h_da
HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES
fbeit
FACHBEREICH ELEKTROTECHNIK
UND INFORMATIONSTECHNIK

Module Description

Master of Science
in Electrical Engineering and Information Technology

International Master of Science
in Electrical Engineering and Information Technology

Automation
Communications
Embedded and Microelectronics
Power Engineering

vom 08.11.2011
geändert am 23.04.2013

Content

Structure of the program

Structure of the International Master of Science in Electrical Engineering and Information technology

The following diagram illustrates the structure of the international master program. Every student has to pass the compulsory modules for all majors as well as the compulsory modules of the chosen major. In addition, every student has to choose two additional elective modules which may be selected out of the complete pool of all major modules.
The international master program starts in the winter semester only.

	Winter Semester	Summer Semester	Semester 3	Semester 4
All majors	System Design (M01 - compulsory)	Technical Management (M02 - compulsory)	Industrial Project (M03 - compulsory / 30CP)	Master Thesis (M04 - compulsory / 30CP)
Major Automation	Advanced Automation (MA01 - compulsory)	Avanced Feedback Control (MA03 - compulsory)		
	Advanced Information Technology (MA02 - compulsory)	Advanced Robotics (MA04 - compulsory)		
	Autonomous Systems (MA05 - elective)	Information and simulation systems in industrial development and automation (MA06 - elective)		
Major Communication	Advanced Modulation and Coding (MC01 - compulsory)	Digital Signal Processing (MC03 - compulsory)		
	Information Networks (MC02 - compulsory)	Microwave Components and Systems (MC04 - compulsory)		
	Mobile and Satellite Communications (MC05 - elective)	Optical Communications (MC06 - elective)		
Major Embedded and Microelectronics	Microelectronic Systems (MM03 - compulsory)	Complex Digital Architectures (MM01 - compulsory)		
	Advanced Embedded Systems (MM02 - compulsory)	Design and Test of Microelectronic Systems (MM04 - compulsory)		
	Signal Processing Hardware (MM05 - elective)	CMOS analog circuits (MM6 - elective)		
Major Power	Advanced High Voltage Technology and Theory of Electrical Fields (ME01 - compulsory)	Control of electrical Drives & E-Mobility (ME03 - compulsory)		
	Power Systems and Control Technology (ME02 - compulsory)	Power- Electronics & Switching Power Supply (ME04 - compulsory)		
	Renewable Energy Systems (ME05 - elective)	Smart-Grids (ME06 - elective)		

*unless otherwise noted, all modules have 7.5 CP

Structure of the Master of Science in Electrical Engineering and Information technology

The structure of the Master of Science in Electrical Engineering and Information technology is identical to the International Master except for the module "Industrial Project". The prerequisites for this master program are described in the BBPO.

This master program starts in the winter semester as well as in the summer semester.

	Winter Semester	Summer Semester	Semester 3
All majors	System Design (M01 - compulsory)	Technical Management (M02 - compulsory)	Master Thesis (M04 - compulsory / 30CP)
Major Automation	Advanced Automation (MA01 - compulsory)	Avanced Feedback Control (MA03 - compulsory)	
	Advanced Information technology (MA02 - compulsory)	Advanced Robotics (MA04 - compulsory)	
	Autonomous Systems (MA05 - elective)	Information and simulation systems in industrial development and automation (MA06 - elective)	
Major Communication	Advanced Modulation and Coding (MC01 - compulsory)	Digital Signal Processing (MC03 - compulsory)	
	Information Networks (MC02 - compulsory)	Microwave Components and Systems (MC04 - compulsory)	
	Mobile and Satellite Communications (MC05 - elective)	Optical Communications (MC06 - elective)	
Major Embedded and Microelectronics	Microelectronic Systems (MM03 - compulsory)	Complex Digital Architectures (MM01 - compulsory)	
	Advanced Embedded Systems (MM02 - compulsory)	Design and Test of Microelectronic Systems (MM04 - compulsory)	
	Signal Processing Hardware (MM05 - elective)	CMOS analog circuits (MM6 - elective)	
Major Power	Advanced High Voltage Technology and Theory of Electrical Fields (ME01 - compulsory)	Control of electrical Drives & E-Mobility (ME03 - compulsory)	
	Power Systems and Control Technology (ME02 - compulsory)	Power- Electronics & Switching Power Supply (ME04 - compulsory)	
	Renewable Energy Systems (ME05 - elective)	Smart-Grids (ME06 - elective)	
	*unless otherwise noted, all modules have 7.5 CP		

Modules for all majors

M01 (System Design)

Identifier	Module Name	Type	Course	Sem. 1
M01	System Design	Compulsory module for all majors	Advanced Programming Techniques and Engineering Processes	7,5CP 4V/1L

Module Responsible and Instructor	Additional Instructor(s)
Fromm	Lipp, Schaefer, Rücklé

1. Module content

Content of course "Advanced Programming Techniques and Engineering Processes"

Review of fundamental concepts of a widely used object oriented programming language. The course will cover

- requirements engineering methods,
- introduction to the UML
- class design and class relations in C++,
- operator overloading,
- generic programming,
- introduction to the STL, string and stream library of C++ and
- coding guidelines and systematic testing.

Design aspects like modularity and software re-use will be discussed. Developing software designs using the UML and CASE tools as well as extensive hands-on programming assignments in C/C++ are an integral part of the course.

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student is able to plan and execute a project applying state of the art engineering methods. The concepts of modern object oriented programming languages are understood and the student is able to develop complex software in C++. Object oriented designs can be visualized using the UML.

3. Course organization and structure

Class lecture, lab and programming assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 75 hours lectures and labs

5. Examination modalities

The exam consists of the following parts:

- Module exam (80% of the module mark): Written exam with a duration of 180 min covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
- Lab exam (20% of the module mark): Code walkthrough during the lab.

Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is the successful participation in the lab „Advanced Programming Techniques"

7. Duration and frequency of course

The module lasts one semester. It is offered in the winter semester.

8. Applicability/utilization

The module is valid for all majors.

M02 (Technical Management)

Identifier	Module Name	Type	Course	Sem. 2
M02	Technical Management	Compulsory module for all majors	Project Management and Management Processes	2,5 CP
				2V
			Team Project	5CP
				1P

Module Responsible and Instructor	Additional Instructor(s)
Fromm	all professors of the department

1. Module content

Content of course "Project Management and Management Processes"

This course provides an introduction to professional project management. It covers the areas

- introduction into industry process models, e.g. CMMi and SPICE,
- project roles and workflow,
- team building and team management, change and configuration management,
- planning and estimation methods,
- quality assurance and reviews,
- project tracking and product metrics and
- agile methods like SCRUM.

Content of course "Team Project"

In this course, the students execute a practical project using the methods presented in the lecture "Project Management and Management Processes". 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.

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student is able to plan, execute and present a medium size project as project manager and/or technical member.

3. Course organization and structure

Class lecture, teamwork, presentation of the results in a seminar.

