HASOVNE EK 2010/2011

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

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

$ke^{-at} \circ\!\!-\!\!\bullet \frac{K}{s+a}$

$ke^{-\sigma t}\sin(\omega t) \circ\!\!-\!\!\bullet k\frac{\omega}{(s+\sigma)^2+\omega^2}$

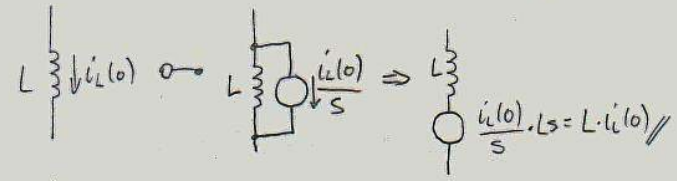
$k\cdot e^{-\sigma t}\cos(\omega t) \circ\!\!-\!\!\bullet k\frac{s+\sigma}{(s+\sigma)^2+\omega^2}$

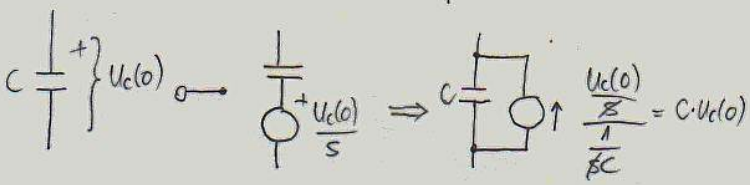
Otpor: $u(t) = R\cdot i(t) \quad \circ\!\!-\!\!\bullet \quad U(s) = R\cdot I(s) \quad Z_r = R$

Zavojnica: $L\cdot\frac{di}{dt} \quad \circ\!\!-\!\!\bullet \quad U(s) = sL\cdot I(s) \quad Z_L = sL$

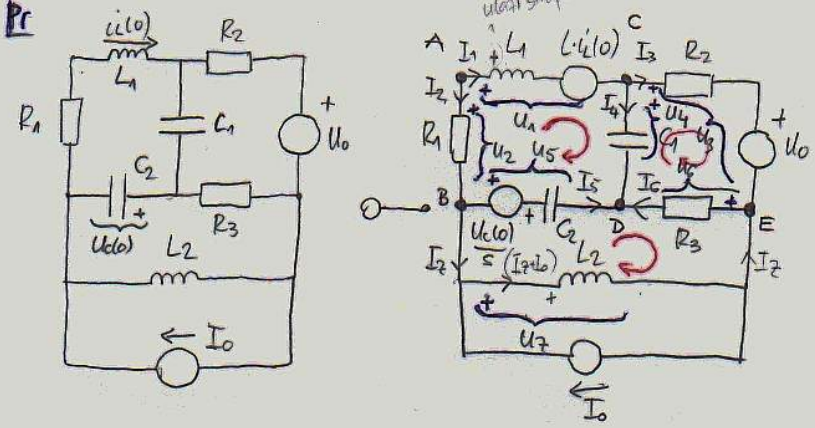
Kondenz: $\frac{1}{C}\int_0^t i(\tau)d\tau \quad \circ\!\!-\!\!\bullet \quad U(s) = \frac{1}{sC}\cdot I(s) \quad Z_C = \frac{1}{sC}$

Početni uvjeti





Pr

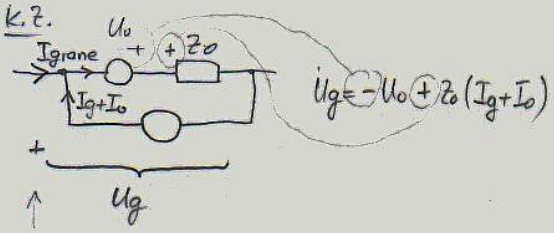


6 načina: KZN, KZS, Norton, Thevenin, konturne struje

Grana toliko elemenata - 7

Čvorova - 5

K.Z.



