Simulation and Control

1	Module Number	Study Programme	Semester	Offered in	Duration	Module Type	Workload (h)	ECTS Points
	3903	ASM	1	☒WS ☐SS	1 Semester	compulsory	240	8

2	Courses	Teaching and Learning Forms	Contact Time (SWS)	Contact Time (h)	Self-Study Time (h)	Language
	a) Microcontroller, Modelling and Simulation	Lecture + Lab	2+1	45 30	120	Englisch
	b) Basic Control	Lecture	2	45		
	c) Advanced Control	Lecture	3	[1 SWS = 15h]		

3 **Learning Outcomes and Competences**

Once the module has been successfully completed, the students can...

Knowledge and Understanding

- ... understand and know the basic methods of modelling, system simulation and control engineering
- … know how and where to use these methods in the development of automotive systems
- … build up basic control loops using a small Microcontroller (e.g. Arduino)

Use, Application and Generation of Knowledge

Use and Transfer

- ... apply physical laws to derive mathematical system models in different domains (mechanical, electrical, thermal)
- ... apply methods of system simulation and control engineering in automotive applications
- ... analyse and evaluate the behaviour of automotive systems and subsystems by use of simulation results
- … develop small circuits with sensors and actuators and develop programs for Microcontroller, build up, test and calibrate control functions

Scientific Innovation

- … use simulation and control engineering methods and tools to gain new insights into automotive systems or subsystems.
- ... create and optimize the behaviour of automotive systems based on system models
- … get acquainted with practical realization of the simulated problem in a microcontroller environment

Communication und Cooperation

- ... create, communicate and discuss technical information’s in the area of the course subject
- ... communicate actively within an organization and obtain information.

Scientific Self-Conception/ Professionalism

- ... justify the solution theoretically and methodically to improve development methods.
- ... reflect and assess one's own abilities in a group comparison.

4 **Contents**

1. Microcontroller, Modelling and Simulation (2h)

- Systematic System Modelling and Identification in different domains (mechanical, electrical, thermal)
- Adding sensors and actuators to the modelled system to get the complete transfer function
- Integration of Control loops to manage system control and dynamics

- Linearization of sensors / actuators or models (practical example)
- Do Simulations using Simulink and Simscape and evaluate results
- Build up small control system examples in Hardware and transfer control algorithm to a Real-Time Environment and do AutoCoding (Simulink to Arduino)
- Compare pure Simulink/Simscape Simulation with the System realized in Hardware with Microcontroller

BasicControl (2h)

System Representation of SISO Systems (e.g. LDE, Transfer functions, Block diagrams)

- Basic principles of open loop and closed loop feedback control

	• Elements of control loops • Linearization of nonlinear differential equations • Laplacetransformation (Definition,rules,examples) • Basic Controllers (PID) • Bode diagramm • Stability, Nyquist criteria, amplitude margin, phase edge • Root locus **2. Advanced Control I** (3h) • Linear and non-linear State Space Representation • State Space Controller Design (Pole Placement) • Observer Design and Separation Theorem • Digital Control / Discrete State Space Design • LQR-Controller Design • Diskretisierung, Matrix Exponentionalfunktion • **3. Computer Lab (1h)** • System Representations using Matlab/Simulink, Numerical Simulation • Modelling/Identification and Controller Design of an Electric Drive System • Controller Design of an Electric Drive System • System Modelling and Simulation of State Machines → System Design
5	**Participation Requirements** compulsory: Mathematics, Physics, Mechanics , Control Engineering Basics recommended: Basics in Matlab/Simulink
6	**Examination Forms and Prerequisites for Awarding ECTS Points** Written Examination, 120 minutes
7	**Further Use of Module** Autonomous Systems, Propulsion Systems, Team project, Master Thesis
8	**Module Manager and Full-Time Lecturer** Prof. Dr.-Ing. Walter Lindermeir , Prof. Mathias Oberhauser, Prof. Georg Mallebrein
9	**Literature** • Lecture Notes and Scripts • Ogata, K.: Modern Control Engineering, Pearson Verlag • Liu, Xiangjie: Systems Control Theory, Science Press Beijing • Palm, W. J.: MATLAB for Engineering Applications, McGraw-Hill • Hanselman D.C., Littlefield B.: Mastering Matlab, Pearson Verlag • Dabney, J.B.; Harman, T.L.: Mastering Simulink • Mohthari: Engineering Applications in Process Control, Fuzzy Control
10	**Last Updated** 18.10.2022