# School of Electrical Engineering, Computer Science and Mathematics

Study Packages for exchange incoming students of the School of Electrical Engineering, Computer Science and Mathematics

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School of Electrical Engineering, Computer Science and Mathematics

TUHH
Hamburg University of Technology

Elektrotechnik
Informatik
Mathematik

# Overview of the study packages

## Study Package Computer Science BS – Bachelor Summerterm

| Modul | ECTS | Lecturer |
|---|---|---|
| **Compiler Construction** | 6 | Prof. Sybille Schupp |
| **Embedded Systems** | 6 | Prof. Heiko Falk |
| **Software Development** | 6 | Prof. Sybille Schupp |
| **Software Engineering** | 6 | Prof. Sybille Schupp |
| **Startup Engineering I - Basics** | 2 | Prof. Christoph Ihl |
| **German as a foreign Language** | 4 | Dagmar Richter |

## Study Package Computer Science BW – Bachelor Winterterm

| Modul | ECTS | Lecturer |
|---|---|---|
| **Computer Architecture** | 6 | Prof. Heiko Falk |
| **Computernetworks and Internet Security** | 6 | Prof. Andreas Timm-Giel |
| **Functional Programming** | 6 | Prof. Sybille Schupp |
| **Introduction to Information Security** | 6 | Prof. Dieter Gollmann |
| **German as a foreign Language** | 4 | Dagmar Richter |
| **Ethics for Engineers** | 2 | Gunnar Jeremias |

## Study Package Computer Science MS1 – Master Summerterm

| Modul | ECTS | Lecturer |
|---|---|---|
| **Application Security** | 6 | Prof. Dieter Gollmann |
| **Software for Embedded Systems** | 6 | Prof. Christian Renner |
| **Software Testing** | 6 | Prof. Sibylle Schupp |
| **Computer Graphics** | 6 | Prof. Tobias Knopp |
| **Artificial Intelligence and Robotics: Historical Development and Present State (Seminar)** | 2 | Prof. Hans-Joachim Braun |
| **German as a foreign Language** | 4 | Dagmar Richter |

## Study Package Computer Science MS2 – Master Summerterm

| Modul | ECTS | Lecturer |
|---|---|---|
| **Simulation of Communication Networks** | 6 | Prof. Andreas Timm-Giel |
| **Compilers for Embedded Systems** | 6 | Prof. Heiko Falk |
| **Design of Dependable Systems** | 6 | Prof. Görschwin Fey |
| **Pattern Recognition and Data Compression** | 6 | Prof. Rolf-Rainer Grigat |
| **“What’s up, Doc?” Science and Stereotypes in Literature and Film** | 2 | Dr. Jennifer Henke |
| **Cradle to Cradle: material cycles** | 2 | Dr. Tanja Scheelhaase |
| **Intercultural Management - Theory and Awareness Training** | 2 | Prof Jürgen Rothlauf |

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## Study Package Computer Science WS1 – Master Winterterm

| Modul | ECTS | Lecturer |
|---|---|---|
| **Communication Networks** | 6 | Prof. Andreas Timm-Giel |
| **Soft Computing – Introduction to Machine Learning** | 6 | Prof. Karl-Heinz Zimmer-mann |
| **Advanced System-on-Chip Design** | 6 | Prof. Heiko Falk |
| **Software Security** | 6 | Prof. Dieter Gollmann |
| **German as a foreign Language** | 4 | Dagmar Richter |
| **Artificial Intelligence and Robotics: Historical Development and Present State (Seminar)** | 2 | Prof. Hans-Joachim Braun |

## Study Package Computer Science WS2 – Master Winterterm

| Modul | ECTS | Lecturer |
|---|---|---|
| **Intelligent Systems in Medicine** | 6 | Prof. Alexander Schlaefer |
| **Soft-Computing – Introduction to Machine Learning** | 6 | Prof. Karl-Heinz Zimmer-mann |
| **Intelligent Autonomous Agents and Cognitive Robotics** | 6 | Rainer Marrone |
| **Distributed Algorithms** | 6 | Prof. Volker Turau |
| **Seminar Medical Technology** | 2 | Prof. Alexander Schlaefer |
| **Introduction to the Science & Technology Studies** | 2 | Simon Egbert |
| **Intercultural Communication** | 2 | Prof. Margarete Jarchow |

