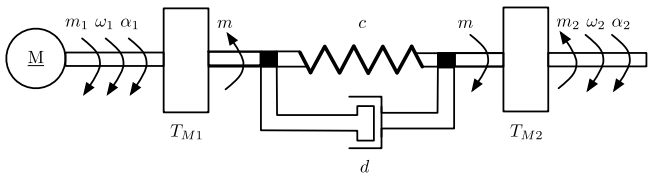
Auditorne vježbe

26. siječnja 2018.

---

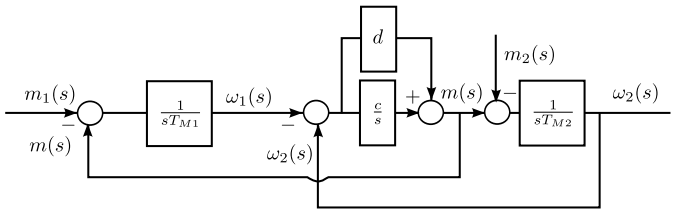
1. zadatak

Za dvomaseni elastični sustav prikazan Slikom 1 potrebno je nacrtati strukturnu blokovsku shemu.



Slika 1: Načelna shema dvomasenog elastičnog sustava

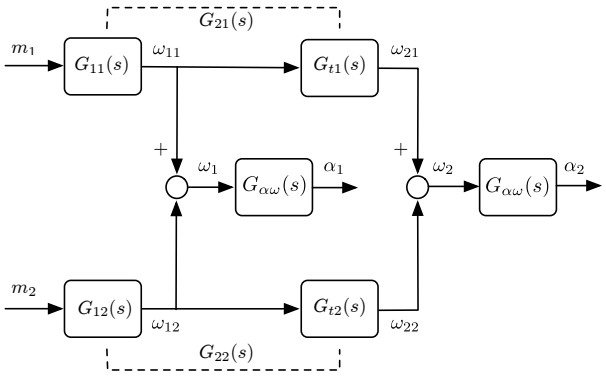
Rješenje:



Slika 2: Blokovska shema dvomasenog elastičnog sustava

2. zadatak

Za dvomaseni elastični sustav prikazan Slikom 3 potrebno je izvesti prijenosne funkcije $G_{11} = \frac{\omega_1(s)}{m_1(s)}$ i $G_{t1} = \frac{\omega_2(s)}{\omega_1(s)}$.

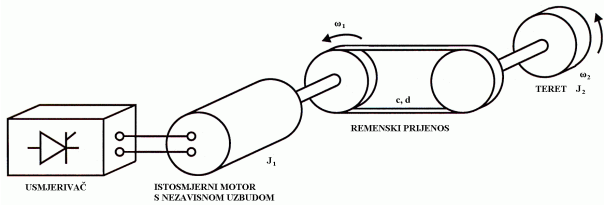


Slika 3: Blokovska shema dvomasenog elastičnog sustava

Rješenje:

$$G_{11}(s) = \frac{\omega_1(s)}{m_1(s)} = \frac{\frac{d}{c}s + 1}{(T_{M1} + T_{M2})s\left(\frac{s^2}{c\left(\frac{1}{T_{M1}} + \frac{1}{T_{M2}}\right)}\right) + \frac{d}{c}s + 1}, \; G_{t1}(s) = \frac{\omega_2(s)}{\omega_1(s)} = \frac{ds + c}{T_{M2}s^2 + ds + c}. \quad (1)$$

3. zadatak



Slika 4: Načelna shema dvomasenog elastičnog sustava

Za dvomaseni sustav s elastičnim prijenosom, uz pretpostavku da postoji brza zatvorena petlja **po brzini** pogonskog motora $\frac{\omega_1(s)}{\omega_{1r}(s)} = \frac{1}{T_\omega s+1}$, koja se za potrebe sinteze regulatora brzine tereta može **zanemariti**, potrebno je odrediti parametre **klasičnog PI regulatora** tako da karakteristični odnosi budu što je bliže moguće optimalnom iznosu $D_2 = 0.5$, $D_3 = 0.5$. Zadano je: $T_{M2} = 1.5$ s, $c = 100$ Nm/rad, $d = 0.25$ Nms/rad , $T_\omega = 25$ ms.

