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EUROPEAN UNIVERSITY
OF TECHNOLOGY

Anlage 5
Modulhandbuch des Studiengangs

Electrical Engineering and Information Technology - International
Master of Science

des Fachbereichs Elektrotechnik und Informationstechnik
der Hochschule Darmstadt - University of Applied Sciences

vom 16.06.2026 („PO 20270“)
Zugrundeliegende BBPO vom 16.06.2026 (Amtliche Mitteilungen Jahr 2026)

Inhaltsverzeichnis

MA02	Adaptive Control, Modeling and Identification	4
MC01	Advanced Digital Signal Processing & AI	6
MPwp05	Advanced Driver Assistance Systems	8
ME03	Advanced Embedded Operating Systems	10
MAwp03	Advanced Graphical Programming	12
MCwp01	Advanced IoT Networking	14
MAwp02	Advanced Machine Learning for Industrial Automation	16
MCE02	Advanced Microcontroller Systems	18
MAE01	Advanced Programming Techniques	21
MCwp05	Advanced Security	23
MEwp04	Advanced UAV Sensor Fusion and Control	25
MC05	Advanced Wireless Communication Techniques	27
MEwp02	Applied Edge-AI on Embedded Accelerators	29
MEwp05	Applied Low Power Embedded Sensor Systems	31
MPwp03	Automotive Electrical Powertrain	33
MA03	Computer Vision	35
MP06	Control of Power Electronic Converters	38
MP03	Electrical Drives and Actuators	41
ME05	Embedded Architectures and Applications	44
MEwp01	Embedded Communication	46
ME07	Embedded Signal Processing Systems	48
MC07	Fields and Waves	51
ME04	FPGA-based System on Chip Design	53
MP01	High Voltage Systems Engineering	56
MAwp04	Human Machine Interaction (HMI)	59
MCwp03	Image and Video Processing	61
M03	Industrial Project (BPP)	63
MA05	Industry 4.0 / IIoT and the Digital Factory	66
MC04	Information Networks	68
MNTwp01	Legal English	70
M04	Master Module	72
MCwp07	Mobile and Wireless Networks	74
MA04	Mobile Robotics	76
MA06	Model-Based Control of Industrial Robots	78
MP07	Model-Based Design for Power Electronic Systems	80
MCwp02	Optical Communications	82
MP04	Power Electronics for Drives and Energy Systems	84
MP02	Power System Operation	86
MPwp04	Power System Protection	88

MPwp01	Power Systems Planning	90
MP05	Renewable Energy Systems	92
Mwp02	Research Project	94
MC03	RF Systems Engineering	96
MAwp01	ROS for Robotic Systems Engineering	98
MEwp03	Safety in Embedded Control Systems	100
MCwp06	Satellite Communications	102
Mwp01	Selected Research Topics	104
MPwp02	Smart Grids	106
MNTwp02	Social and Cultural Studies	108
MCwp04	Software Defined Radio	110
MA07	State Space Control Design	112
MCE06	System-Driven Hardware Design	114
M02	Team Project	116
M01	Technical Management	118

MA02 Adaptive Control, Modeling and Identification

1.0 Modulname
Adaptive Control, Modeling and Identification

1.1 Modulkürzel
MA02

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Automation

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Adaptive Control, Modeling and Identification – Seminar
Adaptive Control, Modeling and Identification – Lab

2.1 Inhalt
- Introduction to and classification of Adaptive Control Systems
- Adaptation of Optimal Controllers and Controller Design by Pole Placement
- Dynamic Behavior of Adaptive Control Loops and Configuration Issues
- Modeling of Linear and Non-linear Time-invariant and -variant Dynamic Systems
- Algorithms and Filters for Online Process Identification
- Computer based applications using Matlab/Simulink or comparable tools

3.0 Learning Outcomes
Upon completion of this module, students will have reached the following levels of proficiency in the specified areas of knowledge and skills:

to understand: the basic applications, concepts, components and challenges of adaptive control loops; the basic principles for modeling and identification of complex dynamic systems

to apply: to classify a control application and select an appropriate approach for adaptive control; to know the advantages and disadvantages of modeling and identification algorithms and structures; to implement and simulate the components of an adaptive control loop

to transfer: the design process of adaptive control systems to problems from various domains in automation

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Adaptive Control, Modeling and Identification – Seminar: 3 SWS (Sem)
Adaptive Control, Modeling and Identification – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully pass the laboratory part of the module. This is measured by:

- laboratory attendance
- successfull completion of all laboratory assignments

The laboratory rules and assessment criteria will be communicated at the start of the course. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter term

7.0 Modulverantwortliche(r)
Dr. Karl Kleinmann

8.0 Literatur
The course material for lecture and laboratory will be provided electronically.
Further literature recommendations will be provided during the lecture.

MC01 Advanced Digital Signal Processing & AI

1.0 Modulname
Advanced Digital Signal Processing & AI

1.1 Modulkürzel
MC01

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Communications

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Digital Signal Processing & AI – Seminar
Advanced Digital Signal Processing & AI - Lab

2.1 Inhalt
Content of "Advanced Digital Signal Processing – Seminar":

The course will cover:

- Discrete-time signal transforms (e.g., discrete-time Fourier transform, z-transform, DFT/FFT, DCT)
- Principles and methods of digital filter design (IIR and FIR filters)
- Multi-rate Systems.
- Introduction to modern Machine Learning Algorithms for digital signal processing (e.g., Adaptive filters, CNN, LSTM Transformers neural networks).

Content of "Advanced Digital Signal Processing – Lab":

The lab exercises cover:

- Discrete-time signal transforms.
- Digital Filter design and implementation.
- Multi-rate Systems.
- Adaptive digital Filters and Machine Learning for digital Signal Processing

3.0 Learning Outcomes
to understand:

- Principles of advanced digital signal processing methods.
- Principles of Machine Learning Methods for digital signal processing

to apply:

- Design, implement and evaluate digital filters for different scenarios.
- Apply concepts of multi-rate systems and filter banks.
- Design and evaluate adaptive digital systems.
- Machine Learning for digital Signal Processing.

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and lab and 94 hours of self-study.

Advanced Digital Signal Processing & AI – Seminar: 3 SWS (Sem)
Advanced Digital Signal Processing & AI - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / lab (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfillment of prerequisites is measured by:

- laboratory attendance
- completion of laboratory assignments

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes.

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
Basic knowledge in digital signal processing from bachelor studies.

6.2 Empfohlenes Fachsemester
winter term

7.0 Modulverantwortliche(r)
Dr. Georgi Nikolov

8.0 Literatur
The following literature material will be provided:

- Electronic lecture notes

Further literature recommendations will be provided during the seminar.

MPwp05 Advanced Driver Assistance Systems

1.0 Modulname
Advanced Driver Assistance Systems

1.1 Modulkürzel
MPwp05

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Driver Assistance Systems and Automated Driving – Seminar
Advanced Driver Assistance Systems and Automated Driving – Laboratory

2.1 Inhalt
ADAS Seminar:
- Basics of driver assistance systems
- Examples of ADAS functions (ACC, lateral guidance, front collision protection including automated emergency braking, navigation, automated driving, automated parking
- Development and test environments for driver assistance systems and validation methods
- Legal regulations and functional safety
- Sensor technology for driver assistance systems (ultrasonic, video, lidar, 3d TOF, radar and others)
- Actuator technology for driver assistance systems
- Basics and limits of driving dynamics
- Human-machine interface (HMI)
- Driver assistance at stabilization level
- Driver assistance at guidance and navigation level
- Future of driver assistance systems

ADAS Lab:
- Testing of selected function under usage of defined methods
- Functional examples
- Hazard and risk analysis

3.0 Learning Outcomes
The aim of the module is to provide students with the following levels of competence with regard to the knowledge and skills specified in each case.

to know:
Students know the basics of driver assistance systems and automated driving, the associated technology with a particular focus on system understanding. They know various evaluation criteria for component selection, functional limits, sensors and actuators. Students have become familiar with the functional areas of existing systems through driving tests during demonstrations and trials.
to understand:
Students understand the physical principles of the interrelationships of driver assistance systems with machine perception.
to apply:
Students are able to design and construct systems and components for driver assistance systems.
to transfer:
Students are able to transfer the technology and its application to other ADAS

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Advanced Driver Assistance Systems and Automated Driving – Seminar: 3 SWS (Sem)
Advanced Driver Assistance Systems and Automated Driving – Laboratory: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finishe the laboratory part of the module. Successful fulfilment of prerequisites are measured by:
- laboratory attendance
- laboratory reports

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam or oral presentation at the end of the semester covering the complete content of the module. The exact examination type will be communicated at the start of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Jens Hoffmann

8.0 Literatur
Recommended:
Winner, H.: Handbook of Driver Assistance Systems
Further literature recommendations will be provided during the seminar / are included in the seminar material.

ME03 Advanced Embedded Operating Systems

1.0 Modulname
Advanced Embedded Operating Systems

1.1 Modulkürzel
ME03

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Embedded Systems

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Embedded Operating Systems – Seminar
Advanced Embedded Operating Systems – Lab

2.1 Inhalt
Advanced Embedded Operating Systems – Seminar:
Design and implementation of multithreading realtime embedded software on a 32-bit microcontroller running a realtime operating system (RTOS):

- Structure and implementation of embedded realtime operating systems
- Scheduling algorithms
- Tasks, Events, Messages, Semaphores
- Critical Sections, Priority Ceiling, Deadlocks
- Intertask Communication
- Realtime Criteria and Design of Realtime Applications
- Design and Implementation of Reactive Systems / Statemachines
- Debugging of Multithreading Applications
- Introduction of industrial RTOS (e.g. Autosar, FreeRTOS, PXROS)
- Multicore architectures

Advanced Embedded Operating Systems – Lab:

- Use of elementary RTOS elements (tasks, cyclic and event triggered activations, protection of critical regions)
- Design of RTOS based applications and data / controlflows

3.0 Learning Outcomes
to know: the components of industrial realtime operating systems

to understand: the concept and challenges of multithreading software design and the configuration and use of RTOS services for such architectures

to apply: RTOS services to develop reliable realtime multithreading systems

to transfer: the structure of presented RTOS examples to new microcontrollers and advanced operating systems

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Advanced Embedded Operating Systems – Seminar: 3 SWS (Sem)
Advanced Embedded Operating Systems – Lab: Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to have successfully finished the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- successful completion of the individual laboratory assignments
- successful participation in a technical discussion

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
- Basic understanding of microcontroller architectures
- Good knowledge of C programming

6.2 Empfohlenes Fachsemester
winter term

7.0 Modulverantwortliche(r)
Dr. Peter Fromm

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MAwp03 Advanced Graphical Programming

1.0 Modulname
Advanced Graphical Programming

1.1 Modulkürzel
MAwp03

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Graphical Programming – Seminar

2.1 Inhalt
- Statemachine
- Modeling of user interaction
- Queued Message Handler
- One-to-many communication .
- Managing Software Engineering in Graphical Languages
- Advanced Architectures for Graphical Languages
- Object-Oriented Design and Graphical Programming
- Performance of Graphical Languages

3.0 Learning Outcomes
to understand:
- different advanced architectural appoaches

to apply:
- realization of applications with the help of graphical programming language

to transfer:
- Transferring this knowledge to other graphics-based development environments

4.0 Arbeitsaufwand und Credit Points
2,5 CP / 75 hours in total, including 28 hours classroom teaching and 47 hours of self-study.

AGP - Seminar: 2 SWS (Sem)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Type: Written exam or oral presentation at the end of the semester covering the complete content of the module.

The exact examination type will be communicated at the start of the module.

Examination Duration: 60 minutes (written exam), 20 minutes (oral presentation)

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
Basic knowledge of LabVIEW

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Markus Haid

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MCwp01 Advanced IoT Networking

1.0 Modulname
Advanced IoT Networking

1.1 Modulkürzel
MCwp01

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced IoT Networking – Seminar

2.1 Inhalt
Participants will be exposed to gain experience in Internet of Things (IoT) networking, in particular Smart Home and Cloud Networking, Smart-Grid-Communication and Cloud based industrial networks.
The course will cover:

- Development trends of the IoT and technological roadmap
- Reference model for IoT networks and industrial Internet
- General terminology, structure and components of IoT and Cloud networks
- Technological challenges of IoT
- Assessment of network technologies and protocols for Fog and Cloud networks
- Security assessment of IoT networks
- Network design for Smart Grid/Smart Home and Industrial Internet
- Lab demonstration of IoT applications

3.0 Learning Outcomes
to know:

- about actual developments and protocols used in IoT networks

to understand:

- the different types of cloud networks and network structures
- the usage of protocols for connecting Smart Grid/Smart Home/Industrial networks to the Internet
- the special requirements on communications and components in Smart Industry networks

to apply:

- Design of Smart Grid/ Smart Home and Industry networks
- Selection of adequate network components and protocols for local and distributed data transmission
- Evaluation of security requirements of Cloud networks and adequate network design

to transfer:

- application of the learned protocols and network principles to new evolving services in the internet of things in private, public and industry networks

4.0 Arbeitsaufwand und Credit Points
2,5 CP / 75 hours in total, including 28 hours classroom teaching and 47 hours of self-study.

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Johannes Gerdes

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MAwp02 Advanced Machine Learning for Industrial Automation

1.0 Modulname
Advanced Machine Learning for Industrial Automation

1.1 Modulkürzel
MAwp02

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Machine Learning for Industrial Automation – Seminar
Advanced Machine Learning for Industrial Automation – Lab

2.1 Inhalt
- Machine Learning Fundamentals: Terminology, history, and methodology; fundamentals of learning and implementation of ML algorithms in Python.
- Foundations and State-of-the-Art ML Algorithms: Advanced algorithms for industrial automation, including physics-based machine learning, Reinforcement Learning and Imitation Learning.
- Vision Systems & Advanced Deep Learning: study of neural vision architectures for object detection, image captioning, and segmentation; synthetic data generation; introduction to Transformer models.
- Cognitive Assistance: Local deployment and fine-tuning of Large Language Models (LLMs); utilizing domain-specific data (e.g., technical documentation) for model specialization and context-aware support.
- Edge AI & Real-Time Deployment: Deployment strategies for heterogeneous hardware and embedded systems; analysis of processing latencies versus the requirements of deterministic real-time control.
- MLOps & Agile Project Execution: Operationalization, automated retraining, and drift detection; managed through agile methodologies to ensure reliability in changing industrial environments.

3.0 Learning Outcomes
<u>to understand:</u>

- Foundations and Reliability: The fundamentals of Machine Learning and the MLOps lifecycle,
- State-of-the-art Vision and Data Scarcity: The potential of Synthetic Data Generation and Transformer models for overcoming data scarcity in industrial vision tasks.
- Advanced Learning Paradigms: State of the art methodologies and how they serve as scalable alternatives for programming complex robotic or automation solutions.
- The potential of fine-tuning local Large Language Models (LLMs) for process support.

