Electrical Engineering and Embedded Systems

Master of Engineering

Module Manual

Study and examination regulations (PO) 12

Valid from: SoSe25

Content Modules

Master studies

Program Objectives

The consecutive Master's program of Electrical Engineering and Embedded Systems comprises three semesters and has been designed especially for graduates of Electrical Engineering and Computer Science programs having at least a Bachelor degree.

The program teaches specialised knowledge, and methods for familiarising with complex contexts and for systematic problem solving, and the development of social skills required for productive teamwork. The requirements for engineers in the Electrical Engineering and Embedded Systems fields are very diverse. The program aims to convey the subject-specific technical skills in the required breadth and depth, and it teaches key qualifications such as language skills, knowledge of project management, and communication skills and time management.

The program graduates are well prepared for working in research, industry, and public service.

Connection of the modules

The consecutive Master’s program of Electrical Engineering and Embedded Systems in the 1st semester teaches the required subject-specific and methodical mathematical fundamentals. The Mathematics modules place special emphasis on a well-founded and broad-based basic education in mathematics beyond the Bachelor's level.

The program then offers two course specializations from the 1st to the 2nd semester: System-On-Chip Design & Operation and Sensor Data Processing, which are supported by common subjects and conveyed through selected special subjects, providing a deep insight into the respective fields.

Common modules Embedded Computing, Signal Processing, Communication, and Advanced Control Systems provide the foundation for the two course specializations. Additional individual focus is provided by an elective module, or alternatively, by a research project work in one of the university’s laboratories.

The acquisition of key competences such as teamwork, self-organisation and project management, is promoted through team-based Embedded Computing Project and Embedded Control Seminar.

The Master's thesis in the 3rd semester is built upon these foundations and specializations.

Implementation of RWU mission statement

The consecutive Master's program of Electrical Engineering and Embedded Systems closely reflects RWU mission statements. The program is connected to local industries, fostering possibilities like internships and thesis work, which are often career primers. The program is in step with actual practice, tailored to the needs of the job market, and also reflects current research in related fields. This makes graduates highly sought-after.

Teaching is conducted in small groups, in a familiar manner. Most of the courses are taught in presence, complemented by digital formats. From its foundation, the program was built as an international study program, with the inherent goal of bonding together different cultures. This effort can be particularly observed through the Embedded Computing Project, an engineering project to be conducted in international teams, and the Embedded Control Seminar, a team-based research effort. To further foster integration of different cultures, a broad range of language courses is offered.

The program emphasizes respectful and appreciative interaction between teachers and students. Direct approach of professors is always possible. Students are encouraged to positively influence the future of the program through participation in the study committee.

SEM.	MODULE OVERVIEW						ECTS
1	Embedded Computing 1 5	Communication 1 (Nearfield Communication) 5	Signal Processing 1 (Sensor and Actuator Signals) 5	Profile Module: System-On-Chip Modeling & Design or Computer Vision 5	Applied Mathematics 5	Numerical Methods 5	**30**
2	Embedded Computing 2 4	Communication 2 (Wireless Communication) 5	Elective Module or Research Project 5	Profile Module: System-On-Chip Operation & Test or Lidar and Radar Systems 5	Profile Module: Computer Architecture or Signal Processing 2 (Digital Filters) 5	Advanced Control Systems 6	**30**
3	Embedded Control 5	Master-Thesis incl. Colloquium 25					**30**

■ Lecture subjects ■ Thesis

Advanced Control Systems

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM03
Modul title:	Advanced Control Systems
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Language of lecture:	english
Typ of module:	Mandatory module
Module Content:	Attendees are first given an introduction to analysis and modeling of dynamic systems - electrical, mechanical, and thermal. Then, design and optimization of single and multiple stage digital PID control is presented, as well as single-input and multi-input state control - without and with observer, optimal control, and model-predictive control. Finally, adaptive control methods are illustrated; based upon recursive parameter estimation, and neural nets. Within the complementary lab, attendees are educated to choose and implement suitable digital control methods for given dynamic systems - like mixer tank setup and balanced beam setup - utilizing computer-based tools like MATLAB/Simulink; as C programmed algorithms.
Courses:	Advanced Control Systems Advanced Control Systems Lab
Teaching and learning forms:	Lecture; Lab - or - E-Learning: Lessons, Exercises; Homework: Practical work
Prerequisites for participation:	Applied Mathematics Numerical Methods
Applicability of the module:	Embedded Control, Simulation of Mechatronic Systems, Integration of Mechatronic Systems, Robotics, Research Project, Master Thesis
Prerequisites allocation ECTS:	K90: Written examination; 90 minutes
ECTS credits:	6
Grading:	graded - Lab attendance documented by not graded lab report is required for admission to exam
Workload:	Presence: 72h, Self-study: 108h - or - Online: 48h, Self-study: 108h, Homework: 24h
Duration of the module:	one semester
Frequency of offering:	Summer semester only