$U_g = -U_0 + Z_0(I_g+I_0)$

Svi plusevi s ljeve strane → stavimo +

1. K.Z. → struje

$(č-1)$ puta $= 4$

(A) $I_1+I_2=0$

(B) $-I_2+I_5+I_7=0$

(D) $-I_4-I_5-I_6=0$

(E) $-I_3-I_7+I_6=0$

2. K.Z. → naponi

$(g-č+1)$ puta $= 3$ puta

(I) $U_1+U_4-U_5-U_2=0$

(II) $U_3+U_6-U_4=0$

(III) $U_5-U_6-U_7=0$

struje koje ulaze → negativne

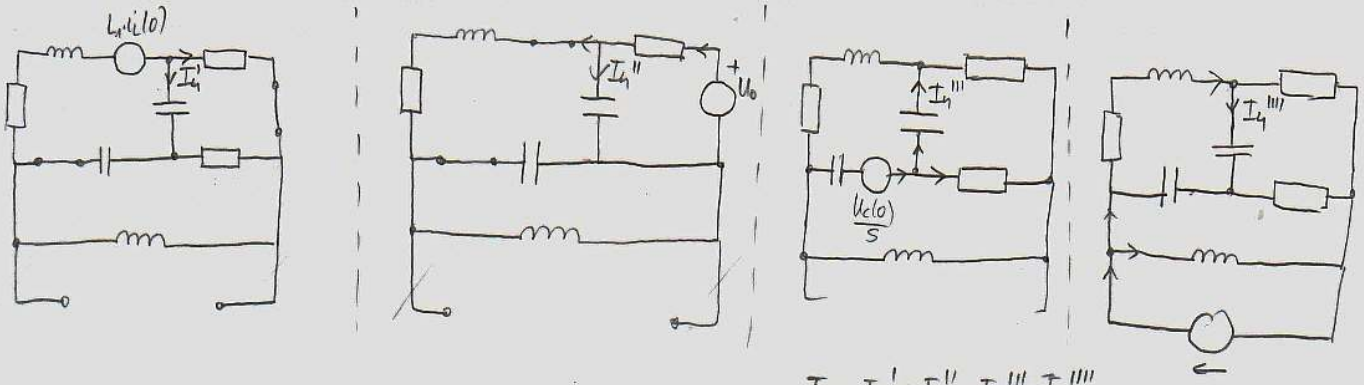
$U_0 = I_1 sL_1 - L_1 i_L(0)$

$U_7 = (I_7+I_0)\cdot sL_2$

(2)

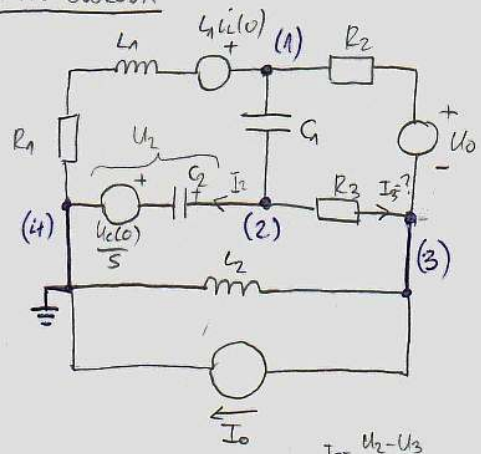
Superpozicija - Broj rješavanja = Broju nezavisnih izvora + broj početnih uvjeta

strujni odspajamo, naponski kratko spojimo



$$I_4 = I_4' + I_4'' - I_4''' + I_4''''$$

NAPON ČVOROVA



$I_3 = \frac{U_2 - U_3}{R_3}$

$U_2 = I_2 \cdot \frac{1}{sC_2} + \frac{U_c(0)}{s}$

(1.) napon. vodljivost - susjedni čvorovi = dporugrani

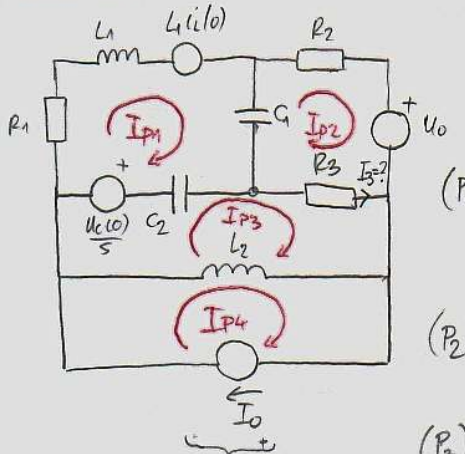
$$U_1 \cdot \left[\frac{1}{R_1 + sL_1} + sC_1 + \frac{1}{R_2}\right] - \phi - U_2 sC_1 - U_3 \frac{1}{R_2} = \frac{L_1 i_L(0)}{R_1 + sL_1} + \frac{U_0}{R_2}$$