<u>to apply:</u>

- Implementation of state-of-the-art Systems: Implementing advanced vision systems and developing Reinforcement Learning solutions for autonomous control and motion refinement in simulation.
- Agile Project Management: Managing complex lab projects by leveraging agile implementation and methodologies to organize and deliver ML solutions.
- Deployment & Hardware: Deploying ML models to heterogeneous systems, including the practical setup on cloud-based infrastructures or Edge-level hardware.

<u>to transfer:</u>

- Evaluate cognitive systems via latency analysis to judge trade-offs with real-time requirements and design IT architectures between high-level AI and low-level control.
- Strategic Integration: Choose and judge appropriate machine learning solutions to decide when and how to integrate them into existing industrial structures and digital transformation strategies.

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Advanced Machine Learning for Industrial Automation – Seminar: 3 SWS (Sem)
Advanced Machine Learning for Industrial Automation – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:

In order to participate in the module exam, it is required to have successfully finished the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

winter or summer term

7.0 Modulverantwortliche(r)

Dr. Benjamin Menz

8.0 Literatur

- Goodfellow, Deep Learning, 1. Auflage. Frechen: mitp
- Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition. O'Reilly Media, Inc.
- S. Matzka, Künstliche Intelligenz in den Ingenieurwissenschaften: Maschinelles Lernen verstehen und bewerten. Wiesbaden: Springer Fachmedien

Further literature recommendations will be provided during the lecture or are included in the lecture material.

MCE02 Advanced Microcontroller Systems

1.0 Modulname
Advanced Microcontroller Systems

1.1 Modulkürzel
MCE02

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Embedded Systems and Major Communications

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Microcontroller Systems – Lecture
Advanced Microcontroller Systems – Lab

2.1 Inhalt
Lecture:
- Architecture of modern microcontrollers, including an overview of core components and their internal structure
- Interrupt handling, with emphasis on the Nested Vectored Interrupt Controller (NVIC), interrupt prioritization, and preemption
- Clock systems in microcontrollers, including different clock sources and their impact on stability, performance, and energy efficiency
- Serial communication interfaces, focusing on the design of communication applications using protocols such as UART and SPI
- Memory organization and address spaces in microcontrollers, including principles of data alignment and memory protection
- Direct Memory Access (DMA) for efficient data transfer between peripherals and memory
- Startup procedures of microcontroller-based systems, covering both hardware and software initialization
- Debugging and validation of embedded systems using internal and external debugging mechanisms (e.g. logic analyzers)
- Analysis of internal behavior and ressources (e.g. timing, memory, CPU-usage, ...)

Lab:
- Development of low-level embedded components e.g. design and configuration of custom digital functionality

3.0 Learning Outcomes
Students are able:

to understand:

- the internal structure and architecture of a microcontroller, including core components, memory organization, and address spaces.
- the functionality of the Nested Vectored Interrupt Controller (NVIC), including interrupt handling, priorities, and preemption
- the principles and characteristics of different clock sources with respect to stability, power consumption, and efficiency.
- describe the hardware and software startup procedures of microcontroller-based systems.
- explain the basics of data alignment and memory access in embedded systems.

to apply the knowledge to:

- implement serial communication applications using standard protocols such as UART and SPI.
- configure and use Direct Memory Access (DMA) for efficient data transfer between peripherals and memory.
- configure microcontroller clock systems and interrupt settings for given application requirements.
- Use debugging and measurement tools, including logic analyzers, to test and verify embedded software behavior.
- Design and implement custom digital hardware functionality.

to transfer:

- Analyze embedded system designs with respect to timing, performance, and resource utilization.
- Transfer fundamental microcontroller concepts to new devices, architectures, or application scenarios.
- Evaluate and justify design decisions for communication, clocking, and data transfer mechanisms in embedded systems.

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Advanced Microcontroller Systems – Lecture: 2 SWS (V)
Advanced Microcontroller Systems – Lab: 2 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

lecture (V) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments
- laboratory report / review

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

winter term

7.0 Modulverantwortliche(r)

Dr. Heiko Koch

8.0 Literatur

The following literature material will be provided:

- Electronic lecture notes
- Workbooks for the lab

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MAE01 Advanced Programming Techniques

1.0 Modulname
Advanced Programming Techniques

1.1 Modulkürzel
MAE01

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Automation and Major Embedded Systems

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Programming Techniques – Lecture
Advanced Programming Techniques – Lab

2.1 Inhalt
This module provides an in-depth review and extension of object-oriented and modern software development concepts with a strong focus on high-performance, embedded, and systems-oriented applications relevant to Electrical and Computer Engineering.

Advanced Programming Techniques – Lecture:

- Fundamental concepts of widely used object-oriented and systems programming languages (primarily C++)
- Unified Modeling Language (UML) for software specification and documentation
- Object-Oriented Analysis and Design (OOA/OOD) and model-driven development techniques
- Advanced class design, inheritance, polymorphism, and template-based programming in modern C++ (C++17/20)
- Operator overloading and advanced language features
- Design and implementation of efficient data structures and algorithms
- Introduction to common software design patterns and architectural styles
- Systematic software testing, verification, and debugging techniques (unit testing, integration testing)
- Secure and robust software development practices

Advanced Programming Techniques – Lab:

- UML-based design of software architechture (class diagram, state diagram)
- Completion and Implementation of exisiting software architectures
- (Semi-)automated documentaion of architecture and code
- (Semi-)automated testing of code and interfaces

3.0 Learning Outcomes
to know: vocabulary of OOD and OOP

to understand: concepts of oo-based software architectures

to apply: design of software architectures in UML / implementaion of software archiutectures in C++

to transfer: software design patterns in complex software architectures / testing concepts in different levels of software maturity

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Advanced Programming Techniques – Lecture: 2 SWS (V)
Advanced Programming Techniques – Lab: 2 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
lecture (V) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to have successfully finished laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments / review

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam or practical exam on PC at the end of the semester covering the complete content of the module.

The exact examination type will be communicated at the start of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
Basic programming skills, ideally in an object-oriented programming language.

6.2 Empfohlenes Fachsemester
winter term

7.0 Modulverantwortliche(r)
Dr. Christian Bürgy

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Recommended:

- UML @ Classroom: An Introduction to Object-Oriented Modeling (Seidl, Martina et. al)
- Design Patterns: Elements of Reusable Object-Oriented Software (Gamma, Erich et. al)
- C++ Software Design: Design Principles and Patterns for High-Quality Software (Iglberger, Klaus)

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MCwp05 Advanced Security

1.0 Modulname
Advanced Security

1.1 Modulkürzel
MCwp05

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Security - Seminar

2.1 Inhalt
- Authentication, access control, data integrity
- Encryption including the mathematical foundation of ciphering
- Attack scenarios
- Security measures including network security
- Quantum-computing related risks (e.g. "harvest now, decrypt later")
- Security in case of critical infrastructures
- Mobile and wireless network security (e.g. WLAN, 5G)
  - Detailed analysis of the attack scenarios (e.g. IMSI catchers)
  - Different generations of mobile and wireless networks and their security-related functionality

3.0 Learning Outcomes
to understand: Attack scenarios, Quantum-computing related risks

to apply: Authentication, access control, data integrity, encryption methods, encryption methods, privacy, security measures inclusive network security

to transfer: wireless network security, security in case of critical infrastructure

4.0 Arbeitsaufwand und Credit Points
2,5 CP / 75 hours in total, including 28 hours classroom teaching and 47 hours of self-study.

Advanced Security - Seminar: 2 SWS (Sem)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Type: Written exam or oral presentation at the end of the semester covering the complete content of the module.

The exact type of examination will be communicated at the start of the module

Examination Duration: 60 minutes (written exam), 20 minutes (oral presentation)

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Jakob Belschner

8.0 Literatur
Literature recommendations will be provided during the lecture / are included in the lecture material.

MEwp04 Advanced UAV Sensor Fusion and Control

1.0 Modulname
Advanced UAV Sensor Fusion and Control

1.1 Modulkürzel
MEwp04

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced UAV Sensor Fusion and Control – Seminar
Advanced UAV Sensor Fusion and Control – Lab

2.1 Inhalt
- Fundamentals of UAV (unmanned aerial vehicles) dynamics
- Equations of motion and rotor-based thrust/torque generation
- Sensor principles: inertial sensors (IMU), GNSS, barometer
- Kalman filter
- State estimation via sensor fusion
- Flight control architectures and PID/INDI/MPC-based control
- Model Predictive Control (MPC) for multirotor UAVs (state-space models, solvers, constraints)
- Control allocation
- Practical challenges: sensor errors, drift, fault detection, tuning

3.0 Learning Outcomes
<u>to know:</u>

- UAV sensor technologies and sources of measurement error
- Implications of actuator delays and sensor errors
- Inertial error propagation and GNSS augmentation
- Kalman filter variants and their application to UAV navigation

<u>to understand:</u>

- Mathematical models for estimation and control of UAVs
- UAV state estimation and control loop design
- UAV control allocation

<u>to apply:</u>

- Implement attitude and altitude estimation using real sensor data
- Design and tune controllers for UAV dynamics in simulation and on real airborne UAVs

<u>to transfer:</u>

- Apply state estimation and control techniques to mobile robots or other systems (e.g. automotive)
- Use robust sensor fusion in embedded systems under real-time constraints

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and lab and 94 hours of self-study.

Advanced UAV Sensor Fusion and Control – Seminar: 3 SWS (Sem)
Advanced UAV Sensor Fusion and Control – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the lab part of the module. Successful fulfilment of prerequisites is measured by the completion of laboratory exercises.
The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Jan Zwiener

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes

Recommended:

- Wendel, Jan.: Integrierte Navigationssysteme: Sensordatenfusion, GPS und Inertiale Navigation , 2nd Edition, Oldenbourg Wissenschaftsverlag GmbH, 2011, ISBN: 978-3-486-70439-6
- Stephan, Johannes: Multicopter Flight Control Fundamentals of Flight Mechanics, Control Allocation, and Control Design , 2025, Springer, ISBN: 978-3-031-78487-3
- Wang, Liuping: Model Predictive Control System Design and Implementation Using MATLAB , 2009, Springer, ISBN: 978-1-84882-330-3

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MC05 Advanced Wireless Communication Techniques

1.0 Modulname
Advanced Wireless Communication Techniques

1.1 Modulkürzel
MC05

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Communications

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Advanced Wireless Communication Techniques – Seminar
Advanced Wireless Communication Techniques – Lab

2.1 Inhalt
Content of course "Advanced Wireless Communication Techniques - Seminar":
Participants will be exposed to and gain working experience with advanced modulation schemes, multiple antenna transmitters and receivers, parameter and synchronization techniques, and channel coding schemes. The course will cover:

- Detection and estimation of parameters in white Gaussian noise
- Multicarrier modulation
- OFDM
- Vector coding
- Filter-bank multi-carrier
- Synchronization and parameter estimation
- Capacity of wireless channels
- Water-filling optimization
- Multi-antenna systems (SIMO, MISO, MIMO)

Content of course "Advanced Wireless Communication Techniques - Lab":
Lab exercises with Matlab and software-defined radio (SDR) modules will cover e.g.

- Implementation of transmitter and receiver (QAM and OFDM)
- Channel capacity and waterfilling optimization
- Multi-antenna systems

3.0 Learning Outcomes
to understand:

- the concepts of estimation theory
- the difference between various multicarrier schemes (advantages/problems)
- the channel capacity of MIMO and multicarrier systems
- multi-antenna concepts

to apply:

- the gained knowledge to design, implement, and evaluate multicarrier transmitters and receivers
- the gained knowledge to calculate the channel capacity of frequency-flat and frequency-selective channels
- the concept of waterfilling (margin-adaptive and rate-adaptive)
- peak-to-average-power reduction techniques

- the gained knowledge to define the parameters of OFDM systems (e.g. pilot patterns, cyclic prefix length, subcarrier spacing, etc.)
- multiple-antenna schemes

to transfer:

- the concepts of optimization approaches to similar parameter estimation, detection, and synchronization problems in communications

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and lab and 94 hours of self-study.

Advanced Wireless Communication Techniques – Seminar: 3 SWS (Sem)
Advanced Wireless Communication Techniques – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / lab (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the lab part of the module. Successful fulfillment of prerequisites are measured by:

- laboratory attendance
- laboratory entrance test
- completion of laboratory preparation tasks

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
summer term

7.0 Modulverantwortliche(r)
Dr. Michael Kuhn

8.0 Literatur
The following literature material will be provided:

- Electronic lecture notes
- Workbook for the lab

Further literature recommendations will be provided during the seminar and are listed in the seminar notes.

MEwp02 Applied Edge-AI on Embedded Accelerators

1.0 Modulname
Applied Edge-AI on Embedded Accelerators

1.1 Modulkürzel
MEwp02

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Applied Edge-AI – Seminar
Applied Edge-AI – Lab

2.1 Inhalt
Content of course "Applied Edge-AI - Seminar":
This course focuses on the specialized hardware accelerators powering modern Edge-AI. The course will cover

- Hardware Architectures for AI Acceleration,
- Embedded Software Stack,
- Deep Learning Optimization for the Edge,
- Real-Time Frameworks,
- Future Trends in Edge-AI

Content of course "Applied Edge-AI - Lab":
Practical design assignments on different hardware platforms are part of the course.

- Sensor Fusion on Edge-TPU
- Multi-Camera Video Analytics on dedicated hardware accelerator
- Visual AI Agent on AI-Enabled SoC

3.0 Learning Outcomes
to understand:

- the cloud-centric vs. edge-centric AI paradigms
- the internal architecture of an AI-enabled SoC
- the understanding the resource requirements for different AI models
- the deep learning optimization for Edge-AI

to apply:

- deploy functional AI pipelines on physical embedded hardware
- configure the embedded Linux environment for peripheral sensors
- select specialized libraries for model deployment on edge devices

to transfer:

- critically evaluate an industrial use case to determine the optimal hardware/software stack
- formulate a deployment strategy for AI models on edge hardware

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Applied Edge-AI - Seminar: 3 SWS (Sem)
Applied Edge-AI - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to have successfully finished laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory review

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Thomas Schumann

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Further literature recommendations will be provided during the lecture.

MEwp05 Applied Low Power Embedded Sensor Systems

1.0 Modulname
Applied Low Power Embedded Sensor Systems

1.1 Modulkürzel
MEwp05

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Applied Low Power Embedded Sensor Systems - Seminar
Applied Low Power Embedded Sensor Systems - Lab

2.1 Inhalt
This module provides knowledge, skills and experience for the selection, design, implementation and test of sensor systems with limited power supply.

The seminar covers:

- Analyzation of multiple design examples of sensor systems: mobile sensors, urban systems without grid connection, systems for temporary measurement in vehicles, systems for energy-autonomous measurement in rural environments and agriculture, systems for use on and under water, and for measurement at infrastructure.
- Application of fundamentals in system design
- Modeling of ambient energy capturing, conversion, storage and consumption
- Applied low power system programming
- Sensor data backend options and usage
- Extended requirements for system deployment

One modern embedded sensor system topic is selected as design example for seminar and laboratory. Students will design the selected sensor system type. Design reviews in the form of short presentation by students are expected during the course. The laboratory gives room to test the design assumptions, to experience the design requirements using the physical setup, and to evaluate the performance of the self-developed solutions.