Literature:	Script - or - lessons, exercises, and sample solutions; and complementary: Burns, R.S., Advanced Control Engineering, Butterworth-Heinemann Macia, N. F., Thaler, G. J.: Modeling and Control of Dynamic Systems, Cengage Learning Moudgalya, K. M.: Digital Control, Wiley Press, W. H., Teukolsky, S. A., Numerical Recipes in C, Cambridge
Compulsory attendance:	no

Competence dimensions Advanced Control Systems

Knowledge and understanding: Deepening of individual components of knowledge

Attendees learned about models of dynamic systems - electrical, mechanical, and thermal - and both classical control methods, like digital PID control, and advanced control methods, like state control without/with observer, model-predictive control, and adaptive control.

Use, application and generation of knowledge/art: Scientific innovation

Attendees learned to characterize, model, and simulate dynamic systems - electrical, mechanical, and thermal - and choose and implement suitable digital control methods, from both established methods, like digital PID control, and advanced methods, like state control without/with observer, optimal control, model-predictive control, and adaptive control. Attendees learned to assess these digital control methods, regarding effort, safety, and cost-effectiveness; and how to implement these, utilizing computer-based tools like MATLAB/Simulink; as C programmed algorithms. Through the complementary lab, attendees learned to choose and implement suitable digital control methods for given dynamical systems; like mixer tank setup and balanced beam setup.

Communication and cooperation

Attendees learned about presenting and applying advanced digital control methods as a systems science; aimed at interdisciplinary projects; operated within a team of scientists, engineers, designers, and economists.

Scientific / artistic self-image and professionalism

Attendees learned about economical and ecological considerations in choosing, implementing, and optimizing advanced digital control methods for industrial processes.

Embedded Control

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM04
Modul title:	Embedded Control
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Language of lecture:	english
Typ of module:	Mandatory module
Module Content:	Attendees are first given an overview of recent research in control engineering, applicable for industrial process embedded control, like optimal control, nonlinear robust control, data driven control, application of Kalman filter, and machine learning control. Then attendees group in teams, and each team selects one method for working upon. Each team collaborates in researching literature, working out implementation, visualization, and operation of selected process model and embedded control algorithm, within the lab, either through simulation or embedded design; and prepares a seminar paper and seminar presentation. This seminar presentation is then given by all members of a team consecutively, to the audience of all attendees.
Courses:	Embedded Control Seminar Embedded Control Lab
Teaching and learning forms:	Seminar; Lab - or - E-Learning: Seminar; Homework: Practical work
Prerequisites for participation:	Advanced Control Systems
Applicability of the module:	Master Thesis
Prerequisites allocation ECTS:	RPA: 50% PA graded and 50% R graded; Practical work documented by seminar paper and presentation
ECTS credits:	5
Grading:	benotet
Workload:	Presence: 48h, Self-study: 102h - or - Online: 24h, Self-study: 102h, Homework: 24h
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	
Compulsory attendance:	no

Competence dimensions Embedded Control

Knowledge and understanding: Knowledge Comprehension

Attendees learned about recent research in control engineering, applicable for industrial process embedded control, like optimal control, nonlinear robust control, data driven control, application of Kalman filter, and machine learning control.

Use, application and generation of knowledge/art: Scientific innovation

Attendees learned researching literature, working out implementation, visualization, and operation of industrial process model and embedded control algorithm, and preparing a seminar paper and seminar presentation.

Communication and cooperation

Attendees learned presenting scientific results in a structured manner, utilizing adequate terminology, and gained experience in intercultural team collaboration and communication.

Scientific / artistic self-image and professionalism

Attendees learned developing scientific results through adequate proceeding and planning.

Embedded Computing 1

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM05
Modul title:	Embedded Computing 1
Module responsible:	Prof. Dr. rer. nat. Markus Pfeil
Language of lecture:	english
Typ of module:	Mandatory module
Module Content:	- Embedded Systems in motor management, ABS, medical devices and its increasing programming needs. - Modeling of embedded systems (Cyber-Physical Systems) - Functions of 32-bit micro controllers (ARM), interface functions, its programming under Linux - Implementation of operating systems on microcontrollers
Courses:	Embedded Computing
Teaching and learning forms:	Lecture and Laboratory / practical course and Project Lecture with integrated applications, development and programming of functions for embedded systems, project management (project idea, realization, presentation)
Prerequisites for participation:	Bachelor knowledge
Applicability of the module:	Electrical Engineering and Embedded Systems Mechatronics
Prerequisites allocation ECTS:	PF
ECTS credits:	5
Grading:	graded
Workload:	5 ECTS Embedded Computing 150 h (60 h Lecture, 90 h Homework)
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	B. P. Douglas; "Real-Time UML", Second Edition. Addision Wesley Longman, Inc., 2000. P. Marwedel; "Embedded System Design", Springer Verlag, 2006. D. Abbott; "Linux for Embedded and Real-time Applications", Elsevier Science, 2003
Compulsory attendance:	no

