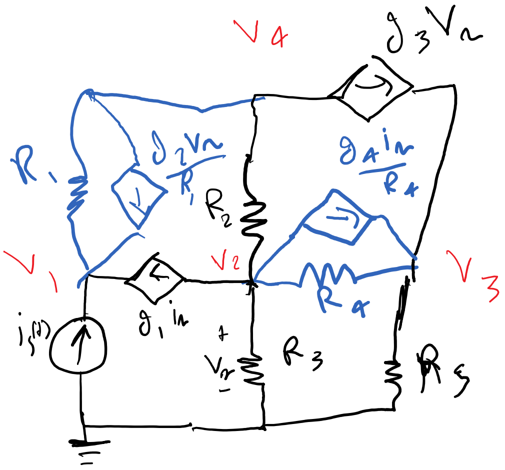
2)

الف)



تبدیل ولتاژ به جریان

$\Longrightarrow$



$$Y_n E = i_s$$

$$\begin{array}{c}V_1\\V_2\\V_3\\V_4\end{array}\underbrace{\begin{bmatrix}-\frac{1}{R_1} & \frac{1}{R_1} & 0 & 0\\ -\frac{1}{R_2} & 0 & \frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4} & -\frac{1}{R_4}\\ 0 & 0 & -\frac{1}{R_4} & \frac{1}{R_4}+\frac{1}{R_5}\\ \frac{1}{R_1}+\frac{1}{R_2} & -\frac{1}{R_1} & -\frac{1}{R_2} & 0\end{bmatrix}}_{Y_n}\underbrace{\begin{bmatrix}V_1\\V_2\\V_3\\V_4\end{bmatrix}}_{E}=\overbrace{\begin{bmatrix}\frac{g_2V_x}{R_1}+i_s+g_1i_x\\ -g_1i_x-\frac{g_4i_x}{R_4}\\ \frac{g_4i_x}{R_4}+g_3V_x\\ -g_3V_x-\frac{g_2V_x}{R_1}\end{bmatrix}}^{i_s}$$

$$\left.\begin{array}{l}\frac{V_3}{R_5}=i_x\\ V_x=V_2\end{array}\right\}$$ می دانیم با توجه به شکل می توان فهمید

$\Downarrow$ i_s جاگذاری در

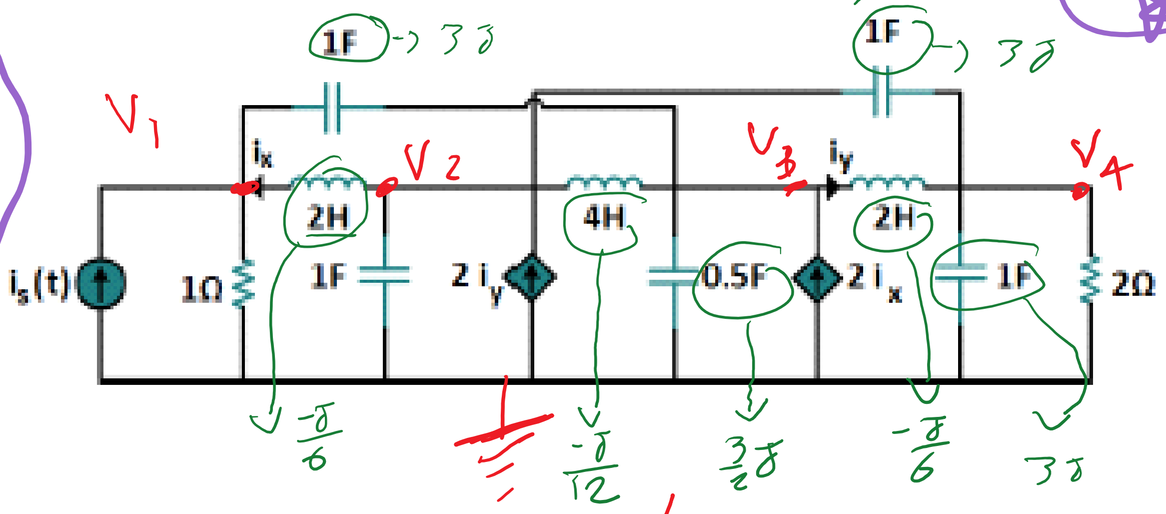
$$\begin{bmatrix} -\frac{1}{R_1} & \frac{1}{R_1} & 0 & 0 \\ -\frac{1}{R_2} & 0 & \frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4} & -\frac{1}{R_4} \\ 0 & 0 & -\frac{1}{R_4} & \frac{1}{R_4}+\frac{1}{R_5} \\ \frac{1}{R_1}+\frac{1}{R_2} & -\frac{1}{R_1} & -\frac{1}{R_2} & 0 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} i_s(t) \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

