Solutions to TSEI10 Analog Filters 150610

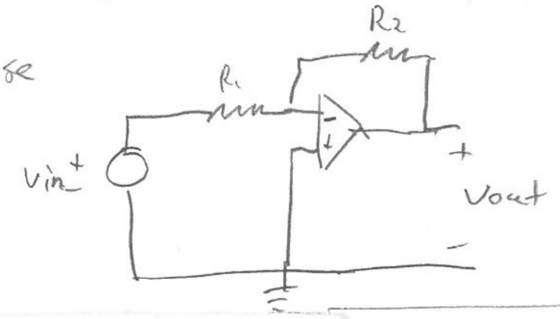
1a) Passive - can only dissipate power, always stable
Active - can generate power, can become unstable

b) May have to be overdesigned due to passb./stopb. symmetry requirements and only one A_{max} & A_{min}

c) Can be designed using max. power transfer principle

d) periodic freq. response

e) $V_{out} = -\frac{R_2}{R_1} V_{in}$



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2) $\Omega_c = \frac{\omega_I^2}{\omega_c}$ / set $\omega_I^2 = \omega_c$ / $= 1$, $\Omega_s = \frac{\omega_I^2}{\omega_s} = \frac{\omega_c}{\omega_s} = 3 \Rightarrow N = 5$

Normalized poles $-0{,}3623196$

$-0{,}111963 \pm j1{,}0115574$

$-0{,}2931227 \pm j0{,}625177$

zeros 5 at $s = \infty$

Denormalized poles/zeros the same since $\Omega_c = 1$

LP → HP $s = \frac{\omega_I^2}{s'} = \frac{\omega_c}{s'}$

poles $-1{,}040493 \times 10^6$

$(-0.0407508 \pm j0.3681734) \times 10^6$

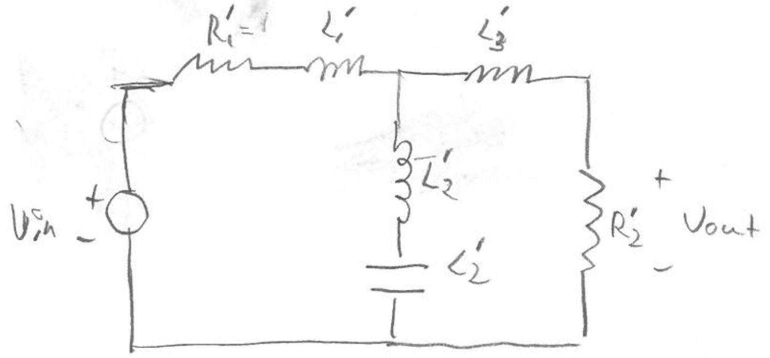
$(-0{,}2317792 \pm j0.4943423) \times 10^6$

zeros 5 at $s = 0$

$\omega_s/\omega_c = 5 \Rightarrow$

3) $N = 3$, Use $A_{max} = 0{,}09883$, $12 \le \Theta \le 13$

Choose $\Theta = 13 \Rightarrow$



$R_1' = R_2' = 1\ \Omega$

$L_1' = L_3' = 1{,}002943\ H$

$L_2' = 0{,}034496\ H$

$C_2' = 1{,}107291\ F$

Denormalize $L \to L \cdot \dfrac{R_1}{\omega_c}$, $C \to C \cdot \dfrac{1}{\omega_c R_1} \Rightarrow$

$R_1 = R_2 = 50\ \Omega$ $\quad L_1 = L_3 = 2{,}66039 \times 10^{-4}\ H$

$L_2 = 9{,}15035 \times 10^{-6}\ H$

$C_2 = 1{,}17487 \times 10^{-7}\ F$

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6) $H(s) = \dfrac{s - 1/R_0C}{s + 1/R_0C}$ $\quad$ pole at $-\dfrac{1}{R_0C}$

zero at $\dfrac{1}{R_0C}$

Allpass filter

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7) $\begin{pmatrix} V_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} V_2 \\ -I_2 \end{pmatrix} = \begin{pmatrix} 0 & 1000 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} V_2 \\ -I_2 \end{pmatrix}$, $Z_2 = -\dfrac{V_2}{I_2}$

$Z_{in}(s) = \dfrac{V_1(s)}{I_1(s)} = \dfrac{-I_2(s) \cdot 1000}{V_2(s)} = \dfrac{1000}{Z_2(s)} = 10^{-4} \cdot s$

$L = 0{,}1\ mH$

Impedance converter (from capacitor to inductor)

4a) BP: $s + \frac{\omega_I^2}{s} - s_{LP} = 0 \Leftrightarrow s^2 - s_{LP} \cdot s + \omega_I^2 = 0 \Rightarrow$

poles at $\frac{s_{LP}}{2} \pm \sqrt{\frac{s_{LP}^2}{4} - \omega_I^2}$

zeros at $s = 0$ e $s = \infty$ $\left(s + \frac{\omega_I^2}{s} - \infty = 0 \right)$

BS: $\frac{\omega_I^2}{s + \frac{\omega_I^2}{s}} - s_{LP} = 0 \Leftrightarrow \frac{\omega_I^2 \cdot s}{s^2 + \omega_I^2} - s_{LP} = 0$

$\Leftrightarrow s_{LP} \cdot s^2 - \omega_I^2 \cdot s + \omega_I^2 \cdot s_{LP} = 0$

$\Leftrightarrow s^2 - \frac{\omega_I^2}{s_{LP}} \cdot s + \omega_I^2 = 0 \Rightarrow$

poles at $\frac{\omega_I^2}{2 s_{LP}} \pm \sqrt{\left(\frac{\omega_I^2}{2 s_{LP}}\right)^2 - \omega_I^2}$

zeros at $s = \pm j \omega_I$ $(s^2 + \omega_I^2 = 0)$

b) $sL \rightarrow \frac{\omega_I^2 \cdot L}{s + \frac{\omega_I^2}{s}} = \frac{1}{\frac{s}{\omega_I^2 L} + \frac{1}{sL}} = \frac{1}{\frac{1}{z_1} + \frac{1}{z_2}}$

$\updownarrow$ Parallel connection of z_1 e z_2

with $z_1 = \frac{\omega_I^2 L}{s}$, $z_2 = sL$

$= \frac{1}{sC}$ with $C = \frac{1}{\omega_I^2 L}$

5a) LP: $a = b = 0, c \neq 0$ HP: $b = c = 0, a \neq 0$ BP: $a = c = 0, b \neq 0$

b) Poles at $-\frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 - e}$ complex if $e > \left(\frac{d}{2}\right)^2$

c) $-2 \sigma_p = d$, $r_p^2 = e \Rightarrow Q = \frac{\sqrt{e}}{d}$