13.10.2008

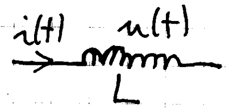
Linearnost

$$\mathcal{H}(a_1 x_1 + a_2 x_2) = \mathcal{H}(a_1 x_1) + \mathcal{H}(a_2 x_2)$$

Časovna invariantnost

$$\mathcal{H}(x(t-\tau)) = y(t-\tau)$$
$$\mathcal{H}(x(t)) = y(t)$$

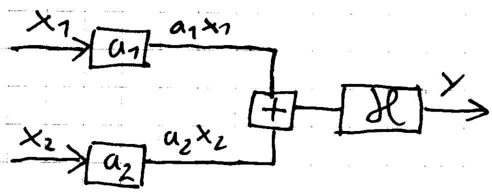
1.) Ali je tuljava linearna in ali je časovno invariantna?



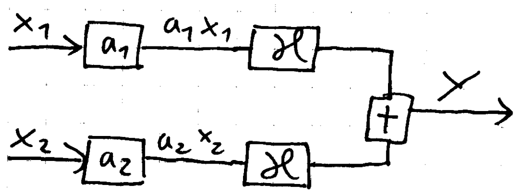
$$u(t) = \underbrace{L \frac{\partial}{\partial t}}_{\mathcal{H}} i(t)$$

Linearna?

$\boxed{\text{Levi del enačbe:}}$



$\boxed{\text{Desni del enačbe:}}$



$$L\frac{d}{dt}\left(a_1 i_1(t) + a_2 i_2(t)\right)$$
$$\downarrow$$
$$\underline{L\frac{d}{dt} a_1 i_1(t) + L\frac{d}{dt} a_2 i_2(t)} = \underline{L\frac{d}{dt} a_1 i_1(t) + L\frac{d}{dt} a_2 i_2(t)}$$

Tuljava je linearen element.

časovno inv ?

$\boxed{\text{Leva stran}}$

$$x(t) \longrightarrow \boxed{\tau} \longrightarrow \boxed{\mathcal{H}} \longrightarrow y$$

$$i(t) \rightarrow i(t-\tau)$$
$$\underline{u(t-\tau) = L \frac{d}{dt} i(t-\tau)}$$

$\boxed{\text{Desna stran}}$

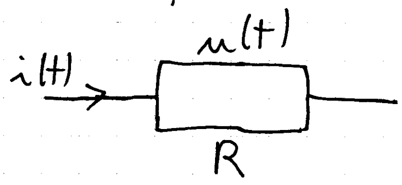
$$x(t) \longrightarrow \boxed{\mathcal{H}} \longrightarrow \boxed{\tau} \longrightarrow y$$

$$i(t)$$
$$u(t) = L \frac{d}{dt} i(t)$$
$$u(t-\tau) = L \frac{d}{dt} i(t) \Big|_{t-\tau}$$
$$\underline{u(t-\tau) = L \frac{d}{dt} i(t-\tau)}$$

$$\parallel$$

Tuljava je časovna invariantna.

2.) Ali je temperaturno odvisni upor R časovno invarianten?



$$\underline{T \rightarrow T(t)}$$
$$T(t) = T_2$$
$$T(t-\tau) = T_1$$

$$u(t) = R \cdot i(t)$$
$$\Downarrow$$
$$u(t) = R(t) \cdot i(t)$$

L

$$i(t) \longrightarrow i(t-\tau)$$
$$u(t-\tau) = R(T(t-\tau)) \cdot i(t-\tau)$$
$$u(t-\tau) = R(T_1) \cdot i(t-\tau)$$

D

$$u(t) = R(T(t)) \cdot i(t)$$
$$u(t-\tau) = R(T(t)) \cdot i(t-\tau)$$
$$u(t-\tau) = R(T_2) \cdot i(t-\tau)$$

Če $T_1 = T_2$ je sistem časovno invarianten.

Če $T_1 \neq T_2$ ni sistem časovno invarianten.

3.) Ugotovi ali je sistem

- linearen ? ✓
- časovno invarianten ? ✗

$$\int_0^t x(u)\,du = \frac{y(t)}{2}$$

$$y(t) = 2\int_0^t x(u)\,du$$

L | D

$$2\cdot\int_0^t (a_1x_1(u) + a_2\,x_2(u))\,du \qquad 2\cdot\int_0^t a_1x_1(u)\,du + 2\int_0^t a_2x_2(u)\,du$$

$$= 2\cdot\int_0^t a_1x_1(u)\,du + 2\cdot\int_0^t a_2x_2(u)\,du$$

L = D

L | D

$$x(u) \rightarrow x(u-\tau)$$

$$2\int_0^t x(u-\tau)\,du$$

$$2\int_0^t x(u)\,du = ; \qquad \boxed{\begin{array}{l} v = u + \tau ;\ u = v - \\ dv = du \end{array}}$$

$$= 2\int_\tau^t x(v-\tau)\,dv$$

$L \neq D$

4.) Ugotovi ali je sistem linearen ✓ in časovno invarianten ✓?

$y(t) = \frac{d}{dt}x(t) + 2x(t)$

Linearnost:

L:

$\frac{d}{dt}(a_1 x_1(t) + a_2 x_2(t)) + 2(a_1 x_1(t) + a_2 x_2(t))$

$\frac{d}{dt} a_1 x_1(t) + 2a_1 x_1(t) + \frac{d}{dt} a_2 x_2(t) + 2a_2 x_2(t)$

D:

$\frac{d}{dt} a_1 x_1(t) + 2a_1 x_1(t) + \frac{d}{dt} a_2 x_2(t) + 2a_2 x_2(t)$

Časovna invariantnost:

L:

$x(t) \rightarrow x(t-\tau)$

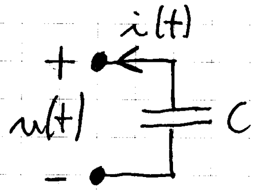
$\frac{d}{dt} x(t-\tau) + 2x(t-\tau)$

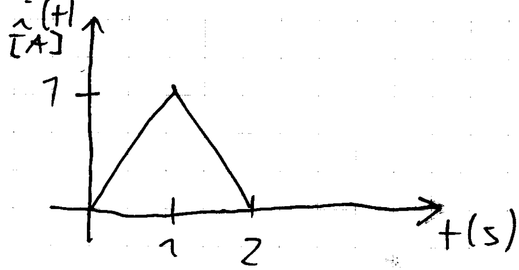
D:

$\frac{d}{dt} x(t) + 2x(t) \Big|_{t-\tau}$

$\frac{d}{dt} x(t-\tau) + 2x(t-\tau)$

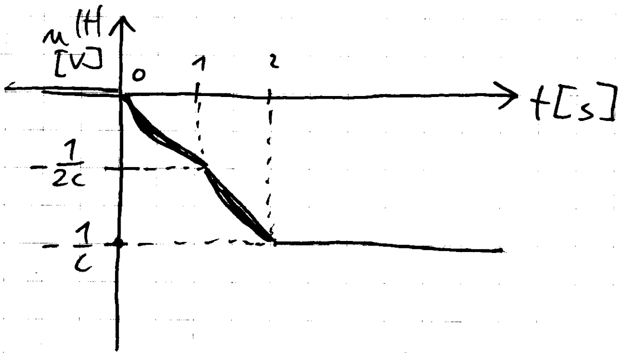
5.) Skiciraj napetost na kondenzatorju $u(t)$





$$\boxed{u(t) = \pm\frac{1}{C}\int_{-\infty}^{t} i(\tau)\cdot d\tau}$$

$$u(t) = -\frac{1}{C}\int_{-\infty}^{t} i(\tau)d\tau = \underbrace{-\frac{1}{C}\int_{-\infty}^{0} i(\tau)d\tau}_{=0} - \frac{1}{C}\int_{0}^{t} i(\tau)d\tau$$



$$i(t) = \begin{cases} 0 & t < 0\,s \\ t & t \in [0,1)\,s \\ 2-t & t \in [1,2]\,s \\ 0 & t > 2\,s \end{cases}$$

$$u(t) = -\frac{1}{C}\int_{0}^{t} t\,dt = -\frac{t^2}{2C}\Big|_{0}^{t} = \underline{\underline{-\frac{t^2}{2C}}}$$

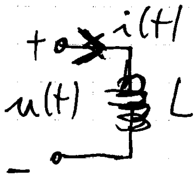
$$u(t) = -\frac{1}{C}\int_{0}^{t} i(t)dt = -\frac{1}{C}\int_{0}^{1} t\,dt - \frac{1}{C}\int_{1}^{t}(2-t)dt =$$

$$= -\frac{1}{2C} - \frac{1}{C}\int_{1}^{t}(2-t)\,dt = -\frac{1}{2C} - \frac{1}{C}\left(2t - \frac{t^2}{2}\right)\Big|_{1}^{t}$$

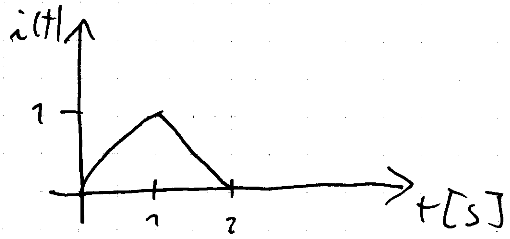
$$= -\frac{1}{C} + \frac{1}{2C}(t-2)^2$$

$$u(t) = -\frac{1}{C}\int_{0}^{t} i(t)dt = -\frac{1}{C}\int_{0}^{1} t\,dt - \frac{1}{C}\int_{1}^{2}(2-t)dt - \frac{1}{C}\int_{2}^{t} 0\,dt$$

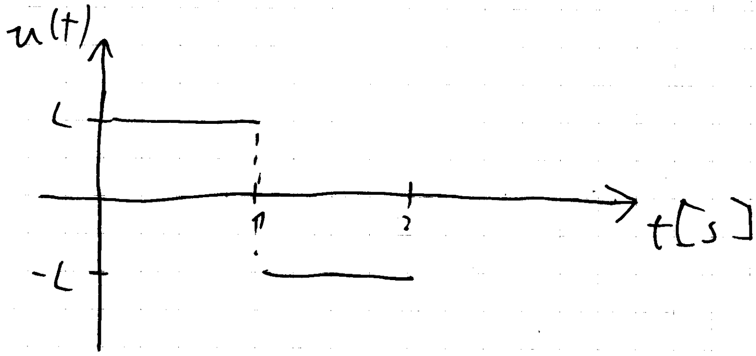
6.1 Skiciraj $u(t)$



$$\boxed{u(t) = L \frac{d}{dt} i(t)}$$



$$i(t) = \begin{cases} 0 & t < 0\,s \\ t & t \in [0,1)\,s \\ 2-t & t \in [1,2]\,s \\ 0 & t > 2\,s \end{cases}$$



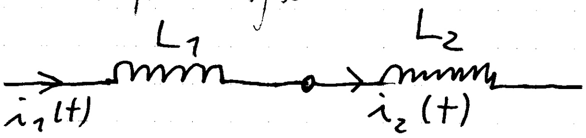
$t \in [0,1)$

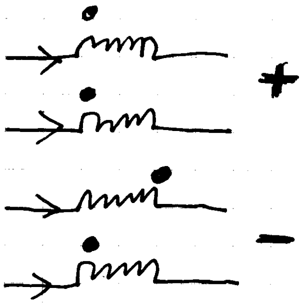
$u(t) = L \frac{d}{dt} t = L$

$t \in [1,2]$

$u(t) = L \frac{d}{dt}(2-t) = -L$

Sklop tuljava

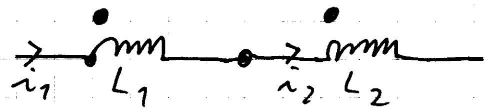




$$u_1(t) = L_1 \frac{d}{dt} i_1(t) \pm M \frac{d}{dt} i_2(t)$$
$$u_2(t) = L_2 \frac{d}{dt} i_2(t) \pm M \frac{d}{dt} i_1(t)$$

$$M = k \cdot \sqrt{L_1 L_2}$$

7.) Izračunaj nadomestno induktivnost – L_s



$i_1(t) = i_2(t) = i(t)$

$u(t) = u_1(t) + u_2(t) = L_1 \frac{d}{dt} i(t) + M \frac{d}{dt} i(t) + L_2 \frac{d}{dt} i(t) + M \frac{d}{dt} i(t)$

$$u(t) = \underbrace{(L_1 + L_2 + 2M)}_{L_s} \frac{d}{dt} i(t)$$

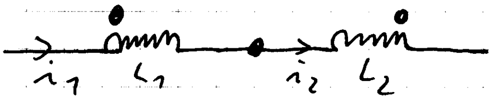
$L_1 = L_2 = L$

$k = 1$

$u(t) = ?$

$M = \sqrt{L^2} = L \Rightarrow u(t) = (L + L + 2L) \frac{d}{dt} i(t)$

$$u(t) = 4L \frac{d}{dt} i(t)$$



$u(t) = u_1(t) + u_2(t) = L_1 \frac{d}{dt} i(t) - M \frac{d}{dt} i(t) + L_2 \frac{d}{dt} i(t) - M \frac{d}{dt} i(t)$

$$u(t) = (L_1 + L_2 - 2M) \frac{d}{dt} i(t)$$

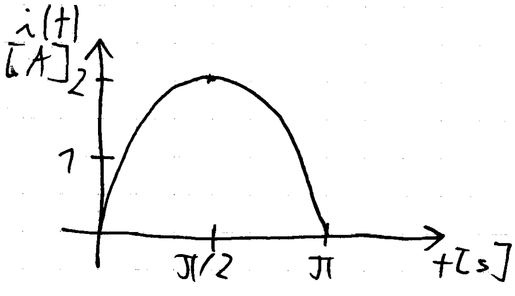
$L_1 = L_2 = L$

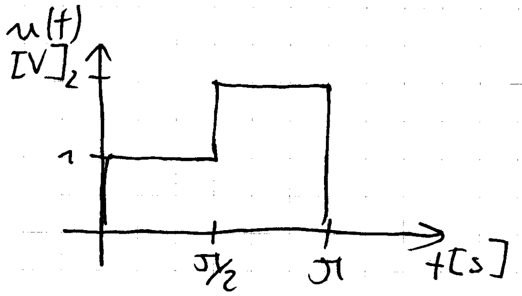
$k = 1$

$u(t) = ?$

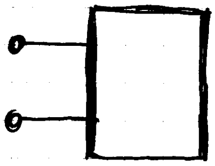
$u(t) = (L + L - 2L) \frac{d}{dt} i(t) = 0$

8.) Izračunaj energijo W, ki se je v času $0 \leq t \leq \pi$ stekla v duopol.





$i(t) = 2\sin(t)$



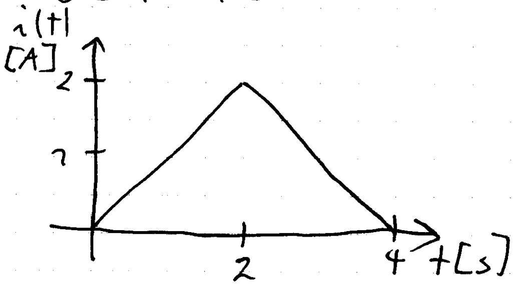
$$W = \int_0^{\pi} i(t)\cdot u(t)\,dt = \int_0^{\pi/2} 2\sin(t)\,dt + \int_{\pi/2}^{\pi} 4\sin(t)\,dt$$

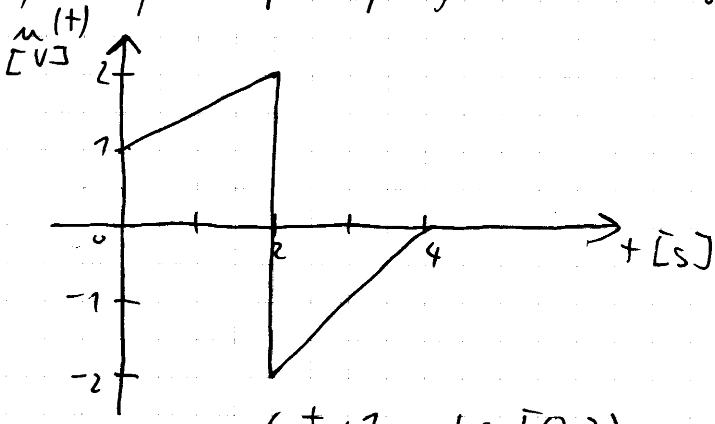
$$W = 2(-\cos(t))\Big|_0^{\pi/2} + 4(-\cos(t))\Big|_{\pi/2}^{\pi}$$

$$W = 2(0+1) + 4(1-0) = \underline{\underline{6\,J}}$$

9.) Izračunaj energijo W, ki jo dopol sprejme od 0 do 4 s.

$0 \leq t \leq 4\,s$





$$i(t) = \begin{cases} t & t \in [0,2)\,s \\ 4-t & t \in [2,4]\,s \end{cases}$$

$$u(t) = \begin{cases} \frac{t}{2}+1 & t \in [0,2)\,s \\ t-4 & t \in [2,4]\,s \end{cases}$$

$$p(t) = \begin{cases} \frac{t^2}{2}+t & t \in [0,2) \\ (4-t)(t-4) & t \in [2,4] \end{cases}$$

$$W = \int_0^4 p(t)\cdot dt = \int_0^2 \left(\frac{t^2}{2}+t\right)dt + \int_2^4 (t-4)(4-t)\,dt = \left(\frac{t^3}{6}+\frac{t^2}{2}\right)\Big|_0^2 + \left(\frac{t^3}{3} - \frac{8t^2}{2} + 16t\right)\Big|_2^4$$

8 $W = \underline{\underline{\frac{2}{3}\,J}}$

20.10.2008

$W(t_0) + W(t_0, t) \geq 0$ je pasivno

Ali je kondenzator pasiven element?

$$\boxed{\begin{aligned} W(t_0) &= W(-\infty, t_0) \\ W(t_0, t) &= \int_{t_0}^{t} u(t)\cdot i(t)\, dt \end{aligned}}$$

$$W(t_0) + W(t_0, t) = \int_{-\infty}^{t_0} u(t)\, i(t)\, dt + \int_{t_0}^{t} u(t)\, i(t)\, dt =$$

$$= \int_{-\infty}^{t_0} u(t) \frac{du(t)}{\cancel{dt}} \cdot C \cdot \cancel{dt} + \int_{t_0}^{t} u(t) \cdot C \frac{du(t)}{\cancel{dt}} \cdot \cancel{dt} =$$

$$= \int_{-\infty}^{t_0} C \cdot u(t)\, du(t) + \int_{t_0}^{t} C\, u(t)\, du(t) = \frac{C}{2}\left(\cancel{u^2(t_0)} - \underbrace{u^2(-\infty)}_{=0 \text{, ker ni bil nabit}}\right) +$$

$$+ \frac{C}{2}\left(u^2(t) - \cancel{u^2(t_0)}\right) = \underline{\underline{\frac{C}{2} u^2(t) \geq 0}}$$

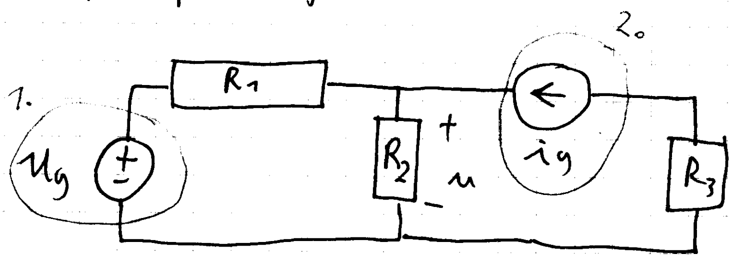
Dokaži, da je upor pasiven.

$$W = \int_{-\infty}^{t_0} u(t)\, i(t)\, dt + \int_{t_0}^{t} u(t)\, i(t)\, dt =$$

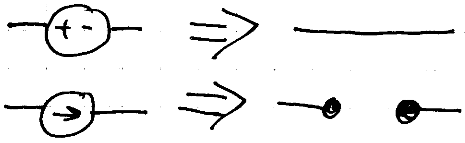
$$= \int_{-\infty}^{t_0} R\, i^2(t)\, dt + \int_{t_0}^{t} R\, i^2(t)\, dt \geq 0$$

Upor je pasiven.

Superpozicija

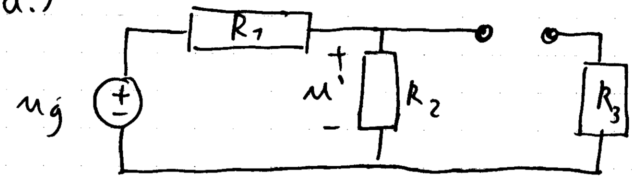


1. Označi neodvisne vire
2. Izbereš enega, ostale izklopiš



3. Seštej delne rezultate

a.)



$$\boxed{u' = \frac{R_2}{R_1+R_2} \cdot u_g}$$

$i_{R_1} = i_{R_2}$, $u_{R_1} + u_{R_2} = u_g$

$$\frac{u_{R_1}}{R_1} = \frac{u_{R_2}}{R_2}$$

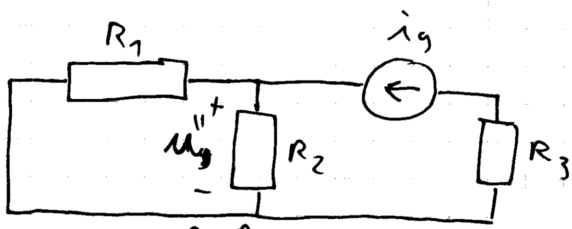
$$u_{R_1} = \frac{R_1}{R_2} \cdot u_{R_2}$$

$$\frac{R_1}{R_2} u_{R_2} + u_{R_2} = u_g$$

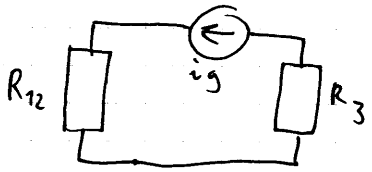
$$\frac{R_1+R_2}{R_2} \cdot u_{R_2} = u_g$$

$$\boxed{u_{R_2} = \frac{R}{R_1+R_2} u_g}$$

b.)

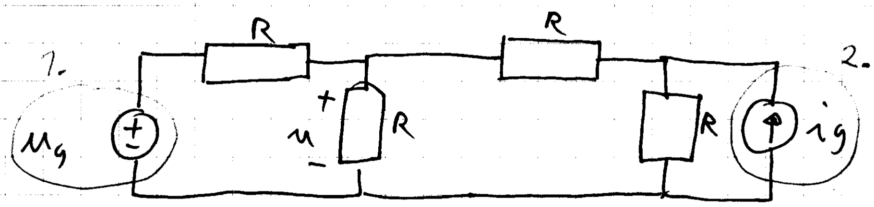


$$R_{12} = \frac{R_1 R_2}{R_1+R_2}$$

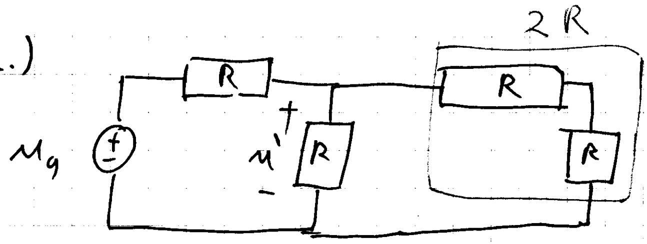


$$\boxed{u'' = \frac{R_1 R_2}{R_1+R_2} \cdot i_g}$$

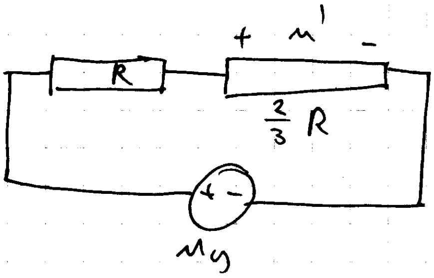
Izračunaj napetost $u(t)$.



a.)



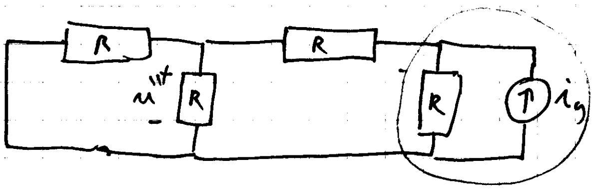
$$\left(\frac{1}{2R}+\frac{1}{R}\right)^{-1}=\frac{2}{3}R$$

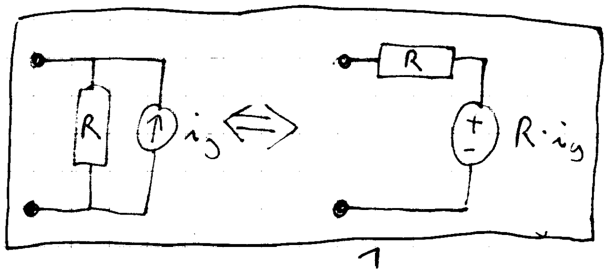


$$u'=\frac{\frac{2}{3}R}{R+\frac{2}{3}R}\cdot u_g$$

$$u'=\frac{\frac{2}{\cancel{3}}\cancel{R}}{\frac{5}{\cancel{3}}\cancel{R}}=\underline{\underline{\frac{2}{5}u_g}}$$

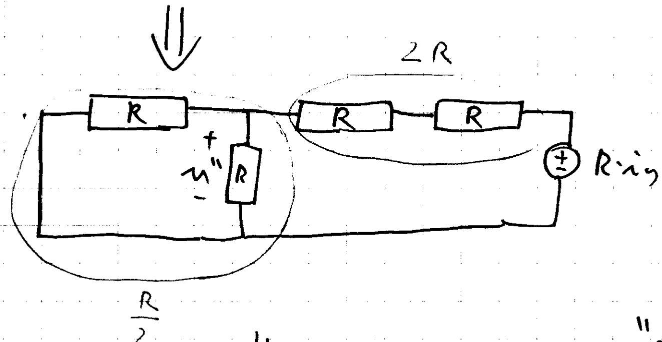
b.)