4. Credits and work load

Project Management and Management Processes: 2,5 CP, 75 hours total workload, 30 hours lecture
Team Project: 5CP, 150 hours total workload, team project,

5. Examination modalities

Project Management and Management Processes: Exam (Duration: 90 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Team Project: Seminar with a presentation of the technical and management results at the end of the semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

None.

7. Duration and frequency of course

The module lasts one semester. It is offered in the summer semester.

8. Applicability/utilization

The module provides the prerequisites for the industrial placement and the master thesis.

M03 (Industrial Project)

Identifier	Module Name	Type	Course	Sem. 1+2	Sem. 3
M03	Industrial Project	Compulsory module for all majors	German Class	5CP	
			Preliminary seminar		
			Practical part		25 CP
Module Responsible and Instructor		Additional Instructor(s)			
Götze		All lecturers of the MSE program			

1. Module content

Content of German Class:

- German Course A1 Level
- German Course A2 Level or higher

Content of preliminary seminar

- In the preliminary seminar preparative items (as regulations, application) are presented.

Content of the Practical Part:

- In the practical part the student has to solve an engineering task on the area of electrical engineering and information technology.

2. Learning outcome / competencies

The connection between theoretical university study and industrial work is established.
By participating in the process of industrial work the student gains knowledge of technical, organizational and economical aspects of engineering work. The student can find a first orientation in the desired area of business.

3. Course organization and structure

Seminar, practical work by fulfilling tasks of engineering work, documentation, presentation

4. Credits and work load

German class: 5CP, 60hours class lectures, total workload 100h. Additional intensive preparation courses will be offered during semester breaks.
Practical part: 25 CP, 19 weeks full-time work in a company

5. Examination modalities

German Class: For the language courses, a combined written and oral examination on A2 level or higher will be offered.
For the practical part: a technical project documentation has to be written.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

The German Level A2 (or better) must be achieved before the start of the internship (practical part).

7. Duration and frequency of course

German classes are offered during winter semester (extensive phase). Additional intensive courses will be offered in the month September and February/March (intensive phase). The module lasts one semester. The practical part is offered in both winter and summer semester.

8. Applicability/utilization

The module provides the prerequisites for the Master thesis.

M04 (Master Thesis)

Identifier	Module Name	Type	Course	Sem. 4
M04	Master Thesis	Compulsory module for all majors	Thesis	30 CP
			Colloquium	
Module Responsible and Instructor		Additional Instructor(s)		
Chairman of the Examination Board		All instructors of the master's program		

1. Module contents

- Practically and/or theoretically oriented scientific work in the area of the chosen major
- Written report
- Colloquium

2. Learning outcome / competencies

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

3. Course organization and structure

Supervised project and colloquium

4. Credits and work load

30 CP, total work load of 900 hours

5. Assessment

The master thesis must be submitted in written and electronic (PDF document) form. A colloquium is mandatory.

According to § 23 ABPO, the thesis and the colloquium are assessed at a ratio 1:3.

6. Prerequisites

A total of 75 CP (International Master of Science), respectively a total of 22.5 CP

Module M0, industrial project successfully completed.

The German Level A2 (or better) must be achieved before the start of the Master Thesis.

7. Duration and frequency of course

The master thesis must not exceed 6 months. With the approval of the examination board, the master thesis may be undertaken at any time.

8. Applicability/utilization

The module is valid for all majors.

Modules for major automation

MA01 (Advanced Automation)

Identifier	Module Name	Type	Course	Sem. 1
MA01	Advanced Automation	Compulsory module for major automation	Event-discrete Systems	2,5 CP
				2V
			Intelligent Automation for Safe Processes and Products	5 CP
				3V/0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Simons		Kleinmann		

1. Module content

Content of course "Event-discrete Systems"

- Characterization and examples for event-discrete systems
- Deterministic and non-deterministic automata
- System modelling using Petri nets
- Introduction to Markov theory
- Design of event-discrete control systems
- Hybrid system modelling
- Computer-based simulation and analysis of event-discrete systems

Content of course "Intelligent Automation for Safe Processes and Products"

- Basics of safety critical systems
- Fault detection and fault tolerance
- Design and development of automation systems based on PLC for safety critical systems
- Verification and validation
- Approval procedures
- Lifecycle safety
- Selected methods in modern automation technology based on PLC
- Case studies and laboratory experiences

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The students gain theoretical and practical knowledge in two important fields of modern and advanced automation technology. Upon completing the course successfully, the students will be capable to use the acquired knowledge within characteristical industrial problems. They will have theoretical and practical knowledge in designing plc based safe systems as well as in theory, design and simulation of process modelling methods for event-discrete systems.

3. Course organization and structure

Class lecture and laboratory exercises

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

The final examination (duration: 180 min) will cover the overall content of the module at the end of the semester. Test repetition will be arranged at the beginning of the following semesters.
Prerequisite for attending the exam is a successful participation in the lab „Intelligent Automation for Safe Processes and Products"
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

None.

7. Duration and frequency of course

The module lasts one semester. It is offered in every winter term.

8. Applicability/utilization

The module covers important knowledge for a variety of automation systems in different application fields not only in electronic engineering but also in related fields, e.g. in mechanical engineering and mechatronics.

MA02 (Advanced Information Technology)

<table>
<tr><th>Identifier</th><th>Module Name</th><th>Type</th><th>Course</th><th>Sem. 1</th></tr>
<tr><td rowspan="4">MA02</td><td rowspan="4">Advanced Information Technology</td><td rowspan="4">Compulsory module for major automation</td><td rowspan="2">High Level Languages and Frameworks</td><td>5 CP</td></tr>
<tr><td>3V/0,5L</td></tr>
<tr><td rowspan="2">Distributed Systems</td><td>2,5 CP</td></tr>
<tr><td>2V</td></tr>
<tr><td colspan="2">Module Responsible and Instructor</td><td colspan="3">Additional Instructor(s)</td></tr>
<tr><td colspan="2">Lipp</td><td colspan="3">Rücklé</td></tr>
</table>

1. Module content

Content of course "High Level Languages and Frameworks"

Participants will be introduced to the development of graphical applications using Android and JAVA. The course will cover

- JAVA classes and interfaces
- Threads and synchronization
- Network interfaces
- Framework development tools, e.g. Android
- Graphical user interfaces

Practical programming assignments in JAVA and Android will be part of the course.

Content of course "Distributed Systems"

Participants will be introduced to the principals of distributed computing environments. The course will cover

- hardware and software components of distributed systems,
- topological organization,
- impact on software design,
- network layers and protocols,
- operating system support for distributed systems,
- standardized higher level access to distributed resources (remote procedure calls, distributed objects),
- directory/naming services,
- security

Practical examples are part of the course.

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student is able to design and implement complex embedded systems in hardware and software.

3. Course organization and structure

Class lecture, lab and programming assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 180 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is a successful participation in the lab „Embedded Operating Systems"

7. Duration and frequency of course

The module lasts one semester. It is offered in the winter semester.

