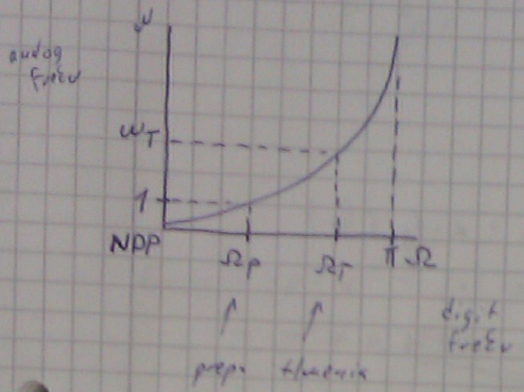
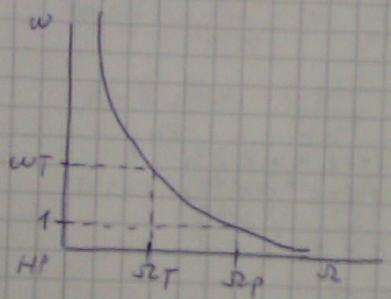
CSS-CG

Nepriame metódy návrhu filtrov

Tustin → Bilineárna metóda



DP $\omega = \alpha \cdot tg\left(\frac{\Omega}{2}\right)$



HP: $\omega = \alpha \cdot \cot g\left(\frac{\Omega}{2}\right)$

DP

$A = 10 \log\left(1 + \varepsilon^2 \cdot \omega^{2m}\right)$

$G(p) \cdot G(-p) = 1 + \varepsilon^2 (p)^m \cdot (-p)^m$

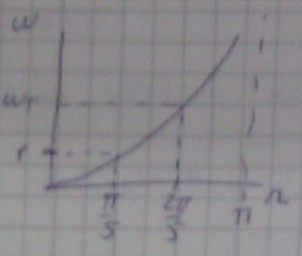
$H(p) = \frac{1}{G(p)}$

$H(z) =$

DP: $p = \alpha \cdot \frac{1 - z^{-1}}{1 + z^{-1}}$

$f_p \rightarrow \Omega_p \rightarrow$ NDP $\rightarrow$ Butterw. $\rightarrow G(p) \rightarrow H(p) \rightarrow p = \dots \rightarrow H(z)$

$f_{vz} = 40\,kHz$
$f_p = 4\,kHz$
$f_T = 8\,kHz$
$A_{max} = 3\,dB$
$A_{min} = 20\,dB$



1) $\Omega_p = 2\pi \frac{f_p}{f_{vz}} = 2\pi \cdot 0{,}1 = \frac{\pi}{5}$

$\Omega_T = 2\pi \frac{f_T}{f_{vz}} = 2\pi \cdot \frac{8}{40} = \frac{2}{5}\pi$

2) $\omega = \alpha \cdot tg\left(\frac{\Omega}{2}\right)$

$1 = \alpha \cdot tg\left(\frac{\frac{\pi}{5}}{2}\right)$

$1 = \alpha \cdot tg\left(\frac{\pi}{10}\right)$

$\alpha = cotg\left(\frac{\pi}{10}\right)$

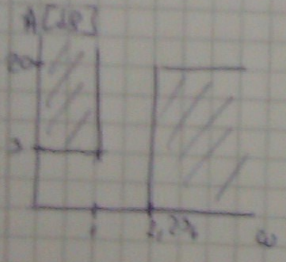
$\underline{\underline{\alpha = 3{,}078}}$

$\omega_T = \alpha \cdot tg\left(\frac{\pi}{5}\right)$

$\underline{\underline{\omega_T = 2{,}236}}$

3

Tol. diagr.



$20 = 10 \log\left(1 + \varepsilon^2 \cdot 2{,}236^{2n}\right)$

$3 = 10 \log\left(1 + \varepsilon^2 \cdot 1^{2n}\right)$

$0{,}3 = \log\left(1 + \varepsilon^2\right)$

$10^{0{,}3} = 1 + \varepsilon^2$

$\varepsilon = \sqrt{10^{0{,}3} - 1}$

$\varepsilon = 0{,}9976 \cong 1$

ε^2

$2 = \log\left(1 + 1^2 \cdot 2{,}236^{2n}\right)$

$2 = \log\left(1 + 2{,}236^{2n}\right)$

$10^2 = 1 + 2{,}236^{2n}$

$100 - 1 = 2{,}236^{2n}$

$99 = 2{,}236^{2n}$

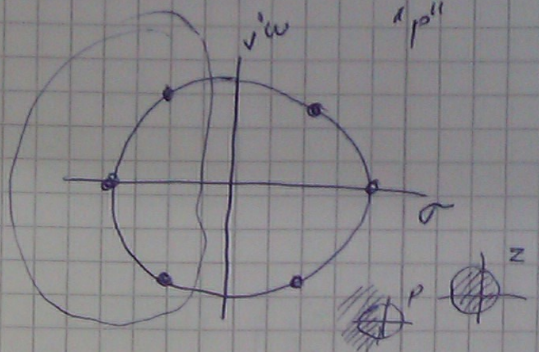
$\Rightarrow 2n \log 2{,}236 = \log 99$

$n = \frac{\log 99}{2 \log 2{,}236} = 2{,}85 \Rightarrow \underline{\underline{3}}$