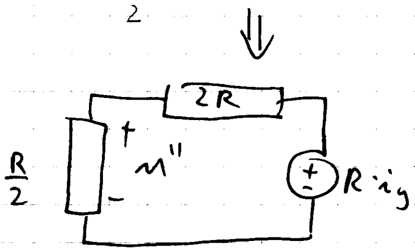




$$i_g=\frac{1}{R}\cdot u_g$$

$$R\cdot i_g=u_g$$



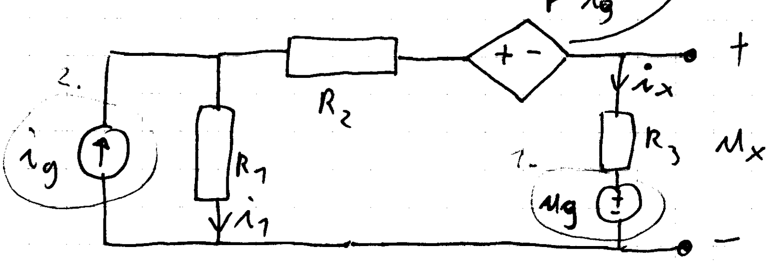


$$u''=\frac{\frac{R}{2}}{\frac{R}{2}+2R}\cdot R\cdot i_g=\frac{\frac{\cancel{R}}{\cancel{2}}}{\frac{5}{\cancel{2}}\cancel{R}}\cdot R\cdot i_g$$

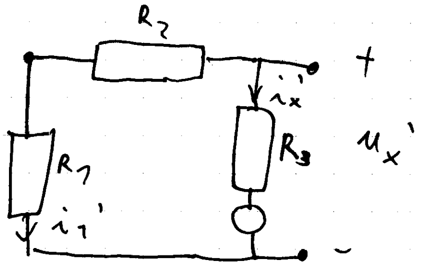
$$u''=\underline{\frac{1}{5}R\cdot i_g}$$

$$u(t)=u'+u''=\boxed{\frac{2}{5}u_g+\frac{1}{5}R\cdot i_g}$$

Izračunaj napetost



a.)



$$i_1' = \frac{u_g}{R_1+R_2+R_3}$$

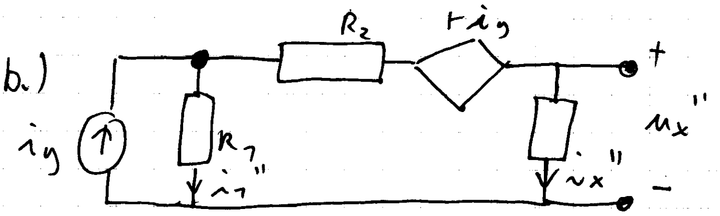
$$u_{R_3}' = i_x' \cdot R_3$$

$$u_x' = u_{R_3} + u_g = i_x' \cdot R_3 + u_g \quad ; \; i_x' = -i_1'$$

$$u_x' = -\frac{R_3}{R_1+R_2+R_3} u_g + u_g =$$

$$\underline{\underline{u_x' = \frac{R_1+R_2}{R_1+R_2+R_3} u_g}}$$

b.)



$$-i_g + i_1'' + i_x'' = 0$$

$$i_1'' + i_x'' = i_g$$

$$u_{R_1} = u_{R_2} + u_{R_3} + r i_g$$

$$i_1'' \cdot R_1 = i_x'' \cdot R_2 + i_x'' R_3 + r i_g$$

$$i_1'' = i_g - i_x''$$

$$(i_g - i_x'') \cdot R_1 = i_x''(R_2 + R_3) + r i_g$$

$$i_g (R_1 - r) = i_x'' (R_1 + R_2 + R_3)$$

$$i_x'' = \frac{i_g (R_1 - r)}{R_1+R_2+R_3}$$

$$\underline{\underline{u_x'' = \frac{R_3 (R_1 - r)}{R_1+R_2+R_3} i_g}}$$

$$u_x = u_x' + u_x''$$

$$\boxed{u_x = \frac{R_1+R_2}{R_1+R_2+R_3} u_g + \frac{R_3(R_1-r)}{R_1+R_2+R_3} i_g}$$

Imamo 2. harmonična generatorja. Velja $\omega_1 \neq \omega_2$. Ali superpozicij moči velja ali ne?

$P_{12} = P_1 + P_2$

$\cos(a) + \cos(b) = \frac{1}{2}(\cos(a+b) + \cos(a-b))$

$$\boxed{P = \overline{ui} = \frac{1}{T}\int_0^T u(t)\,i(t)\,dt}$$

$u_1(t) = U_{g10} \cdot \cos(\omega_1 t + \varphi_1)$ $\qquad$ $u_2(t) = U_{g20} \cdot \cos(\omega_2 t + \varphi_2)$

$i_1(t) = I_{g10} \cdot \cos(\omega_1 t + \psi_1)$ $\qquad$ $i_2(t) = I_{g20} \cdot \cos(\omega_2 t + \psi_2)$

$$P_{12} = \overline{(u_1+u_2)\cdot(i_1+i_2)} = \overline{u_1 \cdot i_1} + \underline{\overline{u_1 \cdot i_2}} + \overline{u_2 \cdot i_2} + \underline{\overline{u_2 \cdot i_1}}$$

$$\overline{u_1 i_2} = \frac{1}{T}\int_0^T U_{g10} \cdot \cos(\omega_1 t + \varphi_1) \cdot I_{g20} \cdot \cos(\omega_2 t + \psi_2)\,dt$$

$$= \frac{1}{2T}\Big(\underbrace{\int_0^T U_{g10} I_{g20} \cdot \cos((\omega_1+\omega_2)t + \varphi_1 + \psi_2)\,dt}_{0} +$$

$$+ \int_0^T U_{g10} I_{g20} \cos((\omega_1 - \omega_2)t + \varphi_1 - \psi_2)\,dt\Big)$$

$$\int_0^T \cos(\omega t + \varphi)\,dt \begin{cases} 0 & \omega > 0 \\ T\cos(\varphi) & \omega = 0 \end{cases}$$

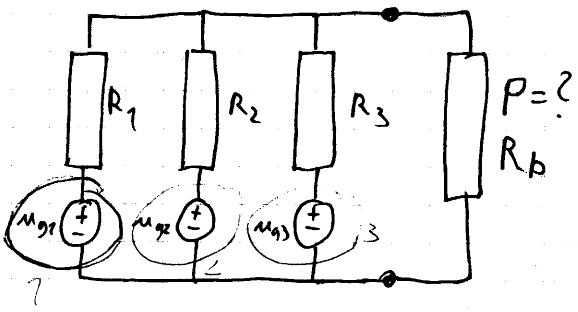
$$\overline{u_1 i_2} = \begin{cases} \frac{U_{g10} I_{g20}}{2T} \cos(\varphi_1 + \psi_2) & ; \omega_1 = \omega_2 \\ 0 & \omega_1 \neq \omega_2 \end{cases}$$

Če sta frekvenci enaki potem ne velja.

Če frekvenci nista enaki potem velja.

Akta

Moć na otporu R_b?



$$\cancel{P = P_1 + P_2 + P_3}$$

$$P = P_{12} + P_3$$

$R_1 = 1\Omega$

$R_2 = 2\Omega$

$R_3 = 3\Omega$

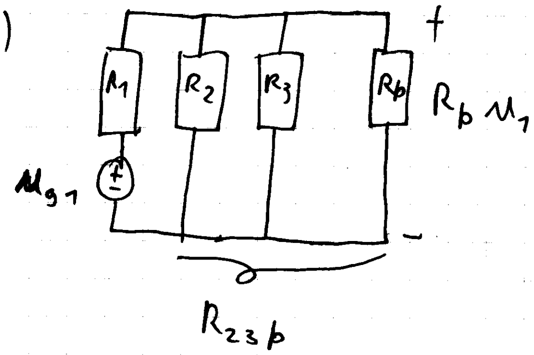
$R_b = 1\Omega$

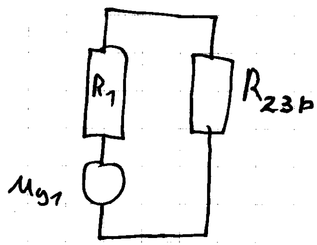
$u_{g1} = 10V \cdot \cos(0)$

$u_{g2} = 20V \cdot \cos(0)$

$u_{g3} = 10\cos(\omega t)V$

a.)



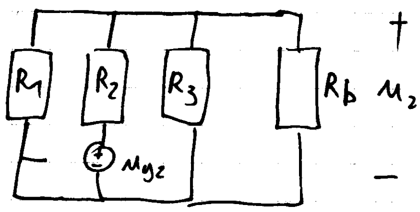


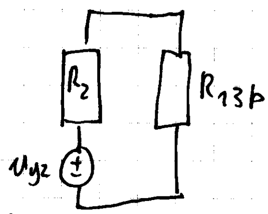
$$u_1 = \frac{R_{23b}}{R_1 + R_{23b}} \cdot u_{g1}$$

$$R_{23b} = \frac{R_2 R_3 R_p}{R_2 R_3 + R_2 R_p + R_3 R_p} = \frac{6}{11}\Omega$$

$$u_1 = \frac{60}{17} V$$

b.)





$$u_2 = \frac{R_{13b}}{R_2 + R_{13b}} u_{g2} =$$

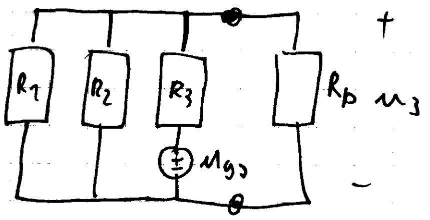
$$R_{13b} = \frac{R_1 R_3 R_3}{R_1 R_3 + R_1 R_p + R_3 R_p} = \frac{3}{7}\Omega$$

$$u_2 = \frac{60}{17} V$$

$$u_{12} = u_1 + u_2 = \frac{120}{17} V$$

$$P_{12} = u_{12}^2 / R_b = \left(\frac{120}{17}\right)^2 = 49{,}8W$$

c.) $P_3 = \frac{u_3^2}{R_p}$



$$u_3 = \frac{R_{12p}}{R_3 + R_{12p}} \cdot u_{g3}$$

$$R_{12p} = \frac{R_1 \cdot R_2 \cdot R_p}{R_1R_2 + R_1R_p + R_2R_p} = \frac{2}{5}\,\Omega$$

$$u_3 = \frac{\frac{2}{5}}{3 + \frac{2}{5}} \cdot 10 \cos(\omega t)$$

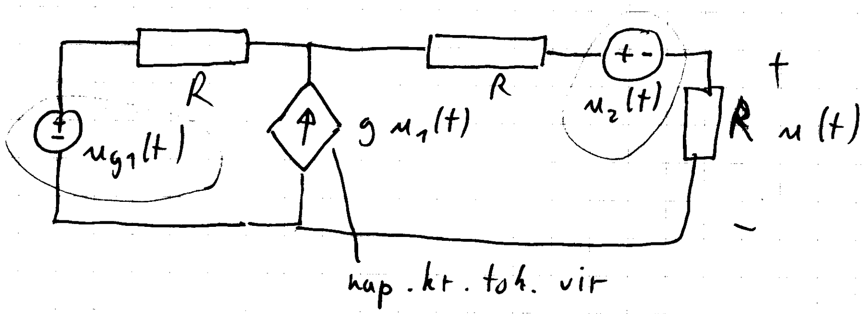
$$u_3 = \frac{20}{17} \cos(\omega t)\,V$$

$$P_3 = \frac{1}{2}\, U_{p_3} \cdot I_{p_3} \cdot \cos(\varphi) \quad ; \quad i_{p_3} = \frac{u_p}{R_p} = \frac{20}{17} \cdot \cos(\omega t)\,A$$

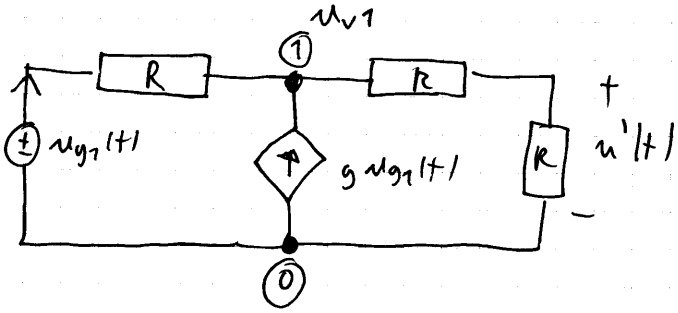
$$P_3 = \frac{1}{2}\, \frac{20}{17} \cdot \frac{20}{17} \cos(0) = \frac{1}{2} \left(\frac{20}{17}\right)^2 = 0{,}69\,W$$

$$P = P_{12} + P_3 = 50{,}5\,W$$

Napetost s pomočjo superpozicije!



a.)



$$1: \quad \frac{u_{V1}}{R} - \frac{u_{g1}}{R} - g\,u_{g1}(t) + \frac{u_{V1}}{2R} = 0$$

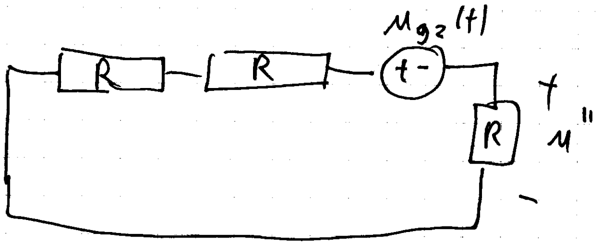
$$u_{V1} \cdot \left(\frac{1}{R} + \frac{1}{2R}\right) = \frac{u_{g1}(t)}{R} + g\,u_{g1}(t)$$

$$u_{V1}\,\frac{3}{2R} = u_{g1}(t)\left(\frac{1}{R} + g\right)$$

$$u_{V1} = \frac{2}{3}\left(u_{g1}(t) + gR\,u_{g1}(t)\right) \quad ; \quad u'(t) = \frac{1}{2}\,u_{V1}$$

$$u'(t) = \frac{1}{3}\left(u_{g1}(t) + gR\,u_{g1}(t)\right)$$

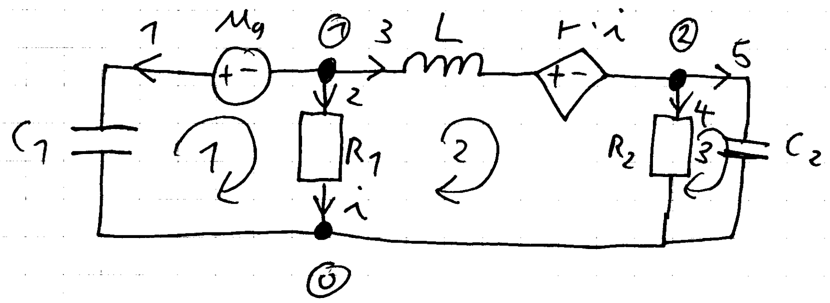
b.)



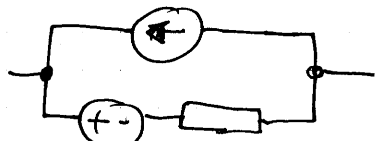
$$u'' = \frac{u_{g2}(t)}{3}$$

27.10.2008

Opis vezja



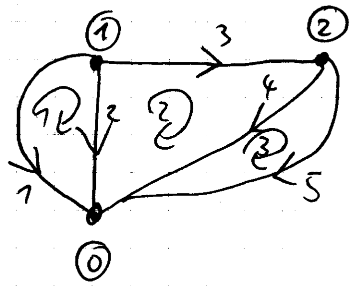
1. Izberi referenčno vozlišče 0

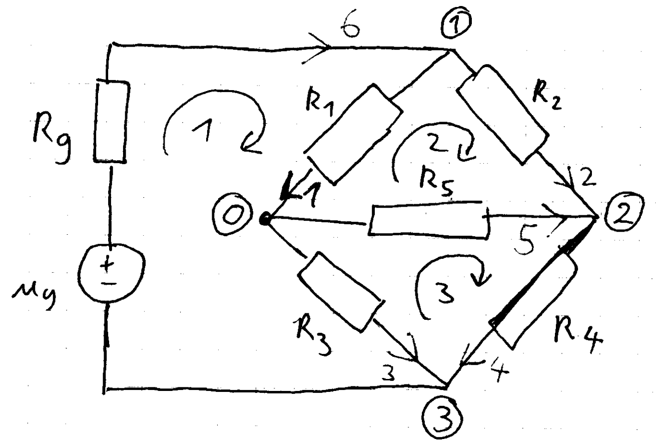


RILIC

2. Označimo/oštevilčimo ostala vozlišča
3. Označi smer vej
4. Označimo okna

Graf vezja





Vejna

- samo —(−+)—
- iščemo vejne tokove $i_1, i_2, i_3, \dots, i_n$
- Kirch. tokovne enačbe → vozlišča

  $\circ\!\leftarrow$ − $\circ\!\rightarrow$ +

- Kirch. napetostne enačbe po zankah

  $\rightrightarrows$ + $\rightleftarrows$ −

① $i_1+i_2-i_6=0$

② $-i_2+i_4-i_5=0$

③ $-i_3-i_4+i_6=0$

1 $R_1\cdot i_1+R_3\cdot i_3-u_g+R_g i_6=0$

2 $-R_1\cdot i_1+R_2\cdot i_2-R_5\cdot i_5=0$

3 $-R_3 i_3+R_4\cdot i_4+R_5\cdot i_5=0$

Zančna

- samo
- iščemo zančne tokove $i_{z1}, i_{z2}, i_{z3}, \dots i_{zn}$
- Kirc. napetostne enačbe po zankah

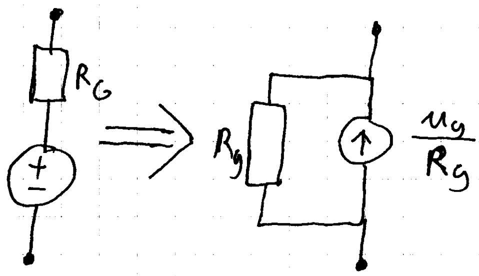
(1) $R_1(i_{z1}-i_{z2}) + R_3(i_{z1}-i_{z3}) \underline{-u_g} + R_g i_{z1} = 0$ $\qquad i_{z1} \nrightarrow i_{z2}, i_{z3}$

(2) $R_1(i_{z2}-i_{z1}) + R_2(i_{z2}) + R_5(i_{z2}-i_{z3}) = 0$ $\qquad i_{z2} \nrightarrow i_{z1}, i_{z3}$

(3) $R_3(i_{z3}-i_{z1}) + R_4 i_{z3} + R_5(i_{z3}-i_{z2}) = 0$ $\qquad i_{z3} \nrightarrow i_{z2}, i_{z1}$

Vozliščna

- samo



- iščemo vozliščne napetosti $u_{v1}, u_{v2}, \dots u_{vn}$
- Kirch. tokovne enačbe po vozliščih

(1) $\frac{u_{v1}}{R_1} + \frac{u_{v1}-u_2}{R_2} - \frac{u_g}{R_g} + \frac{u_{v1}-u_{v3}}{R_g} = 0$ $\qquad u_{v1} \nrightarrow u_{v2}, u_{v3}$

(2) $\frac{u_{v2}-u_{v1}}{R_2} + \frac{u_{v2}}{R_5} + \frac{u_{v2}-u_{v3}}{R_4} = 0$ $\qquad u_{v2} \nrightarrow u_{v1}, u_{v3}$

(3) $\frac{u_{v3}}{R_3} + \frac{u_{v3}-u_{v2}}{R_4} + \frac{u_g}{R_g} + \frac{u_{v3}-u_{v1}}{R_g} = 0$ $\qquad u_{v3} \nrightarrow u_{v1}, u_{v2}$

Enako vezje kot prej. Izračunaj tok skozi upor R_5!

1. $R_1(i_{z1}-i_{z2})+R_3(i_{z1}-i_{z3})-u_g+R_g i_{z1}=0$
2. $R_1(i_{z2}-i_{z1})+R_2(i_{z2})+R_5(i_{z2}-i_{z3})=0$
3. $R_3(i_{z3}-i_{z1})+R_4(i_{z3})+R_5(i_{z3}-i_{z2})=0$

$R=1\,\Omega$
$u_g=10\ V$

$$i_{z1}(R_1+R_3+R_g)-i_{z2}R_1-i_{z3}\cdot R_3=u_g$$
$$-i_{z1}R_1+i_{z2}(R_1+R_2+R_5)-i_{z3}R_5=0$$
$$-i_{z1}R_3-i_{z2}R_5+i_{z3}(R_3+R_4+R_5)=0$$

$$3i_{z1}-i_{z2}-i_{z3}=10$$
$$\left.\begin{array}{l}-i_{z1}+3i_{z2}-i_{z3}=0\\ -i_{z1}-i_{z2}+3i_{z3}=0\end{array}\right\} - \quad (4i_{z2}-4i_{z3})=0$$
$$i_{z2}=i_{z3}$$

$$3\cdot i_{z1}-2i_{z2}=10$$
$$i_{z1}=\frac{10+2i_{z2}}{3}$$
$$-\frac{10+2i_{z2}}{3}-i_{z2}+3i_{z2}=0\ /\cdot 3$$
$$-10-2i_{z2}-3i_{z2}+9i_{z2}=0$$
$$-10=-4i_{z2}$$
$$i_{z2}=\frac{5}{2}\,A=i_{z3}\qquad i_{z1}=5\,A$$

$$i_5=i_{z3}-i_{z2}=0\,A$$

Reducirana vpadna: Enako vezje kot prej

$$\begin{array}{c|c} \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & -1 \\ 0 & -1 & 0 & 1 & -1 & 0 \\ 0 & 0 & -1 & -1 & 0 & 1 \end{bmatrix} & \text{VOZLIŠČA} \\ \text{VEJE} & \end{array}$$

veje v/iz vozlišča

0 - ne stika
1 - stika

Reducirana matrika mreže

$$\begin{array}{c|c} \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 1 \\ -1 & 1 & 0 & 0 & -1 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 \end{bmatrix} & \text{ZANKE} \\ \text{VEJE} & \end{array}$$

zanka - veja

1 - soupada
-1 - nasprotuje

Matrika tokovih operatorjev

$$\begin{array}{c|c} \begin{bmatrix} R_1 & & & & 0 & \\ & R_2 & & & & \\ & & R_3 & & & \\ & & & R_4 & & \\ & 0 & & & R_5 & \\ & & & & & R_6 \end{bmatrix} & \text{Napetost veje} \\ \text{Tok veje} & \end{array}$$

Napetostni operatorji

$$\begin{array}{c|c} \begin{bmatrix} \frac{1}{R} & & & & 0 & \\ & \frac{1}{R_2} & & & & \\ & & \frac{1}{R_3} & & & \\ & & & \frac{1}{R_4} & & \\ & 0 & & & \frac{1}{R_5} & \\ & & & & & \frac{1}{R_6} \end{bmatrix} & \text{Tok veje} \\ \text{Napetost veje} & \end{array}$$

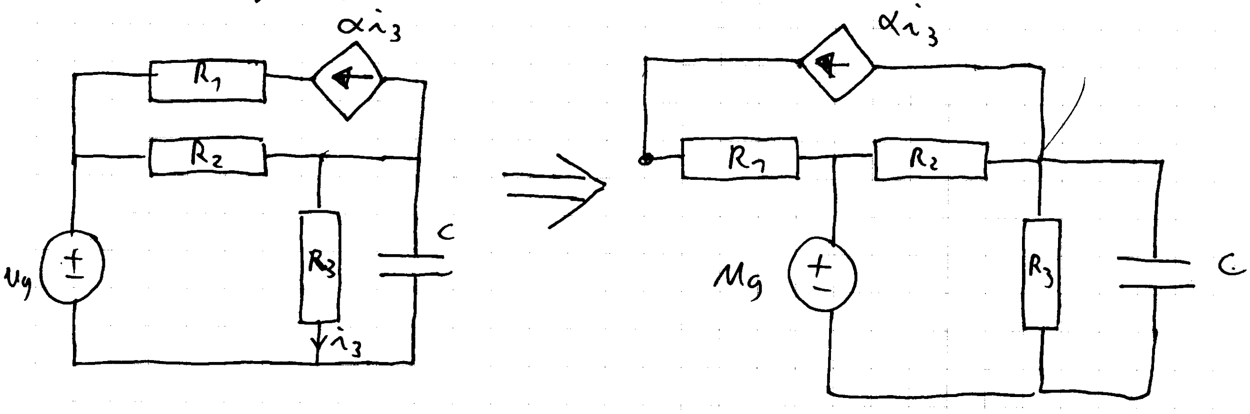
Napetostno in tokovno vzbujana vektorja

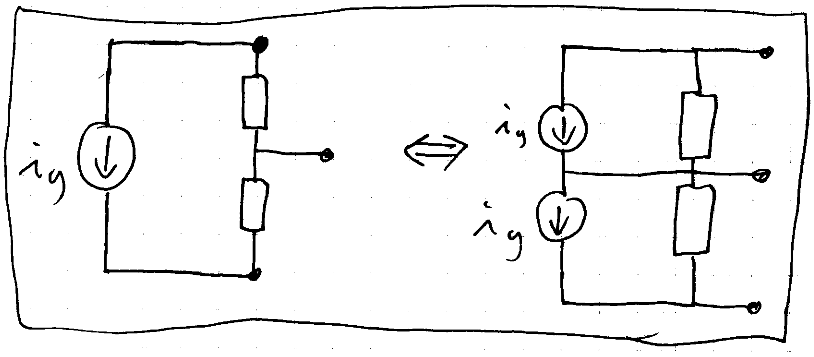
$$i_g = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \qquad u_g = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ u_g \end{bmatrix}$$

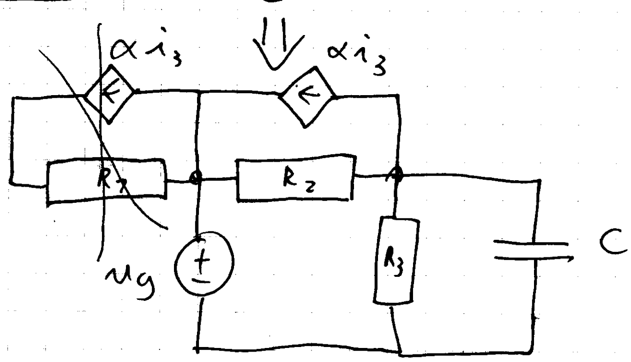
$$M\cdot Z(D)\cdot M^T=\begin{bmatrix} R_1+R_3+R_9 & -R_1 & -R_3 \\ -R_1 & R_1+R_2+R_5 & -R_5 \\ -R_3 & -R_5 & R_3+R_4+R_5 \end{bmatrix}$$

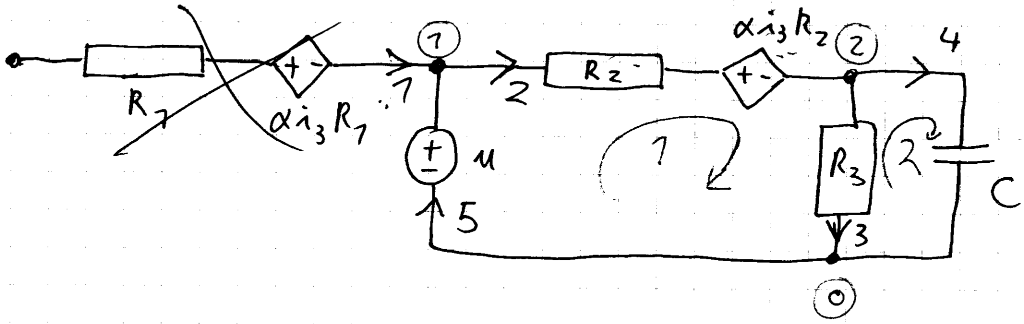
$$A\,Y(D)\,A^T=\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_9} & -\frac{1}{R_2} & -\frac{1}{R_9} \\ -\frac{1}{R_2} & \frac{1}{R_2}+\frac{1}{R_4}+\frac{1}{R_5} & -\frac{1}{R_4} \\ -\frac{1}{R_9} & -\frac{1}{R_4} & \frac{1}{R_3}+\frac{1}{R_4}+\frac{1}{R_9} \end{bmatrix}$$ Dalje.