3.0 Learning Outcomes
to understand:

- different applications and concepts of sensor systems

to apply:

- modeling energy flows, selection of sensor principles and data acquisition, selection of microcontrollers, integration of power-saving programming, energy-efficient data processing and wireless data transmission, robust packaging of sensor systems, test of outdoor application of sensor system

to transfer:

- conversion, storage, and utilization of ambient energy

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total. 56 total hours classroom teaching and 94 hours of self-study.

Applied Low Power Embedded Sensor Systems - Seminar: 3 SWS (Sem)
Applied Low Power Embedded Sensor Systems - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequesites:
In order to write the end-of term exam, it is required to successfully finish the laboratory part of the module. Successful fulfillment of prerequisites are measured by:

- presentations (10 minutes)
- laboratory attendance
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module. 30% of the module grade are obtained by the laboratory during the term.

Examination Type: Written exam (70%) at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Thorsten Meiß

8.0 Literatur
Literature recommendations will be provided during the lecture.

MPwp03 Automotive Electrical Powertrain

1.0 Modulname
Automotive Electrical Powertrain

1.1 Modulkürzel
MPwp03

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Automotive Electrical Powertrain - Seminar
Automotive Electrical Powertrain - Lab

2.1 Inhalt
The aim of this course is to provide students with a solid background in automotive electrical powertrain. Emphasis is placed on the seamless workflow from physical system understanding to selection of building blocks and methods of validation.
Fundamentals:

- powertrain topologies of electric vehicles
- components of the electrical power train
- electrical on-board power network
- energy storage – technology, selection criteria and comparison
- power electronics, electrical machines and motor control – technology, selection criteria and comparison
- component sizing
- physical basics and dynamic vehicle model
- tractive effort, power flow and energy consumption
- Design of electric drives and acutators
- Requirements for concept development
- Various electric machines in automotive powertrain
- Test and validation methods

3.0 Learning Outcomes
The aim of the module is to provide students with the following levels of competence with regard to the knowledge and skills specified in each case.

to know:
Students know the basics of automotive electrical powertrain, the associated technology with a particular focus on system understanding. They know various criteria for component selection. Students have become familiar with examples in different applications.

to understand:
Students understand the principles of different concepts and are familiar with the selected exemplary fields of technology.
Students understand the concepts and the interaction of the different components of the electrical powertrain.

to apply:
Students are able to design systems and components for automotive electrical powertrain.

Students are able to independently conduct experiments in accordance with scientific standards and interpret their results.
Students learned to identify and formulate subject-specific problems.
Students are able to design and dimension the components of a power train according to the requirements on the performance of the vehicle. They are able to rate and benchmark different technologies.

to transfer:
Students are able to transfer the technology to other domains and problems.

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Automotive Electrical Powertrain – Seminar: 3 SWS (Sem)
Automotive Electrical Powertrain – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to have successfully finished laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
Students should be familiar with the basics electrical machines.

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Jens Hoffmann

8.0 Literatur
Literature recommendations will generally be provided during the seminar.

MA03 Computer Vision

1.0 **Modulname**
Computer Vision

1.1 **Modulkürzel**
MA03

1.2 **Art**
Pflichtfach

1.3 **Modulniveau**
Master / Major Automation

1.4 **Lehrsprache(n)**
English

2.0 **Lehrveranstaltung(en)**
Computer Vision – Seminar
Computer Vision – Lab

2.1 **Inhalt**
Imaging Systems:

- Elements of imaging systems: optics and camera technology
- Imaging chain as a system: lighting, optics, sensors, data transmission and algorithms

Classic computer vision:

- Image formation and digital images
- Image enhancement
- Object recognition techniques (e.g. blob analysis and histogram based segmentation with grayscale and HSV color space)
- Feature based methods (SIFT / ORB)

Geometry based vision and 3D-Sensing:

- Camera models and camera calibration
- Stereo vision
- Principals and applications of time-of-flight and triangulation bases 3D-sensors

Deep Learning for Computer Vision:

- Principals of Convolutional Neural Networks
- Common network architectures for imaging
- Best practices for training: (e.g. data preparation, hyperparameters and evaluation)
- Transfer learning of common CNN architectures and models

Case studies of selected imaging solutions for Automation, Robotics and Industrial Image Processing

3.0 **Learning Outcomes**
to understand:

- the imaging chain as an interaction of physics, geometry, data and algorithms
- principles and limitations of classical and learning-based vision methods
- foundations of camera calibration, stereo vision and their applications
- working principles of CNNs
- the uses and limitations of computer vision through practical case studies

to apply:

- to select appropriate lighting, lenses, sensors and algorithms for a given vision task
- to perform camera calibration using suitable models and image sets
- to configure classical image processing and feature-based methods and to train and adapt given deep learning architectures using appropriate datasets, splits and evaluation criteria

to transfer:

- to transfer vision concepts to new problems in Robotics, Automation and Industrial Image Processing
- to critically assess whether classical, learning-based or hybrid approaches are fit for purpose

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Computer Vision – Seminar: 3 SWS (Sem)
Computer Vision – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the lab part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory reports

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam or practical exam on PC.

The exact examination type will be communicated at the start of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

winter term

7.0 Modulverantwortliche(r)

Dr. Johannes Gregori

8.0 Literatur

Recommended:

- Szeliski: Computer Vision: Algorithms and Applications
- Elgendy: Deep Learning for Vision Systems
- Steeger, Ulrich, Widemann: Machine Vision Algorithms and Applications
- Hartley, Zissermann: Multiple View Geometry

Further literature recommendations will be provided during the lecture.

MP06 Control of Power Electronic Converters

1.0 Modulname
Control of Power Electronic Converters

1.1 Modulkürzel
MP06

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Power Engineering

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Control of Power Electronic Converters - Seminar
Control of Power Electronic Converters - Lab

2.1 Inhalt
Fundamentals:

- Transformations and coordinate systems (Park- and Clarke-transformation)
- Standard controller design methods for PID Controllers with regard to converter systems
- Sensors for controlling power electronic converter systems (Voltage, current, speed, and position)
- Phase-locked loop (PLL) and its applications in power electronic converter systems

Control of electrical drives:

- Generic modelling of linear and nonlinear synchronous machines (PMSM, IPMSM, RSM, etc.)
- Basic modelling of two-level inverters for control purposes (e. g., impact of interlock time)
- Field-oriented control (structure and design of current-, speed-, and position controllers)
- Operation strategies for linear synchronous machines (MTPA, FW, MTPV, etc.)
- Outlook on advanced techniques like encoderless and predictive control

Control in AC grids/transmission networks:

- Modelling approaches for AC grids/transmission networks
- Control of grid-following and grid-forming voltage-source converter systems
- Power and frequency control, stability
- Potential examples: Control of PV systems, wind turbine systems, and High-Voltage Direct Current (HVDC) systems

3.0 Learning Outcomes
know:

- principle operation strategies of synchronous machines,
- advanced techniques like encoderless and predictive control for controlling electrical drives,
- classification of stability phenomena in AC grids/transmission networks.

understand:

- the role of coordinate transformations for simplifying control problems,
- how controllers can be designed for drive and grid-connected applications,
- the impact of sensor characteristics on control performance,
- the function of PLLs in drive and grid-connected applications,
- how drives and AC grids/transmission networks can be modelled for control purposes,

- the principles of grid-following and grid-forming voltage-source converter systems,
- the structure of field-oriented control (FOC) for current, speed, and position control,
- the principles of power and frequency control in AC grids.

apply:

- are able to design and optimize PID controllers for drive and grid-connected applications on an experimental stage,
- can design the principal structure of current, voltage, speed, and position control for drive and grid-connected applications,
- can design PLL-based synchronization for grid-connected converters on an experimental level,
- are able to design power and frequency control on a prototype level.

transfer:

- can analyze high-level requirements, identify candidate converter control schemes, and refine control strategies.

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours of classroom teaching and 94 hours of self-study.

Control of Power Electronic Converters - Seminar: 3 SWS (Sem)
Control of Power Electronic Converters - Laboratory: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:
In order to participate in the module exam, it is required to successfully complete the laboratory part of the module. Successful fulfilment of prerequisites is measured by:

- laboratory attendance
- completion of laboratory assignments
- laboratory reports

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

summer term

7.0 Modulverantwortliche(r)

Dr. Matthias Laumann

8.0 Literatur

The following literature material will be provided

- Electronic Lecture Notes

Further literature recommendations will be provided during the seminar / are included in the seminar material.

MP03 Electrical Drives and Actuators

1.0 Modulname
Electrical Drives and Actuators

1.1 Modulkürzel
MP03

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Power Engineering

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Electical Drives and Actuators – Seminar
Electical Drives and Actuators – Lab

2.1 Inhalt
The aim of this course is to provide students with a solid background in electrical drives and actuators with a focus on stationary application as renewable energies and various mobile application (ie. automotive industry). Emphasis is placed on the seamless workflow from physical system understanding to selection of building blocks and methods of validation.

Fundamentals:

- Energy Conversation
- Design of electric drives and acutators
- Requirements for concept development
- Various electric machines and their control
- Switch-Mode-Power-Electronics
- Special machines

Electric Drives:

- Induction motor and PMAC motor
- Space Vector Control
- Examples in renewable energy systems, stationary and mobile applications
- Test and validation methods

Actuators:

- Brushed and brushless DC motors
- Elements of actuators
- Test and validation methods
- Selection of applications

3.0 Learning Outcomes
The aim of the module is to provide students with the following levels of competence with regard to the knowledge and skills specified in each case.

to know:
Students know the basics of electric drives and actuators, the associated technology with a particular focus on system understanding. They know various criteria for component selection. Students have become familiar with examples in stationary and mobile applications.

to understand:
Students understand the principles of different concepts and are familiar with the selected exemplary fields of technology.

to apply:
Students are able to design systems and components for electric drives and actuators.
Students are able to independently conduct experiments in accordance with scientific standards and interpret their results.
Students learned to identify and formulate subject-specific problems.

to transfer:
Students are able to transfer the technology to other domains and problems.

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Electical Drives and Actuators – Seminar: 3 SWS (Sem)
Electical Drives and Actuators – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to have successfully finished the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter term

7.0 Modulverantwortliche(r)
Dr. Jens Hoffmann

8.0 Literatur
Literature recommendations will generally be provided during the seminar.
Recommended:
MOHAN, Ned und RAJU, Siddharth, 2021. Analysis and control of electric drives : simulations and laboratory implementation.
Hoboken: John Wiley & Sons, Inc. ISBN 9781119584537.

ME05 Embedded Architectures and Applications

1.0 Modulname
Embedded Architectures and Applications

1.1 Modulkürzel
ME05

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Embedded Systems

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Embedded Architectures and Applications - Seminar
Embedded Architectures and Applications - Lab

2.1 Inhalt
Content of course "Embedded Architectures and Applications - Seminar":
Participants will be exposed to and gain working experience with complex embedded systems and architecture development. The course will cover:

- system engineering of embedded applications
- architectural development of embedded, realtime, multitasking systems
- analysis of embedded industrial architectures and design patterns (Basic Software, Application Software, Runtime Environment)
- peripheral driver design and driver configuration
- distributed systems and communication services
- embedded control system design
- design and implementation of embedded runtime environments (e.g. AUTOSAR RTE)
- design of reactive systems, state machine design and coding pattern,
- systematic error detection and handling
- model based code generation (e.g. Matlab)
- multicore architectures

Content of course "Embedded Architectures and Applications - Lab":
Practical programming assignments in C/C++ using state of the art operating systems are part of the course.

- Configuring an embedded Operating System and Runtime Environment
- Developing a simple multithreading, reactive application
- Separating basic software and application software introducing a runtime environment

3.0 Learning Outcomes
to understand:

- the functionality of embedded operating systems
- the challenges and risks of multithreading architectures
- the structure of multicore controllers
- key design patterns of industrial embedded architectures

to apply:

- the gained knowledge to implements tasks and intertask communication on embedded controllers
- design and implement flat statemachines

- review, test and debug multithreading applications
- separate base and application software using the concepts of embedded runtime environments

to transfer:

- the design patterns and concepts to more complex embedded architectures using new operating systems and controllers.

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Embedded Architectures and Applications - Seminar: 3 SWS (Sem)
Embedded Architectures and Applications - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to have successfully finished the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- successful completion of the individual laboratory assignments
- successful participation in a technical discussion

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam covering the complete content of the module at the end of the semester.

Examination Duration: 90 minuten

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
- Good knowledge of microcontroller architectures and peripherals
- Good knowledge of embedded C/C++
- Basic Understanding of Realtime Operating Systems (RTOS)

6.2 Empfohlenes Fachsemester
summer term

7.0 Modulverantwortliche(r)
Dr. Peter Fromm

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Further literature recommendations will be provided during the seminar / are included in the seminar material.

MEwp01 Embedded Communication

1.0 Modulname
Embedded Communication

1.1 Modulkürzel
MEwp01

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Embedded Communication - Seminar
Embedded Communication - Laboratory

2.1 Inhalt
The module covers communication principles, interfaces and protocols used in modern embedded systems.
Students investigate, implement and analyze wired and wireless communication mechanisms in distributed embedded applications.

Topics may include:

- fundamentals of embedded communication systems
- synchronous and asynchronous communication
- serial communication interfaces and protocols
- local and distributed embedded networks
- real-time and deterministic communication
- sensor and actuator communication
- wired and wireless communication technologies
- low-power communication concepts
- protocol architecture and message handling
- communication timing, latency and synchronization
- robustness, fault handling and diagnostics
- protocol analysis, debugging and measurement techniques
- interoperability between heterogeneous embedded systems
- integration of embedded nodes into distributed applications

Practical hands-on exercises and project work may include the implementation, evaluation and analysis of communication interfaces and distributed embedded systems using contemporary embedded hardware and software platforms.

3.0 Learning Outcomes
After successful completion of the module, students are able to:

- explain fundamental concepts of communication in embedded systems
- select suitable communication technologies and protocols for embedded applications
- design and implement wired and wireless communication interfaces
- integrate distributed embedded nodes into heterogeneous systems
- analyze communication behavior with respect to timing, reliability and resource constraints
- apply methods for debugging, measurement and protocol analysis
- evaluate communication architectures regarding bandwidth, latency, robustness and energy efficiency

- develop and document practical embedded communication solutions in small teams
- present and discuss technical concepts and implementation results in a scientific and engineering-oriented context

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Embedded Communication - Seminar: 3 SWS (Sem)
Embedded Communication Integrated - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Type: oral presentation or practical exam covereing the complete content of the module at the end of the semester.

The exact format of the examination will be communicated at the start of the module.

