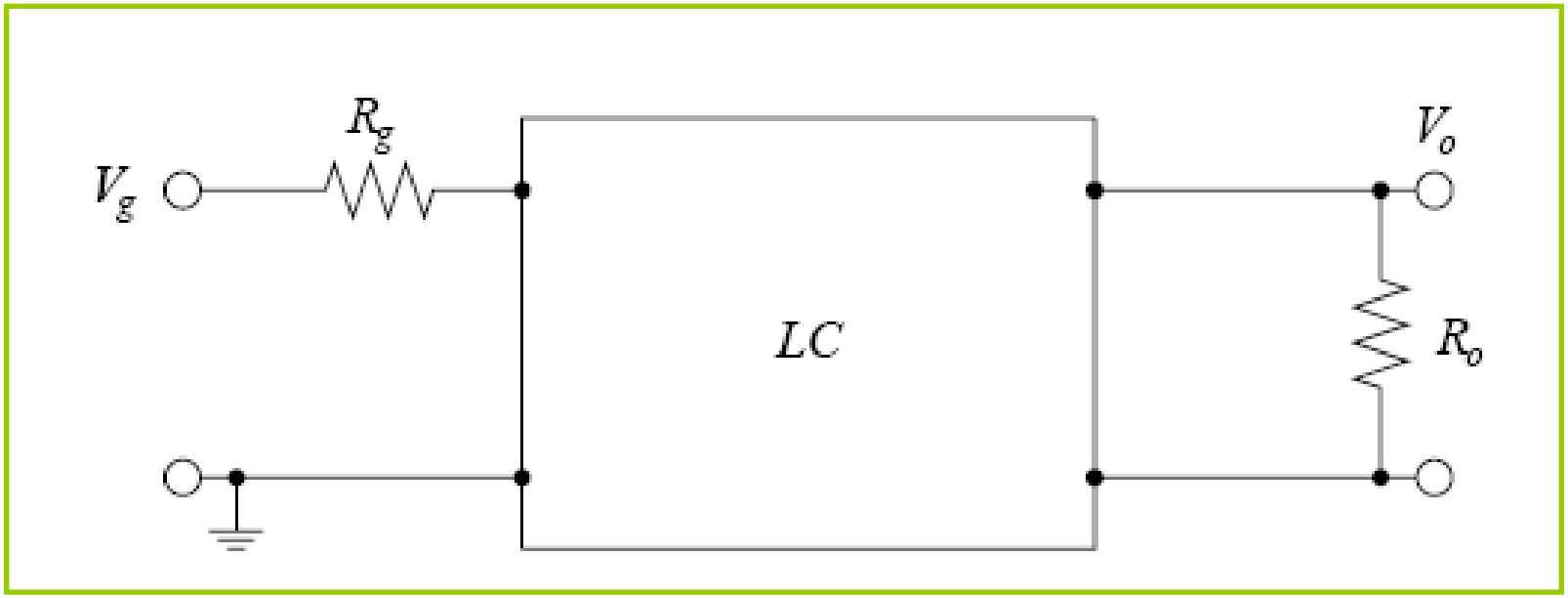
Sinteza električnih filtara

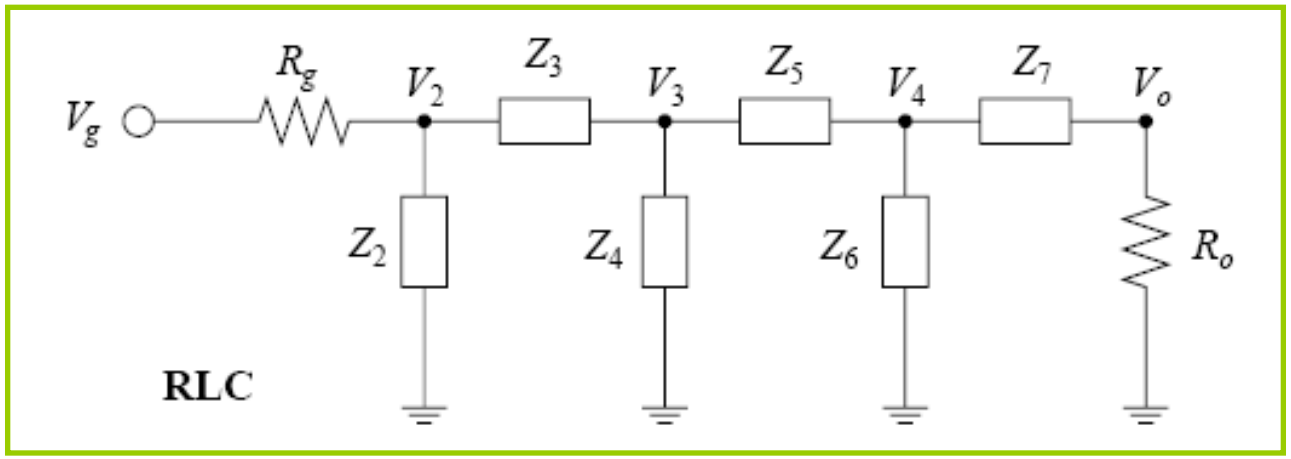
Dr Miroslav Lutovac

LC filtri (bez gubitaka)

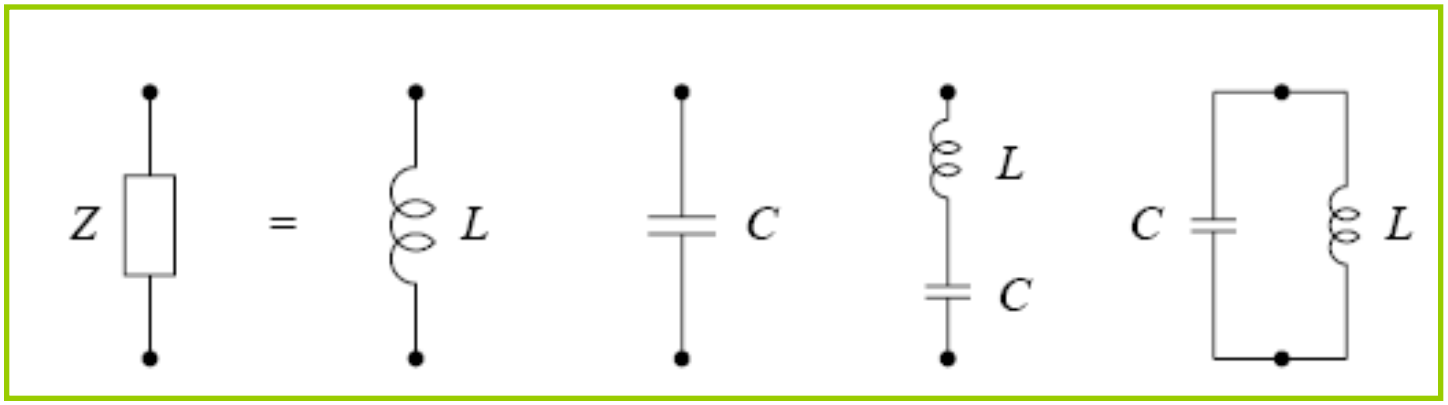
- Singly terminated ladder realization (Rg=0)
- Doubly terminated ladder realization (Rg≠0)