8. Applicability/utilization

This module provides fundamental knowledge of embedded system development and its content is strongly related tomany other microelectronic and automation courses, hence it can be useful to all master students.

MA03 (Advanced Feedback Control)

Identifier	Module Name	Type	Course	Sem. 2
MA03	Advanced Feedback Control	Compulsory module for major automation	Adaptive and learning control	2,5 CP
				2V
			Synthesis of dynamic systems using state-space models	5 CP
				3V/0,5L

Module Responsible and Instructor	Additional Instructor(s)
Weigl-Seitz	Schnell, Kleinmann

1. Module content

Content of course "Adaptive and learning control"

The course covers the areas:

- Formulation of the Adaptive Control Problem
- Classification of Adaptive Control Systems
- Digital Process Modelling and Online Identification using the RLS Method
- Adaptation of Deadbeat Controllers and Controller Design by Pole Placement
- Dynamic Behavior of Adaptive Control Loops and Configuration Issues
- Motivation for Learning Control and Basic Structure of Learning Control Loops
- Neural Networks as Memory Blocks for Controller and Process Model in Learning Control Loops
- Computer based applications using Matlab/Simulink

Content of course "Synthesis of dynamic systems using state-space models"

This course covers the areas:

- Modelling of dynamic systems using state variables
- State space representation, canonical forms
- Correlation between transfer functions and state space representation
- Structural properties (stability, controllability , observability)
- State space transformations
- Solution of the time-invariant state-space equations
- Design of state variable feedback controllers
- Design of state variable observers
- State feedback by optimal control
- Computer based applications using Matlab/Simulink

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. Students will gain theorectical and practical knowledge on modern control engineering using state-space feedback control as well as adaptive and learning control.

3. Course organization and structure

Class lecture and lab

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 135 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is the successful participation in the lab „Synthesis of dynamic systems using state-space models".

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semester.

8. Applicability/utilization

The module is a mandatory module for the major Automation and an elective module for all other majors.

MA04 (Advanced Robotics)

Identifier	Module Name	Type	Course	Sem. 2
MA04	Advanced Robotics	Compulsory module for major automation	Telemanipulators	2,5 CP
				2V
			Model-based non-linear robot control	5 CP
				3V/0,5L

Module Responsible and Instructor	Additional Instructor(s)
Weber	Kleinmann, Weigl-Seitz

1. Module content

Content of course "Telemanipulators"

Overview of telemanipulation, telerobotics and telepresence. Control architectures in telemanipulator control, requirements in telemanipulator direct control, control schemes, control unit design on the base of a single axis telemanipulator system.

Content of course "Model-based non-linear robot control"

Introduction to robot arm control, necessary basics of kinematics, robot kinematics, model of robot arm and actuator system, model-based control on the base of defined input-output characteristics, model-based cascaded control, model reference adaptive control

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student is able to plan and design the control unit of a telemanipulator system with focus on position control and force feedback. He/she is capable of modelling the multi-body system robot arm including the actuator system. The model based and adaptive design of position control can be performed.

3. Course organization and structure

Class lecture, lab and programming assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 180 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is the successful participation in the lab „Model-based non-linear robot control"

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semester.

8. Applicability/utilization

The module is a mandatory module for the major Automation and an elective module for all other majors.

MA05 (Autonomous Systems)

Identifier	Module Name	Type	Course	Sem. 1
MA05	Autonomous Systems	Elective module	Mobile Robots	2,5 CP
				2V
			Task Planning in Unstructured Environments	5 CP
				3V/0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Haid		Simons, Schnell		

1. **Module content**

   Content of course "Mobile Robots":

   Introduction to
   - Locomotion
   - Construction and kinematics of mobile robots
   - Sensors for mobile robots
   - Mobile robot localization
   - Basics of motion planning, navigation and obstacle avoidance

   Content of course "Task Planning in Unstructured Environments":
   - Characteristics of autonomous systems in unstructured environments and examples
   - Localization methods, sensors and algorithms
   - Path planning using maps and methods for autonomous map generation
   - Motion planning and interaction of manipulator and platform
   - Task execution in cooperating mobile swarms
   - Showcase demonstration and validation of methods using laboratory systems

2. **Learning outcome / competencies**

   The student achieves competencies in the above mentioned topics. Upon completing the course, the students will be able to understand the fundamental of autonomous mobile systems. To develop the mobile systems, the students will experience analyzing and solving the engineering problems. This course provides some basic knowledge to improve the background knowledge of the students.

3. **Course organization and structure**

   Lecture and laboratory

4. **Credits and work load**

   7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. **Examination modalities**

   The final examination (duration: 180 min) will test overall contents of the module at the end of the semester. Test repetition will be arranged at the beginning of the following semester.
   Possible changes to the examination modalities may be communicated upon start of the module.

6. **Prerequisites**

   To be able to participate in the final examination of "Autonomous Systems", the pass of "Laboratory of Task Planning in Unstructured Environment" is required.

7. **Duration and frequency of course**

   The module lasts one semester. It will be given in every winter term.

8. **Applicability/utilization**

   This module can be applied to aplenty of applications in the field of autonomous systems and related fields, e.g. mechanical engineering, mechatronics.

MA06 (Information and simulation systems in industrial development and automation)

Identifier	Module Name	Type	Course	Sem. 2
MA06	Information and simulation systems in industrial development and automation	Elective module	Model-based real-time simulation of mechatronic systems	2,5 CP 2V
			Information systems in industrial automation	5CP 3V/0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Schnell		Garrelts		

1. Module content

Content of course "Model-based real-time simulation of mechatronic systems"

This course provides an introduction to the concepts of model-based real-time simulation and system design.

The course covers the areas:

- Modelling and classification of mechatronic systems
- Application area, requirements
- Software and function development process
- Real-time simulation and rapid prototyping methods
- Hardware-in-the-loop, software-in-the-loop and processor-in-the-loop
- Automatic code generation
- Experimental validation and testing methods
- Summary, conclusion and future prospects

Content of course "Information systems in industrial automation"

This course provides an introduction to the concepts of information systems used in industrial automation. It covers the areas

- Enterprise management levels
- Manufacturing Execution Systems (tasks, aims and structures of MES)
- Data Acquisition (e. g. OPC-technologies)
- Data exchange to ERP-systems
- Data structures (XML in industrial automation, AutomationML)
- Summary, conclusion and future prospects

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The students learn the concepts of information systems in industrial automation. This includes the main software tools, the data structures and the data exchange methods between the different enterprise management levels.

Furthermore this module enables the students to model and simulate mechatronic systems. These models can be used to improve the design and implementation process, to improve the system's documentation and maintainability and to support the system diagnosis. The students learn to simulate and test the systems using different testing methods.

Students will gain practical knowledge on modern engineering methods using model-based real-time simulation methods and tools.

3. Course organization and structure

Class lecture and lab

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (duration: 135 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.

Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is the successful participation in the lab „Information systems in industrial automation" and "Model-based real-time simulation of mechatronic systems".

7. Duration and frequency of course

The module lasts one semester. It is offered in winter semester.

8. Applicability/utilization

The module is applicable in all technical master courses (electrical/mechanical engineering, mechatronics, industrial engineering and management).

Modules for major communications

MC01 (Advanced Modulation and Coding)

Identifier	Module Name	Type	Course	Sem. 1
MC01	Advanced Modulation and Coding	Mandatory module for major communications	Advanced Modulation and Coding	7.5 CP 5V + 0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Kuhn		Götze		

1. Module contents

- Information Theory
- Digital Modulation
- MIMO technology
- Channel equalization
- Synchronization of receivers
- Channel Coding
- Source Coding
- Applications/ Practical Systems

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student knows and understands the concepts and design parameters of modern modulation and coding schemes. The student is able to understand further developments on his own and is able to participate in research and implementation projects dealing with modulation and coding schemes.

3. Course organization and structure

Class lecture and lab.

4. Credits and work load

7.5 CP, total work load of 225 hours, 82.5 hours lectures and labs

5. Examination modalities

Presentation and/or written exam (90 min) or oral exam covering the complete content of the module. Possible changes to the examination modalities be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is a successful participation in the lab exercises.

7. Duration and frequency of course

The module lasts one semester. It is offered in winter semester.

8. Applicability/utilization

The module is a mandatory module of major Communications and an elective module for all other majors

MC02 (Information Networks)

Identifier	Module Name	Type	Course	Sem. 1
MC02	Information Networks	Mandatory module for major communications	Information Networks	7,5 CP 5V/0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Chen		Gerdes		

1. Module content

Content of the course "Information Networks"

This course provides a detailed introduction to information & communication technologies and networks, and covers the following important topics

Review of LAN networks

- Protocols of the OSI-layer 1 and layer 2 in Access, MAN, WAN
- Dynamic Routing Algorithms
- Advanced Queuing Theory
- Analysis of the availability of the network elements and connections

- Concept of network security
- Specific requirements of the multimedia mission-critical real-time applications
- Broadband Multimedia Network Technologies
- Advanced Network Security Technologies (Encryption, Digital Signature, Authentication, Firewall, VPN etc.)
- Network Management Systems TMN and SNMP

Content of the Laboratory exercises "Information Networks"

- VoIP or Routing
- Virtual Private Network VPN

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. After completing the course, the student will be able to analyze, evaluate and plan the network in MAN/WAN environments. Furthermore the student is able to analyze the performance parameters, protocols, security and network management aspects for multimedia applications in an IP-based Next Generation Network.

3. Course organization and structure

Class room lecture, laboratory exercises

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 90 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

It is stand-alone with respect to examination pre-condition.

7. Duration and frequency of course

The module lasts one semester. It is offered in winter semester.

8. Applicability/utilization

This module provides fundamental knowledge of information and communication networks and its content is strongly related to many other communication courses, hence it can be useful to all master students.

MC03 (Digital Signal Processing)

Identifier	Module Name	Type	Course	Sem. 2
MC03	Digital Signal Processing	Mandatory module for major communications	Digital Signal Processing	7,5CP 5V/0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Krauß		Götze, Schultheiß, Wirth		

1. Module content

This course provides an introduction into the theory of digital signal processing and its application to important domains. It covers the following areas:

- Discrete-time signals and systems
- Discrete-time signal transforms (discrete-time Fourier transform, z-transform, DFT/FFT, DCT)
- Principles and methods of digital filter design (IIR and FIR filters)
- Implementation aspects of digital filters
- Application of digital signal processing in audio and image processing
- Multi-rate systems (interpolation, decimation, sampling rate conversion) and filter banks
- Spectral estimation methods
- Adaptive digital systems

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The participants will master both theory and applications of discrete-time signals and systems covering the areas listed above. After successful completion of the module the student is able to understand further developments on his own and is able to participate in respective R&D projects.

3. Course organization and structure

Classroom lecture and laboratory exercises

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and laboratory

5. Examination modalities

Examination in written form (duration: 90 min.) or oral examination (duration: 30 min.) at the end of the semester. A make-up examination will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

This module is designed as a stand-alone module. It is based upon the contents from bachelor studies of electrical engineering. Prerequisite for attending the examination is a successful participation in the laboratory exercises.

7. Duration and frequency of course

The module lasts one semester. It is offered in the summer semester.

8. Applicability/utilization

The module is a mandatory module of major Communications and an elective module for all other majors

MC04 (Microwave Components and Systems)

<table>
<tr><th>Identifier</th><th>Module Name</th><th>Type</th><th>Course</th><th>Sem. 3</th></tr>
<tr><td rowspan="4">MC04</td><td rowspan="4">Microwave Components and Systems</td><td rowspan="4">Mandatory module for major communications</td><td rowspan="2">Microwave Components</td><td>5 CP</td></tr>
<tr><td>3 V + 0,5 L</td></tr>
<tr><td rowspan="2">Microwave Systems</td><td>2.5 CP</td></tr>
<tr><td>2 V</td></tr>
<tr><th colspan="2">Module Responsible and Instructor</th><th colspan="3">Additional Instructor(s)</th></tr>
<tr><td colspan="2">Schmiedel</td><td colspan="3">Gaspard</td></tr>
</table>

1. Module content

Content of course "Microwave Components":

- microwave theory
  - Maxwell's equations
  - field simulation
- microwave technology
  - transmission lines
  - RF- and microwave circuits
  - RF and microwave measurements (lab)

Content of course "Microwave systems":

- receiver and transmitter architectures
  - design and performance issues
  - superhet-, low-IF-, DC- and SDR concepts
- analysis of microwave sub-systems
  - harmonic balance and its application to nonlinear microwave circuits, e.g. power amplifiers, oscillators and mixers
  - method of moments and its application to antenna problems

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student knows modern microwave technology and is able to analyze, simulate, develop, and test microwave components and systems. After completion of the module the student is able to participate in R&D projects.

3. Course organization and structure

Class lecture, student presentations, and lab.

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Presentation and/or written exam (90 min) or oral exam covering the complete content of the module. Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is a successful participation in the lab exercises.

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semester.

8. Applicability/utilization

The module is a mandatory module of major Communications and an elective module for all other majors.