Opiši vezje po vseh treh metodah.









$i_2 = i_5$

Vejna

$\alpha i_3 R_2$

$$① \quad i_2 - i_5 = 0$$

$$② \quad -i_2 + i_3 + i_4 = 0$$

$$1^Z \quad -u_g + R_2 i_2 + \alpha i_3 R_2 + R_3 \cdot i_3 = 0$$

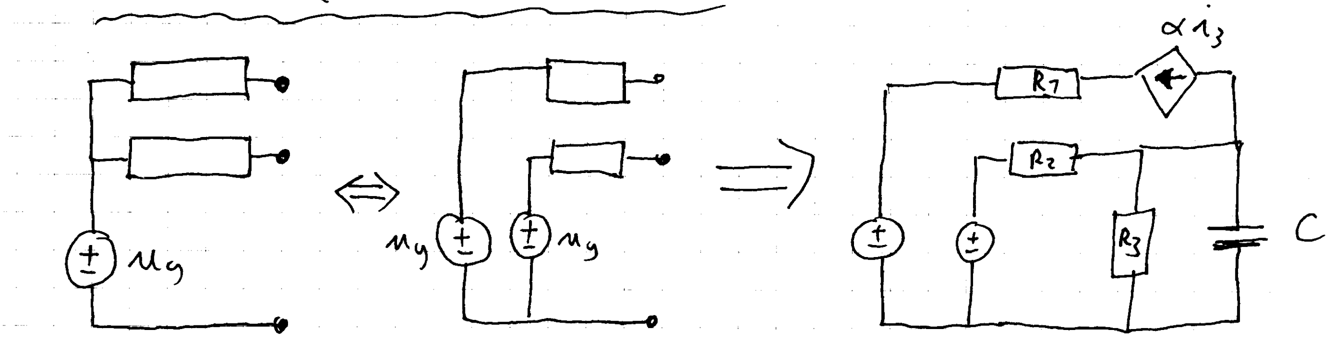
$$2^Z \quad -R_3 i_3 + \frac{1}{CD} i_4 = 0$$

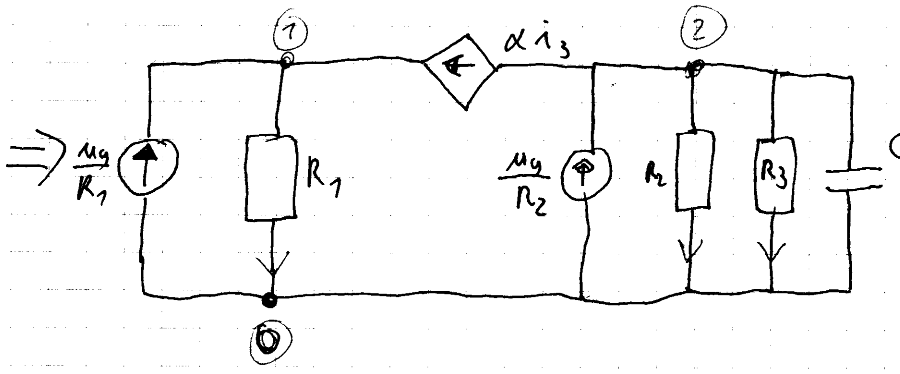
Zanka

$$\alpha i_3 R_2 = \alpha R_2 (i_{z1} - i_{z2})$$

$$1^Z \quad -u_g + R_2 i_{z2} + \alpha R_2 (i_{z1} - i_{z2}) + R_3 (i_{z1} - i_{z2})$$

$$2^Z \quad R_3 (i_{z2} - i_{z1}) + \frac{1}{CD} i_{z2} = 0$$





$$i_3 = \frac{u_{v2}}{R_3} \qquad \alpha i_3 \Rightarrow \alpha \frac{u_{v2}}{R_3}$$

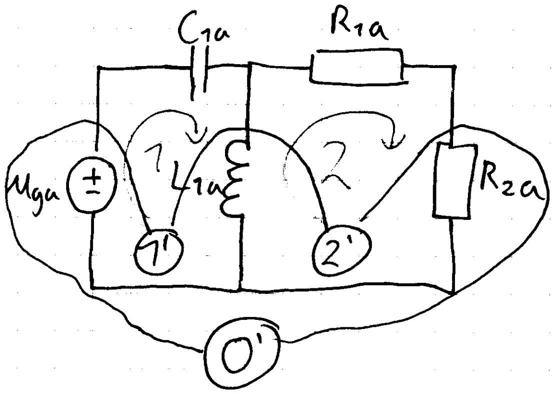
$$① \quad -\frac{u_g}{R_1} + \frac{u_{v1}}{R_1} - \alpha \frac{u_{v2}}{R_3} = 0$$

$$② \quad \alpha \frac{u_{v2}}{R_3} - \frac{u_g}{R_2} + \frac{u_{v2}}{R_2} + \frac{u_{v2}}{R_3} + CD u_{v2} = 0$$

$R \leftrightarrow G$ okno $\leftrightarrow$ vozlišče

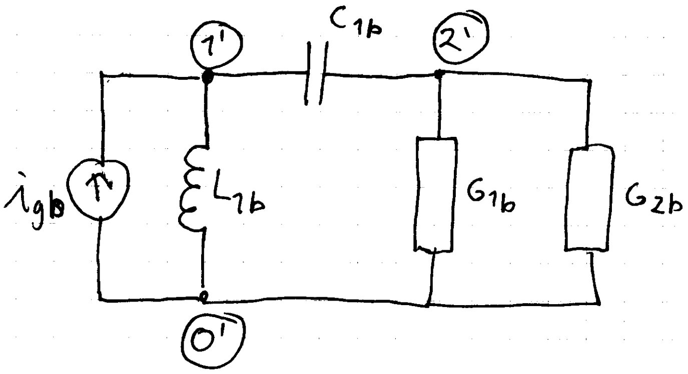
$C \leftrightarrow L$ zaporedna $\leftrightarrow$ vzporedna

$u \leftrightarrow i$



$$\text{(1)} \quad -u_{ga} + \frac{1}{C_{1a}D} i_{z1} + L_{1a} D (i_{z1} - i_{z2}) = 0$$

$$\text{(2)} \quad L_{1a} D (i_{z2} - i_{z1}) + R_{1a} i_{z2} + R_{2a} i_{z1} = 0$$



$R_{1a} \Leftrightarrow G_{1b}$

$R_{2a} \Leftrightarrow G_{2b}$

$L_{1a} \Leftrightarrow C_{1b}$

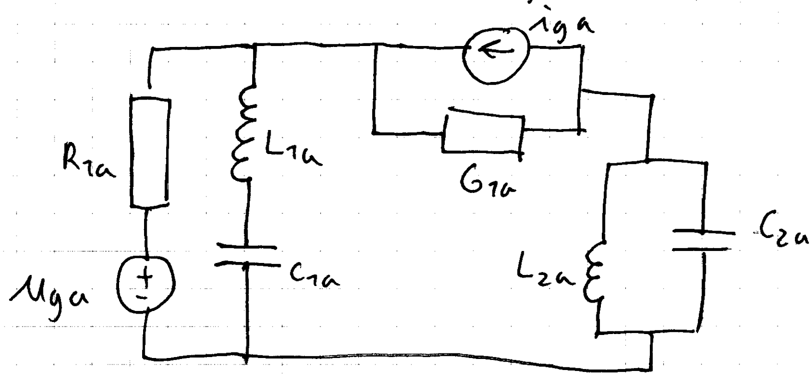
$C_{1a} \Leftrightarrow L_{1b}$

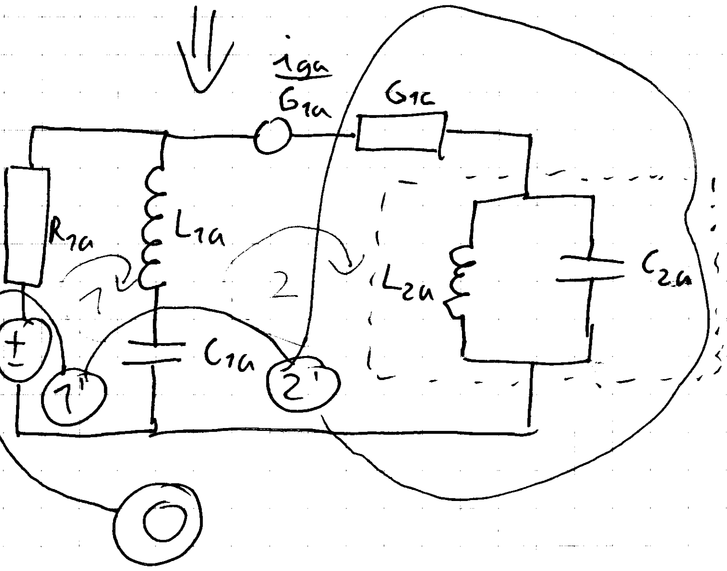
$u_{ga} \Leftrightarrow i_{gb}$

$$\text{(1')} \quad -i_{gb} + \frac{1}{L_{1b}D} u_{v1} + C_{1b} D (u_{v1} - u_{v2}) = 0$$

$$\text{(2')} \quad C_{1b} D (u_{v2} - u_{v1}) + G_{1b} u_{v2} + G_{2b} u_{v2} = 0$$

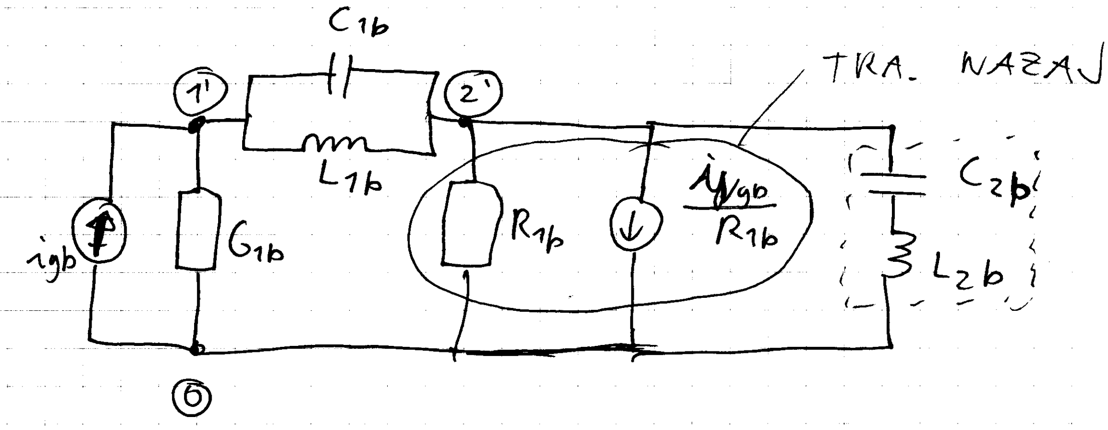
Poišči dualno vezje in poišči dualnost sistema enačb.





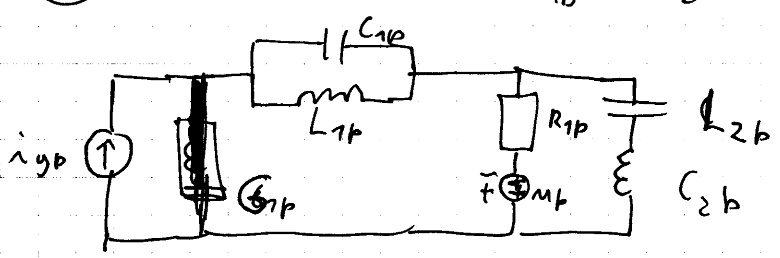
1': $-u_{ga} + R_{1a} i_{z1} + L_{1a} D (i_{z1} - i_{z2}) + \frac{1}{C_{1a} D}(i_{z1} - i_{z2}) = 0$

2': $L_{1a} D(i_{z2} - i_{z1}) + \frac{1}{C_{1a} D}(i_{z2} - i_{z1}) + \frac{i_{ga}}{G_{1a}} + \frac{i_{z2}}{G_{1a}} + Z i_{z2} = 0$



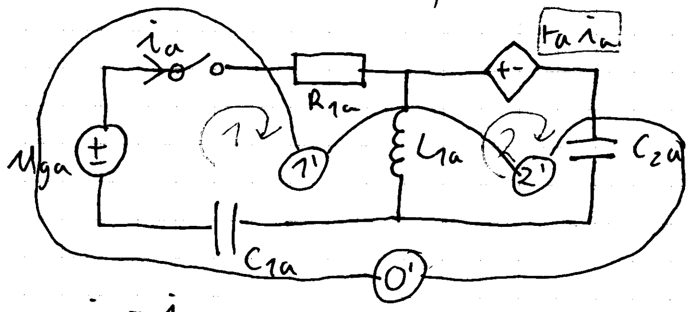
1': $-i_{gb} + u_{v1} G_{1b} + C_{1b} D (u_{v1} - u_{v2}) + \frac{1}{L_{1b} D}(u_{v1} - u_{v2}) = 0$

2': $C_{1b} D (u_{v2} - u_{v1}) + \frac{1}{L_{1b} D}(u_{v2} - u_{v2}) + \frac{u_{gb}}{R_{1b}} + \frac{u_{v2}}{R_{1b}} + Y u_{v2} = 0$

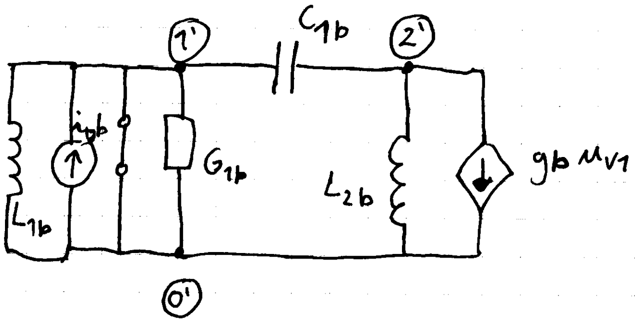


03.11.2008

Poišči dualno vezje.

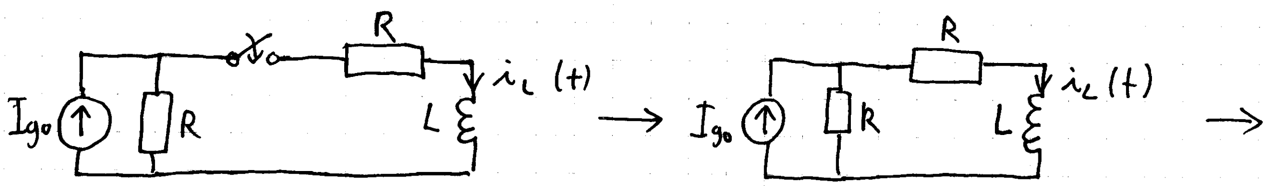


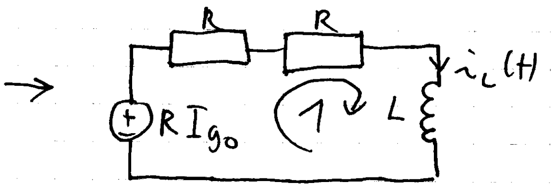
$i_a = i_{z1}$



Klasična analiza

zapiši DE za $t \geq 0$ s



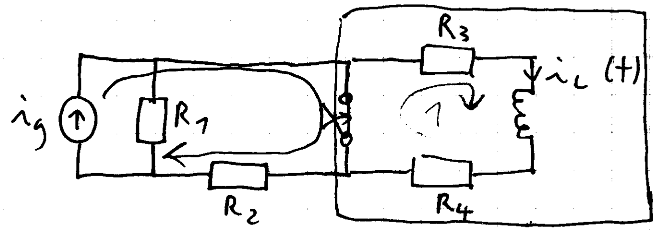


$i_L(t) = i_{z1}$

1: $-RI_{g0} + Ri_{z1} + Ri_{z1} + LDi_{z1} = 0$

$$\underline{LDi_{z1} + 2Ri_{z1} = RI_{g0}}$$

Zapiši DE $t \geq 0s$

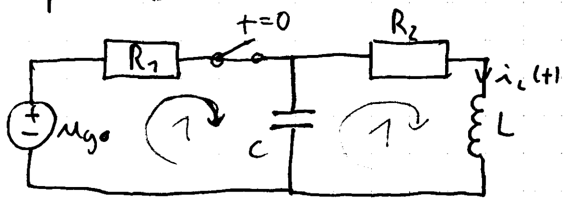


$1: \; R_3 i_{z1} + R_4 i_{z1} + LD i_{z1} = 0$

$i_L(t) = i_{z1}$

$\underline{LD i_{z1} + (R_3 + R_4)\cdot i_{z1} = 0}$

Zapiši DE $t \geq 0s$



$i_L(t) = i_{z2}$

$1: \; -u_{g0} + R_1 i_{z1} + \frac{1}{CD}(i_{z1} - i_{z2}) = 0$

$2: \; \frac{1}{CD}(i_{z2} - i_{z1}) + R_2 i_{z2} + LD i_{z2} = 0$

$i_{z1}\left(R_1 + \frac{1}{CD}\right) = u_{g0} + i_{z2}\cdot\frac{1}{CD} \quad /\cdot CD$

$i_{z1}(R_1 CD + 1) = CD\, u_{g0} + i_{z2}$

$i_{z1} = \frac{CD\, u_{g0} + i_{z2}}{1 + R_1 CD}$

$\frac{1}{CD}(i_{z2}) + i_{z2}(R_2 + LD) - \frac{1}{CD}\left(\frac{CD u_{g0} + i_{z2}}{1 + R_1 CD}\right) = 0$

$\frac{1}{CD} i_{z2} - \frac{1}{CD}\frac{i_{z2}}{1 + R_1 CD} + i_{z2}(R_2 + LD) = \frac{1}{\cancel{CD}}\frac{\cancel{CD} u_{g0}}{1 + R_1 CD}$

$\frac{i_{z2}(1 + R_1 CD) - i_{z2}}{CD(1 + R_1 CD)} + i_{z2}(R_2 + LD) = \frac{u_{g0}}{1 + R_1 CD}$

$\frac{\cancel{i_{z2}} + i_{z2} R_1 \cancel{CD} - \cancel{i_{z2}}}{\cancel{CD}(1 + R_1 CD)} + i_{z2}(R_2 + LD) = \frac{u_{g0}}{1 + R_1 CD}$

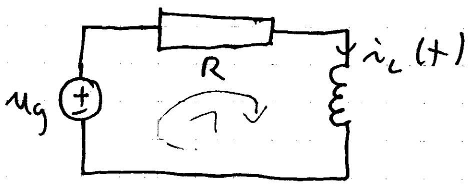
$\frac{i_{z2} R_1}{1 + R_1 CD} + i_{z2}(R_2 + CD) = \frac{u_{g0}}{1 + R_1 CD} \quad /\cdot(1 + R_1 CD)$

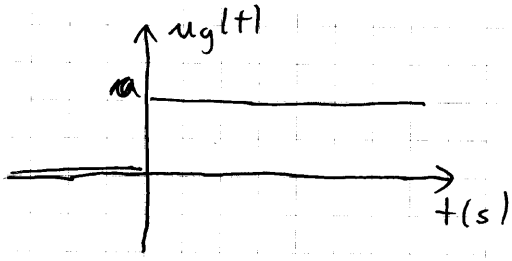
$i_{z2} R_1 + i_{z2}(R_2 + CD)(1 + R_1 CD) = u_{g0}$

$\underline{R_1 LCD^2 i_{z2} + (L + R_1 R_2 C) D i_{z2} + (R_1 + R_2) i_{z2} = u_{g0}}$

Akta

Izračunaj in nariši $i_L(t)$





1) $-u_g + R_1 i_{z1} + LD i_{z1} = 0$

$i_L = i_{z1}$

$LD i_L + R i_L = u_g$

$t<0 \quad i_L(t) = 0$

a) <u>Homogena</u>

$LD i_L + R i_L = 0$ $\quad \boxed{i_H(t) = K \cdot e^{pt}}$

$Lp + R = 0$ $\quad$ - kar. pol.

$p = -\frac{R}{L}$

$i_H(t) = K \cdot e^{-\frac{R}{L}t}$

b) <u>Partikularni del</u>

$i_p(t) = k$

$LD i_p(t) + R i_p(t) = a$

$\underset{0}{LDk} + Rk = a$

$Rk = a$

$k = \frac{a}{R}$

$i_p(t) = \frac{a}{R}$

c) <u>Določi konstanto</u>

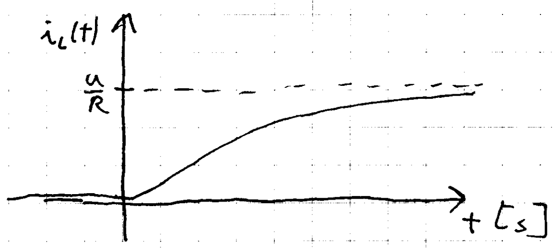
$i_L(t) = i_H(t) + i_p(t) = K e^{-\frac{R}{L}t} + \frac{a}{R}$

začetni pogoj: $i_L(t<0_s) = 0\,A \quad i_L(t<0_s) = i_L(0_s)$

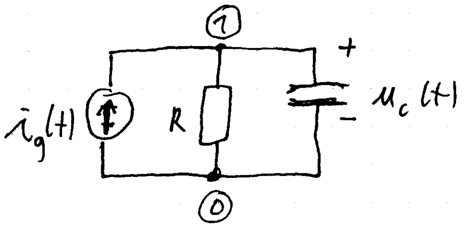
$i_L(0) = K + \frac{a}{R} = 0 \; ; \; K = -\frac{a}{R}$

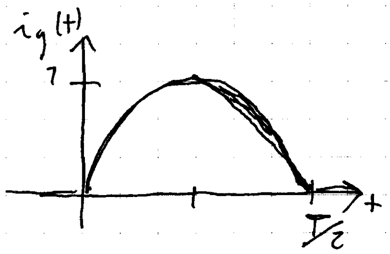
$$i_L(t) = \frac{a}{R} - \frac{a}{R} e^{-\frac{R}{L}t}$$

$$i_L(t) = \frac{a}{R}\left(1 - e^{-\frac{R}{L}t}\right)$$



Izračunaj $u_C(t)$.





$$i_g(t) = \begin{cases} 0, & t < 0\,s \\ \sin(\omega t), & t \in [0, T/2] \\ 0, & t > T/2 \end{cases}$$

(1) $-i_g(t) + \frac{u_{V1}}{R} + C D u_{V1} = 0$

$u_C(t) = u_{V1}$ $\qquad\qquad t < 0 \quad u_C(t) = 0$

$C D u_C(t) + \frac{1}{R} u_C(t) = i_g(t)$

a) Homogeni del

$C D u_C(t) + \frac{1}{R} u_C(t) = 0$

$u_C(t) = K e^{pt}$; $Cp + \frac{1}{R} = 0$; $p = -\frac{1}{RC}$

$u_C(t) = K e^{-\frac{t}{RC}}$

b) Partikularni del $\qquad t \in [0, T/2] \Rightarrow i_g \neq 0$

$i_g(t) = \sin(\omega t)$; $u_{Cp}(t) = a\sin(\omega t) + b\cos(\omega t)$

$C D u_{Cp}(t) + \frac{1}{R} u_{Cp}(t) = \sin(\omega t)$

$C \cdot (a\omega\cos(\omega t) - b\omega\sin(\omega t)) + \frac{1}{R}(a\sin(\omega t) + b\cos(\omega t)) = \sin(\omega t)$

$(a\omega + \frac{b}{RC})\cos(\omega t) + (\frac{a}{RC} - b\omega)\sin(\omega t) = \frac{1}{C}\sin(\omega t)$

$a\omega + \frac{b}{RC} = 0 \qquad \frac{a}{RC} - b\omega = \frac{1}{C}$

$a\omega = -\frac{b}{RC}$

$a = -\frac{b}{\omega RC} \qquad \frac{-\frac{b}{\omega RC}}{RC} - b\omega = \frac{1}{C} \Rightarrow -\frac{b}{\omega R^2C^2} - b\omega = \frac{1}{C}$

$b\left(-\frac{1}{\omega R^2C^2} - \omega\right) = \frac{1}{C}$

$a = -\frac{-\frac{\omega R^2 C}{1+\omega^2R^2C^2}}{\omega RC} = \frac{R}{1+\omega^2R^2C^2} \qquad b = \frac{-\omega R^2 C}{1+\omega^2R^2C^2}$

Akta

$$u_{cp}(t) = \frac{R}{1+w^2R^2C^2}\sin(wt) - \frac{wR^2C}{1+w^2R^2C^2}\cos(wt)$$

$t \in [0, T/2]$

$$u_H(0) + u_p(0) = 0$$

$$K - \frac{wR^2C}{1+w^2R^2C^2} = 0$$

$$\underline{\underline{k = \frac{wR^2C}{1+w^2R^2C^2}}}$$

$t > T/2 \rightarrow u_p = 0$

$$u_H(T/2) = K e^{-\frac{t}{2RC}} = \frac{wR^2C}{1+w^2R^2C^2}\left(wRCe^{-\frac{t}{2RC}} - 1\right)$$

$$K = \frac{w^2R^2C}{1+w^2R^2C^2}\left(1 - e^{\frac{T}{2RC}}\right)$$

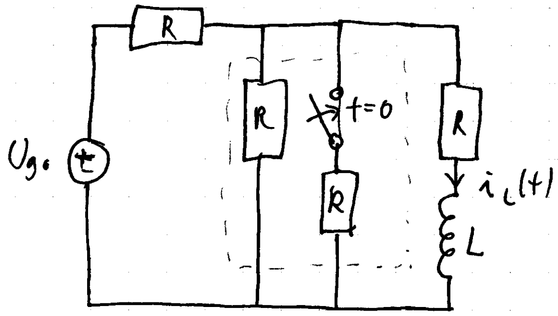
$t < 0s \quad u_c(t) = 0$

$t \in [0, T/2] \quad u_c(t) = \frac{R}{1+w^2R^2C^2}\left(wRCe^{-\frac{t}{RC}} + \sin(wt) - wRC \cdot \cos(wt)\right)$

