Module Handbook
Master Computer Engineering

Faculty for Computer Science, Electrical Engineering and Mathematics
Paderborn University

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Chapter 1

Description of Program Master Computer Engineering

This module handbook describes the modules and courses of the master program Computer Engineering with their goals, contents and relationships. For students, the module handbook shall provide useful and binding information to support them in planning their studies. For teachers and the interested reader the handbook provides an in-depth view into the structure and organization of the study program.

The following paragraphs present a list of abbreviations, the curriculum of the Master program Computer Engineering and an exemplary schedule of courses, comment on the training of soft skills and show the schemes for describing modules and courses used in this handbook. Details and regulations regarding examination modalities and grading rules are provided in the document „Prüfungsordnung für den Master-Studiengang Computer Engineering“.

1.1 List of Abbreviations

LP	Credit points according to ECTS
SWS	Weekly presence hours for the course
2V	Lecture with 2 SWS
2Ü	Exercise with 2 SWS
2P	Project with 2 SWS
2S	Seminar with 2 SWS
WS	Winter semester
SS	Summer semester

1.2 Curriculum & Schedule

Figure 1.1 shows the curriculum and an exemplary schedule of courses for the master program Computer Engineering. The master program comprises four mandatory modules (6 LP each), elective modules (42 LP), a seminar module (6 LP), the module project group (18 LP) and the master theses (30 LP). For the elective modules, the program defines six focus areas for which this handbook lists corresponding module catalogs. Each student selects one out of these focus areas and completes modules totalling 24 LP in this focus area. Another set of modules totalling 18 LP can be selected from any of the focus areas. The seminar module contains a seminar with 4 LP and an elective, ungraded course with 2 LP.

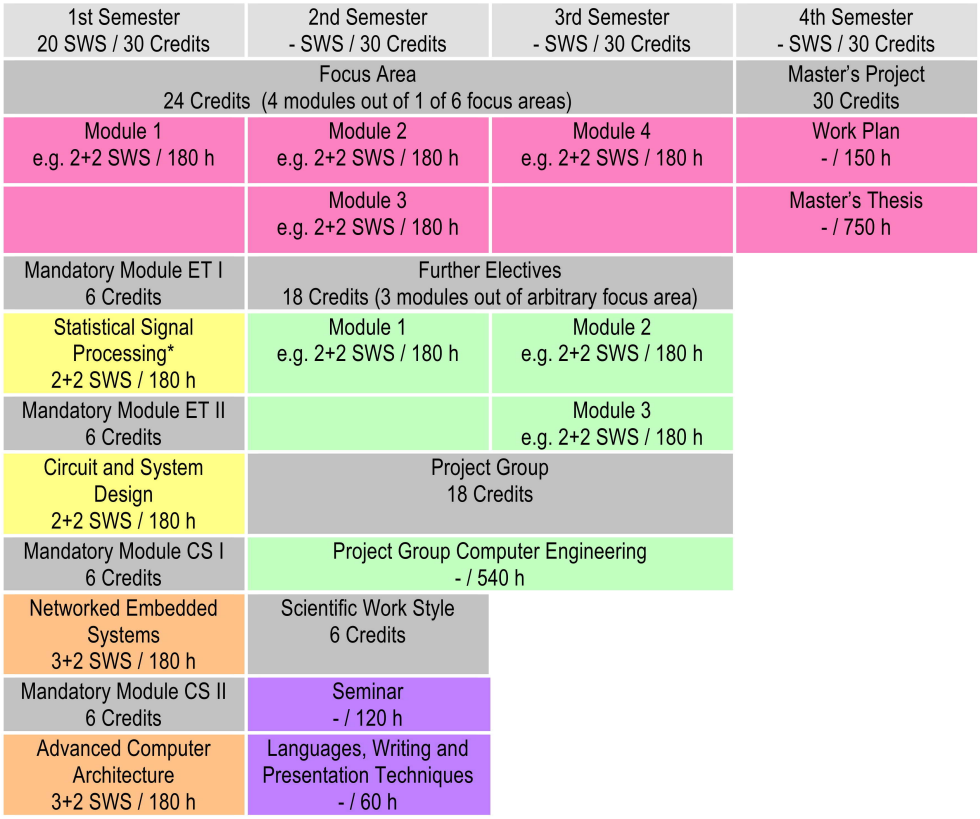

Figure 1.1: Curriculum and Schedule Master Computer Engineering

1.3 Training of Soft Skills

The master program Computer Engineering includes a number of courses in which training of soft skills is an integral component:

- project group Computer Engineering (module Project Group)
- seminar (module Seminar)
- an elective course in languages or scientific writing (module Seminar)
- master thesis including the presentation of the theses and the work schedule (module Master Thesis)

Besides providing training in a joined-up scientific-technical way of thinking, these courses greatly strengthen communication, presentation, moderation and self-reflection skills. The amount of credit points devoted to soft skills training totals to 54 LP. Actually, the number of courses including soft skills training is much higher, since exercise sessions often require and train communication skills, the ability to work in a team and competences in using modern information technology. This also applies to many of the lectures when using novel forms of teaching.

1.4 Scheme for Module Descriptions

The module descriptions are consistently structured according to the following scheme:

Module name	<Module Name>
Workload	<Overall Workload in hours>
Credits	<Credits in ECTS>
Semester	<Summer, winter, or arbitrary>

Courses: Teaching form (Contact hours / Self study / Language / Date / Group size)
<List of the contained course elements, dividing the workload into contact time and self study time. Language the course is given in, winter semester or summer semester, group size>

Choices in Module
<List of choices>

Course prerequisites
<Prerequisites for participation>

Recommended proficiencies
<Recommendations, not checked as prerequisites>

Content
<Overview over the module's main content>

Learning objectives
<Enumeration of the intended knowledge, abilities and professional expertise>

Implementation Method
<Working forms and teaching methods applied>

Assessment modalities (duration)
<Form and duration of the examination>

Partial module exams
<Form of partial examinations, if any>

Course achievement / qualifying participation
<Form of course achievement or qualifying participation>

Prerequisites for participation in module exam
<Formal prerequisites for taking the module exam>

Prerequisites for obtaining credits
<Formal Prerequisites for obtaining credits>

Weight for overall grade
<Modules weight when computing the overall grade>

Module contained in the following programmes
<List of programs that use that module>

Person responsible for the module
<Person who is responsible for the module.>

Lerning material, Literature
<List of references to literature, teaching material, etc.>

Remarks
<Further remarks>

1.5 List of organization forms

The following organization forms are used in this program:

Final thesis

Lecture with exercices and practical work Combination of a lecture with exercises and a phase of practical work.

Lecture with practical assignments A combination constisting of a lecture and exercises. Usually practical problems are solved during the exercises. There may also be homework assignments.

Project

Seminar and elective courses

1.6 List of examination forms

The following examination forms are used in this program:

Written Exam In written examinations the candidate has to demonstrate that she or he is capable of recognizing problems of the subject with the help of the tools allowed by the examiner and solve them with the common methods within the given time frame. A list of the allowed aids has to be announced together with the date of the examination.

Every written examination is graded by one examiner. In case of the last repetition, the assessment is conducted by two examiners.

The duration of a sit-down examination depends on the sum of the credit points in a module. It takes 90 to 120 minutes in case of up to 5 credit points and 120 to 180 minutes in case of more than 5 credit points.

Oral Exam In oral examinations the candidate has to demonstrate that she or he recognizes the interrelations within the examined area, is able to put specific questions into context and find solutions within the time given.

Oral examinations are performed in front of two examiners or one examiner in presence of one competent observer as group examinations or as single examinations. In any case it must be possible to differentiate and grade the contribution counted as an examination performance of each candidate separately. Before setting a grade the examiner consults the observer in absence of the candidate. In case of the last repetition, two examiners do the grading.

The duration of an oral examination per candidate depends on the sum of the credit points of the underlying courses. It takes 20 to 30 minutes in case of up to 5 credit points and 30 to 45 minutes in case of more than 5 credit points. For group examinations the total duration of the examination extends accordingly. The essential content and results of the examination have to be recorded in the minutes of the examination. The result of the examination has to be announced to the candidate subsequent to the oral examination by the examiner.

Students who want to take the same examination at a later examination date will be admitted as listeners according to the spatial conditions, as long as no candidate disagrees. Admission does not extend to the consultation and announcement of the examination result.

Presentation A presentation is a performance of about 30 minutes on the basis of a written composition. Thereby students have to prove that they are able to elaborate a topic scientifically and can present results.

Written Term Paper Within the framework of a written term paper with a scope of ten DIN-A4 pages a task is dealt with and solved properly within a thematic area of a course with the help of relevant literature, if necessary. The performance can also be made as a group performance, as long as an individual assessment and evaluation of each group member is possible.

Colloquium In a colloquium students have to prove that they can recognize technical interrelations and are able to put specific questions into a context in a conversation of 20 to 30 minutes with the examiner and other participants of the colloquium.

Project In a project the students work on a topic given by the lecturer by themselves or in a group. Projects usually include a draft and structure of hardware and software prototypes, as well as an ensuing experimental evaluation. Other parts of a project are usually the technical documentation and the presentation of the work and its results.

Qualified Participation A qualified participation is given, if the achieved performances indicate that the subjects underlying a given problem have been dealt with more than just superficially. The evidence of a qualified participation can be requested in a module, if this is necessary for ensuring the acquisition of competences in the module besides the module examination. The evidence of a qualified participation in a module can be a requirement for the allocation of credit points or a requirement for the participation in examinations. The evidence of a qualified participation is provided especially by one or more short written examinations, an expert discussion, the preparation of a protocol, exercises prepared during the course or as homework, short tests ("Testate"), a presentation. Details are provided in the module description. If the module description only sets the framework, then the exact rules must be published by the lecturer in the campus management system or in another suitable way no later than three weeks after the beginning of semester.

Course Work As a course work exercises can be requested which usually are put as homework and / or presence tasks on a weekly basis. Further forms of course work can be a written paper or report of 5 - 10 pages, a presentation of 10 - 20 minutes duration or a short written examination of at most 30 minutes duration. Details are provided in the module description. If the module description only sets the framework, then the exact rules must be published by the lecturer in the campus management system or in another suitable way no later than three weeks after the beginning of semester.

Bonus System Voluntary bonus work is possible in addition to examinations. Bonus work can be delivered in the form of exercises or homework, short tests ("Testate") or projects. The goal of bonus work is to prepare students for examinations step by step. Bonus work can be graded and improve the final grade of the module according to predefined rules. The module exam must be passed independent of the bonus work. The final grade can be improved by the bonus system by at most 0.7.

Chapter 2

Focus Areas

2.1 Communication and Networks

Focus Area	Communication and Networks
Koordination	Prof. Dr. Sybille Hellebrand Computer Engineering Electrical Engineering
Included Modules	• Advanced Distributed Algorithms and Data Structures (S. 23) • Cooperative Mobile Systems (S. 59) • Empiric performance evaluation (S. 83) • Foundations of Cryptography (S. 94) • Future Internet (S. 97) • Integrated Circuits for Wireless Communication (S. 109) • Mobile Communication (S. 124) • Network Simulation (S. 129) • Optical Communication A (S. 131) • Optical Communication B (S. 134) • Optical Communication C (S. 137) • Optimal and Adaptive Filters (S. 140) • Routing and Data Management in Networks (S. 155) • Fast Integrated Circuits for Wireline Communication (S. 88) • Topics in Signal Processing (S. 184) • Vehicular Networking (S. 188) • Wireless Communications (S. 197)

Description

2.2 Computer Systems

Focus Area	Computer Systems
Koordination	Prof. Dr. Sybille Hellebrand Computer Engineering Electrical Engineering
Included Modules	• Algorithms and Tools for Test and Diagnosis of Systems on Chip (S. 34) • Algorithms for Synthesis and Optimization of Integrated Circuits (S. 37) • Approximate Computing (S. 40) • Architectures of Parallel Computer Systems (S. 43) • Databases and Information Systems (S. 62) • Empiric performance evaluation (S. 83) • Hardware/Software Codesign (S. 100) • High-Performance Computing (S. 106) • Intelligence in Embedded Systems (S. 112) • Reconfigurable Computing (S. 146) • VLSI Testing (S. 194)
Description	

2.3 Control and Automation

Focus Area	Control and Automation
Koordination	Prof. Dr. Sybille Hellebrand Computer Engineering Electrical Engineering
Included Modules	• Advanced Control (S. 20) • Advanced System Theory (S. 26) • Advanced Topics in Robotics (S. 29) • Biomedical Measuring Technologies (S. 45) • Dynamic Programming and Stochastic Control (S. 74) • Controlled AC Drives (S. 56) • Reinforcement Learning (S. 149) • Robotics (S. 152) • Topics in Automatic Control (S. 178) • Ultrasonic Measurement Technology (S. 186) • Environmental Monitoring and Measuring Technologies (S. 86)
Description	

2.4 Embedded Systems

Focus Area	Embedded Systems
Koordination	Prof. Dr. Sybille Hellebrand Computer Engineering Electrical Engineering
Included Modules	• Advanced VLSI Design (S. 32) • Algorithms and Tools for Test and Diagnosis of Systems on Chip (S. 34) • Algorithms for Synthesis and Optimization of Integrated Circuits (S. 37) • Approximate Computing (S. 40) • Architectures of Parallel Computer Systems (S. 43) • Cooperative Mobile Systems (S. 59) • Hardware/Software Codesign (S. 100) • Integrated Circuits for Wireless Communication (S. 109) • Intelligence in Embedded Systems (S. 112) • Model-Driven Software Development (S. 127) • Network Simulation (S. 129) • Reconfigurable Computing (S. 146) • Fast Integrated Circuits for Wireline Communication (S. 88) • Software Quality Assurance (S. 164) • VLSI Testing (S. 194) • Vehicular Networking (S. 188)
Description	

2.5 Nano/Microelectronics

Focus Area	Nano/Microelectronics
Koordination	Prof. Dr. Sybille Hellebrand Computer Engineering Electrical Engineering
Included Modules	• Advanced VLSI Design (S. 32) • Algorithms and Tools for Test and Diagnosis of Systems on Chip (S. 34) • Introduction to High-Frequency Engineering (S. 115) • Semiconductor Device Integration (S. 161) • High Frequency Engineering (S. 103) • Integrated Circuits for Wireless Communication (S. 109) • Fast Integrated Circuits for Wireline Communication (S. 88) • Technology of Highly Integrated Circuits (S. 172) • VLSI Testing (S. 194)
Description	

2.6 Signal, Image and Speech Processing

Focus Area	Signal, Image and Speech Processing
Koordination	Prof. Dr. Sybille Hellebrand Computer Engineering Electrical Engineering
Included Modules	• Advanced System Theory (S. 26) • Digital Image Processing I (S. 65) • Digital Image Processing II (S. 68) • Digital Speech Signal Processing (S. 71) • Cognitive Sensor Systems (S. 47) • Machine Learning I (S. 118) • Machine Learning II (S. 121) • Statistics in Measurement (S. 170) • Optimal and Adaptive Filters (S. 140) • Statistical and Machine Learning (S. 167) • Cognitive Systems Engineering (S. 49) • Topics in Audio, Speech, and Language Processing (S. 175) • Topics in Pattern Recognition and Machine Learning (S. 181) • Topics in Signal Processing (S. 184) • Video Technology (S. 191) • Wireless Communications (S. 197)
Description	

Chapter 3

Modules

3.1 Elective Module: Advanced Control

Module name	Advanced Control / Advanced Control
Workload	180 h
Credits	6 LP
Semester	• Advanced Control : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Advanced Control: Lecture (30h / 120h / EN / WS / 100)
Advanced Control: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Advanced Control: Undergraduate-level systems theory and automatic control.