Realizacija



$$H(s) = \frac{V_o}{V_g}$$



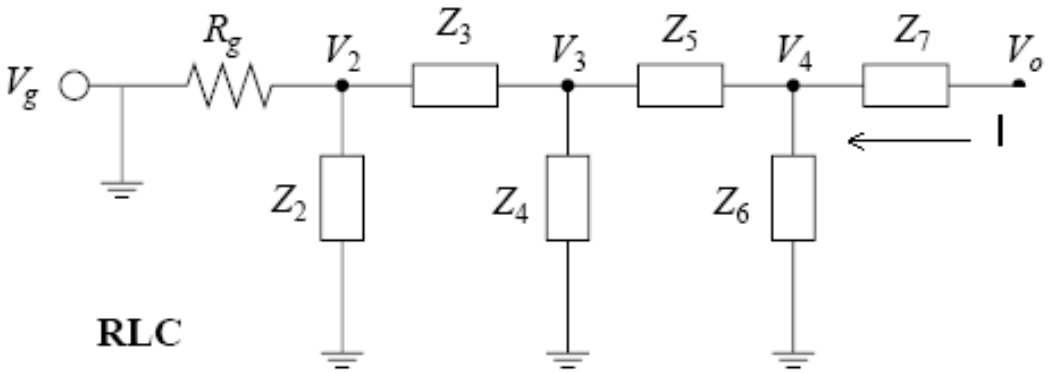
Singly Terminated Ladder Realization

$$H(s) = -\frac{y_{21} R_o}{1 + y_{22} R_o}$$

$$y_{21} = -\frac{I_{Ro}}{V_g}, \qquad R_o = 0$$

Struja kroz kratak spoj na izlaznim krajevima

Generator sa kratko spoji, priključi se generator umesto Ro i izmeri struja koja ulazi u mrežu



$$y_{22} = \frac{I_{Z_7}}{V_{Ro}}, \qquad V_g = 0$$

$R_o \neq 0$

Osobine

$$H(s) = \frac{N_{\text{even}} + N_{\text{odd}}}{D_{\text{even}} + D_{\text{odd}}}, \qquad N_{\text{even}} = 0 \quad \text{or} \quad N_{\text{odd}} = 0$$

$$H(s) = \frac{\dfrac{N_{\text{odd}}}{D_{\text{even}}}}{1 + \dfrac{D_{\text{odd}}}{D_{\text{even}}}}, \quad N_{\text{even}} = 0$$

$$H(s) = \frac{\dfrac{N_{\text{even}}}{D_{\text{odd}}}}{1 + \dfrac{D_{\text{even}}}{D_{\text{odd}}}}, \quad N_{\text{odd}} = 0$$

Admitansa y_{22}

$$y_{21} R_o = \frac{N_{\text{odd}}}{D_{\text{even}}} \quad \text{and} \quad y_{22} R_o = \frac{D_{\text{odd}}}{D_{\text{even}}}$$

$$y_{21} R_o = \frac{N_{\text{even}}}{D_{\text{odd}}} \quad \text{and} \quad y_{22} R_o = \frac{D_{\text{even}}}{D_{\text{odd}}}$$

Sinteza filtra koristeći Foster ili Kauer proceduru.
Gde je generator? Na kraju se traži port.

Primer

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

$R_o = 1\,\Omega.$

$$N_{\text{odd}} = s$$

$$N_{\text{even}} = 0$$

$$D_{\text{odd}} = 3s^3 + 3s$$

$$D_{\text{even}} = s^4 + 3s^2 + 1$$

Određivanje admitanse

$$N_{\text{odd}} = s$$

$$N_{\text{even}} = 0$$

$$D_{\text{odd}} = 3s^3 + 3s$$

$$D_{\text{even}} = s^4 + 3s^2 + 1$$

$$y_{21} = \frac{N_{\text{odd}}}{R_o D_{\text{even}}} = \frac{s}{s^4 + 3s^2 + 1}$$

$$y_{22} = \frac{D_{\text{odd}}}{R_o D_{\text{even}}} = \frac{3s^3 + 3s}{s^4 + 3s^2 + 1}$$

Impedansa ili admitansa?

$$y_{22} = \frac{D_{\text{odd}}}{R_o D_{\text{even}}} = \frac{3s^3 + 3s}{s^4 + 3s^2 + 1}$$

$$Z_{22} = \frac{1}{y_{22}} = \frac{s^4 + 3s^2 + 1}{3s^3 + 3s}$$

$$Z_{22} = \frac{s}{3} + \frac{2s^2 + 1}{3s^3 + 3s}$$

Prvi element

$$Z_{22} = \frac{s}{3} + \frac{2s^2 + 1}{3s^3 + 3s}$$

$$Z_{22} = L_1 s + Z_2, \qquad L_1 = \frac{1}{3}, \qquad Z_2 = \frac{2s^2 + 1}{3s^3 + 3s}$$

Drugi element

$$Z_{22} = L_1 s + Z_2, \qquad L_1 = \frac{1}{3}, \qquad Z_2 = \frac{2s^2 + 1}{3s^3 + 3s}$$

$$Y_2 = \frac{1}{Z_2} = \frac{3s^3 + 3s}{2s^2 + 1}$$

$$Y_2 = \frac{3}{2}s + \frac{\frac{3}{2}s}{2s^2 + 1}$$

$$Y_2 = C_1 s + Y_3, \qquad C_1 = \frac{3}{2}, \qquad Y_3 = \frac{\frac{3}{2}s}{2s^2 + 1}$$

