FER2.net

Električni krugovi

Zadaci za vježbu za prvi međuispit

- verzija: v2.0.14
- redoslijed zadataka po kojima je rješavano razlikuje se spram onog danom na FERweb stranicama

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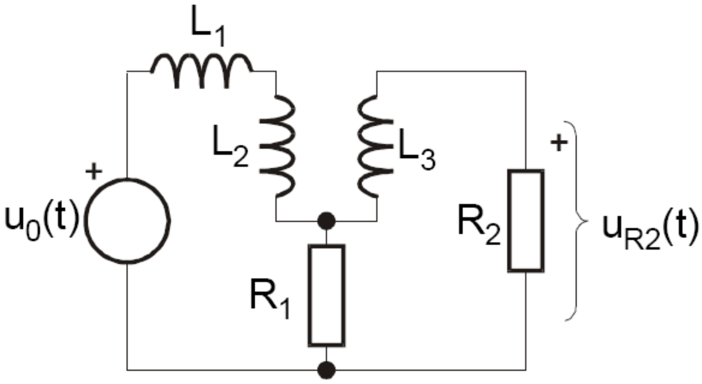
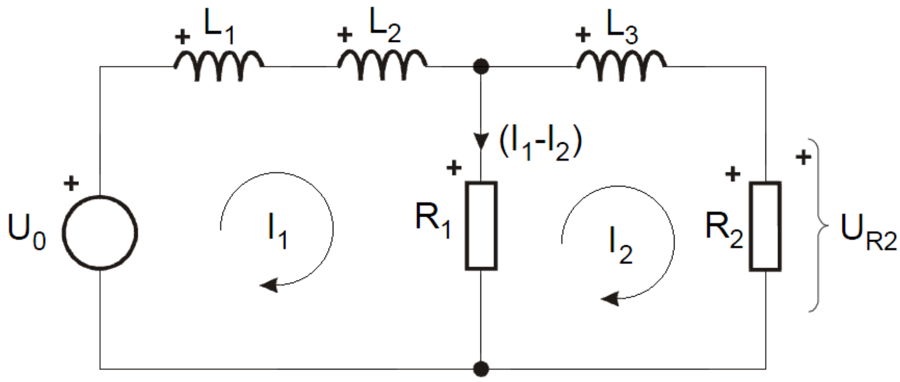
Rujan 2009.

1. Za mrežu prikazanu slikom izračunati napon $u_{R2}(t)$ ako su zadane normalizirane vrijednosti elemenata: $R_1 = 1$, $R_2 = 1$, $L_1 = 1$, $L_2 = 2$, $L_3 = 4$ te napon generatora $u_0(t) = S(t)$.



Rješenje:

Sliku ćemo malo preuredit tako da bolje vidimo što imamo. Označit ćemo si struje, proizvoljno, prema njima označiti mjesto višeg potencijala na elementima (plusom) te smjer obilaska petlje.



(I) $$U_0 - I_1(sL_1 + sL_2) - (I_1 - I_2)R_1 = 0$$

(II) $$(I_1 - I_2)R_1 - I_2(sL_3 + R_2) = 0$$

(I) $$\frac{1}{s} - 3sI_1 - I_1 - I_2 = 0$$

(II) $$I_1 - I_2 - I_2(4s + 1) = 0$$

(II) $$I_1 = I_2(4s + 2)$$

(I) $$\frac{1}{s} - I_1(3s + 1) - I_2 = 0$$

(II) u (I) $$\frac{1}{s} - I_2(4s + 2)(3s + 1) - I_2 = 0$$

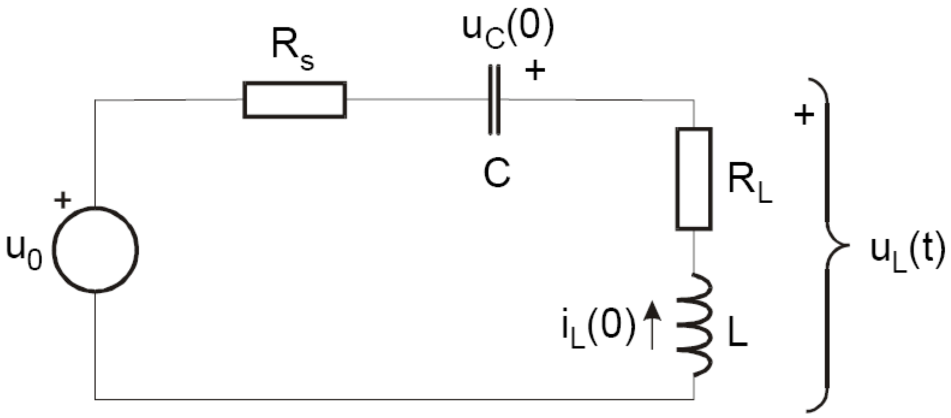
$$I_2[(4s + 2)(3s + 1) + 1] = \frac{1}{s}$$

$$I_2(12s^2 + 10s + 1) = \frac{1}{s}$$

$$I_2 = \frac{1}{s\,(12s^2 + 10s + 1)}$$

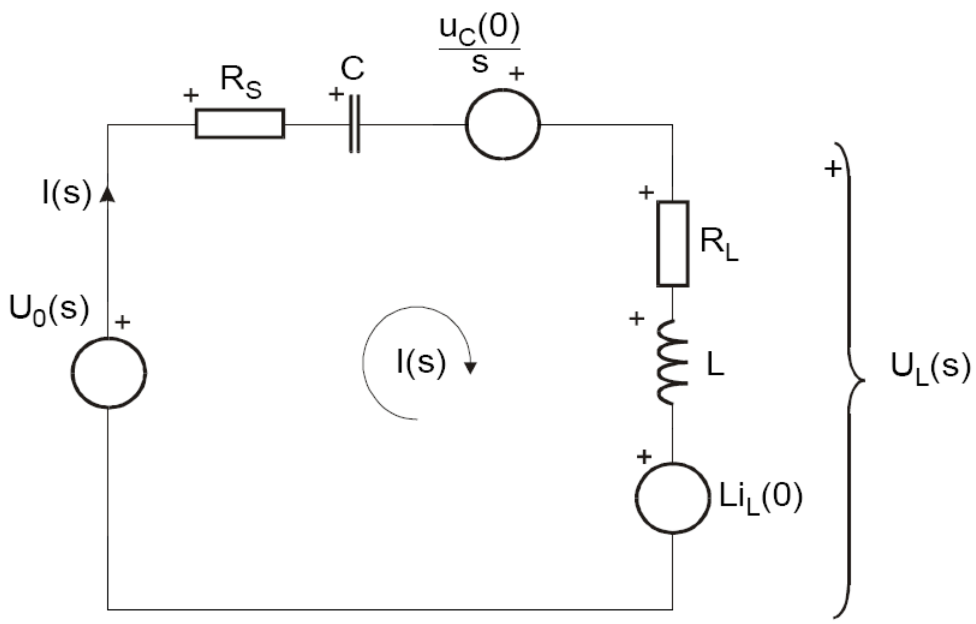
$$\boxed{U_{R2}(s) = I_2 R_2 = \frac{1}{s\,(12s^2 + 10s + 1)}}$$

2. Odrediti odziv $u_L(t)$ mreže prikazanom slikom ako je zadano: $R_s = R_L = 1$, $L = 1$, $C = 1$, $i_L(0) = 1$, $u_C(0) = 1$ i poticaj: $u_0(t) = e^{-t}S(t)$.



Rješenje:

Kao i prošli put, a tako ćemo i svaki put, prema potrebi modificirati sliku. Prebaciti je u Laplaceovo područje (početni uvjeti) te si označiti struje, smjerove obilaska, mjesta višeg potencijala i sve ostalo po potrebi.



Prvo je potrebno prebaciti izvor u Laplaceovu domenu:

$$u_0(t) = e^{-t} \cdot S(t) \xrightarrow{\mathcal{L}} U_0(s) = \frac{1}{s+1}$$

Samo je jedna petlja pa za nju pišemo:

$$U_0 - I\left(R_S + \frac{1}{sC} + R_L + sL\right) + \frac{u_C(0)}{s} - Li_L(0) = 0$$

$$I\left(2 + s + \frac{1}{s}\right) = \frac{1}{s+1} + \frac{1}{s} - 1$$

$$I\left(\frac{s^2 + 2s + 1}{s}\right) = \frac{s + s + 1 - s^2 - s}{s(s+1)}$$

$$I\frac{(s+1)^2}{s} = \frac{-s^2 + s + 1}{s(s+1)}$$

$$I = \frac{-s^2 + s + 1}{(s+1)^3}$$

A napon koji tražimo $U_L(s)$ iznosi:

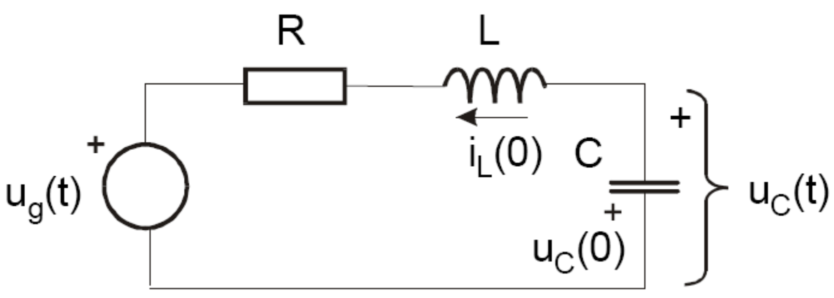
$$U_L = Li_L(0) + I(sL + R_L)$$

$$U_L = 1 + \frac{-s^2 + s + 1}{(s+1)^3}(s+1) = 1 + \frac{-s^2 + s + 1}{(s+1)^2} = 1 + \frac{-s^2 + s + 1}{s^2 + 2s + 1}$$

$$U_L = \frac{3s + 2}{s^2 + 2s + 1} = \frac{3s + 2}{(s+1)^2} = \frac{3s + 3 - 1}{(s+1)^2} = 3\frac{s+1}{(s+1)^2} - \frac{1}{(s+1)^2}$$

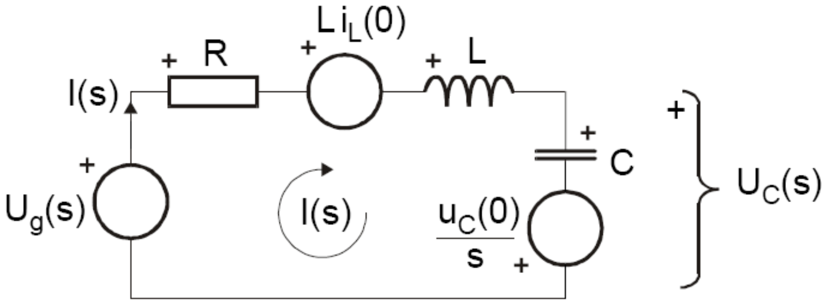
$$U_L = \frac{3}{s+1} - \frac{1}{(s+1)^2} \xrightarrow{\mathcal{L}^{-1}} \boxed{u_L(t) = (3 - t) \cdot e^{-t} \cdot S(t)}$$

3. Za mrežu na slici odrediti napon na kapacitetu $u_C(t)$. Zadano je: $R = 4$, $C = {}^1/_2$, $L = 2$, $i_L(0) = 1.2\ A$, $u_C(0) = 2.6\ V$, $u_g(t) = S(t)$.



Rješenje:

Mreža smo prilagodili i prema njoj pišemo jednadžbu konture:



$$U_g - I\left(R + sL + \frac{1}{sC}\right) - Li_L(0) + \frac{u_C(0)}{s} = 0$$

$$I\left(4 + 2s + \frac{2}{s}\right) = \frac{1}{s} - 2.4 + \frac{2.6}{s}$$

$$I\,\frac{2s^2 + 4s + 2}{s} = \frac{-2.4s + 3.6}{s}$$

$$I = \frac{-1.2s + 1.8}{s^2 + 2s + 1} = \frac{-1.2s + 1.8}{(s+1)^2}$$

A napon koji tražimo $U_C(s)$ iznosi:

$$U_C = -\frac{u_C(0)}{s} + I\,\frac{1}{sC}$$

$$U_C = -\frac{2.6}{s} + \frac{2}{s} \cdot \frac{-1.2s + 1.8}{(s+1)^2} = -\frac{2.6}{s} + \frac{-2.4s + 3.6}{s(s+1)^2}$$

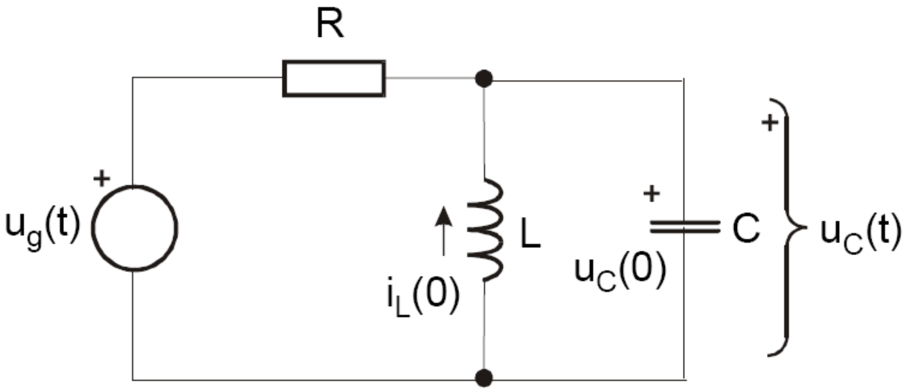
$$\left\{ \begin{array}{c} \dfrac{-2.4s + 3.6}{s(s+1)^2} = \dfrac{A}{s} + \dfrac{Bs + C}{(s+1)^2} = \dfrac{As^2 + 2As + A + Bs^2 + Cs}{s(s+1)^2} \\ A + B = 0 \\ 2A + C = -2.4 \\ A = 3.6 \\ C = -9.6\ ;\ \ B = -3.6 \end{array} \right\}$$

$$U_C = -\frac{2.6}{s} + \frac{3.6}{s} + \frac{-3.6s - 9.6}{(s+1)^2} = \frac{1}{s} + \frac{-3.6s - 3.6 - 6}{(s+1)^2}$$

$$U_C = \frac{1}{s} + \frac{-3.6s - 3.6}{(s+1)^2} + \frac{-6}{(s+1)^2} = \frac{1}{s} - \frac{3.6}{s+1} - \frac{6}{(s+1)^2}$$

