Master Program Business Administration with Electrical Engineering and Information Technology (PO 2020)

Module manual
Date: 01.10.2020

TECHNISCHE UNIVERSITÄT DARMSTADT

Department of Electrical Engineering and Information Technology

Module manual: Master Program Business Administration with Electrical Engineering andInformation Technology (PO 2020

Date: 01.10.2020

Department of Electrical Engineering and Information Technology
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Contents

1 Electrical Engineering and Information Technology - Options

1.1 Option Automation Systems (AUT)

1.1.1 AUT - Mandatory Courses

Module name System Dynamics and Automatic Control Systems III						
Module Nr. 18-ad-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe	
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy			
1	**Content** Topics covered are: • basic properties of non-linear systems, • limit cycles and stability criteria, • non-linear control of linear systems, • non-linear control of non-linear systems, • observer design for non-linear systems					
2	**Learning objectives / Learning Outcomes** After attending the lecture, a student is capable of: • explaining the fundamental differences between linear and non-linear systems, • testing non-linear systems for limit cycles, • stating different definitions of stability and testing the stability of equilibria, • recalling the pros and cons of non-linear controllers for linear systems, • recalling and applying different techniques for controller design for non-linear systems, • designing observers for non-linear systems					
3	**Recommended prerequisite for participation**					
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)					
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)					
6	**Usability of this module** MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik					
7	**Grade bonus compliant to §25 (2)**					

8	**References** Adamy: Systemdynamik und Regelungstechnik III (available for purchase at the FG office)			
Courses				
	Course Nr. 18-ad-2010-vl	**Course name** System Dynamics and Automatic Control Systems III		
	Instructor Prof. Dr.-Ing. Jürgen Adamy		**Type** Lecture	**SWS** 2
	Course Nr. 18-ad-2010-ue	**Course name** System Dynamics and Automatic Control Systems III		
	Instructor Prof. Dr.-Ing. Jürgen Adamy		**Type** Practice	**SWS** 1

Module name Technical Thermodynamics I					
Module Nr. 16-14-5010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Peter Christian Stephan		

1 Content

Fundamental terms of thermodynamics; thermodynamic equilibrium and temperature; different forms of energy (internal energy, heat, work, enthalpy); properties and equations of state for gases and incompressible substances; first law of thermodynamics and energy balances for technical systems; second law of thermodynamics and entropy balances for technical systems; exergy analysis; thermodynamic behaviour during phase change; the carnot cycle for power generation or refrigeration; energy efficiency and coefficient of performance; cyclic processes for gas turbines, combustion engines, power plants, refrigerators and heat pumps.

2 Learning objectives / Learning Outcomes

On successful completion of this module, students should be able to:

- Explain the relationships between thermodynamic properties and the thermodynamic state of a system and apply them within calculations of thermal system behaviour.
- Distinguish between different types of energy (e.g. work, heat, internal energy, enthalpy) and define them.
- Analyse technical systems and processes using energy balances and equations of state.
- Assess energy conversion processes by means of an entropy balance or an exergy analysis.
- Characterise the thermal behaviour of gases, liquids and solids and corresponding phase change processes.
- Apply this basic knowledge (1.-5.) to examine machines (turbines, pumps etc.) and processes for energy conversion (combustion engine, power plants, refrigerators, heat pumps).

3 Recommended prerequisite for participation

None

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Standard Grading System)

Written exam 150 min

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)

6 Usability of this module

Bachelor MPE Pflicht
Bachelor WI-MB
Master ETiT MFT, Bachelor Mechatronik

7 Grade bonus compliant to §25 (2)

8 References

P. Stephan; K. Schaber; K. Stephan; F. Mayinger: Thermodynamik, Band 1: Einstoffsysteme, Springer Verlag.
Further material (slides, collection of exercises, table of fomulas etc.) is available through the Moodle system of TU Darmstadt.

Courses

	Course Nr. 16-14-5010-vl	**Course name** Technical Thermodynamics I		
	Instructor		**Type** Lecture	**SWS** 3
	Course Nr. 16-14-5010-hü	**Course name** Technical Thermodynamics I		
	Instructor		**Type** Lecture Hall Practice	**SWS** 1
	Course Nr. 16-14-5010-gü	**Course name** Technical Thermodynamics I - Group Exercise		
	Instructor		**Type** Group Practice	**SWS** 1

Module name Digital Control Systems I					
Module Nr. 18-ko-2020	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** Theoretical fundamentals of sampled control systems: Discrete-time functions, sample/hold element, z-transform, convolution sum, z-transfer function, stability of sampled systems, design of digital controllers, discrete PI-, PD-, and PID-controllers, compensation and dead-beat controller, anti-windup methods
2	**Learning objectives / Learning Outcomes** The students know the fundamental analysis and design methods for digital feed-forward and feed-back control systems. They know the fundamental differences between continuous-time and discrete-time control systems and can design and analyze discrete-time control systems using different methods.
3	**Recommended prerequisite for participation** Helpful is knowledge of the Laplace- and Fourier-transforms as well as continuous-time control systems. These fundamentals are taught in the lecture “System Dynamics and Control Systems I”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** BSc/MSc Wi-ETiT, MSc ETiT, BSc/MSc CE, MSc MEC, BSc/MSc iST, MSc iCE, MSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes Konigorski: “Digitale Regelungssysteme” Ackermann: "Abtastregelung" Aström, Wittenmark: "Computer-controlled Systems" Föllinger: "Lineare Abtastsysteme" Phillips, Nagle: "Digital control systems analysis and design" Unbehauen: "Regelungstechnik 2: Zustandsregelungen, digitale und nichtlineare Regelsysteme"

Courses

Course Nr.	**Course name**		
18-ko-2020-vl	Digital Control Systems I		
Instructor Prof. Dr.-Ing. Ulrich Konigorski		**Type** Lecture	**SWS** 2
Course Nr.	**Course name**		
18-ko-2020-ue	Digital Control Systems I		
Instructor Prof. Dr.-Ing. Ulrich Konigorski		**Type** Practice	**SWS** 1

Module name Power Systems I					
Module Nr. 18-hs-1010	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Content** Three-phase network and symmetrical components; overhead lines; cables; transformers; calculation of short-circuit currents; switch equipment; switchgears
2	**Learning objectives / Learning Outcomes** The education goals are • Presentation of components of power system • Functional elaboration of equipment • Calculation of the component rating • Impact on the electrical power system
3	**Recommended prerequisite for participation** Contents of the lecture Electrical Power Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc/MSc WI-ET, BSc EPE, BSc/MSc CE, BSc/MSc iST, MSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Script, lecture slides, guiding questions, excercises

Courses

	Course Nr. 18-hs-1010-vl	**Course name** Power Systems I		
	Instructor Prof. Dr.-Ing. Jutta Hanson		**Type** Lecture	**SWS** 2
	Course Nr. 18-hs-1010-ue	**Course name** Power Systems I		
	Instructor Prof. Dr.-Ing. Jutta Hanson		**Type** Practice	**SWS** 2

Module name					
Fuzzy Logic, Neural Networks and Evolutionary Algorithms					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ad-2020	4 CP	120 h	75 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Jürgen Adamy		

1 Content

Fuzzy systems: basics, rule based fuzzy logic, design methods, decision making, fuzzy control, pattern recognition, diagnosis; Neural networks: basics, multilayer perceptrons, radial basis functions, pattern recognition, identification, control, interpolation and approximation, Neuro-fuzzy: optimization of fuzzy systems, data driven rule generation; Evolutionary algorithms: optimization problems, evolutionary strategies and their applications, genetic programming and its applications

2 Learning objectives / Learning Outcomes

After attending the lecture, a student is capable of:

- recalling the elements and set-up of standardized fuzzy-logic, neural networks and evolutionary algorithms,
- discussing the pros and cons of certain set- ups of systems from computational intelligence for solving a given problem,
- recognizing situations in which tools taken from computational intelligence can be applied for problem solving,
- creating programs from algorithms taught in the lecture, and
- extending the learned standard procedures in order to solve new problems.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

BSc iST, MSc ETiT, MSc MEC, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik

7 Grade bonus compliant to §25 (2)

8 References

Adamy: Fuzzy Logik, Neuronale Netze und Evolutionäre Algorithmen, Shaker Verlag (available for purchase at the FG office)
www.rtr.tu-darmstadt.de (optionales Material)

Courses

Course Nr.	Course name		
18-ad-2020-vl	Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Fabian Müller		Lecture	2
Course Nr.	**Course name**		
18-ad-2020-ue	Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Fabian Müller		Practice	1

Module name Identification of Dynamic Systems					
Module Nr. 18-ko-2040	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1 Content

- Introduction into the determination of mathematical process models based on measured data
- Theoretical and experimental modeling of dynamic systems
- System identification using continuous time signals:
  - Aperiodic signals
    - Fourier analysis
    - Evaluation of characteristic values (stepresponses)
  - Periodic signals
    - Frequency response analysis
    - Correlation analysis
- System identification using discrete time signals:
  - Deterministic and stochastic signals
  - Basics in estimation theory
  - Correlation analysis
- Parameter estimation techniques:
  - Least-squares estimation
  - Model structure determination
  - Recursive estimation algorithms
- Kalman Filter and Extended Kalman Filter
- Numerical Methods
- Implementation under MatLab Numerous examples with real experimental data

2 Learning objectives / Learning Outcomes

The students are taught the fundamental methods in signal and system analysis. Furthermore, the students master methods such as Fourier analysis, correlation analysis and parameter estimation methods. Based on this foundation, the students are able to assess and to apply the individual methods and can derive non-parametric as well as parametric models from measured data.

3 Recommended prerequisite for participation

MSc ETiT, MSc MEC

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

All disciplines of Electrical Engineering and Information Technology and similar disciplines (Mechatronics, Mechanical and Process Engineering, . . .), Master of Science

7 Grade bonus compliant to §25 (2)

8 References

	Pintelon, R.; Schoukens, J.: System Identification: A Frequency Domain Approach. IEEE Press, New York, 2001. Ljung, L.: System Identification: Theory for the user. Prentice Hall information and systems sciences series. Prentice Hall PTR, Upper Saddle River NJ, 2. edition, 1999.

Courses

	Course Nr. 18-ko-2040-vl	**Course name** Identification of Dynamic Systems		
	Instructor Dr. Ing. Eric Lenz, M.Sc. Jonathan Hermann		**Type** Lecture	**SWS** 2
	Course Nr. 18-ko-2040-ue	**Course name** Identification of Dynamic Systems		
	Instructor Dr. Ing. Eric Lenz, M.Sc. Jonathan Hermann		**Type** Practice	**SWS** 1

Module name Controller Design for Multivariable Systems in State Space					
Module Nr. 18-ko-2050	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** Pole assignment, Coupling and decoupling of linear multivarible systems, Optimal control, Design of state observers, Dynamic state feedback control, Structurally constrained state feedback
2	**Learning objectives / Learning Outcomes** The students will be able to analyse and design linear time-invariant multivariable systems by means of different state space design methods.
3	**Recommended prerequisite for participation** Basic knowledge of linear control theory ("System Dynamics and Control Systems I and II")
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Skript Konigorski: “Mehrgrößenregler im Zustandsraum”, Anderson, Moore: "Optimal Control: Linear Quadratic Methods", Föllinger:"Regelungstechnik: Einführung in die Methoden und ihre Anwendung", Föllinger: "Optimale Regelung und Steuerung: Eine Einführung für Ingenieure", Roppenecker: "Zeitbereichsentwurf linearer Regelungen: Grundlegende Strukturen und eine Allgemeine Methodik ihrer Parametrierung", Unbehauen: "Regelungstechnik II:Zustandsregelungen, digitale und nichtlineare Regelungssysteme", Zurmühl: "Matrizen und ihre Anwendung: Für Angewandte Mathematiker, Physiker und Ingenieure. Teil 1: Grundlagen"

Courses

Course Nr. 18-ko-2050-vl	**Course name** Controller Design for Multivariable Systems in State Space		
Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Viktor Kisner		**Type** Lecture	**SWS** 2
Course Nr. 18-ko-2050-ue	**Course name** Controller Design for Multivariable Systems in State Space		
Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Viktor Kisner		**Type** Practice	**SWS** 2

Module name					
Modeling and Simulation					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ko-2010	4 CP	120 h	75 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** aim of modeling, theoretical modeling by application of fundamental physical laws, generalized network analysis, modeling of distributed parameter systems, model reduction, linearization, order reduction, digital simulation of linear systems, numerical integration methods
2	**Learning objectives / Learning Outcomes** The students will know different techniques for the mathematical modeling of dynamic systems from various domains. They will acquire the ability to digitally simulate the dynamic behavior of the modeled systems and to systematically apply the available numerical integration methods.
3	**Recommended prerequisite for participation** Basic knowledge of continuous- and discrete-time control theory. Supplementary lectures are “System Dynamics and Control Systems I and II” as well as “Digital Control Systems I and II”.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes Konigorski: “Modellbildung und Simulation”, Lunze: „Regelungstechnik 1 und 2“, Föllinger: „Regelungstechnik: Einführung in die Methoden und ihre Anwendung“

Courses

Course Nr.	Course name		
18-ko-2010-vl	Modeling and Simulation		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ulrich Konigorski		Lecture	2

Course Nr.	Course name		
18-ko-2010-ue	Modeling and Simulation		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ulrich Konigorski		Practice	1

Module name					
Computer Systems I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hb-1020	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Christian Hochberger		

1	**Content** Types of instruction sets, memory organization and its impact on the runtime, pipelining, instruction level parallelism, superscalar processors, VLIW processors, floating point numbers and operations, memory subsystem, cache types, virtual address spaces, benchmarking and performance prediction, system architecture and bus systems, peripheral devices
2	**Learning objectives / Learning Outcomes** Successful students can analyze and evaluate processors, memory systems and bus systems. They can transform structures of high-level programming languages like subroutine calls into sequences of machine instructions. They are able to measure the performance of computers. They know how instructions are executed in modern processors and thus, they can predict the influence of a specific memory hierarchy onto the execution time of a given program. They know how internal and external bus systems work and can define the essential parameters for their dimension and operation.
3	**Recommended prerequisite for participation** Basic knowledge of digital design as it can be obtained by the lecture “Logic Design”.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Hennessy/Patterson: Computer architecture - a quantitative approach

Courses

	Course Nr. 18-hb-1020-vl	**Course name** Computer Systems I		
	Instructor Prof. Dr.-Ing. Christian Hochberger		**Type** Lecture	**SWS** 3
	Course Nr. 18-hb-1020-ue	**Course name** Computer Systems I		
	Instructor Prof. Dr.-Ing. Christian Hochberger		**Type** Practice	**SWS** 1

Module name Fundamental Fluid Mechanics					
Module Nr. 16-11-5010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Cameron Tropea		

1	**Content** Properties of fluids, flow kinematics, conservation equations, constitutive equations, equations of motion, Navier-Stokes equations, hydrostatics, exact solutions, turbulent flows, stream filament theory, flow around bodies.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • Explain the origins and limitations of the basic conservation equations of fluid mechanics (mass, momentum, moment of momentum, energy). • Choose the correct equations, simplifications, and boundary conditions for a given application and recognise avenues for solution. • Use stream filament theory and loss coefficients to compute flow networks. These capabilities are developed for incompressible, single phase flows.
3	**Recommended prerequisite for participation** knowledge of ordinary and partial differential equations
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Written exam 2x 150 min
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)
6	**Usability of this module** Bachelor MPE Pflicht Master ETiT AUT; Bachelor Mechatronik
7	**Grade bonus compliant to §25 (2)**
8	**References** Spurk: Strömungslehre, Springer Verlag. Spurk: Aufgaben zur Strömungslehre, Springer Verlag.

Courses

	Course Nr. 16-11-5010-vl	**Course name** Fundamental Fluid Mechanics		
	Instructor		**Type** Lecture	**SWS** 3
	Course Nr. 16-11-5010-ue	**Course name** Fundamental Fluid Mechanics		
	Instructor		**Type** Practice	**SWS** 1

1.1.3 AUT - Specialization

1.1.3.1 AUT - Lectures (open catalogue)

Module name Digital Control Systems II					
Module Nr. 18-ko-2030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** State space description of discrete-time systems, controllability, observability, state feedback controller, pole assignment, PI-state feedback controller, discrete state observers, modified Luenberger observer
2	**Learning objectives / Learning Outcomes** The students know the state spacel description of sampled control systems and the corresponding analysis and design methods. They can design deadbeat controllers, state feedback controllers by pole assignment and PI- state feedback controllers for single input systems and know how to implement state feedback controllers together with a discrete- time observer.
3	**Recommended prerequisite for participation** Knowledge of the z-transform as well as the fundamentals of discrete-time control systems. These fundamentals are taught in the lecture “Digital Control systems I”.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, BSc/MSc iST, MSc MEC, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes Konigorski: “Digitale Regelungssysteme” Ackermann: "Abtastregelung" Aström, Wittenmark: "Computer-controlled Systems" Föllinger: "Lineare Abtastsysteme" Phillips, Nagle: "Digital control systems analysis and design" Unbehauen: "Regelungstechnik 2: Zustandsregelungen, digitale und nichtlineare Regelsysteme"

Courses

Course Nr. 18-ko-2030-vl	**Course name** Digital Control Systems II		
Instructor Prof. Dr.-Ing. Ulrich Konigorski		**Type** Lecture	**SWS** 1
Course Nr. 18-ko-2030-ue	**Course name** Digital Control Systems II		
Instructor Prof. Dr.-Ing. Ulrich Konigorski		**Type** Practice	**SWS** 1

Module name Control of Drives					
Module Nr. 18-gt-2020	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Content** Control structures for drives; Design of controllers for drives; VSIs for drives; Space Vectors as basis of modelling AC-machines; Reference frames for description of AC-machines; Control oriented block diagram for DC-drive; Structure and design of the controllers; Control oriented block diagram for Permanent Magnet Synchronous Machine (PMSM); Control oriented block diagram for Induction machine (IM) Torque control for AC-machines using linear or switching controllers. Field Oriented Control and Direct Torque Control for PMSM and IM. Models and observers for rotor flux of IM Speed control, including oscillatory load. Resolver and Encoder.
2	**Learning objectives / Learning Outcomes** After an active participation in the course including solving all exercises prior to the respective tutorial students should be able to: 1.) develop the control-oriented block diagrams for the DC-machine operating in base speed range as well as in field weakening range. 2.) design the control loops for 1.) concerning the structure and the control parameters. 3.) Understand and apply space vectors and master their application in different rotating frames of reference. 4.) Develop the dynamic equations of the permanent exited synchronous machine and the induction machine and to simplify these equations by help of suitable rotating reference frames and represent these equations as non-linear control-oriented block diagram. 5.) Design the control loops according to 4.) especially the field-oriented control concerning the structure of the control loops and the control parameters. 6.) Understand the deduction of equations given in the literature for machine types, which are not discussed in this lecture, e.g. for the doubly fed induction machine. 7.) Derive the models and the observers for the rotor flux for the induction machine in different frames of reference and to apprise the benefits and drawbacks of the different solutions. 8.) Design the control loops for the super-imposed speed controls even for mechanically oscillating loads.
3	**Recommended prerequisite for participation** BSc ETiT or equivalent, especially Control Theory and Electrical Machines / Drives
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc EPE, MSc MEC, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Lecture notes, instructions for exercises are available in Moodle for download.
Literature:

- Mohan, Ned: “Electric Drives and Machines”
- De Doncker, Rik; et. al.: “Advanced Electrical Drives”
- Schröder, Dierk: “Elektrische Antriebe – Regelung von Antriebssystemen”
- Leonhard, W.: “Control of Electrical Drives”

Courses

Course Nr.	**Course name**		
18-gt-2020-vl	Control of Drives		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog		Lecture	2

Course Nr.	**Course name**		
18-gt-2020-ue	Control of Drives		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog		Practice	2

Module name					
Technical Electrodynamics					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-dg-1070	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Fields in materials, Green's functions, separation of variables in generalized orthogonal coordinates, conformal mapping, elliptic integrals and elliptic functions, electromagnetic forces, quasi-stationary fields, general waveguides, resonators, antennas.
2	**Learning objectives / Learning Outcomes** Starting with Maxwell´s equations the lecture´s aim is to provide a general understanding of electromagnetic phenomena. Students will be able to apply analytical methods to simple problems. Students will exhibit the ability to deal with more complex electromagnetic formulations and tasks.
3	**Recommended prerequisite for participation** Vector analysis, infinitesimal calculus, basics in differential equations. Knowledge of "Introduction to Electrodynamics"
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Course notes available (including references)

Courses

Course Nr. 18-dg-1070-vl	**Course name** Technical Electrodynamics		
Instructor Prof. Dr.-Ing. Herbert De Gersem, Dr.-Ing. Wolfgang Ackermann		**Type** Lecture	**SWS** 2
Course Nr. 18-dg-1070-ue	**Course name** Technical Electrodynamics		
Instructor Prof. Dr.-Ing. Herbert De Gersem, Dr.-Ing. Wolfgang Ackermann		**Type** Practice	**SWS** 2

Module name					
Computer Vision in Engineering					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ad-2090	4 CP	120 h	75 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Jürgen Adamy		

1 Content

A Basics

- Scene Representation2D and 3D Geomtery
- Image Acquisition
  - Geometric Projections Camera Calibration
- Objective and Illumination
- Discrete 2D signals
  - Separability, Sampling
  - Transformation, Interpolation
  - Convolution, Correlation
  - Discrete Fourier Transformation

B Basics of Image Analysis

- Filtering
  - Basics2D Filter Design
  - Linear Filtering
  - Nichtlinear Filtering
- Image Decompositions
  - Multi-scale Representation
  - Pyramids
  - Filter Banks
- Image Features
  - Structure
  - Moments, Histograms

2 Learning objectives / Learning Outcomes

The lecture communicates mathematical basics needed to solve computer vision problems in the field of engineering. The focus is on methods that are relevant for measuring and control tasks. Applications range from visual quality inspection, visual robotics, photogrammetry, visual odometry up to visually guided driver assistance etc.
The students should obtain a good understanding for the relations between the three-dimensional world and its two-dimensional projection onto the image plane of a camera. They also should learn about methods that exist to infer knowledge from the world given image data. They should develop some feeling for the different kinds of problems that arise in computer vision and how to choose an efficient solution in terms of algorithms.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

	Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc CE, MSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References** References / Textbooks: Lecture slides, exercise sheets and matlab-code. Further reading • Yi Ma, Stefano Soatto, Jana Kosecka und Shankar S. Sastry, An Invitation to 3-D Vision - From Images to Geometric Models, Springer, 2003. • Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, 2004. • Karl Kraus, Photogrammetrie, Band 1 Geometrische Informationen aus Photographien und Laserscanneraufnahmen 7. Auflage, de Gruyter Lehrbuch, 2004. • Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer 2006. • Bernd Jähne, Digital Image Processing, 6. Auflage, 2005.

Courses

Course Nr. 18-ad-2090-vl	**Course name** Computer Vision in Engineering		
Instructor Dr.-Ing. Volker Willert, Prof. Dr.-Ing. Jürgen Adamy		**Type** Lecture	**SWS** 2
Course Nr. 18-ad-2090-ue	**Course name** Computer Vision in Engineering		
Instructor Dr.-Ing. Volker Willert		**Type** Practice	**SWS** 1

Module name Real Time Applications and Communication with Microcontrollers and programmable Logic Devices					
Module Nr. 18-gt-2040	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1 Content

Microcontroller and programmable logic devices are being used for a variety of control tasks for industrial and residential products and systems. For the control of drives and power electronics, those devices are used for the control of frequency converters or DC/DC converters.
In most of these applications, real time requirements have to be met. Simultaneously a communication interface has to be served.
The module will impart knowledge and expertise on how to realize successfully control task.
More in detail, the following content will be taught:

- Architecture of microcontroller
- Structure and function of FPGAs, tools and programming languages
- Typical peripheral components for microcontrollers
- Capture & Compare, PWM, A/D-converter
- I2C, SPI, CAN, Ethernet
- Programming of microcontrollers in C
- Software: real-time properties, interrupt handling, interrupt latency
- Control of inductive components
- Basic of circuit design for power electronics, Power-MOSFETS, IGBTsNumerical methods

2 Learning objectives / Learning Outcomes

Students will be able to:

- Separate a digital control task into HW and SW parts
- Specify the HW-content in a HW description language and implement the SW by means of a micro-controller
- Evaluate the real-time capabilities of a program and to determine upper limits for the response time of the systemTransfer the developed solution to the target system by means of a development kit and debug the software onto the target system.