Ostali elementi

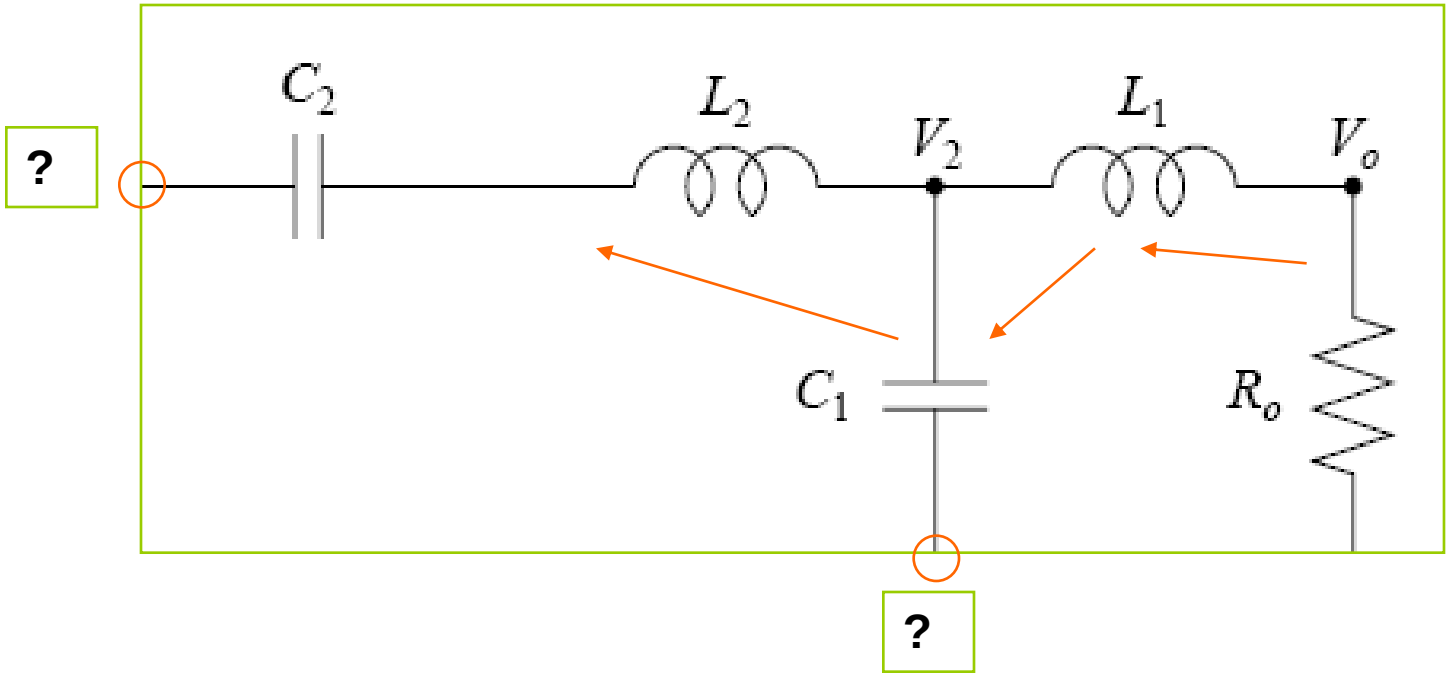
$$Z_3 = \frac{1}{Y_3} = \frac{2s^2 + 1}{\frac{3}{2}s}$$

$$Z_3 = \frac{4}{3}s + \frac{1}{\frac{3}{2}s}$$

$$Z_3 = L_2 s + \frac{1}{C_2 s}, \qquad L_2 = \frac{4}{3}, \qquad C_2 = \frac{3}{2}$$

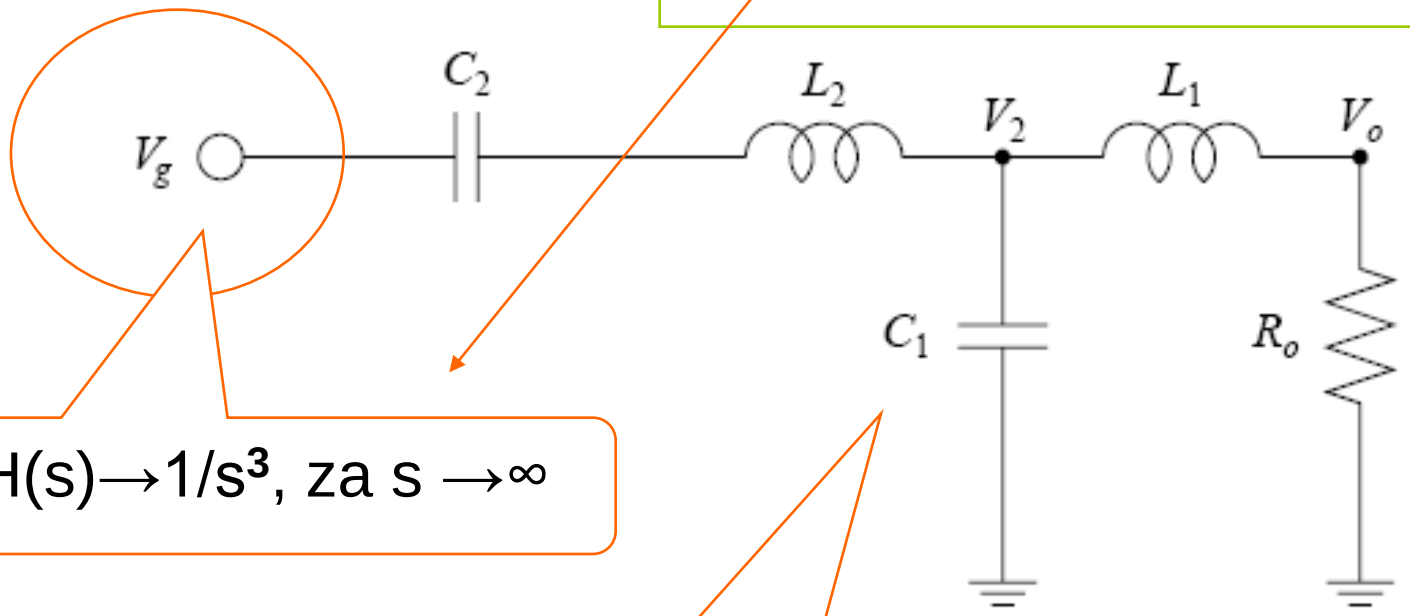
$$L_1 = \frac{1}{3}\text{H}, \qquad C_1 = \frac{3}{2}\text{F}, \qquad L_2 = \frac{4}{3}\text{H}, \qquad C_2 = \frac{3}{2}\text{F}$$

Gde je ulaz u filtar?



Određivanje porta za pobudu

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



H(s)→1/s³, za s →∞

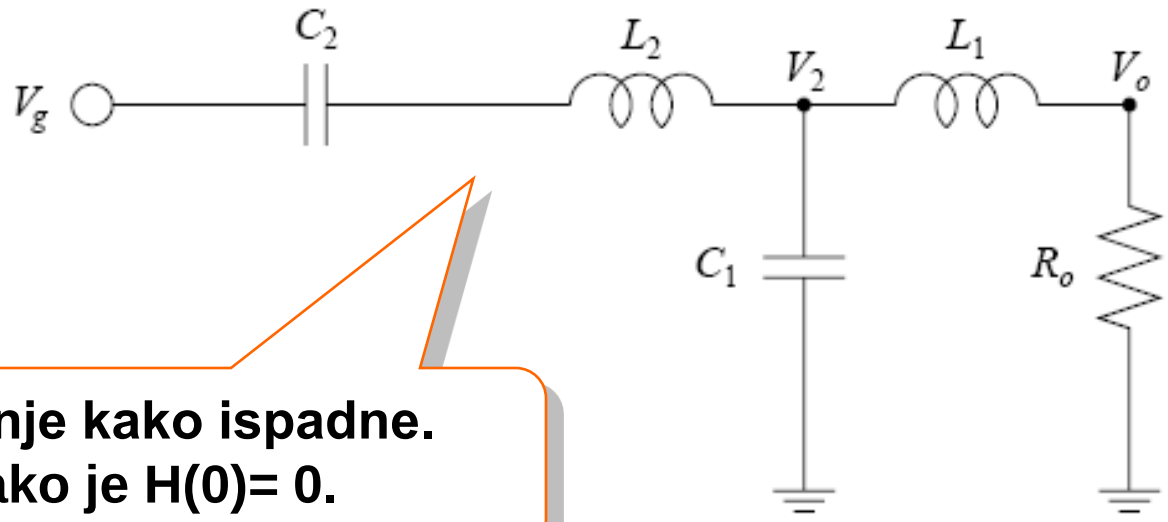
H(s)→1/s, za s →∞

Da li uvek ima rešenje?

$$H_2(s) = \frac{\frac{3}{2}s}{s^4 + 3s^3 + 3s^2 + 3s + 1} = \frac{3}{2}H(s)$$

Ne može sa pojačanjem 3/2

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



Pojačanje kako ispadne.
Samo ako je H(0)= 0.