MC05 (Mobile and Satellite Communications)

Identifier	Module Name	Type	Course	Sem. 1
MC05	Mobile and Satellite Communications	Elective module	Mobile Communications	5 CP
				3 V + 0,5 L
			Satellite Communications	2.5 CP
				2 V
Module Responsible and Instructor		**Additional Instructor(s)**		
Kuhn		Schmiedel, Chen, Krauß, Gaspard		

1. Module content

Content of course "Mobile Communications":

- use-cases, applications of Mobile Systems
- signals and signal propagation in mobile applications
- multiplexing, modulation, spread spectrum, cellular system
- wireless telecommunication systems
    - DECT
    - TETRA
    - GSM, HSCSD, GPRS, EDGE
    - UMTS, IMT-2000
    - LTE
- Wireless LANs (802.11 a/b/g/n)
- PAN (Bluetooth, RFID, ZigBee, HomeRF)
- broadcast systems
- network protocols
- mobile IP, ad-hoc networking, routing
- transport protocols
- reliable transmission
- flow control
- Quality of Service
- support for mobility
- network planning

Content of Course "Satellite Communications":

- introduction (brief):
    - satellite orbits
    - link analysis, incl. antennas
    - communication payload, i.e. modulation and access
- satellite application (focus on one state-of-the-art technology)
  e.g.
  - global navigation satellite systems (GNSS), or
  - worldwide mobile communication systems, or
  - remote sensing, or
  - etc.

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student knows modern wireless communications systems for the transmission of voice and data and is able to understand the differences between different systems as well as their pro and cons.
The student shall be able to evaluate and develop components for satellite systems.
After completion of the module the student is able to participate in R&D projects and operation of satellite and mobile communication systems.

3. Course organization and structure

Class lecture, student presentations, and lab.

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Presentation and/or written exam (90 min) or oral exam covering the complete content of the module. Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is a successful participation in the lab exercises.

7. Duration and frequency of course

The module lasts one semester. It is offered in winter semester.

8. Applicability/utilization

The module is an elective module for all majors.

MC06 (Optical Communications)

Identifier	Module Name	Type	Course	Sem. 2
MC06	Optical Communications	Elective module	Optical Communications	7,5 CP 5V/0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Loch		Chen		

1. Module content

Content of course "Optical Communications"

This course provides an in-depth introduction into the Optical Communications Theory and Technologies. It covers the areas

- advanced characteristics and production technologies of optical fibers
- theory: wave equation solution
- advanced analyses of the mechanisms for dispersions and attenuations
- nonlinear effects and their impacts and applications (e.g. soliton features)
- optical fiber connections: theoretical and practical considerations
- advanced theoretical considerations and optimizations of optical sources (LASER / LED) and detectors, 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 mode dispersion PMD)
- fiber optical systems: fundamentals and limitations
- basics of coherent optical communication systems
- special optical communication devices and modern systems

Content of laboratory exercises "Optical Communications"

- measurement/monitoring procedures for characterization of optical fibers
- advanced simulations of complex optical communication networks

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student will learn the most important components of optical communications, and the numerical simulation methods to analyze these components. The student should be able to evaluate, apply and further develop different system concepts. Moreover the student will learn and apply the optical measurement methods in the laboratory. After successful completion of this course the student should be able to conduct research and development projects in the area of the optical communications.

3. Course organization and structure

Class room lecture, laboratory exercises

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 90 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the module is the fundamental knowledge from Bachelor course in the field of Electrical Engineering. The module is stand-alone with respect to examination pre-condition.

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semester.

8. Applicability/utilization

Even though this module provides fundamental knowledge for optical communication networks and technologies, and its content is strongly related to many other communication courses, it is stand-alone with respect to examination pre-condition.

The module is an elective module for all majors.

Modules for major embedded and microelectronics

MM01 (Complex Digital Architectures)

Identifier	Module Name	Type	Course	Sem. 2
MM01	Complex Digital Architectures	Compulsory module for major micro electronics	Complex Digital Architectures	7,5 CP 5V/0,5L
Module Responsible and Instructor	Additional Instructor(s)			
Meuth				

1. Module content

Use of modern FPGA and software technology and tools in a hardware/software co-design process

- Automata, state machines
- Digital coding and number systems and their hardware relevance Interfacing
- error coding, error detection, and recovery
- Complex hardware algorithms and their architectures, performance and tradeoffs
- Software acceleration by special purpose hardware
- Hardware/Software partitioning in embedded environments

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. Successful participants will be able to specify and/or design as well as implement on digital hardware platforms hardware algorithms and systems, specifically subject to constraints as maximum clock rates, bit-widths and through-puts, on the basis of a synoptic system view.

3. Course organization and structure

In-class lecture, lab sessions and design (homework) assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (min. duration: 90 min) covering the complete content of the module at the end of the semester, mandatory lab attendance. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for participating in the exam is a successful attendance during lab sessions

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semesters only.

8. Applicability/utilization

The module is a mandatory module of major Embedded and Microelectronics and an elective module for all other majors

MM02 (Advanced Embedded Systems)

Identifier	Module Name	Type	Course	Sem. 1
MM02	Advanced Embedded Systems	Compulsory module for major micro electronics	Embedded Operating Systems / Embedded Design	5 CP 3V/0,5L
			Advanced Microcontroller Architectures	2,5 CP 2V
Module Responsible and Instructor		Additional Instructor(s)		
Fromm		Lipp, Schaefer, Rücklé		

1. Module content

Content of course "Embedded Operating Systems / Embedded Design"

Participants will be exposed to and gain working experience with embedded operating systems. The course will cover

- introduction to multitasking concepts and operating systems,
- processes, threads, memory and data management,
- scheduling algorithms,
- data and time consistency,
- interprocess communication and synchronization,
- design of reactive systems, state machine design and coding,
- case studies of industrial embedded operating systems
- development of embedded, realtime, multitasking systems

Practical programming assignments in C/C++ using state of the art operating systems are part of the course.

Content of course "Advanced Microcontroller Architectures"

Participants will be introduced to the design and programming of modern microcontrollers. The course will cover

- microcontroller architectures,
- IP components, system on chip design,
- microcontroller driver development,
- memory protection and memory management,
- hardware/software co-design,
- embedded code design,
- development and test tools

Practical examples are part of the course.

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student is able to design and implement complex embedded systems in hardware and software.

3. Course organization and structure

Class lecture, lab and programming assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Written exam (180 min) or oral exam covering the complete content of the module. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is a successful participation in the lab „Embedded Operating Systems"

7. Duration and frequency of course

The module lasts one semester . It is offered in the winter semester.

8. Applicability/utilization

This module provides fundamental knowledge of embedded system development and its content is strongly related to with many other microelectronic and automation courses, hence it can be useful to all master students.

MM03 (Microelectronic Systems)

Identifier	Module Name	Type	Course	Sem. 1
MM03	Microelectronic Systems	Compulsory module for major micro electronics	Microelectronic Systems	7,5 CP 5V/0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Schumann				

1. Module content

Content of course "Microelectronic Systems"

This module aims to give a detailed understanding of the design methodology for microelectronic systems. The course covers

- hardware description language VHDL
- semi custom design methodology
- pros./cons. of FPGA vs. ASIC implementation
- influence of transistor scaling on system performance
- hardware architectures of arithmetic circuits
- power dissipation in CMOS

Practical design assignments in VHDL including FPGA implementation using state-of-the-art engineering tools are part of this course.

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student is able to design a digital system using hardware description language VHDL. The concepts of logic and physical synthesis of a digital system are understood and the student is able to do design verification and performance analysis.