Content

Advanced Control: This course builds on undergraduate-level systems theory and automatic control courses and focuses on the design of discrete-time control systems, using transfer function and state space methods. The course is primarily intended to serve engineering students, but can also be useful to students in physics and other natural sciences.

Learning objectives

After successfully completing the module, students are able to
- study the dynamics of discrete-time feedback systems,
- design appropriate control systems.

Implementation method

Advanced Control:
- Lectures using blackboard and, at times, transparencies

- Tutorials with study guides and computer simulations

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Daniel E. Quevedo

Learning material, literature

Advanced Control: The course uses a selection of material from the books included in the list below. In addition, lecture notes and study guides are provided.
- K. J. Astrom and B. Wittenmark, Computer controlled systems. Theory and design. Englewood Cliffs, N.J.: Prentice Hall, second ed., 1990.
- G. C. Goodwin, S. F. Graebe, and M. E. Salgado, Control System Design. Prentice-Hall, 2001.
- J. B. Rawlings and D. Q. Mayne, Model Predictive Control: Theory and Design. Madison, WI: Nob Hill Publishing, 2009.
- B. D. O. Anderson and J. Moore, Optimal Filtering. Englewood Cliffs, NJ: Prentice Hall, 1979.
- K. J. Astrom, Introduction to Stochastic Control Theory. New York, N.Y.: Academic Press, 1970.

Remarks
none

3.2 Elective Module: Advanced Distributed Algorithms and Data Structures

Module name	Advanced Distributed Algorithms and Data Structures / Advanced Distributed Algorithms and Data Structures
Workload	180 h
Credits	6 LP
Semester	• Advanced Distributed Algorithms and Data Structures : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Advanced Distributed Algorithms and Data Structures: Lecture (45h / 105h / EN / WS / 30)
Advanced Distributed Algorithms and Data Structures: Tutorial (30h / 0h / EN / WS / 30)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Advanced Distributed Algorithms and Data Structures: Algorithms and data structures, distributed algorithms and data structures

Content

Advanced Distributed Algorithms and Data Structures: The lecture presents advanced methods that allow the design of highly scalable distributed algorithms and data structures. It splits into separate areas that are currently very relevant in the area of distributed systems. This includes locality-preserving systems, robust information systems, and programmable matter.

Learning objectives

Students get to know advanced methods and algorithms for currently very relevant distributed systems. They are able to adapt algorithms to new situations and to determine their complexity. They can implement basic distributed algorithms.

Implementation method

Advanced Distributed Algorithms and Data Structures: Lecture with tutorials and software project

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. rer. nat. Christian Scheideler

Learning material, literature

Advanced Distributed Algorithms and Data Structures: Lectures notes

Remarks
none

3.3 Elective Module: Advanced System Theory

Module name	Advanced System Theory / Advanced System Theory
Workload	180 h
Credits	6 LP
Semester	• Advanced System Theory : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Advanced System Theory: Lecture (30h / 120h / EN / WS / 100)
Advanced System Theory: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Advanced System Theory: Recommended is a basic understanding of differential equations, linear algebra, and Laplace transforms, as they are covered in a typical undergraduate course on system theory.

Content

Advanced System Theory: Building on an undergraduate system theory course, this course studies the dynamical behavior of linear systems with greater mathematical rigor. The course is primarily intended to serve students in engineering, but it can also be useful to students in physics and other natural sciences.

Learning objectives

After attending this module, students will be familiar with the most important concepts and results in linear system theory. Students will develop confidence in their ability to solve mathematical problems of analysis and design. Many of their timeless insights and intuitions about the dynamical behavior of systems will be drawn from this course.
This course presents material broad enough so that students will have a clear understanding of the dynamical behavior of linear systems, including their power and limitations. This will allow students

to apply the theory to other fields.

Implementation method

Advanced System Theory: Lectures and exercises (including some computer simulations)

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Peter Schreier

Learning material, literature

Advanced System Theory: Handouts and tutorial questions, literature references will be given in the first lecture.

Remarks
none

3.4 Elective Module: Advanced Topics in Robotics

Module name	Advanced Topics in Robotics / Advanced Topics in Robotics
Workload	180 h
Credits	6 LP
Semester	• Advanced Topics in Robotics : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Advanced Topics in Robotics: Lecture (30h / 120h / EN / WS / 0)
Advanced Topics in Robotics: Tutorial (30h / 0h / EN / WS / 0)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Advanced Topics in Robotics: None

Content

Advanced Topics in Robotics: The course Advanced Topics in Robotics is based on the course Robotics. The students are introduced to current research topics in the field of autonomous and teleoperated mobile robots to solve interdisciplinary issues. The challenges encountered in developing intelligent mobile systems are analyzed and current solutions presented.

Learning objectives

After successfully completing the module the students
- are able to name and analyze the basic robot architectures for mobile robots,
- have a good command of the methods for the navigation and control of mobile robots and
- are able to implement, test and apply them.

Implementation method

Advanced Topics in Robotics:
- The theoretical and methodical fundamentals will be introduced during the lecture.
- The methods presented will be practiced during the subsequent exercise / lab part.
- Finally, the participants will implement, test, and apply simple algorithms.
- The necessary programming skills will be taught during the practical, this is explicitly not considered a programming course.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Bärbel Mertsching

Learning material, literature

Advanced Topics in Robotics: Allocation of lecture notes; information on textbooks stocked in the textbook collection will be announced later.
- Mertsching, Bärbel: Robotics (lecture notes)
- McKerrow, Phillip J.: Introduction to Robotics. Addison-Wesley, 1991

• Siegwart, Roland; Nourbakhsh, Illah R. and Scaramuzza, David: Introduction to Autonomous Mobile Robots. The MIT Press, 2011, ISBN-13: 978-0262015356

Remarks
none

3.5 Elective Module: Advanced VLSI Design

Module name	Advanced VLSI Design / Advanced VLSI Design
Workload	180 h
Credits	6 LP
Semester	• Advanced VLSI Design : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Advanced VLSI Design: Lecture (30h / 120h / EN / WS / 200)
Advanced VLSI Design: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

Wird nachgetragen

Course prerequisites

To be completed

Recommended proficiencies

Advanced VLSI Design: To be completed

Content

Advanced VLSI Design: To be completed

Learning objectives

Implementation method

Advanced VLSI Design: To be completed

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks

of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Dr. rer. nat. Wolfgang Müller

Learning material, literature

Advanced VLSI Design: To be completed

Remarks

To be completed

3.6 Elective Module: Algorithms and Tools for Test and Diagnosis of Systems on Chip

Module name	Algorithms and Tools for Test and Diagnosis of Systems on Chip / Algorithms and Tools for Test and Diagnosis of Systems on Chip
Workload	180 h
Credits	6 LP
Semester	• Algorithms and Tools for Test and Diagnosis of Systems on Chip : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Algorithms and Tools for Test and Diagnosis of Systems on Chip: Lecture (30h / 120h / EN / WS / 20)
Algorithms and Tools for Test and Diagnosis of Systems on Chip: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Algorithms and Tools for Test and Diagnosis of Systems on Chip: Digital Design, Introduction to Algorithms, VLSI Testing

Content

Algorithms and Tools for Test and Diagnosis of Systems on Chip: The course “Algorithms and Tools for Test and Diagnosis of Systems on Chip” deals with advanced topics in test and diagnosis of integrated systems. The focus is on algorithms and tools for computer-aided preparation and application of test and diagnosis procedures.

Learning objectives

The module “Algorithms and Tools for Test and Diagnosis of Systems on a Chip” deals with recent approaches in test and diagnosis of integrated systems. The student work with research papers to extract and understand the underlying models and algorithms. They learn to explain the specific challenges of

nanoscale integration and evaluate test strategies accordingly.

Implementation method

Algorithms and Tools for Test and Diagnosis of Systems on Chip:
- Lecture based on slide presentation, extensions on blackboard
- Self-study on recent approaches based on recent conference and journal publications
- Oral presentation
- Manuscript

Assessment modalities (duration)

Seminar Presentation and Paper
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Sybille Hellebrand

Learning material, literature

Algorithms and Tools for Test and Diagnosis of Systems on Chip:
- Slides
- Publications
- Michael L. Bushnell, Vishwani D. Agrawal, "Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal VLSI Circuits," Kluwer Academic Publishers, ISBN: 0792379918
- Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen, "VLSI Test Principles and Architectures: Design for Testability," Morgan Kaufmann Series in Systems on Silicon, ISBN: 0123705975

Remarks

none

3.7 Elective Module: Algorithms for Synthesis and Optimization of Integrated Circuits

Module name	Algorithms for Synthesis and Optimization of Integrated Circuits / Algorithms for Synthesis and Optimization of Integrated Circuits
Workload	180 h
Credits	6 LP
Semester	• Algorithms for Synthesis and Optimization of Integrated Circuits : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Algorithms for Synthesis and Optimization of Integrated Circuits: Lecture (45h / 105h / EN / SS / 30)
Algorithms for Synthesis and Optimization of Integrated Circuits: Tutorial (30h / 0h / EN / SS / 30)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Algorithms for Synthesis and Optimization of Integrated Circuits: Knowledge of "Digital Design" is beneficial.

Content

Algorithms for Synthesis and Optimization of Integrated Circuits: The course provides the most remarkable features of digital synthesis, and explains the details of transforming hardware description languages into circuit descriptions. Besides, the major techniques for logic optimization are discussed, and then the efficient use of current design tools are exercised in practical sessions.

Learning objectives

After attending the course, the students are able to
• select among the available optimisation methods in design of digital circuits,

- identify major problems in design of integrated circuits and recognize circuit design tradeoffs
- examine current digital design tools and methods

Implementation method

Algorithms for Synthesis and Optimization of Integrated Circuits:
- Lecture with projector and board
- Interactive exercises in the lecture room
- Computer-based exercises with hardware synthesis tools

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Dr. Hassan Ghasemzadeh Mohammadi

Learning material, literature

Algorithms for Synthesis and Optimization of Integrated Circuits:
- Lecture slides and exercise sheets
- Exercise sheets and technical documentation for the for the computer-based exercises
- Micheli, Giovanni De. Synthesis and optimization of digital circuits. McGraw-Hill Higher Education, 1994.
- Information about alternative and additional literature as well as teaching material on the course's website and in the lecture slides

Remarks

none

3.8 Elective Module: Approximate Computing

Module name	Approximate Computing / Approximate Computing
Workload	180 h
Credits	6 LP
Semester	• Approximate Computing : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Approximate Computing: Lecture (45h / 105h / EN / WS / 100)
Approximate Computing: Tutorial (30h / 0h / EN / WS / 25)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Approximate Computing:
- Bachelor-level knowledge in digital design and computer architecture
- Bachelor-level knowledge in mathematics, in particular linear algebra and probability theory

Content

Approximate Computing: Approximate Computing is an emerging paradigm that trades-off computational accuracy for a significant reduction in energy, execution time, or chip area. This research-oriented course introduces to the field of Approximate Computing and its most remarkable aspects, and explains the main methods used to implement efficient computing systems by reducing accuracy. The course discusses approximations at all levels of a computing system, from applications down to hardware technologies. In exercise/tutorial sessions the efficiency of these techniques in various domains are examined, including deep learning and digital signal processing.

Learning objectives

After attending this course, the students are able
- to name and explain approximation techniques at all levels of a computing system,
- to identify major engineering/research problems when building approximate computing systems,
- to judge the suitability of approximation techniques for different application domains, and
- to apply approximation techniques to realize efficient hardware accelerators, in particular for deep

learning and digital signal processing

Implementation method

Approximate Computing:
- Lecture with projector and black/white board
- Interactive exercises/discussions in the lecture room
- Computer-based tutorials

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Dr. Hassan Ghasemzadeh Mohammadi

Learning material, literature

Approximate Computing:
- Lecture slides, exercise sheets, and tutorial assignments
- Adrian Sampson, Luis Ceze, and Dan Grossman: Good-Enough Computing. *IEEE Spectrum*, 50(10):54–59, 2013.
- Ravi Nair. Big Data Needs Approximate Computing: Technical Perspective. *Communications of the ACM*, 58(1): 104, 2015.
- Sparsh Mittal. A Survey of Techniques for Approximate Computing. *ACM Computing Surveys*, 48(4), 2016.
- Qiang Xu, Todd Mytkowitz, and Nam Sung Kim. Approximate Computing: A Survey. *IEEE Design & Test*, 33(1):8-22, 2016.
- Additional resources and links to current research papers are provided in the lecture

Remarks

none

3.9 Elective Module: Architectures of Parallel Computer Systems

Module name	Architectures of Parallel Computer Systems / Architectures of Parallel Computer Systems
Workload	180 h
Credits	6 LP
Semester	• Architecture of Parallel Computer Systems : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Architecture of Parallel Computer Systems: Lecture (45h / 105h / DE / SS / 20)
Architecture of Parallel Computer Systems: Tutorial (30h / 0h / DE / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Architecture of Parallel Computer Systems: Principles of computer architectures

Content

Architecture of Parallel Computer Systems: The lecture considers computer architectures of actual parallel computer systems and the usage of this systems. The focus of the lecture is on high-performance computers (supercomputers).

Learning objectives

wird nachgetragen

Implementation method

Architecture of Parallel Computer Systems: Presentation of slides. Exercises on available high performance computers to practise the usage of the systems and deepen the knowledge of the lecture.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Dr. Jens Simon

Learning material, literature

Architecture of Parallel Computer Systems: slides

Remarks

none

3.10 Elective Module: Biomedical Measuring Technologies

Module name	Biomedical Measuring Technologies / Biomedical Measuring Technologies
Workload	180 h
Credits	6 LP
Semester	• Biomedical Measuring Technologies : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Biomedical Measuring Technologies: Lecture (30h / 120h / DE / SS / 0)
Biomedical Measuring Technologies: Tutorial (30h / 0h / DE / SS / 0)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Biomedical Measuring Technologies: None

Content

Biomedical Measuring Technologies: The lecture concentrates on determining measurements characterizing the physiological state of a human. Main methods are described and characterized, e.g., tomography.

Learning objectives

Students are able to understand the root causes and mechanisms of bioelectrical and biomagnetic signals and their propagation in a biological body. They understand the basics and applicability of electrodiagnostic procedures and can characterize important tomographic methods.

Implementation method

Biomedical Measuring Technologies: Lecture with slides and practical lab work.

Assessment modalities (duration)
Oral exam (ca. 40 Minutes) The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams
none

Course achievement / qualifying participation
none

Prerequisites for participation in module exam
none

Prerequisites for obtaining credits
Passing of module exam.

Weight for overall grade
The module is weighted with 6 credits.

Person responsible for the module
Prof. Dr.-Ing. Bernd Henning

Learning material, literature
Biomedical Measuring Technologies: none

Remarks
none

3.11 Elective Module: Cognitive Sensor Systems

Module name	Cognitive Sensor Systems / Cognitive Sensor Systems
Workload	180 h
Credits	6 LP
Semester	• Cognitive Sensor Systems : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Cognitive Sensor Systems: Lecture (30h / 120h / DE / WS / 100)
Cognitive Sensor Systems: Tutorial (30h / 0h / DE / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Cognitive Sensor Systems: None

Content

Cognitive Sensor Systems: The lecture discusses how (possibly massive) amounts of information can be suitably reduced. Tasks include detection, classification or identification. Techniques from multivariate data analysis and artificial neural networks are relevant tools.

