# Službeni šalabahter za kolegij Računalno upravljanje sustavima

1. Tablica $\mathcal{L}$ i $\mathcal{Z}$-transformacija:

| $f(t)$ | $F(s)$ | $f(kT)$ | $F(z)$ |
|---|---|---|---|
| $\delta(t)$ | $1$ | $1,\ k=0$<br>$0,\ k\neq 0$ | $1$ |
| $1$ | $\frac{1}{s}$ | $1$ | $\frac{1}{1-z^{-1}}$ |
| $t$ | $\frac{1}{s^2}$ | $kT$ | $\frac{Tz^{-1}}{(1-z^{-1})^2}$ |
| $e^{-at}$ | $\frac{1}{s+a}$ | $e^{-akT}$ | $\frac{1}{1-e^{-aT}z^{-1}}$ |
| $te^{-at}$ | $\frac{1}{(s+a)^2}$ | $kTe^{-akT}$ | $\frac{Te^{-aT}z^{-1}}{(1-e^{-aT}z^{-1})^2}$ |
| $1-e^{-at}$ | $\frac{a}{s(s+a)}$ | $1-e^{-akT}$ | $\frac{(1-e^{-aT})z^{-1}}{(1-z^{-1})(1-e^{-aT}z^{-1})}$ |
| $\sin at$ | $\frac{a}{s^2+a^2}$ | $\sin akT$ | $\frac{(\sin aT)z^{-1}}{1-(2\cos aT)z^{-1}+z^{-2}}$ |
| $\cos at$ | $\frac{s}{s^2+a^2}$ | $\cos akT$ | $\frac{1-(\cos aT)z^{-1}}{1-(2\cos aT)z^{-1}+z^{-2}}$ |
| $e^{-aT}\sin bt$ | $\frac{b}{(s+a)^2+b^2}$ | $e^{-akT}\sin bkT$ | $\frac{e^{-aT}(\sin bT)z^{-1}}{1-2e^{-aT}(\cos bT)z^{-1}+e^{-2aT}z^{-2}}$ |
| $e^{-aT}\cos bt$ | $\frac{s+a}{(s+a)^2+b^2}$ | $e^{-akT}\cos bkT$ | $\frac{1-z^{-1}e^{-aT}\cos bT}{1-2e^{-aT}(\cos bT)z^{-1}+e^{-2aT}z^{-2}}$ |

2. Veza karakterističnih veličina u vremenskom području s karakterističnim veličinama u frekvencijskom području:

| | |
|---|---|
| $t_m=\frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$ | $\omega_b\approx(1.2\div 1.5)\omega_c$, $\omega_b\approx\frac{2.3}{t_{a,50}}$, za $0.3<\zeta<0.8$ |
| $\sigma_m[\%]=100e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}}$ | $\gamma[^\circ]\approx 70-\sigma_m[\%]$, za $0.3<\zeta<0.8$ |
| | $\omega_c t_{a,50}\approx 1.5-\frac{\sigma_m[\%]}{250}$, za $0<\zeta<1$ |
| $t_{1\%}\approx\frac{4.6}{\zeta\omega_n}$ | $\omega_c\approx\frac{3}{t_m}$, za $0.3<\zeta<0.8$ |
| $t_r\approx\frac{1.8}{\omega_n}$ | $\omega_r=\omega_n\sqrt{1-2\zeta^2}$ |

3. Preporuke za odabir perioda uzorkovanja:

$$T=(0.16\div 1.05)\frac{2}{\omega_b},\quad T=(0.17\div 0.34)\frac{1}{\omega_c},\quad T=(0.08\div 0.5)t_r$$

4. Postupci diskretizacije:

| Postupak diskretizacije | $G(s)$ |
|---|---|
| ZOH | $G(z)=(1-z^{-1})\mathcal{Z}\{\frac{G(s)}{s}\}$ |
| Tustinov postupak | $s=\frac{2}{T}\frac{z-1}{z+1}$ |
| Eulerova unazadna diferencija | $s=\frac{z-1}{Tz}$ |
| Eulerova unaprijedna diferencija | $s=\frac{z-1}{T}$ |

5. Standardni oblici željenog zatvorenog kruga: $G_m(s) = \frac{\alpha(s)}{\beta(s)} = \frac{\alpha_0+\alpha_1 s+...+\alpha_\nu s^\nu}{\beta_0+\beta_1 s+...+\beta_u s^u}$.

Standardni polinom $\beta(s)$ za $u = 1, 2, ..., 6$ | Pripadajuće prijelazne funkcije $h_x(\omega_n t)$

