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

Module manual
Date: 01.09.2021



TECHNISCHE
UNIVERSITÄT
DARMSTADT

Department of Electrical Engineering
and Information Technology

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

Date: 01.09.2021

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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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Written exam 150 min				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 formulas 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

1.1.2 AUT - Elective Courses

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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ko-2020-vl	Course name Digital Control Systems I			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski			Type Lecture	SWS 2
	Course Nr. 18-ko-2020-ue	Course name 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ad-2020	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 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ad-2020-vl	Course name Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Lecture	SWS 2
	Course Nr. 18-ad-2020-ue	Course name Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Practice	SWS 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> – Aperiodic signals <ul style="list-style-type: none"> * Fourier analysis * Evaluation of characteristic values (stepresponses) – Periodic signals <ul style="list-style-type: none"> * Frequency response analysis * Correlation analysis • System identification using discrete time signals: <ul style="list-style-type: none"> – Deterministic and stochastic signals – Basics in estimation theory – Correlation analysis • Parameter estimation techniques: <ul style="list-style-type: none"> – 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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		Type Lecture	SWS 2
	Course Nr. 18-ko-2040-ue	Course name Identification of Dynamic Systems		
	Instructor Dr. Ing. Eric Lenz		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 multivariable 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ko-2010	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 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ko-2010-vl	Course name Modeling and Simulation			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski			Type Lecture	SWS 2
	Course Nr. 18-ko-2010-ue	Course name Modeling and Simulation			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski			Type Practice	SWS 1

Module name Computer Systems I					
Module Nr. 18-hb-1020	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German			Module owner 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 Harris & Harris: Digital Design and Computer Architecture 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. Jeanette Hussong		
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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Written exam 2x 150 min				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 space 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. Problem of Motion control				
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 excited 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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, M.Sc. Ivan Kliasheu		Type Practice	SWS 2

Module name Technical Electrodynamics					
Module Nr. 18-dg-1070	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language German			Module owner 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ad-2090	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 A Basics <ul style="list-style-type: none"> • Scene Representation 2D and 3D Geometry • Image Acquisition <ul style="list-style-type: none"> – Geometric Projections Camera Calibration • Objective and Illumination • Discrete 2D signals <ul style="list-style-type: none"> – Separability, Sampling – Transformation, Interpolation – Convolution, Correlation – Discrete Fourier Transformation B Basics of Image Analysis <ul style="list-style-type: none"> • Filtering <ul style="list-style-type: none"> – Basics 2D Filter Design – Linear Filtering – Nichtlinear Filtering • Image Decompositions <ul style="list-style-type: none"> – Multi-scale Representation – Pyramids – Filter Banks • Image Features <ul style="list-style-type: none"> – 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading				

	Module Final Examination: <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • 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. Thomas Guthier, Prof. Dr.-Ing. Jürgen Adamy		Type Lecture
			SWS 2
	Course Nr. 18-ad-2090-ue	Course name Computer Vision in Engineering	
	Instructor Dr.-Ing. Thomas Guthier		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: <ul style="list-style-type: none"> • 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, IGBTs Numerical methods 				
2	Learning objectives / Learning Outcomes Students will be able to: <ul style="list-style-type: none"> • 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 system Transfer 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ad-2050	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 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				
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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ad-2050-vl	Course name Evolutionary Systems - From Biology to Technology			
	Instructor Dr. rer. nat. Bernhard Sendhoff			Type Lecture	SWS 2

Module name					
Materials of Electrical Engineering					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
11-01-6410	3 CP	90 h	60 h	1	Every 2. Sem.
Language			Module owner		
German			Prof. Dr. rer. nat. Lambert Alff		
1	Content				
2	Learning objectives / Learning Outcomes				
3	Recommended prerequisite for participation				
4	Form of examination				
	Module Ecompanying Examination: <ul style="list-style-type: none"> [11-01-6410-vl] (Technical Examination, Technical Examination, Standard BWS) 				
5	Grading				
	Module Ecompanying Examination: <ul style="list-style-type: none"> [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.	Course name				
11-01-6410-vl	Materials of Electrical Engineering				
Instructor	Type			SWS	
	Lecture			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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100%) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> • 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, Keras and TensorFlow. 2. Aufl., O'Reilly, 2019 				
Courses					

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

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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 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 Automated Driving					
Module Nr. 18-ad-2110	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content <ul style="list-style-type: none"> • History of Automated Driving • Terminology and Paths towards Automated Driving • Architectures, Building Blocks, and Components • Perception & Environment Models • Data Fusion & State Estimation <ul style="list-style-type: none"> – Deep Dive: Target Tracking & Traffic Participant Fusion – Deep Dive: Grid Fusion & Free Space Estimation – Deep Dive: Road Model Fusion • Localization, Digital Maps, and Vehicle-To-X Communication • Situation Understanding, Prediction, and Criticality Assessment <ul style="list-style-type: none"> – Deep Dive: Probabilistic Driving Maneuver Detection • Behavior & Trajectory Planning, Decision Making • Automated Driving Software Development & Test • Open Challenges & State-of-the-Art Research Topics 				
2	Learning objectives / Learning Outcomes After visiting the lecture, the student <ul style="list-style-type: none"> • is familiar with the history and terminology of automated driving systems, • knows important architectures, building blocks, and components of automated vehicles, • understands different perception, environment model, and data fusion approaches, • has an idea about relevant methods (e.g. Bayesian Inference & Probabilistic Graphical Models, State Estimation, Deep Learning, Dempster-Shafer Theory) and knows how they can be beneficially applied in different of automated driving areas (e.g. detection, target tracking & traffic participant fusion, grid fusion, road model fusion, localization), • is familiar with the challenges of situation understanding, prediction, and criticality assessment and knows exemplary methods to tackle the problem, • is aware of exemplary behavior & trajectory planning approaches, • knows best practices about automated driving software development & test (e.g. continuous integration, verification & validation, test-driven development, key performance indicators), and • is familiar with open challenges and research topics. 				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100 %) 				
6	Usability of this module Msc etit, Msc MEC, Msc Wi-etit, Msc ICE, Msc CE, Msc Informatik				

7	Grade bonus compliant to §25 (2)		
8	References Own lecture slides are distributed in advance of any lecture. For more detailed insights into the topic area, the following books can be recommended: <ul style="list-style-type: none"> • Eskandarian, A.: Handbook of Intelligent Vehicles. Springer, London, 2012. • Siciliano, B.; Khatib, O.: Springer Handbook of Robotics. 2nd Edition, Springer, Berlin Heidelberg 2016. • Thrun, S.; Burgard, W.; Fox, D.: Probabilistic Robotics. Intelligent Robotics and Autonomous Agents. The MIT Press, Cambridge, 2006. • Watzenig, D.; Horn, M.: Automated Driving. Safer and More Efficient Future Driving. Springer, Switzerland, 2017. • Winner, H. et al.: Handbook of Driver Assistance Systems. Basic Information, Components and Systems for Active Safety and Comfort. Springer, Switzerland, 2016. 		
Courses			
	Course Nr. 18-ad-2110-vl	Course name Automated Driving	
	Instructor Prof. Dr.-Ing. Jürgen Adamy	Type Lecture	SWS 2

1.1.3.2 AUT - Labs and Project Seminars (open catalogue)

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 numerical 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ad-2080	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered WiSe
Language German			Module owner 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ad-2080-pj	Course name Project Seminar Automatic Control Systems			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Project Seminar	SWS 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ad-2070	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content The following topics are taught in the lecture: Industrial robots <ul style="list-style-type: none"> • Types and applications • Geometry and kinematics • Dynamic model • Control of industrial robots Mobile robots <ul style="list-style-type: none"> • Types and applications • Sensors • Environmental maps and map building • Trajectory planning <p>Group projects are arranged in parallel to the lectures in order to apply the taught material in practical exercises.</p>				
2	Learning objectives / Learning Outcomes After attending the lecture, a student is capable of: 1. recalling the basic 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ad-2070-pj	Course name Project Seminar Robotics and Computational Intelligence			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Project Seminar	SWS 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • ETiT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++) Additionally desired: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading				

	Module Final Examination: <ul style="list-style-type: none"> • 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. 18-su-2070-pj	Course name Autonomous Driving Lab I	
	Instructor Prof. Dr. rer. nat. Andreas Schürr, Dr. Ing. Eric Lenz, M.Sc. Stefan Tomaszek	Type Project Seminar	SWS 3

Module name					
Artificial Intelligence in Medicine Challenge					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-ha-2010	8 CP	240 h	180 h	1	WiSe/SoSe
Language			Module owner		
German			Prof. Dr.-Ing. Christoph Hoog Antink		
1	Content Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.				
2	Learning objectives / Learning Outcomes Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.				
3	Recommended prerequisite for participation <ul style="list-style-type: none"> • Basic programming skills in Python • 18-zo-1030 Fundamentals of Signal Processing 				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture. 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100%) 				
6	Usability of this module BSc/MSc (WI-)etit, AUT, DT, KTS BSc/MSc iST MSc iCE				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> • Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001. • Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006. 				
Courses					
Course Nr.	Course name				
18-ha-2010-pj	Artificial Intelligence in Medicine Challenge				
Instructor				Type	SWS
Prof. Dr.-Ing. Christoph Hoog Antink				Project Seminar	4

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 180h	Self study 120 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Ralf Steinmetz		
1	<p>Content</p> <p>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.</p> <p>Topics are:</p> <ul style="list-style-type: none"> • 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	<p>Learning objectives / Learning Outcomes</p> <p>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.</p>				
3	<p>Recommended prerequisite for participation</p> <p>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.</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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. 18-hb-2030	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Christian Hochberger		
1	Content <ul style="list-style-type: none"> Configurable Technologies FPGA architectures and properties System-On-Chip, HW components, SW toolchain, support SW Coarse grained reconfigurable architectures, PE architecture, Modulo scheduling 				
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 appropriate 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 architecture. as can be obtained in the lectures “Logischer Entwurf” and “Rechnersysteme I”. Additionally, students should be able to write simple programs in the programming language C.				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-hb-2030-vl	Course name Computer Systems II			
	Instructor Prof. Dr.-Ing. Christian Hochberger, M.Sc. Ramon Wirsch			Type Lecture	SWS 3
	Course Nr. 18-hb-2030-ue	Course name Computer Systems II			
	Instructor Prof. Dr.-Ing. Christian Hochberger, M.Sc. Ramon Wirsch			Type Practice	SWS 1

Module name Software-Engineering - Maintenance and Quality Assurance					
Module Nr. 18-su-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German			Module owner 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ho-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language English			Module owner 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, Synchronous 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 DT - Specialization

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 150h	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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 High-Level Synthesis					
Module Nr. 18-hb-2020	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Christian Hochberger		
1	Content <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-hb-2020-vl	Course name High-Level Synthesis			
	Instructor Prof. Dr.-Ing. Christian Hochberger			Type Lecture	SWS 3
	Course Nr. 18-hb-2020-ue	Course name High-Level Synthesis			
	Instructor Prof. Dr.-Ing. Christian Hochberger			Type Practice	SWS 1

Module name Low-Level Synthesis					
Module Nr. 18-hb-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language English			Module owner 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-hb-2010-vl	Course name Low-Level Synthesis			
	Instructor Prof. Dr.-Ing. Christian Hochberger			Type Lecture	SWS 3
	Course Nr. 18-hb-2010-ue	Course name Low-Level Synthesis			
	Instructor Prof. Dr.-Ing. Christian Hochberger			Type Practice	SWS 1

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 <p>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.</p> <p>Topics are:</p> <ul style="list-style-type: none"> • 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 <p>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.</p>				
3	Recommended prerequisite for participation <p>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.</p>				
4	Form of examination <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System) 				
5	Grading <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100 %) 				
6	Usability of this module <p>MSc ETiT, MSc iST, Wi-ETiT, CS, Wi-CS</p>				
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 Software Defined Networking					
Module Nr. 18-sm-2280	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language German and English			Module owner Prof. Dr.-Ing. Ralf Steinmetz		
1	Content The course deals with topics in the area of software defined networking: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-sm-2280-vl	Course name Software Defined Networking			
	Instructor Prof. Dr. Boris Koldehofe, M.Sc. Ralf Kundel			Type Lecture	SWS 2
	Course Nr. 18-sm-2280-ue	Course name Software Defined Networking			
	Instructor Prof. Dr. Boris Koldehofe, M.Sc. Ralf Kundel			Type Practice	SWS 2

Module name Real-Time Systems					
Module Nr. 18-su-2020	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German			Module owner 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 Structure 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 successful 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 components, 3. deeply understand the functioning of analog building blocks, 4. understand relevant field bus systems, 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 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. 18-ho-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language English			Module owner 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, Synchronous 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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