Exam Duration: 20 minutes (oral presentation), 90 minutes (practical exam)

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
Prior experience with embedded systems, microcontroller programming in C/C++, and basic communication interfaces is recommended.

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Eiken Lübbers

8.0 Literatur
Literature recommendations will be provided during the seminar.

ME07 Embedded Signal Processing Systems

1.0 Modulname
Embedded Signal Processing Systems

1.1 Modulkürzel
ME07

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Embedded Systems

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Embedded Signal Processing Systems - Seminar
Embedded Signal Processing Systems - Lab

2.1 Inhalt
Embedded Signal Processing Systems - Seminar:
The aim of this course is to provide students with a solid understanding of the design of complex embedded signal processing systems using modern microcontroller and FPGA architectures. Key topics include the design, modeling, and simulation of DSP algorithms, as well as their efficient hardware/ software implemen-tation on state-of-the-art processing platforms. In particular, the course covers the following subjects:

- Introduction to modern digital signal processing systems, including emerging applications, architectures, and design challenges.
- Theory of discrete-time systems and fixed-point arithmetic.
- Processing architectures for signal processing: DSP-specific features of microcontrollers and FPGAs, such as SIMD/DSP instructions, MAC units, and optional floating-point support.
- Design and implementation of digital filters, including FIR and IIR filter design and specification, retiming techniques (cut-set and delay scaling).
- Digital signal synthesis techniques: direct digital synthesis (DDS) using phase accumulators, CORDIC-based signal generation, and recursive (IIR-based) oscillators.
- Digital correlator architectures, including auto-correlation and cross-correlation techniques.
- Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT) algorithms and architectures, and design issues related to word-length growth and numerical accuracy.

Embedded Signal Processing Systems – Lab:
The lab focuses on developing practical skills in the design and implementation of embedded signal processing systems using C and SystemVerilog. In particular, students will work on:

- Analysis, modeling, and simulation of digital signal processing algorithms.
- Mapping DSP algorithms (e.g., digital filters and signal synthesis techniques) to microcontroller and FPGA platforms.
- Hardware/software implementation, profiling, and benchmarking of the resulting solutions.

3.0 Learning Outcomes
to understand:

- architectural features of modern digital signal processing systems.
- tools, design flows, and methodologies for embedded DSP development.
- fundamental strategies for mapping DSP algorithms to hardware and software platforms.

to apply:

- analyze, model, and simulate dedicated DSP algorithms.
- transform floating-point DSP algorithms into fixed-point implementations
- implement fixed-point DSP algorithms on state-of-the-art hardware/software platforms
- explore design trade-offs between real-time performance, implementation complexity, and re-source usage, and relate implementation results to high-level design decisions.

to transfer:

- transfer learned patterns and methodologies to more complex DSP design scenarios in order to derive optimized hardware/software solutions under constraints such as cost, performance, and power consumption.

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Embedded Signal Processing Systems - Seminar: 3 SWS (Sem)
Embedded Signal Processing Systems - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- Technical discussion at the end of the Lab

The laboratory rules and assessment criteria will be communicated at the start of the module. 25% of the module grades are obtained by the laboratory part during the term.

Examination Type: Written exam (75%) covering the complete content of the module at the end of the semester.

Examination Duration: 90 minuten

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

summer term

7.0 Modulverantwortliche(r)

Dr. Christian Jakob

8.0 Literatur

The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Further literature recommendations will be are included in the seminar material.

MC07 Fields and Waves

1.0 Modulname
Fields and Waves

1.1 Modulkürzel
MC07

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Communications

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Fields and Waves – Seminar
Fields and Waves – Lab

2.1 Inhalt
The goal of the module is to treat electromagnetic (EM) theory concepts in depth, which were used in a variety of applications in different communications engineering fields like microwave engineering, optical communications, electromagnetic compatibility, mobile and satellite communications, radar technology, antenna engineering etc.

Fields and Waves – Seminar:
The lecture is covering topics like

- Maxwell's equations,
- fields in different media,
- the wave equation and basic plane wave solution,
- plane wave reflection from a media interface,
- polarization,
- basic antenna concepts,
- transmission lines and waveguides,
- simulation methods.

Fields and Waves - Lab:
In the laboratory part where state-of-the-art CAD (computer aided design) tools are applied to design and analysis of exemplary applications of the concepts covered in the lecture, e.g.

- Design and analysis of antennas
- Analysis of transmission lines and optical waveguides

3.0 Learning Outcomes
to understand:

- principles and structures of:
  - RF transmission lines
  - waveguides
  - antennas
- fundamental concepts, terminology, and models of electromagnetic theory
- Maxwell's Equations and their relevance to electromagnetic field behavior
- physical mechanisms of transmission, reflection, and attenuation in transmission lines
- operating principles of waveguides and antennas across microwave and optical spectra
- the influence of geometry and material properties on EM field distribution and propagation

- the role of electromagnetic theory in RF and optical engineering applications

to apply:

- Maxwell's equations to design RF transmission lines, waveguides, and antenna structures
- simulation software tools to model and characterize EM systems

to transfer:

- the theoretical and conceptional knowledge to the design, implementation and measurement process

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Fields and Waves – Seminar: 3 SWS (Sem)
Fields and Waves – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the lab part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
summer term

7.0 Modulverantwortliche(r)
Dr. Manuel Rosenberger

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Descriptions for the laboratory for numerical simulations or measurements

Further literature recommendations will be provided during the seminar.

ME04 FPGA-based System on Chip Design

1.0 Modulname
FPGA-based System on Chip Design

1.1 Modulkürzel
ME04

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Embedded Systems

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
FPGA-based System on Chip Design - Seminar
FPGA-based System on Chip Design - Lab

2.1 Inhalt
FPGA-based System on Chip Design – Seminar:
The aim of this course is to provide students with a solid and comprehensive understanding of the design of complex FPGA-based System-on-Chip (SoC) architectures. The course covers the complete development flow, starting from high-level functional specifications through design, implementation, and verification, up to deployment and testing on modern FPGA SoC platforms. Both hardware description languages and embedded software programming are addressed. In particular, the course covers the following topics:

- Introduction to FPGA-based System-on-Chip design, including applications, architectures, and design challenges.
- Architecture and internal structure of modern embedded System-on-Chip platforms.
- Hard Processor Systems and FPGA fabric: configuration, boot process, and system integration.
- RTL hardware design using SystemVerilog, including simulation and functional verification.
- Design methodologies for timing closure, multi-clock domain systems, and clock-domain crossing synchronization techniques.
- Design strategies targeting performance, area, and power optimization.
- Embedded processor systems in FPGA SoCs: hard and soft processors, on-chip bus architectures, and memory-mapped interfaces.
- Design and implementation of custom hardware accelerators, including co-processor integration, ISA customization, and the development of efficient hardware/software interfaces.
- High-Level Synthesis (HLS): algorithmic design and interface synthesis, design-space exploration, performance evaluation, and optimization.

FPGA-based System on Chip Design – Lab:
The lab focuses on teaching practical skills related to FPGA-based System-on-Chip design using C and SystemVerilog. In particular, students will work on:

- Design and implementation of custom hardware accelerators, including co-processors and ISA ex-tensions.
- Hardware/software integration of custom accelerators into existing FPGA-based SoC architec-tures.
- Profiling, performance analysis, and benchmarking of the implemented solutions.

3.0 Learning Outcomes
to understand:

- the architecture of FPGA-based System-on-Chip (SoC) platforms and their role in modern electronic system design.
- tools, design flows, and methodologies for FPGA-based SoC development.
- core principles of hardware/software co-design.

to apply:

- partition software applications into dedicated hardware and software components.
- apply design patterns and methodologies to application-specific problems in order to derive optimized FPGA SoC hardware/software solutions with respect to performance, power, and resource constraints.
- analyze existing hardware/software architectures, identify performance bottlenecks, and improve system efficiency through appropriate hardware/software mapping.
- optimize hardware/software architectures through transformations at both hardware and software levels.
- evaluate implementation results (e.g., timing, resource utilization, power consumption) and relate them to high-level design decisions.

to transfer:

- transfer and adapt hardware/software co-design concepts to new FPGA-based SoC platforms and application domains, and justify architectural decisions based on quantitative metrics and system-level trade-offs.

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

FPGA-based System on Chip Design - Seminar: 3 SWS (Sem)
FPGA-based System on Chip Design - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- technical discussion at the end of each lab

The laboratory rules and assessment criteria will be communicated at the start of the module. 25% of the module grades are obtained by the laboratory part during the term.

Examination Type: Written exam (75%) covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

winter term

7.0 Modulverantwortliche(r)

Dr. Christian Jakob

8.0 Literatur

The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Further literature recommendations will be are included in the seminar material.

MP01 High Voltage Systems Engineering

1.0 Modulname
High Voltage Systems Engineering

1.1 Modulkürzel
MP01

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Power Engineering

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
High Voltage Systems Engineering – Seminar
High Voltage Systems Engineering – Lab

2.1 Inhalt
Seminar:

- System Engineering Fundamentals like System Life Cycle, V-model and development phases.
- Methods and Tools like Requirements Specification, Use Cases, Risk and Hazard analysis (FEM calculations, FMEA, FMECA, Hara) and Basics of Model-based Systems Engineering.
- Use-case analysis based on Requirements Engineering (creepage and arcing distances, electrical field strength, failure discharges) and System Architecture of HV systems (industrial and electric vehicles applications).
- Deriving HV-specific system and component requirements like insulation coordination, thermal management and mechanical behavior of single components for different insulating media (gases, liquids, solids) considering the relevant standards.
- High-level architecture of a multi-HV-component-arrangement and evaluation of the dielectric behavior of the insulating system based on given technical requirements.
- Selected Methods of Systems Engineering to optimize the dielectric/thermal and mechanical behavior of multi-component-systems (i.e. model-based effect chain analysis).
- Verification, Validation and Testing of HV systems

Laboratory:

- Investigations on High Voltage Insulation Systems applied to Lightning Impulse Voltage Stress.
- Dielectric optimization of a Multi-Component-Insulating System with regard to AC-, DC- and Lightning Impulse Voltage behavior and proof by related tests.
- Investigations on the Partial Discharge Behavior of selected HV components and systems. Recognition of failure patterns.

3.0 Learning Outcomes
to understand:

- the Systems Engineering Principles (V-model, requirement engineering, architecture, verification & validation).
- the Model-based systems engineering (MBSE) approaches to describe and analyze HV systems.
- the implications of dielectric HV specifics like arcing distance, creepage distance, maximum electric field strength and discharges for system design and requirements.
- the behavior or HV components and systems in case of lightning impulse stress (based on lecture and lab)

to apply:

- To apply stakeholders needs into technical requirements for High Voltage Systems.
- To develop system architectures for HV components and HV systems.
- Dielectric, mechanical and thermal dimensioning rules to HV components and systems.
- Optimization of existing HV components and systems based on learnings from the lecture and the lab.
- Quality insurance of HV systems based on innovative measuring methods like Partial Discharge Measurements (see lab).

to transfer:

- Transfer design, test procedures and system architectures to other applications (based on lecture and lab).
- To classify dielectric failure types of new insulation systems by use of Partial Discharge Measurement (based on lecture and lab).

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

High Voltage Systems Engineering - Seminar: 3 SWS (Sem)
High Voltage Systems Engineering - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

winter term

7.0 Modulverantwortliche(r)

Dr. Thomas Betz

8.0 Literatur

The following literature material will be provided

- Electronic Lecture Notes

- Workbook for the Lab

Further literature recommendations will be provided during the seminar.

MAwp04 Human Machine Interaction (HMI)

1.0 Modulname
Human Machine Interaction (HMI)

1.1 Modulkürzel
MAwp04

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Human Machine Interaction (HMI) – Seminar
Human Machine Interaction (HMI) – Lab

2.1 Inhalt
This module provides an introduction to the design and implementation of human-machine interfaces.

Human Machine Interaction (HMI) – Seminar:

- Human senses and perception
- Interaction channels between humans and machines
- General design aspects
- Modeling of user interaction (UML-based architecture design)
- Usability / user experience
- Multi-modal human machine interfaces (widgets, IO, WIMP and post-WIMP interfaces)
- Testing (software, user and field tests)
- Psychological aspects in HMI

Human Machine Interaction (HMI) – Lab:

- Requirements elicitation
- Identification of user interfaces
- Selection of appropritae interaction means
- (AI-based) implementation of software mock-ups
- Documentation and presentation of mock-up implementations

3.0 Learning Outcomes
to know: mechanisms of human senses and perception; rules for UI design

to understand: concepts of good design; elements of UI/UX

to apply: modeling of human machine interaction; user testing and surveys

to transfer: design and implementation of multi-modal user interfaces

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Human Machine Interface (HMI) - Seminar: 2 SWS (Sem)
Human Machine Interaction (HMI) – Lab: 2 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / lab (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to have successfully finished the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments
- technical discussion at the end of each lab

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam or oral presentation at the end of the semester covering the complete content of the module.

The exact examination type will be communicated at the start of the module.

Exam Duration: 90 minutes (written exam), 20 minutes (oral presentation)

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Christian Bürgy

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Recommended:

- Dix, F.; Abowd, B.: Human-Computer Interaction, 3rd Edition, Pearson Education Ltd., 2004978-0130461094
- Norman, D.: The Design of Everyday Things, revised and expanded edition, Basic Books, 2013, ISBN: 978-0-465-05065-9
- Scott MacKenzie: Human-Computer Interaction: An Empirical Research Perspective, 2013, Morgan Kaufmann; ISBN: 978-0124058651

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MCwp03 Image and Video Processing

1.0 Modulname
Image and Video Processing

1.1 Modulkürzel
MCwp03

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Major Communication

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Image and Video Processing – Seminar
Image and Video Processing – Lab

2.1 Inhalt
The course will cover an introduction to the following areas:

- Image and Video processing techniques such as e.g.:
  - Fundamentals of digital image and video representation.
  - Intensity transformations and spatial filtering.
  - Frequency domain processing

- Modern Machine Learning Architectures for:
  - Pattern Recognition (e.g., Convolutional Neural Networks. Vision Transformers).
  - Image Segmentation and Object Detection (e.g., U-Nets, YOLO Networks).
  - Reconstruction & Denoising (e.g., Convolutional Neural Networks.)
  - Image and Video Generation (e.g., Diffusion Models, Generative Adversarial Networks, Autoencoders).
  - Video frame prediction/generation (e.g., Convolutional Neural Networks, Long Short Term Memory networks, Vision Transformers).

3.0 Learning Outcomes
to know:
- Sophisticated methods for image and video processing.
- Modern Machine Learning Architectures for Image and Video Processing

to understand:
- Fundamentals of digital image and video representation
- Fundamentals of Machine Learning for Image and Video Processing.

to apply:
- Basic image and Video Processing algorithms.
- Modern Machine Learning Architectures in the Context of Image and Video Processing.

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and lab and 94 hours of self-study.