Competence dimensions Embedded Computing 1

Knowledge and understanding: Knowledge Comprehension

The graduates have broadened their knowledge in the following fields and are capable of reproducing this knowledge:

- Mechatronic and electrical engineering
- Model and simulate mechatronic systems
- Construct electrical and IT components

Use, application and generation of knowledge/art:

Communication and cooperation

With the contents for the module, sustainable work, design and economics will be teached. It will be improved to a level, that it fits to the needs of companies. The intercultural competence of the graduates will be developed by

- international tandem teams
- mixed teams in the labs
- mixed teams for projects and seminars

Scientific / artistic self-image and professionalism

In the course of their study, the graduates have already reached a level of knowledge and understanding that enables them to analyze not only simple but also complex interactions. On this basis, they are capable of independently identifying scientific or practice-related issues in the following fields:

- mechatronic questions
- model and simulate mechatronic systems
- construct electrical and IT components
- present mechatronic projects

Embedded Computing 2

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM06
Modul title:	Embedded Computing 2
Module responsible:	Prof. Dr. rer. nat. Markus Pfeil
Language of lecture:	english
Typ of module:	Mandatory module
Module Content:	- Embedded Systems in motor management, ABS, medical devices and its increasing programming needs. - Modeling of embedded systems (Cyber-Physical Systems) - Functions of 32-bit micro controllers (ARM), interface functions, its programming under Linux - Implementation of operating systems on microcontrollers
Courses:	Embedded Computing Lab Embedded Computing Seminar
Teaching and learning forms:	Lecture and Laboratory / practical course and Project Lecture with integrated applications, development and programming of functions for embedded systems, project management (project idea, realization, presentation)
Prerequisites for participation:	Bachelor knowledge
Applicability of the module:	Electrical Engineering and Embedded Systems Mechatronics
Prerequisites allocation ECTS:	PF
ECTS credits:	4
Grading:	graded
Workload:	4 ECTS Embedded Computing Lab 60 h (30 h Lecture, 30 h Homework) Embedded Semiar 90 h (30 Lecture, 60 h Homework)
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	B. P. Douglas; "Real-Time UML", Second Edition. Addision Wesley Longman, Inc., 2000. P. Marwedel; "Embedded System Design", Springer Verlag, 2006. D. Abbott; "Linux for Embedded and Real-time Applications", Elsevier Science, 2003
Compulsory attendance:	no

Competence dimensions Embedded Computing 2

Knowledge and understanding: Knowledge Comprehension

The graduates have broadened their knowledge in the following fields and are capable of reproducing this knowledge:

- Mechatronic and electrical engineering
- Model and simulate mechatronic systems
- Construct electrical and IT components

Use, application and generation of knowledge/art:

Communication and cooperation

With the contents for the module, sustainable work, design and economics will be teached. It will be improved to a level, that it fits to the needs of companies. The intercultural competence of the graduates will be developed by

- international tandem teams
- mixed teams in the labs
- mixed teams for projects and seminars

Scientific / artistic self-image and professionalism

In the course of their study, the graduates have already reached a level of knowledge and understanding that enables them to analyze not only simple but also complex interactions. On this basis, they are capable of independently identifying scientific or practice-related issues in the following fields:

- mechatronic questions
- model and simulate mechatronic systems
- construct electrical and IT components
- present mechatronic projects

Signal Processing 1: Sensor and Actuator Signals

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM07
Modul title:	Signal Processing 1: Sensor and Actuator Signals
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Language of lecture:	english
Typ of module:	Mandatory module
Module Content:	- Introduction, Overview of Continuous and Digital Sensors - System Theory, Fourier- and Laplace Transform (Repetition) - Electronic Circuits for Sensor Signal Processing (OPamps, AD, SH) - PWM Actuator Control - Discrete System Theory, Digital Signals, MATLAB exercises - Sampling, Discrete Time-Domain, Discrete Convolution, FIR basics - Frequency-Domain, Discrete FOURIER-Transform (DFT, FFT) - Bilinear Transform, First- and Second Order IIR - DDS deterministic signal generation, Random Siggnals - Real-Time DSP Algorithms on Microcontrollers (SP-Lab)
Courses:	Signal Processing 1 Signal Processing 1 Lab
Teaching and learning forms:	Lecture and Laboratory / practical course
Prerequisites for participation:	Bachelor knowledge
Applicability of the module:	Electrical Engineering and Embedded Systems
Prerequisites allocation ECTS:	K90: Written examination; 90 minutes
ECTS credits:	5
Grading:	graded
Workload:	150 h
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	[Ghausi] Ghausi, Laker Modern Filter Design, Prentice-Hall, 1981 [Horowitz] Paul Horowitz, W. Hill The Art of Electronics, Cambridge University Press [Cooper] Cooper G. R., McGillem C. D., Probabilistic Methods of Signal an System Analysis, CBS 1986 [Doe] Doetsch, G. Anleitung zum praktischen Gebrauch der Laplace-Transformation. Oldenbourg, 1989
Compulsory attendance:	no