Module name Mobile Networking					
Module Nr. 20-00-0748	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered Every 2. Sem.
Language English			Module owner Prof. Dr.-Ing. Thorsten Strufe		
1	<p>Content</p> <p>Mobile communications and wireless networking technology has seen a thriving development in recent years. The integrated course addresses the characteristics/principles of mobile networks in detail, and practical solutions are presented. Hereby our focus is on the network layer, which is often regarded as the glue of communication systems. In addition to describing the state of the art in technology we discuss actual research problems and learn about methodologies to approach such problems systematically. The contents of the course will be deepened by exercises.</p> <p>Course contents:</p> <ul style="list-style-type: none"> - Introduction to mobile and wireless communications: Applications, history, market vision - Overview of wireless transmission: frequencies & regulations, signals, antennas, signal propagation, multiplexing, modulation, spread spectrum, cellular systems - Medium access control in the wireless domain: SDMA, FDMA, CDMA TDMA (fixed, Aloha, CSMA, DAMA, PRMA, MACA, collision avoidance, polling) - Wireless local area networks: IEEE 802.11 standard including physical layer, MAC layer and access schemes, quality of service and power management - Wireless metropolitan area networks: Wireless mesh networks, IEEE 802.16 standard including modes of operation, medium access control, quality of service and scheduling - Mobility at network layer: Concepts to support mobility on various layers, Mobile IP - Ad hoc networks: Terminology, basics and applications, characteristics of ad hoc communication, ad hoc routing paradigms and protocols - Performance evaluation of mobile networks: Overview of performance evaluation, systematic approach / common mistakes and how to avoid them, experimental design and analysis - Mobility at transport layer: Variants of TCP (indirect TCP, snoop TCP, mobile TCP, wireless TCP) - Mobility at application layer. Outlook: Applications for mobile networks and wireless sensor networks 				
2	<p>Learning objectives / Learning Outcomes</p> <p>After successfully attending the course, students have an in-deep knowledge on the working of mobile communication networks. They have gained insight into media access control mechanisms dedicated to wireless communication and have a thorough understanding of mechanisms based on the network and the transport layers, with a focus on ad hoc and mesh networks. Moreover, the students have acquired knowledge about the connections between the different protocol layers and are able to apply the acquired knowledge on methodological analysis of real communication systems. The students are therefore be conversant with the characteristics and basic principles of wireless and mobile communications in theory and practice. The exercise-parts of the integrated course deepen the theoretical foundations by means of exercises, which consist of literature, calculation as well as practical implementation/application examples.</p>				
3	<p>Recommended prerequisite for participation</p> <p>Basic courses in Communication Networks are recommended.</p>				
4	<p>Form of examination</p> <p>Module Ecompanying Examination:</p> <ul style="list-style-type: none"> • [20-00-0748-iv] (Technical Examination, Written/Oral Examination, Standard BWS) 				
5	<p>Grading</p> <p>Module Ecompanying Examination:</p> <ul style="list-style-type: none"> • [20-00-0748-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %) 				
6	<p>Usability of this module</p>				

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.		
7	Grade bonus compliant to §25 (2) In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.		
8	References Selected literature, details are given in lecture.		
Courses			
	Course Nr. 20-00-0748-iv	Course name Mobile Networking	
	Instructor Prof. Dr.-Ing. Thorsten Strufe	Type Integrated Course	SWS 4

Module name Energy Management and Optimization					
Module Nr. 18-st-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr. rer. nat. Florian Steinke		
1	Content <p>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.</p> <p>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.</p>				
2	Learning objectives / Learning Outcomes <p>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.</p> <p>Moreover, students are independently able to formulate (energy) optimization problems and solve them with the tool GAMS/AMPL.</p>				
3	Recommended prerequisite for participation <p>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 necessary.</p>				
4	Form of examination <p>Module Final Examination:</p> <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading <p>Module Final Examination:</p> <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module <p>MSc ETiT, MSc iST, MSc Wi-ETiT, MSc CE</p>				
7	Grade bonus compliant to §25 (2) <p>Improvement of grades up to 0.4 compliant to APB §25(2) through bonus system for regular attention of exercises and practical courses</p>				
8	References <p>Boyd, Vandenberghe: Convex Optimization, Cambridge University Press, 2004 GAMS Tutorial by Richard E. Rosenthal, https://www.gams.com/24.8/docs/userguides/userguide/_u_g_tutorial.html</p>				
Courses					
	Course Nr. 18-st-2010-v1	Course name Energy Management and Optimization			
	Instructor Prof. Dr. rer. nat. Florian Steinke			Type Lecture	SWS 2

	Course Nr. 18-st-2010-pr	Course name Energy Management and Optimization Lab		
	Instructor Prof. Dr. rer. nat. Florian Steinke		Type Internship	SWS 1
	Course Nr. 18-st-2010-ue	Course name Energy Management and Optimization		
	Instructor Prof. Dr. rer. nat. Florian Steinke		Type Practice	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: <ul style="list-style-type: none"> • 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 activities 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Oral exam 30 min				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 Communication Networks IV					
Module Nr. 18-sm-2030	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Ralf Steinmetz		
1	<p>Content</p> <p>The lecture communication networks IV deals with modelling and performance evaluation of computer networks and communication systems. The emphasis is on current analytical approaches. Owing to these methods a fundamental understanding of major performance related aspects in networking is achieved and basic knowledge for planning, optimization and advancement of communications networks is provided. The relevance and implications of individual theories are illustrated using examples which are drawn mainly from the Internet. Apart from analytical methods the lecture gives an introduction to simulation of communication networks as well as measuring in real or prototypical systems and testbeds. In addition to well-known methods and their applications selected aspects of current research questions will be elaborated on.</p> <p>Topics of the lecture are:</p> <ul style="list-style-type: none"> • Introduction to performance evaluation and applications • Leaky bucket traffic regulators, deterministic traffic models, deterministic and empirical envelopes • Scheduling, generalized processor sharing • Network calculus, min-plus systems theory, deterministic performance bounds • Poisson processes, Markov-chains, classical queuing theory, M M 1 and M G 1 models • Modeling of packet data traffic, self-similarity • Effective bandwidths, moment generating functions, statistical multiplexing • Statistical network calculus, effective envelopes, effective performance bounds • Simulation, generation of random numbers, distributions, confidence intervals • Instrumentation, measurements, bandwidth estimation in the Internet 				
2	<p>Learning objectives / Learning Outcomes</p> <p>Students attending this lecture obtain an overview on the impact, fundamental methods, and important applications of performance evaluation of communication networks. They are acquainted with characteristic mechanisms and scheduling algorithms used in quality of service networks and are able to explain their functionality in terms of network calculus and the framework of min-plus systems theory. In addition to basic queuing theory the students acquire sound knowledge of the theory of effective bandwidths and thus exhibit a theoretically founded understanding of statistical multiplexing. Beyond analytical methods, the students gain insight into simulation as well as selected measurement methods and tools used in real networks. They are able to define the scope of individual theories and methods, select suitable, problem tailored techniques, apply these to typical problems, and draw relevant conclusions.</p>				
3	<p>Recommended prerequisite for participation</p> <p>Basic courses of the first 4 semesters are required. Knowledge of lectures Communication Networks I and II are recommended.</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Weighting: 100%) 				
6	<p>Usability of this module</p> <p>Wi-CS, Wi-ETiT, BSc/MSc CS, MSc ETiT, MSc iST</p>				
7	<p>Grade bonus compliant to §25 (2)</p>				

8	References Ausgewählte Kapitel aus folgenden Büchern: <ul style="list-style-type: none"> • J.-Y. Le Boudec, P. Thiran: "Network Calculus: A Theory of Deterministic Queuing Systems for the Internet", Springer LNCS 2050, http://ica1www.epfl.ch/PS_files/netCalBookv4.pdf, 2004. • A. Kumar, D. Manjunath, J. Kuri: "Communication Networking: An Analytical Approach", Morgan Kaufmann, 2004. • A. M. Law, W. D. Kelton: "Simulation, Modeling and Analysis", McGraw Hill, 3rd Ed., 2000. • Selected Journal Articles and Conference Papers 		
Courses			
	Course Nr.	Course name	
	18-sm-2030-v1	Communication Networks IV: Performance Evaluation of Communication Networks	
	Instructor		Type
	Dr.-Ing. Amr Rizk, Prof. Dr.-Ing. Ralf Steinmetz		Lecture
			SWS
			2

Module name Machine Learning & Energy					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-st-2020	6 CP	180 h	120 h	1	WiSe
Language German			Module owner Prof. Dr. rer. nat. Florian Steinke		
1	<p>Content</p> <p>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.</p> <p>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, ...).</p> <p>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.</p>				
2	<p>Learning objectives / Learning Outcomes</p> <p>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).</p>				
3	<p>Recommended prerequisite for participation</p> <ul style="list-style-type: none"> • 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	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>MSc etit, MSc iST, MSc Wi-etit, MSc CE</p>				
7	<p>Grade bonus compliant to §25 (2)</p> <p>Notenverbesserungen bis zu 0,4 nach APB §25(2) durch Bonus für regelmäßig besuchte Übungs-/Praktikumstermine und mindestens einmaliges Vorrechnen in den Übungen</p>				
8	<p>References</p> <ul style="list-style-type: none"> • 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. techn. Heinz Köppl		
1	<p>Content</p> <p>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.</p> <ul style="list-style-type: none"> • 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	<p>Learning objectives / Learning Outcomes</p> <p>Students are able to interpret and categorize specific engineering problems from the ICT domain in terms of machine learning problems.</p> <p>They are able to reduce such problems to standard machine learning problems and are able to determine suitable solution methods for them.</p> <p>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.</p> <p>They are able to determine the involved computational complexity of a method and choose an appropriate solution algorithms based on application constraints.</p> <p>They are able to apply the acquired methods to other domains, such as data analysis in biomedical engineering, analysis of social network data, etc.</p>				
3	<p>Recommended prerequisite for participation</p> <p>Good command of Matlab (for instance knowledge from course 18-st-2030 Matlab Grundkurs) and engineering mathematics</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>MSc etit, BSc/MSc iST, MSc iCE, MSc CE</p>				

7	Grade bonus compliant to §25 (2)		
8	References <ul style="list-style-type: none"> • 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		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		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		Type Practice
	SWS 1		

Module name Modelling and simulation of circuits					
Module Nr. 18-sc-2010	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered SoSe
Language German and English			Module owner Prof. Dr. rer. nat. Sebastian Schöps		
1	Content The content of this course is the following: <ul style="list-style-type: none"> • Circuit interpretation as directed graphs • Modified nodal and loop analysis • Flux and charge oriented formulations • Differential algebraic equations • Linear system solver • Numerical solution of nonlinear systems • Time-domain methods • Frequency-domain solution • Implementation of the numerical methods 				
2	Learning objectives / Learning Outcomes Students understand the theoretical and numerical fundamentals of circuit simulation and how the equations can be derived from Maxwell's equations. Circuit properties can be expressed in terms of graph theory. The sparse systems of equations such as the flux/charge oriented modified nodal analysis can be assembled. In order to solve the obtained systems, different numerical methods for the simulation of circuits are relevant. This includes methods for the solution of linear systems (direct and iterative solvers), root-finding algorithms for nonlinear systems and implicit time integration methods. Mathematical concepts such as stability, convergence order or complexity are known and can be employed to judge the advantages and disadvantages of the various methods. Eventually, the students are able to program their own circuit simulator, that can return both frequency as well as time domain solutions of electric networks.				
3	Recommended prerequisite for participation 18-hs-1070 Elektrotechnik und Informationstechnik I 18-gt-1020 Elektrotechnik und Informationstechnik II 20-00-0304 Allgemeine Informatik I 04-00-0112 Mathematik IV				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 20 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Weighting: 100%) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2) Grade bonus of 0,4 if correctly implemented programs are submitted				
8	References				

- L. W. Nagel, “SPICE2: A computer program to simulate semiconductor circuits”, University of Berkeley, Tech. Rep., 1975.
- C.-W. Ho, A. E. Ruehli, and P. A. Brennan, “The modified nodal approach to network analysis”, IEEE Trans. Circ. Syst., vol. 22, no. 6, pp. 504–509, Jun. 1975.
- J. Vlach, K. Singhal, Computer methods for circuit analysis and design. New York : Van Nostrand Reinold, 1983.