## Study Package Electrical Engineering MS1 – Master Summerterm

| Modul | ECTS | Lecturer |
|---|---|---|
| **Semiconductor Technology** | 6 | Prof. Hoc Khiem Trieu |
| **EMC I: Coupling Mechanisms, Countermeasures and Test Pro-cedures** | 6 | Prof. Christian Schuster |
| **Information Theory and Coding** | 6 | Prof. Gerhard Bauch |
| **Optimal and Robust Control** | 6 | Prof. Herbert Werner |
| **Intercultural Management - Theory and Awareness Training** | 2 | Prof. Jürgen Rothlauf |
| **German as a foreign Language** | 4 | Dagmar Richter |

## Study Package Electrical Engineering MS2 – Master Summerterm

| Modul | ECTS | Lecturer |
|---|---|---|
| **Bioelectromagnetics: Principles and Applications** | 6 | Prof. Christian Schuster |
| **Linear and Nonlinear System Identifikation** | 3 | Prof. Herbert Werner |
| **Fibre and Integrated Optics** | 6 | Prof. Dr. Manfred Eich |
| **Optical Communications** | 4 | Dr. Hagen Renner |
| **Introduction to the Science & Technology Studies** | 2 | Simon Egbert |
| **Intercultural Communication** | 2 | Prof. Margarete Jarchow |
| **Creative Processes in Technology, Music and the Arts** | 2 | Prof. Hans-Joachim Braun |

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| Study Package Electrical Engineering MW1 – Master Winterterm | | |
|---|---|---|
| **Modul** | ECTS | Lecturer |
| **Advanced Topics in Control** | 6 | Prof. Herbert Werner |
| **Integrated Circuit Design** | 6 | Prof. Matthias Kuhl |
| **EMC II: Signal Integrity and Power Supply of Electronic Systems** | 6 | Prof. Christian Schuster |
| **Control Lab** | 4 | Prof. Herbert Werner |
| **German as a foreign Language** | 4 | Dagmar Richter |
| **Cradle to Cradle: material cycles** | 2 | Dr. Tanja Scheelhaase |

| Study Package Electrical Engineering MW2 – Master Winterterm | | |
|---|---|---|
| **Modul** | ECTS | Lecturer |
| **Mixed-Signal Circuit Design** | 6 | Prof. Matthias Kuhl |
| **Electronic Circuits for Medical Applications** | 6 | Prof. Matthias Kuhl |
| **Microsystem Engineering** | 6 | Prof. Manfred Kasper |
| **Integrated Circuit Design** | 6 | Prof. Matthias Kuhl |
| **Seminar Medical Technology** | 2 | Prof. Alexander Schlaefer |
| **Intercultural Management - Theory and Awareness Training** | 2 | Prof. Jürgen Rothlauf |
| **Artificial Intelligence and Robotics: Historical Development and Present State (Seminar)** | 2 | Prof. Hans-Joachim Braun |

Alternatively, one module in each study package can be substituted with:

- 2 Nontechnical Elective Complementary Courses (each 2 ECTS) or 1 language course of 4 ECTS

and

- 1 course of Business and Management (2ECTS)

# Study Package Computer Science BS – Bachelor Summer-term

## Compiler Construction | 6 ECTS

### Recommended Previous Knowledge

Practical programming experience, Automata theory and formal languages, Functional programming or procedural programming, Object-oriented programming, algorithms, and data structures, Basic knowledge of software engineering

### Theoretical Knowledge

Students explain the workings of a compiler and break down a compilation task in different phases. They apply and modify the major algorithms for compiler construction and code improvement. They can re-write those algorithms in a programming language, run and test them. They choose appropriate internal languages and representations and justify their choice. They explain and modify implementations of existing compiler frameworks and experiment with frameworks and tools.

### Capabilities

Students design and implement arbitrary compilation phases. They integrate their code in existing compiler frameworks. They organize their compiler code properly as a software project. They generalize algorithms for compiler construction to algorithms that analyze or synthesize software.
Students develop the software in a team. They explain problems and solutions to their team members. They present and defend their software in class. They communicate in English.