Singly Terminated Ladder Realization with Complex Zeros

$$R_o = 1\,\Omega.$$

$$H(s) = \frac{(s^2 + 3.476896154)(s^2 + 8.227391422)}{55.3858\,(s + 0.60913)\left(s^2 + 0.263147s + 1.166357185\right)\left(s^2 + 0.85422659s + 0.7269594794\right)}$$

$$N_{\text{odd}} = 0$$

$$N_{\text{even}} = 0.516482303994966 + 0.2113228946047543s^2 + 0.01805516937554391s^4$$

$$D_{\text{odd}} = 1.571315794907603s + 2.79872960375543s^3 + s^5$$

$$D_{\text{even}} = 0.516477923182808 4 + 2.477831112275122s^2 + 1.72650359s^4$$

$$y_{21} = \frac{0.516482303994966 + 0.2113228946047543s^2 + 0.01805516937554391s^4}{1.571315794907603s + 2.79872960375543s^3 + s^5}$$

$$y_{22} = \frac{0.516477923182808 4 + 2.477831112275122s^2 + 1.72650359s^4}{1.571315794907603s + 2.79872960375543s^3 + s^5}$$

Nule funkcije prenosa

$$s_1 = +j2.86834297495958 5$$

$$s_2 = -j2.86834297495958 5$$

$$s_3 = +j1.86464370698533 2$$

$$s_4 = -j1.86464370698533 2$$

$$s_1^2 = s_2^2 = -8.2273914225$$

$$s_3^2 = s_4^2 = -3.476896154$$

Prvi korak sinteze

1

$$Z_{22} = \frac{1}{y_{22}} = \frac{1.571315794907 6s + 2.798729603755 43s^3 + s^5}{0.5164779231828 + 2.477831112275s^2 + 1.72650359s^4}$$

$$s_1^2 = s_2^2 = -8.2273914225$$

$$Z_{22} = L_1 s + Z_2, \qquad Z_2(s_1) = Z_2(s_2) = 0$$

$$L_1 = \left.\frac{Z_{22}}{s}\right|_{s=s_1} = \frac{1.5713157949 + 2.7987296s_1^2 + s_1^4}{0.516477923 + 2.47783s_1^2 + 1.7265s_1^4} = 0.47666285$$

Drugi korak sinteze

$$Z_2 = Z_{22} - L_1 s = s\frac{0.76752227 + 0.93694538s^2 + 0.102542432s^4}{0.2991467415 + 1.43517286997s^2 + s^4}$$

$$Z_2 = s\frac{(s^2 + 8.2273914225)(0.093288654 + 0.102542432s^2)}{0.2991467415 + 1.43517286997s^2 + s^4}$$

$$Y_2 = \frac{1}{Z_2} = \frac{0.2991467415 + 1.43517286997s^2 + s^4}{s(s^2 + 8.2273914225)(0.093288654 + 0.102542432s^2)}$$

Realizacija 1. nule funkcije prenosa

$$Y_2 = \frac{1}{sL_2 + \frac{1}{sC_2}} + Y_3 = \frac{\frac{s}{L_2}}{s^2 + \frac{1}{C_2 L_2}} + Y_3 = \frac{\frac{s}{L_2}}{s^2 + s_1 s_2} + Y_3$$

$$L_2 = Z_2 \frac{s}{s^2 + 8.2273914225}\bigg|_{s=s_1} = s_1^2 \frac{(0.093288654 + 0.102542432 s_1^2)}{0.2991467415 + 1.43517286997 s_1^2 + s_1^4}$$

$$L_2 = 0.1098864$$

$$C_2 = -\frac{1}{L_2 s_1^2} = \frac{1}{8.2273914225 L_2} = 1.1060985$$

Eliminacija prve nule

$$Y_3 = Y_2 - \frac{\frac{s}{0.1098864}}{s^2+8.2273914225}$$

$$= \frac{0.2991467415 + 1.43517286997s^2 + s^4}{s(s^2 + 8.2273914225)(0.093288654 + 0.102542432s^2)} - \frac{\frac{s}{0.1098864}}{s^2+8.2273914225}$$

$$Y_3 = \frac{0.06683258(0.5440438232 + s^2)}{s(0.093288654 + 0.102542432s^2)} = \frac{0.65175537(0.5440438232 + s^2)}{s(0.909756595 + s^2)}$$

Smanjen red funkcije za 2

Realizacija sledeće nule H(s)

$$Z_3 = \frac{1}{Y_3} = \frac{s(0.909756595 + s^2)}{0.65175537(0.5440438232 + s^2)}$$

$$Z_3 = L_3 s + Z_4$$

$$L_3 = \left.\frac{Z_3}{s}\right|_{s=s_3} = \frac{0.909756595 + s_3^2}{0.65175537(0.5440438232 + s_3^2)} = 1.342996$$

Ostatak impedanse

$$Z_4 = Z_3 - L_3 s = s\frac{0.665207337596 + 0.1913221759s^2}{0.54404382321885 + s^2}$$

$$Z_4 = s\frac{0.1913221759(3.476896154 + s^2)}{0.54404382321885 + s^2}$$

$$Y_4 = \frac{1}{Z_4} = \frac{0.54404382321885 + s^2}{0.1913221759s(3.476896154 + s^2)}$$

Realizacija sledeće nule

$$Y_4 = \frac{1}{sL_4 + \dfrac{1}{sC_4}} + Y_5 = \frac{\dfrac{s}{L_4}}{s^2 + \dfrac{1}{C_4 L_4}} + Y_5 = \frac{\dfrac{s}{L_4}}{s^2 + s_3 s_4} + Y_5$$

$$L_4 = Z_4 \frac{s}{s^2 + 3.476896154}\bigg|_{s=s_3} = s_3^2 \frac{0.1913221759}{0.54404382321885 + s_3^2} = 0.226812421$$