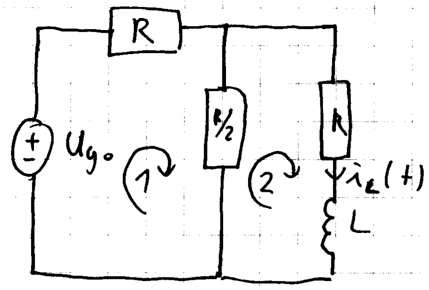
$t > T/2 \quad u_c(t) = \frac{wR^2C}{1+w^2R^2C^2}\left(1 - e^{-\frac{T}{2RC}}\right) \cdot e^{-\frac{t}{RC}}$

10.11.2008

Kakšen je tok skozi tuljavo



$\Rightarrow$



$$(1)\quad -U_{g0} + R i_{z1} + \frac{R}{2}(i_{z1} - i_{z2}) = 0$$

$$i_L(t) = i_{z2}$$

$$(2)\quad \frac{R}{2}(i_{z2} - i_{z1}) + R\, i_{z2} + LD\, i_{z2} = 0$$

$$\frac{3R}{2} i_{z1} - \frac{R}{2} i_{z2} - U_{g0} = 0$$

$$\frac{3R}{2} i_{z1} = \frac{R}{2} i_{z2} + U_{g0} \quad / \cdot \frac{2}{3R}$$

$$\underline{i_{z1} = \frac{1}{3} i_{z2} + \frac{2}{3R} U_{g0}}$$

$$\frac{3R}{2} i_{z2} + L D_{i_{z2}} - \frac{R}{2} i_{z1} = 0$$

$$\frac{3R}{2} i_{z2} + LD\, i_{z2} - \frac{R}{2}\left(\frac{1}{3} i_{z2} + \frac{2}{3R} U_{g0}\right) = 0$$

$$\frac{3R}{2} i_{z2} + LD\, i_{z2} - \frac{R}{6} i_{z2} - \frac{U_{g0}}{3} = 0$$

$$\frac{9R-R}{6} i_{z2} + L D_{i_{z2}} = \frac{U_{g0}}{3}$$

$$\frac{4}{3}\cancel{\frac{8R}{6}} i_{z2} + L D_{i_{z2}} = \frac{U_{g0}}{3} \quad / \cdot 3$$

$$3 \cdot L D_{i_{z2}} + 4R\, i_{z2} = U_{g0}$$

a) Homogeni

$$3LD i_L + 4R i_L = 0 \quad ; \quad i_H(t) = K \cdot e^{pt}$$

$$3Lp + 4R = 0$$

$$p = -\frac{4R}{3L}$$

Akta

b) Partikularni

$$3LDi_L + 4Ri_L = U_{go} \quad ; \quad i_p(t) = n$$

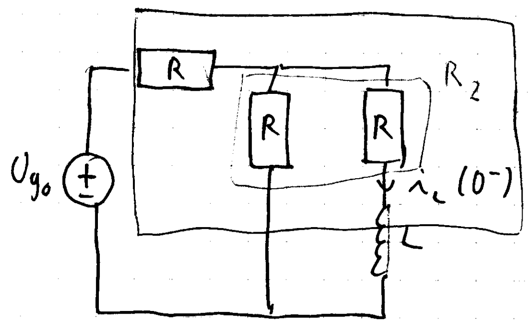
$$\underbrace{3LDn}_{=0} + 4Rn = U_{go}$$

$$n = \frac{U_{go}}{4R}$$

$$i_L(t) = K \cdot e^{-\frac{4R}{3L}t} + \frac{U_{go}}{4R}$$

c) Posebna rešitev - začetni pogoj!

$$i_L(0) = i_L(0^-)$$

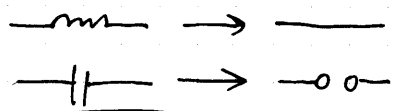


$\frac{3R}{2}$

$$i = \frac{U_{go}}{\frac{3R}{2}} = \frac{2}{3R} U_{go}$$

$$i_L(0^-) = \frac{1}{3R} U_{go} \quad \text{(tok razpolovi)}$$

Zač. pogoj / stacionarno stanje

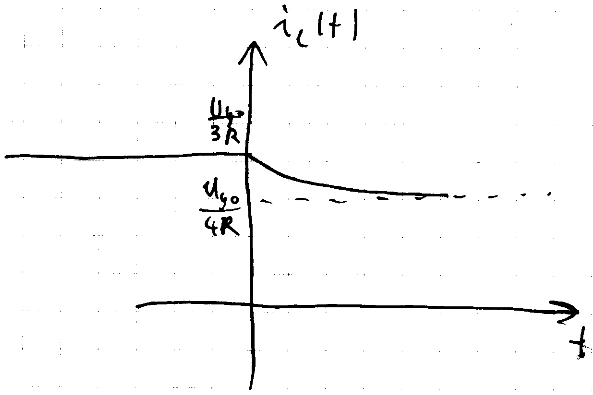


$$i_L(0^-) = i_L(0)$$

$$\frac{U_{go}}{3R} = K \cdot e^0 + \frac{U_{go}}{4R}$$

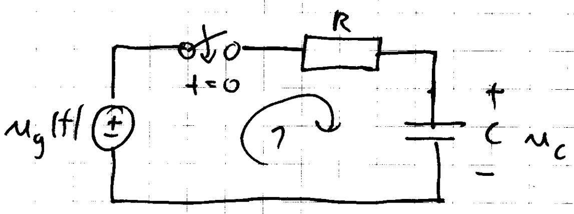
$$\frac{4U_{go} - 3U_{go}}{12R} = K \Rightarrow \underline{K = \frac{U_{go}}{12R}}$$

$$i_L(t) = \frac{U_{go}}{12R} \cdot e^{-\frac{4R}{3L}t} + \frac{U_{go}}{4R}$$



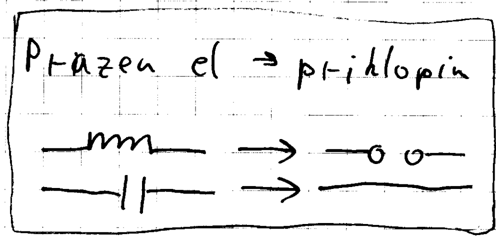
Določi začetne pogoje $u_c(0)$, $i_c(0)$, $Di_c(0)$. $u_g(t) = U_{g0} \cdot \cos(\omega t)$

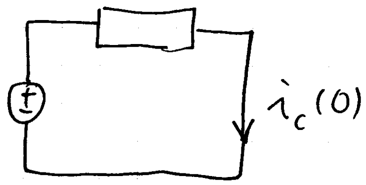
$u_c(0) = u_c(0^-) = \underline{\underline{0\,V}}$



$i_c(0) =$

$Di_c(0) =$





$$i_c(0) = \frac{u_g(t)}{R} = \underline{\underline{\frac{U_{g0}}{R}\cos(\omega \cdot 0)}}$$

$$(1)\quad -u_g(t) + R i_{z1} + \frac{1}{CD} i_{z1} = 0 \quad / \cdot \frac{D}{R}$$

$$-\frac{D}{R} u_g(t) + D i_{z1} + \frac{1}{RC} i_{z1} = 0$$

$t=0$

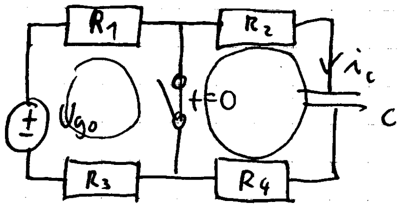
$$-\frac{D}{R} u_g(0) + D i_{z1}(0) + \frac{1}{RC} \underbrace{i_{z1}(0)}_{\frac{U_{g0}}{R}} = 0$$

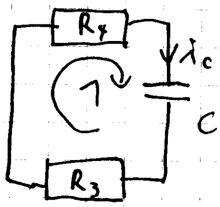
$$-\frac{U_{g0}}{R}\omega \sin(0) + D i_{z1}(0) + \frac{1}{R^2 C} \cdot U_{g0} = 0$$

$$D i_{z1}(0) = -\frac{1}{R^2 C} U_{g0}$$

Izračunaj tok kondenzatorja!

$i_c(t) = ?$ $\qquad t \geq 0\,s$





$$R_3 i_z + R_4 i_z + \frac{1}{CD} i_z = 0 \,/\cdot CD \qquad i_c(t) = i_z$$

$$(R_3 + R_4)\cdot CD\, i_c + i_c = 0$$

a.) Homogeni

$$(R_3 + R_4)\cdot CD\, i_c + i_c = 0$$

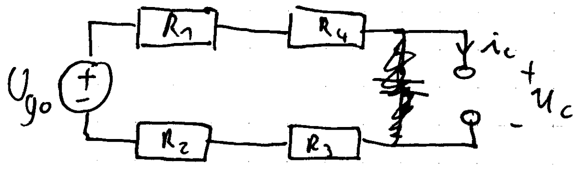
$$i_H(t) = K \cdot e^{pt}$$

$$(R_3 + R_4)Cp + 1 = 0$$

$$p = \frac{-1}{(R_3 + R_4)\cdot C}$$

$$i_c(t) = K \cdot e^{-\frac{t}{(R_3+R_4)\cdot C}}$$

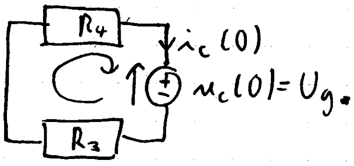
Začetni pogoj



$$i_c(0^-) = 0 \neq i_c(0)$$

$$u_c(0^-) = U_{g0} = u_c(0)$$

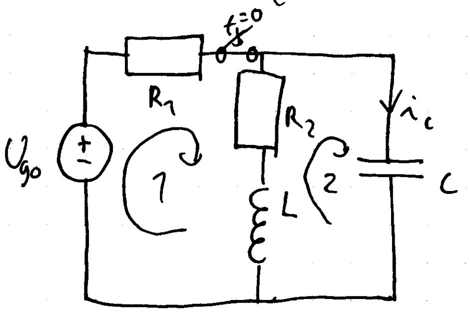
$t = 0$



$$i_{z1} = \frac{U_{g0}}{R_3 + R_4} \qquad \underline{i_c(0) = -\frac{U_{g0}}{R_3 + R_4}}$$

$$i_c(0) = K \cdot e^0 = -\frac{U_{g0}}{R_3 + R_4} \Rightarrow i_c(t) = -\frac{U_{g0}}{R_3 + R_4} \cdot e^{-\frac{t}{(R_3+R_4)\cdot C}}$$

Določi $i_C(t)$.



$u_C(0)=0V$

$i_L(0)=0A$

$R_1=500\Omega$

$R_2=1,5k\Omega$

$C=5pF$

$L=10\mu H$

$U_g=1V$

1: $-U_{g0}+R_1 i_{z1}+R_2(i_{z1}-i_{z2})+LD(i_{z1}-i_{z2})=0$

2: $LD(i_{z2}-i_{z1})+R_2(i_{z2}-i_{z1})+\frac{1}{CD}i_{z2}=0$

$\underline{i_C(t)=i_{z2}}$

1 + 2: $-U_{g0}+R_1 i_{z1}+\frac{1}{CD}i_{z2}=0$

$$R_1 i_{z1}=U_{g0}-\frac{1}{CD}i_{z2}$$

$$i_{z1}=\frac{U_{g0}}{R_1}-\frac{1}{R_1CD}i_{z2}$$

$$i_{z2}\left(LD+R_2+\frac{1}{CD}\right)-i_{z1}(R_2+LD)=0$$

$$i_{z2}\left(LD+R_2+\frac{1}{CD}\right)-\left(\frac{U_{g0}}{R_1}-\frac{i_{z2}}{R_1CD}\right)(R_2+LD)=0$$

$$i_{z2}\left(LD+R_2+\frac{1}{CD}\right)-\frac{R_2}{R_1}U_{g0}-\underbrace{\cancel{\frac{LDU_{g0}}{R_1}}}_{=0}+\frac{R_2}{R_1CD}i_{z2}+\frac{LD}{R_1CD}i_{z2}=0$$

$$i_{z2}\left(\frac{LCD^2+R_2CD+1}{CD}+\frac{R_2}{R_1CD}+\frac{LD}{R_1CD}\right)=\frac{R_2}{R_1}U_{g0}\quad /\cdot R_1CD$$

$$i_{z2}(R_1LCD^2+R_1R_2CD+R_1+R_2+LD)=R_2\underbrace{C\cancel{D}U_{g0}}_{=0}$$

$$\underbrace{R_1LCD^2}_{a_2}i_{z2}+\underbrace{(R_1R_2C+L)D}_{a_1}i_{z2}+\underbrace{(R_1+R_2)}_{a_0}i_{z2}=0$$

$a_2=2,5\cdot10^{-14}\,\frac{Vs^2}{A}$ $\quad a_1=13,75\cdot10^{-6}\,\frac{Vs}{A}$ $\quad a_0=2k\Omega$

a) Homogeni

$$a_2 p^2 + a_1 p + a_0 = 0 \qquad i_H(t) = K_1 \cdot e^{p_1 t} + K_2 e^{p_2 t}$$

$$p_{1,2} = \frac{a_1 \pm \sqrt{a_1^2 - 4a_2 a_0}}{2a_2}$$

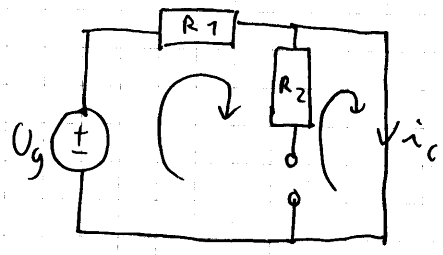
$$p_1 = -275 \cdot 10^6 + j\, 66{,}14 \cdot 10^7 \ 1/s$$

$$p_2 = \underbrace{-275 \cdot 10^6}_{\delta} - j\, \underbrace{66{,}14 \cdot 10^7}_{\omega} \ 1/s$$

b) Posebna rešitev

$$i_c(0) = \frac{U_{g0}}{R_1}$$

$$Di_c(0) = -\frac{U_{g0}}{R_1^2 C}$$



① + ②

$$-U_g + R \cdot i_{z1} + \frac{1}{CD} i_{z2} = 0 \quad / \cdot CD$$

$$\underbrace{-CD\,U_g}_{=0} + R\,CD\,i_{z1} + i_{z2} = 0$$

$$Di_{z1} = -\frac{i_{z2}}{R_1 C} \quad ; \quad i_{R_2} = 0 = i_{z1} - i_{z2} \Rightarrow i_{z1} = i_{z2}$$

$$Di_{z2}(0) = -\frac{i_{z2}(0)}{R_1 C} = -\frac{U_{g0}}{R_1^2 C}$$

$$i_c(0) = K_1 e^0 + K_2 e^0 = \frac{U_{g0}}{R_1} \quad ; \quad K_1 + K_2 = \frac{U_{g0}}{R_1} \quad ; \quad K_2 = \frac{U_{g0}}{R_1} - K_1$$

$$Di_c(0) = K_1 p_1 e^0 + K_2 p_2 e^0 = -\frac{U_{g0}}{R_1^2 C}$$

$$K_1 \cdot p_1 + p_2 \left(\frac{U_{g0}}{R_1} - K_1\right) = -\frac{U_{g0}}{R_1^2 C}$$

$$K_1 (p_1 - p_2) = -\frac{U_{g0}}{R_1^2 C} - \frac{p_2}{R_1} U_{g0}$$

$$K_1 = 0{,}001 + j\, 0{,}019$$

$$K_2 = K_1^* = 0{,}001 - j\, 0{,}019$$

$$i_C(t) = K_1 e^{p_1 t} + K_2 e^{p_2 t}$$

$$= e^{\delta t}\left(K_1 e^{j\omega t} + K_1^{*} e^{-j\omega t}\right)$$

$$= e^{\delta t}\cdot 2\, Re\left(K_1 \cdot e^{j\omega t}\right) = 2 \cdot \underbrace{e^{\overset{Re(p)}{\delta} t} \cdot Re\left(|K_1|\right.}_{\text{amplituda}} \cdot \underbrace{e^{j\arg(K_1)} \cdot e^{j\overset{Im(p)}{\omega} t}}_{\text{krožna frekvenca nihanje}}\left.\right)$$

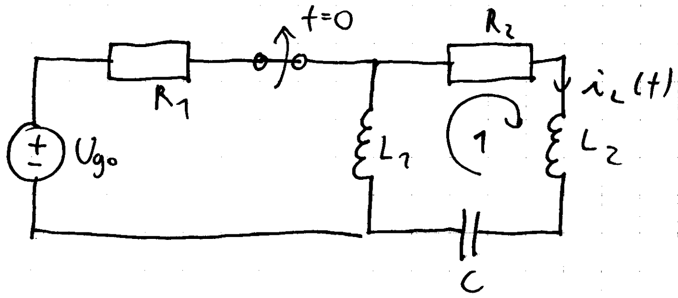
$$e^{j\omega t} = \cos(\omega t) + j\sin(\omega t)$$

$\arg = \operatorname{arctg}\frac{Im}{Re}$

$-Re, -Im = -\pi$

$-Re, +Im = +\pi$

$i_C(t)$?



$$L_1 D i_{z1} + L_2 D i_{z1} + R i_{z1} + \frac{1}{CD} i_{z1} = 0 \ /\cdot CD$$

$$(L_1 + L_2)\, C D^2 i_C(t) + R\, C D\, i_C(t) + i_C(t) = 0$$

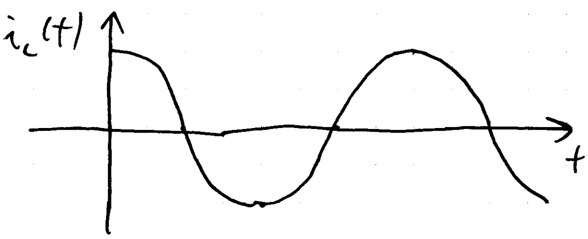
$$(L_1 + L_2)\, C p^2 + R C p + 1 = 0$$

$$p_{1,2} = \frac{-RC \pm \sqrt{(RC)^2 - 4(L_1+L_2)C}}{2\cdot(L_1+L_2)C}$$

$$-\frac{RC}{2\cdot(L_1+L_2)C} = \delta$$

$$(RC)^2 - 4(L_1+L_2)C < 0$$

a) <u>nedušeno</u>, $p_{1,2} \in \mathbb{C}$ in $\delta = 0$

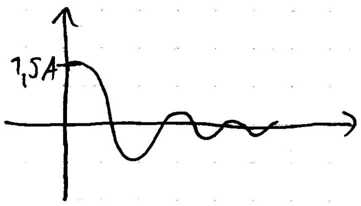


$p_1 = j2 \quad p_2 = j4$

$Re = 0$

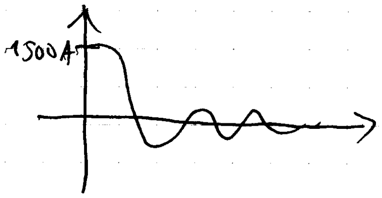
$p_{1,2}$, različni, čisto imaginarni

b) podkritično $D<0,\ \delta>0\ ;\ D=(RC)^2-4(L_1+L_2)C<0$



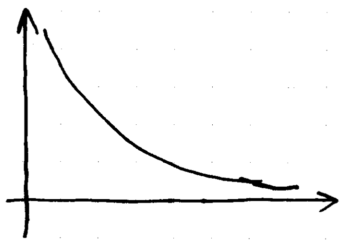
$p_1=p_2^*\quad Re\neq 0$

c) kritično



$Im=0\quad p_1=p_2$

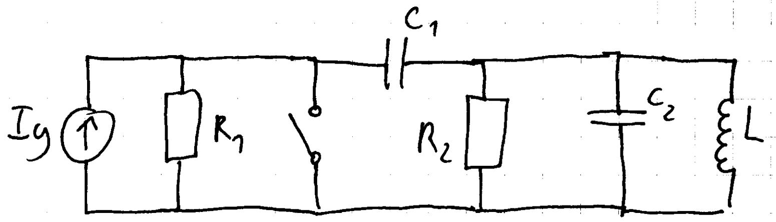
d) nadkritično



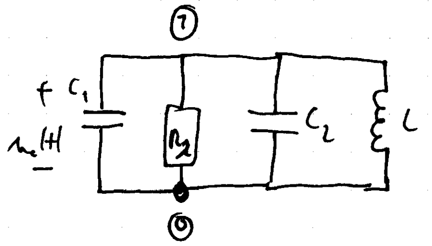
$Im=0\quad p_1\neq p_2$

17.11.2008

$u_{c1}(t)$!



$R_1 = 1\Omega$
$R_2 = 1\Omega$
$C_1 = C_2 = 1mF$
$L = 160\ mH$
$I_{g0} = 5A$



$$C_1 D u_{v1} + \frac{u_{v1}}{R_2} + C D u_{v1} + \frac{1}{LD} u_{v1} = 0 \quad / \cdot R_2 L D$$

$$R_2 C_1 L D^2 u_{v1} + R_2 C_2 L D^2 u_{v1} + \cancel{L} D u_{v1} + R_2 u_{v1} = 0$$

$$\underbrace{(R_2 C_1 L + R_2 C_2 L)}_{a_2} D^2 u_{v1} + \underbrace{L D}_{a_1} u_{v1} + \underbrace{R_2}_{a_0} u_{v1} = 0$$

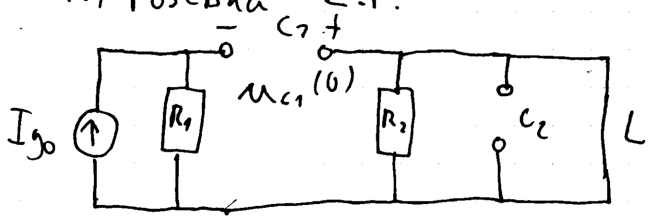
a) Homogeni

$$u_H(t) = K_1 e^{p_1 t} + K_2 e^{p_2 t}$$

$$a_2 p^2 + a_1 p + a_0 = 0$$

$$p_{1,2} = (-2{,}5 \pm j\, 17{,}5) \cdot 10^2\ A/s$$ /podkritično prigušeno titranje

b.) Posebno Z.P.



$$u_{c1}(0) = -I_{g0} R_1$$

$D u_c(0) =$

$u_c(0) = -I_{g0} \cdot R_1$ — samo u stac. stanju

$$D u_c(0) = \cancel{D} \frac{i_c(0)}{\cancel{D} C} = \frac{i_c(0)}{C} = 0$$

$$\left.\begin{aligned} u_{c1}(0) &= -I_{g0} R_1 = K_1 e^0 + K_2 e^0 \\ D u_{c1}(0) &= 0 = K_1 p_1 e^0 + K_2 p_2 e^0 \end{aligned}\right\} \quad \begin{aligned} K_1 &= -\frac{5}{2} - \frac{5}{14} j \\ K_2 &= -\frac{5}{2} + \frac{5}{14} j \end{aligned}$$

Akta

$u_c(t) = e^{\delta t} \cdot 2|K_1| \cdot \cos(\omega t + \arg(K_1))$; $\arg(K_1) = \operatorname{arctg}\left(\frac{\frac{5}{14}}{\frac{3}{2}}\right) - \pi$

$u_c(t) = -5{,}05 \cdot e^{-2{,}5 \cdot 10^2 t} \cdot \cos(17{,}5 \cdot 10^2 t + 8{,}13°)\ V$

Izmenična analiza

$u(t) = 2 \cdot \sin(\omega t) - 3\cos\left(\omega t - \frac{\pi}{4}\right)\ V$ sin $\rightarrow$ cos

$= \underline{2} \cdot \cos\left(\omega t + \left(-\frac{\pi}{2}\right)\right) - \underline{3}\cos\left(\omega t + \left(-\frac{\pi}{4}\right)\right) V$

$U = 2 \cdot e^{j\left(-\frac{\pi}{2}\right)} - 3 \cdot e^{j\left(-\frac{\pi}{4}\right)} = *$

$u(t) = \mathrm{Re}\left[U \cdot e^{j\omega t}\right] = \mathrm{Re}\left[2 \cdot e^{j\left(-\frac{\pi}{2}\right)} e^{j\omega t}\right] = \mathrm{Re}\left[2 \cdot e^{j\left(\omega t - \frac{\pi}{2}\right)}\right] =$

$= \mathrm{Re}\left[2\left(\cos\left(\omega t - \frac{\pi}{2}\right) + j\sin\left(\omega t - \frac{\pi}{2}\right)\right)\right]$

$* = \underbrace{2 \cdot \left(\cos\left(-\frac{\pi}{2}\right) + j\sin\left(-\frac{\pi}{2}\right)\right)}_{-2j} - \underbrace{3\left(\cos\left(-\frac{\pi}{4}\right) + j\sin\left(-\frac{\pi}{4}\right)\right)}_{-3 \cdot \left(\frac{1-j}{\sqrt{2}}\right)} =$

$= \frac{-2 \cdot \sqrt{2}}{\sqrt{2}} j - \frac{3 - 3j}{\sqrt{2}} = \overbrace{-\frac{3}{\sqrt{2}} + \frac{-2\sqrt{2} - 3}{\sqrt{2}} j}^{a + jb} =$

$= \sqrt{\left(\frac{-3}{\sqrt{2}}\right)^2 + \left(\frac{-2\sqrt{2}-3}{\sqrt{2}}\right)^2} \cdot e^{j \operatorname{arctg}\left(\frac{\frac{-2\sqrt{2}-3}{\sqrt{2}}}{-\frac{3}{\sqrt{2}}}\right)} = \sqrt{a^2 + b^2}\ e^{j \operatorname{arctg}\left(\frac{b}{a}\right)}$ — pazi na $\pm \pi$

1) $\cos \rightarrow |k| \cdot e^{j\varphi}$

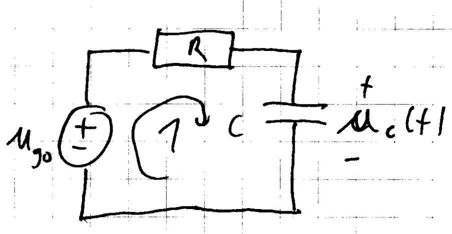
2) $|k| \cdot e^{j\varphi} \rightarrow |k| \cdot (\cos(\varphi) + j\sin(\varphi))$

3.) izvrši operacijo

4.) $a + jb = \sqrt{a^2 + b^2} \cdot e^{j \operatorname{arctg}\left(\frac{b}{a}\right)}$

$u_c(t) = ?$

$u_g(t) = U_{g0} \cdot \sin(\omega t)$



$u_g(t) \to U_g$

$u_g(t) = U_{g0} \cdot \cos(\omega t - \frac{\pi}{2})$

$\underline{U_g = U_{g0} \cdot e^{j(-\frac{\pi}{2})} = -j U_{g0}}$

$-U_g + R I_z + U_c = 0$

$U_c + R I_z = U_g$

sistemska f. med vh. in izh. $H(j\omega) = \frac{U_c}{U_g} = \frac{U_c}{U_c + R I_z} = \frac{U_c}{U_c + R \cdot j\omega C U_c} = \frac{\cancel{U_c}}{\cancel{U_c}(1 + R j\omega C)} =$

$i_c = C D u_c$

$I_c = C j\omega \cdot U_c$

$= \underline{\frac{1}{1 + j\omega RC}}$

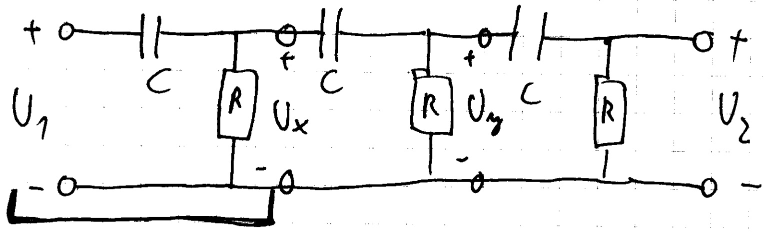
$H(j\omega) = \frac{U_c}{U_g} \Rightarrow U_c = H(j\omega) \cdot U_g$

$U_c = \frac{1}{1 + j\omega RC} \cdot (-j U_g) = \frac{-j U_g}{1 + j\omega RC} = \frac{-j U_g (1 - j\omega RC)}{1 + (\omega RC)^2} =$

$= \frac{-U_g \omega RC - j U_g}{1 + (\omega RC)^2} = \underbrace{\sqrt{\left(\frac{-U_g \omega RC}{1 + (\omega RC)^2}\right)^2 + \frac{(-U_g)^2}{(1 + (\omega RC)^2)^2}}}_{|U_c|} \cdot e^{j(\mathrm{arctg}(\frac{-U_g}{-U_g \omega RC}) - \pi)}$

$u_c(t) = |U_c| \cdot \cos(\omega t - \pi + \mathrm{arctg}(\frac{\cancel{-U_g}}{\cancel{-U_g}\omega RC})) = -|U_c| \cdot \cos(\omega t + \mathrm{arctg}(\frac{1}{\omega RC}))$

U_1 in U_2 v protifazi!