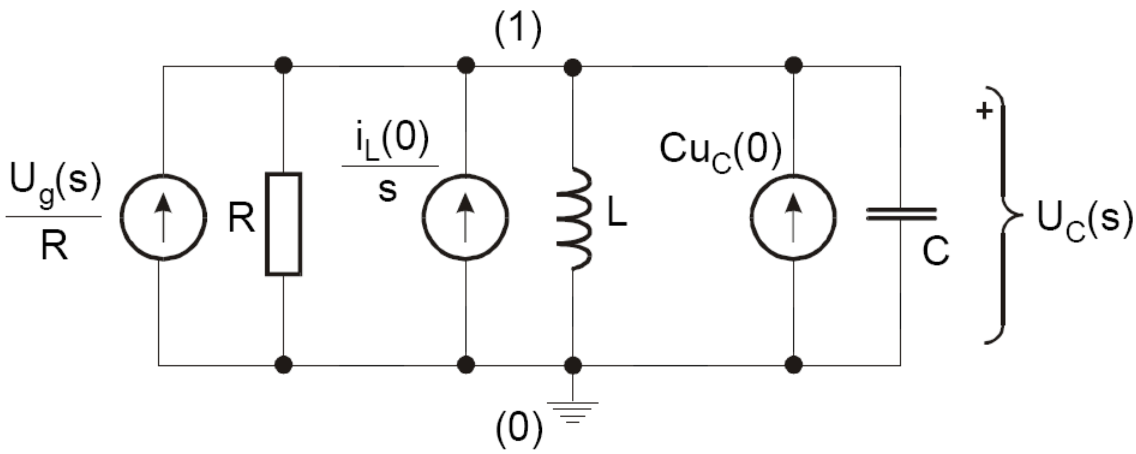
$$U_C(s) \xrightarrow{\mathcal{L}^{-1}} \boxed{u_C(t) = [1 - 3.6e^{-t} - 6te^{-t}]S(t)}$$

4. Odrediti napon $u_C(t)$ u prikazanoj mreži ako je zadano: $R = 2$, $C = 0.5$, $L = 1$, $u_C(0) = 2$, $i_L(0) = 4$, $u_g(t) = 2e^{-t}S(t)$.



Rješenje:

Prepoznajemo samo dva čvora u mreži i dvije konture. Prema tome, lakše je koristiti se metodom napona čvorova pa za nju preoblikujemo mrežu i proizvoljno uzemljimo jedan čvor:



Za početak, napon izvora je:

$$u_g(t) = 2e^{-t} \cdot S(t) \xrightarrow{\mathcal{L}} U_g(s) = \frac{2}{s+1}$$

A za drugi čvor (1) pišemo jednadžbu:

$$U_1\left[\frac{1}{R} + \frac{1}{sL} + sC\right] = \frac{U_g}{R} + \frac{i_L(0)}{s} + Cu_C(0)$$

$$U_1\left[\frac{1}{2} + \frac{1}{s} + \frac{s}{2}\right] = \frac{2}{s+1} + \frac{4}{s} + 1$$

$$U_1\frac{s^2 + s + 2}{2s} = \frac{s^2 + 6s + 4}{s(s+1)}$$

$$U_1 = \frac{2s^2 + 12s + 8}{(s+1)(s^2 + s + 2)} = \frac{A}{s+1} + \frac{Bs + C}{s^2 + s + 2}$$

$$= \frac{As^2 + As + 2A + Bs^2 + Cs + Bs + C}{(s+1)(s^2 + s + 2)}$$

$$\begin{cases} A + B = 2 \\ A + B + C = 12 \\ 2A + C = 8 \\ A = -1 \ ; \ B = 3 \ ; \ C = 10 \end{cases}$$

$$U_1 = -\frac{1}{s+1} + \frac{3s+10}{s^2+s+2} = U_C(s)$$

$$U_C = -\frac{1}{s+1} + \frac{3s+10}{s^2+s+2} = -\frac{1}{s+1} + \frac{3s+10}{\left(s+\frac{1}{2}\right)^2 + \frac{7}{4}}$$

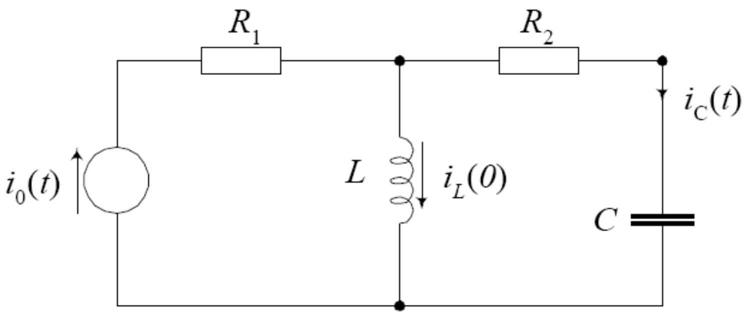
$$U_C = -\frac{1}{s+1} + \frac{3s+\frac{3}{2}+\frac{17}{2}}{\left(s+\frac{1}{2}\right)^2 + \left(\frac{\sqrt{7}}{2}\right)^2}$$

$$U_C = -\frac{1}{s+1} + \frac{3s+\frac{3}{2}}{\left(s+\frac{1}{2}\right)^2 + \left(\frac{\sqrt{7}}{2}\right)^2} + \frac{\frac{17}{2}\cdot\frac{2}{\sqrt{7}}\cdot\frac{\sqrt{7}}{2}}{\left(s+\frac{1}{2}\right)^2 + \left(\frac{\sqrt{7}}{2}\right)^2}$$

$$U_C = -\frac{1}{s+1} + 3\frac{s+\frac{1}{2}}{\left(s+\frac{1}{2}\right)^2 + \left(\frac{\sqrt{7}}{2}\right)^2} + \frac{17}{\sqrt{7}}\frac{\frac{\sqrt{7}}{2}}{\left(s+\frac{1}{2}\right)^2 + \left(\frac{\sqrt{7}}{2}\right)^2}$$

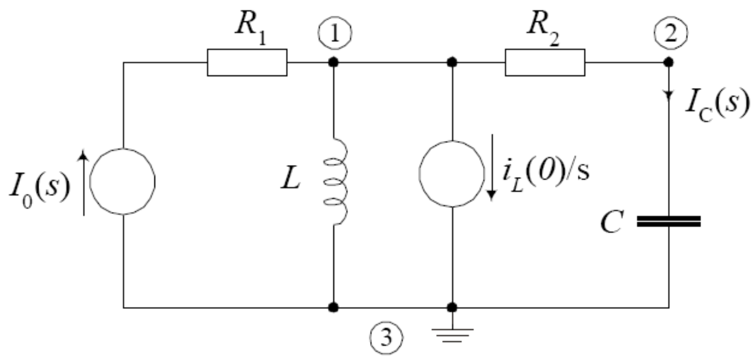
$$U_C(s) \xrightarrow{\mathcal{L}^{-1}} \boxed{u_C(t) = \left[-e^{-t} + 3e^{-\frac{t}{2}}\cos\left(\frac{\sqrt{7}}{2}t\right) + \frac{17}{\sqrt{7}}e^{-\frac{t}{2}}\sin\left(\frac{\sqrt{7}}{2}t\right)\right]\cdot S(t)}$$

5. Za mrežu prikazanu slikom napisati jednadžbe čvorišta. Izračunati struju $i_C(t)$, ako je zadana pobuda $i_0(t) = \delta(t)$, početna struja kroz induktivitet $i_L(0) = 1$ i normirane vrijednosti elemenata $R_1 = 1, R_2 = 1, L = 1$ i $C = 1$.



Rješenje:

Prvo, slika ☺:



Iako nije običaj postavit si ovakvo čvorove i tako ih označit, kao su ih oni već tako označili onda zapišimo:

(1) $$U_1\left(\frac{1}{sL}+\frac{1}{R_2}\right)-U_2\frac{1}{R_2}-U_3\frac{1}{sL}=I_0-\frac{i_L(0)}{s}$$

(2) $$U_2\left(\frac{1}{R_2}+sC\right)-U_1\frac{1}{R_2}-U_3\,sC=0$$

(3) $$U_3\left(\frac{1}{sL}+sC\right)-U_1\frac{1}{sL}-U_2\,sC=\frac{i_L(0)}{s}-I_0$$

Kako samo čvor (3) proizvoljno uzemljili, za njega nije potrebno pisat jednadžbu – pošto nam je njegov napon poznat $U_3=0$, koji možemo uvrstit u preostale dvije jednadžbe. Isto tako, čvor (2) je tu tako postavljen iako ga za rješavanje nije nužno imati, ali kako bi udovoljili autoru ovog zadatka budemo ga ostavili i rješavali s njim.

(1) $$U_1\left(\frac{1}{sL}+\frac{1}{R_2}\right)-U_2\frac{1}{R_2}=I_0-\frac{i_L(0)}{s}$$

(2) $$U_2\left(\frac{1}{R_2}+sC\right)-U_1\frac{1}{R_2}=0$$

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(1) $$U_1\left(\frac{1}{s}+1\right)-U_2=1-\frac{1}{s}$$

(2) $$U_2(1+s)-U_1=0$$

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(2) $$U_1=U_2(1+s)$$

(2) u (1) $$U_2(1+s)\left(\frac{1}{s}+1\right)-U_2=1-\frac{1}{s}$$

$$U_2\left(\frac{1}{s}+1+1+s\right)-U_2=\frac{s-1}{s}$$

$$U_2\left(\frac{1}{s}+1+s\right)=\frac{s-1}{s}$$

$$U_2=\frac{s-1}{s^2+s+1}$$

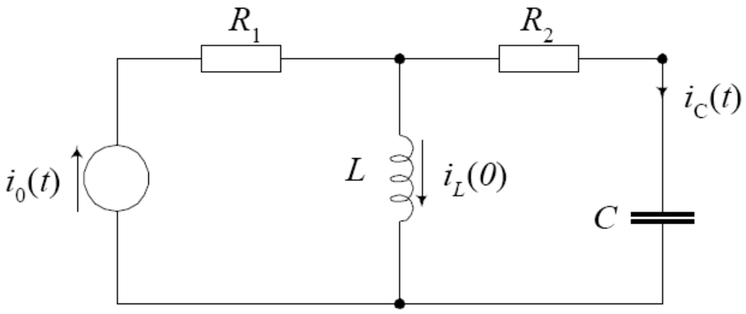
Sada možemo odrediti struju $I_C(s)$:

$$I_C = U_2 \cdot sC = \frac{s^2 - s}{s^2 + s + 1} = \frac{s^2 + s + 1 - 2s - 1}{s^2 + s + 1} = 1 - \frac{2s + 1}{s^2 + s + 1}$$

$$I_C = 1 - \frac{2s + 1}{(s + \frac{1}{2})^2 + \frac{3}{4}} = 1 - \frac{2s + 1}{(s + \frac{1}{2})^2 + \left(\frac{\sqrt{3}}{2}\right)^2} = 1 - 2\frac{s + \frac{1}{2}}{\left(s + \frac{1}{2}\right)^2 + \left(\frac{\sqrt{3}}{2}\right)^2}$$

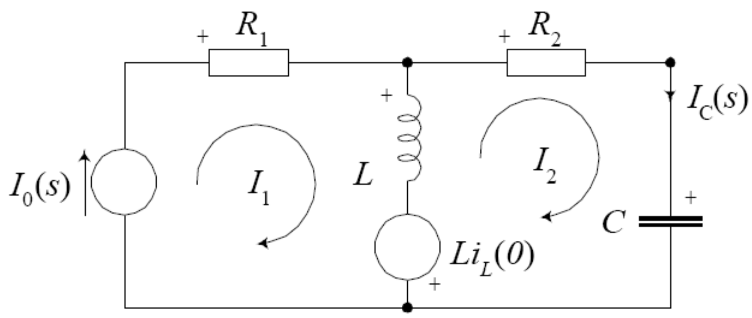
$$I_C(s) \xrightarrow{\mathcal{L}^{-1}} \boxed{i_C(t) = \delta(t) - 2e^{-\frac{t}{2}} \cos\left(\frac{\sqrt{3}}{2} t\right) S(t)}$$

6. Za mrežu prikazanu slikom napisati jednadžbe petlji. Izračunati struju $i_C(t)$, ako je zadana pobuda $i_0(t) = \delta(t)$, početna struja kroz induktivitet $i_L(0) = 1$ i normirane vrijednosti elemenata $R_1 = 1, R_2 = 1, L = 1$ i $C = 1$.