Learning objectives

Students learn to analyse complex tasks in complex multi-variate data analysis and to develop own solutions. They will exercise using artificial neural networks for pattern recognition and interpolation.

Implementation method

Cognitive Sensor Systems: Lecture with interactive whiteboard, practical lab exercises, students prepare small presentations and lead discussions.

Assessment modalities (duration)
Oral exam (ca. 40 Minutes) The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams
none

Course achievement / qualifying participation
none

Prerequisites for participation in module exam
none

Prerequisites for obtaining credits
Passing of module exam.

Weight for overall grade
The module is weighted with 6 credits.

Person responsible for the module
Prof. Dr.-Ing. Bernd Henning

Learning material, literature
Cognitive Sensor Systems: Supplementary material and textbooks.

Remarks
none

3.12 Elective Module: Cognitive Systems Engineering

Module name	Cognitive Systems Engineering / Cognitive Systems Engineering
Workload	180 h
Credits	6 LP
Semester	• Cognitive Systems Engineering : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Cognitive Systems Engineering: Lecture (30h / 120h / DE / WS / 100)
Cognitive Systems Engineering: Tutorial (30h / 0h / DE / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Cognitive Systems Engineering: To be completed

Content

Cognitive Systems Engineering: To be completed

Learning objectives

==¿ Text will be added

Implementation method

Cognitive Systems Engineering: To be completed

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks

of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Bärbel Mertsching

Learning material, literature

Cognitive Systems Engineering: To be completed

Remarks

none

3.13 Mandatory Module: Computer Science I

Module name	Computer Science I / Computer Science I
Workload	180 h
Credits	6 LP
Semester	• Networked Embedded Systems : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Networked Embedded Systems: Lecture (45h / 105h / EN / WS / 60)
Networked Embedded Systems: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Networked Embedded Systems: System software and system-level programming

Content

Networked Embedded Systems: The objective of this course is gain insights into the operation and programming of embedded systems. A strong focus is on wireless sensor networks. We study the fundamentals of such sensor networks. In the sopce of the exercises, we discuss selected topics in more detail.

Learning objectives

The learning objective is to unserstand the fundamental concepts of networded embedded systems. Students understand these concepts and are able to apply this knowledge.

Implementation method

Networked Embedded Systems: Lecture with practical exercises

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Falko Dressler

Learning material, literature

Networked Embedded Systems: Slides, textbooks, papers

Remarks

none

3.14 Mandatory Module: Computer Science II

Module name	Computer Science II / Computer Science II
Workload	180 h
Credits	6 LP
Semester	• Advanced Computer Architecture : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Advanced Computer Architecture: Lecture (45h / 105h / EN / WS / 50)
Advanced Computer Architecture: Tutorial (30h / 0h / EN / WS / 25)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Advanced Computer Architecture: Basic knowledge in computer architecture.

Content

Advanced Computer Architecture: The course teaches concepts and methods used in modern processor architecture to exploit the available parallelism at the levels of instructions, data and threads.

Learning objectives

After attending the course, the students
- are able to explain principles of modern memory hierarchies,
- to analyze different levels of parallelism,
- to assess the suitability of different architectural concepts and thus
- to evaluate modern developments in computer architecture.

Implementation method

Advanced Computer Architecture:
- Lecture with projector and board

- Interactive exercises in the lecture room item Computer-based exercises with simulation tools
- Analysis of case studies

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Marco Platzner

Learning material, literature

Advanced Computer Architecture:
- Lecture slides and exercise sheets
- Exercise sheets and technical documentation for the for the computer-based exercises
- Hennessey, Patterson: Computer Architecture: A Quantitative Approach (5th edition or newer), Morgan Kauf- mann, 2012.
- Information about alternative and additional literature as well as teaching material on the course's

website and in the lecture slides

Remarks
none

3.15 Elective Module: Controlled AC Drives

Module name	Controlled AC Drives / Controlled AC Drives
Workload	180 h
Credits	6 LP
Semester	• Controlled AC Drives : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Controlled AC Drives: Lecture (30h / 120h / EN / WS / 0)
Controlled AC Drives: Tutorial (30h / 0h / EN / WS / 0)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Controlled AC Drives:

Content

Controlled AC Drives: The course introduces the principle of flux-oriented control of three-phase AC motors, which is today's standard of electrical drives in industry. Unlike the course of the bachelor's program, focus is put on the dynamics behavior and on the control structures. As most important examples, the permanent magnet synchronous motor and the induction motor are treated.

Learning objectives

The module introduces the principle of flux-oriented control of three-phase AC motors, which is today's standard of electrical drives in industry. Unlike the course of the bachelor's program, focus is put on the dynamics behavior and on the control structures.
The students will understand the most important types of AC drives, their properties and should be able to select and to design such drives by themselves.

Implementation method
Controlled AC Drives: Parts of the course are organized as computer-based exercises

Assessment modalities (duration)
Oral exam (ca. 40 Minutes) The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams
none

Course achievement / qualifying participation
none

Prerequisites for participation in module exam
none

Prerequisites for obtaining credits
Passing of module exam.

Weight for overall grade
The module is weighted with 6 credits.

Person responsible for the module
Prof. Dr.-Ing. Joachim Böcker

Learning material, literature
Controlled AC Drives: Lecture notes, slides. Other literature will be given in the lecture.

Remarks
none

3.16 Elective Module: Cooperative Mobile Systems

Module name	Cooperative Mobile Systems / Cooperative Mobile Systems
Workload	180 h
Credits	6 LP
Semester	• Cooperative Mobile Systems : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Cooperative Mobile Systems: Lecture (30h / 105h / EN / SS / 40)
Cooperative Mobile Systems: Tutorial (45h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Cooperative Mobile Systems: System software and system-level programming

Content

Cooperative Mobile Systems: Vehicle-to-everything communication can serve as the basis for novel applications enabling cooperation among mobile systems of the future. Trucks, cars, bikes, pedestrians, and cities are all part of such a system. This course will cover the basis and the application of communication concepts to the design of such cooperative mobile systems. A practical part covers the application of learned theoretical concepts to the design of novel cooperative mobile systems, as well as the study of such systems via simulative performance evaluation.

Learning objectives

Students will be able to understand how vehicle-to-everything communication can serve as the basis for applications enabling cooperation among trucks, cars, bikes, pedestrians, and cities. They will also be able to apply this knowledge to the design of future cooperative mobile systems - both in theory and in practice.

Implementation method
Cooperative Mobile Systems: Lecture with practical exercises

Assessment modalities (duration)
Oral exam (ca. 40 Minutes) The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams
none

Course achievement / qualifying participation
Qualifying Participation: written exercises The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam
Passing of course achievement.

Prerequisites for obtaining credits
Passing of module exam.

Weight for overall grade
The module is weighted with 6 credits.

Person responsible for the module
Jun.-Prof. Dr.-Ing. Christoph Sommer

Learning material, literature
Cooperative Mobile Systems: Slides, textbooks, papers

Remarks
none

3.17 Elective Module: Databases and Information Systems

Module name	Databases and Information Systems / Databases and Information Systems
Workload	180 h
Credits	6 LP
Semester	• Databases and Information Systems : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Databases and Information Systems: Lecture (45h / 105h / EN / WS / 120)
Databases and Information Systems: Tutorial (30h / 0h / EN / WS / 30)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Databases and Information Systems: Studentes are required to have previous knowledge of relational database systems and SQL comparable to the course "Datanbanksysteme" and programming knowledge and skills comparable to the courses "Programming" and "Grundlagen der Programmiersprachen".

Content

Databases and Information Systems: Data storage and data management play a central role in enterprises since a large part of the companies' knowledge is stored as data. For large data volumes, it is essential that future application developers know concepts beyond that of traditional database systems, in particular for NoSQL and non-standard data models, main-memory databases, compression, indexing, and efficient search, in order to develop applications or information systems that lead to acceptable response times. This module focusses on querying and processing of massive data, including tree structured data, text, streaming data, on NoSQL, and on main-memory databases. This module covers algorithms, technologies and practical skills in these areas.

Learning objectives

After completing the module students can comprehend, design, implement and assess (with respect to time and space complexity) XML processing in software systems. They known pivotal search and query techniques to acquire information in uncompressed and compressed XML data. They can appropriately

process infinite data streams. They can acquire new research results from scientific publications.

Implementation method

Databases and Information Systems: The fundamental concepts are presented in a lecture. Additioanlly, theoretical concepts are deepened in small groups during class-based tutorials. This method is used in particular for core concepts of databases (searching in and querying Big Data, distributed databases, and mobile data and manangement). Additionally, practical skills are acquired through computer-based exercises, where the students have to develop their own information systems, search or compression algorthms, based on the introduction given in the lecture.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module
Prof. Dr. Stefan Böttcher

Learning material, literature
Databases and Information Systems: Links to material will be provided during the lecture

Remarks
none

3.18 Elective Module: Digital Image Processing I

Module name	Digital Image Processing I / Digital Image Processing I
Workload	180 h
Credits	6 LP
Semester	• Digital Image Processing I : 1

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Digital Image Processing I: Lecture (30h / 120h / EN / WS / 0)
Digital Image Processing I: Tutorial (30h / 0h / EN / WS / 0)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Digital Image Processing I: None

Content

Digital Image Processing I: The course "Digital Image Processing I" provides a fundamental introduction to digital image processing.

Learning objectives

After successfully completing the module the students
• are able to describe the basics of image generation and image digitization and
• are able to implement, test and apply methods for the enhancement of images in the spatial and frequency domain, image segmentation and data reduction independently for complex image processing tasks

Implementation method

Digital Image Processing I:
• The theoretical and methodic fundamentals will be introduced during the lecture.
• The methods presented will be practiced during the subsequent exercise / lab part.
• Finally, the participants will implement, test, and apply simple image processing algorithms.

• The necessary programming skills will be taught during the practical, this is explicitly not considered a programming course.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Bärbel Mertsching

Learning material, literature

Digital Image Processing I: Lecture notes, exercise sheets and advanced literature (excerpt):
• Mertsching, Bärbel: Digital Image Processing I (lecture notes)
• Forsyth, David and Ponce, Jean: Computer Vision - A Modern Approach. Prentice Hall, 2nd ed., 2011. ASIN: B006V372KG
• Gonzalez, Rafael C. and Woods, Richard E.: Digital Image Processing. Prentice Hall, 3rd ed., 2007. ISBN-13: 978-013168728
• Jähne, Bernd: Digitale Bildverarbeitung. Springer, 7.Aufl., 2012. ISBN-13: 978-3642049514

Remarks
none

3.19 Elective Module: Digital Image Processing II

Module name	Digital Image Processing II / Digital Image Processing II
Workload	180 h
Credits	6 LP
Semester	• Digital Image Processing II : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)
Digital Image Processing II: Lecture (30h / 120h / EN / SS / 0) Digital Image Processing II: Tutorial (30h / 0h / EN / SS / 0)

Choices in Module
none

Course prerequisites
none

Recommended proficiencies
Digital Image Processing II: Basic knowledge of image processing

Content
Digital Image Processing II: The course “Digital Image Processing II” follows the fundamental course “Digital Image Processing I” and describes methods for feature extraction and object recognition.

Learning objectives
After successfully completing the module the students • are able use the basic methods for image segmentation, • have a good command of the probabilistic methods for the description of image features and object recognition, • are able to transfer the acquired knowledge of image processing to the processing of other multi-dimensional signals and • are able to describe the state-of-the-art of the presented topics

Implementation method

Digital Image Processing II:
• The theoretical and methodic fundamentals will be introduced during the lecture.
• During the subsequent exercise / lab part the participants will implement, test, and apply the presented methods

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Bärbel Mertsching

Learning material, literature

Digital Image Processing II: Lecture notes, exercise sheets and advanced literature (excerpt):
• Mertsching, Bärbel: Digital Image Processing I (lecture notes)
• Forsyth, David and Ponce, Jean: Computer Vision - A Modern Approach. Prentice Hall, 2nd ed., 2011. ASIN: B006V372KG
• Gonzalez, Rafael C. and Woods, Richard E.: Digital ImageProcessing. Prentice Hall, 3rd ed., 2007. ISBN-13: 978-0131687288

• Jähne, Bernd: Digitale Bildverarbeitung. Springer, 7.Aufl., 2012. ISBN-13: 978-3642049514

Remarks
none

3.20 Elective Module: Digital Speech Signal Processing

Module name	Digital Speech Signal Processing / Digital Speech Signal Processing
Workload	180 h
Credits	6 LP
Semester	• Digital Speech Signal Processing : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Digital Speech Signal Processing: Lecture (30h / 120h / DE / SS / 30)
Digital Speech Signal Processing: Tutorial (30h / 0h / DE / SS / 30)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Digital Speech Signal Processing: Prior knowledge from the module Higher Mathematics is helpful.

Content

Digital Speech Signal Processing: The course introduces the basic techniques and theories of digital speech signal processing. A focal point of the first part of the lecture is the topic "Listening and Speaking", which is concerned with psychological effects of human sound perception and speech production. Subsequently, time discrete signals and systems, as well as computer based data processing are discussed. Further topics are non-parametric short-time analysis of speech signals, speech coding and IP-phones.

Learning objectives

After attending the course, the students will be able to
• analyze digital signals, e.g., audio signals, in the time or frequency domain,
• represent audio signals efficiently and
• implement widely-used algorithms for speech analysis and speech processing in the frequency or time domain.

Implementation method

Digital Speech Signal Processing:
- Lectures using the blackboard and presentations,
- Alternating theoretical and practical exercise classes with exercise sheets and computer and
- Demonstration of real technical systems in the lecture hall.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Häb-Umbach

Learning material, literature

Digital Speech Signal Processing: Allocation of a script; information on textbooks ; matlab scripts

Remarks
none

3.21 Elective Module: Dynamic Programming and Stochastic Control

Module name	Dynamic Programming and Stochastic Control / Dynamic Programming and Stochastic Control
Workload	180 h
Credits	6 LP
Semester	• Dynamic Programming and Stochastic Control : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Dynamic Programming and Stochastic Control: Lecture (30h / 120h / EN / WS / 0)
Dynamic Programming and Stochastic Control: Tutorial (30h / 0h / EN / WS / 0)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Dynamic Programming and Stochastic Control:
• Basic knowledge on control of discrete-time systems, e.g. as covered in the course Regelungstechnik - Automatic Control
• An introductory course on probability and random processes, e.g. the course Stochastik für Ingenieure

Content

Dynamic Programming and Stochastic Control: Dynamic programming is a method for solving decision making problems consisting of a number of stages, by breaking down the problem into simpler sub-problems. These methods have wide applicability in areas such as optimization, control, communications, and machine learning. This course will cover the modelling and solution of problems of sequential decision making under uncertainty. We will consider problems with both a finite and an infinite number of stages, as well as cases with perfect and imperfect observations of the system. Numerical techniques for solving these problems will be described, including suboptimal methods for when the state and/or action spaces are large.

Learning objectives

After attending this course, students will have understood the basics of dynamic programming and stochastic control. Students will learn the dynamic programming optimality principle and how it can be used to solve multi-stage decision making problems. They will learn how to formulate and solve, using dynamic programming, problems in different areas such as control, communications, signal processing, and machine learning.