#2 :)

$\boxed{w = 3}$

$i_s(t) = 2\sin(3t - 60) \Rightarrow 2\angle -60^\circ = \boxed{1 - j\sqrt{3}}$ ★

$$\boxed{\begin{aligned} i_x &= \frac{V_2 - V_1}{6j} \\ I_y &= \frac{V_3 - V_4}{6j} \end{aligned}}$$ ★



$Y_n E = i_s$

$$\begin{bmatrix} 1 + \frac{-j}{6} + 3j & +\frac{j}{6} & -3j & 0 \\ +\frac{j}{6} & \frac{-j}{6} + 3j + \frac{-j}{12} + 3j & +\frac{j}{12} & -3j \\ -3j & +\frac{j}{12} & \frac{3}{2}j - \frac{j}{12} - \frac{j}{6} + 3j & +\frac{j}{6} \\ 0 & -3j & +\frac{j}{6} & \frac{-j}{6} + 3j + \frac{1}{2} + 3j \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} I_s(t) \\ 2I_j \\ 2I_x \\ 0 \end{bmatrix} = \begin{bmatrix} 1 - j\sqrt{3} \\ \frac{V_3 - V_4}{3j} \\ \frac{V_2 - V_1}{3j} \\ 0 \end{bmatrix}$$

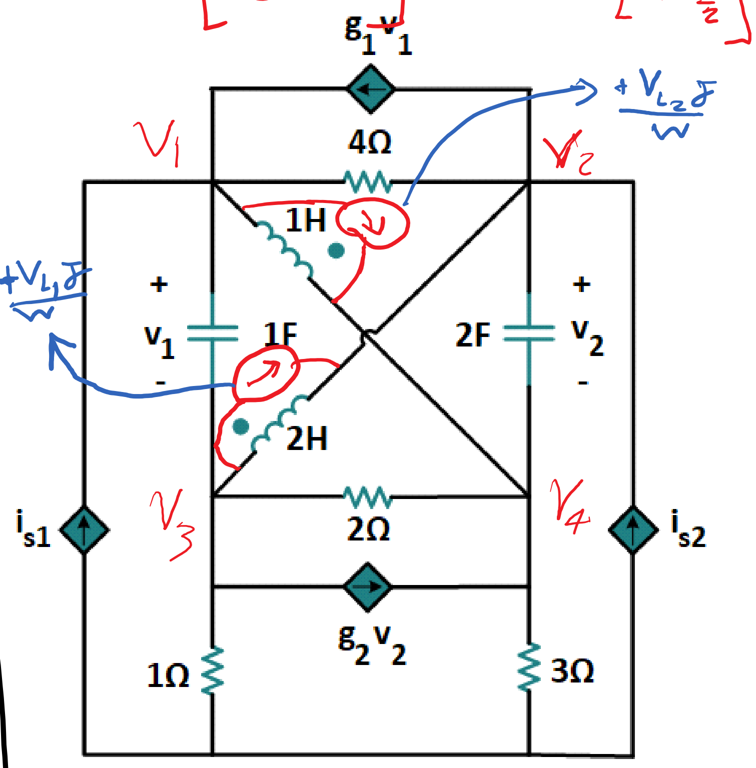
$$\begin{bmatrix} 1 + \frac{-j}{6} + 3j & +\frac{j}{6} & -3j & 0 \\ +\frac{j}{6} & \frac{-j}{6} + 3j + \frac{-j}{12} + 3j & +\frac{j}{12} + \frac{j}{3} & -3j - \frac{j}{3} \\ -3j - \frac{j}{3} & +\frac{j}{12} + \frac{j}{3} & \frac{3}{2}j - \frac{j}{12} - \frac{j}{6} + 3j & +\frac{j}{6} \\ 0 & -3j & +\frac{j}{6} & \frac{-j}{6} + 3j + \frac{1}{2} + 3j \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} 1 - j\sqrt{3} \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

3)