Competence dimensions Signal Processing 1: Sensor and Actuator Signals

Knowledge and understanding: Deepening of individual components of knowledge

The students are able to explain sensor and actuator signals.

Use, application and generation of knowledge/art: Scientific innovation

The graduates understand specifications for analog circuits for signal processing. Thus being able to design new circuits based on the basic circuits and methods known in theory and in practice from the teaching module.

Communication and cooperation

Attendees learned about presenting and applying sensors and actuators; aimed at interdisciplinary projects; operated within a team of scientists, engineers, designers, and economists.

Scientific / artistic self-image and professionalism

Attendees learned about economical and ecological considerations in choosing, implementing, and optimizing sensors and actuators in industrial processes.

Signal Processing 2: Digital Filters (Profile: Sensor Data Processing)

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM08
Modul title:	Signal Processing 2: Digital Filters (Profile: Sensor Data Processing)
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Language of lecture:	english
Typ of module:	Compulsory elective module
Module Content:	- Design of higher order FIR filters - Design of higher order IIR filters using analog prototypes (MATLAB) - Numerical Issues with integer arithmetics: Limit Cycles - Verification of digital filters on a Microcontroller board (SP-Lab) - Spectral Analysis - Advanced topics: Learning Algorithms: LPC and LMS - Individual design of a high order IIR filter (RPA) - Optional Content: - Patents (introduction) - Cyber Security on Microcontrollers (Introduction)
Courses:	Signal Processing 2 Signal Processing 2 Lab
Teaching and learning forms:	Lecture and Laboratory / practical course
Prerequisites for participation:	Signal Processing 1: Sensor and Actuator Signals
Applicability of the module:	Electrical Engineering and Embedded Systems
Prerequisites allocation ECTS:	RPA: 50% PA graded and 50% R graded; Practical work documented by seminar paper and presentation
ECTS credits:	5
Grading:	graded
Workload:	150 h
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	[Ghausi] Ghausi, Laker Modern Filter Design, Prentice-Hall, 1981 [Horowitz] Paul Horowitz, W. Hill The Art of Electronics, Cambridge University Press [Cooper] Cooper G. R., McGillem C. D., Probabilistic Methods of Signal an System Analysis, CBS 1986 [Doe] Doetsch, G. Anleitung zum praktischen Gebrauch der Laplace-Transformation. Oldenbourg, 1989
Compulsory attendance:	no

Competence dimensions Signal Processing 2: Digital Filters (Profile: Sensor Data Processing)

Knowledge and understanding: Deepening of individual components of knowledge

The students are able to explain digital filters, stability, and signals.

Use, application and generation of knowledge/art: Scientific innovation

The graduates understand specifications for analog circuits for signal processing. Thus being able to design new circuits based on the basic circuits and methods known in theory and in practice from the teaching module.

Communication and cooperation

Attendees learned about presenting and applying digital filters; aimed at interdisciplinary projects; operated within a team of scientists, engineers, designers, and economists.

Scientific / artistic self-image and professionalism

Attendees learned about economical and ecological considerations in choosing, implementing, and optimizing digital filters for industrial processes.

Communication 1: Nearfield Communication

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM09
Modul title:	Communication 1: Nearfield Communication
Module responsible:	Prof. Dr.-Ing. Raphael Ruf
Language of lecture:	english
Typ of module:	Mandatory module
Module Content:	Basics of near- and farfield communication Frequency ranges Transmission standards Protocols Applications
Courses:	Nearfield Communication
Teaching and learning forms:	Lecture and Project
Prerequisites for participation:	Basics of Communication (Bachelor)
Applicability of the module:	Electrical Engineering and Embedded Systems
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	benotet
Workload:	
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	Finkenzeller, Klaus: RFID Handbook Coscun et. al.: Near Field Communication (NFC): From Theory to Practice Wiley, 2012 Hendry :Near Field Communications Technology and Applications. Cambridge University Press, 2014
Compulsory attendance:	no

Competence dimensions Communication 1: Nearfield Communication

Knowledge and understanding: Broadening of prior knowledge

The graduates have deepened their existing knowledge in the following areas and are capable of not only reproducing the corresponding contents but also of explaining them. They understand the underlying principles, the whys and wherefores: - describe the function of NFC systems with own words.

