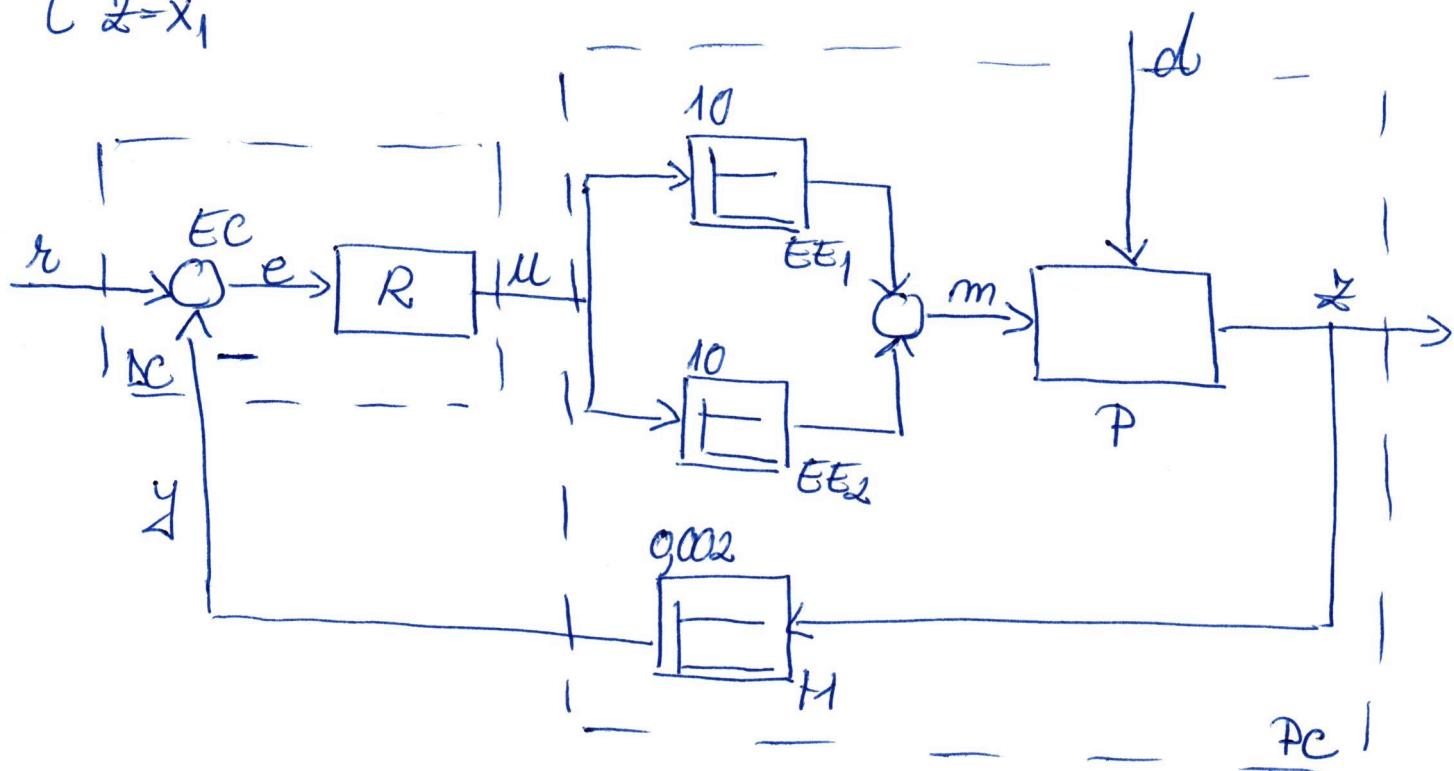


Se consideră sistemul de reglare automată cu schema bloc prezentată în figură, în care  $r(t)$  este referință,  $e(t)$  este eroarea de reglare și modelul de stocare (HII-isi) al blocului P este:

$$\begin{cases} \dot{x}_1 = -2x_1 + 2x_2 + 40d \\ \dot{x}_2 = -0,5x_2 + 12,5m \\ z = x_1 \end{cases}$$



Sunt considerate 2 variante de reglatoare (R) cu f.d.t.:

$$R_1: H_R(\Delta) = k_R \left(1 + \frac{1}{T_i \Delta}\right) = \frac{k_R (1 + \Delta T_i)}{\Delta T_i} (ET - PI)$$

$$R_2: H_R(\Delta) = \frac{k_R (1 + T_d \Delta)}{1 + T_g \Delta} (ET - PI)$$

$$\text{For } R_2: \quad \downarrow d \quad \Rightarrow \quad H_{Zm}(\Delta) = \frac{z(\Delta)}{m(\Delta)} \Big|_{d=0} \quad \text{and} \quad H_{Zd}(\Delta) = \frac{z(\Delta)}{d(\Delta)} \Big|_{m=0}$$