Rješenje:

Iako je zadatak isti kao prijašnji, mrežu ćemo prebacit u Laplaceovo područje tako odgovara zahtjevu (jednadžbama petlji):



Za svaku petlju pišemo jednadžbu:

(1) $$U_1 - I_1 R_1 - (I_1 - I_2)sL + Li_L(0) = 0$$

(2) $$-Li_L(0) + (I_1 - I_2)sL - I_2\left(R_2 + \frac{1}{sC}\right) = 0$$

Pri tome smo dogovorno označili da je napon strujnog izvora U_1 i da je mjesto višeg potencijala u smjeru struje I_0. Također, taj nam strujni izvor određuje struju u toj grani pa prema tome znamo iznos struje $I_1 = I_0 = \mathcal{L}(i_0(t)) = 1$ pa jednadžba (1) više nije potrebna i ostaje za riješit samo jednadžbu (2) za koju vrijedi $I_2 = I_C$.

$$-Li_L(0) + (I_0 - I_C)sL - I_C\left(R_2 + \frac{1}{sC}\right) = 0$$

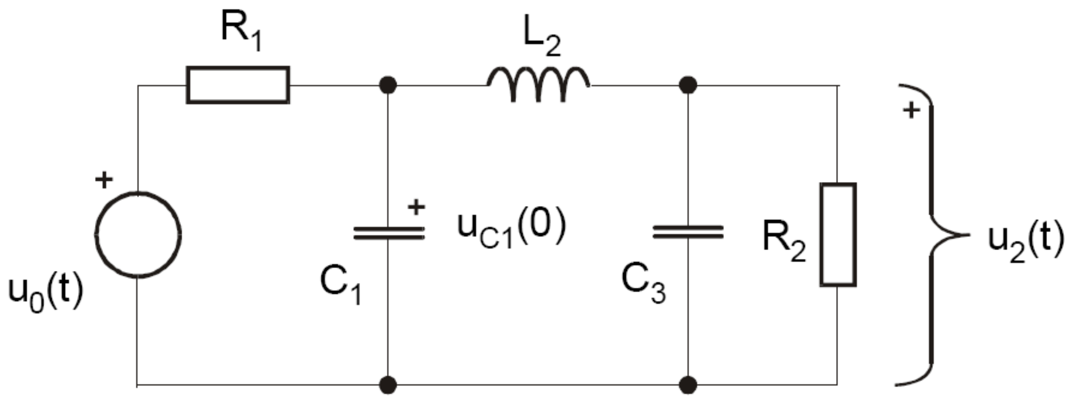
$$-1 + (1 - I_C)s - I_C\left(1 + \frac{1}{s}\right) = 0$$

$$-1 + s - sI_C - I_C - \frac{1}{s}I_C = 0$$

$$I_C\left(s + 1 + \frac{1}{s}\right) = s - 1$$

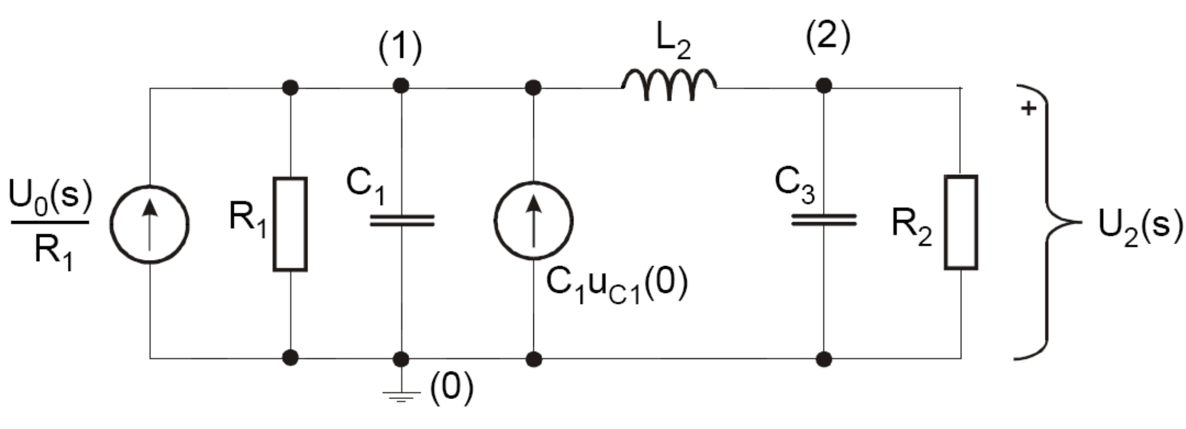
$$I_C = \frac{s^2 - s}{s^2 + s + 1} \xrightarrow{\mathcal{L}^{-1}} \boxed{i_C(t) = \delta(t) - 2e^{-\frac{t}{2}}\cos\left(\frac{\sqrt{3}}{2}t\right)\,S(t)}$$

7. Izračunati odziv napona $u_2(t)$ na otporu R_2 za mrežu prikazanu slikom. Zadano je: pobuda $u_0(t) = \delta(t)$, početni uvjet na kondenzatoru C_1 je $u_{C1}(0) = 1$ i normalizirane vrijednosti elemenata $R_1 = R_2 = 1,\ C_1 = C_3 = 1,\ L_2 = 2$.



Rješenje:

Tri čvora – dvije nepoznanice od kojih je jedna koju tražimo, tri petlje – tri nepoznanice i još dodatni račun za traženu nepoznanicu. Dakle, metoda napona čvorova pa za nju prilagođena Laplaceova transformacija je:



(1) $$U_1\left(\frac{1}{R_1}+sC_1+\frac{1}{sL_2}\right)-U_2\frac{1}{sL_2}=\frac{U_0}{R_1}+C_1u_C(0)$$

(2) $$U_2\left(\frac{1}{sL_2}+sC_3+\frac{1}{R_2}\right)-U_1\frac{1}{sL_2}=0$$

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

(2) $$U_2\left(\frac{1}{2s}+s+1\right)-U_1\frac{1}{2s}=0$$

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(2) $$U_1=U_2(1+2s^2+2s)$$

(2) u (1) $$U_2(2s^2+2s+1)\left(\frac{2s^2+2s+1}{2s}\right)-U_2\frac{1}{2s}=2$$

$$U_2\left(\frac{4s^4+4s^3+2s^2+4s^3+4s^2+2s+2s^2+2s+1}{2s}-\frac{1}{2s}\right)=2$$

$$U_2(4s^3+8s^2+8s+4)=4$$

$$U_2(s^3+s^2+s^2+s+s+1)=1$$

$$U_2\big(s^2(s+1)+s(s+1)+(s+1)\big)=1$$

$$U_2(s+1)(s^2+s+1)=1$$

$$U_2=\frac{1}{(s+1)(s^2+s+1)}=\frac{A}{s+1}+\frac{Bs+C}{s^2+s+1}$$

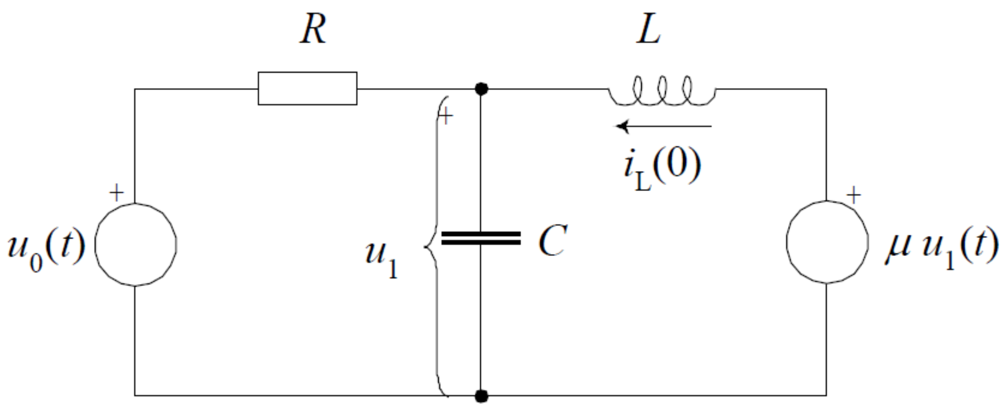
$$\left\{\begin{matrix}\dfrac{As^2+As+A+Bs^2+Cs+Bs+C}{(s+1)(s^2+s+1)}\\ A+B=0\\ A+B+C=0\\ A+C=1\\ A=1\ ;\ B=-1\ ;\ C=0\end{matrix}\right\}$$

$$U_2=\frac{1}{s+1}-\frac{s}{s^2+s+1}=\frac{1}{s+1}-\frac{s+\frac{1}{2}-\frac{1}{2}}{\left(s+\frac{1}{2}\right)^2+\left(\frac{\sqrt{3}}{2}\right)^2}$$

$$U_2=\frac{1}{s+1}-\frac{s+\frac{1}{2}}{\left(s+\frac{1}{2}\right)^2+\left(\frac{\sqrt{3}}{2}\right)^2}+\frac{1}{\sqrt{3}}\frac{\frac{\sqrt{3}}{2}}{\left(s+\frac{1}{2}\right)^2+\left(\frac{\sqrt{3}}{2}\right)^2}$$

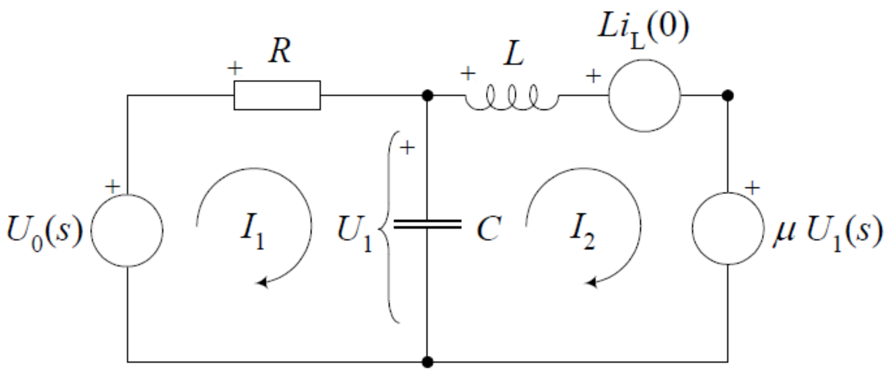
$$U_2(s)\xrightarrow{\mathcal{L}^{-1}}\boxed{u_2(t)=\left[e^{-t}-e^{-\frac{t}{2}}\cos\left(\frac{\sqrt{3}}{2}t\right)+\frac{\sqrt{3}}{3}e^{-\frac{t}{2}}\sin\left(\frac{\sqrt{3}}{2}t\right)\right]S(t)}$$

8. Za mrežu prikazanu slikom napisati jednadžbe petlji. Konačni oblik jednadžbi prikazati u formi matrične jednadžbe. Izračunati napon $U_1(s)$, ako je zadana pobuda $u_0(t) = S(t)$, $\mu = {}^2/_3$, početna struja kroz induktivitet $i_L(0) = 1$ i normirane vrijednosti elemenata: $R = 1, L = {}^1/_2$ i $C = {}^1/_3$.



Rješenje:

Mreža nakon Laplaceove transformacije, prilagođena za jednadžbe petlji:



Za svaku petlju pišemo jednadžbu:

(1) $$U_0 - I_1 R_1 - (I_1 - I_2)\frac{1}{sC} = 0$$

(2) $$(I_1 - I_2)\frac{1}{sC} - Li_L(0) - I_2 sL - \mu U_1 = 0$$

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(1) $$I_1\left(1 - \frac{3}{s}\right) - I_2\frac{3}{s} = \frac{1}{s} \qquad /\cdot s$$

(2) $$I_2\left(\frac{3}{s} + \frac{s}{2}\right) - I_1\frac{3}{s} = -\frac{1}{2} - \frac{2}{3}U_1 \qquad /\cdot 6s$$

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(1) $$I_1(s+3) - 3I_2 = 1$$

(2) $$I_2(3s^2 + 18) - 18I_1 = -3s - 4sU_1$$

A zapišimo i napon na kondenzatoru:

$$U_1 = (I_1 - I_2)\frac{1}{sC} \quad \Rightarrow \quad I_1 = U_1 sC + I_2$$

$$I_1 = U_1 \frac{s}{3} + I_2 \qquad u\ (1)\ i\ (2)$$

(1) $$U_1 \frac{s}{3}(s+3) + I_2(s+3) - 3I_2 = 1$$

(2) $$I_2(3s^2+18) - 18U_1 \frac{s}{3} - 18I_2 = -3s - 4sU_1$$

---

(1) $$U_1 \frac{s}{3}(s+3) + sI_2 = 1 \qquad /\cdot 3$$

(2) $$3s^2 I_2 + 18I_2 - 6sU_1 - 18I_2 = -3s - 4sU_2$$

---

(1) $$U_1(s^2+3s) + 3sI_2 = 3$$

(2) $$3sI_2 = 2U_1 - 3$$

---

(2) u (1) $$U_1(s^2+3s) + 2U_1 - 3 = 3$$

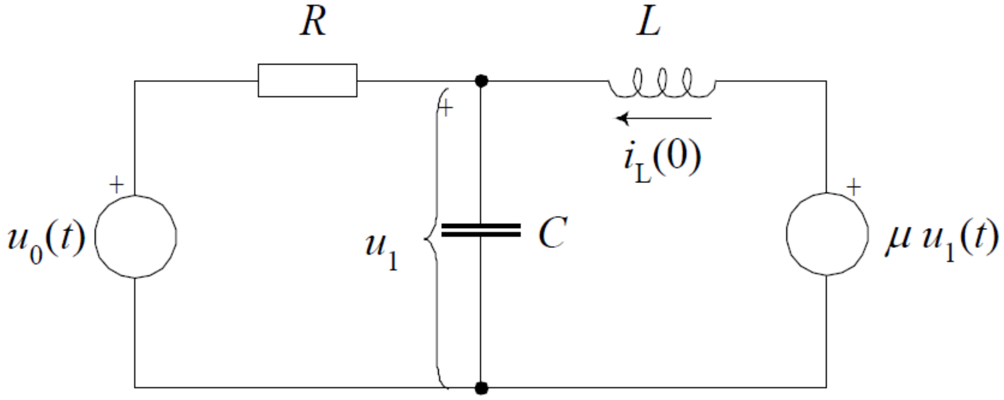
$$U_1 = \frac{6}{s^2+3s+2} = \frac{6}{(s+1)(s+2)}$$

$$\left\{\begin{array}{c} \dfrac{A}{s+1} + \dfrac{B}{s+2} = \dfrac{As+2A+Bs+B}{(s+1)(s+2)} \\ A+B=0 \\ 2A+B=6 \\ A=6 \quad ; \quad B=-6 \end{array}\right\}$$

$$U_1 = \frac{6}{s+1} - \frac{6}{s+2} = 6\left(\frac{1}{s+1} - \frac{1}{s+2}\right)$$