Use, application and generation of knowledge/art: Scientific innovation

The graduates are capable of applying the knowledge they have acquired in the following fields and, additionally, of assessing their own approach to the theory-praxis-transfer and the result thereof: - evaluate and optimize NFC systems. The graduates can not only apply their knowledge and assess the application methods and / or results, they can also independently develop further research questions in the following fields: - create applications.

Communication and cooperation

Scientific / artistic self-image and professionalism

Communication 2: Wireless Communication

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM10
Modul title:	Communication 2: Wireless Communication
Module responsible:	Prof. Dr.-Ing. Frank Fechter
Language of lecture:	english
Typ of module:	Mandatory module
Module Content:	A. Channel models for wireless communications 1 Wave propagation 2 Noise and Interference 3 Spectrum issues B. Technology components of modern wireless systems48 4 Digital signal transmission 5 Diversity 6 Multi-Hop Networks 7 Network Coding 8 Cognitive radio 9 Scheduling and rate control C. Wireless Systems 10 Basics of Mobile Communication 11 Global System for Mobile Communications (GSM) 12 Long Term Evolution and System Architecture Evolution 13 The Fifth Generation of Mobile Communication (5G) 14 6G - The future of wireless communications
Courses:	Wireless Communication
Teaching and learning forms:	Lecture, exercise, self-study
Prerequisites for participation:	Basics of Communication (Bachelor)
Applicability of the module:	Electrical Engineering and Embedded Systems
Prerequisites allocation ECTS:	K90
ECTS credits:	5
Grading:	graded The Grade can be improved according to §9a Study and Examination Regulations. Details can be found in Moodle.
Workload:	150h
Duration of the module:	one semester
Frequency of offering:	Summer semester only

Literature:	Dahlman, E. et al:4G: LTE/LTE-Advanced for Mobile Broadband. Academic Press, 2014 Dahlman, E. et al:4G: LTE-Advanced Pro and the road to 5G Academic Press, 2016. Molisch, A. F.: Wireless Communications. John Wiley & Sons, 2011 Holma H.; Toskala, A.: WCDMA for UMTS: HSPA Evolution and LTE. John Wiley & Sons, 2006 Holma H.; Toskala, A.: LTE for UMTS: HSPA Evolution to LTE-Advanced. John Wiley & Sons, 2011 Haykin, S.; Moher, M.: Modern Wireless Communications. Pearson Prentice Hall, 2005 Lescuyer, P.; Lucidarme, T.: Evolved Packet System (EPS) – The LTE and SAE Evolution of 3G UMTS. Wiley 2008. Larmo A. et al: The Link-Layer Design. IEEE Communications Magazine. April 2009 Wannstrom J.: LTE-Advanced. www.3gpp.org/technologies/keywords-acromyms/97-lte-advanced. Kosta, C,; Hunt, B.; Quddus, A ; Tafazolli, R.: On Interference Avoidance through Inter-Cell Interference Coordination (ICIC) based on OFDMA mobile systems. IEEE Communcations Surveys & Tutuorials. 2013 M.2083-0: IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond. ITU-R WP5D Recommendation. 09/2015 5GPPP Architecture Working Group. View on 5G Architecture. Version 2.0. December 2017. Retrieved from https://5g-ppp.eu/white-papers/. Retrieved 21.01.2022. System architecture for the 5G System (5GS); Stage 2 (Release 17). 3GPP. December 2021.
Compulsory attendance:	no

Competence dimensions Communication 2: Wireless Communication

Knowledge and understanding: Broadening of prior knowledge

The graduates have broadened their knowledge in the following fields and are capable of reproducing this knowledge: Describe construction and functionality of modern mobile communication systems. They have understood the basic technologies, the architecture and protocols of selected wireless communication systems and they are be able to describe it with his/her own words.

Use, application and generation of knowledge/art: Use and transfer

The graduates are capable of applying the knowledge they have acquired in the following fields: Mathematical methods for planning and optimization of communication systems.

The students are able to calculate mathematically selected problems of wireless communications, e.g. the range of radio transmission systems, diversity gain by multi-antenna systems and channel capacity of channels with relay nodes.

Communication and cooperation

The students work together in groups cooperative and responsible.

Scientific / artistic self-image and professionalism

The students know their own strength and weaknesses with respect to their study achievements.

