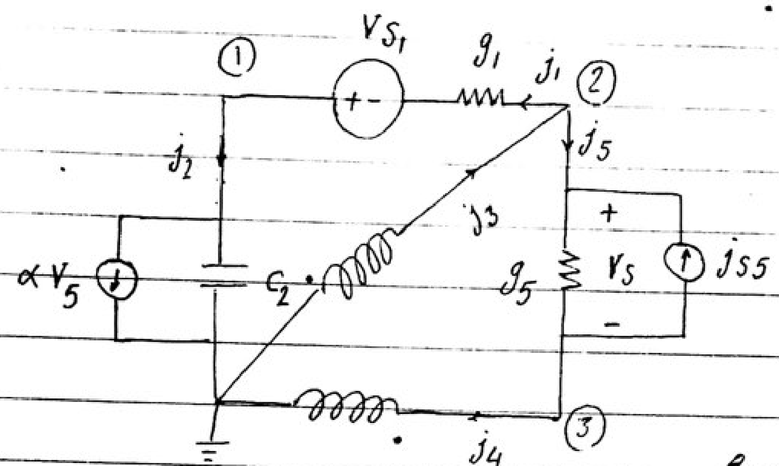
تئوری مدار ۱۸/۱۲/



$$j_1(0) = j_3(0) - j_4(0)$$

$$e_1(0) = V_{C_2}(0)$$

$$e_2(0) = e_1(0) + \frac{j_1(0)}{g_1} - v_{s_1}(0)$$

$$e_3(0) = e_2(0) - \frac{[j_4(0) + j_{s5}(0)]}{g_5}$$

$$e_2 = D\phi_2 \qquad e_3 = D\phi_3$$

$$\phi_2(0) - 0 \qquad \phi_3(0)$$

$$j_1 = g_1 v_1 + g_1 v_{s_1}$$

$$j_2 = c_2 \dot{v}_2 + \alpha v_5$$

$$j_3 = \Gamma_{33} \int_0^t v_3(\tau)\, d\tau + j_3(0) + \Gamma_{34} \int_0^t v_4(\tau)\, d\tau$$

$$j_4 = \Gamma_{34} \int_0^t v_3(\tau)\, d\tau + \Gamma_{44} \int_0^t v_4(\tau)\, d\tau + j_4(0)$$

$$j_5 = g_5 v_5 - j_{s5}$$

$$\begin{bmatrix} j_1 \\ j_2 \\ j_3 \\ j_4 \\ j_5 \end{bmatrix} = \begin{bmatrix} g_1 & 0 & 0 & 0 & 0 \\ 0 & c_2 D & 0 & 0 & \alpha \\ 0 & 0 & \Gamma_{33} D^{-1} & \Gamma_{34} D^{-1} & 0 \\ 0 & 0 & \Gamma_{34} D^{-1} & \Gamma_{44} D^{-1} & 0 \\ 0 & 0 & 0 & 0 & g_5 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{bmatrix} + \begin{bmatrix} g_1 v_{s_1} \\ 0 \\ j_3(0) \\ j_4(0) \\ -j_{s5} \end{bmatrix}$$

$$\underbrace{A Y_b A^T}_{Y_n} = \begin{array}{c} \\ ① \\ ② \\ ③ \end{array} \begin{array}{ccc} ① & ② & ③ \\ \left[\begin{array}{ccc} g_1 + C_2 D & \overset{g_1 D}{-g_1} + \alpha & \overset{\alpha D}{-\cancel{\alpha}} \\ -g_1 & \overset{g_1 D}{\cancel{g_1}} + \Gamma_{33} \cancel{D^{-1}} + \overset{g_5 D}{\cancel{g_5}} & -\Gamma_{34} \cancel{D^{-1}} - g_5 \\ 0 & -\Gamma_{34} \cancel{D^{-1}} - \underset{g_5 D}{\cancel{g_5}} & \Gamma_{44} \cancel{D^{-1}} + \underset{g_5 D}{g_5} \end{array}\right] \end{array} \begin{bmatrix} e_1 \\ D\phi_2 \\ D\phi_3 \end{bmatrix}$$

$$Y_n E = I_S$$

$$I_S = \begin{bmatrix} g_1 v_{S_1} \\ -g_1 v_{S_1} + j_3(0) + j_{S5} \\ -j_{S5} - j_4(0) \end{bmatrix}$$

درخت :

۱- بهم پیوسته

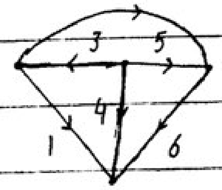
۲- شامل تمام گره‌ها

۳- شامل هیچ حلقه‌ای نباشد

n_t : تعداد گره‌ها $\qquad n = n_t - 1$

b : تعداد شاخه‌ها

تعداد لینک‌ها = $b - n$

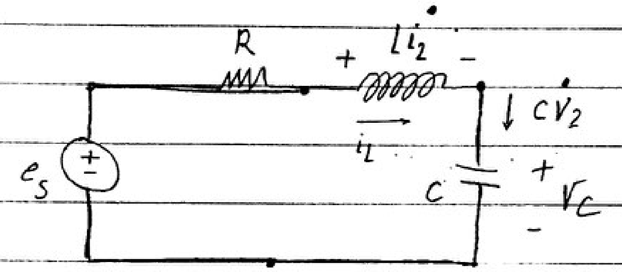


درخت ← $2,5,6$

$\{3,4,6\}$ درخت ⟶ لینک $\{2,1,5\}$

حداقل اطلاعاتی که در کنار منابع مستقل نیاز داریم تا برای همه زمان ها رفتار مدار را تعیین کنیم ← حالت مدار