$M=2 \Rightarrow M=-2$

ترتیب کننده

$L=\begin{bmatrix}1 & -2\\ -2 & 2\end{bmatrix} \Rightarrow \Gamma=\begin{bmatrix}-1 & -1\\ -1 & -\frac{1}{2}\end{bmatrix}$



$$\begin{bmatrix} jw+\frac{1}{4}+\frac{j}{w} & \frac{-1}{4} & -\frac{j}{w} & -jw \\ \frac{-1}{4} & 2jw+\frac{1}{4}-\frac{2j}{w} & -2jw & \frac{-2}{jw} \\ \frac{-j}{w} & -2j & \frac{1}{3}+\frac{1}{2}+\frac{j}{w}+2jw & -\frac{1}{2} \\ -jw & \frac{-2}{w} & \frac{-1}{2} & 1+\frac{1}{2}-\frac{2j}{w}+jw \end{bmatrix} \begin{bmatrix} e_1\\ e_2\\ e_3\\ e_4 \end{bmatrix} = \begin{bmatrix} I_{s_1}+g_1v_1-\left(\frac{-V_{L_2}}{jw}\right) \\ I_{s_2}-g_1v_1-\frac{V_{L_1}}{jw} \\ g_2V_2-\frac{V_{L_2}}{jw} \\ -g_2V_2+\frac{V_{L_1}}{jw} \end{bmatrix}$$

با توجه به شکل می توان فهمید

$$\begin{cases} V_{L_1}=e_1-e_3 \\ V_{L_2}=e_4-e_2 \\ V_1=e_1-e_4 \\ V_2=e_2-e_3 \end{cases} \Longrightarrow$$

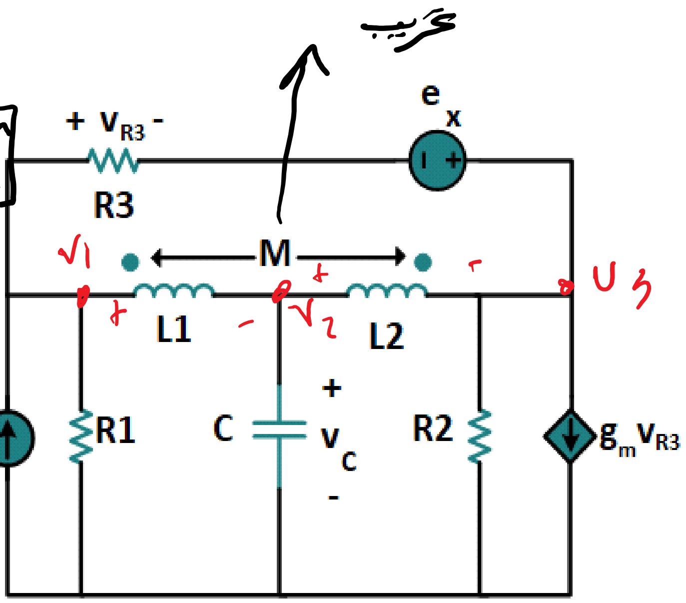
$$\begin{bmatrix} I_{s_1}+g_1e_1-g_1e_4+\frac{e_4}{jw}-\frac{e_2}{jw} \\ I_{s_2}-g(e_1-e_4)-\frac{e_1}{jw}+\frac{e_3}{jw} \\ g_2e_2-g_2e_3+\frac{e_2}{jw}-\frac{e_4}{jw} \\ -g_2e_2+g_2e_3+\frac{e_1}{jw}-\frac{e_3}{jw} \end{bmatrix}$$