Courses

Course Nr. 18-sc-2010-v1	Course name Modelling and simulation of circuits			
Instructor			Type Lecture	SWS 2
Course Nr. 18-sc-2010-ue	Course name Modelling and simulation of circuits			
Instructor			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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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, M.Sc. Julian Zobel, M.Sc. Daniel Bischoff, M.Sc. Tim Steuer	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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-hb-2040-pj	Course name Projektseminar Rekonfigurable Systems			
	Instructor Prof. Dr.-Ing. Christian Hochberger			Type Project Seminar	SWS 3

Module name HDL Lab					
Module Nr. 18-ho-1090	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 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ho-1090-pr	Course name HDL Lab			
	Instructor Prof. Dr.-Ing. Klaus Hofmann			Type Internship	SWS 3

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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 Project Seminar Design for Testability					
Module Nr. 18-ho-2130	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 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ho-2130-pj	Course name Project Seminar Design for Testability			
	Instructor Prof. Dr.-Ing. Klaus Hofmann			Type Project Seminar	SWS 3

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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • ETiT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++) Additionally desired: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading				

	Module Final Examination: <ul style="list-style-type: none"> • 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. 18-su-2070-pj	Course name Autonomous Driving Lab I	
	Instructor Prof. Dr. rer. nat. Andreas Schürr, Dr. Ing. Eric Lenz, M.Sc. Stefan Tomaszek	Type Project Seminar	SWS 3

Module name Autonomous Driving Lab II					
Module Nr. 18-su-2100	Credit Points 6 CP	Workload 180 h	Self study 135 h	Duration 1	Cycle offered SoSe
Language German and English			Module owner Prof. Dr. rer. nat. Andreas Schürr		
1	Content				
2	Learning objectives / Learning Outcomes Students learn to independently develop, implement and present new concepts and algorithms in the field of autonomous driving. Realistic problems from the Carolo Cup are solved with existing knowledge and skills practically and the implementation is ensured by quality assurance measures. Students who have successfully participated in this project seminar are able to independently analyze and solve a complex and realistic task in the field of autonomous driving. The participants acquire the following skills in detail: <ul style="list-style-type: none"> • Further development and optimization of an existing software system and the used algorithms independently • Solving and implementation of non-trivial, realistic control engineering challenges • Extensive use of tools for version, configuration, change, and quality assurance management • Realistic time planning and resource allocation (project management) • Further development and optimization of complex hardware/software systems under realistic environmental conditions • Planning and implementation of extensive quality assurance measures • Collaboration, communication and organization within the team 				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2)				
8	References https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-ii und Moodle				
Courses					
	Course Nr. 18-su-2100-pj	Course name Autonomous Driving Lab II			
	Instructor Prof. Dr. rer. nat. Andreas Schürr, Dr. Ing. Eric Lenz			Type Project Seminar	SWS 3

Module name Multimedia Communications Project Seminar II					
Module Nr. 18-sm-2080	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 scientific and development topics in the area of multimedia communication systems. Besides a general overview it provides a deep insight into a special scientific topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and scientific competences in one or more of the following topics: <ul style="list-style-type: none"> • 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 technical and scientific problems in the area of design and development of future multimedia communication networks and applications using state of the art scientific methods shall be acquired. Acquired competences are: <ul style="list-style-type: none"> • Searching and reading of project relevant literature • 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 • Systematic evaluation and analyzing of technical and scientific experiments • Writing of software documentation and project reports • Presentation of project advances and outcomes 				
3	Recommended prerequisite for participation Keen interest to develop and explore challenging solutions and applications in cutting edge multimedia communications systems using scientific methods. Further we expect: <ul style="list-style-type: none"> • Solid experience in programming Java and/or C (C/C++) • Solid knowledge in object oriented analysis and design • Basic knowledge of design patterns, refactoring and project management • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Weighting: 100 %) 				

6	Usability of this module Wi-CS, Wi-ETiT, BSc/MSc CS, MSc ETiT, MSc iST		
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: <ul style="list-style-type: none"> • Andrew Tanenbaum: "Computer Networks". Prentice Hall PTR (ISBN 0130384887) • Raj Jain: "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling" (ISBN 0-471-50336-3) • 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) • Martin Fowler: "Refactorings - Improving the Design of Existing Code" (ISBN-13: 978-0201485677) • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654) 		
Courses			
	Course Nr. 18-sm-2080-pj	Course name Multimedia Communications Project Seminar II	
	Instructor Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Julian Zobel, M.Sc. Daniel Bischoff, M.Sc. Tim Steuer	Type Project Seminar	SWS 3

Module name Projektseminar Software Systems					
Module Nr. 18-su-1060	Credit Points 9 CP	Workload 270 h	Self study 210 h	Duration 1	Cycle offered WiSe/SoSe
Language German			Module owner Prof. Dr. rer. nat. Andreas Schürr		
1	Content <p>The course deals with various development and research topics in the area of model-driven engineering and object-oriented software engineering. Besides a general overview, it provides a deep insight into a special scientific topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and scientific competences in one or more of the following topics:</p> <ul style="list-style-type: none"> • Model-Driven Engineering and Model Synchronization • Model Transformation • Object-Oriented Refactorings • Program Variability (Software Product Lines) • Feature Model Analysis <p>Additional information and topic description for the current semester: http://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/projektseminar-softwaressysteme/</p>				
2	Learning objectives / Learning Outcomes <p>The student gains practical experience in development (reengineering and maintenance) of complex software systems. He/She learns to work and function in a team, and to analyze and solve a non-trivial task. Moreover, students exercise using theoretical knowledge in the group (e.g. from lectures like software engineering – introduction / Design / Maintenance & Quality Assurance) to solve a concrete and practical problem.</p> <p>Students that have successfully completed this seminar are able to independently organize and set-up a non-trivial software project and function to analyze and solve a certain task. Attendees gain the following skills in detail:</p> <ul style="list-style-type: none"> • realistic time and resource management (project management) • experience with tools for version control and change management • usage of CASE tools for model-based software development • planning and execution of quality assurance measures 				
3	Recommended prerequisite for participation Mandatory: Basic software technology knowledge and advanced knowledge of object-oriented programming languages				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Weighting: 100%) 				
6	Usability of this module BSc ETiT, MSc ETiT, BSc iST				
7	Grade bonus compliant to §25 (2)				
8	References Each topic is covered by a specific selection of papers and articles.				
Courses					

	Course Nr. 18-su-1060-pj	Course name Projektseminar Software Systems		
	Instructor Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Lars Luthmann		Type Project Seminar	SWS 4

Module name Seminar Integrated Electronic Systems Design A					
Module Nr. 18-ho-2160	Credit Points 4 CP	Workload 120 h	Self study 90 h	Duration 1	Cycle offered WiSe/SoSe
Language English			Module owner 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 <ul style="list-style-type: none"> • gain a deep understanding of the chosen research subject in the field of integrated electronic systems, • write an essay on the chosen subject in a comprehensive 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 45 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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					
Multimedia Communications Seminar II					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-sm-2090	4 CP	120 h	90 h	1	WiSe/SoSe
Language			Module owner		
German and English			Prof. Dr.-Ing. Ralf Steinmetz		
1	Content This seminar deals with current and upcoming trends relevant to the future development of multimedia communication systems. The educational objective of this seminar is to gain knowledge about future research trends in different areas. To this aim, an extensive literature research will be performed, as well as the writing-up of a report and the presentation of selected, high-quality research topics from current leading magazines, newspapers and conferences in the web technologies research area. Some potential topics are: <ul style="list-style-type: none"> • Knowledge & Educational Technologies • Self organizing Systems & Overlay Communication • Mobile Systems & Sensor Networking • Service-oriented Computing • Multimedia Technologies & Serious Games 				
2	Learning objectives / Learning Outcomes Students shall acquire profound knowledge from current scientific publications, standards and literature on multimedia communication systems and applications which will build the future Internet. In so doing, the students will develop the following competencies: <ul style="list-style-type: none"> • Search for and review relevant scientific literature. • Analyse and evaluate complex technical and scientific information. • Write technical and scientific abstracts and summary reports. • Present technical and scientific information. 				
3	Recommended prerequisite for participation Solid knowledge in computer communication networks. Lectures in Communication Networks I and II are recommended.				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Weighting: 100 %) 				
6	Usability of this module CS, Wi-CS, ETiT, Wi-ETiT, MSc CS, MSc ETiT, MSc iST				
7	Grade bonus compliant to §25 (2)				
8	References Depending on specific topic (selected articles of journals, magazines, and conferences).				
Courses					
Course Nr.	Course name				
18-sm-2090-se	Multimedia Communications Seminar II				
Instructor	Type	SWS			
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Julian Zobel, M.Sc. Daniel Bischoff, M.Sc. Tim Steuer	Seminar	2			

Module name Seminar Software System Technology					
Module Nr. 18-su-2080	Credit Points 4 CP	Workload 120 h	Self study 90 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr. rer. nat. Andreas Schürr		
1	Content In this course, the students produce scientific reports from changing subject areas. Each student has to explore a subject related to IT system development and produce a written report as well as a final talk with a presentation. A list of the subjects of the current semester is available at www.es.tu-darmstadt.de/lehre/sst .				
2	Learning objectives / Learning Outcomes After a successful participation, the students will be able to explore an unknown topic under scientific aspects. The students learn to support the exploration by a literature research and to analyze the subject critically. They achieve the skills to present a definite subject in a written report as well as in an oral presentation.				
3	Recommended prerequisite for participation Basic knowledge in software engineering and programming languages				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %) 				
6	Usability of this module BSc iST, BSc Informatik, MSc ETiT				
7	Grade bonus compliant to §25 (2)				
8	References www.es.tu-darmstadt.de/lehre/sst				
Courses					
	Course Nr. 18-su-2080-se	Course name Seminar Software System Technology			
	Instructor Prof. Dr. rer. nat. Andreas Schürr			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 Circuits 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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

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 <p>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.</p> <p>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, ...).</p> <p>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.</p>				
2	Learning objectives / Learning Outcomes <p>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).</p>				
3	Recommended prerequisite for participation <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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			
	<ul style="list-style-type: none"> • 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. 18-hi-2010	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Volker Hinrichsen		
1	Content Layered Dielectrics, Methods of Field Control and Potential Control, Breakdown in Gases (air and SF ₆), 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • 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. 18-hi-2010-v1	Course name High Voltage Technology II			
	Instructor Prof. Dr.-Ing. Volker Hinrichsen			Type Lecture	SWS 2

	Course Nr. 18-hi-2010-ue	Course name High Voltage Technology II		
	Instructor Prof. Dr.-Ing. Volker Hinrichsen		Type Practice	SWS 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: <ul style="list-style-type: none"> • 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 understanding 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-bi-2010	Credit Points 7 CP	Workload 210 h	Self study 135 h	Duration 1	Cycle offered WiSe
Language English			Module owner 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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, MOSFET 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 drive-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 relieving 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-gt-2010-vl	Course name Advanced Power Electronics		
Instructor Prof. Dr.-Ing. Gerd Griepentrog	Type Lecture	SWS 2	
Course Nr. 18-gt-2010-ue	Course name Advanced Power Electronics		
Instructor Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Vefa Karakasli	Type Practice	SWS 2	

1.3.2 EET - Specialization

1.3.2.1 EET - Lectures (open catalogue)

Module name Control of Drives					
Module Nr. 18-gt-2020	Credit Points 5 CP	Workload 150h	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. Problem of Motion control				
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 excited 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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	<p>References</p> <p>Lecture notes, instructions for exercises are available in Moodle for download.</p> <p>Literature:</p> <ul style="list-style-type: none"> • 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”
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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, M.Sc. Ivan Kliasheu	Type Practice	SWS 2

Module name Railway Vehicle Engineering					
Module Nr. 18-bi-2050	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered SoSe
Language German			Module owner 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: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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. 18-bi-2050-v1	Course name Railway Vehicle Engineering			
	Instructor			Type Lecture	SWS 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. Bätzold, 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-v1	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: <ul style="list-style-type: none"> • Power transmission and voltage stability • Ancillary services • Power quality Technology of innovative equipment: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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-v1	Course name Electrothermal Processes			
	Instructor Dr.-Ing. Jörg Neumeyer			Type Lecture	SWS 2

Module name Regulation of Power Supply					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-hs-2010	3 CP	90 h	60 h	1	SoSe
Language German			Module owner Prof. Dr.-Ing. Jutta Hanson		
1	Content <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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-v1	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. 18-bi-2020	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language German and English			Module owner 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 Prof. Dr. Georg Traxler-Samek			Type Lecture	SWS 2
	Course Nr. 18-bi-2020-ue	Course name Large Generators and High Power Drives			
	Instructor Prof. Dr. Georg Traxler-Samek			Type Practice	SWS 1

Module name High Voltage Switchgear and Substations					
Module Nr. 18-hi-2020	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 This lecture covers the basic designs of high voltage substations as well as the design and working principles of high voltage switchgear: <ul style="list-style-type: none"> • Types 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 45 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-hi-2020-vl	Course name High Voltage Switchgear and Substations			
	Instructor Prof. Dr. Claus Neumann			Type Lecture	SWS 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	<p>Content</p> <p>In this class the technologies that make today's communication networks work are introduced and discussed.</p> <p>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.</p> <p>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.</p> <p>Detailed Topics are:</p> <ul style="list-style-type: none"> • 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	<p>Learning objectives / Learning Outcomes</p> <p>This lecture teaches about basic functionalities, services, protocols, algorithms and standards of network communication systems. Competencies acquired 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.</p>				
3	<p>Recommended prerequisite for participation</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>Wi-CS, Wi-ETiT, BSc CS, BSc ETiT, BSc iST</p>				

