Complete Catalogue of all modules FB 18 Electrical Engineering and Information Technology

Module manual
Date: 01.10.2020

TECHNISCHE UNIVERSITÄT DARMSTADT

Department of Electrical Engineering and Information Technology

Module manual: Complete Catalogue of all modules FB 18 Electrical Engineering and Information Technology

Date: 01.10.2020

Department of Electrical Engineering and Information Technology
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Contents

1 Bachelor

1.1 Lectures

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System Dynamics and Automatic Control Systems II</td></tr>
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18-ad-1010</td><td>Credit Points
7 CP</td><td>Workload
210 h</td><td>Self study
135 h</td><td>Duration
1</td><td colspan="2">Cycle offered
SoSe</td></tr>
<tr><td colspan="4">Language
German</td><td colspan="4">Module owner
Prof. Dr.-Ing. Jürgen Adamy</td></tr>
<tr><td>1</td><td colspan="7">Content
Main topics covered are:
Root locus method (construction and application),
State space representation of linear systems (representation, time solution, controllability, observability, observer- based controller design)</td></tr>
<tr><td>2</td><td colspan="7">Learning objectives / Learning Outcomes
After attending the lecture, a student is capable of:
constructing and evaluating the root locus of given systems
describing the concept and importance of the state space for linear systems
defining controllability and observability for linear systems and being able to test given systems with respect to these properties
stating controller design methods using the state space, and applying them to given systems
applying the method of linearization to non-linear systems with respect to a given operating point</td></tr>
<tr><td>3</td><td colspan="7">Recommended prerequisite for participation
System Dynamics and Control Systems I</td></tr>
<tr><td>4</td><td colspan="7">Form of examination
Module Final Examination:
Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)</td></tr>
<tr><td>5</td><td colspan="7">Grading
Module Final Examination:
Module Examination (Technical Examination, Written Examination, Weighting: 100 %)</td></tr>
<tr><td>6</td><td colspan="7">Usability of this module
BSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik</td></tr>
<tr><td>7</td><td colspan="7">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td colspan="7">References
Adamy: Systemdynamik und Regelungstechnik II, Shaker Verlag (available for purchase at the FG office)
http://www.rtr.tu-darmstadt.de/lehre/e-learning (optionales Material)</td></tr>
<tr><td colspan="8">Courses</td></tr>
</table>

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

Module name Programming in Automatic Control (C/C++)					
Module Nr. 18-ad-1020	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** Programming in LINUX, Makefiles, C - Programming (Program structures in C, pointer, developer environment and debugger), C++ (object oriented programming)
2	**Learning objectives / Learning Outcomes** After attending the lecture, a student is capable of: 1. operating LINUX computers, 2. assembling and using makefiles, 3. recalling and applying the syntax for standard C-blocks, 4. explaining and applying the use of pointers, 5. explaining the concept of object oriented programming in C++
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc iST, MSc MEC, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Adamy: Lecture notes

Courses

Course Nr.	**Course name**		
18-ad-1020-vl	Programming in Automatic Control (C/C++)		
Instructor		**Type**	**SWS**
Dr.-Ing. Volker Willert		Lecture	1
Course Nr.	**Course name**		
18-ad-1020-ue	Programming in Automatic Control (C/C++)		
Instructor		**Type**	**SWS**
Dr.-Ing. Volker Willert		Practice	1

Module name					
Electrical Power Engineering					
Module Nr. 18-bi-1010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** The lecture gives an introduction to the technical processes for the use of energy for the human civilization in general and to the basic tasks and challenges of the electrical energy in particular. Biochemical energy processes such as the human metabolism are therefore not subject of the course. First, the physical basics of the term “energy” are repeated and the different forms of energy (mechanical, thermal, electromagnetic, chemical and nuclear) are explained in terms of the technical use of energy as heat, mechanical movement and electricity. Then, an overview of the energy resources is given, starting from the solar radiation and its direct and indirect impact, such as the solar heat and the motion of air mass, surface water and sea waves. Next, the energy source of biomass due to solar radiation and the fossil energy sources oil, natural gas and coal will be discussed. The energy sources of nuclear fission (uranium deposits) and nuclear fusion (heavy water), and geothermal energy due to nuclear effects in the Earth’s interior are explained as well as the tidal effects caused by planetary motion. The increasing energy demand of the rapidly growing world population and the geographic distribution of energy sources (deposits, acreage, solar radiation, wind maps, tidal currents, ...) are described. The resulting energy flows on transport routes such as pipelines, waterways, ..., are briefly presented. In another section, energy conversion processes (direct and indirect methods) are illustrated. Large-scale processes such as thermal cycles or hydraulic processes in power plants are discussed mainly, but also marginal processes such as thermionic converters are addressed.Afterwards, a specialization takes place on the subject of electric power supply with respect to the increasing proportion of the electric power applications. The chain from the electric generator to the consumer with an overview of the required resources, the hiring electrical load flow and its stability is addressed. The storage of energy and in particular of electrical energy by converting into other forms of energy will be discussed. Finally, questions for the contemporary use of energy resources in regard to sustainability are mentioned.
2	**Learning objectives / Learning Outcomes** Students know the physically based energy basics and have an overview of the energy resources of our planet Earth. They understand the fundamental energy conversion processes on the technical use of energy in the form of heat as well as mechanical and electrical work. They have acquired basic knowledge of electrical engineering in the chain of effects from electric power producer to the consumer and are able to educate themselves about current issues of energy use and its future development. They are able to perform basic calculations for energy content, energy conversion, efficiencies, storage, and for conversion and transportation losses.They are prepared for advanced lectures on energy components and systems, energy industry, and on future forms of energy supply.
3	**Recommended prerequisite for participation** Basic knowledge of physics (mechanics, thermodynamics, electrical engineering, structure of matter) and chemistry (binding energy) are desirable and facilitate understanding of the energetic processes.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6	**Usability of this module** BSc ETiT, BSc WI-ETiT, BSc MEC, BSc iST, BSc CE, MSc ESE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes (slides) Practice documents (examples, solutions) Additional and more detailed literature: Grothe/Feldhusen: Dubbel-Taschenbuch für den Maschinenbau, Springer, Berlin, 2007, 22. Aufl.; besonders: Kapitel „Energietechnik und Wirtschaft“; Sterner/Stadler: Energiespeicher – Bedarf, Technologien, Integration, Springer-Vieweg, Berlin, 2011; Rummich: Energiespeicher, expert-verlag, Renningen, 2015, 2. Aufl.; Strauß: Kraftwerkstechnik zur Nutzung fossiler, nuklearer und regenerativer Energiequellen, Springer, Berlin, 2006, 5. Aufl.; Hau: Windkraftanlagen –Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer-Vieweg, Berlin, 2014, 5. Aufl.; Heuck/Dettmann/Schulz: Elektrische Energieversorgung, Springer-Vieweg, Berlin, 2014, 9. Aufl.;Quaschning: Regenerative Energiesystem, Hanser, München, 2001, 7. Aufl.

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-bi-1010-vl	Electrical Power Engineering	Prof. Dr. techn. Dr.h.c. Andreas Binder	Lecture	3
18-bi-1010-ue	Electrical Power Engineering	Prof. Dr. techn. Dr.h.c. Andreas Binder	Practice	1

Module name Electrical Machines and Drives					
Module Nr. 18-bi-1020	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1 Content

Construction and function of induction machine, synchronous machine, direct current machine. Electromagnetic field within machines, armature windings, steady-state performance as motor/generator, application as line-fed and inverter-fed drives. Significance for electric power generation, both to the grid and in stand-alone version.

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:

- calculate and explain the stationary operation performance of the three basic types of electric machine sin motor and generator mode,
- understand the application of electrical machines in modern drive systems and to design simple drive applications by yourself,
- understand and explain the function and physical background of the components of electrical machines
- understand and explain the impact of basic electromagnetic field and force theory on the basic function of electrical machines.

3 Recommended prerequisite for participation

Mathematics I to III, Electrical Engineering I and II, Physics, Mechanical Engineering

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

BSc ETiT, BSc/MSc Wi-ETiT, BEd

7 Grade bonus compliant to §25 (2)

8 References

Detailed textbook and collection of exercices; Complete set of PowerPoint presentations
L.Matsch: Electromagnetic and electromechanical machines, Int.Textbook, 1972
A.Fitzgerald et al: Electric machinery, McGraw-Hill, 1971
S.Nasar et al: Electromechanics and electric machines, Wiley&Sons, 1995
R.Fischer: Elektrische Maschinen, C.Hanser-Verlag, 2004

Courses

Course Nr.	Course name		
18-bi-1020-vl	Electrical Machines and Drives		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Dr.h.c. Andreas Binder		Lecture	2

	Course Nr.	Course name		
	18-bi-1020-ue	Electrical Machines and Drives		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Dr.h.c. Andreas Binder		Practice	2

<table>
<tr><td colspan="6">Module name
Technology of Micro- and Precision Engineering</td></tr>
<tr><td>Module Nr.
18-bu-1010</td><td>Credit Points
4 CP</td><td>Workload
120 h</td><td>Self study
75 h</td><td>Duration
1</td><td>Cycle offered
WiSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Ph.D. Thomas Peter Burg</td></tr>
</table>

<table>
<tr><td>1</td><td>Content
To explain production processes of parts like: casting, sintering of metal and ceramic parts, injection moulding, metal injection moulding, rapid prototyping, to describe manufacturing processes of parts like: forming processes, compression moulding, shaping, deep-drawing, fine cutting machines, ultrasonic treatment, laser manufacturing, machining by etching, to classify the joining of materials by: welding, bonding, soldering, sticking, to discuss modification of material properties by: tempering, annealing, composite materials.</td></tr>
<tr><td>2</td><td>Learning objectives / Learning Outcomes
Provide insights into the various production and processing methods in micro- and precision engineering and the influence of these methods on the development of devices and components.</td></tr>
<tr><td>3</td><td>Recommended prerequisite for participation</td></tr>
<tr><td>4</td><td>Form of examination
Module Final Examination:
Module Examination (Technical Examination, Optional, Standard Grading System)</td></tr>
<tr><td>5</td><td>Grading
Module Final Examination:
Module Examination (Technical Examination, Optional, Weighting: 100 %)</td></tr>
<tr><td>6</td><td>Usability of this module
BSc ETiT, MSc MEC, MSc WI-ETiT</td></tr>
<tr><td>7</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td>References
Script for lecture: Technology of Micro- and Precision Engineering</td></tr>
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<tr><td rowspan="2"></td><td>Course Nr.
18-bu-1010-vl</td><td colspan="3">Course name
Technology of Micro- and Precision Engineering</td></tr>
<tr><td colspan="2">Instructor
Prof. Ph.D. Thomas Peter Burg, M.Sc. Florian Klug</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-bu-1010-ue</td><td colspan="3">Course name
Technology of Micro- and Precision Engineering</td></tr>
<tr><td colspan="2">Instructor
Prof. Ph.D. Thomas Peter Burg, M.Sc. Florian Klug</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name					
Introduction to Electrodynamics					
Module Nr. 18-dg-1010	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Vector calculus, orthogonal coordinate systems, Maxwell's equations, interface and boundary conditions, layered media, electrostatics, scalar potential, Coulomb integral, separation of variables, method of image charges, magnetostatics, vector potential, Biot-Savart law, stationary current fields, fields in matter, energy flow, skin effect, plane waves, polarization, TEM waves, reflection and multi-layer problems, multi conductor transmission lines (capacitance, inductance, and conductance matrix), velocity definitions, basics of rectangular waveguides.
2	**Learning objectives / Learning Outcomes** Students will be familiar with Maxwell's equations in integral and differential form for static and dynamic field problems. They will have a mental picture of wave phenomena in free space. They are able to recognice and interpret wave effects in the different areas of electrical engineering. They are able to derive the wave effects from Maxwell's equations and have a good understanding of the necessary mathematical tools.
3	**Recommended prerequisite for participation** Lecture notes. Further literature recommendations are given in the course.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)** Improvement by up to 0.4 due to bonus points which can be acquired by means of e-learning online tests.
8	**References** Lecture notes. Further literature recommendations are given in the course.

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-dg-1010-vl	Introduction to Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem	Lecture	2
18-dg-1010-ue	Introduction to Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem	Practice	2

<table>
<tr><td colspan="6">Module name
Computational Electromagnetics and Applications I</td></tr>
<tr><td>Module Nr.
18-dg-1030</td><td>Credit Points
3 CP</td><td>Workload
90 h</td><td>Self study
60 h</td><td>Duration
1</td><td>Cycle offered
SoSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Herbert De Gersem</td></tr>
</table>

1	**Content** Basics FIT, electrostatics, magnetostatics, magnetoquasistatics, high frequency simulations, convergence studies, discretisation, time- and frequency domain simulations.
2	**Learning objectives / Learning Outcomes** Students learn the basic concepts of the Finite Integration Technique (FIT) for the numerical solution of Maxwell's equations. Students are, furthermore, introduced to the practical application of the method for numerical field problems.
3	**Recommended prerequisite for participation** Basics of Maxwell's equations, linear algebra. Recommended: Basic knowledge in knowledge in "Technical Electrodynamics"
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Course notes, lecture slides.

Courses

<table>
<tr><td rowspan="2"></td><td>Course Nr.
18-dg-1030-vl</td><td colspan="3">Course name
Computational Electromagnetics and Applications I</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Sebastian Schöps</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

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: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Course notes available (including references)

Courses

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

Module name Power Electronics					
Module Nr. 18-gt-1010	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Content** Power electronic devices convert the energy from the distribution network to the form required by the load. This conversion does not wear out, can be controlled very fast and has a high efficiency. In lecture “Power Electronics“ the most important circuits required for the energy conversion are treated, using ideal switches. The main chapters are I.) Line commutated converters in order to understand the basic concepts of power electronic systems. II.) Self- commutated converters (one, two and four quadrant converters, 3-phase- VSI)
2	**Learning objectives / Learning Outcomes** After an active participation in the lecture, as well as by solving all exercises prior to the respective tutorial students should be able to: • Understand the ideal concept of power semiconductors • Calculate and sketch the time-characteristics of all currents and voltages in a line-commutated converter using defined simplifications as well as represent the behavior of currents and voltages during commutation in line-commutated converters for center –tapped as well as for bridge circuits. • Specify the basic circuit diagrams for one, two and four quadrant DC/DC converters and calculate the characteristics of voltages and currents in these circuits. • Explain the function of single-phase and three-phase voltage source inverters and calculate the currents and voltages in these circuits using defined simplifications. • Understannd the concept und operation of HVDC transmission
3	**Recommended prerequisite for participation** Mathe I und II, ETiT I und II, Energietechnik
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes, instructions for exercises are available for download in Moodle. Literature: Probst U.: „Leistungselektronik für Bachelors: Grundlagen und praktische Anwendungen“, Carl Hanser Verlag GmbH & Co. KG, 2011 Jäger, R.: „Leistungselektronik: Grundlagen und Anwendungen“, VDE-Verlag; Auflage 2011 Heumann, K.: „Grundlagen der Leistungselektronik“; Teubner; Stuttgart; 1985 Lappe, R.: „Leistungselektronik“; Springer-Verlag; 1988 Mohan, Undeland, Robbins: Power Electronics: Converters, Applications and Design; John Wiley Verlag; New York; 2003

Courses				
	Course Nr. 18-gt-1010-vl	**Course name** Power Electronics		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Milad Khani		**Type** Lecture	**SWS** 2
	Course Nr. 18-gt-1010-ue	**Course name** Power Electronics		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Milad Khani		**Type** Practice	**SWS** 2

Module name Electrical Engineering and Information Technology II					
Module Nr. 18-gt-1020	**Credit Points** 7 CP	**Workload** 210 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Content** Electrostatic fields; stationary electrical flow fields; stationary magnetic fields; temporally variable magnetic fields; capacitor networks, transmission lines
2	**Learning objectives / Learning Outcomes** The students have detached themselves from the conception that all electrical procedures are line- bound; they have a clear idea of the field term, can read and interpret field plots and also design simple field plots themselves; they understand the difference between a curl and a divergence field, can describe this difference mathematically and are able to recognize the field type from a mathematical description, respectively; they are able to calculate field distributions for simple rotationally symmetric arrangements analytically; they can deal surely with the definitions of the electrostatic, the electrical quasi-static, the magnetostatic and the magneto-electric field; they have recognized the connection and dualism of electricity and magnetism; they control the mathematical apparatus necessary for their description and can apply it to simple examples; they can calculate with nonlinear magnetic circuits; they can compute inductance, capacity and resistance of simple geometrical arrangements and understand them now as physical characteristics of the respective arrangement; they have recognized, how different forms of energy can be transferred into each other and are thereby already able to solve simple scientific engineering problems; they have understood the underlying physical backgrounds for many applications of electrical engineering and are able to describe them mathematically, develop it further in a simple way and apply it to other examples; they are familiar with the system of Maxwell's equations and can transfer them from the integral into the differential form; they have a first idea of the importance of Maxwell's equations for all conceptual formulations of electrical engineering and they understand the propagation of electromagnetic waves in the free space and on transmission lines
3	**Recommended prerequisite for participation** Electrical Engineering and Information Technology I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc Wi-ETiT, LA Physik/Mathematik, BSc CE, BSc iST
7	**Grade bonus compliant to §25 (2)** Notenverbesserung entsprechend §25 (2) APB TU Darmstadt
8	**References** • Downloadable slides • Clausert, Wiesemann, Hinrichsen, Stenzel: „Grundgebiete der Elektrotechnik I und II"; ISBN 978-3-486-59719-6 • Prechtl, A.: „Vorlesungen über die Grundlagen der Elektrotechnik – Band 2" ISBN: 978-3-211-72455-2

Courses

	Course Nr. 18-gt-1020-vl	**Course name** Electrical Engineering and Information Technology II		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog		**Type** Lecture	**SWS** 3
	Course Nr. 18-gt-1020-ue	**Course name** Electrical Engineering and Information Technology II		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog		**Type** Practice	**SWS** 2

Module name Logic Design					
Module Nr. 18-hb-1010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Content** Boolean algebra, logic gates, hardware description languages, flipflops, sequential circuits, state-diagrams and -tables, technology mapping, programmable logic circuits
2	**Learning objectives / Learning Outcomes** By this module, Students will be enabled to • rewrite boolean expressions and transform them into circuits of logic gates • analyze and synthesize digital circuits • describe digital circuits in a hardware description language • extract finite state machines from informal descriptions and implement them with synchronous circuits
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** R.H. Katz: Contemporary Logic Design

Courses

Course Nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-hb-1010-vl	Logic Design	Prof. Dr.-Ing. Christian Hochberger, M.Sc. Alexander Schwarz	Lecture	3
18-hb-1010-ue	Logic Design	Prof. Dr.-Ing. Christian Hochberger, M.Sc. Alexander Schwarz	Practice	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: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Hennessy/Patterson: Computer architecture - a quantitative approach

Courses

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

Module name High Voltage Technology I					
Module Nr. 18-hi-1020	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Volker Hinrichsen		

1	**Content** Choice of Voltage Level, Generation of High AC Voltage, Generation of High DC Voltage, Generation of Impulse Voltages, Measurement of High AC/DC/Impulse Voltages, Electrical Fields, Two excursions to manufacturers of high voltage products
2	**Learning objectives / Learning Outcomes** The students know why electrical energy is transported and distributed at high voltages and what is the optimal voltage level for different purposes; they are able to identify different basic kinds of electrical stress in the system; they know how to generate and to measure high test voltages in the laboratory; they have understood the requirements in the test standards and why standards are so important at all; they are able to interpret and correctly apply the standards; they know the basic test circuits for generating alternating, direct and impulse voltages, and they can extend and adopt them for special purposes; they are aware of the particular problems of high-voltage measuring techniques and are able to apply high-voltage measuring systems and optimize them for particular tasks; thus, in sum they are basically prepared to plan, erect and operate a high-voltage test laboratory; they can analytically solve the electrical field equations for basic electrode configurations and make use of them for optimizing configurations with regard to dielectric strength; they know about surge propagation on lines and are aware that this is also relevant for impulse measuring techniques and how to handle related problems.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** • All lecture slides (ca. 600 pcs.) available for download • Kind, Feser: High-voltage test techniques, SBA publications • Kind, Kärner: High-voltage insulation technology, Vieweg

Courses

Course Nr.	Course name		
18-hi-1020-vl	High Voltage Technology I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Volker Hinrichsen, Dipl.-Ing. Martin Urban Hallas		Lecture	2

	Course Nr.	**Course name**		
	18-hi-1020-ue	High Voltage Technology I		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Volker Hinrichsen, Dipl.-Ing. Martin Urban Hallas		Practice	2

Module name Electronics					
Module Nr. 18-ho-1010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Semiconductor Devices: Diode, MOSFET, Bipolar Transistor; Design of Electronic Circuits; Analog Circuits: Basic Properties, Properties and Application of Operational Amplifiers, Circuit Simulation with SPICE, Small Signal Gain, Single Stage Amplifiers; Frequency Response; Digital Circuits: CMOS Logic Circuits
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. analyse Diodes, MOS- und Bipolartransistors in simple circuits, 2. calculate the properties of single transistor circuits, such as small signal gain, input and output resistance, 3. design inverting and non-inverting amplifiers from operational amplifiers and knows their ideal and non-ideal properties 4. calculate the frequency behavior of simple transistor circuits, , 5. distinguish the different methods to construct a logical gate from basic transistors and explain their fundamental properties.
3	**Recommended prerequisite for participation** Basics of Electrical Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT,BSc iST, BEd
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Slide Copies; Richard Jaeger: Microelectronic Circuit Design

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-ho-1011-vl	Electronics	Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Oliver Bachmann	Lecture	2
18-ho-1011-ue	Electronics	Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Oliver Bachmann	Practice	1

Module name Electronics					
Module Nr. 18-ho-1011	**Credit Points** 7 CP	**Workload** 210 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** **18-ho-1011-vl bzw. –ue:** Semiconductor Elements: Diode, MOSFET, Bipolartransistor. Electronic Circuit Design; Basic Analog Circuits and their properties, Behavior and properties of operational amplifiers, circuit simulation with SPICE, small signal amplification, single stage amplifiers, frequency response; digital circuits: CMOS-logic **18-ho-1011-pr:** Practical experiments in the fields: • digital circuits: FPGA-programming • analog circuits: basic building blocks, amplifiers, operational amplifiers, filters and demodulators
2	**Learning objectives / Learning Outcomes** A student is after successful attending the lecture able to • analyse the behavior of diodes, MOS- and Bipolartransistors in simple circuits, • assess the properties of single-transistor amplifiers (MOSFET and BJT), such as small signal behavior, input- and output-resistance; • design inverting and non-inverting operational amplifiers with passive components and knows the ideal and non-ideal properties; • calculate the frequency response of simple transistor circuits; • knows the different circuit techniques (CMOS, NMOS) of logical gates and knows the basic functions (inverter, NAND, NOR). A student is after successful attending the lab able to • perform measurements in time and frequency domain using an oscilloscope on simple operational amplifiers; • design and realize a traffic light controller based on a finite state machine using a FPGA as the target implementation; • mount passive and active components on a PCB (including preparation of components, soldering) and put the system to function, • simulate a circuit (filter) using SPICE and perform measurements on the realization.
3	**Recommended prerequisite for participation** Basics of Electrical Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) Module Eccompanying Examination: • [18-ho-1011-pr] (Study Achievement, Optional, Standard BWS)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 4) Module Eccompanying Examination: • [18-ho-1011-pr] (Study Achievement, Optional, Weighting: 3)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc iST, BEd

7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-ho-1011-vl	Electronics	Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Oliver Bachmann	Lecture	2
18-ho-1011-pr	Electronics Lab	Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Ferdinand Keil	Internship	2
18-ho-1011-ue	Electronics	Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Oliver Bachmann	Practice	1

Module name					
Analog Integrated Circuit Design					
Module Nr. 18-ho-1020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Basic analog Building Blocks: Current Mirrors, Reference Circuits; Multi Stage Amplifier, internal Structure and Properties of Differential and Operational Amplifiers, Feedback Techniques, Frequency Response, Oscillators
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. derive the fundamental properties of the MOS-Transistors from knowledge of the layout or fabrication process, 2. derive fundamental MOSFET-circuits (current source, current mirror, switch, active resistors, inverting amplifiers, differential amplifiers, output amplifiers, operational amplifiers, comparators) and knows their fundamental properties (y-Parameters, DC- and AC-properties), 3. understands simulation methods for analog circuits on transistor level using SPICE, 4. analyse feedback amplifiers regarding frequency gain, stability, bandwidth, root locus, amplitude and phase-margin, 5. derive and calculate the analog propierties of digital logic gates
3	**Recommended prerequisite for participation** Lecture “Electronics”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, MSc iCE, BSc/MSc iST, BSc/MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Slide Copies; Richard Jaeger: Microelectronic Circuit Design

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-ho-1020-vl	Analog Integrated Circuit Design	Prof. Dr.-Ing. Klaus Hofmann	Lecture	3
18-ho-1020-ue	Analog Integrated Circuit Design	Prof. Dr.-Ing. Klaus Hofmann	Practice	1

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

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

Courses

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

Module name Electrical Engineering and Information Technology I					
Module Nr. 18-hs-1070	**Credit Points** 7 CP	**Workload** 210 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Content** Units and Equations: Unit systems, equation writing. Basic definitions: Charge, current, voltage, resistance, energy and power. Currents and voltages in electrical circuits: Ohmic law, node and mesh equations, parallel and series connections, current and voltage measurement, linear and nonlinear elements, superposition method, star-delta-transformation, node and mesh analysis in linear circuits, controlled sources. AC systems: Time-dependent currents and voltages, steady-state mode sinusoidal currents and voltages in linear RLC-circuits, phasor diagrams, resonances in RLC circuits, AC power, locus diagrams, two-port networks, transformer, polyphase systems.
2	**Learning objectives / Learning Outcomes** Students will be able after visiting this lecture * to utilize the basic equations in electrical engineering, * to determine the currents and voltages in linear and nonlinear circuits, * to analyze DC and AC systems, * to calculate simple filter and resonant circuits, * to apply the complex calculation in electrical AC systems.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc. ETiT, BSc iST, BSc MEC, BSc. Wi-ETiT, BSc CE, LA Physik/Mathematik
7	**Grade bonus compliant to §25 (2)**
8	**References** Frohne, H. u.a. Moeller Grundlagen der Elektrotechnik Clausert, H. u.a. Grundgebiete der Elektrotechnik 1 + 2

Courses

Course Nr.	**Course name**		
18-hs-1070-vl	Electrical Engineering and Information Technology I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jutta Hanson, M.Sc. Carl Schweinsberg, M.Sc. Martin Albrecht Coumont, M.Sc. Simon Massat		Lecture	3

	Course Nr.	Course name		
	18-hs-1070-ue	Electrical Engineering and Information Technology I		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Jutta Hanson, M.Sc. Carl Schweinsberg, M.Sc. Martin Albrecht Coumont, M.Sc. Simon Massat		Practice	2

Module name					
Fundamentals of Communication					
Module Nr. 18-jk-1010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Part 1: Chap. 1 will be a brief introduction in "Electrical Information- and Communication Engineering", presenting signals as carrier of information, classifying electrical signals and describing elements of communication systems. Then, Chap. 2 introduces various line-conducted and wireless transmission media, power budget calculations for both media types, basics of antenna radiation and parameters etc., which will be emphasized by application examples like TV-satellite reception and mobile communication channels. Part 2: Chap. 3 is focused on signal distortions and interferences, especially thermal noise, considering noisy two-port devices and its concatenations, lossy networks, antenna noise temperature and the impact of noise on analog and digital signals. This chap. ends with basics of information theory and channel capacity for AWGN-channels. In contrast, chap 4 deals with noise-reduction and distortion-compensation methods. Part 3: Chap. 5 introduces sampling of band-limited signals and analog modulation of a pulse carrier (pulse-amplitude- pulse-duration- and pulse-angle-modulation), which will be extended on digital modulation in the baseband by means of pulse-code modulation (PCM), focusing on signal quantizing, analog-digital conversion, minimum bandwidth, bit error rate and error probability of a PCM word. At least, PCM-time-division multiplex and –systems will be discussed. Part 4: Chap. 7 deals with fundamentals of multiplex- and RF-modulation schemes as well as with frequency conversion, frequency multiplication and mixing strategies. Then, receiver principles and image frequency problems of heterodyne-receivers as well as amplitude modulation of a sinus carrier will close this chapter. Chap. 8 introduces digital modulation of a harmonic carrier, including band-limited inter-symbol interference-free transmission, matched filtering and binary shift keying of a sinusoidal carrier in amplitude (ASK), phase (PSK) or frequency (FSK). From this follows higher-order modulation schemes like M-PSK or M-QAM. A brief outlook on the functionality of channel coding and interleaving in chap. 9 will end up the lecture.
2	**Learning objectives / Learning Outcomes** Aim of the Lecture: To teach the fundamentals of communications (physical layer), primarily the transmission of signals from a source to a sink, possible modulation and access methods as well as signal distortion and noise. The introduction of communications is a basement for further lectures like Communication Technology, Laboratories of Communication Technology (NTP A, B), Microwave Eng., Optical Communications, Mobile Communications and Terrestrial and satellite-based radio systems.
3	**Recommended prerequisite for participation** Deterministic Signals and Systems
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**

8	**References** Complete Script and Literature: Pehl, E.: Digitale und analoge Nachrichtenübertragung, Hüthig, 1998; Meyer, Martin: Kommunikationstechnik, Vieweg, 1999; Stanski, B.: Kommunikationstechnik; Kammeyer, K.D.: Nachrichtenübertragung. B.G. Teubner 1996; Mäusl, R.: Digitale Modulationsverfahren. Hüthig Verlag 1995; Haykin, S.: Communication Systems. John Wiley 1994; Proakis, J., Salehi M.: Communication Systems Engineering. Prentice Hall 1994; Ziemer, R., Peterson, R.: Digital Communication. Prentice Hall 2001; Cheng, D.: Field and Wave Electromagnetics, Addision-Wesley 1992.

Courses

Course Nr.	Course name		
18-jk-1010-vl	Fundamentals of Communications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby		Lecture	3
Course Nr.	**Course name**		
18-jk-1010-ue	Fundamentals of Communications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby		Practice	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: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script will be hand out; Literature will be recommended in first lecture

Courses

Course Nr.	Course name		
18-jk-1020-vl	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 Application of Electrodynamics					
Module Nr. 18-kb-1040	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Content** Vector calculus, Maxwell's equations, electrostatics, magnetostatics, fields of stationary currents, electromagnetic waves and ultrasonic waves, analytical and numerical calculation techniques, wave propagation, reflection and transmission, diffraction, interference and polarization, applications of electromagnetic and ultrasonic waves in medical technology
2	**Learning objectives / Learning Outcomes** The students get knowledge and intuition on electromagnetic fields and wave propagation phenomena. They are able to recognize and calculate field and wave phenomena in an electrical engineering context. They are familiar with the required mathematical tools. The students have a feeling for the application of electromagnetic fields and waves in medical engineering.
3	**Recommended prerequisite for participation** Recommended: "Elektrotechnik und Informationstechnik II" (18-gt-1020), "Mathematics II" (04-00-0109), and "Mathematics III" (04-00-0111)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Presentation slides can be downloaded. Further references will be given in the lecture.