← دانستن جریان Lها و ولتاژ Cها



KCL: $C\dot V_C = i_L$

KVL: $L\dot i_L = -V_C - Ri_L + e_S$

$$\begin{bmatrix} \dot V_C \\ \dot i_L \end{bmatrix} = \begin{bmatrix} 0 & \frac{1}{C} \\ -\frac{1}{L} & -\frac{R}{L} \end{bmatrix} \begin{bmatrix} V_C \\ i_L \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{L} \end{bmatrix} [e_S]$$

$$\dot x = Ax + Bu$$

درخت مناسب برای نوشتن معادلات حالت:

۱- شامل تمام منابع ولتاژ باشد

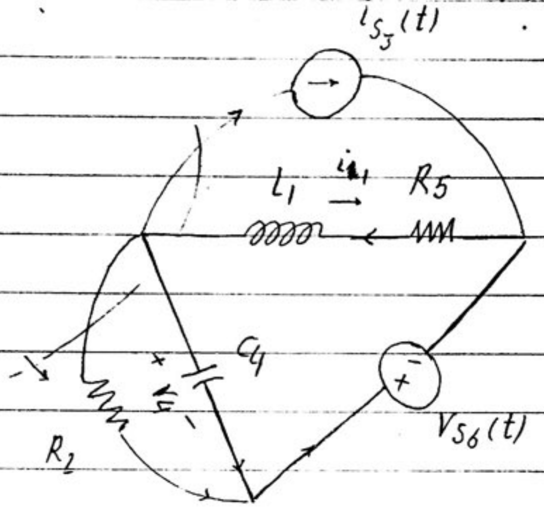
۲- شامل هیچ منبع جریان نباشد

۳- شامل حداکثر ممکن از خازن ها

۹۳/۱۲/۲۳ تئوری مدار

$$\dot{x} = Ax + BU + E\dot{U}$$

$$Y = Cx + DU + F\dot{U}$$



V_4 & i_1

kcl: $C_4\dot{V}_4 + i_1 + \dfrac{V_4}{R_2} + i_{S_3} = 0$

KVL: $L_1\dot{i}_1 + R_5 i_1 - V_{S6} - V_4 = 0$

$$\begin{bmatrix} \dot{i}_1 \\ \dot{V}_4 \end{bmatrix} = \underbrace{\begin{bmatrix} -R_5/L_1 & 1/L_1 \\ -1/C_4 & -1/C_4R_2 \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} i_1 \\ V_4 \end{bmatrix}}_{x} + \underbrace{\begin{bmatrix} 0 & \frac{1}{L_1} \\ \frac{-1}{C_4} & 0 \end{bmatrix}}_{B} \underbrace{\begin{bmatrix} i_{S_3} \\ V_{S6} \end{bmatrix}}_{V}$$

$$\phi_1(t) = L_1 i_1(t)$$

$$q_4 = C_4 V_4(t)$$

Kcl: $\dot{q}_4 + \dfrac{q_4}{C_4R_2} + \dfrac{\phi_1}{L_1} + i_{S_3} = 0$

$$\text{KVL}: \dot{\phi}_1 + \frac{\phi_1}{L_1} R_5 - V_{S6} - \frac{q_4}{V_4} = 0$$

$$\phi(t) = L_1(t) i_1(t) \qquad q_4^{(t)} = c_4(t) V_4(t)$$

$$\Rightarrow \begin{bmatrix} \dot{\phi}_1 \\ \dot{q}_4 \end{bmatrix} = \begin{bmatrix} -\frac{R_5(t)}{L_1(t)} & \frac{1}{C_4(t)} \\ -\frac{1}{L_1(t)} & -\frac{1}{R_2^{(t)} C_4^{(t)}} \end{bmatrix} \begin{bmatrix} \phi_1 \\ q_4 \end{bmatrix} + \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \begin{bmatrix} i_{S3} \\ V_{S6} \end{bmatrix}$$

$$\text{KCL}: \dot{q}_4 = \dot{c}_4(t) V_4(t) + c_4(t) \dot{V}_4(t)$$

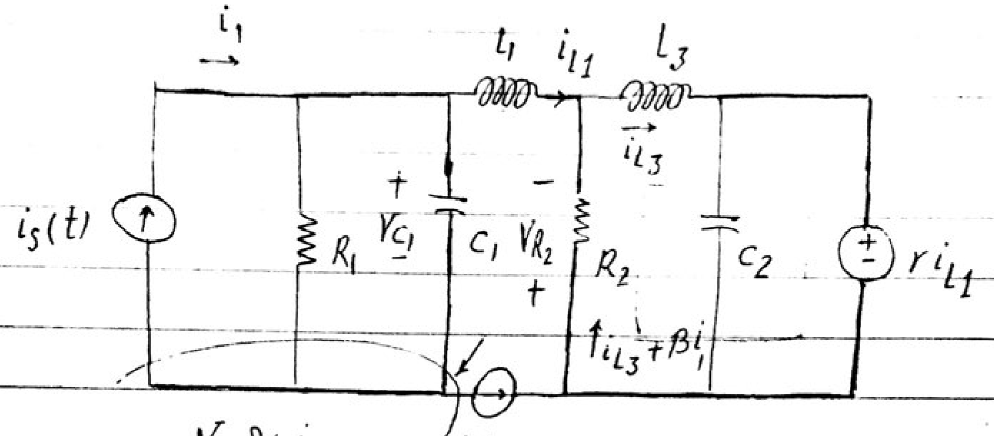
$$\dot{q}_4 + \frac{V_4}{R_2(t)} + i_1 + i_{S3} = 0$$

