MRC → URO = RM podľa zhody ?

↑

ZR (RS) ← nie ... nepoznáme... iné ? ...

ADAPT. ZR

- nepriamo..
- priamo...

čo nepoznáme ?

- parametre

priame

↓

klasické MRAC

adapt. odch.

$e = y - y_m$

e → „min"

MIT pravidlo ...

$J(\Theta) = \frac{1}{2} e^2$

$\Downarrow$

$\dot{\Theta} = -\alpha e \left(\frac{\partial e}{\partial \Theta} \right)$

citl. fcn

? stabilita ?

... analytické otázky ...

... analytické otázky ...

! poznáme štruktúru !

Stavový opis x

A Frobeniusov tvar

RS

ZR ← „stavový" p.z. ✓

Θ^*

↑ hľadáme !!!

– čo existuje (for real)

priamo adaptovať ...

$$\dot{x} = Ax + bu$$

$$\dot{x} = Ax + bu + bu^* - bu^*$$

$$\dot{x} = Ax + bu + b\left(k^{*T}x + l^* r\right) - b\left(k^{*T}x + l^* r\right)$$

$$\dot{x} = \underbrace{\left(A + bk^{*T}\right)}_{A_m}x + \underbrace{bl^*}_{b_m} r + b\left(u - k^{*T}x + l^* r\right)$$

$$\dot{x} = A_m x + b_m r + b\left(u - \Theta^{*T}\omega\right)$$

$$e = x - x_m$$

$$\dot{e} = A_m x + \cancel{b_m r} + b\left(u - \Theta^{*T}\omega\right) - A_m x_m - \cancel{b_m r}$$

$$\dot{e} = A_m e + b\left(\Theta^T\omega - \Theta^{*T}\omega\right)$$

$$\boxed{\dot{e} = A_m e + b\Theta^T\omega}$$

⟵⟶ ďalej ukázať ...

$e \to 0$

$e = x - x_m$

$$\tilde{\theta} = \hat{\Theta} - \Theta^*$$

$$\tilde{\theta}(t)$$

$$e \Rightarrow 0$$

$$\begin{cases} \dot{e} = \dots \\ \dot{\tilde{\theta}} = \dots ? \end{cases}$$

$$b = \begin{bmatrix} 0 \\ \vdots \\ 0 \\ b_0 \end{bmatrix} \qquad \operatorname{sign}(b_0)|b_0|\,q \qquad q = \begin{bmatrix} 0 \\ \vdots \\ 0 \\ 1 \end{bmatrix}$$

$$\hat{c} \qquad 1\left(\operatorname{sign}(\hat{c})/|\hat{c}|\right) \qquad b = \begin{bmatrix} 0 \\ 0 \\ \hat{c}\,1 \end{bmatrix}$$

$$\boxed{\operatorname{sign}(\hat{c})|\hat{c}| \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}}$$

$$V = e^T P e + |b_0| \left(\theta^T \Gamma^{-1} \theta\right)$$

$$V \geq 0$$

$$\dot{V} \leq 0 \quad ?$$

$$\dot{V} = ?$$

$$\dot{V} = \dot{e}^T P e + e^T P \dot{e} + |b_0| \left(\dot{\theta}^T \Gamma^{-1} \theta + \theta^T \Gamma^{-1} \dot{\theta}\right)$$

$$\theta^T \Gamma^{-1^T} \dot{\theta}^{T^T}$$

$$\theta^T \Gamma^{-1} \dot{\theta}$$

$$\left(2\, \theta^T \Gamma^{-1} \dot{\theta} \right)$$

$$\left(A_m^T P + P A_m\right) = -Q$$

$$\dot{V} = \underline{\left(e^T A_m^T + \omega^T \theta^T b^T\right) P e + e^T P \left(A_m e + b \theta^T \omega\right)} + |b_0|\, 2 \theta^T \Gamma^{-1} \dot{\theta}$$