Courses

	Course Nr. 18-kb-1040-vl	**Course name** Application of Electrodynamics		
	Instructor Prof. Dr.-Ing. Harald Klingbeil		**Type** Lecture	**SWS** 2
	Course Nr. 18-kb-1040-ue	**Course name** Application of Electrodynamics		
	Instructor Prof. Dr.-Ing. Harald Klingbeil		**Type** Practice	**SWS** 2

Module name					
Deterministic Signals and Systems					
Module Nr. 18-kl-1010	**Credit Points** 7 CP	**Workload** 210 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Content** Fourier Series: Motivation; Fourier series with real coefficients; Fourier series with complex coefficients;examples and applications Fourier Transform: Motivation - Derviation from Fourier series - Dirichlet conditions - delta function - step function - properties of F-transform - special cases - examples and applications - transmissions systems-expansion into partial fractions Convolution: Time invariant systems - convolution in frequency domain- Parseval's theorem - properties-examples and applications Systems and Signals: Bandlimited and time limited systems - systems with only one energy store - examples and applications Laplace Transform: Motivation - single sided L-transform - inverse L-transform - theorems of L- transform - examples and applications Linear differential equations: Time invariant systems - rules - general differentiation - linear passive electrical networks - equivalent circuits for passive electrical elements - examples and applications z-Transform: motivation - sampling - numerical order - definition - examples - transfer function - sampling theorem - examples and applications Discrete Fourier Transform: motivation, derivation sampling, examples and applications
2	**Learning objectives / Learning Outcomes** The student should understand the principles of integral transformations. He should apply them for the solution of physical problems. The techniques of this lecture are essential tools which will be needed in many follow-up lectures and exercises.
3	**Recommended prerequisite for participation** Elektrotechnik und Informationstechnik I und Elektrotechnik und Informationstechnik II
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc Wi-ETiT, LA Physik/Mathematik, BSc CE, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

	A script of the lecture or slides respectively, will be provided in electronic form. Basic Literature: Wolfgang Preuss, “Funktionaltransformationen”, Carl Hanser Verlag, 2002; Klaus-Eberhard Krueger "Transformationen", Vieweg Verlag, 2002; H. Clausert, G. Wiesemann "Grundgebiete der Elektrotechnik 2", Oldenbourg, 1993; Otto Föllinger "Laplace-, Fourier- und z-Transformation", Hüthig, 2003; T. Frey, M. Bossert, Signal- und Systemtheorie, Teubner Verlag, 2004 Further Literature: Dieter Mueller-Wichards "Transformationen und Signale", Teubner Verlag, 1999 Exercises: Hwei Hsu "Signals and Systems", Schaum’s Outlines, 1995

Courses

Course Nr.	Course name		
18-kl-1010-vl	Deterministic Signals and Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, M.Sc. Tobias Mahn, Prof. Dr.-Ing. Marius Pesavento		Lecture	3
Course Nr.	**Course name**		
18-kl-1010-ue	Deterministic Signals and Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, M.Sc. Tobias Mahn, Prof. Dr.-Ing. Marius Pesavento		Practice	2

Module name Communication Technology I					
Module Nr. 18-kl-1020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Content** Signals and Communication Systems, Base-band Communications, Detection of Base-band Signals in AWGN Channels, Bandpass-Signals und -Systems, Linear Digital Modulation Schemes, Digital Modulation und Detection, Multi-carier Transmission, OFDM, Spread-Spectrum Techniques, CDMA, Multiple Access
2	**Learning objectives / Learning Outcomes** After completion of the lecture, students possess the ability to: • classify signals and communication systems, • understand, model and analyse basic components of communication systems, • understand, evaluate and compare communication systems for transmission over additive white Gaussian noise channels, • model and analyse base-band commnication systems, • describe and analyse bandpass signals and bandpass communication systems in the equivalent base-band, • understand, model, evaluate, compare and apply linear modulation schemes, • design receiver structures for different modulation schemes, • detect linear modulated data after transmission over additive white Gaussian noise channels in an optimum way, • understand and model OFDM, • understand and model CDMA, • understand and compare the basic properties of multiple access schemes.
3	**Recommended prerequisite for participation** Electrical Engineering I and II, Deterministische Signale und Systeme, Mathematics I to IV
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc CE, MSc iST, BSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in the lecture

Courses

Course Nr. 18-kl-1020-vl	**Course name** Communication Technology I	
Instructor Prof. Dr.-Ing. Anja Klein	**Type** Lecture	**SWS** 3

<table>
<tr><td rowspan="2"></td><td>Course Nr.
18-kl-1020-ue</td><td colspan="3">Course name
Communication Technology I</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Anja Klein, M.Sc. Sabrina Klos, M.Sc. Kilian Kiekenap</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name Measuring Technique					
Module Nr. 18-kn-1011	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 105 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1 Content

The module includes theoretical discussion and practical application of the measuring chain in detail on example the electrical variables (current, voltage, impedance, power) and selected non-electrical variables (frequency, time, force, pressure and acceleration).

In the lecture the following chapter will be thematically treated measuring signals and measuring equipment (oscilloscope, laboratory testing equipment), static measurement error and disturbance variables (especially temperature), basic measurement circuits, AD conversion principles and filtering, measurement method non-electrical variables and the statistics of measurements (distributions, statist safe tests).

The topics of the lecture are discussed in the exercise of the module. Examples are analyzed and their application in measurement scenarios are practiced.

The practicum of the module consists of five experiments which are time closely matched in time to the lecture:

- Measuring of signals in the time range with digital storage oscilloscope, trigger conditions
- Measuring of signals in the frequency range with digital storage oscilloscope, error of measurement (aliasing / subsampling, leackage) and window functions
- Measuring of mechanical dimensions with suitable primary sensors, sensor electronics / amplifier circuits
- computer-based measuring
- Importing of sensor signals, whose processing and the resulting automated control of a process using a programmable logic controller (PLC)

2 Learning objectives / Learning Outcomes

The students know the structure of the measuring chain and the specific properties of the corresponding elements. They know the structure of electronic measuring instruments and basic measuring circuits for electrical and selected non-electrical variables and can apply them. They know the basics of capturing, processing, transferring and storage of measurement data and can describe error sources and quantifying their influences.

In the practicum, the students deepen the basis of the measurements with the oscilloscope, the understanding of the relationship between time and frequency range. Methodically they are able to document and evaluate the data during laboratory measuring.

3 Recommended prerequisite for participation

Basics of ETiT I-III, Math I-III, Electronic

4 Form of examination

Module Final Examination:

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

Module Eccompanying Examination:

- [18-kn-1011-pr] (Study Achievement, Optional, Standard BWS)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 4)

Module Eccompanying Examination:

- [18-kn-1011-pr] (Study Achievement, Optional, Weighting: 2)

6 Usability of this module

BSc ETiT, BSc Wi-ETiT, BSc MEC

7	**Grade bonus compliant to §25 (2)**
8	**References** • Slide set of lecture • Textbook and exercise book Lerch: „Elektrische Messtechnik“, Springer • Exercise documents • Practical experiment manuals

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-kn-1011-vl	Measuring Technique	Prof. Dr. Mario Kupnik	Lecture	2
18-kn-1011-pr	Measuring Technique Lab	Prof. Dr. Mario Kupnik, M.Sc. Bastian Patrick Latsch, M.Sc. Romol Chadda	Internship	2
18-kn-1011-ue	Measuring Technique	Prof. Dr. Mario Kupnik	Practice	1

Module name Electromechanical Systems I					
Module Nr. 18-kn-1050	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** Structure and design methods of elektromechanical systems, mechanical, acoustical and thermal networks, transducers between mechanical and acoustical networks. Design and devices of electromechanical transducers.
2	**Learning objectives / Learning Outcomes** Comprehension, description, calculation and application of the most relevant electromechanical transducers, comprising electrostatic transducer (e.g. microphone and accelerometer), piezoelectric transducers (e.g micro motors, micro sensors), electrodynamic transducer (loudspeaker, shaker), piezomagnetic transducer (e.g. ultrasonic source). Design of complex electromechanical systems like sensors and actuators and their applications by applying the discrete element network method.
3	**Recommended prerequisite for participation** Electrical Engineering and Information Technology I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc WI-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Book: Electromechanical Systems in Microtechnic und Mechatronic, Springer 2012, Script for lecture Electromechanical Systems I, Workbook

Courses

Course Nr.	**Course name**		
18-kn-1050-vl	Electromechanical Systems I		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik, Prof. Dr. techn. Dr.h.c. Andreas Binder, M.Sc. Sascha Neusüs, M.Sc. Omar Ben Dali		Lecture	2

Course Nr.	**Course name**		
18-kn-1050-ue	Electromechanical Systems I		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik, Prof. Dr. techn. Dr.h.c. Andreas Binder, M.Sc. Sascha Neusüs, M.Sc. Omar Ben Dali		Practice	2

Module name System Dynamics and Automatic Control Systems I					
Module Nr. 18-ko-1010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** Description and classification of dynamic systems; Linearization around an equilibrium point; Stability of dynamic systems; Frequency response; Linear time-invariant closed-loop systems; Controller design; Control structure optimization
2	**Learning objectives / Learning Outcomes** Students will know how to describe and classify different dynamic systems. They will be able to analyse the dynamic behaviour in time and frequency domain. The students will be able to design controllers for linear time invariant systems.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, MSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Skript Konigorski: “Systemdynamik und Regelungstechnik I”, Aufgabensammlung zur Vorlesung, Lunze: "Regelungstechnik 1: Systemtheoretische Grundlagen, Analyse und Entwurf einschleifiger Regelungen", Föllinger: "Regelungstechnik: Einführung in die Methoden und ihre Anwendungen", Unbehauen: "Regelungstechnik I:Klassische Verfahren zur Analyse und Synthese linearer kontinuierlicher Regelsysteme, Fuzzy-Regelsysteme", Föllinger: "Laplace-, Fourier- und z-Transformation", Jörgl: "Repetitorium Regelungstechnik", Merz, Jaschke: "Grundkurs der Regelungstechnik: Einführung in die praktischen und theoretischen Methoden", Horn, Dourdoumas: "Rechnergestützter Entwurf zeitkontinuierlicher und zeitdiskreter Regelkreise", Schneider: "Regelungstechnik für Maschinenbauer", Weinmann: "Regelungen. Analyse und technischer Entwurf: Band 1: Systemtechnik linearer und linearisierter Regelungen auf anwendungsnaher Grundlage"

Courses

Course Nr.	**Course name**		
18-ko-1010-vl	System Dynamics and Automatic Control Systems I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Florian Hermann Weigand		Lecture	3

Course Nr.	**Course name**		
18-ko-1010-tt	System Dynamics and Automatic Control Systems I- Auditorium Exercise		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Florian Hermann Weigand		Tutorial	1

<table>
<tr><td colspan="6">Module name
Information Theory I</td></tr>
<tr><td>Module Nr.
18-kp-1010</td><td>Credit Points
6 CP</td><td>Workload
180 h</td><td>Self study
120 h</td><td>Duration
1</td><td>Cycle offered
WiSe</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr. techn. Heinz Köppl</td></tr>
</table>

1	**Content** This lecture course introduces the fundamentals of information and network information theory. Outline: information, uncertainty, entropy, mutual information, capacity, differential entropy, typical sequences, Gaussian channels, basics of source and channel coding, linear block codes, Shannon's source coding theorem, Shannon's channel coding theorem, capacity of Gaussian channels, capacity of bandlimited channels, Shannon's bound, bandwidth efficiency, capacity of multiple parallel channels and waterfilling, Gaussian vector channel, Multiple Access Channel, Broadcast Channel, rate region..
2	**Learning objectives / Learning Outcomes** Students will understand the fundamentals of classic information theory.
3	**Recommended prerequisite for participation** Knowledge of basic communication theory und probability theory
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc iST, MSc iCE, BSc Wi-ETiT, BSc/MSc CE
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley & Sons, 1991. 2. Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011. 3. S. Haykin, Communication Systems, Wiley & Sons, 2001.

Courses

Course Nr.	Course name		
18-kp-1010-vl	Information Theory I		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl, M.Sc. Anam Tahir		Lecture	3

Course Nr.	Course name		
18-kp-1010-ue	Information Theory I		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl, M.Sc. Anam Tahir		Practice	1

Module name					
Bioinformatics I					
Module Nr. 18-kp-1020	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. techn. Heinz Köppl		

1 Content

- Biomolecular foundations of high-throughput measurement techniques (Microarrays, RNA-Seq, genome sequencing, proteinarrays, mass-spectrometry, flow-cytometry, mass-cytometry, genomics, proteomics, metabolomics)
- Foundations of statistics and machine learning (decision theory, regression, classification and clustering)
- Exact substring search, dynamic programming, algorithms for sequence comparison (PAM, BLAST, BLAST2, etc), alignment of multiple sequences (ClustalW, DAlign, etc)
- Important databases in bioinformatics and their use in medicine and biology (GenBank, Gene Expression Omnibus, Rfam, UniProt, Pfam, KEGG, BRENDA, Pathway Commons)
- Analysis of interaction networks (modularity, graph partitioning, spanning trees, differential network analysis, network motifs, STRING database, PathBLAST)
- Introduction to structural biology, structure prediction for RNA and proteins, Protein Data Bank (PDB)

2 Learning objectives / Learning Outcomes

After successful completion students are aware of frequently used high-throughput methods in molecular biology and are familiar with the resulting data format. They know the most important bioinformatics databases and acquired the necessary background to understand standard bioinformatics algorithms and to implement them from scratch in R or Matlab. Students are familiar with the basics of structural analysis and with structure prediction. With respect to communication skills, students learned to exchange informatio, ideas, problems and solutions related to bioinformatics with experts and with lay persons.

3 Recommended prerequisite for participation

Recommended is „General Computer Science I“

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

BSc Biomedical Engineering

7 Grade bonus compliant to §25 (2)

8 References

Courses

Course Nr.	Course name		
18-kp-1020-vl	Bioinformatics I		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl		Lecture	2

Module name					
Optical Communications 1 – Components					
Module Nr. 18-ku-1060	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr. rer. nat. Thomas Kusserow		

1	**Content** Optical telecommunication and data networks Optical transmisison systems The nature of light / wave-partical dualism Wave equation / planar wave Polarization Absorption, transmission, reflexion, refraction Connectors and splices Mirrors, HR-/AR coatings Film waveguides Fiber-optic waveguides Attenuation, modes, dispersion Fiber types Dispersion and dispersion compensation Kerr nonlinearity and self-phase modulation Optical filters Wavelength division multiplexers Magneto-optical effect / optical isolator / circulator Lasers / basics, concepts, types Erbium-doped fiber lasers / amplifiers (EDFL / EDFA) Optical semiconductor laser / amplifier (laser diode) Electro-optic modulator Other selected components and devices
2	**Learning objectives / Learning Outcomes** Students understand concepts, basics of physics, design criteria and system requirements (component specifications) of the most important passive and active components of optical communications.
3	**Recommended prerequisite for participation** ET 1-4, Physics
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides Textbook (M. Cvijetic, I. B. Djordjevic: „Advanced Optical Communication Systems and Networks“)

Courses

	Course Nr. 18-ku-1060-vl	**Course name** Optical Communications 1 – Components		
	Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Lecture	**SWS** 3
	Course Nr. 18-ku-1060-ue	**Course name** Optical Communications 1 – Components		
	Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Practice	**SWS** 1

Module name Microelectronic Devices					
Module Nr. 18-pr-1030	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1	**Content** • Introduction: Semiconductor Devices & Microelectronic • Semiconductor: Materials, Physics & Technology • PN-Junction • Metal-Oxide-Semiconductor Capacity • Schottky Contact • MOS-Field-Effect-Transistor (MOSFET) • CMOS: Digital Applications • MOS-Memory • Bipolar- Junction-Transistor • Outlook: Scaling Limits & SET,...
2	**Learning objectives / Learning Outcomes** • Understand the physical properties and processes in semiconductor devices and materials • the operation of basic semiconductor devices like diode, MOS-Transistor and bipolar transistor • Understand functionality of basic circuits like rectifier circuit , 1-transistor amplifier and inverter from the device point of view. • Goal: Understand state-of-the art semiconductor devices and circuits as a basis for a successful engineering career
3	**Recommended prerequisite for participation** Electrical Engineering and Information Technology I, Electrical Engineering and Information Technology II, Laboratory ETiT, Laboratory Electronics, Mathematics I, Mathematics II, Physics
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Skript: Microelectronic devices - the Basics • Robert F. Pierret: Semiconductor Device Fundamentals, ISBN 0201543931 • Roger T. How, Charles G. Sodini: Microelectronics - an Integrated Approach, ISBN 0135885183 • Richard C. Jaeger: Microelectronic Circuit Design, ISBN 0071143866 • Y. Taur, T.H. Ning, Fundamentals of Modern VLSI Devices, ISBN 0521559596 • Thomas Tille, Doris Schmidt-Landsiedel: Mikroelektronik, ISBN 3540204229 • Michael Reisch: Halbleiter-Bauelemente, ISBN 3540213848
Courses	

	Course Nr.	Course name		
	18-pr-1030-vl	Microelectronic Devices		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Sascha Preu		Lecture	2
	Course Nr.	**Course name**		
	18-pr-1030-ue	Microelectronic Devices		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Sascha Preu, M.Sc. Stefan Regensburger		Practice	1

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

1 Content

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

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

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

Detailed Topics are:

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

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

Courses

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

Module name					
Software Engineering - Introduction					
Module Nr. 18-su-1010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The lecture gives an introduction to the broad discipline of software engineering. All major topics of the field - as entitled e.g. by the IEEE's "Guide to the Software Engi-neering Body of Knowledge" - get addressed in the indicated depth. Main emphasis is laid upon requirements elicitation techniques (software analysis) and the design of soft-ware architectures (software design). UML (2.0) is introduced and used throughout the course as the favored modeling language. This requires the attendees to have a sound knowledge of at least one object-oriented programming language (preferably Java). During the exercises, a running example (embedded software in a technical gadget or device) is utilized and a team-based elaboration of the tasks is encouraged. Exercises cover tasks like the elicitation of re-quirements, definition of a design and eventually the implementation of executable (proof-of-concept) code.
2	**Learning objectives / Learning Outcomes** This lecture aims to introduce basic software engineering techniques - with recourse to a set of best-practice approaches from the engineering of software systems - in a practice-oriented style and with the help of one running example. After attending the lecture students should be able to uncover, collect and document essential requirements with respect to a software system in a systematic manner using a model-driven/centric approach. Further-more, at the end of the course a variety of means to acquiring insight into a software system's design (architecture) should be at the student's disposal.
3	**Recommended prerequisite for participation** sound knowledge of an object-oriented programming language (preferably Java)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc iST, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/se-i-v/

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-su-1010-vl	Software Engineering - Introduction	Prof. Dr. rer. nat. Andreas Schürr	Lecture	3
18-su-1010-ue	Software Engineering - Introduction	Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Lars Fritsche	Practice	1

<table>
<tr><td colspan="6">Module name
Fundamentals of Signal Processing</td></tr>
<tr><td>Module Nr.
18-zo-1030</td><td>Credit Points
6 CP</td><td>Workload
180 h</td><td>Self study
120 h</td><td>Duration
1</td><td>Cycle offered
SoSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Abdelhak Zoubir</td></tr>
</table>

1	**Content** The course covers the following topics: • The basic concepts of stochastic • The sampling theorem • Discrete-time noise processes and their properties • Description of noise processes in the frequency domain • Linear time-invariant systems: FIR and IIR filters • Filtering of noise processes: AR, MA, and ARMA models • The Matched filter • The Wiener filter • Properties of estimators • The method of least squares
2	**Learning objectives / Learning Outcomes** The course covers basic concepts of signal processing, and illustrates them with practical examples. It serves as an introductory course for advanced lectures in digital signal processing, adaptive filtering, communications, and control theory.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 10 students register in semesters in which the lecture does not take place, there will will be an oral examination (duration: 30 min.). The type of examination will be announced within one working week after the end of the examination registration phase.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC
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:

- A. Papoulis: Probability, Random Variables and Stochastic Processes. McGraw-Hill, Inc., third edition, 1991.
- P. Z. Peebles, Jr.: Probability, Random Variables and Random Signal Principles. McGraw-Hill, Inc., fourth edition, 2001.
- E. Hänsler: Statistische Signale; Grundlagen und Anwendungen. Springer Verlag, 3. Auflage, 2001.
- J. F. Böhme: Stochastische Signale. Teubner Studienbücher, 1998.
- A. Oppenheim, W. Schafer: Discrete-time Signal Processing. Prentice Hall Upper Saddle River,1999.

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-zo-1030-vl	Fundamentals of Signal Processing	Prof. Dr.-Ing. Abdelhak Zoubir	Lecture	3
18-zo-1030-ue	Fundamentals of Signal Processing	Prof. Dr.-Ing. Abdelhak Zoubir	Practice	1

1.2 Internships

Module name					
Actuators for Mechatronic Systems Lab					
Module Nr. 18-bi-1030	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** Safety instructions; Practical experiments about electrical energy conversion and mechatronic actuators: • Record preparation (one for each group) for every experiment. • One exam for all practical experiments at the end of the semester. • The mark for the students result from the practical experiments, the prepared records and the results of the 2 short exams.
2	**Learning objectives / Learning Outcomes** The use of mechanical actors is trained and knowledge in using the actors is acquired.
3	**Recommended prerequisite for participation** Recommended lecture “Elektrische Antriebe (MEC)” and "Maschinenelemente und Mechatronik 1"
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Detailed textbook with description for the performance of the lab tests

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-bi-1030-pr	Actuators for Mechatronic Systems Lab	Prof. Dr. techn. Dr.h.c. Andreas Binder	Internship	3
18-bi-2090-tt	Laboratory Briefing	Prof. Dr. techn. Dr.h.c. Andreas Binder	Tutorial	0

Module name Actuators for Mechatronic Systems Lab (for MB)					
Module Nr. 18-bi-1031	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1 Content

Safety instructions; Practical experiments about electrical energy conversion and mechatronic actuators:

- Record preparation (one for each group) for every experiment.
- One exam for all practical experiments at the end of the semester.
- The mark for the students result from the practical experiments, the prepared records and the results of the 2 short exams.

2 Learning objectives / Learning Outcomes

The use of mechanical actors is trained and knowledge in using the actors is acquired.

3 Recommended prerequisite for participation

Recommended lecture “Elektrische Antriebe (MEC)” and "Maschinenelemente und Mechatronik 1"

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

BSc Maschinenbau

7 Grade bonus compliant to §25 (2)

8 References

Detailed textbook with description for the performance of the lab tests

Courses

Course Nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-bi-1030-pr	Aktuators for mechatronic systems Lab	Prof. Dr. techn. Dr.h.c. Andreas Binder	Internship	2
18-bi-2090-tt	Laboratory Briefing	Prof. Dr. techn. Dr.h.c. Andreas Binder	Tutorial	0

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

1 Content

During the mechatronic workshop students get the possibility to design and construct their own fixture, which contains a ball track and a ball elevator mechanism. Herefore dimensional plans have to be understood correctly. Afterwards all components (i.e. circuit board, rails and holders) have to be designed and manufactured within the electronic lab and the workshop, where students work independently with turning, drilling and milling machines.

The mechatronic workshop allows students to gain practical experience and knowledge in contruction, assembling and PCB layout design.

2 Learning objectives / Learning Outcomes

Understanding of construction plans, circuit layout design, practical experience with turning, drilling and milling machines.

3 Recommended prerequisite for participation

You have to bring your **own printed** copy of the script. This is mandatory for attending the course. The script will be published on the moodle platform.

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

BSc/MSc ETiT, BSc/MSc MEC

7 Grade bonus compliant to §25 (2)

8 References

- Lecture Notes „Mechatronics Workshop“
- J. Dillinger et al.: Fachkunde Metall, Europa-Lehrmittel, 2007
- U. Tietze, C. Schenk, E. Gamm: Halbleiter-Schaltungstechnik, Springer, 2012

Courses

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

Module name					
Software Lab Computational Electromagnetics and Applications I					
Module Nr. 18-dg-1041	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 195 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Various topics are: 1. Introduction, 2. Basics of FIT I, 3. Basics of FIT II, 4. Static problems (electrical/magnetical) (scalar potential), 5. Magnetostatic problems, frequency domain, 5. Time domain integration techniques: Leapfrog I, 7. Time domain integration techniques: Leapfrog II, 8. Other physical problems: heat conduction, 9. Other discretization methods: Finite Element Method.
2	**Learning objectives / Learning Outcomes** Students will understand basic concepts of numerical solution techniques to field problems related to different physical domains. They will exhibit the ability to write small simulation programs in Matlab.
3	**Recommended prerequisite for participation** Recommended: "Computational Electromagnetics and Applications" (also in parallel).
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc ETiT, BSc CE
7	**Grade bonus compliant to §25 (2)**
8	**References** Course notes will be provided.

Courses

Course Nr.	Course name		
18-dg-1041-pr	Software Lab Computational Electromagnetics and Applications I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Internship	3

Module name Digital Design Lab					
Module Nr. 18-hb-1030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 45 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Content** • Introduction to the MP3 encoding standard for audio signals • Analysis of the individual steps of the decoding process wrt. the used algo-rithms • Analysis of the individual steps of the decoding process wrt. the storage of in-termediate results • Design and configuration of the datapath to realize the individual process steps • Simulation on functional level and with timing annotation • Check, whether the design meets all restrictions • Test of the final HW design with all relevant MP3 variants (short and long frames)
2	**Learning objectives / Learning Outcomes** Students are able to manually map complex problems onto a digital target architecture. They are proficient in using the design tools to implement their solution on FPGAs. They know strategies to systematically find errors in their design. They can explore de-signs by simulation.
3	**Recommended prerequisite for participation** Basic knowledge of digital design
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-hb-1030-pr	Digital Design Lab		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Internship	3

Module name Electronics					
Module Nr. 18-ho-1011	**Credit Points** 7 CP	**Workload** 210 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Content

18-ho-1011-vl bzw. –ue:

Semiconductor Elements: Diode, MOSFET, Bipolartransistor. Electronic Circuit Design; Basic Analog Circuits and their properties, Behavior and properties of operational amplifiers, circuit simulation with SPICE, small signal amplification, single stage amplifiers, frequency response; digital circuits: CMOS-logic

18-ho-1011-pr:

Practical experiments in the fields:

- digital circuits: FPGA-programming
- analog circuits: basic building blocks, amplifiers, operational amplifiers, filters and demodulators

2 Learning objectives / Learning Outcomes

A student is after successful attending the lecture able to

- analyse the behavior of diodes, MOS- and Bipolartransistors in simple circuits,
- assess the properties of single-transistor amplifiers (MOSFET and BJT), such as small signal behavior, input- and output-resistance;
- design inverting and non-inverting operational amplifiers with passive components and knows the ideal and non-ideal properties;
- calculate the frequency response of simple transistor circuits;
- knows the different circuit techniques (CMOS, NMOS) of logical gates and knows the basic functions (inverter, NAND, NOR).

A student is after successful attending the lab able to

- perform measurements in time and frequency domain using an oscilloscope on simple operational amplifiers;
- design and realize a traffic light controller based on a finite state machine using a FPGA as the target implementation;
- mount passive and active components on a PCB (including preparation of components, soldering) and put the system to function,
- simulate a circuit (filter) using SPICE and perform measurements on the realization.

3 Recommended prerequisite for participation

Basics of Electrical Engineering

4 Form of examination

Module Final Examination:

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

Module Eccompanying Examination:

- [18-ho-1011-pr] (Study Achievement, Optional, Standard BWS)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 4)

Module Eccompanying Examination:

- [18-ho-1011-pr] (Study Achievement, Optional, Weighting: 3)

6 Usability of this module

BSc ETiT, BSc Wi-ETiT, BSc iST, BEd

<table>
<tr><td>7</td><td colspan="4">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td colspan="4">References</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-ho-1011-vl</td><td colspan="3">Course name
Electronics</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Oliver Bachmann</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-ho-1011-pr</td><td colspan="3">Course name
Electronics Lab</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Ferdinand Keil</td><td>Type
Internship</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-ho-1011-ue</td><td colspan="3">Course name
Electronics</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Oliver Bachmann</td><td>Type
Practice</td><td>SWS
1</td></tr>
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Module name					
Electronics Lab					
Module Nr. 18-ho-1030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Lab experiments on: • Digital Circuits: FPGA programming • Analog Ciruits: Basic Components, Amplifiers, Operational Amplifiers, Filters and Demodulators
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • perform measurement on operational amplifier circuits in the time- and frequency domain using an oscilloscope • design a traffic light controller using state diagrams and download the program to a FPGA,
3	**Recommended prerequisite for participation** Basics of Electrical Engineering; Lecture “Electronics” which is running in parallel
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies of Lecture “Electronics”; Richard Jaeger: Microelectronic Circuit Design

Courses

Course Nr.	Course name		
18-ho-1011-pr	Electronics Lab		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Ferdinand Keil		Internship	2
Course Nr.	**Course name**		
18-ho-1030-ev	Electronics Lab - Introductory Meeting		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Introductory Course	0

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: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, BSc/MSc Wi-ETiT, MSc iCE, BSc/MSc iST, BSc/MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides „HDL: Verilog and VHDL“

Courses

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

Module name Measuring Technique					
Module Nr. 18-kn-1011	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 105 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** The module includes theoretical discussion and practical application of the measuring chain in detail on example the electrical variables (current, voltage, impedance, power) and selected non-electrical variables (frequency, time, force, pressure and acceleration). In the lecture the following chapter will be thematically treated measuring signals and measuring equipment (oscilloscope, laboratory testing equipment), static measurement error and disturbance variables (especially temperature), basic measurement circuits, AD conversion principles and filtering, measurement method non-electrical variables and the statistics of measurements (distributions, statist safe tests). The topics of the lecture are discussed in the exercise of the module. Examples are analyzed and their application in measurement scenarios are practiced. The practicum of the module consists of five experiments which are time closely matched in time to the lecture: • Measuring of signals in the time range with digital storage oscilloscope, trigger conditions • Measuring of signals in the frequency range with digital storage oscilloscope, error of measurement (aliasing / subsampling, leackage) and window functions • Measuring of mechanical dimensions with suitable primary sensors, sensor electronics / amplifier circuits • computer-based measuring • Importing of sensor signals, whose processing and the resulting automated control of a process using a programmable logic controller (PLC)
2	**Learning objectives / Learning Outcomes** The students know the structure of the measuring chain and the specific properties of the corresponding elements. They know the structure of electronic measuring instruments and basic measuring circuits for electrical and selected non-electrical variables and can apply them. They know the basics of capturing, processing, transferring and storage of measurement data and can describe error sources and quantifying their influences. In the practicum, the students deepen the basis of the measurements with the oscilloscope, the understanding of the relationship between time and frequency range. Methodically they are able to document and evaluate the data during laboratory measuring.
3	**Recommended prerequisite for participation** Basics of ETiT I-III, Math I-III, Electronic
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) Module Eccompanying Examination: • [18-kn-1011-pr] (Study Achievement, Optional, Standard BWS)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 4) Module Eccompanying Examination: • [18-kn-1011-pr] (Study Achievement, Optional, Weighting: 2)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc MEC

<table>
<tr><td>7</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td>References
Slide set of lecture
Textbook and exercise book Lerch: „Elektrische Messtechnik“, Springer
Exercise documents
Practical experiment manuals</td></tr>
</table>

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<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-kn-1011-vl</td><td colspan="3">Course name
Measuring Technique</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Mario Kupnik</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-kn-1011-pr</td><td colspan="3">Course name
Measuring Technique Lab</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Mario Kupnik, M.Sc. Bastian Patrick Latsch, M.Sc. Romol Chadda</td><td>Type
Internship</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-kn-1011-ue</td><td colspan="3">Course name
Measuring Technique</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Mario Kupnik</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name Electrical Engineering and Information Technology Lab I					
Module Nr. 18-kn-1040	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 0 h	**Duration** 2	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1 Content

After a safety instruction for electrical equipment, students dolab experiments covering foundations of electrical engineering by using theoretical and experimental instructions to improve basic electrical understanding. Building up a test set autonomously and performing of measurements and evaluations in the form of logs to confirm the theoretical knowledge and lead to independent work in practice.
The following experiments are performed:
- Investigate real behavior of ohmic resistors
- Investigate real behavior of capacitors and inductors
- Calculate impedances of basic two-terminal circuits using network theory
- Measure of electrical power in AC circuits and investigate in the real behaviour of transformers
- DC technology, capacity and inductors, AC technology - Impedances and two-terminal circuits, transformer & power;

2 Learning objectives / Learning Outcomes

After preparing the afternoons independently and self-implementing the measurement setup and measurement tasks by active participation in the practical group and by thorough preparation of the associated measurement protocols, you should be able to:
- Perform the measurement of basic electrical parameters of DC and AC circuits, independently and in compliance with safety rules
- measuring the frequency response of passive electrical networks and resonant circuits, and electric power measurement
- the measurement of circuits for the determination of magnetic, electro-thermal and high-frequency. You have to be able to build and run your own measurements
- interpretations of the measurement results in terms of its technical meaning, but also their accuracy and error sources safely.