jer gledo prema grani za koju pišemo

$$(2.)\ U_2\left[sC_2 + sC_1 + \frac{1}{R_3}\right] - \phi - \underbrace{U_1 sC_1}_{\text{čvor(1)}} - \underbrace{\frac{U_3}{R_3}}_{\text{čvor(3)}} = \frac{\frac{U_c(0)}{s}}{\frac{1}{sC_2}}$$

$$(3)\ U_3\left[\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{sL_2}\right] - \phi - \underbrace{\frac{U_1}{R_2}}_{(1)} - \underbrace{U_2 \cdot \frac{1}{R_3}}_{(2)} = \underbrace{-\frac{U_0}{R_2} - I_0}_{\text{samo napišemo strujne izvore}}$$

STRUJA PETLJI



U_i - proizvoljan smjer

$$I_3 = -I_{P2} + I_{P3}$$

$$(P_1)\ I_{P1}\left[R_1 + sL_1 + \frac{1}{sC_1} + \frac{1}{sC_2}\right] - \underbrace{I_{P2} \cdot \frac{1}{sC_1}}_{\text{DODIRNI ELEMENTI}} - \underbrace{I_{P3} \cdot \frac{1}{sC_2}}_{\text{DODIRNI ELEMENTI}} = L_1 i_L(0) - \frac{U_c(0)}{s}$$

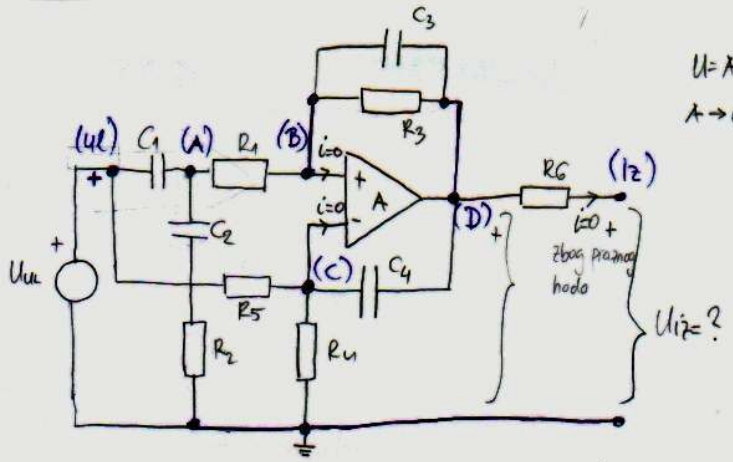
$$(P_2)\ I_{P2}\left[R_2 + R_3 + \frac{1}{sC_1}\right] - I_{P1} \cdot \frac{1}{sC_1} - I_{P3} \cdot R_3 = -U_0$$

$$(P_3)\ I_{P3}\left[\frac{1}{sC_2} + sL_2 + R_3\right] - I_{P2} \cdot R_3 - I_{P1} \cdot \frac{1}{sC_2} - I_{P4} sL_2 = \frac{U_c(0)}{s}$$

!!! $(P_4)\ I_{P4} \cdot sL_2 - I_{P3} sL_2 = -U_i \qquad I_0 = I_{P4}$

(3)