Binomni oblik:

$$s + \omega_n$$

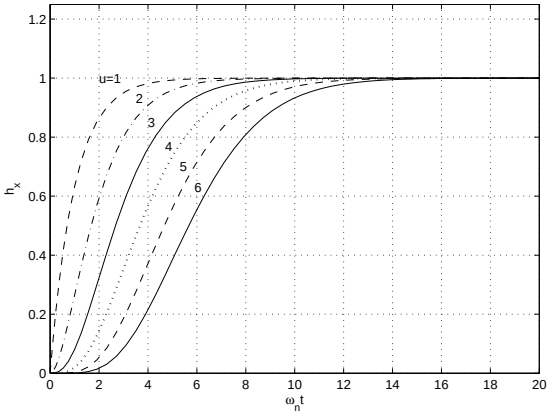
$$s^2 + 2\omega_n s + {\omega_n}^2$$

$$s^3 + 3\omega_n s^2 + 3{\omega_n}^2 s + {\omega_n}^3$$

$$s^4 + 4\omega_n s^3 + 6{\omega_n}^2 s^2 + 4{\omega_n}^3 s + {\omega_n}^4$$

$$s^5 + 5\omega_n s^4 + 10{\omega_n}^2 s^3 + 10{\omega_n}^3 s^2 + 5{\omega_n}^4 s + {\omega_n}^5$$

$$s^6 + 6\omega_n s^5 + 15{\omega_n}^2 s^4 + 20{\omega_n}^3 s^3 + 15{\omega_n}^4 s^2 + 6{\omega_n}^5 s + {\omega_n}^6$$




Butterworthov oblik:

$$s + \omega_n$$

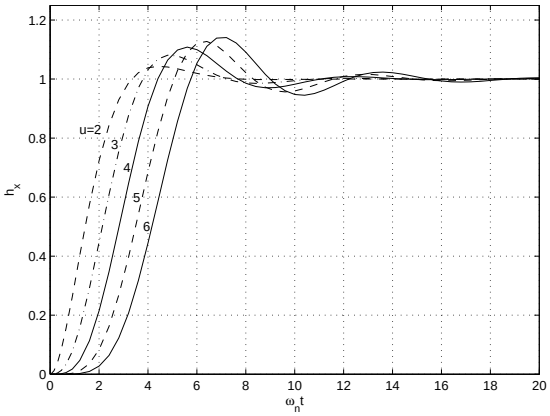
$$s^2 + 1.4\omega_n s + {\omega_n}^2$$

$$s^3 + 2.0\omega_n s^2 + 2.0{\omega_n}^2 s + {\omega_n}^3$$

$$s^4 + 2.6\omega_n s^3 + 3.4{\omega_n}^2 s^2 + 2.6{\omega_n}^3 s + {\omega_n}^4$$

$$s^5 + 3.24\omega_n s^4 + 5.24{\omega_n}^2 s^3 + 5.24{\omega_n}^3 s^2 + 3.24{\omega_n}^4 s + {\omega_n}^5$$

$$s^6 + 3.86\omega_n s^5 + 7.46{\omega_n}^2 s^4 + 9.14{\omega_n}^3 s^3 + 7.46{\omega_n}^4 s^2 + 3.86{\omega_n}^5 s + {\omega_n}^6$$




$\int_0^\infty |e(t)|tdt$ oblik:

$$s + \omega_n$$

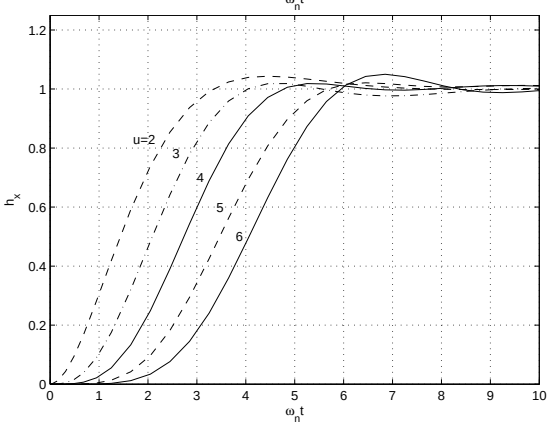
$$s^2 + 1.4\omega_n s + {\omega_n}^2$$

$$s^3 + 1.75\omega_n s^2 + 2.15{\omega_n}^2 s + {\omega_n}^3$$

$$s^4 + 2.1\omega_n s^3 + 3.4{\omega_n}^2 s^2 + 2.7{\omega_n}^3 s + {\omega_n}^4$$

$$s^5 + 2.8\omega_n s^4 + 5.0{\omega_n}^2 s^3 + 5.5{\omega_n}^3 s^2 + 3.4{\omega_n}^4 s + {\omega_n}^5$$

$$s^6 + 3.25\omega_n s^5 + 6.60{\omega_n}^2 s^4 + 8.60{\omega_n}^3 s^3 + 7.45{\omega_n}^4 s^2 + 3.95{\omega_n}^5 s + {\omega_n}^6$$




Oblik zasnovan na minimizaciji vremena ustaljenja $t_{5\%}$:

$$s + \omega_n$$

$$s^2 + 1.4\omega_n s + {\omega_n}^2$$

$$s^3 + 1.55\omega_n s^2 + 2.10{\omega_n}^2 s + {\omega_n}^3$$

$$s^4 + 1.60\omega_n s^3 + 3.15{\omega_n}^2 s^2 + 2.45{\omega_n}^3 s + {\omega_n}^4$$

$$s^5 + 1.575\omega_n s^4 + 4.05{\omega_n}^2 s^3 + 4.10{\omega_n}^3 s^2 + 3.025{\omega_n}^4 s + {\omega_n}^5$$

$$s^6 + 1.45\omega_n s^5 + 5.10{\omega_n}^2 s^4 + 5.30{\omega_n}^3 s^3 + 6.25{\omega_n}^4 s^2 + 3.425{\omega_n}^5 s + {\omega_n}^6$$