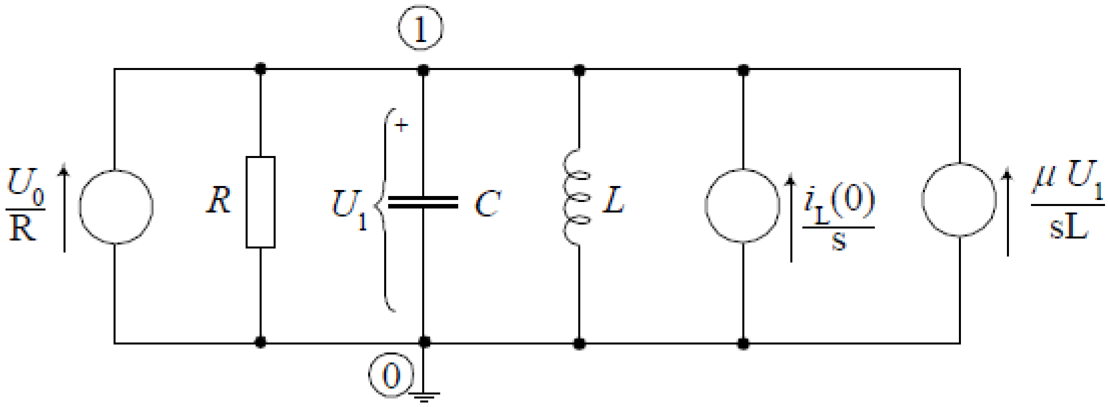
$$U_1(s) \xrightarrow{\mathcal{L}^{-1}} \boxed{u_1(t) = 6(e^{-t} - e^{-2t})S(t)}$$

9. Za mrežu prikazanu slikom napisati jednadžbe petlji. Konačni oblik jednadžbi prikazati u formi matrične jednadžbe. Izračunati napon $U_1(s)$, ako je zadana pobuda $u_0(t) = S(t)$, $\mu = {}^2/_3$, početna struja kroz induktivitet $i_L(0) = 1$ i normirane vrijednosti elemenata: $R = 1, L = {}^1/_2$ i $C = {}^1/_3$.



Rješenje:

Mreža nakon Laplaceove transformacije, prilagođena za jednadžbe petlji:



Samo je jedan čvor (jer smo drugi (0) uzemljili) pa za njega pišemo jednadžbu:

$$U_1\left(\frac{1}{R}+sC+\frac{1}{sL}\right)=\frac{U_0}{R}+\frac{i_L(0)}{s}+\frac{\mu U_1}{sL}$$

$$U_1\left(\frac{1}{R}+sC+\frac{1-\mu}{sL}\right)=\frac{U_0}{R}+\frac{i_L(0)}{s}$$

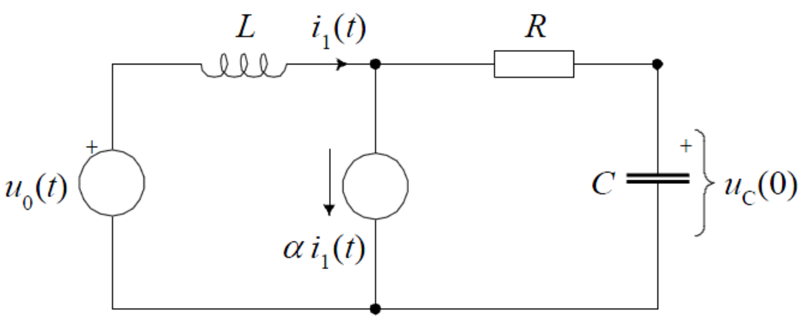
$$U_1\left(1+\frac{s}{3}+\frac{\frac{1}{3}}{\frac{s}{2}}\right)=\frac{1}{s}+\frac{1}{s}$$

$$U_1\left(1+\frac{s}{3}+\frac{2}{3s}\right)=\frac{2}{s}$$

$$U_1=\frac{6}{s^2+3s+2}=6\left(\frac{1}{s+1}-\frac{1}{s+2}\right)$$

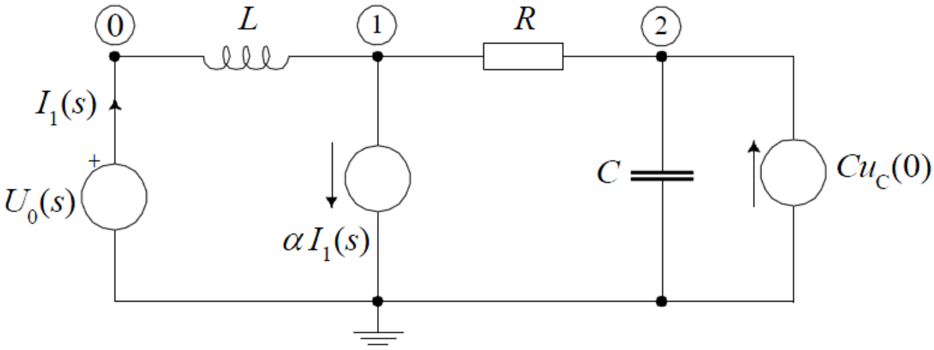
$$U_1(s)\xrightarrow{\mathcal{L}^{-1}}\boxed{u_1(t)=6(e^{-t}-e^{-2t})S(t)}$$

10. Za mrežu prikazanu slikom napisati jednadžbe čvorišta. Konačni oblik jednadžbi prikazati u formi matrične jednadžbe. Izračunati struju $I_1(s)$, ako je zadana pobuda $u_0(t)=S(t)$, $\alpha={}^1/_2$, početni napon na kapacitetu $u_C(0)={}^1/_2$, i normirane vrijednosti elemenata $R=2, L=1$ i $C=1$.



Rješenje:

Nakon Laplaceove transformacije mreže:



Sada imamo 4 čvora, što znači 3 nepoznanice. No kako je čvor (0) na naponu izvora U_0 tada njegov iznos znamo pa je jedna nepoznanica manje, a baš smo iz tog razloga stavili tom čvoru oznaku (0) – da se poklapa sa naponom izvora. No kako smo ga stavili na to mjesto znači da nekako moramo i zapisati struju izvora a to je baš ona struja koju mi tražimo i koja nam je nepoznata I_1.

(0) $$U_0\frac{1}{sL} - U_1\frac{1}{sL} = I_1$$

(1) $$U_1\left(\frac{1}{sL}+\frac{1}{R}\right) - U_0\frac{1}{sL} - U_2\frac{1}{R} = -\alpha I_1$$

(2) $$U_2\left(\frac{1}{R}+sC\right) - U_1\frac{1}{R} = Cu_C(0)$$

---

(0) $$\frac{1}{s^2} - \frac{U_1}{s} = I_1$$

(1) $$U_1\left(\frac{1}{s}+\frac{1}{2}\right) - \frac{1}{s^2} - \frac{U_2}{2} = -\frac{I_1}{2}$$

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

---

(0) $$I_1 = \frac{1}{s^2} - \frac{U_1}{s}$$

(2) $$U_2\left(\frac{2s+1}{2}\right) = \frac{U_1+1}{2} \quad \Rightarrow \quad U_2 = \frac{U_1}{2s+1} + \frac{1}{2s+1}$$

---

(0) i (2) u (1) $$U_1\frac{s+2}{2s} - \frac{1}{s^2} - U_1\frac{1}{2}\cdot\frac{1}{2s+1} - \frac{1}{2}\cdot\frac{1}{2s+1} = U_1\frac{1}{2s} - \frac{1}{2s^2}$$

$$U_1\left(\frac{s+2}{2s} - \frac{1}{2(2s+1)} - \frac{1}{2s}\right) = \frac{1}{s^2} + \frac{1}{2(2s+1)} - \frac{1}{2s^2}$$

$$U_1\frac{2s^2+s+4s+2-s-2s-1}{2s(2s+1)} = \frac{4s+2+s^2-2s-1}{2s^2(2s+1)}$$

$$U_1(2s^2+2s+1) = \frac{s^2+2s+1}{s}$$

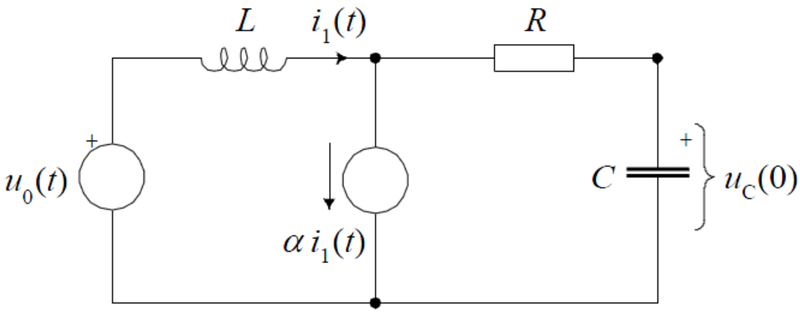
$$U_1 = \frac{s^2+2s+1}{s(2s^2+2s+1)} \qquad u\ (0)$$

$$(0) \qquad I_1 = \frac{1}{s^2} - \frac{s^2+2s+1}{s^2(2s^2+2s+1)} = \frac{2s^2+2s+1-s^2-2s-1}{s^2(2s^2+2s+1)}$$

$$I_1 = \frac{1}{2s^2+2s+1} = \frac{1}{2}\cdot\frac{1}{s^2+s+\frac{1}{2}} = \frac{\frac{1}{2}}{\left(s+\frac{1}{2}\right)^2+\left(\frac{1}{2}\right)^2}$$

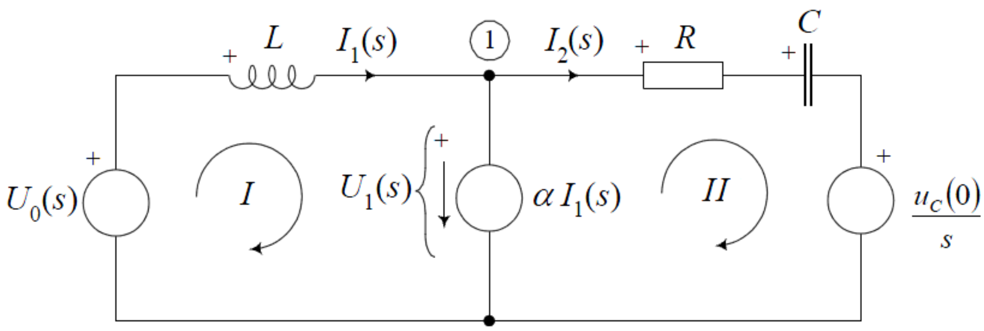
$$I_1(s) \xrightarrow{\mathcal{L}^{-1}} \boxed{i_1(t) = e^{-\frac{t}{2}}\sin\left(\frac{t}{2}\right)\cdot S(t)}$$

11. Za mrežu prikazanu slikom napisati jednadžbe petlji. Izračunati struju $I_1(s)$, ako je zadana pobuda $u_0(t) = S(t)$, $\alpha = {}^1/_2$, početni napon na kapacitetu $u_C(0) = {}^1/_2$, i normirane vrijednosti elemenata $R = 2, L = 1$ i $C = 1$.