3 Recommended prerequisite for participation

Parallel attending the lectures and exercises, “Electrical Engineering I and II”

4 Form of examination

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

5 Grading

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

6 Usability of this module

BSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

detailed script with instructions for the experiments; Clausert, H. / Wiesemann, G.: Grundgebiete der Elektrotechnik, Oldenbourg,1999

Courses

	Course Nr. 18-kn-1041-pr	**Course name** Electrical Engineering and Information Technology Lab I B		
	Instructor Prof. Dr. Mario Kupnik		**Type** Internship	**SWS** 2
	Course Nr. 18-kn-1040-pr	**Course name** Electrical Engineering and Information Technology Lab I A		
	Instructor Prof. Dr. Mario Kupnik, M.Sc. Gianni Allevato		**Type** Internship	**SWS** 2
	Course Nr. 18-kn-1040-tt	**Course name** Electrical Engineering and Information Technology I, Safety instructions and rules		
	Instructor Prof. Dr. Mario Kupnik, Dr.-Ing. Axel Jäger		**Type** Tutorial	**SWS** 0

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

1	**Content** • Control of a 2-tank system. • Control of pneumatic and hydraulic servo-drives. • Control of a 3 mass oscillator. • Position control of a MagLev system. • Control of a discrete transport process with electro-pneumatic components. • Microcontroller-based control of an electrically driven throttle valve. • Identification of a 3 mass oscillator. • Process control using PLC.
2	**Learning objectives / Learning Outcomes** After this lab tutorial the students will be able to practically apply the modelling and design techniques for different dynamic systems presented in the lecture "System dynamics and control systems I" to real lab experiments and to bring them into operation at the lap setup.
3	**Recommended prerequisite for participation** System Dynamics and Control Systems I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Lab handouts will be given to students

Courses

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

Module name					
Laboratory Matlab/Simulink I					
Module Nr. 18-ko-1030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 45 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** In this lab tutorial, an introduction to the software tool MatLab/Simulink will be given. The lab is split into two parts. First the fundamentals of programming in Matlab are introduced and their application to different problems is trained. In addition, an introduction to the Control System Toolbox will be given. In the second part, the knowledge gained in the first part is applied to solve a control engineering specific problem with the software tools.
2	**Learning objectives / Learning Outcomes** Fundamentals in the handling of Matlab/Simulink and the application to control engineering tasks.
3	**Recommended prerequisite for participation** The lab should be attended in parallel or after the lecture “System Dynamics and Control Systems I”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT; BSc MEC
7	**Grade bonus compliant to §25 (2)** In case of E-Learning: Possibility to improve the grade up to 1,0
8	**References** Lecture notes for the lab tutorial can be obtained at the secretariat Lunze; Regelungstechnik I Dorp; Bishop: Moderne Regelungssysteme Moler: Numerical Computing with MATLAB

Courses

Course Nr.	Course name		
18-ko-1030-pr	Laboratory Matlab/Simulink I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Alexander Steinke		Internship	3

Module name Laboratory Course Control of Mechatronic Systems					
Module Nr. 18-ko-1040	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** • Control of a 2-tank system. • Control of pneumatic and hydraulic servo-drives. • Control of a 3 mass oscillator. • Position control of a MagLev system. • Control of a discrete transport process with electro-pneumatic components. • Microcontroller-based control of an electrically driven throttle valve. • Identification of a 3 mass oscillator. • Process control using PLC.
2	**Learning objectives / Learning Outcomes** After this lab tutorial the students will be able to practically apply the modelling and design techniques for different dynamic systems presented in the lecture ”System dynamics and control systems I” to real lab experiments and to bring them into operation at the lap setup.
3	**Recommended prerequisite for participation** System Dynamics and Control Systems I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc MEC
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 Praktikum Regelung mechatronischer Systeme (für MB)					
Module Nr. 18-ko-1041	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** • Control of a 2-tank system. • Control of pneumatic and hydraulic servo-drives. • Control of a 3 mass oscillator. • Position control of a MagLev system. • Control of a discrete transport process with electro-pneumatic components. • Microcontroller-based control of an electrically driven throttle valve. • Identification of a 3 mass oscillator. • Process control using PLC.
2	**Learning objectives / Learning Outcomes** After this lab tutorial the students will be able to practically apply the modelling and design techniques for different dynamic systems presented in the lecture "System dynamics and control systems I" to real lab experiments and to bring them into operation at the lap setup.
3	**Recommended prerequisite for participation** System Dynamics and Control Systems I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc Maschinenbau
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 Project Seminar Communication and Sensor Systems					
Module Nr. 18-kp-1041	**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. techn. Heinz Köppl		

1	**Content** Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives / Learning Outcomes** After completion of the course, students possess: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisite for participation** Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in the lecture

Courses

Course Nr.	**Course name**		
18-kp-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl		Project Seminar	4

Module name Laboratory of Biomedical Engineering					
Module Nr. 18-kp-1050	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. techn. Heinz Köppl		

1	**Content** This module addresses the different branches of biomedical engineering. Contents of lab experiments cover current topics of biomedical engineering like medical robotics, measuring and sensor technology, biomechanics, radiotherapy, imaging techniques, biosignal-monitoring, gerontology or Lab-on-a-Chip.
2	**Learning objectives / Learning Outcomes** After successful completion of this module students will be familiar with practical applications of medical engineering and have learnt to identify necessary practical methods and work techniques and to implement them correctly. They will also have gained experience in experimental works in autonomous small groups from a medical engineering context.
3	**Recommended prerequisite for participation** Recommended are „Electrical Engineering and Information Technology I“, and „Electrical Engineering and Information Technology II“
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Duration: 60 min, Standard Grading System) Module final exam: * Module exam (Study achievements, oral/written, Duration: 30 min. for oral examination / Duration: 60 min. for written examination, standard grading system)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc Biomedical Engineering
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-kp-1050-pr	Laboratory of Biomedical Engineering	Prof. Dr. techn. Heinz Köppl	Internship	2
18-kp-1050-tt	Preliminary	Prof. Dr. techn. Heinz Köppl	Preliminary Discussion	0

Module name Multimedia Communications Lab I					
Module Nr. 18-sm-1020	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 45 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. Beside a general overview it provides a deep insight into a special development topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and basic scientific competences in one or more of the following topics: • Network planning and traffic analysis • Performance evaluation of network applications • Discrete event simulation for network services • Protocols for mobile ad hoc networks / sensor networks • Infrastructure networks for mobile communication / mesh networks • Context-aware communication and services • Peer-to-peer systems and architectures • Content distribution and management systems for multimedia/e-learning • Multimedia authoring and re-authoring tools • Web service technologies and service-oriented architectures • Applications for distributed workflows • Resource-based Learning
2	**Learning objectives / Learning Outcomes** The ability to solve simple problems in the area of multimedia communication shall be acquired. Acquired competences are: • Design of simple communication applications and protocols • Implementing and testing of software components for distributed systems • Application of object-oriented analysis and design techniques • Presentation of project advances and outcomes
3	**Recommended prerequisite for participation** Keen interest to explore basic topics of cutting edge communication and multimedia technologies. Further we expect: • Basic experience in programming Java/C# (C/C++). • Knowledge in computer communication networks. Lectures in Communication Networks I and/or Net Centric Systems are recommended.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc/MSc iST, MSc MEC, Wi-CS, Wi-ETiT, BSc/MSc CS
7	**Grade bonus compliant to §25 (2)**
8	**References**

Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:

- Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887)
- Christian Ullenboom: "Java ist auch eine Insel: Programmieren mit der Java Standard Edition Version 5 / 6" (ISBN-13: 978-3898428385)
- Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)

Courses

Course Nr.	Course name		
18-sm-1020-pr	Multimedia Communications Lab I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Florian Jomrich		Internship	3

Module name Software Lab					
Module Nr. 18-st-1020	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Content** The lab covers the following basic software development skills: • working together and software development in teams • lightweight software engineering process eXtreme Programming (XP) • training of advanced OO/Java programming skills and coding standards • software documentation using JavaDoc • the basics of the development tool eclipse • regression testing methods (test framework JUnit) to increase software quality • more sophisticated data structures and algorithms
2	**Learning objectives / Learning Outcomes** Students participating in the lab deepen their basic programming knowledge (acquired in Computer Science for Engineers). The focus is on development of “medium-size” software in contrast to programming small toy examples, working in teams and evolution of existing software (framework). Afterwards students are expected to be able to develop small software systems using a "light-weight" software development process. Furthermore, they will appreciate training in more sophisticated software engineering techniques needed for the development of "real-world" software systems.
3	**Recommended prerequisite for participation** Basics in Java (as taught in Introduction to Computer Science for Engineers). Windows-Account of the ETiT PC-Pool
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/sp/

Courses

Course Nr.	**Course name**		
18-st-1020-pr	Software Lab		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke		Internship	3

Module name					
C/C++ Programming Lab					
Module Nr. 18-su-1030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 45 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The six-day programming lab is divided into two sections. In the first four days, the programming languages C and C++ are taught with practical tasks and lectures. All covered aspects are extensively practiced under supervision. Based on the fundamental basics of C++, manual memory management and dynamic data structures are handled from a procedural as well as from an object-oriented perspective. Object orientation with C++ is extensively addressed by treating multiple inheritance, polymorphism and parametric polymorphism. The last two days are dedicated to microcontroller programming in C including the opportunity of programming of a distributed application (via a CAN-bus).
2	**Learning objectives / Learning Outcomes** During the lab, the students acquire a fundamental understanding of the programming languages C and C++ with emphasis not only on procedural but also on object-oriented characteristics. The students gain hands-on experience with applying C++ and discover the challenges of using C++ safely and properly especially in the context of embedded system software development.
3	**Recommended prerequisite for participation** Java skills
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** http://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/c-und-c-p

Courses

Course Nr.	Course name		
18-su-1030-pr	C/C++ Programming Lab		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Sebastian Ehmes		Internship	3

Module name Seminar Electronic Circuits					
Module Nr. 18-ho-1070	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Analysis of state-of-the-art circuit concepts and presentation of selected examples
2	**Learning objectives / Learning Outcomes** After attending the seminar, a student is capable of analysing of state-of-the-art circuit concepts and preparing didactical materials and presentations, based on the know-how gained in the lectures "Electronics" and "Analog Integrated Circuit Design"
3	**Recommended prerequisite for participation** Electronics, Analog Integrated Circuit Design
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be provided at the begin of the seminar

Courses

Course Nr.	**Course name**		
18-ho-1070-se	Seminar Electronic Circuits		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Seminar	**SWS** 4

Module name Seminar Terahertz Components & Applications					
Module Nr. 18-pr-1010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1 Content

Investigating and solving specific problems concerning the development of Terahertz devices as well as of applications of THz technology. The specific task will be defined based on current research topics. The project seminar includes working on a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience. Topics include, e.g.:

- Optics on chip
- Semiconductor devicesLight-matter interaction

2 Learning objectives / Learning Outcomes

After completion of the course, students possess:

- the ability to apply theoretical models to practical problems
- deep and special knowledge in a particular field related to THz science, optics or semiconductor physics
- the skills to find, analyze and evaluate scientific reference papers for a particular topic
- the capability to summarize the achieved scientific findings in the form of a concise reportthe ability to present and discuss achieved results in the form of a presentation in front of an audience

3 Recommended prerequisite for participation

Previous knowledge one of the following disciplines: Optics, semiconductor physics, or THz technology

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

Will be announced once the topic is defined.

Courses

Course Nr.	Course name		
18-pr-1010-se	Seminar Terahertz Components & Applications		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Seminar	2

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-ad-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-ad-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor Prof. Dr.-Ing. Jürgen Adamy		**Type** Introductory Seminar Course	**SWS** 2

Module name Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-bi-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-bi-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Dr.h.c. Andreas Binder		Introductory Seminar Course	2

<table>
<tr><td colspan="6">Module name
Proseminar Electrical Engineering and Information Technology</td></tr>
<tr><td>Module Nr.
18-bu-1000</td><td>Credit Points
2 CP</td><td>Workload
60 h</td><td>Self study
60 h</td><td>Duration
1</td><td>Cycle offered
WiSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Ph.D. Thomas Peter Burg</td></tr>
</table>

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-dg-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-dg-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor Prof. Dr.-Ing. Herbert De Gersem		**Type** Introductory Seminar Course	**SWS** 2

Module name Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-gt-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 18-gt-1000-ps	**Course name** Proseminar Electrical Engineering and Information Technology		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog		**Type** Introductory Seminar Course	**SWS** 2

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-hb-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-hb-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor Prof. Dr.-Ing. Christian Hochberger		**Type** Introductory Seminar Course	**SWS** 2

Module name Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-hi-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Volker Hinrichsen		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology. Additional information can be found here.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-hi-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Johannes Wiener		Introductory Seminar Course	2

Module name Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-ho-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Analysis of basic electronic circuits and presentation of selected examples
2	**Learning objectives / Learning Outcomes** After attending the seminar, a student is capable of analysing basic electronic circuits and preparing didactical materials and presentations
3	**Recommended prerequisite for participation** Electronics
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be provided at the begin of the seminar

Courses

Course Nr.	**Course name**		
18-ho-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Introductory Seminar Course	2

Module name Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-hs-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-hs-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor Prof. Dr.-Ing. Jutta Hanson		**Type** Introductory Seminar Course	**SWS** 2

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-jk-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-jk-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		Introductory Seminar Course	2

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-kl-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation** Basic knowledge from the first four semesters
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-kl-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, M.Sc. Kilian Kiekenap		Introductory Seminar Course	2

Module name Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-kh-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-kh-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Introductory Seminar Course	**SWS** 2

Module name					
Proseminar ETiT					
Module Nr. 18-kn-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-kn-1000-ps	Proseminar ETiT		
Instructor Prof. Dr. Mario Kupnik		**Type** Introductory Seminar Course	**SWS** 2

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-ko-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-ko-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ulrich Konigorski		Introductory Seminar Course	2

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-kp-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. techn. Heinz Köppl		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-kp-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor Prof. Dr. techn. Heinz Köppl		**Type** Introductory Seminar Course	**SWS** 2

Module name Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-pe-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-pe-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor Prof. Dr.-Ing. Marius Pesavento, M.Sc. Wassim Suleiman		**Type** Introductory Seminar Course	**SWS** 2

<table>
<tr><td colspan="6">Module name
Proseminar Electrical Engineering and Information Technology</td></tr>
<tr><td>Module Nr.
18-pr-1000</td><td>Credit Points
2 CP</td><td>Workload
60 h</td><td>Self study
30 h</td><td>Duration
1</td><td>Cycle offered
WiSe/SoSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Sascha Preu</td></tr>
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<table>
<tr><td>1</td><td>Content
Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.</td></tr>
<tr><td>2</td><td>Learning objectives / Learning Outcomes
The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.</td></tr>
<tr><td>3</td><td>Recommended prerequisite for participation</td></tr>
<tr><td>4</td><td>Form of examination
Module Final Examination:
• Module Examination (Study Achievement, Optional, Standard Grading System)</td></tr>
<tr><td>5</td><td>Grading
Module Final Examination:
• Module Examination (Study Achievement, Optional, Weighting: 100 %)</td></tr>
<tr><td>6</td><td>Usability of this module
BSc ETiT, BSc MEC, BSc iST</td></tr>
<tr><td>7</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td>References</td></tr>
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<tr><td rowspan="2"></td><td>Course Nr.
18-pr-1000-ps</td><td colspan="2">Course name
Proseminar Electrical Engineering and Information Technology</td></tr>
<tr><td>Instructor
Prof. Dr. rer. nat. Sascha Preu</td><td>Type
Introductory Seminar Course</td><td>SWS
2</td></tr>
</table>

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-sc-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-sc-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sebastian Schöps		Introductory Seminar Course	2

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-sm-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.

This seminar addresses students of Electrical Engineering disciplines and covers various topics from the fields of computer science and electrical engineering. It is usually the first seminar that students take during their studies. Therefore, the focus lies on the process of finding, reading, and understanding scientific publications (conference papers, articles) related to a given topics and on categorizing and summarizing the results in oral form (presentation) and written form (short paper). Some potential topics are:

- Knowledge & Educational Technologies
- Adaptive Communication Systems
- Multimedia Technologies & Serious Games

For more information please refer to the webpage: https://www.kom.tu-darmstadt.de/en/teaching/current-courses/11/proseminar-etit/

2 Learning objectives / Learning Outcomes

The students will be able to understand and analyse scientific papers, as well as to present technical facts in a proper and well structured manner. They know how to summarize and present publications from a given topic area.

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:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

BSc ETiT, BSc MEC, BSc 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-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz		Introductory Seminar Course	2

Module name					
Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-st-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology. Additional information can be found here.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-st-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Christopher Thomas Peter Ripp		**Type** Introductory Seminar Course	**SWS** 2

<table>
<tr><td colspan="6">Module name
Proseminar Electrical Engineering and Information Technology</td></tr>
<tr><td>Module Nr.
18-su-1000</td><td>Credit Points
2 CP</td><td>Workload
60 h</td><td>Self study
30 h</td><td>Duration
1</td><td>Cycle offered
SoSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Andreas Schürr</td></tr>
</table>

<table>
<tr><td>1</td><td>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.</td></tr>
<tr><td>2</td><td>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.</td></tr>
<tr><td>3</td><td>Recommended prerequisite for participation
Introduction to Computer Science for Engineers, Software Lab; Software Engineering I or comparable skills</td></tr>
<tr><td>4</td><td>Form of examination
Module Final Examination:
• Module Examination (Study Achievement, Optional, Standard Grading System)</td></tr>
<tr><td>5</td><td>Grading
Module Final Examination:
• Module Examination (Study Achievement, Optional, Weighting: 100 %)</td></tr>
<tr><td>6</td><td>Usability of this module
BSc ETiT, Informatik, iST, Wi-ETiT</td></tr>
<tr><td>7</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td>References
http://www.es.tu-darmstadt.de/lehre/proseminar-etit/</td></tr>
</table>

<table>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-su-1000-ps</td><td colspan="3">Course name
Proseminar Electrical Engineering and Information Technology</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Andreas Schürr</td><td>Type
Introductory Seminar Course</td><td>SWS
2</td></tr>
</table>

Module name Proseminar Electrical Engineering and Information Technology					
Module Nr. 18-zo-1000	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Content** Read published books or papers on a given subject in Electrical Engineering and Information Technology. Write a summary and present it using multi media technology.
2	**Learning objectives / Learning Outcomes** The student will be able to understand and analyse scientific papers, to present technical facts properly and well structured. He knows how to summarize and present the given topic.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-zo-1000-ps	Proseminar Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Introductory Seminar Course	2

Module name Project Seminar Electromagnetic CAD					
Module Nr. 18-dg-1060	**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. Herbert De Gersem		

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

Courses

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

Module name Project Seminar Computer Systems					
Module Nr. 18-hb-1040	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 210 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Content** Students elaborate on a research-oriented subject in the area of computer-systems. They present a written documentation and 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.
3	**Recommended prerequisite for participation** Basic knowledge of digital design
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc/MSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-hb-1040-pj	Project Seminar Computer Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Project Seminar	4

Module name					
Project Seminar Integrated Electronic Systems					
Module Nr. 18-ho-1060	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 210 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Research-oriented project in the domain of Integrated Electronic Systems or Microelectronic System Design, Final Report and Presentation of Results in a Team
2	**Learning objectives / Learning Outcomes** After attending this projectseminar, a student is able to fulfill/implement a given task or project in the domain of Integrated Electronic System design (optionally in a group of students), write a final report and present the results to an audience.
3	**Recommended prerequisite for participation** Lecture Analog Integrated Circuit Design
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, Wi ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Material on the subject will be handed out

Courses

Course Nr.	Course name		
18-ho-1060-pj	Project Seminar Integrated Electronic Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Project Seminar	4

Module name Project Seminar Communication and Sensor Systems					
Module Nr. 18-jk-1041	**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** Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives / Learning Outcomes** After completion of the course, students possess: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisite for participation** Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in the lecture

Courses

Course Nr.	**Course name**		
18-jk-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		Project Seminar	4

Module name Project Seminar Particle Accelerator Technology					
Module Nr. 18-kb-1020	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 210 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Content** Work on a more complex project in the field of particle accelerator technology. Depending on the specific problem, measurement aspects, analytical aspects, and simulation aspects will be included.
2	**Learning objectives / Learning Outcomes** Students will be able to solve complex engineering problems with different measurement techniques, analytical approaches or simulation methods. They are able to estimate measurement errors and modeling and simulation 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, broad knowledge of different electrical engineering disciplines.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Suitable material is provided based on specific problem.

Courses

Course Nr.	Course name		
18-kb-1020-pj	Project Seminar Particle Accelerator Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Harald Klingbeil		Project Seminar	4

Module name Project Seminar Communication and Sensor Systems					
Module Nr. 18-kl-1041	**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. Anja Klein		

1	**Content** Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives / Learning Outcomes** After completion of the course, students possess: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisite for participation** Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in the lecture

Courses

Course Nr.	**Course name**		
18-kl-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein		Project Seminar	4

Module name					
Product Development Methodology I					
Module Nr. 18-kn-1025	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** Practical experience in the methods used for the development of technical products. Work in a project team.
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 aspart lists, 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** Parallel attendance of Proseminar ETiT Option MPE
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr.	Course name		
18-kn-1025-pj	Product Development Methodology I		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Ph.D. Thomas Peter Burg		Project Seminar	3

<table>
<tr><td colspan="6">Module name
Project Seminar Communication and Sensor Systems</td></tr>
<tr><td>Module Nr.
18-pe-1041</td><td>Credit Points
8 CP</td><td>Workload
240 h</td><td>Self study
180 h</td><td>Duration
1</td><td>Cycle offered
WiSe/SoSe</td></tr>
<tr><td colspan="3">Language
German and English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Marius Pesavento</td></tr>
</table>

1	**Content** Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives / Learning Outcomes** After completion of the course, students possess: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisite for participation** Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in the lecture

Courses

<table>
<tr><td>Course Nr.
18-pe-1041-pj</td><td colspan="2">Course name
Project Seminar Communication and Sensor Systems</td></tr>
<tr><td colspan="1">Instructor
Prof. Dr.-Ing. Marius Pesavento</td><td>Type
Project Seminar</td><td>SWS
4</td></tr>
</table>

Module name Project Seminar Terahertz Systems & Applications					
Module Nr. 18-pr-1020	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 210 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1	**Content** Investigating and solving specific problems concerning the development of Terahertz devices and systems as well as of applications of THz technology. The specific task will be defined based on current research topics. The project seminar includes working on a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience. Topics include, e.g.: • Optics on chip • Semiconductor devicesLight-matter interaction
2	**Learning objectives / Learning Outcomes** After completion of the course, students possess: • the ability to apply theoretical models to practical problems • deep and special knowledge in a particular field related to THz science, optics or semiconductor physics • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise reportthe ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisite for participation** Previous knowledge one of the following disciplines: Optics, semiconductor physics, or THz technology
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc/MSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced once the topic is defined

Courses

Course Nr.	**Course name**		
18-pr-1020-pj	Project Seminar Terahertz Systems & Applications		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Project Seminar	4

Module name Project Seminar Communication and Sensor Systems					
Module Nr. 18-pr-1041	**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. Sascha Preu		

1	**Content** Investigating and solving specific problems concerning the development of Terahertz sensors and -systems as well as of applications of THz technology. The specific task will be defined based on current research topics. The project seminar includes working on a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience. Topics include, e.g.: • Optics on chip • Semiconductor devicesLight-matter interaction
2	**Learning objectives / Learning Outcomes** After completion of the course, students possess: • the ability to apply theoretical models to practical problems • deep and special knowledge in a particular field related to THz science, optics or semiconductor physics • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise reportthe ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisite for participation** Previous knowledge one of the following disciplines: Optics, semiconductor physics, or THz technology
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced once the topic is defined.

Courses

Course Nr.	**Course name**		
18-pr-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Project Seminar	**SWS** 4

Module name Multimedia Communications Project I					
Module Nr. 18-sm-1030	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 210 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:

- 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
- Resource-based Learning

2 Learning objectives / Learning Outcomes

The ability to solve and evaluate technical problems in the area of design and development of future multimedia communication networks and applications using state of the art scientific methods. Acquired competences are among the following:

- Searching and reading of project relevant literature
- Design of communication applications and protocols
- Implementing and testing of software components
- Application of object-orient analysis and design techniques
- Acquisition of project management techniques for small development teams
- Evaluation and analyzing of technical 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 communication systems. Further we expect:

- Basic experience in programming Java/C# (C/C++).
- Basic knowledge in Object oriented analysis and design.
- Knowledge in computer communication networks. Lectures in Communication Networks I and/or Net Centric Systems are recommended.

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

<table>
<tr><td>6</td><td colspan="4">Usability of this module
BSc ETiT, BSc/MSc iST, MSc MEC, Wi-CS, Wi-ETiT, BSc/MSc CS</td></tr>
<tr><td>7</td><td colspan="4">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td colspan="4">References
Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:
• Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887)
• Raj Jain: "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling" (ISBN 0-471-50336-3)
• 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)</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-sm-1030-pj</td><td colspan="3">Course name
Multimedia Communications Project I</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Florian Jomrich</td><td>Type
Project Seminar</td><td>SWS
4</td></tr>
</table>

Module name Project Seminar Energy Information Systems					
Module Nr. 18-st-1010	**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. Florian Steinke		

1	**Content** Students elaborate on a research-oriented subject in the area of computer-systems. 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 terminolo-gy.
3	**Recommended prerequisite for participation** no
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System) Module final exam: * Module exam (Study achievements, Optional, weighting: 100)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-st-1010-pj	Project Seminar Energy Information Systems		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke		Project Seminar	4

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

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:

- Model-Driven Enginnering and Model Synchronization
- Model Transformation
- Object-Oriented Refactorings
- Program Variability (Software Product Lines)
- Feature Model Analysis

Additional information and topic description for the current semester: http://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/projektseminar-softwaresysteme/

2 Learning objectives / Learning Outcomes

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.

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:

- 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:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

Module name Project Seminar Communication and Sensor Systems					
Module Nr. 18-zo-1041	**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. Abdelhak Zoubir		

1	**Content** Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives / Learning Outcomes** After completion of the course, students possess: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisite for participation** Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in the lecture

Courses

Course Nr.	**Course name**		
18-zo-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Project Seminar	4

Module name Introductionary Project					
Module Nr. 18-de-1010	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Content** Based on a complex technical problem students will get to know an idea of the diversity of electrical and information enginering. The introductionary project gives a perspective of the upcoming course of studies. It gives an introduction in engineering thinking and working. Groups of students will work in teams for one complete week. Each group of students will be accompanied by a team- and a technical tutor.
2	**Learning objectives / Learning Outcomes** Students get to know problem analysis, information acquisition, team work, project management, and presentation of results.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 15 min, Pass/Fail Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References** lecture notes (will be handed out)

Courses

Course Nr.	**Course name**		
18-de-1010-pj	Introductionary Project (Project Week)		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Harald Klingbeil, M. A. Stephanie Bockshorn, Dipl.-Soz. Goran Beil		Project	2

Module name Mentoring als Fachspezifisches Instrument (für iST)					
Module Nr. 18-de-1031	**Credit Points** 1 CP	**Workload** 30 h	**Self study** 0 h	**Duration** 2	**Cycle offered** WiSe
Language German			**Module owner** PD Dr.-Ing. Oktay Yilmazoglu		

1	**Content** The following learning content is taught in the Mentoring: • reflection of own study decision and situation, • basics of the working techniques, • learning techniques and time management methods. The mentoring consists of student-led tutorials in the scope of normally twelve units consist-ing of group and one-on-one talks, as well as workshop elements and the simulation of an examination situation. For students without exam success in the first semester (WiSe) in an examination in the field of fundamentals (catalog 1 to 3) of the study and examination plan, the second semester (SoSe) takes place, usually in the scope of three units consisting of one-to-one-talks and workshop elements.
2	**Learning objectives / Learning Outcomes** Through the mentoring, the students were encouraged to reflect on their study decision and situation. Mentoring enables students to learn and to train working methods and learning methods. They realize the importance of application of time management methods in learn-ing processes and acquire the ability to implement them target-oriented for enhancement of learning success. Students reflect own actions in learning processes and receive feedback from the mentor to gain a higher level of self-competence. After completion of this module students have the ability to optimize time management for learning success, to develop the personal learning style and methods and apply learning methods adequate to the met situation and conditions. Students have the ability to analyse reasons for personal problems of understanding and solve them by means of adequate actions and methods.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Pass/Fail Grading System) • participation in the moodle-course, usually until the end of the second semester, also answering of questionnaires, completion of homework and other activities in the context of the meetings • seminar paper (optional repetition of the examination)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References** * Kurt Landau, Arbeitstechniken für Studierende der Ingenieurswissenschaften; Verlag ergonomia oHG, Stuttgart, ISBN 3-935089-65-1 * Kurt Landau, Besser studieren! Übungsbuch zum Werk Arbeitstechniken; Verlag er-gonomia oHG, Stuttgart, ISBN 3-935089-67-X * Other materials are provided in Moodle

Courses				
	Course Nr. 18-de-1031-tt	**Course name** Mentoring (for iST)		
	Instructor PD Dr.-Ing. Oktay Yilmazoglu, Dr.-Ing. Emna Zoghlami EP Ayari		**Type** Lecture	**SWS** 1

Module name Mentoring als fachspezifisches Instrument					
Module Nr. 18-de-1032	**Credit Points** 1 CP	**Workload** 30 h	**Self study** 0 h	**Duration** 2	**Cycle offered** WiSe
Language German			**Module owner** PD Dr.-Ing. Oktay Yilmazoglu		

1 Content

The following learning content is taught in the Mentoring:
* reflection of own study decision and situation,
* basics of the working techniques,
* learning techniques and time management methods.