Implementation method

Dynamic Programming and Stochastic Control: Lectures and exercises

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Dr. Alex Leong

Learning material, literature

Dynamic Programming and Stochastic Control: D. Bertsekas, Dynamic Programming and Optimal Control, Vol I, 3rd Ed, Athena
Some other material will be taken from:

- D. Bertsekas, Dynamic Programming and Optimal Control, Vol II, 4th Ed, Athena Scientific, 2012
- M. Puterman, Markov Decision Processes, John Wiley and Sons, 1994
- B. Anderson and J. Moore, Optimal Filtering, Prentice-Hall, 1979
- various research papers

Remarks

none

3.22 Mandatory Module: Electrical Engineering I

Module name	Electrical Engineering I / Electrical Engineering I
Workload	180 h
Credits	6 LP
Semester	• Statistical Sgnal Processing : 1 • Verarbeitung statistischer Signale : 1

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Statistical Sgnal Processing: Lecture (30h / 120h / EN / WS / 60)
Statistical Sgnal Processing: Tutorial (30h / 0h / EN / WS / 20)
Verarbeitung statistischer Signale: Lecture (30h / 120h / DE / WS / 0)
Verarbeitung statistischer Signale: Tutorial (30h / 0h / DE / WS / 0)

Choices in Module

One of the listed courses must be selected.

Course prerequisites

none

Recommended proficiencies

Statistical Sgnal Processing: Undergraduate courses in signal processing and probability

Verarbeitung statistischer Signale: Basics in stochastic signal description.

Content

Statistical Sgnal Processing: Statistical signal processing comprises the techniques that engineers and statisticians use to draw inference from imperfect and incomplete measurements. This course covers a selection of topics from the major domains of detection, estimation, and time series analysis.

Verarbeitung statistischer Signale: Statistics in many fields of computer engineering. Estimators and detectors. Statistical time series. Statistical significance.

Learning objectives

After attending this course, students will be familiar with the basic principles of statistical signal processing. They will understand how to apply statistical signal processing techniques to relevant fields in electrical engineering (such as communications). Students will develop confidence in their ability to solve mathematical problems of analysis and design. They will be able to apply the principles they have

learned in this course to other areas.

Implementation method

Statistical Sgnal Processing: Lectures and exercises (including some computer simulations)

Verarbeitung statistischer Signale: Lecture with blackboard, homework assignments, practical work with matlab.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Peter Schreier

Learning material, literature

Statistical Sgnal Processing: Handouts and tutorial questions, literature references will be given in the first lecture.

Verarbeitung statistischer Signale: Script and textbooks.
- N. Henze, Stochastik für Einsteiger, 8. Auflage, Vieweg-Teubner Verlag, 2010

• E. Hänsler, Statistische Signale — Grundlagen und Anwendungen, 3. Auflagen, Springer, 2001
• S. M. Kay, Fundamentals of Statistical Signal Processing — Estimation Theory, Prentice Hall, 1993
• J. L. Mela, D. L. Cohn, Decision and Estimation Theory, McGraw-Hill, Kogakusha, 1987.
• A. Papoulis, Probability, Random Variables, and Stochastic Processes, 2. Ausgabe, McGraw-Hill, New York, 1984.

Remarks

none

3.23 Mandatory Module: Electrical Engineering II

Module name	Electrical Engineering II / Electrical Engineering II
Workload	180 h
Credits	6 LP
Semester	• Circuit and System Design : 1

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Circuit and System Design: Lecture (30h / 120h / EN / WS / 60)
Circuit and System Design: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Circuit and System Design: It builds on basic knowledge of electronic devices and system theory.

Content

Circuit and System Design: The lecture gives an introduction to analysis and design of analog and digital circuits and systems.

Learning objectives

After completing the module, the students will be able to
- describe appropriate methods for analysis and design of analog systems
- describe appropriate methods for analysis and design of digital systems
- assess the limitations of the different methods
- understand and calculate the behaviour of simple analog and digital circuits
- use a numeric simulation tool for electronic systems and circuit simulation

Implementation method

Circuit and System Design:
- Powerpoint and Whiteboard
- Mathematical exercises and design exercises with modern IC design software

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Christoph Scheytt

Learning material, literature

Circuit and System Design: See course webspage.

Remarks
none

3.24 Elective Module: Empiric performance evaluation

Module name	Empiric performance evaluation / Empiric performance evaluation
Workload	180 h
Credits	6 LP
Semester	• Empiric performance evaluation : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Empiric performance evaluation: Lecture (45h / 105h / EN / SS / 15)
Empiric performance evaluation: Tutorial (30h / 0h / EN / SS / 15)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Empiric performance evaluation: Bachelor-level stochastics.

Content

Empiric performance evaluation: This lecture discusses methods and procedures to conduct experimental and simulation-based performance evaluations, along with a statistically solid evaluation of results. The techniques of this class are applicable to a wide range of systems.

Learning objectives

Participants can determine whether a given system or modell is amenable to a particular performance evaluation method. They can design an experiment or a simulation and execute it; they can choose a suitable stochastic model and interprete the experimental results correctly. They can derive statistically justified conclusions, e.g., which system can be regarded as the best system out of a given collection.

Implementation method

Empiric performance evaluation: Lecture with slides and blackboard; homework assignments.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. rer. nat. Holger Karl

Learning material, literature

Empiric performance evaluation: Slides, homework assignments, textbook Kelton & Law, Simulation Modelling and Analysis.

Remarks
none

3.25 Elective Module: Environmental Monitoring and Measuring Technologies

Module name	Environmental Monitoring and Measuring Technologies / Environmental Monitoring and Measuring Technologies
Workload	180 h
Credits	6 LP
Semester	• Environmental Monitoring and Measuring Technologies : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)
Environmental Monitoring and Measuring Technologies: Lecture (30h / 120h / DE / WS / 100) Environmental Monitoring and Measuring Technologies: Tutorial (30h / 0h / DE / WS / 20)

Choices in Module
none

Course prerequisites
none

Recommended proficiencies
Environmental Monitoring and Measuring Technologies: None

Content
Environmental Monitoring and Measuring Technologies: Measuring the environment.

Learning objectives
Students will be able to analyse mechanisms under increasing environmental problems, chose suitable measurements techniques, and characterize and analyze measurement results.

Implementation method
Environmental Monitoring and Measuring Technologies: Lecture with slides; practical work in small groups.

Assessment modalities (duration)
Oral exam (ca. 40 Minutes) The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams
none

Course achievement / qualifying participation
none

Prerequisites for participation in module exam
none

Prerequisites for obtaining credits
Passing of module exam.

Weight for overall grade
The module is weighted with 6 credits.

Person responsible for the module
Prof. Dr.-Ing. Bernd Henning

Learning material, literature
Environmental Monitoring and Measuring Technologies: Script and textbooks.

Remarks
none

3.26 Elective Module: Fast Integrated Circuits for Wireline Communication

Module name	Fast Integrated Circuits for Wireline Communication / Fast Integrated Circuits for Wireline Communication
Workload	180 h
Credits	6 LP
Semester	• Fast Integrated Circuits for Wireline Communication : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Fast Integrated Circuits for Wireline Communication: Lecture (30h / 120h / DE / WS / 100)
Fast Integrated Circuits for Wireline Communication: Tutorial (30h / 0h / DE / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Fast Integrated Circuits for Wireline Communication: None

Content

Fast Integrated Circuits for Wireline Communication: In modern fiber-optic communication systems data rates of several 100 Gb/s per optical channel and several Tb/s per fiber are transmitted. In a similar way nowadays the data transmission between electronic chips reaches data rates of more than 10 Gb/s over a single package pin which has to be transmitted over low-cost serial cable and printed circuit boards. In the future the progress in digital CMOS technologies these data rates will be continuously increased. Goal of the lecture is to convey a methodical design process of fast integrated electronic circuits for digital wireline communications.

Learning objectives

With successful completion of the module the students will be able to
- describe architectures and circuits of fast digital data transmission links,
- describe and calculate fundamental signal transmission properties of digital systems,

- apply design methods to design basic integrated broadband circuits,

Implementation method

Fast Integrated Circuits for Wireline Communication:
- Powerpoint and Whiteboard
- Mathematical exercises and design exercises with modern IC design software

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Christoph Scheytt

Learning material, literature

Fast Integrated Circuits for Wireline Communication: Lecture and exercise slides, Literature
- Paul Gray et al. “Analysis And Design of Analog Integrated Circuits”, Wiley & Sons 2001
- Eduard Säckinger “Broadband Circuits for Optical Fiber Communication”, Wiley & Sons 2005

• Behzad Razavi “Design of ICs for Optical Communications”, McGraw-Hill, 2003

Remarks
none

3.27 Mandatory Module: Final Project

Module name	Final Project / Final Project
Workload	900 h
Credits	30 LP
Semester	• Master Thesis : 4 • Work Plan : 4

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Master Thesis: (0h / 750h / EN / SS / 0)
Work Plan: (0h / 150h / EN / SS / 0)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Master Thesis: Depending on chosen topic.

Work Plan: Depending on chosen topic.

Content

Master Thesis: In the Master thesis, a problem is solved using scientific methods within a given time. The thesis' topic comes from the scientific context of the departments or leverage the multitude of collaborations with industry. Apart from practical relevance, a Master thesis ensures the ability to work scientifically and based on solid methods.

Work Plan: Based on a topic defined jointly with the advisor of the thesis, the student familiarizes herself/himself with the area by doing a literature search and surveying existing results and approaches. On this basis, a work plan has to be prepared that documents the intended results and milestones for the thesis.

Learning objectives

In their final project, students work on and solve a problem using scientific methods in a given amount of time. They should use knowledge and competences acquired during their studies, in particular, how to plan and structure a project into individual steps and how to present results of their work in written

and oral form.

Implementation method

Master Thesis: Independent work, supported by individual tutoring.

Work Plan: Direct contact with advisor.

Assessment modalities (duration)

Final thesis
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifizierte Teilnahme: Workplan
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 60 credits.

Person responsible for the module

Prof. Dr. Sybille Hellebrand

Learning material, literature
Master Thesis: Depending on topic and as recommended by advisor. Work Plan: Depending on topic and as recommended by advisor.

Remarks
Die Masterarbeit muss aus dem Vertiefungsgebiet sein.

3.28 Elective Module: Foundations of Cryptography

Module name	Foundations of Cryptography / Foundations of Cryptography
Workload	180 h
Credits	6 LP
Semester	• Foundations of Cryptography : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)
Foundations of Cryptography: Lecture (45h / 105h / EN / SS / 25) Foundations of Cryptography: Tutorial (30h / 0h / EN / SS / 25)

Choices in Module
none

Course prerequisites
none

Recommended proficiencies
Foundations of Cryptography: Basic Knowledge in IT-Security and cryptography useful but not necessary, basic concepts of complexity theory and probability theory

Content
Foundations of Cryptography: The most important primitives of modern cryptography will be presented. These include encryption schemes, digital signatures, identification protocols, and multiparty computations. In each case we will define precise security notions. Starting from precisely stated assumptions, we develop constructions that provably satisfy these security definitions.

Learning objectives
Students understand fundamental concepts and methods of modern cryptography. They are able to choose appropriate cryptographic tools for various security problems. Students are able to combine and modify basic cryptographic primitives, they are able to define new security concepts, they are able to the the security of new constructions with respect to the security concepts.

Implementation method

Foundations of Cryptography: Lectures, exercises, reading groups

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. rer. nat. Johannes Blömer

Learning material, literature

Foundations of Cryptography: Oded Gorldreich, Foundations of Cryptography I,II, Jonathan Katz, Yehuda Lindell, Introduction to Modern Cryptogtraphy
Slides from the lectures

Remarks
none

3.29 Elective Module: Future Internet

Module name	Future Internet / Future Internet
Workload	180 h
Credits	6 LP
Semester	• Future Internet : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Future Internet: Lecture (45h / 105h / EN / SS / 20)
Future Internet: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Future Internet: Basic knowledge of computer networks is required, e.g., a Bachelor-level class "Computer networks".

Content

Future Internet: This lecture deals with up-to-date, close-to-research developments in the Future Internet context as well as data center (networking) context. The lecture is dynamically updated to reflect current research and is predominantly based on research publications.

Learning objectives

Participants of this class are introduced to the current state of the art in Internet research. They know weaknesses of today's architecture, can criticize them and contrast them with current proposals as well as discuss and assess advantages and disadvantages. For different usage scenarios, they can predict the suitability of different solution proposals. Methodically, they can design and execute networking experiments. Participants can create new Internet protocols and synthesize them into new architectures; they can compare such creations with competing approaches and assess and decide for a superior solution. Since the lecture is based on scientific publications, participants are able to make use of original work that has not been didactically prepared.

Implementation method

Future Internet: Lecture with slides and blackboard; homework assignments. The homework assignments will include architecture experiments, e.g., based on OpenFlow.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. rer. nat. Holger Karl

Learning material, literature
Future Internet: Slide set, but mostly based on current publications. No perfect textbook available; parts of the class are covered by Stallings, Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud.

Remarks
none

3.30 Elective Module: Hardware/Software Codesign

Module name	Hardware/Software Codesign / Hardware/Software Codesign
Workload	180 h
Credits	6 LP
Semester	• Hardware/Software Codesign : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Hardware/Software Codesign: Lecture (45h / 105h / EN / SS / 40)
Hardware/Software Codesign: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Hardware/Software Codesign: Digital design, computer architecture, programming skills

Content

Hardware/Software Codesign: Hardware/Software Codesign denotes the integrated and automated design of hardware and software in computer systems. The course Hardware/Software Codesign teaches concepts and methods that are used in computer aided design tools for design-space exploration, design optimization, and compilation for specialized computer systems.

Learning objectives

Participants of this course can name the goals and challenges in the design of specialized computer systems. They are able to chose the suitable modeling approaches for a given HW/SW system and its functional and non-functional requirements and to create a specification in the selected formalism. They can characterize target architectures for the implementation of HW/SW systems and evaluate the suitability of a given application. They are able to describe the design of a compiler, to understand and apply basic blocks and control-flow graphs, and to discuss optimization and code generation methods. They are able to demonstrate how programs are translated to hardware using high-level synthesis methods. The understand the integer linear programming method and can apply it to problems from

the domain of synthesis, scheduling and software performance estimation.

Implementation method

Hardware/Software Codesign:
- Lecture with projected slides and notes on blackboard
- Interactive assignments in lecture room
- Self-study and discussion of scientific publications
- Practical programming projects for applying methods of the area Hardware/Software Codesign

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Christian Plessl

Learning material, literature
Hardware/Software Codesign: Slides, standard textbooks, assignment sheets, scientific articles

Remarks
none

3.31 Elective Module: High Frequency Engineering

Module name	High Frequency Engineering / High Frequency Engineering
Workload	180 h
Credits	6 LP
Semester	• High Frequency Engineering : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

High Frequency Engineering: Lecture (30h / 120h / EN / WS / 100)
High Frequency Engineering: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

High Frequency Engineering: Higher Mathematics, Physics, and the Foundations of Electrical Engineering

Content

High Frequency Engineering: The course "High Frequency Engineering" has the goal to enable the listeners for developing tasks e. g. of the high-frequency part of a mobile phone. High-frequency engineering aspects have to be considered also in common digital cirquits. The main issues of this lecture are passive cirquits, high-frequency properties of transistor cirquits, linear and nonlinear amplifiers, noisy multi-port devices, mixers, oscillators, synchronization and phase locked loop.

Learning objectives

The module "High Frequency Engineering" has the goal to enable the listeners for developing tasks e. g. of the high-frequency part of a mobile phone. After attending the course, the students will be able to

- understand and apply the physics of high-frequency components, cirquits and systems,
- develop systems and cirquits in the high-frequency and highest-frequency domain and
- develop and make up electronic cirquits under consideration of high-frequency aspects.

