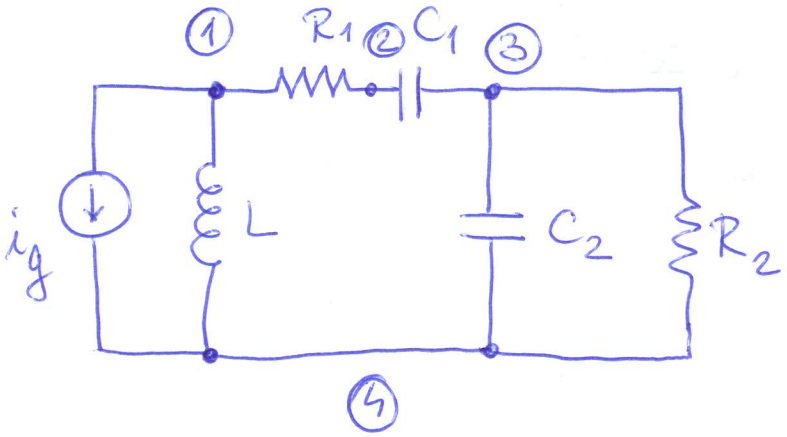
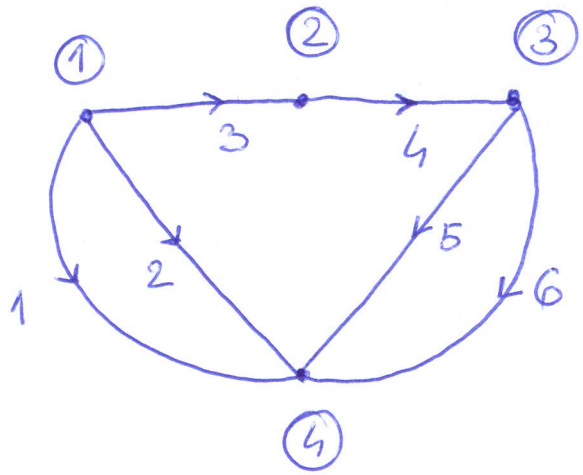
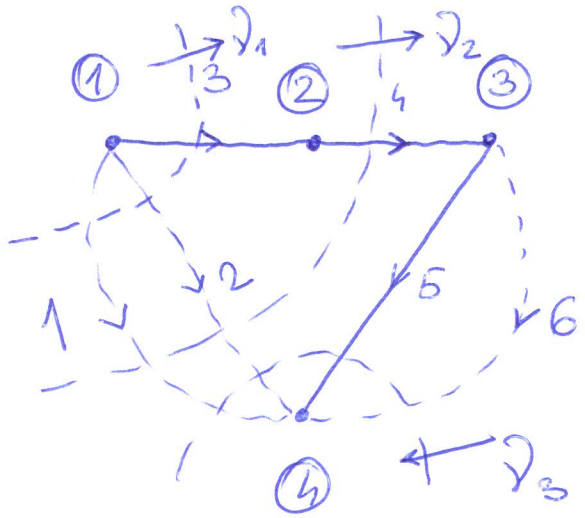
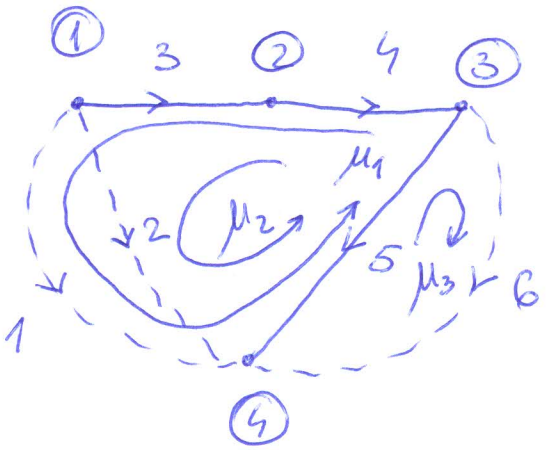