The mentoring consists of student-led tutorials in the scope of normally twelve units consisting of group and one-on-one talks, as well as workshop elements and the simulation of an examination situation.
For students without exam success in the first semester (WiSe) in an examination in the field of “fundamentals of electrical engineering and information technology” or "fundamentals of mathematics" of the study and examination plan, the second semester (SoSe) takes place, usually in the scope of three units consisting of one-to-one-talks and workshop elements.

2 Learning objectives / Learning Outcomes

Through the mentoring, the students were encouraged to reflect on their study decision and situation. Mentoring enables students to learn and to train working methods and learning methods. They realize the importance of application of time management methods in learn-ing processes and acquire the ability to implement them target-oriented for enhancement of learning success. Students reflect own actions in learning processes and receive feedback from the mentor to gain a higher level of self-competence. After completion of this module students have the ability to optimize time management for learning success, to develop the personal learning style and methods and apply learning methods adequate to the met situation and conditions. Students have the ability to analyse reasons for personal problems of understanding and solve them by means of adequate actions and methods.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:
- Module Examination (Study Achievement, Optional, Pass/Fail Grading System)

5 Grading

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

6 Usability of this module

BSc etit, BSc Mec

7 Grade bonus compliant to §25 (2)

8 References

- Kurt Landau, Arbeitstechniken für Studierende der Ingenieurswissenschaften; Verlag ergonomia oHG, Stuttgart, ISBN 3-935089-65-1
- Kurt Landau, Besser studieren! Übungsbuch zum Werk Arbeitstechniken; Verlag er-gonomia oHG, Stuttgart, ISBN 3-935089-67-X
- Other materials are provided in Moodle

Courses

	Course Nr.	Course name		
	18-de-1032-tt	Mentoring		
	Instructor		**Type**	**SWS**
	PD Dr.-Ing. Oktay Yilmazoglu		Lecture	1

Module name Mentoring for Biomedical Engineering					
Module Nr. 18-de-1033	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 45 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** PD Dr.-Ing. Oktay Yilmazoglu		

1	**Content** This module addresses the main features of work techniques, studying methods and time management methods. In addition the specificity of interdisciplinary collaboration and individual challenges arising from it are discussed.
2	**Learning objectives / Learning Outcomes** Mentoring enables students to learn, to identify and to train working methods and learning methods. They realize the importance of application of time management methods in learning processes and acquire the ability to implement them target-oriented for enhancement of learning success. Students reflect their own actions in learning processes and receive feed-back from the mentor to gain a higher level of self-competence. After completion of this module students have the ability to optimize time management for learning success, to develop the personal learning style and methods and apply learning methods adequate to the met situation and conditions. Students have the ability to analyse reasons for personal understanding and solve them by means of adequate actions and methods, as well as shape further learning processes autonomously.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Special Form, Pass/Fail Grading System) Module final exam: *Module exam (Study achievements, Special form, pass/fail grading system)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Special Form, Weighting: 100 %)
6	**Usability of this module** BSc Biomedical Engineering
7	**Grade bonus compliant to §25 (2)**
8	**References** Kurt Landau, Arbeitstechniken für Studierende der Ingenieurswissenschaften; Verlag ergonomia oHG, Stuttgart, ISBN 3-935089-65-1 Kurt Landau, Besser studieren! Übungsbuch zum Werk Arbeitstechniken; Verlag ergonomia oHG, Stuttgart, ISBN 3-935089-67-X Other relevant materials are provided in Moodle.

Courses

Course Nr.	**Course name**		
18-de-1033-vl	Mentoring for Biomedical Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr		Lecture	1

Module name					
Product Development Methodology II					
Module Nr. 18-ho-1025	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

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 organization 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: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc WI-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr.	Course name		
18-ho-1025-pj	Product Development Methodology II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Peter Burg		Project Seminar	3

<table>
<tr><td colspan="6">Module name
Product Development Methodology I</td></tr>
<tr><td>Module Nr.
18-kn-1025</td><td>Credit Points
5 CP</td><td>Workload
150 h</td><td>Self study
105 h</td><td>Duration
1</td><td>Cycle offered
WiSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. Mario Kupnik</td></tr>
</table>

1	**Content** Practical experience in the methods used for the development of technical products. Work in a project team.
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 aspart lists, 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** Parallel attendance of Proseminar ETiT Option MPE
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr.	**Course name**		
18-kn-1025-pj	Product Development Methodology I		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Ph.D. Thomas Peter Burg		Project Seminar	3

1.7 Field Trip

1.8 Modules of the B.Sc. Biomedical Engineering

Module name					
Terminology, Medical Morphology and Applied Anatomy					
Module Nr. 18-mt-1010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 60 h	**Duration** 2	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Thomas Vogl		

1	**Content** The module deals with the fundamentals of the morphology of the human body, its tissue structures and their relationships. In particular, human organs are discussed in their microscopic and macroscopic anatomy including the sensory systems, the musculoskeletal system, the cardiovascular system, the digestive system, the nervous system and the stomatognathic system. This includes the knowledge transfer of medical and dental terminology. Anatomical structures and functional relationships are explained on the basis of common clinical cases and thus the direct reference to the clinic is established. At the same time, the module discusses methods and devices that can be used to represent the anatomy and functions of the body, such as medical imaging. In addition, the participants gain initial knowledge about the organizational structures of diagnostic processes. On the basis of a discussion of medical methods and theoretical approaches in surgical disciplines, the participant learns central medical problems.
2	**Learning objectives / Learning Outcomes** After successfully completing the module, the students understand the basics of medical terminology and can tap into the most important and common medical terms. They are familiar with the fundamentals of the microscopic and macroscopic anatomy of important body systems and have acquired a deeper understanding of common medical problems, especially in the fields of surgery, internal medicine and dentistry. They know various media for obtaining information about the morphology of the body and can assess their differential diagnostic reliability. In addition, the students are familiar with important clinical pictures, can explain them in diagnostics and therapy as an example and discuss them with medical professionals and as well as with laypersons.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Eccompanying Examination: • [18-mt-1011-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) • [18-mt-1010-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) Module final exam: *Module exam (per course one Technical examination, Written examination, Duration: 60 min, standard grading system)
5	**Grading** Module Eccompanying Examination: • [18-mt-1011-vl] (Technical Examination, Written Examination, Weighting: 50 %) • [18-mt-1010-vl] (Technical Examination, Written Examination, Weighting: 50 %)
6	**Usability of this module** BSc Biomedical Engineering
7	**Grade bonus compliant to §25 (2)**
8	**References** Caspar: Medizinische Terminologie, Thieme Verlag Schünke/Schumacher/Schulte: Prometheus – Lernpaket Anatomie, Thieme Verlag Vogl: Diagnostische und Interventionelle Radiologie, Springer Verlag

Courses				
	Course Nr. 18-mt-1011-vl	**Course name** Applied Anatomy		
	Instructor		**Type** Lecture	**SWS** 2
	Course Nr. 18-mt-1010-vl	**Course name** Terminology and Medical Morphology		
	Instructor Prof. Dr. Thomas Vogl		**Type** Lecture	**SWS** 2

Module name Natural Scientific Principles for Medical Engineering					
Module Nr. 18-mt-1020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 0 h	**Duration** 2	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Ingrid Fleming		

1	**Content** This module deals with medical biological fundamentals, which are the basis for the application of engineering methods to living systems in biology, medicine and dentistry. In addition to the fundamentals of terminology, cell biology, chemistry and genetics, basic knowledge about chemical and biochemical procedures and processes are also conveyed. Hereon building up, the participants gain insight into first physiological processes within the human body and their relationships. Physiological and exemplary pathophysiological functional relationships are explained on the basis of common clinical pictures and thus the direct clinical reference is established. At the same time, the participants gain their first knowledge of diagnostic procedures in medicine and dentistry and get an overview of the organizational structures of diagnostic processes. On the basis of discussion of medical methods and theoretical approaches in conservative or metabolically-related disciplines, the participants learn key medical questions.
2	**Learning objectives / Learning Outcomes** Students who have successfully completed this module can understand the biological, biochemical and physiological context and apply it to the development and evaluation of biomedical diagnostic and therapeutic systems. In addition, the students, having understood cell and molecular biological processes acquired in this module, will be prepared to discuss medical content with medical professionals and laymen and to understand the basic biomedical literature. They know various media for gathering information about metabolic processes in the body and can assess their reliability.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Eccompanying Examination: • [18-mt-1021-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) • [18-mt-1020-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) • [18-mt-1022-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) Module final exam: *Module exam (per course one Technical examination, Written examination, Duration: 60 min, standard grading system)
5	**Grading** Module Eccompanying Examination: • [18-mt-1021-vl] (Technical Examination, Written Examination, Weighting: 1) • [18-mt-1020-vl] (Technical Examination, Written Examination, Weighting: 1) • [18-mt-1022-vl] (Technical Examination, Written Examination, Weighting: 1)
6	**Usability of this module** BSc Biomedical Engineering
7	**Grade bonus compliant to §25 (2)**
8	**References** Buselmeier: Biologie für Mediziner, Springer-Verlag Zeek, Zeek, Gromd: Chemie für Mediziner, Elsevier-Verlag Müller-Esterl: Biochemie, Spektrum Verlag Walter, Huippelsberg: Kurzlehrbuch der Physiologie, Thieme Verlag
Courses	

	Course Nr. 18-mt-1021-vl	**Course name** Biochemistry		
	Instructor Prof. Dr. Ingrid Fleming		**Type** Lecture	**SWS** 2
	Course Nr. 18-mt-1020-vl	**Course name** Cell Biology		
	Instructor Prof. Dr. Ingrid Fleming		**Type** Lecture	**SWS** 2
	Course Nr. 18-mt-1022-vl	**Course name** Physiology		
	Instructor		**Type** Lecture	**SWS** 2

Module name Biomechanics and Biomaterials						
Module Nr. 18-mt-1030	**Credit Points** 6 CP	**Workload** 180 h		**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German				**Module owner**		

1	**Content** This module deals with the basics of biomechanics. Basis for this is the anatomy of the musculoskeletal system. Among these is integrated the introduction into rigid bodies, multi-body models of human body parts, different modeling variants or the determination of the reaction forces and moments in human joints. In addition, this module deals with material sciences for considering the human body and with materials that are used in particular in medical technology. These include medical-grade materials used to make implants that remain temporarily or permanently in the body, as well as biomaterials used to replace body tissues (skin, bones, cartilage, etc.). In the areas of biomechanics and biomaterials, the basics of osteosynthesis techniques with implants and endoprosthetics are presented as well as basic principles of tissue engineering in the fields of medicine and dentistry.
2	**Learning objectives / Learning Outcomes** After successfully completing this module, students gain knowledge and understanding of the biomechanical basis of human body functions. They shall be able to independently and critically use biomechanical methods. Students are familiar with the basic materials and their mechanical and biological properties used in the human body. In particular, students are familiar with the requirement profile for material behavior regarding medical engineering. They are able to independently select materials for an application from medical engineering, to assess their advantages and disadvantages and to explain them in an argumentative manner.
3	**Recommended prerequisite for participation** Recommended is „ Terminology, Medical Morphology and Applied Anatomy“
4	**Form of examination** Module Eccompanying Examination: • [18-mt-1030-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) • [18-mt-1031-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) Module final exam: *Module exam (per course one Technical examination, Written examination, Duration: 60 min, standard grading system)
5	**Grading** Module Eccompanying Examination: • [18-mt-1030-vl] (Technical Examination, Written Examination, Weighting: 50 %) • [18-mt-1031-vl] (Technical Examination, Written Examination, Weighting: 50 %)
6	**Usability of this module** BSc Biomedical Engineering
7	**Grade bonus compliant to §25 (2)**
8	**References** Sommerfeld, Klein: Biomechanik der menschlichen Gelenke, Elsevier-Verlag Frobin, Brinckmann, Leivseth: Musculosceletal Biomechanics, Thieme Verlag Grifka, Krämer: Orthopädie-Unfallchirurgie, Springer-Verlag Hausamen: Mund-Kiefer-Gesichtschirurgie, Elsevier-Verlag Epple: Biomaterialien und Biomineralisation, Springer Verlag Curtis, Watson: Dental Biomaterials, Elsevier-Verlag

Courses

	Course Nr.	Course name		
	18-mt-1030-vl	Biomechanics		
	Instructor		**Type**	**SWS**
	Prof. Dr. Ingo Marzi		Lecture	3
	Course Nr.	**Course name**		
	18-mt-1031-vl	Biomaterials		
	Instructor		**Type**	**SWS**
	Prof. Dr. Ingo Marzi		Course	3

Module name Biomedical Engineering					
Module Nr. 18-mt-1040	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 0 h	**Duration** 2	**Cycle offered** SoSe
Language German			**Module owner**		

1	**Content** Biomedical engineering supports medicine with technical solutions in the areas of prevention, diagnostics and therapy. This module focuses on applications in the fields of anesthesiology, internal medicine, neurology and dentistry. Punctually, other disciplines complement the program. In particular, current research and development projects in the field of device technology are presented, taking into account the underlying biotechnology. In addition, anatomy and functional processes in the human body are presented and discussed in the context of common clinical pictures. By this, the transfer of scientific questions from a fundamental area and theory into real clinical application will be illustrated by practical examples. Methods and devices with which the anatomy and functions of the body can be represented, are in a particular focus. One core area is the understanding and application of medical imaging and image processing such as segmentation, filtering and image reconstruction. The use and importance of different devices and methods are presented in a problem-oriented manner. This includes the use of interventional procedures that includes invasive patient treatment by imaging support. The second core area is presentation and application of intracorporeal sensory and actuarial systems detecting and affecting body functions minimal invasively.
2	**Learning objectives / Learning Outcomes** After successful completion of the module, the students gained insights into the implementation and application of medical devices and biotechnological procedures. They are informed about the current R & D-status of medical device technologies and special biotechnology. In addition, they can independently apply their acquired knowledge to interdisciplinary questions in medicine and engineering and thus express a position related to a specific field.
3	**Recommended prerequisite for participation** Recommended are „ Terminology, Medical Morphology and Applied Anatomy“ and „ Natural Scientific Principles for Medical Engineering“
4	**Form of examination** Module Eccompanying Examination: • [18-mt-1042-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) • [18-mt-1041-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) • [18-mt-1043-vl] (Technical Examination, Written Examination, Duration: 60 min, Standard BWS) Module final exam: *Module exam (per course one Technical examination, Written examination, Duration: 60 min, standard grading system)
5	**Grading** Module Eccompanying Examination: • [18-mt-1042-vl] (Technical Examination, Written Examination, Weighting: 1) • [18-mt-1041-vl] (Technical Examination, Written Examination, Weighting: 1) • [18-mt-1043-vl] (Technical Examination, Written Examination, Weighting: 1)
6	**Usability of this module** BSc Biomedical Engineering
7	**Grade bonus compliant to §25 (2)**
8	**References** Leonhardt, Steffen, Walter, Marian: Medizintechnische Systeme, Springer-Verlag, einschlägige Lehrbücher und Fachartikel zu den verschiedenen klinischen Einsatzgebieten
Courses	

	Course Nr. 18-mt-1042-vl	**Course name** Biosensors		
	Instructor		**Type** Lecture	**SWS** 2
	Course Nr. 18-mt-1040-vl	**Course name** Biomedical Engineering I		
	Instructor		**Type** Lecture	**SWS** 2
	Course Nr. 18-mt-1041-vl	**Course name** Biomedical Engineering II		
	Instructor		**Type** Lecture	**SWS** 3
	Course Nr. 18-mt-1043-vl	**Course name** Medical Imaging		
	Instructor		**Type** Lecture	**SWS** 2

Module name Clinical Practical Courses					
Module Nr. 18-mt-1120	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 180 h	**Duration** 2	**Cycle offered** WiSe
Language German			**Module owner**		

1	**Content** In small groups, students have the opportunity to participate in the everyday clinical practice of various medical disciplines and to experience the use of medical devices in daily use as well as to experience the possibilities and limitations of the device technologies. They participate in various everyday clinical situations in a hospital and learn the clinical communication channels, workflows and treatment strategies.
2	**Learning objectives / Learning Outcomes** Students know the day-to-day work of a physician and the communication structures of a hospital. They understand the terminology and “language” of a medical doctor and can communicate with them sufficiently. They are familiar with a wide range of applications of medical devices and products and are informed about the current state of development of medical devices.
3	**Recommended prerequisite for participation** Recommended are „ Terminology, Medical Morphology and Applied Anatomy“ and „ Natural Scientific Principles for Medical Engineering“ und „Biomedical Engineering“. As well as being vaccinated against measles, mumps, varicella, tetanus and hepatitis B according to the recommendation of the Standing Committee on Vaccinations.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Report, Pass/Fail Grading System) Module final exam: *Module exam (Technical examination, Presentation, pass/fail grading system) After course II the examinee compiles a two-page summary of a medical device, describing functional principle and possible applications but also its limitations in the medical field.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Report, Weighting: 100 %)
6	**Usability of this module** BSc Biomedical Engineering
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-mt-1120-pr	Clinical Practical Courses I		Internship	0
18-mt-1121-pr	Clinical Practical Courses II		Internship	0

Module name					
Medical Law, Forensic Medicine and Ethics					
Module Nr. 18-mt-1140	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 45 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner**		

1	**Content** This module deals with the legal foundations of the (inter-) national health system and the medical law (among these the medical drug law (AMG), the medical device law (MPG), the transplantation law (TPG)) and practical aspects, eg. in forensic medicine. It will also cover the basics of medical ethics and bioethics, which will give a closer look to the ethical aspects of research on humans and the development of medical technologies in a legal-ethical context.
2	**Learning objectives / Learning Outcomes** Upon successful completion of this module, students are sensitized to legal issues, current case law and ethical aspects in medical engineering and (bio) medicine, including actual and future research projects. They can derive scientifically based judgments that take into account social, legal, scientific, ethical and practical knowledge.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System) Module final exam: *Module exam (Technical examination, Written examination, Duration: 60 min, standard grading system)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc Biomedical Engineering
7	**Grade bonus compliant to §25 (2)**
8	**References** Legal commentaries and textbooks of relevant areas of law, current case-law from legal databases, ethic basic literature.

Courses

Course Nr.	Course name		
18-mt-1140-vl	Medical Law, Forensic Medicine and Ethics		
Instructor		**Type** Lecture	**SWS** 3

2 Master

2.1 Lectures

Module name System Dynamics and Automatic Control Systems III					
Module Nr. 18-ad-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** Topics covered are: • basic properties of non-linear systems, • limit cycles and stability criteria, • non-linear control of linear systems, • non-linear control of non-linear systems, • observer design for non-linear systems
2	**Learning objectives / Learning Outcomes** After attending the lecture, a student is capable of: • explaining the fundamental differences between linear and non-linear systems, • testing non-linear systems for limit cycles, • stating different definitions of stability and testing the stability of equilibria, • recalling the pros and cons of non-linear controllers for linear systems, • recalling and applying different techniques for controller design for non-linear systems, • designing observers for non-linear systems
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Adamy: Systemdynamik und Regelungstechnik III (available for purchase at the FG office)
Courses	

	Course Nr.	Course name		
	18-ad-2010-vl	System Dynamics and Automatic Control Systems III		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Jürgen Adamy		Lecture	2
	Course Nr.	**Course name**		
	18-ad-2010-ue	System Dynamics and Automatic Control Systems III		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Jürgen Adamy		Practice	1

<table>
<tr><td colspan="6">Module name
Fuzzy Logic, Neural Networks and Evolutionary Algorithms</td></tr>
<tr><td>Module Nr.
18-ad-2020</td><td>Credit Points
4 CP</td><td>Workload
120 h</td><td>Self study
75 h</td><td>Duration
1</td><td>Cycle offered
WiSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Jürgen Adamy</td></tr>
</table>

<table>
<tr><td>1</td><td>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</td></tr>
<tr><td>2</td><td>Learning objectives / Learning Outcomes
After attending the lecture, a student is capable of:
• recalling the elements and set-up of standardized fuzzy-logic, neural networks and evolutionary algorithms,
• discussing the pros and cons of certain set- ups of systems from computational intelligence for solving a given problem,
• recognizing situations in which tools taken from computational intelligence can be applied for problem solving,
• creating programs from algorithms taught in the lecture, and
• extending the learned standard procedures in order to solve new problems.</td></tr>
<tr><td>3</td><td>Recommended prerequisite for participation</td></tr>
<tr><td>4</td><td>Form of examination
Module Final Examination:
• Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)</td></tr>
<tr><td>5</td><td>Grading
Module Final Examination:
• Module Examination (Technical Examination, Written Examination, Weighting: 100 %)</td></tr>
<tr><td>6</td><td>Usability of this module
BSc iST, MSc ETiT, MSc MEC, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik</td></tr>
<tr><td>7</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td>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)</td></tr>
</table>

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-ad-2020-vl</td><td colspan="2">Course name
Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms</td></tr>
<tr><td>Instructor
Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Fabian Müller</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-ad-2020-ue</td><td colspan="2">Course name
Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms</td></tr>
<tr><td>Instructor
Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Fabian Müller</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

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

Courses

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

Module name					
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

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

B Basics of Image Analysis

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

2 Learning objectives / Learning Outcomes

The lecture communicates mathematical basics needed to solve computer vision problems in the field of engineering. The focus is on methods that are relevant for measuring and control tasks. Applications range from visual quality inspection, visual robotics, photogrammetry, visual odometry up to visually guided driver assistance etc.

The students should obtain a good understanding for the relations between the three-dimensional world and its two-dimensional projection onto the image plane of a camera. They also should learn about methods that exist to infer knowledge from the world given image data. They should develop some feeling for the different kinds of problems that arise in computer vision and how to choose an efficient solution in terms of algorithms.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

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

5 Grading

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

Courses

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

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

1 Content

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

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

5 Grading

Module Final Examination:

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

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

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

Courses

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

Module name Didactics for Engineers					
Module Nr. 18-ad-2300	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** What is didactics? What is methodology? Various didactic models; German educations sys-tem in profes-sional training (Duales System); objectivism and subjectivism; grading; technol-ogy didactics
2	**Learning objectives / Learning Outcomes** Students are able to impart knowledge. A student is, after successful completion of this module, able to understand • the difference between didactics an methodology, • which didactic models exist, • the german educations system in professional training, • what important aspects of grading exist.
3	**Recommended prerequisite for participation** none
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, MEC, iST, MedTec, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** slide copies, record, current literature (list will bei provide in lecture)

Courses

Course Nr.	**Course name**		
18-ad-2300-vl	Didactics for Engineers		
Instructor		**Type** Lecture	**SWS** 2

Module name Accelerator Physics					
Module Nr. 18-bf-2010	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1	**Content** Beam dynamics in linear- and circular accelerators, working principles of different accelerator types and of accelerator components, measurement of beam properties, high-intensity effects and beam current limits.
2	**Learning objectives / Learning Outcomes** The students will learn the working principles of modern accelerators. The design of accelerator magnets and radio-frequency cavities will discussed. The mathematical foundations of beam dynamics in linear and circular accelerators will be introduced. Finally the origin of beam current limitations will be explained.
3	**Recommended prerequisite for participation** BSc in ETiT or Physics
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Physics
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes, transparencies

Courses

Course Nr.	Course name		
18-bf-2010-vl	Accelerator Physics		
Instructor		**Type**	**SWS**
Prof. Dr. Oliver Boine-Frankenheim		Lecture	2

Module name Plasma Physics					
Module Nr. 18-bf-2020	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1	**Content** The lecture will cover the following topics: Occurrence of plasma in our environment – definition of a plasma – particle dynamics in em fields – fluid description of a plasma – waves in plasmas – plasma instabilities – kinetic description of a plasma – plasma generation – plasma diagnostics – plasma applications in the industry.
2	**Learning objectives / Learning Outcomes** The fundmental properties of plasmas, waves in plasmas as well as the interaction of electromagnetic fields with plasmas should be worked out and understood by the students during the course of this lecture.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Physik
7	**Grade bonus compliant to §25 (2)**
8	**References** The transparencies can be downloaded from the TUCaN site.

Courses

Course Nr.	**Course name**		
18-bf-2020-vl	Plasma Physics		
Instructor		**Type**	**SWS**
Prof. Dr. Oliver Boine-Frankenheim		Lecture	2

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

1 Content

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

Electrodynamics (Maxwell’s equations)

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

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

Courses

<table>
<tr><td rowspan="2"></td><td>Course Nr.
18-bf-2030-vl</td><td colspan="3">Course name
Applied Superconductivity</td></tr>
<tr><td colspan="2">Instructor
Dr.-Ing. Uwe Niedermayer</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

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: • do and explain the electromagnetic design of an induction machine both analytically and with use of computer program, • understand and predict the thermal performance of electrical drives in a simplified way, • calculate the instationary performance of separately excited DC drives • to predict the dynamical performance of AC polyphase machines with space vector theory and use the MATLAB/Simulink package for this purpose.
3	**Recommended prerequisite for participation** Bachelor of Science in Electrical Engineering, Power Engineering or similar
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Detailed textbook and collection of exercises; Complete set of PowerPoint presentation Leonhard, W.: Control of electrical drives, Springer, 1996 Fitzgerald, A.; Kingsley, C.: Kusko, A.: Electric machinery, McGraw-Hill, 1971 McPherson, G.: An Introduction to Electrical Machines and Transformers, Wiley, 1981 Say, M.: Alternating Current Machines, Wiley, 1983 Say, M.; Taylor, E.: Direct Current Machines, Pitman, 1983 Vas, P.: Vector control of ac machines, Oxford Univ. Press, 1990 Novotny, D,; Lipo, T.: Vector control and dynamics of ac drives, Clarendon, 1996
Courses	

	Course Nr.	Course name		
	18-bi-2010-vl	Energy Converters - CAD and System Dynamics		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Dr.h.c. Andreas Binder		Lecture	3
	Course Nr.	**Course name**		
	18-bi-2010-ue	Energy Converters - CAD and System Dynamics		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Dr.h.c. Andreas Binder		Practice	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: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc EPE, MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Detailed textbook with calculated examples; Vas, P.: Parameter estimation, condition monitoring, and diagnosis of electrical machines, Clarendon Press, 1993 Fitzgerald, A.; Kingsley, C.; Kusko, A.: Electric machinery, McGraw-Hill, 2003 Leonhard, W.: Control of electrical drives, Springer, 1996

Courses

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

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

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

Courses

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

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

1	**Content** Goal: The application of new technologies, i.e. super conduction, magnetic levitation techniques and magneto-hydrodynamic converter principles, are introduced to the students. The physical operation mode in principle, implemented prototypes and the current state of the development are described in detail. Content: Application of the superconductors for electrical energy converters: • rotating electrical machines (motors and generators), • solenoid coils for the fusion research, • locomotive- and railway transformers, • magnetic bearings. Active magnetic bearings ("magnetic levitation"): • basics of the magnetic levitation technique, • magnetic bearings for high speed drives in kW to MW range, • application for high-speed trains with linear drives. Magneto-hydrodynamic energy conversion: • physical principle, • state of the art and perspectives. Fusion research: • magnetic field arrangements for contactless plasma inclusion, • state of the current research.
2	**Learning objectives / Learning Outcomes** Basic knowledge in application of superconductivity in energy systems is understood as well as magnetic levitation, magnetohydrodynamics and fusion technology.
3	**Recommended prerequisite for participation** Physics, Electrical Machines and Drives, Electrical Power Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc EPE, MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Detailed textbook; Komarek, P.: Hochstromanwendungen der Supraleitung, Teubner, Stuttgart, 1995 Buckel, W.: Supraleitung, VHS-Wiley, Weinheim, 1994 Schweitzer, G.; Traxler, A.; Bleuler, H.: Magnetlager, Springer, Berlin, 1993 Schmidt, E.: Unkonventionelle Energiewandler, Elitera, 1975

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

Module name 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: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System) In general, the examination takes place in form of a written exam (duration: 90 minutes). If up to 20 students register in semesters in which the lecture does not take place, there will be an oral examination (duration: 30 min.). The type of examination will be announced within one working week after the end of the examination registration phase.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc EPE, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** References/Textbooks: Detailed textbook; Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995. Obermayer, H.J.: Internationaler Schnellverkehr.Franckh-Kosmos, Stuttgart, 1994.