$$C_4 = -\frac{1}{L_4 s_3^2} = \frac{1}{3.476896154 L_4} = 1.2680648$$

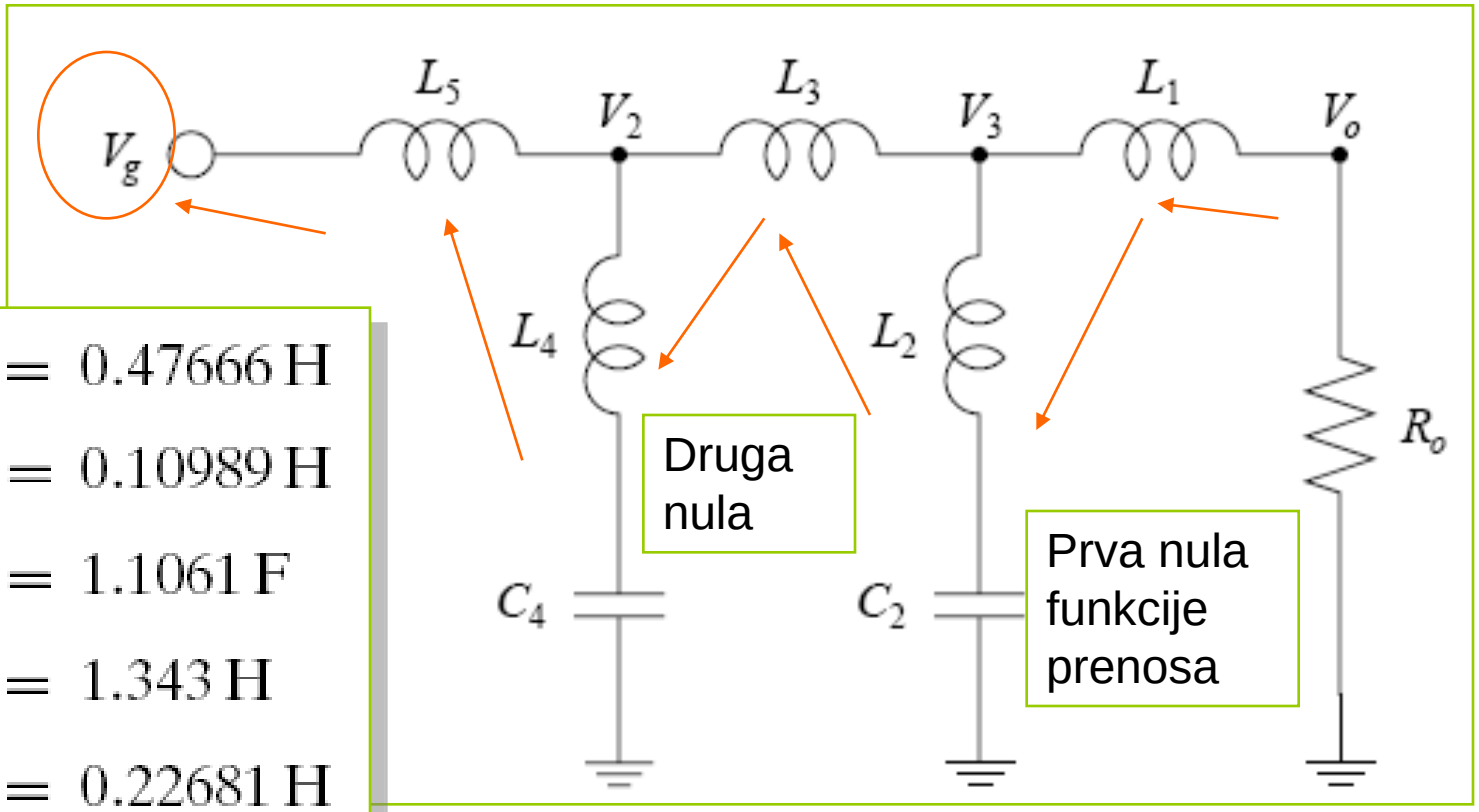
Ostatak impedanse

$$Y_5 = Y_4 - \frac{\frac{s}{L_4}}{s^2 - s_3^2} = \frac{0.54404382321885 + s^2}{0.1913221759s(3.476896154 + s^2)} - \frac{\frac{s}{0.226812421}}{s^2+3.47689615}$$

$$= \frac{0.156474(3.476896154 + s^2)}{0.1913221759s(3.476896154 + s^2)} = \frac{1}{1.22270919s} = \frac{1}{L_5 s}$$

$$L_5 = 1.22270919$$

$$H(s) = \frac{(s^2 + 3.476896154)(s^2 + 8.227391422)}{55.3858\,(s + 0.60913)\,(s^2 + 0.263147s + 1.166357185)\,(s^2 + 0.85422659s + 0.7269594794)}$$



$L_1 = 0.47666\,\mathrm{H}$

$L_2 = 0.10989\,\mathrm{H}$

$C_2 = 1.1061\,\mathrm{F}$

$L_3 = 1.343\,\mathrm{H}$

$L_4 = 0.22681\,\mathrm{H}$

$C_4 = 1.268\,\mathrm{F}$

$L_5 = 1.2227\,\mathrm{H}$

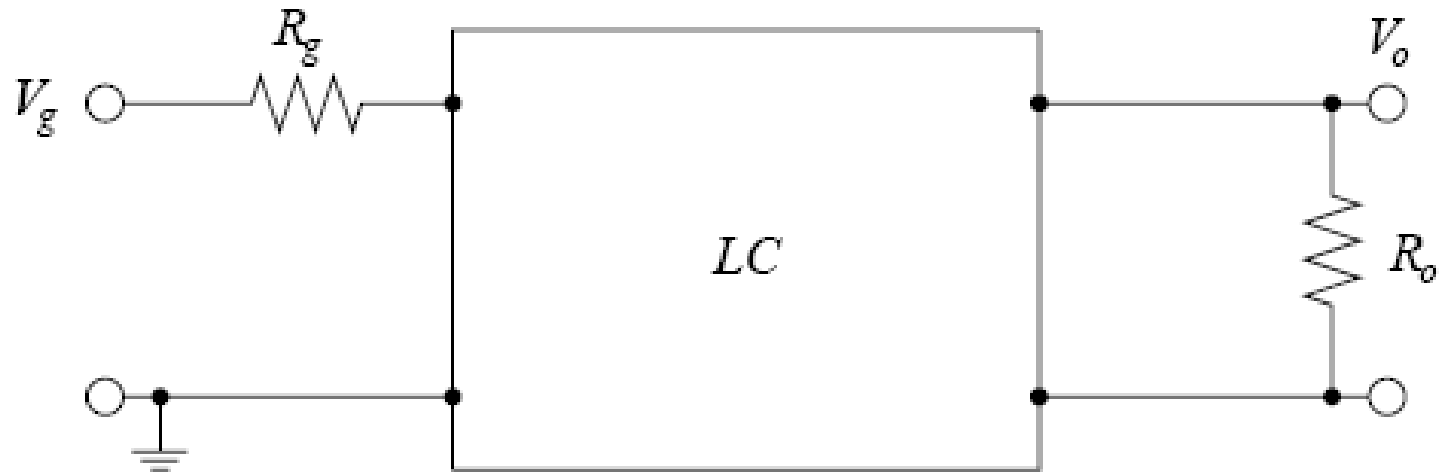
zero shifting technique

Doubly Terminated Ladder Networks

- y ili z parametri
- Maksimalan prenos snage
- Orčardov kriterijum

Funkcija prenosa

Doubly terminated ladder realization (Rg≠0)