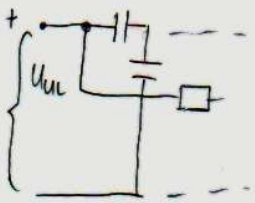
Pr POJAČALA



$U = A(U_+ - U_-)$

$A \to \infty \to \boxed{U_+ = U_-} \to U_B = U_C$

ili

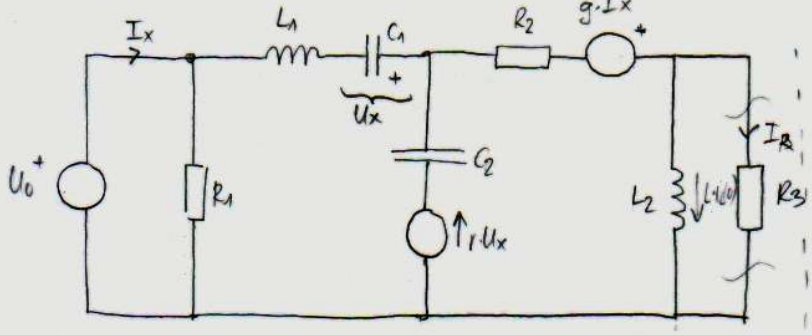


(A) $U_A\left[sC_1 + \frac{1}{R_2 + \frac{1}{sC_2}} + \frac{1}{R_1}\right] - U_{ul} \cdot sC_1 - U_B \cdot \frac{1}{R_1} = \phi$

(B) $U_B\left[\frac{1}{R_1} + \frac{1}{R_3} + sC_3\right] - U_A \cdot \frac{1}{R_1} - U_D\left[\frac{1}{R_3} + sC_3\right] = \phi$

(C) $U_C\left[\frac{1}{R_5} + \frac{1}{R_4} + sC_4\right] - U_{ul} \cdot \frac{1}{R_5} - U_D sC_4 = \phi$

Pr Uz pomoć Theveninа naći I_R



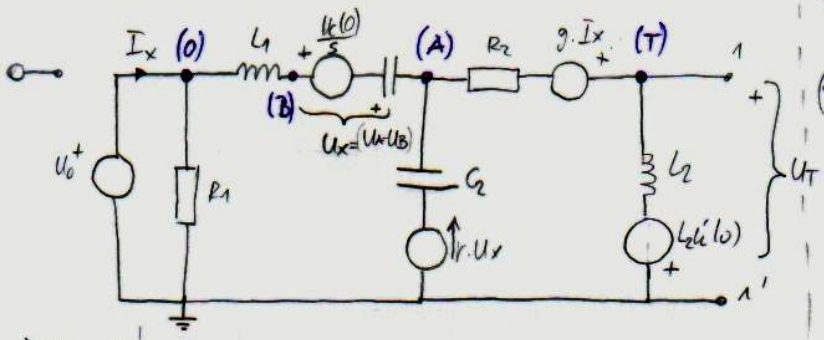
Grane koje ne znamo izračunati, zapisemo struju

(0) $U_0\left[\frac{1}{sL_1} + \frac{1}{R_1}\right] - U_B \cdot \frac{1}{sL_1} - \phi = I_x$ (B)

(B) $U_B\left[\frac{1}{sL_1} + sC_1\right] - U_0 \frac{1}{sL_1} - U_A \cdot sC_1 = \frac{\frac{u_c(0)}{s}}{\frac{1}{sC_1}}$

(A) $U_A\left[sC_1 + \cancel{sC_2} + \frac{1}{R_2}\right] - U_B sC_1 - U_T \cdot \frac{1}{R_2} = \frac{-\frac{u_c(0)}{s}}{\frac{1}{sC_1}} + r \cdot U_x - g \cdot \frac{I_x}{R_2}$

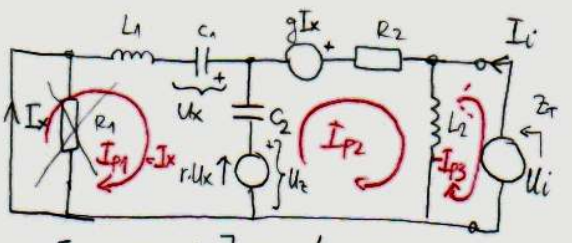
(T) $U_T\left[\frac{1}{R_2} + \frac{1}{sL_2}\right] - U_A \cdot \frac{1}{R_2} = \frac{g I_x}{R_2} - \frac{L_2 i_L(0)}{sL_2}$