$$\dot{\phi}_1 = \dot{L}_1(t) i_1(t) + L_1(t) \dot{i}_1(t)$$

$$\therefore \quad \dot{\phi}_1 + R_5 i_1 - V_{S6} - V_4 = 0$$

تئوری مدار ۲۳/۱۲

مثال:



V_{C_1} & i_{L_3}

$$KCL: C_1\dot{V}_{C_1} - \beta i_1 + \frac{V_{C_1}}{R_1} - i_s(t) = 0$$

$i_s(t)$

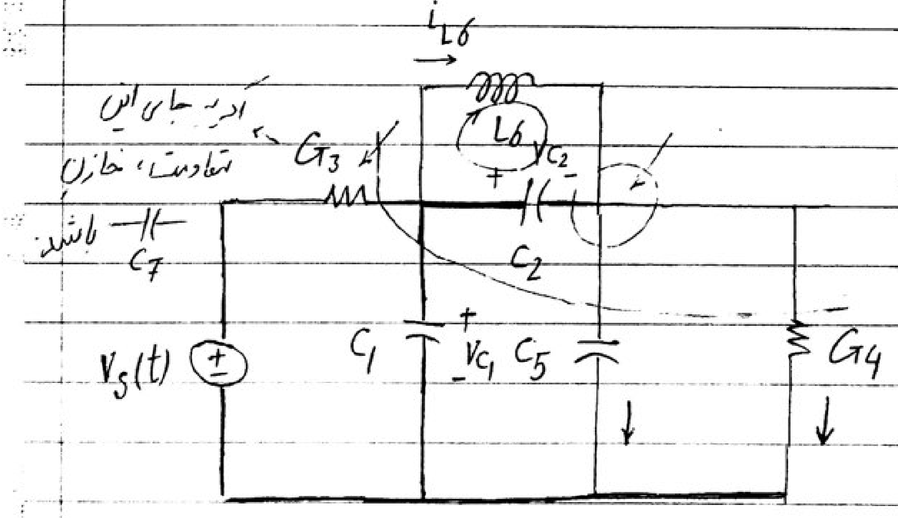
$$KVL: L_3\dot{i}_{L_3} + r i_{L_1} + V_{R_2} = 0$$

$$i_{L_1} = -\beta i_1$$

$$\dot{x} = Ax + Bu$$

$$V_{R_2} = R_2\left(i_{L_3} + \beta i_s(t)\right)$$

مثال:



V_{C_1} & V_{C_2} & i_{L_6}

اگر خازن جایگزین شود

$$\overset{\dot{V}_{C_1} - \dot{V}_S(t)}{} \qquad C_7$$

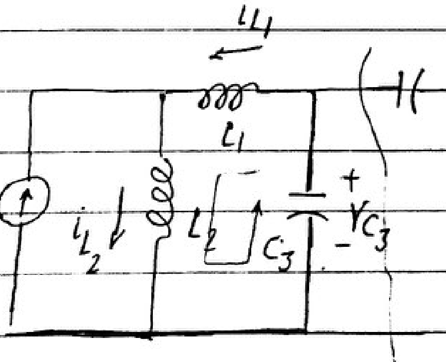
$$KCL: C\dot{V}_{C_1} + [V_{C_1} - V_S(t)]\cancel{G_4}_{3} + (V_{C_1} - V_{C_2})G_4 + C_5(\dot{V}_{C_1} - \dot{V}_{C_2}) = 0$$

$$KCL: C_2\dot{V}_{C_2} + i_{L_6} + C_4(V_{C_2} - V_{C_1}) + C_5(\dot{V}_{C_2} - \dot{V}_{C_1}) = 0$$

$$KVL: L_6\dot{i}_{L_6} - V_{C_2} = 0$$

$$\begin{bmatrix} C_1 + C_5 & -C_5 & 0 \\ -C_5 & C_2 + C_5 & 0 \\ 0 & 0 & L_6 \end{bmatrix} \begin{bmatrix} \dot{V}_{C_1} \\ \dot{V}_{C_2} \\ \dot{i}_{L_6} \end{bmatrix} =$$