7	<p>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.</p>		
8	<p>References</p> <ul style="list-style-type: none"> • 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 Prof. Dr.-Ing. Ralf Steinmetz		Type Lecture
			SWS 3
	Course Nr. 18-sm-1010-ue	Course name Communication Networks I	
	Instructor 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 English			Module owner Prof. Dr.-Ing. Ralf Steinmetz		
1	<p>Content</p> <p>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.</p> <p>Topics are:</p> <ul style="list-style-type: none"> • 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	<p>Learning objectives / Learning Outcomes</p> <p>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.</p>				
3	<p>Recommended prerequisite for participation</p> <p>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.</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>MSc ETiT, MSc iST, Wi-ETiT, CS, Wi-CS</p>				
7	<p>Grade bonus compliant to §25 (2)</p>				
8	<p>References</p>				

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 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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	<p>Content</p> <p>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.</p> <p>Content:</p> <p>Application of the superconductors for electrical energy converters:</p> <ul style="list-style-type: none"> • rotating electrical machines (motors and generators), • solenoid coils for the fusion research, • locomotive- and railway transformers, • magnetic bearings. <p>Active magnetic bearings (“magnetic levitation”):</p> <ul style="list-style-type: none"> • 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. <p>Magneto-hydrodynamic energy conversion:</p> <ul style="list-style-type: none"> • physical principle, • state of the art and perspectives. <p>Fusion research:</p> <ul style="list-style-type: none"> • magnetic field arrangements for contactless plasma inclusion, • state of the current research. 				
2	<p>Learning objectives / Learning Outcomes</p> <p>Basic knowledge in application of superconductivity in energy systems is understood as well as magnetic levitation, magneto-hydrodynamics and fusion technology.</p>				
3	<p>Recommended prerequisite for participation</p> <p>Physics, Electrical Machines and Drives, Electrical Power Engineering</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>MSc EPE, MSc ETiT, MSc MEC, MSc WI-ETiT</p>				
7	<p>Grade bonus compliant to §25 (2)</p>				
8	<p>References</p> <p>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</p>				

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. 18-ad-1010	Credit Points 7 CP	Workload 210 h	Self study 135 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content Main topics covered are: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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)				
Courses					
	Course Nr. 18-ad-1010-vl	Course name System Dynamics and Automatic Control Systems II			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Lecture	SWS 3
	Course Nr. 18-ad-1010-ue	Course name System Dynamics and Automatic Control Systems II			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Practice	SWS 2

Module name Overvoltage Protection and Insulation Coordination in Power System					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-hi-2030	4 CP	120 h	75 h	1	WiSe
Language English			Module owner Prof. Dr.-Ing. Volker Hinrichsen		
1	<p>Content</p> <ul style="list-style-type: none"> • Introduction, basics and overview • Determination of representative overvoltages <ul style="list-style-type: none"> – 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 <ul style="list-style-type: none"> – Insulation strength for different voltage shapes and geometric configurations (gap factors) – Performance criterion – Insulation coordination procedure • Determination of required withstand voltage <ul style="list-style-type: none"> – General remarks – Atmospheric correction – Safety factor for internal and external insulations • Standard withstand voltage and testing procedures <ul style="list-style-type: none"> – General remarks – Test conversion factors – Determination and verification of insulation withstand by type tests – Table of test voltages and required clearances 				
2	<p>Learning objectives / Learning Outcomes</p> <p>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.</p>				
3	<p>Recommended prerequisite for participation</p> <p>High Voltage Technology I and II</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System) 				
5	<p>Grading</p>				

	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, Dr.-Ing. 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, Dr.-Ing. Constantin Balzer, M.Sc. Tobias Trautmann	Type Practice	SWS 1

Module name Applied Superconductivity					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-bf-2030	3 CP	90 h	60 h	1	SoSe
Language German and English			Module owner Prof. Dr. Oliver Boine-Frankenheim		
1	Content <ul style="list-style-type: none"> • 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 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • 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. 18-bf-2030-v1	Course name Applied Superconductivity		
	Instructor Dr.-Ing. Uwe Niedermayer		Type Lecture	SWS 2

Module name Lightning Physics and Lightning Protection					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-hi-2090	3 CP	90 h	60 h	1	SoSe
Language German			Module owner Prof. Dr.-Ing. Volker Hinrichsen		
1	Content <ul style="list-style-type: none"> • Introduction • Thunderstorms and Cloudclassification, 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 <p>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 deviate 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.</p> <p>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 uncertainties 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.</p> <p>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 students are sensitised about research results in general.</p>				
3	Recommended prerequisite for participation Recommended: BSc ETiT, BSc Wi-ETiT				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading				

	Module Final Examination: <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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: Erläuterungen 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. 18-bi-2150	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language English			Module owner 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2)				
8	References				
Courses					
	Course Nr. 18-bi-2150-vl	Course name Electric drives for cars			
	Instructor Prof. Dr. Annette Mütze			Type Lecture	SWS 2
	Course Nr. 18-bi-2150-ue	Course name Electric drives for cars			
	Instructor Prof. Dr. Annette Mütze			Type Practice	SWS 1

Module name Energy Management and Optimization					
Module Nr. 18-st-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr. rer. nat. Florian Steinke		
1	Content <p>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.</p> <p>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.</p>				
2	Learning objectives / Learning Outcomes <p>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.</p> <p>Moreover, students are independently able to formulate (energy) optimization problems and solve them with the tool GAMS/AMPL.</p>				
3	Recommended prerequisite for participation <p>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 necessary.</p>				
4	Form of examination <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module <p>MSc ETiT, MSc iST, MSc Wi-ETiT, MSc CE</p>				
7	Grade bonus compliant to §25 (2) <p>Improvement of grades up to 0.4 compliant to APB §25(2) through bonus system for regular attention of exercises and practical courses</p>				
8	References <p>Boyd, Vandenberghe: Convex Optimization, Cambridge University Press, 2004 GAMS Tutorial by Richard E. Rosenthal, https://www.gams.com/24.8/docs/userguides/userguide/_u_g_tutorial.html</p>				
Courses					
	Course Nr. 18-st-2010-v1	Course name Energy Management and Optimization			
	Instructor Prof. Dr. rer. nat. Florian Steinke			Type Lecture	SWS 2

	Course Nr. 18-st-2010-pr	Course name Energy Management and Optimization Lab		
	Instructor Prof. Dr. rer. nat. Florian Steinke		Type Internship	SWS 1
	Course Nr. 18-st-2010-ue	Course name Energy Management and Optimization		
	Instructor Prof. Dr. rer. nat. Florian Steinke		Type Practice	SWS 1

Module name Gasinsulated Switchgear and Lines					
Module Nr. 18-hi-2080	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Volker Hinrichsen		
1	Content <ul style="list-style-type: none"> • 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 (VF_{TO}) • 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 properties of the insulating gas sulfur hexafluoride (SF ₆). They know the climate impact of SF ₆ 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 VF _{TO} 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-hi-2080-v1	Course name Gasinsulated Switchgear and Lines	
	Instructor Dr.-Ing. Maria Kosse, M.Sc. David Christopher Kothe		Type Lecture SWS 2

Module name Designing the Energiewende					
Module Nr. 18-st-2080	Credit Points 6 CP	Workload 180 h	Self study 135 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Stefan Nießen		
1	Content Energy technological, economical and political frame of the Energiewende with a focus on electricity in Germany. The module consists of three elements: <ul style="list-style-type: none"> • 6 double-lectures, two of them being taught by Prof. Michèle Knodt from Department of History and Social Sciences, by Prof. Florian Steinke and Prof. Stefan Niessen from Department of Electrical Engineering and Information Technology . • a seminar consisting of 3 times 90 minutes, during which interdisciplinary teams of students from political and engineering sciences jointly analyse a recent study on the Energiewende and mutually present a short synthesis to each other. • two half-days practical training during which the interdisciplinary teams based on a computer simulation take their own decisions on the regulatory framework, the expansion of the energy system and its operation. They experience in accelerated mode the impact on CO2 emissions, costs and security of supply. In the practical part the students apply the learnings practically by means of a computer based serious game. They take the roles of electricity suppliers, industry, private homes and politicians, they take decisions on operation and expansion of the energy system. Through the computer simulation the students experience the consequences of their decisions on costs, CO2 emissions and security of supply in in time-lapse for the period 2020 to 2050. 				
2	Learning objectives / Learning Outcomes The students know different methods for techno-economical analysis of energy systems and base parameters of energy systems. Furthermore they have an overview on main technologies for energy conversion and storage today and possible future evolutions. They also comprehend governance basics consisting in EU legal acts, German laws and directives and an overview on the institutions implementing these.				
3	Recommended prerequisite for participation A completed Bachelor in any of the following subjects: electrical engineering, mechanical engineering, mechatronics, environmental sciences, business administration/electrical engineering (Wirtschaftsingenieurwesen-Elektrotechnik und Informationstechnik), Political Sciences				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) The type of examination will be announced in the first lecture. Possible types include <ul style="list-style-type: none"> • a presentation and a report of the parts of the module 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100%) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2)				
8	References				

- Downloadable slides
- Book.energytransition.org/en
- https://www.agora-energiewende.de/fileadmin2/Projekte/2018/A_word_on/Agora_Energiewende_a-word-on_flexibility_WEB.pdf

Courses

Course Nr. 18-st-2080-vl	Course name Designing the Energiewende - lecture		
Instructor Prof. Dr.-Ing. Stefan Nießen, Prof. Dr. phil. Michèle Knodt, Prof. Dr. rer. nat. Florian Steinke	Type Lecture	SWS 1	
Course Nr. 18-st-2080-pr	Course name Designing the Energiewende – serious game		
Instructor Prof. Dr.-Ing. Stefan Nießen, Prof. Dr. phil. Michèle Knodt, Prof. Dr. rer. nat. Florian Steinke	Type Internship	SWS 1	
Course Nr. 18-st-2080-se	Course name Designing the Energiewende - seminar		
Instructor Prof. Dr.-Ing. Stefan Nießen, Prof. Dr. phil. Michèle Knodt, Prof. Dr. rer. nat. Florian Steinke	Type Seminar	SWS 1	

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 extended 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 Development 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: <ul style="list-style-type: none"> • 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. Interpretation 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-hs-2100-pr	Course name Simulation of Electrical Power Networks			
	Instructor Prof. Dr.-Ing. Jutta Hanson, Dipl.-Ing. Andreas Saciak			Type Internship	SWS 2

Module name Power Laboratory I					
Module Nr. 18-bi-2091	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language German and English			Module owner Prof. Dr. techn. Dr.h.c. Andreas Binder		
1	Content Safety instructions for laboratory; Topic of experiments: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 Insulation Technology, Friedr. Vieweg & Sohn, Braunschweig Wiesbaden, 1985, ISBN 3-528-08599-1				
Courses					
	Course Nr. 18-bi-2091-pr	Course name Power Laboratory I			
	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 Power Laboratory II					
Module Nr. 18-bi-2092	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 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 systems, 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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			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.	Credit Points	Workload	Self study	Duration	Cycle offered
18-ko-1020	4 CP	120 h	60 h	1	SoSe
Language			Module owner		
German			Prof. Dr.-Ing. Ulrich Konigorski		
1	Content				
	<ul style="list-style-type: none"> • 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 lab setup.				
3	Recommended prerequisite for participation				
	System Dynamics and Control Systems I				
4	Form of examination				
	Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading				
	Module Final Examination: <ul style="list-style-type: none"> • 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.	Course name				
18-ko-1020-pr	Laboratory Control Engineering I				
Instructor	Type	SWS			
Prof. Dr.-Ing. Ulrich Konigorski	Internship	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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-bi-2110	Credit Points 5 CP	Workload 150 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German and English			Module owner 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-bi-2110-se	Course name Design of Electrical Machines and Actuators with Numerical Field Calculation			
	Instructor Dr.-Ing. Bogdan Funieru			Type Seminar	SWS 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-hi-2070-pj	Course name Project Seminar Application in High-Voltage Technology			
	Instructor Prof. Dr.-Ing. Volker Hinrichsen			Type Project Seminar	SWS 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 theoretical 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, Presentation				
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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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 <p>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.</p>				
2	Learning objectives / Learning Outcomes The Competences are: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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.	Credit Points	Workload	Self study	Duration	Cycle offered
18-hs-2060	6 CP	180 h	150 h	1	SoSe
Language			Module owner		
German			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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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.	Course name				
18-hs-2060-se	Calculation of Transients in electrical Power Systems				
Instructor				Type	SWS
Prof. Dr.-Ing. Jutta Hanson				Seminar	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 construction, 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 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			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 procedures 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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