Implementation method

High Frequency Engineering:
- Lectures using presentations via transparencies,
- Exercise classes with exercise sheets and demonstrations on computer.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Noé

Learning material, literature

High Frequency Engineering: Meinke, H.; Gundlach, F.: Taschenbuch der Hochfrequenztechnik, Springer, 2006 German only

Remarks
none

3.32 Elective Module: High-Performance Computing

Module name	High-Performance Computing / High-Performance Computing
Workload	180 h
Credits	6 LP
Semester	• High-Performance Computing : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

High-Performance Computing: Lecture (30h / 105h / EN / WS / 40)
High-Performance Computing: Tutorial (45h / 0h / EN / WS / 40)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

High-Performance Computing:
- Programming skills in C/C++
- Computer architecture

Content

High-Performance Computing: This course teaches the foundations of high-performance computing with an emphasis on the programming of parallel computer systems and novel hardware accelerators.

Learning objectives

After attending this course, the students are able to
- name models and programming patterns for HPC and to select patterns for a given application,
- name and apply the basic constructs of frequently used HPC libraries, in particular, MPI, OpenMP and OpenCL,
- analyze the performance of applications by using profiling tools and use the gathered information to create a systematic optimization strategy,
- apply the taught concepts and methods for parallelizing and optimizing existing applications

Implementation method

High-Performance Computing:
- Lecture with projected slides and blackboard notes
- Interactive assignments in lecture room
- Practical programming projects on parallel computer systems (teamwork in small groups)

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Christian Plessl

Learning material, literature
High-Performance Computing: • Lecture slides • Assignment sheets • Task descriptions and technical documentation for programming projects • Lehrbuch: Pacheco: An Introduction to Parallel Programming. Morgan Kaufmann, 2011.

Remarks
none

3.33 Elective Module: Integrated Circuits for Wireless Communication

Module name	Integrated Circuits for Wireless Communication / Integrated Circuits for Wireless Communication
Workload	180 h
Credits	6 LP
Semester	• Integrated Circuits for Wireless Communication : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Integrated Circuits for Wireless Communication: Lecture (30h / 120h / EN / SS / 100)
Integrated Circuits for Wireless Communication: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Integrated Circuits for Wireless Communication: Schaltungstechnik and Circuit and System Design, respectively

Content

Integrated Circuits for Wireless Communication: Mobile communications, wireless networks, and RFID technology are application examples of wireless communications. Wireless communications has found widespread use in everyday life and will become even more important in the future.
The design of electronic circuits for radio frequencies requires a good system knowledge with respect to typical transmitter and receiver architectures in wireless communications, components, and radio signal properties. Furthermore a thorough understanding of integrated circuit design as well as precise high-frequency modeling of passive and active devices are required.
Goal of the lecture is to convey a methodical approach to the design of integrated circuits for wireless communications. A part of the exercises will pertain to calculation of circuit design problems another will be performed in small teams as a hands-on exercise using modern IC design software.
The lecture is based on the compulsory lectures "Schaltungstechnik" rsp. "Circuit and System Design" and addresses the following topics:
• Transmitter and receiver architectures for wireless communications
• System Theory Basics

  - Signals and noise
  - Modulation and demodulation
  - Transmission properties of wireless communcations systems
- Semiconductor technologies and integrated high-frequency devices
- Amplifiers (low-noise and variable-gain amplifiers)
- Mixers
- Oscillators
- Frequency synthesizer PLLs

Learning objectives

The students will be able
- to describe architectures and circuits of wireless communication systems
- to describe and calculate fundamental signal transmission properties of wireless systems
- to apply design methods to design components of radio frequency ICs

Implementation method

Integrated Circuits for Wireless Communication:
- Lecture with Powerpoint presentation and handwritten mathematical derivations using tablet and beamer
- Exercises partly as handwritten calculation exercises using tablet and beamer and partly as practical IC design exercises using modern IC design software

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Christoph Scheytt

Learning material, literature

Integrated Circuits for Wireless Communication: Lecture and exercise slides will be made available through PAUL system.
Recommended books:
• Behzad Razavi "RF Microelectronics", Prentice Hall, 2011
• Thomas Lee "The Design of CMOS Radio-Frequency Integrated Circuits", Cambridge University Press 2003

Remarks

none

3.34 Elective Module: Intelligence in Embedded Systems

Module name	Intelligence in Embedded Systems / Intelligence in Embedded Systems
Workload	180 h
Credits	6 LP
Semester	• Intelligence in Embedded Systems : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Intelligence in Embedded Systems: Lecture (45h / 105h / EN / SS / 25)
Intelligence in Embedded Systems: Tutorial (30h / 0h / EN / SS / 25)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Intelligence in Embedded Systems:

Content

Intelligence in Embedded Systems: Intelligent embedded systems are technical systems that use different sensors and actors to perceive their environment and interact with it in a (partly) autonomous way. Often their behavior is controlled by methods and algorithms from artificial intelligence (AI). Such methods enable for instance that systems plan their behavior in a goal directed manner or optimize it via self-adaptation and learning. Systems of that kind are becoming increasingly important, not only on a scientific level but also in a social context: Autonomous or semi-autonomous systems such as service robots, self-driving cars or medical help and diagnosis systems will have a deep impact on our future private and professional life.
This course covers important aspects for the development of intelligent embedded systems and conveys corresponding theoretical and methodological foundations. This includes lectures on architectures, intelligent sensor processing, environment modelling, intelligent behavior control and self-adaptation.

Learning objectives

Students know and explain methods and algorithms for intelligent sensor processing and control of actions (e.g. computer vision, sensor fusion, maps, navigation, planning and machine learning). They understand and solve problems arising when realizing them in embedded systems with restricted resources.

Furthermore, they are able to understand, use and adapt new methods and algorithms especially in the context of embedded systems.

Implementation method

Intelligence in Embedded Systems:
- Lecture with slides
- Interactive exercises, where students deepen their understanding and apply their knolwledge obtained in the lectures

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Dr. Bernd Kleinjohann

Learning material, literature
Intelligence in Embedded Systems: Lecture slides, publications, books: • St. Russel, P. Norvig: Artificial Intelligence: A Modern Approach • R. Arkin: Behavior-Based Robotics Other literature (books, publications) will be announced in the lecture.

Remarks
none

3.35 Elective Module: Introduction to High-Frequency Engineering

Module name	Introduction to High-Frequency Engineering / Introduction to High-Frequency Engineering
Workload	180 h
Credits	6 LP
Semester	• Introduction to High-Frequency Engineering : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Introduction to High-Frequency Engineering: Lecture (30h / 120h / DE / WS / 100)
Introduction to High-Frequency Engineering: Tutorial (30h / 0h / DE / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Introduction to High-Frequency Engineering: Higher Mathematics and Foundations of Electrical Engineering

Content

Introduction to High-Frequency Engineering: The course “Introduction to High-Frequency Engineering” provides basic knowledge of high-frequency engineering in particular with respect to signal propagation along transmission lines on circuit boards and integrated circuits.

Learning objectives

The course Introduction to “High-Frequency Engineering” provides basic knowledge of high-frequency engineering. The students learn to describe circuits comprising distributed and lumped components, to analyze, and to design the latter.

Implementation method

Introduction to High-Frequency Engineering:
• Lectures with black board presentation, supported by animated graphics and transparencies,
• Presence exercises with task sheets to be solved by the students together, supported by the teacher, and partially using CAD software.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Andreas Thiede

Learning material, literature

Introduction to High-Frequency Engineering: A. Thiede, Einführung in die Hochfrequenztechnik, Vorlesungsskript Universität Paderborn
Continuative and deepening literature
• P. Vielhauer, Lineare Netzwerke, Verlag Technik und Hüthig (65 YCF 1469)
• M. Hoffmann, Hochfrequenztechnik, Springer Verlag (51 YDA 1913)
• O. Zinke, H. Brunswig, Hochfrequenztechnik, Bd.1+2, Springer Verlag (51 YDA 1086)

- G. Gonzalez, Microwave Transistor Amplifiers, Prentice Hall (51 YEP 3142)
- P.C.L. Yip, High-Frequency Circuit Design and Measurements, Chapman & Hall (51 YDA 1751)
- R.E. Collin, Foundations for Microwave Engineering, Mc Graw-Hill (51 YGA 1240)

Remarks
none

3.36 Elective Module: Machine Learning I

Module name	Machine Learning I / Machine Learning I
Workload	180 h
Credits	6 LP
Semester	• Machine Learning I : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Machine Learning I: Lecture (45h / 105h / EN / WS oder SS / 60)
Machine Learning I: Tutorial (30h / 0h / EN / WS oder SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Machine Learning I: Basic knowledge in mathematics (linear algebra, statistics), programming and algorithms.

Content

Machine Learning I: Due to the ever increasing amount of data that is routinely produced in our information society, the topic of machine learning has become increasingly important in the recent years, not only as a scientific discipline but also as a key technology of modern software and intelligent systems. This lecture provides an introduction to the topic of machine learning, with a specific focus on supervised learning for classification and regression. The lecture covers theoretical foundations of generalisation as well as practical topics and concrete learning algorithms.

Learning objectives

The students understand the statistical foundations of generalisation, i.e., the induction of models from data, as well as practical tools for model validation. They are able to apply basic methods of supervised learning to problems of classification and regression.

Implementation method

Machine Learning I: Theoretical foundations and concepts of machine learning will be taught in the form of a lecture and deepened in practical exercise courses, group work as well as individual homework.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Eyke Hüllermeier

Learning material, literature

Machine Learning I: Script and a List of book recommendations:
- Y.S. Abu-Mostafa, M. Magdon-Ismail, H.T. Lin. Learning from Data, AMLBook, 2012.
- P. Flach. Machine Learning, Cambridge Univ. Press, 2012.
- E. Alpaydin. Machine Learning, Oldenbourg, 2008.
- C.M. Bishop. Pattern Recognition and Machine Learning, Springer, 2006.

Remarks
none

3.37 Elective Module: Machine Learning II

Module name	Machine Learning II / Machine Learning II
Workload	180 h
Credits	6 LP
Semester	• Machine Learning II : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Machine Learning II: Lecture (45h / 105h / EN / WS oder SS / 20)
Machine Learning II: Tutorial (30h / 0h / EN / WS oder SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Machine Learning II: Basic knowledge in machine learning (as conveyed, for example, by the Machine Learning I lecture).

Content

Machine Learning II: This lecture, which is conceived as a continuation of the Machine Learning I, covers advanced topics in contemporary machine learning research, such as reinforcement learning, online learning and bandit algorithms, multi-task learning, multi-target and structured output prediction, preference learning, learning from weak supervision, and uncertainty in machine learning. The focus of the lecture will be on methods and algorithms, though theoretical issues and applications will be addressed, too.

Learning objectives

The students have an overview of methods for multi-class classification, the learning of nonlinear models, and extensions of the simple setting of supervised learning. They understand algorithmic concepts of corresponding methods and are able to apply them to real problems.

Implementation method

Machine Learning II: Theoretical foundations and concepts of machine learning will be taught in the form of a lecture and deepened in practical exercise courses, group work as well as individual homework.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Eyke Hüllermeier

Learning material, literature

Machine Learning II: Script and a list of book recommendations:
- Y.S. Abu-Mostafa, M. Magdon-Ismail, H.T. Lin. Learning from Data, AMLBook, 2012.
- P. Flach. Machine Learning, Cambridge Univ. Press, 2012.
- E. Alpaydin. Machine Learning, Oldenbourg, 2008.
- C.M. Bishop. Pattern Recognition and Machine Learning, Springer, 2006.

Remarks
none

3.38 Elective Module: Mobile Communication

Module name	Mobile Communication / Mobile Communication
Workload	180 h
Credits	6 LP
Semester	• Mobile Communication : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Mobile Communication : Lecture (45h / 105h / EN / WS / 20)
Mobile Communication : Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Mobile Communication : Basic knowledge of computer networks is required, e.g., a Bachelor-level class "Computer networks".

Content

Mobile Communication : The lecture discusses foundations of mobile communication (e.g., wireless channel models) and fundamental techniques (e.g., spread spectrum communication), important protocol mechanisms (e.g., medium access in wireless systems), mobile communication systems, and MobileIP. In addition to technological and conceptual aspects, we shall also discuss approaches and methods for performance evaluation of mobile communication systems.

Learning objectives

Participants of this class know challenges and problems arising in design and operation of mobile communication systems. They can differentiate between challenges based in physics and those arising from a particular system design; they can choose suitable protocols or design new ones. They are able to select mechanisms from different architectural layers, integrate them into a new complete architecture and justify their selection and integration decisions. They are also able to quantitatively evaluate protocol mechanisms.

Implementation method

Mobile Communication : Lecture with slides and blackboard; homework assignments with (among others) some programming assignments to simulate wireless systems.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. rer. nat. Holger Karl

Learning material, literature

Mobile Communication : Slide set; chapters from various textbooks (J. Schiller, Mobile Communication, Addison Wesley, 2nd edition; D. Tse und P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005).

Remarks
none

3.39 Elective Module: Model-Driven Software Development

Module name	Model-Driven Software Development / Model-Driven Software Development
Workload	180 h
Credits	6 LP
Semester	• Model-Driven Software Development : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)
Model-Driven Software Development: Lecture (45h / 105h / EN / WS / 100) Model-Driven Software Development: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module
none

Course prerequisites
none

Recommended proficiencies
Model-Driven Software Development: wird noch ergaenzt

Content
Model-Driven Software Development: Model-driven software development aims at the development of software solely based on models. Ideally, the final system is completely generated and analysed based on the model. The lecture Model-Driven Software Development introduces in details methods and processes for model-driven development.

Learning objectives
See detailed description of associated course.

Implementation method
Model-Driven Software Development: wird noch ergaenzt

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Dr. Matthias Meyer

Learning material, literature

Model-Driven Software Development: wird noch ergaenzt

Remarks

none

3.40 Elective Module: Network Simulation

Module name	Network Simulation / Network Simulation
Workload	180 h
Credits	6 LP
Semester	• Network Simulation : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Network Simulation: Lecture (30h / 105h / EN / SS / 20)
Network Simulation: Tutorial (45h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Network Simulation: System software and system-level programming

Content

Network Simulation: This course offers the chance to get in touch with the network simulation framework OMNeT++. Simulation is one possibility (others are experiments or mathematical analysis) to evaluate the performance of systems which might even not be available in reality.
After getting a basic introduction to simulation and modeling, we will study a small example project already using OMNeT++. Finally, we will work in small groups of 2-3 people on interesting research-focused projects of the areas vehicular communication and wireless sensor networks.

Learning objectives

The learning objective is to unserstand the fundamental concepts of network simulation. Students understand these concepts and are able to apply this knowledge.

Implementation method

Network Simulation: Lecture with practical exercises

Assessment modalities (duration)

The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

Written exam (60 minutes, 50% of module grade) and final project (50% of module grade)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Falko Dressler

Learning material, literature

Network Simulation: Slides, textbooks, papers

Remarks

none

3.41 Elective Module: Optical Communication A

Module name	Optical Communication A / Optical Communication A
Workload	180 h
Credits	6 LP
Semester	• Optical Communication A : 1

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Optical Communication A: Lecture (30h / 120h / EN / WS / 100)
Optical Communication A: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Optical Communication A: Higher Mathematics, Physics, and the Foundations of Electrical Engineering.