3. Course organization and structure

Class lecture, lab assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 90 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.

Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is a successful participation in the lab "Microelectronic Systems".

7. Duration and frequency of course

The module lasts one semester. It is offered in winter semester.

8. Applicability/utilization

The module is a mandatory module of major Embedded and Microelectronics and an elective module for all other majors

MM04 (Design and Test of Microelectronic Systems)

Identifier	Module Name	Type	Course	Sem. 2
MM04	Design and Test of Microelectronic Systems	Compulsory module for major micro electronics	Design and Test of Microelectronic Systems	7,5 CP 5V/0,5L

Module Responsible and Instructor	Additional Instructor(s)
Schumann	

1. Module content

Content of course "Design and Test of Microelectronic Systems"

This course covers modern aspects of digital CMOS circuit design, memory circuit design and testing of integrated circuits. In particular the course covers the areas

- pipelining, parallel processing, clock skew reduction
- low-power design concepts
- memory circuit design
- manufacturing test principles
- design for testability

Practical design assignments using state-of-the-art engineering tools are part of this course.

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The student is able to make decisions on different implementation choices of digital integrated circuits, on transistor, architectural and platform level regarding design constraints like speed and power dissipation. Also the concepts of the main memory devices are understood. The student is able to use state-of-the-art engineering tools for IC design including design-for-testability features.

3. Course organization and structure

Class lecture, lab assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 90 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.

Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is a successful participation in the lab "Design and Test of Microelectronic Systems".

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semester.

8. Applicability/utilization

The module is a mandatory module of major Embedded and Microelectronics and an elective module for all other majors

MM05 (Signal Processing Hardware)

Identifier	Module Name	Type	Course	Sem. 1
MM03	Signal Processing Hardware	Elective module	Signal Processing Hardware	7,5 CP 5V/0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Meuth				

1. Module content

The module aims at a hardware design perspective of the entire signal processing chain and the interdependency of hardware design parameters, rather than the programming of commercial digital signal processors.

The course will cover

- Anti-aliasing and reconstruction filters
- Sampling (in time), bit quantization (in value), conversion and reconstruction
- Actual hardware issues (system interfacing, signal integrity, limitations)
- Over-sampling, under-sampling
- Noise, noise-shaping and reduction, Sigma-Delta
- Precision of algorithms, errors and error propagation
- DFT and FFT, binary architectures
- Binary digital signal / function generation. (PWM, saw-tooth, triangle, CORDIC sin/cos, noise)
- Digital filter design principles. Digital feedback and control architectures
- Actual hardware implementations of digital systems in FPGA
- Error coding, error detection, and recovery
- Z-transform and bit-true representations in time and frequency domain

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. Successful participants will be able to specify and/or design as well as implement on digital hardware platforms signal processing component and systems, specifically subject to constraints as maximum clock rates, bit-widths and through-puts, on the basis of a synoptic system view.

3. Course organization and structure

In-class lecture, lab sessions and design (homework) assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (min. duration: 90 min) covering the complete content of the module at the end of the semester, mandatory lab attendance. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for participating in the exam is a successful attendance during lab sessions

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semesters every second year.

8. Applicability/utilization

The module is applicable and open also to other related engineering Master courses.

MM06 (CMOS analog circuits)

<table>
<tr><th>Identifier</th><th>Module Name</th><th>Type</th><th>Course</th><th>Sem. 2</th></tr>
<tr><td rowspan="2">MM06</td><td rowspan="2">CMOS analog circuits</td><td rowspan="2">Elective module</td><td rowspan="2">CMOS analog circuits</td><td>7,5 CP</td></tr>
<tr><td>5V/0,5L</td></tr>
<tr><th colspan="2">Module Responsible and Instructor</th><th colspan="3">Additional Instructor(s)</th></tr>
<tr><td colspan="2">Hoppe</td><td colspan="3"></td></tr>
</table>

1. Module content

This module provides an introduction to CMOS analog circuit design. It covers the areas

- CMOS-technology,
- MOS-transistors and passive components,
- Integrated circuit layout,
- CMOS device modelling (large signal and small signal), SPICE-simulation
- Analog subcircuits: Switches, sinks/sources, current mirrors, references
- CMOS amplifiers: single transistor amplifiers, differential amplifiers, cascode amplifiers
- Operational amplifiers, OpAmps: Compensation, two-stage-architectures, cascade OpAmps)
- Digital-analog and analog-digital converters (flash, sequential and oversampling converters)

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. After the completion of the module the student is able to design analog building blocks and integrated analog systems starting from a specification to a verified integrated circuit layout. The module covers complex design problems and identifies common mistakes made by beginning engineers. Design recipes are presented taking the student step by step through the creation of real circuits. The module leaves out bipolar analog circuits, since CMOS is the dominant fabrication technology.

3. Course organization and structure

Class lecture, lab assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 90 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

The module is appropriate to students with background knowledge in basic electronics, including biasing, modeling and circuit analysis, as well frequency response.

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semester every two years.

8. Applicability/utilization

The module is part of the curriculum for majoring in Microelectronics.

Modules for major power

ME01 (Advanced High Voltage Technology and Theory of Electric Fields)

Identifier	Module Name	Type	Course	Sem. 1
ME01	Advanced High Voltage Technology and Theory of Electrical Fields	Compulsory module for major power	High Voltage Technology	5CP
				3 V/0,5L
			Theory of Electric Fields	2,5 CP
				2 V
Module Responsible and Instructor		Additional Instructor		
Betz		Frontzek		

1. Module content

Content of Course "High Voltage Technology":

The aim of this course is to enable the master students to cope with the dimensioning criteria of high voltage equipment and to assess the related design with regard to voltage withstand ability. Within this course, the basic dimensioning rules, the development of insulation systems and the testing procedures will be main part of the lessons. The course covers the areas

- Overview about different kind of voltage stress appearing in a high voltage network
- Design examples of ultra high voltage **ac** and **dc** switchgear applications (actual trends)
- Test set-up configurations for generating ac and dc high voltage sources
- Requirements and dimensioning rules of standardized impulse voltage generation
- Dielectric performance of gaseous, liquid and solid insulation materials
- Basic rules for dimensioning of high voltage insulation systems
- Introduction into the development process of a high voltage insulation system
    - o Dielectric calculations
    - o Thermal calculations
    - o Basic design
    - o Failure mode analysis (FMEA)
    - o Patent procedures
    - o Requirements of different standards (IEC, DIN VDE, ANSII)
    - o Procedure of Type Tests and Routine Tests
    - o Verification of the voltage withstand ability of an real high voltage module (see part: High Voltage Laboratory)
- Introduction into first steps of product cost estimation of the related high voltage module
- Lightning surge and lightning protection

Contents of Course "Theory of Electric Fields":

- Basics of maxwell equations
- Electric Field and Potential distribution of basic elements like cylinder, sphere etc.
- Electric Field distribution of inhomogeneous elements like spike-plate arrangements
- Methods to create an electric field distribution "by hand"
- Introduction into calculation of Electric Fields and comparison of FEM- and Boundary Element-Methods
- Introduction into simulation tools and overview about their practical limits

Content of High Voltage Laboratory:

Experiments and measurements with different module set-ups, which will be built up by the students on their own (supported by the Instructor of the course):

- Measurement of voltage withstand ability of different insulation media (liquid, gaseous) and surface discharges in case of solid insulations
- Basic design and basic dimensioning of a test set-up with regard to
    - ▪ AC-voltage test in combination with partial discharge measurement
    - ▪ Lightning impulse test and evaluation of the dielectric strength
    - ▪ Evaluation and quantification of the measuring failure
- Optimization of the first set-up including design change, dimensioning check and building up a second (optimized) test set-up based on the experience and the measuring results of the first set-up.