4.

$$G(p)\cdot G(-p) = 1 + 1^2 (p)^3 \cdot (-p)^3$$
$$G(p)\cdot G(-p) = 1 - p^6$$

$$0 = 1 - p^6$$
$$p^6 = 1$$
$$p =$$



v p-rovine (l-strana) - stabilita

$$G(p) = \left(p - e^{j\frac{2\pi}{3}}\right)\cdot\left(p - e^{j\pi}\right)\cdot\left(p - e^{j\frac{4\pi}{3}}\right) =$$
$$= p^3 + a_2 p^2 + a_1 p + a_0$$

$$H(p) = \frac{1}{G(p)} = \frac{1}{p^3 + a_2 p^2 + a_1 p + a_0}$$

$$p = 3{,}078 \cdot \frac{1 - z^{-1}}{1 + z^{-1}}$$

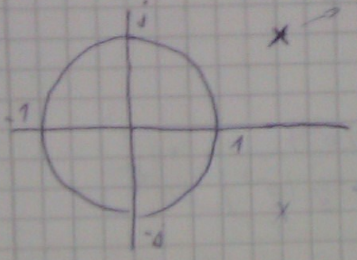
$$H(z) = \frac{1}{\left(3{,}078 \cdot \frac{1-z^{-1}}{1+z^{-1}}\right)^3 + \left(3{,}078 \cdot \frac{1-z^{-1}}{1+z^{-1}}\right)^2 \cdot a_2 + \left(3{,}078\ \frac{1-z^{-1}}{1+z^{-1}}\right) a_1 + a_0}$$

CSS-C

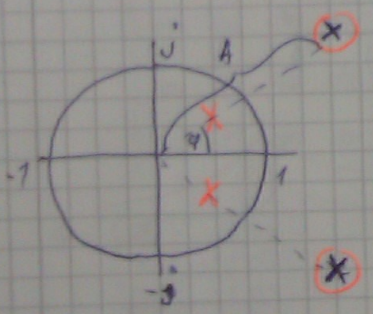
stabilná sústava: póly v kružnici (jednotkovej)
na hranici stability " " " " na jednotkovej

nestabilná sústava: treba stabilizovať
↳ nahradiť zlé póly ale tak aby sa nezmenila magnitúdová charakt.

- stabilizovanie - fázovacie články
- planárny algoritmus



ak nemá komplex. združený pól
→ nemá reálny výstup (sústava)



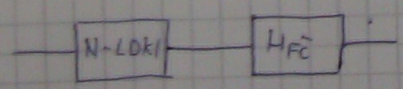
nestabilné póly nahradíme nulami a dokreslíme nové póly do kružnice
→ dosiahneme stabilitu

$$H(z) = \frac{1}{z^{-1}+a} \qquad a = |a|\, e^{j\varphi}$$

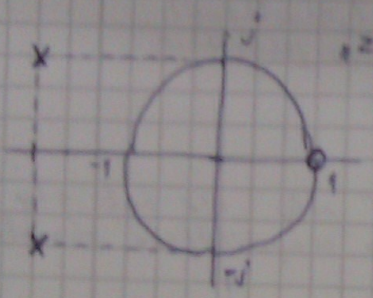
$$H_{FČ}(z) = \frac{z^{-1}+a}{\left(z^{-1}+\frac{1}{|a|}e^{j\varphi}\right)\cdot|a|} = \frac{z^{-1}+a}{1-a^{*}z^{-1}}$$

$$|H_{FČ}| = 1$$

$$H_s(z) = H(z)\cdot H_{FČ}(z)$$



8c)



$H(z) = \frac{1-z^{-1}}{(1-(-2+j)z^{-1})(1-(-2-j)z^{-1})}$

$z_{n1} = |-2+j| > 1$

$z_{n2} = |-2-j| > 1$ $\Rightarrow$ nestabilní systém

stabilizující:

$z_{s1} = \frac{1}{z_{n1}} = \frac{1}{-2+j} \cdot \frac{-2-j}{-2-j} = -\frac{2}{5} - \frac{j}{5}$

