d.) Vstup: $\delta_e(s)$
Výstup: $h(s)$

$$G(s) = \frac{-15000s + 15000}{s(14s+1)} e^{-1s}$$

~~$14\ddot{y}(t) + \dot{y}(t) =$~~

$$14\ddot{y}(t) + \dot{y}(t) = -15000\dot{u}(t-1) + 15000u(t-1)$$

Padeho aprox. pomocou pade ( ) - MATLAB

$$G1(s) = \frac{15000s^2 - 45000s + 30000}{14s^3 + 29s^2 + 2s}$$

$$Y(s) = \frac{15000s^2 - 45000s + 30000}{s^2(s+2)(s+0{,}0714)}$$

$$= \frac{A}{s^2} + \frac{B}{s} + \frac{C}{s+2} + \frac{D}{s+0{,}0714}$$

residue

$$= -\frac{240000}{s} + \frac{15000}{s^2} + \frac{-1666{,}7}{s+2} + \frac{241666{,}7}{s+0{,}0714}$$

Prechodová char:

$$y(t) = -240000 + 15000t - 1666{,}7 \cdot e^{-2t} + 241666{,}7e^{-0{,}0714t}$$

$$Y(s) = \frac{15000s^2 - 45000s + 30000}{s(s+2)(s+0{,}0714)}$$

$$= \frac{A}{s} + \frac{B}{s+2} + \frac{C}{s+0{,}0714} = \frac{15000}{s} + \frac{3333}{s+2} - \frac{17262}{s+0{,}0714}$$

Impulzová char:

$$y(t) = 15000 + 3333e^{-2t} - 17262e^{-0{,}0714t}$$

3.) $\lim_{s \to 0} s \cdot \frac{E}{w} \cdot w = \lim_{s \to 0} s \cdot \frac{1}{1+G_r G_p} \cdot w =$

$= \lim_{s \to 0} \cancel{s} \frac{1}{1+G_r G_p} \cdot \frac{1}{\cancel{s}} = 0$

$$\frac{-15000s + 15000}{s(14s+1)} e^{-1s}$$

↳ keďže máme astatizmus, vhodné reg. sú P, alebo PD.

4.) Pomocou Synreg sme určili optimálne parametre:

- Naslinova metóda:

$$G_R = \frac{0{,}000848s^2 + 0{,}00061s}{s}$$

- Metóda štand. tvarov

a) Graham

$$G_R = \frac{0{,}000322s^2 + 6{,}05 \cdot 10^{-5}s}{s}$$

kritéria pre Naj
- Naj
- Prereg.
- doba reg.

b) Butterworth:

$$G_R = \frac{0{,}000393\,s^2 + 8{,}73 \cdot 10^{-5}s}{s}$$

- Metóda čas. konštánt:
  - Nieje vhodná pre našu funkciu

- Metóda optimálneho modulu
  - Nieje vhodná

- Z všetky nieje Naslin, lebo dá hodnoty 10^8 a preto ...

- lepší je Graham, lebo má menšie preregulovanie aj menší čas regulácie.

b.) Overenie:

$$G_P(s) = \frac{15000s^2 - 45000s + 30000}{14s^3 + 29s^2 + 2s}$$

$$\underline{\underline{G_R = P + Ds}}$$

$$CH_{URO} = AP + BQ = s(14s+1)(1+Ds) + 15000(-s+1)(P+Ds)$$

$$= (14s^2+s)(D_1s+1) + 15000(-Ps+P-Ds^2+Ds) =$$

$$= 14D_1s^3 + D_1s^2 + 14s^2 + s - 15000Ps + 15000P - 15000Ds^2 + 15000Ds =$$

$$= 14s^3 + s^2(15 - 15000D) + s(1 - 15000P + 15000D) + 15000P$$

Graham:

$$\frac{1 + 2{,}15q + 1{,}75q^2 + q^3}{1 + 2{,}15\frac{s}{\omega_0} + 1{,}75\frac{s^2}{\omega_0^2} + \frac{s^3}{\omega^3}} \bigg/ \cdot \omega_0^3$$

$$\omega_0^3 + 2{,}15s\omega_0^2 + 1{,}75s^2\omega_0 + s^3$$

Potrebujem 1 pri s^3:

$$s^3 + s^2\left(\frac{15 - 15000D}{14}\right) + s\left(\frac{1 - 15000P - 15000}{14}\right) + \frac{15000}{14}P$$

$$\omega_0 = \frac{15 - 15000D}{14 \cdot 2{,}15}$$

$$\omega_0^2 = \frac{1 - 15000P + 15000D}{14 \cdot 1{,}75}$$

$$\omega_0^3 = \frac{15000}{14} \cdot P$$

6.1

$$\boxed{P = \frac{14}{15000}\omega_0^3}$$

$$\omega_0 = \frac{15}{14\cdot 2{,}15} - \frac{15000\,D}{14\cdot 2{,}15}$$

$$D = \frac{14\cdot 2{,}15}{15000}\left(\omega_0 - \frac{15}{14\cdot 2{,}15}\right) = \frac{14\cdot 2{,}15\cdot\omega_0}{15000} - \frac{\overset{1}{\cancel{14\cdot 15\cdot 2{,}15}}}{\cancel{14\cdot 2{,}15\cdot 15000}}\,1000$$

