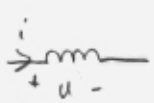
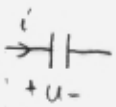
EL. KRUGOVI - MASONE



$u = L\frac{di}{dt}$

(derivacija ide u množenje sa s)

$U(s) = L \cdot s \cdot I_s$

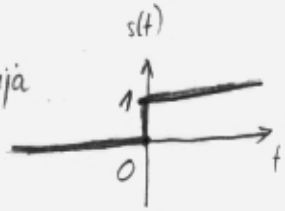


$u = \frac{1}{C}\int i\,dt$

integral ide u dijeljenje sa s

$U = \frac{1}{s \cdot C} I(s)$

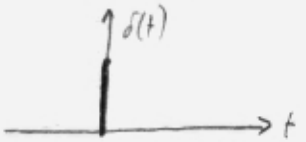
$s(t)$ → step funkcija

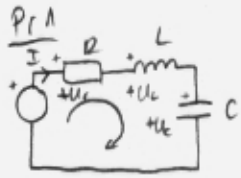


$s(t) \circ\!\!-\!\!\bullet \frac{1}{s}$

$\delta(t)$

$\delta(t) \circ\!\!-\!\!\bullet 1$





$U_0 - U_R - U_L - U_C = 0$

$U_0 - iR - L\frac{di}{dt} - \frac{1}{C}\int i\,dt = 0$

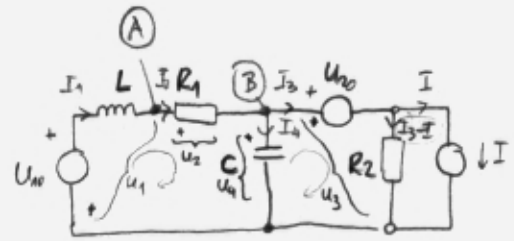
$= U_0(s) - IR - sL \cdot I - \frac{1}{sC} \cdot I = 0$

$I = \frac{U_0(s)}{R + sL + \frac{1}{sC}} = s(t) = \frac{1}{sR + s^2L + \frac{1}{C}}$

$\frac{A}{s+b} \circ\!\!-\!\!\bullet A \cdot e^{-bt} s(t)$

$\frac{A(s+b)}{(s+b)^2 + \omega^2} \circ\!\!-\!\!\bullet A \cdot e^{-bt} \cos(\omega t) \cdot s(t)$

$\frac{A\omega}{(s+b)^2 + \omega^2} \circ\!\!-\!\!\bullet A \cdot e^{-bt} \sin(\omega t) \cdot s(t)$



2 petlje

Svaki element - 1 grana

• - 3 čvora

+ → struja ulazi

II KZN $\begin{cases} -U_1 - U_2 - U_4 = 0 \\ U_4 - U_3 = 0 \end{cases}$

I KZS → (Broj čvorova - 1) = 2

$\begin{cases} I_1 = I_2 \ (A) \\ I_2 = I_3 + I_4 \ (B) \end{cases}$

$U_1 = -U_{10} +$ (gledamo pluseve

$U_2 = I_2 R_1$

$U_4 = I_4 \frac{1}{sC}$

$U_3 = U_{20} + (I_3 - I)R_2$

$U_{10} - I_1 sL + U_1 = 0$

$U_1 = I_1 sL - U_{10}$

NORMIRANJE NA:

R_0 i ω_0

$R_0 = 1\,k\Omega$

$\omega_0 = 10^3\,rad^{-1}$

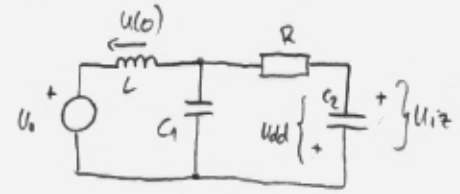
Normirati:

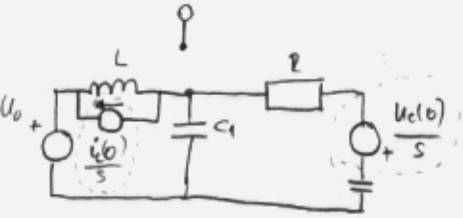
$R_1 = 2\,k\Omega \rightarrow R = \frac{R_1}{R_0} = 2$