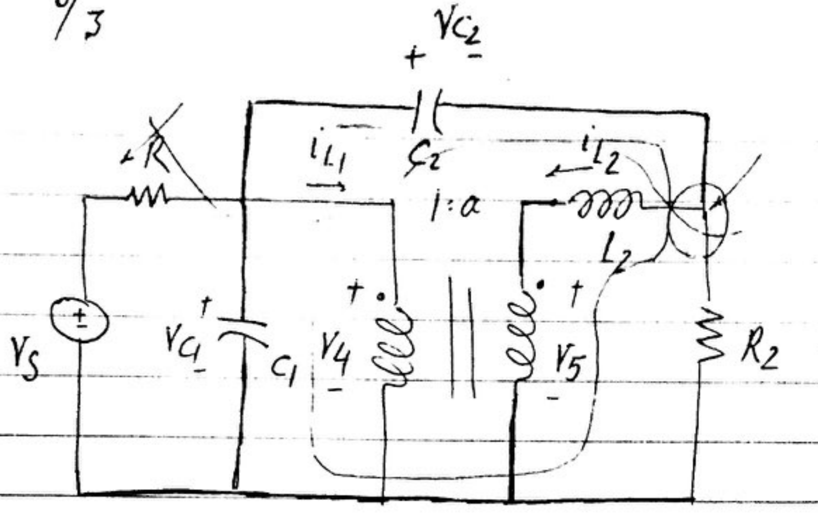
$$= \begin{bmatrix} -(G_3 + G_4) & G_4 & 0 \\ G_4 & -G_4 & -1 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} V_{C_1} \\ V_{C_2} \\ i_{L_6} \end{bmatrix} + \begin{bmatrix} G_3 \\ 0 \\ 0 \end{bmatrix} V_S$$



$$L_2\dot{i}_{L_2} - V_{C_3} + L_1\dot{i}_{L_1} = 0$$

3/3

تئوری مدار ۱۲٫۲۳



$$C_1 \dot{v}_{C_1} + \frac{v_{C_1} - v_S}{R_1} + i_4 + i_{L_2} + \frac{v_{C_1} - v_{C_2}}{R_2} = 0$$

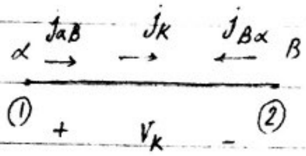
$$i_4 = -a\, i_{L_2}$$

قضیه‌ی تلگان :

b : تعداد شاخه‌ها

x_t : تعداد گره‌ها

شدت جریان‌ها در جهت‌های دلخواه

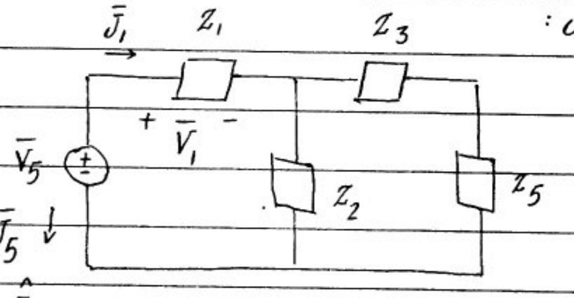


$$v_k j_k = \frac{1}{2}(e_\alpha - e_\beta) j_{\alpha\beta} + \frac{1}{2}(e_\beta - e_\alpha) j_{\beta\alpha}$$

$$\sum_{k=1}^{b} v_k j_k = \frac{1}{2}\sum_{\alpha=1}^{x_t}\sum_{\beta=1}^{x_t}(e_\alpha - e_\beta) j_{\alpha\beta} = \frac{1}{2}\sum_{\alpha=1}^{x_t} e_\alpha \underbrace{\sum_{\beta=1}^{x_t} j_{\alpha\beta}}_{kcl:\alpha} - \frac{1}{2}\sum_{\beta=1}^{x_t} e_\beta \underbrace{\sum_{\alpha=1}^{x_t} j_{\beta\alpha}}_{kcl:\beta} = 0$$

$$\sum_{k=1}^{b} \underbrace{\bar{V}_k}_{Z_k J_k} \bar{J}_k = \sum_{k=1}^{b} Z_k \bar{J}_k \hat{\bar{J}}_k = \sum_{k=1}^{n} \bar{J}_k \overbrace{\hat{\bar{V}}_k}^{Z_k \hat{\bar{J}}_k}$$

مثال :



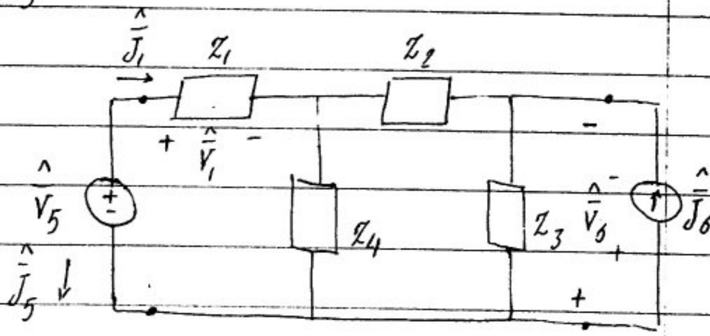
$$\sum_{k=1}^{4} \bar{V}_k \bar{J}_k + \bar{V}_5 \bar{J}_5 = 0 = \sum_{k=1}^{4} \hat{V}_k \hat{J}_k + \hat{V}_5 \hat{J}_5$$