- trebuie găsite matricile A, B și C pentru a se găsi matricea de transfer  $H(\Delta) = C \cdot (\Delta I - A)^{-1} \cdot B = C \cdot \Delta^{-1} \cdot B$

$$\begin{cases} \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \underbrace{\begin{bmatrix} -2 & 2 \\ 0 & -0,5 \end{bmatrix}}_A \cdot \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \underbrace{\begin{bmatrix} 0 & 40 \\ 12,5 & 0 \end{bmatrix}}_B \cdot \begin{bmatrix} m \\ d \end{bmatrix} \\ z = \underbrace{\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}}_C \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \end{cases}$$

$$\text{dec} A = \begin{bmatrix} -2 & 2 \\ 0 & -0,5 \end{bmatrix}, B = \begin{bmatrix} 0 & 40 \\ 12,5 & 0 \end{bmatrix} \text{ & } C = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

$$H(\Delta) = C \cdot (\Delta I - A)^{-1} \cdot B = \begin{bmatrix} H_{x_1m}(\Delta) & H_{x_1d}(\Delta) \end{bmatrix} = \begin{bmatrix} H_{zm}(\Delta) & H_{zd}(\Delta) \end{bmatrix}$$

$$H = (\Delta I - A) = \begin{bmatrix} \Delta & 0 \\ 0 & \Delta \end{bmatrix} - \begin{bmatrix} -2 & 2 \\ 0 & -0,5 \end{bmatrix} = \begin{bmatrix} \Delta+2 & -2 \\ 0 & \Delta+0,5 \end{bmatrix} \Rightarrow$$

$$H^T = H^* = \begin{bmatrix} \Delta+2 & 0 \\ -2 & \Delta+0,5 \end{bmatrix}, \quad \det(H) = (\Delta+2)(\Delta+0,5) = 2(1+0,5\Delta) \cdot 0,5(1+2\Delta) \Rightarrow \det(H) = (1+0,5\Delta)(1+2\Delta)$$

$$H^{-1} = \frac{1}{\det(H)} \cdot H^*, \quad H^* = \begin{bmatrix} (-1)^{1+1}(\Delta+0,5) & (-1)^{1+2}(-2) \\ (-1)^{2+1} \cdot 0 & (-1)^{2+2}(\Delta+2) \end{bmatrix} = \begin{bmatrix} \Delta+0,5 & 2 \\ 0 & \Delta+2 \end{bmatrix}$$

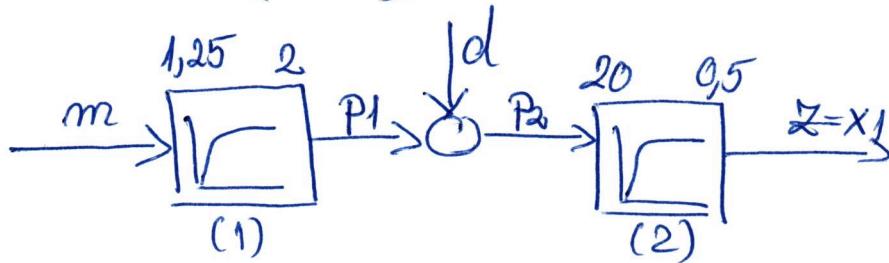
$$H^{-1} = \frac{1}{(1+0,5\Delta)(1+2\Delta)} \begin{bmatrix} \Delta+0,5 & 2 \\ 0 & \Delta+2 \end{bmatrix}$$

$$\begin{aligned} H(\Delta) &= \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot \frac{1}{(1+0,5\Delta)(1+2\Delta)} \begin{bmatrix} \Delta+0,5 & 2 \\ 0 & \Delta+2 \end{bmatrix} \begin{bmatrix} 0 & 40 \\ 12,5 & 0 \end{bmatrix} = \\ &= \frac{1}{(1+0,5\Delta)(1+2\Delta)} \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} \Delta+0,5 & 2 \\ 0 & \Delta+2 \end{bmatrix} \begin{bmatrix} 0 & 40 \\ 12,5 & 0 \end{bmatrix} = \frac{1}{(1+0,5\Delta)(1+2\Delta)} \begin{bmatrix} 0 & 40 \\ 12,5 & 0 \end{bmatrix} \end{aligned}$$

$$\begin{aligned} &= \frac{1}{(1+0,5\Delta)(1+2\Delta)} \begin{bmatrix} 25 & 40(\Delta+0,5) \end{bmatrix} = \begin{bmatrix} \frac{25}{(1+0,5\Delta)(1+2\Delta)} & \frac{40 \cdot 0,5(1+2\Delta)}{(1+0,5\Delta)(1+2\Delta)} \end{bmatrix} \\ &= \begin{bmatrix} \frac{25}{(1+0,5\Delta)(1+2\Delta)} & \frac{20}{(1+0,5\Delta)(1+2\Delta)} \end{bmatrix} = \begin{bmatrix} H_{zm}(\Delta) & H_{zd}(\Delta) \end{bmatrix} \end{aligned}$$