$L = 0{,}1\,mH \rightarrow L = \frac{\omega_0 L}{R_0} = 0{,}1$

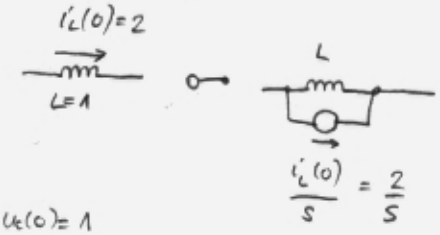
$C = 10\,\mu F \rightarrow \frac{1}{\omega_0 C R_0} = 0{,}1$

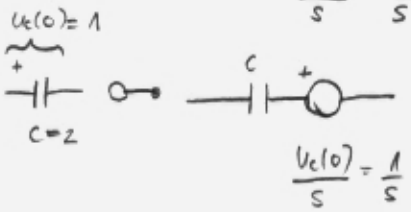
Zad 1



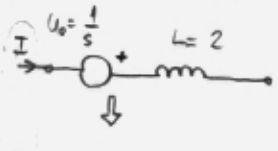


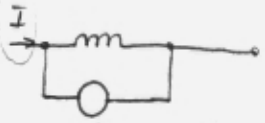
Početni uvjeti



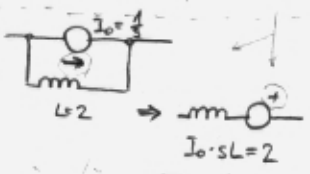


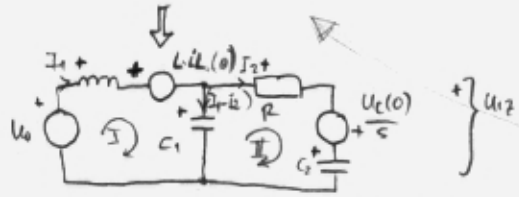
Transformacija izvora





$I = \frac{U_0}{sL} = \frac{1}{2s^2}$ → strelica u desno jer je + na naponskom izvoru bio desno



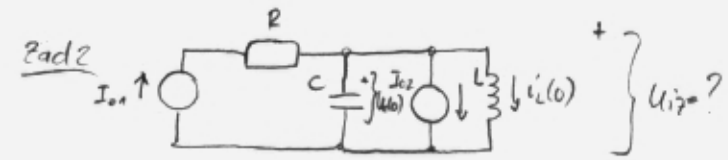


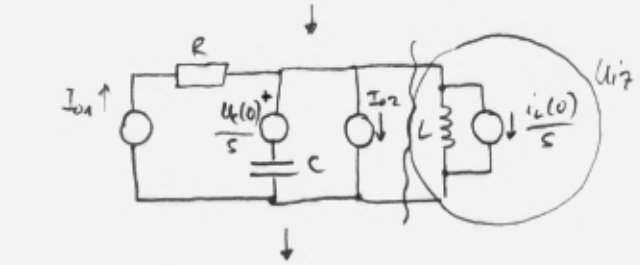
(I) $U_0 - I_1 sL - L\cdot i_L(0) - (I_1 - I_2)\frac{1}{sC_1} = 0$

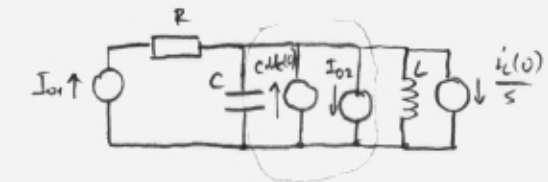
(II) $(I_1 - I_2)\frac{1}{sC_1} - I_2 R + \frac{U_c(0)}{s} - I_2\frac{1}{sC_2} = 0$

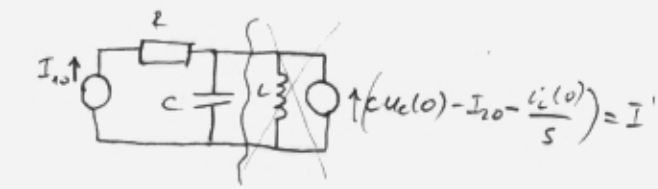
$U_{i7} = I_2\cdot\frac{1}{sC} - \frac{U_c(0)}{s}$