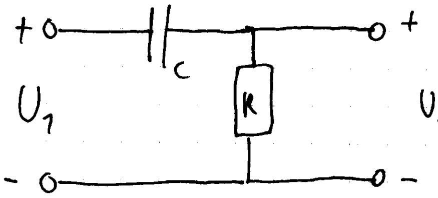


$U_1 = |U_1| \cdot e^{j\varphi_1}$

$U_2 = |U_2| \cdot e^{j\varphi_2}$

$$H(j\omega) = \frac{U_2}{U_1} = \frac{|U_2|}{|U_1|} \cdot e^{j(\varphi_2 - \varphi_1)}$$

$$\varphi_2 - \varphi_1 = \arg\left(\frac{|U_2|}{|U_1|}\right) = \pi$$



$$U_x = \frac{R}{R + \frac{1}{j\omega C}} U_1 = \frac{j\omega CR}{1 + j\omega CR} U_1$$

$Z_C = \frac{1}{j\omega C}$

$Z_L = j\omega L$

$$H'(j\omega) = \frac{U_x}{U_1} = \frac{j\omega CR}{1 + j\omega CR}$$

$$U_y = \underline{U_x} \cdot H'(j\omega) = \underline{U_1 \cdot H'(j\omega)} \cdot H'(j\omega) = U_1 \cdot \left(H'(j\omega)\right)^2$$

$$U_2 = (H'(j\omega))^3 \cdot U_1$$

$$H(j\omega) = \frac{U_2}{U_1} = \underbrace{\left(\frac{j\omega CR}{1 + j\omega CR}\right)}_{|H| \cdot e^{j\psi}}{}^3 \quad ; \quad \arg(H(j\omega)) = \pi$$

$$(|H| \cdot e^{j\psi})^3 = |H|^3 \cdot e^{j3\psi}$$

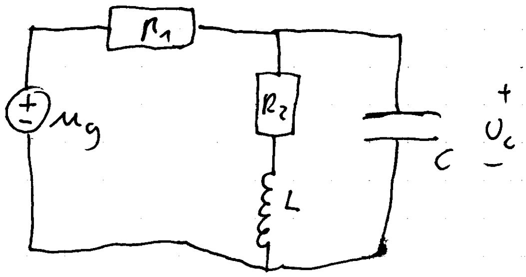
$$\arg\left(\frac{j\omega CR}{1 + j\omega CR}\right) = \frac{\pi}{3} \quad ; \quad \frac{j\omega CR\,(1 - j\omega CR)}{1 + (\omega CR)^2} = \frac{(\omega CR)^2 + j\omega CR}{1 + (\omega CR)^2}$$

$$\arg(H'(j\omega)) = \operatorname{arctg}\left(\frac{\frac{\omega C R}{1+(\omega C R)^2}}{\frac{(\omega C R)^2}{1+(\omega C R)^2}}\right) = \operatorname{arctg}\left(\frac{1}{\omega C R}\right) = \frac{\pi}{3}$$

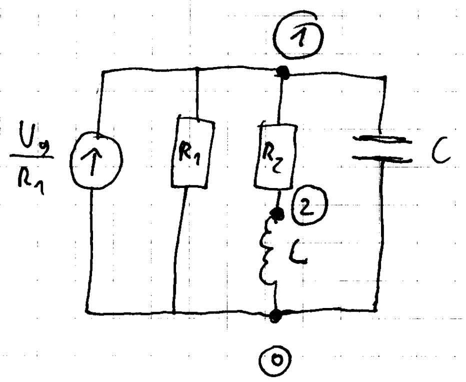
$$\operatorname{tg}\left(\frac{\pi}{3}\right) = \sqrt{3}$$

$$\frac{1}{\omega C R} = \sqrt{3} \Rightarrow \underline{\omega = \frac{1}{\sqrt{3}\, R C}}$$

U_c ?



$\Rightarrow$



$$(1)\quad -\frac{U_g}{R_1} + \frac{U_{v1}}{R_1} + \frac{U_{v1}-U_{v2}}{R_2} + j\omega C U_{v1} = 0$$

$$(2)\quad \frac{U_{v2}-U_{v1}}{R_2} + \frac{U_{v2}}{j\omega L} \qquad U_c = U_{v1}$$

$$U_{v2}\left(\frac{1}{R_2} + \frac{1}{j\omega L}\right) = \frac{U_{v1}}{R_2}$$

$$U_{v2}\,\frac{j\omega L + R_2}{\cancel{R_2}\, j\omega L} = \frac{U_{v1}}{\cancel{R_2}} \Rightarrow U_{v2} = \frac{j\omega L}{R_2 + j\omega L}\cdot U_{v1}$$

$$U_{v1}\left(\frac{1}{R_1} + \frac{1}{R_2} + j\omega C\right) - \frac{1}{R_2} U_{v2} = \frac{U_g}{R_1}$$

$$U_{v1}\,\frac{R_2 + R_1 + R_1 R_2 j\omega C}{R_1 R_2} - \frac{1}{R_2}\,\frac{j\omega L}{R_2 + j\omega L}\, U_{v1} = \frac{U_g}{R_1} \quad / \cdot R_2$$

$$U_{v1}\,\frac{R_2 + R_1 + R_1 R_2 j\omega C}{R_1} - \frac{j\omega L}{R_2 + j\omega L}\, U_{v1} = \frac{R_2}{R_1} U_g$$

$$U_{v1}\,\frac{R_1 + R_2 + j\omega L + j\omega C R_1 R_2 - \omega^2 L C R_1}{R_1 (R_2 + j\omega L)} = U_g$$

Aleta

$$U_{V1} = \underbrace{\frac{R_2 + j\omega L}{R_1 + R_2 - \omega^2 R_1 L C + j\omega L + j\omega R_1 R_2 C}}_{H(j\omega)} \cdot U_g \quad \cdot |U_g| \cdot e^{j\varphi} \text{ — v splošnem}$$

$$\left|\frac{a}{b}\right| = \frac{|a|}{|b|}$$

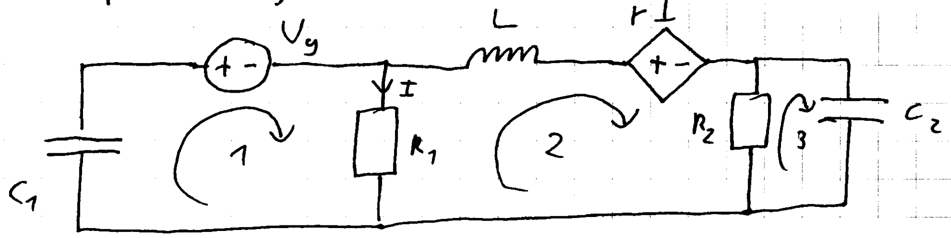
$$U_{V1} = \frac{\sqrt{R_2^2 + (\omega L)^2}}{\sqrt{(R_1 + R_2 - \omega^2 R_1 L C)^2 + (\omega L + \omega R_1 R_2 C)^2}} \cdot |U_g| \cdot e^{j \operatorname{arctg}\left(\frac{\omega L}{R_2}\right)} \cdot e^{j \operatorname{arctg}\left(\frac{\omega(L + R_1 \ldots}{R_1 + R_2 - \omega^2 R_1 \ldots}\right)} \cdot e^{j\varphi}$$

števec — imenovalec

$$e^{j \operatorname{arctg}\left(\frac{Im}{Re}\right)} \cdot e^{-j \operatorname{arctg}\left(\frac{Im}{Re}\right)}$$

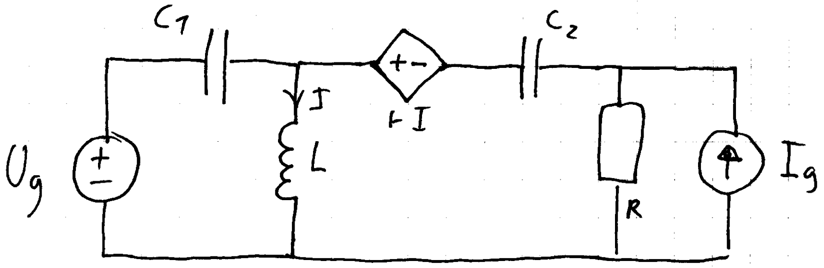
24.11.2008

Opis vezja

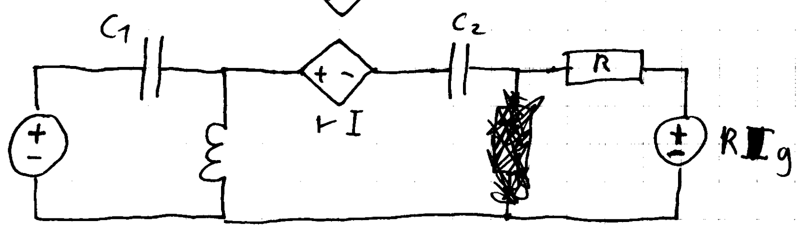


$I = i_{z1} - i_{z2}$

$$\begin{bmatrix} \frac{1}{j\omega C_1} + R_1 & -R_1 & 0 \\ -R_1 + r & R_1 + R_2 + j\omega L - r & -R_2 \\ 0 & -R_2 & R_2 + \frac{1}{j\omega C_2} \end{bmatrix} \begin{bmatrix} I_{z1} \\ I_{z2} \\ I_{z3} \end{bmatrix} = \begin{bmatrix} -U_g \\ 0 \\ 0 \end{bmatrix}$$

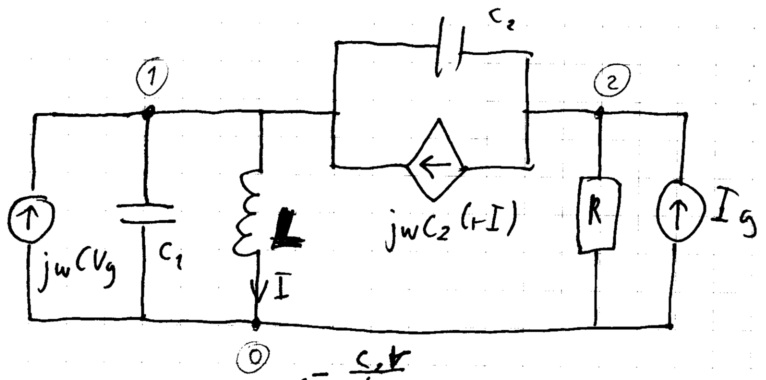


$\Downarrow$



$I = i_{z1} - i_{z2}$

$$\begin{bmatrix} \frac{1}{j\omega C_1} + j\omega L & -j\omega L \\ -j\omega L + r & R + j\omega L + \frac{1}{j\omega C_2} - r \end{bmatrix} \begin{bmatrix} I_{z1} \\ I_{z2} \end{bmatrix} = \begin{bmatrix} U_g \\ -RI_g \end{bmatrix}$$



$$I = \frac{U}{j\omega L} = \frac{U_{K1}}{j\omega L}$$

$$\cancel{j\omega} C_2 \cdot r \cdot \frac{U_{K1}}{\cancel{j\omega} L} = \frac{C_2 r}{L} U_{V1}$$

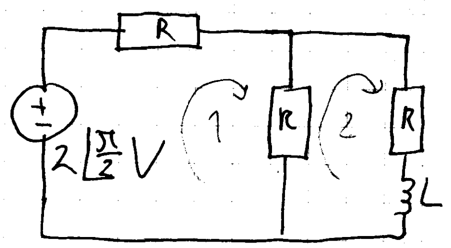
$$- \frac{C_2 r}{L}$$

$$\begin{bmatrix} j\omega C_1 + j\omega C_2 + \frac{1}{j\omega L} & -j\omega C_2 \\ -j\omega C_2 & \frac{1}{R} + j\omega C_2 \end{bmatrix} \begin{bmatrix} U_{V1} \\ U_{V2} \end{bmatrix} = \begin{bmatrix} j\omega C_1 U_g \\ I_g \end{bmatrix}$$

$$+ \frac{C_2 r}{L}$$

Izračunaj tok skozi tuljavo $R = 100\,\Omega$.

$R = 100\,\Omega$
$L = 10\,\mu H$



$$2\angle\frac{\pi}{2} V = 2\cdot\cos(\omega t - \frac{\pi}{2})\,V = u_g(t)$$

$$① \; -U_g + R I_{z1} + R(I_{z1} - I_{z2}) = 0$$

$$② \; R(I_{z2} - I_{z1}) + R I_{z2} + j\omega L I_{z2} = 0$$

$$I_L = I_{z2}$$

$$2 R I_{z1} = U_g + R \cdot I_{z2}$$

$$I_{z1} = \frac{U_g + R I_{z2}}{2R}$$

$$2R I_{z2} + j\omega L I_{z2} - R I_{z1} = 0$$

$$2R I_{z2} + j\omega L I_{z2} - R\left(\frac{U_g + R I_{z2}}{2R}\right) = 0$$

$$2R I_{z2} + j\omega L I_{z2} - \frac{R I_{z2}}{2} = \frac{U_g}{2} \quad / \cdot 2$$

$$U_g = 2 \cdot e^{j(-\frac{\pi}{2})} = 2 \cdot (-j)$$

$$3R I_{z2} + 2 j\omega L I_{z2} = U_g$$

$$I_{z2}(3R + 2j\omega L) = U_g$$

$$I_L = I_{z2} = \frac{U_g}{3R + 2j\omega L} = \frac{-2j}{300 + 2\cdot 10^{-5}\,\omega j} = \frac{-2j\,(300 - 2\cdot 10^{-5}\omega j)}{300^2 + (2\cdot 10^{-5}\omega)^2}$$

$$I_L = \frac{2}{\sqrt{(300)^2 + (2\cdot 10^{-5}\omega)^2}} \cdot e^{j\left(\mathrm{arctg}\left(\frac{-600}{-4\cdot 10^{-6}\omega}\right) - \pi\right)}$$

$$i_L(t) = \mathrm{Re}\left[I_L \cdot e^{j\omega t}\right] = \frac{2}{\sqrt{300^2 + (2\cdot 10^{-5}\omega)^2}} \cdot \cos\left(\omega t + \mathrm{arctg}\left(\frac{-600}{-4\cdot 10^{-5}\omega}\right) - \pi\right) A$$

Fazni zusuk!

$$(D^2 + aD + b)\, y(t) = D^2 x(t)$$

$$\downarrow$$

$$(jw^2 + a \cdot jw + b)\, Y = (jw^2)\, X$$

$$(-w^2 + ajw + b)\, Y = -w^2 \underline{X}$$

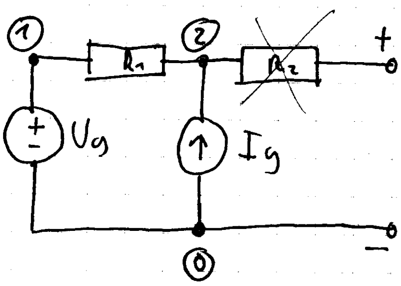
$$H = \frac{Y}{X} = \frac{-w^2}{b - w^2 + ajw}$$

fazni zasuk = arg $(H(jw))$

$$H(jw) = \frac{-w^2\,\left((b-w^2) - ajw\right)}{(b-w^2)^2 + (aw)^2} = \frac{-w^2(b-w^2) + ajw^3}{(b-w^2)^2 + (aw)^2}$$

$$\arg(H(jw)) = \text{arctg}\left(\frac{a\cancel{j}w^{\cancel{3}}}{-\cancel{w^2}(b-w^2)}\right) = \text{arctg}\left(\frac{aw}{-(b-w^2)}\right)$$

$$\arg(H(jw)) = \begin{cases} b < w^2 \rightarrow \text{arctg}\left(\frac{aw}{-(b-w^2)}\right) \\ b = w^2 \longrightarrow \frac{\pi}{2} \\ b > w^2 \rightarrow \text{arctg}\left(\frac{aw}{-(b-w^2)}\right) \pm \pi \end{cases}$$



Thevenin

U_{os}, Z_n

U_{os} - odstrani el. brez I

- vozliščna metoda

Linearni del

- izklopi vse vire

- izračunaj Z_L

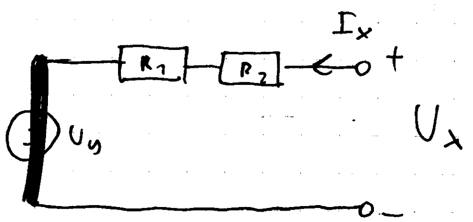
$$Z_L = \frac{U_x}{I_x}$$

$$U_{v1} = U_g$$

$$② \quad \frac{U_{v2} - U_g}{R_1} - I_g = 0 \quad / \cdot R_1$$

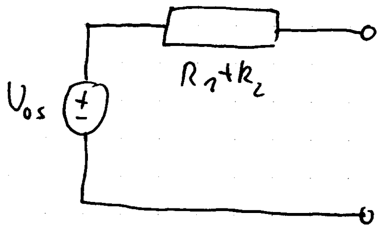
$$U_{v2} = R_1 I_g + U_g = \underline{\underline{U_{os}}}$$

Linearni del



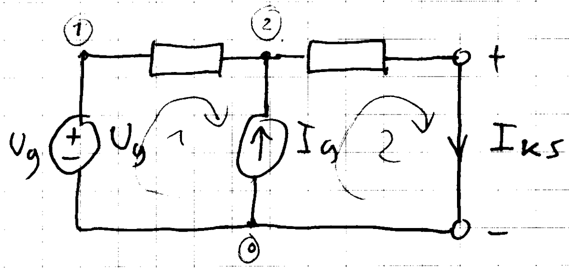
$$Z_L = \frac{U_x}{I_x} = \frac{R_1 I_x + R_2 I_x}{I_x} = R_1 + R_2$$

<u>vezje se prelevi v Theveninov vir:</u>



Norton

- Na vhod postavi kratek stik

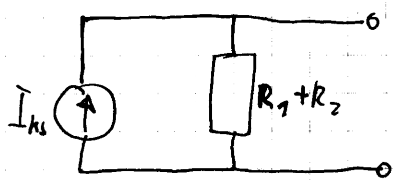


$$I_g = I_{z2} - I_{z1} \Rightarrow I_{z1} = I_{z2} - I_g$$

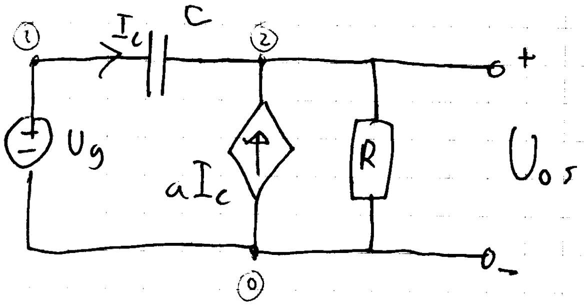
(1,2) $-U_g + R_1 I_{z1} + R_2 I_{z2} = 0$

$I_{ks} = I_{z2}$

$$R_2 I_{z2} + R_1 I_{z1} = U_g$$
$$R_2 I_{z2} + R_1 \cdot (I_{z2} - I_g) = U_g$$
$$I_{z2}(R_2 + R_1) = U_g + R_1 I_g$$
$$\underline{I_k = \frac{U_g + R_1 I_g}{R_2 + R_1}}$$



Določi Theveninov in Nortonov vir.



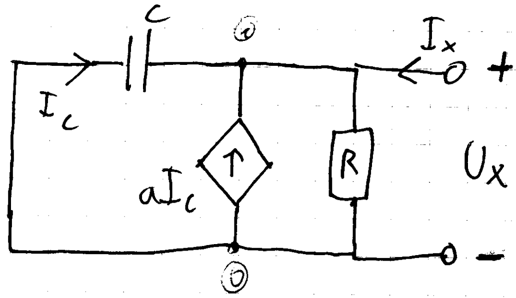
$U_{v1} = U_g$; $I_c = j\omega C(U_{v1} - U_{v2}) = j\omega C(U_g - U_{v2})$

(2) $j\omega C(U_{v2} - U_g) - a\, j\omega C(U_g - U_{v2}) + \frac{U_{v2}}{R} = 0$

$j\omega C(U_{v2} - U_g) + a\, j\omega C(U_{v2} - U_g) + \frac{U_{v2}}{R} = 0$

$U_{v2} \cdot \left(j\omega C(1+a) + \frac{1}{R}\right) = U_g \cdot j\omega C(1+a)$

$$U_{v2} = \frac{U_g \cdot j\omega C(1+a)}{j\omega C(1+a) + \frac{1}{R}} = U_{0S}$$



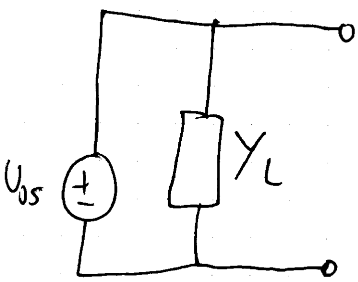
$I_c = j\omega C \cdot U_{v1} = j\omega C(0 - U_{v1})$ $\quad U_x = U_{v1}$

(1) $j\omega C\, U_{v1} - a(-j\omega C U_{v1}) + \frac{U_{v1}}{R} - I_x = 0$

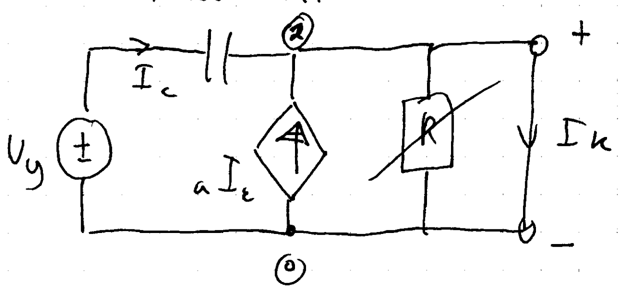
$U_x\left(j\omega C(1+a) + \frac{1}{R}\right) - I_x = 0$

$Z_L = \frac{U_x}{I_x}$ $\qquad U_x\left(j\omega C(1+a) + \frac{1}{R}\right) = I_x$

$Y_L = \frac{I_x}{U_x}$ $\qquad \frac{I_x}{U_x} = j\omega C(1+a) + \frac{1}{R}$



Nortonov vir



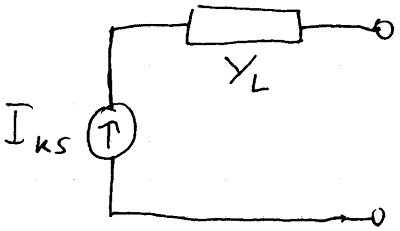
$U_C = U_g$

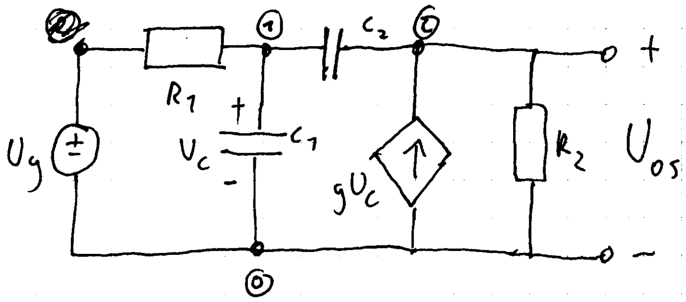
$I_c = j\omega C U_g$

$I_{k.s.}$

(2) $-I_c - aI_c + I_{ks} = 0$

$$I_{ks} = I_c(1+a) = j\omega C(1+a)\cdot U_g$$





(1) $\frac{U_{V1}-U_g}{R_1} + j\omega C_1 U_{V1} + j\omega C_2 (U_{V1} - U_{V2}) = 0$

(2) $j\omega C_2 (U_{V2} - U_{V1}) - gU_{V2} + \frac{U_{V2}}{R_2} = 0$

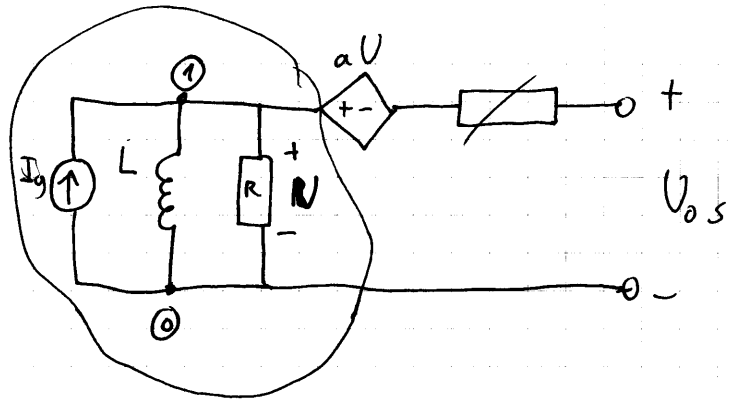
$U_{os} = U_{V2}$

$U_{V1}\left(\frac{1}{R_1} + j\omega C_1 + j\omega C_2\right) = \frac{U_g}{R_1} + j\omega C_2 U_{V2}; \quad U_{V1} = \frac{j\omega C_2 U_{V2} + \frac{U_g}{R_1}}{\left(\frac{1}{R_1} + j\omega C_1 + j\omega C_2\right)}$

$U_{V2}\left(j\omega C_2 + \frac{1}{R_2}\right) - U_{V1}(j\omega C_2 + g) = 0$

$U_{V2}\left(j\omega C_2 + \frac{1}{R_2}\right) - (j\omega C_2 + g)\cdot \qquad = 0$

$$U_{os} = \frac{g + j\omega C_2}{1 + j\omega R_2(C_1+C_2)\left(\frac{1}{R_2} + j\omega C_2\right) - j\omega C_2(g + j\omega C_2)} U_g$$



$U = U_{v1}$

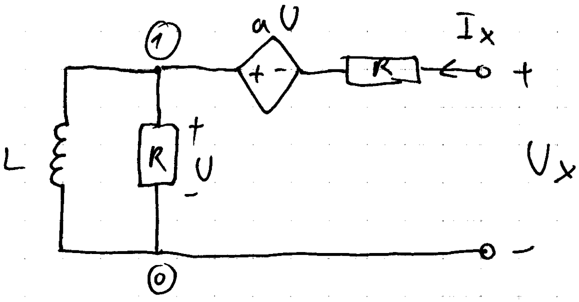
① $-I_g + \frac{U_{v1}}{j\omega L} + \frac{U_{v1}}{R} = 0$

$$U_{v1}\left(\frac{1}{j\omega L} + \frac{1}{R}\right) = I_g$$

$$U_{v1}\,\frac{j\omega L + R}{j\omega L R} = I_g$$

$$\underline{U_{v1} = I_g\,\frac{j\omega L R}{j\omega L + R}}$$

$$U_{os} = U_{v1} - a\,U_{v1} = \frac{j\omega L R}{j\omega L + R}(1-a)\,I_g$$



$$U_x = R\cdot I_x - aU + U$$

$$= R\cdot I_x + (1-a)\cdot\frac{j\omega L R}{j\omega L + R}\cdot I_x$$

① $\frac{U_{v1}}{j\omega L} + \frac{U_{v1}}{R} - I_x = 0$

$$U_{v1}\left(\frac{1}{j\omega L} + \frac{1}{R}\right) = I_x$$

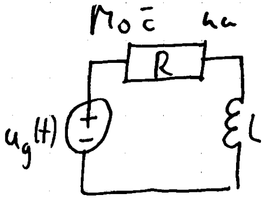
$$U_{v1}\,\frac{j\omega L + R}{j\omega L R} = I_x$$

$$U_{v1} = \frac{j\omega L R}{j\omega L + R}\cdot I_x$$

$$\underline{\underline{Z_c = \frac{U_x}{I_x} = R + (1-a)\,\frac{j\omega L R}{j\omega L + R}}}$$

01.12.2008

Moč na uporu (delovna)?