1.) Odspojiti

2.) $U_T = ?$

3.) Ugasiti sve nezavisne izvore. $Z_T = ?$



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

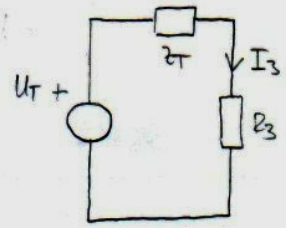
(x) $I_x\left[sL_1 + \frac{1}{sC_1} + \frac{1}{sC_2}\right] - I_{P2}\frac{1}{sC_2} = -U_z$

(P2) $I_{P2}\left[\frac{1}{sC_2} + sL_2 + R_2\right] - I_x \frac{1}{sC_2} + I_i sL_2 = U_z + g \cdot I_x$

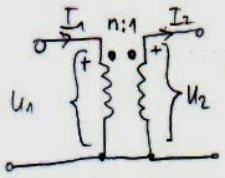
(i) $I_i[sL_2] + I_{P2} sL_2 = U_i$

$U_x = -I_x \cdot \frac{1}{sC_1}$, $r \cdot U_x = I_{P2} - I_x$

4.)

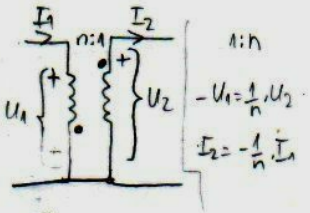


Girator, transformator, NC...



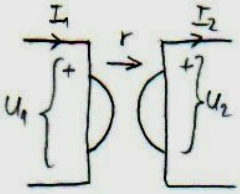
$U_1 = n \cdot U_2$

$I_2 = n \cdot I_1$



$-U_1 = n \cdot U_2$

$I_2 = -n I_1$

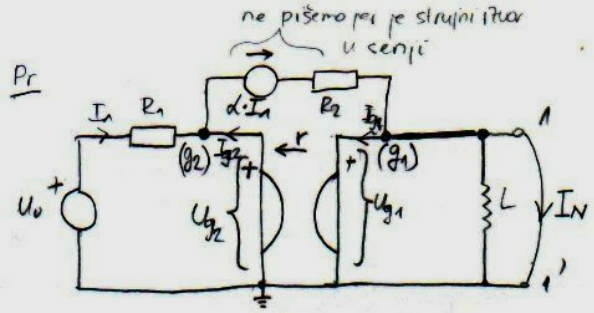


$U_1 = r I_2$

$U_2 = r I_1$

Pr

ne pišemo jer je struja izvor u cenji



$(g_2) \rightarrow U_{g2}\left[\frac{1}{R_1}\right] = \frac{U_0}{R_1} - \alpha I_1 + I_{g2}$

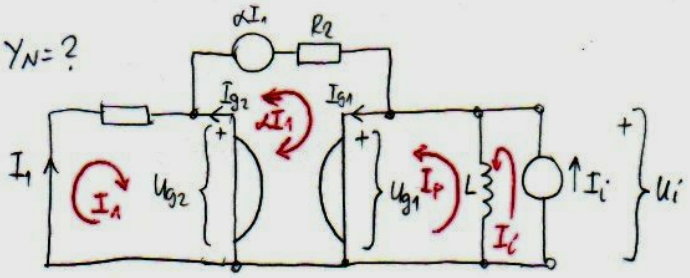
$(g_1) \quad U_{g1}\left[\frac{1}{sL}\right] = \alpha I_1 - I_{g1} - I_N$

2) kratko spojiti 1-1', $I_N = ?$

$U_{g1} = r I_{g2}$ $\quad I_1 = \frac{U_0 - U_{g2}}{R_1}$

$U_{g2} = r \cdot I_{g1}$ $\quad U_{g1} = \phi$

3.) $Y_N = ?$



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

(1) $I_1 R_1 = -U_{g2}$ $\quad U_i = U_{g1}$

(p) $I_p sL - I_i \cdot sL = -U_{g1}$ $\quad I_{g1} = I_p + \alpha I_1$

(i) $I_i sL - I_p sL = U_i$ $\quad I_{g2} = \alpha I_1 - I_1$

4.)