Circuits & Systems 1: System-On-Chip Modeling & Design (Profile: System-On-Chip Design & Operation)

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM11
Modul title:	Circuits & Systems 1: System-On-Chip Modeling & Design (Profile: System-On-Chip Design & Operation)
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Language of lecture:	english
Typ of module:	Compulsory elective module
Module Content:	- ASIC-Design - Bus-Systems - Peripherals in a System-on-Chip (SoC) - Test and Debug of SoC - Principles of Micro-controller - MMU - Parallel Architectures
Courses:	System-On-Chip Modeling & Design
Teaching and learning forms:	Lecture and Project
Prerequisites for participation:	Knowledge of computer architectures from Bachelor courses
Applicability of the module:	Electrical Engineering and Embedded Systems
Prerequisites allocation ECTS:	PF: - Requirements (10%) - 1. Specification (10%) - Simulation Sign-Off (10%) - Synthesis Sign-Off (10%) - Final Specification (40%) - Presentation (20%)
ECTS credits:	5
Grading:	benotet
Workload:	30 h per ECTS = 150 h in total 60 h for lectures 90 h for preparations
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	1. John L. Hennessy, David A. Patterson; Computer Architecture: A Quantitative Approach 2. David A. Patterson, John L. Hennessy; Computer Organization and Design: The Hardware/Software Interface

Compulsory attendance:	yes
Reason:	Exercises in the Lab.

Competence dimensions Circuits & Systems 1: System-On-Chip Modeling & Design (Profile: System-On-Chip Design & Operation)

Knowledge and understanding: Broadening of prior knowledge

The graduates know the principle of computer architectures. They know how to design an ASIC.

Use, application and generation of knowledge/art: Use and transfer

The graduates can implement and organize a system on Chip with its peripherals. They can implement and use Test- and- Debug methods.

Communication and cooperation

With the contents for the module, sustainable work, design and economics will be teached. It will be improved to a level, that it fits to the needs of companies. The intercultural competence of the graduates will be developed by

- international tandem teams
- mixed teams in the labs
- mixed teams for projects and seminars

Scientific / artistic self-image and professionalism

Circuits & Systems 2: System-On-Chip Operation & Test (Profile: System-On-Chip Design & Operation)

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM12
Modul title:	Circuits & Systems 2: System-On-Chip Operation & Test (Profile: System-On-Chip Design & Operation)
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Language of lecture:	english
Typ of module:	Compulsory elective module
Module Content:	- ASIC-Design - Bus-Systems - Peripherals in a System-on-Chip (SoC) - Test and Debug of SoC - Principles of Micro-controller - MMU - Parallel Architectures
Courses:	System-On-Chip Operation & Test
Teaching and learning forms:	Lecture and Project
Prerequisites for participation:	Knowledge of computer architectures from Bachelor courses
Applicability of the module:	Electrical Engineering and Embedded Systems
Prerequisites allocation ECTS:	PF: - Requirements (10%) - 1. Specification (10%) - Simulation Sign-Off (10%) - Synthesis Sign-Off (10%) - Final Specification (40%) - Presentation (20%)
ECTS credits:	5
Grading:	benotet
Workload:	30 h per ECTS = 150 h in total 60 h for lectures 90 h for preparations
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	1. John L. Hennessy, David A. Patterson; Computer Architecture: A Quantitative Approach 2. David A. Patterson, John L. Hennessy; Computer Organization and Design: The Hardware/Software Interface

Compulsory attendance:	yes
Reason:	Exercises in the Lab.

Competence dimensions Circuits & Systems 2: System-On-Chip Operation & Test (Profile: System-On-Chip Design & Operation)

Knowledge and understanding: Broadening of prior knowledge

The graduates know the principle of computer architectures. They know how to design an ASIC.

Use, application and generation of knowledge/art: Use and transfer

The graduates can implement and organize a system on Chip with its peripherals. They can implement and use Test- and- Debug methods.

Communication and cooperation

With the contents for the module, sustainable work, design and economics will be teached. It will be improved to a level, that it fits to the needs of companies. The intercultural competence of the graduates will be developed by

- international tandem teams
- mixed teams in the labs
- mixed teams for projects and seminars

Scientific / artistic self-image and professionalism

Computer Architecture (Profile: System-On-Chip Design & Operation)