(2)

$$H_{zm}(\Delta) = \frac{25}{(1+0,5\Delta)(1+2\Delta)} \quad \text{și} \quad H_{zd}(\Delta) = \frac{20}{1+0,5\Delta}$$



$\Rightarrow$  verificăm să vedem dacă ultimul HHI-ișii este respectat.

$$p_1(\Delta) = \frac{1,25}{1+2\Delta} m(\Delta) \Rightarrow p_1(\Delta) + 2\Delta p_1(\Delta) = 1,25 m(\Delta) \Rightarrow \text{trebuie să avem } 12,5 m(\Delta) \Rightarrow \text{despartim}$$

primul bloc în 2 blocuri (un ET-P1 și un ET-P)

$$\begin{array}{c} \text{m} \rightarrow \boxed{\begin{matrix} 25 \\ 2 \end{matrix}} \xrightarrow{x_2} \boxed{\begin{matrix} 0,05 \\ - \end{matrix}} \xrightarrow{p_1} \\ H_1(\Delta) \qquad \qquad H_2(\Delta) \end{array} \quad H_1(\Delta) \cdot H_2(\Delta) = \frac{25}{1+2\Delta} \cdot 0,05 = \frac{1,25}{1+2\Delta}$$

$$p_1(\Delta) = 0,05 x_2(\Delta) \Rightarrow p_1 = 0,05 x_2$$

$$x_2(\Delta) = \frac{25}{1+2\Delta} m(\Delta) \Rightarrow x_2(\Delta) + 2\Delta x_2(\Delta) = 25 m(\Delta) \Rightarrow x_2 + 2x_2 = 25 m \Rightarrow$$

$$2x_2 = -x_2 + 25m \Rightarrow \dot{x}_2 = -0,5x_2 + 12,5m,$$

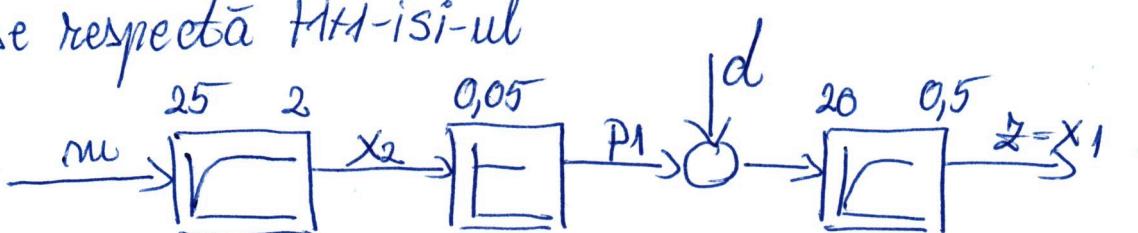
$$p_2(\Delta) = p_1(\Delta) + d(\Delta) \Rightarrow p_2 = p_1 + d$$

$$z(\Delta) = \frac{20}{1+0,5\Delta} p_2(\Delta) \xrightarrow{z=x_1} x_1(\Delta) + 0,5x_1(\Delta)\Delta = 20 p_2(\Delta) \Rightarrow x_1 + 0,5\dot{x}_1 = 20 p_2$$

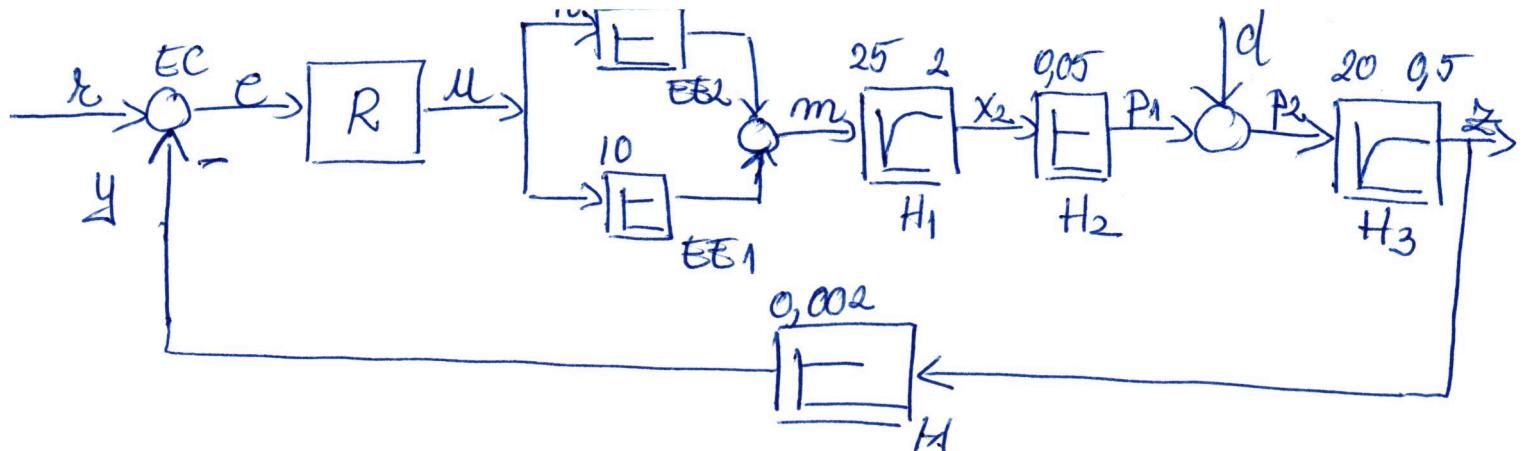
$$\begin{array}{l} \Rightarrow 0,5\dot{x}_1 = -x_1 + 20p_2 \\ p_2 = p_1 + d \end{array} \quad \left. \begin{array}{l} \Rightarrow 0,5\dot{x}_1 = -x_1 + 20p_1 + 20d \\ p_1 = 0,05x_2 \end{array} \right. \quad \Rightarrow$$