$u_g(t) = U_{g0}\sin(\omega t)$

$u_g(t) = U_{g0}\cos(\omega t - \frac{\pi}{2})$

$$\boxed{P = \frac{1}{2}\mathrm{Re}[U \cdot I^*]}$$

$$P = \frac{1}{2}\mathrm{Re}[R \cdot I \cdot I^*]$$

$$P = \frac{R}{2}\mathrm{Re}[|I|^2]$$

$$\boxed{P = \frac{R}{2} \cdot |I|^2}$$

(1) $-U_g + R I_{z1} + j\omega L I_{z1} = 0$

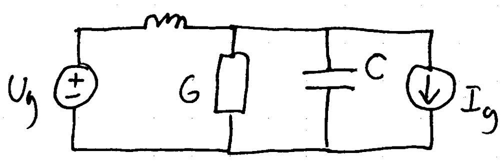
$$I_{z1}(R + j\omega L) = U_g$$

$$I = \frac{U_g}{R + j\omega L} = \frac{-j U_{g0}}{R + j\omega L}$$

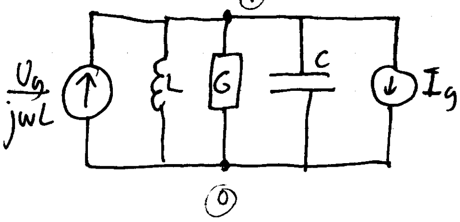
$$U_g = U_{g0} \cdot e^{j(-\frac{\pi}{2})} = -j U_{g0}$$

$$P = \frac{R}{2} \cdot \frac{U_g^2}{R^2 + (\omega L)^2}$$

Moč na prevodnosti (delovna)?



$\Downarrow$



$u_g(t) = U_{g0}\cos(\omega t)$ $\quad i_g = I_{g0}\sin(\omega t) = I_{g0}\cos(\omega t - \frac{\pi}{2})$

$$P = \frac{1}{2}\mathrm{Re}[U \cdot G^* \cdot U^*]$$

$$P = \frac{G}{2}\mathrm{Re}[U \cdot U^*]$$

$$\boxed{P = \frac{G}{2}|U|^2}$$

(1) $-\frac{U_g}{j\omega L} + \frac{U_{v1}}{j\omega L} + G \cdot U_{v1} + j\omega C U_{v1} + I_g = 0 \quad / \cdot j\omega L$

$$U_{v1} + j\omega L G U_{v1} - \omega^2 C L U_{v1} = U_g - j\omega L I_g$$

$$U_{v1} = \frac{U_g - j\omega L I_g}{1 - \omega^2 CL + j\omega LG}$$

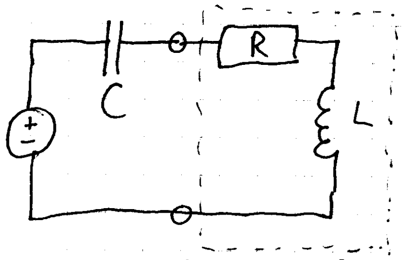
$$U_g = U_{g0} \cdot e^{j0} = U_{g0} \qquad I_g = I_{g0} \cdot e^{j(-\frac{\pi}{2})} = -j I_{g0}$$

$$U_{v1} = \frac{U_{g0} - \omega L I_{g0}}{1 - \omega^2 CL + j\omega LG}$$

$$\Downarrow$$

$$P = \frac{(U_{g0} - \omega L I_{g0})^2}{(1 - \omega^2 CL)^2 + (\omega LG)^2}$$

Določi vrednost kondenzatorja za maksimalno delovno moč!



$C = ?$

$$\boxed{Z_p = Z_g^*}$$

$$\boxed{\begin{aligned} Re[Z_p] &= Re[Z_g] \\ Im[Z_p] &= -Im[Z_g] \end{aligned}}$$

$$Z_g = \frac{1}{j\omega C} = \frac{-j}{\omega \cdot C}$$

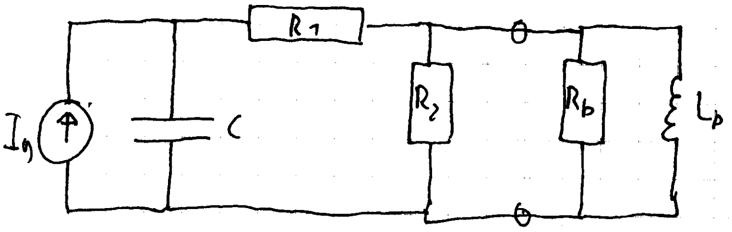
$$Z_p = R + j\omega L$$

$$\omega L = -\left(-\frac{1}{\omega C}\right)$$

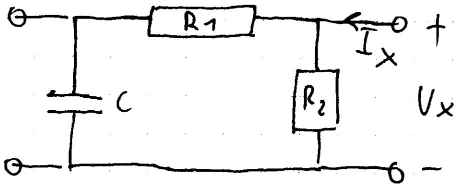
$$\omega L = \frac{1}{\omega C}$$

$$\underline{C = \frac{1}{\omega^2 L}}$$

Določi vrednost za max. delovno moč.



$$Y_p = \frac{1}{R_p} + \frac{1}{j\omega L_p} = \frac{1}{R_p} - \frac{j}{\omega L_p}$$



$$Y_g = \frac{1}{R_2} + \frac{1}{R_1 + \frac{1}{j\omega C}} =$$

$$Y_g = \frac{1}{R_2} + \frac{1}{1 + j\omega C R_1} = \frac{1}{R_2} + \frac{j\omega C(1 - j\omega R_1 C)}{1 + (\omega R_1 C)^2} =$$

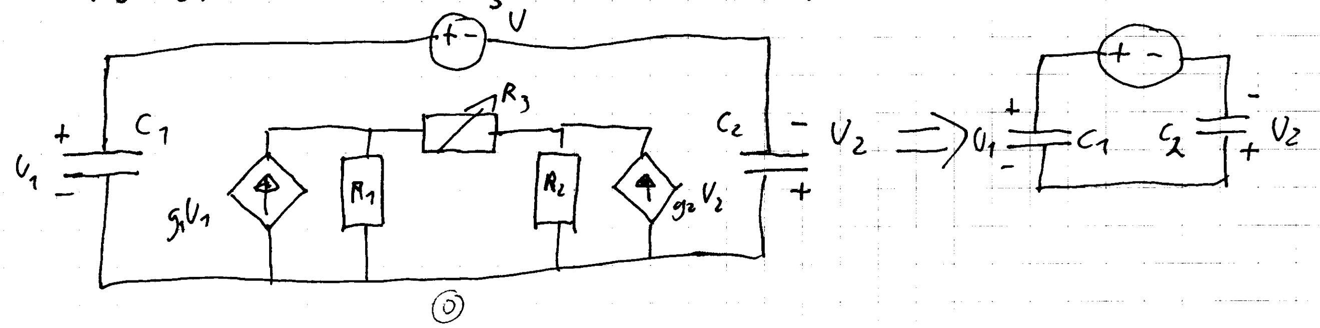
$$Y_g = \frac{1}{R_2} + \frac{\omega^2 C^2 R + j\omega C}{1 + (\omega R_1 C)^2}$$

$$\frac{1}{R_p} = \frac{1}{R_2} + \frac{\omega^2 C^2 R}{1 + (\omega R_1 C)^2}$$

$$-\frac{1}{\omega L_p} = \frac{-\omega C}{1 + (\omega R_1 C)^2}$$

$$\frac{1}{\omega L_p} = \frac{\omega C}{1 + (\omega R_1 C)^2}$$

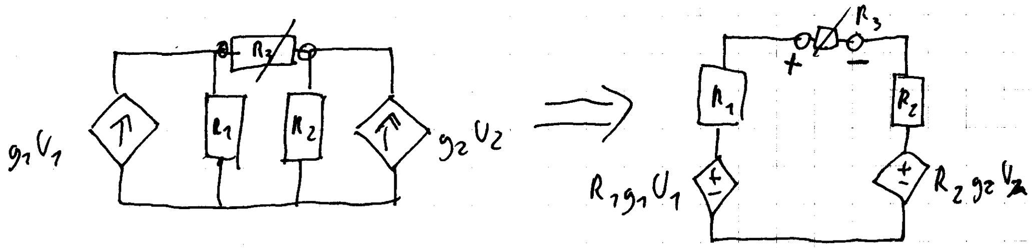
Določi vrednost R_3 za maks. moč.



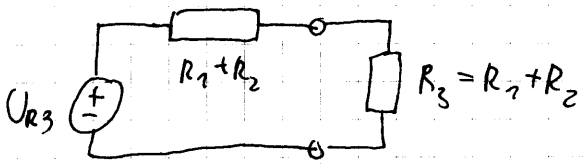
$$U_1 = \frac{\frac{1}{j\omega C_1}}{\frac{1}{j\omega C_1}+\frac{1}{j\omega C_2}}\, U = \frac{C_2}{C_1+C_2}\, U$$

$/\cdot j\omega C_1 C_2$

$$U_2 = \frac{C_1}{C_1+C_2}\, U$$



$$U_{R_3} = R_1 g_1 U_1 - R_2 g_2 U_2$$



$$Z_L = R_1 + R_2$$

$$\left.\begin{matrix} Z_p = R_3 \\ Z_g = R_1+R_2 \end{matrix}\right\} R_3 = R_1 + R_2$$

$$U = \frac{1}{2}\left(R_1 g_1 U_1 - R_2 g_2 U_2\right)$$

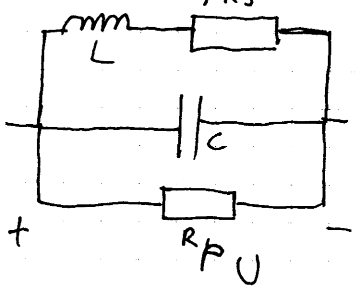
$$I = \frac{U}{R_3} = \frac{1}{2R_3}\left(R_1 g_1 U_1 - R_2 g_2 U_2\right)$$

$$P = \frac{1}{2}\,\mathrm{Re}\left[U\cdot I^*\right] = \frac{1}{2}\cdot\frac{1}{2}\cdot\frac{1}{2R_3}\cdot \mathrm{Re}\left[\left(R_1g_1U_1 - R_2g_2U_2\right)\left(R_1g_1U_1-R_2g_2U_2\right)^*\right]$$

$$= \frac{1}{8R_3}\left[\left(R_1g_1\frac{C_2}{C_1+C_2}\cdot U - R_2g_2\frac{C_1}{C_1+C_2}U\right)\left(R_1g_1\frac{C_2}{C_1+C_2}U^* - R_2g_2\frac{C_1}{C_1+C_2}U^*\right)\right]$$

$$P = \frac{1}{8R_3}\cdot\frac{\left(R_1g_1C_2 - R_2g_2C_1\right)^2}{\left(C_1+C_2\right)^2}\cdot|U|^2$$

Izračunaj resonančno frekvenco in kvaliteto vezja.



$$Y = \frac{1}{R_p} + j\omega C + \frac{1}{R_s + j\omega L}$$
$$= \frac{1}{R_p} + j\omega C + \frac{R_s - j\omega L}{R_s^2 + (\omega L)^2}$$

ADMITANCA, KO JE VEČ VZPOREDNO VEZANIH.

$$\mathrm{Im}(Y) = 0$$

$$\omega C - \frac{\omega L}{R_s^2 + (\omega L)^2} = 0$$

$$\cancel{\omega} C \cdot (R_s^2 + (\omega L)^2) - \cancel{\omega} L = 0$$

$$R_s^2 C + \omega^2 L^2 C = L$$

$$\omega^2 L^2 C = L - R_s^2 C$$

$$\omega^2 = \frac{L - R_s^2 C}{L^2 C} = \sqrt{\frac{L - R_s^2 C}{L^2 C}}$$

$$\boxed{Q_c = \overset{Y}{\frac{B_c(\omega_0)}{G(\omega_0)}} = \overset{Z}{\frac{B_c(\omega_0)}{R(\omega_0)}}}$$

1. var.

$$Q_c = \frac{\omega_0 C}{\frac{1}{R_p} + \frac{R_s}{R_s^2 + (\omega_0 L)^2}}$$

2. var

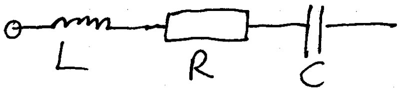
$$\boxed{Q = \omega_0 \frac{\sum W_c}{\sum P} = \omega_0 \frac{\sum W_c}{\sum P}}$$

$$P_p = \frac{1}{2R_p} |U|^2 \ ; \quad P_s = \frac{1}{2R_s} \left| \frac{R_s}{R_s + j\omega L} U \right|^2$$

$$W_c = \frac{1}{2} C |U|^2$$

$$Q = \frac{\frac{1}{2} C |U|^2 \cdot \omega_0}{\frac{1}{2R_p} |U|^2 + \frac{1}{2R_s} \left| \frac{R_s}{R_s + j\omega L} U \right|^2}$$

Izračunaj resonančno frekvenco in kval. vezja.



$$Z = R + j\omega L + \frac{1}{j\omega C} = R + j\omega L - \frac{j}{\omega C}$$

$$\operatorname{Im}(Z) = 0$$

$$\omega L - \frac{1}{\omega C} = 0 \; ; \; \omega L = \frac{1}{\omega C} \; ; \; \omega^2 = \frac{1}{LC} \; ; \; \underline{\underline{\omega_0 = \sqrt{\frac{1}{LC}}}}$$

1. var.

$$Q = \frac{\omega_0 L}{R}$$

2. var.

$$Q = \omega_0 \frac{W_L(\omega_0)}{P} \; ; \; P = \frac{1}{2} R |I|^2 \; ; \; W_L = \frac{1}{2} L |I|^2$$

$$Q = \omega_0 \cdot \frac{\cancel{\frac{1}{2}} L \cancel{|I|^2}}{\cancel{\frac{1}{2}} R \cancel{|I|^2}} = \frac{\omega_0 L}{R}$$

Tokova resonanca $\longrightarrow Z$

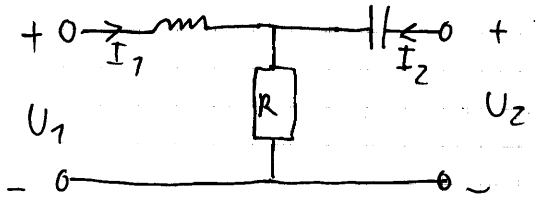
Napetostna resonanca $\longrightarrow Y$

Četveropoli

Impedančni parametri

$U_1 = z_{11} I_1 + z_{12} I_2$

$U_2 = z_{21} I_1 + z_{22} I_2$



a) $I_2 = 0$ $(\cancel{\ell})$

$$z_{11} = \frac{U_1}{I_1} = \frac{j\omega L I_1 + R I_1}{I_1} = \underline{j\omega L + R}$$

$$z_{21} = \frac{U_2}{I_1} = \frac{R \cdot I_1}{I_1} = \underline{R}$$

KO NI KRMILJENIH VIROV JE RECIPROČEN.

b) $I_1 = 0$ $(\cancel{k})$

$$z_{22} = \underline{R + \frac{1}{j\omega C}}$$

$$z_{12} = \frac{U_1}{I_2} = \frac{R I_2}{I_2} = \underline{R}$$

SIMETRIČNOST

$z_{11} = z_{22}$

RECIPROČNOST

$z_{12} = z_{21}$

$$j\omega L + \cancel{R} = \cancel{R} + \frac{1}{j\omega C}$$

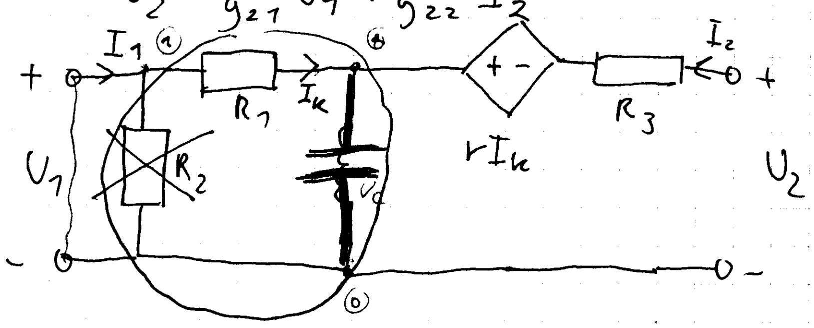
$$\underline{-\omega^2 LC = 1}$$

ni simetrično

Hibridni $\boxed{g}$ parametri

$I_1 = g_{11} U_1 + g_{12} I_2$

$U_2 = g_{21} U_1 + g_{22} I_2$



RECIPROČNOST
$g_{21} = -g_{12}$
SIMETRIČNOST
$\underset{\text{det}}{\Delta g} = 1$
$g_{11} g_{22} - g_{12} g_{21} = 1$

a) $I_2 = 0$

$$g_{11} = \frac{I_1}{U_1} = \frac{1}{R_2 +} + \frac{1}{R_1 + \frac{1}{j\omega C}} = \underline{\frac{1}{R_2} + \frac{j\omega C}{1 + j\omega R_1 C}}$$

$$g_{21} = \frac{U_2}{U_1} = \quad ; \quad U_{v2} = U_c \quad ; \quad \frac{U_c - U_1}{R_1} + j\omega C U_c = 0$$

$$U_c - U_1 + j\omega R_1 C U_c = 0$$

$$(j\omega R_1 C + 1) U_c = U_1$$

$$U_c = \frac{U_1}{j\omega R_1 C + 1}$$

$$U_2 = U_c - r I_k$$

$$= U_c - r \frac{U_1 - U_c}{R_1}$$

$$= U_c \left(1 + \frac{r}{R_1}\right) - \frac{r}{R_1} U_1$$

$$= \frac{U_1 \left(1 + \frac{r}{R_1}\right)}{j\omega R_1 C + 1} - \frac{r}{R_1} U_1$$

$$\underline{g_{21} = \frac{U_2}{U_1} = \frac{1 + \frac{r}{R_1}}{1 + j\omega R_1 C} - \frac{r}{R_1}}$$

b) $U_1 = 0$ (kratak spoj R_2 zgine)

$$g_{12} = \frac{I_1}{I_2} \quad ; \quad I_1 = \frac{U_c}{R_1} = \frac{1}{R_1} \cdot \frac{I_1 + I_2}{j\omega C} = \frac{I_1}{j\omega R_1 C} + \frac{I_2}{j\omega R_1 C}$$

$$I_1 = \frac{I_2}{j\omega R_1 C - 1}$$

$$\underline{g_{12} = \frac{1}{j\omega R_1 C - 1}}$$

$$g_{22} = ? \qquad U_2 = R_3 \cdot I_2 - r I_k - R_1 I_1$$

$$U_2 = R_3 I_2 - I_1 (r + R_1) = R_3 I_2 - \frac{I_2}{j\omega R_1 C - 1} (r + R_1) \quad / : I_2$$

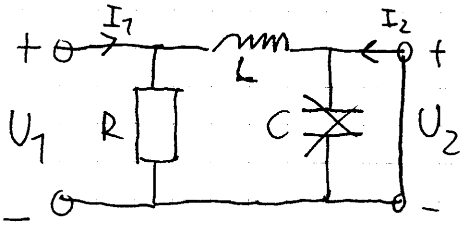
$$g_{22} = \frac{U_2}{I_2} = R_3 - \frac{r + R_1}{j\omega R_1 C + 1}$$

Akta

08.12.2008

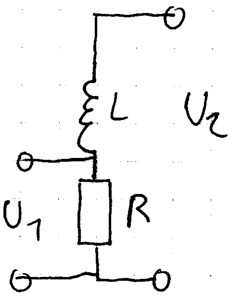
Hibridni h parametri

$$U_1 = h_{11} I_1 + h_{12} U_2$$
$$I_2 = h_{21} I_1 + h_{22} U_2$$



a) $I_1 = 0$

$$h_{12} = \frac{U_1}{U_2} = \frac{R}{R + j\omega L}$$



$$h_{22} = \frac{I_2}{U_2} = j\omega C + \frac{1}{R + j\omega L}$$ admitanca

b) $U_2 = 0$ kratek stik (C odpade)

$$h_{11} = \frac{U_1}{I_1} = \left(\frac{1}{R} + \frac{1}{j\omega L}\right)^{-1} = \frac{j\omega L R}{j\omega L + R}$$

$$h_{21} = \frac{I_2}{I_1} \qquad I_2 = -\frac{U_1}{j\omega L} \qquad I_1 = \frac{j\omega L + R}{j\omega L R} U_1$$

$$h_{21} = \frac{-\frac{\cancel{U_1}}{\cancel{j\omega L}}}{\frac{j\omega L + R}{\cancel{j\omega L} R} \cancel{U_1}} = \frac{-R}{j\omega L + R}$$

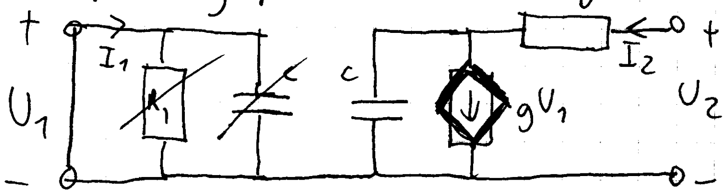
reci. $y_{12} = y_{21}$
sim. $y_{12} = y_{21}$, $y_{11} = y_{22}$

$$I_1 = y_{11} U_1 + y_{12} U_2 \qquad I_1 = g_{11} U_1 + g_{12} I_2$$
$$I_2 = y_{21} U_1 + y_{22} U_2 \qquad U_2 = g_{21} U_1 + g_{22} I_2$$

$$I_2 = \frac{U_2 - g_{21} U_1}{g_{22}} = \underbrace{-\frac{g_{21}}{g_{22}}}_{y_{21}} U_1 + \underbrace{\frac{1}{g_{22}}}_{y_{22}} U_2$$

$$I_1 = g_{11} U_1 + \frac{g_{12}}{g_{22}} U_2 - \frac{g_{12} g_{21}}{g_{22}} U_1 = \underbrace{\frac{g_{11} g_{22} - g_{12} g_{21}}{g_{22}}}_{y_{11}} U_1 + \underbrace{\frac{g_{12}}{g_{22}}}_{y_{12}} U_2$$

Zapiši g parametre in ugotovi sim. ter reci.!



a) $U_1 = 0$ (kratek stik)

$$g_{12} = \frac{I_1}{I_2} = 0$$

$$g_{22} = \frac{U_2}{I_2} = R_2 + \frac{1}{j\omega C}$$

b) $I_2 = 0$

$$g_{11} = \frac{I_1}{U_1} = \frac{1}{R_1} + j\omega C$$

$$g_{21} = \frac{U_2}{U_1} \qquad U_2 = -\frac{gU_1}{j\omega C}$$

$$g_{21} = -\frac{g}{j\omega C}$$

$C \to 0$ — kratek stik
$L \to 0$
$R \to 0$
$R \to \infty$ — odprte sponke

reč. $(g_{12} = -g_{21})$

$$0 = -\left(-\frac{g}{j\omega C}\right)$$
$$0 = \frac{g}{j\omega C}$$
$$\downarrow$$
$$g = 0$$

sim. $g_{11} g_{22} - g_{12} g_{21} = 1$

$$\left(R_2 + \frac{1}{j\omega C}\right)\left(\frac{1}{R_1} + j\omega C\right) = 1$$
$$\frac{R_2}{R_1} + \frac{1}{j\omega R_1 C} + j\omega R_2 C + 1 = 1$$
$$\frac{R_2}{R_1} + \frac{1}{j\omega R_1 C} + j\omega R_2 C = 0 \Rightarrow \begin{matrix} R_1 = \infty \\ R_2 = 0 \end{matrix}$$