Rješenje: $D_2 = 0.25$, $T_e = 0.005$ s, $T_e = 0.0025$ s, $K_R = 9599$.

4. zadatak

Za regulacijski sustav s dvomasenim elastičnim prijenosom, potrebno je pronaći parametre **modificiranog** PI **regulatora** koristeći optimum dvostrukog odnosa.

Zadano je: $T_{M2} = 1.5$ s, $c = 100$ Nm/rad, $d = 0.25$ Nms/rad, $T_{ei} = 0.01$ s, $T = 0.001$ s.

Rješenje: $T_e = 0.366$ s, $T_I = 0.364$ s, $K_{\omega_1} = 17.76$.

5. zadatak

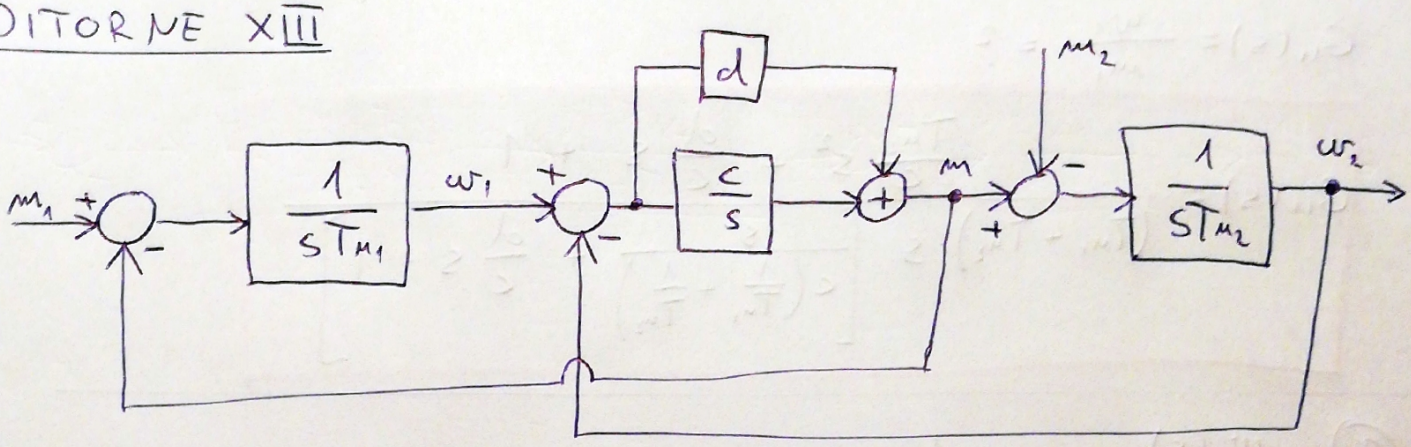
Za regulacijski sustav s dvomasenim elastičnim prijenosom, potrebno je pronaći parametre **modificiranog** PI **regulatora** tako da vrijedi $T_e = 0.3s$, $D_2 = 0.5$. Koliko tada iznosi D_3?

Zadano je: $T_{M2} = 1.5$ s, $c = 100$ Nm/rad, $d = 0.25$ Nms/rad, $T_{ei} = 0.01$ s, $T = 0.001$ s.

Rješenje: $T_e = 0.3$ s, $T_I = 0.296$ s, $K_{\omega_1} = 25.3$, $D_3 = \frac{a_3}{D_2^2 T_e^3} = 0.72$.

AUDITORNE XIII

1.



