RAPID PROTOTYPING OF ENERGY-EFFICIENT DRIVING SYSTEMS

Topic: **Design of discrete control system with a DC motor.**
Motor shaft position control.

Plant (contained in the file: model_silnik_dykretny_lock.slx) - DC brush motor working under the appropriate load.

Aim of the project - design and prototyping of the motor shaft position control system.

- Control signal range: -2÷2 [V],
- Output signal range: -180÷180 [^{O}],
- Sampling period: 0.01.

Instruction:

1. Recalculate output of the plant *y* to obtain the motor shaft position in radians [rad].
2. Obtain a static characteristic *y=f(u)* of the given plant if it is possible. If it isn't, explain why.
3. Perform an open-loop step response of the given plant using as a step value a 50% of control signal value. On this basis, analyze the dynamic properties of the control object (determine the type, order of the system).
4. Identify the model of the plant using analytical methods (eg the two-point method: Appendix A or instruction for exercise 4) or computer-aided identification methods - toolbox IDENT.
5. Based on the step response, propose the type of PID controller (P, PI, PD, PID) suitable for the object under consideration (two suggestions are required). In the designed control system, pay attention to the steady-state error and the dynamics of the closed system.
6. Determine the values of the discrete controller parameters using the <u>QDR method</u> (Appendix A).

   <u>TIP</u>: Use at least two step responses for averaging the controller parameters calculations. Use step time response for lower and higher range value of control signal but not minimum and maximum values (e.g. 30% and 70%).
7. In Simulink create control system with previously designed controller using the given plant.
8. Perform simulations to check the control system for a couple of step responses.
9. Check whether it is possible to improve the quality of control by changing the controller settings. To do this, prototype the system for the following forcing signals:
   - For the assumed operating point, enter the square wave as the set value. Select such a period of the square wave that it is possible to change the value of the controller parameters in the low and high

states. Observe the results of the program operation for different values of the controller parameters. Plan meaningful experiments to show the effect of controller settings on the operation of the control system.

- Then change the set value to sine wave. Select the controller settings in such a way as to obtain the best possible following the set value. Test the operation of the control system with selected controller parameters for different sine wave frequencies.
- Using the *Chirp Signal block* in Simulink, set a sinusoidal input with a frequency varying over time. Perform several simulations for different gain values of the controller and record the waveforms. What can be said about the tracking indicator. On the basis of the recorded signal try to recreate the Bode characteristics of a closed loop system.

10. Repeat the tuning of the controller using computer aided design of control systems - use the following application (SisoTool).
11. Based on the tests performed, select the optimal controller settings.
12. Implement the controller using the *S-function* (instruction for exercise 6). Implement the discrete controller in the form of a difference equation (instruction for exercise 5) using:
    - incremental algorithm,
    - positional algorithm and rectangular integration by the backward difference method.