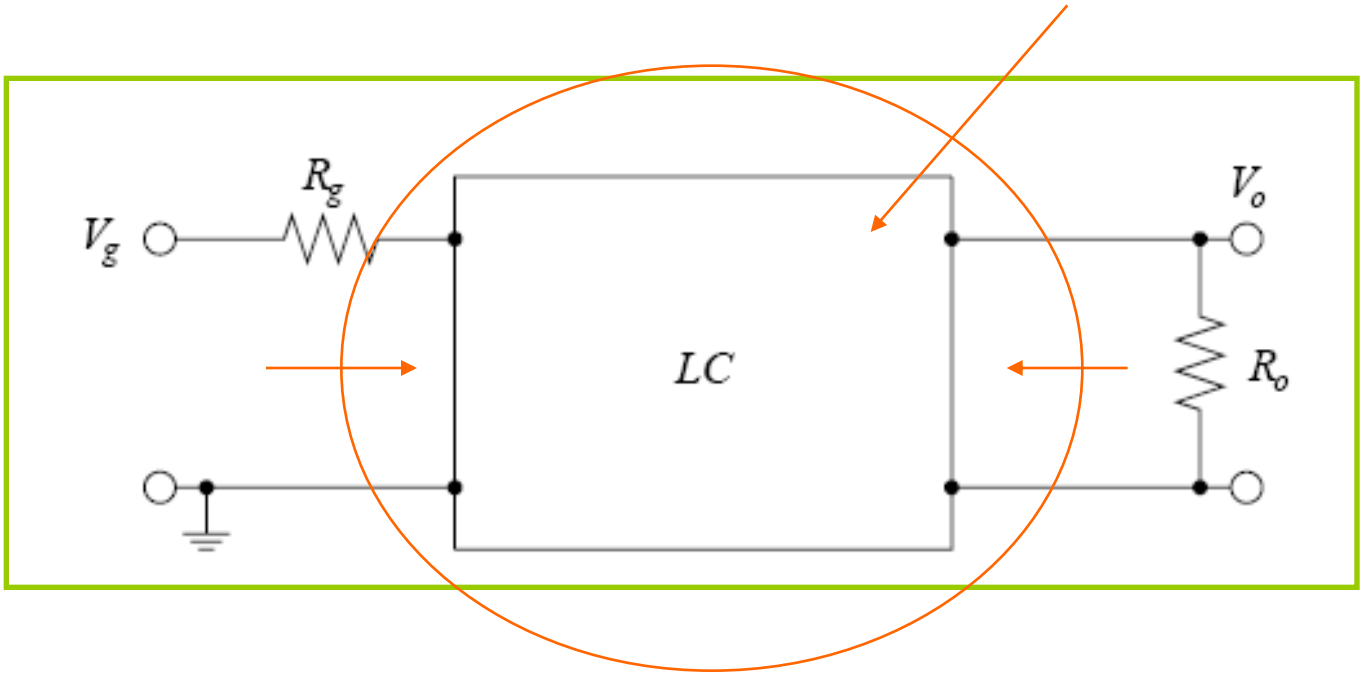
$$H(s) = \frac{V_o}{V_g} = \frac{R_o z_{21}}{R_g R_o + R_o z_{11} - z_{12} z_{21} + R_g z_{22} + z_{11} z_{22}}$$

z parametri

$$z_{12} = z_{21}$$

$$V_1 = z_{11} I_1 + z_{12} I_2$$

$$V_2 = z_{21} I_1 + z_{22} I_2$$



Maksimalan prenos snage

$$K(s)K(-s)|_{s^2=-\omega^2} = \mathcal{K}(\omega^2) = \mathcal{K}(-s^2) = \frac{M_{\max}^2}{M^2(\omega)} - 1$$

$$M(\omega) = |H(j\omega)|$$

$$M_{\max} = \max_{\omega} M(\omega)$$

$$\mathcal{K}(\omega^2) \geq 0$$

Kako da odredimo K(s)?

Normalizacija funkcije prenosa

$$H_n(s) = \frac{H(s)}{M_{\max}}$$

$$H_n(s) = \frac{P(s)}{D_{\text{even}} + D_{\text{odd}}} = \frac{P_{\text{even}} + P_{\text{odd}}}{D_{\text{even}} + D_{\text{odd}}}$$

$$K(s) = \frac{N_{\text{even}} + N_{\text{odd}}}{P(s)} = \frac{N_{\text{even}} + N_{\text{odd}}}{P_{\text{even}} + P_{\text{odd}}}$$

z parametri i funkcija prenosa

$$z_{11} = R_g \frac{D_{\text{even}} - N_{\text{even}}}{D_{\text{odd}} + N_{\text{odd}}}, \qquad z_{22} = R_o \frac{D_{\text{even}} + N_{\text{even}}}{D_{\text{odd}} + N_{\text{odd}}}$$

$$z_{11} = R_g \frac{D_{\text{odd}} - N_{\text{odd}}}{D_{\text{even}} + N_{\text{even}}}, \qquad z_{22} = R_o \frac{D_{\text{odd}} + N_{\text{odd}}}{D_{\text{even}} + N_{\text{even}}}$$

Primer (1)

$$H(s) = \frac{(s^2 + 3.476896154)(s^2 + 8.227391422)}{55.3858\,(s + 0.60913)\left(s^2 + 0.263147s + 1.166357185\right)\left(s^2 + 0.85422659s + 0.7269594794\right)}$$

$$R_g = R_o = 1\,\Omega.$$

$$M_{\max} = \max_{\omega} |H(j\omega)| = 1.00000848$$

$$H_n(s) = \frac{H(s)}{1.00000848}$$

$$H_n(s) = \frac{P_{\text{even}} + P_{\text{odd}}}{D_{\text{even}} + D_{\text{odd}}}$$

Primer (2)

$$P_{\text{odd}} = 0$$

$$P_{\text{even}} = 28.6058 + 11.7043s^2 + s^4$$

$$D_{\text{odd}} = 87.0293s + 155.011s^3 + 55.3863s^5$$

$$D_{\text{even}} = 28.6058 + 137.238s^2 + 95.6246s^4$$

$$\mathcal{K}(-s^2) = \frac{D_{\text{even}}^2 - D_{\text{odd}}^2}{P_{\text{even}}^2 - P_{\text{odd}}^2} - 1 = \frac{D_{\text{even}}^2 - D_{\text{odd}}^2 - P_{\text{even}}^2 + P_{\text{odd}}^2}{P_{\text{even}}^2 - P_{\text{odd}}^2}$$

$$= \frac{N_{\text{even}}^2 - N_{\text{odd}}^2}{P_{\text{even}}^2 - P_{\text{odd}}^2}$$

Nule K(-s^2)

$$D^2_{\text{even}} - D^2_{\text{odd}} - P^2_{\text{even}} + P^2_{\text{odd}} = 0$$

$$\begin{aligned}
s_{k1} &= 0 & s_{k6} &= 0 \\
s_{k2} &= -0.00102181 + 0.95906j & s_{k7} &= 0.00102181 + 0.95906j \\
s_{k3} &= -0.00102181 - 0.95906j & s_{k8} &= 0.00102181 - 0.95906j \\
s_{k4} &= -0.00284197 + 0.623457j & s_{k9} &= 0.00284197 + 0.623457j \\
s_{k5} &= -0.00284197 - 0.623457j & s_{k10} &= 0.00284197 - 0.623457j
\end{aligned}$$

Nule K(-s^2) – sve kombinacije

$$
\begin{aligned}
s_{k1} &= 0 \\
s_{k2} &= \alpha_1 0.00102181 + 0.95906\,j \\
s_{k3} &= \alpha_1 0.00102181 - 0.95906\,j \\
s_{k4} &= \alpha_2 0.00284197 + 0.623457\,j \\
s_{k5} &= \alpha_2 0.00284197 - 0.623457\,j
\end{aligned}
$$

$$
\begin{aligned}
\alpha_1 &\in \{1, -1\} \\
\alpha_2 &\in \{1, -1\}
\end{aligned}
$$