Rješenje:

Ovaj put mrežu prilagođujemo za jednadžbe petlji:



$$\text{(I)} \qquad U_0 - I_1 sL - U_1 = 0$$

$$\text{(II)} \qquad U_1 - I_2\left(R+\frac{1}{sC}\right) - \frac{u_C(0)}{s} = 0$$

$$\text{(1)} \qquad I_1 = \alpha \mathrm{I}_1 + \mathrm{I}_2$$

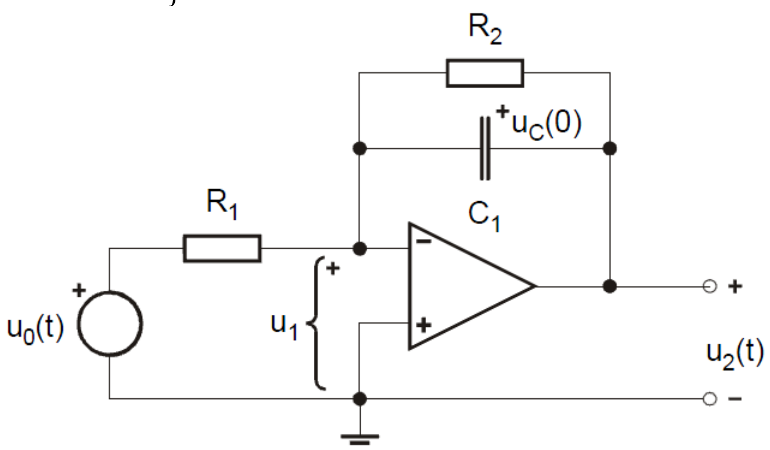
(I) + (II)	$\frac{1}{s} - I_1 s - I_2\left(2 + \frac{1}{s}\right) - \frac{1}{2s} = 0$
(1)	$I_2 = \frac{I_1}{2}$
(1) u (I) + (II)	$I_1 s + \frac{I_1}{2}\left(\frac{2s+1}{s}\right) = \frac{1}{s} - \frac{1}{2s}$

$$I_1\left(s + \frac{2s+1}{2s}\right) = \frac{1}{2s}$$

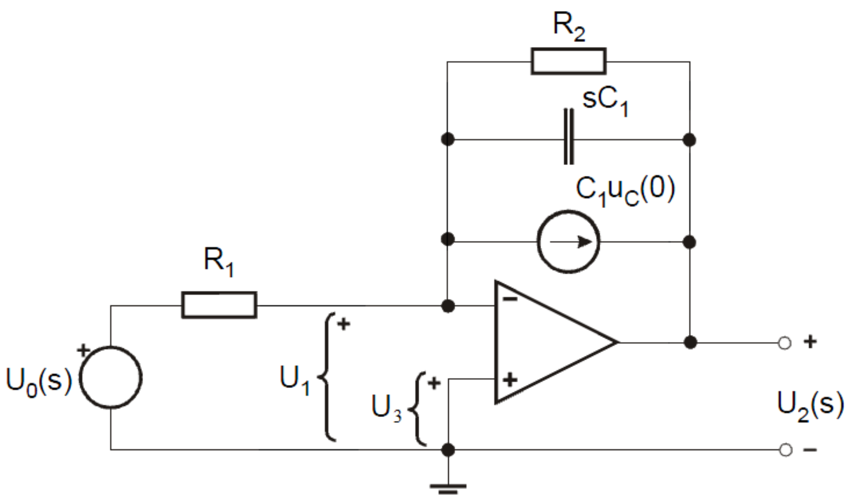
$$I_1 \cdot \frac{2s^2+2s+1}{s} = \frac{1}{2s} \quad \Rightarrow \quad I_1 = \frac{1}{2s^2+2s+1}$$

$$I_1(s) \xrightarrow{\mathcal{L}^{-1}} \boxed{i_1(t) = e^{-\frac{t}{2}} \sin\left(\frac{t}{2}\right) \cdot S(t)}$$

12. Za mrežu na slici odrediti i skicirati odziv napona $u_2(t)$ ako je zadano: $u_0(t) = S(t), R_1 = 1, R_2 = 1, C_1 = 1, u_C(0) = 1$. Odziv izračunati rješavanjem Laplaceove transformacije.



Rješenje:



Zapišimo prvo jednadžbu pojačala:

$$\left.\begin{matrix} U_2 = A(U_3 - U_1) \\ A \to \infty \end{matrix}\right\} U_1 = U_3$$

A kako je napon U_3 uzemljen znači da vrijedi $U_1 = U_3 = 0$

Sad zapišemo jednadžbu za čvor (1), odnosno za napon U_1

$$U_1\left(\frac{1}{R_1} + \frac{1}{R_2} + sC_1\right) - U_2\left(\frac{1}{R_2} + sC_1\right) - U_0\frac{1}{R_1} = -Cu_C(0)$$

$$U_2\left(\frac{1}{R_2} + sC_1\right) = Cu_C(0) - U_0\frac{1}{R_1}$$

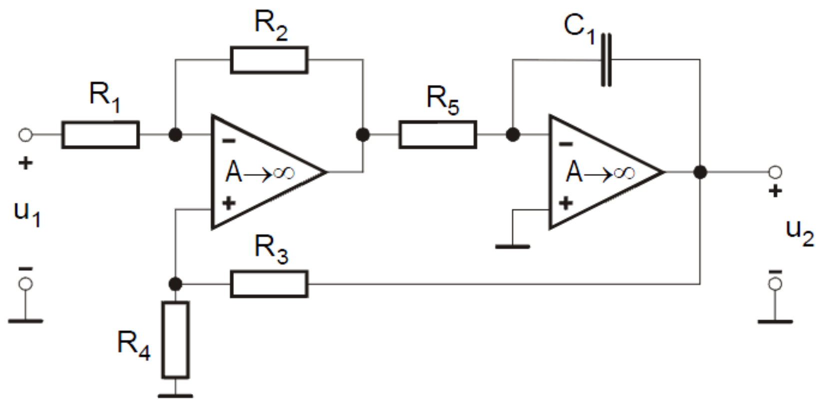
$$U_2(1+s) = 1 - \frac{1}{s} \qquad \Rightarrow \qquad U_2 = \frac{s-1}{s(s+1)}$$

$$\left\{\begin{matrix} \dfrac{s-1}{s(s+1)} = \dfrac{A}{s} + \dfrac{B}{s+1} = \dfrac{As + A + Bs}{s(s+1)} \\ A + B = 1 \\ A = -1 \\ B = 2 \end{matrix}\right\}$$

$$U_2 = \frac{2}{s+1} - \frac{1}{s}$$

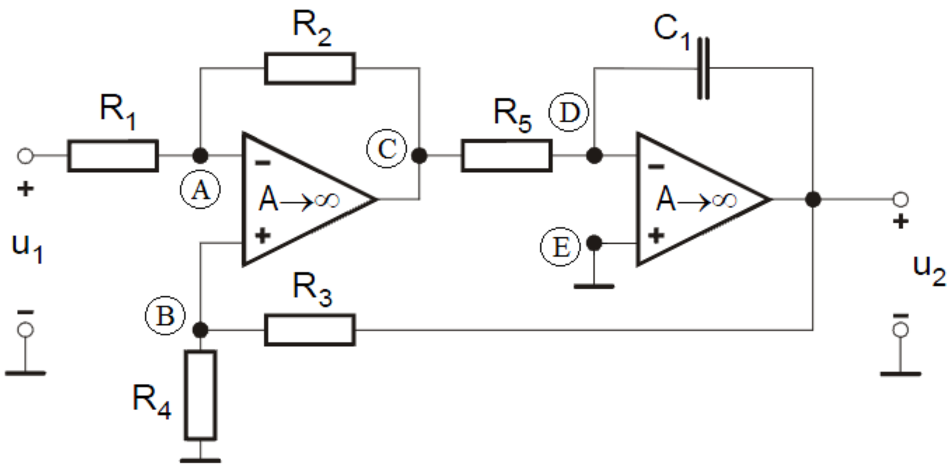
$$U_2(s) \xrightarrow{\mathcal{L}^{-1}} \boxed{u_2(t) = (2e^{-t} - 1) \cdot S(t)}$$

13. Odredi odziv $U_{izl}(s)$ za mrežu prikazanu slikom ako je pobuda $U_1(s) = {}^{1}/_{s}$. Zadano je $R_1 = R_2 = R_3 = R_4 = R_5 = 1$, $C_1 = 1$.



Rješenje:

Za potrebe rješavanja, na mreži ćemo si označiti čvorove koje ćemo koristiti prilikom rješavanja. Pritom, naravno, moramo paziti da nećemo zapisati jednadžbe čvorova za sve čvorove!



(A)	$U_A\left(\frac{1}{R_1}+\frac{1}{R_2}\right)-U_1\frac{1}{R_1}-U_C\frac{1}{R_2}=0$
(B)	$U_B\left(\frac{1}{R_4}+\frac{1}{R_3}\right)-U_2\frac{1}{R_3}=0$
(D)	$U_D\left(\frac{1}{R_5}+sC_1\right)-U_C\frac{1}{R_5}-U_2sC_1=0$
(p1)	$U_A=U_B$
(p2)	$U_D=U_E=0$

Nakon uvrštavanja brojeva te (p1) i (p2) u (A), (B) i (D):

(A)	$2U_A-\frac{1}{s}-U_C=0$
(B)	$2U_A-U_2=0 \quad \Rightarrow \quad U_A=\frac{U_2}{2}$
(D)	$U_C+U_2s=0 \quad \Rightarrow \quad U_C=-U_2s$

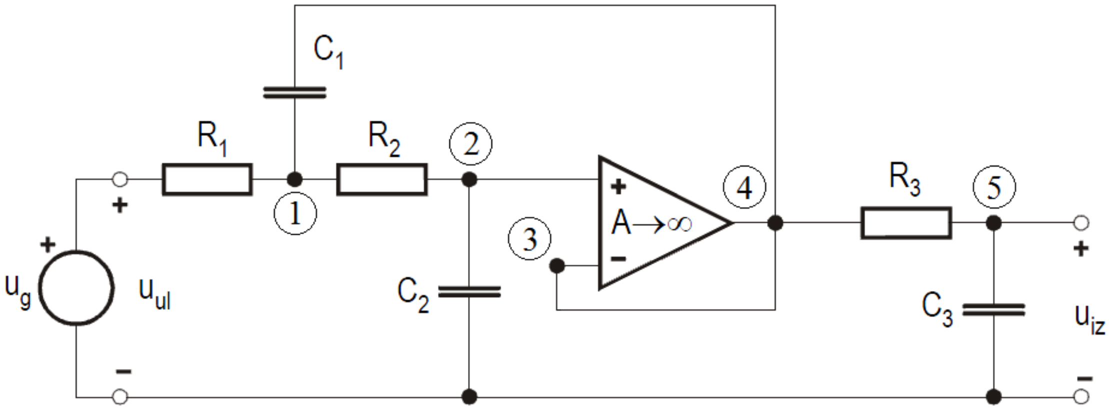
(B) i (D) u (A)

$$U_2-\frac{1}{s}+U_2s=0$$

$$U_2(1+s)=\frac{1}{s}$$

$$U_2=\frac{1}{s(s+1)}$$

14. Za mrežu prikazanu slikom odrediti odziv napona $U_{iz}(s)$, ako je zadan poticaj $U_{ul}(s) = 1$. Zadano je $R_1 = R_2 = R_3 = 1, C_1 = 2, C_2 = {}^1\!/_2, C_3 = 1$.



Rješenje:

(1) $$U_1\left(\frac{1}{R_1} + sC_1 + \frac{1}{R_2}\right) - U_{ul}\frac{1}{R_1} - U_4 sC_1 - U_2\frac{1}{R_2} = 0$$

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

(3) $$U_3 = U_4$$

(5) $$U_5\left(\frac{1}{R_5} + sC_3\right) - U_4\frac{1}{R_3} = 0$$

(p1) $$U_2 = U_3$$

Uz uvrštavanje brojeva, $U_5 = U_{iz}$ te $U_g(s) = 1$ imamo:

(1) $$U_1(2 + 2s) - 1 - 2sU_4 - U_2 = 0$$

(2) $$U_2\left(1 + \frac{s}{2}\right) - U_1 = 0 \quad \Rightarrow \quad U_1 = U_2\frac{s+2}{2}$$