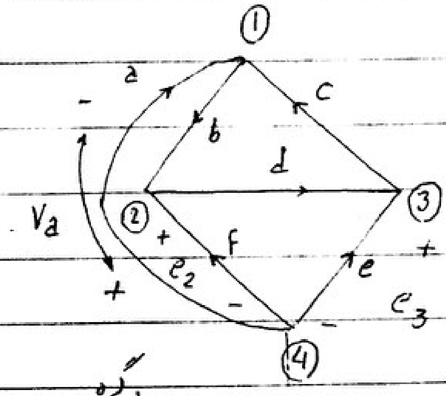
$$\sum_{k=1}^{4} \bar{V}_k \hat{\bar{J}}_k + \hat{\bar{V}}_5 \hat{\bar{J}}_5 = 0 = \sum_{k=1}^{4} Z_k \bar{J}_k \hat{\bar{J}}_k + \bar{V}_5 \hat{\bar{J}}_5$$

$$= \sum_{k=1}^{4} \hat{\bar{V}}_k \bar{J}_k + \bar{V}_5 \hat{\bar{J}}_5$$

$$\sum_{k=1}^{4} \hat{\bar{V}}_k \bar{J}_k + \hat{\bar{V}}_5 \bar{J}_5 = 0$$

$$\hat{\bar{V}}_6 \bar{J}_6 + \hat{\bar{V}}_5 \bar{J}_5 = \bar{V}_5 \hat{\bar{J}}_5 + \bar{V}_6 \hat{\bar{J}}_6$$





گره

شاخه

$a\ j_k$

$$A_c = \begin{array}{c} \\ ① \\ ② \\ ③ \\ ④ \end{array} \begin{array}{c} \begin{array}{cccccc} a & b & c & d & e & f \end{array} \\ \begin{bmatrix} -1 & 1 & -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & -1 & -1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 \end{bmatrix} \end{array} \times$$

این سطر حذف می‌شود.

$$\times \begin{bmatrix} J_a \\ J_b \\ J_c \\ J_d \\ J_e \\ J_e \end{bmatrix} = \begin{array}{c} ① \\ ② \\ ③ \\ ④ \end{array} \overbrace{\begin{bmatrix} -J_a + J_b - J_c \\ -J_b + J_d - J_f \\ J_c - J_d - J_e \\ J_a + J_e + J_f \end{bmatrix}}^{kcl} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

این سطر حذف می‌شود.

$$kcl\,① + kcl\,② + kcl\,③ = -(kcl\,④)$$

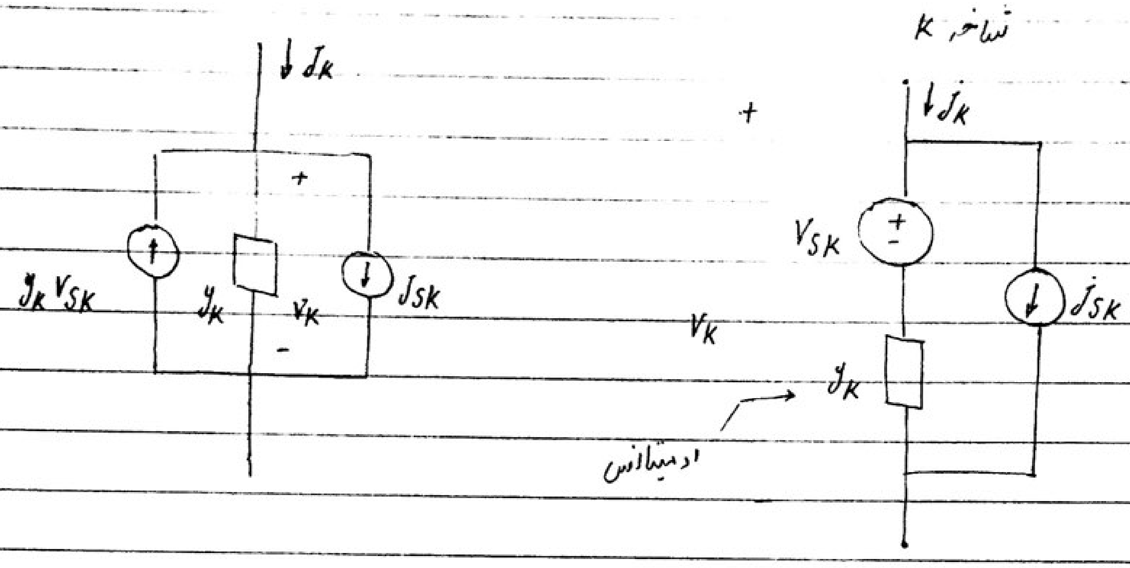
مستقل نیستند.

$$\begin{array}{c} \\ a \\ b \\ c \\ d \\ e \\ f \end{array} \begin{array}{c} \begin{array}{cccc} ① & ② & ③ & ④ \end{array} \\ \begin{bmatrix} -1 & 0 & 0 & 1 \\ 1 & -1 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 1 & -1 & 0 \\ 0 & 0 & -1 & 1 \\ 0 & -1 & 0 & 1 \end{bmatrix} \end{array} \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ \cancel{e_4} \to 0 \end{bmatrix} = \begin{array}{c} a \\ b \\ c \\ d \\ e \\ f \end{array} \begin{bmatrix} -e_1 + \cancel{e_4} \to 0 \\ e_1 - e_2 \\ -e_1 + e_3 \\ e_2 - e_3 \\ -e_3 + \cancel{e_4} \to 0 \\ e_2 + \cancel{e_4} \to 0 \end{bmatrix} = \begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ V_e \\ V_f \end{bmatrix}$$

