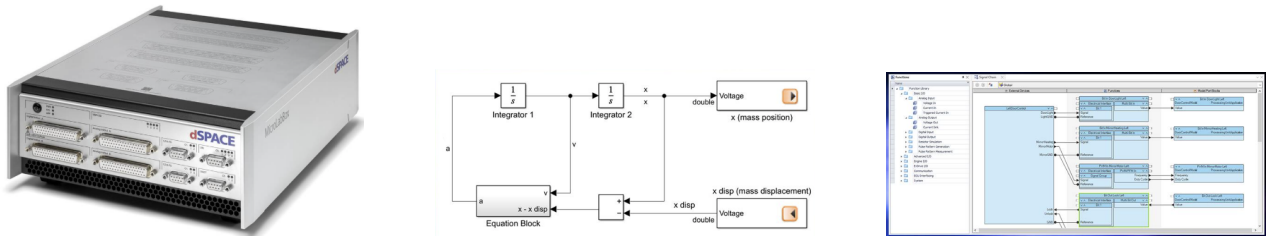
Student research project
Real-time implementation of control algorithms

Improving the control strategies of electric drives utilizing optimal control techniques is a major challenge in academia and industry. In general, new control methods are first developed within a simulation environment as MATLAB/ Simulink or Python. However, to finally evaluate and show the benefit of the proposed method, real-world experiments at the test bench are necessary, which requires the implementation of the control algorithm on hardware. Therefore, rapid control prototyping (RCP) systems are used, e.g., the MicroLabBoxII from dSPACE which can be seen on the left side in Fig. 1. Moreover, the Simulink model has to be adapted in a way to send and receive signals from the MicroLabBoxII, that is indicated in the center of the figure. The link of the outputs from the Simulink model with the MicroLabBoxII is done with the software ConfigurationDesk, which is shown on the right side.
The MicroLabBoxII contains a central processing unit (CPU) and a field programmable gate array (FPGA), which allows fast processing of the signals, due to the parallel routing inside the FPGA. This means, that as most as possible standard control blocks must be implemented in the FPGA to achieve low timing rates.



(a) MicroLabBoxII (b) Simulink model (c) ConfigurationDesk

Figure 1: dSPACE products for the control implementation [1].

In this project, standard control algorithm blocks for electric drives should be developed and used for the design of an exemplary control algorithm. In addition, the overall goal is to develop an IAS firmware for all the MicroLabBoxII systems at the IAS chair, which will be hosted on GitHub. Thus, the first steps should be done during this project.

Necessary requirements:

- Finished course work on electrical machine and power electronic fundamentals
- Experience with MATLAB/ Simulink
- Fundamental knowledge of control engineering
- Interest on real-time implementations

WP 1: Literature research **[2 weeks]**
Scanning the scientific literature for relevant publications and application notes related to the RCP system is the first step. Also, getting familiar with the MicroLabBoxII is part of this WP. Relevant work will be stored in a literature review software (e.g., JabRef) and summarized in the final report.

WP 2: Development of individual blocks **[4 weeks]**
In this WP, the individual blocks which are necessary for typical control structures, i.e., a pulse with modulator (PWM) or a proportional integral (PI) controller, should be developed.

WP 3: Setup GitHub repository **[2 weeks]**
All MicroLabBoxII systems should have access to the same firmware. In addition, version control is crucial and, therefore, it should be maintained on GitHub. Hence, a repository must be created and the new standard control blocks must be included.

WP 4: Design control algorithm **[4 weeks]**
In this WP an exemplary control algorithm should be developed and evaluated with regard to the FPGA's utilization and the timing.

WP 5: Documentation **[3 weeks]**
All work packages should be reported in a structured way within the thesis. A LaTeX template should be used for this purpose: `https://github.com/IAS-Uni-Siegen/thesis_latex_template`.

Gantt chart

The planned timetable is shown in the Gantt diagram below.

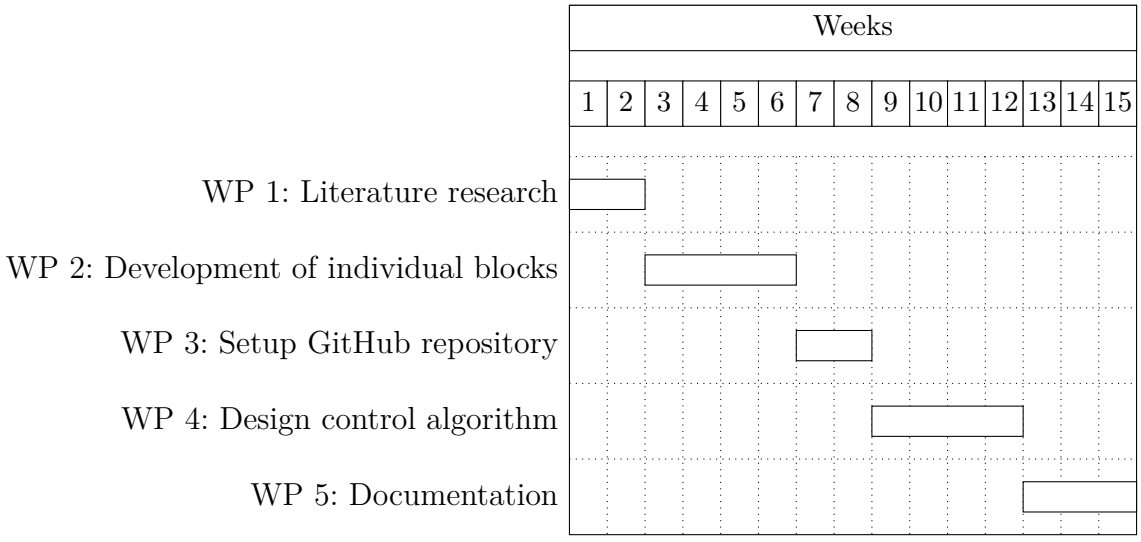


Figure 2: Gantt chart for the thesis.

References

[1] dSPACE, *MicroLabBox II*, Apr. 2025.