-graf kola



-normalno stablo





promjenljive stanja: u_4, u_5, i_2

KZS za glavne presjeke

$\mathcal{P}_1: i_1 + i_2 + i_3 = 0$

$\mathcal{P}_2: i_1 + i_2 + i_4 = 0$

$\mathcal{P}_3: i_1 + i_2 + i_5 + i_6 = 0$

KZN za glavne konture

$\mu_1: u_1 - u_5 - u_4 - u_3 = 0$

$\mu_2: u_2 - u_5 - u_4 - u_3 = 0$

$\mu_3: u_6 - u_5 = 0$

karakteristike elemenata

$i_1 = i_g$

$u_2 = L \frac{di_2}{dt}$

$u_3 = R_1 i_3$

$i_4 = C_1 \frac{du_4}{dt}$

$i_5 = C_2 \frac{du_5}{dt}$

$u_6 = R_2 i_6$

Formiranje sistema j. s.

$$C_1 \frac{du_4}{dt} = -i_1 - i_2$$

$$C_2 \frac{du_5}{dt} = -i_1 - i_2 - i_6$$

$$L \frac{di_2}{dt} = u_4 + u_5 + u_3$$

$$i_6 \overset{(R_2)}{=} \frac{1}{R_2} u_6 \overset{(u_3)}{=} \frac{1}{R_2} u_5$$

$$u_3 = R_1 i_3 \overset{(2.)}{=} -R_1 i_2 - R_1 i_1 = -R_1 i_2 - R_1 i_g$$

$$C_1 \frac{du_4}{dt} = -i_2 - i_g$$

$$C_2 \frac{du_5}{dt} = -i_2 - \frac{1}{R_2} u_5 - i_g$$

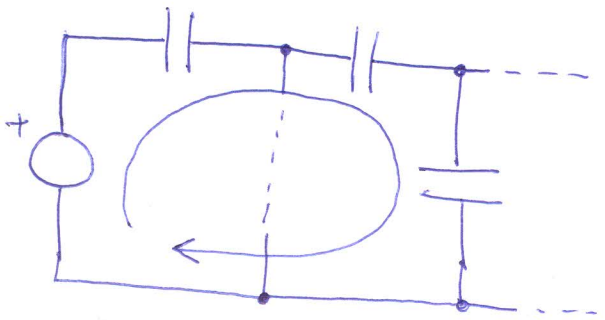
$$L \frac{di_2}{dt} = u_4 + u_5 - R_1 i_2 - R_1 i_g$$

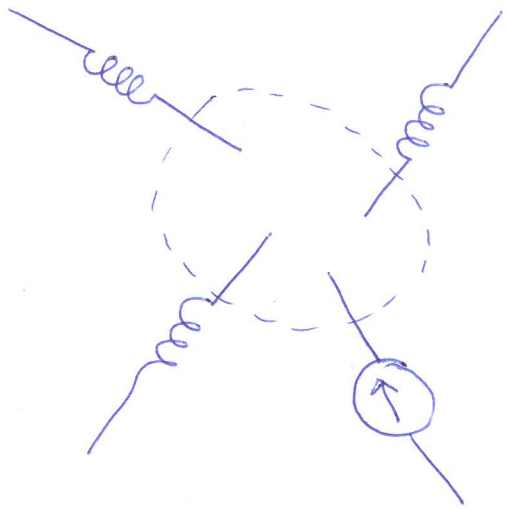
$$\frac{du_4}{dt} = 0 \cdot u_4 + 0 \cdot u_5 - \frac{1}{C_1} i_2 - \frac{1}{C_1} i_g$$

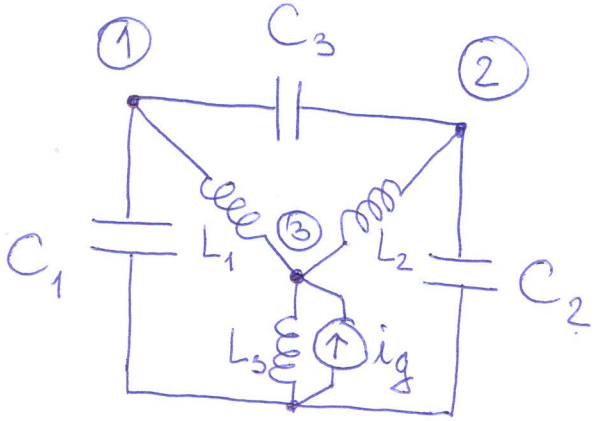
$$\frac{du_5}{dt} = 0 \cdot u_4 - \frac{1}{R_2 C_2} u_5 - \frac{1}{C_2} i_2 - \frac{1}{C_2} i_g$$