Određivanje polinoma N i D

$$N_{\text{odd}} = 0.357531s + 1.30852s^3 + s^5$$

$$N_{\text{even}} = 0.00602244s^2 + 0.00772756s^4$$

$$D_{\text{odd}} = 1.57132s + 2.79873s^3 + s^5$$

$$D_{\text{even}} = 0.516478 + 2.47783s^2 + 1.7265s^4$$

$\alpha_1 = 1 \qquad \alpha_2 = 1;$

numerator of $K(s)$ and the denominator of $H_n(s)$

Ulazna impedansa

$$z_{11} = R_g \frac{D_{\text{even}} - N_{\text{even}}}{D_{\text{odd}} + N_{\text{odd}}} = \frac{0.516478 + 2.47181s^2 + 1.71878s^4}{1.92885s + 4.10724s^3 + 2s^5}$$

$$s_1 = +j2.868342974959585$$
$$s_2 = -j2.868342974959585$$
$$s_3 = +j1.864643706985332$$
$$s_4 = -j1.864643706985332$$

$$s_1^2 = s_2^2 = -8.2273914225$$
$$s_3^2 = s_4^2 = -3.476896154$$

Prvi element sinteze

$$Y_{11} = \frac{1}{z_{11}} = \frac{1.92885s + 4.10724s^3 + 2s^5}{0.516478 + 2.47181s^2 + 1.71878s^4}$$

$$Y_{11} = C_1 s + Y_2, \qquad Y_2(s_1) = Y_2(s_2) = 0$$

$$s_1^2 = s_2^2 = -8.2273914225$$

$$C_1 = \left.\frac{Y_{11}}{s}\right|_{s=s_1} = \frac{1.92885 + 4.10724s^2 + 2s^4}{0.516478 + 2.47181s^2 + 1.71878\,s^4} = 1.07245$$

Drugi deo ulazne impedanse

$$Y_2 = Y_{11} - C_1 s = s\frac{1.37495 + 1.45636s^2 + 0.156701s^4}{0.516478 + 2.47181s^2 + 1.71878s^4}$$

$$Y_2 = s\frac{0.0911699\ (8.22739 + s^2)\ (1.06648 + s^2)}{(0.253704 + s^2)\ (1.18442 + s^2)}$$

$$Z_2 = \frac{1}{Y_2} = \frac{(0.253704 + s^2)\ \ (1.18442 + s^2)}{0.0911699s\ (8.22739 + s^2)\ (1.06648 + s^2)}$$

Realizacija 1. nule funkcije prenosa

$$s_1^2 = s_2^2 = -8.2273914225$$

$$Z_2 = \frac{1}{sC_2 + \frac{1}{sL_2}} + Z_3 = \frac{\frac{s}{C_2}}{s^2 + \frac{1}{L_2C_2}} + Z_3 = \frac{\frac{s}{C_2}}{s^2+s_1s_2} + Z_3$$

$$C_2 = Y_2 \frac{s}{s^2+8.2273914225}\bigg|_{s=s_1} = s_1^2 \frac{0.0911699\ (1.06648 + s_1^2)}{(0.253704 + s_1^2)\ (1.18442 + s_1^2)}$$

$$C_2 = 0.0956459$$

$$L_2 = -\frac{1}{C_2 s_1^2} = \frac{1}{8.2273914225 C_2} = 1.27078$$

Preostali deo ulazne impedanse

$$Z_3 = Z_2 - \frac{\frac{s}{0.0956459}}{s^2+8.2273914225}$$

$C_2 = 0.0956459$

$s_1^2 = s_2^2 = -8.2273914225$

$$Z_3 = \frac{0.513303\,(0.78045 + s^2)}{s\,(1.06648 + s^2)}$$

$$Y_3 = \frac{1}{Z_3} = \frac{s\,(1.06648 + s^2)}{0.513303\,(0.78045 + s^2)}$$

Realizacija sledeće nule prenosa

$$Y_3 = C_3 s + Y_4$$

$$s_3^2 = s_4^2 = -3.476896154$$

$$C_3 = \left.\frac{Y_3}{s}\right|_{s=s_3} = \frac{1.06648 + s_3^2}{0.513303\,(0.78045 + s_3^2)} = 1.74151$$

$$Y_4 = Y_3 - C_3 s = s\frac{0.718527 + 0.206658\,s^2}{0.78045 + s^2} = s\frac{0.206658\,(3.4769 + s^2)}{0.78045 + s^2}$$

$$Z_4 = \frac{1}{Y_4} = \frac{0.78045 + s^2}{0.206658 s\,(3.4769 + s^2)}$$

Sinteza sledećeg LC dela

$$Z_4 = \frac{1}{sC_4 + \frac{1}{sL_4}} + Z_5 = \frac{\frac{s}{C_4}}{s^2 + \frac{1}{L_4C_4}} + Z_5 = \frac{\frac{s}{C_4}}{s^2+s_3s_4} + Z_5$$

$$s_3^2 = s_4^2 = -3.476896154$$

$$C_4 = Y_4 \frac{s}{s^2 + 3.476896154}\bigg|_{s=s_3} = s_3^2 \frac{0.206658}{0.78045 + s_3^2} = 0.266472$$