(3) + (p1) $$U_3 = U_4 = U_2$$

(5) $$U_{iz}(1 + s) - U_4 = 0 \quad \Rightarrow \quad U_4 = U_{iz}(s + 1)$$

---

(2) u (1) $$U_2(s+1)(s+2) - U_2 - 2sU_4 = 1$$

(3)+(p1) u (1) $$U_4(s^2 + 3s + 2) - U_4 - 2sU_4 = 1$$

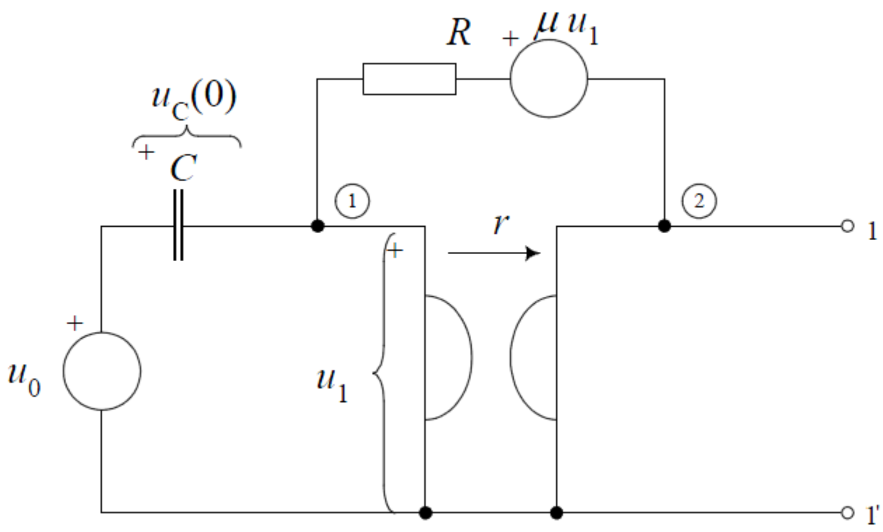
$$U_4(s^2 + 3s + 2 - 1 - 2s) = 1$$

---

(5) u (1) $$U_{iz}(s+1)(s^2 + s + 1) = 1$$

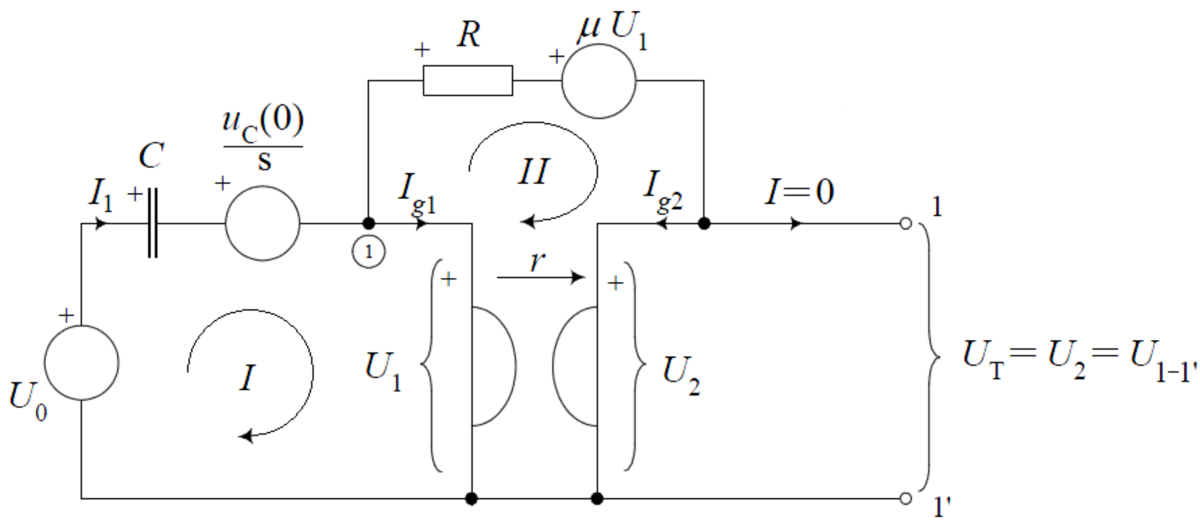
$$U_{iz} = \frac{1}{(s+1)(s^2+s+1)}$$

15. Za mrežu prikazanu slikom odrediti nadomjesnu shemu po Theveninu obzirom na priključnice 1-1', primjenom jednadžbi petlji, ako je pobuda $u_0(t) = S(t)$. Zadane su normirane vrijednosti elemenata: $R = 0.5,\ r = 0.5,$ $\mu = 0.5, C = 1$ i početni napon na kapacitetu $u_C(0) = 2$.



Rješenje:

Prvo ćemo odrediti Theveninov napon pa za te potrebe mrežu označujemo na slijedeći način, a uz te oznake ćemo pisat i jednadžbe petlji.



(I) $$U_0 - I_1 \frac{1}{sC} - \frac{u_C(0)}{s} - U_1 = 0$$

(II) $$-I_{g2}R - \mu U_1 - U_2 + U_1 = 0$$

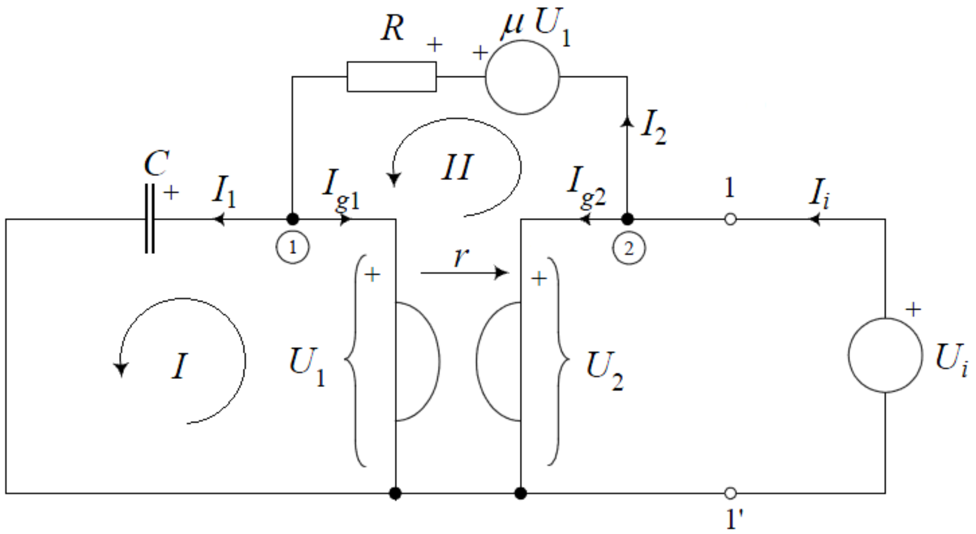
(1) $$I_1 = I_{g1} + I_{g2}$$

(g1) $$U_1 = r \cdot I_{g2} \quad \Rightarrow \quad I_{g2} = \frac{U_1}{r}$$

(g2) $$U_2 = -r \cdot I_{g1} \quad \Rightarrow \quad I_{g1} = -\frac{U_2}{r}$$

(g1) i (g2) u (1)	$I_1 = -\frac{U_2}{r} + \frac{U_1}{r} = \frac{U_1 - U_2}{r}$
(1) u (I)	$\frac{1}{s} - \frac{U_1 - U_2}{0.5s} - \frac{2}{s} - U_1 = 0$
(II)	$-U_1 - 0.5U_1 - U_2 + U_1 = 0$
(I)	$1 - 2U_1 + 2U_2 - 2 - sU_1 = 0$
(II)	$U_1 = -2U_2$
(II) u (I)	$6U_2 + 2sU_2 = 1$
	$U_2(s) = U_T(s) = \frac{1}{2(s+3)}$

Zatim određujemo iznos Theveninove impedancije Z_T i za to primjenjujemo poznata pravila te postavljamo proizvoljno oznake:

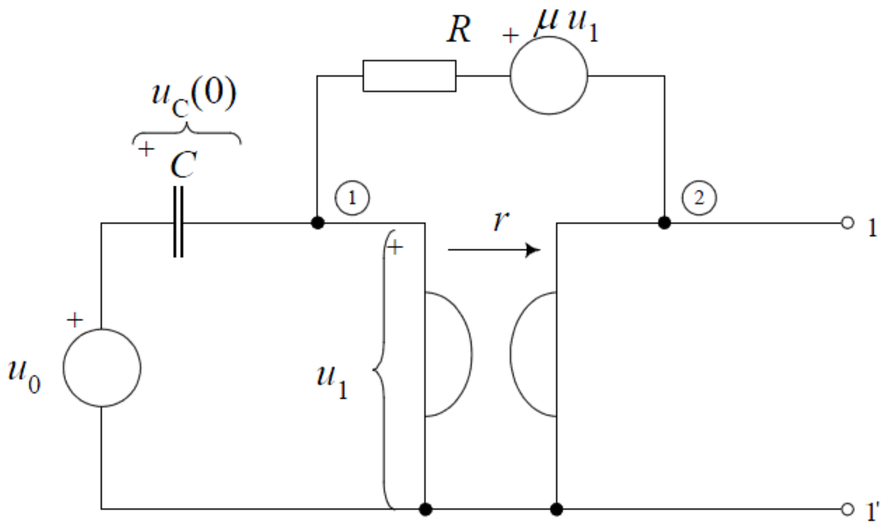


$$Z_T = \frac{U_i}{I_i} = \frac{U_2}{I_i}$$

(I)	$U_1 - I_1 \frac{1}{sC} = 0$
(II)	$U_2 + \mu U_1 - I_2 R - U_1 = 0$
(1)	$I_2 = I_{g1} + I_1 \quad \Rightarrow \quad I_1 = I_2 - I_{g1}$
(2)	$I_i = I_2 + I_{g2} \quad \Rightarrow \quad I_2 = I_i - I_{g2}$
(g1)	$U_1 = r \cdot I_{g2} \quad \Rightarrow \quad I_{g2} = \frac{U_1}{r}$
(g2)	$U_2 = -r \cdot I_{g1} \quad \Rightarrow \quad I_{g1} = -\frac{U_2}{r}$
(2) u (1)	$I_1 = I_i - I_{g1} - I_{g2}$
(1) u (I)	$U_1 - \frac{1}{sC}(I_i - I_{g1} - I_{g2}) = 0$

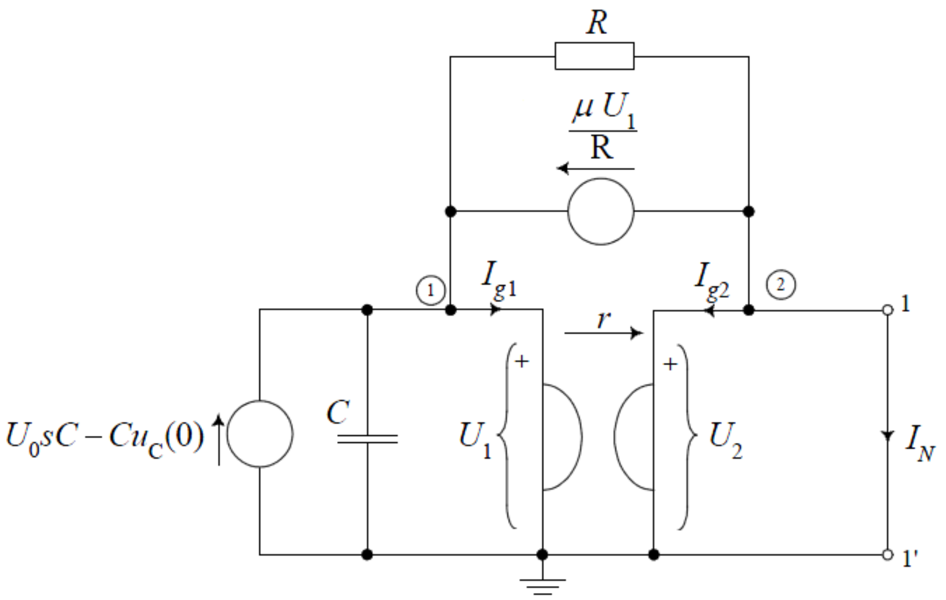
(2) u (II)	$U_2 + \mu U_1 - R(I_i - I_{g2}) - U_1 = 0$
(g1)+(g2) u (I)	$U_1 - \frac{I_i}{s} - \frac{2U_2}{s} + \frac{2U_1}{s} = 0$
(g1)+(g2) u (II)	$U_2 + 0.5U_1 - 0.5I_i + U_1 - U_1 = 0$
(I)	$U_1(s+2) - I_i - 2U_2 = 0$
(II)	$2U_2 + U_1 - I_i = 0 \quad \Rightarrow \quad U_1 = I_i - 2U_2$
(II) u (I)	$(I_i - 2U_2)(s+2) - I_i - 2U_2 = 0$
	$U_2(2 + 2s + 4) = I_i(s + 2 - 1)$
	$U_2 = I_i \frac{s+1}{2s+6}$
	$Z_T(s) = \frac{U_2}{I_i} = \frac{s+1}{2(s+3)}$

16. Za mrežu prikazanu slikom odrediti nadomjesnu shemu po Nortonu obzirom na priključnice 1-1', primjenom jednadžbi čvorišta, ako je pobuda $u_0(t) = S(t)$. Zadane su normirane vrijednosti elemenata: $R = 0.5,\ r = 0.5,\ \mu = 0.5, C = 1$ i početni napon na kapacitetu $u_C(0) = 2$.



Rješenje:

Za početak ćemo prilagoditi mrežu kako bi je što lakše mogli riješiti pomoću jednadžbi čvorišta.



(1)	$U_1\left(sC+\frac{1}{R}\right)-U_2\frac{1}{R}=U_0sC-Cu_C(0)+\frac{\mu U_1}{R}-I_{g1}$
(2)	$U_2\frac{1}{R}-U_1\frac{1}{R}=-\frac{\mu U_1}{R}-I_{g2}-I_N$
(g1)	$U_1=r\cdot I_{g2}$
(g2)	$U_2=-r\cdot I_{g1}$

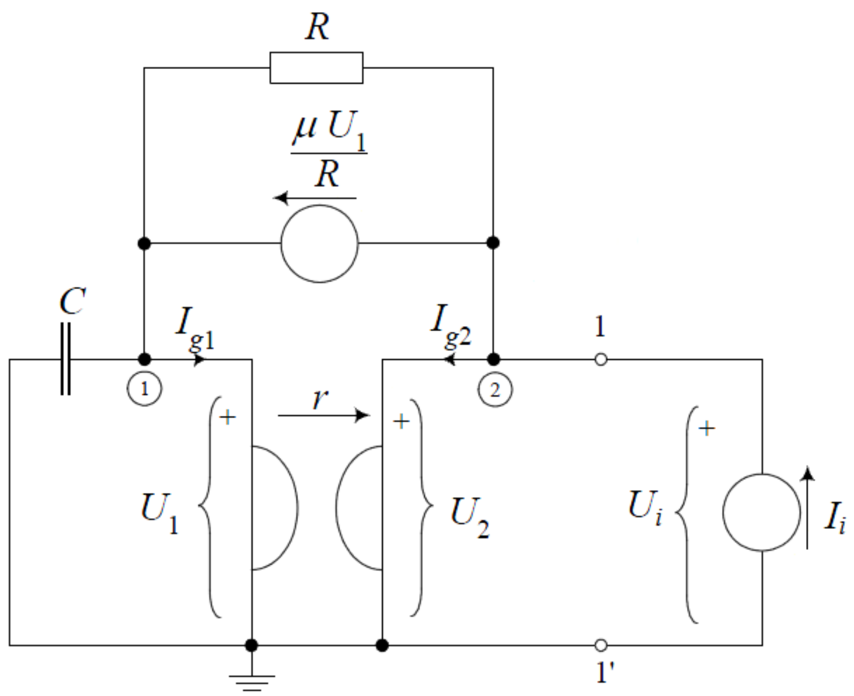
Na izlazu 1-1' je kratki spoj pa vrijedi $U_2=0$ a prema (g2) to znači $I_{g1}=0$.