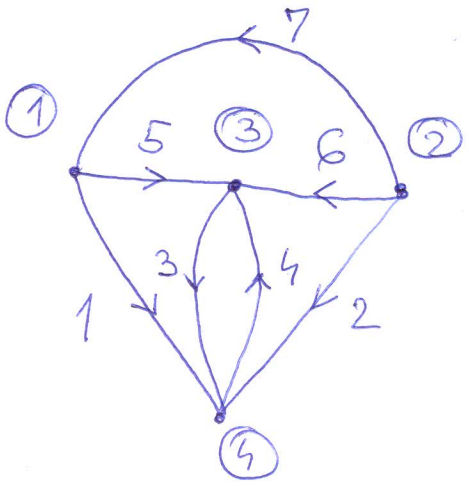
$$\frac{di_2}{dt} = \frac{1}{L} u_4 + \frac{1}{L} u_5 - \frac{R_1}{L} i_2 - \frac{R_1}{L} i_g$$

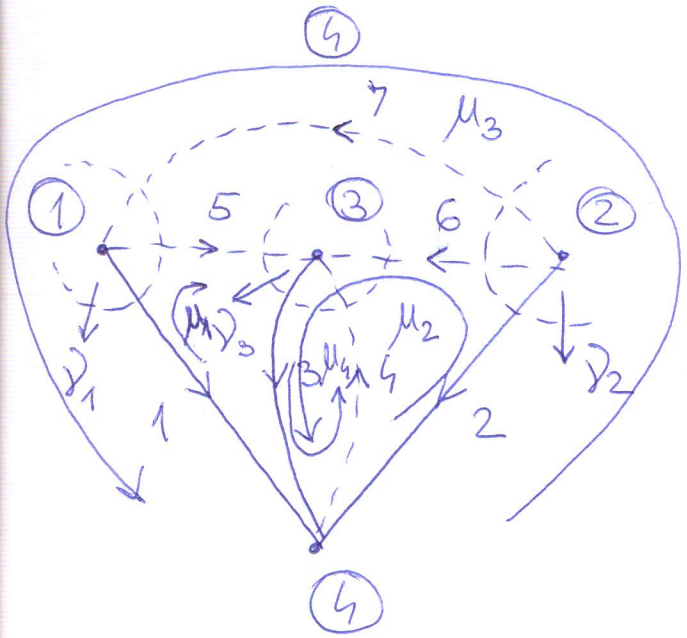
$$\frac{d}{dt}\begin{bmatrix} u_4 \\ u_5 \\ i_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 & -\frac{1}{C_1} \\ 0 & -\frac{1}{R_2 C_2} & -\frac{1}{C_2} \\ \frac{1}{L} & \frac{1}{L} & -\frac{R_1}{L} \end{bmatrix} \begin{bmatrix} u_4 \\ u_5 \\ i_2 \end{bmatrix} + \begin{bmatrix} -\frac{1}{C_1} \\ -\frac{1}{C_2} \\ -\frac{R_1}{L} \end{bmatrix} i_g$$











promjenljive stanja:

$u_{C_1}, u_{C_2}, i_{L_1}, i_{L_2}$

KZS za glavne presjeke

ν_1: $i_{C_1} + i_{L_1} - i_{C_3} = 0$

ν_2: $i_{C_2} + i_{L_2} + i_{C_3} = 0$

ν_3: $i_{L_3} - i_{L_1} - i_{L_2} - i_g = 0$

KZN za glavne konture

$$\mu_1: u_{L_1} + u_{L_3} - u_{C_1} = 0$$

$$\mu_2: u_{L_2} + u_{L_3} - u_{C_2} = 0$$

$$\mu_3: u_{C_3} + u_{C_1} - u_{C_2} = 0$$

$$\mu_4: u_4 + u_{L_3} = 0$$

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karakteristike elemenata

$$i_{C_1} = C_1 \frac{du_{C_1}}{dt} \qquad u_{L_1} = L_1 \frac{di_{L_1}}{dt}$$

$$i_{C_2} = C_2 \frac{du_{C_2}}{dt} \qquad u_{L_2} = L_2 \frac{di_{L_2}}{dt}$$

$$i_{C_3} = C_3 \frac{du_{C_3}}{dt} \qquad u_{L_3} = L_3 \frac{di_{L_3}}{dt}$$

$$i_{C_1} = -i_{L_1} + i_{C_3}$$

$$i_{C_2} = -i_{L_2} - i_{C_3}$$

$$u_{L_1} = -u_{L_3} + u_{C_1}$$

$$u_{L_2} = -u_{L_3} + u_{C_2}$$

$$C_1 \frac{du_{C_1}}{dt} = -i_{L_1} + i_{C_3} \qquad L_1 \frac{di_{L_1}}{dt} = u_{C_1} - u_{L_3}$$

$$C_2 \frac{du_{C_2}}{dt} = -i_{L_2} - i_{C_3} \qquad L_2 \frac{di_{L_2}}{dt} = u_{C_2} - u_{L_3}$$

$$u_{C_3} = -u_{C_1} + u_{C_2}$$

$$i_{C_3} = C_3 \frac{du_{C_3}}{dt} = -C_3 \frac{du_{C_1}}{dt} + C_3 \frac{du_{C_2}}{dt}$$

$$C_1 \frac{du_{C_1}}{dt} = -i_{L_1} - C_3 \frac{du_{C_1}}{dt} + C_3 \frac{du_{C_2}}{dt}$$

$$C_2 \frac{du_{C_2}}{dt} = -i_{L_2} + C_3 \frac{du_{C_1}}{dt} - C_3 \frac{du_{C_2}}{dt}$$

$$(C_1 + C_3) \frac{du_{C_1}}{dt} = -i_{L_1} + C_3 \frac{du_{C_2}}{dt}$$

$$(C_2 + C_3) \frac{du_{C_2}}{dt} = -i_{L_2} + C_3 \frac{du_{C_1}}{dt}$$

$$(C_1 + C_3) \frac{du_{C_1}}{dt} = -i_{L_1} - \frac{C_3}{C_2 + C_3} i_{L_2} + \frac{C_3^2}{C_2 + C_3} \frac{du_{C_1}}{dt}$$

$$(C_2 + C_3) \frac{du_{C_2}}{dt} = -i_{L_2} - \frac{C_3}{C_1 + C_3} i_{L_1} + \frac{C_3^2}{C_1 + C_3} \frac{du_{C_2}}{dt}$$

$$\left(C_1 + C_3 - \frac{C_3^2}{C_2 + C_3}\right) \frac{du_{C_1}}{dt} = -i_{L_1} - \frac{C_3}{C_2 + C_3} i_{L_2}$$

$$\left(C_2 + C_3 - \frac{C_3^2}{C_1 + C_3}\right) \frac{du_{C_2}}{dt} = -\frac{C_3}{C_1 + C_3} i_{L_1} - i_{L_2}$$

$$i_{L_3} = i_{L_1} + i_{L_2} + i_g$$

$$u_{L_3} = L_3 \frac{di_{L_3}}{dt} = L_3 \frac{di_{L_1}}{dt} + L_3 \frac{di_{L_2}}{dt} + L_3 \frac{di_g}{dt}$$

$$L_1 \frac{di_{L_1}}{dt} = u_{C_1} - L_3 \frac{di_{L_1}}{dt} - L_3 \frac{di_{L_2}}{dt} - L_3 \frac{di_g}{dt}$$