$$\boxed{= \frac{14\cdot 2{,}15\,\omega_0}{15000} - \frac{1}{1000} = D}$$

$$\omega_0^2 = \frac{1}{14\cdot 1{,}75} - \frac{\cancel{15000}\cdot\cancel{14}}{\cancel{14}\cdot 1{,}75\cdot\cancel{15000}}\omega_0^3$$

$$+ \frac{\cancel{15000}\cdot\cancel{14}\cdot 2{,}15}{\cancel{14}\cdot 1{,}75\cdot\cancel{15000}}\omega_0 - \frac{15\cancel{000}\cdot 1}{14\cdot 1{,}75\cdot\cancel{1000}}$$

$$\omega_0^2 = \frac{1}{14\cdot 1{,}75} - \frac{1}{1{,}75}\omega_0^3 + \frac{2{,}15}{1{,}75}\omega_0 - \frac{15}{14\cdot 1{,}75}$$

$$14\cdot 1{,}75\cdot\omega_0^2 = 1 - 14\omega_0^3 + 14\cdot 2{,}15\,\omega_0 - 15$$

$$14\omega_0^3 + 14\cdot 1{,}75\,\omega_0^2 - 14\cdot 2{,}15\,\omega_0 = -14 \qquad /:14$$

$$\cancel{\omega_0(\omega_0 + 2{,}5825)(\omega_0 - 0{,}83252)} = -14$$

$$\omega_0^3 + 1{,}75\,\omega_0^2 - 2{,}15\,\omega_0 = -1$$

$$\Downarrow$$

Korene sú komplexné čísla.

7.) $\lim_{s\to 0} s\,Y(s) = \lim_{s\to 0} s \cdot G_{Yw}(s) \cdot W(s)$

$$= \lim_{s\to 0} s \frac{G_P G_R}{1+G_P G_R} \cdot W(s)$$

$$= \frac{\frac{B}{A}\cdot\frac{Q}{R}}{1+\frac{B}{A}\cdot\frac{Q}{P}} = \frac{\frac{BQ}{\cancel{AP}}}{\frac{AP+QB}{\cancel{AP}}} = \frac{BQ}{AP+BQ} = \cancel{BQ}$$

$$= \lim_{s\to 0} \frac{BQ}{BQ} = \underline{\underline{1}}$$

$$AP = 14s^2+s = \underline{0}$$

$$\lim_{s\to 0} s \cdot E(s) = \lim_{s\to 0} \cancel{s} \cdot \frac{1}{1+G_P G_R} \cdot \overset{\cancel{1}/\cancel{s}}{W(s)} =$$

$AP=0$

$$= \frac{1}{1+\frac{B}{A}\cdot\frac{Q}{P}} = \frac{1}{1+\frac{BQ}{AP}} = \frac{\frac{1}{1}}{\frac{AP+BQ}{AP}} = \frac{AP}{AP+BQ} \Rightarrow \lim_{s\to 0} \frac{0}{BQ} = \underline{\underline{0}}$$

$$\lim_{s\to 0} s \cdot G_{uw}(s) \cdot W(s) = \lim_{s\to 0} \frac{G_R}{1+G_P G_R} = \lim_{s\to 0} \frac{\frac{Q}{P}}{1+\frac{B}{A}\frac{Q}{P}} =$$

$$= \lim_{s\to 0} \frac{\frac{Q}{R}}{\frac{AP+BQ}{AR}} = \lim_{s\to 0} \frac{\overset{0}{A}\,Q}{\underbrace{AP}_{=0}+BQ} = \frac{0\cdot\cancel{Q}}{B\cdot\cancel{Q}} = \underline{\underline{0}}$$

$$G_P = \frac{-15000+15000}{14s^2+s} \simeq \frac{B}{A}$$

$$G_R = \frac{\cancel{s}(0{,}000322s+6{,}05\cdot 10^{-5})}{\cancel{s}} = \frac{0{,}000322s+6{,}05\cdot 10^{-5}}{1} = \frac{Q}{P}$$

8.) Do CHURO dosadíme P a D z Graham.

$$14s^3 + 10{,}17s^2 + 4{,}9225s + 0{,}9075$$

Póly:

$(-2{,}1942 \cdot 10^{-1} + 4{,}2102 \cdot 10^{-1} \cdot i)$ ~~2 násobný~~

$(-2{,}8758 \cdot 10^{-1} + 0{,}000 \cdot i)$

$(-2{,}1942 \cdot 10^{-1} - 4{,}2102 \cdot 10^{-1} \cdot i)$

Grafy.

Nyquist: Pretína sa pred "-1" => stabilné

Bode : Pre hodnotu -180° pripada záporná hodnote v dB => stabilné