$$0,5\dot{x}_1 = -x_1 + x_2 + 20d \quad | : 0,5 \Rightarrow \dot{x}_1 = -2x_1 + 2x_2 + 40d,$$

$\Rightarrow$  se respectă HHI-ișii



(3)



$$\begin{aligned} H_{EE1}(s) &= 10(ET - P) \\ H_{EE2}(s) &= 10(ET - P) \end{aligned} \quad \left. \begin{aligned} \Rightarrow H_{EE}(s) &= H_{EE1}(s) + H_{EE2}(s) \\ (\text{conexiune paralel}) & \Rightarrow H_{EE}(s) = 20(ET - P) \end{aligned} \right\}$$

$$H_1(s) = \frac{25}{1+2s} (ET - PT_1)$$

$$H_2(s) = 0,05 (ET - P)$$

$$H_3(s) = \frac{20}{1+0,5s} (ET - PT_1)$$

$$H_{H4}(s) = 0,002 (ET - P)$$

① Calculați c.d.t. adică  $H_{y,r}(s)$ ,  $H_{y,d}(s)$  și f.d.t.  $H_0(s)$

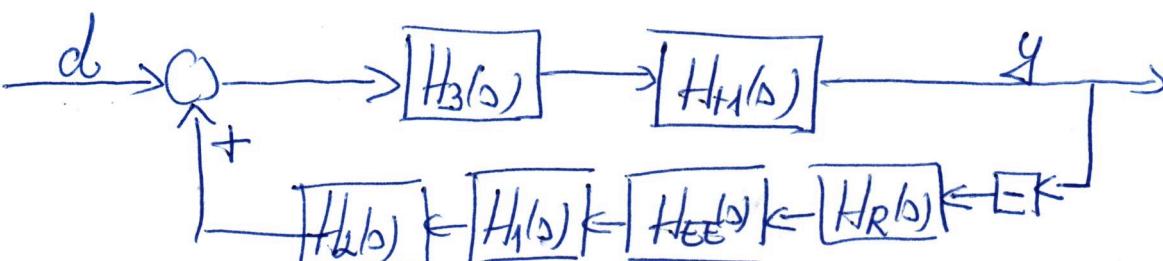
f.d.t. a sistemului deschis

pentru:  $R_1 : T_1 = 2,5 \text{ sec}$

$R_2 : T_0 = 2,5 \text{ sec}, T_f = 0,1 \text{ sec}$ .

$$H_{y,r}(s) = \frac{Y(s)}{R(s)} \Big|_{d=0} = \frac{H_R(s) \cdot H_{EE}(s) H_1(s) H_2(s) H_3(s) H_{H4}(s)}{1 + H_R(s) H_{EE}(s) H_1(s) H_2(s) H_3(s) H_{H4}(s)}$$

$$H_{y,d}(s) = \frac{Y(s)}{D(s)} \Big|_{r=0} = \frac{H_3(s) H_{H4}(s)}{1 - H_3(s) H_{H4}(s) [ -H_R(s) H_{EE}(s) H_1(s) H_2(s) ]}$$



(A)

$$H_{y,d}(\Delta) = \frac{H_3(\Delta) H_M(\Delta)}{1 + H_R(\Delta) H_E(\Delta) H_1(\Delta) H_2(\Delta) H_3(\Delta) H_M(\Delta)}$$

$$H_0(\Delta) = H_R(\Delta) H_{PC}(\Delta) = H_R(\Delta) \cdot H_E(\Delta) H_1(\Delta) H_2(\Delta) H_3(\Delta) H_M(\Delta)$$

$$\boxed{R_1}: H_{y,r}(\Delta) = \frac{\frac{k_R(1+2,5\Delta)}{2,5\Delta} \cdot 20 \cdot \frac{25}{1+2\Delta} \cdot 0,05 \cdot \frac{20}{1+0,5\Delta} \cdot 0,002}{1 + \frac{k_R(1+2,5\Delta) \cdot 1}{2,5\Delta(1+2\Delta)(1+0,5\Delta)}} =$$