Content

Optical Communication A: The course "Optical Communications A" introduces into modern optical communications on which internet and telephony rely. This lecture will impart also knowledge on ultra-broadband communication systems. Every optical waveguide is about 1000 times as broadband as most efficient microwave communication satellites. Optical transmission can be explained by the wave model whereas effects like emission, absorption and amplification of photons are modeled by the particle aspect. This dualism and basic knowledge of communications and electronics lead to an understanding of optical communications. Wavelength multiplex has an eminent importance because of it's high capacity beyond 10Tbit/s or transoceanic spans.

Learning objectives

After attending the course, the students will be able to
• describe, model and apply the function of components, systems and effects of optical communications and
• apply knowledge of optoelectronics.

Implementation method

Optical Communication A:
- Lectures using presentations via transparencies,
- Exercise classes with exercise sheets and demonstrations on computer.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Noé

Learning material, literature

Optical Communication A: R. Noé, Essentials of Modern Optical Fiber Communication, Springer-Verlag, 2010 Scriptum for a major part of the lectures Optical Communications A, B, C, D as well an Optical Transmission Technology, English only

Remarks
none

3.42 Elective Module: Optical Communication B

Module name	Optical Communication B / Optical Communication B
Workload	180 h
Credits	6 LP
Semester	• Optical Communication B : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Optical Communication B: Lecture (30h / 120h / EN / SS / 100)
Optical Communication B: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Optical Communication B: Higher Mathematics, Physics, and the Foundations of Electrical Engineering. Optical Communications A recommended.

Content

Optical Communication B: The course "Optical Communications B" gives an introduction into mode coupling in optical communications. A mode is a wave which has a unique propagation constant at a given frequency. In case of mode coupling, there is a power exchange between different modes, which happens according to the setup in co- or contradirectional way. In this course, there are mechanisms and applications explained.

Learning objectives

After attending the course, the students will be able to
- understand the meaning and importance of wave modes and mode coupling in optical communications,
- make up and understand mathematical models of optical components and systems and
- understand and abstract how optical components work

Implementation method

Optical Communication B:
- Lectures using presentations via transparencies,
- Exercise classes with exercise sheets and demonstrations on computer.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Noé

Learning material, literature

Optical Communication B: R. Noé, Essentials of Modern Optical Fiber Communication, Springer-Verlag, 2010 Scriptum for a major part of the lectures Optical Communications A, B, C, D as well an Optical Transmission Technology, English only

Remarks
none

3.43 Elective Module: Optical Communication C

Module name	Optical Communication C / Optical Communication C
Workload	180 h
Credits	6 LP
Semester	• Optical Communication C : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Optical Communication C: Lecture (30h / 120h / EN / WS / 100)
Optical Communication C: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Optical Communication C: Higher Mathematics, Physics, and the Foundations of Electrical Engineering. Optical Communications A recommended.

Content

Optical Communication C: The course “Optical Communications C” has the subject of modulation formats. Besides the classical On/Off-keying (OOK), there are different ways to modulate an optical signal either to improve the signal to noise ratio or to transmit more than one bit per symbol as quarternary modulation (four signal states) or polarization mode multiplex. In this lecture, also advanced modu-lation formats are treated.

Learning objectives

After attending the course, the students will be able to
- know and evaluate different modulation schemes in Optical Communications in their meaning,
- see the importance of efficient modulation schemes in Optical Communications and
- realize and develop efficient optical communication systems.

Implementation method

Optical Communication C:
- Lectures using presentations via transparencies, or directly on the computer
- Exercise classes with exercise sheets and demonstrations on computer.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Noé

Learning material, literature

Optical Communication C: R. Noé, Essentials of Modern Optical Fiber Communication, Springer-Verlag, 2010 Scriptum for a major part of the lectures Optical Communications A, B, C, D as well an Optical Transmission Technology, English only

Remarks
none

3.44 Elective Module: Optimal and Adaptive Filters

Module name	Optimal and Adaptive Filters / Optimal and Adaptive Filters
Workload	180 h
Credits	6 LP
Semester	• Optimal and Adaptive Filters : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Optimal and Adaptive Filters: Lecture (30h / 120h / EN / WS / 100)
Optimal and Adaptive Filters: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Optimal and Adaptive Filters: Prior knowledge from the modules Higher Mathematics and Digital Signal Processing is helpful.

Content

Optimal and Adaptive Filters: The course “Optimal and adaptive filters” gives an introduction to the basic techniques and theories of adaptive filters. Based upon the basics of estimation theory optimal filters are discussed. Subsequently the topics Wiener filter theory, deterministic optimization under constraints and stochastic gradient methods are regarded. Concluding the Least Squares approach for solving filter tasks and the Kalman filter are introduced. The latter is regarded as a brief introduction to state based filters.

Learning objectives

The module “Optimal and adaptive filters” gives an introduction to the basic techniques and theories of adaptive filters. After attending the course, the students will be able to analyze tasks in the field of adaptive filters and to formulate requirements mathematically, develop filter using cost functions and implement selected adaptive filters in the frequency or time domain.

Implementation method

Optimal and Adaptive Filters:
- Lectures using the blackboard and presentations,
- Alternating theoretical and practical exercise classes with exercise sheets and computer and
- Demonstration of real technical systems in the lecture hall.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Häb-Umbach

Learning material, literature

Optimal and Adaptive Filters: Allocation of a script; information on textbooks; matlab scripts

Remarks
none

3.45 Mandatory Module: Project group

Module name	Project group / Project group
Workload	540 h
Credits	18 LP
Semester	• Project group : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Project group: (0h / 540h / EN / SS / 12)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Project group: Secure knowledge of Bachelor-level topics; depending on the group topic, a small amount of Master-level classes may be required as well.

Content

Project group: A project group consists of a group of student (typically 8–12) who jointly work on a topic from current research; the group lasts for one calendar year. As a team, the participants elaborate a problem, find solutions, realize them and present their results in regular meetings. Additionally, a project group comprises a seminar phase where team members educate themselves to an expert-level knowledge for relevant areas and provide this knowledge to the group.
New projet groups start each semester. Their topics are presented publicly at the end of the previous semester and students can register with a group in which they are interested.

Learning objectives

Methodically, students lean
• how to structure a complex problem setting into smaller, manageable tasks,
• to identify missing knowledge and skills and how to obtain them independently, possibly even across disciplines,
• to specify complex problems,
• to develop a suitable project plan, to control it and adapt it if needs be,
• to validate their results their specifications, to evaluate them and critically judge them,

- to keep thinking on the basis of their results and to develop new questions and development options.

Implementation method

Project group: Self-organised team work, based on a given task from up-to-date research. The group is assisted topic-wise and methodically by the supervisors. A seminar is integrated to provide technical expertise needed to achieve the project goals. Regular meetings of the group with the supervisors to present intermediate results, work plans, etc; nevertheless, the groups are encouraged to work self-organized as much as possible.

Assessment modalities (duration)

Project
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 9 credits.

Person responsible for the module

Prof. Dr. rer. nat. Holger Karl

Learning material, literature
Project group: Will be published on the course website.

Remarks
none

3.46 Elective Module: Reconfigurable Computing

Module name	Reconfigurable Computing / Reconfigurable Computing
Workload	180 h
Credits	6 LP
Semester	• Reconfigurable Computing : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Reconfigurable Computing: Lecture (30h / 105h / EN / WS / 50)
Reconfigurable Computing: Tutorial (45h / 0h / EN / WS / 25)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Reconfigurable Computing: Knowledge of "Digital Design" and "Computer Architecture" is beneficial.

Content

Reconfigurable Computing: This lecture provides an understanding of architectures and design methods for reconfigurable hardware systems and presents applications in the areas of high performance computing and embedded systems.

Learning objectives

After attending the course, the students
- are able to explain the architectures of reconfigurable hardware devices,
- to name and analyze the main design methods and
- to judge the suitability of reconfigurable hardware for different application domains.

Implementation method

Reconfigurable Computing:
- Lecture with projector and board
- Interactive exercises in the lecture room

- Computer-based exercises with reconfigurable systems

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Marco Platzner

Learning material, literature

Reconfigurable Computing:
- Lecture slides and exercise sheets
- Exercise sheets and technical documentation for the for the computer-based exercises
- S. Hauck and A. DeHon (editors): Reconfigurable Computing, Volume 1: The Theory and Practice of FPGA-Based Computation, Morgan Kaufmann, 2008
- Information about alternative and additional literature as well as teaching material on the course's website and in the lecture slides

Remarks
none

3.47 Elective Module: Reinforcement Learning

Module name	Reinforcement Learning / Reinforcement Learning
Workload	180 h
Credits	6 LP
Semester	• Reinforcement Learning : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Reinforcement Learning: Lecture (30h / 120h / EN / SS / 50)
Reinforcement Learning: Tutorial (30h / 0h / EN / SS / 25)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Reinforcement Learning: It is recommended to have a sound basic knowledge in the field of system and control theory. Ideally, the students have knowledge in the field of un-/supervised machine learning and numerical optimization. In addition, at least some experience with Python will be advantageous for the exercise and tutorial tasks.

Content

Reinforcement Learning: The course covers the basics of reinforcement learning (RL) in an engineering context. RL stands for a series of methods of machine learning in which an agent independently learns a strategy (policy) to maximize the rewards received during interaction with an (unknown) system. This can be, for example, a control loop in which an adaptive controller tries to determine an optimal control law from previous observations of the control and measurement variables, which maximizes certain benchmark criteria with regard to controller performance. Well-known fields of application include the operation of autonomous vehicles and industrial robots or the identification of optimal strategies in the context of leisure games.
The course has an application-oriented focus in the engineering sciences but is also designed for students of natural sciences (e.g. computer science, mathematics). In addition to teaching the methodological fundamentals within the lecture, great importance is attached to practical implementation and programming tasks during the exercise and tutorial hours.

Learning objectives

Domain-specific competences: After attending the course, the students are able to
- differentiate, apply and analyze basic RL methods,
- name and explain differences as well as advantages and disadvantages of RL compared to neighboring approaches (e.g. model-predictive control),
- educate themselves independently in this branch of science on the basis of the methods learned for the analysis and synthesis of RL techniques.

Interdisciplinary competences: The students
- can apply or transfer the acquired knowledge to interdisciplinary problems,
- have gained practical experience in programming which they can use across domains and
- are able to critically evaluate methods and results.

Implementation method

Reinforcement Learning:
- Lecture based on slides, which also serve as lecture notes.
- Presence exercises with tutorial sheets (with many programming tasks)

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade
The module is weighted with 6 credits.

Person responsible for the module
Dr.-Ing. Oliver Wallscheid

Learning material, literature
Reinforcement Learning: • Richard S. Sutton, Andrew G. Barto, "Reinforcement Learning", 2. Ed., MIT Press, 2018 • David Silver, "Reinforcement Learning"(Skriptum), University College London, 2015

Remarks
none

3.48 Elective Module: Robotics

Module name	Robotics / Robotics
Workload	180 h
Credits	6 LP
Semester	• Robotics : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Robotics: Lecture (30h / 120h / EN / SS / 100)
Robotics: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Robotics: None

Content

Robotics: The course "Robotics" introduces basic concepts and techniques in the field of mobile robotics. The challenges for the development of autonomous intelligent systems will be analyzed and the current solutions will be presented.

Learning objectives

After successfully completing the module the students
• know how to transfer basic methods from control and system theory to robotics and
• are able to apply the adequate methods to describe as well as plan and control the movements of robot arms and mobile robots.

Implementation method

Robotics:
• The theoretical and methodical fundamentals will be introduced during the lecture.
• The methods presented will be practiced during the subsequent exercise / lab part.
• Finally, the participants will implement, test, and apply simple algorithms.

• The necessary programming skills will be taught during the practical, this is explicitly not considered a programming course.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Bärbel Mertsching

Learning material, literature

Robotics: Allocation of lecture notes; information on textbooks stocked in the textbook collection will be announced later.
• Mertsching, Bärbel: Robotics (lecture notes)
• McKerrow, Phillip J.: Introduction to Robotics. Addison-Wesley, 1991
• Siegwart, Roland; Nourbakhsh, Illah R. and Scaramuzza, David: Introduction to Autonomous Mobile Robots. The MIT Press, 2011, ISBN-13: 978-0262015356

Remarks
none

3.49 Elective Module: Routing and Data Management in Networks

Module name	Routing and Data Management in Networks / Routing and Data Management in Networks
Workload	180 h
Credits	6 LP
Semester	• Routing and Data Management in Networks : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Routing and Data Management in Networks: Lecture (45h / 105h / EN / SS / 40)
Routing and Data Management in Networks: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Routing and Data Management in Networks: Algorithm design, theoretical correctness and efficiency proofs, tools from combinatorics and probability theory.

Content

Routing and Data Management in Networks: Routing and data management are fundamental tasks to be solved in order to ensure efficient use of large networks, e.g. the Internet, peer-to-peer systems, or wireless mobile ad-hoc networks. This lecture deals with algorithms and their analysis for routing and data management in such systems and describes, in particular, methods for dealing with their dynamics (movement of nodes, joining and exiting nodes). In particular, local, distributed algorithms, often as online algorithms, are considered.

Learning objectives

The students get to know fundamental techniques in the area of routing and data management of large networks. They can decide in which situation which data management, scheduling, or routing algorithm is most appropriate. They can adapt algorithms to a new situation.

Implementation method

Routing and Data Management in Networks:
- Lecture with beamer and blackboard
- Practice in small groups
- Expected activities of the students: Solving homework exercises, contributing to the tutorials

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Friedhelm Meyer auf der Heide

Learning material, literature
Routing and Data Management in Networks: Introduction to Parallel Algorithms and Architectures: Arrays, Trees, Hypercubes, Frank Thomson Leighton, M. Kaufmann Publishers, 1992. Research papers, script, slide set of the lecture, exercise sheets

Remarks
none

3.50 Mandatory Module: Scientific Work Style

Module name	Scientific Work Style / Scientific Work Style
Workload	180 h
Credits	6 LP
Semester	• Languages, Writing and Presentation skills : 2 • Seminar : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Languages, Writing and Presentation skills: (30h / 30 h / DE / SS / 0)
Seminar: Seminar (30h / 90 h / EN / SS / 15)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Languages, Writing and Presentation skills: None.

Seminar: None in general; depending on the particular topic, some prior contact with the area can be helpful (e.g., in Bachelor classes).

Content

Languages, Writing and Presentation skills: Students are free to choose, depending on their interests, prior knowledge, and talents, a course on language, scientific writing or presentation skills. The choice can be made from the courses offered by the University of Paderborn.

Seminar: Goal of a seminar is in-depth, autonomous work in a complex, scientific topic, the necessary literature research, and the presentation of the results in speech and writing. They also serve to familiarize students with the main mechanisms used by the scientific community (conferences, peer reviews, ...). Seminars are offered by all lecturers; topics are taken from their research areas and change from semester to semester.

Learning objectives

The goal of this module is to enable students (a) to autonomously familiarize themselves with complex technical and scientific material and (b) to effectively and efficiently communicate such material in speech and writing. To this end, the module comprises a seminar on scientific topics from computer engineering and an elective class on language, technical writing, presentation techniques, etc.

Implementation method

Languages, Writing and Presentation skills: Depends on chosen course.

Seminar: Seminars are based on a list of topics, from which participants can choose. A seminar encompasses meetings where topic assignment, literature research, selecting relevant literature, presentation techniques, technical writing etc. are discussed. In close interaction between participants and advisors, a couple of milestones are undertaken to develop a seminare writeup and a presentation, which is later on presented to the group and discussed.

Assessment modalities (duration)

Seminar Presentation and Paper
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifizierte Teilnahme:
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade
The module is weighted with 6 credits.