3 Recommended prerequisite for participation

Basic knowledge in programmig language C (syntax, operators, pointer)

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc MEC, MSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

Script, Instruction for practical lab courses, ppt-Slides; either in hard-copy or for download; User Manuals of the used devices and development kits

Courses

	Course Nr. 18-gt-2040-vl	**Course name** Real Time Applications and Communication with Microcontrollers and programmable Logic Devices		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog		**Type** Lecture	**SWS** 1
	Course Nr. 18-gt-2040-pr	**Course name** Real Time Applications and Communication with Microcontrollers and programmable Logic Devices		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog, Prof. Dr.-Ing. Christian Hochberger		**Type** Internship	**SWS** 2

Module name					
Evolutionary Systems - From Biology to Technology					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ad-2050	3 CP	90 h	60 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** theory of biological evolution, introduction to genetics, population genetics, population growth, evolutionary algorithms, applications, DNA computing, artificial life, theory of evolutionary algorithms, optimization algorithms, multi-objective optimization, meta models, co-evolution, genetic coding, representations of evolutionary algorithms, developmental processes, self-adaptation, evolution and learning
2	**Learning objectives / Learning Outcomes** After attending the lecture, a student is capable of: 1.understanding the basic principles of evolutionary biology on a systems level, 2. transferring of this knowledge to the technical domain (evolutionary algorithms), 3. applying evolutionary algorithms to hard optimization problems, 4. gaining insight into the potentials and challenges of interdisciplinary research (natural and engineering/computer science).
3	**Recommended prerequisite for participation** Introductory courses mathematics. Basic computer skills.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik, Biotechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** D.J. Futuyama: Evolutionary Biology. W. Henning, Genetik, Springer Verlag; D.B. Fogel: Evolutionary Computation, IEEE Press; I. Rechenberg: Evolutionsstrategie ‘94; H.-P. Schwefel: Evolution and Optimum Seeking

Courses

Course Nr.	Course name		
18-ad-2050-vl	Evolutionary Systems - From Biology to Technology		
Instructor		**Type**	**SWS**
Dr. rer. nat. Bernhard Sendhoff		Lecture	2

Module name Materials of Electrical Engineering					
Module Nr. 11-01-6410	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. rer. nat. Lambert Alff		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [11-01-6410-vl] (Technical Examination, Technical Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [11-01-6410-vl] (Technical Examination, Technical Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 11-01-6410-vl	**Course name** Materials of Electrical Engineering		
	Instructor		**Type** Lecture	**SWS** 2

Module name Machine Learning and Deep Learning for Automation Systems					
Module Nr. 18-ad-2100	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1 Content

- Concepts of machine learning
- Linear methods
- Support vector machines
- Trees and ensembles
- Training and assessment
- Unsupervised learning
- Neural networks and deep learning
- Convolutional neuronal networks (CNNs)
- CNN applications
- Recurrent neural networks (RNNs)

2 Learning objectives / Learning Outcomes

Students will get a broad and practical view on the field of machine learning. First, the most relevant algorithm classes of supervised and unsupervised learning are discussed. After that, the course addresses deep neural networks, which enable many of today's applications in image and signal processing. The fundamental characteristics of all algorithms are compiled and demonstrated by programming examples. Students will be able to assess the methods and apply them to practical tasks.

3 Recommended prerequisite for participation

Fundamental knowledge in linear algebra and statistics
Preferred: Lecture "Fuzzy logic, neural networks and evolutionary algorithms"

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 7 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

- T. Hastie et al.: The Elements of Statistical Learning. 2. Aufl., Springer, 2008
- I. Goodfellow et al.: Deep Learning. MIT Press, 2016
- A. Géron: Hands-On Machine Learning with Scikit-Learn and TensorFlow. O'Reilly, 2017

Courses

	Course Nr.	Course name		
	18-ad-2100-vl	Machine Learning and Deep Learning for Automation Systems		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Michael Vogt		Lecture	2

Module name Laboratory Matlab/Simulink II					
Module Nr. 18-ko-2070	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** The lab is split into the two parts Simulink and Control Engineering II. First the fundamentals of the simulation tool Simulink are introduced and their application to problems from different fields of application is trained. In the second part, the knowledge gained in the first part is applied to autonomously solve several control design problems as well as simulation tasks.
2	**Learning objectives / Learning Outcomes** The students will be able to work with the tool MatLab/Simulink on their own and can solve tasks from the areas of control engineering and numericial simulation. The students will know the different design methods of the control system toolbox and the fundamental concepts of the simulation tool Simulink. They can practically apply the knowledge gathered in the lectures “System Dynamics and Control Systems I and II” and “Modelling and Simulation”.
3	**Recommended prerequisite for participation** The lab should be attended in parallel or after the lectures “System Dynamics and Control Systems II” and “Modelling and Simulation”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSC MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes for the lab tutorial can be obtained at the secretariat

Courses

	Course Nr. 18-ko-2070-pr	**Course name** Laboratory Matlab/Simulink II		
	Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Marcel Bonnert		**Type** Internship	**SWS** 4

Module name Laboratory Control Engineering II					
Module Nr. 18-ad-2060	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** During the laboratory course the following experiments will be conducted: Coupling control of a helicopter, Non-linear control of a gyroscope, Nonlinear multivariable control of an aircraft, Servo control systems, Control of an overhead crane system, Programmable logic control of a stirring process
2	**Learning objectives / Learning Outcomes** After attending this laboratory course, a student is capable of: • recalling the basics of the conducted experiments, • organize and comprehend background information for experiments, • assemble experimental set-ups based on manuals, • judge the relevance of experimental results by comparing them with theoretically predicted outcomes, • present the results of the experiments
3	**Recommended prerequisite for participation** System Dynamics and Control Systems II, the attendance of the additional lecture “System Dynamics and Control Systems III” is recommended
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc iST, MSc Wi-ETiT, Biotechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Adamy: Instruction manuals for the experiments (available during the kick-off meeting)

Courses

	Course Nr. 18-ad-2060-pr	**Course name** Laboratory Control Engineering II		
	Instructor Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Jan Christian Zimmermann		**Type** Internship	**SWS** 4

Module name					
Project Seminar Automatic Control Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ad-2080	8 CP	240 h	180 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** The students work in small groups, supervised by a scientific staff member, on individual problems taken from the field of automatic control. A compulsory training course is part of the project course and will cover the topics 1. team work and project management, 2. professional presentation skills, and 3. scientific writing skills.
2	**Learning objectives / Learning Outcomes** After attending the project course, a student is capable of: 1. planing a small project, 2. organizing the work within a project team, 3. searching for scientific background information on a given project, 4. creating ideas on how to solve problems arising in the project, 5. presenting the results in a scientific report, and 6. giving a talk on the results of the project.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Training course material

Courses

Course Nr.	Course name		
18-ad-2080-pj	Project Seminar Automatic Control Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Project Seminar	4

Module name Project Course Control Engineering					
Module Nr. 18-ko-2090	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1 Content

Teams of 2 - 4 students work on different control engineering projects under the guidance of a project coordinator from the institute. The projects mainly cover the following subject areas:

- Modelling, analysis and design of multivariable control systems
- Modelling, analysis and design of distributed parameter systems
- Robust control design
- System analysis, supervision and fault diagnosis
- Modelling and identification

Application areas are machine tools, production lines, test benches, process control, automobiles.

2 Learning objectives / Learning Outcomes

After completing the project the students will be familiar with the individual steps of investigating a control engineering project. This includes in particular the compilation of a system specification as well as critical discussions and systematic selection of appropriate control engineering solutions and their real technical implementation. Doing so the students learn the practical application of control engineering methods taught in the lecture “System Dynamics and Control Systems I” to real world problems. Additionally, in this project course the students are supposed to improve their professional skills. These skills include e.g. teamwork, presentation techniques and systematic information retrieval.

3 Recommended prerequisite for participation

Lecture “System Dynamics and Control Systems I”

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc MEC

7 Grade bonus compliant to §25 (2)

8 References

Handouts will be distributed at start of the project (e.g. Hints for writing a project documentation, etc.)

Courses

Course Nr. 18-ko-2090-pj	**Course name** Project Course Control Engineering	
Instructor Prof. Dr.-Ing. Ulrich Konigorski	**Type** Project Seminar	**SWS** 4

Module name					
Project Seminar Robotics and Computational Intelligence					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ad-2070	8 CP	240 h	180 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** The following topics are taught in the lecture: 1. Industrial robots, 1a. Types and applications, 1b. Geometry and kinematics, 1c. Dynamic model, 1d. Control of industrial robots, 2. Mobile robots, 2a. Types and applications, 2b. Sensors, 2c. Environmental maps and map building, 2d. Trajectory planning. Group projects are arranged after the lectures in order to apply the taught material in practical exercises.
2	**Learning objectives / Learning Outcomes** After attending the lecture, a student is capable of: 1. recalling the basis elements of industrial robots, 2. recalling the dynamic equations of industrial robots and be able to apply them to describe the dynamics of a given robot, 3. stating model problems and solutions to standard problems in mobile robotics, 4. planing a small project, 5. organizing the work load in a project team, 6. searching for additional background information on a given project, 7. creating ideas on how to solve problems arising in the project, 8. writing an scientific report about the outcome of the project 8. presenting the results of the project.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Adamy: Lecture notes (available for purchase at the FG office)

Courses

Course Nr.	**Course name**		
18-ad-2070-pj	Project Seminar Robotics and Computational Intelligence		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Project Seminar	4

Module name Autonomous Driving Lab I					
Module Nr. 18-su-2070	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Content

- Hands-on programming experience with C++ in the development of embedded software systems for autonomous driving based on a model car
- Application of control methods from the area of autonomous driving
- Application of software engineering techniques (design, documentation, test, ...) of a non-trivial embedded software system with hard real-time requirements and limited resources (memory, ...)
- Use of a given software framework and further libraries including a modular (real-time) operating system
- Hands-on experience using source code management systems, time management and other project management tools
- Presentations of the project results

2 Learning objectives / Learning Outcomes

During this project seminar students gain practical experience in software development for embedded systems in the field of autonomous driving using a model car. In teamwork, they learn to cope with an extensive task. In order to solve this task they practice to use the theoretical knowledge available in the group (from other courses such as real-time systems, software engineering - introduction, C++ lab, digital control systems).

Students that have successfully participated in this project seminar are able to organize and set-up a non-trivial software project in an interdisciplinary team according to a given problem independently. The participants acquire the following skills in detail:

- Independent familiarization with a given software framework and ready-made libraries
- Transfer of theoretic knowledge into a software system
- Extensive use of tools for version, configuration, and change management
- Realistic time and resource management (project management)
- Development of hardware/software systems with C++ considering important limitations of embedded systems
- Planning and implementation of extensive quality assurance measures
- Collaboration and communication in and between teams

3 Recommended prerequisite for participation

Recommended prerequisites are:

- ETiT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++)

Additionally desired:

- Basic knowledge of the development of real-time systems or image processing
- ETiT/AUT, MEC: Basic knowledge in control engineering including state space control design, some additional basic knowledge in digital control design may be helpful

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

	Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-i/ and Moodle

Courses

Course Nr.	**Course name**		
18-su-2070-pj	Autonomous Driving Lab I		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr, Dr. Ing. Eric Lenz, M.Sc. Stefan Tomaszek		Project Seminar	3

1.2 Option Computer Engineering (DT)

1.2.1 DT - Fundamentals

Module name Communication Networks II					
Module Nr. 18-sm-2010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

Topics are:

- Basics and History of Communication Networks (Telegraphy vs. Telephony, Reference Models, ...)
- Transport Layer (Addressing, Flow Control, Connection Management, Error Detection, Congestion Control, ...)
- Transport Protocols (TCP, SCTP)
- Interactive Protocols (Telnet, SSH, FTP, ...)
- Electronic Mail (SMTP, POP3, IMAP, MIME, ...)
- World Wide Web (HTML, URL, HTTP, DNS, ...)
- Distributed Programming (RPC, Web Services, Event-based Communication)
- SOA (WSDL, SOAP, REST, UDDI, ...)
- Cloud Computing (SaaS, PaaS, IaaS, Virtualization, ...)
- Overlay Networks (Unstructured P2P, DHT Systems, Application Layer Multicast, ...)
- Video Streaming (HTTP Streaming, Flash Streaming, RTP/RTSP, P2P Streaming, ...)
- VoIP and Instant Messaging (SIP, H.323)

2 Learning objectives / Learning Outcomes

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

3 Recommended prerequisite for participation

Basic courses of first 4 semesters are required. Knowledge in the topics covered by the course Communication Networks I is recommended. Theoretical knowledge obtained in the course Communication Networks II will be strengthened in practical programming exercises. So, basic programming skills are beneficial.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6	**Usability of this module** MSc ETiT, MSc iST, Wi-ETiT, CS, Wi-CS			
7	**Grade bonus compliant to §25 (2)**			
8	**References** Selected chapters from following books: • Andrew S. Tanenbaum: Computer Networks, Fourth 5th Edition, Prentice Hall, 2010 • James F. Kurose, Keith Ross: Computer Networking: A Top-Down Approach, 6th Edition, Addison-Wesley, 2009 • Larry Peterson, Bruce Davie: Computer Networks, 5th Edition, Elsevier Science, 2011			
Courses				
	Course Nr. 18-sm-2010-vl	**Course name** Communication Networks II		
	Instructor Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		**Type** Lecture	**SWS** 3
	Course Nr. 18-sm-2010-ue	**Course name** Communication Networks II		
	Instructor Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		**Type** Practice	**SWS** 1

Module name					
Computer Systems II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hb-2030	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Christian Hochberger		

1 Content

- Configurable Technologies
- FPGA architectures and properties
- System-On-Chip, HW components, SW toolchain, support SW
- Coarse grained reconfigurable architectures, PE architecture, Modulo schedu-ling

2 Learning objectives / Learning Outcomes

After completion of the module, students know reconfigurable technologies as well as chip architecture that employ them (e.g. FPGAs and CGRAs). They can select an ap-propriate technology for a given specific application. They know the components a system-on-chip (SoC) consists of. Students can configure and program an application specific SoC. They can map simple applications to a CGRA and know the limitations and pitfalls of this mapping.

3 Recommended prerequisite for participation

Thorough basic knowledge of digital circuits and computer achitecture. as can be ob-tained in the lectures “Logischer Entwurf” and “Rechnersysteme I”. Additionally, stu-dents should be able to write simple programs in the programming language C.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, MSc iCE, MSc Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

The slides (in German) of the lecture can be obtained through moodle.

Courses

Course Nr.	Course name		
18-hb-2030-vl	Computer Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger, M.Sc. Johanna Rohde		Lecture	3
Course Nr.	**Course name**		
18-hb-2030-ue	Computer Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger, M.Sc. Johanna Rohde		Practice	1

Module name					
Software-Engineering - Maintenance and Quality Assurance					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-su-2010	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The lecture covers advanced topics in the software engineering field that deal with maintenance and quality assurance of software. Therefore, those areas of the software engineering body of knowledge which are not addressed by the preceding introductory lecture, are in focus. The main topics of interest are: software maintenance and reengineering, configuration management, static programme analysis and metrics, dynamic programme analysis and runtime testing as well as programme transformations (refactoring). During the exercises, a suitable Java open source project has been chosen as running example. The participants analyze, test and restructure the software in teams, each dealing with different subsystems.
2	**Learning objectives / Learning Outcomes** The lecture uses a single running example to teach basic software maintenance and quality assuring techniques in a practice-oriented style. After attendance of the lecture a student should be familiar with all activities needed to maintain and evolve a software system of considerable size. Main emphasis is laid on software configuration management and testing activities. Selection and usage of CASE tool as well as working in teams in conformance with predefined quality criteria play a major role.
3	**Recommended prerequisite for participation** Introduction to Computer Science for Engineers as well as basic knowledge of Java
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc Wi-ETiT, Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/se_ii/

Courses

Course Nr. 18-su-2010-vl	**Course name** Software-Engineering - Maintenance and Quality Assurance		
Instructor Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Sebastian Marvin Ruland		**Type** Lecture	**SWS** 3
Course Nr. 18-su-2010-ue	**Course name** Software-Engineering - Maintenance and Quality Assurance		
Instructor Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Sebastian Marvin Ruland		**Type** Practice	**SWS** 1

Module name					
Advanced Digital Integrated Circuit Design					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2010	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** MOS Transistor Models, CMOS Logic Gates, Chip Layout and Design Rules, Static and Dynamic Behavior of CMOS Circuits, Synchonous CMOS Circuits, Performance and Power Characterisation, Design Techniques and CAD Tools, FPGA and Gate Array Technologies, Memory Technologies, Chip Test.
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • understand the short-channel effects of modern CMOS transistors, • derive and analyse the most important circuit concepts for digital logic gates, • understand the design flow of digital ASICs based on standard cells (design, layout, simulation/verification), • knows the pros and cons of synchronous vs. asynchronous logic, multiclockphase systems, • understands the differential design methods of integrated circuits (ASIC, ASIP, Full-custom/Semicustom, PLA, PLD, FPGA), • understands basic circuitry of logic and arithmetic units (adders, multipliers, PLL/DLL), • knows the design principles and properties of integrated semiconductor memory (DRAM, SRAM, Flash. MRAM, FeRAM)
3	**Recommended prerequisite for participation** Lecture “Electronics”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design

Courses

Course Nr. 18-ho-2010-vl	**Course name** Advanced Digital Integrated Circuit Design		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 3
Course Nr. 18-ho-2010-ue	**Course name** Advanced Digital Integrated Circuit Design		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1

1.2.2.1 AUT - Lectures (open catalogue)

Module name Computer Aided Design for SoCs					
Module Nr. 18-ho-2200	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Content

CAD-Concepts for the design and simulation of integrated system-on-chips

2 Learning objectives / Learning Outcomes

A student is, after successful completion of this module, able to understand

- The most important design and verification abstractions as well as the design flow for the design of integrated electronic systems,
- Selected algorithms for optimization, simulation and solving of design tasks,
- Advanced methods for the design and simulation of analog integrated circuits in modern CMOS technologies,
- Advanced concepts of hardware description languages and their concepts (Verilog, VHDL, Verilog-A, Verilog-AMS, System-Verilog)

3 Recommended prerequisite for participation

Lecture "Advanced Digital Integrated Circuit Design" (can be attended in parallel) and „Analog Integrated Circuit Design" and "Logic Design"

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, MSc MEC, MSc Wi-ETiT, MSc iCE

7 Grade bonus compliant to §25 (2)

8 References

Slide Copies

Courses

Course Nr. 18-ho-2200-vl	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 2
Course Nr. 18-ho-2200-ue	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1

	Course Nr.	Course name		
	18-ho-2200-pr	Computer Aided Design for SoCs		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Klaus Hofmann		Internship	1

Module name					
High-Level Synthesis					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hb-2020	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Christian Hochberger		

1 Content

- Mapping of behavioral descriptions (e.g. in the form of program fragments) on FPGA and CGRA structures
- Sub-tasks allocation, scheduling, binding
- Exact or heuristic solutions
- Design principles of heuristic solutions

2 Learning objectives / Learning Outcomes

Students that have completed this module know alternative approaches for all of the tasks of the high level synthesis and can select appropriate ones for specific applications. They can evaluate the memory and time complexity of the given algorithms. They are enabled to adapt the algorithms for new constraints and new target technologies.

3 Recommended prerequisite for participation

Knowledge of hardware synthesis on the basis of at least one hardware description language is required (e.g. Reese/Thornton: Introduction to Logic Synthesis Using Verilog Hdl oder Brown/Vranesic: Fundamentals of Digital Logic with VHDL Design). The student should have basic knowledge of at least one object oriented programming language, preferably Java

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, BSc/MSc iST, MSc iCE

7 Grade bonus compliant to §25 (2)

8 References

English slides can be obtained through Moodle.

Courses

Course Nr.	Course name		
18-hb-2020-vl	High-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Lecture	3
Course Nr.	**Course name**		
18-hb-2020-ue	High-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Practice	1

Module name					
Low-Level Synthesis					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hb-2010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Christian Hochberger		

1 Content

The module deals with synthesis steps on all abstraction layers below the register transfer level focusing on approaches suitable for FPGAs. At the logic level different types of minimization are explained (exact and heuristic two level minimizations, exact and heuristic multi level logic minimizations). The transition to the technology level is achieved by different decomposition and structural mapping techniques (FlowMap). Place&Route add geometric information to the technology mapped circuit. Analytical and heuristic placers are discussed (Simulated Annealing, Genetic Placers) and routing is illustrated through the PathFinder algorithm.

2 Learning objectives / Learning Outcomes

After completion of the module, students are enabled to investigate synthesis approaches for low level synthesis tasks. They can evaluate these approaches regarding their time and space complexity, as well as regarding their applicability to specific implementation technologies.
Students can apply these approaches to new architectures and technologies.

3 Recommended prerequisite for participation

Knowledge of hardware synthesis on the basis of at least one hardware description language is required (e.g. Reese/Thornton: Introduction to Logic Synthesis Using Verilog Hdl oder Brown/Vranesic: Fundamentals of Digital Logic with VHDL Design). The student should have basic knowledge of at least one object oriented programming language, preferably Java

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iCE, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

A script of the lecture (in German) and English foils can be obtained from here: http://www.rs.tu-darmstadt.de/

Courses

Course Nr.	Course name		
18-hb-2010-vl	Low-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Lecture	3
Course Nr.	**Course name**		
18-hb-2010-ue	Low-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Practice	1

Module name					
Communication Networks II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-2010	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

Topics are:

- Basics and History of Communication Networks (Telegraphy vs. Telephony, Reference Models, ...)
- Transport Layer (Addressing, Flow Control, Connection Management, Error Detection, Congestion Control, ...)
- Transport Protocols (TCP, SCTP)
- Interactive Protocols (Telnet, SSH, FTP, ...)
- Electronic Mail (SMTP, POP3, IMAP, MIME, ...)
- World Wide Web (HTML, URL, HTTP, DNS, ...)
- Distributed Programming (RPC, Web Services, Event-based Communication)
- SOA (WSDL, SOAP, REST, UDDI, ...)
- Cloud Computing (SaaS, PaaS, IaaS, Virtualization, ...)
- Overlay Networks (Unstructured P2P, DHT Systems, Application Layer Multicast, ...)
- Video Streaming (HTTP Streaming, Flash Streaming, RTP/RTSP, P2P Streaming, ...)
- VoIP and Instant Messaging (SIP, H.323)

2 Learning objectives / Learning Outcomes

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

3 Recommended prerequisite for participation

Basic courses of first 4 semesters are required. Knowledge in the topics covered by the course Communication Networks I is recommended. Theoretical knowledge obtained in the course Communication Networks II will be strengthened in practical programming exercises. So, basic programming skills are beneficial.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, Wi-ETiT, CS, Wi-CS

7 Grade bonus compliant to §25 (2)

8 References

Selected chapters from following books:

- Andrew S. Tanenbaum: Computer Networks, Fourth 5th Edition, Prentice Hall, 2010
- James F. Kurose, Keith Ross: Computer Networking: A Top-Down Approach, 6th Edition, Addison-Wesley, 2009
- Larry Peterson, Bruce Davie: Computer Networks, 5th Edition, Elsevier Science, 2011

Courses

Course Nr.	**Course name**		
18-sm-2010-vl	Communication Networks II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		Lecture	3

Course Nr.	**Course name**		
18-sm-2010-ue	Communication Networks II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		Practice	1

Module name					
Software Defined Networking					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-2280	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course deals with topics in the area of software defined networking:

- SDN Data Plane
- SDN Control Plane
- SDN Application Plane
- Network Function Virtualization
- Network Virtualization and Slicing
- QoS and QoE in Software Defined Networks

2 Learning objectives / Learning Outcomes

Students will get a deep insight into Software Defined Networking as well as underlying technologies and applications.

3 Recommended prerequisite for participation

Basic courses of the first 4 semesters are required. Knowledge of lectures Communication Networks I and II are recommended.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, BSc/MSc iST, MSc Wi-ETiT, CS, Wi-CS

7 Grade bonus compliant to §25 (2)

8 References

Textbooks as indicated.
Slides and paper copies as necessary.

Courses

Course Nr.	Course name		
18-sm-2280-vl	Software Defined Networking		
Instructor		**Type**	**SWS**
Prof. Dr. Boris Koldehofe, M.Sc. Ralf Kundel		Lecture	2
Course Nr.	**Course name**		
18-sm-2280-ue	Software Defined Networking		
Instructor		**Type**	**SWS**
Prof. Dr. Boris Koldehofe, M.Sc. Ralf Kundel		Practice	2

Module name					
Real-Time Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-su-2020	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The lecture basically covers a model-driven software engineering process which is specially customized for real-time systems. This process is more deeply explored in the exercise using an automotive example. A focus is laid on object-oriented techniques. In this context, a real-time specific state-of-the-art CASE tool is introduced and used. Furthermore, fundamental characteristics of real-time systems and system architectures are introduced. Scheduling algorithms are discussed to get insights into real-time operating systems. Finally, a comparison between the Java programming language and its expansion for real-time operating systems (RT Java) will conclude the lecture.
2	**Learning objectives / Learning Outcomes** Students, who have successfully attended this lecture have acquired skills needed for the model-driven and object-oriented development of embedded real-time systems. This includes a deeper understanding of the following topics: • classification of real-time systems • create and analyze executable models • application of real-time scheduling algorithms • evaluation and comparison of pros/cons of real-time programming languages as well as real-time operating systems
3	**Recommended prerequisite for participation** Basic knowledge of software engineering techniques and excellent knowledge of at least one object-oriented programming language (preferably Java)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, BSc iST, MSc Wi-ETiT, BSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/es/

Courses

Course Nr. 18-su-2020-vl	**Course name** Real-Time Systems		
Instructor Prof. Dr. rer. nat. Andreas Schürr		**Type** Lecture	**SWS** 3
Course Nr. 18-su-2020-ue	**Course name** Real-Time Systems		
Instructor Prof. Dr. rer. nat. Andreas Schürr		**Type** Practice	**SWS** 1

Module name Industrial Electronics					
Module Nr. 18-ho-2210	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Typical Struture of Industrial Electronics Components. Characteristics of Typical Building Blocks (Digital Core, Sensor Frontend, Actuator Frontend, Supply and Reference Level), Functioning of Relevant Field Bus Systems, Knowledge of Relevant Standards and Technical Regulations.
2	**Learning objectives / Learning Outcomes** After successfull completion of the module, students are able to: 1. understand the use of electronic components in typical industrial environments, 2. understand the function of the building blocks of typical IE comonents, 3. deeply understand the functioning of analog bulding blocks, 4. understand relevant field bus systemes, 5. understand the regulatory and technical standards of industrial electronics components.
3	**Recommended prerequisite for participation** Lecture “Elektronik“ and “Analog IC Design”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, M.Sc. iCE, M.Sc. MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** • Dietmar Schmid, Gregor Häberle, Bernd Schiemann, Werner Philipp, Bernhard Grimm, Günther Buchholz, Jörg Oestreich, Oliver Gomber, Albrecht Schilling: „Fachkunde Industrieelektronik und Informationstechnik“; Verlag Europa-Lehrmittel, 11 th Ed. 2013. • Gunter Wellenreuther, Dieter Zastrow; „Automatisieren mit SPS – Theorie und Praxis“; Springer Verlag, 6 th Ed. 2015. • Ulrich Tietze, Christoph Schenk, Eberhard Gamm: „Halbleiter-Schaltungstechnik“; Springer Verlag, 15 th Ed. 2016.