Image and Video Processing – Seminar: 3 SWS (Sem)
Image and Video Processing – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / lab (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:

In order to participate in the module exam, it is required to successfully finish the lab part of the module. Successful fulfillment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam or oral exam (will be communicated upon start of the module) covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes (written exam), 20 minutes (oral exam)

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
Advanced Digital Signal Processing & AI.

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Georgi Nikolov

8.0 Literatur
The following literature material will be provided:

- Electronic lecture notes

Further literature recommendations will be provided during the seminar.

M03 Industrial Project (BPP)

1.0 Modulname
Industrial Project (BPP)

1.1 Modulkürzel
M03

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / all Majors

1.4 Lehrsprache(n)
English / German

2.0 Lehrveranstaltung(en)
German Class 1 and 2 – Seminar
Company Presentations - Lecture
Internship

2.1 Inhalt
Content of German Class:

- German Class 1: A1 level or higher
- German Class 2: A2 level or higher

Content of Company Presentations:
Presentations of different companies about various engineering job possibilities. The presenters are generally industry representatives; this is intended to ensure the authenticity and up-to-dateness of the presentations. They give inside to their company, their products, daily life of an engineer, job description and application process.

Content of Internship:
The student has to solve an engineering task in the area of electrical engineering and information technology under the guidance of an industrial supervisor and an academic supervisor. This internship work can involve one of the following areas:

- Research and development work
- Project planning and design
- Manufacturing, preparation of work
- Assembly
- Test bed, quality control

3.0 Learning Outcomes
The objectives of the German Classes are as follows:

- Every student has to extend her/his level by at least 2 competence levels (one competence level is represented by two courses e.g. A1.1 plus A1.2)

The objectives of the internship and company presentations are as follows:

- Create a linkage between the studies and the world of work
- Orientation in the profession strived for
- Get to know technical and organizational contexts
- Involvement in the process of work
- Practical training in the engineering trade in one or several projects.

4.0 Arbeitsaufwand und Credit Points
30 CP / 900 hours in total, including 168 hours classroom teaching

German Class 1 – Seminar: 6 SWS (Sem)
German Class 2 - Seminar: 6 SWS (Sem)
Internship: 6 month full-time work in a company

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
- The German classes are divided into an intensive and an extensive phase. The extensive courses are offered every semester, the intensive courses are offered in the semester break.
- Company presentations are offered every semester.
- The internship can be started any time upon approval by the examination board

4.2 Veranstaltungsart
Lecture, seminar, internship

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
German Classes

Examination Prerequisites (German Class 1 & 2):

In order to write the end-of term exam, it is required

- to attend a minimum of 75% all classes
- to attend "German 2", it is necessary to have successfully completed "German 1"

The examination prerequisites are ungraded.

Examination type:
A combined written and oral examination covering the complete content of the module will be offered in each class at the end of the semester. The examination specifics will be communicated at the start of the course. The exam duration is 90 minutes. The examination is ungraded.

Internship

Examination Prerequisites:

- at least 45 CP credits from semester 1 and 2
- at least one level of the German language courses (two courses) successfully completed, with a minimum proficiency level of A1.2.
- Company presentations attended

Examination Type:
Technical report on their internship work with a typical range of 30 to 40 pages. The report shall be submitted to the academic supervisor at the latest 2 weeks after the work has ended. The internship report is ungraded.

The successful completion of the internship part is acknowledged by the academic supervisor, provided that the prerequisites defined in the BBPO are fulfilled. The internship is ungraded.

6.0 Notwendige Kenntnisse
The necessary prerequisites are defined in the BBPO.

6.1 Empfohlene Kenntnisse
All mandatory modules of semester 1 and 2.

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Stephan Bannwarth

8.0 Literatur
Literature recommendations will be provided during the lecture / internship.

MA05 Industry 4.0 / IIoT and the Digital Factory

1.0 Modulname
Industry 4.0 / IIoT and the Digital Factory

1.1 Modulkürzel
MA05

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Automation

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Industry 4.0/IIoT and the Digital Factory – Seminar
Industry 4.0/IIoT and the Digital Factory – Lab

2.1 Inhalt
Participants will be exposed to and gain working experience to design, implement, verify and validate safe systems in industrial automation. The course will cover:

- Goals and Key technologies for modern production
- Basics of Industry 4.0, IoT and Digital transformation, Structures of modern production systems
- Product identification systems, e.g. RFID, 2D Codes
- Data acquisition and data exchange, e.g. OPC UA, MQTT
- Simulation systems (HIL/SIL, virtual commissioning, material flow and energy consumption simulation)
- Product lifecycle management and product data management (PLM / PDM)
- Manufacturing execution systems (MES)
- Enterprise resource planning systems (ERP)
- Remote control, Security and safety in industrial automation
- Assistance systems, e.g. VR and AR
- Cloud computing
- Machine Learning
- Sustainable Manufacturing
- Data driven businesses and identification of use cases

3.0 Learning Outcomes
<u>to understand:</u>

- the goals and key technologies of the digital transformation of manufacturing systems
- the structure of modern production systems
- the possibilities, the advantages and the challenges of digitalized production
- the characteristics and possibilities of appropriate product identification systems
- the basics of security for digitalized companies
- the basics of MES, ERP, PLM/PDM, Assistance systems and cloud computing
- data driven businesses and how to identify use cases

<u>to apply:</u>

- implementing und using data acquisition systems, e.g. OPC UA
- implementing digital twins and using simulation systems for virtual commissioning
- implementing and using machine learning in the manufacturing context
- developing ideas for new business processes of digitalized production companies

to transfer:
Students shall be able to play a significant role in the digital transformation of companies, by being able

- to give impulses and develop scenarios for the digitalization of production companies
- to choose appropriate information technologies/components, to judge about the advantages and challenges of these technologies and
- to implement the communication between the information technology and the control system.

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Industry 4.0/IIoT and the Digital Factory – Seminar: 3 SWS (Sem)
Industry 4.0/IIoT and the Digital Factory – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
summer term

7.0 Modulverantwortliche(r)
Dr. Benjamin Menz

8.0 Literatur
The following literature material will be provided:

- Electronic Script (excerpt of slides)
- Workbook for the lab

Further literature recommendations will be provided during the lecture or are included in the lecture material.

MC04 Information Networks

1.0 Modulname
Information Networks

1.1 Modulkürzel
MC04

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Communications

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Information Networks - Seminar
Information Networks - Lab

2.1 Inhalt
Information Networks - Seminar:

- OSI protocol stack for the WAN
- Optical transport networks (Layer 1 and 2 in WAN)
- Layer 2 protocols for network access
- Packet Swichting Architectures (e.g. MPLS and SRv6)
- Development from IPv4 to IPv6
- Dynamic Routing in the WAN
- Software Defined Networks (SDN) and SD-WAN
- Quality of Service

Information Networks - Lab will cover e.g.:

- Routing
- Software defined networks
- Quality of Service

3.0 Learning Outcomes
to understand: OSI protocol stack for the WAN, Optical transport networks (Layer 1 and 2 in WAN), Layer 2 protocols for network access, Packet Swichting Architectures (e.g. MPLS and SRv6), Dynamic Routing in the WAN

to apply: Development from IPv4 to IPv6

to transfer: Routing, software defined networks, quality of service

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and lab and 94 hours of self-study.

Information Networks - Seminar: 3 SWS (Sem)
Information Networks - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:

In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory entrance test
- optional presentation

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

winter term

7.0 Modulverantwortliche(r)

Dr. Jakob Belschner

8.0 Literatur

The following literature material will be provided

- Electronic Lecture Notes

Further literature recommendations will be provided during the seminar / are included in the seminar material.

MNTwp01 Legal English

1.0 Modulname
Legal English

1.1 Modulkürzel
MNTwp01

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Legal English for Engineers - Seminar

2.1 Inhalt
Safety and security:

- Current and future legal framework (of eg. autonomous driving) in European countries and North America
- Vehicle design in accordance with various legal frameworks
- Legal responsibilities (Government, Manufacturer, Consumer) regarding design, manufacturing etc.

Contracts:

- Reading and understanding service agreements and manufacturing contracts
- Legal jargons for technicians

Legal aspects of doing business:

- Right and responsibilities of Manufacturers under contracts
- General and specific Liabilities issues in Industry agreements
- Patents, design rights etc.

Professional Presentations in a Legal–Technical Context:

- Structuring and delivering technical and legal presentations in English
- Presenting legal information to non-legal stakeholders (engineers, managers, clients)
- Explaining complex legal frameworks clearly, accurately, and persuasively
- Using appropriate legal and technical terminology in spoken communication
- Visual support (slides, diagrams, summaries) for legal–technical content

3.0 Learning Outcomes
This course will help students develop both a theoretical and practical understanding of legal English in an Engineering context.

to know: How to read, analyze and conform to legal framework and requirements

to understand: How to understand basic and technical legal agreements as they relate to the field of Engineering

to apply: How to utilize legal jargons and terminology in spoken and written form in practice

to transfer: How to be able to transfer legal knowledge in daily tasks and services.

Students will be able to communicate at the level B2 according to CEFR.

Students will also be able to:

- Present legal and regulatory information confidently and coherently in English
- Adapt presentations to different audiences (technical experts, non-technical stakeholders, international partners)
- Argue and justify technical and legal positions clearly and professionally
- Respond appropriately to questions and discussion in a legal–technical setting

4.0 Arbeitsaufwand und Credit Points

2.5 CP / 75 hours in total including 34 hours classroom teaching and 41 hours of self-study.

Legal English for Engineers - Seminar: 2 SWS (Sem)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart

The course is structured as a seminar either in block form or on a weekly basis. It is based on lectures, projects, presentations, exercises and group work.

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:

Successful fulfillment of prerequisites are measured by:

- class attendance (in minumum 75% of all classes)
- completion of exercises and tasks
- project work
- project presentations

The rules and assessment criteria will be communicated at the start of the module.
20% of the module grade are obtained by the sucessfull completion of exercises and tasks.
30% of the module grade are obtained by the project presentation.

Examination Type:
Written exam (50%) covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes (written exam)

6.0 Notwendige Kenntnisse

English Language proficiency B2.

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

winter or summer term

7.0 Modulverantwortliche(r)

Dr. Tamara Onnis

8.0 Literatur

Will be provided during the course.

M04 Master Module

1.0 Modulname
Master Module

1.1 Modulkürzel
M04

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / all Majors

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Thesis

Colloquium

2.1 Inhalt
- Practically and/or theoretically oriented scientific work in the area of the chosen Major
- Written thesis
- Colloquium

3.0 Learning Outcomes
Students should demonstrate the following qualifications within the area of the defined topic:

- Capability of independent work
- Systematic analysis and solutions using engineering and scientific methods
- Professional competence in scientific documentation and presentation of results

4.0 Arbeitsaufwand und Credit Points
30 CP / 900 hours in total

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
The master thesis must not exceed 6 months. The master thesis can be started any time upon approval by the examination board.

4.2 Veranstaltungsart
final thesis

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination:

Master Thesis (75 %)
Colloquium (25 %)

The total duration of the colloquium is at least 45 minutes and no more than 60 minutes.

Further details are specified in the BBPO.

6.0 Notwendige Kenntnisse
The necessary prerequisites are defined in the BBPO.

6.1 Empfohlene Kenntnisse
All mandatory modules of study program.

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Christian Weiner

8.0 Literatur
Will be recommended by supervisors.

MCwp07 Mobile and Wireless Networks

1.0 **Modulname**
Mobile and Wireless Networks

1.1 **Modulkürzel**
MCwp07

1.2 **Art**
Wahlpflichtfach

1.3 **Modulniveau**
Master / Majors as communicated by the faculty

1.4 **Lehrsprache(n)**
English

2.0 **Lehrveranstaltung(en)**
Mobile and Wireless Networks - Seminar

2.1 **Inhalt**

- Use cases, frequencies, propagatation channels for mobile and wireless systems, adaptive modulation and coding, multiplexing, duplexing
- Link budgets
- Standardization bodies and principles
- Wireless local area networks
- Wireless personal area networks
- Broadcast systems
- Mobile networks (5G and previous generations)
- Network planning

3.0 **Learning Outcomes**
to understand:

- Fundamentals: Use cases, frequencies, propagatation channels for mobile and wireless systems, adaptive modulation and coding, multiplexing, duplexing
- Standardization bodies and principles

to apply:

- Network planning
- Principles of wireless local area networks, wireless personal area networks, broadcast systems and mobile networks

to transfer:

- Link budgets

4.0 **Arbeitsaufwand und Credit Points**
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

4.1 **Dauer, zeitliche Gliederung und Häufigkeit des Angebots**
Each elective subject will take one semester and may be offered once a year.

4.2 **Veranstaltungsart**
seminar (Sem)

5.0 **Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung**

Examination Type/Duration:
Written examination (90 minutes) or oral presentation (20 minutes) at the end of the semester covering the complete content of the module. The format of the examination will be communicated at the start of the module.

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Jakob Belschner

8.0 Literatur
Literature recommendations will be provided during the lecture / are included in the lecture material.

MA04 Mobile Robotics

1.0 Modulname
Mobile Robotics

1.1 Modulkürzel
MA04

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Automation

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Mobile Robotics – Seminar
Mobile Robotics – Lab

2.1 Inhalt
The module covers fundamental and advanced concepts of mobile robotic systems with a focus on perception, motion, and autonomous behavior. The following topics are addressed:

1) Fundamentals of Mobile Robotic Systems
   - System architecture, components, and classification of mobile robots
2) Kinematics and Motion Models
   - Kinematic models of mobile robots, with emphasis on wheeled robots
3) Sensors and Perception
   - Distance sensors, inertial sensors, and encoders
   - Sensor data acquisition and basic preprocessing
4) Localization and Environment Representation
   - Pose estimation and basic environment representations (e.g. grid-based models)
5) Navigation and Path Planning
   - Cell-based navigation and basic planning and search strategies
6) Control and Behavior Design
   - Motion control, reactive behaviors, and basic decision-making strategies
7) Embedded Implementation for Mobile Robots
   - Real-time constraints, embedded software structures, and hardware integration
8) Practical Mobile Robot Systems
   - Implementation and evaluation of mobile robot applications using real robotic platforms

3.0 Learning Outcomes
The aim of the module is for students to achieve the following competence levels with regard to the specified knowledge and skills:

<u>to understand:</u>
- the principles of mobile robot kinematics, perception, and motion control
- the interaction between sensing, localization, navigation, and decision-making
- grid-based environment representations and their role in navigation and planning
- constraints arising from embedded and real-time robotic systems

<u>to apply:</u>
- kinematic models to describe and analyze the motion of mobile robots
- sensor data for localization, navigation, and control tasks
- navigation and path planning strategies in structured environments
- control and behavior design concepts for mobile robotic systems

to transfer:

- localization, navigation, and control algorithms on mobile robot platforms
- integrated perception–control pipelines for autonomous robot behavior
- mobile robotic applications under embedded and real-time constraints
- experimental evaluation of mobile robot behavior in real or simulated environments

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Mobile Robotics – Seminar: 3 SWS (Sem)
Mobile Robotics – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:

In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory entrance test

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

- fundamentals of sensor data acquisition and actuator control
- basic programming skills in C or C++
- basic knowledge of control systems
- introductory knowledge of robotics or autonomous systems

6.2 Empfohlenes Fachsemester

winter term

7.0 Modulverantwortliche(r)

Dr. Eiken Lübbers

8.0 Literatur

The following literature material will be provided

- Electronic Lecture Notes

Further literature recommendations will be provided during the lecture.