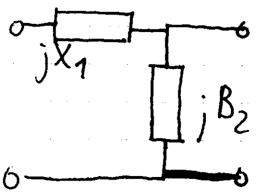
Akta

C, L prilagoditvenega četveropola

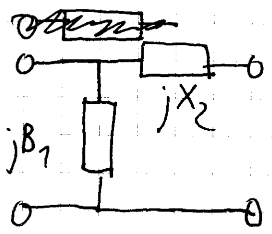
$Z_b = (30 + j40)\,\Omega$ $\qquad G_g = \frac{1}{50}\,S =$

$Z_g = 50\,\Omega$ $\qquad Y_b = \frac{1}{30+j40}\,S = \frac{3-4j}{250}\,S$

a)



b)



$$B_2 = \pm\sqrt{\frac{G_b}{R_g}(1 - G_b R_g)} - B_b \qquad X_2 = \pm\sqrt{\frac{R_b}{G_g}(1 - R_b G_g)} - X_b$$

$$X_1 = \pm\sqrt{\frac{R_g}{G_b}(1 - G_b R_g)} - X_g \qquad B_1 = \pm\sqrt{\frac{G_g}{R_b}(1 - R_b G_g)} - B_g$$

$\boxed{G_b R_g < 1}$ če je to < 1 uporabimo a

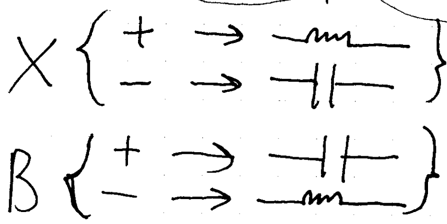
$\boxed{R_b G_g < 1}$ če je to < 1 uporabimo b

če oboje < 1 ~~katerikoli~~ oboje

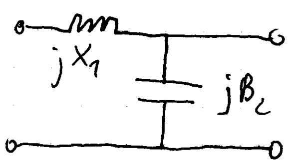
$$B_2 = \left\{ \frac{2}{125} + \frac{\sqrt{\frac{3}{2}}}{125} \;;\; \frac{2}{125} - \frac{\sqrt{\frac{3}{2}}}{125} \right\}$$

$$X_1 = \left\{ 50\sqrt{\frac{2}{3}} \;;\; -50\sqrt{\frac{2}{3}} \right\}$$

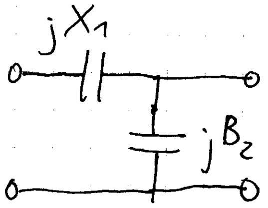
① ②



①



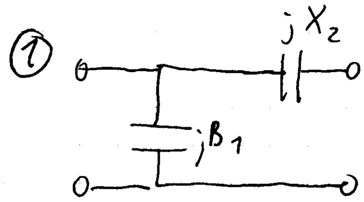
②

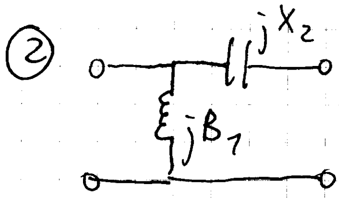


① ②

$$X_2 = \{ -40 + 10\sqrt{6},\ -40 - 10\sqrt{6} \}$$

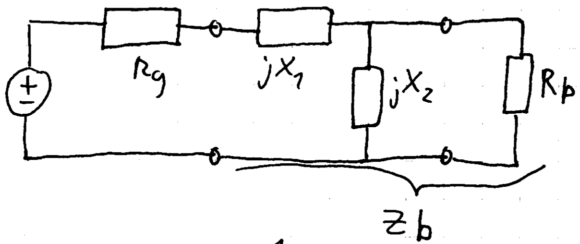
$$B_1 = \{ \frac{1}{25\sqrt{6}},\ -\frac{1}{25\sqrt{6}} \}$$





Izračunaj vrednost x_1 in x_2.

$x_1, x_2 = ?$



$R_g = 70\,\Omega$

$R_p = 600\,\Omega$

$f = 1\,kHz$

X
$+x = \omega L$
$-x = -\frac{1}{\omega C}$
B
$x = \omega C$
$-x = -\frac{1}{\omega L}$

$$Z_b = jX_1 + \frac{1}{\frac{1}{jx_2} + \frac{1}{R_p}} = jX_1 + \frac{x_2^2 R_p + j X_2 R_p^2}{R_p^2 + x_2^2}$$

$$Z_g = R_g$$

$$\underline{\underline{Z_b = Z_g^*}}$$

$$R_g = \frac{x_2^2 R_p}{R_p^2 + x_2^2} \qquad 0 = x_1 + \frac{x_2 R_p^2}{R_p^2 + x_2^2}$$

$$R_p^2 R_g + R_g x_2^2 = x_2^2 R_p \qquad x_1 = -\frac{x_2 R_p^2}{R_p^2 + x_2^2} = \mp 192{,}6\,\Omega$$

$$x_2^2 (R_p - R_g) = R_p^2 R_g$$

$$x_2^2 = \frac{R_p^2 R_g}{R_p - R_g}$$

$$x_2 = \pm \sqrt{\frac{R_p^2 R_g}{R_p - R_g}}$$

$$x_2 = \pm 218{,}05\,\Omega$$

① $x_1 = 192{,}6\,\Omega$ ② $x_1 = -192{,}6\,\Omega$

$x_2 = -218{,}05\,\Omega$ $\quad x_2 = 218{,}05\,\Omega$

$j\omega L \qquad +x = \omega L$

$-\frac{j}{\omega C} \qquad -x = -\frac{1}{\omega C}$

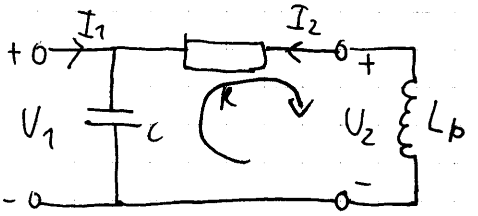
① $192{,}6 = \omega L$

$L = \frac{192{,}6}{\omega} = 0{,}031\,H$

$-218{,}05 = -\frac{1}{\omega C}$

$C = \frac{1}{218{,}05\,\omega} = 7{,}29 \cdot 10^{-7}\,F$

Določi sistemsko prevajalno funkcijo $Z(j\omega) = \frac{I_2}{I_1}$.



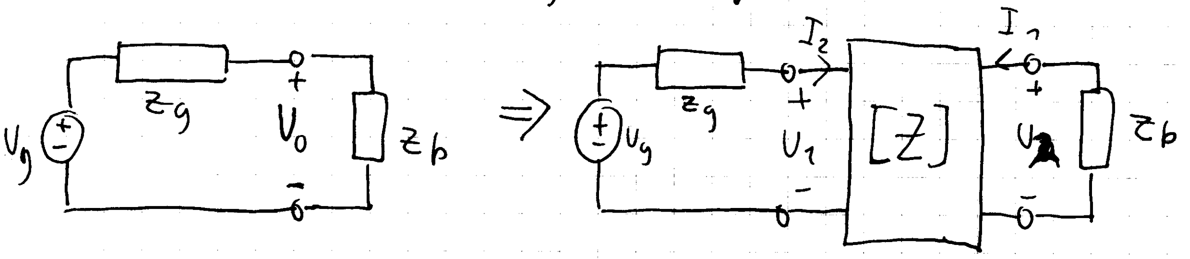
$$① \quad -\frac{I_1 + I_2}{j\omega C} - R I_2 - j\omega L_b I_2 = 0$$

$$I_2 \left(\frac{1}{j\omega C} + R + j\omega L_b\right) = -\frac{I_1}{j\omega C}$$

$$\frac{1 + j\omega RC - \omega^2 LC}{\cancel{j\omega C}} I_2 = -\frac{I_1}{\cancel{j\omega C}}$$

$$\frac{I_2}{I_1} = \frac{-1}{1 - \omega^2 LC + j\omega RC}$$

Določi ustavitveno funkcijo $H(j\omega) = \frac{U_2}{U_0}$



$$\boxed{U_0 = \frac{Z_b}{Z_b + Z_g} U_g}$$

$$U_1 = U_g - Z_g I_1$$

$$Z_b I_2 = -U_2$$

$$U_1 = z_{11} I_1 + z_{12} I_2$$

$$U_2 = z_{21} I_1 + z_{22} I_2$$

$$2. \quad I_1 = \frac{U_2 - z_{22} I_2}{z_{21}}$$

$$1. \quad z_{11} I_1 + z_{12} I_2 = U_g - Z_g I_1$$

$$I_1 (z_{11} + Z_g) = U_g - z_{12} I_2$$

$$I_2 = -\frac{U_2}{Z_b}$$

$$3. \quad \frac{U_2 - z_{22} I_2}{z_{21}} \cdot (z_{11} + Z_g) = U_g - z_{12} I_2$$

$$\frac{(U_2 - z_{22} I_2)(z_{11} + Z_g)}{z_{21}} + z_{12} I_2 = U_g$$

$$\frac{U_2 z_{11} Z_b + z_{22} z_{11} U_2 + U_2 Z_g Z_b + z_{22} Z_g U_2 - z_{12} z_{21} U_2}{z_{21} Z_b} = U_g$$

15.12.2008

$$\frac{\Delta Z\, U_2 + z_{11} z_b U_2 + z_g z_b U_2 + z_{22} z_g U_2}{z_{21} z_b} = U_g$$

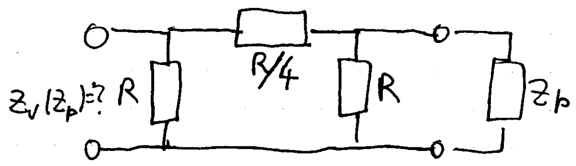
$$U_2 = \frac{z_{21} z_b}{\Delta Z + z_{11} z_b + z_g z_b + z_{22} z_g}\, U_g$$

$$H(j\omega) = \frac{U_2}{U_0} = \frac{z_{21}(z_b + z_g)}{\Delta Z + z_{11} z_b + z_g z_b + z_{22} z_g}$$

Kakšna je karakteristična inpedanca od četveropola?

$Z_k = ?$

Na izhod moramo dati breme!



1.) $$\left(\frac{1}{R} + \frac{1}{Z_b}\right)^{-1} = \frac{R Z_b}{R + Z_b}$$

2.) $$\frac{R}{4} + \frac{R Z_b}{R + Z_b} = \frac{R^2 + R Z_b + 4 R Z_b}{4(R + Z_b)} = \frac{R^2 + 5 R Z_b}{4R + 4 Z_b}$$

3.) $$\left(\frac{1}{R} + \frac{4R + 4Z_b}{R^2 + 5 R Z_b}\right)^{-1} = \left(\frac{R + 5 Z_b + 4R + 4 Z_b}{R^2 + 5 R Z_b}\right)^{-1} = \left(\frac{5R + 9 Z_b}{R^2 + 5 R Z_b}\right)^{-1}$$

$$Z_v(Z_b) = \frac{R^2 + 5 R Z_b}{5R + 9 Z_b}$$

$$\boxed{Z_v(Z_k) = Z_k}$$

$$\frac{R^2 + 5 R Z_k}{5R + 9 Z_k} = Z_k$$

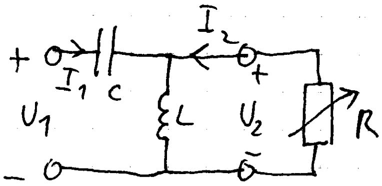
$$R^2 + \cancel{5 R Z_k} = \cancel{5 R Z_k} + 9 Z_k^2$$

$$Z_k = \frac{R^2}{9}$$

$$Z_k = \sqrt{\frac{R^2}{9}} = \frac{R}{3}$$

Nariši potek od Z_V kot funkcije upora. ($\omega C = 1$, $\omega L = 2$)

$Z_V(R)$ $\quad \omega C = 1 \quad \omega L = 2$



$$U_1 = Z_{11} I_1 + Z_{12} I_2$$
$$U_2 = Z_{21} I_1 + Z_{22} I_2$$

a) $I_2 = 0$

$$Z_{11} = \frac{U_1}{I_1} = \frac{1}{j\omega C} + j\omega L = \frac{1}{j} + 2j = j$$

$$Z_{21} = \frac{U_2}{I_1} = j\omega L = 2j$$

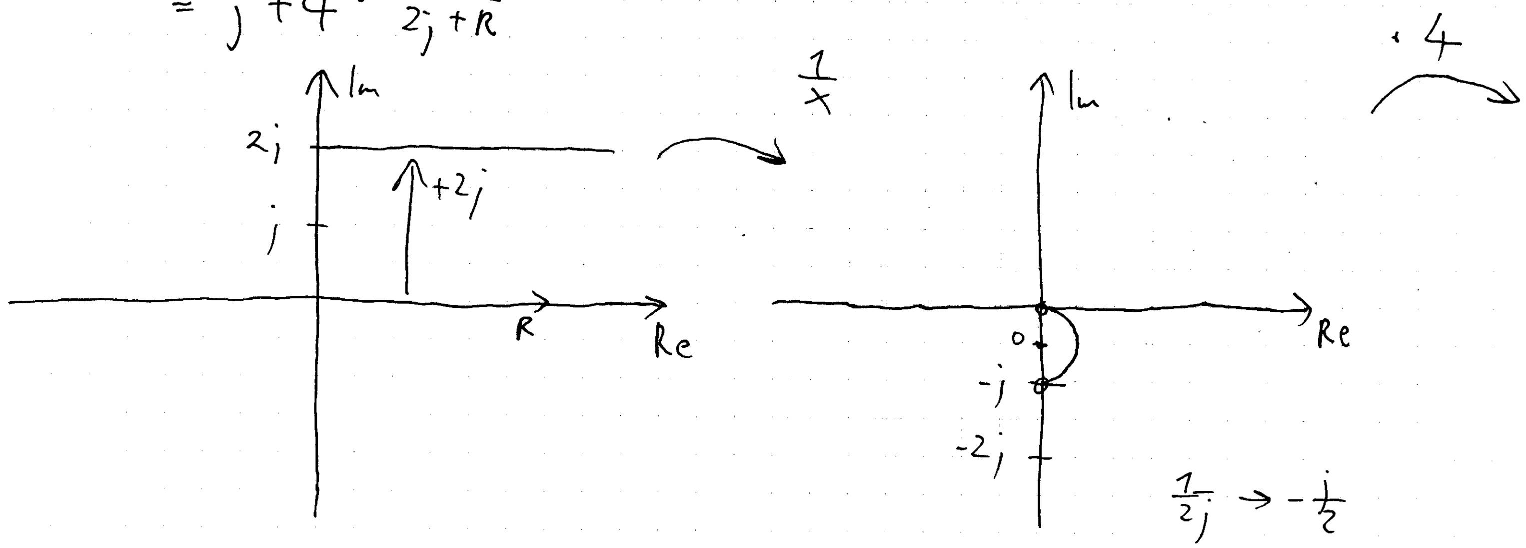
b) $I_1 = 0$

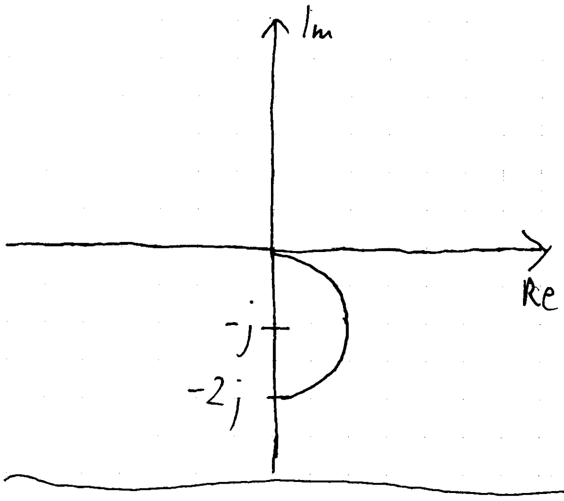
$$Z_{12} = \frac{U_1}{I_2} = j\omega L = 2j$$

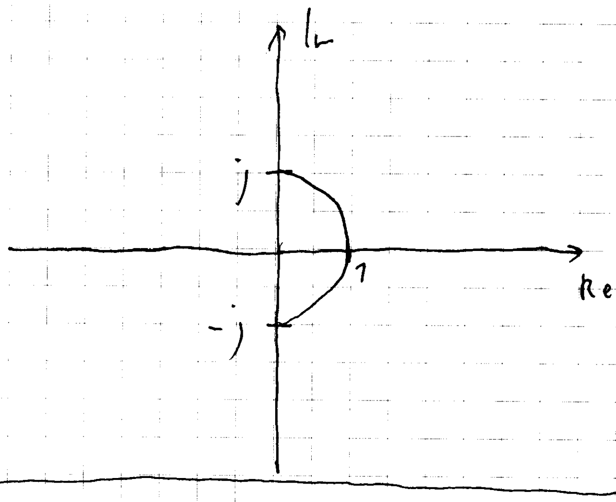
$$Z_{22} = \frac{U_2}{I_2} = j\omega L = 2j$$

$$\boxed{Z_V(Z_p) = Z_{11} - Z_{12} Z_{21} \frac{1}{Z_{22} + Z_p}}$$

$$Z_V(R) = j - 2j \cdot 2j \frac{1}{2j + R}$$
$$= j + 4 \cdot \frac{1}{2j + R}$$

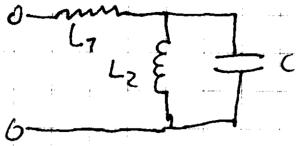






Izračunaj resonančno frekvenco, kvaliteto in nariši potek vhodne impe.

ω_0, Q, potek $Z_v(\omega)$



a) Tokovna

$$Z_V = j\omega L_1 + \frac{1}{\frac{1}{j\omega L_2} + j\omega C} = j\omega L_1 + \frac{j\omega L_2}{1-\omega^2 L_2 C}$$

$$Im(Z_v) = 0$$

$$\omega L_1 + \frac{\omega L_2}{1-\omega^2 L_2 C} = 0 \qquad \cancel{\omega = 0}$$

resonance ni brez frek.

$$L_1 + L_2 - \omega^2 L_2 C L_1 = 0$$

$$\omega^2 L_2 C L_1 = L_1 + L_2$$

$$\omega^2 = \frac{L_1 + L_2}{L_1 L_2 C} \Rightarrow \omega_0 = \sqrt{\frac{L_1 + L_2}{L_1 L_2 C}}$$

$$Q_L = \frac{X_L}{R} = \infty$$

b) Napetostna

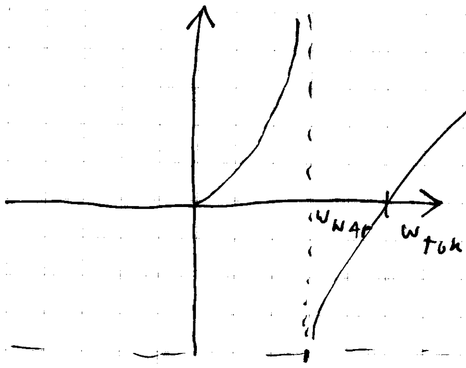
$$Y_V = (Z_V)^{-1} = \left(\frac{j\omega L_1 - j\omega^3 L_1 L_2 C + j\omega L_2}{1-\omega^2 L_2 C}\right)^{-1} = \frac{1-\omega^2 L_2 C}{j\omega(L_1+L_2) - j\omega^3 L_1 L_2 C} =$$

$$= -j\,\frac{1-\omega^2 L_2 C}{\omega(L_1+L_2) - \omega^3 L_1 L_2 C}$$

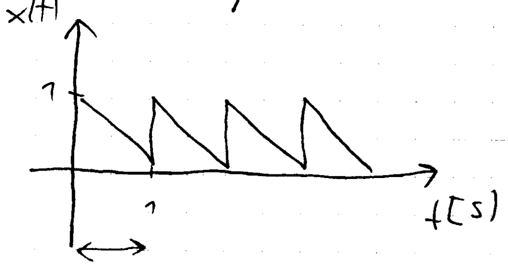
$$Im(Y_V) = 0 \Rightarrow \frac{1-\omega^2 L_2 C}{\omega(L_1+L_2) - \omega^3 L_1 L_2 C} = 0 \Rightarrow 1-\omega^2 L_2 C = 0$$

$$\omega^2 L_2 C = 1 \Rightarrow \omega = \sqrt{\frac{1}{L_2 C}}$$

w_{OTOK} = ničla
w_{ONAP} = pol
$w=0$, ničla



Fourierjeva vrsta



$$f(t)=a_0+\sum_{n=1}^{\infty}\left(a_n\cos(n\omega t)+b_n\sin(n\omega t)\right)$$
$$a_0=\frac{1}{T}\int_0^T f(t)\,dt$$
$$a_n=\frac{2}{T}\int_0^T f(t)\cos(n\omega t)\,dt$$
$$b_n=\frac{2}{T}\int_0^T f(t)\sin(n\omega t)\,dt$$

LIHA: $a_n=0$

SODA: $b_n=0$

$T=1s \qquad t\in[0,1]$

$w=2\pi \qquad f(t)=1-t$

$$a_0=\frac{1}{1}\int_0^1(1-t)\,dt=\left(t-\frac{t^2}{2}\right)\Big|_0^1=1-\frac{1}{2}=\frac{1}{2}$$

$$a_n=\frac{2}{1}\int_0^1(1-t)\cos(n\cdot 2\pi\cdot t)\,dt=2\cdot\underbrace{\int_0^1\cos(2\pi n t)\,dt}_{=0}-2\int_0^1 t\cdot\cos(2\pi n t)\,dt=$$
$$=-2\cdot\left(\frac{t}{2\pi n}\sin(2\pi n t)+\frac{1}{(2\pi n)^2}\cos(2\pi n t)\right)\Big|_0^1=$$
$$=-2\cdot\left[\left(0+\frac{1}{(2\pi n)^2}\right)-\left(0+\frac{1}{(2\pi n)^2}\right)\right]=0$$

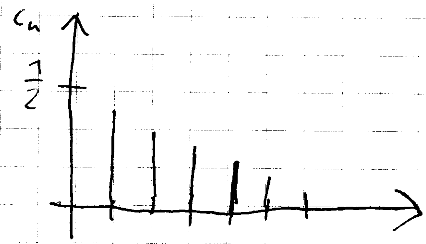
$$b_n=\frac{2}{1}\int_0^1(1-t)\sin(2\pi n t)\,dt=2\cdot\underbrace{\int_0^1\sin(2\pi n t)\,dt}_{=0}-2\int_0^1 t\sin(2\pi n t)\,dt=$$
$$=-2\left(-\frac{t}{2\pi n}\cos(2\pi n t)+\frac{1}{(2\pi n)^2}\sin(2\pi n t)\right)\Big|_0^1$$
$$=-2\left(\left(-\frac{1}{2\pi n}+0\right)-(0+0)\right)=\frac{2}{2\pi n}=\frac{1}{\pi n}$$

$$f(t)=\frac{1}{2}+\sum_{n=1}^{\infty}\frac{1}{\pi n}\cdot(\sin(2\pi n t))$$

amplitudni spekter

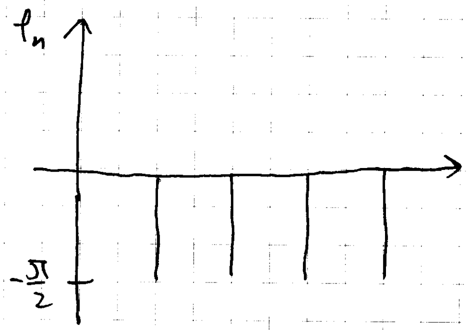
$$\boxed{c_0 = |a_0|} = \frac{1}{2}$$

$$\boxed{c_n = \sqrt{a_n^2 + b_n^2}} = \sqrt{b_n^2} = |b_n| = \frac{1}{n\pi}$$

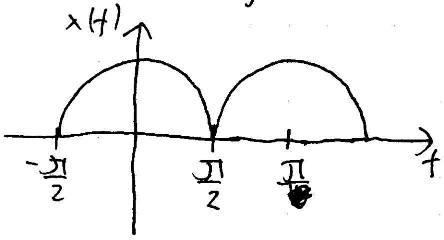


fazni spekter

$$\boxed{\varphi_n = -\mathrm{arctg}\left(\frac{b_n}{a_n}\right)} = -\frac{\pi}{2}$$



Izračunaj F vrsto, spektra, delovno moč, F eksponentno vrsto



$x(t) = |\cos(t)|$ $\qquad$ $x(t)$ = soda

$T = \pi$ $\qquad$ $t \in [-\frac{\pi}{2}, \frac{\pi}{2}]$

$\omega = \frac{2\pi}{\pi} = 2$

$$a_0 = \frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos(t)\,dt = \frac{1}{\pi}\sin(t)\Big|_{-\frac{\pi}{2}}^{\frac{\pi}{2}} = \frac{1}{\pi}(1-(-1)) = \frac{2}{\pi}$$

$$a_n = \frac{2}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos(t)\cdot\cos(2nt)\,dt = \frac{2}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\frac{1}{2}\left(\cos((2n-1)t) + \cos((2n+1)t)\right)dt =$$

$$= \frac{1}{\pi}\left(\frac{\sin((2n-1)t)}{2n-1} + \frac{\sin((2n+1)t)}{2n+1}\right)\Big|_{-\frac{\pi}{2}}^{\frac{\pi}{2}} =$$

$$= \frac{1}{\pi}\left(\frac{(-1)^{n+1}}{2n-1} + \frac{(-1)^n}{2n+1} - \left(\frac{(-1)^n}{2n-1} + \frac{(-1)^{n+1}}{2n+1}\right)\right)$$

$\sin(\frac{\pi}{2}(2n-1)) \rightarrow (-1)^{n+1}$	$\sin(-\frac{\pi}{2}(2n-1)) \rightarrow (-1)^{n+1}$
$\sin(\frac{\pi}{2}(2n+1)) \rightarrow (-1)^n$	$\sin(-\frac{\pi}{2}(2n+1)) \rightarrow (-1)^n$

$$a_n = \frac{2}{\pi}(-1)^{n+1}\left[\frac{1}{2n-1} - \frac{1}{2n+1}\right] = \frac{2}{\pi}(-1)^{n+1}\frac{\cancel{2n+1-2n-1}}{(2n-1)(2n+1)} = \frac{4(-1)^{n+1}}{\pi(4n^2-1)}$$