$$\dot{V} = \underline{e^T A_m^T P e} + \omega^T \theta^T b^T P e + \underline{e^T P A_m e} + e^T P b \theta^T \omega + (\dots)$$

$$= e^T \left(A_m P + P A_m\right) e \qquad e^T P b^T \theta^T \omega^T$$

$$+ 2\left(e^T P b\, \theta^T \omega\right) \qquad + (\dots)$$

$$\dot{V} = e^T (-Q) e + \underbrace{2\left(e^T P b\right) \theta^T \omega + |b_0| 2 \theta^T \Gamma^{-1} \dot{\theta}}_{\stackrel{!}{=} 0}$$

$$2\left(e^T P b\right) \theta^T \omega + |b_0| 2 \theta^T \Gamma^{-1} \dot{\theta} \stackrel{!}{=} 0$$

$$\cancel{|b_0|}\, \cancel{2}\, \cancel{\theta^T} \Gamma^{-1} \dot{\theta} = -2\left(e^T P b\right) \theta^T \omega$$

$$\cancel{|b_0|}\,\cancel{2}\,\tilde{\theta}^T\Gamma^{-1}\dot{\tilde{\theta}} = -2(e^TPb)\tilde{\theta}^T\omega$$

$$= -\cancel{2}(e^TP)\left\{\cancel{|b_0|}\,\mathrm{sign}(b_0)\,q\right\}\cancel{\tilde{\theta}^T}\omega$$

$$\Gamma^{-1}\dot{\tilde{\theta}} = -\mathrm{sign}(b_0)(e^TPq)\,\omega$$

$$\dot{\tilde{\theta}} = -\mathrm{sign}(b_0)(e^TPq)\,\Gamma\omega$$

$$\dot{\Theta} = -\mathrm{sign}(b_0)\,\Gamma(e^TPq)\,\omega$$

$$\tilde{\theta} = \Theta - \Theta^*$$

$$\dot{\tilde{\theta}} = \dot{\Theta} - 0$$

$$\boxed{\dot{V} \le 0}$$

$$\boxed{e \to 0 \qquad e = x - x_m}$$

$\tilde{\theta} \overset{?}{\to} 0$ nie $\dot{V}$ neobsahuje $\tilde{\theta}$

Čo ak nemáme x? $u = k^T x + l r$

všeob. MRC problém...

$$u = \Theta_1^T\left[\frac{\alpha(s)}{\Lambda(s)}\right]u + \Theta_2^T\left[\frac{\alpha(s)}{\Lambda(s)}\right]y + \Theta_3 y + \Theta_4 r$$

$\Theta^* \Leftarrow$ chceme...

naozaj? podm. z.?

$n = 2$

$\frac{y}{u} = k_p \frac{Z_p}{R_p}$

$y_m = k_m Z_m$

$$\boxed{u = \Theta_1 \frac{1}{\Lambda} u + \Theta_2 \frac{1}{\Lambda} y + \Theta_3 y + \Theta_4 r}$$

$$\frac{y_m}{r} = \frac{k_m Z_m}{R_m}$$

$u \to RS \to URO = RM$

$u = ?$

$$u - \Theta_1 \frac{1}{\Lambda} u = \frac{\Theta_2 + \Theta_3 \Lambda}{\cancel{\Lambda}} y + \frac{\Theta_4 \Lambda}{\cancel{\Lambda}} r$$

$$\frac{\Lambda - \Theta_1}{\cancel{\Lambda}} u =$$

$$\boxed{u = \frac{\Theta_2 + \Theta_3 \Lambda}{\Lambda - \Theta_1} y + \frac{\Theta_4 \Lambda}{\Lambda - \Theta_1} r}$$

$$y = \frac{k_p Z_p}{R_p}\left(\frac{\Theta_2 + \Theta_3 \Lambda}{\Lambda - \Theta_1} y + \frac{\Theta_4 \Lambda}{\Lambda - \Theta_1} r\right)$$

$$y = \frac{k_p Z_p (\Theta_2 + \Theta_3 \Lambda)}{R_p(\Lambda - \Theta_1)} y + \frac{\Theta_4 \Lambda k_p Z_p}{R_p(\Lambda - \Theta_1)} r$$