MA06 Model-Based Control of Industrial Robots

1.0 Modulname
Model-Based Control of Industrial Robots

1.1 Modulkürzel
MA06

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Automation

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Model-Based Control of Industrial Robots – Seminar
Model-Based Control of Industrial Robots – Lab

2.1 Inhalt
- Overview on applications, systems and technologies of industrial robot systems
- Kinematic and kinetic models for industrial robots
- Path planning and control algorithms for industrial robots
- Integration of sensors (e.g. force control, visual servoing)
- Prediction and simulation of motor currents during motion
- Model-based control algorithms based on the dynamic model of the robot
- Technological aspects (e.g., accuracy, safety issues, energy consumption)

3.0 Learning Outcomes
to understand:

- the basic applications, systems, and technologies of industrial robotic systems
- the basic principles for the design of a robotic system with regard to a specific task

to apply the knowledge:

- to classify robotic applications and describe the necessary system architecture
- to design the fundamental kinetic and kinemtatic models and algorithms for industrial robots
- to plan and control the path of an industrial robot
- to integrate sensors such as cameras to achieve a certain overall task behavior
- to predict and simulate motor currents in any static or dynamic situation for a specified task
- to design a model-based control algorithm based on the dynamic model of the robot

to transfer:

- the control of 6-axis robots to new kinematics

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Model-Based Control of Industrial Robots – Seminar: 3 SWS (Sem)
Model-Based Control of Industrial Robots – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:

In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

summer term

7.0 Modulverantwortliche(r)

Dr. Heiko Koch

8.0 Literatur

The following literature material will be provided:

- Electronic lecture notes
- Workbooks for the lab

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MP07 Model-Based Design for Power Electronic Systems

1.0 Modulname
Model-Based Design for Power Electronic Systems

1.1 Modulkürzel
MP07

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Power Engineering

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Model-Based Design for Power Electronic Systems – Seminar
Model-Based Design for Power Electronic Systems – Lab

2.1 Inhalt
The aim of this course is to provide students with a solid background in Model-Based Design (MBD) methods with a strong focus on embedded control software development for electrical drives and power electronic systems. Emphasis is placed on the seamless workflow from physical system modeling to real-time implementation, testing and validation.

- Introduction to Model-Based Design: motivation; basic principles and application areas; comparison to conventional software development methods
- Model-Based Design Workflow: non real-time and real-time simulation; MDB toolchain and tools (MiL, ACG, SiL, PiL, HiL, RCP) and real hardware testing
- Modelling of Power Electronics Systems: continuous-time and discrete-time models; state-space modeling; average converter models; real-time capable models; model fidelity vs. computational time; techniques for improving the computational efficiency; stability of real-time simulations; model verification and validation
- Model-Based Control Design: control structures; controller design; small-signal analysis; stability and frequency response analysis; digital implementation
- Model Implementation on Real-Time Targets: configuration of processor peripherals and interfaces incl. sensor interfaces; task scheduling (e.g. multi-tasking, task priorisation) and real-time constrains; deployment on real-time platforms; real-time testing

3.0 Learning Outcomes
<u>to understand:</u>

- the advantages and benefits of model-based design in the development and validation of embedded control systems for power electronic applications
- the structure and workflow of a model-based toolchain and tools
- the key aspects, limitations and constrains of digital control implementation, testing and validation

<u>to apply:</u>

- the gained knowledge to develop non real-time and real-time simulation models for power electronics and drive systems suitable for control design
- the gained knowledge to design and analyse closed-loop controllers using model-based methods
- the gained knowledge to implement model-based software code on dedicated target systems
- the gained knowledge to validated simulation models and controllers by experimental validation

<u>to transfer:</u>

- the patterns and methodologies to new or unfamiliar systems as well as more complex control design scenarios

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours of classroom teaching and 94 hours of self-study.

Model-Based Design for Power Electronic Systems - Seminar: 3 SWS (Sem)
Model-Based Design for Power Electronic Systems - Laboratory: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully complete the laboratory part of the module. Successful fulfilment of prerequisites is measured by:

- laboratory attendance
- laboratory progress
- laboratory report / review

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
summer term

7.0 Modulverantwortliche(r)
Dr. Christian Weiner

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook / Exercises
- Laboratory Instructions

Further literature recommendations will be provided during the seminar and are included in the seminar material.

MCwp02 Optical Communications

1.0 Modulname
Optical Communications

1.1 Modulkürzel
MCwp02

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Optical Communications – Seminar
Optical Communications – Lab

2.1 Inhalt
Optical Communications - Seminar:

- Advanced characteristics and production technologies of optical fibers
- Solutions of the electromagnetic wave equations
- Advanced analyses of the mechanisms for dispersions and attenuations
- Nonlinear effects and their impacts and applications (e.g. soliton)
- Optical fiber connections: theoretical and practical considerations
- Advanced theoretical considerations and optimizations of optical sources (Laser Diode / LED) and detectors (PIN-, APD-Photodiode), receivers for optical communications
- Optical amplifiers: characterization and comparison of different principles
- Polarization: theoretical and practical fundamentals and their influence to fiber optical systems (e.g. polarization modal dispersion PMD)
- Fiber optical systems: fundamentals and limitations
- Basics of coherent optical communication systems
- Special optical communication devices and modern systems

Optical Communications – Lab:
In the laboratory part practical experiments are conducted based on the content covered in the lecture including

- Handling and characterization of optical fiber
- Optical transmission systems

3.0 Learning Outcomes
to understand:

- components of advanced optical communication systems
- physical mechanisms that affect optical signal transmission (attenuation, dispersion, nonlinear effects)
- the impact of system parameters on the performance of optical transmission links

to apply:

- techniques for optimizing transmission performance to achieve maximum data rates

to transfer:

- methods for analyzing and designing optical communication systems under given conditions

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Optical Communications – Seminar: 3 SWS (Sem)
Optical Communications – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- completion of laboratory assignments

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Manuel Rosenberger

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Descriptions for the Laboratory

Further literature recommendations will be provided during the seminar / are included in the seminar material.

MP04 Power Electronics for Drives and Energy Systems

1.0 Modulname
Power Electronics for Drives and Energy Systems

1.1 Modulkürzel
MP04

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Power Engineering

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Power Electronics for Drives and Energy Systems – Seminar
Power Electronics for Drives and Energy Systems – Lab

2.1 Inhalt
Fundamentals:

- Basic Principles and Components of Power Electronics
- Mathematical Analysis and Computer Simulation for Steady State Analysis of Power Electronic Circuits
- Semiconductor Switches, passive Components, Converter Design and recent Advances
- Basic and Advanced Converter Topologies
- Modulation Principles

Power Electronic Systems for Drives:

- Voltage Source Converter for Electric Drives
- Active Front End

Power Electronic Systems for Renewables and Distribution:

- Converter for Wind Energy Conversion System
- Converter for Photovoltaic Energy Conversion Systems
- Converter for High-Voltage DC Transmission
- Active Power Filter

3.0 Learning Outcomes
to understand:

- the function and operation principles of power electronic systems for drives and energy systems
- the implications of power electronics on source and load
- the common design principles for power electronic converter and the impact of advanced components and technologies on converter design

to apply:

- set-up, simulate and compare power systems for drives and energy systems
- select suitable converter topologies for specific applications and justify their selection
- dimension and design power electronic equipment
- conduct practical experiments and simulations to investigate power electronic circuits and document, discuss and technically evaluate the results

to transfer:

- suggest solutions for applications and implications in power electronics

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Power Electronics for Drives and Energy Systems – Seminar 3 SWS (Sem)
Power Electronics for Drives and Energy Systems – Lab 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully complete the laboratory part of the module. Successful fulfilment of prerequisites is measured by:

- laboratory attendance
- completion of laboratory assignments
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter term

7.0 Modulverantwortliche(r)
Dr. Athanasios Krontiris

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook / Exercises
- Laboratory Instructions

Further literature recommendations will be provided during the seminar and are included in the seminar material.

MP02 Power System Operation

1.0 Modulname
Power System Operation

1.1 Modulkürzel
MP02

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Power Engineering

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Power System Operation – Seminar
Power System Operation – Lab

2.1 Inhalt
This course provides an introduction to professional power system operations including operational planning based on standard tools like SCADA and Training Systems. The course covers the theoretical side and explains the grid operations in real time on a training system using an industry standard control system. The lab covers fundamental concepts of power grid operations in real situations.

Power System Operation – Seminar:

- Review of the relevant component models of power systems
- Structure of power systems and Interaction of power system components in the system context
- Architecture of control centers including information technology (RTU)
- SCADA and EMS software functions in control centers
- Strategies for operational planning and optimization
- Significance and means of voltage and reactive power control
- Power frequency control and power system stability
- Power system faults and functions of protection relays
- Strategies for clearing power system emergencies

Power System Operation – Lab:
The participants will use a power system training simulator to get experience of basic operational tasks including normal operation and handling of disturbances.

- Analyzing power system components and their interaction in the system context
- Operational tasks during normal operation
- Exploring component limits
- Reactions of power system components during power system disturbances
- Analyzing power system faults, operational tasks during emergencies
- Control center operational handling in coordination with grid service staff

3.0 Learning Outcomes
to understand:

- behavior of power system components in the system context
- power system operational tasks and planning
- voltage control and reactive power resources and demand
- power frequency control and active power balance
- fault clearing by protection devices

to apply:

- handling control center software (SCADA)
- solving operational tasks in the training simulation
- execute fault localization and service restoration on the training system

to transfer:

- optimization of the system state by finding suitable control actions
- assess the impact of renewable energy sources on the power system
- do the master thesis with a utility company

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Power System Operation – Seminar: 3 SWS (Sem)
Power System Operation – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module.
20% of the module grades are obtained by the laboratory part during the term.

Examination Type: Written exam (80%) at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

winter term

7.0 Modulverantwortliche(r)

Dr. Sebastian Weck

8.0 Literatur

The following literature material will be provided:

- Electronic Lecture Notes
- Laboratory Notes

Further literature recommendations will be provided during the seminar.

MPwp04 Power System Protection

1.0 Modulname
Power System Protection

1.1 Modulkürzel
MPwp04

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Power System Protection – Seminar
Power System Protection – Lab

2.1 Inhalt
Seminar:
Planning, design and dimensioning of the protection technology of electrical power supply networks (e.g. high-voltage overhead lines, cable networks, gas-insulated switchgear). The following aspects are covered:

- Design, mode of operation, nominal data of current and voltage transformers
- Function of protective devices and selectivity in electrical systems and networks
- Use of overcurrent relays as well as distance, differential and breaker failure backup protection in high-voltage networks
- IEC 61850 station communication protocoll

Laboratory:

- Examination of current transformers
- Setting and testing of overcurrent relays and differential relays
- Investigation of distance protection in radial, ring and parallel line networks
- Earth fault detection

3.0 Learning Outcomes
to understand:

- Students know the function of protective devices for the power supply (overcurrent relays as well as distance, differential and breaker failure backup protection).
- Students are familiar with the behaviour of current and voltage transformers.
- Students understand the function of protective devices and their selectivity in electrical systems and networks.

to apply:

- Students know how to set and check protective devices and can apply the different types of relays.

to transfer:

- Students are able to apply different testing methods and can assess the effectiveness of the protective devices in the model system and in the network.

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Power System Protection – Seminar: 3 SWS (Sem)
Power System Protection – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory work report

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.
Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Athanasios Krontiris

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes

Further literature recommendations will be provided during the seminar / are included in the seminar material.

MPwp01 Power Systems Planning

1.0 Modulname
Power Systems Planning

1.1 Modulkürzel
MPwp01

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Power Systems Planning – Seminar
Power Systems Planning – Lab

2.1 Inhalt
Participants will be exposed to and gain theoretical and practical experience with planning of power systems. Focus lies with distribution networks (medium and low voltage) under the presence of dispersed generation. The course covers:

- Network topology for high, medium and low voltage
- Steady state analysis of power systems
- Power quality and voltage stability in power systems
- Optimization in power system planning and operation
- Voltage control in distribution networks for integration of dispersed generation (wind and solar)
- Normative references
- Future trends

Theoretical knowledge is applied in the laboratory to study cases for computer-aided network planning (panda power and DIgSILENT PowerFactory). The gained theoretical and practical knowledge is applied in project work (innovative planning of distribution system with high share of renewables).

3.0 Learning Outcomes
<u>to understand:</u>

- Characteristic values of system loading and generation economics
- Challenges arising by the connection of dispersed generation (wind and solar) to distribution networks

<u>to apply:</u>

- Power system modelling in per unit system
- Load forecasting with conventional and AI-based forecasting methods
- Power flow and short circuit algorithms to power systems
- Optimal power flow analysis
- Calculate voltage stability curves for simple study cases
- Calculate flicker, harmonics and other power quality measures for simple study cases

<u>to transfer:</u>

- Choose the preferred network topology for distribution networks
- Innovative network planning alternatives to distribution networks
- Coordinated voltage control

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Power Systems Planning – Seminar: 3 SWS (Sem)
Power Systems Planning – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory work report
- technical discussion at the end of each lab

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Athanasios Krontiris

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes

Recommended:

- Seifi, Sepasian: "Electric Power System Planning: Issues, Algorithms and Solutions"; Springer
- Grisby: "Electric Power Engineering Handbook – Volume I (Power Systems)"; CRC Press
- Gönen: "Modern Power System Analysis"; CRC Press
- Sallam & Malik: "Electric Distribution Systems"; Willey
- National and international standards EN 50160, IEC 61000 series, VDE AR 4105, VDE 4100, VDE 4110

Further literature recommendations will be provided during the seminar / are included in the seminar material.

MP05 Renewable Energy Systems

1.0 Modulname
Renewable Energy Systems

1.1 Modulkürzel
MP05

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Power Engineering

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Renewable Energy Systems - Seminar

2.1 Inhalt
Todays and future societies crucially rely on a secure, stable and uninterruptible energy supply. A key factor in this context represents the strategic expansion and integration of renewable energy systems in present and future energy systems. In detail, the course covers the following subjects:

- Analysis of current energy needs and future energy demands as well as the resulting environmental, social and economically implications.
- Fundamentals of renewable energy sources like solar radiation, wind-, hydro- and geothermal power.
- Use of solar power by solar thermal electricity systems
- Power generation by photovoltaic, photovoltaic power electronics as well as photovoltaic system design.
- Wind energy resources, site analysis, wind energy conversion systems (onshore and offshore), electrical generators and power electronics as well as wind energy system design.
- Besides the topics of solar and wind energy conversion systems, the lecture addresses hydro power systems as well as geothermal power systems.
- The role of energy storage in renewable energy systems: Possible options and solutions: From pumped hydro storage up to power-to-gas technology.
- Simulation of renewable energy systems
- Future outlook on renewable energy: Potentials, limitations and future challenges.