Courses

Course Nr. 18-ho-2210-vl	**Course name**		
Instructor Dr.-Ing. Roland Steck		**Type** Lecture	**SWS** 2
Course Nr. 18-ho-2210-ue	**Course name**		
Instructor Dr.-Ing. Roland Steck		**Type** Practice	**SWS** 1

Module name					
Advanced Digital Integrated Circuit Design					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2010	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** MOS Transistor Models, CMOS Logic Gates, Chip Layout and Design Rules, Static and Dynamic Behavior of CMOS Circuits, Synchonous CMOS Circuits, Performance and Power Characterisation, Design Techniques and CAD Tools, FPGA and Gate Array Technologies, Memory Technologies, Chip Test.
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • understand the short-channel effects of modern CMOS transistors, • derive and analyse the most important circuit concepts for digital logic gates, • understand the design flow of digital ASICs based on standard cells (design, layout, simulation/verification), • knows the pros and cons of synchronous vs. asynchronous logic, multiclockphase systems, • understands the differential design methods of integrated circuits (ASIC, ASIP, Full-custom/Semicustom, PLA, PLD, FPGA), • understands basic circuitry of logic and arithmetic units (adders, multipliers, PLL/DLL), • knows the design principles and properties of integrated semiconductor memory (DRAM, SRAM, Flash. MRAM, FeRAM)
3	**Recommended prerequisite for participation** Lecture “Electronics”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design

Courses

Course Nr. 18-ho-2010-vl	**Course name** Advanced Digital Integrated Circuit Design		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 3
Course Nr. 18-ho-2010-ue	**Course name** Advanced Digital Integrated Circuit Design		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1

1.2.2.2 AUT - Seminars, Labs, and Project Seminars (open catalogue)

Module name Multimedia Communications Lab II					
Module Nr. 18-sm-2070	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course deals with cutting edge development topics in the area of multimedia communication systems. Besides a general overview it provides a deep insight into a special development topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and basic scientific competences in one or more of the following topics:

- Network planning and traffic analysis
- Performance evaluation of network applications
- Discrete event simulation for network services
- Protocols for mobile ad hoc networks / sensor networks
- Infrastructure networks for mobile communication / mesh networks
- Context-aware communication and services
- Peer-to-peer systems and architectures
- Content distribution and management systems for multimedia / e-learning
- Multimedia authoring and re-authoring tools
- Web service technologies and service-oriented architectures
- Applications for distributed workflows

2 Learning objectives / Learning Outcomes

The ability to solve and evaluate problems in the area of design and development of future multimedia communication networks and applications shall be acquired. Acquired competences are:

- Design of complex communication applications and protocols
- Implementing and testing of software components for distributed systems
- Application of object-oriented analysis and design techniques
- Acquisition of project management techniques for small development teams
- Writing of software documentation and project reports
- Presentation of project advances and outcomes

3 Recommended prerequisite for participation

Keen interest to explore challenging topics which are cutting edge in technology and research. Further we expect:

- Solid experience in programming Java and/or C# (C/C++)
- Solid knowledge in object oriented analysis and design
- Solid knowledge in computer communication networks are recommended
- Lectures in Communication Networks I (II, III, or IV) are an additional plus

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iCE, BSc/MSc iST, Wi-ETiT, BSc/MSc CS, Wi-CS,

7	**Grade bonus compliant to §25 (2)**
8	**References** Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books: • Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887) • Christian Ullenboom: "Java ist auch eine Insel: Programmieren mit der Java Standard Edition Version 5 / 6" (ISBN-13: 978-3898428385) • Joshua Bloch: "Effective Java Programming Language Guide" (ISBN-13: 978-0201310054) • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2) • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)

Courses

Course Nr.	**Course name**		
18-sm-2070-pr	Multimedia Communications Lab II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, Dr. Ing. Björn Richerzhagen, M.Sc. Florian Jomrich		Internship	3

Module name Projektseminar Rekonfigurable Systems					
Module Nr. 18-hb-2040	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Content** Students will work in small groups in this course. Topics and application context will be defined individually for each group. All projects will follow the same approach. At first, the given problem will be described in a programmatic way. Following, it will be implemented by a reconfigurable system. Depending on the nature of the application, either predefined architectures will be used, parameterizable architectures will be adapted to the needs of the application or new architectures may be designed. The programmatic description will now be mapped (semi-)automatically to the chosen architecture with the help of the supporting tools. Usually, this requires to rewrite the programmatic description to better suit the tools. Finally, the solution will be evaluated using some benchmark data sets.
2	**Learning objectives / Learning Outcomes** Successful students will know how to use reconfigurable systems within a given application context. They can use tools to program these systems and know how to map an application onto a given reconfigurable architecture. They are capable to evaluate the performance critical parts of an application. They understand the implications of different coding styles for a particular task.
3	**Recommended prerequisite for participation** • Knowledge of reconfigurable devices (cf. course computer systems II) • Knowledge of computer architecture (cf. course computer systems I) • Solid programming skills (either in C or Java depending on the application scenario).
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc Informatik, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be made available through the Moodle page for this course.

Courses

Course Nr.	**Course name**		
18-hb-2040-pj	Projektseminar Rekonfigurable Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Project Seminar	3

Module name					
HDL Lab					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-1090	6 CP	180 h	135 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Realisation of a VHDL- or Verilog-based VLSI System Design Project in a Team with industrial constraints
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. design, optimize and verify a complex digital system (e.g. a pipelined CPU or signal processor) using Verilog or VHDL, 2. synthesize the HDL description using commercial CAD software to a gate level description
3	**Recommended prerequisite for participation** Mandatory Prerequisite: Lecture Computer Aided Design for System on Chips, At least one high-level Programming Language, Basic Know-How Linux/Unix, Computer Architectures
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, BSc/MSc Wi-ETiT, MSc iCE, BSc/MSc iST, BSc/MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides „HDL: Verilog and VHDL“

Courses

	Course Nr.	**Course name**		
	18-ho-1090-pr	HDL Lab		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Klaus Hofmann		Internship	3

Module name					
Project Seminar Energy Information Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-st-2040	6 CP	180 h	135 h	1	WiSe/SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Florian Steinke		

1	**Content** Students elaborate on a research-oriented subject in the area of computer-systems in a self-responsible manner. They present a written documentation and/or a presentation of the acquired advanced knowledge. They provide a set of alternative solutions to a given problem.
2	**Learning objectives / Learning Outcomes** Students are able to systematically develop design alternatives to a given problem. They learn to acquire the necessary fundamental knowledge in terms of references and terminology. The found solutions are reflected critically and the students decide for a suitable solution which they are able to argue for and accomplish.
3	**Recommended prerequisite for participation** no
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System) Module finale exam: • Module exam (Study achievements, Optional, weighting: 100)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 18-st-2040-pj	**Course name** Project Seminar Energy Information Systems		
	Instructor Prof. Dr. rer. nat. Florian Steinke		**Type** Project Seminar	**SWS** 3

1.3 Option Electrical Power Engineering (EET)

1.3.1 EET - Fundamentals

1.3.1.1 EET - Electric Power Systems

Module name Machine Learning & Energy					
Module Nr. 18-st-2020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Content** The analysis and interpretation of data becomes ever more important, also for engineers. Digitalization and Smart Grids are terms to describe a host of novel data-based services in the field of generation, distribution, consumption and marketing of (renewable) energy. The lecture presents the recent developments and their underlying principles of machine learning technology. For a start we will describe the different problem settings of machine learning in a structured way (classification, regression, clustering, dimensionality reductions, time series models, ...) and present for each setting relevant applications from the energy sector (prediction of renewable energy or consumption in multimodal energy systems, fault detection and prediction, data visualization, robust investments decisions, customer analysis, probabilistic load flow, ...). Thereafter we will briefly review necessary tools from optimization and probability theory, as well as introduce probabilistic graphical models. With these tools we will then study for each problem setting one or more machine learning algorithms in detail, together with use cases from the energy domain. Classic algorithms will be developed (e.g. linear regression, k-means, principal component analysis, ...) as well as modern ones (e.g. SVMs, Deep Learning, Collaborative filtering, ...). Practical exercise with Matlab will deepen the understanding and support student's active knowledge.
2	**Learning objectives / Learning Outcomes** Students understand important machine learning problem settings and some key algorithms for each task. They know common applications thereof in the energy domain. Moreover, the students are able to apply and adapt those methods independently to new applications (not only from the energy domain).
3	**Recommended prerequisite for participation** • Good knowledge of linear algebra and the foundations of numerical optimization (e.g. from the course 18-st-2010 Energieanagement & Optimierung) • Using Matlab for programming the practical examples should pose no difficulty. A block tutorial on the use of Matlab is offered as 18-st-2030 Matlab Grundkurs.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc etit, MSc iST, MSc Wi-etit, MSc CE
7	**Grade bonus compliant to §25 (2)** Notenverbesserungen bis zu 0,4 nach APB §25(2) durch Bonus für regelmäßig besuchte Übungs-/Praktikumstermine und mindestens einmaliges Vorrechnen in den Übungen

8	**References** • A Géron: Hands on Machine Learning with scikit-learn and Tensorflow, 2017 • Friedman, Hastie, Tibshirani: The elements of statistical learning, 2001 • Koller, Friedmann: Graphical Models, 2009			
Courses				
	Course Nr. 18-st-2020-vl	**Course name** Machine Learning & Energy		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Tim Christian Janke		**Type** Lecture	**SWS** 2
	Course Nr. 18-st-2020-ue	**Course name** Machine Learning & Energy		
	Instructor Prof. Dr. rer. nat. Florian Steinke		**Type** Practice	**SWS** 1
	Course Nr. 18-st-2020-pr	**Course name** Machine Learning & Energy Lab		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Tim Christian Janke		**Type** Internship	**SWS** 1

Module name					
High Voltage Technology II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hi-2010	4 CP	120 h	75 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Volker Hinrichsen		

1 Content

Layered Dielectrics, Methods of Field Control and Potential Control, Breakdown in Gases (air and SF6), Breakdown in Vacuum, Surface Discharges, Lightnings and Lightning Protection, Travelling Waves on Conductors; Excursion to a substation

2 Learning objectives / Learning Outcomes

The students are now able to optimize insulation systems also by choice of the dielectrics, by capacitive, refractive or resistive internal grading systems or by external geometrical/capacitive grading elements; they have understood why equipment is designed as it is and how and where it can or has to be optimized if requirements from service are changing; they have understood the physical phenomena behind the dielectric breakdown of gases and do know which are the main influencing parameters; they know the effect of strongly inhomogeneous electrode configurations and of extremely large gaps; they know the time dependencies of a dielectric breakdown and their impact on dielectric strength under impulse voltage stress; they are able to identify critical surface discharge configurations, know about the problems under severe external pollution of insulators and how to solve them; they are thus qualified to predict the dielectric strength of any electrode configuration under any kind of voltage stress and to design a particular required dielectric strength of equipment; they are particularly enabled to realize the demands of emerging UHV systems and to manage them; they have understood the mechanism of thunderstorms and lightning flashes and are able to derive protective measures for buildings, substations and overhead lines; they are skilled to calculate travelling wave effects and their effect on fast-front overvoltages and to develop adequate countermeasures.

3 Recommended prerequisite for participation

High Voltage Technology I

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

- all lecture slides (ca. 460 pcs.) available for download
- Kind, Feser: High-voltage test techniques, SBA publications
- Kind, Kärner: High-voltage insulation technology, Vieweg

Courses

Course Nr.	Course name		
18-hi-2010-vl	High Voltage Technology II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Volker Hinrichsen		Lecture	2

	Course Nr.	Course name		
	18-hi-2010-ue	High Voltage Technology II		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Volker Hinrichsen		Practice	1

Module name Power Systems II					
Module Nr. 18-hs-2030	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1 Content

This lecture covers the essential aspects of the operation and analysis of power systems. The following topics will be covered:

- Operation of synchronous generators (steady-state operation, power chart, steady-state stability, transient stability, transient behavior)
- Calculation of short-circuit currents (Decaying three-phase short-circuit currents)
- Neutral grounding in MV- and HV-Systems (Systems with isolated neutrals, resonant grounding and solidly grounded neutrals)
- Network Protection

2 Learning objectives / Learning Outcomes

At the end of the lecture, the student should have a profound understanding of synchronous generator behavior, decaying short-circuit currents and their calculation and a basic understandning of neutral point treatment and network protection. The different types of power system stability are known.

3 Recommended prerequisite for participation

Knowledge comparable to “Energieversorgung I” or basic knowledge of power system equipment and calculations using symmetrical components.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc EPE, MSc Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

A script of the lecture, tutorials and past exams are available via Moodle.

Courses

Course Nr. 18-hs-2030-vl	**Course name** Power Systems II	
Instructor Prof. Dr.-Ing. Jutta Hanson, M.Sc. Christina Fuhr, M.Sc. Benjamin Braun, M.Sc. Anna Pfendler	**Type** Lecture	**SWS** 2

Course Nr. 18-hs-2030-ue	**Course name** Power Systems II	
Instructor Prof. Dr.-Ing. Jutta Hanson, M.Sc. Christina Fuhr, M.Sc. Benjamin Braun, M.Sc. Anna Pfendler	**Type** Practice	**SWS** 2

1.3.1.2 EET - Converter and Drive Technology (open catalogue)

Module name					
Energy Converters - CAD and System Dynamics					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bi-2010	7 CP	210 h	135 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr. techn. Dr.h.c. Andreas Binder		

1 Content

Design of cage-rotor and wound-rotor induction machines: Calculation of forces, torque, losses, efficiency, cooling and temperature rise. Transient machine performance of converter-fed dc machines and line-fed and inverter-fed ac machines. Theory is illustrated by examples: Sudden short circuit, load step, run up. For control design transfer functions of machines are derived. In the exercise lessons demonstration examples of power transformer and induction motor design are given. The students design one induction machine in small groups by themselves. Transient performance calculation is trained by using Laplace-Transformation and MATLAB.

2 Learning objectives / Learning Outcomes

With active collaboration during lectures by asking questions related to those parts, which have not been completely understood by you, as well as by independent solving of examples ahead of the tutorial (not as late as during preparation for examination) you should be able to:

- do and explain the electromagnetic design of an induction machine both analytically and with use of computer program,
- understand and predict the thermal performance of electrical drives in a simplified way,
- calculate the instationary performance of separately excited DC drives
- to predict the dynamical performance of AC polyphase machines with space vector theory and use the MATLAB/Simulink package for this purpose.

3 Recommended prerequisite for participation

Bachelor of Science in Electrical Engineering, Power Engineering or similar

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc MEC, MSc EPE

7 Grade bonus compliant to §25 (2)

8 References

Detailed textbook and collection of exercises; Complete set of PowerPoint presentation

Leonhard, W.: Control of electrical drives, Springer, 1996
Fitzgerald, A.; Kingsley, C.: Kusko, A.: Electric machinery, McGraw-Hill, 1971
McPherson, G.: An Introduction to Electrical Machines and Transformers, Wiley, 1981
Say, M.: Alternating Current Machines, Wiley, 1983
Say, M.; Taylor, E.: Direct Current Machines, Pitman, 1983
Vas, P.: Vector control of ac machines, Oxford Univ. Press, 1990
Novotny, D,; Lipo, T.: Vector control and dynamics of ac drives, Clarendon, 1996

Courses

	Course Nr. 18-bi-2010-vl	**Course name** Energy Converters - CAD and System Dynamics		
	Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder		**Type** Lecture	**SWS** 3
	Course Nr. 18-bi-2010-ue	**Course name** Energy Converters - CAD and System Dynamics		
	Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder		**Type** Practice	**SWS** 2

Module name Advanced Power Electronics					
Module Nr. 18-gt-2010	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Content** Switch mode power supplies (insulating DC/DC-converters) Realistic behavior of power semiconductors: Basics of semiconductor physics; Behavior of diode, bipolar transistor, SCR, GTO, MOSDFET and IGBT, Important circuits for switching real semiconductors with low losses Forced commutation of SCRs, Loss reducing snubbers, quasi- resonant circuits, resonant switching. Topologies and control strategies for multilevel converter Thermal design and thermo mechanical aging of power electronics systems
2	**Learning objectives / Learning Outcomes** After an active participation in the lecture, especially by asking all questions on topics which you did not fully understand as well by solving all exercises prior to the respective tutorial (i.e. not just shortly before the examination) you should be able to 1.) Explain und understand the cross sectional layers and the basic modes of operation for power semiconductors (diode, thyristor, GTO. Mosfet and IGBT). Describe the steady state and dynamic behavior of these devices. 2.) Identify the circuit diagrams for isolating DC/DC converters, especially for use in switched mode power supplies. Calculate the currents and voltages in these circuits using defined simplifications. 3.) Describe the functions of gate dive-circuits for ITGBTs. 4.) Calculate the thermal behavior and design the cooling equipment for a voltage source inverter equipped with IGBT modules. 5.) Describe the stress reliving circuits to reduce switching losses in IGBTs. 6.) Calculate the current and voltage characteristics in quasi-resonant and resonant circuits used in power electronics. 7.) Explain multilevel converters such as 3L-NPC and MMC 8.) Know the main concepts for cooling of power electronics incl. the ability to design a cooling concept and should know main aspects which influence lifetime
3	**Recommended prerequisite for participation** BSc ETiT or equivalent, especially Power Electronics and Basics of Semiconductors
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc EPE, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Script available in Moodle for download
Literature:

- Schröder, D.: “Leistungselektronische Schaltungen”, Springer-Verlag, 1997
- Mohan, Undeland, Robbins: Power Electronics: Converters, Applications and Design; John Wiley Verlag; New York; 2003
- Luo, Ye: “Power Electronics, Advanced Conversion Technologies”, Taylor and Francis, 2010

Courses

Course Nr.	**Course name**		
18-gt-2010-vl	Advanced Power Electronics		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Vefa Karakasli		Lecture	2
Course Nr.	**Course name**		
18-gt-2010-ue	Advanced Power Electronics		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Vefa Karakasli		Practice	2

1.3.2.1 EET - Lectures (open catalogue)

Module name Control of Drives					
Module Nr. 18-gt-2020	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Content** Control structures for drives; Design of controllers for drives; VSIs for drives; Space Vectors as basis of modelling AC-machines; Reference frames for description of AC-machines; Control oriented block diagram for DC-drive; Structure and design of the controllers; Control oriented block diagram for Permanent Magnet Synchronous Machine (PMSM); Control oriented block diagram for Induction machine (IM) Torque control for AC-machines using linear or switching controllers. Field Oriented Control and Direct Torque Control for PMSM and IM. Models and observers for rotor flux of IM Speed control, including oscillatory load. Resolver and Encoder.
2	**Learning objectives / Learning Outcomes** After an active participation in the course including solving all exercises prior to the respective tutorial students should be able to: 1.) develop the control-oriented block diagrams for the DC-machine operating in base speed range as well as in field weakening range. 2.) design the control loops for 1.) concerning the structure and the control parameters. 3.) Understand and apply space vectors and master their application in different rotating frames of reference. 4.) Develop the dynamic equations of the permanent exited synchronous machine and the induction machine and to simplify these equations by help of suitable rotating reference frames and represent these equations as non-linear control-oriented block diagram. 5.) Design the control loops according to 4.) especially the field-oriented control concerning the structure of the control loops and the control parameters. 6.) Understand the deduction of equations given in the literature for machine types, which are not discussed in this lecture, e.g. for the doubly fed induction machine. 7.) Derive the models and the observers for the rotor flux for the induction machine in different frames of reference and to apprise the benefits and drawbacks of the different solutions. 8.) Design the control loops for the super-imposed speed controls even for mechanically oscillating loads.
3	**Recommended prerequisite for participation** BSc ETiT or equivalent, especially Control Theory and Electrical Machines / Drives
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc EPE, MSc MEC, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**

8	**References** Lecture notes, instructions for exercises are available in Moodle for download. Literature: • Mohan, Ned: “Electric Drives and Machines” • De Doncker, Rik; et. al.: “Advanced Electrical Drives” • Schröder, Dierk: “Elektrische Antriebe – Regelung von Antriebssystemen” • Leonhard, W.: “Control of Electrical Drives”

Courses

	Course Nr. 18-gt-2020-vl	**Course name** Control of Drives		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog		**Type** Lecture	**SWS** 2
	Course Nr. 18-gt-2020-ue	**Course name** Control of Drives		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog		**Type** Practice	**SWS** 2

Module name					
Railway Vehicle Engineering					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bi-2050	3 CP	90 h	60 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** From the comprehensive and interdisciplinary domain of the railway technology (vehicle technology, signal and safety technology, construction engineering and railway operating technology) the lecture picks out the domain of the automotive engineering with the emphasis of the mechanical part. It offers an interrelated introduction into selected chapters of the rail vehicle engineering with special emphasis in the railway-specific technical solutions and procedures. The lecture is divided into 7 chapters, whereby four chapters the theoretical basic topics cover and three chapters the fundamental components of the rail vehicle present. In a one-day excursion, it is possible to gain insights into the production of modern rail vehicles. Participation is voluntary.
2	**Learning objectives / Learning Outcomes** Basic understanding of mechanical parts of railways and their components.
3	**Recommended prerequisite for participation** Bachelor in Electrical Engineering, Mechatronics or Mechanical Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System) In general, the examination takes place in form of a written exam (duration: 90 minutes). If up to 20 students register in semesters in which the lecture does not take place, there will be an oral examination (duration: 30 min.). The type of examination will be announced within one working week after the end of the examination registration phase.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc EPE, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** References/Textbooks: Detailed textbook; Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995. Obermayer, H.J.: Internationaler Schnellverkehr.Franckh-Kosmos, Stuttgart, 1994.

Courses

Course Nr.	Course name		
18-bi-2050-vl	Railway Vehicle Engineering		
Instructor		**Type**	**SWS**
		Lecture	2

Module name Electric Railways					
Module Nr. 18-bi-2140	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** • Mechanics of traction • Electrical part of traction vehicles • Converter and motors for electrical traction • Monitoring systems • Comparison of different power supply systems • DC- and AC- systems for light- and heavy rail • Problems of earthing and earth return currents • Sub stations, converters, power plants
2	**Learning objectives / Learning Outcomes** Comprehension of the basic concepts of electric traction vehicles and power supply for electric railways
3	**Recommended prerequisite for participation** Basic knowledge in electrical machines and drives
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Text book for the lecture. Bendel, H. u.a.: Die elektrische Lokomotive. Transpress, Berlin, 1994. Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995. Steimel, A.: Elektrische Triebfahrzeuge und ihre Energieversorgung. Oldenburg Industrieverlag, 2006. Bäzold, D. u.a.: Elektrische Lokomotion deutscher Eisenbahnen. Alba, Düsseldorf, 1993. Obermayer, H. J.: Internationaler Schnellverkehr. Franckh-Kosmos, Stuttgart, 1994; Guckow, A.; Kiessling, F.; Puschmann, R.: Fahrleitungen el. Bahnen. Teubner, Stuttgart, 1997. Schaefer, H.: Elektrotechnische Anlagen für Bahnstrom. Eisenbahn-Fachverlag, Heidelberg, 1981

Courses

Course Nr. 18-bi-2140-vl	**Course name** Electric Railways	
Instructor Prof. Harald Neudorfer, Dipl.-Ing. Björn Deusinger, M.Sc. Nicolas Ludwig Erd	**Type** Lecture	**SWS** 3

Module name Power Systems III					
Module Nr. 18-hs-2080	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1 Content

System behaviour of innovative equipment in the Transmission System
Fields of application:

- Power transmission and voltage stability
- Ancillary services
- Power quality

Technology of innovative equipment:

- Power Electronics theory
- Motivation, technical realisation and operation / control of HVDC systems (LCC and VSC)
- Motivation, technical realisation and operation / control of power electronic devices for reactive power compensation (SVC, STATCOM, SC)
- Practical examples and outlook

2 Learning objectives / Learning Outcomes

After successful completion of this module, a student knows the driving forces for the utilisation of innovative equipment (HVDC, reactive power compensation) in power systems. He understands the system behaviour and operation of these devices and has realised the importance of modelling and simulation for safe and reliable design and operation.