ولتاژها را به سمت Y_n می بریم

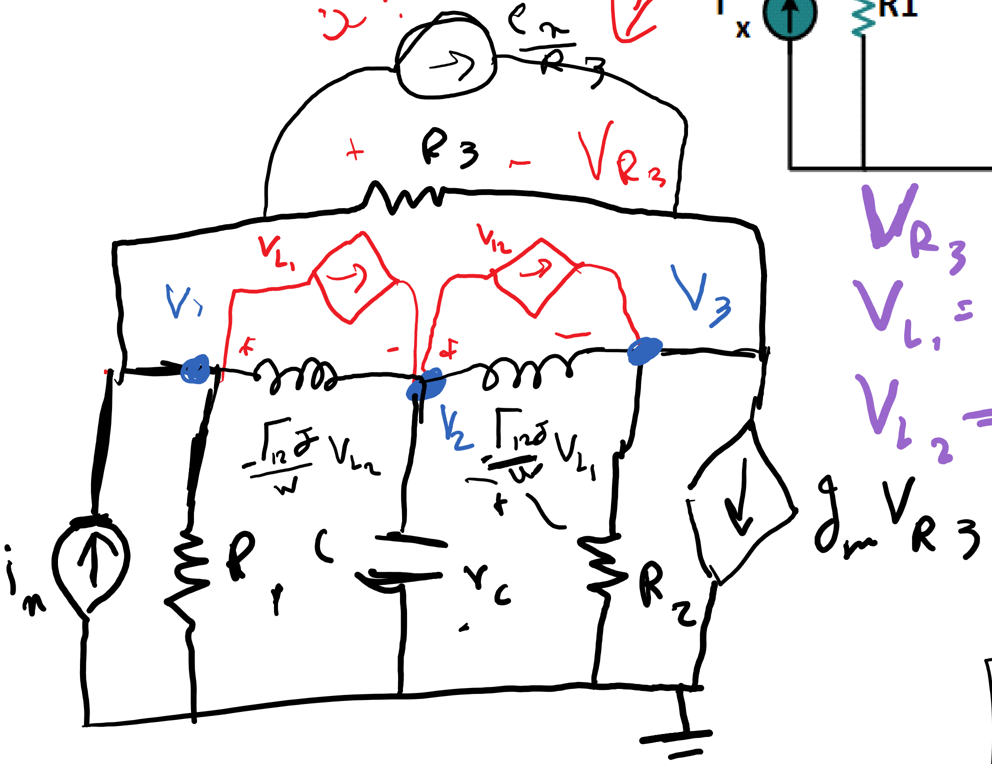
$$\begin{bmatrix} jw+\frac{1}{4}+\frac{j}{w}-g_1 & \frac{-1}{4}+\frac{1}{jw} & -\frac{j}{w} & -jw-\frac{1}{jw}+g_1 \\ \frac{-1}{4}+\frac{1}{jw}+g_1 & 2jw+\frac{1}{4}-\frac{2j}{w} & -2jw-\frac{1}{jw} & \frac{-2}{jw}-g_1 \\ \frac{-j}{w} & -2j-g_2-\frac{1}{jw} & \frac{1}{3}+\frac{1}{2}+\frac{j}{w}+2jw+g_2 & -\frac{1}{2}+\frac{1}{jw} \\ -jw-\frac{1}{jw} & \frac{-2}{w}+g_2 & \frac{-1}{2}-g_2+\frac{1}{jw} & 1+\frac{1}{2}-\frac{2j}{w}+jw \end{bmatrix} \begin{bmatrix} e_1\\ e_2\\ e_3\\ e_4 \end{bmatrix} = \begin{bmatrix} I_{s_1}\\ I_{s_2}\\ 0\\ 0 \end{bmatrix}$$

4) الف

$$L = \begin{bmatrix} L_1 & -M \\ -M & L_2 \end{bmatrix} \Rightarrow \Gamma = \frac{1}{L_1 L_2 - M^2}\begin{bmatrix} L_2 & M \\ M & L_1 \end{bmatrix}$$



تبدیل منابع ولتاژ به جریان



$$V_{R_3} = V_1 - V_3 + e_x$$

$$V_{L_1} = V_1 - V_2$$

$$V_{L_2} = V_2 - V_3$$

$$\begin{bmatrix} R_1 + \bar{R}_3 - \frac{\Gamma_{11}}{\omega j} & -\frac{\Gamma_{11}}{\omega j} & \frac{-1}{R_3} \\ \frac{-\Gamma_{11} j}{j\omega} & j\omega C + \frac{\Gamma_{11}}{\omega j} + \frac{\Gamma_{22}}{\omega j} & \frac{-\Gamma_{22}}{\omega j} \\ \frac{-1}{R_3} & -\frac{\Gamma_{22}}{j\omega} & \frac{1}{R_2} + \frac{\Gamma_{22}}{j\omega} + \frac{1}{R_3} \end{bmatrix}_{3\times 3} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} i_x - \frac{\Gamma_{12}}{j\omega} V_{L_2} - \frac{e_x}{R_3} \\ \frac{\Gamma_{12}}{j\omega} \cdot V_{L_2} - \frac{\Gamma_{12}}{j\omega} V_{L_1} \\ \frac{e_x}{R_3} - g_m V_{R_3} + \frac{\Gamma_{12}}{j\omega} V_{L_1} \end{bmatrix}$$

$$\Downarrow$$

$$\begin{bmatrix} i_x - \frac{\Gamma_{12}}{j\omega}(V_2 - V_3) - \frac{e_x}{R_3} \\ \frac{\Gamma_{12}}{j\omega}(V_2 - V_3) - \frac{\Gamma_{12}}{\omega j}(V_1 - V_2) \\ \frac{e_x}{R_3} - g_m(V_1 - V_3 + e_x) + \frac{\Gamma_{12}}{j\omega}(V_1 - V_2) \end{bmatrix}_{3\times 1}$$