3.0 Learning Outcomes
to understand:
The students understand the physical calculation and simulation methods of solar radiation. Furthermore, they understand the structure, the technology and the behavior of the treated regenerative power generation plants.

to apply:
The students apply calculation and simulation methods for the design of regenerative energy generation plants and can thus determine, for example, the energy yield.

to transfer:
Application to new regenerative energy systems by calculation and simulation methods. In addition, students are qualified in planning and designing complex systems of different renewable energy systems.

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total. including 56 hours classroom teaching and 94 hours of self-study.

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Type: Written exam covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
summer term

7.0 Modulverantwortliche(r)
Dr. Thomas Glotzbach

8.0 Literatur
The following literature material will be recommended

- Volker Quaschning: Understanding Renewable Energy Systems
- Kaltschmitt Martin: Renewable Energy Systems

Further literature recommendations will be provided during the seminar / are included in the seminar material.

Mwp02 Research Project

1.0 Modulname
Research Project

1.1 Modulkürzel
Mwp02

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Research Project

2.1 Inhalt
In this course, the students execute a research focused project at the university. It covers the areas:

- Introduction to research methodologies
- Work on state of the art research questions
- Development of a research strategy
- Execution of the research work
- Presentation of the results

3.0 Learning Outcomes
to understand:

- state of the art research topics

to apply:

- research methodology
- professional team communication techniques
- project presentation

to transfer:

- research techniques into new project scenarios

4.0 Arbeitsaufwand und Credit Points
2,5 CP / 75 hours in total

Research Project: 2 SWS (Pro)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
project (Pro)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
The examination consists of the project work and the project presentation. As a consequence, a withdrawal from the project is only possible once within the first 2 weeks of the project. A later withdrawal will be marked as "not passed". For details, please check the BBPO.

Examination Prerequisites:
Successful fulfillment of prerequisites are measured by:

- attending Project
- completion of project assignments
- project report

The project rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Coursework assessment and oral presentation

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
Depending on the project content, individual agreement with the supervising professor required.

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Peter Fromm

8.0 Literatur
Literature recommendations will be provided during the project.

MC03 RF Systems Engineering

1.0 Modulname
RF Systems Engineering

1.1 Modulkürzel
MC03

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Communications

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
RF Systems Engineering – Seminar
RF Systems Engineering – Lab

2.1 Inhalt
RF Systems Engineering - Seminar:

- transmission lines and waveguides
- scattering parameters
- impedance matching and Smith chart
- RF components, e.g. power dividers, directional couplers and filters
- oscillators/synthesizers and mixers
- noise and nonlinear distortion
- system aspects of antennas and wave propagation

RF Systems Engineering - Lab:
gaining in depth practical measurement experiences in RF in chosen topics of the lecture

3.0 Learning Outcomes
to understand: design principles and key concepts/components of RF systems

to apply: methods to analyze, develop and evaluate of RF systems

to transfer: the concepts of noise and nonlinear distortion to more complex systems; testing of complex RF systems by modern measurement equipment (e.g. network/spectrum analyzers)

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

RF Systems Engineering – Seminar: 3 SWS (Sem)
RF Systems Engineering – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- technical discussion at the end of each lab

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.
Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter term

7.0 Modulverantwortliche(r)
Dr. Ingo Gaspard

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Descriptions for the laboratory measurements

Recommended:
Gustrau, F.: RF and Microwave Engineering, Wiley.
Pozar, D.M.: Microwave and RF Design of Wireless Systems, Wiley.
Pozar, D.M.: Microwave engineering, Wiley.
Further literature recommendations will be provided during the seminar.

MAwp01 ROS for Robotic Systems Engineering

1.0 Modulname
ROS for Robotic Systems Engineering

1.1 Modulkürzel
MAwp01

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
ROS for Robotic Systems Engineering – Seminar
ROS for Robotic Systems Engineering – Lab

2.1 Inhalt
- Introduction to ROS as middleware for robotics
- ROS filesystem, nodes, communication; ROS development tools
- Simulating robotic task execution
- Examples for sensor integration and perception
- ROS control interfaces
- ROS MoveIt Motion Planning Framework
- Modelling robots using URDF
- Interfacing ROS and Matlab
- Case Study using the TurtleBot and/or Tiago and/or comparable mobile manipulator platforms

3.0 Learning Outcomes
Upon completion of this module, students will have reached the following levels of proficiency in the specified areas of knowledge and skills:

to understand: components of the ROS ecosystem; ROS-based software packages for robotics systems

to apply: using ROS for simulation and real-world robot control; ROS path planning capabilities; Interaction and integration with other 3rd party software

to transfer: design and complete an examplary robotic system application; transfer of applications to different robotic platforms

4.0 Arbeitsaufwand und Credit Points
150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

ROS for Robotic Systems Engineering – Seminar: 3 SWS (Sem)
ROS for Robotic Systems Engineering – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:

In order to participate in the module exam, it is required to successfully pass the laboratory part of the module.

This is measured by:

- laboratory attendance
- satisfactory completion of all laboratory tasks

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Oral Exam. The examination specifics will be communicated at the start of the module.

Examination Duration: 45 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Karl Kleinmann

8.0 Literatur
The course material for lecture and laboratory will be provided electronically.
Further literature recommendations will be provided during the lecture.

MEwp03 Safety in Embedded Control Systems

1.0 Modulname
Safety in Embedded Control Systems

1.1 Modulkürzel
MEwp03

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Safety in Embedded Control Systems - Seminar
Safety in Embedded Control Systems - Lab

2.1 Inhalt
Content of course "Safety in Embedded Control Systems - Seminar":
Participants will be exposed to and gain working experience with safety standards and safety architectures for embedded control systems, focussing on fail safe architectures. The course will cover

- motivation for safety and reliability in embedded projects
- introduction to safety standards like IEC61508 and ISO26262 and the safety lifecycle,
- performing systematic hazard and risk analysis,
- creation of a functional safety case, definition of safety goals and safety requirements
- creation of a technical safety case, definition of a safety architecture
- assessing hardware reliability (FIT rates and MTTF, hardware architecture, diagnostic coverage)
- reliable communication, black channel design
- analysis of the features of modern safety controllers,
- developing concepts for detecting and handling sporadic hardware errors,
- assessing software reliability (software architecture, process requirements, design and coding guidelines)
- concepts for avoiding systematic software errors (separation, error detection and handling, control and data flow design),
- qualification, systematic test concepts (unit test, integration test, system test), test automation (MIL, SIL, PIL, HIL)
- creation of the safety case argument

Content of course "Safety in Embedded Control Systems - Lab":
Participants will work on a safety case

- Performing a hazard and risk analysis
- Creation of a functional and technical safety concept
- Implementation of the concept
- Evaluation of the achieved safety case

3.0 Learning Outcomes
to understand:

- the structure and concept of safety standards and typical safety lifecycles
- the development of a safety case

to apply:

- the gained knowledge to implements an embedded safety architecture (fail safe)
- systematic methods to assess stochastical hardware errors
- systematic methods to limit systematic software errors

to transfer:

- the knowledge to different domain safety standards
- the design patterns and concepts to more complex fail operational architectures.

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and lab and 94 hours of self-study.

Safety in Embedded Control Systems - Seminar: 3 SWS (Sem)
Safety in Embedded Control Systems - Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:

In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete contend of the module.

Examination Duration : 90 minutes

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Peter Fromm

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Workbook

Further literature recommendations will be provided during the lecture / are included in the lecture material.

MCwp06 Satellite Communications

1.0 Modulname
Satellite Communications

1.1 Modulkürzel
MCwp06

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Satellite Communications – Seminar

2.1 Inhalt
- Use cases & history
- Satellite orbits
- Satelllite launch
- Satellite subsystems
- Satellite communication (propagation and link budget)
- Satellite network architecture
- Global navigation satellite systems
- Satellites networks for broadband internet connectivity

3.0 Learning Outcomes
to understand: use cases & history, satellite orbits, satellite launch, satellite subsystems

to apply: global navigation satellite systems, satellite networks for broadband internet coverage

to transfer: satellite network architecture, satellite communication (propagation and link budget)

4.0 Arbeitsaufwand und Credit Points
2.5 CP / 75 hours in total, including 28 hours classroom teaching and 47 hours of self-study.

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Type/Duration:
Written examination (60 min) or oral presentation (20 min) at the end of the semester covering the complete content of the module.
The format of examination will be communicated at the start of the module.

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Jakob Belschner

8.0 Literatur
Literature recommendations will be provided during the seminar / are included in the seminar material.

Mwp01 Selected Research Topics

1.0 **Modulname**
Selected Research Topics

1.1 **Modulkürzel**
Mwp01

1.2 **Art**
Wahlpflichtfach

1.3 **Modulniveau**
Master / Majors as communicated by the faculty

1.4 **Lehrsprache(n)**
English

2.0 **Lehrveranstaltung(en)**
Selected Research Topics - Seminar / Project

2.1 **Inhalt**
In this course, the students will be introduced to selected state of the art research topics in the following areas

- Automation, robotics, factory automation and (I)IoT
- Communication systems and technologies, signal processing
- Embedded systems, hardware and software engineering, SOC and FPGA development
- Power generation and distribution, advanced control systems, e-mobility
- Other topics upon availability

3.0 **Learning Outcomes**
to understand:

- Research methodologies

to apply:

- Working with literature and other information sources
- Scientific writing skills
- Scientific presentation skills and discussions

to transfer:

- The gained knowledge to own research work, e.g. master thesis

4.0 **Arbeitsaufwand und Credit Points**
2,5 CP / 75 hours in total, including 35 hours classroom teaching and 40 hours of self-study.

4.1 **Dauer, zeitliche Gliederung und Häufigkeit des Angebots**
Each elective subject will take one semester and may be offered once a year.

4.2 **Veranstaltungsart**
seminar (Sem) / project (Pro)

5.0 **Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung**
Examination Prerequisites: Term paper. The examination prerequisites are ungraded.

Examination Type: Coursework assessment and oral presentation or written examination (60 minutes). The examination type will be communicated at the start of the module.

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Peter Fromm

8.0 Literatur
Required literature recommendations will be provided during the seminar / project.

MPwp02 Smart Grids

1.0 Modulname
Smart Grids

1.1 Modulkürzel
MPwp02

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Smart Grids – Seminar
Smart Grids – Lab

2.1 Inhalt
This module deals with the transformation of the electrical power system that is necessitated by changing boundary conditions.

Smart Grids – Seminar:

- Power generation: regionally and temporally distributed renewable energy sources, changing energy mix, resulting changes needed in networks and regulation
- Load: load modelling and forecasting, changes in electrical load, demand side management, innovative energy tariffs, incentive models
- Storage systems: Role of storage system in future power systems, categories and parameters of storage technologies, control and economic modeling of storage solutions
- Electric vehicles (EV): Role of EV as electric load, use of EV in future power systems as controllable load or intermediate storage
- Technical solutions: distribution system automation, distribution system applications, voltage control in low voltage grid

Smart Grids – Lab:

- The participants will use a power system training simulator to get experience of operational tasks in future energy systems based on renewable and distributed energy sources.
- wind energy, storage management, virtual power plants, load management, weather depending renewable production

3.0 Learning Outcomes
to understand:

- overview of smart grid technology topics, discussed approaches and proposed solutions
- challenges and approaches for future energy systems based on renewable and distributed resources
- properties of the different renewable energy sources and storage technologies

to apply:

- analyze and evaluate approaches and building blocks of future energy concepts
- analyze and evaluate storage management concepts
- solving operational tasks in the training simulation

to transfer:

- assess the impact of renewable energy sources on the power system
- do the master thesis with a utility company

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Smart Grids – Seminar: 3 SWS (Sem)
Smart Grids – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to have successfully finished the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam or oral presentation at the end of the semester covering the complete content of the module.

The exact examination type will be communicated at the start of the module.

Examination Duration: 90 Minutes (written exam), 20 minutes (oral presentation)

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Sebastian Weck

8.0 Literatur
The following literature material will be provided

- Electronic Lecture Notes
- Lab script

Further literature recommendations will be provided during the seminar.

MNTwp02 Social and Cultural Studies

1.0 Modulname
Social and Cultural Studies

1.1 Modulkürzel
MNTwp02

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master - all majors

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Courses offered by the Interdisciplinary Program in Social and Cultural Studies within the Department of Social Sciences

2.1 Inhalt
The module includes courses offered by the Interdisciplinary Division of Social and Cultural Studies within the Department of Social Sciences. Students have the opportunity to choose from the subject areas of Work, Career & Self-Employment, Culture, Information & Communication, Politics, Institutions & Society, and Knowledge, Innovation & Sustainable Development. The selection of courses for the module is made each semester via a whitelist (i.e., courses potentially available for selection), which the program administration for the Master's in Electrical Engineering and Information Technology announces to students as a course catalog before the start of the semester.

3.0 Learning Outcomes
Knowledge: Students learn to engage critically with issues related to future-oriented and responsible action within a democratic and social constitutional state, as well as to develop interdisciplinary cooperation and intercultural communication skills from a cross-disciplinary perspective.
Skills: Students are able to engage expertly and critically with their own professional tasks and responsibilities as aspiring electrical and information technology engineers across a wide range of subject areas and fields, as well as with their own professional field within the broader societal context. They learn to work in interdisciplinary groups and to approach problems and situations within a societal context. Competencies: Students are able to relate and integrate interdisciplinary competencies with their primary professional field. Additional competencies vary depending on the course selected from the offerings of the Interdisciplinary Study Area in Social and Cultural Sciences.

4.0 Arbeitsaufwand und Credit Points
2,5 CP / 75 hours in total, including 28 hours classroom teaching and 47 hours of self-study.

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Courses available for this module are announced per semester.

4.2 Veranstaltungsart
Lecture, Seminar

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
A prerequisite for taking the final exam is regular attendance in the course amounting to at least 80 percent. In some cases, a prerequisite for taking the exam is passing a prerequisite exam. This depends on the specific course selected within the Interdisciplinary Field of Social and Cultural Studies and will be announced at the beginning of the respective course.

Examination Type:
Courses in the Interdisciplinary Field of Social and Cultural Studies conclude with an exam. The following examination formats are possible: written exam, oral presentation with a written paper (approx. 8 to 10 pages), term paper, creation of a poster, etc. The specific examination format depends on the particular course selected within the interdisciplinary field of study in Social and Cultural Sciences. It can be found in the online course catalog and will be announced at the beginning of the respective course.

Generally, the interdisciplinary field of Social and Cultural Studies does not offer opportunities to retake exams.

Examination Duration: 60 to 90 minutes (written exam), 20 minutes (oral presentation)

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
This information can be found in the syllabus for the specific course offered by the Interdisciplinary Program in Social and Cultural Studies.