3 Recommended prerequisite for participation

Contents of "Power Systems I“

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc MEC, MSc Wi-ETiT

7 Grade bonus compliant to §25 (2)

Yes

8 References

Presentation slides

Courses

Course Nr. 18-hs-2080-vl	**Course name** Power Systems III	
Instructor Prof. Dr.-Ing. Jutta Hanson	**Type** Lecture	**SWS** 2

Module name					
Electromagnetic Compatibility					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hi-2060	4 CP	120 h	75 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Volker Hinrichsen		

1	**Content** Fundamentals of Electromagnetic Compatibility, sources of emission, coupling mechanisms and counter measures, components for noise suppression, electromagnetic shields, EMC measuring and test techniques, excursion to VDE Offenbach
2	**Learning objectives / Learning Outcomes** The students know that from every electromagnetic system a interaction is possible and that every electromagnetic (and also biological) system can be effected; they can differ between typical interference sources and sinks; they know the typical coupling paths und can identify and describe them mathematically; they know the basic methods to avoid interference at the source side and can derive their own actions against interference from this basic understanding; they know the basic actions to avoid interference at the sink side and can also derive actions to avoid interference; they have the ability to recognize coupling paths and can systematically influence or interrupt them completely; they know the situation of the EMC standardization and know basically which requirements have to be fulfilled and how to do this (also i.e. how to give a device a CE-label); they have learned the most important EMC testing and measurement techniques theoretically and practically know on the field trip.
3	**Recommended prerequisite for participation** BSc
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** • All lecture slides (ca. 500 pcs.) available for download • Adolf J. Schwab: Elektromagnetische Verträglichkeit, Springer-Verlag • Clayton R. Paul: Introduction to Electromagnetic Compatibility, Wiley & Sons

Courses

Course Nr. 18-hi-2060-vl	**Course name** Electromagnetic Compatibility		
Instructor Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Peter Hock		**Type** Lecture	**SWS** 2
Course Nr. 18-hi-2060-ue	**Course name** Electromagnetic Compatibility		
Instructor Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Peter Hock		**Type** Practice	**SWS** 1

Module name Electrothermal Processes					
Module Nr. 18-bi-2070	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** First the technical and economic importance of electrothermal processes will be pointed out. In addition to that, advantages, characteristics and applications of electroheat processes will be shown by typical examples. The second part of the lecture is about thermotechnical and electrotechnical basics, which are necessary to understand electrothermal processes. The main part of the lecture deals with examples of electrothermal processes, like induction heating (focus), conductive and dielectric heating as well as indirect resistance heating. Examples from industry are shown, and it will be explained how the applications are designed with numerical simulation tools (FEM-based) and analytical methods (calculation of electromagnetic fields). At the end of the lecture special processes like laser applications will be shown.
2	**Learning objectives / Learning Outcomes** Understanding of design and calculation of electrothermal processes and their applications
3	**Recommended prerequisite for participation** B.Sc. Electrical Engineering or Mechatronics
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc EPE, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes; Fasholz, J., Orth, G.: Induktive Erwärmung, RWE Energie AG, Essen, 4. Aufl., 1991; Nacke, B.; Baake, E. (Hsg.): Induktives Erwärmen, Vulkan-Verlag, 2014

Courses

Course Nr. 18-bi-2070-vl	**Course name** Electrothermal Processes	
Instructor Dr.-Ing. Jörg Neumeyer, M.Sc. Nicolas Ludwig Erd	**Type** Lecture	**SWS** 2

Module name Power Cable Systems					
Module Nr. 18-hi-2040	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner** Prof. Dr.-Ing. Volker Hinrichsen		

1 Content

In the lecture, in addition to theoretical knowledge, also the practical side of high voltage cable technology will be treated. These are technical issues, e.g. water sensitivity of plastic cables, cable inspection, testing of already installed cables and the latest developments as in the field of superconductivity etc..
The contents of the lecture are:

- Cable construction: materials / requirements / design
- Cable Manufacturing: conductors / extrusion / shield / sheath (oil-paper insulation) / reinforcement
- Quality requirements and routine-/selection-/type- long term test / ISO 9001, standards, aging, endurance
- Cable junction technique: sockets / terminations / materials / field grading systems / cable connection
- Cable Systems: load / mech. requirements / ind. voltage / short circuit requirements / transient requirements / installation techniques
- Design and operation: route planning / laying / commissioning / monitoring / maintenance
- Trends: High-temperature superconductivity, Submarine cable, DC cable, forced cooling, GIL

2 Learning objectives / Learning Outcomes

Students learn the basic structure of a cable. They know the technical requirements both for the material and the design of a high voltage cable. The basics of manufacturing technology and the necessary tests are learned. The students are also able to evaluate new trends in cable technology.

3 Recommended prerequisite for participation

BSc. ETiT Electrical Power Systems

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System)

In general, the examination takes place in form of a written exam (duration: 90 minutes). If up to 5 students register, there examination can be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture or in semesters without a lecture within one working week after the end of the examination registration phase.

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

Slides, litrature sources

Courses

Course Nr. 18-hi-2040-vl	**Course name** Power Cable Systems	
Instructor Dr. Ing. Johannes Kaumanns	**Type** Lecture	**SWS** 2

Module name Regulation of Power Supply					
Module Nr. 18-hs-2010	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1 Content

- Structure of the German energy economy with focus on electrical power supply
- Changes in the regulatory framework (unbundling, grid regulation)
- Effects of the "Energiewende" on the energy economy in Germany
- Energy turnaround: technologies, energy balance
- Renewable energy law (EEG)
- Incentive regulation ("Anreizregulierung")
- Excursion to Mainova AG

2 Learning objectives / Learning Outcomes

A student knows after successful completion of this module the basics, the driving forces and developments of the German energy economy.
The effects of the German "Energiewende" and necessary technical changes for the energy sector are also taught.

3 Recommended prerequisite for participation

Good knowledge of content of the lecture "Energietechnik"

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc EPE, MSc Wi-ETiT, MSc MEC, MSc iST, MSc iCE, MSc CE

7 Grade bonus compliant to §25 (2)

8 References

Lecture Notes

Courses

Course Nr. 18-hs-2010-vl	**Course name** Regulation of Power Supply		
Instructor Prof. Dr.-Ing. Ingo Jeromin		**Type** Lecture	**SWS** 2

Module name					
Large Generators and High Power Drives					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bi-2020	4 CP	120 h	75 h	1	WiSe
Language			**Module owner**		
German and English			Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** Design of large electric generators: Special cooling methods with air, hydrogen and water, loss evaluation, especially eddy current losses, and measures to reduce the additional losses. Design of big hydrogenerators up to 800 MVA and turbo generators up to 2000 MVA with desing examples. Application of power electronics in large variable speed drives with synchronous motors: Synchronous converter and cyclo-converter. Numerous photographs to illustrate applications, excursion with students to special firms or plants.
2	**Learning objectives / Learning Outcomes** Expert knowledge in design of generators, large drives, their cooling systems and operational performance is acquired.
3	**Recommended prerequisite for participation** Physics, Electrical Machines and Drives, Electrical Power Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc EPE, MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Detailed textbook with calculated examples; Vas, P.: Parameter estimation, condition monitoring, and diagnosis of electrical machines, Clarendon Press, 1993 Fitzgerald, A.; Kingsley, C.; Kusko, A.: Electric machinery, McGraw-Hill, 2003 Leonhard, W.: Control of electrical drives, Springer, 1996

Courses

Course Nr. 18-bi-2020-vl	**Course name** Large Generators and High Power Drives		
Instructor Dr. techn. Georg Traxler-Samek		**Type** Lecture	**SWS** 2
Course Nr. 18-bi-2020-ue	**Course name** Large Generators and High Power Drives		
Instructor Dr. techn. Georg Traxler-Samek		**Type** Practice	**SWS** 1

Module name					
High Voltage Switchgear and Substations					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hi-2020	3 CP	90 h	60 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Volker Hinrichsen		

1 Content

This lecture covers the basic designs of high voltage substations as well as the design and working principles of high voltage switchgear:

- Tyes of switching and stresses induced by switching
- Arc behaviour in air, SF6 and vacuum
- Types of switchgear: earthing switches, disconnectors and circuit breakers
- Design and working principles of earthing switches and disconnectors in air and SF6
- Design and working principles of circuit breakers: vacuum breakers, pressured air and SF6 breakers (thermal blast and self-blast chambers)
- Stresses of earthing switches and disconnectors by short circuit conditions
- Testing of Switchgear
- Reliability of Switchgear
- Future developments: Intelligent control of switchgear, static switches, superconducting switchgear

2 Learning objectives / Learning Outcomes

The student should understand the purpose and working principles of high voltage switchgear as well as their usage in high voltage substations.

3 Recommended prerequisite for participation

Prior attendance of the lectures High Voltage Technology I and II is recommended

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 45 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, BSc/MSc iST, MSc Wi-ETiT, MSc EPE

7 Grade bonus compliant to §25 (2)

8 References

A script of the lecture (in German) can be obtained from here: http://www.hst.tu-darmstadt.de/index.php?id=30

Courses

Course Nr.	Course name		
18-hi-2020-vl	High Voltage Switchgear and Substations		
Instructor		**Type**	**SWS**
Prof. Dr. Claus Neumann		Lecture	2

Module name					
Communication Networks I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-1010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

In this class the technologies that make today's communication networks work are introduced and discussed.

This lecture covers basic knowledge about communication networks and discusses in detail the physical layer, the data link layer, the network layer and parts of the transport layer.

The physical layer, which is responsible for an adequate transmission across a channel, is discussed briefly. Next, error control, flow control and medium access mechanisms of the data link layer are presented. Then the network layer is discussed. It comprises mainly routing and congestion control algorithms. After that basic functionalities of the transport layer are discussed. This includes UDP and TCP. The Internet is thoroughly studied throughout the class.

Detailed Topics are:

- ISO-OSI and TCP/IP layer models
- Tasks and properties of the physical layer
- Physical layer coding techniques
- Services and protocols of the data link layer
- Flow control (sliding window)
- Applications: LAN, MAN, High-Speed LAN, WAN
- Services of the network layer
- Routing algorithms
- Broadcast and Multicast routing
- Congestion Control
- Addressing
- Internet protocol (IP)
- Internetworking
- Mobile networking
- Services and protocols of the transport layer
- TCP, UDP

2 Learning objectives / Learning Outcomes

This lecture teaches about basic functionalities, services, protocols, algorithms and standards of network communication systems. Competencies aquired are basic knowledge about the lower four ISO-OSI layers: physical layer, datalink layer, network layer and transport layer; Furthermore, basic knowledge about communication networks is taught. Attendants will learn about the functionality of today's network technologies and the Internet.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

Wi-CS, Wi-ETiT, BSc CS, BSc ETiT, BSc iST

7	**Grade bonus compliant to §25 (2)** A bonus of 0.3 or 0.7 can be obtained. For 0.3 bonus: 7 out of 9 exercises are to be solved to the best of your knowledge. That is, every question needs to be answered. However, not every question needs to be answered correctly. Additionally, at least one wiki article or applet concerning a topic of the lecture has to be provided (written). For the 0.7 bonus: Additionally, present one exercise and write at least three wiki articles, or write at least 5 wiki articles. An oral exam ("Fachgespräch") is mandatory in order to receive the bonus. The bonus can only be applied if the exam grade is 4.0 or better.
8	**References** • Andrew S. Tanenbaum: Computer Networks, 5th Edition, Prentice Hall, 2010 • Andrew S. Tanenbaum: Computernetzwerke, 3. Auflage, Prentice Hall, 1998 • Larry L. Peterson, Bruce S. Davie: Computer Networks: A System Approach, 2nd Edition, Morgan Kaufmann Publishers, 1999 • Larry L. Peterson, Bruce S. Davie: Computernetze, Ein modernes Lehrbuch, 2. Auflage, Dpunkt Verlag, 2000 • James F. Kurose, Keith W. Ross: Computer Networking: A Top-Down Approach Featuring the Internet, 2nd Edition, Addison Wesley-Longman, 2002 • Jean Walrand: Communication Networks: A First Course, 2nd Edition, McGraw-Hill, 1998

Courses

Course Nr. 18-sm-1010-vl	**Course name** Communication Networks I		
Instructor Dr.-Ing. Amr Rizk, Prof. Dr.-Ing. Ralf Steinmetz		**Type** Lecture	**SWS** 3
Course Nr. 18-sm-1010-ue	**Course name** Communication Networks I		
Instructor Dr.-Ing. Amr Rizk, Prof. Dr.-Ing. Ralf Steinmetz		**Type** Practice	**SWS** 1

Module name					
Communication Networks II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-2010	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

Topics are:

- Basics and History of Communication Networks (Telegraphy vs. Telephony, Reference Models, ...)
- Transport Layer (Addressing, Flow Control, Connection Management, Error Detection, Congestion Control, ...)
- Transport Protocols (TCP, SCTP)
- Interactive Protocols (Telnet, SSH, FTP, ...)
- Electronic Mail (SMTP, POP3, IMAP, MIME, ...)
- World Wide Web (HTML, URL, HTTP, DNS, ...)
- Distributed Programming (RPC, Web Services, Event-based Communication)
- SOA (WSDL, SOAP, REST, UDDI, ...)
- Cloud Computing (SaaS, PaaS, IaaS, Virtualization, ...)
- Overlay Networks (Unstructured P2P, DHT Systems, Application Layer Multicast, ...)
- Video Streaming (HTTP Streaming, Flash Streaming, RTP/RTSP, P2P Streaming, ...)
- VoIP and Instant Messaging (SIP, H.323)

2 Learning objectives / Learning Outcomes

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

3 Recommended prerequisite for participation

Basic courses of first 4 semesters are required. Knowledge in the topics covered by the course Communication Networks I is recommended. Theoretical knowledge obtained in the course Communication Networks II will be strengthened in practical programming exercises. So, basic programming skills are beneficial.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, Wi-ETiT, CS, Wi-CS

7 Grade bonus compliant to §25 (2)

8 References

Selected chapters from following books:

- Andrew S. Tanenbaum: Computer Networks, Fourth 5th Edition, Prentice Hall, 2010
- James F. Kurose, Keith Ross: Computer Networking: A Top-Down Approach, 6th Edition, Addison-Wesley, 2009
- Larry Peterson, Bruce Davie: Computer Networks, 5th Edition, Elsevier Science, 2011

Courses

Course Nr.	**Course name**		
18-sm-2010-vl	Communication Networks II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		Lecture	3

Course Nr.	**Course name**		
18-sm-2010-ue	Communication Networks II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		Practice	1

Module name Power Plants and Renewable Energies					
Module Nr. 18-hs-2090	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Content** Forms of energy, Characteristics and figures of electricity industry, Importance of power generation – Energy Conversion in thermal processes (Carnot-Process), Categorization of power plants – Operation principle of steam power plants, gas power plants, water power plants, wind power plants, Use of solar energy (Photovoltaics, Solar thermal technology) and further regenerative energy sources (geothermal energy, biomass) – Technologies for Energy Converting and Storing (Power 2 X) – Electrical systems – Grid Connection for power plants
2	**Learning objectives / Learning Outcomes** Goals are: • Overview of concepts of power generation by various energy sources • Comprehension of physical processes • Operation principle and design of conventional and renewable power plants and storage • Comprehension of electrical devices and control concepts
3	**Recommended prerequisite for participation** Basics in Electrical Engineering, Power Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ET, MSc EPE, MSc MEC, MSc CE, MSc MB, MSc WI-MB
7	**Grade bonus compliant to §25 (2)**
8	**References** Script

Courses

	Course Nr. 18-hs-2090-vl	**Course name** Power Plants and Renewable Energies		
	Instructor Prof. Dr.-Ing. Jutta Hanson		**Type** Lecture	**SWS** 2
	Course Nr. 18-hs-2090-ue	**Course name** Power Plants and Renewable Energies		
	Instructor Prof. Dr.-Ing. Jutta Hanson, M.Sc. Benjamin Niersbach, M.Sc. Xiong Xiao		**Type** Practice	**SWS** 1

Module name Motor Development for Electrical Drive Systems					
Module Nr. 18-bi-2032	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** For the wide field of the drive technology at low and medium power range from 1 kW up to about 500 kW. . . 1 MW the conventional drives and the current trends of developments are explained to the students. Grid operated and inverter-fed induction drives, permanent-magnet synchronous drives with and without damper cage (“brushless dc drives”), synchronous and switched reluctance drives and permanent magnet and electrically excited DC servo drives are covered. As a "newcomer" in the electrical machines field, the transversal flux machines and modular synchronous motors are introduced.
2	**Learning objectives / Learning Outcomes** For the students who are interested in the fields of design, operation or development of electrical drives in their future career, the latest knowledge about • modern computational methods (e.g. finite elements), • advanced materials (e.g. high energy magnets, ceramic bearings), • innovative drive concepts (e.g. transversal flux machines) and • measurement and experiment techniques are imparted.
3	**Recommended prerequisite for participation** Completed Bachelor of Electrical Engineering or equivalent degrees
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, **not** MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** A detailed script is available for the lecture. In the tutorials design of PM machines, switched reluctance drives and inverter-fed induction motors are explained.

Courses

Course Nr. 18-bi-2030-vl	**Course name** Motor Development for Electrical Drive Systems		
Instructor Dr.-Ing. Andreas Jöckel		**Type** Lecture	**SWS** 2
Course Nr. 18-bi-2030-ue	**Course name** Motor Development for Electrical Drive Systems		
Instructor Dr.-Ing. Andreas Jöckel		**Type** Practice	**SWS** 1

Module name New Technologies of Electrical Energy Converters and Actuators					
Module Nr. 18-bi-2040	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1 Content

Goal: The application of new technologies, i.e. super conduction, magnetic levitation techniques and magneto-hydrodynamic converter principles, are introduced to the students. The physical operation mode in principle, implemented prototypes and the current state of the development are described in detail.
Content:
Application of the superconductors for electrical energy converters:

- rotating electrical machines (motors and generators),
- solenoid coils for the fusion research,
- locomotive- and railway transformers,
- magnetic bearings.

Active magnetic bearings ("magnetic levitation"):

- basics of the magnetic levitation technique,
- magnetic bearings for high speed drives in kW to MW range,
- application for high-speed trains with linear drives.

Magneto-hydrodynamic energy conversion:

- physical principle,
- state of the art and perspectives.

Fusion research:

- magnetic field arrangements for contactless plasma inclusion,
- state of the current research.

2 Learning objectives / Learning Outcomes

Basic knowledge in application of superconductivity in energy systems is understood as well as magnetic levitation, magnetohydrodynamics and fusion technology.

3 Recommended prerequisite for participation

Physics, Electrical Machines and Drives, Electrical Power Engineering

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc EPE, MSc ETiT, MSc MEC, MSc WI-ETiT

7 Grade bonus compliant to §25 (2)

8 References

Detailed textbook; Komarek, P.: Hochstromanwendungen der Supraleitung, Teubner, Stuttgart, 1995
Buckel, W.: Supraleitung, VHS-Wiley, Weinheim, 1994
Schweitzer, G.; Traxler, A.; Bleuler, H.: Magnetlager, Springer, Berlin, 1993
Schmidt, E.: Unkonventionelle Energiewandler, Elitera, 1975

Courses				
	Course Nr. 18-bi-2040-vl	**Course name** New Technologies of Electrical Energy Converters and Actuators		
	Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder		**Type** Lecture	**SWS** 2
	Course Nr. 18-bi-2040-ue	**Course name** New Technologies of Electrical Energy Converters and Actuators		
	Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder		**Type** Practice	**SWS** 1

Module name					
System Dynamics and Automatic Control Systems II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ad-1010	7 CP	210 h	135 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Jürgen Adamy		

1 Content

Main topics covered are:

- Root locus method (construction and application),
- State space representation of linear systems (representation, time solution, controllability, observability, observer- based controller design)

2 Learning objectives / Learning Outcomes

After attending the lecture, a student is capable of:

- constructing and evaluating the root locus of given systems
- describing the concept and importance of the state space for linear systems
- defining controllability and observability for linear systems and being able to test given systems with respect to these properties
- stating controller design methods using the state space, and applying them to given systems
- applying the method of linearization to non-linear systems with respect to a given operating point

3 Recommended prerequisite for participation

System Dynamics and Control Systems I

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

BSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik

7 Grade bonus compliant to §25 (2)

8 References

Adamy: Systemdynamik und Regelungstechnik II, Shaker Verlag (available for purchase at the FG office)
http://www.rtr.tu-darmstadt.de/lehre/e-learning (optionales Material)

Courses

Course Nr.	Course name		
18-ad-1010-vl	System Dynamics and Automatic Control Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Lecture	3
Course Nr.	**Course name**		
18-ad-1010-ue	System Dynamics and Automatic Control Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Practice	2

Module name Overvoltage Protection and Insulation Coordination in Power System					
Module Nr. 18-hi-2030	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Volker Hinrichsen		

1 Content

- Introduction, basics and overview
- Determination of representative overvoltages
  - Origin and classification of overvoltages
  - Normal distribution of overvoltage probability and derivated variables
  - Operating voltage and temporary overvoltages
  - Slow front overvoltages
  - Fast front overvoltages
  - Characteristics of overvoltage protective devices
  - Operation and design of metal-oxide surge arresters
  - Travelling wave effect and protective distance of surge arresters
  - Representative voltage and overvoltages in the case of using surge arresters
- Determination of coordination withstand voltage
  - Insulation strength for different voltage shapes and geometric configurations (gap factors)
  - Performance criterion
  - Insulation coordination procedure
- Determination of required withstand voltage
  - General remarks
  - Atmospheric correction
  - Safety factor for internal and external insulations
- Standard withstand voltage and testing procedures
  - General remarks
  - Test conversion factors
  - Determination and verification of insulation withstand by type tests
  - Table of test voltages and required clearances

2 Learning objectives / Learning Outcomes

The student have understood the main procedures of insulation coordination based on the relevant IEC standard (and the main difference with related IEEE standard procedure) which leads to selection of the electric strength of equipment in relation to the voltages which can appear on the system. In addition, they have learned the origin of different type of overvoltages as well as the protection of equipment against them. The operation and design of surge arresters as an important instrument of insulation coordination in power systems have been understood. The theoretical knowledge about the procedure of insulation coordination has been confirmed and expanded by practical case studies. The students are finally be able to carry out the insulation coordination independetly in any application.

3 Recommended prerequisite for participation

High Voltage Technology I and II

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

	Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)			
6	**Usability of this module** MSc ETiT, MSc EPE, MSc Wi-ETiT			
7	**Grade bonus compliant to §25 (2)**			
8	**References** The related IEC standard can be borrowed during the lecture time. Lecture notes (in English) and other helpful materials can be downloaded from HST homepage: www.hst.tu-darmstadt.de.			
Courses				
	Course Nr. 18-hi-2030-vl	**Course name** Overvoltage Protection and Insulation Coordination in Power System		
	Instructor Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Constantin Balzer, M.Sc. Tobias Trautmann		**Type** Lecture	**SWS** 2
	Course Nr. 18-hi-2030-ue	**Course name** Overvoltage Protection and Insulation Coordination in Power System		
	Instructor Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Constantin Balzer, M.Sc. Tobias Trautmann		**Type** Practice	**SWS** 1

Module name Applied Superconductivity					
Module Nr. 18-bf-2030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1 Content

- Basics of electrical conductivity at DC and RF
- Kamerligh-Onnes experiment, Meissner effect
- Superconductor state diagram
- London equations, Typ I / II Superconductor
- Cooper pairs (briefly: BCS theory, GL theory)
- Flux quantization, Flux vortices
- AC superconductivity, two fluid model, RF cavities
- Cooper pair tunneling, Josephson junctions
- Metrology: SQUIDs, (quantum-) Hall effect
- Superconductor magnetization, Hysteresis, Bean‘s model
- Applications: Magnets in accelerator and medical technology, precision field and current measurements, energy engineering

2 Learning objectives / Learning Outcomes

The students obtain a phenomenological understanding of superconductivity, which enables them to apply superconductors in engineering practice. Starting from Maxwellian electrodynamics, superconductors are in introduced as perfect conductors at zero frequency. Both their DC and AC properties are discussed. Theory shall be reduced as much as possible. Quantum mechanics is not a requirement for the course, however, simplified quantum mechanical models will be introduced. The focus of the lecture is put on applications, e.g. magnet technology or precision metrology.

3 Recommended prerequisite for participation

Electrodynamics (Maxwell’s equations)

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc WI-ETiT, MSc iCE, BSc/MSc CE

7 Grade bonus compliant to §25 (2)

8 References

- W. Buckel, R. Kleiner: „Supraleitung Grundlagen und Anwendungen“; Wiley VCH, 7. Auflage 2013.
- R.G. Sharma; „Superconductivity, Basics and Applications to Magnets“; Springer International Publishing, 2015 (online available).
- H. Padamsee, J. Knobloch, T. Hays: „RF-Superconductivity for Accelerators“; 2nd edition; Wiley VCH Weinheim, 2011.
- P. Seidel (Ed.), „Applied Superconductivity“, Wiley VCH Weinheim, 2015.

Courses

	Course Nr.	Course name		
	18-bf-2030-vl	Applied Superconductivity		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Uwe Niedermayer		Lecture	2

Module name Lightning Physics and Lightning Protection					
Module Nr. 18-hi-2090	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Volker Hinrichsen		

1 Content

- Introduction
- Thunderstorms and Cloadclassification, formation and electrification
- Lightning, terminology, types, charge transfer, typical parameters
- Streamer- leader process, inception and development in large gaps
- Electric and magnetic fields in vicinity of lightning discharge
- Return stroke models, charge distributions and neutralization
- The Finite-Difference Time Domain Method for solving Maxwell's equations
- Lightning location, the technical use of field information
- Lightning effects in the middle and upper atmosphere
- Lightning hazard and deleterious effects
- Lightning protection and related threats, historical overview, standards and present lightning protection concepts
- Outer lightning protection, Lightning rods, down conductors, grounding systems, potential bonding and separation distances
- Inner lightning protection, surge protection devices, installation, test standards
- Lightning protection on transmission lines, faults and effects, calculation of outage rates and opportunities of improvement
- Lightning and surge protection for wind turbines

2 Learning objectives / Learning Outcomes

The students know the inception, development and effects of natural lightning. They are able to differentiate between types of lightning and know all typical parameters, related to different surges and types of lightning. They know that the parameters may devite in different places over the earth and know the reason for this deviation. The students learn about all relevant components of a lightning strike as well as their technical relevance in lightning protection, surge protection and lightning location. The theory and most relevant models of lightning attachment and also its successive return stroke are known. All relevant lightning threats in terms of lightning protection are known and can be calculated.

The students know how a standardized lightning protection system has to look like. They know about lightning protection levels, lightning protection zones and are able to apply measures on building, transmission lines and wind mills. The students know about simulation methodologies used in lightning research, taking into account the full retarded Maxwell equations. The students are aware of the uncertainities in lightning protection and lightning research. They know about open questions in the field of research related to the inception, discharge and effects of lightning.

The students learn about unconventional lightning protection, which cannot be found in the standard, and also get to know why they are not found there. The studentes are sensitised about research results in general.