Courses

Course Nr.	**Course name**		
18-bi-2050-vl	Railway Vehicle Engineering		
Instructor		**Type** 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: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc EPE, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes; Fasholz, J., Orth, G.: Induktive Erwärmung, RWE Energie AG, Essen, 4. Aufl., 1991; Nacke, B.; Baake, E. (Hsg.): Induktives Erwärmen, Vulkan-Verlag, 2014

Courses

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

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

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

Courses

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

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: • Module Examination (Technical Examination, Optional, Standard Grading System) Module final exam: * Module exam (Technical examination, optional, standard grading system)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-bi-2150-vl	Electric drives for cars	Prof. Dr. Annette Mütze	Lecture	2
18-bi-2150-ue	Electric drives for cars	Prof. Dr. Annette Mütze	Practice	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: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Script for lecture: Mikrosystemtechnik

Courses

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

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

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

Courses

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

Module name Computational Electromagnetics and Applications II					
Module Nr. 18-dg-2010	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** • Fundamentals of the Finite Element Method: weighted residuals, projection methods, variational formulations, weak formulations; Finite elements: definitions, classification, first order Whitney element complex, higher order elements; convergence and precision; • Implementation details: data structures, matrix assembly, postprocessing of the solution; • FEM application to electromagnetic problems: electrostatics, magnetostatics, stationary currents, quasistatics, wave propagation.
2	**Learning objectives / Learning Outcomes** Students will master the theoretical basics of finite element methods. They understand details regarding the implementation of the method for stationary and quasistationary fields. They can apply the finite element method in electrical engineering.
3	**Recommended prerequisite for participation** Maxwell's equations, infinitesimal calculus, vector calculus. Basics of differential equations and linear algebra.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** • Lecture slides. • Willi Törnig, Michael Gipser, Bernhard Kaspar. Numerische Lösung von partiellen Differentialgleichungen der Technik: Differenzenverfahren, Finite Elemente und die Behandlung großer Gleichungssysteme. Teubner, 1991 • Rolf Steinbuch. Finite Elemente - Ein Einstieg. Springer, 1998. • Alain Bossavit. Computational electromagnetism: variational formulations, complementarity, edge elements. Academic Press, 1997 • Klaus Knothe, Heribert Wessels. Finite Elemente: Eine Einführung für Ingenieure (3. Aufl.). Springer, 1999. • P. P. Silvester, R. L. Ferrari. Finite Elements for Electrical Engineers, Cambridge Universtity Press, 1991 • O. C. Zienkiewicz, R. L. Taylor. The finite element method (4. ed.). McGraw-Hill, 1989
Courses	

	Course Nr.	Course name		
	18-dg-2010-vl	Computational Electromagnetics and Applications II		
	Instructor		**Type**	**SWS**
	Prof. Dr. Irina Munteanu		Lecture	2

Module name Computational Electromagnetics and Applications III					
Module Nr. 18-dg-2020	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Finite Difference, Finite Volume and Finite Element Methods for the solution of Maxwell equations in the time domain. High order Discontinuous Galerkin methods. Stability and convergence analysis. High performance computing. Particle based simulations for beams and plasmas.
2	**Learning objectives / Learning Outcomes** Students lern the theoretical basis of advanced simulation techniques for time dependent electromagnetic fields. Furthermore, the lecture mediates practical skills for the implementation, analysis and application of simulation codes for common problems of Electrical Engineering
3	**Recommended prerequisite for participation** Maxwell's equations, infinitesimal calculus, vector calculus. Basics of differential equations and linear algebra
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides, matlab scripts, various literature sources

Courses

Course Nr.	**Course name**		
18-dg-2020-vl	Computational Electromagnetics and Applications III		
Instructor		**Type**	**SWS**
Privatdozent Dr. rer. nat. Erion Gjonaj		Lecture	2

Module name					
Electromagnetics and Differential Forms					
Module Nr. 18-dg-2030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** In the recent years, the amount of literature that deals with physical models in terms of differential forms (DF) has increased strongly. For instance, DF allow a clear and elegant representation of electromagnetics (EM). The operators grad, curl, and div of vector analysis are replaced by a single operator of the exterior derivative. Similarly, the integral theorems of Gauss and Stokes are replaced by a single integral theorem. Vector analysis is limited to three dimensions, while DF can be applied to any dimensions. This is useful for the relativistic formulations in four dimensions. Since DF can be canonically integrated over appropriate domains they lend themselves naturally to discretizations of the finite integration type. This lecture series provides an introduction into DF calculus, and its relation to vector analysis. Maxwell‘s equations and the constitutive relations are expressed in terms of DF, and the main steps into discretization are outlined briefly.
2	**Learning objectives / Learning Outcomes** Students will acquire a detailed understanding of how to describe EM in terms of DF. *How “space” (and “time”) can be modelled by differentiable manifolds; *How a class of physical fields can be represented by differential forms; *How Maxwell’s equations and constitutive relations translate into the language of DF; *How this continuous representation can be discretized.
3	**Recommended prerequisite for participation** It is recommended that the students have basic knowledge about *Electromagnetics (Maxwell’s equations in differential and integral form; constitutive relations; EM potentials); *Vector analysis (scalar and vector fields; differential operators grad, curl, and div; integral theorems of Gauss and Stokes).
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) Module final exam: oral examination, details will be fixed in the first lecture
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** M.Sc. CE; M.Sc. etit, particularly major in CED; M.Sc. Mechatronics
7	**Grade bonus compliant to §25 (2)**
8	**References** M. Fecko: Differential Geometry and Lie Groups for Physicists, Cambridge University Press, 2006 F. Hehl, Y. Obukhov: Foundations of Classical Electrodynamics, Birkhäuser, 2003 K. Jänich: Vector Analysis, Springer, 2001
Courses	

	Course Nr.	Course name		
	18-dg-2030-vl	Electromagnetics and Differential Forms		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Stefan Kurz		Lecture	2

Module name X-Ray Free Electron Lasers					
Module Nr. 18-dg-2110	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Optical lasers cannot produce x-rays of photons and high-gain free-electron lasers (FELs) are being developed as extremely bright sources of x-ray radiation. The peak brightness of these facilities exceeds that of other sources by more than ten orders of magnitude. FELs produce hard x-ray beams with very high transverse coherence and femtosecond pulse length. These characteristics open up new areas of x-ray science, such as femtosecond time-domain spectroscopy etc. In this course an overview of the basics of FEL physics is given. We start our discussion from basics principles of particle acceleration and synchrotron radiation, consider the electron motion in an undulator and explain the most important steps to derive the high-gain FEL model. The performance of the high-gain FEL in the linear and the non-linear regimes is considered. The self-amplified spontaneous emission (SASE) option is introduced and characterized. We discuss new schemes for enhancing of the FEL performance. The theoretical considerations in the course are partially illustrated by the results of numerical simulations and experiments. The numerical algorithms are shortly discussed.
2	**Learning objectives / Learning Outcomes** The student should understand the basics of physics of free electron lasers.
3	**Recommended prerequisite for participation** Maxwell's equations, integral and differential calculus, vector analysis
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc iCE, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** The foils of the lecture will be available at: http://www.desy.de/~zagor/lecturesFEL K. Wille, Physik der Teilchenbeschleuniger und Synchrotron- strahlungsquellen, Teuner Verlag, 1996. P. Schmüser, M. Dohlus, J. Rossbach, Ultraviolet and Soft X-Ray Free-Electron Lasers, Springer, 2008. E. L. Saldin, E. A. Schneidmiller, M. V. Yurkov, The Physics of Free Electron Lasers, Springer, 1999.

Courses

Course Nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-dg-2110-vl	X-Ray Free Electron Lasers	PD Dr. Igor Zagorodnov	Lecture	2
18-dg-2110-ue	X-Ray Free Electron Lasers	PD Dr. Igor Zagorodnov	Practice	1

Module name Technical Electrodynamics for iCE					
Module Nr. 18-dg-2150	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** 1) Fundamentals of electromagnetic field theory – Maxwell's equations in differential and integral form; Electromagnetic waves: propagation in free space, polarization, reflection/refraction. 2) Numerical solution of electromagnetic field problems – Space discretization with surface and volume meshes; Main numerical algorithms for discrete local approximation of Maxwell's equations; Finite Integration Technique; Time and frequency domain solution methods; Stability, convergence. 3) Practical aspects of electromagnetic simulation – Introduction to accuracy issues; Preprocessing: 3D geometry, computational domain, boundary conditions, electromagnetic field sources; Time vs frequency domain; Postprocessing; Network parameter extraction. 4) Application to typical high-frequency devices: Waveguide / resonator structures, planar structures
2	**Learning objectives / Learning Outcomes** Students will understand fundamental principles of wave propagation, guided waves and antennas. They will be able to model microwave components with simulation software tools. They will have experience with state of the art software tools for electromagnetic fields.
3	**Recommended prerequisite for participation** Fundamentals of electrodynamics (Grundlagen der Elektrodynamik)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Course manuscript Additional References: • D.K. Cheng: Field and Wave Electromagnetics. Addison-Wesley, New York, 1992 • C.A. Balanis: Advanced Engineering Electromagnetics. Wiley, New York, 1989 • Andrew F. Peterson et al. Computational Methods for Electromagnetics. Wiley-IEEE Press, 1997.

Courses

Course Nr.	**Course name**		
18-dg-2150-vl	Technical Electrodynamics for iCE		
Instructor		**Type**	**SWS**
Prof. Dr. Irina Munteanu, M.Sc. Armin Herbert Galetzka		Lecture	2

Course Nr.	**Course name**		
18-dg-2150-ue	Technical Electrodynamics for iCE		
Instructor		**Type**	**SWS**
Prof. Dr. Irina Munteanu, M.Sc. Armin Herbert Galetzka		Practice	2

<table>
<tr><td colspan="6">Module name
Fast Boundary Element Methods for Engineers</td></tr>
<tr><td>Module Nr.
18-dg-2160</td><td>Credit Points
3 CP</td><td>Workload
90 h</td><td>Self study
60 h</td><td>Duration
1</td><td>Cycle offered
WiSe</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Herbert De Gersem</td></tr>
</table>

1 **Content**

How to solve field problems numerically on the computer? The Boundary Element Method (BEM) has developed into an important alternative to domain-oriented approaches (like Finite Elements), ever since fast implementations are available. The BEM reduces the dimensionality of the problem and can easily take into account unbounded domains.
Starting from the representation formulas of Kirchhoff and Stratton-Chu boundary integral equations are derived. Next, their discretization by collocation and Galerkin methods is discussed.
The resulting fully populated matrices have to be compressed for practical applications, by Fast Multipole or Adaptive Cross Approximation methods.
Industrial examples for application of the BEM are considered, for instance acoustic and electromagnetic scattering problems, and thermal analysis.Programming homework will be assigned, to deepen the students' understanding of the contents.

2 **Learning objectives / Learning Outcomes**

Students will acquire a detailed understanding of Modeling and Simulation with BEM.
- Derivation: convert certain types of partial differential equations to boundary integral equations
- Discretization: obtain boundary element methods from boundary integral equations
- Compression: efficiently store and solve the resulting linear systems of equationsApplication: solve practical field problems in engineering, in the acoustic, electromagnetic and thermal domains

3 **Recommended prerequisite for participation**

Basic knowledge about numerical methods for the solution of partial differential equations (e.g., Finite Elements).
Basic knowledge about modelling and simulation in an application domain (e.g., acoustic domain: wave equation; electromagnetic domain: Maxwell's equations; thermal domain: heat equation).

4 **Form of examination**

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

5 **Grading**

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

6 **Usability of this module**

MSc ETiT, MSc MEC, MSc CE

7 **Grade bonus compliant to §25 (2)**

8 **References**

O. Steinbach: Numerical Approximation Methods for Elliptic Boundary Value Problems
S. Rjasanow, O. Steinbach: The Fast Solution of Boundary Integral Equations

Courses

<table>
<tr><td colspan="2">Course Nr.
18-dg-2160-vl</td><td colspan="2">Course name
Fast Boundary Element Methods for Engineers</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Stefan Kurz</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

Module name					
Simulation of beam dynamics and electtromagnetic fields in accelerators					
Module Nr. 18-dg-2170	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Particle tracking methods: types of particle methods, relationship to Vlasov model – Integration of equations of motion: Boris pusher, numerical stability, symplecticity – Electrostatic PIC: Green functions, FFT and FD methods, charge deposition, field interpolation, spline shape functions – DC-gun simulation: space charge limited emission – Tracking in the Lorenz frame – Map based tracking methods – Electromagnetic PIC: FDTD method, charge-conserving current deposition, Boris scheme, low dispersion methods – Wakefields and impedances: simulation of ultra-relativistic beams – Plasma Wakefield Acceleration – Parallel computing
2	**Learning objectives / Learning Outcomes** The lecture gives an overview on the numerical modeling of charged particle beams and electromagnetic fields in acceerators. Emphasis is given to the simulation of collective effects caused by space-charge and electromagnetic wakefields. The lecture targets master students focusing on different discilines of electrical engineering and physics. These include the theory of electromagnetic fields, computational engineering as well as computational and experimental accelerator physics. The level is sufficient to provide a solid foundation for contemporary simulation methods for particle beams in accelerators. Furthermre, for experimental accelerator physicists, the lecture provides insight into the different simulation tools, their application, their advantages and also their pitfalls and ranges of validity. During the course, practical simulation examples referring to actual problems at DESY, GSI and the S-DALINAC will be presented.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Physik
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name		
18-dg-2170-vl	Simulation of beam dynamics and electtromagnetic fields in accelerators		
Instructor		**Type**	**SWS**
Privatdozent Dr. rer. nat. Erion Gjonaj, Prof. Dr. Oliver Boine-Frankenheim		Lecture	2

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

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

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

Courses

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

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

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

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

Courses

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

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

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

1 Content

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

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

2 Learning objectives / Learning Outcomes

Students will be able to:

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc MEC, MSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

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

Courses

<table>
<tr><td rowspan="2"></td><td>Course Nr.
18-gt-2040-vl</td><td colspan="3">Course name
Real Time Applications and Communication with Microcontrollers and programmable Logic Devices</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Gerd Griepentrog</td><td>Type
Lecture</td><td>SWS
1</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-gt-2040-pr</td><td colspan="3">Course name
Real Time Applications and Communication with Microcontrollers and programmable Logic Devices</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Gerd Griepentrog, Prof. Dr.-Ing. Christian Hochberger</td><td>Type
Internship</td><td>SWS
2</td></tr>
</table>

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: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE, MSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References** A script of the lecture (in German) and English foils can be obtained from here: http://www.rs.tu-darmstadt.de/

Courses

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

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

Module name					
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

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc ETiT, BSc/MSc iST, MSc iCE

7 Grade bonus compliant to §25 (2)

8 References

English slides can be obtained through Moodle.

Courses

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

1 Content

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

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

Courses

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

Module name Processor Microarchitecture					
Module Nr. 18-hb-2050	**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** Lectures (each block takes 3 * 90 minutes) 1. Processor execution. Sources of performance loss, latency. Possible techniques to improve performance. Simultaneous multi-threading as an established solution. Motivation for multi-threading – p-threads as a model of execution in SW, micro-threading as a model of execution in HW. 2. Definition of micro-threading, its requirements on the microarchitecture. Microthreaded assembly instructions, design alternatives for extended instruction sets. Required support in micro-architecture – self-synchronizing register file, cache controllers, thread scheduler. 3. Execution in the micro-threaded pipeline. Interaction between cache controllers, register file, thread scheduler, integer pipeline. Data dependences between threads and its influence on execution (embarrassingly parallel vs. sequential programs). Interaction with legacy code, execution modes, OS support. 4. Developing for the real world: Writing testbenches. Performance profiling. Indicators of efficient silicon use. 5. Microthreading in multi-core architectures. Big issues: Scalability, sufficient parallelism, trade-off between clock frequency and access latency Labs: 1. Set up the utgrlib VHDL sources in the home directory. Set up the utbinutils in the home directory. Compilation of introductory examples. 2.-3. Analysis of execution traces for introductory examples. Design of a FIR filter in micro-threaded assembly. Compilation, execution, analysis of pipeline efficiency. 4.-9. Re-design of existing blocks (choose from dcache, icache, regfile). Preparation of a TLM testbench. Coding and testing of the block in a stand-alone testbench. 10.-15. Integration of the block in UTLEON3, execution of micro-threaded programs, evaluation of performance analysis (% performance gain over the original block, % decreased resource requirements).
2	**Learning objectives / Learning Outcomes** After completion of the module, students will be able to design a customized microarchitecture of a modern RISC processor and analyze its performance. The course will be taught using a VHDL implementation of an existing micro-threaded processor UTLEON3 in an FPGA, nevertheless the knowledge gained in the lecture will be applicable to other HDLs, different processor architectures and other implementation technologies.
3	**Recommended prerequisite for participation** Hands-on experience with at least one of Verilog or VHDL is expected. Basic understanding of FPGA technology and thorough knowledge of digital circuit design and computer architecture. Several tools used throughout the labs might require additional programming languages and tools (Perl, C, bash). This knowledge can be obtained during the labs.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE, MSc iST
7	**Grade bonus compliant to §25 (2)**

8	**References** A script is available as a published book and English slides can be obtained through moodle.

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-hb-2050-vl	Processor Microarchitecture	Ph.D. Martin Danek	Lecture	2
18-hb-2050-pr	Processor Microarchitecture	Ph.D. Martin Danek	Internship	2

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 SF6), Breakdown in Vacuum, Surface Discharges, Lightnings and Lightning Protection, Travelling Waves on Conductors; Excursion to a substation
2	**Learning objectives / Learning Outcomes** The students are now able to optimize insulation systems also by choice of the dielectrics, by capacitive, refractive or resistive internal grading systems or by external geometrical/capacitive grading elements; they have understood why equipment is designed as it is and how and where it can or has to be optimized if requirements from service are changing; they have understood the physical phenomena behind the dielectric breakdown of gases and do know which are the main influencing parameters; they know the effect of strongly inhomogeneous electrode configurations and of extremely large gaps; they know the time dependencies of a dielectric breakdown and their impact on dielectric strength under impulse voltage stress; they are able to identify critical surface discharge configurations, know about the problems under severe external pollution of insulators and how to solve them; they are thus qualified to predict the dielectric strength of any electrode configuration under any kind of voltage stress and to design a particular required dielectric strength of equipment; they are particularly enabled to realize the demands of emerging UHV systems and to manage them; they have understood the mechanism of thunderstorms and lightning flashes and are able to derive protective measures for buildings, substations and overhead lines; they are skilled to calculate travelling wave effects and their effect on fast-front overvoltages and to develop adequate countermeasures.
3	**Recommended prerequisite for participation** High Voltage Technology I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** • all lecture slides (ca. 460 pcs.) available for download • Kind, Feser: High-voltage test techniques, SBA publications • Kind, Kärner: High-voltage insulation technology, Vieweg

Courses

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

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

Module name 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:

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

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

Courses

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

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

1 Content

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

High Voltage Technology I and II

4 Form of examination

Module Final Examination:

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

5 Grading

	Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc EPE, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** The related IEC standard can be borrowed during the lecture time. Lecture notes (in English) and other helpful materials can be downloaded from HST homepage: www.hst.tu-darmstadt.de.

Courses

Course Nr.	Course name		
18-hi-2030-vl	Overvoltage Protection and Insulation Coordination in Power System		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Constantin Balzer, M.Sc. Tobias Trautmann		Lecture	2

Course Nr.	Course name		
18-hi-2030-ue	Overvoltage Protection and Insulation Coordination in Power System		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Constantin Balzer, M.Sc. Tobias Trautmann		Practice	1

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

1 Content

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

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

BSc. ETiT Electrical Power Systems

4 Form of examination

Module Final Examination:

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

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

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

Slides, litrature sources

Courses

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

Module name					
High Voltage Measuring Techniques					
Module Nr. 18-hi-2050	**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** **1. Measurement of High DC Voltages** 1.1 Resistor Voltage Dividers 1.2 Electrostatic Voltmeters 1.3 Generating Voltmeters 1.4 Rod/Rod Gaps 1.5 DKD-Calibration of a 1500 kV-DC-Measuring System **2. Measurement of High AC Voltages in High Voltage Transmission Systems** 2.1 Inductive Voltage Transformers with Oil and with SF6-Insulation 2.2 Capacitor Voltage Transformers 2.3 Electronic Voltage Transformers 2.4 Electro-Optical Voltage Transformers 2.5 Calibration of Voltage Transformers **3. Measurement of High AC Voltages in the Laboratory** 3.1 Resistor Voltage Dividers 3.2 Capacitor Voltage Dividers 3.3 Measuring Sphere Gap 3.4 Electronic Peak Voltmeter 3.5 DKD-Calibration of a 1200 kV AC-Measuring System **4. Measurement of High Impulse Voltages** 4.1 Standard Impulse Voltages and their Normalized Amplitude Frequency Spectra 4.2 Designs of R- , C- and RC-Dividers 4.3 Computation of the Step Response of Impulse Voltage Dividers 4.4 Analytical Calculation of the Response Time of a Divider with a Lead 4.5 EMTP-Calculation of the Divider Output Voltage for Lightning Impulse Voltages 4.6 DKD-Calibration of a 3 MV Lightning Impulse Measuring System 4.7 DKD-Calibration of a 2 MV Switching Impulse Measuring System
2	**Learning objectives / Learning Outcomes**

	The students learn the fundamentals, the dimensions, the application and the operation of voltage dividers up to 1,5 MV DC, 1,2 MV AC, 3,2 MV LI and 2 MV Si. They know and have understood the standards IEC 60060-2 High-Voltage Measuring systems and the Calibration Procedures of the German Calibration Service (DKD) for High-Voltage Measuring Systems which show that the uncertainty of the High-Voltage Measuring results of approved measuring systems are lower than the maximal permissible uncertainty for Type tests in an accredited High-Voltage Test Laboratory. They know, how the material of the resistors and the Isolationsystem influence the measuring uncertainty, the costs and the the level of the maximal DC Voltage. The students know and understand the equivalent circuits for power frequency of inductive and capacitive voltage transformer and are able to deduce the measuring errors and their dependency of the dimensioning of the magnetic and electric components. The students learn and understand, why an ohmic resistor voltage divider in contrary to a capacitor voltage divider is not applicable for the measurement of high AC voltages. They are able to calculate the influence of the distance between a wall and the capacitor voltage divider with oil-paper insulation on the measuring error. The students know, why capacitor voltage dividers without serious resistors are not applicable to the measurement of lightning impulse voltages. They can describe the advantages and the disadvantages of a low damped capacitor voltage divider as front capacitor of a lightning impulse voltage generator and as voltage divider. They know, why at LI-voltage measurements the test object must be situated between the generator and the divider. The students are able to reduce the interference of steep currents in the walls and in the ground of a high voltage test lab on the secondary voltage signal in the measuring cable from the divider to the recorder.
3	**Recommended prerequisite for participation** BSc ETiT, BSc Wi-ETiT
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** • Breilmann, W.: Skriptum zur Vorlesung " Messverfahren der Hochspannungstechnik" im WS 2014/2015 • Kuffel, E.; Zaengl, W.S.: High Voltage Engineering, Fundamentals ISBN-13:987-0750636346; Butterworth Heinemann; July 2000. 539 Seiten; 81,20 Euro. • VDE 0432: Hochspannungs-Prüftechnik: Teil 1: Allgemeine Begriffe und Prüfbedingungen; (2011-10) : 78 Euro • VDE 0432: Hochspannungs-Prüftechnik: Teil 2: Messsysteme (2011-10) : 78 Euro • Schon, K.: Stoßspannungs- und Stoßstrommesstechnik ISBN 978-3-642-13117-2; Springer Heidelberg; September 2010, 285 Seiten; 88 Euro

Courses

Course Nr.	Course name		
18-hi-2050-vl	High Voltage Measuring Techniques		
Instructor		**Type**	**SWS**
Dr. Ing. Wolfgang Breilmann		Lecture	2

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

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

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-hi-2060-vl	Electromagnetic Compatibility	Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Peter Hock	Lecture	2
18-hi-2060-ue	Electromagnetic Compatibility	Prof. Dr.-Ing. Volker Hinrichsen, M.Sc. Peter Hock	Practice	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** • Introduction, properties of the insulating gas sulfur hexafluoride (SF6) and gas mixture SF6/N2, SF6 handling • Historical development of gasinsulated systems, life time, statistics on age of installed switchgear, space consumption • Components and configuration of a GIS (3-phase, 1-phase; bushings, insulators, disconnectors, earthing switches, circuit breakers, instrument transformers, cable boxes, surge arresters, bus bars; particle traps; secondary equipment) • Test requirements and specifications for GIS • Insulation coordination and overvoltage protection, response to very fast transients (VFTO) • Defects in GIS and diagnostic tools • Gasinsulated medium voltage switchgear • Gasinsulated lines (design, laying techniques, comparison with cables and overhead lines) • Current carrying capability, thermo-mechanical stress • Alternative insulating gases for application in “Eco”-GIS / - GIL (F-ketones, F-nitriles, “Clean Air” etc.) • Gas-solid insulation systems under DC stress • Special challenges of HVDC systems (impact factors, particle behavior, test requirements and specifications)
2	**Learning objectives / Learning Outcomes** The students know the propoerties of the insulating gas sulfur hexafluoride (SF6). They know the climate impact of SF6 and are familiar with adequate gas handling. They are well informed about the alternatives that are actually under discussion and investigated for application in eco-friendly GIS. The students know the pros and cons of gasinsulated systems (GIS) compared with air insulated systems (AIS) in power supply systems, and they have understood, for which applications GIS might be favorable. They know the basic design and configuration of MV and HV GIS and can explain the functionality of each component in such systems. The students have learnt to know the test requirements and are able to distinguish routine-, type and on-site commissioning tests. They know why VFTO have to be especially regarded in the process of insulation coordination and which measures can and have to be taken for overvoltage protection in GIS. The students know the defects typical for GIS and how they can be monitored. They know the laying methods of gasinsulated lines (GIL) and can compare GIL to other transmission options in the power system. Furthermore, they can calculate the current carrying capacity of simple gasinsulated lines and estimate the resulting thermo-mechanical stress. The students have understood the basic differences in the requirements on insulation systems under DC and under AC stress, and what are the consequences on design and testing of DC-GIS and DC-GIL.
3	**Recommended prerequisite for participation** HST I and HST II
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module**

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

Courses

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

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

1 Content

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

2 Learning objectives / Learning Outcomes

The students know the inception, development and effects of natural lightning. They are able to differentiate between types of lightning and know all typical parameters, related to different surges and types of lightning. They know that the parameters may devite in different places over the earth and know the reason for this deviation. The students learn about all relevant components of a lightning strike as well as their technical relevance in lightning protection, surge protection and lightning location. The theory and most relevant models of lightning attachment and also its successive return stroke are known. All relevant lightning threats in terms of lightning protection are known and can be calculated.
The students know how a standardized lightning protection system has to look like. They know about lightning protection levels, lightning protection zones and are able to apply measures on building, transmission lines and wind mills. The students know about simulation methodologies used in lightning research, taking into account the full retarded Maxwell equations. The students are aware of the uncertainities in lightning protection and lightning research. They know about open questions in the field of research related to the inception, discharge and effects of lightning.
The students learn about unconventional lightning protection, which cannot be found in the standard, and also get to know why they are not found there. The studentes are sensitised about research results in general.

3 Recommended prerequisite for participation

Recommended: BSc ETiT, BSc Wi-ETiT

4 Form of examination

Module Final Examination:

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

5 Grading

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

Courses

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

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

Courses

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

Module name					
Microprocessor Systems					
Module Nr. 18-ho-2040	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Microprocessor Architectures, DSP Architectures and Hardware related Programming
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. gain the overview on the fundamentals of computer architecture and the different processor classes (RISC, CISC, Mikrocontroller, CPU, DSP), 2. understand the central building blocks of a CPU 3. understand the major properties of the required semiconductor memories, I/O blocks and data busses (USB, PCI, RS232), 4. understand the most commonly used Interrupt- and Trap-handling algorithms, 5. know the common software development methodologies for microcontrollers (assembler, pseudooperations, makros, subprograms and subroutines), 6. understand the most important fundamentals of hardware oriented programming using C.
3	**Recommended prerequisite for participation** Basics of Computer Architectures
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies

Courses

Course Nr.	Course name		
18-ho-2040-vl	Microprocessor Systems		
Instructor		**Type**	**SWS**
Dr.-Ing. Matthias Rychetsky		Lecture	2
Course Nr.	**Course name**		
18-ho-2040-ue	Microprocessor Systems		
Instructor		**Type**	**SWS**
Dr.-Ing. Matthias Rychetsky		Practice	1

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

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

Courses

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

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

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

Courses

Course Nr.	Course name		
18-ho-2210-vl			
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 Regulation of Power Supply					
Module Nr. 18-hs-2010	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Content** • Structure of the German energy economy with focus on electrical power supply • Changes in the regulatory framework (unbundling, grid regulation) • Effects of the "Energiewende" on the energy economy in Germany • Energy turnaround: technologies, energy balance • Renewable energy law (EEG) • Incentive regulation ("Anreizregulierung") • Excursion to Mainova AG
2	**Learning objectives / Learning Outcomes** A student knows after successful completion of this module the basics, the driving forces and developments of the German energy economy. The effects of the German "Energiewende" and necessary technical changes for the energy sector are also taught.
3	**Recommended prerequisite for participation** Good knowledge of content of the lecture "Energietechnik"
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc EPE, MSc Wi-ETiT, MSc MEC, MSc iST, MSc iCE, MSc CE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Notes

Courses

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

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

1	**Content** This lecture covers the essential aspects of the operation and analysis of power systems. The following topics will be covered: • Operation of synchronous generators (steady-state operation, power chart, steady-state stability, transient stability, transient behavior) • Calculation of short-circuit currents (Decaying three-phase short-circuit currents) • Neutral grounding in MV- and HV-Systems (Systems with isolated neutrals, resonant grounding and solidly grounded neutrals) • Network Protection
2	**Learning objectives / Learning Outcomes** At the end of the lecture, the student should have a profound understanding of synchronous generator behavior, decaying short-circuit currents and their calculation and a basic understandning of neutral point treatment and network protection. The different types of power system stability are known.
3	**Recommended prerequisite for participation** Knowledge comparable to “Energieversorgung I” or basic knowledge of power system equipment and calculations using symmetrical components.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc EPE, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** A script of the lecture, tutorials and past exams are available via Moodle.

Courses

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

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

1	**Content** System behaviour of innovative equipment in the Transmission System Fields of application: • Power transmission and voltage stability • Ancillary services • Power quality Technology of innovative equipment: • Power Electronics theory • Motivation, technical realisation and operation / control of HVDC systems (LCC and VSC) • Motivation, technical realisation and operation / control of power electronic devices for reactive power compensation (SVC, STATCOM, SC) • Practical examples and outlook
2	**Learning objectives / Learning Outcomes** After successful completion of this module, a student knows the driving forces for the utilisation of innovative equipment (HVDC, reactive power compensation) in power systems. He understands the system behaviour and operation of these devices and has realised the importance of modelling and simulation for safe and reliable design and operation.
3	**Recommended prerequisite for participation** Contents of "Power Systems I“
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)** Yes
8	**References** Presentation slides

Courses

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

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

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

Courses

Course Nr.	Course name		
18-hs-2090-vl	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 Antennas and Adaptive Beamforming					
Module Nr. 18-jk-2020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

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

<table>
<tr><td></td><td colspan="4"></td></tr>
<tr><td>8</td><td colspan="4">References
Jakoby, Skriptum Antennas and Adaptive Beamforming, wird am Beginn der Vorlesung verkauft und kann danach im FG-Sekretariat erworben werden</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-jk-2020-vl</td><td colspan="3">Course name
Antennas and Adaptive Beamforming</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Rolf Jakoby, M.Sc. Matthias Nickel</td><td>Type
Lecture</td><td>SWS
3</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-jk-2020-ue</td><td colspan="3">Course name
Antennas and Adaptive Beamforming</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Rolf Jakoby, M.Sc. Matthias Nickel</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

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

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

Courses

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

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

Courses

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

	Course Nr.	Course name		
	18-jk-2090-pr	Microwave Measurement Technologies Lab		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Holger Maune		Internship	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 souces up to Terahertz.
2	**Learning objectives / Learning Outcomes** Students will gain knowledge on the physics of microwave waveguides, resonators, microwave components (passive and active) as well as microwave circuits.
3	**Recommended prerequisite for participation** Desirable: Introduction to Electrodynamics, Microwave Engineering I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE, MSc IST, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script and slides will be handed out. Literature will be recommended in the lecture.