2.

$$\omega_1 = \frac{1}{sT_{M_1}}(m_1 - m)$$

$$\omega_2 = \frac{1}{sT_{M_2}}(m - m_2), \quad m_2 = 0$$

$$m = \left(d + \frac{c}{s}\right)(\omega_1 - \omega_2)$$

$$G_{t_1}(s) = \frac{\omega_2}{\omega_1} = ?$$

$$m = sT_{M_2} \cdot \omega_2$$

$$\Rightarrow sT_{M_2}\omega_2 = \frac{sd + c}{s}(\omega_1 - \omega_2)$$

$$\frac{T_{M_2}s^2 + ds + c}{s}\omega_2 = \frac{ds + c}{s}\omega_1$$

$$\boxed{G_{t_1}(s) = \frac{\omega_2}{\omega_1} = \frac{ds + c}{T_{M_2}s^2 + ds + c}}$$

$$G_{11}(s) = \frac{\omega_1}{m_1} = ?$$

$$G_{11}(s) = \frac{\frac{T_{M_2}}{c} s^2 + \frac{d}{c} s + 1}{(T_{M_1} + T_{M_2}) \cdot s \left[\frac{s^2}{c\left(\frac{1}{T_{M_1}} + \frac{1}{T_{M_2}}\right)} + \frac{d}{c} s + 1 \right]}$$

---

③ $\frac{\omega_1(s)}{\omega_{1r}(s)} = \frac{1}{T_w s + 1}$

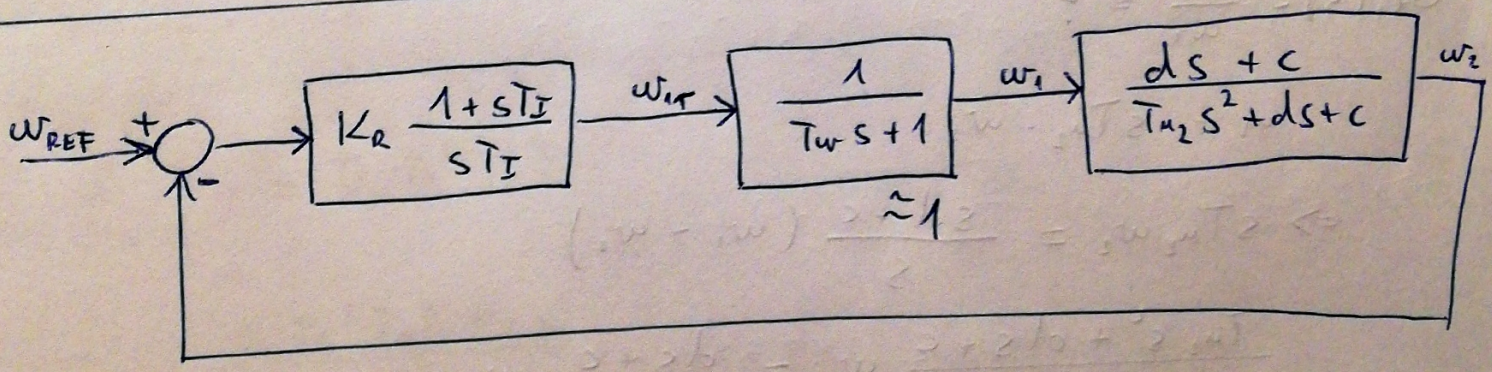
$T_{M_2} = 1.5\ s$

$c = 100\ Nm/rad$

$d = 0.25\ Nm\,s/rad$

$T_w = 25\ ms$

$D_2 = D_3 = 0.5$ (ŠTO BLIŽE)



$$G_r(s) = \frac{T_I \frac{d}{c} s^2 + \left(T_I + \frac{d}{c}\right) s + 1}{\underbrace{\frac{T_I T_{M_2}}{K_R c}}_{a_3} s^3 + \underbrace{\frac{d T_I}{c} \frac{1 + K_R}{K_R}}_{a_2} s^2 + \underbrace{\left(T_I \frac{1 + K_R}{K_R} + \frac{d}{c}\right)}_{a_1} s + 1}$$