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 180h	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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> A. Oppenheim, W. Schaffer: 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. 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. Martin Gölz			Type Practice	SWS 1

Module name Microwave Engineering I					
Module Nr. 18-jk-1020	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language German			Module owner 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-pe-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language English			Module owner 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 network information theory.				
3	Recommended prerequisite for participation Knowledge of basic communication theory				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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, Cambridge, 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. 18-pe-2010-vl	Course name Information Theory II			
	Instructor Prof. Dr.-Ing. Marius Pesavento			Type Lecture	SWS 3
	Course Nr. 18-pe-2010-ue	Course name Information Theory II			
	Instructor Prof. Dr.-Ing. Marius Pesavento			Type Practice	SWS 1

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 <p>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.</p>				
2	Learning objectives / Learning Outcomes <p>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, constraints 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 constraints: (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).</p>				
3	Recommended prerequisite for participation Fundamentals of Communications, Microwave Engineering 1				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • the ability of comparing, evaluating, classifying and 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-kl-2010-ue	Course name Communication Technology II		
	Instructor Prof. Dr.-Ing. Anja Klein		Type Practice	SWS 1

1.4.2 KTS - Specialization

1.4.2.1 KTS - Lectures (open catalogue)

Module name Adaptive Filters					
Module Nr. 18-zo-2010	Credit Points 6 CP	Workload 180h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German and English			Module owner Prof. Dr.-Ing. Abdelhak Zoubir		
1	<p>Content Theory:</p> <ol style="list-style-type: none"> 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. <p>Applications: Parallel to the theory, practical applications are explained. As an example for the Wiener 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.</p>				
2	<p>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.</p>				
3	<p>Recommended prerequisite for participation Digital Signal Processing</p>				
4	<p>Form of examination Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	<p>Grading Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	<p>Usability of this module MSc ETiT</p>				
7	<p>Grade bonus compliant to §25 (2)</p>				
8	<p>References</p>				

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. 18-zo-2010-vl	Course name Adaptive Filters		
Instructor Prof. Dr.-Ing. Henning Puder		Type Lecture	SWS 3
Course Nr. 18-zo-2010-ue	Course name Adaptive Filters		
Instructor Prof. Dr.-Ing. Henning Puder		Type Practice	SWS 1

Module name Acoustics I					
Module Nr. 18-se-2010	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered WiSe
Language German			Module owner 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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. Kuttruff, 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. 18-se-2010-vl	Course name Acoustics I			
	Instructor Prof. (em.) Dr. Gerhard Sessler, Prof. Dr. Mario Kupnik			Type Lecture	SWS 2

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 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, constraints 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 constraints: (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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • the ability of comparing, evaluating, classifying and 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-kl-2010-ue	Course name Communication Technology II		
	Instructor Prof. Dr.-Ing. Anja Klein		Type Practice	SWS 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	<p>Content</p> <p>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 prerequisites 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.</p> <p>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.</p> <p>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.</p>				
2	<p>Learning objectives / Learning Outcomes</p> <p>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:</p> <ul style="list-style-type: none"> • 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 systems <p>System identification/machine learning for stochastic systems</p>				
3	<p>Recommended prerequisite for participation</p> <p>Basic knowledge of programming, Matlab.</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>MSc ETiT, MSc iST, MSc Wi-ETiT, MSc MEC</p>				

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. 18-jk-2130	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 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 sources 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-jk-2130-vl	Course name Microwave Engineering II			
	Instructor PD Dr.-Ing. Oktay Yilmazoglu			Type Lecture	SWS 3
	Course Nr. 18-jk-2130-ue	Course name Microwave Engineering II			
	Instructor PD Dr.-Ing. Oktay Yilmazoglu			Type Practice	SWS 1

Module name Information Theory II					
Module Nr. 18-pe-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language English			Module owner 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 network information theory.				
3	Recommended prerequisite for participation Knowledge of basic communication theory				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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, Cambridge, 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. 18-pe-2010-vl	Course name Information Theory II			
	Instructor Prof. Dr.-Ing. Marius Pesavento			Type Lecture	SWS 3
	Course Nr. 18-pe-2010-ue	Course name Information Theory II			
	Instructor Prof. Dr.-Ing. Marius Pesavento			Type Practice	SWS 1

Module name Convex Optimization in Signal Processing and Communications					
Module Nr. 18-pe-2020	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language English			Module owner 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, mixed 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 14 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-pe-2020-pr	Course name Convex Optimization in Signal Processing and Communications Lab		
	Instructor Prof. Dr.-Ing. Marius Pesavento		Type Internship	SWS 1

Module name Matrix Analysis and Computations					
Module Nr. 18-pe-2070	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language English			Module owner 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 semidefinite 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-pe-2070-vl	Course name Matrix Analysis and Computations			
	Instructor Prof. Dr.-Ing. Marius Pesavento			Type Lecture	SWS 3

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

Module name MIMO - Communication and Space-Time-Coding					
Module Nr. 18-pe-2030	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language English			Module owner 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 modern 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT				
7	Grade bonus compliant to §25 (2)				
8	References <ol style="list-style-type: none"> A.B.Gershman and N.D.Sidiropoulos, Editors, Space-Time Processing for MIMO Communications, Wiley and Sons, 2005. E.G.Larsson and PStoica, Space-Time Block Coding for Wireless Communications, Cambridge University Press, 2003; A.Paulraj, R.Nabar, and D.Gore, Introduction to Space-Time Wireless Communications, Cambridge University Press, 2003. Lin Bai and Jinho Choi, Low Complexity MIMO detectors, Springer, 2012. 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.	Credit Points	Workload	Self study	Duration	Cycle offered
18-kl-2020	6 CP	180 h	120 h	1	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 <ul style="list-style-type: none"> • 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 Deterministic Signals and Systems, Communication Technology I, Mathematics I to IV				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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-v1	Course name Radar Techniques			
	Instructor PD Dr. habil. 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 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) or in a group of 20 students and more a written exam (duration 90 min)				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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-v1	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. 18-zo-2070-se	Course name		
	Instructor Prof. Dr.-Ing. Henning Puder		Type Seminar	SWS 1

Module name Microwave Measurement Technologies					
Module Nr. 18-jk-2090	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. Rolf Jakoby		
1	Content Introduction to microwave measurement technologies, high frequency components and their properties: rf power measurement, spectrum analysis, vector 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 understand the basic principles of microwave measurement technologies. They are able to use them in measurement applications. The following objectives are linked to the lecture: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 45 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 Prof. Dr.-Ing. Rolf Jakoby			Type Lecture	SWS 2
	Course Nr. 18-jk-2090-ue	Course name Microwave Measurement Technologies			
	Instructor Prof. Dr.-Ing. Rolf Jakoby			Type Practice	SWS 1

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

Module name Machine Learning & Energy					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-st-2020	6 CP	180 h	120 h	1	WiSe
Language German			Module owner Prof. Dr. rer. nat. Florian Steinke		
1	<p>Content</p> <p>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.</p> <p>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, ...).</p> <p>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.</p>				
2	<p>Learning objectives / Learning Outcomes</p> <p>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).</p>				
3	<p>Recommended prerequisite for participation</p> <ul style="list-style-type: none"> • 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	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>MSc etit, MSc iST, MSc Wi-etit, MSc CE</p>				
7	<p>Grade bonus compliant to §25 (2)</p> <p>Notenverbesserungen bis zu 0,4 nach APB §25(2) durch Bonus für regelmäßig besuchte Übungs-/Praktikumstermine und mindestens einmaliges Vorrechnen in den Übungen</p>				
8	<p>References</p> <ul style="list-style-type: none"> • 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. techn. Heinz Köppl		
1	<p>Content</p> <p>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.</p> <ul style="list-style-type: none"> • 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	<p>Learning objectives / Learning Outcomes</p> <p>Students are able to interpret and categorize specific engineering problems from the ICT domain in terms of machine learning problems.</p> <p>They are able to reduce such problems to standard machine learning problems and are able to determine suitable solution methods for them.</p> <p>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.</p> <p>They are able to determine the involved computational complexity of a method and choose an appropriate solution algorithms based on application constraints.</p> <p>They are able to apply the acquired methods to other domains, such as data analysis in biomedical engineering, analysis of social network data, etc.</p>				
3	<p>Recommended prerequisite for participation</p> <p>Good command of Matlab (for instance knowledge from course 18-st-2030 Matlab Grundkurs) and engineering mathematics</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>MSc etit, BSc/MSc iST, MSc iCE, MSc CE</p>				

7	Grade bonus compliant to §25 (2)		
8	References <ul style="list-style-type: none"> • 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		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		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		Type Practice
	SWS 1		

Module name Bioinformatics II					
Module Nr. 18-kp-2120	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr. techn. Heinz Köppl		
1	Content <ul style="list-style-type: none"> • Elementary methods of machine learning: Regression, classification, clustering (probabilistic graphical models) • Analysis and visualization of high-dimensional data (multi-dimensional scaling, principal component analysis, embedding methods with deep neural networks, tSNE, UMAP) • Data-driven reconstruction of molecular interaction networks (Bayes nets, solution to Gaussian graphical models, Causality analysis) • Analysis of interaction networks (modularity, graph partitioning, spanning trees, differential networks, network motifs, STRING database, PathBLAST) • Dynamical models of molecular interaction networks (stochastic Markov-modes, differential equations, Reaction rate equation) • Elementary algorithms for structure determination of proteins and RNAs (Secondary structure prediction of RNAs, molecular dynamics, common simulators and force fields) 				
2	Learning objectives / Learning Outcomes After successful completion of this module, students will be familiar with current statistical methods for analyzing high-throughput data in molecular biology. They know how to analyze high-dimensional data by reduction, visualization and clustering and how to find dependencies in these data. They know methods for dynamic description of molecular interactions. They are aware of common methods for structure prediction of biomolecules. Upon completion, students will be able to independently implement the presented algorithms in programming languages, such as Python, R or Matlab. In the area of communicative competence, students have learned to exchange information, ideas, problems and solutions in the field of bioinformatics with experts and with laypersons.				
3	Recommended prerequisite for participation Bioinformatics I				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • 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 11 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100%) 				
6	Usability of this module <i>M.Sc. Biomedical Engineering</i>				
7	Grade bonus compliant to §25 (2)				
8	References				
Courses					

	Course Nr. 18-kp-2120-vl	Course name Bioinformatics II		
	Instructor Prof. Dr. techn. Heinz Köppl		Type Lecture	SWS 2

Module name Terahertz Systems and Applications					
Module Nr. 18-pr-2010	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered SoSe
Language English			Module owner Prof. Dr. rer. nat. Sascha Preu		
1	Content The lecture will give an overview of Terahertz applications, sources and detectors with the focus on semiconductor-based devices and Terahertz systems. Terahertz detection and generation will be discussed in detail for two types of highly important devices: Schottky diodes (mixers, multipliers and rectifiers) and photomixers (photo-diode based and photoconductive). The exercise, where performance parameters of the discussed devices will be derived for experimentally relevant cases, will help to deepen the understanding. The last day will be used for a lab tour showing our measurements facilities and hands-on experiments.				
2	Learning objectives / Learning Outcomes After attending this lecture, the student has gained basic knowledge in the fields of THz generation, detection, systems, and applications of THz radiation, with deepened knowledge in: <ul style="list-style-type: none"> • Working principle, spectra and limits of continuous-wave photomixers • Working principle of Schottky diode mixers/multipliers and rectifiers in the THz range • THz Applications 				
3	Recommended prerequisite for participation Recommended: Bachelor in Electrical engineering, Physics, or Material Science Helpful: Basic knowledge in semiconductor physics, High frequency 1				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) *Oral exam (mandatory)				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Oral Examination, Weighting: 100%) 				
6	Usability of this module MSc etit-KTS, MSc etit-IMNT, MSc etit, MSc iCE				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> • Yun-Shik Lee, „Principles of Terahertz Science and Technology,“ Springer 2009, ISBN 978-0-387-09540-0 • G. Carpintero et al., “Semiconductor Terahertz Technology: Devices and Systems at Room Temperature Operation,“ Wiley 2015, ISBN: 978-1-118-92042-8 				
Courses					
	Course Nr. 18-pr-2010-v1	Course name Terahertz Systems and Applications			
	Instructor Prof. Dr. rer. nat. Sascha Preu			Type Lecture	SWS 2

	Course Nr. 18-pr-2010-ue	Course name Terahertz Systems and Applications		
	Instructor Prof. Dr. rer. nat. Sascha Preu		Type Practice	SWS 1