Courses

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

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

Module name					
Acceleration of Charged Particles in Electromagnetic Fields					
Module Nr. 18-kb-2010	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Content** Basics of Tensor Analysis, Basics of Special Relativity, Covariant Form of Maxwell‘s Equations, Basics of Nonlinear Dynamics, Hamilton Formalism, Phase Space, Basics of Longitudinal Beam Dynamics, Liouville‘s Theorem, Beam Equations, Particle Tracking, Accelerating Cavities and Systems, Longitudinal Beam Manipulations.
2	**Learning objectives / Learning Outcomes** The lecture shows how different theories like electrodynamics, special relativity and nonlinear dynamics merge together in accelerator engineering for the motion of charged particles in electromagnetic fields. The student will get a good understanding of these theories, and he will be able to understand more advanced literature in the area of accelerator engineering and accelerator physics.
3	**Recommended prerequisite for participation** Vector analysis, infinitesimal calculus, basics in differential equations, first contact with Maxwell‘s equations.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides. List of textbooks.

Courses

Course Nr.	**Course name**		
18-kb-2010-vl	Acceleration of Charged Particles in Electromagnetic Fields		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Harald Klingbeil		Lecture	2
Course Nr.	**Course name**		
18-kb-2010-ue	Acceleration of Charged Particles in Electromagnetic Fields		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Harald Klingbeil		Practice	2

<table>
<tr><td colspan="6">Module name
Relativistic Electrodynamics</td></tr>
<tr><td>Module Nr.
18-kb-2020</td><td>Credit Points
5 CP</td><td>Workload
150 h</td><td>Self study
90 h</td><td>Duration
1</td><td>Cycle offered
WiSe</td></tr>
<tr><td colspan="3">Language
German and English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Harald Klingbeil</td></tr>
</table>

1	**Content** Basics of tensor analysis (tensor fields, transformation behavior, invariance, Ricci calculus, covariant derivative, differential operators), Lorentz transform, fundamental relativistic effects (time dilation, length contraction, Doppler effect), covariant form of Maxwell's equations, induction law from relativistic point of view, relation to relativistic mechanics, four-vectors and four-tensors, electromagnetic energy-momentum tensor and Maxwell's stress tensor, applications of relativistic electrodynamics
2	**Learning objectives / Learning Outcomes** The students understand the basic ideas of Special Relativity and are familiar with the scientific vocabulary. They are able to derive and interpret fundamental formulas, and they are familiar with the mathematical tools. The students understand the concept of covariance and a coordinate-free description of physical theories. They are able to quantitatively compute electromagnetic phenomena in the context of Special Relativity.
3	**Recommended prerequisite for participation** Recommended: "Grundlagen der Elektrodynamik" (18-dg-1010)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides are offered for download. Further references are given in the lecture.

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-kb-2020-vl	Relativistic Electrodynamics	Prof. Dr.-Ing. Harald Klingbeil	Lecture	2
18-kb-2020-ue	Relativistic Electrodynamics	Prof. Dr.-Ing. Harald Klingbeil	Practice	2

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

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

Courses

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

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

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

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-kh-2020-vl	Advanced Lighting Technology	Prof. Dr.-Ing. Khanh Quoc Tran	Lecture	2
18-kh-2020-pr	Advanced Lighting Technology	Prof. Dr.-Ing. Khanh Quoc Tran	Internship	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 lithing. Description of the oused lighting sources and the function of these(lowbeam, highbeam, bending light, stop lamp, daytime running light...), visuell perception, glare, detection, traffic infrastructure, traffic elements, interior lighting, driver assistance systems(GPS, Radar, Lidar...), methods of psychophysics, lighting application concepts in future automated vehicles. Voluntary trip planed to an automobile manufacturer
2	**Learning objectives / Learning Outcomes** To describe the basics and deepening knowledge of car lighting, understanding of the light distribution of head and rear lamps, to learn the basics of standardisation, enlarge glare and detection skills, know the traffic elements, as well as the driver assistance systems
3	**Recommended prerequisite for participation** Lighting technology 1(desireable)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc iST, MSc MEC, MSc MPE, MSc Physik
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides, Automotive Lighting and Human Vision, Handbuch Fahrassistenzsysteme

Courses

Course Nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-kh-2041-vl	Optical Technologies in Car Lighting	Prof. Dr.-Ing. Khanh Quoc Tran	Lecture	2
18-kh-2041-pr		Prof. Dr.-Ing. Khanh Quoc Tran	Internship	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.	Course name		
18-kh-2060-vl	Solid State Lighting		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran, M.Sc. Alexander Georg Herzog		Lecture	2

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

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

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

Courses

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

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

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

1 Content

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

2 Learning objectives / Learning Outcomes

After completion of the lecture, students possess

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

will be announced in the lecture

Courses

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

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

Courses

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

Module name					
Sensor Signal Processing					
Module Nr. 18-kn-2130	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** 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: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** • Slide set of lecture • Skript of lecture • Textbook Tränkler „Sensortechnik“, Springer • Textbook Tietze/Schenk „Halbleiterschaltungstechnik“, Springer

Courses

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

Module name					
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: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes Konigorski: “Modellbildung und Simulation”, Lunze: „Regelungstechnik 1 und 2“, Föllinger: „Regelungstechnik: Einführung in die Methoden und ihre Anwendung“

Courses

Course Nr.	Course name		
18-ko-2010-vl	Modeling and Simulation		
Instructor 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 Digital Control Systems I					
Module Nr. 18-ko-2020	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

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

Courses

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

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

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

Courses

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

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

1 Content

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

MSc ETiT, MSc MEC

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

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

Courses

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

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

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

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

Courses

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

Module name					
Robust Control					
Module Nr. 18-ko-2140	**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**
	• Basics (SVD, norms, system representations)
	• Control design in the frequency domain
	  – Expressing control tasks as H2 and Hinf optimization problems
	  – Design of H2 and Hinf optimal controllers
	
	• Robust Control
	  – Uncertainity representations (Additive und multiplicative uncertainities, multi model representations)
	  – Analysis of robustness (Small-Gain-theorem, mu-analysis)
	  – Robust control design in the frequency domainRobust control design by region-based pole placement

2	**Learning objectives / Learning Outcomes** The students are able to express control tasks as H2 and H8 optimization problems, to represent uncertainities of a system in a suitable form and to design a controller which ensures robust stability and robust performance.
3	**Recommended prerequisite for participation** Systemdynamik und Regelungstechnik I und II
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** • S. Skogestad, I. Postlethwaite, Multivariable Feedback Control,2. Auflage, 2005, Wiley • K. Zhou, Essentials of Robust Control, 1998, Prentice-Hall • O. Föllinger, Regelungstechnik, 11. Auflage, 2013, VDE Verlag

Courses

Course Nr.	Course name		
18-ko-2140-vl	Robust Control		
Instructor		**Type**	**SWS**
Dr. Ing. Eric Lenz		Lecture	2

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

1 Content

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

2 Learning objectives / Learning Outcomes

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

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

3 Recommended prerequisite for participation

Basic knowledge of programming, Matlab.

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7	**Grade bonus compliant to §25 (2)**
8	**References** http://www.bcs.tu-darmstadt.de/

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-kp-2080-vl	Computational Methods for Systems and Synthetic Biology	Prof. Dr. techn. Heinz Köppl	Lecture	2
18-kp-2080-ue	Computational Methods for Systems and Synthetic Biology	Prof. Dr. techn. Heinz Köppl	Practice	1

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

1	**Content** The module provides an introduction to the emerging field of machine learning from an engineering perspective. Important models and learning methods are presented and exemplified through problems from information and communication technology. • Fundamentals of probability theory and multivariate statistics • Taxonomy of machine learning problems and models (supervised, unsupervised, generative, discriminative) • Regression and classification: theory, methods and ICT applications • Dimensionality reduction, clustering and big data analytics: methods and application in communications and signal processing • Probabilistic graphical models: categories, inference and parameter estimation • Fundamentals of Bayesian inference, Monte Carlo methods, Bayesian non-parametrics • Fundamentals of convex optimization: Solution methods and application in communications • Approximate algorithms for scalable Bayesian inference; application in signal processing and information theory (e.g. decoding of LDPC codes) • Hidden Markov models (HMM): Theory, Algorithms and ICT applications (e.g. Viterbi decoding of convolutional codes) • High-dimensional statistics (“large p small n” setting), learning dependency structure in high-dimensional data, learning causality relations from observational data. • Sparse estimation, random projections, compressive sensing: Theory and applications in signal processing • Deep neural networks (deep learning): Models, learning algorithms, libraries and ICT applications
2	**Learning objectives / Learning Outcomes** Students are able to interpret and categorize specific engineering problems from the ICT domain in terms of machine learning problems. They are able to reduce such problems to standard machine learning problems and are able to determine suitable solution methods for them. They are able to implement all necessary algorithms from scratch, but they are also familiar with the state-of-the-art libraries in machine learning. They are able to determine the involved computational complexity of a method and choose an appropriate solution algorithms based on application constraints. They are able to apply the acquired methods to other domains, such as data analysis in biomedical engineering, analysis of social network data, etc.
3	**Recommended prerequisite for participation** Good command of Matlab (for instance knowledge from course 18-st-2030 Matlab Grundkurs) and engineering mathematics
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc etit, BSc/MSc iST, MSc iCE, MSc CE

7	**Grade bonus compliant to §25 (2)**
8	**References** • Kevin P. Murphy. Machine Learning – A probabilistic perspective, MIT Press, 2012 • Christopher M. Bishop. Pattern recognition and Machine Learning, Springer, 2006 • Peter Bühlmann und Sara van de Geer. Statistics of high-dimensional data – Methods, theory and applications, Springer, 2011

Courses

Course Nr.	Course name		
18-kp-2110-vl	Machine Learning in Information and Communication Technology (ICT)		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		Lecture	2
Course Nr.	**Course name**		
18-kp-2110-pr	Machine Learning in Information and Communication Technology (ICT) Lab		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		Internship	1
Course Nr.	**Course name**		
18-kp-2110-ue	Machine Learning in Information and Communication Technology (ICT)		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		Practice	1

Module name Spintronics					
Module Nr. 18-me-2010	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr. rer. nat. Markus Meinert		

1	**Content** The lecture covers the following subjects: • Introduction to electron transport in solids • Basic notions of magnetic materials • Concepts of spintronics • Spin-dependent electronic transport • Magnetoresistive effects, anisotropic magnetoresistance • Giant magnetoresistance (GMR) • Tunneling magnetoresistance (TMR) • Materials for spintronics (ferromagnets, antiferromagnets) • Spintronic devices as sensors • Spin-Transfer Torque • Magnetic data storage • Magnetic microwave oscillators • Spin-orbit effects
2	**Learning objectives / Learning Outcomes** The students learn fundamental concepts of spintronics, from properties of magnetic materials to the design and application of spintronic devices in data storage and magnetic sensing. The students acquire the competence to make use of spintronic devices in applications. They further acquire the competence to understand current scientific literature and to dive deeper into the field.
3	**Recommended prerequisite for participation** Module 11-01-6419 Materials of Electrical Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 10 students register in semesters in which the lecture does not take place, there will will be an oral examination (duration: 30 min.). The type of examination will be announced within two working weeks after the end of the examination registration phase.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)** Yes
8	**References** • A script will be made available electronically • Coey, Magnetism and Magnetic Materials, 2009, Cambridge University Press • Skomski, Simple Models of Magnetism, 2008, Oxford University Press • Felser, Fecher, Spintronics: From Materials to Devices, 2013, Springer • Dietl, Awschalom, Kaminska, Ohno, Spintronics, 2008, Academic Press

Courses				
	Course Nr. 11-01-2002-vl	**Course name**		
	Instructor Prof. Dr. rer. nat. Lambert Alff, Prof. Dr. rer. nat. Markus Meinert		**Type** Lecture	**SWS** 2
	Course Nr. 18-me-2010-ue	**Course name** Spintronics		
	Instructor Prof. Dr. rer. nat. Markus Meinert		**Type** Practice	**SWS** 2

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 networkinformation theory.
3	**Recommended prerequisite for participation** Knowledge of basic communication theory
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, BSc iST, MSc Wi-ETiT, MSc iCE, BSc/MSc CE
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011. 2.. T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley Sons, 1991. 3.. D. Tse and P. Vishwanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005.

Courses

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

Module name Convex Optimization in Signal Processing and Communications					
Module Nr. 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, mixted integer linear and non-linear programming, applications.
2	**Learning objectives / Learning Outcomes** Students will learn the basic theory of convex optimization and its applications.
3	**Recommended prerequisite for participation** Knowledge in linear algebra and the basic concepts of signal processing and communications.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 13 students register, there examination can be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture or in semesters without a lecture within one working week after the end of the examination registration phase.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press, 2004. (online Verfügbar: http://www.stanford.edu/~boyd/cvxbook/) 2. D. P. Bertsekas, Nonlinear Programming, Athena Scientific, Belmont, Massachusetts, 2nd Ed., 1999. 3. Daniel P. Palomar and Yonina C. Eldar, Convex Optimization in Signal Processing and Communications, Cambridge University Press, 2009.

Courses

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

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

Module name 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 moden wireless communication networks, multicell and multiuser MIMO (coordinated multipoint).
2	**Learning objectives / Learning Outcomes** Students will understand modern MIMO communications and existing space-time coding techniques.
3	**Recommended prerequisite for participation** Knowledge of basic communication theory and basic information theory.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** 1. A.B.Gershman and N.D.Sidiropoulos, Editors, Space-Time Processing for MIMO Communications, Wiley and Sons, 2005. 2. E.G.Larsson and P.Stoica, Space-Time Block Coding for Wireless Communications, Cambridge University Press, 2003; 3. A.Paulraj, R.Nabar, and D.Gore, Introduction to Space-Time Wireless Communications, Cambridge University Press, 2003. 4. Lin Bai and Jinho Choi, Low Complexity MIMO detectors, Springer, 2012. 5. Howard Huang, Constantinos B. Papadias, and Sivarama Venkatesan, MIMO Communication for Cellular Networks, Springer, 2012.

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-pe-2030-vl	MIMO - Communication and Space-Time-Coding	Prof. Dr.-Ing. Marius Pesavento	Lecture	2
18-pe-2030-ue	MIMO - Communication and Space-Time-Coding	Prof. Dr.-Ing. Marius Pesavento, M.Sc. Fabio Nikolay, M.Sc. Tianyi Liu	Practice	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
Direction-of-arrival estimation (DoA):
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
Adaptive beamforming:
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:
- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

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

6 Usability of this module

BSc / MSc etit, BSc / MSc WI-etit, MSc MEC, MSc iST, MSc iCE

7 Grade bonus compliant to §25 (2)

8 References

- 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)
  - 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 2005Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, Harry L. Van Trees, Wiley Online, 2002.

Courses

	Course Nr.	Course name		
	18-pe-2060-vl	Sensor Array Processing and Adaptive Beamforming		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento		Lecture	2
	Course Nr.	**Course name**		
	18-pe-2060-ue	Sensor Array Processing and Adaptive Beamforming		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento		Practice	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 semidenite matrices, (iv) linear system of equations, LU decomposition, Cholesky decomposition (v) pseudo-inverse, QR decomposition (vi) advanced tensor decomposition, advanced matrix calculus, compressive sensing, structured matrix factorization
2	**Learning objectives / Learning Outcomes** Students will learn matrix analysis and computations at an advanced or research level.
3	**Recommended prerequisite for participation** Basic knowledge in linear algebra.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** 1.Gene H. Golub and Charles F. van Loan, Matrix Computations (Fourth Edition), John Hopkins University Press, 2013. 2.Roger A. Horn and Charles R. Johnson, Matrix Analysis (Second Edition), Cambridge University Press, 2012. 3.Jan R. Magnus and Heinz Neudecker, Matrix Differential Calculus with Applications in Statistics and Econometrics (Third Edition), John Wiley and Sons, New York, 2007. 4.Giuseppe Calaore and Laurent El Ghaoui, Optimization Models, Cambridge University Press, 2014. ECE 712 Course Notes by Prof. Jim Reilly, McMaster University, Canada (friendly notes for engineers) http://www.ece.mcmaster.ca/faculty/reilly/ece712/course_notes.htm

Courses

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

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

Module name 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:

- Motivation, Applications
- Fundamentals
  - definition of graphs, classes of graphs, properties of graphs, signals defined over graphs
  - Adjecency matrix, Graph Laplacian, Graph shift operator
  - Covariance matrix, conditional dependence, precision matrix
- Graph signal processing
  - 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
  - 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
  - Subgraph identification
  - Cliques identification
- Optimization over graphs
  - 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 introdution 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

	Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 20 students register in semesters in which the lecture does not take place, there will 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.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** • Lecture notes and slides can be downloaded here: – www.nts.tu-darmstadt.de – moodle • Further reading: – Petar M. Djuric, Cédric Richard, Cooperative and Graph Signal Processing, Academic Press, 2018, ISBN 9780128136775.

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-pe-2080-vl	Graph signal processing, learning and optimization	Prof. Dr.-Ing. Marius Pesavento	Lecture	3
18-pe-2080-ue	Graph signal processing, learning and optimization	Prof. Dr.-Ing. Marius Pesavento	Practice	1

<table>
<tr><td colspan="6">Module name
Terahertz Systems and Applications</td></tr>
<tr><td>Module Nr.
18-pr-2010</td><td>Credit Points
4 CP</td><td>Workload
120 h</td><td>Self study
75 h</td><td>Duration
1</td><td>Cycle offered
SoSe</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Sascha Preu</td></tr>
</table>

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, multi-pliers and rectifiers) and photomixers (photo-diode based and photoconductive). The exercise, where performance parameters of the discussed devices will be derived for experimentally rele-vant 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: *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: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System) *Oral exam (mandatory)
5	**Grading** Module Final Examination: • 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** *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.	Course name	Instructor	Type	SWS
18-pr-2010-vl	Terahertz Systems and Applications	Prof. Dr. rer. nat. Sascha Preu	Lecture	2
18-pr-2010-ue	Terahertz Systems and Applications	Prof. Dr. rer. nat. Sascha Preu	Practice	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: • the understanding of basic phenomena of generation, propagation, reception, storage and reproduction of sound; • the ability to analyze acoustic components and systems; • the ability to judge and design applications in the audio and ultrasonic frequency ranges.
3	**Recommended prerequisite for participation** Electrical Engineering I and II, Mathematics I to IV, Physics, Basics of Telecommunication
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** H. Kuttruft, Akustik (Hilzel 2004); M. Zollner u. E. Zwicker, Elektroakustik, 3. Auflage (Springer, corrected reprint 1998); H. Fastl, E. Zwicker, Psychoacoustics (Springer 2005); J. Blauert, Communication Acoustics (Springer 2005); R.Lerch, G. Sessler u. D. Wolf, Technische Akustik (Springer 2009)

Courses

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

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

1	**Content** The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I. Topics are: • Basics and History of Communication Networks (Telegraphy vs. Telephony, Reference Models, ...) • Transport Layer (Addressing, Flow Control, Connection Management, Error Detection, Congestion Control, ...) • Transport Protocols (TCP, SCTP) • Interactive Protocols (Telnet, SSH, FTP, ...) • Electronic Mail (SMTP, POP3, IMAP, MIME, ...) • World Wide Web (HTML, URL, HTTP, DNS, ...) • Distributed Programming (RPC, Web Services, Event-based Communication) • SOA (WSDL, SOAP, REST, UDDI, ...) • Cloud Computing (SaaS, PaaS, IaaS, Virtualization, ...) • Overlay Networks (Unstructured P2P, DHT Systems, Application Layer Multicast, ...) • Video Streaming (HTTP Streaming, Flash Streaming, RTP/RTSP, P2P Streaming, ...) • VoIP and Instant Messaging (SIP, H.323)
2	**Learning objectives / Learning Outcomes** The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.
3	**Recommended prerequisite for participation** Basic courses of first 4 semesters are required. Knowledge in the topics covered by the course Communication Networks I is recommended. Theoretical knowledge obtained in the course Communication Networks II will be strengthened in practical programming exercises. So, basic programming skills are beneficial.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, Wi-ETiT, CS, Wi-CS
7	**Grade bonus compliant to §25 (2)**
8	**References**

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

Courses

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

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

Module name					
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 Content

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.

Topics of the lecture are:

- 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 Learning objectives / Learning Outcomes

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.

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8	**References** Ausgewählte Kapitel aus folgenden Büchern: • 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-vl	Communication Netzworks IV: Performance Evaluation of Communication Networks		
Instructor		**Type**	**SWS**
Dr.-Ing. Amr Rizk, Prof. Dr.-Ing. Ralf Steinmetz		Lecture	2

Module name					
Multimedia Communications Project II					
Module Nr. 18-sm-2130	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 180 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:

- 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
- Resource-based Learning

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:

- 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:

- 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 is recommended.
- Lectures in “Communication Networks I” and “Communication Networks II” are recommended

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6	**Usability of this module** MSc Wi-ETiT, BSc/MSc CS, MSc Wi-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: • 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.	Course name		
18-sm-2130-pr	Multimedia Communications Project II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Florian Jomrich		Internship	6

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:

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

Textbooks as indicated.
Slides and paper copies as necessary.

Courses

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

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

Courses

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

<table>
<tr><td rowspan="2"></td><td>Course Nr.
18-st-2010-pr</td><td colspan="3">Course name
Energy Management and Optimization Lab</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Internship</td><td>SWS
1</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-st-2010-ue</td><td colspan="3">Course name
Energy Management and Optimization</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

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

1	**Content** The analysis and interpretation of data becomes ever more important, also for engineers. Digitalization and Smart Grids are terms to describe a host of novel data-based services in the field of generation, distribution, consumption and marketing of (renewable) energy. The lecture presents the recent developments and their underlying principles of machine learning technology. For a start we will describe the different problem settings of machine learning in a structured way (classification, regression, clustering, dimensionality reductions, time series models, ...) and present for each setting relevant applications from the energy sector (prediction of renewable energy or consumption in multimodal energy systems, fault detection and prediction, data visualization, robust investments decisions, customer analysis, probabilistic load flow, ...). Thereafter we will briefly review necessary tools from optimization and probability theory, as well as introduce probabilistic graphical models. With these tools we will then study for each problem setting one or more machine learning algorithms in detail, together with use cases from the energy domain. Classic algorithms will be developed (e.g. linear regression, k-means, principal component analysis, ...) as well as modern ones (e.g. SVMs, Deep Learning, Collaborative filtering, ...). Practical exercise with Matlab will deepen the understanding and support student's active knowledge.
2	**Learning objectives / Learning Outcomes** Students understand important machine learning problem settings and some key algorithms for each task. They know common applications thereof in the energy domain. Moreover, the students are able to apply and adapt those methods independently to new applications (not only from the energy domain).
3	**Recommended prerequisite for participation** • Good knowledge of linear algebra and the foundations of numerical optimization (e.g. from the course 18-st-2010 Energieanagement & Optimierung) • Using Matlab for programming the practical examples should pose no difficulty. A block tutorial on the use of Matlab is offered as 18-st-2030 Matlab Grundkurs.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc etit, MSc iST, MSc Wi-etit, MSc CE
7	**Grade bonus compliant to §25 (2)** Notenverbesserungen bis zu 0,4 nach APB §25(2) durch Bonus für regelmäßig besuchte Übungs-/Praktikumstermine und mindestens einmaliges Vorrechnen in den Übungen
8	**References** • A Géron: Hands on Machine Learning with scikit-learn and Tensorflow, 2017 • Friedman, Hastie, Tibshirani: The elements of statistical learning, 2001 • Koller, Friedmann: Graphical Models, 2009

Courses

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

Module name Technology and Economics of Multimodal Energy Systems					
Module Nr. 18-st-2060	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Stefan Nießen		

1	**Content** Energy economical framework, structures of multimodal energy systems, investment and costing, energy trading, sources for flexibility including storage, regulation, sustainability, social acceptance
2	**Learning objectives / Learning Outcomes** The students learn the structures of energy supply systems including electricity, primary energies, heating, cooling, transport and water desalination. They understand the underlying principles for the design of energy systems for buildings, sites, cities and countries and are able to assess their adequacy for different international locations considering costs, environmental impact and social acceptance. The students learn to assess the economic viability of investments in energy asssets using new present value and annuity. They learn the functionning of energy markets and different forms of trading and settlement for energy transactions. Based on an analysis of the impact of an increasing share of renewables in the system, the students learn the technology of different sources for flexbility including demand-side-management, different technologies for storage and for the coupling of different modes of energy. Storage technologies include batteries, pumped hydro, hydrogen and inertia. Multimodal coupling technologies include power-heat, heat-cooling, power-heat-water and industrial processes. Energy systems are subject to numerous laws and regulations. Therefore, the students learn different elements that define the regulatory framework such as feed-in tarifs, tax incentives, credit programs, quotas and certificates. The regulations are the result of societal processes. Therefore, the students analyze the different interest groups, origins and impact of public opinion and the perception of risk.
3	**Recommended prerequisite for participation** A completed Bachelor in any of the following subjects: electrical engineering, mechanical engi-neering, mechatronics, environmental sciences, business administration/engineering (Wirtschaftsingenieurwesen)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) In general, the module is examined by written examination (duration: 120 min.). If 20 students or less apply, the exam is oral (duration: 30 min.). The mode of examination will be communicated within one working week after the end of the exam application phase.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** *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.	Course name		
	18-st-2060-vl	Technology and Economics of Multimodal Energy Systems		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Stefan Nießen		Lecture	2
	Course Nr.	**Course name**		
	18-st-2060-pj	Technology and Economics of Multimodal Energy Systems - simulation game		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Stefan Nießen		Project	1

Module name					
Energiewende gestalten					
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:

- 6 double-lectures, two of them being tought 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 accellerated mode the impact on CO2 emsissions, 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 persion 2020 to 2050.

2 Learning objectives / Learning Outcomes

The students know different methods for techo-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:

- Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System)

The type of examination will be announced in the first lecture. Possible types include

- a presentation and a report of the parts of the module

5 Grading

Module Final Examination:

- 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.	Course name		
18-st-2080-vl	Designing the Energiewende - lecture		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Stefan Nießen, Prof. Dr. phil. Michèle Knodt, Prof. Dr. rer. nat. Florian Steinke		Lecture	1

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

Course Nr.	Course name		
18-st-2080-se	Designing the Energiewende - seminar		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Stefan Nießen, Prof. Dr. phil. Michèle Knodt, Prof. Dr. rer. nat. Florian Steinke		Seminar	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** WiSe
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: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc Wi-ETiT, Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/se_ii/

Courses

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

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: • classification of real-time systems • create and analyze executable models • application of real-time scheduling algorithms • evaluation and comparison of pros/cons of real-time programming languages as well as real-time operating systems
3	**Recommended prerequisite for participation** Basic knowledge of software engineering techniques and excellent knowledge of at least one object-oriented programming language (preferably Java)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, BSc iST, MSc Wi-ETiT, BSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/es/

Courses

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

Module name
Adaptive Filters

Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-zo-2010	6 CP	180 h	120 h	1	SoSe

Language	Module owner
German and English	Prof. Dr.-Ing. Abdelhak Zoubir

1 Content

Theory:
1) Derivation of optimal filters for stochastic processes, e.g. Wiener filter or linear prediction filter based on suitable cost functions.
2) Elaboration of adaptive procedures, which allow to iteratively approach the optimal solution for non-stationary signals in non-stationary environments. Here, the adaptive procedures such as NLMS adaptation, affine projection, and the RLS algorithm are derived and extensively analysed.
3) Analysis of the adaptation behaviour and control procedures of adaptive filters based on the NLMS procedure.
4) Derivation and analysis of the Kalman filter as optimal filter for non-stationary input signals.
5) Procedures for the decomposition of signals into sub-bands for the realization of optimal filters in the frequency domain, e.g. noise reduction procedures.
Applications:
Parallel to the theory, practical applications are explained. As an example for the Weiner filter, the acoustic noise reduction procedures are explained. Acoustic echo cancellation and feedback cancellation are given as examples for adaptive filters. Furthermore beamforming approaches are introduced.
It is planned to offer an excursion to Siemens Audiology Engineering Group in Erlangen.
In the 4 to 5 exercises, some content of the lecture will be implemented in MATLAB which allows the students to get familiar with practical realizations of the theoretical procedures.

2 Learning objectives / Learning Outcomes

During the lecture, basics of adaptive filters are taught. The necessary algorithms are derived, interpreted and applied to examples of speech, audio and video processing.
Based on the content of the lecture you are able to apply adaptive filters to real practical applications.
For the admission to the exam you give a talk about a topic in the domain of adaptive filters chosen by you. This will allow you to acquire the know-how to read and understand scientific literature, familiarize yourself with an unknown topic and present your knowledge, such as it will be certainly required from you in your professional life as an engineer.

3 Recommended prerequisite for participation

Digital Signal Processing

4 Form of examination

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

5 Grading

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

6 Usability of this module

MSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

Slides of the lecture.
Literature:

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

Courses

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

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

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

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

Courses

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

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

1 Content

Algorithms of speech and audio signal processing: Introduction to the models of speech and audio signals and basic methods of audio signal processing. Procedures of codebook based processing and audio coding. Beamforming for spatial filtering and noise reduction for spectral filtering. Cepstral filtering and fundamental frequency estimation. Mel-filterind cepstral coefficients (MFCCs) as basis for speaker detection and speech recognition. Classification methods based on GMM (Gaussian mixture models) and speech recognition with HMM (Hidden markov models). Introduction to the methods of music signal processing, e.g. Shazam-App or beat detection.

2 Learning objectives / Learning Outcomes

Based on the lecture you acquire an advanced knowledge of digital audio signal processing mainly with the help of the analysis of speech signals. You learn about different basic and advanced methods of audio signal processing, to range from the theory to practical applications. You will acquire knowledge about algorithms such as they are applied in mobile telephones, hearing aids, hands-free telephones, and man-machine-interfaces (MMI). The exercise will be organized as a talk given by each student with one self-selected topic of speech and audio processing. This will allow you to acquire the know-how to read and understand scientific literature, familiarize with an unknown topic and present your knowledge, such as it will be certainly required from you in your professional life as an engineer.