## Embedded Systems | 6 ECTS

### Recommended Previous Knowledge

Computer Engineering

### Theoretical Knowledge

Embedded systems can be defined as information processing systems embedded into enclosing products. This course teaches the foundations of such systems. In particular, it deals with an introduction into these systems (notions, common characteristics) and their specification languages (models of computation, hierarchical automata, specification of distributed systems, task graphs, specification of real-time applications, translations between different models). Another part covers the hardware of embedded systems: Sensors, A/D and D/A converters, real-time capable communication hardware, embedded processors, memories, energy dissipation, reconfigurable logic and actuators. The course also features an introduction into real-time operating systems, middleware and real-time scheduling. Finally, the implementation of embedded systems using hardware/software co-design (hardware/software partitioning, high-level transformations of specifications, energy-efficient realizations, compilers for embedded processors) is covered.

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### Capabilities

After having attended the course, students shall be able to realize simple embedded systems. The students shall realize which relevant parts of technological competences to use in order to obtain a functional embedded system. In particular, they shall be able to compare different models of computations and feasible techniques for systemlevel design. They shall be able to judge in which areas of embedded system design specific risks exist.

## Software Development | 6 ECTS

### Recommended Previous Knowledge

Introduction to Software Engineering, Programming Skills, Experience with Developing Small to Medium-Size Programs

### Theoretical Knowledge

Students explain the fundamental concepts of agile methods, describe the process of test-driven development, and explain how continuous integration can be used in different scenarios. They give examples of selected pitfalls in software development, regarding scalability and other non-functional requirements. They write unit tests and build scripts and combine them in a corresponding integration environment. They explain major activities in requirements analysis, program comprehension, and agile project development.

### Capabilities

For a given task on a legacy system, students identify the corresponding parts in the system and select an appropriate method for understanding the details. They choose the proper approach of splitting a task in independent testable and extensible pieces and, thus, solve the task with proper methods for quality assurance. They design tests for legacy systems, create automated builds, and find errors at different levels. They integrate the resulting artifacts in a continuous development environment.

## Software Engineering | 6 ECTS

### Recommended Previous Knowledge

Automata theory and formal languages, Procedural programming or Functional programming, Object-oriented programming, algorithms, and data structures

### Theoretical Knowledge

Students explain the phases of the software life cycle, describe the fundamental terminology and concepts of software engineering, and paraphrase the principles of structured software development. They give examples of software-engineering tasks of existing large-scale systems. They write test cases for different test strategies and devise specifications or models using different notations, and critique both. They explain simple design patterns and the major activities in requirements analysis, maintenance, and project planning.

### Capabilities

For a given task in the software life cycle, students identify the corresponding phase and select an appropriate method. They choose the proper approach for quality assurance. They design tests for realistic systems, assess the quality of the tests, and find errors at different levels. They apply and modify non-executable artifacts. They integrate components based on interface specifications.

# Study Package Computer Science BW – Bachelor Winterterm

## Computer Architecture | 6 ECTS

### Recommended Previous Knowledge

Computer Engineering

### Theoretical Knowledge

This module presents advanced concepts from the discipline of computer architecture. In the beginning, a broad overview over various programming models is given, both for general-purpose computers and for special-purpose machines (e.g., signal processors). Next, foundational aspects of the micro-architecture of processors are covered. Here, the focus particularly lies on the so-called pipelining and the methods used for the acceleration of instruction execution used in this context. The students get to know concepts for dynamic scheduling, branch prediction, superscalar execution of machine instructions and for memory hierarchies.

### Capabilities

The students are able to describe the organization of processors. They know the different architectural principles and programming models. The students examine various structures of pipelined processor architectures and are able to explain their concepts and to analyze them w.r.t. criteria like, e.g., performance or energy efficiency. They evaluate different structures of memory hierarchies, know parallel computer architectures and are able to distinguish between instruction- and data-level parallelism.

## Computernetworks and Internet Security | 6 ECTS

### Recommended Previous Knowledge

Basics of Computer Science

### Theoretical Knowledge

Students are able to explain important and common Internet protocols in detail and classify them, in order to be able to analyze and develop networked systems in further studies and job.

### Capabilities

Students are able to analyze common Internet protocols and evaluate the use of them in different domains.

## Functional Programming | 6 ECTS

### Recommended Previous Knowledge

Discrete mathematics at high-school level

### Theoretical Knowledge

Students apply the principles, constructs, and simple design techniques of functional programming. They demonstrate their ability to read Haskell programs and to explain Haskell syntax as well as Haskell's read-eval-print loop. They interpret warnings and find errors in programs. They apply the fundamental data structures, data types, and type constructors. They employ strategies for unit tests of functions and simple proof techniques for partial and total correctness. They distinguish laziness from other evaluation strategies.