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM13
Modul title:	Computer Architecture (Profile: System-On-Chip Design & Operation)
Module responsible:	Prof. Dr.-Ing. Andreas Siggelkow
Language of lecture:	english
Typ of module:	Compulsory elective module
Module Content:	- A general overview of computer architectures - Critical discussion of design criteria - Scalar architectures - Instruction level parallelism - Thread level parallelism - Memory hierarchies - ARM and RISC-V architecture
Courses:	Computer Architecture
Teaching and learning forms:	Lecture and Project
Prerequisites for participation:	Basics of computer architectures
Applicability of the module:	Electrical Engineering and Embedded Systems Module: Master-Thesis
Prerequisites allocation ECTS:	PF or K90 PF in SS2023: 1.) Design of a RISC-V in VHDL (50%) 2.) K60 (50%)
ECTS credits:	5
Grading:	graded
Workload:	30 h per ECTS = 150 h in total 60 h for lectures 90 h for preparations
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	J.L. Hennesy, D.A. Patterson; "Computer Architecture"; Morgan Kaufmann Publisher D.A. Patterson, J.L. Hennesy; "Computer Organization and Design"; Morgan Kaufmann Publisher
Compulsory attendance:	no

Competence dimensions Computer Architecture (Profile: System-On-Chip Design & Operation)

Knowledge and understanding: Deepening of individual components of knowledge

The graduates know the difference of scalar and super-scalar architectures, they know how to evaluate the different kinds of caches and memory administrations.

Use, application and generation of knowledge/art: Scientific innovation

The graduates know the difference of scalar and super-scalar architectures, they know how to evaluate the different kinds of caches and memory administrations.

Communication and cooperation

The intercultural competence of the graduates will be developed by - international tandem teams

- mixed teams in the labs
- mixed teams for projects and seminars

With the contents for the module, sustainable work, design and economics will be teached. It will be improved to a level, that it fits to the needs of companies.

Scientific / artistic self-image and professionalism

The graduates can organize an architecture and a team of a CPU project (System Architect).

Computer Vision

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM14
Modul title:	Computer Vision
Module responsible:	Prof. Dr. rer. nat. Stefan Elser
Language of lecture:	english
Typ of module:	Compulsory elective module
Module Content:	1. Brief introduction 2. The pinhole camera model 3. Recognition 4. Motion analysis 5. 3D reconstruction We will take a look at both, traditional and machine learning algorithms in Computer Vision. For traditional algorithms, we will work with OpenCV. For machine learning algorithms, we will take a look at the TensorFlow Object Detection API or a comparable framework. As part of this course, you will implement or evaluate some of these algorithms using C++ or Python. The algorithms will either have to work on already recorded data or a given sensor.
Courses:	7781 Computer Vision
Teaching and learning forms:	Lecture
Prerequisites for participation:	Good understanding of mathematics in general. Good understanding of at least one programming language, preferable Python or C++.
Applicability of the module:	Electrical Engineering and Embedded Systems
Prerequisites allocation ECTS:	PF consisting of 50% PA and 50% K60
ECTS credits:	5
Grading:	graded
Workload:	approx. 50h for lectures, approx. 100h for self-study (preparation and follow-up, exam preparation)
Duration of the module:	one semester
Frequency of offering:	Winter semester only
Literature:	Szeliski, Richard. "Computer vision: algorithms and applications." Springer Science & Business Media Janai, Joel, et al. "Computer vision for autonomous vehicles: Problems, datasets and state of the art.", arXiv:1704.05519v2
Compulsory attendance:	no

Competence dimensions Computer Vision

Knowledge and understanding: Deepening of individual components of knowledge

Absolventinnen und Absolventen haben ihr Wissen auf folgenden Gebieten erweitert und können dieses Wissen auch wiedergeben: Grundlegende Algorithmen der Computer Vision wie Object Detection, Motion Analysis, 3D Reconstruction.

Use, application and generation of knowledge/art: Use and transfer

Absolventinnen und Absolventen haben ihr Wissen auf folgenden Gebieten erweitert und können dieses Wissen auch wiedergeben: Grundlegende Algorithmen der Computer Vision wie Object Detection, Motion Analysis, 3D Reconstruction.

Communication and cooperation

Scientific / artistic self-image and professionalism

Lidar & Radar Systems

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM15
Modul title:	Lidar & Radar Systems
Module responsible:	Prof. Dr. rer. nat. Stefan Elser
Language of lecture:	english
Typ of module:	Compulsory elective module
Module Content:	1. Brief introduction 2. Radar sensors and signals 3. Radar: Velocity and distance measurement 4. Lidar sensors 5. Lidar: Distance measurement 6. Algorithms: simple object detection and tracking We will focus on automotive applications but also will discuss other applications as well. As part of this course, you will use a sensor or already recorded data to implement your own algorithms or evaluate already existing functions or the data itself using C++ or Python.
Courses:	7945 Lidar and Radar Systems
Teaching and learning forms:	Lecture
Prerequisites for participation:	Good understanding of mathematics in general. Good understanding of at least one programming language, preferable Python, C or C++.
Applicability of the module:	Electrical Engineering and Embedded Systems
Prerequisites allocation ECTS:	PF consisting of 50% PA and 50% K60
ECTS credits:	5
Grading:	graded
Workload:	approx. 50h for lectures, approx. 100h for self-study (preparation and follow-up, exam preparation)
Duration of the module:	one semester
Frequency of offering:	Summer semester only
Literature:	Merril Ivan Skolnik: "Introduction to radar systems", McGraw Hill Book Co. Christian Wolff: "Radartutorial", www.radartutorial.eu Feng, Di, et al. "Deep multi-modal object detection and semantic segmentation for autonomous driving: Datasets, methods, and challenges." IEEE Transactions on Intelligent Transportation Systems (2020).