$$= \frac{k_R(1+2,5\Delta)}{2,5\Delta(1+2\Delta)(1+0,5\Delta)} \cdot \frac{2,5\Delta(1+2\Delta)(1+0,5\Delta)}{2,5\Delta(1+2\Delta)(1+0,5\Delta) + k_R(1+2,5\Delta)} =$$

$$= \frac{k_R(1+2,5\Delta)}{2,5\Delta(\Delta^2 + 2,5\Delta + 1) + 2,5k_R\Delta + k_R} = \frac{k_R(1+2,5\Delta)}{2,5\Delta^3 + 6,25\Delta^2 + 2,5\Delta + 2,5k_R\Delta + k_R}$$

$$\Rightarrow H_{y,r}(\Delta) = \frac{k_R(1+2,5\Delta)}{2,5\Delta^3 + 6,25\Delta^2 + 2,5(1+k_R)\Delta + k_R}$$

$$H_{y,d}(\Delta) = \frac{\frac{20}{1+0,5\Delta} \cdot 0,002}{\frac{2,5\Delta^3 + 6,25\Delta^2 + 2,5(1+k_R)\Delta + k_R}{2,5\Delta(1+2\Delta)(1+0,5\Delta)}} = \frac{91\Delta(1+2\Delta)}{2,5\Delta^3 + 6,25\Delta^2 + 2,5(1+k_R)\Delta + k_R}$$

$$H_0(\Delta) = \frac{k_R(1+2,5\Delta)}{2,5\Delta} \cdot \frac{1}{(1+0,5\Delta)(1+2\Delta)} \Rightarrow H_0(\Delta) = \frac{k_R(1+2,5\Delta)}{2,5\Delta(1+0,5\Delta)(1+2\Delta)}$$

$$\boxed{R_2}: H_{y,r}(\Delta) = \frac{\frac{k_R(1+2,5\Delta)}{1+0,1\Delta} \cdot \frac{1}{(1+0,5\Delta)(1+2\Delta)}}{1 + \frac{k_R(1+2,5\Delta)}{(1+0,1\Delta)(1+0,5\Delta)(1+2\Delta)}} = \frac{k_R(1+2,5\Delta)}{(1+0,1\Delta)(1+0,5\Delta)(1+2\Delta) + k_R(1+2,5\Delta)}$$

$$= \frac{k_R(1+2,5\Delta)}{(1+0,1\Delta)(\Delta^2 + 2,5\Delta + 1) + 2,5k_R\Delta + k_R} \Rightarrow \frac{k_R(1+2,5\Delta)}{\Delta^2 + 2,5\Delta + 1 + 0,1\Delta^3 + 0,25\Delta^2 + 91\Delta + 2,5k_R\Delta + k_R}$$

$$\Rightarrow H_{y,r}(\Delta) = \frac{k_R(1+2,5\Delta)}{0,1\Delta^3 + 1,25\Delta^2 + (2,6 + 2,5k_R)\Delta + k_R + 1}$$

(5)

$$H_{y,0}(s) = \frac{\frac{20}{1+0,5s} \cdot 0,002}{\frac{0,1s^3 + 1,25s^2 + (2,6 + 2,5k_R)s + k_R + 1}{(1+0,1s)(1+0,5s)(1+2s)}} = \frac{0,04(1+0,1s)(1+2s)}{0,1s^3 + 1,25s^2 + (2,6 + 2,5k_R)s + k_R + 1}$$

$$H_0(s) = \frac{k_R(1+2,5s)}{1+0,1s} \cdot \frac{1}{(1+0,5s)(1+2s)} \Rightarrow H_0(s) = \frac{k_R(1+2,5s)}{(1+0,1s)(1+0,5s)(1+2s)}$$

② ~~Cat~~ Gasiti valoarea parametrului  $k_R > 0$  pt. care SRA este stabil.

R<sub>1</sub>:  $\Delta(s) = 1 + H_0(s) = 2,5s^3 + 6,25s^2 + 2,5(1+k_R)s + k_R = a_3s^3 + a_2s^2 + a_1s + a_0$

Sunt impuse condițiile necesare specificate în T<sub>2</sub>:

$$a_3 = 2,5 > 0$$

$$a_2 = 6,25 > 0$$

$$\begin{aligned} a_1 = 1 + k_R > 0 \Rightarrow k_R > -1 \Rightarrow k_R \in (-1; +\infty) \\ a_0 = k_R > 0 \Rightarrow k_R \in (0; +\infty) \end{aligned} \quad \left. \begin{aligned} \Rightarrow k_R \in (0; +\infty) \\ (*) \end{aligned} \right\}$$

$$m=3 \Rightarrow H = \begin{bmatrix} a_2 & a_0 & 0 \\ a_3 & a_1 & 0 \\ 0 & a_2 & a_0 \end{bmatrix} = \begin{bmatrix} 6,25 & k_R & 0 \\ 2,5 & k_R + 1 & 0 \\ 0 & 6,25 & k_R \end{bmatrix}$$