Person responsible for the module
Prof. Dr.-Ing. Katrin Temmen

Learning material, literature
Languages, Writing and Presentation skills: Depends on chosen course. Seminar: Current scientific publications.

Remarks
none

3.51 Elective Module: Semiconductor Device Integration

Module name	Semiconductor Device Integration / Semiconductor Device Integration
Workload	180 h
Credits	6 LP
Semester	• Semiconductor Device Integration : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Semiconductor Device Integration: Lecture (30h / 120h / DE / SS / 0)
Semiconductor Device Integration: Tutorial (30h / 0h / DE / SS / 0)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Semiconductor Device Integration: Semiconductor Devices

Content

Semiconductor Device Integration: The course "Semiconductor Device Fabrication" focuses on the integration process of semiconductor devices. Starting from the cleaning process of the silicon crystal to the fabrication of integrated semiconductor circuits. This includes thermal oxidation, lithography, etching, doping, deposition and cleaning. Combinations of these steps to form the integration of MOS-transistors and CMOS-circuits are shown and can be experienced during the tutorials. The wafer dicing, bonding and packaging of microelectronic circuits complete the course.

Learning objectives

Implementation method

Semiconductor Device Integration:
- Lecture based on slide presentation, extensions on blackboard
- Exercises in small groups based on exercise sheets with students presenting their own solutions

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Ulrich Hilleringmann

Learning material, literature

Semiconductor Device Integration:
- Handouts of lecture slides
- Hilleringmann: Silizium-Halbleitertechnologie
- Schumicki, Seegebrecht: Prozesstechnologie
- Widmann, Mader: Technologie hochintegrierter Schaltungen
- Additional links to books and other material available at the webpage

Remarks
none

3.52 Elective Module: Software Quality Assurance

Module name	Software Quality Assurance / Software Quality Assurance
Workload	180 h
Credits	6 LP
Semester	• Software Quality Assurance : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Software Quality Assurance: Lecture (45h / 105h / EN / SS / 90)
Software Quality Assurance: Tutorial (30h / 0h / EN / SS / 30)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Software Quality Assurance: Programming, Modeling, Model-based software development

Content

Software Quality Assurance: The aim of the lecture is to cover approaches, technologies and strategies related to quality assurance for software systems. These include on the one hand constructive approaches such as design patterns, anti-patterns, domain-specific languages, model driven development, model quality analysis, and architectural styles, and on the other hand analytic approaches such as static reviewing techniques and dynamic testing techniques.. Furthermore, approaches for the improvement of the software development process and international standards like ISO 9001, 9126, CMM etc. are covered.

Learning objectives

The students are able to explain quality characteristics of software development processes, software models as well as software systems. They have understood constructive and analytical techniques used to ensure quality properties, and they are able to apply them. They can describe standards for measuring process and product quality. They are able to understand new research approaches in the area of process and product quality.

Implementation method

Software Quality Assurance: Partially slides and partially board writing. All essential concepts and techniques will be repeatedly applied in examples during the tutorial. In a lab part, the techniques will be employed using tools, particularly testing tools.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Gregor Engels

Learning material, literature
Software Quality Assurance: Daniel Galin: Software Quality Assurance: From Theory to Implementation, Pearson / Addison Wesley, 2004 Slides, Exercises

Remarks
none

3.53 Elective Module: Statistical and Machine Learning

Module name	Statistical and Machine Learning / Statistical and Machine Learning
Workload	180 h
Credits	6 LP
Semester	• Statistical and Machine Learning : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Statistical and Machine Learning: Lecture (30h / 120h / EN / SS / 100)
Statistical and Machine Learning: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Statistical and Machine Learning: Elementary knowledge in statistics, as is taught in the course Statistical Signal Processing, is helpful.

Content

Statistical and Machine Learning: The course on "Statistical and Machine Learning" presents an introduction into the components and algorithms prevalent in statistical pattern recognition. Both parametric and non-parametric density estimation and classification techniques will be presented, as well as supervised and unsupervised learning paradigms. The presented techniques can be applied to a variety of classification problems, both for one-dimensional input data (e.g., speech), two-dimensional (e.g., image) or symbolic input data (e.g., documents).

Learning objectives

After completion of the module students will be able to
• Choose an appropriate decision rule for a given classification problem
• Apply supervised or unsupervised learning techniques to data of various kinds and critically assess the outcome of the learning algorithms
• Work with dedicated pattern classification software (e.g., for artificial neural networks, support vector machines) on given data sets and optimize parameter settings
• Find, for a given training set size, an appropriate choice of classifier complexity and feature vector

dimensionality

Implementation method

Statistical and Machine Learning:
• Lectures predominantly using the blackboard or overhead projector, occasional presentations of (powerpoint) slides,
• Exercise classes with exercise sheets and demonstrations on computer and
• Implementation of learning and classification algorithms on a computer by the students themselves; use of algorithms on real-world data or data generated on the computer, evaluation of the simulation results

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Häb-Umbach

Learning material, literature

Statistical and Machine Learning: Course script and summary slides are provided tot he students. Exercises and solutions to exercises, as well as sample implementations of algorithms are provided to the students.
Further literature
- R.O. Duda, P.E. Hart, D.G.˜ Stork, Pattern Classification, Wiley, 2001
- K. Fukunaga, Introduction to Statistical Pattern Recognition, Academic Press, 1990

Remarks

none

3.54 Elective Module: Statistics in Measurement

Module name	Statistics in Measurement / Statistics in Measurement
Workload	180 h
Credits	6 LP
Semester	• Statistics in Measurement : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Statistics in Measurement: Lecture (30h / 120h / DE / SS / 100)
Statistics in Measurement: Tutorial (30h / 0h / DE / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Statistics in Measurement: Knowledge of module “Messtechnik” is helpful.

Content

Statistics in Measurement: The lecture discusses how random fluctuations can be treated by statistical methods, e.g., spectral analysis or correlation techniques. Errors regarding time and quantization are discussed. Practical use in communication and automation is highlighted. Accompanying exercises with lab and Matlab.

Learning objectives

Students can analyse and ascertain complex measurement tasks with stochastically varying values. They will develop own solutions. They can evaluate algorithms regarding computational efficiency, effectiveness, error behaviors and bounds.

Implementation method

Statistics in Measurement: Lecture with interactive whiteboard, homework assignments and lab exercises for practical measurement experiments.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Bernd Henning

Learning material, literature

Statistics in Measurement: Supplementary material and textbooks.

Remarks

none

3.55 Elective Module: Technology of Highly Integrated Circuits

Module name	Technology of Highly Integrated Circuits / Technology of Highly Integrated Circuits
Workload	180 h
Credits	6 LP
Semester	• Technology of Highly Integrated Circuits : 3

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Technology of Highly Integrated Circuits: Lecture (30h / 120h / EN / WS / 100)
Technology of Highly Integrated Circuits: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Technology of Highly Integrated Circuits:

Content

Technology of Highly Integrated Circuits: The course "Technology of highly integrated circuits" focuses on very large-scale integration of semiconductor devices. Starting from standard CMOS-Processing, problems of increasing the integration density and their solutions will be discussed. Here the Local Oxidation of Silicon, Silicon on Insulator and process steps for very large-scale integration are explained. Subsequently integration techniques for bipolar transistors are illustrated.

Learning objectives

After attending the course, the students will be able to
- choose Local Oxidation of Silicon method for integration of transistors and calculate layer thicknesses
- explain the integration of nano-scale transistors
- explain transistor manufracturing with SOI-Technology.
- develop processes for circuits with bipolar transistors.
- explain circuits in BiCMOS-Technology.

Implementation method

Technology of Highly Integrated Circuits:
- Lecture based on slide presentation, extensions on blackboard
- Exercises in small groups based on exercise sheets with students presenting their own solutions

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Ulrich Hilleringmann

Learning material, literature

Technology of Highly Integrated Circuits:
- Handouts of lecture slides
- Hilleringmann, U.: Silizium-Halbleitertechnologie, Teubner Verlag
- Additional links to books and other material available at the webpage

Remarks
none

3.56 Elective Module: Topics in Audio, Speech, and Language Processing

Module name	Topics in Audio, Speech, and Language Processing / Topics in Audio, Speech, and Language Processing
Workload	180 h
Credits	6 LP
Semester	• Topics in Audio, Speech, and Language Processing : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)
Topics in Audio, Speech, and Language Processing: Lecture (30h / 120h / EN / SS / 20) Topics in Audio, Speech, and Language Processing: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module
none

Course prerequisites
None

Recommended proficiencies
Topics in Audio, Speech, and Language Processing: None

Content
Topics in Audio, Speech, and Language Processing: The course “Topics in Audio, Speech, and Language Processing” highlights current research topics in audio, speech, and language processing. From the methodological side we will discuss signal processing and machine learning aspects, and in particular their interaction, which is typical for many real-world applications. The selection of topics may change from year to year. Example topics are • Multi-channel signal processing for microphone arrays • Sampling rate synchronisation • Machine learning for speech enhancement • Blind source separation for speech and audio • “Deep learning” for acoustic and language modeling in automatic speech recognition • Neural architectues für speech recognition, speech synthesis, machine translation, etc. • Natural language processing

Learning objectives

After completion of the module students
• Can assess the challenges and realized solutions of modern speech and audio processing systems
• Know the specific properties of speech, audio and language and know how those are exploited in specific signal processing and machine learning algorithms
• Understand the interplay of algorithmic performance, complexity and latency and identify appropriate operating points
• Apply the learnt signal processing and machine learning algorithms to other tasks in speech and audio processing, and beyond
• Understand current scientific literature in the field of audio, speech, and language processing and assess their importance for the field

Implementation method

Topics in Audio, Speech, and Language Processing:
• Lectures predominantly using the blackboard or overhead projector, occasional presentations of (powerpoint) slides,
• Exercise classes with exercise sheets and demonstrations on computer
• Instructions how to read and analyze scientific publications in this field
• Autonomous analysis of publications and presentation of results and gained insight

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade
The module is weighted with 6 credits.

Person responsible for the module
Prof. Dr.-Ing. Reinhold Häb-Umbach

Learning material, literature
Topics in Audio, Speech, and Language Processing: Will be distributed in the course.

Remarks
none

3.57 Elective Module: Topics in Automatic Control

Module name	Topics in Automatic Control / Topics in Automatic Control
Workload	180 h
Credits	6 LP
Semester	• Topics in Automatic Control : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)
Topics in Automatic Control: Lecture (30h / 120h / EN / WS oder SS / 20) Topics in Automatic Control: Tutorial (30h / 0h / EN / WS oder SS / 20)

Choices in Module
none

Course prerequisites
none

Recommended proficiencies
Topics in Automatic Control:

Content
Topics in Automatic Control: This course covers a selection of current topics in systems control and requires active student participation throughout. For that purpose, students will be given support with reading, analyzing and expanding results in recent papers from the systems control literature. The choice of topics depends upon current research interests and changes every semester. Example Topics: • Networked Control Systems • Security and Privacy of Dynamical Systems • Model Predictive Control • Learning and Control

Learning objectives
In this course, students will familiarize themselves with some current research topics in automatic control. They will learn to read and understand scientific publications and to critically evaluate results.

Implementation method

Topics in Automatic Control:
- Lecture with student participation
- Student presentations

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Daniel E. Quevedo

Learning material, literature

Topics in Automatic Control: References will be given during first lecture.

Remarks
none

3.58 Elective Module: Topics in Pattern Recognition and Machine Learning

Module name	Topics in Pattern Recognition and Machine Learning / Topics in Pattern Recognition and Machine Learning
Workload	180 h
Credits	6 LP
Semester	• Topics in Pattern Recognition and Machine Learning : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Topics in Pattern Recognition and Machine Learning: Lecture (30h / 120h / EN / WS / 20)
Topics in Pattern Recognition and Machine Learning: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

This is an advanced course! For a successful participation it is required that you have already basic knowledge in statistical methods and machine learning. If you are new to the field, please attend first a basic course on machine learning, such as the course "Statistical and Machine Learning" (L.048.92005) offered by myself in the summer semester, and then come back to this course on Topics in Pattern Recognition and Machine Learning next winter term!

Recommended proficiencies

Topics in Pattern Recognition and Machine Learning: Elementary knowledge in Probability Theroy, as is taught in the course Statistical Signal Processing. Basic knowledge in statistical and machine learning.

Content

Topics in Pattern Recognition and Machine Learning: The course on "Topics in Pattern Recognition and Machine Learning" first briefly summarizes the main concepts of statistical pattern recognition and machine learning. Next selected topics will be presented in detail. The choice of topics depends on current research activities and thus may change over time. Examples of such topics to be studied in detail include
• Model estimation in the presence of hidden variables, in order to reveal suspected latent structure buried in the data
• Bias-Variance dilemma and the tradeoff between degree of detail and generalizability of models
• Grafical models

• Sequential data and hidden Markov models
• Specific classification tasks, such as automatic speech recognition
While the first part of the course will follow a regular lecture format, the second part will include active student participation. Students will be asked to read, analyze and present recently published papers from the pattern recognition and machine learning literature. This will often also include the implementation of proposed algorithms in Matlab.

Learning objectives

After completion of the module students will be able to
• Choose an appropriate classifier for a given classification problem and be able to learn the parameters of the classifier from training data
• Choose an appropriate regression method for function approximation and learn its parameters from training data
• Search for latent variables and structure in given data
• Make an informative choice for the model order to find a good compromise between degree of detail and generalizabliliy
• Comprehend and analyze recent publications from the field of pattern recognition and machine learning

Implementation method

Topics in Pattern Recognition and Machine Learning:
• Lectures predominantly using the blackboard or overhead projector, occasional presentations of (powerpoint) slides,
• Exercise classes with exercise sheets and demonstrations on computer
• Instructions how to read and analyze scientific publications in this field
• Autonomous analysis of publications and presentation of results and gained insight

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Häb-Umbach

Learning material, literature

Topics in Pattern Recognition and Machine Learning: Literature
- R.O. Duda, P.E. Hart, D.G. Stork, Pattern Classification, Wiley, 2001
- K. Fukunaga, Introduction to Statistical Pattern Recognition, Academic Press, 1990
- C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006

Remarks

none

3.59 Elective Module: Topics in Signal Processing

Module name	Topics in Signal Processing / Topics in Signal Processing
Workload	180 h
Credits	6 LP
Semester	• Topics in Signal Processing : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Topics in Signal Processing: Lecture (30h / 120h / EN / WS / 20)
Topics in Signal Processing: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Topics in Signal Processing: Signal and system theory, at least a basic understanding of probability and linear algebra

Content

Topics in Signal Processing: This course covers a selection of current topics in signal processing. One part of this course will follow a regular lecture format, while the other part will require student participation. The course will first review relevant aspects of linear algebra and probability theory. Then students will learn how to read, analyze, and present recent papers from the signal processing literature.

Learning objectives

In this course, students will familiarize themselves with some current research topics in signal processing. They will learn to read and understand scientific publications and to critically evaluate results.

Implementation method

Topics in Signal Processing:
• Lecture with student participation

- Student presentations

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Peter Schreier

Learning material, literature

Topics in Signal Processing: References will be given during first lecture.

Remarks

none

3.60 Elective Module: Ultrasonic Measurement Technology

Module name	Ultrasonic Measurement Technology / Ultrasonic Measurement Technology
Workload	180 h
Credits	6 LP
Semester	• Ultrasonic Measurement Technology : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Ultrasonic Measurement Technology: Lecture (30h / 120h / DE / SS / 100)
Ultrasonic Measurement Technology: Tutorial (30h / 0h / DE / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Ultrasonic Measurement Technology: None

Content

Ultrasonic Measurement Technology: Mechanical waves in solids, fluids, gases. Main acoustic measurement principles. Applications for ultrasound tomography.