- Experimental check of the dielectric strength as above

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The target of the combination of lecture and laboratory tests is to familiarize the students with the complete process from the initiation of a new product to the related product introduction into the market. This will be achieved by addressing all necessary theoretical background, especially the theory of Electric Fields and the related application tools. As a verification of the topics of the course, several tests are planned in the high voltage laboratory, where the students are enabled to build up the test set-ups on their own responsibility and to check their technical choices by practical results.
It is the aim of this course to introduce the students into the future real work i.e. in industry. The students understand the correlation between theoretical (physical, mathematical and electrical engineering) aspects and practical boundaries.

3. Course organization and structure

Lecture and Laboratory

4. Credit points and work load

7,5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 120 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is the successful participation in the lab "High Voltage Laboratory"

7. Duration and frequency of course

The module lasts one semester and will be held in the winter semester,

8. Applicability/utilization

The course comprises the basic guidelines to design a high voltage insulation system according to the standards and the theory of physics, mathematics and electrical engineering.

ME02 (Power Systems and Control Technology)

Identifier	Module Name	Type	Course	Sem. 1
ME02	Power Systems and control technology	Compulsory module for major power	Engineering Processes	5,5 CP
				4V
			Power System Operational Training Lab	2 CP
				1L

Module Responsible and Instructor	Additional Instructor(s)
Metz	Graf, Anthes

1. Module content

Content of course "Power Systems and control technology"

This course provides an introduction to professional power system planning and operation based on industry standard tools like SCADA and Training Systems. The course covers the theoretical side and explanations as well as the grid operations in real time on a training system using a standard control system. The lab covers fundamental concepts for planning and operating power grids in real situations.

- Requirements engineering, Asset Management and planning for power system components
- Structure and architecture of power systems and information technology (RTU)
- Extended study of power systems and components in the power system context
- Groundings of neutral transformer star point
- SCADA and EMS software functions in control center
- Studies on regulations for keeping power system voltage
- Studies on regulations for keeping power system frequency
- Studies of real power system outages and accidents
- Strategies for clearing power system emergencies
- Control centre operational handling in coordination with grid service staff,
- Strategies for operational planning and Asset Management

Content of the lab

- SCADA and Energy Management Function in Control Centers
- Operational tasks by remote and by communication to grid staff
- Extended studies on power system components in normal and overload conditions
- Compensations and Energy storages
- Power System islands during overload
- Analyzing and operational tasks for clearance of power system emergencies
- Reactions of power system components during power system emergencies and faults
- Studies of components and regulations in Smart Grids

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The participants' competence to understand power system planning and operation is extended to Master level. They understand the strategies for modern Asset Management and can apply these on examples. The lectures provide the basis of e.g. power system regulations and the labs give the feeling of a real reacting and interacting power system and its components. The participants will get an extended understanding of power systems and the effects of operations. They are able to use control center software tools for analyzing power system state and clearing of emergencies. They shall know the strategies, components and tools for TSO and DSO control centers to analyze the power system state and to stabilize e.g. voltage and frequency even in islanded power systems.

3. Course organization and structure

Class lectures and lab training meetings according to the lectures.

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 120 min) covering the complete content of the module at the end of the semester. A re-exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

Prerequisite for attending the exam is a successful participation in the Power System Training Lab which will be documented by preparing lab reports.

7. Duration and frequency of course

The module lasts one semester. It is regularly offered in summer semester.

8. Applicability/utilization

The module is a mandatory module of major Power and an elective module for all other majors.

ME03 (Control of electrical Drives & E-Mobility)

Identifier	Module Name	Type	Course	Sem. 2
ME03	Control of electrical Drives & E-Mobility	Compulsory module for major power	Controlled Drives	5 CP
				3,0V/0,5L
			E-Mobility	2,5LP
				2,0 V
Module Responsible and Instructor		Additional Instructor(s)		
Wagner		Bauer, Schmidt-Walter		

1. Module content

Content Course Controlled Drives:

- Basics of torque generation, voltage induction, rules
- Basics of electrical machines
- DC-motor, dynamics and simulation
- Three-phase drives (asynchronous-, synchronous-machines,
- Transfer-functions of DC- and asynchronous machines
- Transfer-functions of power-converters
- Sensors for current-, speed-, position-measurement
- Control-Methods and strategies for E-machines (DC- AC-machines)
- Simulation of electromechanical systems
- Stepper motors

Content Course e-mobility:

- History of electric vehicles
- Physical and mechanical basics of vehicle technology
- Electric power supply on vehicles
    - Energy storage, battery, super capacitors
    - Fuel cells and hydrogen storage
    - Charging methods, charging stations
- Electric drive
    - Choose of e-machine type,
    - Power electronics
    - Control
- Hybrids, full-e-vehicles, electrical locomotives
- Infrastructure for e-mobility

Content Laboratory

Experiments and measurements with controlled e-machines:

- Speed controlled DC-machine
- Speed controlled AC-machine

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. The aims of the lecture are to introduce the structure and the most important electrical drive systems. The students shall understand the interplay of mechanics, motor, inverter, control and information technologies in modern drive systems.

The participants will be introduced to devices and circuits for controlling and converting electrical power.

3. Course organization and structure

Class lecture, lab and programming assignments

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 120 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester. The Controlled Drives-Laboratory must be passed.

Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

None

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semester

8. Applicability/utilization

The module is a mandatory module of major Power and an elective module for all other majors. The module can be used in master courses of electrical engineering, mechatronics, mechanical engineering, industrial and automotive Engineering.