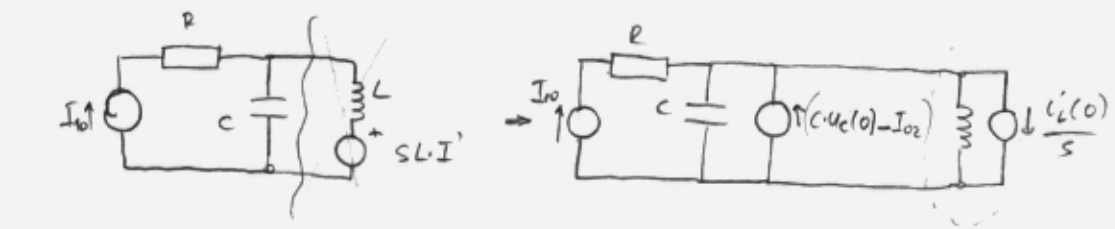
Zad 2

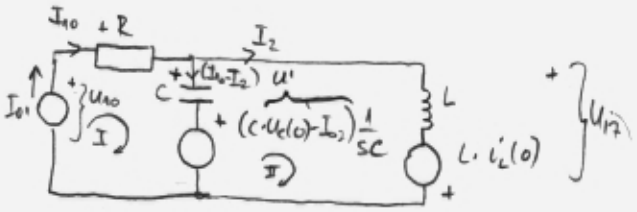










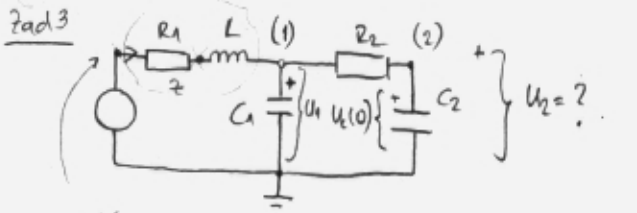


(I) $U_{10} - I_{10}R - (I_1 - I_2)\frac{1}{sC} - U' = 0$ ×

(II) $U' + (I_{10} - I_2)\frac{1}{sC} - I_2 sL + L \cdot i_L(0) = 0$ ←

METODA ČVOROVA

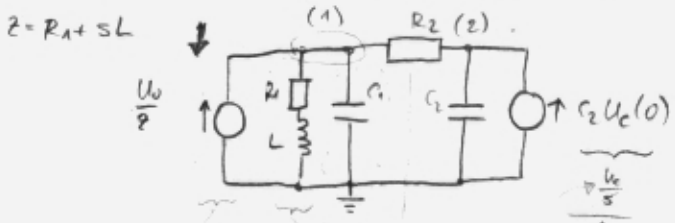
Zad 3



Preporuka: sve izvore pretvoriti u strujne

ovaj čvor je korisan samo ako tražimo struju iz njega.

$z = R_1 + sL$



(1,2) (2,3) (1,3)

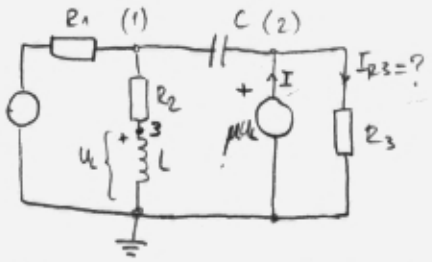
susjedni čvorovi

(1) $U_1\left(\frac{1}{R+sL} + sC_1 + \frac{1}{R_2}\right) - U_2 \frac{1}{R_2} = \frac{U_0}{z}$ (iz grupe prema čvoru 1)

za strujne izvore pišemo samo iznos

(2) $U_2 \cdot \left(\frac{1}{R_2} + sC_2\right) - U_1 \frac{1}{R_2} = C_2 U_c(0)$

Zad 4



$U_2 = U_3$

(1) $U_1\left(\frac{1}{R_1} + \frac{1}{R_2} + sC\right) - U_2 sC - U_3 \frac{1}{R_2} = \frac{U_0}{R_1}$

(2) $U_2\left(sC + \frac{1}{R_3}\right) - U_1 sC = I$

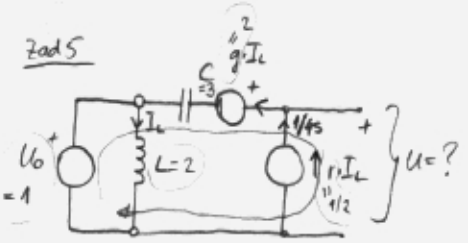
ova nam jednadžba ne treba pošto ne tražimo struju I

$U_2 = U_1 \cdot \frac{sL}{R_2 + sL}$

(3) $U_3\left(\frac{1}{R_2} + \frac{1}{sL}\right) - U_1 \cdot \frac{1}{R_2} = 0$

$I_{R3} = \frac{U_3}{R_3}$

Zad 5



→ čvorovi: → uvodimo nepoznanicu za I_L ...