(1)	$U_1(s+2)=1-2+U_1$
(2)	$2U_1=U_1+I_{g2}+I_N$
(g1)	$I_{g2}=2U_1$
(1)	$U_1=-\frac{1}{s+1}$
(2)	$I_N=U_1-I_{g2}$
(1) u (g2)	$I_{g2}=-\frac{2}{s+1}$
(1) i (g2) u (2)	$I_N=\frac{1}{s+1}$

Zatim određujemo iznos Nortonove impedancije, koja je po iznosu jednaka Theveninovoj impedanciji i prema tome se može računati na isti način. No, primjera radi, odrediti ćemo ju pravilu za traženje Nortonove admintancije, odnosno pomoći strujnog izvora između stezaljki 1-1'.

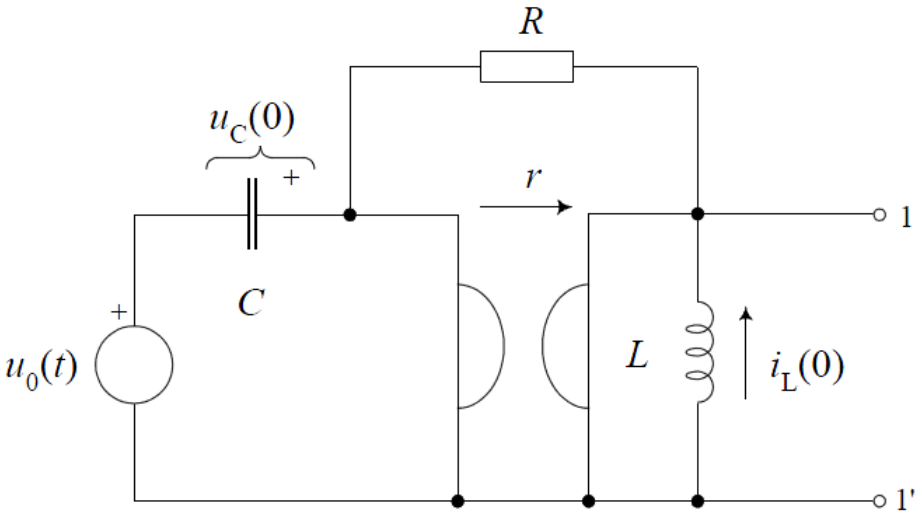
Gdje je Nortonova impedancija iznosa:

$$Y_N=\frac{I_i}{U_i}=\frac{I_i}{U_2}$$

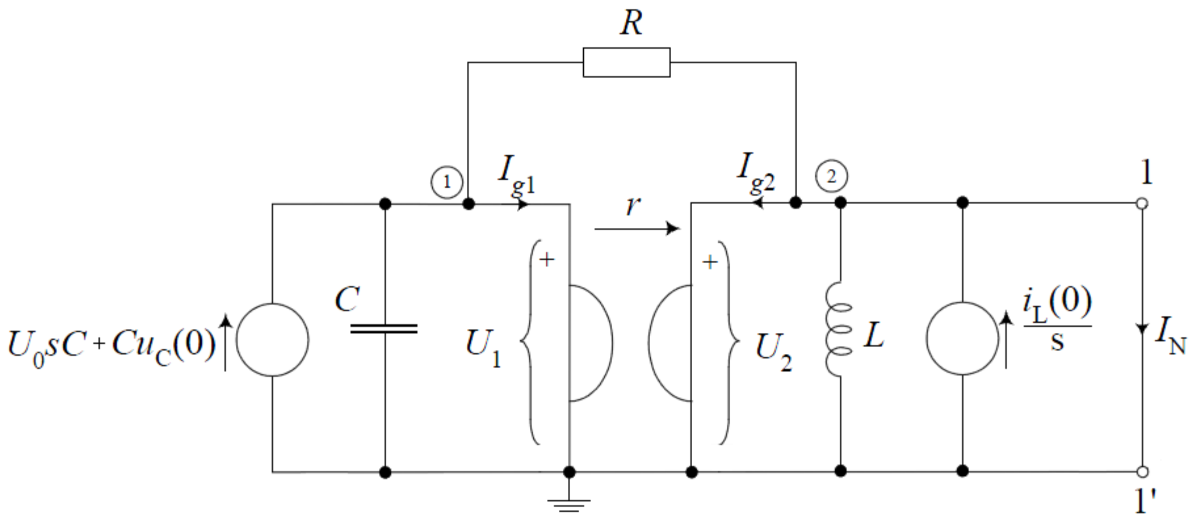


(1)	$U_1\left(sC+\frac{1}{R}\right)-U_2\frac{1}{R}=\frac{\mu U_1}{R}-I_{g1}$
(2)	$U_2\frac{1}{R}-U_1\frac{1}{R}=-\frac{\mu U_1}{R}-I_{g2}+I_i$
(g1)	$U_1=r\cdot I_{g2}\quad\Rightarrow\quad I_{g2}=\frac{U_1}{r}$
(g2)	$U_2=-r\cdot I_{g1}\quad\Rightarrow\quad I_{g1}=-\frac{U_2}{r}$
(g2) u (1)	$U_1(s+2)-2U_2=U_1+2U_2$
(g1) u (2)	$2U_2-2U_1=-U_1-2U_1+I_i$
(1)	$U_1(s+1)-4U_2=0$
(2)	$U_1=I_i-2U_2$
(2) u (1)	$(I_i-2U_2)(s+1)-4U_2=0$
	$I_i(s+1)=U_2(2s+2+4)$
	$Y_N(s)=\frac{I_i(s)}{U_2(s)}=\frac{2(s+3)}{s+1}$

17. Za strujni krug prikazan slikom odrediti nadomjesnu shemu po Nortonu obzirom na priključnice 1-1', koristeći postupak jednadžbi čvorišta, ako je pobuda $u_0(t) = \delta(t)$. Zadane su normirane vrijednosti elemenata: $R = 0.5$, $L = 1$, $C = 1$, $r = 1$ i početni uvjeti $u_C(0) = 0.5, i_L(0) = 1$.



Rješenje:



(1) $$U_1\left(sC + \frac{1}{R}\right) - U_2\frac{1}{R} = U_0 sC + Cu_C(0) - I_{g1}$$

(2) $$U_2\left(\frac{1}{R} + \frac{1}{sL}\right) - U_1\frac{1}{R} = -I_{g2} + \frac{i_L(0)}{s} - I_N$$

(g1) $$U_1 = r \cdot I_{g2}$$

(g2) $$U_2 = -r \cdot I_{g1}$$

Na izlazu 1-1' je kratki spoj pa vrijedi $U_2 = 0$ a prema (g2) to znači $I_{g1} = 0$.

(1) $$U_1(s+2) = s + \frac{1}{2}$$

(2) $$-2U_1 = -I_{g2} + \frac{1}{s} - I_N$$

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(1)
$$U_1 = \frac{2s+1}{2(s+2)}$$

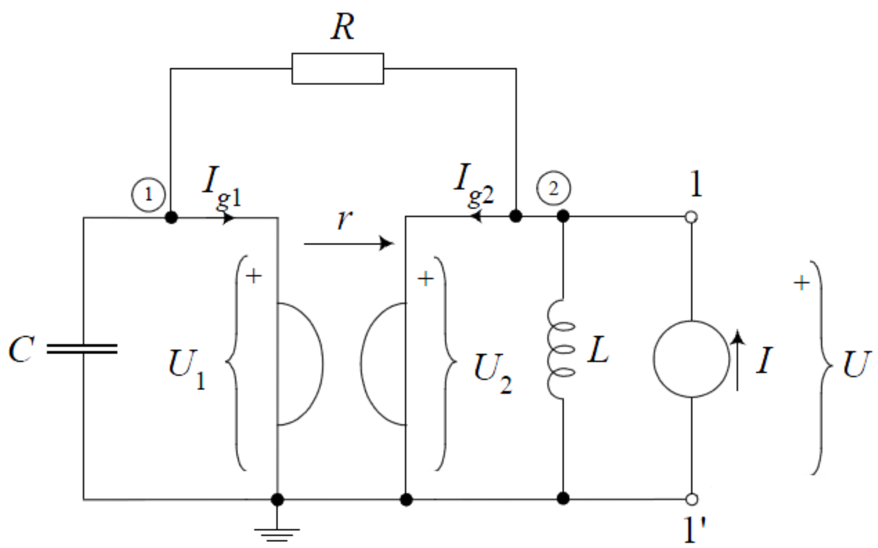
(2)
$$I_N = \frac{1}{s} + 2U_1 - I_{g2}$$

(g1)
$$I_{g2} = \frac{U_1}{r} = \frac{2s+1}{2(s+2)}$$

(1) i (g1) u (2)
$$I_N = \frac{1}{s} + \frac{2s+1}{(s+2)} - \frac{2s+1}{2(s+2)}$$

$$I_N = \frac{1}{s} + \frac{2s+1}{2(s+2)} = \frac{2s^2+3s+4}{2s(s+2)}$$

Za Nortonivu admitanciju:



(1)
$$U_1\left(sC + \frac{1}{R}\right) - U_2\frac{1}{R} = -I_{g1}$$

(2)
$$U_2\left(\frac{1}{R} + \frac{1}{sL}\right) - U_1\frac{1}{R} = -I_{g2} + I$$

(g1)
$$U_1 = r \cdot I_{g2} \quad \Rightarrow \quad I_{g2} = \frac{U_1}{r} = U_1$$

(g2)
$$U_2 = -r \cdot I_{g1} \quad \Rightarrow \quad I_{g1} = -\frac{U_2}{r} = -U_2$$

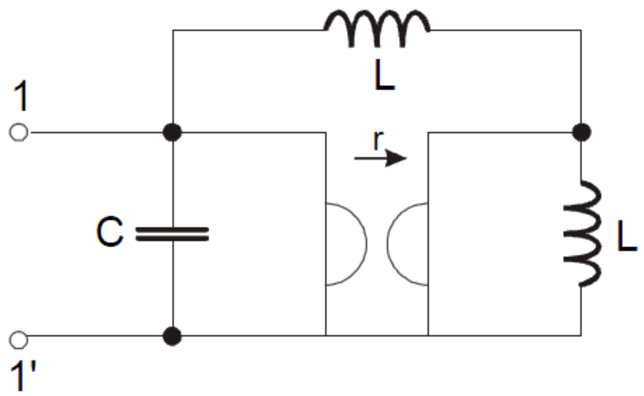
(g1)+(g2) u (1)
$$U_1(s+2) - 2U_2 = U_2 \quad \Rightarrow \quad U_1 = U_2\frac{3}{s+2}$$

(g1)+(g2) u (2)
$$U_2\left(2 + \frac{1}{s}\right) - 2U_1 = -U_1 + I$$

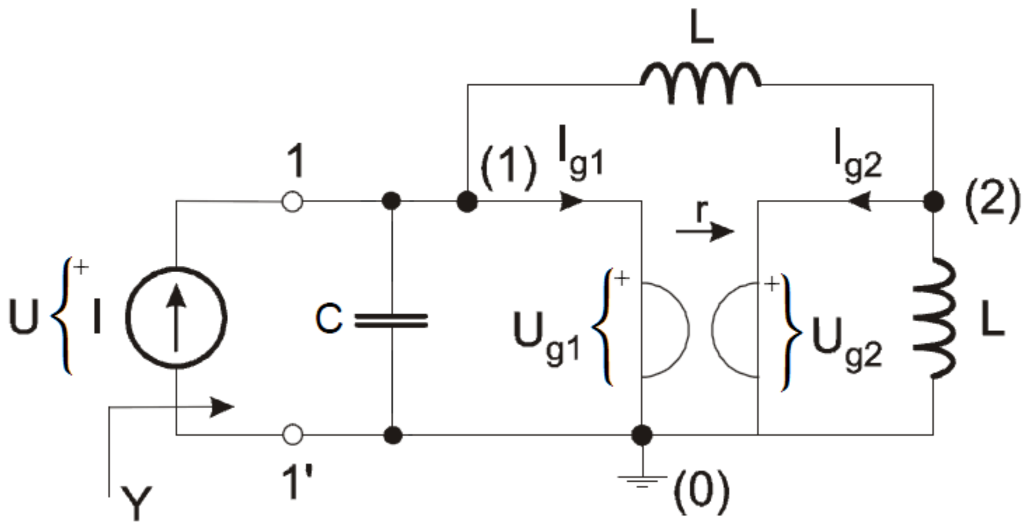
(1) u (2)
$$I = U_2\frac{2s+1}{s} - U_2\frac{3}{s+2} = U_2\frac{2s^2+2s+2}{s(s+2)}$$

$$Y_N(s) = \frac{I(s)}{U_2(s)} = \frac{2s^2+2s+2}{s(s+2)}$$

18. Za prikazani dvopol odrediti admitanciju na priključnicama 1-1'. Zadano je $L = 1,\ C = 1,\ r = 1.$



Rješenje:



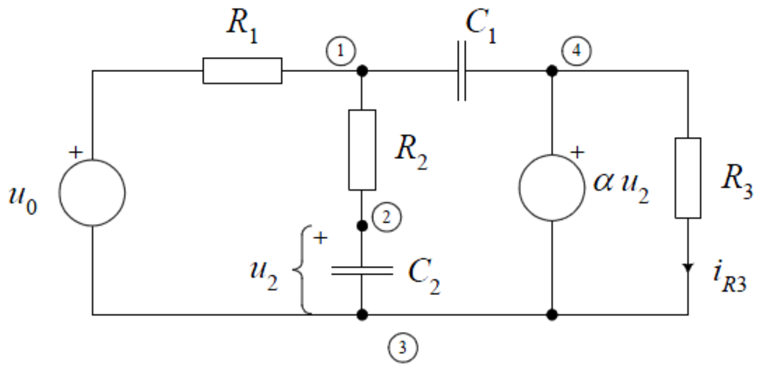
(1)	$U_1\left(sC+\frac{1}{sL}\right)-U_2\frac{1}{sL}=I-I_{g1}$
(2)	$U_2\left(\frac{1}{sL}+\frac{1}{sL}\right)-U_1\frac{1}{sL}=-I_{g2}$
(g1)	$U_1=r\cdot I_{g2} \quad\Rightarrow\quad I_{g2}=\frac{U_1}{r}=U_1$
(g2)	$U_2=-r\cdot I_{g1} \quad\Rightarrow\quad I_{g1}=-\frac{U_2}{r}=-U_2$
(g1)+(g2) u (1)	$U_1\left(s+\frac{1}{s}\right)-U_2\frac{1}{s}=I+U_2$
(g1)+(g2) u (2)	$U_2\left(\frac{1}{s}+\frac{1}{s}\right)-U_1\frac{1}{s}=-U_1$
(2)	$U_2=U_1\frac{1-s}{2}$

(2) u (1) $$I = U_1\left(\frac{s^2+1}{s} - \frac{1-s}{2s} - \frac{1-s}{2}\right)$$

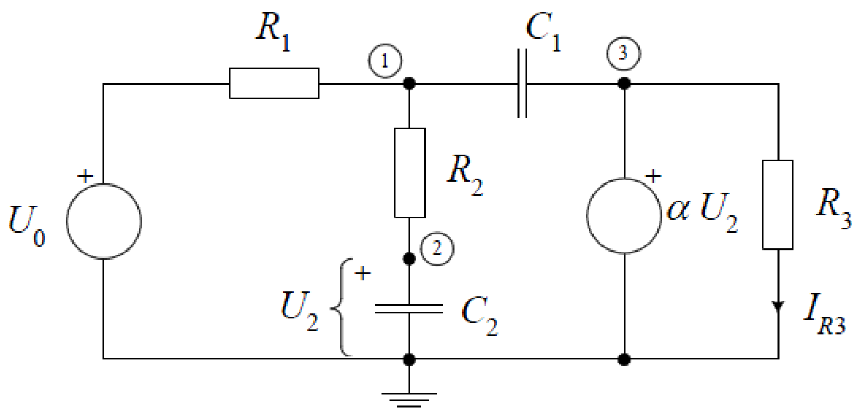
$$I = U\frac{3s^2+1}{2s}$$

$$Y(s) = \frac{I(s)}{U(s)} = \frac{3s^2+1}{2s}$$

19. Odredite odziv $i_{R3}(t)$ mreže na slici ako je pobuda $u_0(t) = \delta(t)$. Zadano je: $R_1 = R_2 = 1, R_3 = 2, C_1 = C_2 = 2, \alpha = 2.$



Rješenje:



(1) $$U_1\left(\frac{1}{R_1} + \frac{1}{R_2} + sC_2\right) - U_0\frac{1}{R_1} - U_2\frac{1}{R_2} - U_3 sC_1 = 0$$

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

Prema mreži se vidi $U_3 = \alpha U_2$ što uvrstimo u (1) te u obje jednadžbe brojeve

(1) $$U_1(2+2s) - 1 - U_2 - 4sU_2 = 0$$

(2) $$U_1 = U_2(1+2s)$$

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(2) u (1) $$U_2\big((2+2s)(1+2s) - 1 - 4s\big) = 1$$

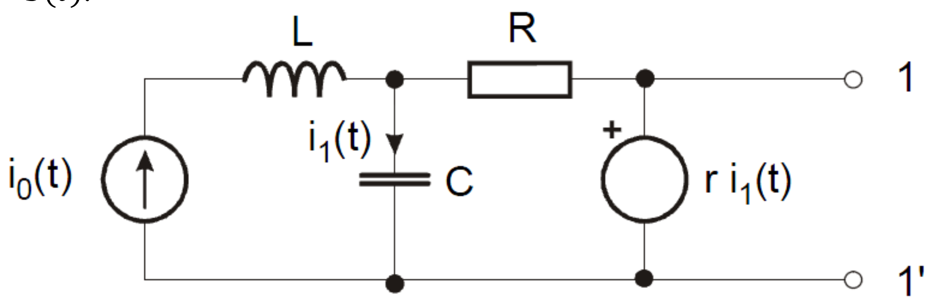
(1) $$U_2 = \frac{1}{4s^2+2s+1}$$

$$I_{R3} = \frac{U_3}{R_3} = \frac{\alpha U_2}{R_3} = \frac{1}{4} \cdot \frac{1}{s^2 + \frac{1}{2}s + \frac{1}{4}}$$

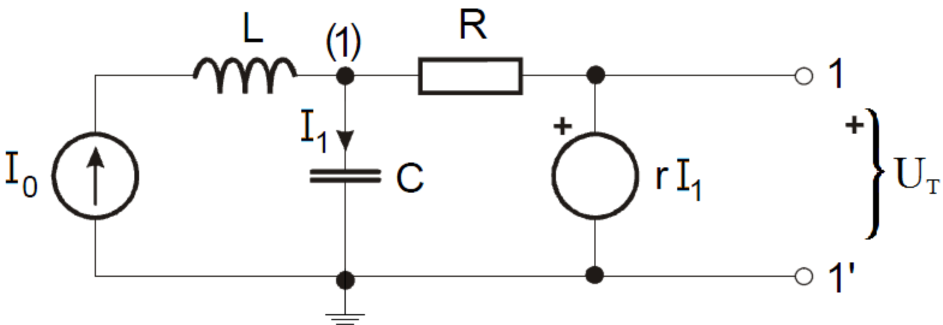
$$I_{R3} = \frac{1}{4} \cdot \frac{\frac{4}{\sqrt{3}} \cdot \frac{\sqrt{3}}{4}}{\left(s + \frac{1}{4}\right)^2 + \left(\frac{\sqrt{3}}{4}\right)^2} = \frac{\sqrt{3}}{3} \cdot \frac{\frac{\sqrt{3}}{4}}{\left(s + \frac{1}{4}\right)^2 + \left(\frac{\sqrt{3}}{4}\right)^2}$$

$$I_{R3}(s) \xrightarrow{\mathcal{L}^{-1}} \boxed{i_{R3}(t) = \frac{\sqrt{3}}{3} e^{-\frac{t}{4}} \sin\left(\frac{\sqrt{3}}{4} t\right) S(t)}$$

20. Za mrežu prikazanu slikom odrediti nadomjesne parametre mreže po Theveninu $U_T(s)$ i $Z_T(s)$ na stezaljkama 1-1'. Zadano je $R = 2,\ r = 1,\ C = 1,$ $i_0(t) = S(t)$.



Rješenje:



Zapišimo jednadžbu čvorišta za čvor (1):

$$U_1\left(sC + \frac{1}{R}\right) - U_T \frac{1}{R} = I_0$$

Također vrijedi:

$$U_T = r \cdot I_1 = r \cdot \frac{U_1}{\frac{1}{sC}} = rsCU_1 = sU_1$$

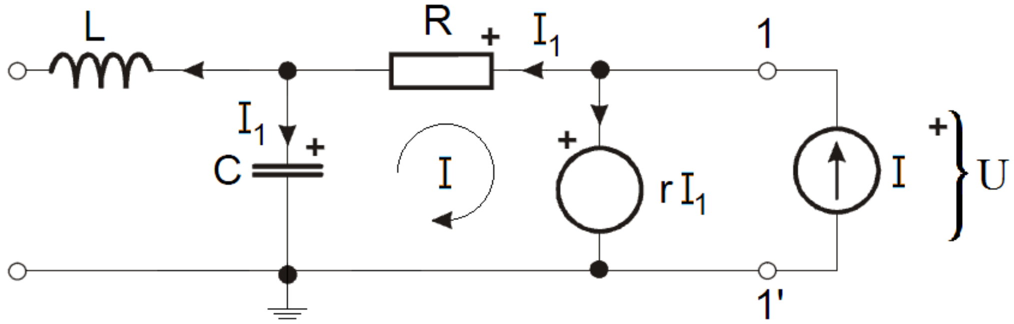
Što uvrstimo u (1)

$$U_1\left(s+\frac{1}{2}\right)-\frac{sU_1}{2}=\frac{1}{s}$$

$$U_1=\frac{2}{s(s+1)}$$

$$U_T(s)=sU_1(s)=\frac{2}{s+1}$$

Za Theveninovu impedanciju:



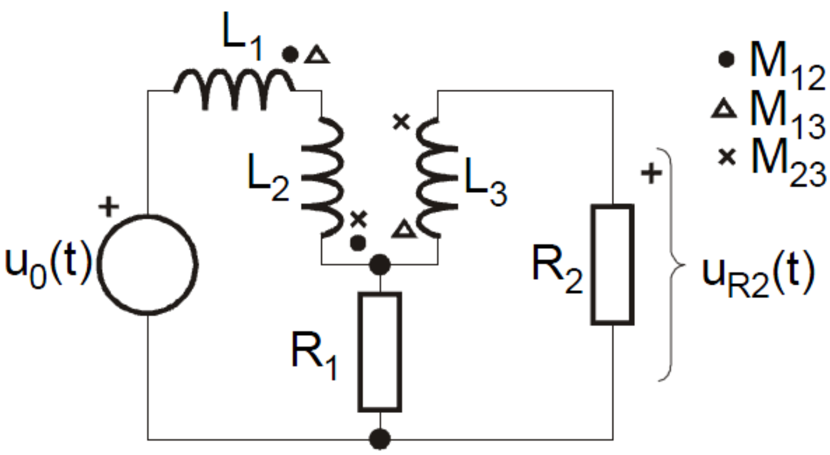
Zapišimo jednadžbu za petlju (I):

$$I_1\left(\frac{1}{sC}+R\right)-rI_1=0$$

Iz čega proizlazi da je $I_1=0$ a Theveninova impedancija iznosi:

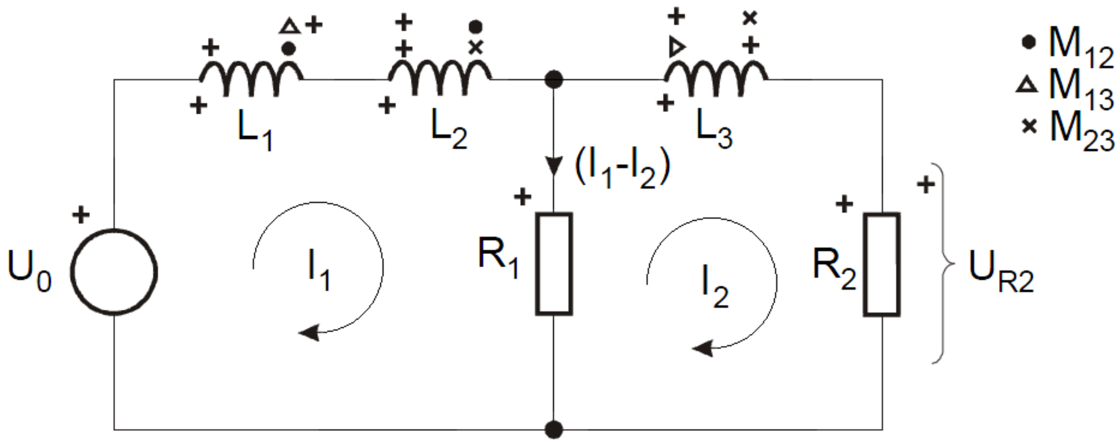
$$Z_T(s)=\frac{U}{I}=\frac{rI_1}{I}=0$$

21. Za mrežu prikazanu slikom izračunati napon $u_{R2}(t)$ ako su zadane normalizirane vrijednosti elemenata: $R_1=1$, $R_2=1$, $L_1=1$, $L_2=2$, $L_3=4$, $M_{12}={}^{1}/_{2}$, $M_{12}=2$, $M_{23}=3$ te napon generatora $u_0(t)=S(t)$.



Rješenje:

Primjena Laplaceove transformacije:



(1) $$U_0 - I_1 sL_1 - I_1 sM_{12} + I_2 sM_{13} - I_1 sL_2 - I_1 sM_{12} - I_2 sM_{23} - (I_1 - I_2)R_1 = 0$$

(2) $$(I_1 - I_2)R_1 - I_2 sL_3 + I_1 sM_{12} - I_1 sM_{23} - I_2 R_2 = 0$$

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(1) $$I_1(7s+1) + I_2(s-1) = \frac{1}{s}$$

(2) $$I_1\left(1 - \frac{5}{2}s\right) - I_2(4s+2) = 0$$

I dalje se može uočit kako je postupak rješavanja ovoga preteško da bi se nastavilo do kraja… tako da ja neću, a vi kako hoćete ;)