Module name Microwaves in Biomedical Applications					
Module Nr. 18-jk-2110	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Rolf Jakoby		
1	Content Electromagnetic properties of technical and biological materials on the microscopic and macroscopic level, polarization mechanisms in dielectrics and their applications, interaction between electromagnetic waves and biological tissue; passive microwave circuits with lumped elements (RLC-circuits) and their graphical representation in a smith chart, impedance matching; theory and applications of transmission lines, scattering-matrix formulation of microwave networks (S-parameters) and their characterization based on s-parameters; microwave components for medical applications, biological effects of electromagnetic fields, microwave-based tissue characterization and mimicking of biological tissue dielectric properties (phantoms); heat transfer in tissue from electromagnetic fields, microwave systems for diagnosis and therapy, e.g., radar-based vital signs monitoring and microwave ablation of cancer.				
2	Learning objectives / Learning Outcomes Students are able to understand basic fundamentals of microwave engineering and their application for biomedical applications. The interaction between electromagnetic waves with dielectric and biological materials are known. The students master the mathematical basis of passive RF-circuits and their graphical representation in a smith chart. They are able to apply the transmission line theory to fundamental applications. They can characterize microwave networks in s-parameter representations. The functionality and application of RF-components for biomedicine are known. Students understand the biological effects of electromagnetic fields and are able to derive diagnostic and therapeutic applications.				
3	Recommended prerequisite for participation Fundamentals of electrical engineering				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100%) 				
6	Usability of this module <i>M.Sc. Biomedical Engineering</i>				
7	Grade bonus compliant to §25 (2)				
8	References The script is provided and a list with recommended literature is presented in the lecture.				
Courses					
	Course Nr. 18-jk-2110-vl	Course name Microwaves in Biomedical Applications			
	Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler			Type Lecture	SWS 3
	Course Nr. 18-jk-2110-ue	Course name Microwaves in Biomedical Applications			
	Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler			Type Practice	SWS 1

Module name Sensor Array Processing and Adaptive Beamforming					
Module Nr. 18-pe-2060	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered SoSe
Language English			Module owner Prof. Dr.-Ing. Marius Pesavento		
1	Content This lecture course introduces the principles of modern sensor array processing and adaptive beamforming. Outline: Motivation and background; applications, narrowband and wideband signal model <u>Direction-of-arrival estimation (DoA):</u> traditional methods based on beamforming, super resolution methods, Maximum-Likelihood methods, Subspace based methods, MUSIC, ESPRIT, MODE, root-MUSIC, multidimensional source localization, beamspace processing, array interpolation, partly calibrated arrays, wideband DOA estimation, spatial smoothing, forward-backward averaging, redundancy averaging, correlated sources, minimum redundancy arrays, compressed sensing and sparse reconstruction based DoA estimation, performance bounds <u>Adaptive beamforming:</u> Point-source model, covariance model, Wiener-Hopf equation, Minimum Variance Distortionless Response (MVDR) beamformer, Capon Beamformer, sample matrix inversion, signal self-nulling effect, robust adaptive beamforming, Hung-Turner projection beamformer, Generalized Sidelobe canceller beamformer, Eigenspace-based beamformer, non-stationary environments, modern convex optimization based beamforming, worst-case based beamforming, multiuser beamforming.				
2	Learning objectives / Learning Outcomes Students will standard and modern sensor array processing techniques for source localization and transmit/receive beamforming				
3	Recommended prerequisite for participation Knowledge in linear algebra.				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module BSc / MSc etit, BSc / MSc WI-etit, MSc MEC, MSc iST, MSc iCE				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> Academic Press Library in Signal Processing: Volume 3 Array and Statistical Signal Processing Edited by Rama Chellappa and Sergios Theodoridis, Section 2, Edited by Mats Viberg, Pages 457-967 (2014) <ul style="list-style-type: none"> Chapter 12 - Adaptive and Robust Beamforming, Sergiy A. Vorobyov, Pages 503-552 Chapter 14 - DOA Estimation Methods and Algorithms, Pei-Jung Chung, Mats Viberg, Jia Yu, Pages 599-650 Chapter 15 - Subspace Methods and Exploitation of Special Array Structures, Martin Haardt, Marius Pesavento, Florian Roemer, Mohammed Nabil El Korso, Pages 651-717 Spectral Analysis of Signals, Petre Stoica, Randolph Moses, Prentice Hall, April 2005 Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, Harry L. Van Trees, Wiley Online, 2002. 				
Courses					

	Course Nr. 18-pe-2060-vl	Course name Sensor Array Processing and Adaptive Beamforming		
	Instructor Prof. Dr.-Ing. Marius Pesavento		Type Lecture	SWS 2
	Course Nr. 18-pe-2060-ue	Course name Sensor Array Processing and Adaptive Beamforming		
	Instructor Prof. Dr.-Ing. Marius Pesavento		Type Practice	SWS 1

Module name Graph signal processing, learning and optimization					
Module Nr. 18-pe-2080	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Marius Pesavento		
1	Content The course covers the following topics: <ul style="list-style-type: none"> • Motivation, Applications • Fundamentals <ul style="list-style-type: none"> – definition of graphs, classes of graphs, properties of graphs, signals defined over graphs – Adjacency matrix, Graph Laplacian, Graph shift operator – Covariance matrix, conditional dependence, precision matrix • Graph signal processing <ul style="list-style-type: none"> – Consensus, Diffusion – Graph spectral analysis, Graph Fourier Transform – Total variational norm, Graph Frequencies – Bandlimited graph signals, smoothness – Graph filters, Graph sampling theorem – Applications • Network topology inference <ul style="list-style-type: none"> – Link prediction – Association network inference – Tomographic network topology inference – Pearson product-moment correlation – Causality, Partial correlation – Conditional independence graph – Gaussian Markov Random Fields – Graphical LASSO, Graphical LASSO with Laplacian constraint – Applications • Graph analysis <ul style="list-style-type: none"> – Subgraph identification – Cliques identification • Optimization over graphs <ul style="list-style-type: none"> – Average consensus, diffusion, exact diffusion – Gradient tracking, push-sum algorithm, etc. – Applications • Graph neuronal (convolutional) network 				
2	Learning objectives / Learning Outcomes Graph signal processing (i.e., processing of signals defined over graphs) and network analysis form an interdisciplinary research area with many diverse applications. The course provides a systematic introduction to the theory of graph signal processing, graphical network analysis, graph topology learning, optimization over graphs and learning with graph neuronal networks. In this course the students will learn the main concepts, algorithms and application areas that are fundamental in graph signal processing.				
3	Recommended prerequisite for participation Basic knowledge in linear algebra and matrix analysis.				
4	Form of examination				

	<p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) <p>In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 20 students register in semesters in which the lecture does not take place, there will be an oral examination (duration: 20 min.). The type of examination will be announced within one working weeks after the end of the examination registration phase.</p>		
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100%) 		
6	<p>Usability of this module</p>		
7	<p>Grade bonus compliant to §25 (2)</p>		
8	<p>References</p> <ul style="list-style-type: none"> • Lecture notes and slides can be downloaded here: <ul style="list-style-type: none"> – www.nts.tu-darmstadt.de – moodle • Further reading: <ul style="list-style-type: none"> – Petar M. Djuric, Cédric Richard, Cooperative and Graph Signal Processing, Academic Press, 2018, ISBN 9780128136775. 		
Courses			
	Course Nr. 18-pe-2080-vl	Course name Graph signal processing, learning and optimization	
	Instructor Prof. Dr.-Ing. Marius Pesavento		Type Lecture
			SWS 3
	Course Nr. 18-pe-2080-ue	Course name Graph signal processing, learning and optimization	
	Instructor Prof. Dr.-Ing. Marius Pesavento		Type Practice
			SWS 1

Module name Robust Signal Processing With Biomedical Applications					
Module Nr. 18-zo-2090	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language English			Module owner Dr.-Ing. Michael Muma		
1	<p>Content</p> <p>1. Robust Signal Processing and Learning</p> <ul style="list-style-type: none"> • Measuring robustness • Robust estimation of the mean and the variance • Robust regression models • Robust filtering • Robust location and covariance estimation • Robust clustering and classification • Robust time-series and spectral analysis <p>2. Biomedical Applications</p> <ul style="list-style-type: none"> • Body-worn sensing of physiological parameters • Electrocardiogram (ECG) • Photoplethysmogram (PPG) • Eye research • Intracranial Pressure (ICP) • Algorithms for cardiac activity monitoring <p>The lecture covers fundamental topics and recent developments in robust signal processing. Unlike classical signal processing, which relies strongly on the normal (Gaussian) distribution, robust methods can tolerate impulsive noise, outliers and artifacts that are frequently encountered in biomedical applications. Robust signal processing and biomedical application lectures alternate. Exercises revise the theory and apply robust signal processing algorithms to real world data.</p>				
2	<p>Learning objectives / Learning Outcomes</p> <p>Students understand the basics of robust signal processing and data science and are able to apply them to a variety of problems. They are familiar with various biomedical applications and know the causes of artifacts, outliers and impulsive noise. They can apply algorithms for robust regression, cluster analysis, classification and spectral analysis.</p>				
3	<p>Recommended prerequisite for participation</p> <p>Fundamental knowledge of statistical signal processing</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100%) 				
6	<p>Usability of this module</p> <p>MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST</p>				
7	<p>Grade bonus compliant to §25 (2)</p>				
8	<p>References</p>				

A manuscript and lecture slides can be downloaded via Moodle. Further reading

- Zoubir, A. M. and Koivunen, V. and Ollila, E. and Muma, M.: Robust Statistics for Signal Processing. Cambridge University Press, 2018.
- Zoubir, A. M. and Koivunen, V. and Chackchoukh J, and Muma, M. Robust Estimation in Signal Processing: A Tutorial-Style Treatment of Fundamental Concepts. IEEE Signal Proc. Mag. Vol. 29, No. 4, 2012, pp. 61-80.
- Huber, P. J. and Ronchetti, E. M.: Robust Statistics. Wiley Series in Probability and Statistics, 2009.
- Maronna, R. A. and Martin, R. D. and Yohai, V. J.: Robust Statistics: Theory and Methods. Wiley Series in Probability and Statistics, 2006.

Courses

Course Nr. 18-zo-2090-vl	Course name Robust Signal Processing With Biomedical Applications		
Instructor Dr.-Ing. Michael Muma		Type Lecture	SWS 3
Course Nr. 18-zo-2090-ue	Course name Robust Signal Processing With Biomedical Applications		
Instructor Dr.-Ing. Michael Muma		Type Practice	SWS 1

Module name Data Science I					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-zo-2110	5 CP	150 h	90 h	1	SoSe
Language			Module owner		
English			Prof. Dr.-Ing. Abdelhak Zoubir		
1	Content The course covers the following topics: <ul style="list-style-type: none"> • Python programming basics • Data science introduction • Data storage and formats • Data exploration and visualization • Statistical methods and inference <ul style="list-style-type: none"> – Descriptive statistics (uni & bivariate) – Inferential statistics • Feature extraction <ul style="list-style-type: none"> – Time Series Data – Image data – Audio data • Statistical learning <ul style="list-style-type: none"> – Cross-validation, overfitting, annotation – Regression – Classification 				
2	Learning objectives / Learning Outcomes The course provides a full introduction to data science with an emphasis on hands-on examples. Students will acquire relevant knowledge of the whole data science chain: From storage/acquisition to statistical inference to visualization. It also serves as an introductory course to the Data Science project seminar.				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • 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 16 students register, the examination will be an oral examination (duration: 45 min.). The type of examination will be announced in the beginning of the lecture.				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100%) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2) Yes				
8	References				

- Lecture notes and slides can be downloaded here:
 - <http://www.spg.tu-darmstadt.de>
 - moodle
- Further reading:
 - Wes McKinney: Python for Data Analysis, O'Reilly, 2017
 - Christopher M. Bishop: Pattern Recognition and Machine Learning, 2011
 - James, Witten, Hastie and Tibshirani, Introduction to Statistical Learning, Springer, 2017

Courses

	Course Nr. 18-zo-2110-vl	Course name Data Science I		
	Instructor Dr.-Ing. Christian Debes		Type Lecture	SWS 2
	Course Nr. 18-zo-2110-ue	Course name Data Science I		
	Instructor Dr.-Ing. Christian Debes		Type Practice	SWS 2