PETLJE:

$$I_L = \frac{U_0}{sL} = \frac{1}{2s}$$

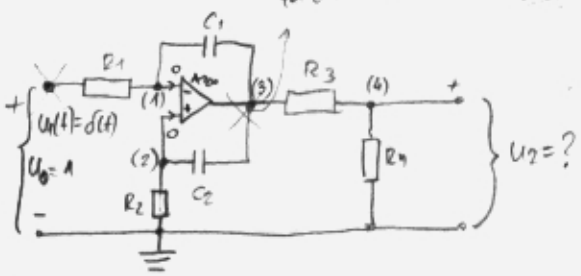
$$\frac{1}{2} \cdot \frac{1}{2s} = \frac{1}{4s}$$

$$1 + \frac{1}{4s} \cdot \frac{1}{3s} + \frac{1}{4s} \cdot \frac{1}{4s} - U = 0$$

$$U = 1 + \frac{1}{4s} \cdot \frac{1}{3s} + \frac{1}{2s} = \frac{12s + 1 + 6}{12s} = \frac{12s+7}{12s}$$

Zad 6

za čvor koji izlazi iz pojačala ne pišemo jednadžbu



+, − na pojačalu nas ne zanima!

(1) $U_1\left(\frac{1}{R_1} + sC_1\right) - U_0\frac{1}{R_1} - U_3 \cdot sC_1 = 0$

(3) ne pišemo jednadžbu

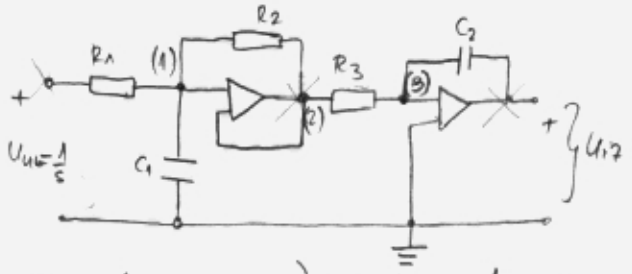
(2) $U_2\left(\frac{1}{R_2} + sC_2\right) - U_3 sC_2 = 0$

(4) $U_{12}\left(\frac{1}{R_3} + \frac{1}{R_4}\right) - U_3\frac{1}{R_3} = 0$

U_{12} napon, $\frac{1}{R_3} + \frac{1}{R_4}$ suma vodljivosti

Jednadžba pojačala: $U_3 = A(U_2 - U_1) \;/: A(=\infty)$

$$\frac{U_3}{\infty} = (U_2 - U_1) \rightarrow \boxed{U_2 = U_1}$$



(1) $U_1\left(\frac{1}{R_1}+sC_1+\frac{1}{R_2}\right)-U_{ul}\frac{1}{R_1}-U_2\frac{1}{R_2}=0$

susjedni čvorovi

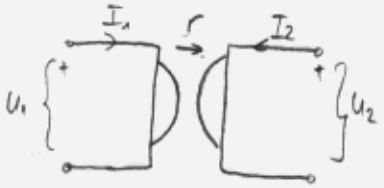
(2) izlaz iz pojačala, ne pišemo!

(3) $U_3\left(\frac{1}{R_3}+sC_2\right)-U_2\frac{1}{R_3}-U_{iz}sC_2=0$

(P1) $U_1=U_2$

(P2) $U_3=0$

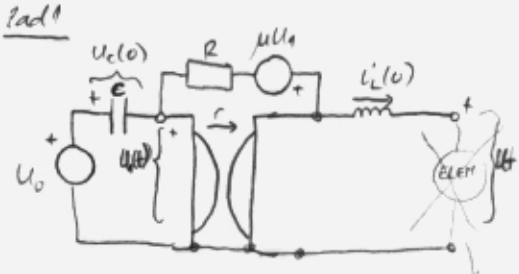
GIRATOR



$U_1=rI_2$

$U_2=-r\cdot I_1$

Zad 1



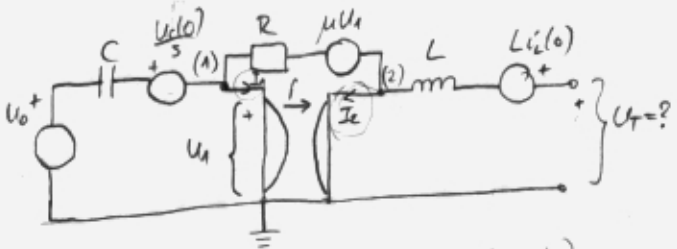
$U_0(t)=s(t)$ $\quad i_L(0)=1$

$C=R=L=1$ $\quad U_c(0)=2$

$\mu=\frac{2}{3}$

$r=2$

micšemo iz mreže element za koji se traži napon i označimo ga U_T



za ono što ne znamo, pišemo struju!