### Capabilities

Students break a natural-language description down in parts amenable to a formal specification and develop a functional program in a structured way. They assess different language constructs, make conscious selections both at specification and implementations level, and justify their choice. They analyze given programs and rewrite them in a controlled way. They design and implement unit tests and can assess the quality of their tests. They argue for the correctness of their program.

## Introduction to Information Security | 6 ECTS

### Recommended Previous Knowledge

Basics of Computer Science

### Theoretical Knowledge

Students can

name the main security risks when using Information and Communication Systems and name the fundamental security mechanisms, describe commonly used methods for risk and security analysis, name the fundamental principles of data protection.

### Capabilities

Students can

evaluate the strengths and weaknesses of the fundamental security mechanisms and of the commonly used methods for risk and security analysis, apply the fundamental principles of data protection to concrete cases.

# Study Package Computer Science MS1 – Master Summer-term

## Application Security | 6 ECTS

### Recommended Previous Knowledge

Familiarity with Information security, fundamentals of cryptography, Web protocols and the architecture of the Web

### Theoretical Knowledge

Students can name current approaches for securing selected applications, in particular of web applications

### Capabilities

Students are capable of performing a security analysis, developing security solutions for distributed applications, recognizing the limitations of existing standard solutions

## Software for Embedded Systems | 6 ECTS

### Recommended Previous Knowledge

Good knowledge and experience in programming language C, Basis knowledge in software engineering, Basic understanding of assembly language

### Theoretical Knowledge

Students know the basic principles and procedures of software engineering for embedded systems. They are able to describe the usage and pros of event based programming using interrupts. They know the components and functions of a concrete microcontroller. The participants explain requirements of real time systems. They know at least three scheduling algorithms for real time operating systems including their pros and cons.

### Capabilities

Students build interrupt-based programs for a concrete microcontroller. They build and use a preemptive scheduler. They use peripheral components (timer, ADC, EEPROM) to realize complex tasks for embedded systems. To interface with external components they utilize serial protocols.

## Software Testing | 6 ECTS

### Recommended Previous Knowledge

Software Engineering, Higher Programming Languages, Object-Oriented Programming, Algorithms and Data Structures, Experience with (Small) Software Projects, Statistics

### Theoretical Knowledge

Students explain the different phases of testing, describe fundamental techniques of different types of testing, and paraphrase the basic principles of the corresponding test process. They give examples of software development scenarios and the corresponding test type and technique. They explain algorithms used for particular testing techniques and describe possible advantages and limitations.

### Capabilities

Students identify the appropriate testing type and technique for a given problem. They adapt and execute respective algorithms to execute a concrete test technique properly. They interpret testing results and execute corresponding steps for proper re-test scenarios. They write and analyze test specifications. They apply bug finding techniques for non-trivial problems.

## Computer Graphics | 6 ECTS

### Recommended Previous Knowledge

Students are expected to have a solid knowledge of object-oriented programming as well as of linear algebra and geometry.

### Theoretical Knowledge

Students have acquired a theoretical basis in computer graphics and have a clear understanding of the process of computer animation.

### Capabilities

Students have acquired solid skills in modelling and shading, solid skills in computer animation techniques, and a thorough command of Maya, a first-class animation system.

# Study Package Computer Science MS2 – Master Summer-term

## Simulation of Communication Networks | 6 ECTS

### Recommended Previous Knowledge

Knowledge of computer and communication networks, Basic programming skills

### Theoretical Knowledge

Students are able to explain the necessary stochastics, the discrete event simulation technology and modelling of networks for performance evaluation.

### Capabilities

Students are able to apply the method of simulation for performance evaluation to different, also not practiced, problems of communication networks. The students can analyze the obtained results and explain the effects observed in the network. They are able to question their own results.

## Compilers for Embedded Systems | 6 ECTS

### Recommended Previous Knowledge

Module "Embedded Systems", C/C++ Programming skills

### Theoretical Knowledge

The relevance of embedded systems increases from year to year. Within such systems, the amount of software to be executed on embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application areas of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized processors impose high demands on compilers which have to generate code of highest quality. After the successful attendance of this course, the students are able to illustrate the structure and organization of such compilers, to distinguish and explain intermediate representations of various abstraction levels, and to assess optimizations and their underlying problems in all compiler phases.
The high demands on compilers for embedded systems make effective code optimizations mandatory. The students learn in particular, which kinds of optimizations are applicable at the source code level, how the translation from source code to assembly code is performed, which kinds of optimizations are applicable at the assembly code level, how register allocation is performed, and how memory hierarchies can be exploited effectively. Since compilers for embedded systems often have to optimize for multiple objectives (e.g., average- or worst-case execution time, energy dissipation, code size), the students learn to evaluate the influence of optimizations on these different criteria.