$\frac{y}{r} = ?$

$$\frac{R_p(\Lambda - \Theta_1) - k_p Z_p(\Theta_2 + \Theta_3 \Lambda)}{\cancel{R_p(\Lambda - \Theta_1)}} y = \frac{\Theta_4 \Lambda k_p Z_p}{\cancel{R_p(\Lambda - \Theta_1)}} r$$

$$\frac{y}{r} = \frac{\Theta_4 \Lambda k_p Z_p}{\underbrace{R_p(\Lambda - \Theta_1) - k_p Z_p(\Theta_2 + \Theta_3 \Lambda)}_{D_Z(s)}}$$

$$\frac{y_m}{r} = \frac{k_m Z_m}{R_m}$$

$$\Theta_4^* = \frac{k_m}{k_p}$$

r R_m k_p

$\Lambda = Z_m \Lambda_0$

$D\dot{z} = Z_p R_m$

$\dot{\Theta} = \ldots\ldots\ (e^T P q)$

???22

~~$e = x - x_m$~~

SPR

MKY

n^*

$\boxed{e_1 = y - y_m} \Leftarrow e_1 = W_m \frac{1}{\theta_4^*} \theta^T \omega$

$\dot{\Theta} = -\mathrm{sign}(\theta_4^*) \Gamma e_1 \omega$

kreslenie schém...

$n^* = 2$

$\frac{y}{u} = k_p \frac{Z_p}{R_p}$

$\frac{y_m}{r} = W_m(s)$

$u = \Theta^T \omega$

$\omega = \begin{bmatrix} \nu_1 \\ \nu_2 \\ y \end{bmatrix}$

$\nu_1 = \left[\frac{\alpha(s)}{\Lambda(s)}\right] u$

2

$\dot{\nu}_1 = \Lambda \nu_1 + q u$

$\dot{\nu}_2 = \Lambda \nu_2 + q y$

$$\dot{\Theta} = -\mathrm{sign}(\Theta_4^*)\Gamma e_1 \omega_f \qquad \omega_f = \left[\frac{1}{L}\right]\omega$$

$$e_1 = y - y_m - W_m L \underbrace{\left(u_f - \bar{\Theta}\omega_f\right)}_{\mathrm{sign}(\Theta_4^*)} \qquad L \Rightarrow W_m L \text{ je SPR}$$

$$u_f = \left[\frac{1}{L}\right]u$$

SPR ? $\boxed{G(s) = \frac{2s+1}{(3s+1)(s+1)}}$

1.) real pre real s

2.) póly stabil ? $3\left(s+\frac{1}{3}\right)(s+1)$ $\quad s_1 = -\frac{1}{3}$, $s_2 = -1$

3.) $\mathrm{Re}\{G(j\omega)\} \geq 0 \quad \forall \quad \omega \in \mathbb{R}$

$$\frac{2j\omega+1}{(3j\omega+1)(j\omega+1)} \cdot \frac{(1-3\omega^2) - j(4\omega)}{(1-3\omega^2) - j(4\omega)}$$

$$-3\omega^2 + 3j\omega + j\omega + 1$$

$$(1-3\omega^2) + j(4\omega)$$

$$\frac{2\omega j(1-3\omega^2) \underbrace{+ 2\omega 4\omega + (1-3\omega^2)}_{8\omega^2} - j4\omega}{(1-3\omega^2)^2 + (4\omega)^2}$$

$$\mathrm{Re}\{G(j\omega)\} = \frac{1+5\omega^2}{\text{kladné}} \geq 0$$