→ $a_1 = T_e$

$a_2 = D_2 T_e^2$

$a_3 = D_3 D_2^2 T_e^3$

$$a_1 = \frac{c}{d} a_2 + \frac{d}{c}$$

$$Te = \frac{c}{d} D_2 Te^2 + \frac{d}{c} \quad / \cdot dc$$

$$c^2 D_2 Te^2 - dc\,Te + d^2 = 0$$

$$d^2 c^2 - 4 d^2 c^2 D_2 = 0$$

$$\boxed{D_2 = 0.25} \qquad \boxed{Te = 5\ ms}$$

$$K_R = \frac{T_{M_2}}{d\, D_3\, D_2\, Te} - 1$$

$$\boxed{K_R = 9599}$$

$$\frac{T_I\, T_{M_2}}{K_R\, C} = D_3\, D_2^2\, Te^3$$

$$T_I = \frac{D_3\, D_2^2\, Te^3 \cdot K_R\, C}{T_{M_2}}$$

$$\boxed{T_I = 2.5\ ms}$$

(4.) $T_{M_2} = 1.5\ s$

$c = 100\ Nm/rad$

$d = 0.25\ Nm\,s/rad$

$T_{ei} = 0.01\ s$, $T = 1\ ms$ $\Big\}$ $T_\Sigma = T_{ei} + T = 11\ ms$

$$G_T(s) = \frac{\omega_2}{\omega_R} = \frac{2\,\xi_2\,\Omega_{o2}^{-1}\,s + 1}{a_5 s^5 + a_4 s^4 + a_3 s^3 + a_2 s^2 + a_1 s + 1}$$

$$a_1 = T_I + 2\,\xi_2\,\Omega_{o2}^{-1}$$

$$a_1 = T_e$$

$$\rightarrow T_e \approx \frac{3}{2} T_\Sigma + \sqrt{\frac{21}{4} T_\Sigma^2 + 8\,\Omega_{o2}^{-2}} \qquad \Omega_{o2} = \sqrt{\frac{c}{T_{M_2}}}$$

$$\xi_2 = \frac{d}{2c}\,\Omega_{o2}$$

$$\boxed{T_e \approx 0.3638\ s}$$

$$\rightarrow T_I = T_e - \frac{d}{c}$$

$$\boxed{T_I = 0.3613\ s}$$

$$\rightarrow K_{\omega 1} = \frac{T_I\,T_{M\Sigma}\,\Omega_{o2}^2}{D_2\,T_e^2\,\Omega_{o2}^2 - 2\,\xi_2\,(T_e\,\Omega_{o2} - 2\,\xi_2) - 1}$$

$$\boxed{K_{\omega 1} = 17.9652}$$

5.

$T_e = 0.3\ s$

$D_2 = 0.5$

$T_{M_2} = 1.5\ s$ $\qquad T_{M\Sigma} = 2.5\ s$ (MEDOSTAJE)

$c = 100\ Nm/rad$

$d = 0.25\ Nms/rad$

$T_{ei} = 0.01\ s$

$T = 0.001\ s$

$\rightarrow T_e = T_I + 2\,\vartheta_2\,\Omega_{02}^{-1}$

$T_I = T_e - \frac{d}{c} \rightarrow$ **$T_I = 0.2975\ s$**

$$\rightarrow K_{\omega 1} = \frac{T_I\,T_{M\Sigma}\,\Omega_{02}^2}{D_2\,T_e^2\,\Omega_{02}^2 - 2\,\vartheta_2\,(T_e\,\Omega_{02} - 2\,\vartheta_2) - 1}$$

$K_{\omega 1} = 25.4219$

$$\rightarrow D_3\,D_2^2\,T_e^3 = K_{\omega 1}^{-1}\,T_I\,T_{M\Sigma}\left(T_\Sigma + 2\,\vartheta\,\Omega_0^{-1}\right) + T_I\,\Omega_{02}^{-2}$$

$D_3 = 0.7196$