ضرایب ولتاژ را Y_n می‌گیریم $\Leftarrow$

$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_3}+\frac{T_{11}}{j\omega} & -\frac{T_{11}}{j\omega}+\frac{T_{12}}{j\omega} & \frac{-1}{R_3}-\frac{T_{22}}{j\omega} \\ -\frac{T_{11}}{j\omega}+\frac{T_{12}}{j\omega} & j\omega C+\frac{T_{11}}{j\omega}+\frac{T_{22}}{j\omega}-\frac{T_{12}}{j\omega}-\frac{T_{12}}{j\omega} & -\frac{T_{22}}{j\omega}+\frac{T_{12}}{j\omega} \\ \frac{-1}{R_3}-\frac{T_{12}}{j\omega}+g_m & \frac{-T_{22}}{j\omega}+\frac{T_{12}}{j\omega} & \frac{1}{R_2}+\frac{T_{22}}{j\omega}+\frac{1}{R_3}-g_m \end{bmatrix}_{3\times3} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}_{3\times1} = \begin{bmatrix} I_n-\frac{e_n}{R_3} \\ 0 \\ \frac{e_n}{R_3}-g_m e_n \end{bmatrix}$$

$v_c(0) = V_0$ و $i_{L1}(0) = I_{01}$، $i_{L2}(0) = I_{02}$

شرایط اولیه را در ماتریس قرار دهیم

$-j\omega$ D ✓

$$\begin{bmatrix} \frac{1}{R_1}+\frac{T_{11}}{D}+\frac{1}{R_3} & -\frac{T_{11}}{D}+\frac{T_{12}}{D} & \frac{-1}{R_3}-\frac{T_{12}}{D} \\ -\frac{T_{11}}{D}+\frac{T_{12}}{D} & Dc+\frac{T_{11}}{D}+\frac{T_{22}}{D}-\frac{T_{12}}{D}-\frac{T_{12}}{D} & -\frac{T_{22}}{D}+\frac{T_{12}}{D} \\ \frac{-1}{R_3}-\frac{T_{12}}{D}+g_m & \frac{-T_{22}}{D}+\frac{T_{12}}{D} & \frac{1}{R_2}+\frac{T_{22}}{D}+\frac{1}{R_3}-g_m \end{bmatrix}_{3\times3} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}_{3\times1} = \begin{bmatrix} I_n-\frac{e_n(0)}{R_3} \\ 0+i_{L_1}(0)-i_{L_2}(0) \\ \frac{e_n}{R_3}-g_m e_n-i_{L_2}(0) \end{bmatrix}$$

$\int V_L = \frac{V_L}{D} = \frac{i_L}{T}$: می‌دانیم

$\Rightarrow$ معادلات انتگرال دیفرانسیل گره

شرایط اولیه

KCL $t=0$

node 1 8 V_1 $$i_n(0) = \frac{e_n(0)}{R_3} + \frac{V_{R_3}(0)}{R_3} + \frac{V_1(0)}{R_1} + i_{L_1}(0) + T_{12}\underbrace{\frac{V_{L_2}(0)}{D}}_{\boxed{\frac{i_{L_2}(0)}{T_{22}}}}$$

node 2 8 V_2 $$V_{L_2}(0) = V_c(0) = V_0$$

node 3 8 V_3 $$\frac{e_n(0)}{R_3} = -i_{L_2}(0) - T_{21}\underbrace{\frac{V_{L_1}(0)}{D}}_{\boxed{\frac{i_{L_1}(0)}{T_{11}}}} + g_m V_{R_3}(0) + \frac{V_{R_3}}{R_3}$$

$V_2(0)$ مشخص
ناشخص $\{V_1(0), V_3(0)\}$

با استفاده از گره 1 و 3 مقدار $V_1(0)$ و $V_3(0)$ بدست می‌آید