این ستون حذف می‌شود

$$A_c J = 0$$

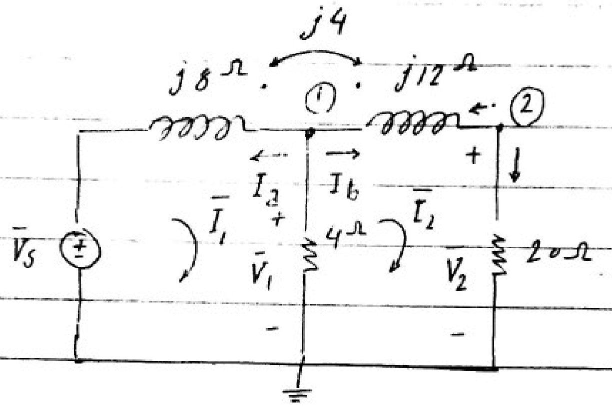
$$A\dot{J} = 0 \qquad A^T E = V$$



$$J_k = y_k V_k + J_{sk} - y_k V_{sk}$$

$$J = \underbrace{Y_b}_{\text{branch}} V + J_s - Y_b V_s$$

ماتریس قطری

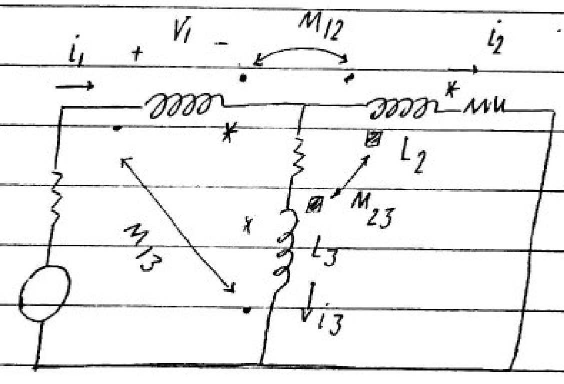


$$j8\bar{I}_1 - j4\bar{I}_2 + 4(\bar{I}_1 - \bar{I}_2) = \bar{V}_S$$

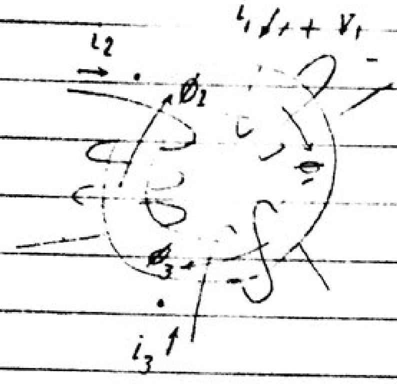
$$j12\,\bar{I}_2 + 20\bar{I}_2 + 4(\bar{I}_2 - \bar{I}_1) - j4\,\bar{I}_1 = 0$$

$$\begin{bmatrix} \bar{V}_1 - \bar{V}_S \\ \bar{V}_1 - \bar{V}_2 \end{bmatrix} = \begin{bmatrix} j8 & j4 \\ j4 & j12 \end{bmatrix} \begin{bmatrix} \bar{I}_a \\ \bar{I}_b \end{bmatrix}$$

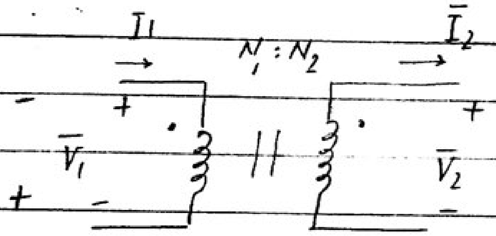
$$\begin{bmatrix} \bar{I}_a \\ \bar{I}_b \end{bmatrix} = \begin{bmatrix} j8 & j4 \\ j4 & j12 \end{bmatrix}^{-1} \begin{bmatrix} \bar{V}_1 - \bar{V}_S \\ \bar{V}_1 - \bar{V}_2 \end{bmatrix}$$



$$V_1 = L_1\dot{i}_1 - L_2\dot{i}_2 - M_{13}\dot{i}_3$$



$$V_1 = L_1 \dot{i}_1 + M_{12}\dot{i}_2 + M_{13}\dot{i}_3$$

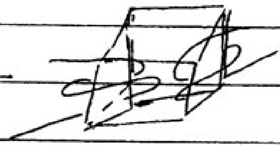


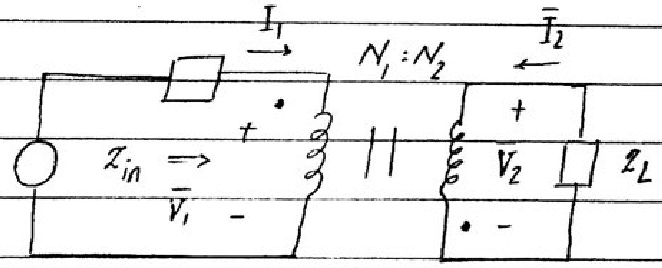
$$\frac{-\bar{V}_1}{\bar{V}_2} = \frac{N_1}{N_2}$$

$$\bar{I}_1 N_1 = -\bar{I}_2 N_2$$

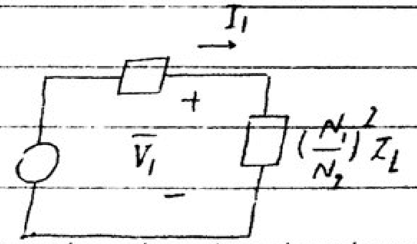
اگر قطب ها عوض شوند یک منفی به فرمول ها اضافه می شود.