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Peter Fromm

8.0 Literatur
The reading list will be provided for each selected course

MCwp04 Software Defined Radio

1.0 Modulname
Software Defined Radio

1.1 Modulkürzel
MCwp04

1.2 Art
Wahlpflichtfach

1.3 Modulniveau
Master / Majors as communicated by the faculty

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Software Defined Radio – Seminar
Software Defined Radio – Lab

2.1 Inhalt
- Architecture and components of SDR front-ends for transmission and reception of signals
- Processing of analytical (I/Q) signals
- Modulation and demodulation
- Signal analysis, measurements, and practical applications

3.0 Learning Outcomes
to understand: Design of SDR systems and implementation of modulators and demodulators for common analog and digital transmission methods, theory of processing complex (I/Q) signals

to apply: Implementation of SDR-systems for signal acquisition and generation, implementation of signal processing algoritgms

to transfer: Design of SDR systems in an SDR framework such as GNU Radio, Open Air Interface, or srsRAN

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

Software Defined Radio – Seminar: 3 SWS (Sem)
Software Defined Radio – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
Each elective subject will take one semester and may be offered once a year.

4.2 Veranstaltungsart
seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung
Examination Prerequisites:
In order to participate in the module exam, it is required to successfully finish the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- laboratory attendance
- laboratory entrance test
- completion of lab assignments

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam or oral exam at the end of the semester covering the complete content of the module.

The exact examination type will be communicated at the start of the module.

Examination Duration: 60 minutes written or 20 minutes oral exam

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
winter or summer term

7.0 Modulverantwortliche(r)
Dr. Michael Kuhn

8.0 Literatur
Literature recommendations will be provided during the seminar / are included in the seminar material.

MA07 State Space Control Design

1.0 Modulname
State Space Control Design

1.1 Modulkürzel
MA07

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Automation

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
State-Space Control Design – Seminar
State-Space Control Design – Lab

2.1 Inhalt
- Modelling of dynamic systems using state variables
- State space representation of dynamic systems
- Correlation between transfer functions and state space representation
- Structural properties (stability, controllability, observability)
- Canonical forms
- State space transformations
- Solution of the time-invariant state-space equations
- Design of state feedback controllers
- Design of state observers
- State feedback design by optimal control
- Computer based applications using Matlab/Simulink
- Exercises on modelling and designing state-space control systems
- Practical programming assignments for state-space applications in Matlab/Simulink

3.0 Learning Outcomes
to understand:

- the concept of state variables and their role in describing dynamic systems,
- application areas of state-space systems,
- the basic concepts of state feedback and observer design

to apply:

- derive state-space models for dynamic systems and convert between transfer function and state-space representation,
- analyze structural properties of state-space systems (stability, controllability, observability) using standard mathematical methods,
- transform systems into canonical forms,
- design state-feedback systems by pole placement,
- design state-feedback systems by optimal control,
- design state-feedback observers by pole placement,
- use the duality principle in state feedback and observer design,
- solve the time-invariant state-space equations and compute system responses,
- use Matlab/Simulink to model, simulate, analyse and evaluate state-space systems

to transfer:

- select appropriate modelling and representation forms for complex or unfamiliar systems,
- interpret structural properties to assess feasibility and implications for controller and observer design,
- adapt state-space methods to practical constraints and performance requirements,
- develop simulation and design workflows in Matlab/Simulink that support real-world implementation and validation.

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

State-Space Control Design – Seminar: 3 SWS (Sem)
State-Space Control Design – Lab: 1 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

seminar (Sem) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:

In order to participate in the module exam, it is required to successfully finish the laboratory part of the module.
Successful fulfilment of prerequisites are measured by:

- laboratory attendence
- successfull completion of laboratory assignments
- laboratory report

The laboratory rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

summer term

7.0 Modulverantwortliche(r)

Dr. Alexandra Weigl-Seitz

8.0 Literatur

The following literature material will be provided

- Electronic Lecture Notes
- Workbook / Exercises
- Laboratory Instructions

Further literature recommendations will be provided are included in the lecture material.

MCE06 System-Driven Hardware Design

1.0 Modulname
System-Driven Hardware Design

1.1 Modulkürzel
MCE06

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / Major Communications and Major Embedded Systems

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
System Driven Hardware Design – Lecture
System Driven Hardware Design - Lab

2.1 Inhalt
Content of the course "System Driven Hardware Design – Lecture":
Participants will gain work experience in developing hardware and software of an electronic system. The course will cover:

- Partitioning of a system in hardware, software parts and necessary peripherals components
- Interface design to peripheral components, to other systems and to humans
- Electronic circuit design for sensor readout
- Software development for sensor control, signal processing and data transmission
- Principals of Signal Processing in the Time and Frequency Domain
- Statistical Detection Threshold determination
- Sesigning of a PCB, taking signal integrity, hardware and software test possibilities and production rules into account
- production methods

Content of the course "System Driven Hardware Design – Lab":
Development of a system consisting of software and hardware parts:

- Developing, layouting and soldering a PCB
- Software Development for sensor control, readout and signal processing
- Hardware and Software start-up and Debugging

3.0 Learning Outcomes
to understand:

- system partitioning and interaction of software and hardware
- the importance of designing for test of hardware and software
- Analog Hardware Interfaces between ICs

to apply:

- taking into account software and hardware testability during hardware design
- systematically developing a PCB
- taking into account mechanical aspects of pcb development
- layout rules for signal integrity and producibility
- software code to test software-hardware interaction
- hardware debugging of serial interfaces
- systematic start-up of a PCB consisting of hardware and software parts

to transfer:

- design patterns and processes to other hardware-software-systems, consisting of different central processing units e.g. microcontrollers, fpgas, psocs or ASIC and peripheral components.
- Sensor signal preconditioning for ADC conversion
- Design standard PCBs up to 100 MHz
- Use signal processing in the frequency domain by evaluating the FFT

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours in total, including 56 hours classroom teaching and 94 hours of self-study.

System Driven Hardware Design – Lecture: 2 SWS (V)
System Driven Hardware Design - Lab: 2 SWS (L)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

lecture (V) / laboratory (L)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Prerequisites:

In order to participate in the module exam, it is required to have successfully finished the laboratory part of the module. Successful fulfilment of prerequisites are measured by:

- presentations and reviews during the lab

30% of the module grades are obtained by the laboratory part.

Examination Type: Written exam (70%) covering the complete content of the module at the end of the semester.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

None

6.2 Empfohlenes Fachsemester

summer term

7.0 Modulverantwortliche(r)

Dr. Stephan Bannwarth

8.0 Literatur

The following literature material will be provided:

- Electronic Script
- Workbook for the lab

Further literature recommendations will be provided during the lecture.

M02 Team Project

1.0 Modulname
Team Project

1.1 Modulkürzel
M02

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / all majors

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Team Project

2.1 Inhalt
In this course, the students execute a practical project using the methods presented in the module "Technical Management". It covers the areas:

- practical development of a technical system (project work)
- project management and work package agreement,
- requirements engineering, system design,
- implementation and testing,
- team building and team communication,
- and documentation and presentation of the results

3.0 Learning Outcomes
to understand:

- project roles, phases and workflows

to apply:

- workpackage definition and assignment
- modern methods of project management and engineering
- professional team communication techniques
- project presentation

to transfer:

- the project management and engineering techniques into new project scenarios

4.0 Arbeitsaufwand und Credit Points
5 CP / 150 hours in total, project work including meetings with the instructors

Team Project - Project: 4 SWS (Pro)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots
This module takes one semester and is offered once a year.

4.2 Veranstaltungsart
project (Pro)

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

The examination consists of the project work and the project presentation. As a consequence, a withdrawal from the project is only possible once within the first 2 weeks of the project. A later withdrawal will be marked as "not passed". For details, please check the BBPO.

Examination Prerequisites:
Successful fulfillment of prerequisites are individually measured by:

- attending Project
- completion of project assignments
- project report

The project rules and assessment criteria will be communicated at the start of the module. The examination prerequisites are ungraded.

Examination Type: oral presentation (30 minutes)

6.0 Notwendige Kenntnisse
None

6.1 Empfohlene Kenntnisse
None

6.2 Empfohlenes Fachsemester
summer term

7.0 Modulverantwortliche(r)
Dr. Peter Fromm

8.0 Literatur
Literature recommendations depend on the project topic and will be provided during the project.

M01 Technical Management

1.0 Modulname
Technical Management

1.1 Modulkürzel
M01

1.2 Art
Pflichtfach

1.3 Modulniveau
Master / all majors

1.4 Lehrsprache(n)
English

2.0 Lehrveranstaltung(en)
Project Management / Systems Engineering – Lecture
Engineering Responsibility – Lecture

2.1 Inhalt
Lecture Project Management / Systems Engineering:

- The systems engineering part introduces structured approaches for analyzing, designing, implementing, and managing complex technical systems and engineering projects across their entire lifecycle. Core topics include system definition, requirements engineering, system architecture, interfaces, lifecycle-oriented development, and decision-making under uncertainty.
- In addition, students are introduced to typical roles and responsibilities within engineering projects and how these interact over the system lifecycle.
- The module further addresses practical project management elements closely linked to systems engineering, including the creation of project plans, scheduling, progress tracking, and basic forms of project monitoring. Elemental aspects of cost estimation and cost awareness are introduced to foster an understanding of economic constraints and trade-offs in technical decision-making.
- Students also learn how to handle change requests in a structured manner, including assessing impacts on requirements, schedule, costs, and quality.
- To support traceability and collaborative development, the use of version management systems is introduced at a basic level. Furthermore, quality assurance practices, such as reviews, documentation checks, and simple validation activities, are discussed as integral parts of responsible system development.
- Particular attention is paid to how systems engineering supports the development of solutions that contribute to sustainable technical, economic, and environmental outcomes, in line with the Sustainable Development Goals (SDGs).

Lecture Engineering Responsibility:

- The engineering responsibility part focuses on the role of engineers as responsible actors within socio-technical systems. Students examine ethical, societal, and organizational dimensions of engineering practice, including risk, long-term consequences, and the impact of engineering decisions on society and the environment. This part explicitly connects professional responsibility with the Inner Development Goals (IDGs), emphasizing individual capabilities such as reflection, critical thinking, collaboration, self-awareness, and responsible decision-making as prerequisites for sustainable engineering practice.
- Throughout the module, SDG- and IDG-related perspectives are deliberately interconnected. Students explore how systems engineering methods, project structures, and quality practices can support sustainable development goals, and how inner development competencies enable engineers to act responsibly, transparently, and effectively in complex, dynamic, and uncertain contexts

3.0 Learning Outcomes

General:

Upon successful completion of the module, students are able to manage the design, evaluation, and shaping of technical systems using project management and systems engineering principles while taking professional, societal, and ethical responsibility into account. They can critically reflect on engineering decisions, underlying assumptions, and their own professional role, and consciously shape their engineering practice in alignment with sustainability goals (SDGs) and inner capabilities such as reflection, responsibility, collaboration, and dealing with uncertainty (IDGs).

Students demonstrate the ability to integrate technical, organizational, economic, and human perspectives when addressing complex socio-technical challenges across the system lifecycle.

Students know:

- core concepts, processes, roles, and terminology of project management and systems engineering across the system lifecycle,
- typical roles and responsibilities in engineering projects and their interaction over different lifecycle phases,
- basic principles of project planning, progress tracking, and quality assurance in engineering contexts,
- fundamental concepts of cost awareness and elementary cost calculation as part of engineering decision-making,
- the Sustainable Development Goals (SDGs) and their relevance for engineering practice,
- the Inner Development Goals (IDGs) as a framework for individual and professional capability development in engineering contexts,
- basic concepts of version management and structured change handling in technical development processes.

Students understand:

- how systems engineering methods, lifecycle models, and project structures contribute to sustainable technical, economic, and socio-economic development,
- the relationships between engineering decisions, system behavior, costs, quality, and societal and environmental impacts,
- the role of structured project planning, tracking, reviews, and quality assurance in managing complexity and uncertainty,
- the purpose and implications of change requests and configuration control within engineering projects,
- how inner capabilities such as reflection, responsibility, collaboration, and self-awareness (IDGs) support sustainable and responsible system design and project execution (SDGs).

Students are able to (apply):

- apply systems engineering methods to structure, analyze, and develop solutions for complex engineering problems with explicit consideration of sustainability goals and lifecycle impacts,
- create and maintain simple project plans, perform basic progress tracking, and reflect deviations with respect to scope, time, cost, and quality,
- use tools and methods for requirements analysis, system modeling, lifecycle-oriented design, and basic configuration management in a methodical and context-appropriate manner,
- apply elementary cost considerations to support informed technical decisions and trade-offs,
- handle change requests in a structured way by assessing their impact on requirements, system architecture, schedule, cost, and quality,
- apply basic quality assurance practices such as reviews, documentation checks, and simple validation activities,
- apply structured approaches to responsible decision-making in engineering contexts, taking into account risks, uncertainties, and long-term consequences.

Students are able to (transfer):

- transfer systems engineering principles, project practices, and sustainability considerations to new or unfamiliar engineering contexts,
- adapt methods, tools, and roles to varying technical, organizational, economic, legal, or societal constraints,
- assess and justify engineering decisions across different application domains with regard to sustainability, responsibility, quality, cost awareness, and professional ethics,
- reflect on how competencies related to the Inner Development Goals (IDGs) support effective, transparent, and resilient action in complex, real-world engineering situations,
- consciously transfer systems-oriented thinking from technical systems to project structures, organizational processes, and their own learning and working practices

4.0 Arbeitsaufwand und Credit Points

5 CP / 150 hours total workloadincluding approx. 56 hours of contact time and 94 hours of self-study.

Project Management / Systems Engineering – Lecture: 2 SWS (V)
Engineering Responsibility – Lecture: 2 SWS (V)

4.1 Dauer, zeitliche Gliederung und Häufigkeit des Angebots

This module takes one semester and is offered once a year.

4.2 Veranstaltungsart

Lecture (V) with integrated discussions, case studies, short analytical exercises, and guided reflection sessions

5.0 Prüfungsform, Prüfungsdauer und Prüfungsvoraussetzung

Examination Type: Written exam at the end of the semester covering the complete content of the module.

Examination Duration: 90 minutes

6.0 Notwendige Kenntnisse

None

6.1 Empfohlene Kenntnisse

Introductory knowledge of systems thinking, project-based engineering, or sustainability-related topics

6.2 Empfohlenes Fachsemester

winter term

7.0 Modulverantwortliche(r)

Dr. Carsten Zahout-Heil

8.0 Literatur

- INCOSE: Systems Engineering Handbook– ISO/IEC/IEEE 15288: Systems and Software Engineering
- System Life Cycle Processes– United Nations: Sustainable Development Goals
- Inner Development Guide: Framework and Research Reports
- Bucciarelli, L.: Designing Engineers
- Nicholas, J. M., & Steyn, H.: Project Management for Engineering,
- Project Management Institute: A Guide to the Project Management Body of Knowledge