Module name Fundamentals of Reinforcement Learning					
Module Nr. 18-kl-2070	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered SoSe
Language English			Module owner Prof. Dr.-Ing. Anja Klein		
1	Content <ul style="list-style-type: none"> Review of Probability Theory Markov Property and Markov Decision Processes The Multi-Armed Bandit Problem vs. the Full Reinforcement Learning Problem Taxonomy of Multi-Armed Bandit Problems (e.g., Stochastic vs. Adversarial Rewards, Contextual MAB) Algorithms for Multi-Armed Bandit Problems (e.g., Upper Confidence Interval (UCB), Epsilon-Greedy, SoftMax, LinUCB) and their Application to Cyber-Physical Networking Fundamentals of Dynamic Programming and Bellman Equations Taxonomy of Approaches for the Full Reinforcement Learning Problem (e.g., Temporal-Difference Learning, Policy Gradient and Actor-Critic) Algorithms for the Full Reinforcement Learning Problem (e.g., Q-Learning, SARSA, Policy Gradient, Actor-Critic) and their Application to Cyber-Physical Networking Linear Function Approximation Non-linear Function Approximation 				
2	Learning objectives / Learning Outcomes The students are able to <ul style="list-style-type: none"> define the Markov property and identify the elements that constitute a Markov decision process. They will be able to use these concepts to model decision-making problems in Cyber-Physical Networking. determine the characteristics of the Multi-Armed Bandit (MAB) Problem and compare them to the characteristics of the Full Reinforcement Learning (RL) Problem. determine under which conditions the MAB or the full RL formulation should be used to solve decision-making problems. differentiate the main MAB strategies, e.g., Upper Confidence Interval (UCB), Epsilon-Greedy and Softmax. choose appropriate MAB strategies for the solution of MAB problems. formulate and solve Contextual-MAB problems. determine under which conditions Dynamic Programming can be used to solve decision-making problems. explain the difference between Dynamic Programming and RL methods. differentiate between Temporal-Difference, Policy Gradient and Actor-Critic RL techniques. identify the limitations of MAB and full RL problems. explain the need for generalization in MAB and full RL problems. choose appropriate approximation techniques and use them in combination with MAB and full RL strategies. apply algorithmic techniques to solve MAB and full RL problems and obtain valid solutions. judge the reasonableness and consistency of the obtained solutions. 				
3	Recommended prerequisite for participation <ul style="list-style-type: none"> Python or Matlab: basic knowledge Engineering mathematics and probability theory 				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written/Oral Examination, Duration: 60 min, Standard Grading System) 				

	The examination takes place in form of a written exam (duration: 60 minutes). If one can estimate that less than 21 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.		
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100%) 		
6	Usability of this module M.Sc. etit: AUT & KTS, M.Sc. ICE, B.Sc. / M.Sc. iST, M.Sc. WI-etit, M.Sc. MEC		
7	Grade bonus compliant to §25 (2)		
8	References <ul style="list-style-type: none"> • Richard S. Sutton and Andrew G. Barto, “Reinforcement Learning: An Introduction”, A Bradford Book, Cambridge, MA, USA, 2018. • Aleksandrs Slivkins, “Introduction to Multi-Armed Bandits”, Foundations and Trends in Machine Learning, Vol. 12: No. 1-2, 2019. 		
Courses			
	Course Nr. 18-kl-2070-vl	Course name Fundamentals of Reinforcement Learning	
	Instructor Dr. rer. nat. Sabrina Klos, Dr.-Ing. Andrea Patricia Ortiz Jimenez		Type Lecture
			SWS 2
	Course Nr. 18-kl-2070-ue	Course name Fundamentals of Reinforcement Learning	
	Instructor Dr. rer. nat. Sabrina Klos, Dr.-Ing. Andrea Patricia Ortiz Jimenez		Type Practice
			SWS 1

1.4.2.2 KTS - Labs, Project Seminars, and Seminars (open catalogue)

Module name Laboratory Communication and Sensor Systems					
Module Nr. 18-kt-2010	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: <ul style="list-style-type: none"> • Communications • Microwave Engineering • Digital Signal Processing 				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-kt-2010-pr	Course name Laboratory Communication and Sensor Systems		
	Instructor Prof. Dr.-Ing. Rolf Jakoby, Prof. Dr.-Ing. Anja Klein, Dr.-Ing. Martin Schüßler, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento, Prof. Dr. rer. nat. Sascha Preu, Prof. Dr.-Ing. Herbert De Gersem		Type Internship	SWS 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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, M.Sc. Sumedh Dongare			Type Project Seminar	SWS 4

Module name Project Seminar Advanced μ Wave 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 <ul style="list-style-type: none"> • 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 discuss 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 μ Wave Components & Antennas			
	Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler			Type Project Seminar	SWS 4

Module name Project Seminar Emerging Topics in Sensor Array and Multichannel Processing					
Module Nr. 18-pe-2040	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Marius Pesavento		
1	Content This project-seminar addresses new trends in sensor array and multichannel processing with multidimensional tensor data representations. The specific thematic focus of the seminar will be adapted from year to year according to the latest trends in the research field. The topics will be announced on the course website well in advance.				
2	Learning objectives / Learning Outcomes Students will understand theory, algorithms and applications of sensor array and multichannel system.				
3	Recommended prerequisite for participation Basic knowledge in linear algebra.				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Oral Examination, Duration: 40 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 Harry L. Van Trees, Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, John Wiley & Sons, 2002. References include the latest scientific publications, seminars and books.				
Courses					
	Course Nr. 18-pe-2040-pj	Course name Project Seminar Emerging Topics in Sensor Array and Multichannel Processing			
	Instructor Prof. Dr.-Ing. Marius Pesavento, M.Sc. David Schenck			Type Project Seminar	SWS 4

Module name Project Seminar Emerging topics in MIMO Communication Networks					
Module Nr. 18-pe-2050	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 addresses new trends in MIMO communications for the next generation of wireless communication systems. The specific thematic focus of the seminar will be adapted from year to year according to the latest trends in wireless communications. The topics will be announced on the course website well in advance.				
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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Oral Examination, Duration: 40 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 References include the latest scientific publications, seminars and books.				
Courses					
	Course Nr. 18-pe-2050-pj	Course name Project Seminar Emerging Topics in MIMO Communication Networks			
	Instructor Prof. Dr.-Ing. Marius Pesavento			Type Project Seminar	SWS 4

Module name International Summer School 'Microwaves and Lightwaves'					
Module Nr. 18-pr-2020	Credit Points 4 CP	Workload 120 h	Self study 90 h	Duration 1	Cycle offered SoSe
Language English			Module owner Prof. Dr. rer. nat. Sascha Preu		
1	Content This summer school covers the fundamentals and the latest developments 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 presented research topics, e.g. <ul style="list-style-type: none"> • topics of microwave engineering, THz engineering, and optical communications • of related electronics • 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 or slides can be downloaded.				
Courses					
	Course Nr. 18-pr-2020-se	Course name International Summer School "Microwaves and Lightwaves"			
	Instructor Prof. Dr. rer. nat. Sascha Preu, Prof. Dr.-Ing. Rolf Jakoby			Type Seminar	SWS 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 English			Module owner 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System) Exam (Duration: 120 min) and a Report (Lab Reports), Details will be announced at the beginning of the lecture.				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-zo-2030-pr	Course name Digital Signal Processing Lab			
	Instructor Prof. Dr.-Ing. Abdelhak Zoubir			Type Internship	SWS 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 English			Module owner Prof. Dr.-Ing. Abdelhak Zoubir		
1	<p>Content</p> <p>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.</p> <p>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 Maximum Likelihood Estimators Sufficiency and the Fisher-Neyman/Factorisation Criterion Unbiasedness and Minimum variance Fisher Information and the CRB Asymptotic properties of the MLE</p>				
2	<p>Learning objectives / Learning Outcomes</p> <p>Students gain deeper knowledge in signal processing based on the fundamentals taught in DSP and ETiT 4. They 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 depth 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 career.</p>				
3	<p>Recommended prerequisite for participation</p> <p>DSP, general interest in signal processing</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Weighting: 100 %) 				
6	<p>Usability of this module</p> <p>MSc ETiT, MSc iST, MSc iCE, Wi-ETiT</p>				
7	<p>Grade bonus compliant to §25 (2)</p>				
8	<p>References</p>				

- 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	

Module name Computational Modeling for the IGEM Competition					
Module Nr. 18-kp-2100	Credit Points 4 CP	Workload 120 h	Self study 90 h	Duration 1	Cycle offered WiSe/SoSe
Language English			Module owner Prof. Dr. techn. Heinz Köppl		
1	Content <p>The International Genetically Engineered Machine (IGEM) competition is a yearly international student competition in the domain of synthetic biology, initiated and hosted by the Massachusetts Institute of Technology (MIT), USA since 2004. In the past years teams from TU Darmstadt participated and were very successfully in the competition. This seminar provides training for students and prospective IGEM team members in the domain of computational modeling of biomolecular circuits. The seminar aims at computationally inclined students from all background, but in particular from electrical engineering, computer science, physics and mathematics. Seminar participants that are interested to become IGEM team members could later team up with biologists and biochemists for the 2017 IGEM project of TU Darmstadt and be responsible for the computational modeling part of the project.</p> <p>The seminar will cover basic modeling approaches but will focus on discussing and presenting recent high-impact synthetic biology research results and past IGEM projects in the domain of computational modeling.</p>				
2	Learning objectives / Learning Outcomes <p>Students that successfully passed that seminar should be able to perform practical modeling of biomolecular circuits that are based on transcriptional and translational control mechanism of gene expression as used in synthetic biology. This relies on the understanding of the following topics:</p> <ul style="list-style-type: none"> • Differential equation models of biomolecular processes • Markov chain models of biomolecular processes • Use of computational tools for the composition of genetic parts into circuits • Calibration methods of computational models from experimental measurement • Use of bioinformatics and database tools to select well-characterized genetic parts 				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Weighting: 100 %) 				
6	Usability of this module BSc etit, MSc etit				
7	Grade bonus compliant to §25 (2)				
8	References				
Courses					
	Course Nr. 18-kp-2100-se	Course name Computational Modeling for the IGEM Competition			
	Instructor Prof. Dr. techn. Heinz Köppl			Type Seminar	SWS 2

Module name European Microwave School					
Module Nr. 18-jk-2080	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Rolf Jakoby		
1	Content Introduction to radar technologies and techniques Radar RF fronts Radarsignal processing Application of radar systems in automobiles, in industrial environments Radar systems for space applications				
2	Learning objectives / Learning Outcomes The programme is designed to lay the foundations, both mathematically as well as conceptually, for microwave measurements. It will enable a fundamental understanding of high frequency measurement techniques, and will prepare students to become intelligent users of commercial microwave measurement devices.				
3	Recommended prerequisite for participation Attending the seminar in Nürnberg (!) is mandatory. Fundamentals of communication theory and techniques, Microwave Engineering I				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Oral Examination, Weighting: 100%) 				
6	Usability of this module BSc ETiT				
7	Grade bonus compliant to §25 (2)				
8	References A handout will be provided during the seminar. Homepage: http://www.eumweek.com/students/studentschool.html				
Courses					
	Course Nr. 18-jk-2080-se	Course name European Microwave School			
	Instructor PD Dr. habil. Holger Maune, Prof. Dr.-Ing. Rolf Jakoby			Type Seminar	SWS 2

Module name Biomedical Microwave-Theranostics: Sensors and Applicators					
Module Nr. 18-jk-2120	Credit Points 6 CP	Workload 180 h	Self study 135 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Rolf Jakoby		
1	Content Application of biomedical sensors based on electromagnetic waves and their advantages. Fundamentals of microfluidics as tool for microwave-based sensing of fluids, electroporation; diagnostic and therapeutic applications of microwaves, microwave applicators for imaging, diagnosis and treatment; computer-based methods for field propagation in biological tissues and those applications. Work on a current scientific issue with individual supervision.				
2	Learning objectives / Learning Outcomes Students understand the physical basics of microwave-based sensors for biomedicine. They are able to derive the advantages of the use of microwaves compared to other technologies. They know fields of applications concerning microwave-based diagnostics and treatments and can handle the physical context of used applicators. Practical examples lead to strengthening these abilities. Students know computer-based simulation tools for the design and characterization of microwave applicators. They gained experience while working on a practical example with such a simulation software. Students are able to solve manageable scientific problems within the frame of a coordinated project work. They can summarize the current state of the art and write a scientific paper about it. The results are presented and discussed in a final presentation.				
3	Recommended prerequisite for participation Biomedical Microwave Engineering				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) The type of examination will be announced in the first lecture. Possible types include presentation (10 minutes) and an oral examination (30 minutes).				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Oral Examination, Weighting: 100 %) 				
6	Usability of this module <i>M.Sc. Biomedical Engineering</i>				
7	Grade bonus compliant to §25 (2)				
8	References Necessary publications and recommended literature as well as simulation software tools are provided.				
Courses					
	Course Nr. 18-jk-2120-pj	Course name Biomedical Microwave-Theranostics: Sensors and Applicators			
	Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler			Type Project Seminar	SWS 3