### Capabilities

After successful completion of the course, students shall be able to translate high-level program code into machine code. They will be enabled to assess which kind of code optimization should be applied most effectively at which abstraction level (e.g., source or assembly code) within a compiler.
While attending the labs, the students will learn to implement a fully functional compiler including optimizations.

## Design of Dependable Systems | 6 ECTS

### Recommended Previous Knowledge

Basic knowledge about data structures and algorithms

### Theoretical Knowledge

In the following "dependable" summarizes the concepts Reliability, Availability, Maintainability, Safety and Security. Knowledge about approaches for designing dependable systems, e.g. Structural solutions like modular redundancy, Algorithmic solutions like handling byzantine faults or checkpointing, Knowledge about methods for the analysis of dependable systems.

### Capabilities

Ability to implement dependable systems using the above approaches, Ability to analyze the dependability of systems using the above methods for analysis

## Pattern Recognition and Data Compression | 6 ECTS

### Recommended Previous Knowledge

Linear algebra (including PCA, unitary transforms), stochastics and statistics, binary arithmetics

### Theoretical Knowledge

Students can name the basic concepts of pattern recognition and data compression. Students are able to discuss logical connections between the concepts covered in the course and to explain them by means of examples.

### Capabilities

Students can apply statistical methods to classification problems in pattern recognition and to prediction in data compression. On a sound theoretical and methodical basis they can analyze characteristic value assignments and classifications and describe data compression and video signal coding. They are able to use highly sophisticated methods and processes of the subject area. Students are capable of assessing different solution approaches in multidimensional decision-making areas.

# Study Package Computer Science WS1 – Master Winterterm

## Communication Networks | 6 ECTS

### Recommended Previous Knowledge

Fundamental stochastics, Basic understanding of computer networks and/or communication technologies is beneficial

### Theoretical Knowledge

Students are able to describe the principles and structures of communication networks in detail. They can explain the formal description methods of communication networks and their protocols. They are able to explain how current and complex communication networks work and describe the current research in these examples.

### Capabilities

Students are able to evaluate the performance of communication networks using the learned methods. They are able to work out problems themselves and apply the learned methods. They can apply what they have learned autonomously on further and new communication networks.

## Soft Computing | 6 ECTS

### Recommended Previous Knowledge

Bachelor in Computer Science, Basics in higher mathematics are inevitable, like calculus, linear algebra, graph theory, and optimization.

### Theoretical Knowledge

Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, neural networks, and fuzzy controllers. In particular, inference and learning in belief networks are important topics that the students should be able to master.

### Capabilities

Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R.

## Advanced System-on-Chip Design | 6 ECTS

### Recommended Previous Knowledge

Successful completion of the practical FPGA lab of module "Computer Architecture" is a mandatory prerequisite.

### Theoretical Knowledge

This module provides in-depth, hands-on experience on advanced concepts of computer architecture. Using the Hardware Description Language VHDL and using reconfigurable FPGA hardware boards, students learn how to design complex computer systems (so-called systems-on-chip, SoCs), that are commonly found in the domain of embedded systems, in actual hardware.
Starting with a simple processor architecture, the students learn to how realize instruction-processing of a computer processor according to the principle of pipelining. They implement different styles of cache-based memory hierarchies, examine strategies for dynamic scheduling of machine instructions and for branch prediction, and finally construct a complex MPSoC system (multi-processor system-on-chip) that consists of multiple processor cores that are connected via a shared bus.

### Capabilities

Students will be able to analyze, how highly specific and individual computer systems can be constructed using a library of given standard components. They evaluate the interferences between the physical structure of a computer system and the software executed thereon. This way, they will be enabled to estimate the effects of design decision at the hardware level on the performance of the entire system, to evaluate the whole and complex system and to propose design options to improve a system.

## Software Security | 6 ECTS

### Recommended Previous Knowledge

Familiarity with C/C++, web programming

### Theoretical Knowledge

Students can name the main causes for security vulnerabilities in software, explain current methods for identifying and avoiding security vulnerabilities, explain the fundamental concepts of code-based access control.