Sunt impuse condițiile de stabilitate:

$$\det(H_1) = 6,25 > 0$$

$$\det(H_2) = 6,25(k_R + 1) - 2,5k_R = 3,75k_R + 6,25 > 0 \Rightarrow k_R > -1,6667 \Rightarrow k_R \in (-1,6667; +\infty) \quad (1)$$

$$\begin{aligned} \det(H_3) = a_0 \det(H_1) = k_R(3,75k_R + 6,25) > 0 \Rightarrow k_R \in (0; +\infty) \cap (-1,6667; +\infty) \\ \Rightarrow k_R \in (0; +\infty) \quad (2) \end{aligned}$$

$$\text{Din } (1) \text{ și } (2) \Rightarrow k_R \in (0; +\infty) \quad (**)$$

$$\text{Din } (*) \text{ și } (**) \Rightarrow k_R \in (0; +\infty)$$

R<sub>2</sub>:  $\Delta(s) = 1 + H_0(s) = 0,1s^3 + 1,25s^2 + (2,6 + 2,5k_R)s + k_R + 1 = a_3s^3 + a_2s^2 + a_1s + a_0$

$$a_3 = 9_1 > 0$$

$$a_2 = 1,25 > 0$$

$$\begin{aligned} a_1 = 2,6 + 2,5k_R > 0 \Rightarrow k_R > -1,04 \Rightarrow k_R \in (-1,04; +\infty) \\ a_0 = \cancel{k_R+1} > 0 \Rightarrow k_R > -1 \Rightarrow k_R \in (-1; +\infty) \end{aligned} \quad \left. \begin{array}{l} \Rightarrow k_R \in (0; +\infty) \cap (-1; +\infty) \cap (-1,04; +\infty) \end{array} \right\} \Rightarrow k_R \in (0; +\infty)$$

$$\Rightarrow \boxed{k_R \in (0; +\infty)} \quad (*)$$

$$m=3 \Rightarrow H = \begin{bmatrix} 1,25 & k_R+1 & 0 \\ 0,1 & 2,5k_R+2,6 & 0 \\ 0 & 1,25 & k_R+1 \end{bmatrix} \Rightarrow \begin{array}{l} \det(H_1) = 1,25 > 0 \\ \det(H_2) = 1,25(2,5k_R+2,6) - 0,1(k_R+1) \end{array}$$

$$\Rightarrow \det(H_2) = 3,125k_R + 3,25 - 0,1k_R - 0,1 = 3,025k_R + 3,15 > 0 \Rightarrow k_R > -1,04 \Rightarrow k_R \in (-1,04; +\infty) \quad (1)$$

$$\det(H_3) = a_0 \det(H_2) = (k_R+1)(3,025k_R + 3,15) > 0 \Rightarrow k_R \in (-1; +\infty) \cap (-1,04; +\infty) \Rightarrow k_R \in (-1; +\infty) \quad (2)$$

$$\text{Din (1) și (2)} \Rightarrow k_R \in (-1; +\infty) \Rightarrow k_R \in (0; +\infty) \cap (-1; +\infty) = \boxed{k_R \in (0; +\infty)} \quad (**)$$

③ Considerând ieșirea  $y(t)$ , acceptând că sistemul este stabil și alegând o valoare a lui  $k_R > 0$ , găsiți valoarea statismului natural  $X_m(y)$ . Acceptând valoile normale  $d_m = 50$  și  $y_m = 100$ , găsiți raportul statisului natural în unități raportate în procente  $\delta_m(y)\%$ .

**R1:** Regulatorul este de tip  $Pi$ , are componentă integratoare  $\Rightarrow$  statisul natural este nul  $\Rightarrow \boxed{\delta_m = 0}$

$$\delta_m(y)\% = \delta_m(y) \cdot \frac{d_m}{y_m} \cdot 100\% \Rightarrow \boxed{\delta_m(y)\% = 0} \quad \left( \text{pe baza relației din L4, pag. 3} \right) \rightarrow \text{relația (28)}$$

**R2:**  $X_m(y) = \frac{y_m}{d_m} \Big|_{k_R=0}$  sau  $X_m(y) = \frac{k_N(y)}{1+k_0}$ ,  $k_0 = k_R \cdot k_{pc}$

luăm  $\boxed{k_R=3}$  și alegem a 2-a opțiune deoarece nu avem valoare

$$f_m(y) = \frac{k_N(y)}{1+k_0} = \frac{0,04}{1+3} \Rightarrow \boxed{f_m(y)=0,01}; \quad f_m(y)' = 0,01 \cdot \frac{50}{100}, 100y = 0,05$$

$$k_N = 20 \cdot 0,002 = 0,04.$$

$$k_0 = k_R \cdot k_{pc}$$

$$k_R = 3$$

$$k_{pc} = 20 \cdot 25 \cdot 0,05 \cdot 20 \cdot 0,002 = 1$$

$$\} \Rightarrow k_0 = 3$$

$$\boxed{f_m(y)' = 0,05} \quad (\text{rel. 28})$$

④ Acceptând că sistemul este stabil și alegând o valoare a lui  $k_R > 0$ , pentru  $d_\infty = 50$  și  $\mathbb{Z}_\infty = 5000$  calculați VRSC  $\{x_\infty, e_\infty, u_\infty, m_\infty, y_\infty\}$