(1) $U_1\left(sC+\frac{1}{R}\right)-U_2\cdot\frac{1}{R}-0=\frac{U_0-(U_c(0)/s)}{\frac{1}{sC}}-\frac{\mu U_1}{R}-I_1$

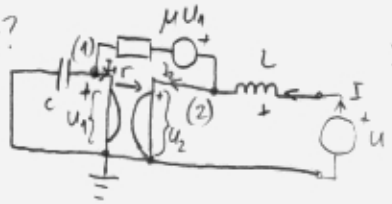
(2) $U_2\left(\frac{1}{R}\right)-U_1\frac{1}{R}=\frac{\mu U_1}{R}-I_2$

Girator $\begin{cases}U_1=r\cdot I_2\\ U_2=-r\cdot I_1\end{cases}$

$U_T=U_2+Li_L(0)$ ✓

$Z_T=?$ - iz mreže izvadimo sve nezavisne izvore. Strujni odspojimo, naponski kratko spojimo.

$Z_T = ?$



$I = \frac{U}{R} \Rightarrow R = \frac{U}{I} \Rightarrow Z_T = \frac{U}{I}$

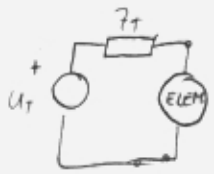
(1) $U_1\left(sC + \frac{1}{R}\right) - U_2 \frac{1}{R} = -\frac{\mu U_1}{R} - I_1$

(2) $U_2\left(\frac{1}{R} + \frac{1}{sL}\right) - U_1 \cdot \frac{1}{R} = \frac{\mu U_1}{R} + \frac{U}{sL} - I_2$

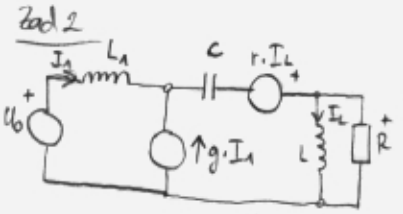
+ jednadžbe idealnog giratora

$I = \frac{U - U_2}{sL}$

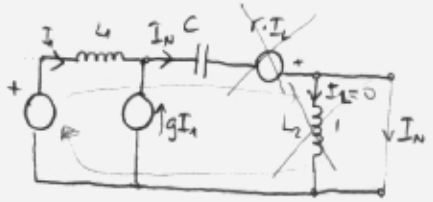
(3) $U\left(\frac{1}{sL}\right) - U_2 \frac{1}{sL} = I$



Zad 2

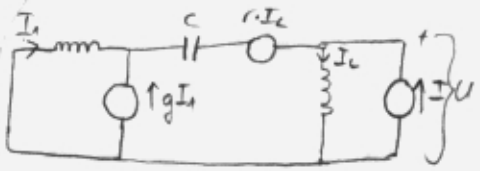


Odspajamo R



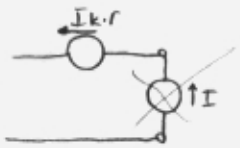
Norton admitancija - $Y_N = \frac{1}{Z_T} = \frac{1}{Z_N}$

$I_N + gI_1 = I_N$ $\quad U_0 - I_1 sL - I_N \frac{1}{sC} = 0$

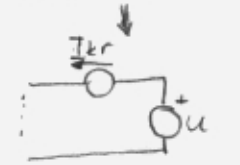


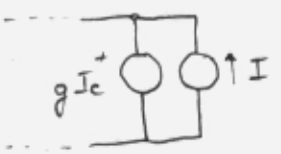
Ako tražimo Y_N → strujni izvor

Ako tražimo Z_T → naponski izvor



Serijski spojeni strujni izvori moraju biti iste unjednosti!





paralelni spoj naponskih izvora mora biti sa izvorima istih unjednosti

$$\begin{cases} I_2 = I_1 + gI_1 \\ I_2 + I = I_L \end{cases} \quad \begin{cases} -I_1 sL - I_2 \frac{1}{sC} + r \cdot I_L - I_L \cdot sL_2 = 0 \\ \rightarrow U = I_L \cdot sL_2 \\ Y_N = ? = \frac{I}{U} \end{cases}$$