### Capabilities

Students are capable of performing a software vulnerability analysis and developing secure code.

# Study Package Computer Science WS2 – Master Winterterm

## Intelligent Systems in Medicine | 6 ECTS

### Recommended Previous Knowledge

principles of math (algebra, analysis/calculus), principles of stochastics, principles of programming, Java/C++ and R/Matlab, advanced programming skills

### Theoretical Knowledge

The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.

### Capabilities

The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.

## Soft Computing | 6 ECTS

### Recommended Previous Knowledge

Bachelor in Computer Science, Basics in higher mathematics are inevitable, like calculus, linear algebra, graph theory, and optimization.

### Theoretical Knowledge

Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, neural networks, and fuzzy controllers. In particular, inference and learning in belief networks are important topics that the students should be able to master.

### Capabilities

Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R.

## Intelligent Autonomous Agents and Cognitive Robotics | 6 ECTS

### Recommended Previous Knowledge

Vectors, matrices, Calculus

### Theoretical Knowledge

Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.

### Capabilities

Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states,e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.

## Distributed Algorithms | 6 ECTS

### Recommended Previous Knowledge

Algorithms and data structures, Distributed systems, Discrete mathematics, Graph theory

### Theoretical Knowledge

Students know the main abstractions of distributed algorithms (synchronous/asynchronous model, message passing and shared memory model). They are able to describe complexity measures for distributed algorithms (round, message and memory complexity). They explain well known distributed algorithms for important problems such as leader election, mutual exclusion, graph coloring, spanning trees. They know the fundamental techniques used for randomized algorithms.

### Capabilities

Students design their own distributed algorithms and analyze their complexity. They make use of known standard algorithms. They compute the complexity of randomized algorithms.

# Study Package Electrical Engineering MS1 – Master Summer-term

## Semiconductor Technology | 6 ECTS

### Recommended Previous Knowledge

Basics in physics, chemistry, material science and semiconductor devices

### Theoretical Knowledge

Students are able to describe and to explain current fabrication techniques for Si and GaAs substrates, to discuss in details the relevant fabrication processes, process flows and the impact thereof on the fabrication of semiconductor devices and integrated circuits and to present integrated process flows.

### Capabilities

Students are capable to analyze the impact of process parameters on the processing results, to select and to evaluate processes and to develop process flows for the fabrication of semiconductor devices.

## EMC I: Coupling Mechanisms, Countermeasures and Test Procedures | 6 ECTS

### Recommended Previous Knowledge

Fundamentals of Electrical Engineering

### Theoretical Knowledge

Students are able to explain the fundamental principles, inter-dependencies, and methods of Electromagnetic Compatibility of electric and electronic systems and to ensure Electromagnetic Compatibility of such systems. They are able to classify and explain the common interference sources and coupling mechanisms. They are capable of explaining the basic principles of shielding and filtering. They are able of giving an overview over measurement and simulation methods for the characterization of Electromagnetic Compatibility in electrical engineering practice.

### Capabilities

Students are able to apply a series of modeling methods for the Electromagnetic Compatibility of typical electric and electronic systems. They are able to determine the most important effects that these models are predicting in terms of Electromagnetic Compatibility. They can classify these effects and they can quantitatively analyze them. They are capable of deriving problem solving strategies from these predictions and they can adapt them to applications in electrical engineering practice. They can evaluate their problem solving strategies against each other.

## Information Theory and Coding | 6 ECTS

### Recommended Previous Knowledge

Mathematics 1-3, Probability theory and random processes, Basic knowledge of communications engineering (e.g. from lecture "Fundamentals of Communications and Random Processes")

### Theoretical Knowledge

The students know the basic definitions for quantification of information in the sense of information theory. They know Shannon's source coding theorem and channel coding theorem and are able to determine theoretical limits of data compression and error-free data transmission over noisy channels. They understand the principles of source coding as well as error-detecting and error-correcting channel coding. They are familiar with the principles of decoding, in particular with modern methods of iterative decoding. They know fundamental coding schemes, their properties and decoding algorithms.

### Capabilities

The students are able to determine the limits of data compression as well as of data transmission through noisy channels and based on those limits to design basic parameters of a transmission scheme. They can estimate the parameters of an error-detecting or error-correcting channel coding scheme for achieving certain performance targets. They are able to compare the properties of basic channel coding and decoding schemes regarding error correction capabilities, decoding delay, decoding complexity and to decide for a suitable method. They are capable of implementing basic coding and decoding schemes in software.