3 Recommended prerequisite for participation

Recommended: BSc ETiT, BSc Wi-ETiT

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

	Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides and other information material supporting the lecture can be downloaded from the HST-Homepage: http://www.hst.tu-darmstadt.de. IEC test standards can be leant out for use during the lecturer time. • Blitz und Blitzschutz, F. Heidler, K. Stimper, ISBN 978-3-8007-2974-6 • Handbuch für Blitzschutz und Erdung, P. Hasse, J. Wiesinger, W. Zischank, ISBN 978-3-7905-0657-0 • Blitzschutzanlagen: Erlauterungen zu DIN 57 185/VDE 0185, VDE-Verlag, ISBN 978-3-8007-1303-9 • Lightning, Physics and Effects, V.A. Rakov, M.A. Uman, ISBN 978-0-521-03541-5 • Lightning Physics and Lightning Protection, E.M. Bazelyan, Y.P. Raizer, ISBN 978-0-750-30477-1 • Electromagnetic Computation Methods for Lightning Surge Protection Studies, Y. Baba, V.A. Rakov, ISBN 978-1-118-27563-4 • Lightning Electromagentics, V. Cooray, ISBN 978-1-84919-215-6 • Lightning: Principles, Instruments and Application, H.D. Betz, U. Schumann, P. Laroche, ISBN 978-1-4020-9078-3

Courses

	Course Nr. 18-hi-2090-vl	**Course name**	
	Instructor Dr.-Ing. Martin Hannig	**Type** Lecture	**SWS** 2

Module name					
Electric drives for cars					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bi-2150	4 CP	120 h	75 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr. techn. Dr.h.c. Andreas Binder		

1 Content

This course introduces the students to the different design aspects of electric drives used in automotive applications, comprising both high power density high speed traction and small mass produced auxiliary drives. Since the target audience comprises students from different degree programmes, the course first reviews basics of electromagnetic power conversion principles and design principles of PM based machines. The discussion of the electric drives themselves comprises the various facets of their design as part of a complex system, such as operating requirements, configurations, material choices, parasitic effects and their mitigation, electric and thermal stress, as well as manufacturing related questions, notably as they affect the design of the mass produced auxiliary drives.

2 Learning objectives / Learning Outcomes

At the end of the course, the students will know about design principles of PM based machines, electric drives: topologies, operating areas, dynamic performance and configuration of traction drives for hybrid cars and electric vehicles as they apply to electric drives for cars. In addition to traction drives, they will also be familiar with auxiliary drives used in cars. They will understand the parasitic effects of inverter induced bearing currents, the insulation material used for the electric winding and the winding stress at inverter supply. They will be familiar with the different cooling principles and thermal modelling, as well as the thermal aspects of the integration into the car. They will also know about the main failure modes that may occur with electric drives used for cars, the different lamination sheets used and their manufacturing.

3 Recommended prerequisite for participation

Completed Bachelor of Electrical Engineering or equivalent degree.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

Module final exam:

* Module exam (Technical examination, optional, standard grading system)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

Courses

Course Nr.	Course name		
18-bi-2150-vl	Electric drives for cars		
Instructor		**Type**	**SWS**
Prof. Dr. Annette Mütze		Lecture	2
Course Nr.	**Course name**		
18-bi-2150-ue	Electric drives for cars		
Instructor		**Type**	**SWS**
Prof. Dr. Annette Mütze		Practice	1

Module name					
Energy Management and Optimization					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-st-2010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Florian Steinke		

1	**Content** The lecture reviews the different levels of energy management. It then focuses on economic dispatch and discusses its different use cases like optimization of self-consumption, virtual power plants, electric vehicle load management or multi-modal neighborhood optimization. Relevant knowledge about the components to be controlled as well as the markets to be addressed is explained. After this introduction to economic dispatch's application environment, the lecture focuses on the methods employed. The underlying mathematical formulations as different types of optimization problems (LP, MILP, QP, stochastic optimization) are reviewed. In parallel, a practical introduction to numerical optimization is given (descent algorithms, convergence, convexity, programming languages for the formulation of optimization problems). Moreover, an introduction into simple methods for the prognosis of future values (linear regression) is provided.All methodological learning is accompanied by hands-on exercises using the Matlab/Octave and the GAMS/AMPL software environments.
2	**Learning objectives / Learning Outcomes** Students know the different use cases and formulations of economic dispatch. They have a basic understanding of the typically employed optimization methods and are able to judge the quality of the achieved results. Moreover, students are independently able to formulate (energy) optimization problems and solve them with the tool GAMS/AMPL.
3	**Recommended prerequisite for participation** Standard knowledge of linear algebra and multivariate analysis as well as basic knowledge in the use of Matlab/Octave is required. Knowledge of the modules „Kraftwerke & EE“ or „Energiewirtschaft“ is helpful but not necessarry.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc Wi-ETiT, MSc CE
7	**Grade bonus compliant to §25 (2)** Improvement of grades up to 0.4 compliant to APB §25(2) through bonus system for re-gular attention of exercises and practical courses
8	**References** Boyd, Vandenberghe: Convex Optimization, Cambridge University Press, 2004A GAMS Tutorial by Richard E. Rosenthal, https://www.gams.com/24.8/docs/userguides/userguide/_u_g__tutorial.html

Courses

Course Nr.	**Course name**		
18-st-2010-vl	Energy Management and Optimization		
Instructor		**Type**	**SWS**
		Lecture	2

	Course Nr. 18-st-2010-pr	**Course name** Energy Management and Optimization Lab		
	Instructor		**Type** Internship	**SWS** 1
	Course Nr. 18-st-2010-ue	**Course name** Energy Management and Optimization		
	Instructor		**Type** Practice	**SWS** 1

Module name					
Gasinsulated Switchgear and Lines					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hi-2080	3 CP	90 h	60 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Volker Hinrichsen		

1 Content

- Introduction, properties of the insulating gas sulfur hexafluoride (SF6) and gas mixture SF6/N2, SF6 handling
- Historical development of gasinsulated systems, life time, statistics on age of installed switchgear, space consumption
- Components and configuration of a GIS (3-phase, 1-phase; bushings, insulators, disconnectors, earthing switches, circuit breakers, instrument transformers, cable boxes, surge arresters, bus bars; particle traps; secondary equipment)
- Test requirements and specifications for GIS
- Insulation coordination and overvoltage protection, response to very fast transients (VFTO)
- Defects in GIS and diagnostic tools
- Gasinsulated medium voltage switchgear
- Gasinsulated lines (design, laying techniques, comparison with cables and overhead lines)
- Current carrying capability, thermo-mechanical stress
- Alternative insulating gases for application in “Eco”-GIS / - GIL (F-ketones, F-nitriles, “Clean Air” etc.)
- Gas-solid insulation systems under DC stress
- Special challenges of HVDC systems (impact factors, particle behavior, test requirements and specifications)

2 Learning objectives / Learning Outcomes

The students know the propoerties of the insulating gas sulfur hexafluoride (SF6). They know the climate impact of SF6 and are familiar with adequate gas handling. They are well informed about the alternatives that are actually under discussion and investigated for application in eco-friendly GIS. The students know the pros and cons of gasinsulated systems (GIS) compared with air insulated systems (AIS) in power supply systems, and they have understood, for which applications GIS might be favorable. They know the basic design and configuration of MV and HV GIS and can explain the functionality of each component in such systems. The students have learnt to know the test requirements and are able to distinguish routine-, type and on-site commissioning tests. They know why VFTO have to be especially regarded in the process of insulation coordination and which measures can and have to be taken for overvoltage protection in GIS. The students know the defects typical for GIS and how they can be monitored. They know the laying methods of gasinsulated lines (GIL) and can compare GIL to other transmission options in the power system. Furthermore, they can calculate the current carrying capacity of simple gasinsulated lines and estimate the resulting thermo-mechanical stress. The students have understood the basic differences in the requirements on insulation systems under DC and under AC stress, and what are the consequences on design and testing of DC-GIS and DC-GIL.

3 Recommended prerequisite for participation

HST I and HST II

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides and other information material supporting the lecture can be downloaded from the HST-Homepage: http://www.hst.tu-darmstadt.de. IEC test standards can be leant out for use during the lecturer time.

Courses

Course Nr.	**Course name**		
18-hi-2080-vl	Gasinsulated Switchgear and Lines		
Instructor		**Type**	**SWS**
Dr.-Ing. Maria Kosse, M.Sc. David Christopher Kothe		Lecture	2

1.3.2.2 EET - Labs (open catalogue)

Module name Practical Training with Drives					
Module Nr. 18-bi-2100	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** The purpose of this laboratory is gaining extented knowledge about realization and behaviour of drive systems. An introduction in measurement problems concerning drives is given. The contents of the laboratory is setting drives to work and investigating drive systems under laboratory conditions. Special attention is paid to inverter-fed AC drives. The laboratory experiments are individually coordinated with the previous knowledge of the respective courses (ETiT or MEC).
2	**Learning objectives / Learning Outcomes** The students get the ability of measurement for electrical motors, generators and transformers.
3	**Recommended prerequisite for participation** Bachelor of Science in Electrical Engineering, Power Engineering or similar
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Textbook with lab instructions; Nürnberg, W.: Die Prüfung elektrischer Maschinen, Springer, 2000; Leonhard, W.: Control of electric drives, Springer, 2000; Textbook – Binder, A.: Motor Developement for Electrical Drive Systems; Lecture notes – Mutschler, P.: Control of Drives

Courses

Course Nr. 18-bi-2100-pr	**Course name** Practical Training with Drives	
Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder	**Type** Internship	**SWS** 3

Course Nr. 18-bi-2090-tt	**Course name** Laboratory Briefing	
Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder	**Type** Tutorial	**SWS** 0

Module name Simulation of Electrical Power Networks					
Module Nr. 18-hs-2100	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Content** Modeling, simulating and planning electrical power networks with a wide range of nominal voltages under consideration of electrical equipment (overhead lines, cables, transformers, conventional power plants, renewable energy resources und reactive power compensation systems)
2	**Learning objectives / Learning Outcomes** The learning targets are the following: • Modeling various electrical power systems using the appropriate techniques. • Choice of static and dynamic simulation techniques after analysing the concrete simulation processes. • Understanding the behaviour of various equipment in the electric power system, especially renewable energy resources.Interpretion of results based on the fundamental questions of modeling and simulating electrical power systems.
3	**Recommended prerequisite for participation** Basics of electrical power systems
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ET, MSc CE
7	**Grade bonus compliant to §25 (2)**
8	**References** Script, Presentation Slides, Description of tutorial and basic network data

Courses

Course Nr.	**Course name**		
18-hs-2100-pr	Simulation of Electrical Power Networks		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jutta Hanson, Dipl.-Ing. Andreas Saciak		Internship	2

Module name					
Power Laboratory I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bi-2091	4 CP	120 h	75 h	1	WiSe
Language			**Module owner**		
German and English			Prof. Dr. techn. Dr.h.c. Andreas Binder		

1 Content

Safety instructions for laboratory;
Topic of experiments:

- Electrical energy conversion
- Power electronics
- High voltage technology
- Electrical energy supply
- Renewable energies

2 Learning objectives / Learning Outcomes

Practical knowledge is gained in measuring and operating electrical devices and apparatus of electrical power engineering in small groups of students.

3 Recommended prerequisite for participation

Power Engineering or similar

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc MEC, MSc WI-ETiT

7 Grade bonus compliant to §25 (2)

8 References

Binder, A. et al.: Textbook with detailed description of experiments; Hindmarsh, J.: Electrical Machines and their Application, Pergamon Press, 1991
Nasar, S.A.: Electric Power systems. Schaum's Outlines
Mohan, N. et al: Power Electronics, Converters, Applications and Design, John Wiley & Sons, 1995
Kind, D., Körner, H.: High-Voltage Insualtion Technology, Friedr. Vieweg & Sohn, Braunschweig Wiesbaden, 1985, ISBN 3-528-08599-1

Courses

Course Nr.	Course name		
18-bi-2091-pr	Power Laboratory I		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Dr.h.c. Andreas Binder, Prof. Dr.-Ing. Volker Hinrichsen		Internship	3
Course Nr.	**Course name**		
18-bi-2090-tt	Laboratory Briefing		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Dr.h.c. Andreas Binder		Tutorial	0

Module name					
Power Laboratory II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bi-2092	4 CP	120 h	75 h	1	SoSe
Language			**Module owner**		
German and English			Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** Practical course on power engineering - Distribution and Application. About 50% of the units are devoted to power distribution and high voltage engineering; About 50% are dealing with application in drive systems, concerning “field-oriented control” of variable speed drives, encoder sytems, linear permanent magnet and switched reluctance machines.
2	**Learning objectives / Learning Outcomes** Practical knowledge is gained in measuring and operating electrical devices and apparatus of electrical power engineering in small groups of students.
3	**Recommended prerequisite for participation** Master program: Power Lab 1
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Text book with detailed laboratory instructions

Courses

	Course Nr. 18-bi-2092-pr	**Course name** Power Laboratory II		
	Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder, Prof. Dr.-Ing. Volker Hinrichsen		**Type** Internship	**SWS** 3
	Course Nr. 18-bi-2090-tt	**Course name** Laboratory Briefing		
	Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder		**Type** Tutorial	**SWS** 0

Module name Laboratory Control Engineering I					
Module Nr. 18-ko-1020	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1 Content

- Control of a 2-tank system.
- Control of pneumatic and hydraulic servo-drives.
- Control of a 3 mass oscillator.
- Position control of a MagLev system.
- Control of a discrete transport process with electro-pneumatic components.
- Microcontroller-based control of an electrically driven throttle valve.
- Identification of a 3 mass oscillator.
- Process control using PLC.

2 Learning objectives / Learning Outcomes

After this lab tutorial the students will be able to practically apply the modelling and design techniques for different dynamic systems presented in the lecture ”System dynamics and control systems I” to real lab experiments and to bring them into operation at the lap setup.

3 Recommended prerequisite for participation

System Dynamics and Control Systems I

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Weighting: 100 %)

6 Usability of this module

BSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

Lab handouts will be given to students

Courses

Course Nr. 18-ko-1020-pr	**Course name** Laboratory Control Engineering I		
Instructor Prof. Dr.-Ing. Ulrich Konigorski		**Type** Internship	**SWS** 4

Module name Laboratory Control Engineering II					
Module Nr. 18-ad-2060	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** During the laboratory course the following experiments will be conducted: Coupling control of a helicopter, Non-linear control of a gyroscope, Nonlinear multivariable control of an aircraft, Servo control systems, Control of an overhead crane system, Programmable logic control of a stirring process
2	**Learning objectives / Learning Outcomes** After attending this laboratory course, a student is capable of: • recalling the basics of the conducted experiments, • organize and comprehend background information for experiments, • assemble experimental set-ups based on manuals, • judge the relevance of experimental results by comparing them with theoretically predicted outcomes, • present the results of the experiments
3	**Recommended prerequisite for participation** System Dynamics and Control Systems II, the attendance of the additional lecture “System Dynamics and Control Systems III” is recommended
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc iST, MSc Wi-ETiT, Biotechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Adamy: Instruction manuals for the experiments (available during the kick-off meeting)

Courses

Course Nr. 18-ad-2060-pr	**Course name** Laboratory Control Engineering II	
Instructor Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Jan Christian Zimmermann	**Type** Internship	**SWS** 4

1.3.2.3 EET - Project Seminars and Seminars (open catalogue)

Module name Project Seminar Energy Information Systems					
Module Nr. 18-st-2040	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Content** Students elaborate on a research-oriented subject in the area of computer-systems in a self-responsible manner. They present a written documentation and/or a presentation of the acquired advanced knowledge. They provide a set of alternative solutions to a given problem.
2	**Learning objectives / Learning Outcomes** Students are able to systematically develop design alternatives to a given problem. They learn to acquire the necessary fundamental knowledge in terms of references and terminology. The found solutions are reflected critically and the students decide for a suitable solution which they are able to argue for and accomplish.
3	**Recommended prerequisite for participation** no
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System) Module finale exam: • Module exam (Study achievements, Optional, weighting: 100)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 18-st-2040-pj	**Course name** Project Seminar Energy Information Systems		
Instructor Prof. Dr. rer. nat. Florian Steinke		**Type** Project Seminar	**SWS** 3

Module name					
Design of Electrical Machines and Actuators with Numerical Field Calculation					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bi-2110	5 CP	150 h	120 h	1	SoSe
Language			**Module owner**		
German and English			Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** Introduction to Finite Element Method (FEM), Basic examples of electromagnetic devices designed in 2D with FEM, 2D electromagnetic Design of transformers, AC machines, permanent magnet devices; eddy current applications such as squirrel-cage machines (Example: Wind generator); Cooling systems and thermal design: Calculation of temperature distribution within power devices
2	**Learning objectives / Learning Outcomes** A good knowledge in applying FEMAG and ANSYS software package to basic field problems is gained.
3	**Recommended prerequisite for participation** Strongly recommended is the attendance of lecture and active co-operation in the tutorial “Energy Converters - CAD and System Dynamics”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc EPE, MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Detailed textbook; User manual FEMAG and ANSYS. Müller, C. Groth: FEM für Praktiker – Band 1: Grundlagen, expert-Verlag, 5. Aufl., 2000

Courses

Course Nr.	Course name		
18-bi-2110-se	Design of Electrical Machines and Actuators with Numerical Field Calculation		
Instructor		**Type**	**SWS**
Dr.-Ing. Bogdan Funieru		Seminar	2

Module name Project Seminar Application in High-Voltage Technology					
Module Nr. 18-hi-2070	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 195 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Volker Hinrichsen		

1	**Content** Realization of a Project from the Design to the Implementation of High Voltage Setups
2	**Learning objectives / Learning Outcomes** The students can apply the methodology of design and development from the very first customer requirements specification up to design and type tests and documentation of equipment in high-voltage technology. They have successfully experienced team work and self-independently developed, built and tested a real device from the beginning.
3	**Recommended prerequisite for participation** High-voltage technology I and II, Power Laboratory I or II
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** depending on actual project

Courses

Course Nr.	**Course name**		
18-hi-2070-pj	Project Seminar Application in High-Voltage Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Volker Hinrichsen		Project Seminar	3

Module name Energy Converters and Electric Drives					
Module Nr. 18-bi-2130	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** From the topics of proposed scientific theses, subtasks are derived. Groups of two to four students will work on these subtasks under supervision of a tutor. The focus of the work can be either theo-retical or experimental and contains scientific problems in the field of electric energy conversion and electric drives. For study program Mechatronics this corresponds to the Advanced Design Project.
2	**Learning objectives / Learning Outcomes** Energy Converters, Electric Drives, Control of Electric Drives, Teamwork, Writing Scientific Reports, Pre-sentation
3	**Recommended prerequisite for participation** Fundamentals on Electrical Engineering, Three-phase Systems, Mechanics; Lecture „Electrical Machines and Drives“
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc MEC, MSc ETiT,MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Depending on the project task; manuscripts from the lectures „Electrical Machines and Drives“, „Motor development for electric Drive Systems“, „Regelungstechnik 1“

Courses

Course Nr. 18-bi-2130-pj	**Course name** Energy Converters and Electric Drives	
Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder	**Type** Project Seminar	**SWS** 3

Module name Project Course Practical Application of Mechatronics					
Module Nr. 18-ko-2130	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1 Content

Teams of 2-4 students work on different mechatronic projects under the guidance of a project coordinator from the institute.The projects mainly cover the following subject areas:

- Modeling, analysis, and design of mechatronic systems
- Robust control design
- System analysis, supervision and fault diagnosis
- Modeling and identification

Application areas are mechatronic actuators, machine tools, production lines, test benches, automobiles, quadrocopters.

2 Learning objectives / Learning Outcomes

After completing the project, the students will be familiar with the individual steps of investigating a mechatronic project. This includes in particular the compilation of a system specification as well as critical discussions and systematic selection of appropriate mechatronic solutions and their real technical implementation. Doing so, the students learn the practical application of mechatronic methods taught in the lectures to real world problems. Additionally, in this project course, the students are supposed to improve their professional skills. These skills include e.g. teamwork, presentation techniques and systematic information retrieval.

3 Recommended prerequisite for participation

Lectures „System Dynamics and Automatic Control Systems I“, „System Dynamics and Automatic Control Systems II“

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc MEC, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

Handouts will be distributed at start of the project (e.g. hints for writing project documentation, etc.)

Courses

Course Nr. 18-ko-2130-pj	**Course name** Project Course Practical Application of Mechatronics	
Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Julian Zeiß	**Type** Project Seminar	**SWS** 4

Module name Application, Simulation and Control of Power Electronic Systems					
Module Nr. 18-gt-2030	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1 Content

In an introductory meeting topics according to power electronics and control of drives are given to the students. During the seminary problems can be treated concerning the following topics:

- Simulation of power electronic systems plus analysis and evaluation of the models
- Implementing and startup of power electronic systems, test stand development plus measurement of characteristic parameters
- Modeling and simulation in the field of control of electrical drives
- Implementing and startup of controlled drive systems
- Suggested topics from the students are welcome

The students are working autonomous on the chosen problem. The results are documented in a written report and at the end of the module, a presentation about the problem must be held.

2 Learning objectives / Learning Outcomes

The Competences are:

- Autonomous familiarization with a given problem
- Selection and evaluation of appropriate development tools
- Familiarization with the used development tools
- Practical experience in power electronics and control of drives
- Logical presentation of the results in a report
- Presentation skills

3 Recommended prerequisite for participation

Lecture „Leistungselektronik 1“ or „Einführung Energietechnik“ and ggf. „Regelungstechnik I“ or similar

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc Wi-ETiT, MSc MEC

7 Grade bonus compliant to §25 (2)

8 References

Definition of project task

Courses

Course Nr. 18-gt-2030-se	**Course name** Application, Simulation and Control of Power Electronic Systems	
Instructor Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Pavel Makin	**Type** Seminar	**SWS** 4

Module name Calculation of Transients in electrical Power Systems					
Module Nr. 18-hs-2060	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 150 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Content** In two introductory lectures, basics of the modelling and simulation of electric power systems for transient studies are presented. Then, the respective simulation software is introduced and used by the participants in exercises. The participants then work on a given task in the field of modelling and simulation of transients in electric power systems.
2	**Learning objectives / Learning Outcomes** The goals of education are • Working on a given technical question out of the area of network planning and network calculation • Supervised und individual Elaboration of a simulation software • Individual elaboration of the given technical task • Logical presentation of results in a report • Presentation of the final report (10 mins)
3	**Recommended prerequisite for participation** Contents of lectures "Energieversorgung“ I and II
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc EPE, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Notes, software manual, exercise task, definition of project task

Courses

	Course Nr. 18-hs-2060-se	**Course name** Calculation of Transients in electrical Power Systems		
	Instructor Prof. Dr.-Ing. Jutta Hanson		**Type** Seminar	**SWS** 2

Module name Grid expansion in the context of the public opinions					
Module Nr. 18-hi-2100	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Volker Hinrichsen		

1	**Content** The construction of new transmission lines and the extension of existing grid infrastructure often encounter public resistance. In the course of this module the students will discuss the actual issues raised e.g. by local initiatives. They will have a closer look on the technical background and link the findings to the social context of the issue.
2	**Learning objectives / Learning Outcomes** In this module the students broaden and deepen their background knowledge of the grid operation and the components of the infrastructure. They know the principles on search techniques and are able to apply them on a specific topic. They can assess the collected data and their relationship. The students know the basics of technical documentations and presentations and they can illustrate their findings accordingly.
3	**Recommended prerequisite for participation** Basic knowledge of electrical energy systems and high voltage engineering
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) Studienleistung fakultativ; Submission of a paper and presentation
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc etit; MSc Wi-etit
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 18-hi-2100-se	**Course name** Grid expansion in the context of the public opinions		
	Instructor Prof. Dr.-Ing. Volker Hinrichsen		**Type** Seminar	**SWS** 2

Module name Mechatronics Workshop					
Module Nr. 18-bi-1050	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 45 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** During the mechatronic workshop students get the possibility to design and construct their own fixture, which contains a ball track and a ball elevator mechanism. Herefore dimensional plans have to be understood correctly. Afterwards all components (i.e. circuit board, rails and holders) have to be designed and manufactured within the electronic lab and the workshop, where students work independently with turning, drilling and milling machines. The mechatronic workshop allows students to gain practical experience and knowledge in contruction, assembling and PCB layout design.
2	**Learning objectives / Learning Outcomes** Understanding of construction plans, circuit layout design, practical experience with turning, drilling and milling machines.
3	**Recommended prerequisite for participation** You have to bring your **own printed** copy of the script. This is mandatory for attending the course. The script will be published on the moodle platform.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, BSc/MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** • Lecture Notes „Mechatronics Workshop“ • J. Dillinger et al.: Fachkunde Metall, Europa-Lehrmittel, 2007 • U. Tietze, C. Schenk, E. Gamm: Halbleiter-Schaltungstechnik, Springer, 2012

Courses

Course Nr. 18-bi-1050-pr	**Course name** Mechatronics Workshop	
Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder, M.Sc. Nicolas Ludwig Erd	**Type** Internship	**SWS** 1

Module name Planning and Application of Electrical Drives (Drives for Electric Vehicles)					
Module Nr. 18-bi-2120	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** Mono- and hybrid drive concepts, motor technology, DC and AC machines, drive systems, car dynamic, energy storage; Seminary work: simulation of car with electric drive train, presentation of seminary work
2	**Learning objectives / Learning Outcomes** Knowledge on design proceduces for electric modulation systems for electric and hybrid cars
3	**Recommended prerequisite for participation** Bachelor in Electrical Engineering or Mechatronics, “Electrical Drives and Machines” and "Power electronics" recommended
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc EPE, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Textbook; Binder, A.: Electric machines and drives I, Darmstadt Univ. of Technology Mitschke, M.: Dynamik der Kraftfahrzeuge, Springer Verlag Berlin

Courses

	Course Nr. 18-bi-2120-se	**Course name** Planning and application of electrical drives (Drives for electric vehicles)	
	Instructor Prof. Harald Neudorfer	**Type** Seminar	**SWS** 2

