

**Miklós Kuczmann: Project Based Teaching of System Modelling and Control**



# • Visegrad Fund

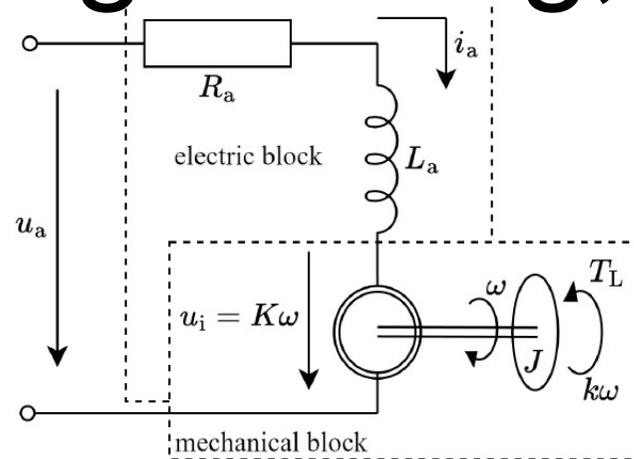
**PAEPEDE: Pathways to Excellence in Power Electronics and Electrical Drives Education**

ID# 22420041

The project is co-financed by the Governments of Czechia, Hungary, Poland and Slovakia through Visegrad Grants from International Visegrad Fund. The mission of the fund is to advance ideas for sustainable regional cooperation in Central Europe.



# Control Engineering, BSc



$$\frac{d}{dt} \begin{bmatrix} i_a \\ \omega \end{bmatrix} = \begin{bmatrix} -\frac{R_a}{L_a} & -\frac{K}{L_a} \\ \frac{K}{J} & -\frac{k}{J} \end{bmatrix} \begin{bmatrix} i_a \\ \omega \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u_a + \begin{bmatrix} 0 \\ -1 \end{bmatrix} T_L$$

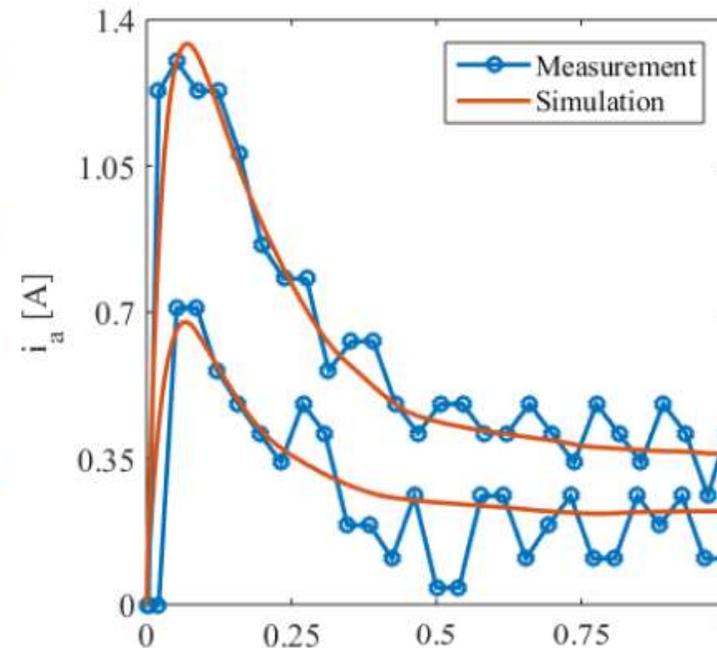
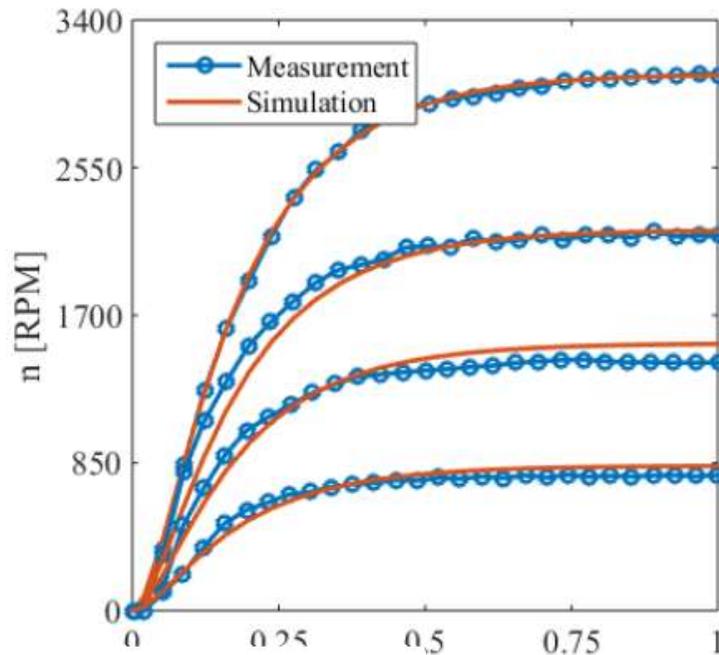
$$y = [0 \quad 1] \begin{bmatrix} i_a \\ \omega \end{bmatrix} + 0u_a.$$