مکعبی که دو صفحه ی آن سیم پیچی شده

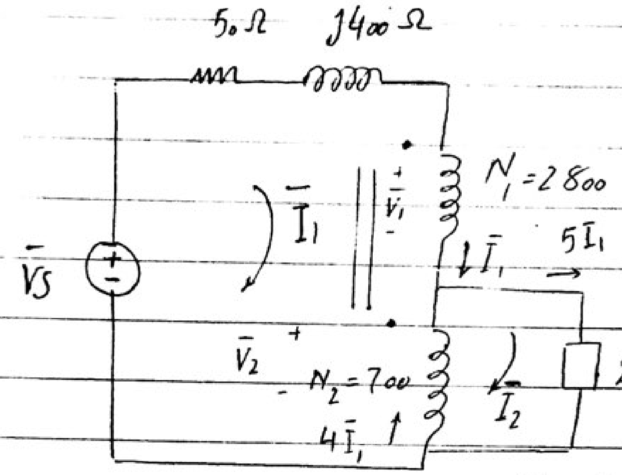




$$\frac{\bar{V}_1}{\bar{I}_1} = \frac{-\frac{N_1}{N_2}\bar{V}_2}{\frac{N_2}{N_1}\bar{I}_2} = \left(\frac{N_1}{N_2}\right)^2\left(\frac{-\bar{V}_2}{\bar{I}_2}\right) = \left(\frac{N_1}{N_2}\right)^2 Z_L$$



تمرین [illegible] ٤،۱۳،



$4\bar{V}_2 = 4 Z_L \bar{I}_2$

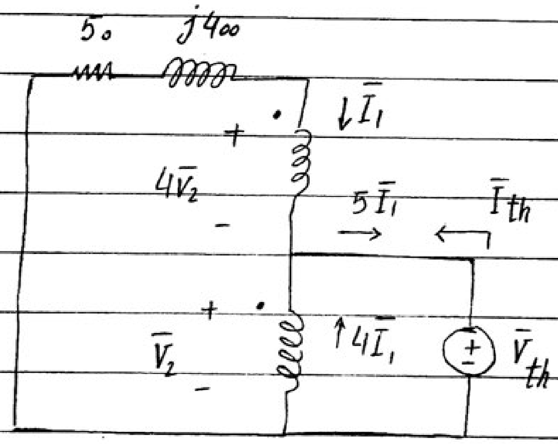
$\bar{V}_S = (50 + j400)\bar{I}_1 + \bar{V}_1 + \bar{V}_2$

$Z_L \bar{I}_2$

$\bar{V}_2 = Z_L \bar{I}_2$

$\bar{I}_2 = 5\bar{I}_1$

$\bar{V}_1 = 4\bar{V}_2$



$5\bar{V}_{th} = -\bar{I}_1'(50 + j400)$

$-\frac{I_{th}}{5}$

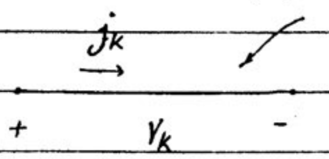
$\bar{V}_{th} = \bar{V}_2$

$$Z_L = Z_{th}^* = \left(\frac{\bar{V}_{th}}{\bar{I}_{th}}\right)^*$$

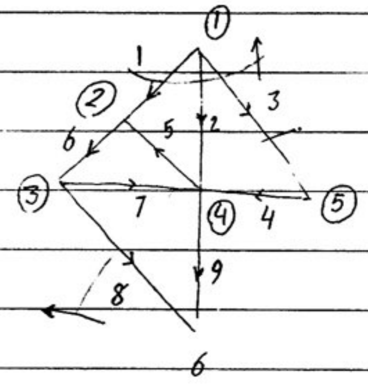
: Graph theory

تئوری گراف :

شاخه‌ی k

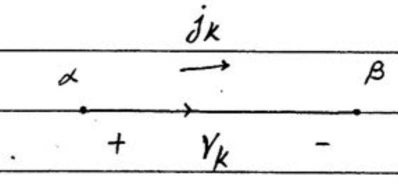


متناظر با هر کات ست می‌توان یک KCL نوشت



$$KCL: \ -j - j_2 - j_3 = 0$$

$$KCL: \ -j_8 - j_7 + j_5 - j_2 - j_3 = 0$$

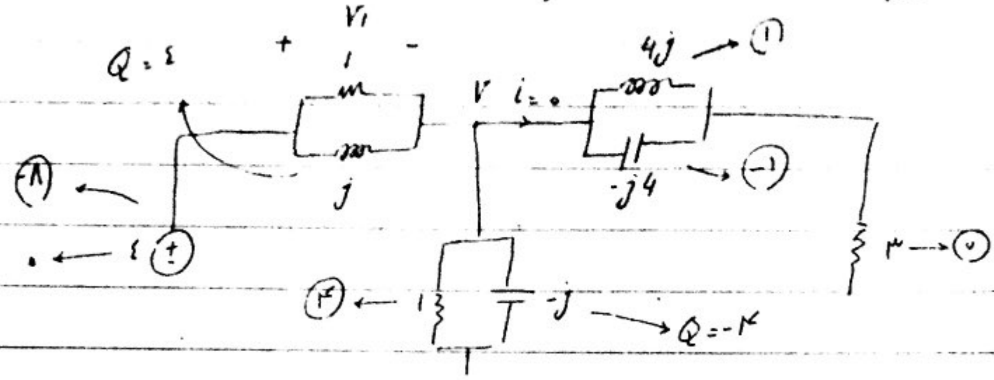


$$v_k j_k = (e_\alpha - e_\beta) j_{\alpha\beta}$$

$$v_k j_k = (e_\beta - e_\alpha) j_{\beta\alpha}$$

$$v_k j_k = \frac{1}{2}(e_\alpha - e_\beta) j_{\alpha\beta} + \frac{1}{2}(e_\beta - e_\alpha) j_{\beta\alpha}$$