Module name Pathways of Decarbonization					
Module Nr. 18-st-2050	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Content** Participants will examine different studies about future multi-modal energy systems. The course will focus mostly on works describing the transition of the energy system today into one with CO2 emissions reduced by 80% in 2050. Each student will examine one study on this topic, extract the most important messages and arguments, understand the background that lead to the publication of the study, and crosscheck the most important facts (either via own calculations or via comparison with further studies). All results will be summarized into a compact, but informative presentation and a short summary report. In a block meeting, students will present their results to their peers. They will thereby obtain a wide overview of future energy scenarios and related discussions.
2	**Learning objectives / Learning Outcomes** Students extend their understanding of the current (political) discussions about the energy transition. They improve their presentation skills and exercise critical reasoning about the studies' results and claims.
3	**Recommended prerequisite for participation** Knowledge of the modules „Energiemanagement & Optimierung “ or „Energiewirtschaft“ is helpful but not necessary.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System) Module final exam: * Module exam (Study achievements, Optional, weighting: 100)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc ESE
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 18-st-2050-se	**Course name** Pathways of Decarbonization		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Christopher Thomas Peter Ripp		**Type** Seminar	**SWS** 2

1.4 Option Communication and Sensor Systems (KTS)

1.4.1 Fundamentals

Module name Digital Signal Processing						
Module Nr. 18-zo-2060	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe	
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir			
1	**Content** 1) Discrete-Time Signals and Linear Systems – Sampling and Reconstruction of Analog Signals 2) Digital Filter Design – Filter Design Principles; Linear Phase Filters; Finite Impulse Response Filters; Infinite Impulse Response Filters; Implementations 3) Digital Spectral Analysis - Random Signals; Nonparametric Methods for Spectrum Estimation; Parametric Spectrum Estimation; Applications; 4) Kalman Filter					
2	**Learning objectives / Learning Outcomes** Students will understand basic concepts of signal processing and analysis in time and frequency of deterministic and stochastic signals. They will have first experience with the standard software tool MATLAB.					
3	**Recommended prerequisite for participation** Deterministic signals and systems theory					
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)					
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)					
6	**Usability of this module** BSc ETiT, Wi-ETiT, MSc Medizintechnik					
7	**Grade bonus compliant to §25 (2)**					
8	**References** Course manuscript Additional References: • A. Oppenheim, W. Schafer: Discrete-time Signal Processing, 2nd ed. • J.F. Böhme: Stochastische Signale, Teubner Studienbücher, 1998					
Courses						
	Course Nr. 18-zo-2060-vl	**Course name** Digital Signal Processing				
	Instructor Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Di Jin, M.Sc. Martin Gölz			**Type** Lecture	**SWS** 3	
	Course Nr. 18-zo-2060-ue	**Course name** Digital Signal Processing				
	Instructor Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Di Jin, M.Sc. Martin Gölz			**Type** Practice	**SWS** 1	

Module name					
Microwave Engineering I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-jk-1020	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Electromagnetic spectrum, kinds of transmission media, frequency ranges, bit rates, applications; Radio-Frequency (RF) and Microwave Circuits, Components and Modules, Passive RF Circuits with R-, L- and C-Lumped Elements: Resonant and Equivalent RLC Circuits, Graphical Representation of RF Circuits with the Smith Chart, Lumped-Element Impedance Matching; Theory and Applications of Transmission Lines: General Transmission-Line Equations, Lossless Transmission Lines as Circuit Elements, Line Terminations, Transmission-Line devices; Scattering-Matrix Formulation of N-Port RF Devices: Characterization of Microwave Networks, Concatenation of Two S-Matrixes, Applications of S-Parameters; Passive microwave components: waveguide splitter, circulator, directional coupler, filter, attenuator, matching network; Antennas: Antenna performance parameter, Ideal dipole with uniform current distribution, Antenna arrays of ideal dipoles, Image theory, Antenna modelling, Transmission Factor and Power Budget of Radio Links: Friis transmission equation, Gain and effective aperture of antennas, Radar equation, System noise temperature, Antenna noise temperature, Power budget of radio links, Basic propagation effects: reflection, transmission, scattering, diffraction; The radio channel: The two-ray propagation model, Doppler shift Multipath propagation, Stochastic behaviour of the mobile radio channel
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation** Nachrichtentechnik, Grundlagen der Technischen Elektrodynamik
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script will be hand out; Literature will be recommended in first lecture

Courses

Course Nr. 18-jk-1020-vl	**Course name** Microwave Engineering I		
Instructor Prof. Dr.-Ing. Rolf Jakoby		**Type** Lecture	**SWS** 3
Course Nr. 18-jk-1020-ue	**Course name** Microwave Engineering I		
Instructor Prof. Dr.-Ing. Rolf Jakoby		**Type** Practice	**SWS** 1

Module name					
Information Theory II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-pe-2010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Marius Pesavento		

1	**Content** This lecture course is devoted to advances of network information theory. Outline: overview of Shannon capacity, outage and ergodic capacity, capacity of channels with state, capacity of Gaussian vector channels, capacity regions of multi-user channels, capacity regions of multiple-access and broadcast fading channels, interference channel, relay channel, multiuser bounds, multi-user diversity., wiretap channel, secrecy rate and physical layer security.
2	**Learning objectives / Learning Outcomes** Students will understand advanced concepts and strategies in networkinformation theory.
3	**Recommended prerequisite for participation** Knowledge of basic communication theory
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, BSc iST, MSc Wi-ETiT, MSc iCE, BSc/MSc CE
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011. 2.. T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley Sons, 1991. 3.. D. Tse and P. Vishwanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005.

Courses

Course Nr.	Course name		
18-pe-2010-vl	Information Theory II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Lecture	3
Course Nr.	**Course name**		
18-pe-2010-ue	Information Theory II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Practice	1

Module name					
Antennas and Adaptive Beamforming					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-jk-2020	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Overview of most important antenna parameters types as well as their applications. Fundamental theories: Fourier transform for far-field pattern calculations, antenna modeling techniques, antenna synthesis methods, image theory, determination of field regions of line sources, of the average radiated power density and power, directivity and gain. Antennas as key elements in power budgets of radio links, introducing the effective aperture of an antenna, deriving the relation between gain and effective aperture. Array antennas are a key hardware for beamforming and smart antenna systems: fundamentals of phased-scanning arrays, non-uniformly excited, equally spaced linear arrays, multi-dimensional planar arrays and mutual coupling effects. Wire antennas: still the most prevalent of all antenna forms, relatively simple in concept, easy to construct, very inexpensive. Antenna radiation fields and antenna parameters for different types of antennas are derived from Maxwell´s equations, applied for aperture antennas (horns, lenses or reflector antennas) and printed antennas (microstrip-patch and coplanar-slot antennas) Some basic numerical calculation methods: integral equation methods in the time and frequency domain, physical optics and uniform theory of diffraction are briefly summarized and compared for antennas and scattering problems. Smart antennas in communication and radar systems, with focus on beam steering and adaptive beamforming.
2	**Learning objectives / Learning Outcomes** Students will know basic antenna parameters: pattern, gain, directivity, half-power beamwidth, side- lobe-level, efficiency and input impedance to compare, assess and evaluate different antennas for various applications and operating frequencies. The antenna field regions, reactive near-field, near-field and far-field, can be differentiated and the far-field pattern of an antenna can be determined from given current distributions along the antenna by using Fourier transformation or integral solutions with distributed ideal dipoles as basic elements (antenna analysis). To assess in general physical requirements, constrains and limitations of antennas, students can use fundamental antenna theory: impedance matching techniques, antenna modeling and far-field pattern analysis, antenna synthesis, image theory and fundamental limits of electrically small antennas. After being incorporated into the different adaptive beamforming techniques, the array theory enables the student to design antenna systems that are assembled of a certain number of separate elements, feeding network, beamforming network etc. for phased-scanning or smart antennas in communications and sensing. Moreover, students are able to determine, analyze and evaluate the most important classes of antennas in wireless technology for many applications, operating frequencies, desired requirements or practical constrains: (1.) wire- dipole antennas, (2.) planar antennas (microstrip, dipole and slot antennas), (3.) aperture antennas (horn antennas, parabolic reflector antennas, lens antennas, Cassegrain and Gregorian double-reflector configurations), (4.) broadband and frequency-independent antennas (V antennas, biconical antennas, helical antennas, spiral and log-periodic antennas).
3	**Recommended prerequisite for participation** Fundamentals of Communications, Microwave Engineering 1
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc ETiT, MSc iCE, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**

8	**References** Jakoby, Skriptum Antennas and Adaptive Beamforming, wird am Beginn der Vorlesung verkauft und kann danach im FG-Sekretariat erworben werden			
Courses				
	Course Nr. 18-jk-2020-vl	**Course name** Antennas and Adaptive Beamforming		
	Instructor Prof. Dr.-Ing. Rolf Jakoby, M.Sc. Matthias Nickel		**Type** Lecture	**SWS** 3
	Course Nr. 18-jk-2020-ue	**Course name** Antennas and Adaptive Beamforming		
	Instructor Prof. Dr.-Ing. Rolf Jakoby, M.Sc. Matthias Nickel		**Type** Practice	**SWS** 1

Module name Communication Technology II					
Module Nr. 18-kl-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Content** linear and nonlinear digital modulation schemes, optimum receivers for AWGN channels, error probability, channel capacity, channel models, channel estimation and data detection for multipath channels, multicarrier schemes, OFDM
2	**Learning objectives / Learning Outcomes** After completion of the lecture, students possess: • the ability of comparing, evaluating, classifying an analyzing linear and nonlinear modulation schemes by means of signal space representations; • the ability to understand, describe and analyze the influence of AWGN on the signal; • the ability to understand and derive optimum receivers in case of AWGN channels; • the ability to understand, describe and analyze the influence of multipath propagation on the signal; • the ability to describe the influence of a multipath channel mathematically (channel model) and estimate the multipath channel at the receiver; • the knowledge of equalizing the received signal in order to undo the influence of multipath propagation, as well as the ability to derive and design several equalizer structures; • the ability to analyze and evaluate the properties and application areas of multicarrier transmission systems, e.g. OFDM-systems; • the ability to design and evaluate the system parameters of multicarrier schemes for the application in realistic mobile radio scenarios;
3	**Recommended prerequisite for participation** Electrical Engineering I and II, Deterministische Signale und Systeme, Stochastische Signale und Systeme, Communication Technology I, Basics of Telecommunication, Mathematics I to IV
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETIT, MSc Wi-ETiT, MSc CE, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** will be announced in the lecture

Courses

Course Nr. 18-kl-2010-vl	**Course name** Communication Technology II	
Instructor Prof. Dr.-Ing. Anja Klein	**Type** Lecture	**SWS** 2

	Course Nr.	Course name		
	18-kl-2010-ue	Communication Technology II		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Anja Klein, M.Sc. Bernd Simon		Practice	1

1.4.2.1 KTS - Lectures (open catalogue)

Module name Adaptive Filters					
Module Nr. 18-zo-2010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Content** **Theory:** 1) Derivation of optimal filters for stochastic processes, e.g. Wiener filter or linear prediction filter based on suitable cost functions. 2) Elaboration of adaptive procedures, which allow to iteratively approach the optimal solution for non-stationary signals in non-stationary environments. Here, the adaptive procedures such as NLMS adaptation, affine projection, and the RLS algorithm are derived and extensively analysed. 3) Analysis of the adaptation behaviour and control procedures of adaptive filters based on the NLMS procedure. 4) Derivation and analysis of the Kalman filter as optimal filter for non-stationary input signals. 5) Procedures for the decomposition of signals into sub-bands for the realization of optimal filters in the frequency domain, e.g. noise reduction procedures. **Applications:** Parallel to the theory, practical applications are explained. As an example for the Weiner filter, the acoustic noise reduction procedures are explained. Acoustic echo cancellation and feedback cancellation are given as examples for adaptive filters. Furthermore beamforming approaches are introduced. It is planned to offer an excursion to Siemens Audiology Engineering Group in Erlangen. In the 4 to 5 exercises, some content of the lecture will be implemented in MATLAB which allows the students to get familiar with practical realizations of the theoretical procedures.
2	**Learning objectives / Learning Outcomes** During the lecture, basics of adaptive filters are taught. The necessary algorithms are derived, interpreted and applied to examples of speech, audio and video processing. Based on the content of the lecture you are able to apply adaptive filters to real practical applications. For the admission to the exam you give a talk about a topic in the domain of adaptive filters chosen by you. This will allow you to acquire the know-how to read and understand scientific literature, familiarize yourself with an unknown topic and present your knowledge, such as it will be certainly required from you in your professional life as an engineer.
3	**Recommended prerequisite for participation** Digital Signal Processing
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Slides of the lecture.
Literature:

- E. Hänsler, G. Schmidt: Acoustic Echo and Noise Control, Wiley, 2004 (Textbook of this course);
- S. Haykin: Adaptive Filter Theory, Prentice Hall, 2002;
- A. Sayed: Fundamentals of Adaptive Filtering, Wiley, 2004;
- P. Vary, U. Heute, W. Hess: Digitale Sprachsignalverarbeitung, Teubner, 1998 (in German)

Courses

Course Nr.	**Course name**		
18-zo-2010-vl	Adaptive Filters		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Henning Puder		Lecture	3

Course Nr.	**Course name**		
18-zo-2010-ue	Adaptive Filters		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Henning Puder		Practice	1

Module name					
Acoustics I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-se-2010	3 CP	90 h	60 h	1	WiSe
Language			**Module owner**		
German			Prof. (em.) Dr. Gerhard Sessler		

1 Content

1.Basic concepts of vibrations; impedance; electromechanical analogues,
2.sound field: wave equation; plane waves; sound absorption and dispersion; room absorption,
3.sound radiation: spherical, dipole, and cardioid source; linear arrays;circular piston membrane,
4.physiological and psychological acoustics: hearing organ; acoustic perception; speech production and-speech intelligibility,
5. electroacoustic transducers; reciprocity relations; electrostatic, piezoelectric, electrodynamic, and other transducers; directional microphones; microphone calibration,
6. acoustic measuring methods: measurements of fundamental acoustic quantities; acoustic testing chambers; vibration measurements,
7 analogical and digital sound recording: digital and analogical disc and magnetic tape methods; movie sound,
8. ultrasound and hypersound: generation and detection; applications

2 Learning objectives / Learning Outcomes

After completion of the lecture, students possess:

- the understanding of basic phenomena of generation, propagation, reception, storage and reproduction of sound;
- the ability to analyze acoustic components and systems;
- the ability to judge and design applications in the audio and ultrasonic frequency ranges.

3 Recommended prerequisite for participation

Electrical Engineering I and II, Mathematics I to IV, Physics, Basics of Telecommunication

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

H. Kuttruft, Akustik (Hilzel 2004); M. Zollner u. E. Zwicker, Elektroakustik, 3. Auflage (Springer, corrected reprint 1998); H. Fastl, E. Zwicker, Psychoacoustics (Springer 2005); J. Blauert, Communication Acoustics (Springer 2005); R.Lerch, G. Sessler u. D. Wolf, Technische Akustik (Springer 2009)

Courses

Course Nr.	Course name		
18-se-2010-vl	Acoustics I		
Instructor		**Type**	**SWS**
Prof. (em.) Dr. Gerhard Sessler, Prof. Dr. Mario Kupnik		Lecture	2

Module name Antennas and Adaptive Beamforming					
Module Nr. 18-jk-2020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Overview of most important antenna parameters types as well as their applications. Fundamental theories: Fourier transform for far-field pattern calculations, antenna modeling techniques, antenna synthesis methods, image theory, determination of field regions of line sources, of the average radiated power density and power, directivity and gain. Antennas as key elements in power budgets of radio links, introducing the effective aperture of an antenna, deriving the relation between gain and effective aperture. Array antennas are a key hardware for beamforming and smart antenna systems: fundamentals of phased-scanning arrays, non-uniformly excited, equally spaced linear arrays, multi-dimensional planar arrays and mutual coupling effects. Wire antennas: still the most prevalent of all antenna forms, relatively simple in concept, easy to construct, very inexpensive. Antenna radiation fields and antenna parameters for different types of antennas are derived from Maxwell´s equations, applied for aperture antennas (horns, lenses or reflector antennas) and printed antennas (microstrip-patch and coplanar-slot antennas) Some basic numerical calculation methods: integral equation methods in the time and frequency domain, physical optics and uniform theory of diffraction are briefly summarized and compared for antennas and scattering problems. Smart antennas in communication and radar systems, with focus on beam steering and adaptive beamforming.
2	**Learning objectives / Learning Outcomes** Students will know basic antenna parameters: pattern, gain, directivity, half-power beamwidth, side- lobe-level, efficiency and input impedance to compare, assess and evaluate different antennas for various applications and operating frequencies. The antenna field regions, reactive near-field, near-field and far-field, can be differentiated and the far-field pattern of an antenna can be determined from given current distributions along the antenna by using Fourier transformation or integral solutions with distributed ideal dipoles as basic elements (antenna analysis). To assess in general physical requirements, constrains and limitations of antennas, students can use fundamental antenna theory: impedance matching techniques, antenna modeling and far-field pattern analysis, antenna synthesis, image theory and fundamental limits of electrically small antennas. After being incorporated into the different adaptive beamforming techniques, the array theory enables the student to design antenna systems that are assembled of a certain number of separate elements, feeding network, beamforming network etc. for phased-scanning or smart antennas in communications and sensing. Moreover, students are able to determine, analyze and evaluate the most important classes of antennas in wireless technology for many applications, operating frequencies, desired requirements or practical constrains: (1.) wire- dipole antennas, (2.) planar antennas (microstrip, dipole and slot antennas), (3.) aperture antennas (horn antennas, parabolic reflector antennas, lens antennas, Cassegrain and Gregorian double-reflector configurations), (4.) broadband and frequency-independent antennas (V antennas, biconical antennas, helical antennas, spiral and log-periodic antennas).
3	**Recommended prerequisite for participation** Fundamentals of Communications, Microwave Engineering 1
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc ETiT, MSc iCE, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**

8	**References** Jakoby, Skriptum Antennas and Adaptive Beamforming, wird am Beginn der Vorlesung verkauft und kann danach im FG-Sekretariat erworben werden			
Courses				
	Course Nr. 18-jk-2020-vl	**Course name** Antennas and Adaptive Beamforming		
	Instructor Prof. Dr.-Ing. Rolf Jakoby, M.Sc. Matthias Nickel		**Type** Lecture	**SWS** 3
	Course Nr. 18-jk-2020-ue	**Course name** Antennas and Adaptive Beamforming		
	Instructor Prof. Dr.-Ing. Rolf Jakoby, M.Sc. Matthias Nickel		**Type** Practice	**SWS** 1

Module name Communication Technology II					
Module Nr. 18-kl-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Content** linear and nonlinear digital modulation schemes, optimum receivers for AWGN channels, error probability, channel capacity, channel models, channel estimation and data detection for multipath channels, multicarrier schemes, OFDM
2	**Learning objectives / Learning Outcomes** After completion of the lecture, students possess: • the ability of comparing, evaluating, classifying an analyzing linear and nonlinear modulation schemes by means of signal space representations; • the ability to understand, describe and analyze the influence of AWGN on the signal; • the ability to understand and derive optimum receivers in case of AWGN channels; • the ability to understand, describe and analyze the influence of multipath propagation on the signal; • the ability to describe the influence of a multipath channel mathematically (channel model) and estimate the multipath channel at the receiver; • the knowledge of equalizing the received signal in order to undo the influence of multipath propagation, as well as the ability to derive and design several equalizer structures; • the ability to analyze and evaluate the properties and application areas of multicarrier transmission systems, e.g. OFDM-systems; • the ability to design and evaluate the system parameters of multicarrier schemes for the application in realistic mobile radio scenarios;
3	**Recommended prerequisite for participation** Electrical Engineering I and II, Deterministische Signale und Systeme, Stochastische Signale und Systeme, Communication Technology I, Basics of Telecommunication, Mathematics I to IV
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETIT, MSc Wi-ETiT, MSc CE, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** will be announced in the lecture

Courses

Course Nr. 18-kl-2010-vl	**Course name** Communication Technology II	
Instructor Prof. Dr.-Ing. Anja Klein	**Type** Lecture	**SWS** 2

	Course Nr.	Course name		
	18-kl-2010-ue	Communication Technology II		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Anja Klein, M.Sc. Bernd Simon		Practice	1

Module name Computational Methods for Systems and Synthetic Biology					
Module Nr. 18-kp-2080	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1 Content

The course covers mathematical methods used in the area of systems and synthetic biology. On the one hand it deals with practical modeling of molecular processes but also with theoretical investigations that reveal general properties of those processes. The course follows a microscopic approach and introduces those processes using probabilistic methods. For that, necessary prerequists are recapitulated, such as definition of Markov processes in different spaces and their properties. With this background, the dynamics of stochastic reaction kinetics in terms of population models is investigated. Limiting cases are introduced, such as the diffusion approximation or the deterministic approximation (fluid approximations) of those systems. Often methods from statistical physics are applied. Numerical methods for solving the corresponding Fokker-Planck and Master equations are discussed. For the limiting case of a deterministic approximation, traditional methods for the stability analysis of nonlinear differential equations are introduced and methods are discussed that just rely on the topology of the reaction network to determine stability properties. In this context, a derivation of the moment dynamics and approximation methods based on moment closure are given. Connections to queueing theory models are shown.
Furthermore, the question is addressed of how the introduced dynamical models are calibrated to data from molecular biology. For that, general methods of statistical inference from statistics and of machine learning from computer science are discussed and specialized algorithms for the considered system class are presented. Additionally, a short introduction to the theory of nonlinear optimal filtering is given and special cases such as hidden Markov models are discussed.
Beyond reaction kinetics, the course provides a basic introduction to the modeling and numerical methods used in molecular dynamics. Newtonian multi-body simulations and classical potentials and their use in molecular dynamics are discussed. Most of the topics in this course are introduced through practical examples from applied modeling in the domain of systems biology. The applicability of the respective methods in synthetic biology is highlighted.

2 Learning objectives / Learning Outcomes

Students that successfully passed that course should be able to perform practical modeling of molecular processes and to determine dynamical properties of model using mathematical methods. It relies on the understanding of the following topics:

- Mathematical abstraction of molecular mechanisms
- General properties of stochastic processes
- Approximation methods for Markovian population models
- Stability analysis of nonlinear differential equations
- Numerical methods for solving/simulating stochastic systemsSystem identification/machine learning for stochastic systems

3 Recommended prerequisite for participation

Basic knowledge of programming, Matlab.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, MSc Wi-ETiT, MSc MEC

7	**Grade bonus compliant to §25 (2)**			
8	**References** http://www.bcs.tu-darmstadt.de/			
Courses				
	Course Nr. 18-kp-2080-vl	**Course name** Computational Methods for Systems and Synthetic Biology		
	Instructor Prof. Dr. techn. Heinz Köppl		**Type** Lecture	**SWS** 2
	Course Nr. 18-kp-2080-ue	**Course name** Computational Methods for Systems and Synthetic Biology		
	Instructor Prof. Dr. techn. Heinz Köppl		**Type** Practice	**SWS** 1

Module name					
Microwave Engineering II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-jk-2130	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Rolf Jakoby		

1 Content

Part 1 Passive microwave components:
Calculation of the properties of simple passive components (microstrip line, filter, resonator, capacitor, inductance) for MMICs
Part 2 Active microwave components:
* Semiconductor material systems: properties, fabrication and requirements
* Contacts to semiconductor devices: properties and characteristics
* Charge carrier transport: characteristics and scattering processes
* Field Effect Transistor (FET) and heterostructure transistors (HEMTs)
Part 3 Active microwave circuits (main part):
* Wave parameter and S-parameter
* FET amplifier: operation, equivalent circuit, gain, matching circuit, stability and circuit implementation
* Oscillator design
* Mixer design
Applications of these circuits range from communication systems such as cell phones to satellite transceivers as well as high-frequency souces up to Terahertz.

2 Learning objectives / Learning Outcomes

Students will gain knowledge on the physics of microwave waveguides, resonators, microwave components (passive and active) as well as microwave circuits.

3 Recommended prerequisite for participation

Desirable: Introduction to Electrodynamics, Microwave Engineering I

4 Form of examination

Module Final Examination:
- Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:
- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iCE, MSc IST, Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

Script and slides will be handed out. Literature will be recommended in the lecture.

Courses

Course Nr.	Course name		
18-jk-2130-vl	Microwave Engineering II		
Instructor		**Type**	**SWS**
PD Dr.-Ing. Oktay Yilmazoglu, Prof. Dr. rer. nat. Sascha Preu		Lecture	3

	Course Nr.	Course name		
	18-jk-2130-ue	Microwave Engineering II		
	Instructor		**Type**	**SWS**
	PD Dr.-Ing. Oktay Yilmazoglu, Dr.-Ing. Shihab Al-Daffaie, Prof. Dr. rer. nat. Sascha Preu		Practice	1

Module name					
Information Theory II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-pe-2010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Marius Pesavento		

1	**Content** This lecture course is devoted to advances of network information theory. Outline: overview of Shannon capacity, outage and ergodic capacity, capacity of channels with state, capacity of Gaussian vector channels, capacity regions of multi-user channels, capacity regions of multiple-access and broadcast fading channels, interference channel, relay channel, multiuser bounds, multi-user diversity., wiretap channel, secrecy rate and physical layer security.
2	**Learning objectives / Learning Outcomes** Students will understand advanced concepts and strategies in networkinformation theory.
3	**Recommended prerequisite for participation** Knowledge of basic communication theory
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, BSc iST, MSc Wi-ETiT, MSc iCE, BSc/MSc CE
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011. 2.. T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley Sons, 1991. 3.. D. Tse and P. Vishwanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005.

Courses

Course Nr.	Course name		
18-pe-2010-vl	Information Theory II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Lecture	3
Course Nr.	**Course name**		
18-pe-2010-ue	Information Theory II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Practice	1

Module name					
Convex Optimization in Signal Processing and Communications					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-pe-2020	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Marius Pesavento		

1	**Content** This graduate course introduces the basic theory of convex optimization and illustrates its use with many recent applications in communication systems and signal processing. Outline: Introduction, convex sets and convex functions, convex problems and classes of convex problems (LP, QP, SOCP, SDP, GP), Lagrange duality and KKT conditions, basics of numerical algorithms and interior point methods, optimization tools, convex inner and outer approximations for non convex problems, sparse optimization, distributed optimization, mixted integer linear and non-linear programming, applications.
2	**Learning objectives / Learning Outcomes** Students will learn the basic theory of convex optimization and its applications.
3	**Recommended prerequisite for participation** Knowledge in linear algebra and the basic concepts of signal processing and communications.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 13 students register, there examination can be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture or in semesters without a lecture within one working week after the end of the examination registration phase.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press, 2004. (online Verfügbar: http://www.stanford.edu/∼boyd/cvxbook/) 2. D. P. Bertsekas, Nonlinear Programming, Athena Scientific, Belmont, Massachusetts, 2nd Ed., 1999. 3. Daniel P. Palomar and Yonina C. Eldar, Convex Optimization in Signal Processing and Communications, Cambridge University Press, 2009.