$$W_{\Omega} = \frac{\Omega}{U_a} = \frac{K}{s^2 J L_a + s J R_a + K^2}$$

$$W_{I_a} = \frac{I_a}{U_a} = \frac{s J}{s^2 J L_a + s J R_a + K^2}$$

<https://www.mdpi.com/2079-9292/13/11/2225>

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OF KOŠICE

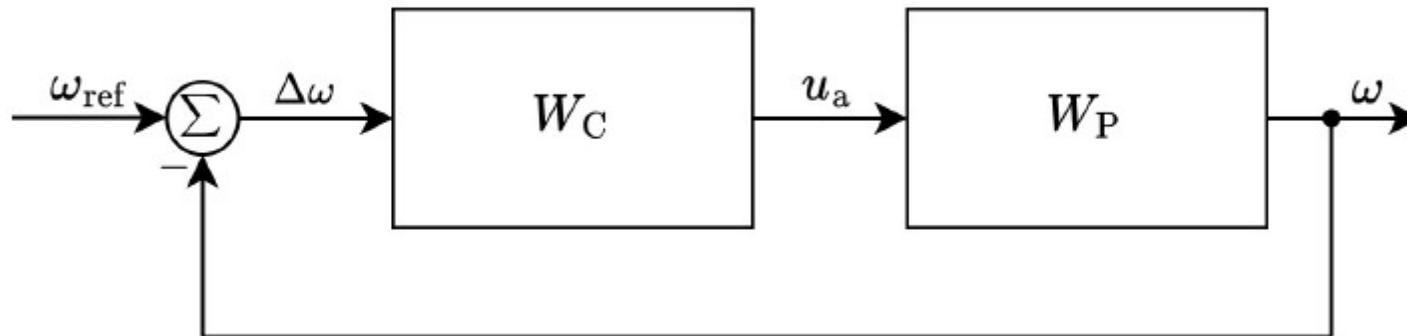


Wrocław University  
of Science and Technology



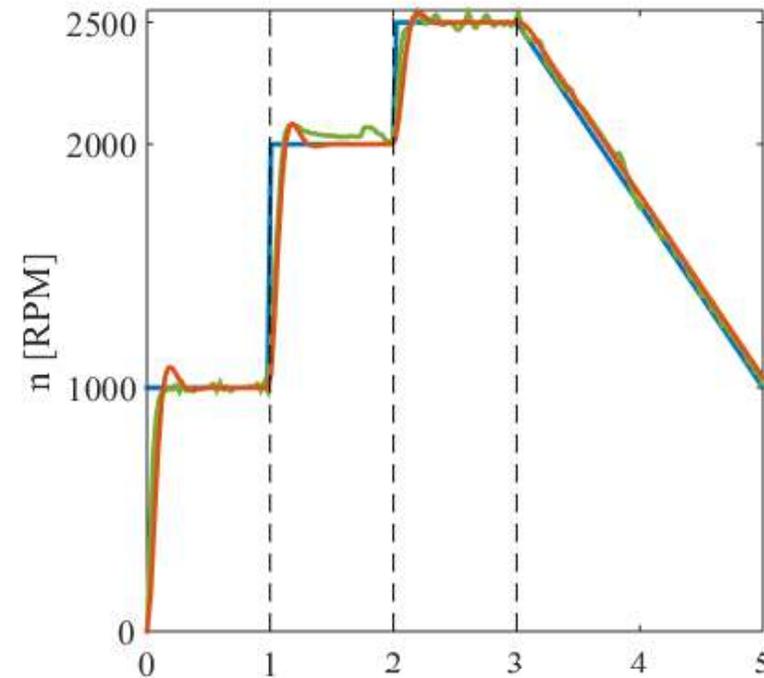
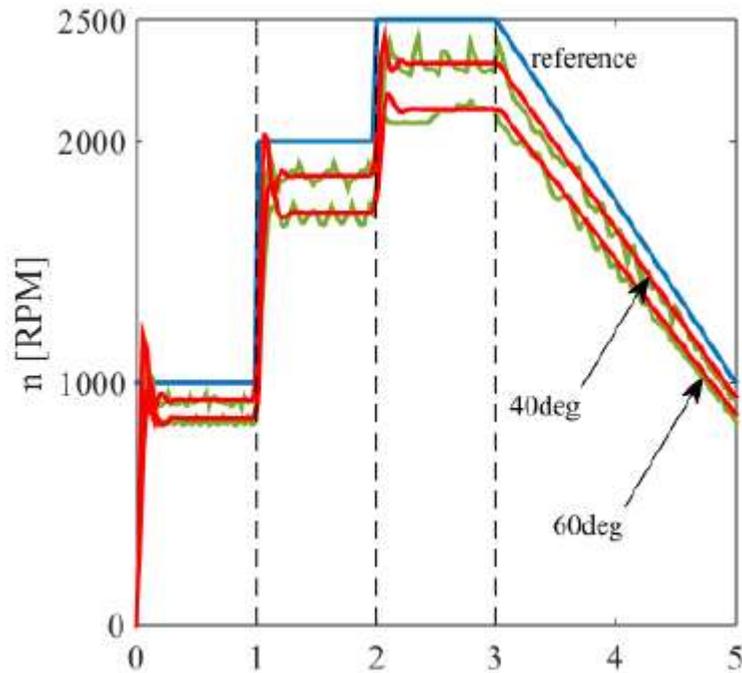
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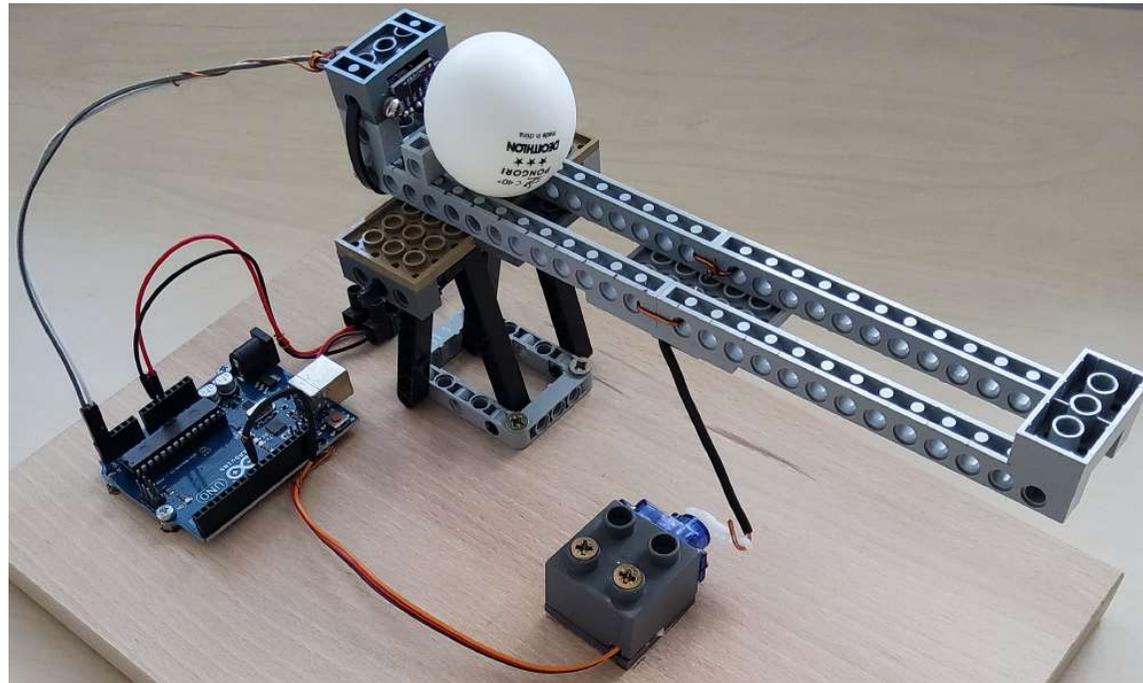


- Modeling by state space model and transfer function
- Identification by Matlab
- PID controller design by phase margin method and Bode plot
- State space controller design by pole placement in discrete time
- Test using Arduino UNO

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$$\dot{\mathbf{x}} = \mathbf{f}(\mathbf{x}, u) = \begin{bmatrix} f_1(\mathbf{x}, u) \\ f_2(\mathbf{x}, u) \\ f_3(\mathbf{x}, u) \\ f_4(\mathbf{x}, u) \end{bmatrix} = \begin{bmatrix} x_2 \\ \frac{mx_1x_4^2 - mg \sin x_3}{m + \frac{\Theta_b}{R^2}} \\ x_4 \\ \frac{-2mx_1x_2x_4 - (mx_1 + M\frac{L}{2})g \cos x_3}{\Theta_r + mx_1^2} + \frac{1}{\Theta_r + mx_1^2} T_{\text{motor}} \end{bmatrix}$$

$$\begin{bmatrix} \dot{\tilde{x}}_1 \\ \dot{\tilde{x}}_2 \\ \dot{\tilde{x}}_3 \\ \dot{\tilde{x}}_4 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & -\frac{mg}{m + \frac{\Theta_b}{R^2}} & 0 \\ 0 & 0 & 0 & 1 \\ -\frac{mg}{\Theta_r + m\tilde{r}^2} & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \tilde{x}_1 \\ \tilde{x}_2 \\ \tilde{x}_3 \\ \tilde{x}_4 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} \tilde{T}_{\text{motor}}$$

$$\begin{bmatrix} \dot{\tilde{x}}_1 \\ \dot{\tilde{x}}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \tilde{x}_1 \\ \tilde{x}_2 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{-mg}{m + \frac{\Theta_b}{R^2}} \end{bmatrix} \tilde{\alpha}$$

$$W_P = \frac{\mathcal{L}\{r\}}{\mathcal{L}\{\vartheta\}} = -\frac{a}{s^2}$$

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