Learning objectives

This module treats mechanicals waves in solids, fluids, and gases. Main acoustic measurement principles and their application in industry are explained. Students will be able to apply ultrasound-based measurement techniques to determine both acoustic and non-acoustic properties.

Implementation method

Ultrasonic Measurement Technology: Lectures with slides; practical work in small groups.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Bernd Henning

Learning material, literature

Ultrasonic Measurement Technology: Script and textbooks.

Remarks

none

3.61 Elective Module: Vehicular Networking

Module name	Vehicular Networking / Vehicular Networking
Workload	180 h
Credits	6 LP
Semester	• Vehicular Networking : arbitrary

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)
Vehicular Networking: Lecture (45h / 105h / EN / SS / 40) Vehicular Networking: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module
none

Course prerequisites
none

Recommended proficiencies
Vehicular Networking: System software and system-level programming

Content
Vehicular Networking: Today's automotive industry is increasingly relying on computer science in product innovation. Young professionals are expected to have specialized knowledge in the fields of electronics, software and vehicular networks – both in-car networks and networks of moving cars. This lecture teaches important concepts from these domains, starting with in-car networks (from individual electronic control units, modern bus systems, system and network architectures, to driver assistance functions, security and safety). The lecture then moves to networks of moving cars (from communication technology and system architectures, to the design of advanced traffic information systems, security and safety). Particular emphasis is given to the relevant question of balancing users' privacy with their safety and security.

Learning objectives
The learning objective is to unserstand the fundamental concepts of vehicular networking. Students understand these concepts and are able to apply this knowledge.

Implementation method

Vehicular Networking: Lecture with practical exercises

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

Qualifying Participation: written exercises
The responsible lecturer announces the requirements for course achievements in the first three weeks of the lecture period at latest.

Prerequisites for participation in module exam

Passing of course achievement.

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Falko Dressler

Learning material, literature

Vehicular Networking: Slides, textbooks, papers

Remarks
none

3.62 Elective Module: Video Technology

Module name	Video Technology / Video Technology
Workload	180 h
Credits	6 LP
Semester	• Video Technology : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Video Technology: Lecture (30h / 120h / DE / SS / 100)
Video Technology: Tutorial (30h / 0h / DE / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Video Technology: Prior knowledge from the modules Higher Mathematics, Digital Signal Processing and Transmission Techniques is helpful.

Content

Video Technology: The course "Video Technology" gives an introduction to the basic techniques and theories of taking , processing and reproduction of motion pictures and transmitting them via analogue and digital links. Starting with the basics of scanning necessary bandwidth and standards of intended systems are discussed. Depending on the colour vision system of the human eye science of colour and analogue and digital colour coding are described.
Electronic camera systems and modern reproduction sets complements the theory.
Digital picture transmission systems combined with data reduction (MPEG) are the main emphasis of modern transmission like DVB (Digital Video Broadcasting).
Video tape recording (VTR), optical (DVD) and electrical picture storing systems are described. New 3 dimensional picture taking and viewing will be shown.

Learning objectives

After attending the course, the students will be able to
- analyze tasks in the field of basics of picture scannings and to formulate requirements mathematically,
- describing of picture data reduction systems

- declaring picture transmission systems.
- describing basic principles of color

The students
- are able to check theoretical results using practical realizations,
- are able to undertake theoretical approaches a systematic analysis using methodical procedures and
- are, due to the precise treatment of the contents, in a position to continue their learning themselves

Implementation method

Video Technology:
- Lectures using the blackboard and presentations,
- Alternating theoretical and practical exercise classes with blackboard
- Demonstration of real technical systems in the lecture hall.

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Häb-Umbach

Learning material, literature

Video Technology:
- Schönfelder, H, Fernsehtechnik im Wandel, Springer Verlag, Heidelberg 1996
- Schiller, Martin et.al , INTERNET: Werkzeuge und Dienste, Springer Verlag, Berlin 1994
- Mäusl, R. , Digitale Modulationsverfahren, Hüthig-Verlag, Heidelberg 1985
- Schönfelder, H., Bildkommunikation, Springer Verlag, Heidelberg 1988
- Jens-Rainer Ohm, Digitale Bildcodierung, Springer Verlag, Berlin 1995
- Reimers, U. (Hrsg.), Digitale Fernsehtechnik (4. Auflage), Datenkompression und Übertragung für DVB, Springer Verlag, Berlin 1995 / 2008
- Hentschel, H.J., Theorie und Praxis der Lichttechnik, Hüthig-Verlag, Heidelberg 1982
- Lang, H., Farbmetrik und Farbensehen, Oldenbourg Verlag, München 1978
- Tauer, Holger, Stereo 3D: Grundlagen, Technik und Bildgestaltung, Verlag Schiele & Schön, Berlin 2011

Remarks

none

3.63 Elective Module: VLSI Testing

Module name	VLSI Testing / VLSI Testing
Workload	180 h
Credits	6 LP
Semester	• VLSI Testing : 1

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

VLSI Testing: Lecture (30h / 120h / EN / WS / 40)
VLSI Testing: Tutorial (30h / 0h / EN / WS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

VLSI Testing: Digital Design

Content

VLSI Testing: The course "VLSI Testing" focuses on techniques for detecting hardware defects in microelectronic circuits. Algorithms for test data generation and test response evaluation as well as hardware structures for design for test (DFT) and on-chip test implementation (BIST) are presented.

Learning objectives

After attending the course, the students will be able to
- describe fault models, DFT techniques, and test tools,
- explain and apply the underlying models and algorithms for fault simulation and test generation,
- analyze systems with respect to their testability and to derive appropriate test strategies.

Implementation method

VLSI Testing:
- Lecture based on slide presentation, extensions on blackboard

- Exercises in small groups based on exercise sheets with students presenting their own solutions
- Hands-on exercises using various software tools

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr. Sybille Hellebrand

Learning material, literature

VLSI Testing:
- Handouts of lecture slides
- M. L. Bushnell, V. D. Agrawal, Essentials of Electronic Testing for Digital, Memory & Mixed-Signal VLSI Circuits, Boston, Dordrecht, London: Kluwer Academic Publishers, 2000
- L.-T. Wang, C.-W. Wu, X. Wen, VLSI Test Principles and Architectures: Design for Testability, Morgan Kaufmann Series in Systems on Silicon, ISBN: 0123705975
- Additional links to books and other material available in koala

Remarks
none

3.64 Elective Module: Wireless Communications

Module name	Wireless Communications / Wireless Communications
Workload	180 h
Credits	6 LP
Semester	• Wireless Communications : 2

Course: Teaching Form (Contact hours / Self study / Language / Date / Group size)

Wireless Communications: Lecture (30h / 120h / EN / SS / 100)
Wireless Communications: Tutorial (30h / 0h / EN / SS / 20)

Choices in Module

none

Course prerequisites

none

Recommended proficiencies

Wireless Communications: Elementary knowledge digital communications, as is taught in Bachelor studies of Electrical Engineering or related disciplines, are helpful.

Content

Wireless Communications: The course on "Wireless Communications" presents an introduction to the principles and techniques for reliable communication over time and/or frequency selective fading channels. The course starts with a detailed discussion of the physical and statistical modeling of wireless communication channels. Next, the most important transmission and receiver techniques will be described, including
• Time diversity: maximum ratio combiner, error rate computation for coherent and incoherent detection, interleaving
• Antenna diversity: tranmit diversity, receive diversity and MIMO techniques
• Frequency diversity: single carrier transmission with sequence detection, direct sequence spread spectrum, multi-carrier techniques
Emphasis will be given on an intuitive understanding of receiver principles from a linear vector space point of view.
Further, an introduction to current cellular systems will be provided: GSM, UMTS and LTE.

Learning objectives

After completion of the module students will be able to
• Develop a discrete-time statistical channel model for a given physical description of a wireless communication channel
• Explain the techniques and algorithms used in the Physical Layer of a wireless communication system
• Understand the fundamental design options an decisions taken to realize reliable communication over time variant and frequency selective or nonselective fading channels
• Appreciate and categorize the techniques used in modern cellular communication systems to realize reliable communication
• Trade off the advantages and disadvantages of different transmission techniques with respect to bandwidth and power efficiency as well as number of users to be served
• Select and design an appropriate transmission technique for a wireless channel
• simulate and analyze simple communication systems using modern software tools
The students
• Can transfer and apply the concept of linear vector spaces to signal processing tasks other than for wireless communications
• Can apply the skills about the generation of data, simulation of systems and analysis of experimental results using modern software tools, that have been acquired in this course, to other disciplines
• Can work cooperatively in a team and subdivide an overall task into manageable subtasks and work packages

Implementation method

Wireless Communications:
• Lectures predominantly using the blackboard or overhead projector, as well as presentations of (powerpoint) slides ,
• Exercise classes with exercise sheets and demonstrations on computer and
• Implementation of discrete-time channel models and building blocks of a wireless communication system using modern software tools; evaluation and presentation of the simulation results

Assessment modalities (duration)

Oral exam (ca. 40 Minutes)
The responsible lecturer announces type and duration of assessment modalities in the first three weeks of the lecture period at latest.

Partial module exams

none

Course achievement / qualifying participation

none

Prerequisites for participation in module exam

none

Prerequisites for obtaining credits

Passing of module exam.

Weight for overall grade

The module is weighted with 6 credits.

Person responsible for the module

Prof. Dr.-Ing. Reinhold Häb-Umbach

Learning material, literature

Wireless Communications: Course script and summary slides are provided to the students. Exercises and solutions to exercises, as well as sample implementations of algorithms are provided to the students. Further literature

- D. Tse and P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.
- K.-D. Kammeyer, Nachrichtenübertragung, Teubner, 2004.

Remarks

none

Appendix A

Summary Tables

A.1 Focus Areas and Modules

	Communication and Networks (S. 12)	Computer Systems (S. 14)	Control and Automation (S. 15)	Embedded Systems (S. 16)	Nano/Microelectronics (S. 17)	Signal, Image and Speech Processing (S. 18)
Abschlussarbeit (S. 91)	-	-	-	-	-	-
Advanced Control (S. 20)	-	-	X	-	-	-
Advanced Distributed Algorithms and Data Structures (S. 23)	X	-	-	-	-	-
Advanced System Theory (S. 26)	-	-	X	-	-	X
Advanced Topics in Robotics (S. 29)	-	-	X	-	-	-
Advanced VLSI Design (S. 32)	-	-	-	X	X	-
Algorithms and Tools for Test and Diagnosis of Systems on Chip (S. 34)	-	X	-	X	X	-
Algorithms for Synthesis and Optimization of Integrated Circuits (S. 37)	-	X	-	X	-	-

	Communication and Networks (S. 12)	Computer Systems (S. 14)	Control and Automation (S. 15)	Embedded Systems (S. 16)	Nano/Microelectronics (S. 17)	Signal, Image and Speech Processing (S. 18)
Approximate Computing (S. 40)	-	X	-	X	-	-
Architektur paralleler Rechnersysteme (S. 43)	-	X	-	X	-	-
Biomedizinische Messtechnik (S. 45)	-	-	X	-	-	-
Cooperative Mobile Systems (S. 59)	X	-	-	X	-	-
Databases and Information Systems (S. 62)	-	X	-	-	-	-
Digital Image Processing I (S. 65)	-	-	-	-	-	X
Digital Image Processing II (S. 68)	-	-	-	-	-	X
Digitale Sprachsignalverarbeitung (S. 71)	-	-	-	-	-	X
Dynamic Programming and Stochastic Control (S. 74)	-	-	X	-	-	-
Einführung in die Hochfrequenztechnik (S. 115)	-	-	-	-	X	-
Elektrotechnik I (S. 77)	-	-	-	-	-	-
Elektrotechnik II (S. 80)	-	-	-	-	-	-
Empiric performance evaluation (S. 83)	X	X	-	-	-	-
Foundations of Cryptography (S. 94)	X	-	-	-	-	-
Future Internet (S. 97)	X	-	-	-	-	-
Gergelte Drehstromantriebe (S. 56)	-	-	X	-	-	-
Halbleiterprozesstechnik (S. 161)	-	-	-	-	X	-
Hardware/Software Codesign (S. 100)	-	X	-	X	-	-
High Frequency Engineering (S. 103)	-	-	-	-	X	-
High-Performance Computing (S. 106)	-	X	-	-	-	-
Informatik I (S. 51)	-	-	-	-	-	-
Informatik II (S. 53)	-	-	-	-	-	-

	Communication and Networks (S. 12)	Computer Systems (S. 14)	Control and Automation (S. 15)	Embedded Systems (S. 16)	Nano/Microelectronics (S. 17)	Signal, Image and Speech Processing (S. 18)
Integrierte Schaltungen für die drahtlose Kommunikation (S. 109)	X	-	-	X	X	-
Intelligence in Embedded Systems (S. 112)	-	X	-	X	-	-
Kognitive Sensorsysteme (S. 47)	-	-	-	-	-	X
Machine Learning I (S. 118)	-	-	-	-	-	X
Machine Learning II (S. 121)	-	-	-	-	-	X
Messstochastik (S. 170)	-	-	-	-	-	X
Mobile Communication (S. 124)	X	-	-	-	-	-
Model-Driven Software Development (S. 127)	-	-	-	X	-	-
Network Simulation (S. 129)	X	-	-	X	-	-
Optical Communication A (S. 131)	X	-	-	-	-	-
Optical Communication B (S. 134)	X	-	-	-	-	-
Optical Communication C (S. 137)	X	-	-	-	-	-
Optimale und adaptive Filter (S. 140)	X	-	-	-	-	X
Projektgruppe (S. 143)	-	-	-	-	-	-
Reconfigurable Computing (S. 146)	-	X	-	X	-	-
Reinforcement Learning (S. 149)	-	-	X	-	-	-
Robotics (S. 152)	-	-	X	-	-	-
Routing and Data Management in Networks (S. 155)	X	-	-	-	-	-
Schnelle integrierte Schaltungen für die leitungsgebundene Kommunikation (S. 88)	X	-	-	X	X	-
Software Quality Assurance (S. 164)	-	-	-	X	-	-
Statistische und maschinelle Lernverfahren (S. 167)	-	-	-	-	-	X

	Communication and Networks (S. 12)	Computer Systems (S. 14)	Control and Automation (S. 15)	Embedded Systems (S. 16)	Nano/Microelectronics (S. 17)	Signal, Image and Speech Processing (S. 18)
Technische kognitive Systeme (S. 49)	-	-	-	-	-	X
Technologie hochintegrierter Schaltungen (S. 172)	-	-	-	-	X	-
Topics in Audio, Speech, and Language Processing (S. 175)	-	-	-	-	-	X
Topics in Automatic Control (S. 178)	-	-	X	-	-	-
Topics in Pattern Recognition and Machine Learning (S. 181)	-	-	-	-	-	X
Topics in Signal Processing (S. 184)	X	-	-	-	-	X
Ultraschall-Messtechnik (S. 186)	-	-	X	-	-	-
Umweltmesstechnik (S. 86)	-	-	X	-	-	-
Vehicular Networking (S. 188)	X	-	-	X	-	-
Videotechnik (S. 191)	-	-	-	-	-	X
VLSI Testing (S. 194)	-	X	-	X	X	-
Wireless Communications (S. 197)	X	-	-	-	-	X
Wissenschaftliches Arbeiten (S. 158)	-	-	-	-	-	-