## Optimal and Robust Control | 6 ECTS

### Recommended Previous Knowledge

Classical control (frequency response, root locus), State space methods, Linear algebra, singular value decomposition

### Theoretical Knowledge

Students can explain the significance of the matrix Riccati equation for the solution of LQ problems.
They can explain the duality between optimal state feedback and optimal state estimation.
They can explain how the H2 and H-infinity norms are used to represent stability and performance constraints.
They can explain how an LQG design problem can be formulated as special case of an H2 design problem.
They can explain how model uncertainty can be represented in a way that lends itself to robust controller design

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They can explain how - based on the small gain theorem - a robust controller can guarantee stability and performance for an uncertain plant.
They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities.

### Capabilities

Students are capable of designing and tuning LQG controllers for multivariable plant models.
They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard software tools for solving it.
They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitivity functions, and of carrying out a mixed-sensitivity design.
They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller.
They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard LMI-solvers for solving them.
They can carry out all of the above using standard software tools (Matlab robust control toolbox).

# Study Package Electrical Engineering MS2 – Master Summerterm

## Bioelectromagnetics: Principles and Applications | 6 ECTS

### Recommended Previous Knowledge

Basic principles of physics

### Theoretical Knowledge

Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.

### Capabilities

Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.

## Linear and Nonlinear System Identification | 6 ECTS

### Recommended Previous Knowledge

Classical control (frequency response, root locus), State space methods, Discrete-time systems, Linear algebra, singular value decomposition, Basic knowledge about stochastic processes

### Theoretical Knowledge

Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures, They can explain how multilayer perceptron networks are used to model nonlinear dynamics, They can explain how an approximate predictive control scheme can be based on neural network models, They can explain the idea of subspace identification and its relation to Kalman realisation theory

### Capabilities

Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear models for dynamic systems, They are capable of implementing a nonlinear predictive control scheme based on a neural network model, They are capable of applying subspace algorithms to the experimental identification of linear models for dynamic systems, They can do the above using standard software tools (including the Matlab System Identification Toolbox)

## Fibre and Integrated Optics | 6 ECTS

### Recommended Previous Knowledge

Basic principles of electrodynamics and optics

### Theoretical Knowledge

Students can explain the fundamental mathematical and physical relations and technological basics of guided optical waves. They can describe integrated optical as well as fibre optical structures. They can give an overview on the applications of integrated optical components in optical signal processing.

### Capabilities

Students can generate models and derive mathematical descriptions in relation to fibre optical and integrated optical wave propagation. They can derive approximative solutions and judge factors influential on the components' performance.

## Optical Communications | 6 ECTS

### Recommended Previous Knowledge

Fundamentals of Electrical Engineering, Communication Engineering, Electronics Components

### Theoretical Knowledge

The aim of this course is imparting profound knowledge and analytical skills in the following fields:

- Fundamentals of Optical Waveguiding

- Properties of Optical Silica Fibers
- Passive Components for Optical Communications
- Fundamentals of Photodiodes and LEDs
- Noise in Photodetectors
- Laser Diodes
- Optical Amplifiers
- Nonlinearities in Optical Fibers
- Optical Communication Systems

### Capabilities

Fundamental skills are imparted with respect to the modelling of basic optical communication systems and fundamental optical components as well as to estimating the influence of important causes of impairement.

# Study Package Electrical Engineering MW1 – Master Winterterm

## Advanced Topics in Control | 6 ECTS

### Recommended Previous Knowledge

H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities

### Theoretical Knowledge

Students can explain the advantages and shortcomings of the classical gain scheduling approach
They can explain the representation of nonlinear systems in the form of quasi-LPV systems
They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions. They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems. They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures. Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems. They can explain the convergence properties of first order consensus protocols
They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models. Students can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/sensor array
They can explain (in outline) the extension of the bounded real lemma to such distributed systems and the associated synthesis conditions for distributed controllers

### Capabilities

Students are capable of constructing LPV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic, LFT or general LPV models
They are able to use standard software tools (Matlab robust control toolbox) for these tasks.
Students are able to design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Matlab tools provided.

Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox.

## Integrated Circuit Design | 6 ECTS

### Recommended Previous Knowledge

Basic knowledge of (solid-state) physics and mathematics.
Knowledge in fundamentals of electrical engineering and electrical networks.