3 Recommended prerequisite for participation

Knowlegde about satistical signal processing is required (lecture „Digital Signal Processing“). Desired – but not mandatory – is knowledge about adaptive filters.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Duration: 20 min, Standard Grading System)

Seminar presentation: Scientific talk about a topic in the field of “Speech and Audio Signal Processing”, single (duration 10-15 min) or in groups of two students (15-20 min)

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc ETiT, MSc iCE

7 Grade bonus compliant to §25 (2)

8 References

Slides (for further details see homepage of the lecture)

Courses

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

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

1. Robust Signal Processing and Learning
   - 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

2. Biomedical Applications
   - Body-worn sensing of physiological parameters
   - Electrocardiogram (ECG)
   - Photoplethysmogram (PPG)
   - Eye research
   - Intracranial Pressure (ICP)
   - Algorithms for cardiac activity monitoring

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.

2 Learning objectives / Learning Outcomes

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.

3 Recommended prerequisite for participation

Fundamental knowledge of statistical signal processing

4 Form of examination

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

5 Grading

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

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

Module name Data Science I					
Module Nr. 18-zo-2110	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Content

The course covers the following topics:

- Python programming basics
- Data science introduction
- Data storage and formats
- Data exploration and visualization
- Statistical methods and inference
  - Descriptive statistics (uni & bivariate)
  - Inferential statistics
- Feature extraction
  - Time Series Data
  - Image data
  - Audio data
- Statistical learning
  - 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:

- 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 15 students register, there will will be an oral examination (duration: 45 min.). The type of examination will be announced within one working week after the end of the examination registration phase.

5 Grading

Module Final Examination:

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

6 Usability of this module

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

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

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

1 Content

During the laboratory course the following experiments will be conducted: Coupling control of a helicopter, Non-linear control of a gyroscope, Nonlinear multivariable control of an aircraft, Servo control systems, Control of an overhead crane system, Programmable logic control of a stirring process

2 Learning objectives / Learning Outcomes

After attending this laboratory course, a student is capable of:
- recalling the basics of the conducted experiments,
- organize and comprehend background information for experiments,
- assemble experimental set-ups based on manuals,
- judge the relevance of experimental results by comparing them with theoretically predicted outcomes,
- present the results of the experiments

3 Recommended prerequisite for participation

System Dynamics and Control Systems II, the attendance of the additional lecture “System Dynamics and Control Systems III” is recommended

4 Form of examination

Module Final Examination:
- Module Examination (Study Achievement, Written Examination, Duration: 180 min, Standard Grading System)

5 Grading

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

Adamy: Instruction manuals for the experiments (available during the kick-off meeting)

Courses

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

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: • Electrical energy conversion • Power electronics • High voltage technology • Electrical energy supply • Renewable energies
2	**Learning objectives / Learning Outcomes** Practical knowledge is gained in measuring and operating electrical devices and apparatus of electrical power engineering in small groups of students.
3	**Recommended prerequisite for participation** Power Engineering or similar
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Binder, A. et al.: Textbook with detailed description of experiments; Hindmarsh, J.: Electrical Machines and their Application, Pergamon Press, 1991 Nasar, S.A.: Electric Power systems. Schaum's Outlines Mohan, N. et al: Power Electronics, Converters, Applications and Design, John Wiley & Sons, 1995 Kind, D., Körner, H.: High-Voltage Insualtion Technology, Friedr. Vieweg & Sohn, Braunschweig Wiesbaden, 1985, ISBN 3-528-08599-1

Courses

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

Course Nr.	Course name		
18-bi-2090-tt	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 sytems, linear permanent magnet and switched reluctance machines.
2	**Learning objectives / Learning Outcomes** Practical knowledge is gained in measuring and operating electrical devices and apparatus of electrical power engineering in small groups of students.
3	**Recommended prerequisite for participation** Master program: Power Lab 1
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Text book with detailed laboratory instructions

Courses

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

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

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

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-bi-2100-pr	Practical Training with Drives	Prof. Dr. techn. Dr.h.c. Andreas Binder	Internship	3
18-bi-2090-tt	Laboratory Briefing	Prof. Dr. techn. Dr.h.c. Andreas Binder	Tutorial	0

Module name Processor Microarchitecture					
Module Nr. 18-hb-2050	**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** Lectures (each block takes 3 * 90 minutes) 1. Processor execution. Sources of performance loss, latency. Possible techniques to improve performance. Simultaneous multi-threading as an established solution. Motivation for multi-threading – p-threads as a model of execution in SW, micro-threading as a model of execution in HW. 2. Definition of micro-threading, its requirements on the microarchitecture. Microthreaded assembly instructions, design alternatives for extended instruction sets. Required support in micro-architecture – self-synchronizing register file, cache controllers, thread scheduler. 3. Execution in the micro-threaded pipeline. Interaction between cache controllers, register file, thread scheduler, integer pipeline. Data dependences between threads and its influence on execution (embarrassingly parallel vs. sequential programs). Interaction with legacy code, execution modes, OS support. 4. Developing for the real world: Writing testbenches. Performance profiling. Indicators of efficient silicon use. 5. Microthreading in multi-core architectures. Big issues: Scalability, sufficient parallelism, trade-off between clock frequency and access latency Labs: 1. Set up the utgrlib VHDL sources in the home directory. Set up the utbinutils in the home directory. Compilation of introductory examples. 2.-3. Analysis of execution traces for introductory examples. Design of a FIR filter in micro-threaded assembly. Compilation, execution, analysis of pipeline efficiency. 4.-9. Re-design of existing blocks (choose from dcache, icache, regfile). Preparation of a TLM testbench. Coding and testing of the block in a stand-alone testbench. 10.-15. Integration of the block in UTLEON3, execution of micro-threaded programs, evaluation of performance analysis (% performance gain over the original block, % decreased resource requirements).
2	**Learning objectives / Learning Outcomes** After completion of the module, students will be able to design a customized microarchitecture of a modern RISC processor and analyze its performance. The course will be taught using a VHDL implementation of an existing micro-threaded processor UTLEON3 in an FPGA, nevertheless the knowledge gained in the lecture will be applicable to other HDLs, different processor architectures and other implementation technologies.
3	**Recommended prerequisite for participation** Hands-on experience with at least one of Verilog or VHDL is expected. Basic understanding of FPGA technology and thorough knowledge of digital circuit design and computer architecture. Several tools used throughout the labs might require additional programming languages and tools (Perl, C, bash). This knowledge can be obtained during the labs.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE, MSc iST
7	**Grade bonus compliant to §25 (2)**

8	**References** A script is available as a published book and English slides can be obtained through moodle.			
Courses				
	Course Nr. 18-hb-2050-vl	**Course name** Processor Microarchitecture		
	Instructor Ph.D. Martin Danek		**Type** Lecture	**SWS** 2
	Course Nr. 18-hb-2050-pr	**Course name** Processor Microarchitecture		
	Instructor Ph.D. Martin Danek		**Type** Internship	**SWS** 2

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

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

Courses

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

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

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

Courses

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

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

1	**Content** The student communications lab consist of 7 fundamental experiments out of the field of Communication Engineering: Mobile Radio Channel + Diversity (SW) Signal Detection and Parameter Estimation (Matlab) Digital Modulation (HW) Coding (SW) Parasitic Effects in Passive RF Devices (SW) RF FET Amplifier (HW) Polarization of Light (HW) Antennas: Fields and Impedance (HW)
2	**Learning objectives / Learning Outcomes** The students are guided to acquaint themselves with given topics. They learn to perform prepared experiments within a defined frame and minute, analyze and discuss the results. In this training the fundamentals of free scientific work are practiced.
3	**Recommended prerequisite for participation** Fundamentals of: • Communications • Microwave Engineering • Digital Signal Processing
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** A description of experiments is offered. It can be bought from Mr. Ziemann (S306/409) or being loaded from the WEB page.

Courses

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

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 technoloies, high frequency components and their poperties: rf power measurement, spectrum analysis, vertor network analysis (s-parameter, x-parameter, calibration techniques), on-wafer measurements, load/source-pull, material characterization

2 Learning objectives / Learning Outcomes

By this module, Students will be enabled to undetstand the basic principles of microwave measuement technologies. They are able to use them in measurement applications. The following objectives are linked to the lecture:

- The students understand the basic features of the power measurements and the effects of a mismatch or pulsed signals and can independently carry out and interpret measurements.
- The students understand the basics of spectrum analysis and can carry out and interpret measurements independently.
- The students understand the basics of s-parameter measurements and calibration of network analyzers and can carry out and interpret measurements independently
- Students are familiar with various methods for material characterization

3 Recommended prerequisite for participation

Recommended: Grundlagen der Nachrichtentechnik, Hochfrequenztechnik I

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc etit, MSc WI-etit, MSc iCE, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

Courses

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

<table>
<tr><td rowspan="2"></td><td>Course Nr.
18-jk-2090-pr</td><td colspan="3">Course name
Microwave Measurement Technologies Lab</td></tr>
<tr><td colspan="2">Instructor
Dr.-Ing. Holger Maune</td><td>Type
Internship</td><td>SWS
1</td></tr>
</table>

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

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

Courses

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

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

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

Courses

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

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

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: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Laboratory script in Electromechanical Systems

Courses

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

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

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

Courses

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

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

1 Content

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

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

2 Learning objectives / Learning Outcomes

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

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

3 Recommended prerequisite for participation

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

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

<table>
<tr><td>8</td><td colspan="3">References
Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:
• Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887)
• Christian Ullenboom: "Java ist auch eine Insel: Programmieren mit der Java Standard Edition Version 5 / 6" (ISBN-13: 978-3898428385)
• Joshua Bloch: "Effective Java Programming Language Guide" (ISBN-13: 978-0201310054)
• Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2)
• Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)</td></tr>
<tr><td colspan="4">Courses</td></tr>
<tr><td></td><td>Course Nr.
18-sm-2070-pr</td><td colspan="2">Course name
Multimedia Communications Lab II</td></tr>
<tr><td></td><td colspan="2">Instructor
Prof. Dr.-Ing. Ralf Steinmetz, Dr. Ing. Björn Richerzhagen, M.Sc. Florian Jomrich</td><td>Type
Internship

SWS
3</td></tr>
</table>

Module name					
Introduction to Scientific Computing with Python					
Module Nr. 18-st-2070	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1 Content

Scientific computing is introduced via six case studies. Exemplary engineering problems that are know from basic engineering courses are solved on a computer using fundamental methods from numerical mathematics. Opportunities and limitations of this approach are highlighted.

The required material on numerical mathematics is taught via preparatory scripts for each case study. During the practical exercises the methods are implemented in the current computing environment Python under the guidance of suitable teaching personnel.

The case studies cover the following numerical topics:

- Formulation and solution of systems of linear equations, sparse methods
- Integration of ordinary differential equations (ODE) and their analysis based on eigenvalues
- Mathematical optimization and automated differentiation
- Linear regression and approximation, first Machine Learning algorithms
- Discretization of simple partial differential equations (PDE)

2 Learning objectives / Learning Outcomes

Students have a first experience of solving engineering problems on a computer. They know how to apply fundamental technologies of numerical mathematics and are familiar with an algorithmic approach to problem solving. They know opportunities and limitations of computer-aided solution methods.

3 Recommended prerequisite for participation

Etit 1 & 2, Mathe for etit 1-3

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System)

The type of examination will be announced in the first lecture. Possible types could be: Creating reports and descriptions of experiments as well as presentations of experiments and results.

5 Grading

Module Final Examination:

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

6 Usability of this module

Etit B.A./M.Sc. with all options, as well as CE, ICE, IST

7 Grade bonus compliant to §25 (2)

8 References

Courses

Course Nr.	Course name		
18-st-2070-pr	Introduction to Scientific Computing with Python		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke, Prof. Dr. rer. nat. Sebastian Schöps, Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. rer. nat. Markus Meinert		Internship	2

Module name Digital Signal Processing Lab					
Module Nr. 18-zo-2030	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** 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: • Module Examination (Study Achievement, Written Examination, Duration: 120 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lab manual

Courses

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

Module name
Design of Electrical Machines and Actuators with Numerical Field Calculation

Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-bi-2110	5 CP	150 h	120 h	1	SoSe

Language	Module owner
German and English	Prof. Dr. techn. Dr.h.c. Andreas Binder

1 Content
Introduction to Finite Element Method (FEM), Basic examples of electromagnetic devices designed in 2D with FEM, 2D electromagnetic Design of transformers, AC machines, permanent magnet devices; eddy current applications such as squirrel-cage machines (Example: Wind generator); Cooling systems and thermal design: Calculation of temperature distribution within power devices

2 Learning objectives / Learning Outcomes
A good knowledge in applying FEMAG and ANSYS software package to basic field problems is gained.

3 Recommended prerequisite for participation
Strongly recommended is the attendance of lecture and active co-operation in the tutorial "Energy Converters - CAD and System Dynamics"

4 Form of examination
Module Final Examination:
- Module Examination (Study Achievement, Optional, Standard Grading System)

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

6 Usability of this module
MSc EPE, MSc ETiT, MSc MEC

7 Grade bonus compliant to §25 (2)

8 References
Detailed textbook; User manual FEMAG and ANSYS. Müller, C. Groth: FEM für Praktiker – Band 1: Grundlagen, expert-Verlag, 5. Aufl., 2000

Courses

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

Module name 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: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc EPE, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Textbook; Binder, A.: Electric machines and drives I, Darmstadt Univ. of Technology Mitschke, M.: Dynamik der Kraftfahrzeuge, Springer Verlag Berlin

Courses

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

Module name Key skills with a focus on language					
Module Nr. 18-de-2112	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Katharina Dehn		

1 Content

- This seminar teaches the students the relevant competences which will be expected within the mechatronics program to handle oral and written communication successfully. Throughout this the seminar scientific texts will be written and analyzed such that they can be beneficial for the student's own studies. Key aspects will be: structuring, techniques for oral and written communication, designing handouts, statements, preparing reports, essays and presentations.
- The seminar „key skills" which will be held in 4 day workshop will teach students how to cope with everyday life in Germany and will provide assistance in order to make the stay in Germany as successfully as possible. Support for the students will be provided in order to structure them, to find answers why Germans are how they are, which values are important to Germans and how different perceptions can lead to misunderstandings. Possible problems will be addressed in the group and solutions will be worked out. The topics of the workshops are:
  - Living and studying in Germany (2 day workshop)
  - Succesful teamwork (1 day workshop)
  - Learning effectively and time management (1 day workshop)
  - Expectations within the university (1 day workshop)

2 Learning objectives / Learning Outcomes

After succesfully attending this module the students will be capable of

- structuring their written and oral communication,
- using techniques for lecturing and presenting,
- designing handouts,
- framing statements and reports scientifically,
- understanding and analyzing Germany's cultural standards and habits,
- coping with misunderstandings appearing in private and university contexts using strategies of de-escalation,
- developing understanding for expectations within the university context and act accordingly,
- defining strategies for successful teamwork and act accordingly,
- employing methods of effective learning,
- carrying out effective time management,
- identifying their own potential and to cope with special challenges.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc MEC, MSc ETiT, MSc MPE

7 Grade bonus compliant to §25 (2)

8	**References** Esselborn-Krumbiegel, H. (2007): Leichter lernen. Paderborn. Franck, N. (2004): Fit fürs Studium. München. Hall, E./Hall, M. (1989): Understanding Cultural Differences: Germans, French and Americans. Yarmouth Minn. Hofstede, G. (1991): Cultures and Organizations. New York. Mehlhorn, G. (2005): Studienbegleitung für ausländische Studierende an deutschen Hochschulen. München Stickel-Wolf, C./Wolf, J. (2006): Wissenschaftliches Arbeiten und Lerntechniken. Wiesbaden.

Courses

Course Nr.	Course name		
18-de-2112-se	Speaking and Writing in Academic Contexts		
Instructor		**Type** Seminar	**SWS** 2

Course Nr.	Course name		
18-de-2113-se	Seminar Key Skills		
Instructor		**Type** Seminar	**SWS** 2

Module name Accelerator Physics and Technology					
Module Nr. 18-dg-2070	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 165 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Learn and understand the theoretical contexts in the field of accelerator physics; application of the theoretical background to practical examples related to current projects in the field.
2	**Learning objectives / Learning Outcomes** The seminar addresses various topics relevant to accelerator physics and technology which in detail depend on the guest lecturers. So, insight into the current developments as well as into the different projects in the area is given. Moreover, the focus is put on the practical challenges arising during the design, construction and commissioning phase of the particular accelerator projects.
3	**Recommended prerequisite for participation** Basic knowledge in the field of accelerator physics and technology is useful, though not mandatory.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-dg-2070-se	Accelerator Physics and Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. rer. nat. Norbert Pietralla		Seminar	1

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

1 Content

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

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

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

2 Learning objectives / Learning Outcomes

The Competences are:

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc ETiT, MSc Wi-ETiT, MSc MEC

7 Grade bonus compliant to §25 (2)

8 References

Definition of project task

Courses

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

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

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

Courses

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

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 1. gain a deep understanding of the chosen research subject in the field of integrated electronic systems, 2. write an essay on the chosen subject in a comprehesive form and present the outcome to an audience
3	**Recommended prerequisite for participation** Advanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 45 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Topic-oriented Materials will be provided

Courses

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

Module name Seminar: Integrated Electronic Systems Design B					
Module Nr. 18-ho-2161	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 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 1. gain a deep understanding of the chosen research subject in the field of integrated electronic systems, 2. write an essay on the chosen subject in a comprehesive form and present the outcome to an audience
3	**Recommended prerequisite for participation** Advanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 45 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Topic-oriented Materials will be provided

Courses

Course Nr.	**Course name**		
18-ho-2161-se	Seminar: Integrated Electronic Systems Design B		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Seminar	3

<table>
<tr><td colspan="6">Module name
Calculation of Transients in electrical Power Systems</td></tr>
<tr><td>Module Nr.
18-hs-2060</td><td>Credit Points
6 CP</td><td>Workload
180 h</td><td>Self study
150 h</td><td>Duration
1</td><td>Cycle offered
SoSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Jutta Hanson</td></tr>
</table>

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

Courses

<table>
<tr><td rowspan="2"></td><td>Course Nr.
18-hs-2060-se</td><td colspan="3">Course name
Calculation of Transients in electrical Power Systems</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Jutta Hanson</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

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** Every 2. Sem.
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: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
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.	**Course name**		
18-jk-2080-se	European Microwave School		
Instructor		**Type**	**SWS**
Dr.-Ing. Holger Maune, Prof. Dr.-Ing. Rolf Jakoby		Seminar	2

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

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.
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.

2 Learning objectives / Learning Outcomes

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:

- 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:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

BSc etit, MSc etit

7 Grade bonus compliant to §25 (2)

8 References

Courses

Course Nr.	Course name		
18-kp-2100-se	Computational Modeling for the IGEM Competition		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl		Seminar	2

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 lecture covers the fundamentals and the latest deveolpments of microwave electronics, THz technology, and optical communication systems with particular focus on the physical concepts involved.
2	**Learning objectives / Learning Outcomes** Students understand • the background of microwave enginering, THz engineering, and optical communications and • of related electronics, and • the influence of the relevant properties of materials and of waveguides on signal processing. They gain inside into the latest developments in these fields.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** A script (English) will be distributed and English slides can be downloaded.

Courses

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

Module name Multimedia Communications Seminar II					
Module Nr. 18-sm-2090	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** 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: • 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: • 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: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** 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		Seminar	2

Module name					
Multimedia Communications Seminar I					
Module Nr. 18-sm-2300	**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.-Ing. Ralf Steinmetz		

1 Content

The seminar investigates current and upcoming topics in multimedia communication systems, which are expected to be of utmost importance for the future evolution of the Internet and information technolgy in goal. The goal is to learn more about multimedia communication systems by studying, summarizing, and presenting top quality papers from recent high quality networking research journals, magazines, or conferences. The selection of topics corresponds to the research area of participating researchers.

Possible topics are:

- Knowledge & Educational Technologies
- Self organizing Systems & Overlay Communication
- Mobile Systems & Sensor Networking
- Service-oriented Computing
- Multimedia Technologies & Serious Games

2 Learning objectives / Learning Outcomes

The students are actively studying cutting edge scientific articles, standards, and books about multimedia communication systems and applications, which are expected to be of utmost important for the future of the Internet.

Students acquire competences in the following areas:

- Searching and reviewing of relevant scientific literature
- Analysis and evaluation of complex technical and scientific information
- Writing of technical and scientific summaries and short papers
- Presentation of complex technical and scientific information

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

CS, WiCS, ETiT, Wi-ETiT, BSc/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-2300-se	Multimedia Communications Seminar I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz		Seminar	3

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

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

Courses

Course Nr.	**Course name**		
18-st-2050-se	Pathways of Decarbonization		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke, M.Sc. Christopher Thomas Peter Ripp		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: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc iST, BSc Informatik, MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/sst

Courses

Course Nr.	**Course name**		
18-su-2080-se	Seminar Software System Technology		
Instructor Prof. Dr. rer. nat. Andreas Schürr		**Type** Seminar	**SWS** 2

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:

- 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:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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

7 Grade bonus compliant to §25 (2)

8 References

- 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.	Course name		
18-zo-2040-se	Advanced Topics in Statistical Signal Processing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Seminar	4

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

1	**Content** Signal detection and parameter estimation are fundamental signal processing tasks. In fact, they appear in many common engineering operations under a variety of names. In this course, the theory behind detection and estimation will be presented, allowing a better understanding of how (and why) to design "good" detection and estimation schemes. These lectures will cover: Fundamentals Detection Theory Hypothesis Testing Bayesian Tests Ideal Observer Tests Neyman-Pearson Tests Receiver Operating Characteristics Uniformly Most Powerful Tests The Matched Filter Estimation Theory Types of Estimators Maxmimum Likelihood Estimators Sufficiency and the Fisher-Neyman/Factorisation Criterion Unbiasedness and Minimum variance Fisher Information and the CRB Asymptotic properties of the MLE
2	**Learning objectives / Learning Outcomes** Students gain deeper knowledge in signal processing based on the fundamentals taught in DSP and EtiT 4. Thexy will study advanced topics of statistical signal processing in the area of detection and estimation. In a sequence of 4 lectures, the basics and important concepts of detection and estimation theory will be taught. These will be studied in dept by implementation of the methods in MATLAB for practical examples. In sequel, students will perform an independent literature research, i.e. choosing an original work in detection and estimation theory which they will illustrate in a final presentation. This will support the students with the ability to work themselves into a topic based on literature research and to adequately present their knowledge. This is especially expected in the scope of the students' future research projects or in their professional carreer.
3	**Recommended prerequisite for participation** DSP, general interest in signal processing
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT,MSc iST, MSc iCE, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

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

Courses

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

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

1	**Content** Signal detection and parameter estimation are fundamental signal processing tasks. In fact, they appear in many common engineering operations under a variety of names. In this course, the theory behind detection and estimation will be presented, allowing a better understanding of how (and why) to design “good” detection and estimation schemes. These lectures will cover: Fundamentals Detection Theory Hypothesis Testing Bayesian Tests Ideal Observer Tests Neyman-Pearson Tests Receiver Operating Characteristics Uniformly Most Powerful Tests The Matched Filter Estimation Theory Types of Estimators Maxmimum Likelihood Estimators Sufficiency and the Fisher-Neyman/Factorisation Criterion Unbiasedness and Minimum variance Fisher Information and the CRB Asymptotic properties of the MLE
2	**Learning objectives / Learning Outcomes** Students gain deeper knowledge in signal processing based on the fundamentals taught in DSP and EtiT 4. Thexy will study advanced topics of statistical signal processing in the area of detection and estimation. In a sequence of 4 lectures, the basics and important concepts of detection and estimation theory will be taught. These will be studied in dept by implementation of the methods in MATLAB for practical examples. In sequel, students will perform an independent literature research, i.e. choosing an original work in detection and estimation theory which they will illustrate in a final presentation. This will support the students with the ability to work themselves into a topic based on literature research and to adequately present their knowledge. This is especially expected in the scope of the students’ future research projects or in their professional carreer.
3	**Recommended prerequisite for participation** DSP, general interest in signal processing
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT,MSc iST, MSc iCE, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

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

Courses

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

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	**Content** A series of 3 lectures provides the necessary background on robust signal processing and machine learning: • Background on robust signal processing • Robust regression and robust filters for artifact cancellation • Robust location and covariance estimation and classification They are followed by two lectures on selected biomedical applications, such as: • Body-worn sensing of physiological parameters • Optical heart rate sensing (PPG) • Signal processing for the electrocardiogram (ECG) • Biomedical image processing 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.
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation** Fundamental knowledge of statistical signal processing
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References** • 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-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:

- Data Science Advanced Methods
- Data Management + Big data frameworks
- Statistical Learning
  - 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:
  - 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:

- 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 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:

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

<table>
<tr><td colspan="7">Module name
Project Seminar Robotics and Computational Intelligence</td></tr>
<tr><td colspan="2">Module Nr.
18-ad-2070</td><td>Credit Points
8 CP</td><td>Workload
240 h</td><td>Self study
180 h</td><td>Duration
1</td><td>Cycle offered
SoSe</td></tr>
<tr><td colspan="4">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Jürgen Adamy</td></tr>
<tr><td>1</td><td colspan="6">Content
The following topics are taught in the lecture: 1. Industrial robots, 1a. Types and applications, 1b. Geometry and kinematics, 1c. Dynamic model, 1d. Control of industrial robots, 2. Mobile robots, 2a. Types and applications, 2b. Sensors, 2c. Environmental maps and map building, 2d. Trajectory planning. Group projects are arranged after the lectures in order to apply the taught material in practical exercises.</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives / Learning Outcomes
After attending the lecture, a student is capable of: 1. recalling the basis elements of industrial robots, 2. recalling the dynamic equations of industrial robots and be able to apply them to describe the dynamics of a given robot, 3. stating model problems and solutions to standard problems in mobile robotics, 4. planing a small project, 5. organizing the work load in a project team, 6. searching for additional background information on a given project, 7. creating ideas on how to solve problems arising in the project, 8. writing an scientific report about the outcome of the project 8. presenting the results of the project.</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisite for participation</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Module Final Examination:
Module Examination (Study Achievement, Optional, Standard Grading System)</td></tr>
<tr><td>5</td><td colspan="6">Grading
Module Final Examination:
Module Examination (Study Achievement, Optional, Weighting: 100 %)</td></tr>
<tr><td>6</td><td colspan="6">Usability of this module
MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik</td></tr>
<tr><td>7</td><td colspan="6">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td colspan="6">References
Adamy: Lecture notes (available for purchase at the FG office)</td></tr>
<tr><td colspan="7">Courses</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Course Nr.
18-ad-2070-pj</td><td colspan="4">Course name
Project Seminar Robotics and Computational Intelligence</td></tr>
<tr><td colspan="4">Instructor
Prof. Dr.-Ing. Jürgen Adamy</td><td>Type
Project Seminar</td><td>SWS
4</td></tr>
</table>

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: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Training course material

Courses

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

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

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

Courses

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

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

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

Courses

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

<table>
<tr><td colspan="6">Module name
Science in Practice I</td></tr>
<tr><td>Module Nr.
18-dg-2130</td><td>Credit Points
8 CP</td><td>Workload
240 h</td><td>Self study
180 h</td><td>Duration
1</td><td>Cycle offered
WiSe/SoSe</td></tr>
<tr><td colspan="3">Language
German and English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Herbert De Gersem</td></tr>
</table>

1	**Content** Acquiring basic scientific skills based on concrete examples from the literature.
2	**Learning objectives / Learning Outcomes** The students possess basic scientific skills. They are able to discover important literature for a given topic and to judge critically the corresponding content. They are familiar with numerical techniques, especially convergence studies relevant for praxis. The students are capable of analyzing errors within simulations and of judging accuracy requirements, e.g., with respect to errors in input data.
3	**Recommended prerequisite for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Material related to the topic is provided.

Courses

Course Nr.	Course name		
18-dg-2130-pj	Science in Practice I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Project Seminar	4

Module name Science in Practice II					
Module Nr. 18-dg-2140	**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. Herbert De Gersem		

1	**Content** Working on different scientific topics based on techniques acquired in Science in Practice I.
2	**Learning objectives / Learning Outcomes** The students are capable of succesfully working on new scientific topics from the numerical field simulation in a reasonable time. They are able to understand new methods, to implement them if necessary and to carry out simulations. Thereby methodologies discussed in Science in Practice I, especially concerning the solution of systems of equations, as well as convergence and error analysis are employed. They know how to document the results by means of a report and how to present them.
3	**Recommended prerequisite for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Material related to the topic is provided.

Courses

Course Nr.	**Course name**		
18-dg-2140-pj	Science in Practice II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Project Seminar	4

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

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

Courses

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

Module name Project Seminar Design for Additive Manufacturing – Interdisciplinary view of potentials and impacts of a new technology					
Module Nr. 18-ho-2220	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** In the tutorial, potentials and effects on products which result from the technology of additive manufacturing are demonstrated from the perspectives of the departments of mechanical engineering, electrical engineering, civil engineering and economics. Here, the following topics are addressed: • Function integration, topology optimization, optimization of electronic components, effects of the manufacturing technology on business models. The participating students first deepen the contents of the introductory lesson by using the provided literature and then apply it in teams using a wind turbine. In this case, a existing CAD data set of a wind turbine is used, to which an exercise task is performed for each of the mentioned topics. Software, for example Siemens NX or INSPIRE, is used to support the modeling and simulation of individual areas of the wind turbine necessary for the performance of the exercises. The results of the exercises are then printed using 3D printers, so that each team has his own optimized wind turbine using the potentials of additive manufacturing at the end of the tutorial.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • Explain the entire process chain of additive manufacturing. • Explain the steps which are necessary for the virtual preparation of 3D printing (component design, slicing, construction of support structures, nesting) such as the steps for preparation of the printer itself, the printing process and the post processing. • Highlight the benefits of additive manufacturing by focusing on function integration, topology optimization, and electronic component optimization, and mapping the impact of the manufacturing process on business models. • Adapt additive manufacturing using the example of a topology-optimized wind turbine tower using software (Siemens NX, INSPIRE, etc.). • To differentiate the perspectives of additive manufacturing of the different departments and to estimate the potentials.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Duration: 20 min, Standard Grading System) Written report and oral exam with discussion, 20 minutes for each topic
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc etit, MSC MEC, MSc MPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slides (moodle) including basic literature
Courses	

	Course Nr.	Course name		
	18-ho-2220-pj	Project Seminar Design for Additive Manufacturing – Interdisciplinary view of potentials and impacts of a new technology		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Alexander Kock, Prof. Dr.-Ing. Ulrich Knaack, Prof. Dr.-Ing. Eckhard Kirchner		Project Seminar	4

<table>
<tr><td colspan="6">Module name
Project Seminar Application in High-Voltage Technology</td></tr>
<tr><td>Module Nr.
18-hi-2070</td><td>Credit Points
8 CP</td><td>Workload
240 h</td><td>Self study
195 h</td><td>Duration
1</td><td>Cycle offered
WiSe/SoSe</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Volker Hinrichsen</td></tr>
</table>

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

Courses

<table>
<tr><td>Course Nr.
18-hi-2070-pj</td><td colspan="3">Course name
Project Seminar Application in High-Voltage Technology</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Volker Hinrichsen</td><td>Type
Project Seminar</td><td>SWS
3</td></tr>
</table>

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: • Module Examination (Study Achievement, Optional, Standard Grading System)					
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)					
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE					
7	**Grade bonus compliant to §25 (2)**					
8	**References** Slide Copies					
Courses						
	Course Nr. 18-ho-2130-pj	**Course name** Project Seminar Design for Testability				
	Instructor Prof. Dr.-Ing. Klaus Hofmann				**Type** Project Seminar	**SWS** 3

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

1	**Content** Groups of 2-3 students per project. Students work out a well defined fundamental or actual research- related problem. The projects will be actualized in each cycle being offered and introduced at the beginning. Each group will be supervised individually. The projects comprises modern antennas for multitudinous applications, electronically-steerable antennas, RFIDs, RF sensors, adaptive tunable components such as matching networks, filter, passive mixer and modulator for next-generation mobile terminals and sensor systems.
2	**Learning objectives / Learning Outcomes** Research-oriented Project Seminar in groups of 2-3 students per project with individual supervision. Students will learn • how to solve scientific hardware-oriented problems • working out concepts • how to design, realize and characterize RF devices • how to use commercial software and characterization tools • to evaluate and discuss their work in the context of the state-of-art in this field • to write a brief scientific report about their work • to present and discus their results at the end of the Project Seminar
3	**Recommended prerequisite for participation** Fundamentals of Microwave Engineering I and Antennas and Adaptive Beamforming
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE, Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Publications will be hand out to them. Software and characterization tools as well as tools to realize RF devices are available.