$$\boxed{R_1: RG - PI \Rightarrow \begin{cases} e_\infty = 0 \\ e_\infty = x_\infty - y_\infty \end{cases}} \Rightarrow y_\infty = x_\infty \Rightarrow \boxed{u_\infty = 10}$$

$$y_\infty = 0,002 \cdot \mathbb{Z}_\infty = 10 \Rightarrow \boxed{y_\infty = 10}$$

$$m_\infty = 20u_\infty \Rightarrow \boxed{m_\infty = 160}$$

$$x_\infty = 25m_\infty = 500u_\infty \Rightarrow \boxed{x_\infty = 4000}$$

$$p_{1\infty} = 0,05x_\infty = 25u_\infty \Rightarrow \boxed{p_{1\infty} = 200}$$

$$p_{2\infty} = p_{1\infty} + d_\infty = 25u_\infty + 50 \Rightarrow \boxed{p_{2\infty} = 250}$$

$$\mathbb{Z}_\infty = x_{1\infty} = 20p_{2\infty} = 500u_\infty + 1000 = 5000 \rightarrow 500u_\infty = 4000 \Rightarrow \boxed{u_\infty = 8}$$

$$\boxed{R_2: RG - PAT_1 \Rightarrow e_\infty \neq 0} \quad \begin{cases} e_\infty = x_\infty - y_\infty \\ e_\infty = x_\infty - 10 \end{cases} \Rightarrow e_\infty = x_\infty - 10 \Rightarrow 4 = x_\infty - 10 \Rightarrow \boxed{x_\infty = 14}$$

$$y_\infty = 0,002 \mathbb{Z}_\infty = 10 \Rightarrow \boxed{y_\infty = 10}$$

$$u_\infty = 2e_\infty (k_R = 2) \Rightarrow \boxed{u_\infty = 8}$$

$$m_\infty = 20u_\infty = 40e_\infty \Rightarrow \boxed{m_\infty = 160}$$

$$x_\infty = 25m_\infty = 1000e_\infty \Rightarrow \boxed{x_\infty = 4000}$$

$$p_{1\infty} = 0,05x_\infty = 50e_\infty \Rightarrow \boxed{p_{1\infty} = 200}$$

$$p_{2\infty} = p_{1\infty} + d_\infty = 50e_\infty + 50 \Rightarrow \boxed{p_{2\infty} = 250}$$

$$\mathbb{Z}_\infty = 20p_{2\infty} = 1000e_\infty + 1000 = 5000 \Rightarrow 1000e_\infty = 4000 \Rightarrow \boxed{e_\infty = 4}$$

⑤ Determinați valoile parametrului  $c$  care garantă stabilitatea sistemului liniar în timp discret.

$$R1: H(z) = \frac{3z^2 - 4z + 1}{z^3 - 2z^2 + (c+1,3)z - 0,1}$$

$$\Delta(z) = z^3 - 2z^2 + (c+1,3)z - 0,1 = a_3 z^3 + a_2 z^2 + a_1 z + a_0 \Rightarrow$$

$$\text{cum } m=3 \text{ și } a_3=1>0$$

$$\begin{aligned} a_3 &= 1 \\ a_2 &= -2 \\ a_1 &= c+1,3 \\ a_0 &= -0,1 \end{aligned}$$

Sunt testate primele 3-condiții de stabilitate:

$$\Delta(1) = 1 - 2 + c + 1,3 - 0,1 = c + 0,2 > 0 \Rightarrow c > -0,2 \Rightarrow c \in (-0,2; +\infty) \quad (1)$$

$$\Delta(-1) = -1 - 2 - (c + 1,3) - 0,1 = -3 - c - 1,3 - 0,1 = -c - 4,4 < 0 \text{ (nu este liniștit)} \Rightarrow$$

$$c + 4,4 > 0 \Rightarrow c > -4,4 \Rightarrow c \in (-4,4; +\infty) \quad (2)$$

$$\begin{aligned} a_0 &= -0,1 \Rightarrow |a_0| = 0,1 \\ a_3 &= 1 \end{aligned} \Rightarrow 0,1 < 1 \Rightarrow |a_0| < a_3$$

$$b_0 = \begin{vmatrix} a_0 & a_3 \\ a_3 & a_0 \end{vmatrix} = \begin{vmatrix} -0,1 & 1 \\ 1 & -0,1 \end{vmatrix} = (-0,1)^2 - 1 = -0,99$$

$$b_1 = \begin{vmatrix} a_0 & a_2 \\ a_3 & a_1 \end{vmatrix} = \begin{vmatrix} -0,1 & -2 \\ 1 & c+1,3 \end{vmatrix} = -0,1(c+1,3) + 2 = -0,1c - 0,13 + 2 = 1,87 - 0,1c$$

$$b_2 = \begin{vmatrix} a_0 & a_1 \\ a_3 & a_2 \end{vmatrix} = \begin{vmatrix} -0,1 & c+1,3 \\ 1 & -2 \end{vmatrix} = 0,2 - (c+1,3) = 0,2 - c - 1,3 = -(c+1,1)$$