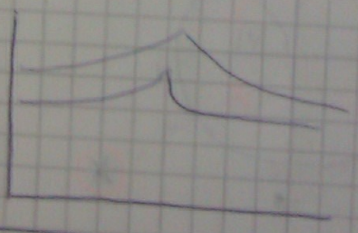
$z_{s2} = -\frac{2}{5} + \frac{j}{5}$

$H_{FC}(z) = \frac{(1-(-2+j)z^{-1})(1-(-2-j)z^{-1})}{(1-(-\frac{2}{5}-\frac{j}{5})z^{-1})(1-(-\frac{2}{5}+\frac{j}{5})z^{-1})} \cdot \frac{1}{5}$

$K = \sqrt{4+1} = \sqrt{5}$

$H_S(z) = \frac{1-z^{-1}}{(1-(-\frac{2}{5}-\frac{j}{5})z^{-1})(1-(-\frac{2}{5}+\frac{j}{5})z^{-1})} \cdot \frac{1}{5}$

$\frac{1}{5}$ posunuté hore



9 Teplicové matice

PŘ.

Newtonův algoritmus

$$H(z) = \frac{1-z^{-1}}{(1-(-2+j)z^{-1})(1-(-2+j)z^{-1})} = B(z)$$

$b_0 + b_1 z^{-1} \dots$

$$\hat{A}(z) = \frac{1}{B(z)}$$

aprox

$$\hat{C}(z) = \frac{1}{\hat{A}(z)}$$

$$\hat{C}(z) \overset{\wedge}{=} B(z)$$

$|k| < 1$ v kruhu. $\quad k > 1$ mimo kruh.

$$Q = \begin{bmatrix} q_0 & q_1 & q_2 & q_3 \\ q_1 & q_0 & q_1 & q_2 \\ q_2 & q_1 & q_0 & q_1 \\ q_3 & q_2 & q_1 & q_0 \end{bmatrix}$$

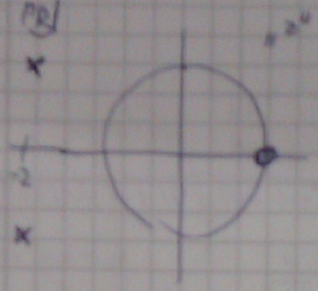
$$q_0 = \sum_{k=0}^{N} b_k^2 = b_0^2 + b_1^2 + b_2^2 \dots$$

$$q_1 = b_0 b_1 + b_1 b_2 + \dots$$

$$q_2 = b_0 b_2 + b_1 b_3$$

$$Q \cdot \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} b_0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

PR



$$H(z) = \frac{1-z^{-1}}{(1-(-2+j)z^{-1})(1-(-2-j)z^{-1})} =$$

$$= \frac{1-z^{-1}}{(1+} =$$

$$= \frac{1}{\cancel{1+4z^{-1}-2jz^{-1}+5z^{-2}}} = B(z)$$

$$Q = \begin{bmatrix} q_0 & q_1 & q_2 \\ q_1 & q_0 & q_1 \\ q_2 & q_1 & q_0 \end{bmatrix} \cdot \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} b_0 \\ 0 \\ 0 \end{bmatrix}$$

$$B(z) = \underset{b_0}{1} + \underset{b_1}{4}z^{-1} + \underset{b_2}{5}z^{-2}$$

$q_0 = 1+16+25 = 42$
$q_1 = 1\cdot 4 + 4\cdot 5 = 24$
$q_2 = 5$

$$\begin{bmatrix} 42 & 24 & 5 \\ 24 & 42 & 24 \\ 5 & 24 & 42 \end{bmatrix} \cdot \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} b_0 \\ 0 \\ 0 \end{bmatrix}$$

$42a_0 + 24a_1 + 5a_2 = 1$
$24a_0 + 42a_1 + 24a_2 = 0$
$5a_0 + 24a_1 + 42a_2 = 0$

$\Rightarrow$ $a_0 = 0{,}039$, $a_1 = -0{,}029$, $a_2 = +0{,}012$

$\hat{A}(z) = 0{,}039 - 0{,}029z^{-1} + 0{,}012z^{-2}$

$q_0 = 0{,}039^2 + 0{,}029^2 + 0{,}012^2 =$
$q_1 = 0{,}039\cdot(-0{,}029) + (-0{,}029)\cdot(-0{,}012)$
$q_2 = 0{,}039\cdot($

$\vdots$

$c_0 = 49{,}92$
$c_1 = -17{,}42$
$c_2 = -59{,}62$

$C(z) = 49{,}92 - 17{,}42z^{-1} - 59{,}62z^{-2}$

$$H(z) = \frac{1-z^{-1}}{C(z)}$$