Courses

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

<table>
<tr><td colspan="6">Module name
Project seminar Applications of Lighting Engineering</td></tr>
<tr><td>Module Nr.
18-kh-2051</td><td>Credit Points
5 CP</td><td>Workload
150 h</td><td>Self study
105 h</td><td>Duration
1</td><td>Cycle offered
WiSe/SoSe</td></tr>
<tr><td colspan="3">Language
German and English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Khanh Quoc Tran</td></tr>
</table>

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

Courses

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

Module name Project seminar Advanced Applications of Lighting Engineering					
Module Nr. 18-kh-2052	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** For the project seminar a question from the following topics can be worked on: automotive lighting, light for the autonomous car, interior lighting, exterior lighting; smart lighting, human centric lighting (hcl); horticultural lighting; generation, perception and cognition of the visual stimulus (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement; illuminating engineering, color perception, virtual reality tests for light-simulation.
2	**Learning objectives / Learning Outcomes** The objective of this project seminar is the practical implementation of the knowledge acquired during the study in the form of a project work. Students participate on their own or in a team. In this project seminar, students learn to plan, implement and validate lighting issues. The basics of the lecture and the project seminar 'Applications of Lighting Engineering' are applied and deepened. This usually includes the selection of suitable illuminants, the development of electronic hardware as well as the use of photometric measuring instruments. In addition, the students learn how to abstract questions, communicate project-dependent information as well as present and discuss results.
3	**Recommended prerequisite for participation** Lighting Technology I-II (desireable), Project seminar Applications of Lighting Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) To conclude the project, every student has to hold a presentation with a short round of questions and answers and also to deliver a written report about the work and the results. The presentation with exam and the report will be graded according to the fixed guidelines of our Laboratory.
5	**Grading** Module Final Examination: • 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 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.	Course name		
18-kh-2052-pj	Project seminar Advanced Applications of Lighting Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran		Project Seminar	3

Module name					
Project seminar Special Applications of Lighting Engineering					
Module Nr. 18-kh-2053	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 195 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1 Content

For the project seminar a question from the following subject areas can be worked on: Automotive lighting, light for autonomous cars, interior lighting, exterior lighting; smart lighting; human centric lighting (HCL); horticulture lighting; generation, perception and cognition of visual stimuli (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement; illuminating engineering, color perception, virtual reality tests for light-simulation.

2 Learning objectives / Learning Outcomes

The objective of this project seminar is the practical implementation of the knowledge acquired during the study in the form of research or project work in an interdisciplinary context, which also takes up topics beyond the lectures. Students participate on their own or in a team. In this project seminar, the students learn the approach, implementation and validation or investigation of inter-disciplinary lighting issues. This requires an introduction into topics that go beyond the subject area of the lectures.
Usually, this includes the selection of suitable illuminants, the development of electronic hardware, the use of photometric measuring instruments as well as the conception, execution and evaluation of studies. In addition, students learn to abstract questions, to develop research questions, to com-municate information depending on the project, and to present and discuss results.

3 Recommended prerequisite for participation

Lighting Technology I-II (desireable), Project seminar Applications of Lighting Engineering (recommended)

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System)

At the beginning of the project, a short introductory presentation has to be held followed by a technical discussion. Each student involved in the project has to conclude the project with a presen-tation followed by a short question and answer session. Every student has to deliver a written re-port about the work and the results.
The final presentation with exam and the report will be graded according to the fixed guidelines of the institute.

5 Grading

Module Final Examination:

- 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 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.	Course name		
18-kh-2053-pj	Project seminar Special Applications of Lighting Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran		Project Seminar	3

Module name Product Development Methodology IV					
Module Nr. 18-kh-2125	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

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 organization 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 part lists, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.
3	**Recommended prerequisite for participation** Product Development Methodology I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr. 18-kh-2125-pj	**Course name** Product Development Methodology IV		
Instructor Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Peter Burg		**Type** Project Seminar	**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 • the ability to classify and analyze special problems concerning mobile communications, • the knowledge to plan and organize projects with temporal limitation, • the capability to setup and test methodologies for analysis and simulation- environments, • skills to evaluate and present achieved results and achieved conclusions.
3	**Recommended prerequisite for participation** Previous knowledge in digital communications, signal processing, mobile radio
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc CE, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture documentation will be provided and specific literature will be announced during the course.

Courses

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

Module name Project Seminar MFT					
Module Nr. 18-kn-2110	**Credit Points** 7 CP	**Workload** 210 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** Consists of „Product Development Methodology I" and "Proseminar ETIT Option MPE". Intense theoretical and practical engagement with development methodology as an individual, but also within a project group at a specific didactic meaningful example.
2	**Learning objectives / Learning Outcomes** Students learn the five major stages of development methodology and apply it to a specific development project. In addition, tools for project planning and resource allocation, issues and assistance for productive team work and knowledge to successfully create technical reports and presentations are learned and trained.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 5) • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 2)
6	**Usability of this module** MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-kn-1025-pj	Product Development Methodology I		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Ph.D. Thomas Peter Burg		Project Seminar	3
Course Nr.	**Course name**		
18-kn-1000-ps	Proseminar ETiT		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Introductory Seminar Course	2

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

1 Content

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

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

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

Lecture "System Dynamics and Control Systems I"

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc ETiT, MSc MEC

7 Grade bonus compliant to §25 (2)

8 References

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

Courses

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

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

1 Content

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

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

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

2 Learning objectives / Learning Outcomes

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

3 Recommended prerequisite for participation

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

4 Form of examination

Module Final Examination:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc ETiT, MSc MEC, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

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

Courses

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

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

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

Courses

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

Module name Projekt Seminar Procedures for Massive MIMO and 5G					
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 introduces the basics concepts of the signal processing algorithms and cross-layer procedures for extremely large so-called Massive MIMO systems and mobile communication networks of the 5th generation (5G). In Massive MIMO systems the number of base transmit and receive antennas at the base station are scaled up, as compared to usual MIMO systems, by several orders of magnitude.In this seminar we investigate advanced signal processing algorithms which allow to exploit the advantages of Massive MIMO in an optimum way (which are high data rate, high reliability, favorable propagation characteristics), to cope with the enormous date volume (linear signal processing) and to master the challenges (pilot contamination, low-cost hardware). Massive MIMO is an integral part of the emerginjg 5G mobile communication networks. In the course of the seminar the fundamental concepts and challenges of 5G networks will be discussed. It includes concepts as Small Cells, Cloud RAN, Network Virtualization, Network slicing, Machine-to-Machine communication, Millimeter Wave Transmission, Flexible Waveforms, etc.
2	**Learning objectives / Learning Outcomes** Students will learn the fundamental concepts, procedures, theories, algorithms and applications of Massive MIMO systems and 5 G mobile communication networks by the latest scientific publications.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 40 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** • http://www.commsys.isy.liu.se/vlm/icc_tutorial_P1.pdf • http://www.commsys.isy.liu.se/vlm/icc_tutorial_P2.pdf • http://www.massivemimo.eu/ • A. Chockalingam and B. Sundar Rajan. *Large MIMO Systems*, Cambridge University Press. Cambridge, 2015 • NGMN Alliance (2015) 5G White Paper https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.

Courses

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

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:

- 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:

- 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:

- 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:

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

5 Grading

Module Final Examination:

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

<table>
<tr><td>6</td><td colspan="4">Usability of this module
Wi-CS, Wi-ETiT, BSc/MSc CS, MSc ETiT, MSc iST</td></tr>
<tr><td>7</td><td colspan="4">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>8</td><td colspan="4">References
Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:
Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887)
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)</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course Nr.
18-sm-2080-pj</td><td colspan="3">Course name
Multimedia Communications Project Seminar II</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Ralf Steinmetz, Dr. Ing. Björn Richerzhagen, M.Sc. Florian Jomrich</td><td>Type
Project Seminar</td><td>SWS
3</td></tr>
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Module name					
Project Seminar Energy Information Systems					
Module Nr. 18-st-2040	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

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

Courses

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

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

2 Learning objectives / Learning Outcomes

During this project seminar students gain practical experience in software development for embedded systems in the field of autonomous driving using a model car. In teamwork, they learn to cope with an extensive task. In order to solve this task they practice to use the theoretical knowledge available in the group (from other courses such as real-time systems, software engineering - introduction, C++ lab, digital control systems).
Students that have successfully participated in this project seminar are able to organize and set-up a non-trivial software project in an interdisciplinary team according to a given problem independently. The participants acquire the following skills in detail:

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

3 Recommended prerequisite for participation

Recommended prerequisites are:

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

Additionally desired:

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

4 Form of examination

Module Final Examination:

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

5 Grading

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

Courses

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

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:

- 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:

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

5 Grading

Module Final Examination:

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

6 Usability of this module

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.	**Course name**		
18-su-2100-pj	Autonomous Driving Lab II		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr, Dr. Ing. Eric Lenz		Project Seminar	3

2.5 Research Seminar

2.6 Field Trip

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: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System) In general, the examination takes place in form of a written exam (duration: 90 minutes). If up to 20 students register in semesters in which the lecture does not take place, there will be an oral examination (duration: 30 min.). The type of examination will be announced within one working week after the end of the examination registration phase.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc EPE, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** References/Textbooks: Detailed textbook; Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995. Obermayer, H.J.: Internationaler Schnellverkehr.Franckh-Kosmos, Stuttgart, 1994.

Courses

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

Module name Excursion SAE					
Module Nr. 18-kn-1060	**Credit Points** 1 CP	**Workload** 30 h	**Self study** 30 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** During the excursion SAE (duration 5 days) several companies working on electrical engineering and information technology and other fields will be visited. Students can become acquainted with close-to-reality examples. Working fields of an electrical engineer can be assessed, with technical- or organizational aspects and conditions of work as the main target. By the attendance of several companies in successive days, a comparison becomes possible. During the excursion the group is accommodated in e.g. hostels.
2	**Learning objectives / Learning Outcomes** Students should be able to understand products and the associated production processes and be able to concisely summarize this in a report.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Pass/Fail Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-kn-1060-ek	Excursion SAE		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Ph.D. Thomas Peter Burg		Field Trip	0

2.7 Colloquia

Module name Industrial Colloquium					
Module Nr. 18-dt-2010	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Content** To get an idea about current trends in industry. In addition, to give a glimpse of job opportunities the industry will provide after graduation. Acquired competences are: • Active knowledge about industry trends and applications in multimedia communications • Build contact with persons from various important companies • Presentation skills improvement
2	**Learning objectives / Learning Outcomes** Today, the Internet is much more than just a browser window on your desktop-PC. It is a part of our every-day life and has become ubiquitous thanks to smartphones, tablet-PCs and laptops. This pervasiveness of the Internet requires tremendous effort on the provider side. This is due to the fact that the Internet itself is a communication system with a vast number of mechanisms running on different functional layers. With the rapid increase of mobile devices, traffic consumption, and the sheer number of users, many of those mechanisms reach their limits. This problem becomes visible to the end user, if, for example, large crowds of people suddenly overload the mobile communication infrastructure. With the recently established collaborative research center MAKI (Multi-Mechanismen-Adaption für das künftige Internet) scientists of TU Darmstadt study the possibilities of coordinated and automated transitions between different mechanisms of a communication system. Thereby, the Future Internet will be able to react to changes by, for example, switching from the mobile communication infrastructure to a local ad-hoc network between users if the demand by users exceeds the resources of the available infrastructure. In this year's industrial colloquium, partners from the industry present their visions, challenges and solutions regarding the Future Internet. Additionally, researches from TU Darmstadt provide insights into current scientific work in the context of the collaborative research center MAKI.
3	**Recommended prerequisite for participation** Mandatory: Basic knowledge in Information Systems and Commubnication Systems. The sutdent has to be capeable to understand the technical aspects and to summerize them in a written report as a short paper.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References**
Courses	

Course Nr.	Course name		
18-dt-2010-ko	Industrial Colloquium		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke, Prof. Dr.-Ing. Ralf Steinmetz		Colloquy	2

3 Interdisciplinary modules of FB 18

Module name Standardization, Testing and Approvals in the Electrotechnical Area					
Module Nr. 18-gt-4010	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1 Content

In the European Union (EU), the fundamental requirements for lectrical equipment, such as safety and electromagnetical compatibility (EMC) including functionality, are stipulated in EC Directives and by national implementation in laws and decrees.
These requirements take shape in harmonized standards. The manufacturer or his authorized agent resident in the EU or, as the case may be, the user of the equipment has to show compliance with the requirements by means of

- Own tests **or**
- Tests carried out by an independent neutral testing laboratory.

During the lecture, these criteria are considered with respect to the following topics:

- Product safety law (ProtSG)
- Energy promotion law (EnWG)
- Law on electromagnetical compatibility of equipment (EMVG)
- Telecommunications law (TKG)
- X-ray decree (RöV)
- Explosion-protection decree
- Standardization by the German Electrotechnical Commission of DIN and VDE (DKE)
- Standardization:
  - In Europe by CENELEC (= European Committee of Electrotechnical Standardization)
  - Worldwide by IEC (= International Electrotechnical Commission).

- Application of regulation on the basis of case studies:
  - Case study 1: Functional Safety
  - Case Study 2: Protection against electric shock

- Separation of device and product standards (which are taught in the course) against grid codes such as BdEW or Entso-e Grid Code

2 Learning objectives / Learning Outcomes

Participants of the course will be aware of connections between basic requirements given by law and technical standards for research adn development of electrotechnical equipment. As an outcome the participants will know the basic requirements for safety and reliability of such products.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

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

5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, MEC, iST
7	**Grade bonus compliant to §25 (2)**
8	**References** • Barz, N., Moritz, D.: EG – Niederspannungsrichtlinie Berlin/Offenbach: vde-verlag, 2008, 230 S. (VDE- Schriftenreihe Band 69) • Link für EG-Richtlinien: eur-lex.europa.eu/de/index.htm • Moritz, D.: Das Geräte- und Produktsicherheitsgesetz (GPSG) Berlin/Offenbach: vde-verlag, 2004, 138 S. (VDE-Schriftenreihe Band 116)

Courses

Course Nr.	Course name		
18-gt-4010-vl	Standardization, Testing and Approvals in the Electrotechnical Area		
Instructor		**Type**	**SWS**
Dr.-Ing. Stefan Heusinger		Lecture	2

Module name What is behind all this?					
Module Nr. 18-hi-3002	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Colloquium, Pass/Fail Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Colloquium, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-hi-3002-ko	What is behind all this?		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Volker Hinrichsen		Colloquy	2

Module name
What is behind all this?

Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-hi-3003	3 CP	90 h	60 h	1	SoSe

Language	Module owner
German	Prof. Dr.-Ing. Herbert De Gersem

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Special Form, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Special Form, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	Course name
18-hi-3002-ko	What is behind all this?

Instructor	Type	SWS
Prof. Dr.-Ing. Volker Hinrichsen	Colloquy	2

Module name Patents – How to protect technical inventions					
Module Nr. 18-ko-3010	**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** Within the scope of this lecture aspects of national and international patent law as well as aspects of the law on employee will be treated as follows: • German, European and international filing procedures and their legal prerequisites (formal and substantive patent law) • Enforcement of technical property rights • Infringement of technical property rights • Law on employee invention – rights and obligations of employees and employers
2	**Learning objectives / Learning Outcomes** Students will be able to deal with basic issues relating to patent law. They will get valuable insights and practical know-how concerning the implementation and enforcement of patents. The capability to innovate is a decisive key factor in today's world of business and work and plays a significant role for our economic success. The protection of such technical innovations is therefore of increasing importance. Engineers have to deal with issues related to patent law on a regular basis such as the implementation and enforcement of industrial property rights or the law on employee invention. Within the scope of this lecture students will learn the basics of national and international patent law while focusing on problems that may occur in the professional everyday life of a patent attorney
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References**

- German Patent Law „Patentgesetz (PatG)“ - www.gesetze-im-internet.de/patg/index.html
- German Utility Model Act „Gebrauchsmustergesetz (GbmG)“ - www.gesetze-im-internet.de/gebrmg/index.html
- German Law on Employee Invention „Arbeitnehmererfindergesetz (ArbEG)“ - www.gesetze-im-internet.de/arbnerfg/index.html
- European Patent Convention „Europäisches Patent Übereinkommen (EPÜ)“ - www.epo.org/law-practice/legal-texts/epc_de.html
- Patent Cooperation Treaty (PCT) - www.wipo.int/pct/en/texts/index.html
- Paris Convention for the Protection of Industrial Property „Pariser Verbandsübereinkunft (PVÜ)“ - www.wipo.int/treaties/en/ip/paris/

Students will find a compilation of the relevant legal texts in the following book:
Patent- und Musterrecht; Beck im dtv - ISBN 978-3-406-66154-9

Courses

Course Nr.	**Course name**		
18-ko-3010-vl	Patents – How to protect technical inventions		
Instructor		**Type**	**SWS**
Dr. Ing. Sebastian Clever		Lecture	2

4 Modules for other departments

Module name Introduction into the numerical computation of electromagnetic fields					
Module Nr. 18-sc-3010	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Content** Maxwell´s equations, basics of numerical calculation of electromagnetic fields, knowledge about different types of possible errors
2	**Learning objectives / Learning Outcomes** Starting from basic electromagnetic problems in terms of electric and magnetic circuits the field aspect inherent to these models is accentuated. After attending the lecture, the student is capable of modeling given geometric structures and devices using the methods of Computational Engineering. Furthermore, the student is able to solve the related task numerically using appropriate software. The student should understand the basics of the numerical calculation of electromagnetic fields as well as become acquainted with the related procedures in practical applications. The gathered solution methods will be applied practically during the laboratory courses. Moreover basic programming skills related to specific simulation tasks as well as for the purpose of postprocessing the results of the numerical simulations are teached.
3	**Recommended prerequisite for participation** Elektrotechnik und Informationstechnik I und 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** BSc CE
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be handed out during the lecture and is provided at www.temf.de

Courses

Course Nr.	Course name	Instructor	Type	SWS
18-sc-3010-vl	Introduction into the numerical computation of electromagnetic fields	Prof. Dr. rer. nat. Sebastian Schöps	Lecture	2
18-sc-3010-pj	Introduction into the numerical computation of electromagnetic fields	Prof. Dr. rer. nat. Sebastian Schöps	Project Seminar	3

Module name Introduction to Electrical Engineering					
Module Nr. 18-sl-3010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** Basic physical quantities, fundamental forces, stationary charges - electrostatics, Coulomb's law, superposition, electrical field, electric flow, Gauss' law, area charge density, electrical potential and difference of potential, capacitor and term capacity, charging process, polarization, moving charge – electric flux field, drift velocity, electrical current, Ohm's law, elektrical power, voltage- and current source, battery, power matching, efficiency ratio, Kirchhoff law, linear DC circuits, term magnetism, magentic field, magnetic flux, electromagnet, electrodynamic principle – Lorentzforce, electric motor, solenoid and term inductance, Biot-Savart and Ampere's law, magentization, magnetic excitation and magnetic flux density, matter in magnetic field and explanation of hesterysis curve, Lenz's law, Faraday's law, generator principle, harmonic functions, basics alternating current quantities, pointer diagrams, basic elements and power in alternating current circuits, term of impedance, transient events in RC- and RL-elements, ODE of first order, complex variable domain, transformer, three-phase current, resonant circuits and mechanical analogy, two and four-port elements, measurement amplifiers, electrical lines and electromagnetic wave.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • comprehend and analyze electric and magnetic fields, as well as the electric flux field, • utilize Maxwell's equations in integral form for this, • calculate currents and voltages in DC and AC circuits, • use complex numbers for electrical engineering, • calculate transient switching events, • comprehend and know the underlying principles of electrical machines (motor, generator, transformer), • comprehend the basics of resonant circuits, measurement amplifiers and closed loop systems, • know the mechanism behind energy- and information transfer via electric lines and electromagnetic waves.
3	**Recommended prerequisite for participation** Mathematics I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 150 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc MPE, BSc Wi-MB
7	**Grade bonus compliant to §25 (2)**
8	**References**

Lecture notes

- Vorlesungsfolien mit Abbildungen zum Download und Mitschreiben in Vorlesung über Lehrplattform,
- Aufzeichnungen (Bild und Ton) von Visualizer über Lehrplattform nach jeder Vorlesung,
- Vorlesungsfolien mit handschriftlichen Ergänzungen und Skizzen des Dozenten zum Download über Lehrplattform nach jeweiliger Vorlesung,
- Giancoli, Douglas C.: Physik Lehr- und Übungsbuch, Kapitel 21-32., 3. erweiterte Auflage, Pearson Studium Verlag, 2010 (Primärliteratur, relevanter Auszug <15% nach UrhG Par 60a Abs. 1 vom 01.03.2018 wird zum Download über Lehrplattform nur für eingeschriebene Studierende bereitgestellt).
- Purcell, Edward M.: Elektrizität und Magnetismus, 4. Auflage, Vieweg Verlag, 1989 (vertiefend).
- Bergmann, Schaefer.: Lehrbuch der Experimentalphysik - Elektromagnetismus, Band 2, 9. Auflage, de Gruyter Verlag, 2006 (vertiefend)

Courses

Course Nr.	Course name		
18-sl-3010-vl	Introduction to Electrical Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Lecture	4

Course Nr.	Course name		
18-sl-3010-ue	Introduction to Electrical Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Practice	2

Module name					
Introduction to Electrical Engineering					
Module Nr. 18-sl-3011	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** Basic physical quantities, fundamental forces, stationary charges - electrostatics, Coulomb's law, superposition, electrical field, electric flow, Gauss' law, area charge density, electrical potential and difference of potential, capacitor and term capacity, charging process, polarization, moving charge – electric flux field, drift velocity, electrical current, Ohm's law, elektrical power, voltage- and current source, battery, power matching, efficiency ratio, Kirchhoff law, linear DC circuits, term magnetism, magentic field, magnetic flux, electromagnet, electrodynamic principle – Lorentzforce, electric motor, solenoid and term inductance, Biot-Savart and Ampere's law, magentization, magnetic excitation and magnetic flux density, matter in magnetic field and explanation of hesterysis curve, Lenz's law, Faraday's law, generator principle, harmonic functions, basics alternating current quantities, pointer diagrams, basic elements and power in alternating current circuits, term of impedance, transient events in RC- and RL-elements, ODE of first order, complex variable domain, transformer, three-phase current, resonant circuits and mechanical analogy, two and four-port elements, measurement amplifiers, electrical lines and electromagnetic wave.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • comprehend and analyze electric and magnetic fields, as well as the electric flux field, • utilize Maxwell's equations in integral form for this, • calculate currents and voltages in DC and AC circuits, • use complex numbers for electrical engineering, • calculate transient switching events, • comprehend and know the underlying principles of electrical machines (motor, generator, transformer), • comprehend the basics of resonant circuits, measurement amplifiers and closed loop systems, • know the mechanism behind energy- and information transfer via electric lines and electromagnetic waves.
3	**Recommended prerequisite for participation** Mathematics I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 150 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc MaWi
7	**Grade bonus compliant to §25 (2)**
8	**References**

Lecture notes

- Vorlesungsfolien mit Abbildungen zum Download und Mitschreiben in Vorlesung über Lehrplattform,
- Aufzeichnungen (Bild und Ton) von Visualizer über Lehrplattform nach jeder Vorlesung,
- Vorlesungsfolien mit handschriftlichen Ergänzungen und Skizzen des Dozenten zum Download über Lehrplattform nach jeweiliger Vorlesung,
- Giancoli, Douglas C.: Physik Lehr- und Übungsbuch, Kapitel 21-32., 3. erweiterte Auflage, Pearson Studium Verlag, 2010 (Primärliteratur, relevanter Auszug <15% nach UrhG Par 60a Abs. 1 vom 01.03.2018 wird zum Download über Lehrplattform nur für eingeschriebene Studierende bereitgestellt).
- Purcell, Edward M.: Elektrizität und Magnetismus, 4. Auflage, Vieweg Verlag, 1989 (vertiefend).
- Bergmann, Schaefer.: Lehrbuch der Experimentalphysik - Elektromagnetismus, Band 2, 9. Auflage, de Gruyter Verlag, 2006 (vertiefend)

Courses

Course Nr.	Course name	Type	SWS
18-sl-3010-vl	Introduction to Electrical Engineering		
Instructor			
Prof. Dr. Mario Kupnik		Lecture	4
Course Nr.	**Course name**		
18-sl-3010-ue	Introduction to Electrical Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Practice	2

Module name					
Introduction to Electrical Engineering for BEd					
Module Nr. 18-sl-3012	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 0 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** Basic physical quantities, fundamental forces, stationary charges - electrostatics, Coulomb's law, superposition, electrical field, electric flow, Gauss' law, area charge density, electrical potential and difference of potential, capacitor and term capacity, charging process, polarization, moving charge – electric flux field, drift velocity, electrical current, Ohm's law, elektrical power, voltage- and current source, battery, power matching, efficiency ratio, Kirchhoff law, linear DC circuits, term magnetism, magentic field, magnetic flux, electromagnet, electrodynamic principle – Lorentzforce, electric motor, solenoid and term inductance, Biot-Savart and Ampere's law, magentization, magnetic excitation and magnetic flux density, matter in magnetic field and explanation of hesterysis curve, Lenz's law, Faraday's law, generator principle, harmonic functions, basics alternating current quantities, pointer diagrams, basic elements and power in alternating current circuits, term of impedance, transient events in RC- and RL-elements, ODE of first order, complex variable domain, transformer, three-phase current, resonant circuits and mechanical analogy, two and four-port elements, measurement amplifiers, electrical lines and electromagnetic wave.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • comprehend and analyze electric and magnetic fields, as well as the electric flux field, • utilize Maxwell's equations in integral form for this, • calculate currents and voltages in DC and AC circuits, • use complex numbers for electrical engineering, • calculate transient switching events, • comprehend and know the underlying principles of electrical machines (motor, generator, transformer), • comprehend the basics of resonant circuits, measurement amplifiers and closed loop systems, • know the mechanism behind energy- and information transfer via electric lines and electromagnetic waves.
3	**Recommended prerequisite for participation** Mathematics I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 150 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BEd, Metalltechnik
7	**Grade bonus compliant to §25 (2)**
8	**References**

Lecture notes

- Vorlesungsfolien mit Abbildungen zum Download und Mitschreiben in Vorlesung über Lehrplattform,
- Aufzeichnungen (Bild und Ton) von Visualizer über Lehrplattform nach jeder Vorlesung,
- Vorlesungsfolien mit handschriftlichen Ergänzungen und Skizzen des Dozenten zum Download über Lehrplattform nach jeweiliger Vorlesung,
- Giancoli, Douglas C.: Physik Lehr- und Übungsbuch, Kapitel 21-32., 3. erweiterte Auflage, Pearson Studium Verlag, 2010 (Primärliteratur, relevanter Auszug <15% nach UrhG Par 60a Abs. 1 vom 01.03.2018 wird zum Download über Lehrplattform nur für eingeschriebene Studierende bereitgestellt).
- Purcell, Edward M.: Elektrizität und Magnetismus, 4. Auflage, Vieweg Verlag, 1989 (vertiefend).
- Bergmann, Schaefer.: Lehrbuch der Experimentalphysik - Elektromagnetismus, Band 2, 9. Auflage, de Gruyter Verlag, 2006 (vertiefend)

Courses

Course Nr.	**Course name**		
18-sl-3010-vl	Introduction to Electrical Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Lecture	4

Course Nr.	**Course name**		
18-sl-3010-ue	Introduction to Electrical Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Practice	2

Module name					
Electrical Engineering and Information Technology					
Module Nr. 18-st-3020	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1 Content

- Direct current circuits: Ohm's law, Kirchhoff's theorems
- Alternating current circuits: dynamic behavior of coils and capacitors, computation via phasors and complex-valued impedances, active and reactive power
- Electro-magnetic fields: source and vortex fields, Coulomb's law, electrical displacement density, influence, magnetic fields, induction, Maxwell's laws in integral form
- Elements of power engineering: three phase systems, transformators, electrical machines, power electronics and power converters
- Introduction into current research topics in power engineering

2 Learning objectives / Learning Outcomes

After the course, students are able to name the electric variables and components, to calculate the electric direct- and alternating current circuits, and to derive electric and magnetic fields in simple, quasi-stationary settings. Moreover, they know the working principles of important power system components.

3 Recommended prerequisite for participation

Basic mathematics: working with complex numbers, matrices / vectors / systems of linear equations, ordinary differential equations

4 Form of examination

Module Final Examination:

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

In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 6 students register, there examination can be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture or in semesters without a lecture within one working week after the end of the examination registration phase.

5 Grading

Module Final Examination:

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

6 Usability of this module

MSc ESE

7 Grade bonus compliant to §25 (2)

8 References

A lecture script and slides are provided via Moodle.

Courses

Course Nr.	Course name		
18-st-3020-vl	Electrical Engineering and Information Technology		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke, Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Edwin Camilo Mora Gil, M.Sc. Pavel Makin		Lecture	3

	Course Nr.	Course name		
	18-st-3020-ue	Electrical Engineering and Information Technology		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Florian Steinke, Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Edwin Camilo Mora Gil, M.Sc. Pavel Makin		Practice	1