Embedded Control Laboratory

Exercise 2 - Modeling and Simulation of the BoiP system with Closed-Loop control in Xcos

Building systems and subsystems with Xcos is done by creating a new model window and adding function blocks and connecting them with their inputs and outputs. For building the BoiP subsystem use the following subsets from the Pallet-Browser:

- Math operations [Mathematische Operationen]
- Time continuous systems [Zeitkontinuierliche Systeme]
- For scopes and constants see library Sinks [Senken] and Sources [Quellen]
- Do not use blocks that directly run scilab code

If you want to change the language to English in Scilab, use the following command:
setdefaultlanguage('en_US')
Or to German:
setdefaultlanguage('de_DE')
And then restart the whole program.
Xcos can be started by entering "xcos" in the Scilab Console.

After creating the subsystem for the controlled system (BoiP), add a continuous PID controller and a constant box for the reference value (position). The resulting window should be similar to Figure 1.

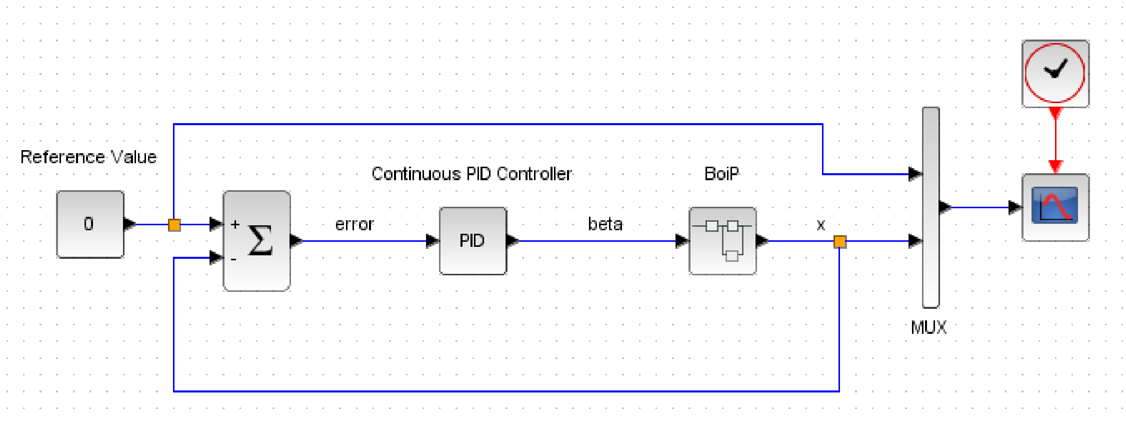

Figure 1: Closed loop control

The control variable is the angle β which is also the input to the BoiP block. The ball position x is the output of the BoiP block. This signal is fed back and used for calculating the error. For building your BoiP subsystem use the SUPER_F block from the Port & Subsystems [Benutzerdefinierte Funktionen] group. Normalize the position signal to the value range of ±1.0 (outer position on each side of the plane).

To-Do list for Exercise 2:

1.) Create a Xcos model and consider the following points and questions
- Build a subsystem for the ball on inclined plane model (BoiP) with **Xcos blocks**. Find the position x as the output from angle β as the input (Refer to Exercise 1).
- Create a closed oop according to Figure 1.
- Simulate the closed-loop control:
  - With start position 1.0 and reference value 0.0 (midpoint of the plane).
  - With start position -1.0 and reference value 0.0 (midpoint of the plane).
- Tune the parameters in the PID block. Start with P=0.7, I=0.2 and D=0.4. Indications of a good tuning result include:
  - Short rising time
  - Small or no overshoot
  - Short settling time
  - No steady-state error of the system response.

2.) Replace the continuous PID block with a discrete **PID** block using state variables. To implement the discrete PID controller
- Use DLR blocks in “Discrete time systems” [Zeitdiskrete Systeme] to form transfer functions in Z-domain.
- Use a “Sampling and hold” block to sample your signals at specified time stamps.
- A simple low-pass filter can be used to reduce the noise of the derivative term.

3.) Questions:
- What are the expected responses of the controlled system when P-, I-, and D-controllers are individually tuned?
- Why is it important to limit the input signal (angle β) to the controlled system? How can it be done? What should be the limitation?
- Why and where do you use limited integrals in the controlled system? What are the limits?
- Add a jumping reference for the system that randomly picks a new reference value from [0.3; 0.5; 0.7] and [-0.3; -0.5; -0.7] every 10s alternatively. An example may be [0.3; -0.5; 0.7; -0.3; 0.5; -0.3; ……]. Plot the desired ball positions and the actual ball positions for 10 jumps. What time period makes sense for the simulation interval? Can the system keep up? Why and why not?

Submission files:

- The report should contain the following with detailed explanations:
  - Implemented Xcos model
  - Continuous and discrete PID equations (Indicate which discretization methods were used)
  - Result plots
  - Answers to the questions

- The zipped file for submission should include the below mentioned files:
  - Report in pdf
  - Working Xcos file for the closed-loop with a continuous PID controller
  - Working Xcos file for the closed-loop with a discrete PID controller
  - Working Xcos file for the closed-loop with a jumping reference (either with a continuous or discrete PID controller)

- The zipped file should be named as follows:
  group<your group ID>_lab<number>.zip/rar
  (e.g. group1_lab1.zip).

  and be sent by E-mail before the deadline to: **ec_lab@eti.uni-siegen.de**

- Please use the file "Lab report cover sheet example" as cover sheet for your report

- The file "Guideline for the lap report" summarizes some important information that may help you prepare a good lab report