Courses

Course Nr. 18-pe-2020-vl	**Course name** Convex Optimization in Signal Processing and Communications		
Instructor Prof. Dr.-Ing. Marius Pesavento		**Type** Lecture	**SWS** 2
Course Nr. 18-pe-2020-ue	**Course name** Convex Optimization in Signal Processing and Communications		
Instructor Prof. Dr.-Ing. Marius Pesavento		**Type** Practice	**SWS** 1

	Course Nr.	Course name		
	18-pe-2020-pr	Convex Optimization in Signal Processing and Communications Lab		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento		Internship	1

Module name					
Matrix Analysis and Computations					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-pe-2070	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Marius Pesavento		

1	**Content** This graduate course is a foundation class on matrix analysis and computations, which are widely used in many different fields, e.g., machine learning, computer vision, systems and control, signal and image processing, communications, networks, optimization, and many more... Apart from the theory this course will also cover the design of efficient algorithm and it considers many different examples from the aforementioned fields including examples from social media and big data analysis, image processing and medical imaging, communication network optimization, and written text classification. Specific topics: (i) basic matrix concepts, subspace, norms, (ii) linear least squares (iii) eigendecomposition, singular value decomposition, positive semidenite matrices, (iv) linear system of equations, LU decomposition, Cholesky decomposition (v) pseudo-inverse, QR decomposition (vi) advanced tensor decomposition, advanced matrix calculus, compressive sensing, structured matrix factorization
2	**Learning objectives / Learning Outcomes** Students will learn matrix analysis and computations at an advanced or research level.
3	**Recommended prerequisite for participation** Basic knowledge in linear algebra.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** 1.Gene H. Golub and Charles F. van Loan, Matrix Computations (Fourth Edition), John Hopkins University Press, 2013. 2.Roger A. Horn and Charles R. Johnson, Matrix Analysis (Second Edition), Cambridge University Press, 2012. 3.Jan R. Magnus and Heinz Neudecker, Matrix Differential Calculus with Applications in Statistics and Econometrics (Third Edition), John Wiley and Sons, New York, 2007. 4.Giuseppe Calaore and Laurent El Ghaoui, Optimization Models, Cambridge University Press, 2014. ECE 712 Course Notes by Prof. Jim Reilly, McMaster University, Canada (friendly notes for engineers) http://www.ece.mcmaster.ca/faculty/reilly/ece712/course_notes.htm

Courses

Course Nr.	Course name		
18-pe-2070-vl	Matrix Analysis and Computations		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Lecture	3

	Course Nr.	Course name		
	18-pe-2070-ue	Matrix Analysis and Computations		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento		Practice	1

Module name					
MIMO - Communication and Space-Time-Coding					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-pe-2030	4 CP	120 h	75 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Marius Pesavento		

1	**Content** This lecture course introduces the principles of space-time and multiple-input multiple-output (MIMO) communications. Outline: Motivation and background; overview of space-time and MIMO communications; fading MIMO channel models, MIMO information theory, receive and transmit diversity; channel estimation, MIMO detectors, Alamouti space-time block code, orthogonal space-time block codes; linear dispersion codes; coherent and non-coherent decoders, differential space-time block coding; MIMO with limited feedback, Multiantenna- and multiuser diversity, BER performance analysis, MIMO in moden wireless communication networks, multicell and multiuser MIMO (coordinated multipoint).
2	**Learning objectives / Learning Outcomes** Students will understand modern MIMO communications and existing space-time coding techniques.
3	**Recommended prerequisite for participation** Knowledge of basic communication theory and basic information theory.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. A.B.Gershman and N.D.Sidiropoulos, Editors, Space-Time Processing for MIMO Communications, Wiley and Sons, 2005. 2. E.G.Larsson and P.Stoica, Space-Time Block Coding for Wireless Communications, Cambridge University Press, 2003; 3. A.Paulraj, R.Nabar, and D.Gore, Introduction to Space-Time Wireless Communications, Cambridge University Press, 2003. 4. Lin Bai and Jinho Choi, Low Complexity MIMO detectors, Springer, 2012. 5. Howard Huang, Constantinos B. Papadias, and Sivarama Venkatesan, MIMO Communication for Cellular Networks, Springer, 2012.

Courses

Course Nr. 18-pe-2030-vl	**Course name** MIMO - Communication and Space-Time-Coding		
Instructor Prof. Dr.-Ing. Marius Pesavento		**Type** Lecture	**SWS** 2
Course Nr. 18-pe-2030-ue	**Course name** MIMO - Communication and Space-Time-Coding		
Instructor Prof. Dr.-Ing. Marius Pesavento, M.Sc. Fabio Nikolay, M.Sc. Tianyi Liu		**Type** Practice	**SWS** 1

Module name Mobile Communications					
Module Nr. 18-kl-2020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1 Content

The lecture covers aspects of mobile communication systems with particular focus on the physical layer.
Mobile radio systems, services, market, standardization
duplex and multiple access techniques, cellular concept
mobile radio channel, deterministic and stochastic description
modulation schemes
code division multiple access (CDMA)
orthogonal frequency division multiplexing (OFDM)
optimum and suboptimum receiver techniques
cellular radio capacity and spectrum efficiency
diversity methods
multiple input multiple output (MIMO) systems
power control and handover
architecture of mobile radio systems

2 Learning objectives / Learning Outcomes

After completion of the lecture, students possess

- a profound understanding of physical layer aspects ,e.g., transmission schemes, multiple access schemes of mobile communication systems, duplex schemes, multi carrier schemes, receiver techniques, multi antenna schemes
- a profound understanding of signal propagation in mobile radio systems (mobile radio channel)
- the ability to understand and solve problems of the field of the physical layer
- the ability to compare, analyse and evaluate different system concepts
- knowledge on modelling of the transmission properties of the mobile radio channel

3 Recommended prerequisite for participation

Electrical Engineering I and II, Deterministic Signals and Systems, Communication Technology I, Mathematics I to IV

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETIT, MSc Wi-ETiT, MSc CE, MSc iCE, MSc iST, MSc MEC

7 Grade bonus compliant to §25 (2)

8 References

will be announced in the lecture

Courses

	Course Nr. 18-kl-2020-vl	**Course name** Mobile Communications		
	Instructor Prof. Dr.-Ing. Anja Klein		**Type** Lecture	**SWS** 3
	Course Nr. 18-kl-2020-ue	**Course name** Mobile Communications		
	Instructor Prof. Dr.-Ing. Anja Klein		**Type** Practice	**SWS** 1

Module name Radar Techniques					
Module Nr. 18-jk-2040	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** First, there will be an introduction of different radar techniques, describing their concepts and principles, their applications and the operating frequency ranges. In a historical survey, the radar ranges and propagation effects will be dealt with. In the second part, various primary and secondary radar techniques will be investigated in detail, including specific techniques of radar signal processing and -analysis.
2	**Learning objectives / Learning Outcomes** Students will know about concepts and principles to detect objects as well as to determine the angular position and range of objects. They learn about the functional principles of various radar systems, including signal processing. They will understand the major physical propagation effects.
3	**Recommended prerequisite for participation** Fundamentals of Communications, Microwave Engineering I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Slides, Latest Publications and Books

Courses

Course Nr. 18-jk-2040-vl	**Course name** Radar Techniques	
Instructor Dr.-Ing. Holger Maune	**Type** Lecture	**SWS** 2

Module name Speech and Audio Signal Processing					
Module Nr. 18-zo-2070	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Content** Algorithms of speech and audio signal processing: Introduction to the models of speech and audio signals and basic methods of audio signal processing. Procedures of codebook based processing and audio coding. Beamforming for spatial filtering and noise reduction for spectral filtering. Cepstral filtering and fundamental frequency estimation. Mel-filterind cepstral coefficients (MFCCs) as basis for speaker detection and speech recognition. Classification methods based on GMM (Gaussian mixture models) and speech recognition with HMM (Hidden markov models). Introduction to the methods of music signal processing, e.g. Shazam-App or beat detection.
2	**Learning objectives / Learning Outcomes** Based on the lecture you acquire an advanced knowledge of digital audio signal processing mainly with the help of the analysis of speech signals. You learn about different basic and advanced methods of audio signal processing, to range from the theory to practical applications. You will acquire knowledge about algorithms such as they are applied in mobile telephones, hearing aids, hands-free telephones, and man-machine-interfaces (MMI). The exercise will be organized as a talk given by each student with one self-selected topic of speech and audio processing. This will allow you to acquire the know-how to read and understand scientific literature, familiarize with an unknown topic and present your knowledge, such as it will be certainly required from you in your professional life as an engineer.
3	**Recommended prerequisite for participation** Knowlegde about satistical signal processing is required (lecture „Digital Signal Processing“). Desired – but not mandatory – is knowledge about adaptive filters.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 20 min, Standard Grading System) Seminar presentation: Scientific talk about a topic in the field of “Speech and Audio Signal Processing”, single (duration 10-15 min) or in groups of two students (15-20 min)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slides (for further details see homepage of the lecture)

Courses

Course Nr. 18-zo-2070-vl	**Course name** Speech and Audio Signal Processing		
Instructor Prof. Dr.-Ing. Henning Puder		**Type** Lecture	**SWS** 2
Course Nr. 18-zo-2070-ue	**Course name** Speech and Audio Signal Processing		
Instructor Prof. Dr.-Ing. Henning Puder		**Type** Practice	**SWS** 1

	Course Nr.	Course name		
	18-zo-2070-se			
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Henning Puder		Seminar	1

Module name					
Microwave Measurement Technologies					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-jk-2090	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Introduction to microwave measurement technoloies, high frequency components and their poperties: rf power measurement, spectrum analysis, vertor network analysis (s-parameter, x-parameter, calibration techniques), on-wafer measurements, load/source-pull, material characterization
2	**Learning objectives / Learning Outcomes** By this module, Students will be enabled to undetstand the basic principles of microwave measuement technologies. They are able to use them in measurement applications. The following objectives are linked to the lecture: • The students understand the basic features of the power measurements and the effects of a mismatch or pulsed signals and can independently carry out and interpret measurements. • The students understand the basics of spectrum analysis and can carry out and interpret measurements independently. • The students understand the basics of s-parameter measurements and calibration of network analyzers and can carry out and interpret measurements independently • Students are familiar with various methods for material characterization
3	**Recommended prerequisite for participation** Recommended: Grundlagen der Nachrichtentechnik, Hochfrequenztechnik I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 45 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc etit, MSc WI-etit, MSc iCE, MSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 18-jk-2090-vl	**Course name** Microwave Measurement Technologies		
Instructor Dr.-Ing. Holger Maune		**Type** Lecture	**SWS** 2
Course Nr. 18-jk-2090-ue	**Course name** Microwave Measurement Technologies		
Instructor Dr.-Ing. Holger Maune		**Type** Practice	**SWS** 1

	Course Nr.	Course name		
	18-jk-2090-pr	Microwave Measurement Technologies Lab		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Holger Maune		Internship	1

Module name Machine Learning & Energy					
Module Nr. 18-st-2020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1 Content

The analysis and interpretation of data becomes ever more important, also for engineers. Digitalization and Smart Grids are terms to describe a host of novel data-based services in the field of generation, distribution, consumption and marketing of (renewable) energy. The lecture presents the recent developments and their underlying principles of machine learning technology.

For a start we will describe the different problem settings of machine learning in a structured way (classification, regression, clustering, dimensionality reductions, time series models, ...) and present for each setting relevant applications from the energy sector (prediction of renewable energy or consumption in multimodal energy systems, fault detection and prediction, data visualization, robust investments decisions, customer analysis, probabilistic load flow, ...).

Thereafter we will briefly review necessary tools from optimization and probability theory, as well as introduce probabilistic graphical models. With these tools we will then study for each problem setting one or more machine learning algorithms in detail, together with use cases from the energy domain. Classic algorithms will be developed (e.g. linear regression, k-means, principal component analysis, ...) as well as modern ones (e.g. SVMs, Deep Learning, Collaborative filtering, ...). Practical exercise with Matlab will deepen the understanding and support student's active knowledge.

2 Learning objectives / Learning Outcomes

Students understand important machine learning problem settings and some key algorithms for each task. They know common applications thereof in the energy domain. Moreover, the students are able to apply and adapt those methods independently to new applications (not only from the energy domain).

3 Recommended prerequisite for participation

- Good knowledge of linear algebra and the foundations of numerical optimization (e.g. from the course 18-st-2010 Energieanagement & Optimierung)
- Using Matlab for programming the practical examples should pose no difficulty. A block tutorial on the use of Matlab is offered as 18-st-2030 Matlab Grundkurs.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc etit, MSc iST, MSc Wi-etit, MSc CE

7 Grade bonus compliant to §25 (2)

Notenverbesserungen bis zu 0,4 nach APB §25(2) durch Bonus für regelmäßig besuchte Übungs-/Praktikumstermine und mindestens einmaliges Vorrechnen in den Übungen

8 References

- A Géron: Hands on Machine Learning with scikit-learn and Tensorflow, 2017
- Friedman, Hastie, Tibshirani: The elements of statistical learning, 2001
- Koller, Friedmann: Graphical Models, 2009

Courses

	Course Nr. 18-st-2020-vl	**Course name** Machine Learning & Energy		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Tim Christian Janke		**Type** Lecture	**SWS** 2
	Course Nr. 18-st-2020-ue	**Course name** Machine Learning & Energy		
	Instructor Prof. Dr. rer. nat. Florian Steinke		**Type** Practice	**SWS** 1
	Course Nr. 18-st-2020-pr	**Course name** Machine Learning & Energy Lab		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Tim Christian Janke		**Type** Internship	**SWS** 1

Module name Machine Learning in Information and Communication Technology (ICT)					
Module Nr. 18-kp-2110	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1 Content

The module provides an introduction to the emerging field of machine learning from an engineering perspective. Important models and learning methods are presented and exemplified through problems from information and communication technology.

- Fundamentals of probability theory and multivariate statistics
- Taxonomy of machine learning problems and models (supervised, unsupervised, generative, discriminative)
- Regression and classification: theory, methods and ICT applications
- Dimensionality reduction, clustering and big data analytics: methods and application in communications and signal processing
- Probabilistic graphical models: categories, inference and parameter estimation
- Fundamentals of Bayesian inference, Monte Carlo methods, Bayesian non-parametrics
- Fundamentals of convex optimization: Solution methods and application in communications
- Approximate algorithms for scalable Bayesian inference; application in signal processing and information theory (e.g. decoding of LDPC codes)
- Hidden Markov models (HMM): Theory, Algorithms and ICT applications (e.g. Viterbi decoding of convolutional codes)
- High-dimensional statistics (“large p small n” setting), learning dependency structure in high-dimensional data, learning causality relations from observational data.
- Sparse estimation, random projections, compressive sensing: Theory and applications in signal processing
- Deep neural networks (deep learning): Models, learning algorithms, libraries and ICT applications

2 Learning objectives / Learning Outcomes

Students are able to interpret and categorize specific engineering problems from the ICT domain in terms of machine learning problems.
They are able to reduce such problems to standard machine learning problems and are able to determine suitable solution methods for them.
They are able to implement all necessary algorithms from scratch, but they are also familiar with the state-of-the-art libraries in machine learning.
They are able to determine the involved computational complexity of a method and choose an appropriate solution algorithms based on application constraints.
They are able to apply the acquired methods to other domains, such as data analysis in biomedical engineering, analysis of social network data, etc.

3 Recommended prerequisite for participation

Good command of Matlab (for instance knowledge from course 18-st-2030 Matlab Grundkurs) and engineering mathematics

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc etit, BSc/MSc iST, MSc iCE, MSc CE

7	**Grade bonus compliant to §25 (2)**			
8	**References** • Kevin P. Murphy. Machine Learning – A probabilistic perspective, MIT Press, 2012 • Christopher M. Bishop. Pattern recognition and Machine Learning, Springer, 2006 • Peter Bühlmann und Sara van de Geer. Statistics of high-dimensional data – Methods, theory and applications, Springer, 2011			
Courses				
	Course Nr. 18-kp-2110-vl	**Course name** Machine Learning in Information and Communication Technology (ICT)		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		**Type** Lecture	**SWS** 2
	Course Nr. 18-kp-2110-pr	**Course name** Machine Learning in Information and Communication Technology (ICT) Lab		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		**Type** Internship	**SWS** 1
	Course Nr. 18-kp-2110-ue	**Course name** Machine Learning in Information and Communication Technology (ICT)		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		**Type** Practice	**SWS** 1

Module name Laboratory Communication and Sensor Systems					
Module Nr. 18-jk-2050	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1 Content

The student communications lab consist of 7 fundamental experiments out of the field of Communication Engineering:
Mobile Radio Channel + Diversity (SW)
Signal Detection and Parameter Estimation (Matlab)
Digital Modulation (HW)
Coding (SW)
Parasitic Effects in Passive RF Devices (SW)
RF FET Amplifier (HW)
Polarization of Light (HW)
Antennas:
Fields and Impedance (HW)

2 Learning objectives / Learning Outcomes

The students are guided to acquaint themselves with given topics. They learn to perform prepared experiments within a defined frame and minute, analyze and discuss the results. In this training the fundamentals of free scientific work are practiced.

3 Recommended prerequisite for participation

Fundamentals of:
- Communications
- Microwave Engineering
- Digital Signal Processing

4 Form of examination

Module Final Examination:
- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:
- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iCE, Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

A description of experiments is offered. It can be bought from Mr. Ziemann (S306/409) or being loaded from the WEB page.

Courses

Course Nr.	**Course name**		
18-jk-2050-pr	Laboratory Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby, Prof. Dr.-Ing. Anja Klein, Dr.-Ing. Martin Schüßler		Internship	3

Module name Project Seminar Wireless Communications					
Module Nr. 18-kl-2040	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Content** Solving special Problems concerning mobile communications (problems concerning signal transmission and processing as well as problems concerning the network are possible, topics will be defined out of the current research topics of the lab), working on the project in teams together (2-3 students) organizing and structuring of a project dealing with scientific publications, reading up the theoretical background of the task practical work on a complex task scientific presentation of the results (report/presentation) defending the work in an oral discussion including an audience
2	**Learning objectives / Learning Outcomes** After completion of the course, students possess • the ability to classify and analyze special problems concerning mobile communications, • the knowledge to plan and organize projects with temporal limitation, • the capability to setup and test methodologies for analysis and simulation- environments, • skills to evaluate and present achieved results and achieved conclusions.
3	**Recommended prerequisite for participation** Previous knowledge in digital communications, signal processing, mobile radio
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc CE, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture documentation will be provided and specific literature will be announced during the course.

Courses

	Course Nr. 18-kl-2040-pj	**Course name** Project Seminar Wireless Communications		
	Instructor Prof. Dr.-Ing. Anja Klein		**Type** Project Seminar	**SWS** 4

Module name Project Seminar Advanced μWave Components & Antennas					
Module Nr. 18-jk-2060	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1 Content

Groups of 2-3 students per project. Students work out a well defined fundamental or actual research- related problem. The projects will be actualized in each cycle being offered and introduced at the beginning. Each group will be supervised individually. The projects comprises modern antennas for multitudinous applications, electronically-steerable antennas, RFIDs, RF sensors, adaptive tunable components such as matching networks, filter, passive mixer and modulator for next-generation mobile terminals and sensor systems.

2 Learning objectives / Learning Outcomes

Research-oriented Project Seminar in groups of 2-3 students per project with individual supervision. Students will learn

- how to solve scientific hardware-oriented problems
- working out concepts
- how to design, realize and characterize RF devices
- how to use commercial software and characterization tools
- to evaluate and discuss their work in the context of the state-of-art in this field
- to write a brief scientific report about their work
- to present and discus their results at the end of the Project Seminar

3 Recommended prerequisite for participation

Fundamentals of Microwave Engineering I and Antennas and Adaptive Beamforming

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iCE, Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

Publications will be hand out to them. Software and characterization tools as well as tools to realize RF devices are available.

Courses

Course Nr. 18-jk-2060-pj	**Course name** Project Seminar Advanced μWave Components & Antennas	
Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler	**Type** Project Seminar	**SWS** 4

Module name Projekt Seminar Advanced Algorithms for Smart Antenna Systems					
Module Nr. 18-pe-2040	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1	**Content** This project-seminar course introduces the basics of the theory and applications of smart antennas including space-time and multiple-input multiple-output communications, direction-of-arrival estimation and source localization in antenna arrays, and adaptive multiantenna techniques for interference suppression, adaptive transmit and receive beamforming, concensus and defusion algorithms for wireless sensor networks.
2	**Learning objectives / Learning Outcomes** Students will understand theory, algorithms and applications of smart antennas.
3	**Recommended prerequisite for participation** Knowledge of basic communication theory
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 40 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. Daniel P. Palomar and Yonina C. Eldar, Convex Optimization in Signal Processing and Communications, Cambridge University Press, 2009. 2. Harry L. Van Trees, Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, John Wiley & Sons, 2002. 3. Y. Hua, A.B. Gershman and Q. Cheng (Editors), High-Resolution and Robust Signal Processing, Marcel Dekker, NY, 2004. 4. A.B. Gershman and N.D. Sidiropoulos (Editors), Space-Time Processing for MIMO Communications, Wiley & Sons, 2005.

Courses

	Course Nr. 18-pe-2040-pj	**Course name** Projekt Seminar Advanced Algorithms for Smart Antenna Systems	
	Instructor Prof. Dr.-Ing. Marius Pesavento, M.Sc. Gerta Kushe	**Type** Project Seminar	**SWS** 4

Module name					
Projekt Seminar Procedures for Massive MIMO and 5G					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-pe-2050	8 CP	240 h	180 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Marius Pesavento		

1 Content

This project-seminar introduces the basics concepts of the signal processing algorithms and cross-layer procedures for extremely large so-called Massive MIMO systems and mobile communication networks of the 5th generation (5G).
In Massive MIMO systems the number of base transmit and receive antennas at the base station are scaled up, as compared to usual MIMO systems, by several orders of magnitude.In this seminar we investigate advanced signal processing algorithms which allow to exploit the advantages of Massive MIMO in an optimum way (which are high data rate, high reliability, favorable propagation characteristics), to cope with the enormous date volume (linear signal processing) and to master the challenges (pilot contamination, low-cost hardware). Massive MIMO is an integral part of the emerginjg 5G mobile communication networks. In the course of the seminar the fundamental concepts and challenges of 5G networks will be discussed. It includes concepts as Small Cells, Cloud RAN, Network Virtualization, Network slicing, Machine-to-Machine communication, Millimeter Wave Transmission, Flexible Waveforms, etc.

2 Learning objectives / Learning Outcomes

Students will learn the fundamental concepts, procedures, theories, algorithms and applications of Massive MIMO systems and 5 G mobile communication networks by the latest scientific publications.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Duration: 40 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc Wi-ETiT, MSc iCE

7 Grade bonus compliant to §25 (2)

8 References

- http://www.commsys.isy.liu.se/vlm/icc_tutorial_P1.pdf
- http://www.commsys.isy.liu.se/vlm/icc_tutorial_P2.pdf
- http://www.massivemimo.eu/
- A. Chockalingam and B. Sundar Rajan. *Large MIMO Systems*, Cambridge University Press. Cambridge, 2015
- NGMN Alliance (2015) 5G White Paper https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.

Courses

Course Nr.	Course name		
18-pe-2050-pj	Projekt Seminar Procedures for Massive MIMO and 5G		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Project Seminar	4

Module name					
International Summer School 'Microwaves and Lightwaves'					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-pr-2020	4 CP	120 h	90 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr. rer. nat. Sascha Preu		

1 Content

This lecture covers the fundamentals and the latest deveolpments of microwave electronics, THz technology, and optical communication systems with particular focus on the physical concepts involved.

2 Learning objectives / Learning Outcomes

Students understand

- the background of microwave enginering, THz engineering, and optical communications and
- of related electronics, and
- the influence of the relevant properties of materials and of waveguides on signal processing.

They gain inside into the latest developments in these fields.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)

6 Usability of this module

BSc ETiT, MSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

A script (English) will be distributed and English slides can be downloaded.