Akta

$$f(t)=\frac{2}{\pi}+\frac{4}{\pi}\sum_{n=1}^{\infty}\frac{(-1)^{n+1}}{(4n^2-1)}\cos(2nt)$$

$$\boxed{x(t)=\sum_{\substack{-\infty \\ n\neq 0}}^{\infty}A_n e^{jwnt}+A_0 \qquad A_0=a_0 \quad A_n=\frac{1}{T}\int_0^T x(t)\,e^{-jnwt}\,dt}$$

eksponentna F vrsta

$$\boxed{e^{jwt}=\cos(wt)+j\sin(wt) \qquad \cos(t)=\frac{e^{jt}+e^{-jt}}{2}}$$

$$A_0=\frac{2}{\pi}$$

$$A_n=\frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\cos(t)\,e^{-2jnt}\,dt$$

$$=\frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\frac{e^{jt}+e^{-jt}}{2}e^{-2jnt}\,dt=\frac{1}{2\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}e^{+(j-2jn)}+e^{+(-j-2jn)}\,dt$$

$$=\frac{1}{2\pi}\left(\frac{e^{j(1-2n)t}}{j(1-2n)}+\frac{e^{-j(1+2n)t}}{-j(1+2n)}\right)\Bigg|_{-\frac{\pi}{2}}^{\frac{\pi}{2}}$$

$$=\frac{1}{2\pi}\left(\left(\frac{(-1)^n\cancel{j}}{\cancel{j}(1-2n)}+\frac{(-1)^{n+1}\cancel{j}}{-\cancel{j}(1+2n)}\right)-\left(\frac{(-1)^{n+1}\cancel{j}}{\cancel{j}(1-2n)}+\frac{(-1)^n\cancel{j}}{-\cancel{j}(1+2n)}\right)\right)=$$

$$\boxed{\begin{aligned} &e^{-j(1-2n)\frac{\pi}{2}}=-(-1)^n j && e^{j(1+2n)\frac{\pi}{2}}=j(-1)^n \\ &e^{j(1-2n)\frac{\pi}{2}}=j(-1)^n && e^{-j(1+2n)\frac{\pi}{2}}=-j(-1)^n \end{aligned}}$$

$$=\frac{2(-1)^{n+1}}{\pi(4n^2-1)}$$

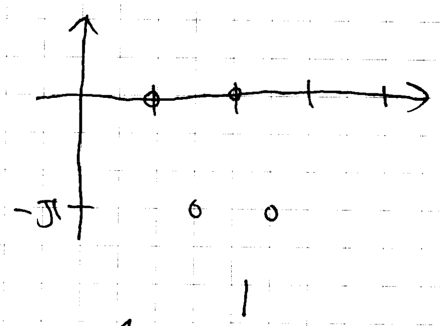
$$f(t)=\frac{2}{\pi}+\frac{2}{\pi}\sum_{n\neq 0}\frac{(-1)^{n+1}}{4n^2-1}e^{j2nt}$$

amplitudni spekter

$$\boxed{\begin{aligned} c_0 &= |A_0| \\ c_n &= 2|A_n| \end{aligned}} \quad \begin{aligned} &= \frac{2}{\pi} \\ &= \frac{4}{\pi(4n^2-1)} \end{aligned}$$

fazni spekter

$$\varphi_n = \arg(A_n) = \begin{cases} 0 & n = 2k+1 \\ -\pi & n = 2k \end{cases}$$



časovni prostor

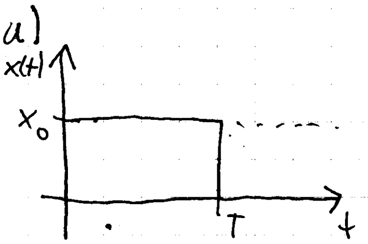
$$P = \frac{1}{T}\int_0^T x^2(t)\,dt = \frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos^2(t)\,dt = \underline{\underline{\frac{1}{2}}}$$

frekvenčni prostor

$$\boxed{P = c_0^2 + \sum_{n=1}^{\infty} \frac{c_n^2}{2}} = \frac{4}{\pi^2} + \frac{8}{\pi^2}\sum_{n=1}^{\infty}\frac{1}{(4n^2-1)^2}$$

05.01.2008

a)



$$x(t) = x_0 \cdot \left(1(t) - 1(t-T)\right)$$

$$\boxed{1(t) \longleftrightarrow \pi\delta(\omega) + \frac{1}{j\omega}}$$

$$\boxed{f(t-\tau) \longleftrightarrow F(\omega)\cdot e^{-j\omega T}}$$

$$X(\omega) = x_0\left(\pi\delta(\omega) + \frac{1}{j\omega}\right) - x_0\left(\pi\delta(\omega) + \frac{1}{j\omega}\right)\cdot e^{-j\omega T} =$$

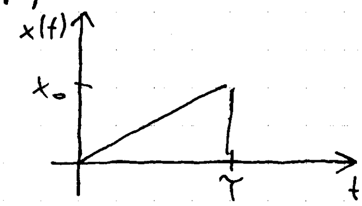
$$= x_0\left(\pi\delta(\omega) - \pi\delta(\omega)\cdot e^{-j\omega\tau}\right) +$$

$$+ x_0\left(\frac{1}{j\omega} + \frac{e^{-j\omega\tau}}{j\omega}\right) =$$

$$= x_0 \cdot \frac{1+e^{-j\omega\tau}}{j\omega} + x_0 \underbrace{\pi\delta(\omega)\cdot\left(1-e^{-j\omega\tau}\right)}_{=0}$$

$$= x_0 \cdot \frac{1+e^{-j\omega\tau}}{j\omega}$$

b)



$$x(t) = \frac{x_0}{\tau} \cdot t \left(1(t) - 1(t-\tau)\right)$$

$$\boxed{t \cdot f(t) \longleftrightarrow \frac{\partial F(\omega)}{\partial \omega}}$$

$$x(t) = \frac{x_0}{\tau}\left(t \cdot 1(t) - t \cdot 1(t-\tau)\right) =$$

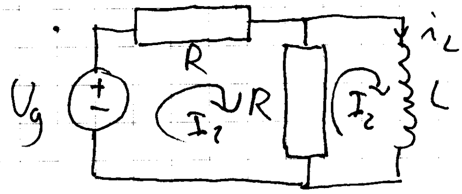
$$= \frac{x_0}{\tau}\left(t \cdot 1(t) - (t-\tau+\tau)\cdot 1(t-\tau)\right) =$$

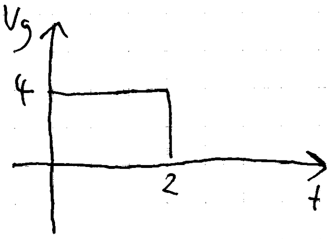
$$= \frac{x_0}{\tau}\left(t \cdot 1(t) - (t-\tau)\,1(t-\tau) - \tau \cdot 1(t-\tau)\right)$$

$$X(\omega) = \frac{x_0}{\tau}\left[\left(-j\pi\frac{\delta(\omega)}{\omega} - \frac{1}{\omega^2}\right)\cdot\left(1-e^{-j\omega\tau}\right) - \tau\left(\pi\delta(\omega) + \frac{1}{j\omega}\right)\cdot e^{-j\omega\tau}\right]$$

Izračunaj tok skozi tuljavo.

$i_L(t) = ?$





$$u_g(t) = 4\left(1(t) - 1(t-2)\right)\,V$$

$$H(j\omega) = \frac{I_L}{U_g}$$

$$U_g(\omega) = 4\cdot\left(\left(\pi\delta(\omega) + \frac{1}{j\omega}\right) - \left(\pi\delta(\omega) + \frac{1}{j\omega}\right)\cdot e^{-2j\omega}\right) =$$

$$= 4\left(\frac{1-e^{-2j\omega}}{j\omega} + \underbrace{\left(\pi\delta(\omega)\cdot(1-e^{-2j\omega})\right)}_{=0}\right)$$

$$= 4\,\frac{1-e^{-2j\omega}}{j\omega}$$

I_1: $$-U_g + RI_1 + R(I_1 - I_2) = 0$$

I_2: $$R(I_2 - I_1) + j\omega L I_2 = 0$$

$$H(j\omega) = \frac{1}{R + 2j\omega L} \qquad U_g(\omega) = 4\cdot\frac{1-e^{-2j\omega}}{j\omega}$$

$$I_L = H(j\omega)\cdot U_g(\omega)$$

$$I_L = 4\cdot\frac{1-e^{-2j\omega}}{j\omega(R+2j\omega L)} = \frac{4}{R}\left(1-e^{-2j\omega}\right)\frac{1}{j\omega - \frac{2L}{R}\cdot\omega^2} =$$

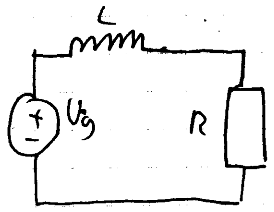
$$j\omega - \frac{2L}{R}\omega^2 = j\omega\left(1 + \frac{2L}{R}j\omega\right)$$

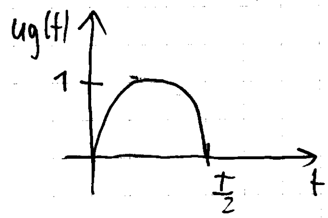
$$= \frac{4}{R}\left(1-e^{-2j\omega}\right)\left[\frac{1}{j\omega} - \frac{1}{j\omega + \frac{R}{2L}}\right]$$

$$\boxed{\begin{array}{c} \frac{1}{j\omega} \longleftrightarrow \frac{1}{2}\,\mathrm{sign}(t) \\ \hline \frac{1}{j\omega + \frac{R}{2L}} \longleftrightarrow 1(t)\,e^{-\frac{R}{2L}t} \end{array}}$$

$$i_L(t) = \frac{4}{R}\left[\frac{1}{2}\,\mathrm{sign}(t) - 1(t)\cdot e^{-\frac{R}{2L}t} - \left(\frac{1}{2}\,\mathrm{sign}(t-2) - 1(t-2)\,e^{-\frac{R}{2L}(t-2)}\right)\right]$$

$U_R(\omega)$





$$\boxed{\sin(\omega_0 t)1(t) \leftrightarrow \frac{\omega_0}{\omega_0^2-\omega^2}}$$

$$u_g(t) = \sin(\omega_0 t)\left(1(t) - 1(t-\tfrac{T}{2})\right) \quad ; \quad \omega_0 = \frac{2\pi}{T} \Rightarrow \pi = \frac{\omega_0 T}{2}$$

$$= \sin(\omega_0 t)\cdot 1(t) - \sin(\omega_0 t)\cdot 1(t-\tfrac{T}{2})$$

$$= \sin(\omega_0 t)\cdot 1(t) + \sin(\omega_0 t - \pi)\cdot 1(t-\tfrac{T}{2})$$

$$= \sin(\omega_0 t)\cdot 1(t) + \sin(\omega_0 (t-\tfrac{T}{2}))\cdot 1(t-\tfrac{T}{2})$$

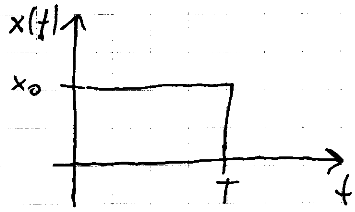
$$U_g(\omega) = \frac{\omega_0}{\omega_0^2-\omega^2}\left(1 + e^{-j\frac{T}{2}\omega}\right)$$

$$H(j\omega) = \frac{R}{R+j\omega L}$$

$$U_R(\omega) = H(j\omega)\cdot U_g(\omega) = \underline{\underline{\frac{R\omega_0}{(R+j\omega L)(\omega_0^2-\omega^2)}\left(1+e^{-j\frac{T}{2}\omega}\right)}}$$

Laplaceova trans.

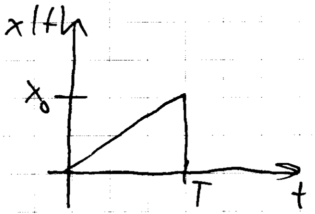
$$1(t) \leftrightarrow \frac{1}{s}$$
$$x(t-\tau)1(t-\tau) \leftrightarrow X(s)e^{-\tau s}$$
$$t\, f(t) \leftrightarrow -\frac{\partial F(s)}{\partial s}$$



$$x(t) = x_0\left(1(t) - 1(t-\tau)\right)$$

$$X(s) = x_0 \frac{1}{s} - x_0 \frac{1}{s}\cdot e^{-Ts}$$

Vedno mora biti enotina stopnica.

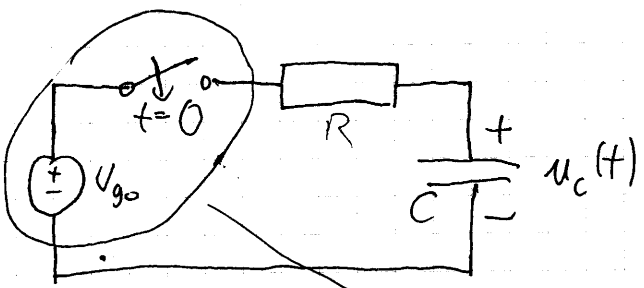


$$x(t) = \frac{x_0}{T}t\left(1(t) - 1(t-T)\right)$$
$$= \frac{x_0}{T}\left(t1(t) - t\cdot 1(t-T)\right)$$
$$= \frac{x_0}{T}\left(t\cdot 1(t) - (t-T+T)\cdot 1(t-T)\right)$$
$$= \frac{x_0}{T}\left(t\cdot 1(t) - (t-T)\cdot 1(t-T) - T1(t-T)\right)$$

$$X(s) = \frac{x_0}{T}\left(\frac{1}{s^2} - \frac{1}{s^2}\cdot e^{-Ts} - T\frac{1}{s}\cdot e^{-Ts}\right.$$

12.01.2009

Poloči napetost na kondenzatorju!



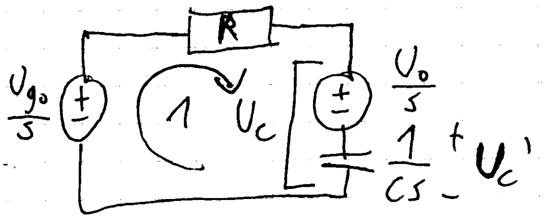
$\underline{\underline{u_c(t) = ?}}$

$\underline{u_c(0) = U_0}$

$\underline{U_g = 5V}$

$U_{g0} \cdot 1(t) \longleftrightarrow \frac{U_{g0}}{s}$

$u_c(0) = U_0 \cdot 1(t) \longleftrightarrow \frac{U_0}{s}$



$z = \frac{1}{Cs}$, $Y = Cs$

$\cancel{Y} = \frac{1}{LD}$, $z = LD$

$$U_C = \frac{U_0}{s} + U_C'$$

$$1 \quad -\frac{U_{g0}}{s} + R\,I(s) + \frac{U_0}{s} + \frac{I(s)}{Cs} = 0$$

$$I(s)\left(R + \frac{1}{Cs}\right) = \frac{U_{g0} - U_0}{s}$$

$$I(s) = \frac{U_{g0} - U_0}{s\left(R + \frac{1}{Cs}\right)} = \underline{\underline{\frac{U_{g0} - U_0}{RCs + 1}\, C}}$$

$$U_C = \frac{U_0}{s} + \frac{I(s)}{Cs} = \frac{U_0}{s} + \frac{1}{\cancel{C}s}\,\frac{(U_{g0} - U_0)\cancel{C}}{RCs + 1} = \frac{U_0}{s} + \frac{U_{g0} - U_0}{s(1 + RCs)} =$$

$$= \frac{U_0}{s} + \frac{(U_{g0} - U_0)}{RC} \cdot \frac{1}{s\left(s + \frac{1}{RC}\right)}$$

$$\frac{1}{(s - s_1)(s - s_2)} = \frac{K_1}{s - s_1} + \frac{K_2}{s - s_2}$$

$s_1 = 0 \quad s_2 = -\frac{1}{RC}$

$$\boxed{K_1 = \frac{1}{s - s_2}\Big|_{s = s_1}} \qquad \boxed{K_2 = \frac{1}{s - s_1}\Big|_{s = s_2}}$$

$$\frac{1}{s(s+\frac{1}{RC})}$$

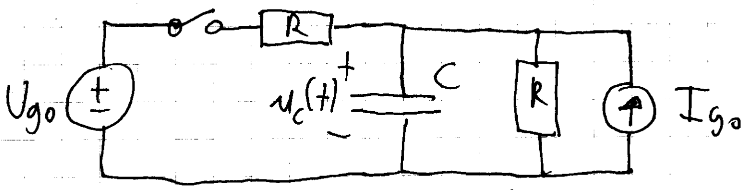
$$K_1 = \frac{1}{s+\frac{1}{RC}}\Big|_{s=0} = \frac{1}{\frac{1}{RC}} = \underline{RC}$$

$$K_2 = \frac{1}{s}\Big|_{s=-\frac{1}{RC}} = \frac{1}{-\frac{1}{RC}} = \underline{-RC}$$

$$U_C = \frac{U_0}{s} + \frac{U_{g0}-U_0}{\cancel{RC}}\cdot\left(\frac{\cancel{RC}}{s} - \frac{RC}{s+\frac{1}{RC}}\right) \qquad \boxed{\frac{1}{s-a} \leftrightarrow e^{at}}$$

$$u_C(t) = U_0\cdot 1(t) + (U_{g0}-U_0)\left(1\cdot(t) - e^{-\frac{t}{RC}}\,1(t)\right)$$

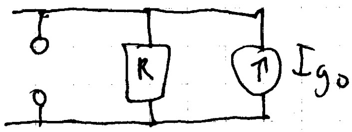
Določi napetost na kondenzatorja!



$$U_{g0}\cdot 1(t) \leftrightarrow \frac{U_{g0}}{s}$$

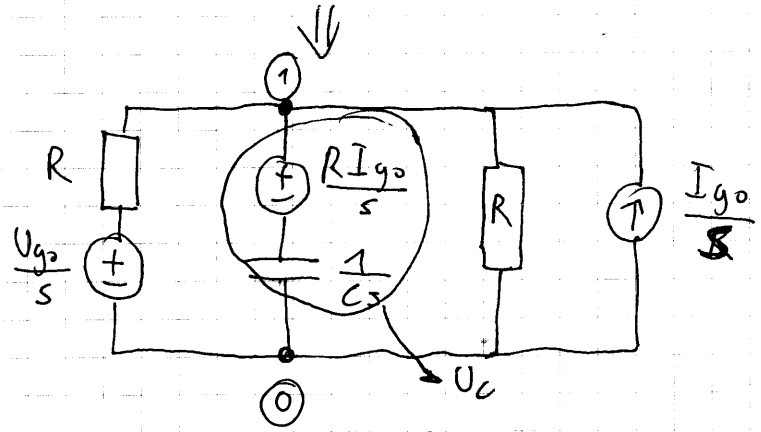
$$I_{g0}\cdot 1(t) \leftrightarrow \frac{I_{g0}}{s}$$

⇓



$$u_C(0) = R\,I_{g0} \leftrightarrow \frac{RI_{g0}}{s}$$

⇓



$$1 \quad \frac{U_{v1}(s) - \frac{U_{g0}}{s}}{R} + Cs\left(U_{v1}(s) - \frac{I_{g0}R}{s}\right) + \frac{U_{v1}(s)}{R} - \frac{I_{g0}}{s} = 0$$

$$U_{v1}(s)\left(\frac{1}{R} + Cs + \frac{1}{R}\right) = \frac{U_{g0}}{Rs} + \frac{I_{g0}CRs}{s} + \frac{I_{g0}}{s}$$

$$U_{v1}(s)\,\frac{2+RCs}{\cancel{R}} = \frac{U_{g0}+I_{g0}R^2Cs+I_{g0}R}{\cancel{R}s}$$

$$U_C = \frac{U_{g0}+I_{g0}R^2Cs+I_{g0}R}{s\,(2+RCs)} = \frac{U_{g0}+RI_{g0}}{RCs(s+\frac{2}{RC})} + \frac{I_{g0}R^2Cs}{RCs(s+\frac{2}{RC})}$$

$$\frac{1}{s(s+\frac{2}{RC})}$$

$s_1=0$
$s_2=-\frac{2}{RC}$

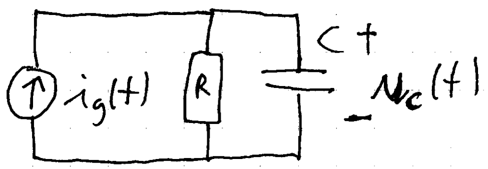
$$K_1=\frac{1}{s+\frac{2}{RC}}\Big|_{s=0}=\frac{RC}{2}$$

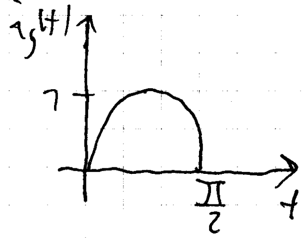
$$K_2=\frac{1}{s}\Big|_{s=-\frac{2}{RC}}=-\frac{RC}{2}$$

$$U_C=\frac{U_{g0}+RI_{g0}}{\cancel{RC}}\left(\frac{\frac{\cancel{RC}}{2}}{s}+\frac{-\frac{\cancel{RC}}{2}}{s+\frac{2}{RC}}\right)+\frac{I_{g0}R}{s+\frac{2}{RC}}$$

$$u_C(t)=\frac{U_{g0}+RI_{g0}}{2}\left(1\cdot(t)-e^{-\frac{2t}{RC}}\cdot 1(t)\right)+I_{g0}R\cdot e^{-\frac{2t}{RC}}1(t)$$

Določi napetost na kondenzatorju. $u_C(t)=?$





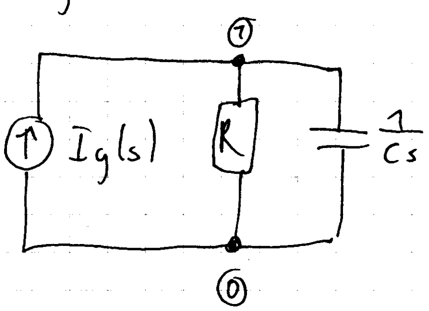
$R=1\,\Omega$
$C=1\,F$
$u_c(0)=0\,V$

$$i_g(t)=\sin(\omega_0 t)\left(1(t)-1(t-\tfrac{\pi}{2})\right)=\sin(2t)\cdot 1(t)-\sin(2t)\,1(t-\tfrac{\pi}{2})$$

$$\omega_0=\frac{2\pi}{T}=\frac{2\pi}{\pi}=\underline{\underline{2}}$$

$$=\sin(2t)\cdot 1(t)+\sin(2t-\pi)\cdot 1(t-\tfrac{\pi}{2})=$$
$$=\sin(2t)\cdot 1(t)+\sin\left(2\cdot(t-\tfrac{\pi}{2})\right)\cdot 1(t-\tfrac{\pi}{2})$$

$$I_g(s)=\frac{2}{4+s^2}+\frac{2}{4+s^2}e^{-\frac{\pi}{2}\cdot s}$$



1 $-I_g(s)+\frac{U_{v1}(s)}{R}+U_{v1}(s)\cdot Cs=0$

$$U_{v1}(s)\cdot\left(\frac{1}{R}+Cs\right)=I_g(s)$$
$$U_{v1}(s)\cdot\frac{1+CRs}{R}=I_g(s)$$

$$U_C=U_{v1}(s)=\frac{I_g(s)\cdot R}{1+RCs}$$
$$=\frac{R}{1+RCs}\cdot\frac{2}{4+s^2}\left(1+e^{-\frac{\pi}{2}s}\right)$$

$$U_C = \frac{2R}{RC}\left(1+e^{-\frac{\pi}{2}s}\right)\cdot\frac{1}{(s+\frac{1}{RC})(4+s^2)}$$

$$= 2\left(1+e^{-\frac{\pi}{2}s}\right)\cdot\frac{1}{(s+1)(s^2+4)}$$

$$= 2\left(1+e^{-\frac{\pi}{2}s}\right)\cdot\frac{1}{(s+1)(s+2j)(s-2j)}$$

$$K_1 = \left.\frac{1}{(s+2j)(s-2j)}\right|_{s=-1} = \left.\frac{1}{s^2+4}\right|_{s=-1} = \frac{1}{5}$$

$$K_2 = \left.\frac{1}{(s+1)(s-2j)}\right|_{s=-2j} = \frac{-2+j}{20}$$

$$K_3 = \left.\frac{1}{(s+1)(s+2j)}\right|_{s=2j} = \frac{-2-j}{20}$$

$$U_C = 2\cdot\left(1+e^{-\frac{\pi}{2}s}\right)\Big(\underbrace{\frac{1}{5}\,\frac{1}{s+1}+\frac{-2+j}{20}\,\frac{1}{s+2j}+\frac{-2-j}{20}\,\frac{1}{s-2j}}_{A}\Big)$$

$$\mathcal{L}^{-1}[A] = \left(\frac{1}{5}\cdot e^{-t}+\frac{-2+j}{20}\,e^{-2jt}+\frac{-2-j}{20}\cdot e^{2jt}\right)\cdot 1(t) =$$

$$= \left(\frac{1}{5}e^{-t}+\frac{-2+j}{20}\left(\cos(-2t)+j\sin(-2t)\right)+\frac{-2-j}{20}\left(\cos(2t)+j\sin(2t)\right)\right)1(t)$$

$$= \frac{1}{5}\left(e^{-t}-\frac{\cos(2t)}{2}-\frac{\cos(2t)}{2}+\frac{\sin(2t)}{4}+\frac{\sin(2t)}{4}\right)\cdot 1\cdot(t)$$

$$= \frac{1}{5}\left(e^{-t}-\cos(2t)+\frac{1}{2}\sin(2t)\right)1(t)$$

$$u_C(t) = 2\Big[\frac{1}{5}\left(e^{-t}-\cos(2t)+\frac{1}{2}\sin(2t)\cdot 1(t)+\frac{1}{5}\left(e^{-t-\frac{\pi}{2}}-\cos(2(t-\frac{\pi}{2}))+\right.\right.$$
$$\left.\left.+\frac{1}{2}\sin\left(2\left(t-\frac{\pi}{2}\right)\right)\right)\cdot 1\left(t-\frac{\pi}{2}\right)\Big]$$

Tuning trik!

$\mathcal{L}^{-1}$: $\dfrac{s-2}{2s^2+s+2}$

$\dfrac{s-2}{(s-s_1)(s-s_2)}$ $\qquad s_{1,2} = \dfrac{-b \pm \sqrt{b^2-4ac}}{2a}$