Linię	$z^0$	$z^1$	$z^2$	$z^3$
1	$-0,1$ $(a_0)$	$c+1,3$ $(a_1)$	$-2$ $(a_2)$	$1$ $(a_3)$
2	$1$ $(a_3)$	$-2$ $(a_2)$	$c+1,3$ $(a_1)$	$-0,1$ $(a_0)$
3	$-0,99$ $(b_0)$	$1,87 - 0,1c$ $(b_1)$	$-(c+1,1)$ $(b_2)$	—
4	$-(c+1,1)$ $(b_2)$	$1,87 - 0,1c$ $(b_1)$	$-0,99$ $(b_0)$	—

$$|b_0| = 0,99$$

$$|b_2| = |-(c+1,1)| = c+1,1 \Rightarrow |b_0| > |b_2| \Rightarrow 0,99 > c+1,1 \Rightarrow c < -0,11$$

$$\text{alpm (1), (2) și (3)} \Rightarrow c \in (-0,2; -0,11)$$

$$R_2: H(z) = \frac{6z^2 - 3z + 0,5}{z^3 + 2z^2 + (c-1,3)z + 0,1}$$

$$\Delta(z) = z^3 + 2z^2 + (c-1,3)z + 0,1 = a_3 z^3 + a_2 z^2 + a_1 z + a_0 \Rightarrow$$

cu  $m=3$  și  $a_3 = 1$

$$\begin{aligned} a_3 &= 1 \\ a_2 &= 2 \\ a_1 &= c-1,3 \\ a_0 &= 0,1 \end{aligned}$$

Sunt testate primele 3. condiții de stabilitate:

$$\Delta(1) = 1 + 2 + c - 1,3 + 0,1 = c + 1,8 > 0 \Rightarrow c > -1,8 \Rightarrow c \in (-1,8; +\infty) | (1)$$

$$\Delta(-1) = -1 + 2 + (c-1,3)(-1) + 0,1 = 1 - c + 1,3 + 0,1 = 2,4 - c < 0 \Rightarrow c > 2,4 \Rightarrow c \in (2,4; +\infty) | (2)$$

$$\begin{aligned} a_0 &= 0,1 \Rightarrow |a_0| = 0,1 \\ a_3 &= 1 \end{aligned} \quad \left. \begin{aligned} |a_0| &< a_3 \Rightarrow 0,1 < 1 \\ &\Rightarrow |a_0| < a_3 \end{aligned} \right. \Rightarrow 0,1 < 1.$$

$$b_0 = \begin{vmatrix} a_0 & a_3 \\ a_3 & a_0 \end{vmatrix} = \begin{vmatrix} 0,1 & 1 \\ 1 & 0,1 \end{vmatrix} = 0,1^2 - 1 = -0,99$$

$$b_1 = \begin{vmatrix} a_0 & a_2 \\ a_3 & a_1 \end{vmatrix} = \begin{vmatrix} 0,1 & 2 \\ 1 & c-1,3 \end{vmatrix} = 0,1(c-1,3) - 2 = 0,1c - 0,13 - 2 = 0,1c - 2,13$$

$$b_2 = \begin{vmatrix} a_0 & a_1 \\ a_3 & a_2 \end{vmatrix} = \begin{vmatrix} 0,1 & c-1,3 \\ 1 & 2 \end{vmatrix} = 0,2 - (c-1,3) = 0,2 - c + 1,3 = -c + 1,5 = -(c-1,5)$$

Linię	$z^0$	$z^1$	$z^2$	$z^3$
1	0,1 ( $a_0$ )	$c-1,3$ ( $a_1$ )	2 ( $a_2$ )	1 ( $a_3$ )
2	1 ( $a_3$ )	2 ( $a_2$ )	$c-1,3$ ( $a_1$ )	0,1 ( $a_0$ )
3	-0,99 ( $b_0$ )	$0,1c-2,13$ ( $b_1$ )	$-(c-1,5)$ ( $b_2$ )	—
4	$-(c-1,5)$ ( $b_2$ )	$0,1c-2,13$ ( $b_1$ )	-0,99 ( $b_0$ )	—

$$\begin{aligned} |b_0| &= 0,99 \\ |b_2| &= |-(c-1,5)| \Rightarrow \\ |b_2| &= c-1,5 \\ \Downarrow |b_0| &> |b_2| \Rightarrow \\ 0,99 &> c-1,5 \Rightarrow \\ c &< 2,49 \Rightarrow \\ c \in (-\infty; 2,49) \end{aligned} | (3)$$

$$\text{Din } (1), (2) \text{ și } (3) \Rightarrow c \in (2,4; 2,49)$$