$$L_2 \frac{di_{L_2}}{dt} = u_{C_2} - L_3 \frac{di_{L_1}}{dt} - L_3 \frac{di_{L_2}}{dt} - L_3 \frac{di_g}{dt}$$

$$(L_1 + L_3) \frac{di_{L_1}}{dt} = u_{C_1} - L_3 \frac{di_{L_2}}{dt} - L_3 \frac{di_g}{dt}$$

$$(L_2 + L_3) \frac{di_{L_2}}{dt} = u_{C_2} - L_3 \frac{di_{L_1}}{dt} - L_3 \frac{di_g}{dt}$$

$$(L_1 + L_3) \frac{di_{L_1}}{dt} = u_{C_1} - \frac{L_3}{L_2 + L_3} u_{C_2} + \frac{L_3^2}{L_2 + L_3} \frac{di_{L_1}}{dt} + \frac{L_3^2}{L_2 + L_3} \frac{di_g}{dt} - L_3 \frac{di_g}{dt}$$

$$(L_2 + L_3) \frac{di_{L_2}}{dt} = u_{C_2} - \frac{L_3}{L_1 + L_3} u_{C_1} + \frac{L_3^2}{L_1 + L_3} \frac{di_{L_2}}{dt} + \frac{L_3^2}{L_1 + L_3} \frac{di_g}{dt} - L_3 \frac{di_g}{dt}$$

$$\left(L_1 + L_3 - \frac{L_3^2}{L_2 + L_3}\right) \frac{di_{L_1}}{dt} = u_{C_1} - \frac{L_3}{L_2 + L_3} u_{C_2} + \left(-L_3 + \frac{L_3^2}{L_2 + L_3}\right) \frac{di_g}{dt}$$

$$\left(L_2 + L_3 - \frac{L_3^2}{L_1 + L_3}\right) \frac{di_{L_2}}{dt} = -\frac{L_3}{L_1 + L_3} u_{C_1} + u_{C_2} + \left(-L_3 + \frac{L_3^2}{L_1 + L_3}\right) \frac{di_g}{dt}$$

$$\left(C_1+C_3-\frac{C_3^2}{C_2+C_3}\right)\frac{du_{C_1}}{dt}=-i_{L_1}-\frac{C_3}{C_2+C_3}i_{L_2}$$

$$\left(C_2+C_3-\frac{C_3^2}{C_1+C_3}\right)\frac{du_{C_2}}{dt}=-\frac{C_3}{C_1+C_3}i_{L_1}-i_{L_2}$$

$$\left(L_1+L_3-\frac{L_3^2}{L_2+L_3}\right)\frac{di_{L_1}}{dt}=u_{C_1}-\frac{L_3}{L_2+L_3}u_{C_2}+\left(\frac{L_3^2}{L_2+L_3}-L_3\right)\frac{di_g}{dt}$$

$$\left(L_2+L_3-\frac{L_3^2}{L_1+L_3}\right)\frac{di_{L_2}}{dt}=-\frac{L_3}{L_1+L_3}u_{C_1}+u_{C_2}+\left(\frac{L_3^2}{L_1+L_3}-L_3\right)\frac{di_g}{dt}$$

$$L_1=L_2=L_3=1H$$

$$C_1=C_2=C_3=1F$$

$$u_{C_1}=x_1,\ u_{C_2}=x_2,\ i_{L_1}=x_3,\ i_{L_2}=x_4$$

$$\frac{dx_1}{dt}=0\cdot x_1+0\cdot x_2-\frac{2}{3}x_3-\frac{1}{3}x_4$$

$$\frac{dx_2}{dt}=0\cdot x_1+0\cdot x_2-\frac{1}{3}x_3-\frac{2}{3}x_4$$

$$\frac{dx_3}{dt}=\frac{2}{3}x_1-\frac{1}{3}x_2+0\cdot x_3+0\cdot x_4-\frac{1}{3}\frac{di_g}{dt}$$

$$\frac{dx_4}{dt}=-\frac{1}{3}x_1+\frac{2}{3}x_2+0\cdot x_3+0\cdot x_4-\frac{1}{3}\frac{di_g}{dt}$$