Module name Advanced Topics in Statistical Signal Processing					
Module Nr. 18-zo-2040	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Abdelhak Zoubir		
1	Content This course extends the signal processing fundamentals taught in DSP towards advanced topics that are the subject of current research. It is aimed at those with an interest in signal processing and a desire to extend their knowledge of signal processing theory in preparation for future project work (e.g. Diplomarbeit) and their working careers. This course consists of a series of five lectures followed by a supervised research seminar during two months approximately. The final evaluation includes students seminar presentations and a final exam. The main topics of the Seminar are: <ul style="list-style-type: none"> • Estimation Theory • Detection Theory • Robust Estimation Theory • Seminar projects: e.g. Microphone array beamforming, Geolocation and Tracking, Radar Imaging, Ultrasound Imaging, Acoustic source localization, Number of sources detection. 				
2	Learning objectives / Learning Outcomes Students obtain advanced knowledge in signal processing based on the fundamentals taught in DSP and ETiT 4. They will study advanced topics in statistical signal processing that are subject to current research. The acquired skills will be useful for their future research projects and professional careers.				
3	Recommended prerequisite for participation DSP, general interest in signal processing is desirable.				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Weighting: 100%) 				
6	Usability of this module MSc ETiT, BSc/MSc iST, MSc iCE, Wi-ETiT				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> • L. L. Scharf, Statistical Signal Processing: Detection, Estimation, and Time Series Analysis (New York: Addison-Wesley Publishing Co., 1990). • S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory (Book 1), Detection Theory (Book 2). • R. A. Maronna, D. R. Martin, V. J. Yohai, Robust Statistics: Theory and Methods, 2006. 				
Courses					
	Course Nr. 18-zo-2040-se	Course name Advanced Topics in Statistical Signal Processing			
	Instructor Prof. Dr.-Ing. Abdelhak Zoubir			Type Seminar	SWS 4

Module name Robust and Biomedical Signal Processing					
Module Nr. 18-zo-2100	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Abdelhak Zoubir		
1	<p>Content</p> <p>A series of 3 lectures provides the necessary background on robust signal processing and machine learning:</p> <ul style="list-style-type: none"> • Background on robust signal processing • Robust regression and robust filters for artifact cancellation • Robust location and covariance estimation and classification <p>They are followed by two lectures on selected biomedical applications, such as:</p> <ul style="list-style-type: none"> • Body-worn sensing of physiological parameters • Optical heart rate sensing (PPG) • Signal processing for the electrocardiogram (ECG) • Biomedical image processing <p>Students then work in groups to apply robust signal processing algorithms to real-world biomedical data. Depending on the application, the data is either recorded by the students, or provided to them. The group results are presented during a 20-minute presentation. The final assessment is based on the presentation and an oral examination.</p>				
2	Learning objectives / Learning Outcomes				
3	Recommended prerequisite for participation Fundamental knowledge of statistical signal processing				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Study Achievement, 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	<p>References</p> <ul style="list-style-type: none"> • Slides can be downloaded via Moodle. <p>Further reading:</p> <ul style="list-style-type: none"> • Zoubir, A. M. and Koivunen, V. and Ollila, E. and Muma, M.: Robust Statistics for Signal Processing. Cambridge University Press, 2018. • Zoubir, A. M. and Koivunen, V. and Chackchoukh J, and Muma, M. Robust Estimation in Signal Processing: A Tutorial-Style Treatment of Fundamental Concepts. IEEE Signal Proc. Mag. Vol. 29, No. 4, 2012, pp. 61-80. • Huber, P. J. and Ronchetti, E. M.: Robust Statistics. Wiley Series in Probability and Statistics, 2009. • Maronna, R. A. and Martin, R. D. and Yohai, V. J.: Robust Statistics: Theory and Methods. Wiley Series in Probability and Statistics, 2006. 				

Courses			
	Course Nr. 18-zo-2100-se	Course name Robust and Biomedical Signal Processing	
	Instructor Dr.-Ing. Michael Muma	Type Seminar	SWS 4

Module name Data Science II					
Module Nr. 18-zo-2120	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered WiSe
Language English			Module owner Prof. Dr.-Ing. Abdelhak Zoubir		
1	Content The course covers the following topics: <ul style="list-style-type: none"> • Data Science Advanced Methods • Data Management + Big data frameworks • Statistical Learning <ul style="list-style-type: none"> – Recommender Systems – Deep Learning – Unsupervised Learning – Text data analysis • Final application project. Flexibility to choose from list of projects or come up with own project. Examples: <ul style="list-style-type: none"> – Sound classification – Heart rate analysis – Activity recognition with acceleration data – Hyperspectral data – Image classification – Health survey 				
2	Learning objectives / Learning Outcomes This seminar provides an advanced understanding of data science with an emphasis on hands-on projects. Students will get to know latest data science technologies – from big data to advanced machine learning and apply them in a real-world project.				
3	Recommended prerequisite for participation Data Science I (Lecture)				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, 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 14 students register, there will be an oral examination (duration: 45 min.). The type of examination will be announced in the first lecture. Possible types include a project presentation, etc.				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100%) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2)				
8	References				

Lecture notes and slides can be downloaded here:

- <http://www.spg.tu-darmstadt.de>
- Moodle platform

Further reading:

- Wes McKinney: Python for Data Analysis, O'Reilly, 2017
- Christopher M. Bishop: Pattern Recognition and Machine Learning, 2011
- James, Witten, Hastie and Tibshirani, Introduction to Statistical Learning, Springer, 2017

Courses

	Course Nr. 18-zo-2120-se	Course name Data Science II		
	Instructor Dr.-Ing. Christian Debes		Type Seminar	SWS 4

Module name					
Artificial Intelligence in Medicine Challenge					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-ha-2010	8 CP	240 h	180 h	1	WiSe/SoSe
Language			Module owner		
German			Prof. Dr.-Ing. Christoph Hoog Antink		
1	Content Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.				
2	Learning objectives / Learning Outcomes Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.				
3	Recommended prerequisite for participation <ul style="list-style-type: none"> • Basic programming skills in Python • 18-zo-1030 Fundamentals of Signal Processing 				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture. 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100%) 				
6	Usability of this module BSc/MSc (WI-)etit, AUT, DT, KTS BSc/MSc iST MSc iCE				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> • Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001. • Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006. 				
Courses					
Course Nr.	Course name				
18-ha-2010-pj	Artificial Intelligence in Medicine Challenge				
Instructor				Type	SWS
Prof. Dr.-Ing. Christoph Hoog Antink				Project 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • 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. 18-bu-2010	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language German			Module owner 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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			Type Lecture	SWS 2
	Course Nr. 18-bu-2010-ue	Course name Microsystem Technology			
	Instructor Prof. Ph.D. Thomas Peter Burg			Type Practice	SWS 1

Module name Advanced Digital Integrated Circuit Design					
Module Nr. 18-ho-2010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered WiSe
Language English			Module owner 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, Synchronous 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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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

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 SAE - Specialization

1.5.2.1 SAE - Lectures (open catalogue)

Module name Lighting Technology I					
Module Nr. 18-kh-2010	Credit Points 5 CP	Workload 150h	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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-kh-2010-vl	Course name Lighting Technology I			
	Instructor Prof. Dr.-Ing. Khanh Quoc Tran			Type Lecture	SWS 2
	Course Nr. 18-kh-2010-pr	Course name Lighting Technology I			
	Instructor Prof. Dr.-Ing. Khanh Quoc Tran			Type Internship	SWS 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. Being 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 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 lighting. Description of the used lighting sources and the function of these (lowbeam, highbeam, bending light, stop lamp, daytime running light...), visual 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 planned 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 German			Module owner 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> Slide set of lecture Skript of lecture Textbook Tränkler „Sensortechnik“, Springer Textbook Tietze/Schenk „Halbleiterschaltungstechnik“, Springer 				
Courses					
	Course Nr. 18-kn-2130-vl	Course name Sensor Signal Processing			
	Instructor Prof. Dr. Mario Kupnik			Type Lecture	SWS 2

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 <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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 activities 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Oral exam 30 min				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 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: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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. 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. 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: <ul style="list-style-type: none"> • Explain the basics of continuum mechanical 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: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Written exam 120 min				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 exercise 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 Robust Signal Processing With Biomedical Applications					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-zo-2090	6 CP	180 h	120 h	1	SoSe
Language English			Module owner Dr.-Ing. Michael Muma		
1	<p>Content</p> <p>1. Robust Signal Processing and Learning</p> <ul style="list-style-type: none"> • Measuring robustness • Robust estimation of the mean and the variance • Robust regression models • Robust filtering • Robust location and covariance estimation • Robust clustering and classification • Robust time-series and spectral analysis <p>2. Biomedical Applications</p> <ul style="list-style-type: none"> • Body-worn sensing of physiological parameters • Electrocardiogram (ECG) • Photoplethysmogram (PPG) • Eye research • Intracranial Pressure (ICP) • Algorithms for cardiac activity monitoring <p>The lecture covers fundamental topics and recent developments in robust signal processing. Unlike classical signal processing, which relies strongly on the normal (Gaussian) distribution, robust methods can tolerate impulsive noise, outliers and artifacts that are frequently encountered in biomedical applications. Robust signal processing and biomedical application lectures alternate. Exercises revise the theory and apply robust signal processing algorithms to real world data.</p>				
2	<p>Learning objectives / Learning Outcomes</p> <p>Students understand the basics of robust signal processing and data science and are able to apply them to a variety of problems. They are familiar with various biomedical applications and know the causes of artifacts, outliers and impulsive noise. They can apply algorithms for robust regression, cluster analysis, classification and spectral analysis.</p>				
3	<p>Recommended prerequisite for participation</p> <p>Fundamental knowledge of statistical signal processing</p>				
4	<p>Form of examination</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System) 				
5	<p>Grading</p> <p>Module Final Examination:</p> <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100%) 				
6	<p>Usability of this module</p> <p>MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST</p>				
7	<p>Grade bonus compliant to §25 (2)</p>				
8	<p>References</p>				

A manuscript and lecture slides can be downloaded via Moodle. Further reading

- Zoubir, A. M. and Koivunen, V. and Ollila, E. and Muma, M.: Robust Statistics for Signal Processing. Cambridge University Press, 2018.
- Zoubir, A. M. and Koivunen, V. and Chackchoukh J, and Muma, M. Robust Estimation in Signal Processing: A Tutorial-Style Treatment of Fundamental Concepts. IEEE Signal Proc. Mag. Vol. 29, No. 4, 2012, pp. 61-80.
- Huber, P. J. and Ronchetti, E. M.: Robust Statistics. Wiley Series in Probability and Statistics, 2009.
- Maronna, R. A. and Martin, R. D. and Yohai, V. J.: Robust Statistics: Theory and Methods. Wiley Series in Probability and Statistics, 2006.

Courses

Course Nr. 18-zo-2090-vl	Course name Robust Signal Processing With Biomedical Applications		
Instructor Dr.-Ing. Michael Muma		Type Lecture	SWS 3
Course Nr. 18-zo-2090-ue	Course name Robust Signal Processing With Biomedical Applications		
Instructor Dr.-Ing. Michael Muma		Type Practice	SWS 1

1.5.2.2 SAE - Seminars, Labs, and Project Seminars (open catalogue)

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 independently.				
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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-bu-2125-pj	Course name Product Development Methodology III			
	Instructor Prof. Ph.D. Thomas Peter Burg, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik			Type Project Seminar	SWS 3

Module name Electromechanical Systems Lab					
Module Nr. 18-kn-2090	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered SoSe
Language German			Module owner 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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 Electromechanical Systems Lab			
	Instructor Prof. Dr. Mario Kupnik			Type Internship	SWS 3
	Course Nr. 18-kn-2090-ev	Course name Electromechanical Systems Lab - Introduction			
	Instructor Prof. Dr. Mario Kupnik			Type Introductory Course	SWS 0

Module name Project Seminar Electromagnetic CAD					
Module Nr. 18-sc-1020	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. rer. nat. Sebastian Schöps		
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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-sc-1020-pj	Course name Project Seminar Electromagnetic CAD			
	Instructor Prof. Dr. rer. nat. Sebastian Schöps			Type Project Seminar	SWS 4

Module name Project Seminar Design for Testability					
Module Nr. 18-ho-2130	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 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ho-2130-pj	Course name Project Seminar Design for Testability			
	Instructor Prof. Dr.-Ing. Klaus Hofmann			Type Project Seminar	SWS 3

Module name Seminar Integrated Electronic Systems Design A					
Module Nr. 18-ho-2160	Credit Points 4 CP	Workload 120 h	Self study 90 h	Duration 1	Cycle offered WiSe/SoSe
Language English			Module owner 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 <ul style="list-style-type: none"> • gain a deep understanding of the chosen research subject in the field of integrated electronic systems, • write an essay on the chosen subject in a comprehensive 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 45 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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 Circuits 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: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • 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. 18-ho-1090	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 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-ho-1090-pr	Course name HDL Lab			
	Instructor Prof. Dr.-Ing. Klaus Hofmann			Type Internship	SWS 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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

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 English			Module owner 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: <ul style="list-style-type: none"> Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System) Exam (Duration: 120 min) and a Report (Lab Reports), Details will be announced at the beginning of the lecture.				
5	Grading Module Final Examination: <ul style="list-style-type: none"> 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. 18-zo-2030-pr	Course name Digital Signal Processing Lab			
	Instructor Prof. Dr.-Ing. Abdelhak Zoubir			Type Internship	SWS 3