$$L_4 = -\frac{1}{C_4 s_3^2} = \frac{1}{3.476896154 C_4} = 1.07934$$

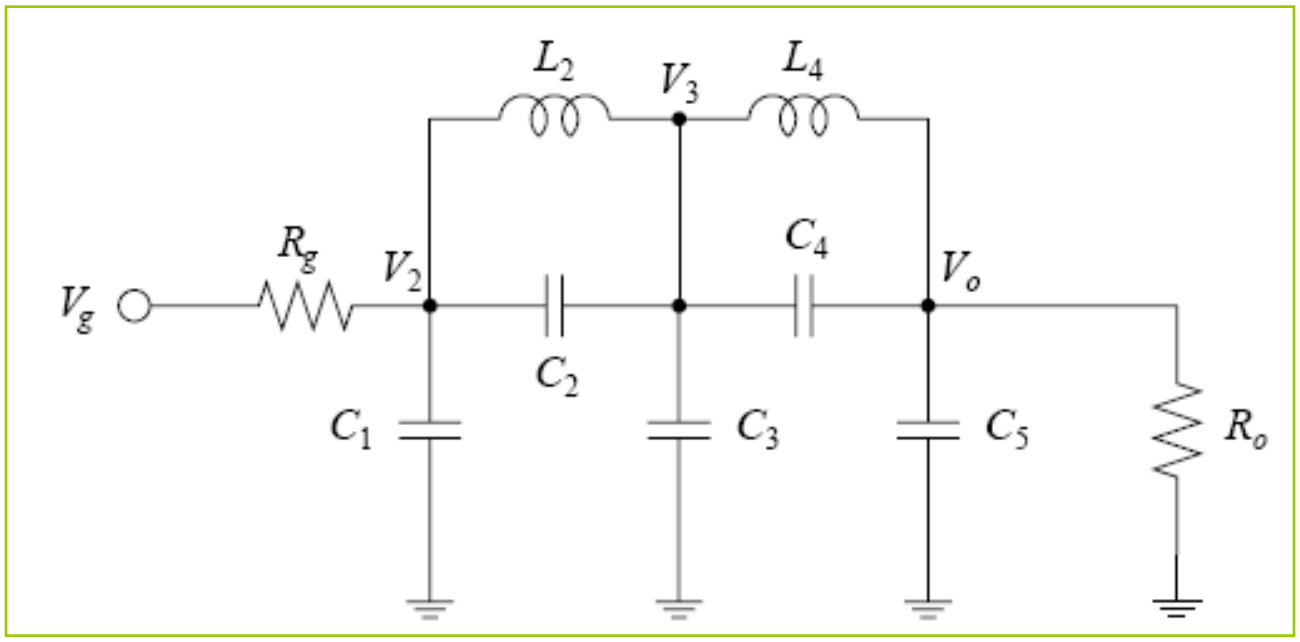
… do kraja sinteze

$$Z_5 = Z_4 - \frac{\frac{s}{C_4}}{s^2 - s_3^2} = \frac{1.08618}{s} = \frac{1}{C_5 s}$$

$$C_5 = 0.920658$$

Izbor optimalnog rešenja

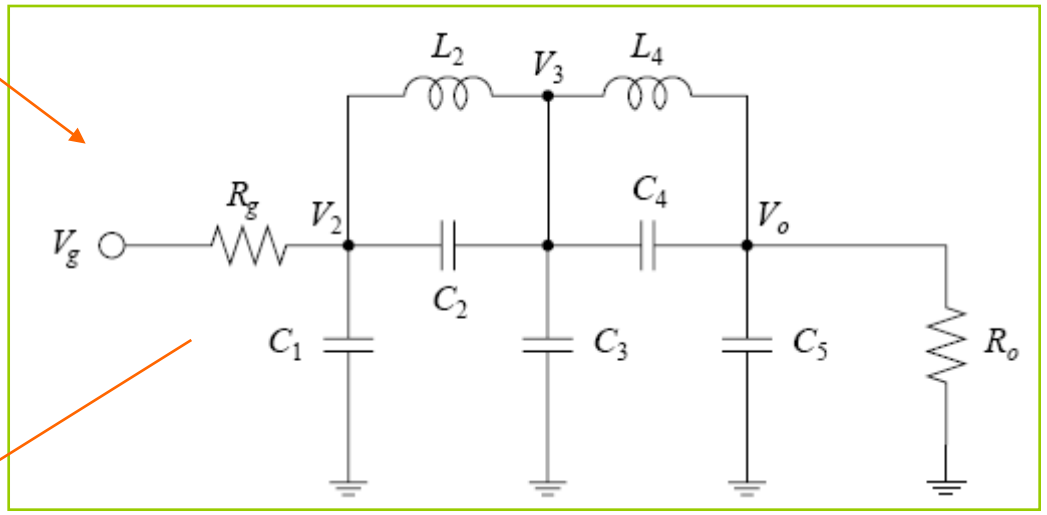
α_1	α_2	C_1 (F)	C_2 (F)	C_3 (F)	C_4 (F)	C_5 (F)	L_1 (H)	L_2 (H)
1	1	1.0724	0.095646	1.7415	0.26647	0.92066	1.2708	1.0793
−1	1	1.0695	0.095821	1.7413	0.26590	0.92382	1.2685	1.0817
1	−1	1.0649	0.095526	1.7417	0.26687	0.92796	1.2724	1.0777
−1	−1	1.0620	0.095700	1.7414	0.26629	0.93117	1.2701	1.0801
0	0	1.0672	0.095675	1.7415	0.26639	0.92594	1.2704	1.0797
1%	→	1.07	0.096	1.74	0.27	0.93	1.27	1.08



Provera

C_1 (F)	C_2 (F)	C_3 (F)	C_4 (F)	C_5 (F)	L_1 (H)	L_2 (H)
1.07	0.096	1.74	0.27	0.93	1.27	1.08

$$R_g = R_o = 1\,\Omega.$$



$$H_{\text{val}}(s) = \frac{(3.4769+s^2)(8.22739+s^2)}{110.773\,(0.60913+s)(1.16636+0.263147s+s^2)\,(0.726959+0.854227s+s^2)}$$

$$H_{\text{val}}(s) = \frac{1}{2}H(s)$$

Sinteza sa obe strane

$$z_{11} = R_g \frac{D_{\text{even}} - N_{\text{even}}}{D_{\text{odd}} + N_{\text{odd}}}$$

$$z_{22} = R_o \frac{D_{\text{even}} + N_{\text{even}}}{D_{\text{odd}} + N_{\text{odd}}}$$

Iste vrednosti – da se obrnu strana generatora i potrošača

Q faktor LC

$$Q_L = \frac{2\pi f L}{R}$$

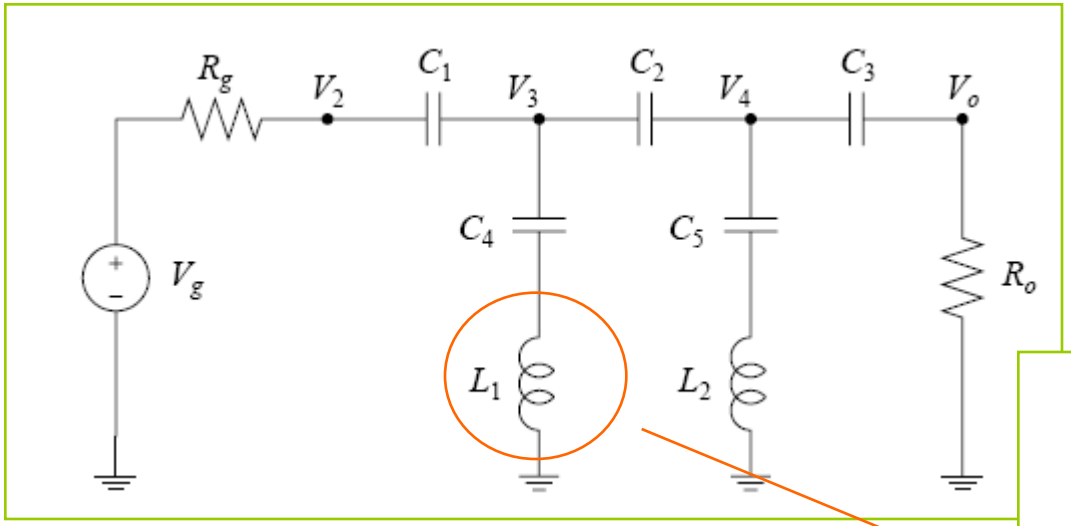
$$Q_C = \frac{2\pi f C}{G}$$

$$s_p \approx s_{p0} + \frac{1}{2Q_L} + \frac{1}{2Q_C}$$

$$Q_C \gg Q_L$$

$$Q_L \gg Q_{\max} \qquad Q_L \geq 3Q_{\max}$$

Primena sa CC



$$L = \frac{C R_1 R_2}{-a_1 a_2} > 0$$