ME04 (Power Electronics and Switching Power Supply)

Identifier	Module Name	Type	Course	Sem. 2
ME04	Power Electronics and Switching Power Supply	Compulsory module for major power	Power Electronics	5 CP
				3V/0,5L
			Switch-mode power supplies	2,5 CP
				2V
Module Responsible and Instructor		Additional Instructor(s)		
Michel		Schmidt-Walter		

1. Module content

Content of course "Power Electronics"

- short repetition of
  - basic semiconductor devices
  - rectifiers and inverters
  - choppers and converters
  - power quality, reactive and distortive power
- new materials, SiC- components
- mathematical analysis of resonant and quasi-resonant circuits
- solar inverters
- simulation of power-electronic circuits and principles
- matrix- and high voltage converters
- circuits for application in HVDC and flexible transmission systems

Content of course "Switch-mode Power Supplies"

- short repetition of basic switch mode topologies, Buck, Boost, Fly-Back
- choking coils
- Forward- and Push-Pull-Converter
- Resonant Converter
- Power-Factor Control
- Control of switch mode power supplies,
- Transistor drive circuits
- Calculation of transformers and choking coils
- Radio Interference Filter
- Design of printed circuit boards

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. On a basic knowledge base of power electronics students shall understand and achieve the capability to analyze and calculate power electronic circuits with advanced components and technologies. They will be able to understand, simulate and calculate concepts in the fields of power conversion, renewable energies and line applications. They are able to design switch-mode power supplies.

3. Course organization and structure

Class lecture and lab
Lab experiments deepening understanding of power electronic circuits and principles.

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures and labs

5. Examination modalities

Exam (Duration: 120 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

The module requires good knowledge of circuit analysis and electronics. Students should be familiar with basics of power electronics.

7. Duration and frequency of course

The module lasts one semester.

8. Applicability/utilization

The module is a mandatory module of major Power and an elective module for all other majors

ME05 (Renewable Energy Systems)

Identifier	Module Name	Type	Course	Sem. 1
ME02	Renewable Energy Systems	Elective module	Renewable Energies	5 CP
				4V
			Fuel Cells and Hydrogen Techniques	2,5 CP
				2V
Module Responsible and Instructor		Additional Instructor(s)		
Petry		Schmidt-Walter, Jakob		

1. Module content

Today's and future societies crucially rely on a secure, stable and uninterruptible energy supply. A key success factor in this context represents the strategic expansion and integration of renewable energy systems in present and future energy supply systems. Besides providing students with up-to-date and advanced knowledge of renewable energy techniques and systems, the lecture also addresses contemporary and future challenges such as net-integration or the storage of electricity generated by fluctuating renewable power generation systems. In detail, the course covers the following subjects:

Content of course "Renewable Energies"

- An analysis of current energy needs and future energy demands as well as the resulting environmental, social, social-economic and political implications.
- A review of the basic physics used in RE studies (Energy fundamentals, heat transfer mechanisms, laws of thermodynamics, conservation of energy and momentum, ...).
- Conventional energy systems (fossil fuels and nuclear energy) and their underlying conversion processes.
- Solar energy, solar radiation, solar thermal and solar thermal electricity systems.
- Photovoltaic power generation, photovoltaic system design (stand-alone and grid connected systems), photovoltaic power electronics.
- Wind energy resources, site analysis, wind energy conversion systems, onshore and offshore wind park design.
- Besides the two main topics, solar and wind energy conversion systems, the lecture also addresses geothermal power systems, hydro and tidal power systems as well as biomass 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.
- Future outlook on renewable energy: Potentials and limitations, drivers and future challenges, policy and planning
- Economics of renewable energy systems

This course uses MATLAB to model, simulate and analyse various aspects of renewable energy systems. The use of this modelling and simulation software aims to sharpen the students understanding of basic principles and concepts (solar sun tracking algorithms, wind site and turbine analysis or the modelling of hydro power systems to name just a few) and is extensively integrated into lecture based demonstrations as well as in homework problems.

There will be reading assignments as well as MATLAB based practise problems assigned for most classes.

Content of course "Fuel Cells and Hydrogen Techniques"

- Hydrogen, combustion, storage and handling
- Hydrogen production and electrolysis
- Fuel cells, basic function, efficiency, electrical behavior
- Fuel cell types, AFC, PEMFC, MCFC, SOFC, DMFC
- Fuel Cell Systems
- Components and assemblies for fuel cell systems

2. Learning outcome

At the completion of the course, successful participants will have an in-depth understanding of the fundamental physical and technical concepts of various renewable energy systems and resources including solar and wind energy systems, geothermal, hydro/tidal power systems, biomass power systems as well as fuel cell power systems and hydrogen technologies. The students will develop the ability to evaluate renewable energy technology options critically and are able to identify, formulate and solve medium to complex problems in this context. In addition to technical relationships, the students will be familiar with contemporary issues and challenges related to energy generation as well as its implications on society and environment from a global perspective.

3. Course organization and structure

Class lecture

4. Credits and work load

7.5 CP, 225 hours total work load, 82.5 hours lectures

5. Examination modalities

Exam (Duration: 120 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

None

7. Duration and frequency of course

The module lasts one semester . It is offered in winter semester.

8. Applicability/utilization

The module provides knowledge of the renewable energy systems, which are fundamental for power systems of today and in the future.

ME06 (Smart Grids)

Identifier	Module Name	Type	Course	Sem. 2
ME06	Smart Grids	Elective module	Smart Grid Technology	6,5 CP
				5V
			Smart Grid operational training	1 CP
				0,5L
Module Responsible and Instructor		Additional Instructor(s)		
Metz		Graf, Anthes, Mengapche		

1. Module content

Content of course "Smart Grids"

- Power systems history, Environment effects, Needs for new structures
- Overview to the vision
- Power stability and regulations
- Power grid components
- TSO and DSO Grids and operational tasks
- Legislation and regulation
- Concepts and components for Smart Grids
- Smart Communication and Smart Metering
- Standardizations
- Energy Management in Smart Grids
- Role of storages
- Energy Butler and Energy Assistants
- Smart Grid Control Centre and operational Tasks for Smart Grids
- Future Challenges

Content of "Smart Grid Operational Training"

- Seeing effects of weather depending renewable sources
- Seeing effects of DMS-tariff orders
- Seeing effects of virtual power plants
- Energy balancing manually and by assistant tools
- Exercising operational Smart Grid tasks

2. Learning outcome / competencies

The student achieves competencies in the above mentioned topics. Participants will obtain a basic physical, technical and economical knowledge of the Smart Grid Technology. Main focuses of the lecture are on component technologies and their interaction in the power system. The students shall also understand the potential and the risks of the change to renewable and distributed production and the efforts that have to be taken for system stability and energy balancing.

3. Course organization and structure

Class lectures and lab exercises

4. Credits and work load

7.5 CP, 225 hours total work load, 82,5 hours lecture.

5. Examination modalities

Exam (Duration: 120 min) covering the complete content of the module at the end of the semester. A make-up exam will be offered during the following semester.
Possible changes to the examination modalities may be communicated upon start of the module.

6. Prerequisites

None obligate, ME03 (Power Systems and Control Technology) is recommended

7. Duration and frequency of course

The module lasts one semester. It is offered in summer semester.

8. Applicability/utilization

The module provides knowledge of the Smart Grid strategy, technology and components as well as the operational side which are fundamental for power systems in the future.
It provides a base for Master Thesis in the field of designing and operation of Smart Grid Power Systems.