### Theoretical Knowledge

Students can qualitatively construct energy band diagrams of the devices for varying applied voltages.
Students are able to qualitatively determine electric field, carrier concentrations, and charge flow from energy band diagrams.
Students can understand scientific publications from the field of semiconductor devices.
Students can calculate the dimensions of MOS devices in dependence of the circuits properties
Students can design complex electronic circuits and anticipate possible problems.
Students know procedure for optimization regarding high performance and low power consumption

## EMC II: Signal Integrity and Power Supply of Electronic Systems | 6 ECTS

### Recommended Previous Knowledge

Fundamentals of electrical engineering

### Theoretical Knowledge

Students are able to explain the fundamental principles, inter-dependencies, and methods of signal and power integrity of electronic systems. They are able to relate signal and power integrity to the context of interference-free design of such systems, i.e. their electromagnetic compatibility. They are capable of explaining the basic behavior of signals and power supply in typical packages and interconnects. They are able to propose and describe problem solving strategies for signal and power integrity issues. They are capable of giving an overview over measurement and simulation methods for characterization of signal and power integrity in electrical engineering practice.

### Capabilities

Students are able to apply a series of modeling methods for characterization of electromagnetic field behavior in packages and interconnect structure of electronic systems. They are able to determine the most important effects that these models are predicting in terms of signal and power integrity. They can classify these effects and they can quantitatively analyze them. They are capable of deriving problem solving strategies from these predictions and they can adapt them to applications in electrical engineering practice. The can evaluate their problem solving strategies against each other.

## Control Lab | 4 ECTS

### Recommended Previous Knowledge

Prof. Dr. Volker Turau
Institute of Telematics, E-17
Deputy Dean International
School of Electrical Engineering, Computer Science and Mathematics

State space methods, LQG control, H2 and H-infinity optimal control, uncertain plant models and robust control, LPV control

### Theoretical Knowledge

Students can explain the difference between validation of a control lop in simulation and experimental validation

### Capabilities

Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis, They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers, They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers, They are capable of representing model uncertainty, and of designing and implementing a robust controller
They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers.

# Study Package Electrical Engineering MW2 – Master Winter-term

## Mixed-signal Circuit Design | 6 ECTS

### Recommended Previous Knowledge

Advanced knowledge of analog or digital MOS devices and circuits

### Theoretical Knowledge

Students can derive the fundamental limitations of different analog-to-digital and digital-to-analog converters
Students can select the most suitable architecture for a specific mixed-signal task
Students can describe complex mixed-signal systems by their functional blocks.
Students can calculate the specifications of mixed-signal circuits

## Electronic Circuits for Medical Applications | 6 ECTS

### Recommended Previous Knowledge

Fundamentals of electrical engineering

### Theoretical Knowledge

Students can explain the basic functionality of the information transfer by the central nervous system
Students are able to explain the build-up of an action potential and its propagation along an axon
Students can exemplify the communication between neurons and electronic devices
Students can describe the special features of low-noise amplifiers for medical applications

Students can explain the functions of prostheses, e. g. an artificial hand
Students are able to discuss the potential and limitations of cochlea implants and artificial eyes

### Capabilities

Students can calculate the time dependent voltage behavior of an action potential
Students can give scenarios for further improvement of low-noise and low-power signal acquisition.
Students can develop the block diagrams of prosthetic systems
Students can define the building blocks of electronic systems for an artificial eye.

## Microsystem Engineering | 6 ECTS

### Recommended Previous Knowledge

Basic courses in physics, mathematics and electric engineering

### Theoretical Knowledge

The students know about the most important technologies and materials of MEMS as well as their applications in sensors and actuators.

### Capabilities

Students are able to analyze and describe the functional behaviour of MEMS components and to evaluate the potential of microsystems.

## Integrated Circuit Design | 6 ECTS

### Recommended Previous Knowledge

Basic knowledge of (solid-state) physics and mathematics.
Knowledge in fundamentals of electrical engineering and electrical networks.

### Theoretical Knowledge

Students can qualitatively construct energy band diagrams of the devices for varying applied voltages.
Students are able to qualitatively determine electric field, carrier concentrations, and charge flow from energy band diagrams.
Students can understand scientific publications from the field of semiconductor devices.
Students can calculate the dimensions of MOS devices in dependence of the circuits properties
Students can design complex electronic circuits and anticipate possible problems.
Students know procedure for optimization regarding high performance and low power consumption

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