Courses

Course Nr.	Course name		
18-pr-2020-se	International Summer School "Microwaves and Lightwaves"		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu, Prof. Dr.-Ing. Rolf Jakoby, Prof. (em.) Dr.-Ing. Dr.h.c. Hans Ludwig Hartnagel, Prof. Dr.-Ing. Franko Küppers		Seminar	2

Module name					
Digital Signal Processing Lab					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2030	6 CP	180 h	135 h	1	WiSe/SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Content** 1) Introduction to MATLAB 2) Discrete-Time Signals and Systems 3) Frequency-Domain Analysis using the DFT 4) Digital FIR Filter Design 5) IIR Filter Design using Analog Prototypes 6) Nonparametric Spectrum Estimation 7) Parametric Spectrum Estimation.
2	**Learning objectives / Learning Outcomes** The students are able to apply skills acquired in the course Digital Signal Processing. These include the design of digital FIR and IIR filters as well as non-parametric and parametric spectrum estimation. Students learn how MATLAB is used to apply theoretical concepts and to demonstrate signal processing techniques by using hands-on application examples.
3	**Recommended prerequisite for participation** Deterministic signals and systems theory
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lab manual

Courses

Course Nr.	Course name		
18-zo-2030-pr	Digital Signal Processing Lab		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Internship	3

Module name					
Signal Detection and Parameter Estimation					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2050	8 CP	240 h	180 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Abdelhak Zoubir		

1 Content

Signal detection and parameter estimation are fundamental signal processing tasks. In fact, they appear in many common engineering operations under a variety of names. In this course, the theory behind detection and estimation will be presented, allowing a better understanding of how (and why) to design "good" detection and estimation schemes.
These lectures will cover: Fundamentals
Detection Theory Hypothesis Testing Bayesian Tests
Ideal Observer Tests
Neyman-Pearson Tests
Receiver Operating Characteristics
Uniformly Most Powerful Tests
The Matched Filter Estimation Theory Types of Estimators
Maxmimum Likelihood Estimators
Sufficiency and the Fisher-Neyman/Factorisation Criterion
Unbiasedness and Minimum variance
Fisher Information and the CRB
Asymptotic properties of the MLE

2 Learning objectives / Learning Outcomes

Students gain deeper knowledge in signal processing based on the fundamentals taught in DSP and EtiT 4. Thexy will study advanced topics of statistical signal processing in the area of detection and estimation.
In a sequence of 4 lectures, the basics and important concepts of detection and estimation theory will be taught. These will be studied in dept by implementation of the methods in MATLAB for practical examples. In sequel, students will perform an independent literature research, i.e. choosing an original work in detection and estimation theory which they will illustrate in a final presentation.
This will support the students with the ability to work themselves into a topic based on literature research and to adequately present their knowledge. This is especially expected in the scope of the students' future research projects or in their professional carreer.

3 Recommended prerequisite for participation

DSP, general interest in signal processing

4 Form of examination

Module Final Examination:
- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:
- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT,MSc iST, MSc iCE, Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

- Lecture slides
- Jerry D. Gibson and James L. Melsa. Introduction to Nonparametric Detection with Applications. IEEE Press, 1996.
- S. Kassam. Signal Detection in Non-Gaussian Noise. Springer Verlag, 1988.
- S. Kay. Fundamentals of Statistical Signal Processing: Estimation Theory. Prentice Hall, 1993.
- S. Kay. Fundamentals of Statistical Signal Processing: Detection Theory. Prentice Hall, 1998.
- E. L. Lehmann. Testing Statistical Hypotheses. Springer Verlag, 2nd edition, 1997.
- E. L. Lehmann and George Casella. Theory of Point Estimation. Springer Verlag, 2nd edition, 1999.
- Leon-Garcia. Probability and Random Processes for Electrical Engineering. Addison Wesley, 2nd edition, 1994.
- P. Peebles. Probability, Random Variables, and Random Signal Principles. McGraw-Hill, 3rd edition, 1993.
- H. Vincent Poor. An Introduction to Signal Detection and Estimation. Springer Verlag, 2nd edition, 1994.
- Louis L. Scharf. Statistical Signal Processing: Detection, Estimation, and Time Series Analysis. Pearson Education POD, 2002.
- Harry L. Van Trees. Detection, Estimation, and Modulation Theory, volume I,II,III,IV. John Wiley & Sons, 2003.
- A. M. Zoubir and D. R. Iskander. Bootstrap Techniques for Signal Processing. Cambridge University Press, May 2004.

Courses

Course Nr.	**Course name**		
18-zo-2050-se	Signal Detection and Parameter Estimation		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Seminar	4

1.5 Sensors, Actuators and Electronics (SAE)

1.5.1 SAE - Fundamentals

Module name Sensor Technique					
Module Nr. 18-kn-2120	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content**
2	**Learning objectives / Learning Outcomes** The Students acquire knowledge of the different measuring methods and their advantages and disadvantages. They can understand error in data sheets and descriptions interpret in relation to the application and are thus able to select a suitable sensor for applications in electronics and information, as well process technology and to apply them correctly.
3	**Recommended prerequisite for participation** Measuring Technique
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc MEC, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** • Slide set of lecture • Script of lecture • Textbook Tränkler „Sensortechnik“, Springer • Exercise script

Courses

Course Nr. 18-kn-2120-vl	**Course name** Sensor Technique		
Instructor Prof. Dr. Mario Kupnik		**Type** Lecture	**SWS** 2
Course Nr. 18-kn-2120-ue	**Course name** Sensor Technique		
Instructor Prof. Dr. Mario Kupnik		**Type** Practice	**SWS** 1

Module name					
Microsystem Technology					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bu-2010	4 CP	120 h	75 h	1	WiSe
Language			**Module owner**		
German			Prof. Ph.D. Thomas Peter Burg		

1	**Content** Introduction and definitions to micro system technology; definitions, basic aspects of materials in micro system technology, basic principles of micro fabrication technologies, functional elements of microsystems, micro actuators, micro fluidic systems, micro sensors, integrated sensor-actuator systems, trends, economic aspects.
2	**Learning objectives / Learning Outcomes** To explain the structure, function and fabrication processes of microsystems, including micro sensors, micro actuators, micro fluidic and micro-optic components, to explain fundamentals of material properties, to calculate simple microsystems.
3	**Recommended prerequisite for participation** BSc
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Script for lecture: Mikrosystemtechnik

Courses

Course Nr. 18-bu-2010-vl	**Course name** Microsystem Technology		
Instructor Prof. Ph.D. Thomas Peter Burg, M.Sc. Daniel Thiem		**Type** Lecture	**SWS** 2
Course Nr. 18-bu-2010-ue	**Course name** Microsystem Technology		
Instructor Prof. Ph.D. Thomas Peter Burg, M.Sc. Daniel Thiem		**Type** Practice	**SWS** 1

Module name					
Advanced Digital Integrated Circuit Design					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2010	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** MOS Transistor Models, CMOS Logic Gates, Chip Layout and Design Rules, Static and Dynamic Behavior of CMOS Circuits, Synchonous CMOS Circuits, Performance and Power Characterisation, Design Techniques and CAD Tools, FPGA and Gate Array Technologies, Memory Technologies, Chip Test.
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • understand the short-channel effects of modern CMOS transistors, • derive and analyse the most important circuit concepts for digital logic gates, • understand the design flow of digital ASICs based on standard cells (design, layout, simulation/verification), • knows the pros and cons of synchronous vs. asynchronous logic, multiclockphase systems, • understands the differential design methods of integrated circuits (ASIC, ASIP, Full-custom/Semicustom, PLA, PLD, FPGA), • understands basic circuitry of logic and arithmetic units (adders, multipliers, PLL/DLL), • knows the design principles and properties of integrated semiconductor memory (DRAM, SRAM, Flash. MRAM, FeRAM)
3	**Recommended prerequisite for participation** Lecture “Electronics”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design

Courses

Course Nr.	Course name		
18-ho-2010-vl	Advanced Digital Integrated Circuit Design		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Lecture	3
Course Nr.	**Course name**		
18-ho-2010-ue	Advanced Digital Integrated Circuit Design		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Practice	1

Module name Solid State Lighting					
Module Nr. 18-kh-2060	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Basics of light and colour perception; basics of solid state light sources; LEDs: material systems, structural shape, optics, phosphors; phosphor mixtures; colour and white LEDs; temperature, current and optical behaviour of LEDs; LED models; lifetime and defect mechanisms of LEDs; OLEDs and semiconductor lasers in lighting engineering; optical sensors; semiconductor based cameras; colour sensors; colour quality of solid state light sources; choice and combination of LEDs in practical LED luminaires; flicker; grouping (binning) of LEDs according to their technological parameters; lighting quality metrics; intelligent indoor lighting with LEDs: colour recognition, spectral reconstruction; intelligent automotive and outdoor lighting with LEDs; practical training: thermic, electric and lighting engineering related measurement of LED light sources.
2	**Learning objectives / Learning Outcomes** Principles and applications of the technology of solid state light sources in lighting engineering; LED technology and the optimisation of visual perception under LED light in modern lighting engineering.
3	**Recommended prerequisite for participation** Lichttechnik I, II
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc etit
7	**Grade bonus compliant to §25 (2)**
8	**References** LED-Lighting: Technology and Perception (Khanh, Bodrogi, Vinh, Winkler; Editors,Wiley-VCH,2015) Introduction to Solid State Lighting (Zukauskas et al., Wiley, 2002) Light Emitting Diodes (Schubert; Cambridge Univ. Press, 2003)

Courses

Course Nr. 18-kh-2060-vl	**Course name** Solid State Lighting		
Instructor Prof. Dr.-Ing. Khanh Quoc Tran, M.Sc. Alexander Georg Herzog		**Type** Lecture	**SWS** 2
Course Nr. 18-kh-2060-pr	**Course name**		
Instructor Prof. Dr.-Ing. Khanh Quoc Tran, M.Sc. Alexander Georg Herzog		**Type** Internship	**SWS** 2

1.5.2.1 SAE - Lectures (open catalogue)

Module name Lighting Technology I					
Module Nr. 18-kh-2010	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Structure and functionality of the human eye, terms and unit in lighting technology, photometry, radiometric and photometric properties of materials, filters, physiology of vision, colour theory, lighting, light sources. Measurement of luminous flux, luminous intensity, illuminance, luminance, determination of the spectral responsivity function of the human eye, colorimetry colour rendering, colour as traffic signals, measuring of optical material characteristics, LED properties
2	**Learning objectives / Learning Outcomes** To list and connect terms, units and radiometric and photometric properties of materials in lighting technology, to describe and understand structure and functionality of the human eye and the physiology of vision, to illustrate basics of lighting, measuring methods and application. Being able to measure base items in lighting technology, applying knowlegde of lighting and enhance them with experiments. Developing a better understanding for light and color.
3	**Recommended prerequisite for participation** MSc ETiT, MSc Wi-ETiT, MSc MEC
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Script for lecture: Lighting Technology I Excersisebook: laboratory: lighting technology I

Courses

Course Nr.	**Course name**		
18-kh-2010-vl	Lighting Technology I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran		Lecture	2
Course Nr.	**Course name**		
18-kh-2010-pr	Lighting Technology I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran		Internship	2

Module name Advanced Lighting Technology					
Module Nr. 18-kh-2020	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Chosen topics in lighting technology – current developments and applications: Street lighting, Physiology: Detektion / Glare / Lighing and Health, LED – Generation of white Light / State of the Art, Modern Methods of Light Measurement, Interiour Lighting, Display Technologies, Non-visual Light Impacts,UV-Applications, Automotive Lighting, Solar Modules.
2	**Learning objectives / Learning Outcomes** To know current developments and applications, list and connect terms, to illustrate special topics of lighting, measuring methods and application. Beeing able to measure base items in lighting technology, applying knowlegde of lighting and dedicated applications and further to enhance them with experiments. Developing a better understanding for light, color, perception and lighting situations.
3	**Recommended prerequisite for participation** Lighting Technology I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Excercisebook: laboratory: lighting technology II

Courses

	Course Nr. 18-kh-2020-vl	**Course name** Advanced Lighting Technology		
	Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Lecture	**SWS** 2
	Course Nr. 18-kh-2020-pr	**Course name** Advanced Lighting Technology		
	Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Internship	**SWS** 2

Module name					
Technology of Microsystems Technology					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bu-2020	4 CP	120 h	75 h	1	SoSe
Language			**Module owner**		
German			Prof. Ph.D. Thomas Peter Burg		

1	**Content** Provide insights into the various production and processing methods in micro- and precision engineering and the influence of these methods on the development of devices and components.
2	**Learning objectives / Learning Outcomes** To describe coating processes like powder coating, electrochemical and vacuum deposition and CVD. To explain manufacturing of glass conponents: glass production, optical components, glass fibres, glass ceramics. To describe microfabrication technologies: photolithography, etching, diffusion, silicon micromachining, LIGA. To report manufacturing of electronic assemblies/modules and surface mount technologies (SMT).
3	**Recommended prerequisite for participation** Technology of Micro and Precision Engineering (recommended)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script for lecture: Technology of Microsystem Technology

Courses

Course Nr. 18-bu-2020-vl	**Course name** Technology of Microsystems Technology		
Instructor Prof. Ph.D. Thomas Peter Burg		**Type** Lecture	**SWS** 2
Course Nr. 18-bu-2020-ue	**Course name** Technology of Microsystems Technology		
Instructor Prof. Ph.D. Thomas Peter Burg		**Type** Practice	**SWS** 1

Module name Optical Technologies in Car Lighting					
Module Nr. 18-kh-2041	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** History and standardisation of car lithing. Description of the oused lighting sources and the function of these(lowbeam, highbeam, bending light, stop lamp, daytime running light...), visuell perception, glare, detection, traffic infrastructure, traffic elements, interior lighting, driver assistance systems(GPS, Radar, Lidar...), methods of psychophysics, lighting application concepts in future automated vehicles. Voluntary trip planed to an automobile manufacturer
2	**Learning objectives / Learning Outcomes** To describe the basics and deepening knowledge of car lighting, understanding of the light distribution of head and rear lamps, to learn the basics of standardisation, enlarge glare and detection skills, know the traffic elements, as well as the driver assistance systems
3	**Recommended prerequisite for participation** Lighting technology 1(desireable)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc iST, MSc MEC, MSc MPE, MSc Physik
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides, Automotive Lighting and Human Vision, Handbuch Fahrassistenzsysteme

Courses

Course Nr. 18-kh-2041-vl	**Course name** Optical Technologies in Car Lighting		
Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Lecture	**SWS** 2
Course Nr. 18-kh-2041-pr	**Course name**		
Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Internship	**SWS** 1

Module name					
Sensor Signal Processing					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kn-2130	3 CP	90 h	60 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. Mario Kupnik		

1	**Content** The module provides knowledge in-depth about the measuring and processing of sensor signals. In the area of primary electronics, some particular characteristics such as errors, noise and intrinsic compensation of bridges and amplifier circuits (carrier frequency amplifiers, chopper amplifiers, Low-drift amplifiers) in terms of error and energy aspects are discussed. Within the scope of the secondary electronic, the classical and optimal filter circuits, modern AD conversion principles and the issues of redundancy and error compensation will be discussed.
2	**Learning objectives / Learning Outcomes** The Students acquire advanced knowledge on the structure of modern sensors and sensor proximity signal processing. They are able to select appropriate basic structure of modern primary and secondary electronics and to consider the error characteristics and other application requirements.
3	**Recommended prerequisite for participation** Measuring Technique, Sensor Technique, Electronic, Digital Signal Processing
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** • Slide set of lecture • Skript of lecture • Textbook Tränkler „Sensortechnik“, Springer • Textbook Tietze/Schenk „Halbleiterschaltungstechnik“, Springer

Courses

Course Nr.	Course name		
18-kn-2130-vl	Sensor Signal Processing		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Lecture	2

Module name					
Computer Aided Design for SoCs					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2200	5 CP	150 h	90 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** CAD-Concepts for the design and simulation of integrated system-on-chips
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to understand • The most important design and verification abstractions as well as the design flow for the design of integrated electronic systems, • Selected algorithms for optimization, simulation and solving of design tasks, • Advanced methods for the design and simulation of analog integrated circuits in modern CMOS technologies, • Advanced concepts of hardware description languages and their concepts (Verilog, VHDL, Verilog-A, Verilog-AMS, System-Verilog)
3	**Recommended prerequisite for participation** Lecture "Advanced Digital Integrated Circuit Design" (can be attended in parallel) and „Analog Integrated Circuit Design" and "Logic Design"
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc MEC, MSc Wi-ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies

Courses

Course Nr. 18-ho-2200-vl	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 2
Course Nr. 18-ho-2200-ue	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1
Course Nr. 18-ho-2200-pr	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Internship	**SWS** 1

Module name Printed Electronics					
Module Nr. 16-17-5110	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Edgar Dörsam		

1 Content

Printing technologies for functional printing (printing methods and systems); Design and materials for printed electronics (aerial, OFET, RFID); Activities for quality assurance; Examples of application (aerial, RFID, OFET, photovoltaic, batteries, lab on a chip).

2 Learning objectives / Learning Outcomes

On successful completion of this module, students should be able to:

- Describe the printing technologies that are applicable for “Printed Electronics”.
- Name materials that are appropriate to printing processes and to describe the impact of the materials on the design e.g. of antennas and OFETs.
- Classify and rate different activites for quality assurance.
- Explain basic functions, configurations, materials, and specific properties of printed antennas, RFIDs, photovoltaics and batteries.
- Describe “Printed Electronics” as a multidisciplinary task that consists of electrical engineering, material science, and mechanical engineering.

3 Recommended prerequisite for participation

Mechanical components and Mechatronics I and II recommended

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Standard Grading System)

Oral exam 30 min

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)

6 Usability of this module

WPB Master MPE III (Wahlfächer aus Natur- und Ingenieurwissenschaft)
WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
Master ETiT IMNT; Master Mechatronik

7 Grade bonus compliant to §25 (2)

8 References

The current lecture notes can be downloaded from the web pages of the institute while the semester is in session.

Courses

Course Nr. 16-17-5110-vl	**Course name** Printed Electronics	
Instructor	**Type** Lecture	**SWS** 2

Module name					
Digital Signal Processing					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2060	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Content** 1) Discrete-Time Signals and Linear Systems – Sampling and Reconstruction of Analog Signals 2) Digital Filter Design – Filter Design Principles; Linear Phase Filters; Finite Impulse Response Filters; Infinite Impulse Response Filters; Implementations 3) Digital Spectral Analysis - Random Signals; Nonparametric Methods for Spectrum Estimation; Parametric Spectrum Estimation; Applications; 4) Kalman Filter
2	**Learning objectives / Learning Outcomes** Students will understand basic concepts of signal processing and analysis in time and frequency of deterministic and stochastic signals. They will have first experience with the standard software tool MATLAB.
3	**Recommended prerequisite for participation** Deterministic signals and systems theory
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, Wi-ETiT, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Course manuscript Additional References: • A. Oppenheim, W. Schafer: Discrete-time Signal Processing, 2nd ed. • J.F. Böhme: Stochastische Signale, Teubner Studienbücher, 1998

Courses

Course Nr. 18-zo-2060-vl	**Course name** Digital Signal Processing		
Instructor Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Di Jin, M.Sc. Martin Gölz		**Type** Lecture	**SWS** 3
Course Nr. 18-zo-2060-ue	**Course name** Digital Signal Processing		
Instructor Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Di Jin, M.Sc. Martin Gölz		**Type** Practice	**SWS** 1

Module name Numerical Methods					
Module Nr. 16-19-5010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. rer. nat. Michael Schäfer		

1 Content

Basics of continuum mechanical modelling, simple field problems, finite-volume method, approximation of surface and volume integrals, discretisation of convective and diffusive fluxes, Galerkin method, finite-element method, simple elements and simple functions, time discretisation, explicit and implicit methods, properties of numerical solution methods, stability, consistency, convergence, boundedness, conservativity, numerical errors, error control.

2 Learning objectives / Learning Outcomes

On successful completion of this module, students should be able to:

- Explain the basics of continuum mechnical modelling of simple field problems
- Explain the theoretical background of finite volume methods.
- Describe the theory of finite-element methods and derive simple elements.
- Describe simple time discretization methods and differentiate between explicit and implicit methods.
- Explain/describe important properties of numerical solution techniques, such as stability, consistency, convergence, and conservativity, and their relevance for the computation.
- Carry out an error estimation of numerical results.

3 Recommended prerequisite for participation

'Numerical Mathematics' recommended

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Standard Grading System)

Written exam 120 min

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)

6 Usability of this module

Bachelor MPE Pflicht
Master ETiT MFT, Master Mechatronik

7 Grade bonus compliant to §25 (2)

8 References

Lecture and exercsie script (available in fnb office)
Schäfer: Numerik im Maschinenbau, Springer Verlag, 1999.
Schäfer, Numerical Methods in Engineering, Springer Verlag, 2006.

Courses

Course Nr. 16-19-5010-vl	**Course name** Numerical Methods		
Instructor		**Type** Lecture	**SWS** 2

Course Nr. 16-19-5010-ue	**Course name** Numerical Methods		
Instructor		**Type** Practice	**SWS** 1

Module name Product Development Methodology III					
Module Nr. 18-bu-2125	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Ph.D. Thomas Peter Burg		

1	**Content** Practical experiences by using methodical procedures in the development of technical products. In addition teamwork, verbal and written representation of results and the organisation of development. Work in a project team and organize the development process independendly.
2	**Learning objectives / Learning Outcomes** Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as bills of materials, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.
3	**Recommended prerequisite for participation** Product Development Methodology I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr.	**Course name**		
18-bu-2125-pj	Product Development Methodology III		
Instructor		**Type**	**SWS**
Prof. Ph.D. Thomas Peter Burg, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik		Project Seminar	3

Module name					
Electromechanical Systems Lab					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kn-2090	4 CP	120 h	75 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. Mario Kupnik		

1	**Content** Electromechanical sensors, drives and actuators, electronic signal processing mechanisms, systems from actuators, sensors and electronic signal processing mechanism.
2	**Learning objectives / Learning Outcomes** Elaborating concrete examples of electromechanical systems, which are explained within the lecture EMS I+II. The Analyzing of these examples is needed to explain the mode of operation and to gather characteristic values. On this students are able to explain the derivative of proposals for the solution. The aim of the 6 laboratory experiments is to get to know the mode of operation of the electro- mechanical systems. The experimental analysis of the characteristic values leads to the derivation of proposed solutions.
3	**Recommended prerequisite for participation** Bachelor ETiT
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Laboratory script in Electromechanical Systems

Courses

	Course Nr. 18-kn-2090-pr	**Course name** Electomechanical Systems Lab		
	Instructor Prof. Dr. Mario Kupnik		**Type** Internship	**SWS** 3
	Course Nr. 18-kn-2090-ev	**Course name** Electomechanical Systems Lab - Introduction		
	Instructor Prof. Dr. Mario Kupnik		**Type** Introductory Course	**SWS** 0

Module name					
Project Seminar Electromagnetic CAD					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-dg-1060	8 CP	240 h	180 h	1	WiSe/SoSe
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Work on a more complex project in numerical field calculation using commercial tools or own software.
2	**Learning objectives / Learning Outcomes** Students will be able to simulate complex engineering problems with numerical field simulation software. They are able to estimate modelling and numerical errors. They know how to present the results on a scientific level in talks and a paper. Students are able to organize teamwork.
3	**Recommended prerequisite for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Course notes “Computational Electromagnetics and Applications I-III”, further material is provided.

Courses

Course Nr.	Course name		
18-dg-1060-pj	Project Seminar Electromagnetic CAD		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. rer. nat. Sebastian Schöps		Project Seminar	4

Module name					
Project Seminar Design for Testability					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2130	6 CP	180 h	135 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Learning advanced Methods for Testing Microchips after Manufacturing and Practical Application in small Design Scenarios, Final Presentation
2	**Learning objectives / Learning Outcomes** Learning advanced Methods for Testing Microchips after Manufacturing and Practical Application in small Design Scenarios, Final Presentation
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies

Courses

Course Nr.	Course name		
18-ho-2130-pj	Project Seminar Design for Testability		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Project Seminar	3

Module name					
Seminar Integrated Electronic Systems Design A					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2160	4 CP	120 h	90 h	1	WiSe/SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Research oriented Formulation of a Topic within the area of Microelectronics System Design; Creation of a written Documentation and Presentation; Team Work
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. gain a deep understanding of the chosen research subject in the field of integrated electronic systems, 2. write an essay on the chosen subject in a comprehesive form and present the outcome to an audience
3	**Recommended prerequisite for participation** Advanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 45 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Topic-oriented Materials will be provided

Courses

Course Nr. 18-ho-2160-se	**Course name** Seminar Integrated Electronic Systems Design A		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Seminar	**SWS** 2

Module name Advanced Integrated Circuit Design Lab					
Module Nr. 18-ho-2120	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Practical Design Tasks in Full Custom Design of Digital or Analog Ciruits using State-of-the-Art Commercial CAD Tools
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. develop and verify transistor circuitry using Cadence 2. simulate logic and analog circuits (Pre- and Postlayout) 3. draw, verify and extract layout
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design” or “Analog Integrated Circuit Design”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** ADIC Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design

Courses

Course Nr. 18-ho-2120-pr	**Course name** Advanced Integrated Circuit Design Lab		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Internship	**SWS** 3

Module name					
HDL Lab					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-1090	6 CP	180 h	135 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Realisation of a VHDL- or Verilog-based VLSI System Design Project in a Team with industrial constraints
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. design, optimize and verify a complex digital system (e.g. a pipelined CPU or signal processor) using Verilog or VHDL, 2. synthesize the HDL description using commercial CAD software to a gate level description
3	**Recommended prerequisite for participation** Mandatory Prerequisite: Lecture Computer Aided Design for System on Chips, At least one high-level Programming Language, Basic Know-How Linux/Unix, Computer Architectures
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, BSc/MSc Wi-ETiT, MSc iCE, BSc/MSc iST, BSc/MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides „HDL: Verilog and VHDL“

Courses

	Course Nr.	**Course name**		
	18-ho-1090-pr	HDL Lab		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Klaus Hofmann		Internship	3

Module name Project seminar Applications of Lighting Engineering					
Module Nr. 18-kh-2051	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** The project seminar deals with the following subjects: automotive lighting, interior lighting, exterior lighting; generation, perception and cognition of the visual stimulus (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement; illuminating engineering, color perception.
2	**Learning objectives / Learning Outcomes** The objective of this project seminar is the practice oriented implementation of the material learned during the lectures in form of a project work. Via communication of the interdisciplinary way of thinking of the lighting engineer, students should carry out autonomous project work on their own or in a team.
3	**Recommended prerequisite for participation** Lighting Technology I-II (desireable)
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc WI-ETiT, MSc MEC, MSc MPE, MSc Phys
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book “LED Lighting: Technology and Perception” (Khanh et al., Wiley); Book „Farbwiedergabe“ (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.

Courses

Course Nr. 18-kh-2051-pj	**Course name** Project seminar Applications of Lighting Engineering	
Instructor Prof. Dr.-Ing. Khanh Quoc Tran	**Type** Project Seminar	**SWS** 3