1/2 تمرین سری 2 ۹۳,۱۲,٤ TA تئوری مدار



2.

$$V = \frac{\frac{-j}{1-j}}{\frac{-j}{1-j} + \frac{j}{1+j}} \longrightarrow |V| = |V_1| = ۲\sqrt{2} \longrightarrow V_{rms} = ۲$$

$\cancel{V_1 + V_2 = 4}$ $\qquad V_{1\,rms} = ۲$

3.

$$\cancel{V = 2i + \frac{d}{۲}\cos t - 1}$$

$2 \to R_{th}$ $\qquad V_{th}$

$V = \alpha i + \beta$ ($\alpha \to R_{th}$, $\beta \to V_{th}$)

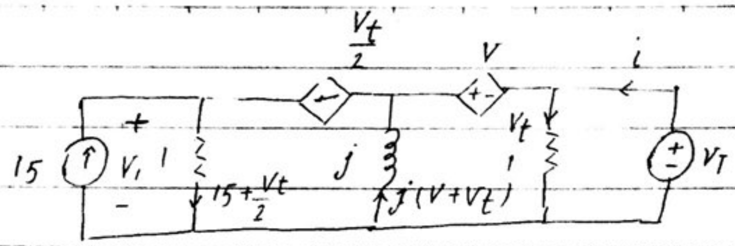
$$\frac{5}{2}\cos t - 1 = \alpha + \beta(2\cos t)$$

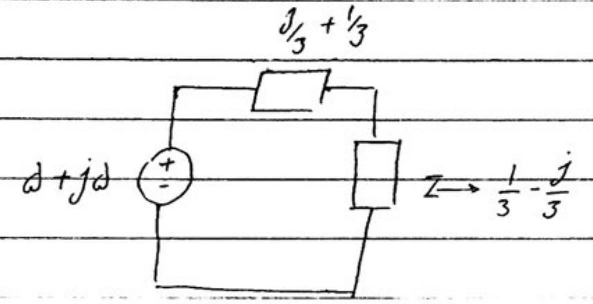
(-1) $\left(\frac{5}{4}\right)$

$$V_{th\ \text{جدید}} = -۳\sin ۳t - 1 - \cos t + \frac{25}{4}\sin 2t + 5\cos t$$

$$V_{th\,rms} = \sqrt{\frac{۹}{۲} + 1 + \frac{۱۶}{۲} + \frac{۶۲۵}{۸}}$$

4.





$Z \to \frac{1}{3} - \frac{j}{3}$

$\left.\begin{array}{l} \frac{V_t}{2} + 1(۵) = V \\ 1 \text{ ,, KCL} \end{array}\right\} \to V_t = (\frac{1}{3}+\frac{j}{3})i + ۵ + ۵j$

$P_M = \frac{5}{4\times\frac{1}{3}}$

.5

$Z_{L_1}: P_1 = 11,\ Q_1 = 0$

$Z_{L_2}: P_2 = 12,\ Q_2 = -9$

$\frac{P_{tot}}{|S_{tot}|} = \frac{23+P_3}{(23+P_3)^2+(P_3-9)^2} = \frac{\sqrt{3}}{10}$

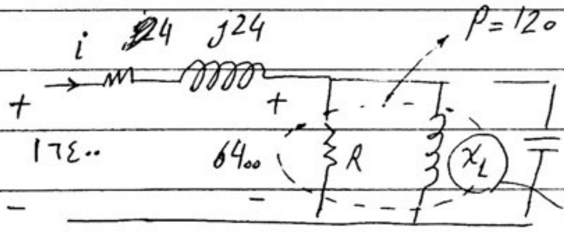
$16\sqrt{10}$

$|P_3| = |Q_3|$ $\to P_3 = 25$

$Q_3 = 25$

$16000 = \frac{400\times 400}{X_{3C}} \to X_C = 10 \to C = \frac{1}{\pi}$

.6

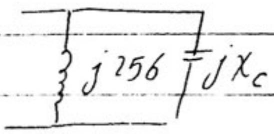


$|۶٤۰۰ + (٤+j24)(a+jb)| = ۶٤۰۰$

$Q = 160 \to X_L = ۲۵۶$

$37b^2 - ۲ab - ۹۶۰۰b + 1600a + a^2 = ۰$ $\quad b = 3.17۲$

$a = ۲۵۸,31$



$X_C = \frac{1}{120\pi} \times \frac{256 + ۱۷۰۶,۷}{۲۵۶ \times ۱۷۰۶,۷} \to C = 11,917\,\mu F$