Compulsory attendance:	no

Competence dimensions Lidar & Radar Systems

Knowledge and understanding: Deepening of individual components of knowledge

Absolventinnen und Absolventen haben ihr Wissen auf folgenden Gebieten erweitert und können dieses Wissen auch wiedergeben: Physikalische Grundlagen von Radar- und Lidar-Sensoren, grundlegende Algorithmen zur Signalauswertung, Geschwindigkeitsberechnung und Objekterkennung.

Use, application and generation of knowledge/art: Use and transfer

Absolventinnen und Absolventen können das Wissen aus folgenden Themenbereichen praktisch anwenden:
Implementierung und Evaluation einer Objekterkennung in Punktewolken.

Communication and cooperation

Scientific / artistic self-image and professionalism

Research Project (optional)

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM16
Modul title:	Research Project (optional)
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Language of lecture:	english
Typ of module:	Elective module
Module Content:	Students should prove their knowledge gained from theoretical and practical lectures on a research transaction.
Courses:	-Research Project activity -Research Project report -Research Project colloquium
Teaching and learning forms:	Research experience
Prerequisites for participation:	Approval of the work topic by dean of studies.
Applicability of the module:	
Prerequisites allocation ECTS:	-Delivery of Research Project report -Presentation of the results in a colloquium public to all members of the university.
ECTS credits:	5
Grading:	graded
Workload:	The Research Project shall have a duration of 6 months.
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	
Compulsory attendance:	no

Competence dimensions Research Project (optional)

Knowledge and understanding: Knowledge Comprehension

The students are able to define, work on, evaluate and explain scientific topics.

Use, application and generation of knowledge/art: Scientific innovation

The students are able to define, work on, evaluate and explain scientific topics.

Communication and cooperation

The students can prove their knowledge achieved during their studies theoretically, practically and will be able to defend it. The students have to discuss throughout the duration of the thesis their work with others.

Scientific / artistic self-image and professionalism

The students see their own strength and weakness with respect to their studies and work on a scenario for their future as an engineer or researcher. The students are open to accept hints and ideas from colleagues. The students are able to design sustainable products.

Master Thesis

Course of study:	Electrical Engineering and Embedded Systems
Degree:	Master of Engineering (M.Eng.)
Modul number:	EMM17
Modul title:	Master Thesis
Module responsible:	Prof. Dr.-Ing. Lothar Berger
Language of lecture:	english
Typ of module:	Mandatory module
Module Content:	Students should prove their knowledge gained from theoretical and practical lectures on an engineering project or a research transaction. Working methodology shall be tailored to the needs of the employer, including sustainability, design and economic aspects.
Courses:	-Master Thesis activity -Master Thesis report -Master Thesis colloquium
Teaching and learning forms:	Engineering and/or research experience
Prerequisites for participation:	The Master's thesis can only be commenced if all courses and related coursework required for semesters EMM1 and EMM2 have been completed, corresponding to at least 50 credit points. Approval of the work topic by dean of studies.
Applicability of the module:	
Prerequisites allocation ECTS:	-Delivery of Master Thesis report -Presentation of the results in a colloquium public to all members of the university.
ECTS credits:	25
Grading:	graded
Workload:	The Master Thesis shall have a duration of 6 months. It will be assessed and graded by one professor lecturing at the Hochschule Ravensburg-Weingarten – University of Applied Sciences as 1st examiner, and a 2nd examiner holding appropriate Master's degree.
Duration of the module:	one semester
Frequency of offering:	Every semester
Literature:	
Compulsory attendance:	no

Competence dimensions Master Thesis

Knowledge and understanding: Knowledge Comprehension

The students are able to define, work on, evaluate and explain scientific topics.

Use, application and generation of knowledge/art: Scientific innovation

The students are able to define, work on, evaluate and explain scientific topics.

Communication and cooperation

The students can prove their knowledge achieved during their studies theoretically, practically and will be able to defend it. The students have to discuss throughout the duration of the thesis their work with others.

Scientific / artistic self-image and professionalism

The students see their own strength and weakness with respect to their studies and work on a scenario for their future as an engineer or researcher. The students are open to accept hints and ideas from colleagues. The students are able to design sustainable products.

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